Safety Regulation Group

Civil Aviation Authority

CAP 670

Air Traffic Services Safety Requirements

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Revision History

Third Edition **Amendment 1/2013 (First Amendment)**

This amendment incorporates the following changes:

Section Affected	Change
Part C, Section 2 ILS 01	Correction of typographical errors incorporated at Issue 3.
Part C, Section 2 ILS 02	Correction of typographical errors incorporated at Issue 3.
Part C, Section 3 SUR 13	Incorporation of new SUR 13 section introducing Requirements for implementation of Wind Turbine interference mitigation techniques on surveillance systems.

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Glossary

Definitions

1 The following terms have been defined to remove any doubt about the meaning of instructions in the text of this and associated documents. In CAA publications, where a term is used, which is defined by ICAO in a relevant Annex or PANS document, that definition will apply unless:

- the contrary is indicated; or
- there is a different definition in the Air Navigation Order or European Regulations.

2 Suitable interpretations, where they exist, have been selected from national and international documents. Some terms appear in more than one document and sometimes have different meanings.

3 Terms that have not been annotated are those which have specific meanings within the text and have been defined to avoid ambiguity or misunderstanding. In some cases they are slight modifications of definitions in other documents.

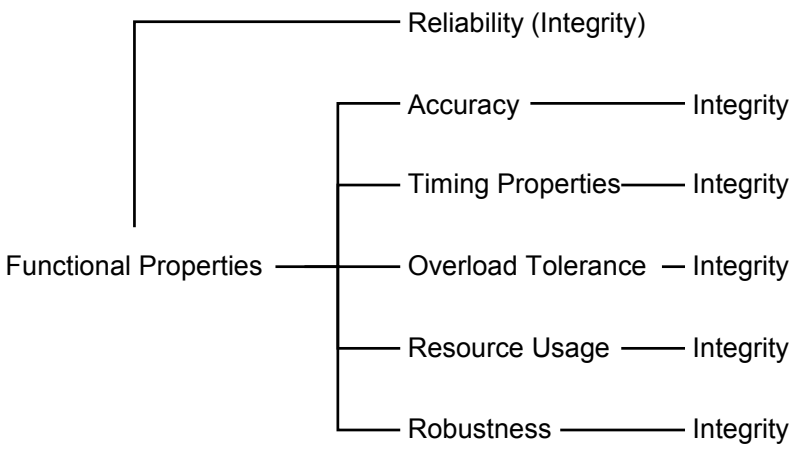
A	
Accuracy	A degree of conformance between the estimated or measured value and the true value. (ICAO) **Note:** For measured positional data the accuracy is normally expressed in terms of a distance from a stated position within which there is a defined confidence of the true position falling.
Aerodrome	A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft. (ICAO)
Aerodrome Traffic Monitor	An electronic display indicating the position and distance from touchdown of arriving aircraft relative to the extended centreline of the runway in use. It may also be used for other purposes. It is also known as the Distance From Touchdown Indicator.

Aeronautical Fixed Service	A telecommunication service between specified fixed points provided primarily for the safety of air navigation and for the regular, efficient and economical operation of air services. (ICAO)
Aeronautical Ground Lighting	Any light specifically provided as an aid to air navigation, other than a light displayed on an aircraft. (ICAO)
Aeronautical Information Service	A service established within the defined area of coverage responsible for the provision of aeronautical information and data necessary for the safety, regularity, and efficiency of air navigation. (EC 549/2004)
Aeronautical Mobile Service (RR S2)	A mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate; emergency position-indicating radio beacon stations may also participate in this service on designated distress and emergency frequencies. (ITU RR S2) (ICAO)
Aeronautical Mobile Station	A Station in the Aeronautical Mobile Service, other than an Aircraft Station, intended to be used while in motion or during halts at unspecified points. [Based on ITU RR S2, S7 & S3 and ICAO Annex 10 Volume II Chapter 1]
Aeronautical Radio Station	A radio station on the surface, which transmits or receives signals for the purpose of assisting aircraft. (ANO)
Aeronautical Station (RR S1)	A land station in the aeronautical mobile service. In certain instances, an aeronautical station may be located, for example, on board ship or on a platform at sea. (ICAO)
Air-Ground Communication	Two-way communication between aircraft and stations or locations on the surface of the earth. (ICAO)
Airspace Management	A planning function with the primary objective of maximising the utilisation of available airspace by dynamic time-sharing and, at times, the segregation of airspace among various categories of airspace users on the basis of short-term needs. (EC 549/2004)
Air Navigation Services	Air traffic services; communication, navigation and surveillance services; meteorological services for air navigation; and aeronautical information services. (EC 549/2004)

Air Navigation Service Provider	Any public or private entity providing air navigation services for general air traffic. (EC 549/2004)
Air Traffic	All aircraft in flight or operating on the manoeuvring area of an aerodrome. (ICAO)
Air Traffic Control Unit	A person appointed by a person maintaining an aerodrome or place to provide an air traffic control service. (ANO)
Air Traffic Control Service	A service provided for the purpose of: 1. preventing collisions: a) between aircraft, and b) in the manoeuvring area between aircraft and obstructions; and 2. expediting and maintaining an orderly flow of air traffic. (EC 549/2004)
Air Traffic Flow Management	A function established with the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilised to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate air traffic Service Providers. (EC 549/2004)
Air Traffic Management	The aggregation of the airborne and ground-based functions (air traffic services, airspace management and air traffic flow management) required to ensure the safe and efficient movement of aircraft during all phases of operations. (EC 549/2004)
Air Traffic Services	The various flight information services, alerting services, air traffic advisory services and ATC services (area, approach and aerodrome control services). (EC 549/2004)

Air Traffic Service Equipment	Ground based equipment, including an aeronautical radio station, used or intended to be used in connection with the provision of a service to an aircraft in flight or on the ground which equipment is not otherwise approved by or under [the ANO] but excluding: any public electronic communications network; and any equipment in respect of which the CAA has made a direction that it shall be deemed not to be air traffic service equipment for the purposes of Articles 205 and 206. (ANO)
Airway	A control area or portion thereof established in the form of a corridor. (ICAO)
Altitude	The vertical distance of a level, a point or an object considered as a point, measured from mean sea level. (ICAO)
Annex 'n'	The Annex number 'n' to the Convention on International Civil Aviation.
Application	The whole system that provides the overall service to the user.
Application Software	The software part of the application, including data.
Approval	The approval, in writing, required under the ANO before a person can provide an air traffic service.
Assurance Evidence Level (AEL)	Assurance Evidence Levels (AELs) are allocated to software safety requirements to identify the type, depth and strength of evidence that must be made available from the software lifecycle for the equipment approval process
ATS Message Handling System (AMSH)	The set of computing and communication resources implemented by ATS organisations to provide the ATS message handling service. (ICAO Annex 10 Vol III)
Authorised by the CAA	An authorisation in writing that amplifies instructions and/or specifies conditions of operation.

Automatic Terminal Information Service	the automatic provision of current, routine information to arriving and departing aircraft throughout 24 hours or a specified portion thereof: 1. Data link-automatic terminal information service (D-ATIS) means the provision of ATIS via data link. 2. Voice-automatic terminal information service (Voice-ATIS) means the provision of ATIS by means of continuous and repetitive voice broadcasts. (ICAO)
Availability	The ability of a system to perform within specified limits a required function under given conditions at a given time.
B	
Barrier	A barrier is a mechanism that constrains interference to an element. A barrier has scope and strength. A barrier constrains rather than eliminates interference. Barriers tend to be orientated to protect from inbound interference rather than prevention of outbound interference. While the concept of protecting a communication path from interference (e.g. corruption) is familiar (parity bit checks, checksums, etc. are all barriers), applying the same concepts to the code is perhaps less familiar. 'Defensive code' would be a partial barrier against interference (e.g. software that checks the format/ structure of inbound messages). More complex barriers would typically be available from an Operating System (e.g. providing protected memory).
Barricade	The set of barriers associated with a Software Architectural Unit that protect the functions of a Software Architectural Unit from interference from other Software Architectural Units.
Base Station	A land station in the land mobile service. (ITU RR S1)

Behavioural Attributes	Functional properties, Timing properties, Robustness, Reliability, Accuracy, Resource usage, Overload tolerance. The relationship between the Behavioural attributes is illustrated below: 
Blocking	When a switching matrix cannot make an immediate connection between any input and output it is said to be blocked. This may also be termed 'limited availability'. The opposite of this condition is 'non-blocking' or 'full availability'.
C	
Chief Executive	The person with the ultimate authority and responsibility for all aspects of the control, planning and organisation of the business.
Controlled Airspace	Airspace which has been notified as Class A, Class B, Class C, Class D or Class E airspace. (ANO)
Contingency Equipment	Equipment which is used for business continuity purposes.
Correct	Free from fault. **Note**: This does not mean mathematically proven. Where Formal proof of Correctness is required it is stated in the text.

D	
Data Link Application	The implementation of data link technology to achieve specific ATM operational functionalities.
Data Link Service	A set of ATM related transactions, both system supported and manual, within a data link application, which have a clearly defined operational goal. Each data link application is a description of its recommended use from an operational point of view.
Data Link Service Provider	The organisation with overall accountability for the data link service. This includes the operational requirements of the data link system.
Data Link System	The total set of component parts, equipment, software and protocols that is required to provide the data link service.
Designated Operational Coverage	Designated Operational Coverage (DOC) is that volume of airspace needed operationally in order to provide a particular service and within which the facility is afforded frequency protection. [ITU RR S] The DOC is quantified by operational range in nautical miles and height in flight level or feet above ground level and defines the limit of the service area associated with the frequency assignment for a particular service. See Radio Service Area.
Design notation	Any notation that has well understood (although not necessarily a formally specified) semantics, which describes the structure or intended behaviour of some aspect of a software system, either by graphical or textual means, or both. Examples of design notations include data and control flow diagrams, state transition diagrams, MASCOT or HOOD diagrams, and decision tables. A high level programming language is regarded here as a particular kind of design notation, although with the special property that it can be compiled directly into executable code.
Distance From Touchdown Indicator	See Aerodrome Traffic Monitor.

Duplex Operation	Operating method in which transmission is possible simultaneously in both directions of a telecommunication channel. (ITU RR S26).
E	
Element	A unit of code. Units of code deliver functionality, which combines to ultimately fulfil requirements. Typically one might think of elements as procedures, tasks, objects etc. Elements are grouped together (with a barricade) to form AUs. An element may belong to more than one AU.
Emergency Equipment	Equipment which is operationally independent of the Main and Standby Equipment, rapidly available for use when required, and used exclusively for the controlled shutdown of an Air Traffic Service in a safe manner.
Endorse	Wherever the term 'endorse' is used in connection with safety regulation matters this shall be taken to mean acceptance. It is not to be confused with an ANO approval where formal methods have been applied to secure acceptable regulatory confidence in the approval holder.
Equipment	A non-specific term used to denote any product (which may be called by a specific name) designed and built to perform a specific function as a self-contained unit or to perform a function in conjunction with other units. Units are physical hardware entities, possibly with software and firmware.
Equipment Categories	Fixed, Stationary, Vehicle, Portable and Hand Held.
Equipment Redundancy	The use of a combination of Main, Standby and Emergency equipment to improve the overall system reliability and to ensure the continuity of service.
Equipment Types	Transmitter, Receiver and Transceiver.
Error Detection	A process of testing for non-valid data, bit error or syntax, and addressing problems or the event of an error being detected.

Error Rate	The number of allowable errors detected within a specified time interval.
F	
Failure	A loss of function, or malfunction, of a system or part thereof. (JAR 25)
Fault Tolerance	The built-in capability of a system to provide continued correct execution, i.e. provision of service as specified, in the presence of a limited or specified number of equipment faults.
Fixed Equipment	Fixed equipment is that which is permanently installed at a specific location with external connections for power supplies, antennas, audio (microphone and loudspeaker) connections, e.g. Cabinet or rack mounted equipment.
Function	A mode of action or activity by which software fulfils its purpose.
Functional Properties	The primary functional behaviour of the software.
G	
Ground-Ground Communications	Two-way communications between or with ATS facilities located on the surface of the earth.
Ground Visibility	The visibility at an aerodrome as reported by an accredited observer or by automatic means. (ICAO)
Gust	The peak wind speed averaged over a 3 second period. (CAP746)
H	
Hand Held Equipment	Equipment with integral battery, antenna, PTT key, microphone and loudspeaker, designed to be operated whilst being carried in the hand or worn on the body. Provisions may be made for external connections for antenna, PTT key, microphone, headphone and external power supply or battery pack and desktop cradle or mounting unit, which may enable it to be classified in the Stationary Equipment Category.
Hazard	Any condition, event, or circumstance which could induce an incident. (EU 1035/2011)

Hazard Analysis	A systematic investigation of the hazards posed by a system, in terms of likely effects of system behaviour.
Heading	The direction in which the longitudinal axis of an aircraft is pointed, usually expressed in degrees from north (true, magnetic, compass or grid). (ICAO)
Height	The vertical distance of a level, a point, or an object considered as a point measured, from a specified datum. (ICAO)
I	
Identification	The situation which exists when the position indication of a particular aircraft is seen on a situation display and positively identified. (ICAO)
ILS – Category I	An ILS which provides guidance information from the coverage limit of the ILS to the point at which the localiser course line intersects the ILS glide path at a height of 60m (200 ft) or less above the horizontal plane containing the threshold. (ICAO)
ILS – Category II	An ILS which provides guidance information from the coverage limit of the ILS to the point at which the localiser course line intersects the ILS glide path at a height of 15 m (50 ft) or less above the horizontal plane containing the threshold. (ICAO)
ILS – Category III	An ILS which, with the aid of ancillary equipment where necessary, provides guidance information from the coverage limit of the facility to, and along, the surface of the runway. (ICAO)
Integrity	That quality which relates to the confidence that can be placed in the validity of the information provided by a system.

Interference	Interference is defined as unintended (therefore un-designed) interaction between elements (either within or between AUs). Interfaces are known as Designed Interactions. Undesigned interactions are synonymous with interference. Interference can be both inbound (i.e. interference to the elements from the outside world) as well as outbound (i.e. interference from the elements to the outside world). Elements are protected from interference by barriers. Sources of interference include: Operating environment (EMC, Hardware faults etc.) Mistakes made when following a design (or specification or requirement) or additional behaviour added to a design, i.e. corrupt behaviour, additional behaviour, omitted behaviour.
International Airport	Any airport designated by the Contracting State in whose territory it is situated as an airport of entry and departure for international air traffic, where the formalities incident to customs, immigration, public health, animal and plant quarantine and similar procedures are carried out. (ICAO)
L	
Land Mobile Service	A mobile service between base stations and land mobile stations, or between land mobile stations. (ITU RR S6)
Land Mobile Station	A mobile station in the land mobile service capable of surface movement within the geographical limits of a country or continent. (ITU RR S3)
Land Station	A station in the mobile service not intended to be used while in motion. (ITU RR S9)
Lines of Communication	A communications link which can be accessed at a particular operating position. Selected lines of communication are those available lines which have been selected by the operator for a particular mode of operation.

Luminance	(L or B, Candela Metre–2) In a given direction at the point on a surface, is the luminous intensity in that direction, of an infinitesimal element of the surface containing the point, by the area of the orthogonal projection of this element on a plane perpendicular to the direction considered. (Commission Internationale De L'Eclairage (CIE))
Luminous Intensity	The luminous flux per unit solid angle in a given direction (candelas). (ICAO) **Note:** Luminous Flux is defined by CIE.
M	
Main Equipment	The terms 'Main' and 'Standby' are generally used to describe identical or similar equipment, configured within a system to provide equipment redundancy, in order to improve the overall reliability and to ensure the continuity of service. The terms may also be applied to sub-equipment and modules as well as facilities, functions and services.
Maintenance	The preservation or restoration of the required system performance over the system lifecycle.
MATS Part 2	The unit specific instructions to controllers produced by the Provider of the Air Traffic Control Service.
May	Used to indicate that the following clause is optional, alternative, or permissive.
Mitigation	Steps taken to control or prevent a hazard from causing harm and reduce risk to a tolerable or acceptable level.
O	
Operating System	A program that controls the execution of application software and acts as an interface to the underlying hardware platform.
Operational Control	The exercise of authority over the initiation, continuation, diversion or termination of a flight in the interest of the safety of the aircraft and the regularity and efficiency of the flight. (ICAO)
Operational Requirement	The basic operational need in the aeronautical environment from the air traffic service perspective.

Overload Tolerance	The behaviour of the system in the event of, and in particular its tolerance to, inputs occurring at a greater rate than expected during normal operation of the system.
P	
Portable Equipment	Equipment with integral battery, antenna, PTT key, microphone and loudspeaker, designed to be operated as a self contained unit either whilst being carried or at a temporary location. Provisions may be made for external connections for antenna, PTT key, microphone, headphone and external power supply or battery pack, which may enable it to be classified in the Stationary Equipment Category.
Position Indication	The visual indication, in non-symbolic and/or symbolic form, on a situation display, of the position of an aircraft, aerodrome vehicle or other object. (ICAO)
Position Symbol	The visual indication in symbolic form, on a situation display, of the position of an aircraft, aerodrome vehicle or other object, obtained after automatic processing of positional data derived from any source. (ICAO)
Power (of a radio transmitter)	The power of a radio transmitter can be expressed in terms of peak envelope power (PX or pX), mean power (PY or pY) and carrier power (PZ or pZ) according to the class of emission. The symbol 'p' denotes power expressed in watts and symbol 'P' denotes power expressed in decibels relative to a reference level. [Based on ITU RR S56]
Pre-existing software	Any software that is not written specifically for a given application but is obtained from other sources and is used either in source code or in object code form. Typical examples of pre-existing software include operating systems and database management systems. Commercial-off-the-shelf (COTS) software is by definition pre-existing, although other sources of pre-existing software exist, for example 'free' software published by various organisations.
Primary Radar	A surveillance radar system which uses reflected radio signals. (ICAO)

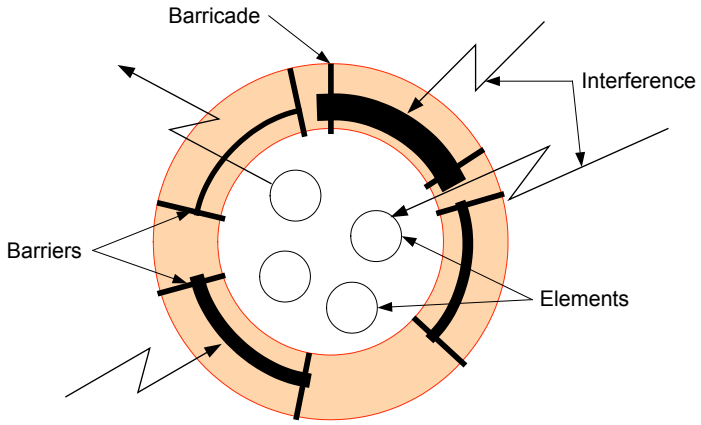
Private Business Radio	Term used by the Radiocommunications Agency for Private land Mobile Radio and related services.
Private land Mobile Radio	Radio equipment and systems in the Land Mobile Service used for the exclusive benefit and solely in the interests of the licensee's business as opposed to Public Mobile Radio equipment and systems which are provided commercially for use by others.
Proof	Convincing evidence. **Note**: This does not mean mathematically proven. Where Formal proof is required it is stated in the text.
Provider (of an Air Traffic Service)	A legal person nominated by an aerodrome or other authority to provide an air traffic service. The Provider will usually be a legal entity such as a company and it is to this entity that the ANO refers in the legal form of a 'person'.
Q	
QNH	Altimeter sub-scale setting to obtain elevation when on the ground. (ICAO)
Qualitative Processes	Those analytical processes which are subjective and non-numerical in manner.
Quantitative Processes	Those analytical processes which are numerical in manner.
R	
Radar	A radio detection device which provides information on range, azimuth and/or elevation of objects. (ICAO)
Radar Approach	An approach in which the final approach phase is executed under the direction of a controller using radar. (ICAO)
Radar Clutter	The visual indication on a situation display of unwanted signals. (ICAO)
Radar Separation	The separation used when aircraft position information is derived from radar sources. (ICAO)
Radial	A magnetic bearing extending from a VOR/VORTAC/ TACAN.

Radiation Shield	A reflective radiation shield housing capable of protecting the internal sensors from direct and reflected solar and terrestrial (long wave) radiation and from precipitation. The shield shall provide adequate ventilation and shall not represent a significant thermal mass.
Radio Service Area	The Radio Service Area is that volume of airspace, bounded by the DOC and a lower height limit within which communications of a specified quality of service are provided. An alternative to defining a lower height limit, where this cannot easily be defined for the whole of the DOC, is to identify areas where the communications quality of service is below that specified.
Reliability	The ability of a system to perform a required function under given conditions for a given time interval.
Report	A documentary justification of a claim.
Reporting Point	A specified geographical location in relation to which the position of an aircraft can be reported. (ICAO)
Resource Usage	The amount of resources within the computer system that can be used by the application software. Resources may include main memory of various categories (such as static data, stack and heap), disc space and communications bandwidth, and may include internal software resources, such as the number of files which may be simultaneously open.
Rigorous Argument	A logically correct argument that is assumed to be mathematically provable, but has not been proven.
Rigorous Inspection	A careful examination of a design or program component to ensure that it meets its requirements, is internally consistent and well formed, and conforms to all necessary standards and procedures. The 'Fagan' technique is one well-known inspection technique that is noted for its rigour.

Risk	The combination of the probability, or frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence. (British Standard BS 4778)
Risk Assessment	Assessment to establish that the achieved or perceived risk is lower or equal to an acceptable or tolerable level.
Robustness	The behaviour of the software in the event of spurious (unexpected) inputs, hardware faults and power supply interruptions, either in the computer system itself or in connected devices.
Routine Maintenance	Maintenance at regular periodic intervals, identified at the systems design stage of equipments, functions, components etc., which are known to cause or potentially cause degradation to the required system performance.
Rule	One of the rules of the ANO.
Runway	A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft. (ICAO)
Runway Visual Range	The range over which the pilot of an aircraft on the centreline of a runway can see the runway surface markings or the lights delineating the runway or its centreline. (ICAO)
S	
Safety	Freedom from unacceptable risk of harm. (IEC 1508)
Safety Assurance	Shall mean all planned and systematic actions necessary to afford adequate confidence that a product, a service, an organisation or a functional system achieves acceptable or tolerable safety. (EU 1035/2011)
Safety Assurance Document/Safety Case	A document which clearly and comprehensively presents sufficient arguments, evidence and assumptions that system hazards have been identified and controlled for both engineering and operational areas to demonstrate that a facility, facilities or organisation is/ are adequately safe in air traffic service requests.
Safety Integrity (SI)	The probability of a safety-related system satisfactorily performing the required safety functions under all the stated conditions within a stated period of time.

Safety Lifecycle	The necessary activities involved in the implementation of safety-related systems, occurring during a period of time which starts at the concept phase of a project and finishes when none of the safety-related systems are any longer available for use.
Safety Objective	Shall mean a qualitative or quantative statement that defines the maximum frequency or probability at which a hazard can be expected to occur. (EU 1035/2011)
Safety Policy	A safety policy is a declaration of a general plan of action set by the authority of management.
Safety Regulatory Audit	A systematic and independent examination conducted by, or on behalf of, a national supervisory authority to determine whether complete safety-related arrangements or elements thereof, related to process and their results, products or services, comply with required safety-related arrangements and whether they are implemented effectively and are suitable to achieve expected results. (EU 1034/2011)
Safety Regulatory Requirements	The requirements established by Community or national regulations for the provision of air navigation services or ATFM and ASM functions concerning the technical and operational competence and suitability to provide these services and functions, their safety management, as well as systems, their constituents and associated procedures. (EU 1035/2011)
Safety Requirement	Shall mean a risk-mitigation means, defined from the risk-mitigation strategy that achieves a particular safety objective, including organisational, operational, procedural, functional, performance, and interoperability requirements or environmental characteristics. (EU 1035/2011)
Secondary Surveillance Radar	A surveillance radar system which uses transmitters/ receivers (interrogators) and transponders. (ICAO)
Semi-Duplex Operation	A method which is simplex operation at one end of the circuit and duplex operation at the other. (ITU RR S27)
Shall (is to, are to, and must)	The requirement or instruction is mandatory.

Should	Means that it is strongly advisable that an instruction or action is carried out, it is recommended or discretionary. It is applied where the more positive 'shall' is unreasonable but nevertheless a provider would need good reason for not complying.
Sidetone	A speech signal derived from the transmit path and fed back at a reduced level to the receive path with negligible delay.
Simplex Operation	Operating method in which transmission is made possible alternately in each direction of a telecommunication channel, for example by means of manual control. (ITU RR S25)
Situation Display	An electronic display depicting the position and movement of aircraft and other information as required. (ICAO)
Software	Software comprises the programs that execute in stored program digital computers (including Programmable Logic Controllers). Software also includes any data contained within the programs or held on external storage media, which is necessary for the safe operation of the system. Software may: be developed for a particular application; be re-used from previous applications, with or without modification; have been obtained from third party software suppliers (commonly called Commercial Off The Shelf (COTS) software), e.g. database systems and operating systems or be any combination of these three types of software.

Software Architectural Unit	A software architectural unit is defined as a set of elements protected against interference by a barricade, as illustrated below.  A point to note is that because different barriers protect against different forms of interference it is entirely possible that the System may be nominally partitioned into one set of software architectural units with respect to one form of interference and into a different set of software architectural units for another form of interference. A consequence of this is that an element may belong to more than one software architectural unit e.g. an element may be adequately protected from corruption of input data by the protocol implemented on the element's interface, hence the software architectural unit in this case is the element with the implementation of the protocol as the barrier. Whereas the element's access to resources such as memory and CPU may be protected by the operating System, which also provides the same protection to all the other elements on the Equipment. Hence in this case the software architectural unit is all the elements on the Equipment, with the operating System acting as the barrier. See SW 01 Appendix A paragraph SW01A.18.
Software Error	A software fault that has been triggered which results in the program deviating from the design intent.
Software Failure	The inability of a program to perform a required function correctly.

Software Fault	A defect in the program code and the primary source of a software failure.
Software Safety Requirements	Those requirements that define the safety behaviour of the software. Each Software Safety Requirement is specified in terms of the Behavioural Attributes.
Special Event	A Royal Flight, an airshow, air rally, or other organised event requiring the establishment of a temporary ATS unit.
Specification	A precise technical definition of the required parameters or performance to be achieved.
Standard	Characteristics, methods, principles and practices that can be used to satisfy a requirement. Standards may be international, national or company internal Standards may be adopted by a regulated organisation in response to a regulatory requirement provided that it is acceptable to the regulator. The regulator may specify a standard to satisfy part or all of a requirement.
Standby Equipment	The terms 'Main' and 'Standby' are generally used to describe identical or similar equipment, configured within a system to provide equipment redundancy, in order to improve the overall reliability and to ensure the continuity of service. The terms may also be applied to sub-equipment and modules as well as facilities, functions and services.
Statement	A claim.
Static analysis	A means of determining certain properties of a program without executing it on a computer. These properties may include aspects of functional behaviour, timing and resource usage. Forms of static analysis include control flow, data flow, information flow, semantic and compliance analysis which are defined elsewhere in these definitions.
Stationary Equipment	Stationary equipment is that which is installed at a specific location with external connections for power supplies, antennas, audio (microphone and loudspeaker) connections, which is physically mounted such that it can easily be moved once external connections have been released, e.g. Desktop equipment.

Suitably Qualified Engineer	An engineer with appropriate working experience on the equipment or system, or has attended a manufacturer's course or similar that covers the areas necessary to provide a competent response / repair to restore the service.
Surface Movement Control Service	A surface movement control service using a two-way communications facility for the control of vehicles on the manoeuvring area.
Surveillance Radar	Radar equipment used to determine the position of an aircraft in range and azimuth. (ICAO)
Surveillance Service	Term used to indicate a service provided directly by means of an ATS surveillance system. (ICAO)
System Failure	The inability of a system to fulfil its operational requirements. Failure may be systematic or due to a physical change.
System Self Test	An automatic test procedure that ensures the system is free from error.
System Safety Requirements	Those requirements that define the safety behaviour of the System. Each System Safety Requirement is specified in terms of the Behavioural Attributes.
T	
Temporary ATS unit	An ATS unit established to provide a service associated with a Special Event and normally comprising no more than 7 consecutive days of air operations.
Terminal Control Area	A control area normally established at the confluence of ATS routes in the vicinity of one or more major aerodromes. (ICAO)
Threshold	The beginning of that portion of the runway usable for landing. (ICAO)
Timing Properties	The time allowed for the software to respond to given inputs or to periodic events, and/or the performance of the software in terms of transactions or messages handled per unit time.

Total service time	The total service time for a (software) system is measured by adding together the total time that each example of the system has been in service (thus if 50 systems of the same type and model have been in service without revealing any dangerous failures for two years, the total operational experience can be regarded as 100 years or approximately 106 hours).
Touchdown	The point where the nominal glide path intercepts the runway. (ICAO) **Note:** 'Touchdown' as defined above is only a datum and is not necessarily the actual point at which the aircraft will touch the runway.
Track	The projection on the earth's surface of the path of an aircraft, the direction of which path at any point is usually expressed in degrees from North (true, magnetic or grid). (ICAO)
Transponder	A receiver/transmitter which will generate a reply signal upon proper interrogation, the interrogation and reply being on different frequencies.
V	
Validity	Sound or defensible. Executed with the proper formalities.
Vehicle Equipment	Equipment designed for operation and permanent or temporary installation in a vehicle with provision for external connections to vehicle battery, antenna, PTT key, microphone and loudspeaker. Provisions may be made for use of an external power supply or battery pack and desktop cradle or mounting unit, which may enable it to be classified in the Stationary Equipment Category.

Visibility	Visibility for aeronautical purposes is the greater of: the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognised when observed against a bright background; the greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background. (ICAO) **Note 1:** The two distances have different values in air of a given extinction coefficient and the latter b) varies with the background illumination. The former a) is represented by the meteorological optical range (MOR). **Note 2:** The definition applies to the observations of visibility in local routine and special reports, to the observations of prevailing and minimum visibility reported in METAR and SPECI and to the observations of ground visibility.

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Abbreviations

A	
AAIB	Air Accident Investigation Branch
AATSD	Aerodrome and Air Traffic Standards Division
ABS	Anti-Blocking System
ACARS	Aircraft Communications Addressing and Reporting System
ACC	Area Control Centre
ADC	Aerodrome Control
ADF	Automatic Direction Finder
ADS	Automatic Dependent Surveillance
AEL	Assurance Evidence Level
AFPEx	Assisted Flight Plan Exchange
AFIS	Aeronautical Flight Information Service
AFTN	Aeronautical Fixed Telecommunications Network
AGCS	Air Ground Communication Service
AGL	Aeronautical Ground Lighting
AIS	Aeronautical Information Service
AMC	Acceptable Means of Compliance
ANO	Air Navigation Order
ANSP	Air Navigation Service Provider
AOC	Air Operators Certificate
APC	Approach Control
ASM	Airspace Management
ASMI	Aerodrome Surface Movement Indicator
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATCU	Air Traffic Control Unit
ATIS	Automatic Terminal Information Service

ATFM	Air Traffic Flow Management
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management Aerodrome Traffic Monitor
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Service
ATSIN	Air Traffic Service Information Notice
ATSU	Air Traffic Service Unit
C	
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAT	Category
CCTV	Closed Circuit Television
CIE	Commission Internationale De L'Eclairage
CPDLC	Controller Pilot Data Link Communications
CSU	Categorisation and Status Unit
CVOR	Conventional VHF Omni-directional Range
CW	Carrier Wave
D	
D8PSK	Differential Eight Phase Shift Keying
D-ATIS	Data Link Automatic Terminal Information Service
DDM	Difference in Depth of Modulation
DDS	Data Display System
D/F	Direction Finding
DFTI	Distance from Touchdown Indicator (also known as Aerodrome Traffic Monitor)
DME	Distance Measuring Equipment
DOC	Designated Operational Coverage
DRACAS	Defect Reporting, Analysis and Corrective Action
DVOR	Doppler VHF Omni-directional Range

E	
EASA	European Aviation Safety Agency
EMC	Electro Magnetic Compatibility
Et	Illuminance Threshold
ETSI	European Telecommunications Standards Institute
ESARR	EUROCONTROL Safety Regulatory Requirement
EUROCAE	European Organisation for Civil Aviation Electronics
F	
FIR	Flight Information Region
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FPS	Flight Progress Strip
ft	Foot (feet)
G	
GFSK	Gaussian Frequency Shift Keying
GMC	Ground Movement Control
GMR	Ground Movement Radar
H	
HF	High Frequency
HMI	Human Machine Interface
hPa	Hectopascal
I	
ICAO	International Civil Aviation Organisation
IEC	International Electrotechnical Commission
IFR	Instrument Flight Rules
IISLS	Improved Interrogation Side Lobe Suppression
ILS	Instrument Landing System
IN	CAA Information Notice
INS	Inertial Navigation System
IRVR	Instrumented Runway Visual Range

ISLS	Interrogation Side Lobe Suppression
ITU	International Telecommunication Union
K	
kg	Kilogramme
km	Kilometre(s)
km/h	Kilometres per hour
kt	Knots
L	
LCI	Landing Clearance Indicator
LDA	Landing Distance Available
LVP	Low Visibility Procedures
M	
m	Metres
MATS	Manual of Air Traffic Services
Met	Meteorology/Meteorological
METAR	Aerodrome Routine Meteorological Report
MF	Medium Frequency
MID	Middle point on a runway
MLS	Microwave Landing System
MOD	Ministry of Defence
Mod.	Modulation
MOR	Mandatory Occurrence Report
MSK	Minimum Shift Keying
MTBF	Mean Time Between Failure
MTBO	Mean Time Between Outages
MTD	Moving Target Detection
MTI	Moving Target Indicator
MTTR	Mean Time To Repair
N	
NATS	National Air Traffic Services Limited

NDB	Non-Directional Beacon
NM	Nautical Mile
NOTAM	Notice To Airmen
O	
Ofcom	Office of Communications
OPC	Operational Control
OR	Operational Requirement
P	
PAPI	Precision Approach Path Indicator
PBR	Private Business Radio
PE	Primary Echo
PES	Proposed EUROCONTROL Standard
PFE	Path Following Error
PFN	Path Following Noise
PMR	Private land Mobile Radio
Ppm	Parts per million
PRF	Pulse Repetition Frequency
PSR	Primary Surveillance Radar
PTT	Press To Talk
Q	
QNH	The pressure to be set on the sub-scale of an aircraft altimeter that would read the aerodrome elevation if the aircraft were on the ground at that aerodrome (ICAO Abbreviations and codes Doc. 8400)
R	
R&TTED	Radio and Telecommunications Terminal Equipment Directive
RAF	Royal Air Force
RFFS	Rescue and Fire Fighting Service
RPM	Revolutions per minute
RSLS	Receiver Side Lobe Suppression
RSS	The Square-root of the Sum of the Squares

R/T	Radio Telephone
RTF	Radio Telephone Facility
RVR	Runway Visual Range
S	
SARPs	Standards and Recommended Practices (ICAO)
SDM	Sum of the Depths of Modulation
SES	Single European Sky
SI	Supplementary Instruction Safety Integrity
SID(s)	Standard Instrument Departure(s)
SINAD	(Signal + Noise + Distortion) / (Noise + Distortion)
SMGCS	Surface Movement Guidance and Control System
SMR	Surface Movement Radar
SRA	Surveillance Radar Approach
SRATCOH	Scheme for the Regulation of Air Traffic Controllers' Hours
SRG	Safety Regulation Group
SSR	Secondary Surveillance Radar
STP	Stop end of a runway
SVFR	Special Visual Flight Rules
T	
TDZ	Touch Down Zone (Runway)
THD	Total Harmonic Distortion
TLS	Target Level of Safety
TMA	Terminal Manoeuvring Area
TOI	Temporary Operating Instruction
U	
UHF	Ultra High Frequency
UTC	Universal Co-ordinated Time

V	
VCCS	Voice Communications Control Systems
VCR	Visual Control Room
VDF	VHF Direction Finding
VDL	VHF Digital Link
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omni-directional Range

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Directory

Aerodrome and Air Traffic Standards Division CAA Safety Regulation Group 2W Aviation House Gatwick Airport South West Sussex RH6 0YR	Email:	ats.enquiries@caa.co.uk	For general enquiries about ATS matters and the content of this document.
Regional Manager, ATS Safety Regulation (Southern) CAA Safety Regulation Group Aerodrome and Air Traffic Standards Division 2W Aviation House Gatwick Airport South West Sussex RH6 0YR	Tel: Fax: Email:	01293 573330 01293 573974 ats.southern.regional.office@caa.co.uk	Regional office for ATS approvals, inspections, audits, etc.
Regional Manager, ATS Safety Regulation (Central) Aerodrome and Air Traffic Standards Division CAA Safety Regulation Group First Floor Atlantic House Atlas Business Park Simonsway Wythenshawe Manchester M22 5PR	Tel: Fax: Email:	0161 216 4514 0161 216 4549 ats.central.regional.office@caa.co.uk	Regional office for ATS approvals, inspections, audits, etc.

Regional Manager, ATS Safety Regulation (Northern) Aerodrome and Air Traffic Standards Division CAA Safety Regulation Group First Floor Kings Park House Laurelhill Business Park Stirling FK7 9JQ Scotland	Tel: Fax: 01786 457 400 Email: 01786 457 440 ats.northern.regional.office@caa.co.uk	Regional office for ATS approvals, inspections, audits, etc.
En-route and College Regulation Aerodrome and Air Traffic Standards Division CAA Safety Regulation Group 2W Aviation House Gatwick Airport South West Sussex RH6 0YR	For general enquiries, email: ats.enquiries@caa.co.uk	Regulation of En-route ATS and ATC colleges.
ATS Investigations and Oversight Assurance Section Aerodrome and Air Traffic Standards Division CAA Safety Regulation Group 2W Aviation House Gatwick Airport South West Sussex RH6 0YR	For general enquiries, email: ats.enquiries@caa.co.uk	Development and implementation of ANS provider certification under the Single European Sky (SES) Regulation

ATS Licensing Section Licensing and Training Standards CAA Safety Regulation Group Aviation House Gatwick Airport South West Sussex RH6 0YR	Tel: Fax: Email:	01293 573700 01293 573996 ats.licensing@caa.co.uk	Applications for Student ATC Licence and Air Traffic Controller's Licence; FISO licence; Air/Ground and Offshore Radio Operator's Certificate of Competence.
Medical Department Licensing and Training Standards CAA Safety Regulation Group Aviation House Gatwick Airport South West Sussex RH6 0YR	Tel:	01293 573700	Initial Medical Examinations and Renewals

- CAA information about Single European Sky: www.caa.co.uk/ses
- CAA information about Interoperability: www.caa.co.uk/sesinteroperability
- Eurocontrol homepage: www.eurocontrol.int
- Europa homepage: www.europa.eu
- EASA homepage: www.easa.eu.int

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PART A

The Regulatory Framework

Introduction

> **Note**: The European Air Traffic Management (ATM) Regulatory Framework is subject to considerable development but under which Single European Sky (SES) and European Aviation Safety Agency (EASA) high-level regulation co-exist. EASA ATM Regulations now consist of Implementing Rules developed under the Basic EASA Regulation, Commission Regulation (EC) No. 216/2008 (as amended by Commission Regulation (EU) No. 1108/2009), but are still subject to elements of SES high-level Regulations, in particular the Service Provision Regulation (Commission Regulation (EU) No. 550/2004). In due course it is expected that the relevant parts of these SES Regulations will be amended to bring them into line with the Basic EASA Regulation.

In view of the timescales involved in updating CAP 670, references in this CAP to EU Level Regulations may not be up to date and it is advised that readers take note of any information promulgated via means such as CAP 670 Supplementary Amendments, CAA Information Notices and website information as at www.caa.co.uk/ATSRequirementsOverview.

The following three EASA ATM Implementing Rules are relevant to ATM/ANS:

- Commission Regulation (EU) No. 805/2011 on Air Traffic Controller Licences (ATCO) Licences (in force from 31 August 2011);
- Commission Regulation (EU) No. 1034/2011 on safety oversight in ATM and Air Navigation Services (ANS) (in force from 7 November 2011); and
- Commission Regulation (EU) No. 1035/2011 on common requirements for ANS provision (in force from 7 November 2011).

The former ATCO Directive (2006/23/EC), now replaced by the ATCO Regulation (Commission Regulation (EU) No. 805/2011), was repealed by the amended Basic EASA Regulation (Commission Regulation (EC) No. 1108/2009). The new Common Requirements and Safety Oversight Regulations respectively repealed their SES equivalents, Commission Regulation (EC) No. 2096/2005 and Commission Regulation (EC) No. 1315/2007. It is expected that now that these

subjects are within the rule-making scope of EASA, further evolutions of these Regulations can be expected during 2012.

References to the earlier Regulations will be removed from promulgated material, including CAP 670, related CAPs and web pages in due course.

A1 This document is published in support of the Civil Aviation Authority (CAA) discretionary powers contained in the Air Navigation Order 2009 (as amended) (ANO). In addition, The Civil Aviation Authority (Chicago Convention) Directions 2007 require the CAA to ensure that it acts consistently with the obligations placed on the United Kingdom (UK) under the Convention on International Aviation (Chicago 1944). Therefore this document also includes the UK implementation of the International Standards and Recommended Practices (SARPs) contained in Annexes to the Chicago Convention. It is the policy of the CAA to have reference to this document when exercising the discretionary powers referred to above, and in particular it will normally exercise those powers so as to ensure the effective implementation of any such international provisions. Where the UK formally differs from any of the SARPs, those differences are recorded in the UK Aeronautical Information Publication (AIP).

Note: The Civil Aviation Authority (Chicago Convention) Directions 2007 are published on the CAA website (www.caa.co.uk) within the Sponsorship and Directions section under 'Corporate Information'.

A2 CAP 670 also takes account of EU legislation and EUROCONTROL Safety Regulatory Requirements (ESARRs). The six ESARRs have all generally been or are being transposed into EU regulations or directives.

A3 Attention is drawn to the SES Regulations, in particular the Common Requirements, Interoperability and Service Provision Regulations. Details can be obtained from the CAA's SES website at:

- www.caa.co.uk/ses
- www.caa.co.uk/seslegislation

A4 These Regulations must be read in conjunction with CAP 670 and other CAPs related to the provision of ANS. As the Regulatory Framework is being developed, the various CAPs will be amended to take into account the effects of these Regulations.

A5 EASA was established by Commission Regulation (EC) No. 216/2008. The extension of this Regulation to include safety and interoperability of ATM and ANS will result in EASA ATM/ATS regulations. As EASA

regulations are developed, details will be communicated to industry and CAPs updated as appropriate. The EASA website can be found at www.easa.eu.int.

A6 The ANO Approval or licensing processes are now subject to SES Certification and Designation. Details of such processes will be incorporated into specific CAPs, communications to industry (such as CAA Information Notices and Safety Notices) and amendments to this CAP.

Note: See ATSIN 193 (www.caa.co.uk/atsin193) and CAA Information Notice IN-2010/001 (www.caa.co.uk/IN2010001) for further information regarding CAA Information Notices and Safety Notices.

A7 The provision of air traffic services and, where appropriate, the technical aspects of services such as Operational Control (OPC), see paragraph A24, are regulated by the United Kingdom Civil Aviation Authority Safety Regulation Group (UK CAA SRG).

A8 CAP 670 Air Traffic Services Safety Requirements describes the manner in which approval is granted, the means by which Air Traffic Service (ATS) providers can gain approval and the ongoing process through which approval is maintained. See also paragraph A5.

A9 The material contained in this document sets out the requirements to be met by providers of civil air traffic services and other services, as defined in paragraph A24, in the UK in order to ensure that those services are safe for use by aircraft and meet internationally agreed standards. In addition to requirements, the text offers explanatory notes and guidance material on acceptable methods of compliance with the requirements.

A10 Whilst the contents of the document may be of interest to other parties, this document is addressed to ATS providers who are expected to demonstrate compliance with applicable requirements either directly or through the provision of safety assurance documentation, which may be in the form known as a safety case.

A11 Where material produced by a third party (an equipment manufacturer, for example) is submitted by an ATS provider in support of application for approval, the provider must endorse the content.

CAP 670 Structure: Format

A12 Document control pages contain the title page, contents, amendment record page and a checklist of pages.

A13 The Contents pages contain an overall list of contents for CAP 670 covering the Glossary, Abbreviations, Directory and Parts A, B, C and D.

A14 The introductory matter contains a Glossary, list of abbreviations and Directory.

A15 **Part A** Requirements and the Regulatory Framework – this part.

A16 **Part B** Generic Requirements and Guidance contains material which is structured according to the subject matter, and organised into individual documents within sections. The documents contain requirements, recommendations and notes which are interpreted in the same way as those for Part C.

A17 **Part C** Communication, Navigation, Surveillance, Meteorological and Information and Alerting Systems contains individual documents, which are structured into Part 1 Preliminary Material and Part 2 Requirements. The Part 1 typically contains an Introduction and Scope. The Part 2 typically contains requirements and guidance material which are divided into:

- Safety objectives;
- Mandatory requirements which have to be satisfied;
- Recommendations with which compliance is desirable but may not be appropriate in all situations;
- Acceptable Means of Compliance (AMC); and
- Guidance and/or notes which provide additional information which may be useful to providers. Annexes and appendices associated with individual documents may also be used for guidance and notes.

A18 **Part D** Human Resources addresses Air Traffic Control (ATC) unit manning and duty hours.

A19 **Reference Numbering** Safety objectives, requirements and recommendations are identified by a unique number, which is to be found in round brackets after the applicable text e.g. (123). This system of numbering enables providers and regulators to know the exact wording against which any means of compliance was implemented and

approval granted. Paragraph numbering may change but this reference number will never change whilst the text remains the same. If the text changes a new number will be allocated to it. Numbering is not sequential and not coded so nothing can be inferred from the number alone. Consecutive requirements may have numbers many hundreds apart.

CAP 670 Structure: Supplementary Amendments

A20 CAP 670 Supplementary Amendments (SAs) will be issued to introduce urgent or safety-critical changes to Regulatory Requirements where the routine amendment cycle would not suffice, or to inform users of changes or developments to Regulatory Requirements (typically EU regulations) and other related standards such as International Civil Aviation Organization (ICAO) SARPs in a timely manner.

A21 The CAP 670 Supplementary Amendment process will not replace the consultation process as described at paragraph A51. Consultations will still take place and will be made available at www.caa.co.uk/consultations.

A22 CAP 670 SAs will be incorporated into the main body of the document in a suitable and timely manner.

Scope

A23 Civil aviation in the UK is governed by legislation (principally European legislation, and the ANO and its associated Rules of the Air Regulations) and International Standards and Conventions (principally those published by ICAO and EUROCONTROL) with which the UK, as a State, has agreed to comply.

A24 The requirements contained in this document are applicable to Air Traffic Services (defined in SES Regulations as Flight Information Services (FIS), alerting services, air traffic advisory services and ATC services (area, approach and aerodrome control services) provided to aircraft within the UK Flight Information Region (FIR) and other airspace) for which responsibility has been designated to the UK through international agreement.

A25 For requirements related to Communication, Navigation and Surveillance/Air Traffic Management (CNS/ATM) Providers and Radio Communications Services (RCS), reference should be made to the

relevant pages in the ATS Requirements Overview Page at: www.caa.co.uk/ATSRequirementsOverview.

A26 Special arrangements may exist in the vicinity of the UK FIR boundary and in respect of certain off-shore installations. ATS Service Providers to whom such arrangements apply are expected to discuss their particular circumstances with the appropriate ATS Regional Manager or the Head of En-Route and College Regulation at Aviation House, Gatwick.

A27 The requirements in this document do not directly consider externally provided services (such as public telephone/telecommunication services), but do encompass the manner in which these services are used within an air traffic service. It should be noted that such services, although external to the provision of an air traffic service, may be subject to regulation by other parts of the CAA or other agency.

A28 Externally supplied services are assumed to meet all relevant requirements and Standards. It is the responsibility of the Air Navigation Service Provider (ANSP) to ensure that the consequences of safety-related failures associated with externally provided data or services are adequately considered and mitigated against.

A29 It should be noted that requirements described in this document may not apply to all types of service. An overview of the requirements applicable to each service is available on the CAA website at www.caa.co.uk/ATSRequirementsOverview. These pages provide a convenient reference point for service providers and operators of various aeronautical radio stations in respect of the major regulatory requirements and associated regulatory documents (including CAPs) pertaining to their operations.

Principles of Regulation

The Regulatory Framework

A30 The Civil Aviation Act established the Civil Aviation Authority (the CAA) and provides the framework for its regulatory powers. CAP 784 State Safety Programme for the United Kingdom provides a detailed description of the UK aviation safety regulatory legal framework. The CAP is available at www.caa.co.uk/cap784.

A31 Under the SES Framework Regulation (EC) No. 549/2004, Member States must appoint a 'National Supervisory Authority' (NSA). The CAA has been appointed as the UK NSA under the Single European Sky

(National Supervisory Authority) Regulations 2004 (SI 2004 No. 1958), available at: www.opsi.gov.uk/si/si2004/uksi_20041958_en.pdf, and the Single European Sky (Functions of the National Supervisory Authority) Regulations 2006 (SI 2006 No. 3104), available at www.opsi.gov.uk/si/si2006/uksi_20063104_en.pdf.

A32 Pursuant to Article 246 of the ANO 2009, the CAA is also the National Aviation Authority (NAA) and the competent authority of the UK for the purposes of the EASA Regulations and EU-OPS.

A33 The Civil Aviation Act enables further legislation, Air Navigation Orders and General Regulations to be made in order to permit the CAA to fulfil its regulatory obligations.

A34 Air Navigation Orders are presented by way of Articles and Regulations, each dealing with a particular subject.

A35 The CAA publishes Civil Aviation Publications (CAPs) that provide details of means of compliance with the ANO Articles and EU Regulations which are acceptable to the CAA.

A36 Civil Air Traffic Services (ATS) and technical elements of associated services are principally regulated in the UK by the CAA. Regulation is achieved, as appropriate, through the grant of Approval to equipment and systems, licensing and certification of personnel and auditing and inspecting the subsequent systems and service provision. However, this regulation is modified by SES related regulations, e.g. Commission Regulation (EC) No. 1315/2007 on safety oversight in air traffic management, which establishes a safety oversight function concerning air navigation services, air traffic flow management (ATFM) and Airspace Management (ASM) for general air traffic.

A37 The CAA and EASA websites referred to in paragraph A3 and A4 should also be consulted in respect of EU legislation.

A38 Appendix A to Part A comprises a schedule of equipment to be regulated under ANO Articles 205 and 206.

Related Legislation

A39 The requirements in this document are not intended to supersede or conflict with statutory requirements, and therefore the obligation to comply with statutory requirements remains. This includes compliance with European Regulations that automatically become UK Law and

European Directives that are enacted into UK legislation before they become binding.

A40 The SES Regulations introduced a number of new procedures and requirements that impact on ANSPs, including ATS Providers (ATC and FIS units) and manufacturers of ATM equipment. The CAA will provide information to ANSPs as details emerge, by the most appropriate means for the matter to be conveyed, such as CAA Information Notices, Safety Notices and bulletins published on the CAA website.

Note: See ATSIN 193 (www.caa.co.uk/atsin193) and CAA Information Notice IN-2010/01 (www.caa.co.uk/IN2010001) for further information regarding CAA Information Notices and Safety Notices.

A41 The Directory of this document contains useful website addresses that provide information relating to SES and other European activities.

A42 ATM CNS radio equipment is required to comply with the Radio and Telecommunications Terminal Equipment Directive (R&TTED) 1999/5/EC. Guidance on the application of the R&TTED for ATM CNS can be found at the following websites:

- DTI: www.dti.gov.uk/strd/rtte.html
- OFCOM: www.ofcom.org.uk/radiocomms/
- European Commission: www.ec.europa.eu/enterprise/sectors/rtte/index_en.htm

Requirements and Guidance Material

A43 The CAA regulates civil aviation in the UK in order to ensure that high safety standards are set and achieved in co-operation with those regulated whilst minimising the regulatory burden.

A44 This objective is achieved by providing the industry with requirements and guidance material to aid the assessment of initial and ongoing compliance with those requirements by Service Providers.

A45 The CAA will continually review its published aviation safety requirements and, where practical, re-state them in terms of the objective that is to be achieved.

A46 This process, subject to the effects of EU legislation, may result in many currently prescriptive requirements being expressed as a safety objective. Many safety objectives will be accompanied by one or more methods of compliance which are acceptable to the CAA (commonly

referred to as Acceptable Means of Compliance or AMCs). ATS Providers will be at liberty to utilise an AMC or an alternative solution of their own choice provided that it is demonstrated that the safety objective is achieved.

A47 It should be noted that not all of the requirements in this document have been re-stated in objective terms.

A48 Existing approval holders must recognise that these requirements may be changed from time to time on grounds of safety, potentially necessitating re-approval. A reasonable period of prior notification would normally be given in such circumstances.

Requirements Capture

A49 Requirements capture is the process of identifying a need for new or amended requirements and may be triggered by:

- Ad Hoc Comments and Formal Consultation on CAP 670
- International Obligations: Changes to ICAO Standards and Recommended Practices related to the provision of Air Traffic Services.
- EUROCONTROL Safety Regulation Commission: Changes introduced as an ESARR.
- UK and European Legislation: Changes to UK Legislation, EU Regulations and EU Directives, directly or indirectly related to the provision of ANS.
- CAA SRG Policy and Strategy: Changes to the scope of regulation or the indication of the CAA SRG position on a particular issue. Re-drafting of existing requirements into Objective Based Safety Requirements.
- Air Traffic Service Environment: Monitoring the ATS environment, by means of the Mandatory Occurrence Reporting (MOR) Scheme or other mechanism, to identify safety risks.
- Industry Demand: ATS Providers may wish to bring into service systems or equipment, or to implement procedures, for which no applicable requirements currently exist.
- New Technology: Introduction and developments of new technology in the provision of ATS.

Requirements Production

A50 Requirements production includes the authorisation and drafting of requirements, internal review processes, consultation and publication. The consultation process is briefly outlined in the following section. As part of the requirements drafting process, the requirements author may draw on any appropriate additional expertise both from within the CAA and externally.

Requirements Consultation

A51 A procedure has been established for the Formal Consultation process and the management of ad hoc comments for CAP 670 in accordance with Group and Departmental Procedures and the SRG Code of Practice. With the exception of editorial changes and requirements or guidance material that needs urgent promulgation, all other material is subject to the Formal Consultation process. Ad hoc comments and those received during the Formal Consultation process will be considered by the authors of the requirements and responses prepared as necessary. Where appropriate, changes will be incorporated into an amendment to CAP 670.

A52 This consultation process does not apply to EU Regulations that become law directly and automatically, once published in the Official Journal of the European Union (OJEU) and which are not Directives. Such EU Regulations are subject to EU level consultation processes.

Formal Consultation

A53 The CAA invites comments on proposals that may have an impact on the provision of ATS in the UK, or on the organisations that provide those services. Once the necessary stages of the CAA internal development and production process have been completed, the consultative material is published on the CAA website to allow consideration by a notified date that marks the end of the consultation period. This Formal Consultation process enables comments on proposed changes to be made by individuals and industry prior to the effective date of the changes. Any documents currently under review as part of the Formal Consultation process may be accessed by following the link to the CAA website: www.caa.co.uk/consultations.

A54 Formal notification of consultations can be received by subscribing to receive CAA Information Notices using the Amendment Notification Service for published documents, as described in paragraph A61.

Consultations will also be notified through the CAA website using the CAA's 'Consultations' RSS newsfeed (www.caa.co.uk/rss).

A55 As far as possible, the CAA will alert industry to EU level consultation processes. This could be via CAA Information Notices.

Ad hoc Comments

A56 Ad hoc comments on the material in this or other regulatory requirements that relate to the provision of ATS may be submitted at any time by e-mail to the editor at ats.documents@caa.co.uk.

Publication of Requirements and Guidance Material

A57 At the end of the consultation process, requirements and guidance material, incorporating any changes that are considered appropriate following the consultation period, are published in CAP 670 as an amendment to the publication. CAP 670 is published in electronic (pdf) format and may be downloaded from the CAA website at www.caa.co.uk/cap670. A printed version may be purchased from the CAA's printers if required; contact details can be found on the inside cover to this document.

A58 In certain circumstances an amendment to CAP 670 may be issued as a CAP 670 Supplementary Amendment (SA). SAs are available on the CAA website at www.caa.co.uk/publications.

A59 Amendments should be incorporated into CAP 670 on receipt, in accordance with any Amendment Instructions, and an entry made in the Amendment Record Page as confirmation that the publication has been updated. The effective date of the amendment should be taken to be the date of publication unless a different date is prescribed. If so, this will be indicated clearly. An example of where this might happen would be publication of requirements in advance of their taking effect in order to allow ATS Providers time to introduce appropriate arrangements.

A60 All changes to the text from the previous version are identified by the use of underlining. The date of publication on each page is also amended and reflected in the List of Effective Pages. Where the only changes needed are to the headers and footers, such as page numbering, the date of publication will need to be revised, but underlining will not be used.

Amendment Notification Service for Published Documents

A61 A free e-mail amendment notification service for published CAA documents is available on the CAA website. Those interested may subscribe to the service at: www.caa.co.uk/publications.

A62 Amendment notification of published CAA documents is also available through RSS News Feeds, a list of which is available at www.caa.co.uk/rss.

Regulation of Air Traffic Services and Air Traffic Service Facilities

Air Navigation Order

A63 Reference should be made to the current issue of the ANO, which is available on the CAA website at www.caa.co.uk/cap393.

Introduction

A64 International standards and regulations are in force which States are required to implement. ICAO Annex 11 Air Traffic Services requires the CAA to implement a programme that ensures that a Safety Management System (SMS) is used at all ATS units. EUROCONTROL, under the auspices of the Safety Regulation Commission (SRC), published ESARR 3 Use of Safety Management Systems by Air Traffic Management (ATM) Service Providers, which required all providers of ATM to establish an SMS.

A65 Since 21 June 2007, it became a legal requirement under the SES Regulations for ANSPs providing ATC or FIS to operate an SMS. The SES Regulations also apply in this regard to CNS providers operating navigational aids such as Non-Directional Beacons (NDBs).

Requirements

A66 An Applicant for an Approval under the ANO shall demonstrate that all safety issues within the provision of an ATM service have been addressed in a satisfactory manner (77).

Process and Regulatory Methods for Demonstrating Safety Adequacy

General

A67 Regulation of civil ATS and technical elements of associated services is achieved through the grant of Approval to equipment and systems, licensing and certification of personnel, and auditing and inspecting the subsequent systems and service provision.

A68 The term 'approval' is used generically in the following descriptions to mean any relevant form of regulatory approval, certification or grant of a licence.

Approval of a Safety Management System

A69 Before an ATS Provider is regulated under an SMS regime, the supporting documentation must be accepted by the appropriate CAA ATS Regional Manager.

A70 Following submission, the SMS descriptive and supporting documentation will be reviewed and the Service Provider advised whether it is acceptable or not. Any areas that are deficient will be identified. The time taken to review the document will depend upon its complexity. If the documentation is not acceptable, the Service Provider should make amendments to address the identified deficiencies and resubmit as necessary.

A71 An acceptable SMS should address all the principles described in CAP 670 Part B, Section 1, APP 01 and will document the strategies by which the stated objectives are to be achieved.

A72 In association with the implementation of an SMS it is necessary to carry out an analysis of the safety significance of existing systems and to demonstrate that they satisfy the current safety requirements of both the CAA and those set out in the unit's SMS. This is usually presented in the form of safety assurance documentation.

A73 When the CAA's representative is satisfied that the SMS and safety assurance documentation provide acceptable assurance that the facility is and will continue to be operated safely, the Service Provider will be granted approval to operate in accordance with its SMS. The approval process is now subsumed into the certification process required under SES regulations.

Safety Management System Regulatory Method

A74 The primary point of contact between an ATC Service Provider and the CAA is the Regional Office (RO). The ATS Regional Manager will be the focal point for all correspondence with the Air Traffic Control Unit (ATCU) in respect of regulatory matters (e.g. the issue of approvals, maintenance of approvals, safety cases, safety management issues and auditing arrangements).

Note: The ATS Regional Manager for Area Control services is the Head of En-Route and College Regulation.

A75 The RO staff, supported by other CAA Departments as appropriate, are responsible for gaining assurance that all appropriate regulatory requirements are being implemented by ATCUs and that the resulting ATS is safe. This will normally be achieved through audits of the ATCU and of the overall provision of air traffic control services, and of any changes to those services or supporting facilities.

A76 The RO staff are responsible for regulating issues associated with ATS personnel licensing, the audit of ATCUs and the associated SMS and, in co-ordination with other appropriate sections of the CAA, responding to issues of immediate safety concern.

A77 Organisational audits are normally conducted over a two-year cycle, such that all requirements are checked over a two-year period. The ROs may, however, implement additional audits, checks, and examinations as considered necessary to address areas of regulatory concern. These activities will include audits of individual projects and changes to the unit, and the sampling, normally on an annual basis, of the ATCU Controller Unit Competence Scheme (UCS). The scope of the audit and its outcome will be influenced by a variety of factors including the robustness of the SMS demonstrated at previous audits, the complexity of the ATCU under consideration and the extent or significance of any changes that are taking place.

Note: Requirements relating to the ATCO UCS and other ATCO licensing issues are contained in CAP 744 Air Traffic Controllers – Licensing.

Regulatory Processes

A78 The mechanism for the regulation of ATC units at aerodromes and En-Route and Terminal Control Centres subject to Certification and Designation processes in respect of EU Regulations.

A79 When an ATCU is satisfied that its SMS is sufficiently developed and that its implementation will result in a service that continues to be safe for use by aircraft, the unit should submit the SMS and any associated documentation to the CAA for assessment (1740).

A80 If the SMS is assessed as satisfactory it will be deemed to be 'accepted' and the unit will be authorised to operate in accordance with the procedures and processes in its SMS. After a suitable period of SMS operation, during which time the unit will be gathering evidence of the application of the SMS and recording the results of applying the relevant processes, the CAA will conduct a baseline audit. The initial baseline audit may involve an assessment of the SMS on a line-by-line basis.

A81 If the baseline audit finds that the SMS meets the relevant requirements and that the application of the SMS is resulting in the provision of an ATC service that is safe, the unit will be required to operate in accordance with its SMS. If the SMS implementation is considered not to be appropriate with respect to one or more of the key criteria, additional guidance will be provided.

A82 Subsequent audits will be conducted by the CAA on a routine basis over a two-year cycle, and in some cases, in response to safety-related changes that take place at the unit.

A83 Safety regulatory audits will consider the operational, engineering and management aspects of the unit. Audits will focus on the safety assurance documentation and processes associated with steady state operation of the unit, and on any changes to the operation or associated equipment. An audit report will be written by the CAA auditor(s) and will be forwarded to the management of the unit concerned. The unit management will be invited to respond to the findings of the report. Follow-up action will be agreed as necessary between the auditor and the unit.

Documentation Required by the CAA

A84 A condition of Certification and Designation in accordance with SES and/or Approval will be that documentation describing the unit SMS be made available to the CAA by the ATS Service Provider within a reasonable period of the request being made. Copies of certain documents will be required to be lodged (and maintained by the submission of any amendments) with the CAA. Other documents may not be required to be lodged in full with the CAA but notification of

their issue or amendment may be required, and submission of the full document made on request.

A85 The following list gives an indication to Service Providers of the documentation that may be requested by the CAA. It should be noted that this list is not definitive or exhaustive and that not all units will utilise all of the documents listed. Specific requirements will be determined by the unit SMS and the documentation that is generated by the management processes and will be agreed with the RO.

- The unit SMS and corporate SMS if appropriate
- The Unit Safety Case (USC)

Note: ATC units may develop a USC in advance of being requested to do so by the CAA if it forms part of their SMS arrangements.

- the unit Manual of Air Traffic Services Part 2
- the unit engineering procedures
- Safety Assurance documentation to include:
  - Information about safety-related changes to the unit (see paragraph A94 to A98)
  - Documentation relating to changes to ATS procedures (Supplementary Instructions (SIs), Temporary Operating Instructions (TOIs) etc.)
  - Safety Assessments and Hazard Analyses associated with changes to the operation
  - Internal safety investigation reports associated with Mandatory Occurrence Reports (MORs), or carried out as a result of safety related events that are not required to be reported and/or have not been reported under the MOR scheme, but have been reported through an internal reporting process
  - Minutes of meetings at which safety-related matters are discussed (e.g. ATC technical or engineering committees, or Safety Management Working Groups, if such groups are established)
  - Internal safety audit reports, reviews, surveys or reports, together with records of actions taken to address resulting recommendations

- Reports of internal audits of the SMS for compliance or effectiveness.

A86 The provision of this documentation will enable the CAA to maintain the assurance required that the ATS Provider has a robust and effective SMS. It should be noted that the documentation required by the CAA is likely to be produced as part of the unit's own safety management processes or other regulatory reporting requirements.

A87 The ROs will establish local arrangements with individual units to determine the specific documents required and the method of submission.

Change Notification Requirements

A88 The CAA requires to be notified of planned safety related changes at ATCUs. These include planned changes to ATC and engineering procedures, equipment, the SMS and associated documentation and unit organisation. Changes to nominated post holders and/or their safety responsibilities and accountabilities within the SMS must also be advised, as far as practicable, ahead of the change (1741).

A89 When notified of a safety-related change, the CAA will take one of four courses of action as described below:

1. Simply acknowledge receipt of the information; in this case the unit may implement the change without further reference to the CAA.
2. Elect to audit the change without requiring further authorisation to implement it; in this case the unit may implement the change without further reference to the CAA, although additional information may be requested in order to complete the audit.
3. Elect to audit the change and require that it is not implemented until the audit is satisfactorily completed. This option may be exercised if the change is substantial or of particular sensitivity.
4. Direct that the change not be implemented. This option is only likely to be exercised if the proposed change contravenes legislation or the UK's international obligations.

A90 Planned changes should, therefore, be notified to the CAA **as soon as practicable** in the change life cycle. This is to ensure, as far as possible, that if a change is selected for audit, the results from the audit are fed back to the unit management at an appropriate point in the life cycle of the change.

A91 For changes associated with ATC procedures, the associated safety assurance documentation should be submitted to the CAA **as early as possible but at least 30 days prior to the planned introduction date** for the change. The Service Provider remains responsible for the completion of any necessary safety assessment and for the mitigation of any hazards, and for ensuring the safe implementation of any changes (1742).

Note: It is recognised that, in order to ensure the continued safety of the ATC service, certain changes, particularly those associated with ATC procedures, normally documented in SIs and TOIs, may have to be introduced at short notice and preclude the submission of documentation to the CAA 30 days in advance of their implementation. In such circumstances, the relevant documentation should be submitted to the CAA as soon as practicable.

A92 Changes to the operation of the unit that require an amendment to the SMS or safety assurance documentation must be notified to the CAA **at least 30 days before the change is scheduled to be implemented** (1743).

A93 The exact detail and processes to be used for notification of changes to the CAA by ATCUs will be agreed following consultation and discussion between the unit management and relevant RO.

Audit Philosophy

A94 The purpose of a regulatory audit is to assess the robustness and effectiveness of the SMS in providing a service that is safe for use by aircraft. This is achieved by ensuring that the operational and management processes and procedures deliver a service that is safe. It also permits assurance to be gained that any safety related change is exposed to a structured hazard/risk assessment process in order to ensure that the change can be implemented whilst maintaining the service that is being provided at an acceptable level of safety.

A95 A regulatory audit takes a sample of the unit's operation. From the audit results, assurance is gained as to the likely safety of the entire ATS provided by the unit. Additional confidence that the sampled elements of the unit reflect the overall safety performance of the unit is gained over a number of consecutive audits of different areas of activity.

A96 The audit will assess whether the SMS addresses relevant safety issues in order to discharge the safety accountabilities of the Service

Provider. The SMS is the principal vehicle by which the Service Provider demonstrates its competence as an organisation to provide a service that is safe for use by aircraft (as required by Certification, Designation or Approval). See also paragraphs A80 to A83.

A97 Following completion of the audit, the ATC unit management will be provided with a report detailing the findings. The unit management will be invited to respond to the findings in the report.

A98 Completion of agreed follow-up actions are overseen by the RO. Regular or ad-hoc meetings will be arranged between the ATCU management and the RO to discuss audit findings, general follow-up actions and specific issues such as safety assurance and SMS developments.

Change of Provider of Air Traffic Control Services

A99 At some licensed aerodromes the ATC services are provided by contractors. Occasionally the contractor will change and the Aerodrome Licensee will wish the transition to be as seamless as possible, while maintaining high levels of safety, particularly if continuous operations are to be provided. Aerodrome Licensees are reminded of their responsibilities under the ANO to secure the aerodrome and airspace especially during the changeover of Providers of ATC. The importance of the contract with their chosen ATC Provider cannot be understated: Licensees may wish to assure themselves that appropriate arrangements are in place to cover the transfer of ATC services to an alternative Provider and that ownership of the Manual of Air Traffic Services Part 2 is addressed.

A100 The Aerodrome Licence and the Approval or Designation to provide ATS are granted by the CAA. In all cases an ANO Approval or Designation to provide ATC services must be granted by the CAA before operations by the new Provider can commence. The new Provider must also have been Certificated in accordance with SES Regulations by the appropriate National Supervisory Authority (NSA).

A101 When the change of Provider of ATC services involves a hand-over/take-over by a replacement company or organisation, the outgoing Provider has the following responsibilities:

- Agree with the incoming Provider a transition plan which addresses aspects of requirements that will need to be actioned by the incoming Provider, taking particular note of training and familiarisation issues.
- Allow mutually agreed access to the incoming Provider prior to handover.
- Provide the incoming Provider and the CAA, well in advance of the handover date, detailed information on equipment and facilities to be handed over within the terms of any change of contract.
- Make relevant documentation available to the incoming Provider which may affect the safety of the service provided after the handover.

Note: This does not necessarily mean documentation which may be considered the 'intellectual property' of the incumbent. It would however be relevant to maintenance documentation and instruction manuals for equipment to be transferred and used by the incoming Provider.

A102 If the nominated incoming Provider is from a replacement company or organisation, the CAA will need to be informed of the approval requirements based on the submission of the detail of all aspects of the proposed operation of the new company or organisation, including opening times of control positions, staffing levels, management structure and support staff.

A103 The CAA will ask the incoming Provider to submit the following, usually to a specified time scale:

- A transition plan which addresses all aspects of requirements that will need to be actioned with the outgoing Provider, including training and familiarisation issues.
- A list of controllers, details of their licences, together with any necessary requests for exemptions to full licensing requirements and justification for same.
- Details of all equipment and facilities to be used to support the air traffic control service.
- All documentation required for the approval of the service provision.

A104 The incoming Provider should give the CAA as much notice as possible of the takeover of service provision but at least that stated in APP 03 of this document (851).

A105 The CAA will agree a programme with the incoming Provider for the following:

- On-site training for all licensed and other operational staff. The training will need to include a period of operational familiarisation in co-operation with the outgoing Provider.
- Presentation of all operational staff for examination or assessment to the CAA. These examinations include oral examination and written examination as required and cover all aspects of local knowledge and use of equipment. At the appropriate time practical examinations will also need to be conducted.

A106 If the agreed timescale for the above items is not achieved, it is possible the CAA will apply restrictions to the proposed operations or require that a new approval process is followed.

A107 The aerodrome licensee has responsibility for making sure that, on satisfactory completion of the items above and compliance with any other notified requirements, the incoming Provider holds the relevant NSA Certification, Designation and Approval(s) for the provision of ATC services as required by the Air Navigation Order and SES regulations.

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Appendix A to Part A: Schedule of Equipment to be Regulated under the ANO Articles 205 and 206

- Communications systems used to communicate with aircraft or vehicles/personnel operating on the aerodrome including any VCCS (and VHF/UHF RT transmitters and receivers and antennae).
- Systems associated with broadcast services (e.g. ATIS/VOLMET) including VHF transmitters/antennae and the message preparation or generation equipment.
- Radar transmitter/receiver equipment including data processing and display equipment and dependent elements (e.g. AMA or radar-based runway incursion detection systems).
- DF receiver and associated processing and display equipment.
- ILS equipment and associated monitoring and control systems.
- IRVR equipment and associated monitoring and control systems.
- MLS equipment and associated monitoring and control systems.
- NDB equipment and associated monitoring and control systems.
- DME equipment and associated monitoring and control systems.
- VOR equipment and associated monitoring and control systems.
- Data processing and communications equipment used for ATM messaging such as OLDI, AFTN and flight data processing systems (e.g. flight progress strip printers). Regulation to be limited to gaining assurance of data integrity only.
- Recording and replay systems, consistent with UK obligations under ICAO Annexes 11 and 13.
- Alarm/alerting systems not covered above.
- Information display systems such as general information displays and CCTV. Regulation to be limited to gaining assurance of data integrity only and applied only where safety-related information is displayed.

- Any other specific item or class of equipment/system deemed to be safety-related and used to support the provision of an air traffic service. These items or classes of equipment/system are to be promulgated in CAP 670.

PART B

Generic Requirements and Guidance

Introduction

B1 The generic requirements and guidance material in Part B have been organised into individual documents within sections under the categories of ATS Certification/Designation/Approval, Air Traffic Control, Systems Engineering and General.

Scope

B2 The 'APP' documents in Section 1 'ATS Certification, Designation and Approval' cover the gaining and maintenance of SES Certification and Designation, Approval of an ATCU and approval (if appropriate) of maintenance arrangements.

B3 The 'ATC' documents in Section 2 'Air Traffic Control' cover the areas of temporary ATCUs, support systems and facilities, documentation and emergency or contingency facilities.

B4 The documents in Section 3 'Systems Engineering' provide regulatory objectives for safety assurance for ATS systems and ATS equipment comprising hardware and software elements.

B5 The 'GEN' documents in Section 4 'General cover a number of miscellaneous subjects comprising guidance on the safeguarding of ATS operations including possible degradation of radio signals due to the presence of wind farms (wind powered turbine generators), the technical safeguarding of radio sites consisting of the two processes of physical protection and radio spectrum protection and operational trials.

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PART B, SECTION 1: ATS CERTIFICATION, DESIGNATION AND APPROVAL

APP 01: Safety Management Systems

Introduction

APP01.1 International standards and regulations (ICAO, EUROCONTROL and EU) applicable to the UK require the CAA to ensure that a SMS is used at all ATS units.

APP01.2 The EU Regulations also apply in this regard to CNS Service Providers. This includes units operating navigational aids such as NDBs.

APP01.3 Where approval under the ANO is required, it is the responsibility of the Service Provider to satisfy the CAA that the system under consideration will be safe for use by aircraft and satisfies all appropriate requirements throughout its lifecycle.

APP01.4 This applies both to initial approval and any subsequent changes to the approved system.

APP01.5 This document provides guidance that can be used by Service Providers when constructing and maintaining an SMS. It contains examples of typical components of an SMS. As these sections are guidance, the term 'should' is used throughout. However, the use of this term should not be interpreted as implying that the particular SMS component is not mandatory. The mandatory nature of SMS components depends upon the latest version of EU Regulations and, where applicable, ANO Requirements, which can be accessed via the ATS Requirements Overview pages (www.caa.co.uk/ATSRequirementsOverview) and the CAA website (www.caa.co.uk).

APP01.6 Additionally, information for organisations regarding SMS can found at the following CAA webpage: www.caa.co.uk/SMS.

Scope/Applicability

APP01.7 The scope and applicability of SMS requirements depends on the latest versions of EU Regulations which can be accessed via the ATS Requirements Overview web pages at www.caa.co.uk/ATSRequirementsOverview.

Rationale

APP01.8 The prime responsibility for the safety of an ATM service rests with the Service Provider. Within the overall management of the service, the Service Provider has a responsibility to ensure that all relevant safety issues have been satisfactorily dealt with, and to provide assurance that this has been done.

APP01.9 Safety management is that function of service provision, which ensures that all safety risks have been identified, assessed and satisfactorily mitigated. A formal and systematic approach to safety management will maximise safety benefits in a viable and traceable way.

Safety Objective

APP01.10 The overall safety objective is to ensure that all safety issues within the provision of an ATM service have been addressed in a satisfactory manner, and to a satisfactory conclusion.

Safety Management Systems (SMS) Components

Safety Management

APP01.11 An ATM Service Provider should, as an integral part of the management of the ATM service, have in place an SMS which:

- Ensures a formalised, explicit and pro-active approach to systematic safety management in meeting its safety responsibilities within the provision of Air Traffic Management (ATM) services (853).
- Operates in respect of all ATM and supporting services which are under its managerial control (854).
- Includes, at its foundation, a statement of safety policy defining the organisation's fundamental approach to managing safety (855).

APP01.12 **Rationale:** An intuitive or ad hoc approach to the management of safety is not, as a fundamental principle of SMS, acceptable.

APP01.13 An acceptable SMS may be defined within several tiers of documentation, for example Safety Management Manuals, Quality Management Manuals, Safety Cases, Manual of Air Traffic Services

(MATS) Part 2 or others. Similarly the SMS may be spread between Corporate and local level documents.

APP01.14 Where the Service Provider uses external standards to achieve a safety objective, the scope, depth and use of these should be explained.

APP01.15 An acceptable SMS should set out the Service Provider's safety management policies and strategy and give assurance that, irrespective of the events which may take place on the ATS unit, clear processes are established and implemented to ensure that the necessary safety standards are maintained at all times.

Safety Responsibility

APP01.16 An ATM Service Provider should, as an integral part of the management of the ATM service, have in place an SMS which ensures that everyone involved in the safety aspects of ATM service provision has an individual safety responsibility for their own actions (856), and that managers are responsible for the safety performance of their own organisations (857).

APP01.17 **Rationale**: Safety responsibilities are necessary to ensure that the Service Provider's organisation is committed, at all levels, to the fulfilment of its stated safety policy. Accountability for safety belongs to all levels of management and the attainment of satisfactory safety performance requires the commitment and participation of all members of the Service Provider's organisation. The SMS depends upon individuals understanding and accepting their delegated responsibility within the Service Provider's organisation. Everybody within the organisation should be made aware of the consequences of mistakes and strive to avoid them. Management should foster this basic motivation within members of the organisation so that everybody accepts their responsibility for safety.

APP01.18 The Service Provider should define and document the safety accountabilities of personnel to explain how any safety significant roles are undertaken (858).

APP01.19 The Service Provider should make a safety policy statement which confirms that everyone has an individual responsibility for the safety of their own actions (859) and that managers are accountable for the safety performance of the activities for which they and their staff have responsibility (860). Additionally, the Service Provider

should identify who is ultimately accountable for safety and how the associated responsibility is delegated (861).

APP01.20 There should be a description of the Organisational Framework for the Management and Operating Team of the Service Provider (862). This should define the Functions, Responsibilities, Authority and Communication Interfaces and accountabilities of all staff with defined safety responsibilities (863). This should include either individual or generic staff (e.g. Watch staff), Operating, Maintenance and Managerial staff (864). Care should be taken to ensure that there is no overlap or duplication of responsibilities (865).

APP01.21 Arrangements should be in place to ensure that individuals are also aware of their safety responsibilities under emergency conditions (866).

Safety Priority

APP01.22 An ATM Service Provider should, as an integral part of the management of the ATM service, have in place an SMS which ensures that the achievement of satisfactory safety in ATM shall be afforded the highest priority over commercial, environmental or social pressures (867).

APP01.23 **Rationale**: The SMS should clearly address and resist business pressures that challenge the safety of the provision of the service (868). Conversely, the SMS should ensure that safety is not used to support commercial, financial, environmental etc. decisions inappropriately, which have little real safety significance (869). If the term 'safety' is abused in this way the SMS cannot be focused on controlling the real risks.

Safety Objective of the ATM Service

APP01.24 An ATM Service Provider should, as an integral part of the management of the ATM service, have in place an SMS which ensures that while providing an ATM service, the principal safety objective is to minimise the ATM contribution to the risk of an aircraft accident as far as is reasonably practicable (870).

Note: Where risk is concerned there is no such thing as absolute safety. 'As far as is reasonably practicable' means that risk in a particular activity can be balanced against the time, cost and difficulty of taking measures to avoid the risk. The greater the risk to safety,

the more likely it is that it is reasonable to go to substantial effort to reduce it. It is implicit, therefore, that hazards have to be identified and the risk assessed before a judgment can be made upon their tolerability.

Competency

APP01.25 Within the operation of the SMS, the Service Provider should ensure that staff are adequately trained, motivated and competent for the job they are required to do, in addition to being properly licensed if so required (871).

APP01.26 **Rationale:** Staff competence is fundamental to safety.

Components for Engineering and Technical Personnel Undertaking Operational Safety Related Tasks

Introduction

1. **Definition**

   - For the purposes of these paragraphs, engineering and technical personnel undertaking operational safety related tasks are personnel who operate and maintain ATM equipment approved for operational use.

2. **Rationale**

   - The competence of ATM personnel and, where applicable, their satisfaction of medical requirements, are fundamental elements of safety achievement, and therefore of safety management, in the provision of ATM services. The application of management controls in this area aims to establish harmonised minimum levels of competence and proficiency for staff having specific ATM safety responsibilities. 'Competence' is taken to mean possession of the required level of knowledge, skills, experience and, where required, proficiency in English, to permit the safe and efficient provision of ATM services.

3. **Applicability**

   - These paragraphs should apply to ATS providers and to all engineering and technical personnel as defined above who are responsible for tasks which, within provision of an ATM service, are identified as safety related.

4. **Safety Objective**

- The overall safety objective is to ensure the competence and, where applicable, the satisfaction of medical requirements, of engineering and technical personnel responsible for safety related tasks within the provision of ATM services.

SMS Components

APP01.27 An ATS provider at an ATS unit should ensure, as part of its overall safety responsibilities, that engineering and technical personnel responsible for tasks supporting the provision of air traffic services which are considered to be related to the safety of air traffic are competent to carry out those tasks and satisfy applicable medical requirements (1722).

APP01.28 A person responsible for tasks supporting the provision of air traffic services which are considered to be related to the safety of air traffic should:

- Not carry out such tasks unless he/she has been declared to be competent and has been duly authorised to do so (1723).
- Be subject to, or initiate, appropriate measures to ensure ongoing competence (1724).
- Meet medical requirements, if any appropriate to the task (1725).

APP01.29 An ATS provider should:

- Ensure that engineering and technical personnel are properly trained and qualified to perform the assigned tasks (1726).
- Ensure that engineering and technical personnel:

  a) Have and maintain sufficient knowledge to ensure a sound understanding of the ATM services they are supporting, and the actual and potential effects of their work on the safety of those services (1727).

  b) Have and maintain sufficient knowledge of the appropriate working limits to be applied when performing safety related tasks (1728).

c) Ensure that, in relation to engineering and technical personnel, evidence of the adequacy of personnel arrangements and qualifications to perform their safety related tasks is documented and made available to the CAA on request. Particular regard should be had to (1729):

i) The availability of sufficient personnel competence assigned to operational safety related tasks, and conformance with these requirements.

ii) Qualification schemes and policy.

iii) The competence, specialisation and recency of engineering and technical personnel.

iv) Training policy and plans.

v) Personnel training records.

vi) Arrangements for the supervision of non-qualified personnel.

- Ensure that engineering and technical personnel do not undertake the assigned operational safety related tasks if it is known or suspected that the individuals' physical or mental condition render them unfit to undertake such tasks (1730).
- Ensure that, from a safety viewpoint, appropriate methods are in place to ensure that individuals assigned to operational safety related tasks meet regulatory requirements (1731).
- Report to the CAA all safety events involving engineering and technical personnel and air traffic management equipment approved for operational use; the level of reporting details should be agreed between the ATS provider and the CAA (1732).
- Ensure that evidence exists, and is provided to the CAA as required, of the qualifications and competence of engineering and technical personnel to perform their operational safety related tasks (1733).

APP01.30 Engineering and technical personnel undertaking operational safety related tasks should:

- Comply with regulatory requirements and ATS provider's schemes to ensure current and ongoing competence (1734).

- Comply with any additional conditions applied by the CAA (1735).
- Not undertake safety related tasks if they know or suspect that their physical or mental condition renders them unfit to undertake such tasks (1736).
- Ensure that they have sufficient knowledge to enable a sound understanding of the ATM services they are supporting and the actual and potential effects of their work on the safety of those services and safety related tasks (1737).
- Systematically and consistently report safety occurrences in accordance with the provisions laid down in regulatory requirements (1738).

APP01.31 Engineering and technical operational personnel should initiate appropriate remedial measures if the requirements of paragraph APP01.30 are not met (1739).

Safety Management Responsibility

APP01.32 Within the operation of the SMS, the Service Provider should ensure that:

- A safety management function is identified with organisational responsibility for development and maintenance of the safety management system (877).
- This point of responsibility is, wherever possible, independent of line management and accountable directly to the highest organisational level (878).
- In the case of small organisations where combination of responsibilities may prevent sufficient independence in this regard, the arrangements for safety assurance are supplemented by additional independent means (879).
- The highest level of the Service Provider organisation plays a general role in ensuring safety management (880).

Quantitative Safety Levels

APP01.33 Within the operation of the SMS, the Service Provider should ensure that, wherever practicable, quantitative safety levels are derived and maintained for all systems (881).

APP01.34 **Rationale:** If the safety performance of a service or product is to be assessed and monitored it is necessary to define the safety objectives that need to be met.

APP01.35 The Service Provider should ensure that for each system the safety analysis leads to a series of quantifiable safety objectives (with the exception of human factors or areas to which only qualitative analysis is applicable) (882).

Risk Assessment and Mitigation

APP01.36 Within the operation of the SMS, the Service Provider should ensure:

- That a risk assessment and mitigation is conducted to an appropriate level to ensure that due consideration is given to all aspects of ATM (883).
- That changes to the ATM system are assessed for their safety significance (884) and ATM system functions are classified according to their safety severity (885).
- Appropriate mitigation of risks where assessment has shown this to be necessary due to the safety significance of the change (886).

Note: Risk assessment involves, in broad terms, hazard identification, hazard assessment for severity and frequency of occurrence, risk tolerability assessment and risk removal or mitigation. More details of this process can be found later in this section.

SMS Documentation

APP01.37 Within the operation of the SMS, the Service Provider should ensure that the SMS is systematically documented in a manner which provides a clear linkage to the organisation's safety policy (887).

Note: The Service Provider should define the Structure, Contents, Authorities, Responsibilities and Mechanisms for SMS Documentation (888). Where available any referenced standards or requirements should be clearly traceable to Corporate, Safety Regulatory, National or International Standards or Requirements (889). In this context, 'Corporate' means applicable to all parts of the organisation, not just a 'headquarters' area. There are no precise definitions of 'standards' or 'requirements'. Both relate generally

to objectives that have to be met and can be interchangeable in meaning. The mandating of such objectives can be organisational or statutory.

External Services

APP01.38 Within the operation of the SMS, the Service Provider should ensure adequate and satisfactory justification of the safety of the externally provided services, having regard to their safety significance within the provision of the ATM service (890).

APP01.39 **Rationale:** A safety assessment requires input from all phases of a product or service development. For externally supplied products or services the external supplier must understand and comply with the organisation's safety and safety management system requirements.

Safety Occurrences

APP01.40 Within the operation of the SMS, the Service Provider should ensure that ATM operational or technical occurrences which are considered to have significant safety implications are investigated immediately (891) and any necessary corrective is taken (892).

APP01.41 **Rationale**: If lessons are to be learnt and remedial action is to be taken promptly, safety occurrences need to be investigated in a timely manner by the organisation. This activity should be additional to any statutory reporting requirements (893).

APP01.42 The Service Provider should have in place a process for investigating potentially safety significant occurrences, identifying any failure of the Service Provider's management of safety, and take corrective action if required (894).

APP01.43 Under the Mandatory Reporting Requirements of the ANO and CAP 382, 'reportable occurrences' should be reported to the CAA (895).

APP01.44 The Service Provider should address the responsibilities and mechanisms that control the reporting, recording, analysis and dissemination of data relating to MORs, incidents, occurrences and failures (896). These should include:

- Interface to external organisations (897).
- Internal reporting paths (898).
- Responsibilities (899).

- Auditing of process (900).
- Notification of incidents to the CAA (901).

APP01.45 Corresponding arrangements should include regular communication to amass, assess and clear safety concerns (902).

Safety Surveys

APP01.46 Within the operation of the SMS, the Service Provider should ensure that safety surveys are carried out as a matter of routine, to recommend improvements where needed (903), to provide assurance to managers of the safety of activities within their areas (904) and to confirm conformance with applicable parts of their SMS (905).

APP01.47 **Rationale**: A safety audit is the pro-active safety management mechanism by which any risks within the organisation's operation are identified and controlled.

APP01.48 The Service Provider should consider detailing the arrangements for the Implementation, Planning, Analysis, Dissemination of Audit Results and Rectification or Enforcement Action in respect of faults found (906).

APP01.49 The Service Provider should consider documentation that details the policy and arrangements for auditing the effectiveness and implementation of the SMS at various levels in the organisation (907).

APP01.50 The Service Provider's safety auditing should be based on the objective of determining the safety consequences if the person, function, facility, procedure or structure failed to perform the pre-planned operational requirements (908).

APP01.51 The Service Provider should define and ensure the competency of the persons responsible for the safety audit, together with reporting and enforcement arrangements (909). Enforcement arrangements should be applicable to the accountabilities assigned to the various levels and areas in the Service Provider's organisation (910). The reason for the rejection of any safety survey recommendations should be documented and held centrally (911).

Safety Monitoring

APP01.52 Within the operation of the SMS, the Service Provider should ensure that methods are in place to detect changes in systems or operations which may suggest any element is approaching a point at which acceptable standards of safety can no longer be met and that corrective action is taken (912).

APP01.53 **Rationale:** Safety performance can deteriorate, or the operational environment can change over time. Such events need to be detected and managed, pro-actively and reactively, to ensure that adequate safety performance continues to be achieved.

APP01.54 The Service Provider should consider the responsibilities, mechanism, authorities and recording arrangements for the collection, analysis and circulation of data to confirm that the safety objectives (where defined) of reliability, integrity and availability continue to be met (913).

Safety Records

APP01.55 Within the operation of the SMS, the Service Provider should ensure that the safety records are maintained throughout the SMS operation as a basis for providing safety assurance to all associated with, responsible for or dependent upon the services provided, and to the safety regulatory authority (914).

APP01.56 **Rationale:** The safety assessment documentation should provide the evidence to the organisation (and other parties) that it meets and continues to meet its safety objectives (915).

APP01.57 A Service Provider should record the safety requirements for its area of activity and the results of the safety assessment process (916).

Risk Assessment and Mitigation Documentation

APP01.58 Within the operation of the SMS, the Service Provider should ensure that the results and conclusions of the risk assessment and mitigation process of a new or changed safety significant system are specifically documented, and that this documentation is maintained throughout the life of the system (917).

Note: The following areas of an ATS operation are those in which issues can arise that may have implications on the safety of a unit. As such the Service Provider should have processes in place to conduct safety assessments of these areas.

- ATM Occurrences (918)
- ATM staff (919)
- ATM Procedures (920)
- ATM Equipment (921)
- the SMS (922)
- Compliance with requirements (923)

APP01.59 Guidance on the possible conduct of safety assessments for these areas is provided below.

Lesson Dissemination

APP01.60 Within the operation of the SMS, the Service Provider should ensure that lessons arising from safety occurrence investigations and other safety activities are disseminated widely within the organisation at management and operational levels (924).

APP01.61 The Service Provider should ensure that lessons learnt from its safety occurrence investigations and the case histories or experience from other organisations are distributed widely and, where appropriate, actioned to minimise the risk of recurrence (925).

APP01.62 **Rationale**: It is essential that lessons should be learned and then remembered, so that the chance of recurrence is reduced. Including the results of such lessons in training programmes will raise staff awareness levels.

Safety Improvement

APP01.63 Within the operation of the SMS, the Service Provider:

- Should ensure that all staff are actively encouraged to propose solutions to identified hazards (926);
- Should ensure that changes are made to improve safety where they appear needed (927).

APP01.64 **Rationale**: This requires an effective means of communicating safety issues and the development of an internal safety culture that encourages every member of staff to focus on the achievement of safety, and to report errors and deficiencies without fear of punitive actions against them.

APP01.65 The Service Provider should have arrangements to allow safety concerns to be highlighted and communicated to those accountable for safety (928).

APP01.66 The Service Provider should have arrangements that allow comments to be raised, discussed and implemented, should the SMS be found to be deficient (929). These arrangements should address Interfaces and Audits (930).

Occurrences

APP01.67 The requirements for assessing safety related incidents at a unit are given in paragraph APP01.23 'Safety Assurance'. Guidance on items to be reported under the MOR scheme are given in CAP 382.

APP01.68 Occurrences include: ATC incident reports, Engineering Occurrence reports and Post-incident ATCO licensing.

Staffing Levels and Training

APP01.69 There should be a policy and arrangements in place that define the person responsible and the process to be followed that ensure that an adequate number of suitably trained and rated staff are available in respect of ATS Safety (931).

APP01.70 Documentation should define the method by which staffing levels are determined in relation to the maintenance requirements and availability of engineering facilities (932).

APP01.71 There should be a policy and arrangements in place that define the management responsibilities and process for ensuring adequate staff supervision (933). Arrangements should include the mechanisms that ensure only trained and competent staff undertake maintenance functions (934).

Procedures

APP01.72 Guidance on the safety assessment of changes to ATC procedures, including TOIs and SIs, is given in Appendix A to APP 01 SMS: Additional Guidance.

APP01.73 Guidance on compliance with CAP 493 MATS Part 1 is given in CAP 670 Part B, Section 2 ATC 02.

APP01.74 Guidance on the hazard and risk assessment of changes that may impact upon airspace is available from the Directorate of Airspace Policy (DAP).

Equipment

Guidance on the assessment of the safety implications of changes to maintenance arrangements of equipment is given in CAP 670 Part B, Section 1 APP 02.

Guidance on the safety assessment of a change of function or change of equipment is given in Appendix A to APP 01 SMS: Additional Guidance. Equipment requirements to be achieved are given in CAP 670 Part C.

Changes to the SMS

APP01.75 Changes in the organisational structure of the unit that change the safety accountabilities of individuals defined in the SMS should be considered as a change to current operations (935) and assessed in accordance with the guidance given in Appendix A to APP 01 SMS: Additional Guidance (936).

APP01.76 Any changes to the SMS should be assessed to ensure the recommendations in this section are still met (937).

APP01.77 The results of any internal Safety Surveys should be assessed for safety significance (938). The CAA is to be informed of any items of Safety Significance that are not notified through other means such as the MOR scheme (939).

The Communication Arrangements for Safety Concerns

APP01.78 Documentation should define the responsibilities, timing and scope for the regular communication that addresses safety concerns (940). This documentation should define the responsibilities for the collection, assessment, and distribution of safety concerns and implementing solutions (941).

APP01.79 There should be an arrangement for organising and disseminating the results of communication in respect of ATS safety issues, both related to on-going safety management, safety improvement programmes and follow-ups to incidents or occurrences (942).

Compliance with Standards and Requirements

APP01.80 The Service Provider should make a safety policy statement committing it to complying with all appropriate safety standards and requirements (943).

APP01.81 The Service Provider should demonstrate the existing facility's compliance with all relevant safety regulatory requirements (944).

APP01.82 Any change to the unit should be assessed for its compliance with national and international requirements (945).

Appendix A to APP 01: SMS: Additional Guidance

Safety Assurance Documentation

APP01A.1 Safety assurance documentation contains **argument** and **evidence** that the system meets or exceeds the appropriate standard of safety.

APP01A.2 Safety assurance documentation usually reflects one of two situations; the safety of the existing, on-going, operation or a change to the existing operation, such as a new project or procedure.

APP01A.3 A service provider may use any reasonable format for presenting safety assurance documentation, as long as its scope is well defined and it provides the necessary arguments and evidence required for its purpose.

APP01A.4 Safety assurance documentation may require amendment to reflect changes in requirements or other external factors.

Unit Safety Assurance Documentation

APP01A.5 The presentation of safety assurance documentation will be different depending upon the subject under consideration. Safety assurance documentation presented in the form that describes the safety arguments and provides evidence that a unit is operating in a safe manner is often presented as unit safety assurance documentation or a Unit Safety Case. These submissions are often associated with a formal safety management system.

APP01A.6 Unit safety assurance documentation will be supported by individual safety documentation that describes projects or changes which occur during the lifetime of the unit. Such documentation should be notified to the CAA, who will advise if specific approval under the ANO is required, or if the safety documentation may be considered for later audit activity, if considered necessary (946). This is likely to be the situation when the CAA has agreed the adoption of a formal SMS at the unit. The approval or acceptance of such documentation may require the amendment of the unit safety assurance documentation.

Current Operations

- The current operations of the unit should be described in the Unit safety assurance documentation (947). The purpose of this documentation is to provide assurance that the operations are safe and will continue to be safe.
- The documentation is used for managing operational safety. It may be accepted by the regulator as a prime regulatory document within the context of a formal SMS.
- In order to provide the necessary assurance, the documentation should present evidence and arguments that demonstrate the safety adequacy of existing operations for their role (948). The following areas should be addressed:
  - SMS (949)
  - Description of operation (950)
  - Safety assessment of operation (951)
  - Compliance with regulations (952)
  - Safety performance (953)
  - Operational procedures (954)
  - Safety accountabilities (955)
  - Safety communications (956)

Safety Related Changes to Current Operations

- Changes to the current operations, which may have an impact on the safe operation of the unit's ATS provision, should be notified to the CAA (957). The following illustrates but is not limited to, the anticipated activities requiring such notification:
  - The installation and commissioning of a system
  - A modification to a piece of equipment which is in service
  - A change to maintenance arrangements
  - The withdrawal of a service or facility
  - The introduction of a new, or a change to an existing, ATS procedure

- The safety assurance documentation supporting the proposed activity should consider all aspects of the proposal, from inception through to routine operational use (958). Typically the following areas should be considered:
  - The identification of operational and functional requirements;
  - The management of the implementation of the activity;
  - The completion of a risk assessment and identification of the safety requirements to be satisfied;
  - The presentation of evidence that the system design will achieve the safety, operational and functional requirements identified;
  - The presentation of measures to control any risks which cannot be satisfactorily mitigated by the system design;
  - The presentation of measures taken to achieve an equivalent level of safety where identified requirements cannot be satisfied by the system design;
  - Evidence that no unpredicted impact will occur to other components of the system as a result of the change;
  - Evidence that operating and maintenance procedures are acceptable for routine operation.

Submission of Safety Related Change Assurance Documentation

APP01A.7 The safety assurance documentation produced that addresses, but is not limited to, the foregoing should be submitted to the CAA if requested, following notification of the intent to introduce the change (959). Typically the submitted documentation may take the form of several sequential parts. The following paragraphs provide guidance and expansion of each typical area.

System Description, Requirements and Hazard Identification

APP01A.8 This should contain the reason for and an overview of, the proposal and intended changes, together with an identification of the safety objectives and regulatory requirements, which must be satisfied, including identification of approval under the ANO.

APP01A.9 A description of the operational and functional requirements should be included to define why the change is needed and what the end result should be.

APP01A.10 A risk assessment should be carried out to identify hazards associated with the change and assess their impact. This may result in additional safety requirements which will remove or mitigate the identified hazards. This process may need to be repeated at a later stage if the design solution does not satisfy all requirements that have been identified.

APP01A.11 Any assumptions that have been made should be clearly stated and justified.

APP01A.12 It should be clearly stated who is responsible for the management and implementation of the change to current operations.

Justification of Selected System or Operational Change

APP01A.13 It should be demonstrated how the selected solution to the required change will meet the identified safety, operational, legislative and functional requirements, during installation, commissioning and operational deployment.

APP01A.14 This may include a high level overview of the new system with lower level detail examining safety related areas of design. The justification should consider any features of the design which are not included in the operational or functional requirements but may still affect system safety. Any such features will need to be mitigated, for example, by disabling a feature or instituting a procedure to preclude the feature being invoked.

APP01A.15 In many cases, it will be necessary for the service provider to obtain assurance from equipment suppliers that any assumptions that have been made are valid. Reference should be made to pertinent sections of CAP 670, particularly when seeking assurances involving software or system installations.

APP01A.16 Any identified safety requirements that cannot be satisfied by the selected solution should be clearly described and mitigated as appropriate, in the safety documentation.

Physical Integration and Handover into Routine Operation

APP01A.17 The safety assurance documentation should describe how the change will be safely integrated into current operations. Any risks introduced by integrating the new system should be identified and mitigation arguments presented.

APP01A.18 Assurance that all staff, including contractors, involved in the change, are competent to perform their task, should be provided. The documentation should describe any operational training and familiarisation which is required and provide assurance that it will have taken place prior to introduction to service.

APP01A.19 Operational and support procedures necessary during the introduction of the change should be described. In many cases it may be necessary to include reversion procedures to be followed if some unforeseen problem prevents the change being completed.

APP01A.20 The documentation should include a summary showing that all hazards identified in the safety assessment have been addressed and that the system will be safe for operational use.

APP01A.21 The safety assurance documentation should provide a description of the steps to be taken during Operational deployment or handover of the change and those required for its continued operation. This should include the satisfactory completion and recording of any test results.

APP01A.22 This should also include a description of any engineering, maintenance, support or operational tasks. It should be demonstrated that any instructions to be followed by ATS staff will provide sufficient guidance for safe operation.

APP01A.23 Following the acceptance of the submitted safety assurance documentation it should be possible for the CAA to grant approval for operational use/deployment of the change.

Post Operational activity

APP01A.24 The safety assurance documentation should be retained for the life of any part of the system to which it relates. Subsequent changes can then be assessed against the safety, operational, legislative and functional requirements which were originally identified.

Safety Assurance Documentation Presentation Guidance

APP01A.25 The Documentation should be uniquely identifiable.

APP01A.26 A system that defines the status of the document should be implemented. This can usually be achieved by a version numbering scheme. It is important that the document clearly indicates whether it is in draft form or has been accepted by the CAA and should provide a point of contact able to confirm the validity of the version number.

Hazard Identification, Risk Assessment and the Production of Safety Assurance Documentation or Safety Cases

APP01A.27 The Common Requirements and ESARR 4 require that the risks associated with hazards in the ATM system are systematically and formally identified, assessed and managed within safety levels, which, as a minimum, meet any that may be required by the CAA or European Regulations.

APP01A.28 The UK is currently engaged in deriving AMC with the Common Requirements and ESARR 4, which will be published when available. In the meantime, guidance on risk assessment and mitigation is provided in CAP 760, Guidance on the conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases for Aerodrome Operators and Air Traffic Service Providers. As the CAA develops AMC, these will be published as either separate guidance or as addendums to CAP 760.

APP01A.29 In assessing risks, adequate attention must be made to Human Factors. This is referenced in CAP 760 and the link below provides a list of useful ICAO documents, including Doc 9758 Human Factors Guidelines for Air Traffic Management (ATM) Systems.

http://www.icao.int/anb/humanfactors/Documents.html

APP 02: Maintenance Arrangements

Introduction

APP02.1 Maintenance arrangements will normally be considered as part of the SMS acceptance or approval as part of the Certification and Designation process. The relevant Engineering Inspector will give guidance on the approval of maintenance arrangements applicable to a specific unit.

Safety Objective

APP02.2 **Equipment maintenance arrangements are adequately safe to ensure ATM facilities remain fit for purpose (1685).**

Acceptable Means of Compliance

APP02.3 The ATS Provider should detail the maintenance arrangements employed at the ATS facility (1686).

APP02.4 Acceptance of the detail will facilitate Approval (normally as part of the SMS) of the maintenance arrangements.

APP02.5 As mentioned in the paragraphs above, the detail will normally be presented as part of the SMS, any approval being included in the ATS Unit approval or as an Exposition leading to the granting of a dedicated approval certificate, as determined by the appropriate Regional Inspector ATS (Engineering).

Note: The term 'maintenance' includes the operation, regular maintenance, repair, modification, overhaul and decommissioning of ATS equipment.

APP02.6 The responsibility for the safety adequacy lies with the person in charge of the ATS facility (1687). Where any or all maintenance is carried out by subcontractors on behalf of the person in charge, any safety argument written by the subcontractor shall be considered as if endorsed by the person in charge (1688).

Person Responsible for the Safety Adequacy of Maintenance Arrangements

APP02.7 To ensure compliance with the safety objective, the person in charge shall consider the safety implications of the organisation structure and its maintenance tasks (1689).

APP02.8 The person in charge is defined as the person who meets the following criteria:

- Is a legal entity in charge of the equipment being maintained.
- Has the technical competence to understand the maintenance arrangements issues.
- Has the authority to act should changes be necessary to any of the maintenance arrangements.

APP02.9 The equipment or systems of interest are only those relating to ATM facilities.

Typical Aspects for which Safety Adequacy should be Considered

Formal Control of Documentation

APP02.10 The person in charge should consider whether documents are traceable and endorsed by the organisation (1690). Typical methods of ensuring this cover inclusion of:

- Organisation Name and Business Address.
- Document Title.
- Date.
- Signed authorisation of document by person in charge.
- Reference Number.
- Amendment record.

General Organisational Aspects

APP02.11 Statements on safety adequacy should include the following subjects (1691):

- Organisation Chart (incl. interfaces and aerodrome licence holder).

- Key personnel:
  - Terms of reference.
  - Responsibilities (including responsibility to consider safety aspects of organisational changes) and the associated accountabilities.
  - Authority to act.
- Description of method for considering safety aspects for additional equipment or changes to existing equipment.

Documentation Arrangements

APP02.12 Statements on safety adequacy should include the following subjects/documents (1692):

- Responsibility for control of documentation, including amendments and out of date versions.
- Reference documents held or readily available, e.g. CAP 382 Mandatory Occurrence Reporting Scheme, CAP 393 (the ANO), CAP 670, ICAO Annexes.
- Local documents in use, e.g.:
  - Log books.
  - Maintenance programme.
  - Maintenance schedules.
  - Modification records.
  - Equipment handbooks.
- Staff instructions:
  - Safety adequacy of the arrangements or procedure for:
  - Taking equipment out of service.
  - Returning equipment to service.
  - Issuing a NOTAM.
  - The control of removable archival media (CAP 670, Part C, Section 1 COM 01 refers).
  - The action to take in the event of an aircraft accident.

- The conduct of flight checks.
- The control of access to sites established for the purpose of ATS provision.

- Documentation for software version control.

Maintenance Arrangements

APP02.13 The safety adequacy of the following arrangements should be considered (1693):

- Assurance that all Safety related ATM facilities are covered, including:
  - Organisation responsible for each level of maintenance.
  - Frequency of maintenance for each equipment, i.e. daily, weekly etc.
- Level of maintenance.
- Selection and control of contractors/subcontractors, including declaration on disclosure of information obtained during inspections or audits by the CAA to the person in charge. It is the responsibility of the person in charge to ensure that the subcontractor is capable of carrying out the maintenance to a satisfactory standard and where appropriate of providing the necessary ongoing support.
- Programme of preventative maintenance.
- Flight checking arrangements, including:
  - Person responsible for the control of flight checking.
  - Equipment subject to regular flight calibration checks.
  - External agency carrying out flight checks.
  - Programme of checks applicable.
  - Instructions to staff for the conduct of flight checks and analysis of the results.
  - Person responsible for notifying the CAA of delays or failures of flight checks.

- Description of records of preventative maintenance, faults, repairs and modifications.
- Use of maintenance schedules.
- Records of readings produced.
- The production of commissioning (baseline/red) figures and the need to notify the CAA of changes to these figures, particularly ILS monitor parameters.
- Modification control and authorisation, and approval.
- Engineering on call and call out arrangements.

Maintenance Support Arrangements

APP02.14 The safety adequacy of the following arrangements should be considered (1696):

- Service Agreement with any third party providing maintenance or installation services.
- Definition and control of any pertinent critical and sensitive areas.
- Spares policy; where necessary expand for individual systems or equipment.
- Spares storage.
- Test equipment policy, provision, control, calibration and review.
- Equipment and System configuration control; build state, modular serial number and modification status.
- Physical and technical safeguarding of radio installations.
- Radio sites protection from electrical interference.
- Workshop facilities.
- Service level agreements for external services.

Competency of Personnel

APP02.15 The safety adequacy of the following arrangements should be considered (1697):

- Number of staff committed to maintenance and repair programme.

- Staff certification schemes and policy.
- Staff qualification, competence, specialisation and recency.
- Staff training policy and plans.
- Staff training and competency records.
- Supervision of ATS contracted staff.

Note: Reference should be made to Part B, Section 1 APP 01, paragraph APP01.27, for details of ESARR 5 requirements.

Personal Technical Certificates

APP02.16 In the absence of an alternate and accepted competency scheme the Personal Technical Certificate (PTC) scheme will apply (1698).

APP02.17 ANSPs using the PTC scheme are still required to comply with ESARR 5 requirements and with the EU Common Requirements Annex 2, paragraph 3.3, Safety requirements for engineering and technical personnel undertaking operational safety related tasks.

APP02.18 PTCs are issued to appropriate engineering personnel (1699).

Group Rating

APP02.19 The certificates specify the equipment that an individual is qualified to maintain (1700). The certificates are authorised by the Regional Inspector based on an individual's training and experience.

Table of Group Types
R/T Comms and/or Ground-Ground Comms
Data Comms
Recorder Systems R/T
Recorder Systems Radar
ILS
MLS
DVOR/VOR
NDB
DF
DME

Table of Group Types
IRVR
Primary Radar Sensor
Secondary Radar Sensor
Radar Displays and Processing
General Data Processing and Computer Techniques
CCTV

Type Rating

APP02.20 The certificates also detail specific equipment types an individual is competent to maintain. It is the responsibility of the senior engineer at a particular location to assess and certify competence on specific equipment. Where staffing may be at the level of one individual, the Regional Inspector may certify competence.

APP02.21 Specific equipment ratings also include the maintenance actions an individual is competent to perform. The following maintenance levels will be specified (1701):

- **Level 1** Front panel maintenance including switching and lamp or fuse changing.
- **Level 2** In depth preventative maintenance, problem solving and repair and authority to return to service.
- **Level 3** Major overhaul and refurbishment.

APP02.22 Specific equipment type ratings are location dependent.

Proficiency Record

APP02.23 Provision is made in the certificates for a record of an individual's proficiency. This may be used to record how often an individual performs maintenance duties on specific equipment and/or lapses in competency on specific equipment.

Inspections and Audits

APP02.24 The Adequacy of Maintenance Arrangements will be subject to audit by CAA representatives from the Regional Office (ATS) or the En-Route Regulation section as appropriate (1702).

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APP 03: The Certification and Designation of an ANSP organisation as required by the EU Regulations

Introduction

APP03.1 This Section refers to the Certification and Designation of ANSPs, specifically ATC, FIS and CNS organisations. It does not refer to the Certification and Designation of MET and AIS organisations, which are dealt with by CAP 779 Regulation of Aeronautical Information Services and CAP 782 Regulation of Aeronautical Meteorological Services. CNS organisations are required to be Certificated but not Designated.

Application Process

APP03.2 The 'Certification and Designation' area of the CAA website provides details of the application process including application instructions, an application form, guidance, a questionnaire, a Compliance Matrix and details of the EU Regulations.

APP03.3 Applicants should therefore access the website and follow the application process. The website is located at www.caa.co.uk/ses.

Note: The SES web pages at www.caa.co.uk/ses are currently under review and will be updated to reflect the EU Regulations. Any changes to these pages will be notified by Information Notice (IN).

Designation

APP03.4 Certificated ANSPs are required to be designated by the CAA in order to provide services in the UK.

Maintaining Certification and Designation

APP03.5 The organisation providing ATC, FIS, Communications, Navigation or Surveillance services shall inform the CAA immediately, in writing, when they are unable to meet any of the following terms or conditions of Certification or Designation:

- continued compliance with the relevant EU Regulations;
- compliance with UK Designation Requirements;

or when:

- the service is being terminated;
- the Certification is no longer required or Designation is no longer valid.

APP03.6 The organisation providing ATC, FIS, Communications, Navigation or Surveillance shall inform the CAA of changes that could affect the validity of the Certification or Designation.

APP03.7 Although CAP 670 in general deals primarily with safety and interoperability related aspects of service provision, ANSP organisations are reminded that Certification and Designation includes security, contingency plans, quality management and finance. Consequently, the changes to be advised to the CAA include all of these elements.

APP03.8 The Compliance Matrix is used in maintaining ANSP certification. All UK ANSP organisations are expected to ensure that their Compliance Matrix remains current and accurate. The Compliance Matrix will be used by the CAA in the design of CAA oversight audit activity and is recognised as facilitating an ANSP's internal oversight activity.

ATS Regional Office and En-Route and College Regulation Responsibilities

APP03.9 ATS ROs are responsible for overseeing the compliance of ANSPs at aerodromes in the UK. En-Route and College Regulation (ER&CR) is responsible for overseeing the compliance of the En-Route Organisation. Included in this task are personnel licensing aspects, inspection and auditing of organisations and the approval of equipment and procedures in the provision of air navigation services.

APP03.10 The ROs are based in three areas: Southern RO at Gatwick, Central RO at Manchester, and the Northern RO at Stirling, with En-Route and College Regulation (ER&CR) located at Aviation House, Gatwick.

APP03.11 The CAA will become involved at an early stage in any application to become Certificated as an ANSP or to become Designated

as a Service Provider in the UK. This involvement will continue throughout the life of the Certificated and/or Designated organisation.

Ongoing Compliance: Commission Regulation (EU) No. 1035/2011 Common Requirements

APP03.12 Once an ANSP is certified against Commission Regulation (EU) No. 1035/2011, the ANSP becomes subject to oversight by the CAA as the Competent Authority in compliance with Commission Regulation (EU) No. 1034/2011 Safety Oversight in ATM and ANS.

APP03.13 In each calendar year the CAA establishes an audit programme based on an assessment of the risks associated with the operations of each organisation. Over a two-year cycle the audit programme seeks to ensure that UK ANSPs are able to demonstrate compliance with Commission Regulation (EU) No. 1035/2011. Audits may cover the complete scope within one or multiple audit visits.

APP03.14 In addition, information is required by the CAA's Consumer Protection Group (CPG) and Regulatory Policy Group (RPG) in accordance with Commission Regulation (EU) No. 1035/2011 and as described on the CAA's Certification and Designation web pages (www.caa.co.uk/ses); this information covers annual financial reports, audited accounts and evidence of adequate insurance cover.

APP03.15 Audits will be based on the current Certification Compliance Matrices held by the CAA and therefore it is essential that these are maintained up to date.

Compliance Matrix Requirements

APP03.16 Certificated ANSPs should establish methods, through their Quality Management System processes or otherwise, to ensure their Compliance Matrix is regularly reviewed and amended where necessary in order to reflect their current compliance status. It is recommended that such a review is conducted at least annually. However, the frequency with which compliance is reviewed should be commensurate with the degree of operational, and where appropriate, organisational change that individual ANSPs are experiencing. ANSPs are not required to routinely submit amended Compliance Matrices to the CAA. Instead, and as part of its planning process for the conduct of compliance audits, the

CAA will request current versions through its ROs as required. The scope and conduct of the compliance audit will be determined, in part, by the statements contained in the Compliance Matrix. The Compliance Matrix may also be used by ANSPs to direct internal audit arrangements, to assist with audit scoping and planning and to provide assurance of compliance with minimum regulatory intervention.

APP03.17 Where ANSPs have been certified to provide bundled services, i.e. ATS, AIS, MET or CNS, audits will be lead by appropriate CAA lead auditors.

APP03.18 Regulatory oversight visits by CAA inspectors will also include ATCO Licensing assessments, competency, etc.

ANSP Reporting Requirements: Commission Regulation (EU) No. 1035/2011

APP03.19 All UK ANSP organisations must be able to provide annual reports of their activities to the satisfaction of the CAA. Further information can be found on the CAA's Certification and Designation web pages (www.caa.co.uk/ses) by following the link to 'ANSP Certification – the Economic and Financial Requirements'.

Regulatory Oversight Audits: Commission Regulation (EU) No. 1034/2011

APP03.20 Oversight audits provide the CAA with satisfactory evidence of compliance and the opportunity to recommend and track improvement or corrective actions. Audit findings are detailed on individual report forms and incorporated into an overall report at the end of each oversight audit.

Corrective Actions: Commission Regulation (EU) No. 1034/2011

APP03.21 Where the CAA detects trends that may indicate that an ANSP is not in compliance with the Common Requirements, the CAA is obliged to seek an agreement for corrective actions in accordance with Commission Regulation (EU) No. 1034/2011.

APP03.22 It is the responsibility of the ANSP to determine corrective actions. The time frame for implementation of the actions shall be agreed with the UK CAA.

APP03.23 Where the CAA is not satisfied that corrective actions are being completed within the agreed timescales, the CAA has the power to vary, revoke, or suspend ANSP certificates. A variation may specify conditions that will place restrictions on the provision of services. Any conditions specified in a variation will be considered for removal when the CAA is satisfied that the required regulations or requirements are met.

APP03.24 ANSPs should be aware of provision in respect of enforcement of EU Regulations. Details of the relevant Statutory Instrument and updates thereto are available from www.opsi.gov.uk/si/si2009/uksi_20091735_en_1.

Oversight of Changes to Functional Systems: Commission Regulation (EU) No. 1034/2011

APP03.25 Changes to functional systems shall be subject to oversight by the CAA, in accordance with Commission Regulation (EU) No. 1034/2011.

Safety Directives: Commission Regulation (EU) No. 1034/2011

APP03.26 A Safety Directive will be issued in the event that the CAA determines the existence of an unsafe condition requiring immediate action. The Safety Directive will identify the unsafe condition, the affected system, the required actions and rationale, the time limit for compliance, and the date of entry into force. Where appropriate, the Safety Directive will be forwarded to other NSAs, the Commission, EASA and EUROCONTROL.

Additional Information

APP03.27 An ANSP organisation objecting to any decision by the CAA to reject an application, to grant it in terms other than those requested by the applicant or to vary, suspend or revoke a Certification or Designation, may, under Regulation 6 of the CAA Regulations 1991, request that the case be decided by the CAA.

APP03.28 Nothing in this document exempts any person from complying with any other relevant legislation (such as the Health and Safety at Work Act, Building and Planning Regulations) pertaining to the provision of facilities or the installation of equipment.

APP03.29 The CAA reserves the right to require an ANSP organisation to install any equipment or facilities or to apply any conditions or procedures, subject to any limited discretionary powers under EU Law, not specifically mentioned in this publication.

APP 04: Temporary ATC Units

Introduction

APP04.1 This document takes into account the following:

- The short-term nature of the need.
- The requirement for flexibility. It is recognised that some special events comprise helicopter operations only, others comprise fixed wing operations only and some are a combination of both.
- The need to achieve suitable levels of safety at reasonable cost.

APP04.2 All Air Traffic Controllers are to be appropriately licensed and validated (88).

APP04.3 The applicability of EU Certification and Designation requirements to particular temporary ATC Units will be determined by the appropriate ATS Regional Office.

APP04.4 In this document it is assumed that there will be no night operations. If the applicant expects that there may be night operations then this must be clearly indicated on the initial application (89). The CAA will indicate any extra requirements after due consideration.

APP04.5 Exceptionally, the CAA may grant one Approval to cover a number of events at the same location throughout the year, e.g. a racecourse. Any contractual arrangements between the applicant and the organiser(s) of the events must have been concluded at the time of application. When one Approval has been granted to cover all the events at a single venue for the year, a Condition will be that the same Provider, location of the VCR, facilities etc. are used on each occasion.

General

APP04.6 A person seeking approval for the temporary provision of an Air Traffic Control Service must give a **minimum of 90 days notice** (90).

APP04.7 This document defines the requirements of the CAA. Further information regarding the conduct of special events may be obtained from the following documents:

- CAP 403 Flying Displays – A Guide to Safety and Administrative Arrangements.
- Aeronautical Information Circular published prior to the commencement of each season.
- CAP 168 Licensing of Aerodromes.
- CAP 744 Air Traffic Controllers – Licensing.

Staffing Requirements (Ref: CAP 670 Part D, Section 1)

APP04.8 Applicants are urged to enter into early discussions with the appropriate ATS Regional Office for information and guidance, particularly if they consider they will be unable to comply with any aspects of the Scheme for the Regulation of Air Traffic Controllers' Hours (SRATCOH).

Communication (Ref: CAP 670 Part C, Section 1)

APP04.9 The CAA will consider such factors as the ambient noise levels affecting the ATCU and the complexities of the task. Applicants should pay particular attention to the following:

- The proximity of aircraft operations and especially helicopter operations.
- The noise caused by air conditioning units.
- The establishment of 'commentary positions' within the ATC unit.
- The use of the ATC unit for other tasks such as collection of landing fees, pilot briefing etc.

Surface Wind Indication (Ref: CAP 670 Part C, Section 4)

APP04.10 Proof will be required that the displays have been calibrated recently by a person competent to perform the calibration.

APP04.11 Sensors: The sensor(s) should be located to comply with the CAA's current siting and exposure requirements as described in CAP 670, Part C, Section 4 MET (92).

APP04.12 A less stringent requirement employing sensors and well-positioned windsleeve(s) may be acceptable. Windsleeves should be positioned on the aerodrome so as to be visible from all directions (93), they

should be free from the effects of any disturbances caused by nearby objects (94) and they should be sited so that at least one sleeve is visible from each take-off position (95). Windsleeves must meet the requirements of CAP 168 Licensing of Aerodromes (96). The applicant must submit diagrams showing the layout of sensors/ windsleeves on the aerodrome (97).

Pressure Setting Information (Ref: CAP 670 Part B Section 2)

APP04.13 The stated accuracy levels may be relaxed for special events. Proof will be required that the equipment has been calibrated together with any correction table by a person competent to perform the task.

Visual Control Room (Ref: CAP 670 Part B, Section 2, ATC 01)

APP04.14 Some mobile and temporary VCR windows are prone to problems associated with reflections and condensation. Applicants should pay particular attention to the avoidance of such problems (98).

Manual of Air Traffic Services Part 2 (Ref: CAP 670 Part B, Section 2, ATC 02)

APP04.15 A MATS Part 2 containing local instructions is to be prepared (99). All such instructions shall be clear, unambiguous and in a logical order (100).

APP04.16 A title page shall be used to identify clearly the unit, location and event to which the instructions relate (101).

APP04.17 A contents page is required (102). Section dividers are to be provided to emphasise different groups of information for quick reference (103).

APP04.18 The Provider is required to lodge a copy of the unit's MATS Part 2 with the CAA (104) together with the application for Approval (105).

APP04.19 The Provider shall ensure that the MATS Part 2 is current and accurately reflects the procedures at that unit for that particular event (106).

APP04.20 If the MATS Part 2 differs in any way from previous submissions the Provider is to indicate clearly the variations and the reasons for them (107).

APP04.21 Any charts, diagrams, maps or schematics included in the MATS Part 2 shall be identical to those submitted to aircrew as part of their briefing documents (108).

APP04.22 Any letters of agreement applicable to the event shall be included in a separate section marked 'Letters of Agreement' (109).

APP04.23 Blank pages are to be marked 'Intentionally Blank' (110).

APP04.24 Particular care should be taken to ensure the correctness of any telephone numbers connected with a particular event. In the interests of easy and effective amendment the applicant may deem it appropriate to place relevant telephone numbers on a clipboard as well as in the MATS Part 2.

APP04.25 Instructions applicable to any 'feeder sites' which are associated with the event shall be submitted as part of the unit MATS Part 2 (111). If any such site is positioned at an airfield which already has an approved ATC unit the TOI for the 'feeder site' unit's MATS Part 2 shall also be forwarded simultaneously with the Special Event unit's instructions (112).

Watch Log (Ref: CAP 670 Part B, Section 2, ATC 02)

APP04.26 An Air Traffic Control watch log shall be maintained in accordance with CAP 493 MATS Part 1 (113).

Other Documents (Ref: CAP 670 Part B, Section 2, ATC 02)

APP04.27 In addition to the MATS Part 2 the minimum further documents to be held on the unit are as follows:

- CAP 493 Manual of Air Traffic Services Part 1 (114).
- Approval of Air Traffic Control Units (CAP 670 Part B, Section 1, APP 03) (845).
- CAP 403 Flying Displays – A Guide to Safety and Administrative Arrangements (846).
- NOTAM and AICs pertinent to the unit and its operation (847).

- Any briefing material supplied to participating pilots/aircrew (848).
- Any other document required by the CAA or by another relevant authority or body, as directed (849).

Other Records

APP04.28 The initial application must give an estimate of the total number of proposed aircraft movements for the event including an approximate breakdown according to type (i.e. fixed wing, rotary wing, balloon etc) (115). Within 90 days after the event the actual number of aircraft movements by day and type is to be forwarded to the CAA (116).

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PART B, SECTION 2: AIR TRAFFIC CONTROL

ATC 01: ATC Support Systems and Facilities

Note: This document should be read in conjunction with document IAS Information and Alerting Systems (Part C Section 5 Information and Alerting Systems).

Operations Rooms

Operational Positions

ATC01.1 The Air Traffic Control operational requirement will dictate which, and how many, operational Air Traffic Control positions are required to enable a unit to provide a service for the safe and efficient conduct of flight. The CAA must be satisfied that the type and number of operating positions is adequate. Providers of Air Traffic Control services will have to take into consideration the requirements of the Scheme for the Regulation of Air Traffic Controllers' Hours.

ATC01.2 The volume of traffic to be handled and the complexity of operations will determine the number of control positions appropriate for the unit. The circumstances in which the responsibilities of more than one sector/position are combined into one operational position (known as bandboxed operations) and the procedures to be followed shall be fully documented.

ATC01.3 The equipment and layout of operations rooms must be ergonomically designed to assist the staff in their task (8).

ATC01.4 Positioning of Visual Display Units should take into account any reflection or glare which is likely to affect the visibility and therefore the usability of the equipment (9).

ATC01.5 Operational support equipment is any equipment or facility used by a controller in the course of his operational duties. Examples of such equipment are aerodrome lighting control panels, data displays, surface wind/IRVR/met displays. Providers shall notify the CAA when operational support equipment is installed, modified or removed (10). This action is to be taken whether or not the facilities require Approval under other Articles of the Air Navigation

Order or Commission Regulation (EU) No. 1035/2011 The Common Requirements Regulation (11).

Information Systems

Serviceability Indicators

ATC01.6 There must be either:

- An indicator showing the serviceability status of any navigation or approach aid provided for the use of aircraft flying to or from the aerodrome (20), or
- A method of communicating with the engineer responsible for the serviceability of such equipment (21). This method of communication is to be detailed in the MATS Part 2 (22).

Display of Meteorological Information

ATC01.7 A display clearly showing current and relevant meteorological information shall be provided (12). As a minimum this should comprise surface wind and direction, atmospheric pressure and where turbine aircraft operate, air temperature.

ATC01.8 Suitable training in the use of meteorological equipment and their associated displays must be provided (1744).

Display of Surface Wind Indication

ATC01.9 Control positions are to be equipped with surface wind indicator(s) simultaneously showing speed and direction (13). Where control positions are adjacent it may be possible to share displays.

Display of Pressure Setting Information

ATC01.10 Pressure measurement equipment or a method of obtaining the pressure setting (16) from an indicator displaying the pressure setting are to be provided (17).

ATC01.11 Suitable training in the use of meteorological equipment must be provided if meteorological information is not provided by a third party meteorological data service provider (1744).

Display of Temperature Information

ATC01.12 Control positions are to be equipped with a display showing the outside air temperature at aerodromes where turbine-engine aircraft routinely operate.

Visual Control Room (VCR)

ATC01.13 The VCR shall be sited so as to permit the controller to survey those portions of the aerodrome and its vicinity over which he exercises control (23). The most significant factors contributing to adequate visual surveillance are the siting of the tower and the height above ground of the VCR.

ATC01.14 Providers should consider the impact of control tower building developments on other CAA requirements such as those of the aerodrome licence (e.g. safeguarding).

ATC01.15 Providers must safeguard the view from an existing VCR from obstruction (24). The view from an existing VCR might be obstructed because of poor site selection, an extension of the manoeuvring area or by the construction of buildings close to the control tower.

ATC01.16 When informed of proposals which may affect the view from the control positions the Provider shall identify operational and functional requirements. From these, safety requirements can be drawn up which will ensure the controllers' view remains unhindered as described above. In setting these safety requirements Providers should consider such things as:

- Sight lines from the VCR following the proposed changes.
- The ability of controllers to observe crucial areas of operations such as the runways, taxiways, approaches and circuits.
- The ability to observe the smallest size of aircraft commonly using the aerodrome.
- The ability to observe unusual circumstances or emergencies e.g. wheel fires.

ATC01.17 The use of electronic aids such as SMR or Closed Circuit Television (CCTV) to enhance the view from the VCR will only be considered for approval in exceptional circumstances.

ATC01.18 Reflections in the VCR glass and sun or lamp glare through the windows are to be kept to a minimum (25).

ATC01.19 Positioning of Visual Display Units should take into account any reflection or glare which is likely to affect the operation of the equipment (26). This is particularly important in the VCR.

ATC01.20 Glare-proof shades or blinds which can be raised or lowered may be required for windows.

ATC01.21 VCR operating positions must permit optimum visibility of ground and air operations' azimuth and elevation (27) whilst allowing the controller to refer easily to all the information on display (28).

ATC01.22 Siting of working positions within the VCR will primarily be determined by the location of the tower in relation to the manoeuvring area, the most frequently used runway and the approach direction. Secondary considerations are simultaneously occupied operating positions and their functions (control of arriving and departing traffic against ground movements, the clearance delivery position, operation of the lighting panel, etc).

ATC01.23 A pair of binoculars is required (29). Additional pairs may be required for other operational positions in the Visual Control Room.

Furniture

ATC01.24 Control room layout should be such that controllers at operational positions are able to operate without distracting one another (30). Staff should be able to use a normal speaking voice when talking to one another, using RTF or telephones irrespective of aircraft or other noise (31).

ATC01.25 Desks and equipment should provide satisfactory working conditions for each controller and assistant and facilitate liaison between them (32).

ATC01.26 Facilities to accommodate manuals and documents, and display information such as NOTAM, weather and royal flights are to be provided (33). Information of a more permanent nature such as instrument approach procedures, topographical maps, telephone and emergency check-lists is to be conveniently located about the position (34).

Noise

ATC01.27 Ambient noise levels within operations rooms should equate to the 'quiet office' environment (35) (approximately 50 dB(A) – source 'Noise Abatement' by C.Duerden,1972; Butterworth).

Lighting

ATC01.28 Suitable minimum or non-glare lighting shall be provided to allow the controller to read and record information (36).

ATC01.29 Lighting in the VCR must be arranged so that it does not diminish the ability of the controller to survey the aerodrome and its vicinity at night (37).

ATC01.30 Operational lighting should be variable in intensity and direction for maximum flexibility (38).

ATC01.31 Ambient lighting in operations rooms and VCRs should be kept to a level consistent with good working conditions and with reflections reduced as much as possible (39). Door openings to lighted adjacent spaces should be screened so that light will not interfere with a controller's vision when doors are opened (40).

ATC01.32 Emergency lighting shall be provided in operational areas in order that controllers will have sufficient light to be able to continue a service in the event of a mains power failure (41).

Heating and Air Conditioning

ATC01.33 Air circulation must be sufficiently adequate to ensure that windows in VCRs can be and will remain de-misted (43); it shall also allow satisfactory ambient working conditions in operations rooms (44).

ATC01.34 A VCR is normally very exposed to changes in atmospheric conditions and therefore experiences a wide variation of temperatures. Where heated/cooled air is provided it should be kept equally distributed around the VCR perimeter (45) and operated so as to provide a stable environment (46) and keep windows free from condensation (47).

ATC01.35 It is desirable to provide separate air conditioning for personnel and electrical equipment requiring cooling.

Rest Facilities

ATC01.36 Controllers are required to take breaks from operational duty; therefore, adequate rest facilities must be provided (48).

ATC01.37 For low activity ATC Units it may be acceptable to provide rest facilities in the VCR although generally this is not recommended.

ATC01.38 ICAO Doc 9426, the ATS Planning Manual gives much useful guidance on the size, layout and facilities to be provided in rest areas.

ATC 02: ATC Documentation

Manual of Air Traffic Services Part 2 (MATS Part 2)

General

ATC02.1 Local instructions for each ATC unit are to be prepared and should be in the format described below (117). The sections to be included are shown at Annex A to ATC 02 (118). These instructions are to be referred to as the Manual of Air Traffic Services (MATS) Part 2 (119).

ATC02.2 A Provider is required to maintain a copy of the unit's MATS Part 2 with the CAA (120). All Amendments, Temporary and Supplementary Instructions are to be sent to the appropriate Principal Inspector, ATS Regional Manager or the Head of En-Route and College Regulation, as appropriate (121).

ATC02.3 Under the EU Regulations, ANSPs providing ATS must operate and maintain a Safety Management System (2258). The EU Regulations also apply in regard to providers of Communications, Navigation and/or Surveillance services, and these providers must also be able to demonstrate compliance with the standards of ICAO Annex 20 (subject to any UK filed differences).

ATC02.4 Changes to safety related procedures shall be subjected to the provider's safety assessment process and the requirements in Part A, paragraph A88, Change Notification Requirements. Such changes include revised control procedures, changes to procedures affecting more than one ATC unit, changes to the location of controllers or changes in the use or levels of equipment. If Providers are in any doubt as to whether approval is required for proposed changes, they should seek guidance from the CAA.

ATC02.5 Responsibility for the detailed information provided in MATS Part 2 and other manuals rests with the Provider.

Purpose and Content

ATC02.6 There should be a policy and arrangements addressing responsibilities, authorities and mechanisms for ensuring that changes to CAP 493 MATS Part 1 are assessed for implications in

MATS Part 2 and vice versa (125) and that any non-compliances with MATS Part 1 are alerted to the CAA (126).

ATC02.7 The MATS Part 2 is to provide information which amplifies and interprets at local level the instructions in MATS Part 1 (127). It shall contain all such information and instructions as may be necessary to enable controllers to perform their duties (128). It should not normally repeat instructions already contained in MATS Part 1 but it may be necessary to emphasise a point which has particular local relevance (129).

ATC02.8 MATS Part 2 must contain full details of the operations at the unit (130). These include such things as operational procedures, co-ordination requirements, variations to standard separation and details of personnel responsibilities (see CAP 493 MATS Part 1).

ATC02.9 MATS Part 2 shall contain the procedures for Message handling from PSTN, Private Wire telephone connections, facsimile, AFTN/AMHS, interface with AFPEx etc. (131).

Note: The responsibilities, authority and mechanisms for raising, responding to and distributing the message should be adequately defined and, in relation to flight plans in the pre-flight phase, shall comply with the requirements contained in Commission Regulation (EC) No. 1033/2006.

ATC02.10 An ATS provider should take all reasonable steps to provide the unit facilities that are promulgated in the UK AIP, including the air-ground radio Communication services as published (1745).

ATC02.11 MATS Part 2 shall contain the ATS procedures to be followed during periods of equipment or operational deficiency (1746). Such situations could include:

- Periods of reduced redundancy or other degraded modes of operation.
- Periods of use of non-preferred Radar or non-preferred Communications services.
- Limitations of emergency Radar or emergency Communications services.
- Taking over tasks from other units.

ATC02.12 MATS Part 2 shall contain appropriate ATS procedures to be applied when equipment or operational deficiency results in facilities

promulgated in the UK AIP not being available. The procedures shall describe the process for dissemination of information on the unavailability of any promulgated RTF frequency or other facility, by appropriate means, to all relevant ATS units and affected aircraft (1747).

ATC02.13 ATS procedures should contain guidance to personnel responsible for managing facility interruptions, to assist them in deciding appropriate action to be undertaken. The procedures should indicate when the period of service withdrawal, or the impact on the provision of ATS, requires that a NOTAM be originated (e.g. unavailability extending beyond a certain time period, or withdrawal of ATS services) (1748).

ATC02.14 In addition, the Provider should add any other information which is considered necessary for the safe operation of aircraft under the jurisdiction of the unit (133).

ATC02.15 ANSPs must provide assurance when combining operational positions into one operational position (known as bandboxed positions) that the combined operation can fulfill the obligations of the relevant task. ANSPs must also ensure that adequate guidance and instructions are promulgated to facilitate informed decision making in advance of combining positions and whilst positions are combined and operational.

Note: CAP 493 MATS Part 1 contains conditions when control positions may or may not be combined.

Arrangement of Material

ATC02.16 The following paragraphs describe how the MATS Part 2 shall be compiled (134). The section format has proved effective and, in order to maintain a consistent approach, is described in Annex A to ATC 02. Therefore, the section numbers and headings shall be adopted (135) and, where a section is not applicable, the contents page shall be annotated 'not issued' (136).

ATC02.17 A list of contents by section and paragraph which, although not exhaustive, covers the requirements of most units is shown at Annex A to ATC 02. The headings should be used as chapter titles but can be arranged and numbered in an order logical to the unit with the insertion of additional subjects as necessary (137). Where entries are made in more than one place then each entry should be cross-referenced to the others (138).

ATC02.18 A check-list of pages and a contents page are to be provided similar to CAP 493 MATS Part 1 (139).

ATC02.19 Sections, chapters, paragraphs and sub-paragraphs should be numbered (140). This assists the author in structuring the text in a logical manner and aids indexing and cross-referencing.

ATC02.20 Every page in the MATS Part 2 is to be headed and numbered (141). If there is no text on a page then that page is to be marked 'Intentionally Blank' (142).

ATC02.21 Each copy of a MATS Part 2 should normally bear a serial number and a list of holders should be maintained by the person responsible for issuing amendments (143). Where this system is not used a Provider should have satisfactory alternative arrangements for controlling the issue and amendments of manuals (144).

ATC02.22 The Provider shall ensure that the MATS Part 2 is current (145) and reflects accurately the procedures at the unit (146).

ATC02.23 Changes, additions and deletions are to be incorporated by the issue of new or additional pages (147). A number of methods can be used to draw attention to changes (coloured paper, briefing notices etc.). New pages are to be dated with the effective date of the new or altered instruction (148). Arrows or a similar system must clearly indicate the changes (149). A system of control should be implemented so that any changes or modifications cannot be inadvertently lost (150) and an accurate historical record is maintained (151).

ATC02.24 Supplementary Instructions (SI) should be issued:

1. To introduce a change to existing instructions where an explanation or historical background to the subject would be helpful to the reader (152).
2. To cover changes of a permanent nature (153).
3. When an urgent amendment is required between routine amendments (154).
4. To re-emphasise an existing instruction (155).

ATC02.25 The SI should be dated (156) and contain the reprinted pages which can be incorporated into the MATS Part 2 with the minimum of delay (157).

ATC02.26 Temporary Operating Instructions (TOI) should be used to notify changes of a short-term nature and **NOT** for changes to actual procedures (158). For example a TOI would be issued to promulgate the non-availability of a piece of ATC equipment. The maximum period of TOI validity is six months and therefore TOIs should be dated. With documented justification, a TOI may be re-issued after it has expired to cover periods of greater than six months (159).

Format

ATC02.27 The main features of a MATS Part 2 should be:

1. Paper size A4 (160).
2. Hard cover loose leaf binder (161).
3. Divider cards with protruding tabs between sections for quick reference (162).
4. A secure page numbering system (163).
5. The effective date at foot of the page (164).
6. The name of the unit on each page (165).
7. Blank pages to be marked 'Intentionally blank' (166).
8. Text is not to be hand-written (167).
9. A logical paragraph numbering system (168).
10. An Amendment Page showing the amendment status of the document (169).
11. A List of Contents or an Index (170).

New Air Traffic Control Units

ATC02.28 Applicants at units seeking approval are to prepare a MATS Part 2 in accordance with the guidance in this document (171). It shall follow, wherever possible, the contents and format described in the following pages (172).

Letters of Agreement

ATC02.29 A Letter of Agreement is a means of formalising matters of operational significance between neighbouring ATS units or other interested parties. It should take the form of a bilateral or multilateral

agreement concerning procedures which apply only to those party to the agreement (173). An example of a letter of agreement is shown in ICAO Doc 9426, the ATS Planning Manual.

ATC02.30 The procedures which are the subject of the Letter of Agreement are to be approved by the CAA (174) and detailed in the MATS Part 2 (175). To facilitate the approval a copy of the Letter of Agreement is to accompany the application (176). The originals of the Letters of Agreement are to be retained by each of the parties concerned (177).

Watch Log

ATC02.31 An ATC watch log shall be maintained in accordance with CAP 493 MATS Part 1 (178). One log is to be maintained in each operations room where they are not adjacent (179).

Retention of Records

ATC02.32 ATS records and log books must be retained and disposed of as detailed in CAP 493 MATS Part 1 (180).

Other Documents

ATC02.33 In addition to the documents required to be available at operational positions (described in the CAP 493 MATS Part 1, Section 8, Chapter 1, Control Room Administration), the following documents shall be available at an ATC unit:

1. CAP 670 ATS Safety Requirements (181).
2. CAP 382 Mandatory Occurrence Reporting Scheme (2036).
3. ICAO Doc 7030/4 Regional Supplementary Procedures at units where air traffic controllers are responsible for sending ATS messages (182).
4. ICAO Doc 4444 PANS-ATM at units where air traffic controllers are responsible for sending ATS messages (183).
5. ATS Information Notices (ATSINs) applicable to ATC units (184).
6. CAA Information Notices (INs) and Safety Notices (SNs) applicable to ATC units (2381).
7. CAP 670 Supplementary Amendments (2395).

8. CAP 744, Air Traffic Controllers – Licensing (2037).
9. CAP 774 UK Flight Information Services (2259).
10. Any other document, including SMS documentation, as required by the CAA (185). Any document so required will normally be specified in the Approval document (186).

ATC02.34 A method of ensuring that all documents required to be held at an ATC unit are correctly amended shall be established (187).

ATC02.35 Unless otherwise approved by the CAA, the documents required to be available at operational positions shall normally be in conventional printed form (1749).

ATC02.36 The conditions below will normally need to be satisfied in order to obtain CAA approval to keep reference documents, either required to be immediately available at operational positions or required to be available in the operational environment/control room, in electronic form (1750):

- Documents should normally be kept on a computer that is dedicated to the function and not used for other functions.
- The computer should not normally be dependent on the availability of a network (including the internet) for its correct operation or for access to the reference documents.
- Arrangements should be made to ensure that, as far as reasonably practicable, the computer should be available and serviceable at all times that an air traffic service is being provided.
- A serviceable printer should be available to permit extracts to be printed if required.
- The computer and its display should be located in a position that enables reference to be made to documents without interfering with the provision of the air traffic service.
- Documents should be available for viewing/printing within a reasonable period of the user making the request (a period better than or comparable to the time taken to obtain the information from a conventional printed version of the document, for example).
- The computer should comprise hardware and software that is demonstrated to be appropriately reliable.

- Security measures should be implemented to ensure that no unauthorised access to the files or computer configuration is possible.
- Security measures should be implemented to ensure that no unauthorised changes can be made to the content of documents made available on the computer.
- It should be possible for the user readily to establish the identification of any document that is kept on the computer (and, if appropriate, the amendment level).
- Document files should normally be kept on non-volatile, non-removable media (e.g. a local hard drive of the computer being used for the purpose).
- Each document should normally appear to the user as a discrete document, i.e. amendments to the content should be incorporated into the main body rather than available as separate files.
- A method of configuration control should be implemented to ensure that amendments to documents are incorporated as soon as practicable after their effective date.
- A method of access control should be implemented to ensure that only the current version of a document can be accessed.
- Any material that may be required to be viewed away from the operational position, procedures to be used following evacuation of the operations room, for example, should be in conventional printed form or available (in amended form at the alternative location).
- Contingency arrangements should be established to ensure that reference documents can be accessed within a reasonable period in the event that the computer normally used for the task fails or is not available.
- The system should be designed to enable access to documents to be intuitive and to enable users quickly to return to a known configuration/access point, such as an index page.
- ANSPs shall take appropriate measures to ensure that aeronautical information supplied by web-based third parties that is used or supplied by that ANSP, is suitable for use.

- Essential and desirable levels of competence to enable users to access documents kept on the computer should be established and, if necessary, training programmes developed to ensure that these levels of competence are maintained by users.

Notes:

1. Whilst experience of the use of electronic documentation is gained, units that are approved to keep reference documents in this manner may be required to provide additional information about the systems used.

2. The conditions set out above are largely self-explanatory; however, the following description of a likely suitable arrangement may be of assistance to units considering the use of electronic reference documentation:

    - *A stand-alone IBM PC compatible computer is provided, running under Microsoft Windows 2000 or Windows XP (Pro), and used as the control room library. The security settings available within the Operating System are utilised to permit read-only access to files for routine users. The computer is not used for any other functions. Documents are kept in Adobe Acrobat format and stored on an integral hard disk. A menu system provides access to each individual document. A laser printer is directly connected. At a low traffic density unit (or one at which support staff will be available), the computer may be located in a readily accessible position away from the control position. The system enables a document to be opened and a known part of the material to be accessed within 45 seconds.*

ATC02.37 ATC units regulated by the CAA and located at military aerodromes shall hold the following additional documents:

- RA 3000 Series (ATM) (1751)
- Manual of Military Air Traffic Management
- Relevant RAF FLIPs (190)
- Relevant documents from the RAF ATCEB list (191)

ATC02.38 With the agreement of the ATS Regional Manager, and provided that they are either not relevant to the operational task or a suitable RAF

issued equivalent is available, the following documents shall not be required:

- Rules of the Air Regulations
- Air Navigation (General) Regulations
- CAP 168 Licensing of Aerodromes
- CAP 772 Birdstrike Risk Management for Aerodromes
- ICAO Doc 7910 Location Indicators
- ICAO Doc 8126 Aeronautical Information Services Manual
- ICAO Doc 8400 Abbreviations and Codes
- ICAO Doc 8585 Abbreviations of Aeronautical Authorities
- ICAO Doc 8643 Aircraft Type Designators
- ICAO Doc 7030 Regional Supplementary Procedures (192)

ATC02.39 Military units employing civil ATCOs are to hold documents listed in column (a) of the following table, and hold documents as required by the operational role of the unit listed in column (b) as agreed between the unit and the ATS Regional Manager (1753).

REQUIRED DOCUMENTS (a)	OPTIONAL DOCUMENTS (b)
RA 3000 Series (ATM) Manual of Military Air Traffic Management RAF FLIPS MATS Part 1 MATS Part 2 ANO	CAP 168 CAP 772 ICAO Doc 8126 ICAO Doc 7910 ICAO Doc 8400 ICAO Doc 8585
REQUIRED DOCUMENTS (a)	**OPTIONAL DOCUMENTS (b)**
UK Integrated AIP AICs NOTAM CAP 670 CAP 413 ICAO Doc 4444	ICAO Doc 8643 ICAO Doc 7030 Selected documents from RAF ATCEB list

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Annex A to ATC 02: Manual of Air Traffic Services Part 2

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Co-ordination with appropriate units.

Response to safety net activation.

SECTION 5 TELECOMMUNICATIONS

CHAPTER 1 RADIO AIDS AND RTF

Serviceability and maintenance.

R/T procedures.

Recordings and action in event of U/S.

Aircraft radio flight tests.

Vehicle callsigns.

Power supplies and standby equipment.

D/F.

CHAPTER 2 TELEPHONES

Equipment serviceability.

Telephone procedures. Identifying position or person.

Limitation of 'outside' calls.

Press queries etc.

'Off airfield' emergency telephone procedures.

SECTION 6 RADAR TECHNICAL

CHAPTER 1 EQUIPMENT DESCRIPTION AND DATA

General.

Technical description – PSR and SSR.

Controls.

Setting up procedures.

Permanent echoes.

Periodic checks.

Closing down.

Coverage (including diagrams).

Technical specification.

Aerodrome Traffic Monitor.

Surface Movement Radar.

CHAPTER 2 RADAR MAINTENANCE AND UNSERVICEABILITY

Maintenance.

Unserviceabilities.

NOTAM action.

Reasons for fade.

SECTION 7 EMERGENCIES

CHAPTER 1 EMERGENCY SERVICES

General.

Aerodrome grid reference map.

Local area map.

Areas of poor R/T coverage.

Radius of action.

Immediate actions.

Responsibilities of key personnel.

Accidents outside radius of action.

Alerting procedures – emergency categories.

Emergency services access.

Rendezvous points.

Logbook entries.

Meteorological special reports.

Voice and surveillance recording and flight progress strip impound requirements.

Runway/aerodrome inspection.

Stand down of emergency services.

CHAPTER 2 REPORTING ACTION

General.

Local reporting procedures.

ACC reporting.

Follow up actions.

Other incident reporting actions – AIRPROX, MOR, breaches of regulations, etc.

Oil slick reports.

CHAPTER 3 DEPLETION OF EMERGENCY SERVICES

General.

Reduced coverage.

Notification by emergency services.

Action by ATC.

CHAPTER 4 TRAINING AND TESTING

General.

Routine testing of emergency alarms and communications.

Emergency exercises.

CHAPTER 5 SEARCH AND RESCUE

General.

Local procedures.

Liaison with local services, coastguard etc.

Parent ACC.

Use of emergency frequencies.

CHAPTER 6 HIJACKING

General.

Notification.

Action to be taken.

CHAPTER 7 BOMB WARNINGS

General.

Notification.

Warning whilst aircraft in-flight.

Warning whilst aircraft on ground.

Action to be taken.

SECTION 8 DISRUPTION OF AIR TRAFFIC SERVICES

CHAPTER 1 EMERGENCY OPERATIONS

Bomb Warning/Threats.

Evacuation.

Resumption of ATC Watch.

CHAPTER 2 FACILITY CONTINGENCY PLANS

Service continuity.

SECTION 9 FACILITY, SYSTEMS, OPERATIONAL DATA AND PERSONNEL SECURITY

SECTION 10 GENERAL ADMINISTRATION

CHAPTER 1 WATCH ROSTERS

Combined (Bandboxed) Operations.

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ATC 03: Emergency or Contingency Facilities

Introduction

ATC03.1 ANSPs are required, under the EU Regulations, to develop and implement Contingency Plans. Advice and guidance on the European requirements and their application to specific units may be obtained from the appropriate ATS Regional Office.

Note: EUROCONTROL has updated and published two guidance documents, which may be found at the following website addresses:

EUROCONTROL Guidelines for Contingency Planning of Air Navigation Services (including Service Continuity)

- www.eurocontrol.int/ses/gallery/content/public/docs/pdf/sesis/guidelines-contingency-planning-ANS-2009.pdf

Reference Guide to EUROCONTROL Guidelines for Contingency Planning of Air Navigation Services (including Service Continuity)

- www.eurocontrol.int/ses/gallery/content/public/docs/pdf/sesis/reference-guide-contingency-planning-ANS-2009.pdf

ATC03.2 At some units, facilities exist to provide an ATC service from an alternative location.

ATC03.3 In practice such an alternative facility is established:

- to enable an ATC service to be provided for a short time after the unexpected withdrawal of the main facility (the alternative facility may be known as an Emergency ATC unit); or
- to enable an ATC service to continue to be provided for an extended period on a planned basis (the alternative facility may be known as a Contingency ATC unit).

ATC03.4 This section provides guidance on the level of facilities to be provided in an Emergency or Contingency ATC unit.

ATC03.5 It is recognised that where an Emergency/Contingency ATC unit is already in existence it may not meet these requirements. When changes are planned to an established facility, the Provider is

expected to meet these requirements in respect of the equipment or procedures which are to be changed.

ATC03.6 Where an established Emergency/Contingency unit exists the Provider is recommended to review the facilities provided with respect to the requirements described below and, where practicable, amend them to comply with the requirements.

General

ATC03.7 The Provider shall provide to the CAA an Operational Requirement (OR) for an Emergency or Contingency ATC unit (194). The OR shall describe the maximum period of time for which the alternative facility is designed to be used together with other operational constraints (195).

Note: The level of equipment required will be dependent on the OR and will be determined by the period that the alternative facility is to be used and the level of ATC service that is to be provided.

ATC03.8 An Emergency ATC unit shall be equipped with facilities to enable traffic already under the control of the ATC unit either to complete a landing or leave the area of responsibility of the unit in an orderly manner (196).

Note: Managers of units wishing to make significant physical or procedural changes to an existing Emergency/Contingency ATC unit or to establish such a facility are advised to enter into early discussions with their ATS Regional Manager.

Documentation

ATC03.9 The OR shall identify any requirements of CAP 670 ATS Safety Requirements that cannot be met from the Emergency/Contingency ATC unit (197). Application for dispensation must be supported by details of the proposed procedures that may mitigate the deficiency (198).

ATC03.10 The OR shall identify any relevant procedures detailed in MATS Part 2 which cannot be achieved from the Emergency/Contingency ATC unit (199). The actions proposed to accommodate the absence of these procedures when operating from the Emergency/Contingency ATC unit shall be included in the OR (200).

Note: These actions might include a restriction to movement rates, limiting the number of aircraft taxiing on an area not visible to the controller or restricting certain types of activity to specific weather conditions.

ATC03.11 Any significant variation to the procedures approved for use in the Emergency/Contingency ATC unit from those used in the main location shall be included in MATS Part 2 (201).

ATC03.12 The procedures to be followed when transferring the provision of ATS from the normal location to the Emergency/Contingency ATC unit, either on a planned or unplanned basis, shall be included in MATS Part 2 (202).

ATC03.13 The procedures to be followed when resuming normal operations shall be included in MATS Part 2 (203).

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PART B, SECTION 3, SYSTEMS ENGINEERING

SW 01: Regulatory Objectives for Software Safety Assurance in ATS Equipment

Part 1 Preliminary Material

Introduction

SW01.1 For the CAA to approve an ATS system (people, procedures and equipment) to enter service, arguments and evidence must be available to provide assurance that the system will perform all of its safety related behaviour within the system's defined integrity targets.

SW01.2 Where equipment is used to provide safety related functions there are three sources from which arguments and assurance evidence can be provided: the system lifecycle, the hardware lifecycle and the software lifecycle. This document defines the assurances to be made available, for the purposes of an approval, from the behaviour of the software and certain aspects of the way in which it has been developed.

SW01.3 EU Regulation (EC) No. 482/2008 is linked to EU Regulation (EU) No. 1035/2011 which requires ANSPs to implement an SMS including risk assessment and mitigation with regard to all changes. EU Regulation (EC) No. 482/2008 specifically addresses how ATS, ASM, ATFM and CNS service providers should define and implement Software Safety Assurance within the framework of its SMS, and as part of its risk assessment and mitigation activities with regard to changes, to deal specifically with software related aspects of a change.

SW01.4 The text of the Regulation is available from the European Union website at the following address:

- eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:141:0005:0010:EN:PDF

SW01.5 Satisfying the objectives of Part 2 of SW 01 will satisfy the objectives of Article 3 of EU Regulation (EC) No. 482/2008. Part 3 of SW 01 gives additional guidance on how the objectives may be met.

SW01.6 Means of compliance with Article 3 of EU Regulation (EC) No. 482/2008 that have been agreed between Service Providers and the CAA are made public via the CAA website at: www.caa.co.uk/publications.

SW01.7 Compliance with Article 4 of EU Regulation (EC) No. 482/2008 and its associated annexes can be achieved by integrating processes that satisfy CAP 670 SW 01 into an organisation's overall risk assessment and mitigation process. However, to achieve full compliance with EU Regulation (EC) No. 482/2008 through the use of SW 01, it is also necessary to introduce processes that mandate the guidance in Part 3 and Appendix A of SW 01. This is required to address specific activities and criteria mandated by the Regulation.

Scope

SW01.8 This document applies to any ATS system where the Software is needed to fulfil a system safety requirement.

SW01.9 The objectives in this document only apply to those software requirements that have an impact on safety. These are called software safety requirements in this document.

SW01.10 This document does not apply to electronic items such as application specific integrated circuits, programmable gate arrays, solid-state logic controllers or software requirements that can be demonstrated not to affect safety.

SW01.11 The guidance in Part 3 of this document (CAP 670 Part B SW 01) primarily applies to software outside of the scope of Article 5 of Regulation (EC) No. 482/2008, i.e. bespoke software. However, it can also be used for additional guidance in circumstances where published guidance does not fully address the needs of software within the scope of Article 5 of Regulation (EC) No. 482/2008, e.g. COTS software and changes to legacy software. Means of compliance for software identified in Article 5 of Regulation (EC) No. 482/2008 will be made available via the CAA website at: www.caa.co.uk/publications.

SW01.12 This document assumes that software safety requirements have been derived from a full risk and safety analysis of the system. This will have established the overall safety requirements that have been refined and allocated in the design to software. This is a

commonplace system safety process and is described in standards and guidelines such as IEC 61508 Part 1 and ARP4754.

SW01.13 This document does not prescribe how the assurance evidence is to be produced or its adequacy argued. International software assurance standards and guidelines, such as IEC 61508 Part 3 and RTCA DO178-B/EUROCAE ED12-B, when used in conjunction with this document may provide an effective way to produce timely and technically valid evidence that can then be used to argue that the SW 01 assurance objectives are satisfied.

Part 2 Requirements

Safety Objectives

Prime Objectives

SW01.14 The prime software safety objective to be met for ATS systems that contain software is:

- **To ensure that the risks associated with deploying any software used in a safety related ATS system have been reduced to a tolerable level (1703).**

SW01.15 To achieve this objective it is necessary:

- **For arguments and assurance evidence to be available which show that the risks associated with deploying any software used in a safety related ATS system are tolerable (1704).**

Sub Objectives

SW01.16 Achievement of the prime software safety objective shall be demonstrated by providing credible arguments and evidence that the following five sub-objectives have been achieved:

1. **To ensure that arguments and evidence are available which show that the software safety requirements correctly state what is necessary and sufficient to achieve tolerable safety, in the system context (1705).**

Note 1: These requirements will include requirements to control hazards identified during implementation.

Note 2: It is assumed that the system-level safety requirements are derived from a hazard and risk analysis of the ATS environment in which the system is required to operate.

Note 3: It is assumed that a necessary and sufficient set of system-level safety requirements exist, which describe the functionality and performance required of the system in order to support a tolerably safe ATS.

Note 4: It is assumed that the failure modes which the software must detect and mitigate in order to meet the system safety requirements have been identified e.g. those failure modes associated with: other systems, system-system interactions, equipments, pre-existing software and all user-system interactions.

Note 5: It is assumed that the failure modes identified include generic failures relevant to the safety related ATS application, e.g. security threats, loss of communications, and loss of power.

Note 6: It is assumed that the failure modes identified (including human errors) are representative of the operational environment for the system and workload on the system operators.

Note 7: During the software development process, functions may be introduced which have repercussions on the safety of the ATS system. These will need to be assessed and if necessary, new or changed safety requirements will have to be generated.

Note 8: The set of software safety requirements includes all software safety requirements derived or changed during the requirements determination and design processes.

2. **To ensure that arguments and evidence are available which show that the software satisfies its safety requirements (1706).**

3. **To ensure that arguments and evidence are available which show that each Safety Requirement can be traced to the same level of design at which its satisfaction is demonstrated (1707).**

4. **To ensure that arguments and evidence are available which show that software implemented as a result of software safety requirements is not interfered with by other software (1708).**

Note 1: Behaviour implemented as a result of software safety requirements should also not interfere with each other.

5. **To ensure that the arguments and evidence, for the safety of the software in the system context, are from: a known executable version of the software, a known range of configuration data and a known set of software products, data and descriptions that have been used in the production of that version (1709).**

SW01.17 For a greater understanding of how the sub-objectives achieve the overall safety objective refer to their derivation provided in Appendix C.

Part 3 Guidance

Introduction

SW01.18 All material from this point is non-mandatory and should only be considered as guidance. This guidance has been included in this regulation for two purposes:

- To assist Service Providers in evaluating the adequacy of the software assurances, provided by their Systems Integrators and/or Equipment Manufacturers, for the purpose of satisfying the safety objectives mandated by this regulation.
- To assist Systems Integrators and/or Equipment Manufacturers in providing assurances, for the behaviour of software in their products, that are appropriate for demonstrating compliance to the safety objectives mandated by this regulation.

SW01.19 Service Providers and/or Equipment Manufacturers are free to propose and use alternative methods of evaluation with the agreement of the CAA. This guidance is only provided for those Service Providers and/or Equipment Manufacturers that do not wish to propose their own methodology for demonstrating compliance with the safety objectives mandated by this regulation.

Guidance on Presenting Arguments and Evidence that the Assurance Objectives have been met

SW01.20 Credible arguments and evidence should be available to demonstrate the achievement of each of the five assurance sub-objectives defined in section SW01.14 to SW01.17. The credible limits and bounds of which are provided in paragraphs SW01.20 to SW01.72 of this document.

SW01.21 To demonstrate the validity of the arguments and evidence it should be possible to show that:

- A coherent and convincing argument with adequate supporting evidence is available to claim the achievement of each of the five assurance objectives defined in section 3.
- For all claims, Direct and Backing evidence are combined into an argument that provides justification for the claim.

SW01.22 Appendix B defines the terms Direct Evidence and Backing Evidence and the principals and concepts upon which the arguments and evidence should be based.

SW01.23 This guidance uses the concept of Assurance Evidence Levels (AELs) to relate the criticality of the software safety requirement to the depth and strength (rigour) of evidence required for the assurance of its correct implementation. AELs are explained in detail in Appendix A.

Guidance on Credible Arguments and Evidence to Demonstrate Requirements Validity Relating to Objective A

Direct Evidence of Requirements Validity

SW01.24 To demonstrate the validity of software safety requirements, arguments and evidence should be available that show:

1. The software safety requirements are a valid sub-set of the system-level safety requirements.
2. The software safety requirements adequately specify the required safety behaviour of the software.
3. Each software safety requirement includes either:

   a) A specification for each of the Behavioural Attributes, or

b) A valid argument that the attribute is not applicable

4. All hazardous failure modes of the software have been identified at the Software requirements (AELs 1, 2, 3, 4 and 5), Software internal design (AELs 2, 3, 4 and 5) and Software source code levels (AELs 4 and 5).

5. All hazardous failure modes identified at each level in the software design or in the software implementation are traceable to a defence (i.e. to a safety requirement for software, hardware or operation) or to a justification that no defence is necessary.

6. The software safety requirements should be specified explicitly and should be set out in such a way as to be easily distinguishable from other requirements.

7. The software safety requirements should be specified in sufficient detail and clarity to allow the design and implementation to achieve the required level of safety.

Backing Evidence of Requirements Validity

SW01.25 To give confidence that the requirements are correct and complete, arguments and backing evidence should be available that demonstrate:

1. The specification notations are capable of supporting the identification of all modes of software failure that cause a system level hazard.

2. The analytic methods and techniques used are appropriate for the attributes of the software safety requirements.

3. The analysis notations are appropriate to the problem domain and representation and allow an adequate analysis of the design.

4. Adequately qualified and experienced staff have applied the analysis techniques.

Note: Staff are deemed to be appropriately qualified and experienced if they understand the design notations, and the analysis approach, are experienced in using them and understand the required software safety requirements attributes and the system context.

5. Any tools, used in the analysis processes, have been verified and validated to an appropriate level for the impact of the tool on the software safety requirement.

6. Any tools, used to derive and/or express the software safety requirements, have been verified and validated to an appropriate level for the impact of the tool on the software safety requirement.

7. A process that is independent of the means by which the requirements were derived in the first place has demonstrated the validity of the software safety requirement.

Note 1: More than one notation may be used at any given requirements or design level.

Note 2: Following the guidance in paragraphs SW01.24 to SW01.25 'Requirements Satisfaction' should highlight those requirements that are unverifiable. Consequently this section and paragraphs SW01.24 to SW01.25 may be used to demonstrate that software safety requirements are complete, are valid and their implementation has been verified.

Guidance on Credible Arguments and Evidence to Demonstrate Requirements Satisfaction Relating to Objective B

General Requirements for Evidence of Requirements Satisfaction

1. Arguments and evidence should be available to show that each and every software safety requirement has been satisfied completely and correctly.

2. This guidance only considers evidence made available from the following sources: testing, field service experience or analysis.

Note 1: Where field service experience fails to show, or any result of the analyses and tests fails to show, that safety requirements are met, it should be regarded as evidence that the software is not safe to enter service (unless an argument with supporting evidence is available to justify the software entering service despite the assurance requirements not being met, e.g. architectural mitigation may be provided).

Note 2: Different sources of evidence of requirements satisfaction may be offered for different software safety requirements within a

component of the application software, provided that it is valid to assess the requirements independently.

Note 3: The same evidence may be offered for different software safety requirements or attributes provided that it is valid to assess them collectively.

3. Arguments and evidence of software safety requirement satisfaction should comply with the generic requirements (i.e. for all attributes) of paragraphs SW01.27 to SW01.34 and the attribute specific requirements of paragraph SW01.35.

Note: It is only necessary to provide evidence of requirements satisfaction for those attributes identified as being pertinent to the software safety requirement.

4. The tables at the start of each paragraphs SW01.36 to SW01.68 show acceptable sources of direct evidence for each software requirement attribute and AEL. The Primary argument should be based on the source of evidence that is shown CAPITALISED in the table. Where a Secondary argument is necessary it should be based on the source of evidence shown in Lower Case. For a greater understanding of Primary and Secondary arguments refer to Appendix B.

Note: Different sources of evidence may be offered for the same attribute of a software safety requirement provided that:

   a) The acceptance criteria for each source, when combined, can be shown to satisfy the acceptance criteria for the attribute; or

   b) It can be shown that the sources of evidence are independent.

5. The tables in paragraphs SW01.35 indicate how this evidence will be assessed. Use multiple columns for a particular AEL (the value of an AEL is the row of the table).

6. Tables 1, 2 and 3 below show how evidence, that the software safety requirements have been implemented completely and correctly, can be collected to an appropriate level of rigour.

Table 1: Test Evidence

AEL	Rigour	
1	Statement –	selection of best practice guidance/standards/tools
	Statement –	all tests meet criteria/justification for failure to meet criteria
	Statement –	verification & validation of tools and procedures
2	Test criteria	
	Test specification	
	Test results	
	Report –	verification of use of standards/guidelines/tools
	Report –	analysis of tool and procedure errors
	Project specific test processes developed and justified Use of formal metrics of test coverage	
3	Report –	verification of test criteria
	Report –	assessment of test results
	Report –	adequacy of test data (including justification for coverage)
	Report –	verification of use of project specific test processes
	Report –	verification & validation of tools and procedures
4	Test assessments performed by independent department	
5	Test assessments performed by independent organisation	

Table 2: Field Service Evidence

AEL	Rigour	
1	Statement –	field service records support claims
	Statement –	SW is relevant to Field service claims
	Statement –	operational environment is relevant to Field service claims
	Statement –	field service records are complete and correct
2	Field service records DRACAS procedure	
	Report –	analysis of tool and procedure errors
3	Report –	analysis of Field service claims
	Report –	analysis of similarity of SW/Justification for differences
	Report –	Analysis of similarity of operating environment/ justification for differences
	Report –	verification of use of DRACAS & supporting tools
4	Assessment of analysis, justification and verification by an independent department	
5	Assessment of analysis, justification and verification by an independent organisation	

Table 3: Analytic Evidence

AEL	Rigour	
1	Statement –	selection of best practice guidance/standards/notations/ techniques/tools
	Statement –	analysis shows criteria are met for all attributes/ justification for failure to meet criteria
	Statement –	verification & validation of tools
2	Report –	analytic criteria including use of formal metrics for criteria coverage
	Results of analysis	
	Report –	verification of use of guidance/standards/notations/ techniques/tools
	Project specific development process developed and justified	
	Staff competency rules and justification	
	Report –	analysis of tool errors
3	Report –	verification of criteria
	Report –	assessment of results
	Report –	assessment of development process (all practicable measures have been taken to ensure the product is free of errors)
	Report –	adequacy of criteria (including justification for coverage)
	Report –	verification of use of project specific development process
	Report –	verification & validation of tools
	Report –	verification of staff competency
4	Assessments performed by independent department	
5	Assessments performed by independent organisation	

Note 1: The above items are cumulative; all items for lower AELs should be included with the items for higher AELs.

Note 2: Often standards and regulations concentrate on when a technique should be applied, making a decision that above a certain criticality technique A is required and below it is not. In this guidance the emphasis is on the rigour and extent of the activity not whether it should be done or not.

For example it is quite obvious that all systems should be tested, but it is the extent of the tests, their independence and the visibility of the associated test cases and results that vary. At low AELs a statement from a competent organisation that test criteria have been defined according to some systematic best practice is sufficient. At higher AELs the test criteria should be justified and documented with additional reports provided.

The tables above and in paragraphs SW01.35 capture how the variation in the rigour of evidence with AEL might occur. However it is the demands of the argument being made and what is necessary to provide a convincing case that is the overriding factor. The tables therefore combine a number of different factors. There are changes in the role of 'testing' within the overall argument as other arguments (e.g. analytical ones) take a more prominent role (paragraphs SW01.35). Also, there are variations in the strength of argument for the testing (e.g. provision of independent oversight) as well as changes to the details of the arguments being made in the tables above (e.g. test criteria are adequate because a certain type of coverage is desired and is being measured). These different factors can interact in a number of ways and it is the overarching need for a convincing and valid argument that should ultimately drive the rigour of the evidence provided.

1. If more than one source of direct evidence is supplied for the attribute of a software safety requirement, backing evidence should be available for each of the chosen sources.

2. Unless an argument can be made that the assurance can be achieved by other means:

    a) Test evidence should be available for each attribute.

    b) Where Field service experience exists, it should be analysed and available as evidence.

    c) If statistical testing or field experience is used in a Primary argument then this should be demonstrated at the 95% confidence level.

    d) If systematic tests are used to demonstrate that a requirement is met, all tests must succeed.

3. Any evidence (e.g. from test, field service or analysis) that contradicts the demonstration of the software safety

requirement should be explicitly identified. If the contradiction cannot be resolved, the software safety requirement should not be considered satisfied.

Direct Evidence for Requirements Satisfaction (all attributes)

SW01.26 For Direct evidence to be acceptable it must comply with the following requirements.

Direct Evidence from Testing

SW01.27 Arguments and evidence should be available that show:

1. Tests were specified for all the relevant behavioural attributes of each safety requirement.
2. Testing was carried out to show that the acceptance criteria for each applicable attribute have been met.
3. The results of the testing show that the specified acceptance criteria for each applicable attribute for each software safety requirement has been met.
4. For direct evidence of testing to be credible it should include test specifications, test criteria, test results, an analysis of test results, and an analysis of faults discovered during testing.

Direct Evidence from Field Service Experience

SW01.28 Arguments and evidence should be available that show:

1. An analysis process, with pass/fail criteria, was specified for each attribute of the software safety requirement that is being justified from field experience.
2. The analysis of the field service records shows that the criteria for each attribute of the software safety requirement being justified from field experience have been satisfied.

SW01.29 For direct evidence from field service experience to be credible, all of the details relevant to the argument being made (e.g. of length of service, history of modifications, list of users) should be included.

Direct Evidence from Design Analysis

SW01.30 Arguments and evidence should be available that show:

1. An analysis process, with pass/fail criteria, was specified for each attribute of the safety requirement that is being justified by analysis of design.
2. The specified acceptance criteria for each attribute of the software safety requirement being justified by analysis of the design, have been satisfied.

Note: Analytic arguments usually rely on the source code and therefore, for high AELs, there should be a demonstration that the object code is a correct translation of the source code.

Backing Evidence for Requirements Satisfaction (all attributes)

SW01.31 For Backing evidence to be credible it should comply with the following.

Backing Evidence from Testing

SW01.32 Arguments and evidence should be available that show:

1. The test methods and techniques used are appropriate for the attributes of the software safety requirement under consideration.
2. Procedures and tools used to support testing have been verified and validated to a level appropriate for the AEL.
3. The tests are sufficiently thorough and are representative of the demands that will be made on the software when it is in service.
4. The test criteria are a complete and correct interpretation of the software safety requirements.
5. The test cases provide adequate coverage of the input domain.
6. Testing was performed independently from design, e.g. independent generation of test requirements and independent performance of test specifications. The extent of independence is shown in Table 1 of section 7.1.
7. Any tools used to support testing maintain the integrity of the results and the operational software.

8. Procedures or tools were used to ensure that testing was carried out as required in the test procedure and that the results satisfy the test criteria.
9. Test guidance, procedures, standards and tools were defined and adhered to.
10. The test environment and procedures were recorded accurately.
11. For AEL 1 to 3, any differences between the operational and test environments are identified, and the impact on test results assessed.
12. For AEL 4 and 5, tests are made on a configuration identical to the operational system.
13. The complexity and input domain of a software safety requirement was analysed and used to support the selection of normal and abnormal test data.
14. The consequences of failing to meet a software safety requirement have been analysed and have been used to support the selection of normal and abnormal test data.
15. All faults and their implied undiscovered faults, discovered during testing, have been analysed and that their existence does not adversely affect safety.

Backing Evidence from Field Service Experience

SW01.33 Arguments and evidence should be available that show:

1. The proposed software and the software for which the field service experience is available are identical or sufficiently similar.
2. The proposed operational environment and the operational environment for which the field service experience is available are identical or sufficiently similar.
3. The proposed hardware and the hardware for which the field service experience is available are identical or sufficiently similar.
4. All attributes of the software safety requirements being justified from field experience have been exercised in the deployed software.
5. A Defect Reporting, Analysis and Corrective Action System (DRACAS) is in place for the deployed software, and is operated

in a reliable manner, adequate to support the claims made for the software.

6. The field service records are correct and complete.
7. Procedures and tools were used to support the analysis of field service experience, to ensure that analysis has been carried out as required in the analysis procedure, and that the results satisfy the analysis criteria.
8. The procedures and tools used to support the analysis of field service experience were verified and validated.
9. Any tools used to support analysis maintain the integrity of the results and the operational software.
10. Sufficient experience exists to demonstrate that the acceptance criteria for each attribute of the software safety requirement have been met.
11. For all reported failures of an attribute in the software architectural unit, the underlying fault has been corrected, or that the fault is not relevant because it has no safety impact.
12. All field reports identifying failures of the attributes, of the software safety requirements being justified from field experience have been made available.

Backing Evidence from Design Analysis

SW01.34 Arguments and evidence should be available which show that:

1. The design notations are capable of supporting the identification of all attributes that are to be analysed.
2. The analytic methods and techniques used are appropriate for the attributes of the software safety requirement.
3. The analysis notations are appropriate to the problem domain and representation and allow an adequate analysis of the design.
4. The analysis techniques have been applied by adequately qualified and experienced staff.
5. Assumptions used in the analysis (e.g. about the environment, hardware, operating system and other interfaces) have been validated.

6. Models or other abstractions used in the analysis are an adequate representation of the software design.
7. The formal proofs or arguments submitted are logically correct. This may be shown either by manual inspection or by tool-based checking.
8. Procedures or tools have been used to ensure that the analyses are carried out adequately.
9. Any procedures and tools used to support analysis, analysis of testing and the analysis of field service experience have been verified and validated.
10. Any tools used to support analysis, maintain the integrity of the results and the operational software.
11. Where analysis has been carried out on source code, the object code is a correct translation of that source code.

Note 1: Staff are deemed to be appropriately qualified and experienced if they understand the design notations, are experienced in using them, and understand the analysis approach, the required attributes and the system context.

Note 2: More than one notation may be used at any given design level.

Evidence for Requirements Satisfaction (by attribute)

SW01.35 This section offers guidance on assessing the behavioural attributes of a software safety requirement in addition to the generic guidance specified in 'Guidance on Credible Arguments and Evidence to Demonstrate Requirements Satisfaction Relating to Objective B' .

Specific Requirements for Evidence of Functional Properties

SW01.36 It is expected that an appropriate form of direct evidence will be selected from the following table in order to demonstrate that the specified functional properties have been correctly implemented.

	Acceptable Sources of Evidence: Functional Properties (Choose 1 column only from the appropriate row)		
AEL 1	TESTING	FIELD SERVICE EXPERIENCE & Testing	ANALYSIS & Testing
AEL 2	TESTING	FIELD SERVICE EXPERIENCE & Testing	ANALYSIS & Testing
AEL 3	ANALYSIS & Testing	ANALYSIS & Testing & Field Service Experience	
AEL 4	ANALYSIS & Testing	ANALYSIS & Testing & Field Service Experience	
AEL 5	ANALYSIS & Testing		

Direct Evidence of Analysis of Functional Properties

SW01.37 Arguments and evidence should be available that show:

1. The source code contains a correct implementation of the functional properties of the software safety requirement, either directly or by means of intermediate design notations or stages. This includes those functional properties that have been derived from non-functional software safety requirements.
2. All parameters and constants used in conjunction with the software system have been checked for correctness and internal consistency.

Specific Requirements for Evidence of Timing Properties

SW01.38 It is expected that an appropriate form of direct evidence will be selected from the following table in order to demonstrate that the specified timing properties have been satisfied.

	Acceptable Sources of Evidence: Timing Properties (Choose 1 column only from the appropriate row)		
AEL 1	TESTING	TESTING & Field service experience	ANALYSIS & Testing
AEL 2	TESTING	TESTING & Field service experience	ANALYSIS & Testing
AEL 3	ANALYSIS & Testing	ANALYSIS & Testing & Field Service Experience	
AEL 4	ANALYSIS & Testing	ANALYSIS & Testing & Field Service Experience	
AEL 5	ANALYSIS & Testing		

Direct Evidence from Testing of Timing Properties

SW01.39 Arguments and evidence should be available which show that:

1. Specified response times for the software safety requirement have been met under minimum or no load conditions, normal and maximum planned load conditions.
2. Specified throughputs for the software safety requirement have been met under minimum or no load conditions, normal and maximum planned load conditions.

Backing Evidence of Testing of Timing Properties

SW01.40 Arguments and evidence should be available which show that the minimum, normal and maximum planned load conditions used in testing are representative of actual operation.

Direct Evidence from Analysis of Timing Properties

SW01.41 Arguments and evidence should be available which show that:

1. The results of a worst-case timing analysis prove that the specified time response for the software safety requirement has been met.

Note: For simple software designs (e.g. using fixed loops and cyclic scheduling) design arguments and supporting evidence may be used to demonstrate that response times and throughput are invariant. This evidence may be used in conjunction with explicit timing and

throughput measurements to show that the timing constraints are met.

2. For complex software designs, the worst-case timing path through the software has been determined by analysis.
3. For complex scheduling, all safety related components that implement safety requirements meet their timing and throughput requirements (e.g. using queue simulation models).
4. For AEL 3, 4 and 5, all practicable measures have been taken to ensure that no timing anomalies exist.
5. For AEL 4, rigorous arguments were used to ensure timing correctness.
6. For AEL 5, proof was used to ensure timing correctness for the safety properties.

Backing for Analysis of Timing Properties

SW01.42 Arguments and evidence should be available which show that the modelling assumptions are applicable and take into account the speed of the hardware on which it will be implemented and any associated input-output devices.

Specific Requirements for Evidence of Robustness

SW01.43 It is expected that an appropriate form of direct evidence will be selected from the following table in order to demonstrate that the specified robustness properties have been satisfied.

	Acceptable Sources of Evidence: Robustness (Choose 1 column only from the appropriate row)		
AEL 1	TESTING	TESTING & Field service experience	ANALYSIS & Testing
AEL 2	TESTING	TESTING & Field service experience	ANALYSIS & Testing
AEL 3	ANALYSIS & Testing	ANALYSIS & Testing & Field Service Experience	
AEL 4	ANALYSIS & Testing	ANALYSIS & Testing & Field Service Experience	
AEL 5	analysis & Testing		

Direct Evidence from Testing for Robustness

SW01.44 Arguments and evidence should be available which show that all credible modes of failure have been covered, including software failures, interface failures, power-loss and restoration, failures of linked equipment, and breaks in communication links.

Backing for Testing of Robustness

SW01.45 Arguments and evidence should be available which show that:

1. The test cases cover a complete credible set of environmental failure modes.
2. Credible sequences of environmental failures are covered by the test cases.

Direct Evidence from Analysis for Robustness

SW01.46 Arguments and evidence should be available which show that:

1. The software design has features that make it robust to internal and external failures. The analysis should identify the failure modes considered and the design strategy used to recover from or mitigate the failures.

   Note: These failures typically include failures of concurrent software processes, the scheduler, input-output interfaces and file storage.

2. Failures of non-safety related components within the same computer do not affect the functioning of safety-related components (i.e. there is adequate segregation of resources).
3. For AEL 3 and above, source code cannot lead to run-time exceptions.

   Note: This does not imply that exception-handling code should not be provided. Exceptions may still arise from transient or permanent hardware failures, or where errors have been made in the demonstration that the source code cannot raise exceptions.

4. For AEL 4, rigorous argument was used to ensure that failures in the environment will not result in failure to meet the software safety requirements.
5. For AEL 5, proof of correctness for the robustness attributes of the safety properties carried out.

Backing for Analysis of Robustness

SW01.47 Arguments and evidence should be available which show that:

1. Fault detection mechanisms used to detect failure are sufficient to detect a high proportion of the failures. This proportion should be defined and justified.
2. Modelling assumptions are applicable and take into account the hardware on which it will be implemented and any associated input-output devices.

Specific Requirements for Evidence of Reliability

SW01.48 Where feasible, software safety requirements should be stated in probabilistic terms involving time (i.e. that a given failure rate must not be exceeded), and testing or field service experience is to be used to obtain direct evidence of requirements satisfaction. For this evidence to be compelling a statistical confidence of at least 95% should be achieved.

SW01.49 It is expected that an appropriate form of direct evidence will be selected from the following table in order to demonstrate that the specified reliability properties have been satisfied.

	Acceptable Sources of Evidence: Reliability (Choose 1 column only from the appropriate row)			
AEL 1	TESTING	FIELD SERVICE EXPERIENCE & Testing	ANALYSIS & Testing	ANALYSIS & Field Service Experience & Testing
AEL 2	TESTING	FIELD SERVICE EXPERIENCE & Testing	ANALYSIS & Testing	ANALYSIS & Field Service Experience & Testing
AEL 3	FIELD SERVICE EXPERIENCE & Testing	ANALYSIS & Testing	ANALYSIS & Testing & Field Service Experience	
AEL 4	ANALYSIS & Testing		ANALYSIS & Field Service Experience & Testing	
AEL 5	Analysis & Field Service Experience & Testing			

Direct Evidence from Testing for Reliability

SW01.50 Arguments and evidence should be available which show that:

1. The demands placed on the software were representative of normal operation.
2. The tests were sufficient to demonstrate that the reliability attribute of the software safety requirement is met to a confidence of 95%.

Direct Evidence from Field Service Experience for Reliability

SW01.51 Arguments and evidence should be available which show that the failure rate for all safety related failures, observed in field service should not be greater than the allowed failure rates stated in the software safety requirements, to a 95% confidence level.

Direct Evidence from Analysis for Reliability

SW01.52 Arguments and evidence should be available which show that there is a low probability of residual faults in the software.

Backing Evidence from Analysis of Reliability

SW01.53 Arguments and evidence should be available which show that:

1. The fault density figures are credible when compared with other projects using a similar development approach.
2. Design and programming standards were in place to:
   a) Minimise the risk of residual errors remaining in the software (for example, from the use of constructs which are open to misinterpretation, are obscure in meaning, or may lead to programs which are difficult to analyse).
   b) Ensure that the clarity and readability of the software design and code are adequate, as appropriate to the design notations and languages used.
3. The design and programming standards were adhered to.
4. Mechanisms were in place to detect software faults at each stage of development.
5. The fault-detection mechanisms were effective at each stage of development.

Specific Requirements for Evidence of Accuracy

SW01.54 It is expected that an appropriate form of direct evidence will be selected from the following table in order to demonstrate that the specified accuracy properties have been satisfied.

	Acceptable Sources of Evidence: Accuracy (Choose 1 column only from the appropriate row)			
AEL 1	TESTING	FIELD SERVICE EXPERIENCE & Analysis & Testing	ANALYSIS & Testing	ANALYSIS & Field Service Experience & Testing
AEL 2	TESTING & Analysis	ANALYSIS & Field Service Experience & Testing		ANALYSIS & Testing
AEL 3	ANALYSIS & Testing		ANALYSIS & Field Service Experience & Testing	
AEL 4	ANALYSIS & Testing			
AEL 5	ANALYSIS & Testing			

Direct Evidence from Testing for Accuracy

SW01.55 Arguments and evidence should be available which show that the required computational precision is demonstrated under worst-case input conditions.

Direct Evidence from Analysis for Accuracy

SW01.56 Arguments and evidence should be available which show that:

1. The sources of error for all computations associated with the software safety requirement have been identified and the worst-case errors are within the specified bounds.
2. All parameters and constants used in conjunction with the software system have been checked for correctness and internal consistency.
3. For AEL 4, the use of rigorous arguments of computational accuracy and stability have been made
4. For AEL 4 and 5, the object code is a correct translation of the source code, i.e. that as far as is reasonably practicable no additional computational inaccuracies are introduced by the translation into object code.

5. For AEL 5, there is proof that the implementation meets the software safety requirements for computational accuracy and stability.

Note: Typical sources of error are numerically unstable algorithms, floating-point truncation (e.g. small numbers added to large numbers), and numerical overflow. Good algorithm design can reduce the errors to tolerable levels.

Backing Evidence from Analysis of Accuracy

SW01.57 Arguments and evidence should be available which show that:

1. The error analysis is based on worst-case input values.
2. Good design practice is used to minimise errors in complex algorithms.

Specific Requirements for Evidence of Resource Usage

SW01.58 It is expected that an appropriate form of direct evidence will be selected from the following table in order to demonstrate that the specified resource-usage properties have been satisfied.

	Acceptable Sources of Evidence: Resource Usage (Choose 1 column only from the appropriate row)			
AEL 1	TESTING	FIELD SERVICE EXPERIENCE & Analysis & Testing	ANALYSIS & Testing	ANALYSIS & Field Service Experience & Testing
AEL 2	TESTING & Analysis	ANALYSIS & Field Service Experience & Testing		ANALYSIS & Testing
AEL 3	ANALYSIS & Testing		ANALYSIS & Field Service Experience & Testing	
AEL 4	ANALYSIS & Testing			
AEL 5	ANALYSIS & Testing			

Direct Evidence from Testing of Resource Usage

SW01.59 Arguments and evidence should be available which show that Resource usage does not exceed the specified resource constraints and has been demonstrated under worst-case conditions.

SW01.60 Typically these resources include: disc storage, main memory, input/output bandwidth, communications bandwidth, and processor time.

Direct Evidence from Analysis of Resource Usage

SW01.61 Arguments and evidence should be available which show that:

1. The resource usage of the software does not exceed the specified resource constraints.

Note: This may be based on design evidence if resources are statically assigned, or by a worst-case resource-use analysis if the resources are assigned dynamically.

2. For AEL 4 and 5, use of rigorous arguments of resource usage has been made.

Backing Evidence for Analysis of Resource Usage

SW01.62 Arguments and evidence should be available which show that:

1. The resource usage analysis is based on worst-case input values.
2. The worst-case conditions are credible under worst-case operational conditions.

Specific Requirements for Evidence of Overload Tolerance

SW01.63 Arguments may be made that design features are not required if the overload conditions are impossible.

SW01.64 Such overloads typically include: Excessive input-output data rates, Excessive processor usage, Disk storage overflows, Buffer overflows, and Virtual Storage overflows.

SW01.65 Arguments and evidence should justify that any claims about the impossibility of overload still apply under failure conditions.

SW01.66 It is expected that an appropriate form of direct evidence will be selected from the following table in order to demonstrate that the specified overload tolerance properties have been satisfied.

	Acceptable Sources of Evidence: Overload Tolerance (Choose 1 column only from the appropriate row)			
AEL 1	TESTING	FIELD SERVICE EXPERIENCE & Analysis & Testing	ANALYSIS & Testing	ANALYSIS & Field Service Experience & Testing
AEL 2	TESTING & Analysis	ANALYSIS & Field Service Experience & Testing		ANALYSIS & Testing
AEL 3	TESTING & Analysis	ANALYSIS & Field Service Experience & Testing		ANALYSIS & Testing
AEL 4	ANALYSIS & Testing (Deterministic overload design)		TESTING & Analysis (Non deterministic overload design)	
AEL 5	ANALYSIS & Testing (Deterministic overload design)		TESTING & Analysis (Non deterministic overload design)	

Direct Evidence from Analysis for Overload Tolerance

SW01.67 Arguments and evidence should be available which show that:

1. The design is capable of degrading gracefully under overload conditions so that software safety requirements are still met.
2. For AEL 4 and 5, the use of rigorous arguments of overload have been made.

Note: Where the design does not allow the loading to be determined analytically then at AELs 4 and 5 such evidence of overload tolerance will not be compelling. The arguments presented in this case will support testing by providing analysis of the test cases.

Backing Evidence for Analysis of Overload Tolerance

SW01.68 Arguments and evidence should be available which show that the overload analysis is credible under worst-case operational conditions.

Guidance on Credible Arguments and Evidence to Demonstrate Requirements Traceability Relating to Objective C

Direct Evidence for Requirements Traceability

SW01.69 Arguments and direct evidence of software safety requirements traceability should be available that demonstrate:

1. Each requirement introduced at each level in the design has been traced to the same level of design at which its satisfaction is demonstrated.
2. Each requirement introduced at each level in the design has been traced to a system safety requirement.

Backing Evidence of Requirements Traceability

SW01.70 To give confidence that the traceability records are correct and complete, arguments and backing evidence should be available that demonstrate:

1. The notation for tracing the software safety requirements is unambiguous and has been used consistently.

   Note: Traceability encompasses all pre-existing software items included in or called from the application.

2. The notation for tracing software safety requirements supports both forward and backward traceability.
3. Any tools used to support traceability did not corrupt the traceability structures and records.
4. Procedures or tools have been used to ensure that any loss of traceability or incorrect traceability is detected and corrected.
5. Any tools used to construct or maintain traceability have been verified and validated to an appropriate level for the impact of the tool on the design.

Guidance on Credible Arguments and Evidence to Demonstrate Freedom from Interference by Non-safety Functions Relating to Objective D

Direct Evidence of Freedom from Interference

SW01.71 Arguments and direct evidence that the software safety requirements integrity is maintained should be available that demonstrate:

- Any non-safety functions existing in the implementation cannot interfere with those functions resulting from software safety requirements.

Backing Evidence of Freedom from Interference

SW01.72 To give confidence that the software safety requirements integrity is maintained arguments and backing evidence should be available that demonstrate:

1. The notations used in the analysis of interference are capable of supporting the identification and correction of all relevant interference mechanisms.
2. The analytic methods and techniques used are appropriate for identifying and analysing interference mechanisms.
3. The analysis notations are appropriate to the problem domain and representation and allow an adequate analysis of the design.
4. The analysis techniques have been applied by adequately qualified and experienced staff.
5. Assumptions used in the analysis (e.g. about the environment, hardware, operating system and other interfaces) have been validated.
6. Models or other abstractions used in the analysis are an adequate representation of the software design.
7. Procedures or tools have been used to ensure that interference is detected and corrected.
8. Any tools used to support the detection or correction of interference did not corrupt the results or the operational software.

9. Any tools used to detect or correct interference have been verified and validated to an appropriate level for the impact of the tool on the code and analysis.

Guidance on Credible Arguments and Evidence to Demonstrate Configuration Consistency Relating to Objective E

Direct Evidence of Configuration Consistency

SW01.73 Arguments and evidence should be available that show:

1. All those artefacts, which are offered as a source of direct or backing evidence are produced by the development of, or related to, the known executable version of the software.

Note: Evidence that is not created during the development process of the known executable version of the software can be related to it. In this case arguments for the validity of the relationship should be made available.

2. The evidence was collected from the processes and products to which it relates.
3. Evidence has not been altered without the alterations and their justification being made visible.
4. The evidence is unambiguously and consistently identified.

Note: Artefacts commonly offered as sources of Direct and Backing Evidence are:

- The object code;
- The source code;
- The requirements (System requirements, Software safety requirements, other Software requirements)
- Any data that has been used in conjunction with the known version of the source code;
- All user manuals and other operating instructions for the software;
- All test specifications, test scripts, test harness programs and test results;
- Versions of all hardware used in the: generation of test data, stimulation of tests and recording of test results;

- Intermediate software design descriptions, either in natural language or formal or semi-formal notations;
- The results of hazard analysis undertaken on the system and software;
- Requirements traceability records (where these are kept separately from the source code);
- The results of manual inspections and static analyses of various kinds;
- All safety arguments;
- Versions of the compilation system and any other development tools, including the hardware upon which they operate.

Backing Evidence of Configuration Consistency

SW01.74 Arguments and evidence should be available that show:

1. Any tools used to support configuration consistency did not corrupt the configuration consistency structures.
2. Any tools used to construct or maintain configuration consistency have been verified and validated to an appropriate level for the impact of the tool on the code.

SW01.75 A computer based change control and configuration management system should be used to maintain the consistency of all products of the development process.

Appendix A to SW 01: Identification of AELs

Introduction

SW01A.1 For the CAA to be satisfied that a software safety requirement has been implemented fully and correctly, the five objectives defined in Part 2 paragraph SW01.18 of SW 01 (Requirements Validity, Requirements Satisfaction, Requirements Traceability, Requirements Integrity, Freedom from Interference and Configuration Consistency) must be achieved.

SW01A.2 In order to demonstrate that the objectives have been achieved, arguments and assurance evidence must be made available to the CAA from the behaviour of the software and certain aspects of the way in which it has been developed. The strength and depth (rigour) of that assurance evidence is driven by the **safety criticality** of the software safety requirement.

SW01A.3 The safety criticality of the software safety requirement is expressed as an index in the range 1 to 5. This index is referred to as the Assurance Evidence Level (AEL). The AEL determines the minimum set of assurance evidence that is required to be available to the regulator for a given software safety requirement for any system proposed for approval. AELs are intended to be used as a strategic project management aid to ensure that appropriate software safety assurance processes are used throughout the lifecycle of safety related software.

SW01A.4 Since the AEL determines the evidence to be available for approval of the system, it affects the products of the development process. Furthermore software safety requirements are dynamic in the sense that they can be created and altered by design decisions, as can their associated AELs. It is therefore extremely impractical for a regulator to either set or agree changes to each AEL as the associated software requirement changes during development. For this reason AELs are to be established by the Service Provider. The regulator will review them when the system is presented for approval.

SW01A.5 The use of the AEL to assist the Service Provider in producing the optimum set of evidence and the use of SWAL does not remove

from the Service Provider, the responsibility of demonstrating satisfaction of the requirement.

SW01A.6 This Appendix provides the means whereby the Service Provider can establish the AEL of a software safety requirement.

SW01A.7 The use of AELs as described here satisfies the requirements for Software Assurance Levels as defined in Annex I in EU Regulation (EC) No. 482/2008.

Safety Criticality

SW01A.8 EU Regulation (EU) No. 1035/2011 (the Common Requirements) requires the assessment of the combined effects of hazards. Annex I of EU Regulation (EC) No. 482/2008 requires Software Assurance Levels to relate the rigour of software assurances to the safety criticality of the software. The use of AELs as described below is compliant with both regulations.

SW01A.9 There are a number of indicators of criticality; the dominant one is the consequence of the software safety requirement not being met. This is expressed in terms of the impact of the failure on the likelihood and/or severity of an ensuing accident. These consequences can also be characterised by the impact of the failure on the continuation of the provision of an ATS or the need for any mandatory reporting of accident or incidents as defined in CAP 382.

SW01A.10 Where architectural and operational defences have been taken against the consequences, they need to be taken into account when judging the criticality of the software safety requirement. Just assessing the AEL on the basis of the worst credible event in the wider system is likely to result in an unduly high AEL for the software safety requirement.

SW01A.11 Conversely, if a failure to meet a software safety requirement can have an impact on a number of different accidents then assessing the AEL solely on the basis of the worst credible event in the wider system is likely to result in an unduly low AEL for the software safety requirement.

SW01A.12 Architectural and operational defences may be accounted for in one of two ways. First, by considering, the tolerable failure rate of the software safety requirement which when combined with other failures will cause the worst-case credible consequence. Second, by

considering the number and strength of defences to be penetrated before causing the worst-case credible consequence.

Calculation of AEL

SW01A.13 An AEL should be assigned using Tables 1 and 2 'AEL Safety Criticality' and 'AEL safety criticality modification due to Architectural and operational defences'.

SW01A.14 The provisional assignment of AEL can be found from Table 1 by relating the worst credible consequence of the failure to meet the requirement (the hazard) to one of the columns in the table. Three sets of guidewords are given: ATS severity categories (based on Regulation (EU) No. 1035/2011, Mandatory occurrence reporting categories (CAP 382) and UK Airprox risk categories). These may help in understanding the hazard.

Note: When using Table 1 the AEL should be adjusted to accommodate the cumulative risk of a failure to meet the software safety requirement. For example if the worst credible consequence of a failure to meet the software safety requirement represents a very large proportion of the risk, then this consequence alone can be used to assign the AEL. However if the risk of the worst credible event only represents a small proportion of the risk of failing to meet the software safety requirement then the AEL should be raised appropriately.

SW01A.15 The assessment of the worst-case consequence may already be documented in the system hazard analysis. When this is not the case, a hazard analysis should be undertaken to assess how the software requirements might lead to one of these system level hazards.

Table 1: AEL safety criticality

AEL	1	2	3	4	5
Characteristic					
(EC) 2096/2005 Severity Classification Scheme	No immediate effect on safety	Significant incident indicating that an Accident, Serious incident or Major Incident could have occurred	Major incident associated with the operation of the aircraft	Serious Incident	Accident
Relationship to the Mandatory Occurrence Reporting Scheme (CAP 382)	No effect on ATC workload	Increased ATC workload	Loss of separation Significant ATC overload Significant degradation of ground based system	Serious loss of separation Serious ATC overload Serious degradation of ground based system	A UK reportable accident Actual risk of collision
Relationship to the UK Airprox Board, Risk categories	N/A	C – no risk of collision	B – Safety not assured	A – Risk of collision	N/A

SW01A.16 If it can be argued that defences in other parts of the system (including other parts of the software) mitigate against the consequences of the failure to meet the software safety requirement then the provisional assignment of AEL can be reduced by using Table 2.

Note: This document assumes that software safety requirements have been derived from a full risk and safety analysis of the system. This will have established the overall safety requirements that

have been refined and allocated in the design to software. This is a commonplace system safety process and is described in standards and guidelines such as IEC 61508 Part 1, ARP4754, Def Stan 00-56.

Table 2: AEL safety criticality modification due to Architectural and operational defences

Reduction of AEL	**-1**	**-2**	**-3**	**-4**
Characteristic				
Number and strength of defensive layers	Requirement is monitored	Requirement is met independently in a redundant channel	At least two forms of mitigation which are not part of the requirement	Many forms of mitigation such that a failure of the implementation to satisfy the requirement is extremely unlikely to result in the hazard.
The probability of the failure of all Architectural and operational defences	10-2/hr	10-3/hr	10-5/hr	10-7/hr

SW01A.17 The provisional AEL from Table 1 is then added to the offset provided by Table 2.

Software Components

SW01A.18 The smallest software component is an element that can be verified. Software safety requirements may be attached to an element to control its behaviour. A grouping of elements that are protected from external reference is called a Software Architectural Unit. These are described in Appendix E. Within a Software Architectural Unit no argument for the independence of the attributes of software functions from each other can be made, consequently all software

safety requirements placed on a Software AU must assume the same AEL.

Note 1: Independence may be physical or logical.

Note 2: A software component may be a single executable program, a number of programs operating together, or a part of a single program e.g. a concurrent process, depending on the system and software architecture.

Note 3: As software components become larger and/or more complex it becomes increasingly difficult to provide arguments and evidence that the ATS system will perform all of its safety related functions without failure. Independence may be used to minimise the size and complexity of software components to ease this difficulty.

SW01A.19 The AEL allocated to the software safety requirements implemented in a Software Architectural Unit should be the highest AEL of the individual software safety requirements of the elements contained within the Software Architectural Unit.

SW01A.20 The evidence required to support arguments of the adequacy of the Software Architectural Unit's barricade is determined by the AEL of the Software Architectural Unit.

SW01A.21 Requirements derived from a software safety requirement cannot be assumed to have the same AEL as the originating requirement. They must be evaluated, as defined in Appendix A to SW01 paragraph SW01A.13, in order to derive their correct AELs.

SW01A.22 Design decisions must be evaluated at the system level in order to identify any new software safety requirements. These new software safety requirements must then be allocated an AEL, as defined in Appendix A to SW01 paragraph SW01A.13.

Note: This document assumes that software safety requirements have been derived from a full risk and safety analysis of the system. This will have established the overall safety requirements that have been refined and allocated in the design to software. This is a commonplace system safety process and is described in standards and guidelines such as IEC 61508 Part 1, ARP4754, and Def Stan 00-56.

Appendix B to SW 01: Argument and Evidence Concepts

Safety Arguments

SW01B.1 SW01 Part 3 guides the service provider in preparing a coherent and convincing argument with adequate supporting evidence to assure the regulator that the prime software safety objective has been achieved:

SW01B.2 **To ensure that the risks associated with deploying any software used in a safety related ATS system have been reduced to a tolerable level.**

SW01B.3 SW 01 provides an argument that assurance of achieving the prime software safety objective may be demonstrated by achieving each of the five assurance objectives elaborated in Part 3, i.e.:

- Safety Requirements Validity;
- Safety Requirements Satisfaction;
- Safety Requirements Traceability;
- Freedom from Interference by Non Safety Functions;
- Configuration Consistency.

SW01B.4 Thus SW 01 provides the basic relationship between software safety and regulatory assurance and it is only necessary to demonstrate achievement of the four assurance objectives to the Authority.

SW01B.5 The guidance in Part 3 defines the bounds of arguments and the types of evidence that may be used to support a claim that an objective has been achieved. The service provider needs to provide the actual claim, arguments and supporting evidence. It is likely that sub-claims will be made by the service provider to support the claim that an objective has been achieved. Any argument and evidence must also justify the choice of sub-claims.

Evidence

SW01B.6 For the purposes of this document, evidence, to support an argument that a safety assurance objective has been met, can take one of two complementary forms, as follows:

- **Direct Evidence** – that which is produced by an activity taking place or software behaviour occurring, which is directly related to the claim being made; and
- **Backing Evidence** – that which shows that the Direct Evidence is both credible and soundly based.

Note 1: Backing is only required for direct evidence actually produced.

Note 2: For example:

For a situation where test specifications, test scripts, test harness programs and test results have been submitted as evidence to support claims that the requirements satisfaction objective (part 3 paragraph SW01.20 to SW01.23) has been achieved. It would be necessary to make a sub-claim that the configuration consistency objective (part 3 paragraphs SW01.71 to SW01.72), for that evidence has also been achieved. To do this, paragraph SW01.72 for direct evidence and paragraph SW01.71 for backing evidence must be satisfied.

SW01B.7 To substantiate a claim that this is true, the following statement could be made:

'The test specifications, test scripts, test harness programs and test results apply to the version of the source code being assessed because a unique numbering system is used, this is controlled by a configuration management system and has been checked by review.'

1. **The claim is:**
   - 'The test specifications, test scripts, test harness programs and test results apply to a known version of the source code.'
2. **Direct evidence is:**
   - The unique numbers are present on all data submitted as evidence and they are controlled by a configuration management system that has been checked by review.

3. **Backing evidence is:**

   - Audit of numbers and reviews, evidence of CMS pedigree, etc.

To be able to claim achievement of the configuration consistency objective in full it would be necessary to:

- Put forward similar sub-claims for all other evidence submitted to support claims of achieving the other objectives;
- Argue that the set of sub-claims is complete.

Rigour of Arguments

SW01B.8 The rigour (depth and strength) required of the arguments, that the assurance objectives have been met, increases with AEL. The increased rigour is introduced by requiring the arguments to be presented to a lower level of design.

Arguing Requirements Satisfaction

Structuring of Arguments

SW01B.9 In arguing achievement of Safety Requirements Satisfaction objective at an AEL greater than 3 in particular, a single argument is considered to be insufficient to adequately demonstrate that the objective has been met. The concept of Primary and Secondary arguments has therefore been introduced, as follows.

Primary Arguments

SW01B.10 Primary Arguments are, as the name suggests, the main arguments (using the Direct and associated Backing evidence) that the software safety requirement is satisfied.

Secondary Arguments

SW01B.11 Secondary Arguments provide additional, independent arguments that the safety requirement is satisfied. They compensate for the possible lack of completeness and uncertainty in the Primary Argument.

SW01B.12 Secondary Arguments need not demonstrate the claim completely, but the result should not contradict the result of the primary argument.

SW01B.13 The Secondary argument might use a similar justification (same clauses as primary justification) by an independent team or an entirely different form of evidence, or both.

Sources of Evidence for Requirements Satisfaction

SW01B.14 Evidence to support an argument that a software safety requirement has been met may be obtained from one or more of the following main sources:

1. Testing of the object code.
2. Field service experience of an identical, or sufficiently similar, system.
3. Analysis of an appropriate level of design.

SW01B.15 Which of the three main sources of evidence is most appropriate will vary according to the attribute concerned and the required AEL, as indicated in Part 3 Section 6.

Note 1: In this context, source code is considered to be an aspect of design.

Note 2: Analysis can include evidence of the effective use of appropriate processes and techniques.

Note 3: For the other assurance objectives (Configuration consistency, Requirements traceability and Requirements validity) analytic evidence is expected.

SW01B.16 The forms of evidence available for each attribute and each source of evidence are listed in Table 1.

Note: Table 1 is not exhaustive; other forms of evidence that support a claim that a given attribute is satisfied may be offered.

Table 1: Forms of Evidence: Satisfaction of Safety Requirements

Software attribute	Test evidence	Field experience	Analytic evidence
Functional properties	Functional testing	Analysis of known faults in a product	Formal proof of logical behaviour

Software attribute	Test evidence	Field experience	Analytic evidence
Timing Properties	Response time tests. Maximum throughput tests	Analysis of known faults in a product	Worst case timing analysis. Performance modelling
Robustness	Fault injection testing (internal and i/o). Power failure and equipment failure tests	Evidence from incident reports on effectiveness of fault tolerance measures	Design evidence that internal and external failures can be detected, and appropriate action taken
Reliability	Reliability testing (using expected operational profile) Evidence of high test coverage	Field reliability measurements (for a similar operational profile) Estimates based on residual faults and operating time (N/T)	Evidence of a low probability of residual faults (from analysis of the process and the product). E.g. Static analysis Compliance analysis Complexity metrics Inspection, Quality of support tools. Fault density in similar projects
Accuracy	Measuring error for known test cases	Analysis of known faults in a product	Numerical analysis Algorithm stability analysis
Resource usage	Worst case load tests (disc, memory, input/output, communications, processor)	Resource usage monitoring data from similar applications	Design evidence of static assignment of resources at start-up. Worst case resource analysis
Overload tolerance	Excess load tests	Analysis of known faults in a product	Design evidence that system will degrade gracefully in overload conditions

Rigour of Evidence

SW01B.17 The rigour (depth and strength) of the evidence gathered (both direct and backing evidence) also increases with AEL. This is reflected in the requirements at paragraph SW01.24, which shows the evidence to be produced from each source of evidence for each AEL.

SW01B.18 The requirements in each table are cumulative – i.e. at a given AEL, its requirements together with all requirements for lower AELs should be complied with.

Safety Cases

SW01B.19 Insofar as SW 01 deals only with the approval of software demonstration of the satisfaction of the requirements herein may be used in support of a system safety case.

Appendix C to SW 01: Derivation of Safety Objectives

SW01C.1 The CAA is required to set objective safety goals which do not remove the Regulatees' freedom of solution by prescribing the means of compliance. The top-level safety goal for software used in CNS/ATM systems states that the Regulatee is:

- **G1. To ensure that the risks in deploying any software used in a safety related CNS/ATM system have been reduced to a tolerable level.**

Note: For the purposes of this section G'n' denotes a Safety Goal and G'n.n' denotes a Safety Sub-Goal to be met by the Regulatee.

SW01C.2 The ANO gives the CAA the responsibility to be assured that the Regulatee is meeting the above goal (G1). Consequently it is the responsibility of the Regulatee to present a claim that the safety goal has been achieved and convince the regulator that it is true. It is not the responsibility of the CAA to construct the claim on behalf of the Regulatee. Hence the CAA requires the Regulatee to demonstrate accomplishment of G1. For accomplishment of G1 to be demonstrated to the CAA it is necessary:

- **A1. For arguments and assurance evidence to be available which show that the risks associated with deploying any software used in a safety related ATS system are tolerable.**

Note: A'n' denotes a Regulatory (Assurance) Goal and A'n.n' denotes a Regulatory (Assurance) Sub-Goal.

SW01C.3 However it is necessary to decompose this Goal into sub-goals that are meaningful regulatory statements that can be comprehended by the Regulatee.

SW01C.4 The decomposition can be assisted through an understanding of the goal for software behaviour:

- **G2. To ensure that any software used in a system only behaves in a manner that is safe and has been predicted.**

SW01C.5 Another way of saying this is that since the tolerability of the risks associated with deploying systems containing software

is established during the system safety process, then the main safety goal for software is to implement those safety requirements allocated to software by the system safety process completely and correctly and to ensure that the implementation of non safety functions does not have an adverse effect on safety.

SW01C.6 Therefore the main software safety goal may be divided into three sub-goals; these are:

- **G2.1 To ensure that the software safety requirements are valid system safety requirements and are necessary and sufficient to achieve the risk tolerability**
- **G2.2 To ensure that safety requirements are implemented completely and correctly**
- **G2.3 To ensure that the implementation contains no functions which have an adverse impact on the safety of the system**

SW01C.7 In order to be assured that the risk of deploying software is tolerable (goal A1) the arguments and assurance evidence must show that safety goals G2.1, G2.2 and G2.3 have been met. For the assurance evidence to be acceptable it must meet the following criteria:

1. It can be demonstrated that the evidence was collected from the processes and products to which it relates.
2. It has not been altered without the alterations and their justification being made visible.
3. It is available for inspection.

SW01C.8 These criteria can be met by the retention and maintenance of all arguments and assurance evidence data and all data used to generate the evidence. They are expressed in the **configuration consistency** goal for software safety assurance:

- **A1.1 To ensure that the arguments and evidence, for the safety of the software in the system context, are from: a known executable version of the software, a known range of configuration data and a known set of software products, data and descriptions that have been used in the production of that version (ref 1709)**

SW01C.9 Assurance that Goal G2.1 has been met is obtained by assuring that software safety requirements are valid and remain valid during software implementation, as expressed in the **Validity of Safety Requirements** goal for software safety assurance:

- **A2.1 To ensure that arguments and evidence are available which show that the Software Safety requirements correctly state what is necessary and sufficient to achieve tolerable safety, in the system context (ref 1705)**

Note: This includes requirements to control hazards identified during implementation.

SW01C.10 Assurance that Goal G2.2 has been met is obtained by assuring that the requirements have been correctly and completely implemented as expressed in the **Satisfaction of Safety Requirements** goal for software safety assurance:

- **A2.2 To ensure that arguments and evidence are available, which shows that the software satisfies its safety requirements (ref 1706)**

SW01C.11 However, during the software development process, functions may be introduced which have repercussions on the safety of the ATS system, these will need to be assessed and if necessary, new or changed safety requirements will have to be generated. Otherwise the software safety requirements would no longer be complete and correct.

SW01C.12 In order to be assured that the software safety requirements remain complete and correct and, consequently, that objective G2.1 is met for all stages of the development, the software safety requirements must be traceable to the implementation and vice versa. This is expressed in the **Traceability of Safety Requirements** goal for software safety assurance:

- **A2.3 To ensure that arguments and evidence are available which show that each Safety Requirement can be traced to the same level of design at which its satisfaction is demonstrated (ref 1707)**

SW01C.13 CNS/ATM software will invariably contain software other than that which is derived from software safety requirements. If these (non-safety) software requirements are implemented in such a way that

they interfere with the safe behaviour of the system then objective G2.3 will not be met.

SW01C.14 In order to be assured of compliance with G2.3, behaviour resulting from the implementation of software safety requirements must not be interfered with by behaviour resulting from the implementation of other software requirements. This is expressed in the **Freedom from Interference** goal for software safety assurance:

- **A2.4 To ensure that arguments and evidence are available which show that functions implemented as a result of Software Safety Requirements are not interfered with by other functions implemented in the software (ref 1708)**

SW01C.15 The arguments given above demonstrate that the five assurance sub-goals A1.1 and A2.1 to A2.4 are necessary and that they are sufficient to achieve the top-level safety goal for safety related software in CNS/ATM systems. The reader is invited to confirm this by negating each sub-goal and considering the consequences on the accomplishment of the top-level safety goal.

Appendix D to SW 01: Architectural Considerations

Introduction

SW01D.1 This Appendix discusses various aspects of software architecture that can influence software safety assurance by having an impact on the structure and content of the software safety argument and its supporting evidence.

Architectural Units

SW01D.2 The notion of architecture is often limited to a physical architecture of equipments linked by physical connections. Thus interference is only precluded due to the physical properties of the equipments or interconnections. Such views of architecture originally arose from mechanical and analogue views of the world, where data is represented by a physical property e.g. the length of extension of a rod or the voltage existing on a wire.

SW01D.3 The concept of logical properties, e.g. data value, timeliness, etc., do not exist in this view of the world and so protecting the entities described by such properties from interference cannot be discussed. Consequently, the view adopted makes it difficult to deal with software, as it implies that since all the programmes running on a single computer are part of the same equipment, architecture cannot be used to preclude interference between the programmes.

SW01D.4 This Appendix uses a broader notion of architecture by introducing the concept of logical architecture, where reliance may be placed on physical properties of the system to preclude interference with logical properties. The logical properties of particular interest to a computer programme are those of data, timeliness, order and access to a resource. For example, data is represented in a computer by its value (a number) and its location (in memory). Clearly, it shares its location with other programmes so cannot be physically isolated. Thus it may be interfered with. However, by managing a programme's access to memory, it may be possible to be assured that access to the data of one programme cannot be granted to another.

SW01D.5 There are (at least) two simple ways of limiting access to data:

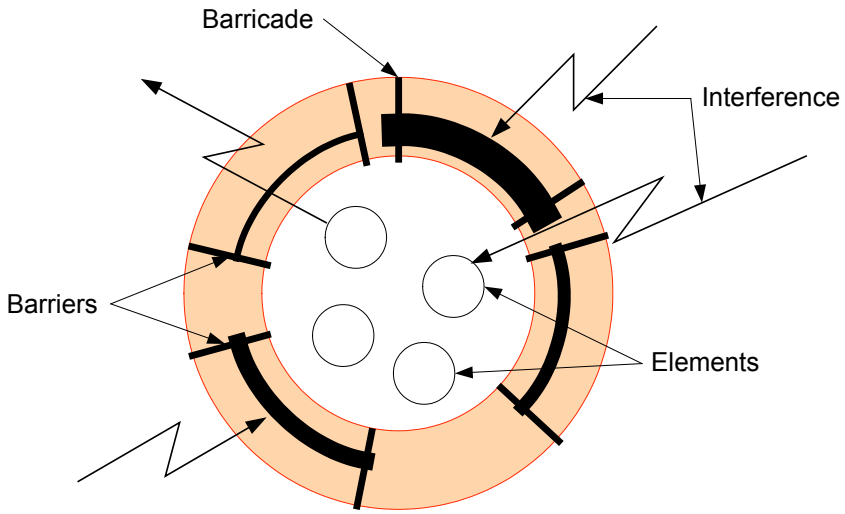
- Make sure a programme runs to completion and does not use data in RAM from one run to the next.
- Set bounds on the memory access for each programme and make sure they do not overlap.

SW01D.6 The first requires a simple non-interruptible scheduler to handle multiple programmes whereas the second usually requires some hardware and software to enforce separation; in both cases the implementation is physical while the policy itself is logical. However in the first case the implementation is via some software, which some may not consider to be 'architectural', whereas in the second case hardware is used, which is always considered 'architectural' – this apparent mix of physical and logical architecture often causes confusion.

SW01D.7 In general all architecture has physical properties and these can be used to protect the logical properties (values, time spans, etc.) of the things we are interested in. A barrier can be drawn around these things, representing the limits of protection from interference for a particular logical property of a particular set of functions of interest. For example, using the simple non-interruptible scheduler described above allows a temporal barrier to be drawn around each programme unit.

SW01D.8 Other sorts of barriers, which limit other forms of interference, can be drawn around a programme unit (element). The functions of the unit are then protected from outside interference. This is illustrated in Figure 1. It shows barriers covering the periphery of a programme unit. This set of barriers is called a barricade.

Figure 1 Architectural Unit



SW01D.9 Barriers are not perfect; a metal box does not reduce the EM (Electromagnetic) environment (due to outside sources of EM interference) within the box to zero. Neither does it provide equal protection for all frequencies. Similarly, for the non-interruptible scheduler, the protection may not extend to cover hardware interrupts or timeliness interference due to errors in the operating system itself. Consequently, the amount of protection provided by an individual barrier is represented in Figure 1 by the thickness of its line.

SW01D.10 The behaviour of the barrier can either be described from an internal perspective or an external perspective. An internal perspective would view the barrier as preventing alteration to a property of the function, whereas an external perspective would view the barrier as preventing a particular type of interference from coming through the barrier wall. For example, an internal perspective on the non-interruptible scheduler is that it protects the timeliness of the functions and so limits interference in time, whereas an external perspective on the metal case round a hardware unit is that it prevents EM interference.

SW01D.11 There are many different types of interference. Consequently, for full protection, many different barriers are needed. The gaps in Figure 1 illustrate where no barrier exists and therefore where there is no protection.

Note: Barriers are put in place to protect the functions of the element from external interference, not to stop interference being

exported. This is normal practice. Standards, such as DO 178, take the view that a high integrity function should take the responsibility of protecting itself from interference from lower integrity functions for two reasons:

- The higher integrity function is expected to carry overheads associated with greater development rigour. To have to carry an overhead for protection as well is not considered too onerous.
- The rigour of development of a lower integrity function would give little support to an argument that it did not export any interference.

SW01D.12 The consequence of this line of reasoning is that functions within an element, which are protected by the same set of barriers, can expect no protection from the other functions operating within the same element. For example, although a metal box provides protection from external EM interference, the electronics within the box also generate interference and consequently one card in a box may be interfered with by the EM radiation of another. Similarly the OS provides no data or timeliness protection from functions that are part of the same programme unit. Thus the data of one function may be corrupted by another function within the same programme unit.

SW01D.13 Even though individual barriers are not perfect and there may not be a complete set of them, the notion of a set of barriers surrounding a function is of practical benefit. Where the logical properties protected are a useful subset of all logical properties known to exist within some identifiable physical component, it enables the construction of systems from independently assessed components.

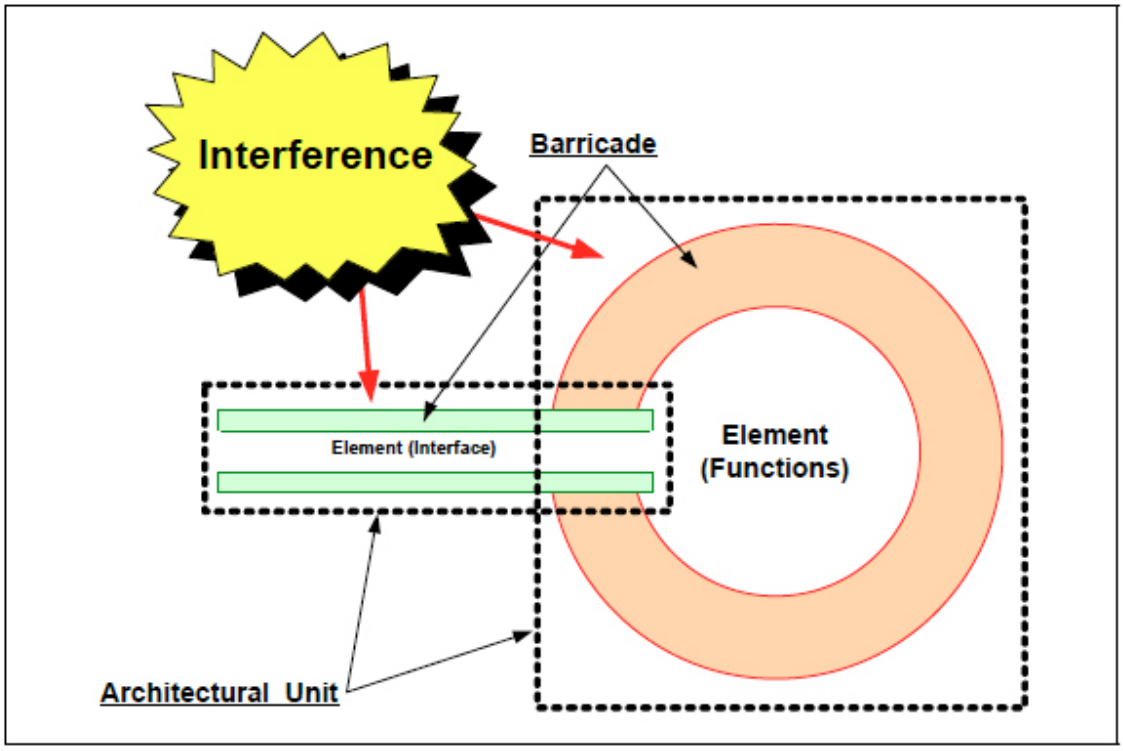
SW01D.14 For example, an operating system may provide protection against data, timeliness and resource interference for all programme units within a computer, thus allowing each programme unit (a physical element) to be thought of as an interference free container. Such containers i.e. elements and associated barricades, are architectural units (architectural components) and represent the basic building blocks for non-interference arguments.

SW01D.15 Another feature of barriers, illustrated in the OS example above, is that the protection afforded to the element (the programme unit) may not be part of the element itself i.e. the barricade is not physically attached to the element. The OS establishes an interference free environment whose properties are inherited by the

elements within the computer. Consequently, although the OS may be considered to provide one or more of the barriers in an elements barricade, the implementation of the barrier is not physically part of that element.

SW01D.16 A barricade cannot completely envelop an element, as, to be useful, the functions within it have to communicate with other functions and ultimately, the outside world. Any communication channel can be thought of as a breach in the barricade, allowing interference contained within it to be transferred to the functions in the element. However, the communications channel itself can be protected from interference e.g. an optical bus is protected from radio frequency EM interference and protocols and checksums may be used to protect any data it carries from most forms of corruption. Consequently the communications channel is also an Architectural Unit, protected from the external environment by its own barricade. This concept is illustrated in Figure 2. Systems of architectural units may therefore be built in this way, allowing non-interference arguments to be created for a complete system.

Figure 2 An Architectural system



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PART B, SECTION 4: GENERIC REQUIREMENTS AND GUIDANCE: GENERAL

GEN 01: Wind Farms

Introduction

GEN01.1 A wind farm will comprise one or more Wind Powered Turbine generators.

GEN01.2 This document provides guidance which an ATS Provider or ANSP can apply in order to safeguard against the possibility of adverse effects on ATS operations caused by a wind farm development in the vicinity of an aeronautical radio station. Sources of guidance to facilitate the process of assessment are also provided.

Capture by ATS Provider of Development Proposal

GEN01.3 An ATS Provider or ANSP should be notified of a proposal to develop a wind farm by the developer. This notification provides the opportunity to enter into consultation with the developer and provide comment, ahead of a formal planning application, on an intention to develop a wind farm site.

GEN01.4 In order to ensure comprehensive notification of any intended development, ATS Providers and ANSPs are advised to arrange for the relevant Local Planning Authority (LPA) to inform and consult with them, when they receive wind farm development proposals within a minimum radius of 20 km from their Aerodrome or Radio Site.

GEN01.5 ATS Providers and ANSPs should also ensure that any area of particularly intense aircraft activity, e.g. an approach to a runway, is also considered by the LPA as requiring safeguarding. This will normally be outside the 'standard' 20 km range and may extend to 34 km for ILS approaches. It should be noted that such ranges could require consultation with more than one LPA.

Responsibilities and Limitations

GEN01.6 Wind farms need to be considered as a safeguarding activity.

GEN01.7 The ATS Provider or ANSP is responsible for ensuring, as far as is reasonably practicable, that such development does not impact on the safety of the ATS environment.

GEN01.8 The ATS Provider or ANSP is responsible for deciding whether or not it can accept any degradation to the ATS environment.

GEN01.9 If the ATS Provider or ANSP predicts that the degradation is unacceptable then it should make representations to the appropriate Local Authority.

GEN01.10 The ATS Provider or ANSP, after consultation with the developer, is responsible for mitigating against any deterioration to ATS caused by wind farms. The CAA may request to examine any mitigation measures taken and may vary approvals for ATS where the deterioration caused by a wind farm has an adverse effect on the continued safe operation of that service.

Assessment of Effect

GEN01.11 Wind farms (Wind powered Turbine Generators) have the potential to adversely affect the ability to provide ATS in several ways, not least because of degradation of radio signals emitted by aeronautical radio stations due to multi-path inference caused by reflection from the static elements (i.e. nacelles and masts) or signal modulation effects due to rotating turbine blades.

GEN01.12 Aerodrome licensees and ATS Providers are reminded that information regarding the technical safeguarding of aeronautical radio stations at their aerodromes, including examples of the minimum dimensions for those areas which must be safeguarded, is contained in CAP 670 Part B, Section 4 GEN 02.

GEN01.13 The CAA has been made aware of research that indicates the possibility of wind turbines adversely affecting the quality of radio communication between air traffic controllers and aircraft under their control. Further work is being undertaken to establish the extent, likelihood and severity of the problem and until further information is available, issues concerning wind turbines and VHF communications should be dealt with on a case by case basis. ANSPs are advised to include the radiation pattern of their antenna systems and the radio horizon in their considerations.

Note: A wind farm whose blade tips, at their maximum height, are below the visual horizon when viewed from a point situated 25 m above an aeronautical radio station site may be acceptable to an ANSP.

Additional Guidance

GEN01.14 Further guidance regarding wind farm planning considerations and issues can be sought from:

- CAP 764 CAA Policy and Guidelines on Wind Turbines (www.caa.co.uk/CAP764). This document aims to provide assistance to aviation stakeholders when addressing wind energy related issues, thereby ensuring greater consistency across the whole aviation industry in the consideration of the potential impact of proposed wind turbine developments.
- Planning Policy Guidance notes: PPG 8 and PPG 22 (in particular paragraphs 52-58), as subsets of the Town and Country Planning Act 1990.
- The Wireless Telegraphy Act 2006.

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GEN 02: Technical Safeguarding of Aeronautical Radio Stations Situated at UK Aerodromes: Guidance Material

Introduction

GEN02.1 Aerodromes licensees together with their ATS Providers are responsible for the technical safeguarding of all of the radio sites for which they hold approvals under the ANO 2009. This document provides guidance to assist with that process.

GEN02.2 Aerodrome Licensees and ATS Providers who register safeguarding maps with the LPA should receive from that LPA a copy of any applications for developments either on or within the vicinity of the Aerodrome. This information should be made available to the person responsible for the technical safeguarding of radio sites.

GEN02.3 If safeguarding is not undertaken then it is likely that a gradual degradation of the integrity of the radio signal will take place. This will be perceived in several ways; for example, complaints from pilots or ATC regarding poor coverage, increased background noise or worsening flight calibration results for ILS. This can be avoided by proactively safeguarding the technical sites.

GEN02.4 The ATS Engineering Inspector will expect to see evidence of adequate technical safeguarding. If the quality of service of the radio signal reduces below acceptable limits, he or she can withdraw the ANO approval for the affected radio facility until corrective measures have been taken.

Definition

GEN02.5 Technical Safeguarding is the process employed to protect radio signals from being affected by physical or electromagnetic changes in their transmission environment.

Background

GEN02.6 Technical Safeguarding consists of two processes, **Physical Protection** and **Radio Spectrum Protection**.

Physical Protection

GEN02.7 Most physical objects act as reflectors or diffractors of radio signals. A combination of object size, material, proximity and incident radio wavelength can make them particularly efficient reflectors or diffractors. Technical site safeguarding, a process applied as part of the technical safeguarding of Radio sites, seeks to prevent any development near to a radio transmitter or receiver site, which may degrade the radio signal by enabling such reflection or diffraction.

Physical Protection Process

GEN02.8 Every aeronautical radio station requires a technical area to be safeguarded against the possibility that buildings or other structures erected within the safeguarded area cause interference to the signal radiated by that station.

GEN02.9 On an aeronautical chart, a frame, representing this area, is drawn around the aerial of the radio aid. If a proposed development falls within that frame or volume, further analysis, or reasoned outright rejection should be considered. In the case of development within an ILS area it is expected that computer modelling of the development is undertaken. The size and shape of the frame or volume is dependent upon the type of equipment and its aerial system.

GEN02.10 The dimensions provided below are examples of frame sizes associated with specific types of equipment. These sizes should be applied in the absence of data from other sources. Aerodromes are encouraged to obtain specific criteria from the manufacturer or supplier of their equipment. It is likely that the manufacturer may specify a smaller area to be safeguarded, which could provide operational benefits to the Aerodrome. Aerodromes are expected to maintain and apply criteria pertinent to their own technical sites. The Engineering Inspector may wish to examine the criteria used.

Example Frame Sizes

ILS

Note: The following dimensions should not be confused with the ILS Critical and Sensitive areas.

ILS Localiser Cat I/II

GEN02.11 The frame can be defined as two separate sectors:

1. A sector of 750 m radius centred on the localiser and ±60° about the runway centreline at ground level, in the direction of the runway threshold.
2. A sector, centred on the localiser, ±15° about the runway centreline and 1500 m along the runway, at ground level, in the direction of the runway threshold.

ILS Localiser Cat III

GEN02.12 The above Cat I/II sectors plus two additional sectors:

1. A rectangle 300 m either side of and parallel to the extended runway centreline commencing 100 m behind the respective localiser and extending to 100 m beyond the end of concrete at the landing end of the respective runway. This area is defined at ground level.
2. A volume commencing 100 m from the end of concrete at ground level on a projected 1:50 slope to a range of 1000 m and ±300 m about the extended runway centreline.

Note 1: These frames are defined with respect to the localiser site and the landing 'end of concrete' to take account of the variable length of runways and inset threshold conditions.

Note 2: Aerodromes may consider extending the above Cat III criteria of ± 300 m to ± 500 m if large scale development on the edge of the ± 300 m boundary is likely.

ILS Glide Path

GEN02.13 This sector is defined with respect to the glide path aerial mast.

GEN02.14 A sector of 750 m radius ±60° about a line originating at the base of the glide path aerial parallel to the approach runway centreline.

DME associated with ILS or MLS

GEN02.15 An inverted cone of 500 m radius with a 2% (1:50) slope, originating at the base of the DME aerial.

MLS

Azimuth System

GEN02.16 A rectangle ±100 m either side of the extended runway centreline originating 100 m behind the aerial and extending to 100 m beyond the landing end of the respective runway. This area is defined at ground level as 4.3.1.2 a.

Elevation Systems

GEN02.17 A sector of 500 m radius, centred at the base of the elevation aerial, ±30° about a line parallel to the approach runway centreline.

VOR

GEN02.18 At ground level a circle of 230 m radius from the site centre with a further slope at 2% (1:50) out to 900 m radially from the site centre.

DME

GEN02.19 The foregoing VOR constraints where co-located with a VOR otherwise a 2% (1:50) slope surface originating at the site ground level extending 300 m radially.

Radar: 10 cm, 23 cm, 50 cm and SSR

GEN02.20 The radar system shall be safeguarded with criteria which are derived from the following as a minimum:

1. Operational Range.
2. Base of Coverage.
3. Operational Usage.
4. Equipment Manufacturer's recommended clearances to prevent deterioration of the system's performance.

GEN02.21 The criteria for safeguarding should include the following for all radar systems:

1. A Sterile Zone around the antenna to permit clean, un-interrupted beam formation:

    a) Which should be precisely defined with respect to a clear reference point on the antenna system,

b) Which should be derived from the vertical and horizontal beam patterns of the antenna type;

c) Which should state both the vertical and horizontal extents of the Sterile Zone.

2. A safeguarded slope should be defined around the system which shall assure the system's performance such that it continues to support the operational requirement:

a) Which should be precisely defined with respect to a clear reference point on the antenna system;

b) Which should define the gradient of the slope.

3. The criteria should also include consideration of the construction, shape, location, orientation and materials used in any application.

Note 1: Example of Sterile Zone criteria: 'The Sterile Zone is an area of z metres in radius centred on the rotation axis of the radar antenna. The zone extends y metres below the electrical centre of the antenna.'

Note 2: Example of slope criteria: 'The protected slope shall be 1 in a*, centred on a point on the rotation axis of the radar antenna that is b* metres below the lower edge of the antenna. The slope shall extend to a ground distance of c* metres from the rotation axis of the antenna.'

*a, b and c are numbers defined by the system characteristics.

GEN02.22 For clarity, the safeguarded areas should be described diagrammatically as well as textually.

Surface Movement Radar

GEN02.23 The airport boundary from ground level.

VHF Direction Finder

GEN02.24 Ground level safeguarding of circle radius 120 m centred on aid, and 2% (1:50) slope from ground level at aid out to 450 m radially.

VHF/UHF Receivers/Transmitters

GEN02.25 Ground level safeguarding of circle radius 91 m centred on the base of the main aerial tower (or equivalent structure). Additionally, from

an elevation of 9 m on this circle a 2% (1:50) slope out to a radius of 610 m.

Radar and Radio Link Routes

GEN02.26 Certain areas of high ground may need to be safeguarded against development in order to protect radar/radio beams. Such areas should be individually specified.

75 MHz Marker Beacons

GEN02.27 Ground level safeguarding out to 100 m radially.

NDB

GEN02.28 From the centre of the aerial, at a height of 5 m out to 30 m radius, with a further slope to a height of 14 m above ground, out to 90 m radius.

Radio Spectrum Protection Process

GEN02.29 Radio signals may also be degraded by interference from other radio sites, such as a broadcast station whose harmonics conflict with an aerodrome frequency. Protection against the development of a site that could produce such interference is managed as part of the Radio site Clearance process.

GEN02.30 The Radio site Clearance process of safeguarding against such third party radio site development, is part of a UK-wide Ofcom notification activity.

GEN 03: Safety Requirements for Operational Trials in Air Traffic Services

Part 1 Preliminary Material

Introduction

GEN03.1 Changes to ATM technologies, procedures and practices are subjected to thorough off-line testing and assessment[1] prior to introduction into an operational environment. It is sometimes necessary, in addition to formal off-line testing, to operate such systems operationally for a trials period prior to complete integration into the ATM system.

GEN03.2 An Operational Trial implements an unproven[2] (or partially proven) change to ATS technology or procedures or practices for the purpose of providing operational ATS.

Scope

GEN03.3 Where trials or testing uses and contributes to the operational ATM function during the course of the trial or testing activity, then this trial shall be performed in accordance with the requirements detailed within this document.

GEN03.4 This document does not apply to off-line testing, or to any proving activity which has no impact on the operational ATM function.

1 Changes to 'ATC Procedures', which can include routine, minor and major changes, may or may not include off-line testing depending on the scope and complexity. Very often the former are subjected to assessment by a panel of selected individuals.

2 Note the term 'unproven' relates to airspace under UK jurisdiction. Technologies, practices and procedures in use elsewhere in the world are considered unproven in terms of utility within the UK's Air Traffic Management environment.

Part 2 Safety Requirements

Safety Objective

GEN03.5 **To ensure that the level of safety of the ATM function is retained or improved during instigation, operation and removal of operational trials equipment, procedures or practices (1720).**

Requirements

GEN03.6 Start and end dates for the Operational Trial shall be submitted and agreed between the CAA and the ATS provider prior to implementation of the trial (833).

GEN03.7 Periods of operation (i.e. part time or continuous) shall be defined for the duration of the trials period described above (834).

GEN03.8 Outline proposals for transition from operational trial to full operation shall be submitted to the CAA for review prior to commencement of the trial (835).

Note: Any approval granted shall relate exclusively to the trial (836), and shall not guarantee or suggest that approval for permanent operation will be granted (837).

GEN03.9 The applicant shall demonstrate that, in the event of short notice failure of the trial, the ability to provide a tolerably safe ATM service is not compromised (838).

GEN03.10 The ATS provider shall provide a Safety Assessment for the operational trial with full and complete adherence to the SMS (839).

Note: The Safety Assessment shall include evidence and arguments demonstrating that the trial does not have a negative impact on the safety of participating or non-participating aircraft and ATCUs (841).

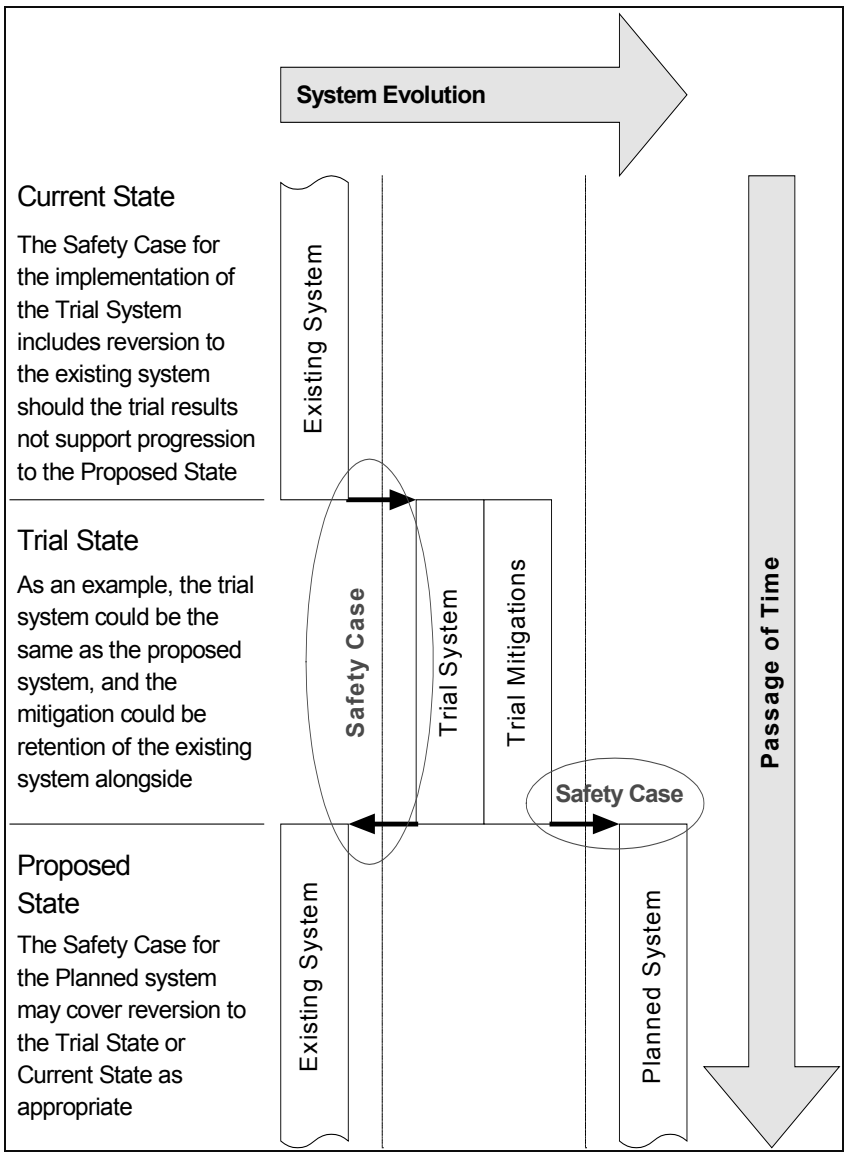
GEN03.11 The terms of approval for an operational trial shall include an undertaking by the proposer to supply to the CAA a report containing analysis of the trial's performance, and conclusions relating to the original objectives (842). Timescales (or progress milestones if appropriate) for the issue of this information shall be agreed prior to implementation of the trial (843).

GEN03.12 An operational trial shall be compatible with established mechanisms, processes and where appropriate, equipment, which provides operational services (844).

Appendix A to GEN 03: Acceptable Means of Compliance

GEN03A.1 A clear distinction is required as to what constitutes an operational trial as opposed to routine testing. Testing, particularly of ground based systems, may use an operational environment in which to perform the test procedures. If the activities taking place affect the method or procedures used to provide the air traffic service, then these should be treated as an Operational Trial.

GEN03A.2 The following diagram illustrates the process by which the Safety of Operational Trials should be managed. Where the term 'Safety Case' is used, this should be taken to mean full and complete adherence to the ATS provider SMS.



GEN03A.3 Procedures for failure of the trials equipment, procedures and/or practices should provide assurance that in the event of short notice failure of the trial, the ability to provide a tolerably safe ATM service is not compromised.

GEN 04: Malicious Software Issues with External Storage Devices

Introduction

GEN04.1 There have been instances of malicious or unwanted software being transferred to operational ATS equipment through the use of external storage devices.

Scope

GEN04.2 This document addresses the use of portable storage devices with operational ATS equipment.

GEN04.3 Any storage device used to transfer information to or from a system should be considered a potential source of harmful software. This may include (but is not limited to) floppy disks, USB memory drives, external hard drives, memory cards and optical media.

Further Information

GEN04.4 External memory devices should be controlled, preferably being dedicated to one system and not used for any other purpose.

GEN04.5 Where it is necessary to use a device not normally associated with a specific equipment, suitable precautionary measures should be taken to ensure that no malicious software is transferred to either device (use of virus checking software before and after transfer and write protection being two such processes). The use of devices by external bodies, e.g. manufacturers and external maintenance organisations, should also be controlled by the same processes.

GEN04.6 Where unwanted software is found on a device, any systems that may have come into contact with this device will need checking to verify their status and appropriate remedial action taken. This may include systems belonging to other organisations.

GEN04.7 **ANSPs should review the potential risks to systems from malicious software introduced by external devices in line with their Safety and Security Management Systems and introduce precautionary processes as necessary.**

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GEN 05: Remote Access to Operational Systems

Introduction

GEN05.1 There is potential for inappropriate system commands, infection by malicious software or uncontrolled system changes to be actioned via remote access to a system.

Scope

GEN05.2 This document addresses the security aspects of remote access facilities to operational systems.

Further Information

GEN05.3 The ability for a manufacturer or maintenance organisation to access a system remotely is often provided in a system to enable remote diagnostics, performance monitoring or software upgrades.

GEN05.4 The correct and controlled use of these facilities is recognised as useful and cost efficient method of providing these functions.

GEN05.5 The nature of these remote links may be dial-up connection, internet connection or other publically accessible technologies.

GEN05.6 To prevent access by anyone other than authorised parties the means to access the systems should, wherever possible, be disabled whenever access is not needed. If the nature of the remote access is such that it may be needed at times when there are no staff on site to enable the access then sufficiently robust password protection should be employed or the privileges of the remote user should be limited to prevent inappropriate actions.

GEN05.7 Remote access should only be done under the prior agreement of local staff and should be controlled and recorded accordingly.

GEN05.8 Once the remote tasks are complete the local staff should be made aware and the means of access disabled as appropriate.

GEN05.9 If changes have been made to the system, record should be made of these and any documentation updated accordingly, e.g. Safety Case or IOP material.

GEN05.10 ANSPs should review the potential risks to systems from remote access in line with their Safety and Security Management Systems and introduce management processes as necessary.

PART B, SECTION 5

Aerodrome Flight Information Service

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AFIS 01: Minimum Levels of Equipment, Facilities and Documentation

This document should be read in conjunction with Part C, Section 1 COM 01 for voice recording aspects at AFIS Units.

Equipment

AFIS01.1 The following items are considered to be essential for a FIS unit established at an aerodrome:

1. Headset or fitted speakers Microphone Transceiver Radio selector panel (if more than one frequency available e.g. UHF vehicle frequency)
2. Telephone selector panel/handsets(s) to public telephone network
3. Main power supply
4. Signal lamp
5. Wind speed and direction indicator
6. Barometric altimeter/precision barometer (or other means of establishing QNH and QFE)
7. Clock (set to UTC)
8. Aerodrome lighting panel (if lights available)
9. Navaid monitoring panel (if navaids available)
10. Internal lighting including emergency lighting
11. Flight progress strip holder
12. Clipboards/displays (NOTAMs etc.)
13. Binoculars
14. System for measuring the outside air temperature.

Guidance

AFIS01.2 Radio and telephone communications, including standby and emergency systems where available, should be sufficient to satisfy the operational requirement of the unit.

AFIS01.3 Procedures for the operational use of all equipment should be available to users.

AFIS01.4 Procedures for the reporting of any un-serviceabilities and arrangements for routine maintenance should be specified.

Facilities

AFIS01.5 The location of the aerodrome FIS unit shall be a place which ensures the best possible view of the aerodrome, the surrounding area and, in particular, the manoeuvring area including the runway together with the approaches. This facility at the chosen location shall be equipped with large unobstructed windows.

AFIS01.6 **Guidance**: The location on the aerodrome from which a FIS is to be provided should be specified. Any limitations on the provision of the service that are imposed by the location (a limited view of the aerodrome, for example) should be identified and measures taken to mitigate these limitations described.

Meteorological Information

AFIS01.7 The FISO shall be able to provide a pilot, upon request, with the following meteorological information:

1. SIGMETS
2. Surface wind direction and speed
3. Relevant altimeter pressure setting(s)
4. Outside air temperature
5. Visibility
6. Present weather
7. Details of cloud cover.

AFIS01.8 **Guidance**: The provision of detailed information on current and forecast weather conditions is essential. The means by which this information is determined should be identified.

Minimum Scale of Documentation

AFIS01.9 The following list is a minimum scale of documentation which shall be provided:

1. CAP 797 Flight Information Service Officer Manual.
2. Unit Manual of Flight Information Service;
3. CAP 32 UK AIP;
4. Aeronautical Information Circulars;
5. NOTAMs pertinent to the unit and its operation;
6. CAP 413 Radiotelephony Manual;
7. CAP 168 Licensing of Aerodromes (at a FIS unit established at an aerodrome);
8. CAP 772 Birdstrike Risk Management for Aerodromes (at a FIS unit established at an aerodrome);
9. CAP 393 Air Navigation: The Order and the Regulations;
10. Aerodrome Manual (at a FIS unit established at an aerodrome);
11. Aerodrome Emergency Orders (at a FIS unit established at an aerodrome);
12. Instructions for the provision of the Alerting Service (at a FIS unit established at an ACC);
13. CAP 1032 Aerodrome Flight Information Service Officers – Licensing.
14. CAP 774 UK Flight Information Services

AFIS01.10 A Watch Log shall be maintained in accordance with the procedures detailed in CAP 410.

AFIS01.11 **Guidance**: Arrangements by which these documents are maintained and the format in which they are stored should be specified.

AFIS01.12 At units located at an aerodrome the MAFIS (Local FIS Instructions) should include local procedures for the management of aircraft on, or in the vicinity of, the aerodrome.

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PART C, SECTION 1

Communication

Introduction

C1.1 Section 1 of Part C contains engineering requirements for communications equipment and systems. These documents should be used in conjunction with the Generic Requirements and Guidance contained in Part B as appropriate.

Scope

C1.2 COM 01 'Voice/Data Recording' covers the requirements for the recording of voice and data communications at ATC Units.

C1.3 COM 02 'VHF Aeronautical Radio Stations' covers the engineering and operational requirements for radio equipment and systems used for ATS.

C1.4 The other documents are COM 03 'Voice Communications Control Systems', COM 04 'ATC Datalinks', COM 05 'Automatic Terminal Information Service (ATIS)' and COM 06 'UHF Radio Equipment Systems'.

Note: 'Information and Alerting Systems' (previously numbered as COM 05) has been moved to Part C, Section 5 and named IAS.

SARPs Compliance

C1.5 In addition to the requirements in the following sections, communications services, including fixed, mobile and broadcast services, shall comply with the SARPs in ICAO Annex 10 Volume 2 – Communication Procedures, including those with PANS status, and Volume 3 – Communication Systems (2260).

Note: Where the UK has filed differences to SARPS, these will be published in Supplements to the Annexes and in the UK AIP.

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COM 01: Voice/Data Recording Equipment

Part 1 Preliminary Material

Introduction

COM01.1 Under the terms of the ANO 2009, as amended, Article 206 (Air traffic service equipment records) paragraph (2), recording apparatus is to be provided by the ATS provider of an Aeronautical Radio Station, used for the provision of an ATC service by an ATC Unit and at the direction of the CAA under the terms of paragraph (3), by the ATS provider of ATC Units where an Aeronautical Radio Station is not an integral part of the unit.

COM01.2 Under the terms of Article 206 paragraph (4)(a), the recording apparatus is required to be capable of recording and replaying the terms or content of any messages or signals transmitted, received, or conveyed through the equipment at the ATC Unit or Aeronautical Radio Station.

COM01.3 Under the terms of Article 206 paragraph (4)(b), the recording apparatus is required to be in operation at all times when an ATC service is being provided.

COM01.4 Under the terms of Article 206 paragraph (4) (d) the recording apparatus requires written approval by the CAA.

Note: Article 206 and its associated Schedule 11 should be consulted for further details as the full terms are not reproduced in this document. References to specific paragraphs of this Article may be included in Part 2 Requirements of this document as appropriate.

COM01.5 The CAA recommends that all RTF communications between FISOs based at aerodromes and pilots are recorded on suitable equipment which has the capability to identify the time the communication took place.

COM01.6 Where a Flight Information Service is provided at an aerodrome at which operations involving aircraft with a maximum total weight authorised exceeding 5700 kg and engaged on public service operations take place, the CAA strongly recommends that such recording equipment is used.

COM01.7 Aerodrome FIS units that use recording equipment are recommended to use the standards contained in this document.

Scope

COM01.8 This document sets out the engineering requirements for voice/data recording equipment at ATC Units providing an ATC service.

Note: The term 'voice/data recording equipment', referred to as 'apparatus' by Article 206, may be abbreviated where appropriate to 'recording equipment' in the remainder of this document. Similarly the term 'communications' applies to both voice and data link communications unless voice or data link are specified.

COM01.9 The requirements apply, but are not limited to, analogue tape recording/replay equipment using reel to reel, cassette or cartridge magnetic tape archival media and to digital computer based equipment using tape cartridge or other magnetic, electronic or optical devices to provide secure and reliable long-term storage/ archive of the recorded data.

COM01.10 The Minimum Performance Specification for recording equipment is included in the Appendix A to COM 01 for use in the design, manufacture and procurement of recording equipment.

COM01.11 EUROCAE document ED-111 'Functional Specifications for CNS/ ATM Ground Recording' may lead to future amendments to this document.

Part 2 Requirements

Safety Objective

COM01.12 **The recording equipment shall provide a complete, identified, intelligible and accurate record of the communications to be recorded which may be used, in the event of an incident, in any investigation by the CAA (960).**

General Requirements

Minimum Performance Specification

COM01.13 Recordings shall be retained for a minimum period of 30 days from the date of the last recorded message (998).

COM01.14 **Acceptable Means of Compliance:** This may be achieved by means of suitably resilient internal storage, e.g. Hard Disk Drives or Solid State Drives, network Storage, removable archive media or by a combination of these.

Note: Attention is drawn to CAP 670 Part B, Section 4 GEN 04 on precautions to be taken with external storage media.

COM01.15 The recording equipment shall comply with the Minimum Performance Specification in the Appendix (2375).

COM01.16 The manufacturer or supplier of the recording equipment may be required to provide evidence of compliance with this requirement as part of the ATS provider approval process.

COM01.17 Archive media shall be controlled and stored in a suitably secure location (2359).

CAA Equipment Compatibility

COM01.18 The Air Traffic Control Unit shall liaise with the CAA to ensure that the recording equipment is compatible with the replay facilities and working practices in use and shall present evidence to support this in any application for approval (962).

COM01.19 **Guidance:** At the initial stages when new or replacement recording equipment is being considered, it will be essential to liaise with the CAA, via the appropriate CAA Regional Offices or other interface, to ensure that compatibility can be achieved.

Time-Recording Devices

Note: Regulatory Requirements for ATS Unit Clocks are set out in paragraph IAS01.8 of IAS 01 (Information and Alerting Systems).

COM01.20 Voice/Data Recording equipment shall include time-recording devices or techniques to ensure the 'time-stamping' of ATS communications (961).

COM01.21 Time-recording devices or techniques shall use Co-ordinated Universal Time (UTC) and shall express each time-stamp in hours, minutes and seconds of the 24 hour day beginning at midnight (963).

COM01.22 The time-recording device or technique shall be checked as necessary to ensure that the time-stamps are maintained within ±2 seconds of UTC or by regular reference to an international time

standard such as the MSF signal radiated from Anthorn in Cumbria or from the Global Positioning System (GPS) (965).

Note: ATS units may already be deriving their master time sources from these signals, but in both cases it is important to ensure that the output from these receivers is UTC.

COM01.23 Wherever Data Link Communications are in operation, time-recording devices shall be accurate to within ±1 second of UTC (966).

Note: In this case the time accuracy is ±1 second and the resolution is 1 second.

Communications to be Recorded

Note: The CAA may require other/additional specific services to be recorded.

Air-Ground Communications (Aeronautical Mobile Service)

Note: Reference should be made to COM 02 VHF Aeronautical Radio Communications Equipment COM02.52.

COM01.24 Direct pilot-controller communications between aircraft stations and aeronautical stations shall be recorded (967).

COM01.25 The voice communications to be recorded shall be derived from a receiver in the aeronautical station providing 'off-air' signals of the pilot and controller transmissions (968).

COM01.26 Where the voice communications to be recorded are routed via a Voice Communications Control System (VCCS) or other air traffic service equipment to the recording equipment, the continuity of recording shall be ensured in the event of a failure of either the VCCS or air traffic service equipment (969).

COM01.27 **Recommendation:** In area coverage systems the output of the voting or selection unit should be recorded (970).

COM01.28 **Recommendation:** Voice communications derived from appropriate points at the controller's operating position should be recorded (971).

Note: This does not preclude unit management taking recordings at other points in the system to facilitate incident/accident investigation.

Ground-Ground Communications (Aeronautical Fixed Service)

Communications within a Flight Information Region

COM01.29 Direct communications between ATS Units and between ATS Units and appropriate Military units shall be recorded (972).

COM01.30 **Recommendation:** Direct communications which are not already covered should be recorded (973).

COM01.31 **Guidance:** ICAO Annex 11 Air Traffic Services § 6.2.2.2.1 and § 6.2.2.2.2 provide information on the communications between ATS Units and other Units which may need to be considered. Communications with appropriate emergency services and adjacent ATC Units with which co-ordination is necessary should also be considered.

Communications between Flight Information Regions

COM01.32 Direct communications between Area Control Centres serving contiguous control areas shall be recorded (974).

COM01.33 Direct communications between adjacent Flight Information Centres or Area Control Centres shall be recorded (975).

COM01.34 **Recommendation:** Direct communications between an Approach Control Office/Aerodrome Control Tower and an Area Control Centre should be recorded (977).

Surface Movement Control Service

COM01.35 Surface Movement Control Service Communications, used for the control of vehicles and personnel on the manoeuvring area, shall be recorded (978).

Communications within an Air Traffic Control Unit

COM01.36 **Recommendation**: In order to comply with the ICAO Recommendation (ICAO Annex 11, 13th edition, Amendment 44 (published November 2006), Chapter 3, paragraph 3.3.3), ATC service providers should consider the introduction of background communication and aural-environment recording at air traffic controller workstations, capable of retaining the information recorded during at least the last twenty-four hours of operation, with the installation of future systems or when major upgrades to existing voice recording systems are carried out. (2254).

Installation

General

COM01.37 The recording equipment shall be installed in accordance with the manufacturer's, supplier's or agent's instructions so as to ensure correct and reliable operation (980).

COM01.38 Long-term archive/storage facilities shall be constructed, maintained and operated in accordance with the manufacturer's, supplier's or agent's instructions so as to ensure the reliable retention of data for the ICAO minimum requirement of 30 days (981).

Equipment and Power Supply Configuration

COM01.39 The equipment and power supply configuration shall be such as to ensure the availability of recording, without interruption, when an ATS is being provided (982).

COM01.40 It is likely that the provision of main and standby equipment or systems, which contain multiple hard disc drives (HDD) or solid state drives (SSD) configured as a Redundant Array of Independent Drives (RAID), will be necessary to achieve the required availability.

COM01.41 The provision of a backup power supply from either a central battery system or individual UPS units shall ensure the availability of power to the recording equipment and other essential equipment in the event of a mains interruption (2261).

COM01.42 **Guidance:** The equipment configuration should take into account such factors as the hours of operation of the ATS unit, provision for maintenance/repair, ability to replay recorded archival media whilst continuing to record, exchange of media.

COM01.43 The incorporation of suitable mains conditioning devices as part of the mains/backup power supply arrangements may be useful in preventing equipment malfunction due to surges, spikes and noise on the power supply.

COM01.44 Where the equipment and power supply configuration is such that the availability of recording, without interruption, cannot be ensured whilst an ATS is being provided, either the provision of the ATS shall cease within a time period defined in the Local Instructions for the ATC Unit or a written record shall be kept in accordance with Article 206 paragraph (4) (c) of the ANO (983).

COM01.45 A practical demonstration of the capability to undertake the requirements of Article 206 paragraph (4) (c) shall be given to the satisfaction of the CAA before this option will be permitted as an alternative to the provision of additional equipment and power supplies to ensure continuity of recording (984).

Note: In the event of a complete failure of the recording equipment, it is generally not practical for a written record to be kept of the particulars and summary of each communication in compliance with Article 206 paragraph (4) (c) of the ANO and hence additional equipment and power supplies are normally provided to cater for this event.

Alarm/Status Indications

COM01.46 The local and remote alarm/status indications of the recording equipment shall be used as appropriate to alert ATC and Engineering personnel to take the necessary actions to ensure the continued operation of the equipment (985).

COM01.47 The remote alarm/status indications shall be 'latching' such that they require positive intervention to check that the recording equipment is operating correctly before any alarm can be cancelled (986).

COM01.48 **Guidance:** Whilst it may be appropriate to be able to cancel an audible alarm, another indication such as a visual alarm should still remain until the alarm condition has been resolved.

Working Facilities

COM01.49 Working facilities shall be provided to enable authorised persons to operate the equipment and undertake other duties such as replay and copying, maintenance, repair and inspection (987).

COM01.50 **Guidance:** Facilities may include provision of lighting and mains electrical power in the vicinity of the recording equipment or control console, together with suitable seating and writing surface. Easily accessible connections to the recording equipment may be provided where copies of recordings are required to be made.

Disposal of Recording Equipment

COM01.51 Before the disposal of any Recording Equipment, the CAA shall be consulted to determine whether there is a need to retain the equipment as a replay facility for any impounded recordings (988).

COM01.52 **Guidance:** Any original recordings that have been impounded for accident/legal reasons may be required to be re-played for some considerable time after the accident/incident and advice should be sought from the CAA before disposal.

Operation and Maintenance

Procedures

COM01.53 Procedures for the operation and maintenance of the recording equipment shall be produced and incorporated into the MATS Part 2 associated with each ATC unit in accordance with the terms of Article 102 of the ANO (989).

COM01.54 **Guidance:** The procedures may refer to Operating or Technical Manuals or other documentation relating to the recording equipment as long as they are readily accessible to the reader. Any preventative maintenance recommended by the manufacturer or supplier of the recording equipment and handling/storage precautions for the removable archive media may be incorporated into or referred to by the procedures.

COM01.55 The objective of any maintenance activity is to ensure the continued operational availability of the equipment. Maintenance includes both routine maintenance, which may be undertaken by suitably qualified persons at the ATC Unit, and repairs/fault finding which may be carried out by the manufacturer, supplier or a maintenance organisation.

Recording Equipment Logbook

COM01.56 Details of the operation and maintenance of the recording equipment, the management of the archive media, and visits by authorised persons from the CAA or ATS Regional Office Inspectors shall be recorded in a logbook and preserved for a period of one year, or longer as directed by the CAA (990).

COM01.57 **Acceptable Means of Compliance**: The ATC or Engineering Watch logbook may be used as an alternative to a separate recording equipment logbook if appropriate.

COM01.58 **Guidance**: Where a separate recording equipment logbook is used, it may be advisable to include a brief entry in the ATC or Engineering Watch logbook to note the status or actions concerning

the recording equipment with full details being kept in the recording equipment logbook.

Serviceability and Recording Function Check

COM01.59 A daily check shall be made of the serviceability and recording function of the recording equipment without interrupting the recording of any active communications to intermediate and archive storage devices. Use may be made of devices or facilities incorporated into the recording equipment which perform automatic checks of the recording function. The results of these daily checks shall be recorded in the logbook (991).

COM01.60 **Acceptable Means of Compliance:** The recording function may be checked manually by making test transmissions on each of the communications channels and confirming that the communications have been recorded and can be replayed.

Note: This check shall be made from the hard drive and without interruption of any ongoing recording activity. If this cannot be achieved, a separate replay from a previously archived recording shall be made at monthly intervals and the result recorded in the log book.

COM01.61 A daily check shall be made of the time and date function of the recording equipment. The results of these checks and any discrepancies shall be recorded in the logbook (992).

COM01.62 **Guidance:** When the recording equipment time and date function is found to be outside acceptable limits, a correction must be made as soon as possible and at an appropriate time which does not affect the recording of any active communications or the archiving process.

Storage Capacity of Hard Disc Drives (HDD) and Solid State Drives (SSD)

COM01.63 Systems using internal storage devices shall have the capability to archive to external media for investigation purposes and where necessary to achieve the required minimum retention period (2357).

COM01.64 Data shall be transferred to long-term storage or archival media in the proprietary format with minimal human intervention (2358). Data shall be protected from loss or corruption during transfer of data from the HDD/SSD to long-term storage or to removable media (2263). Corrupted or incomplete data may result in the inability to replay archived recordings from removable media.

Note: The risks associated with data transfer between source and long term storage should be minimised by using techniques such as a 'read after write' check or by incorporating a 'check sum' into the transferred data which is subsequently compared with that computed from the original source data.

COM01.65 **Recommendation:** Where regular transfer from internal storage to removable archive media takes place the removable archive media should be changed on a regular basis corresponding to ATC or engineering staff duty rosters (996).

Management of Removable Archive Media

Identification

COM01.66 Each item of removable archive media shall each have a unique identity, which shall be used in entries made in the logbook, and shall be shown by the use of an indelible written or printed label firmly attached to the media (993).

COM01.67 The records contained on the media shall comply with Article 206 paragraph (4) (c) and Schedule 11 Part B of the ANO (994).

COM01.68 **Guidance**: The identity and some of the details required by ANO Schedule 11 Part B may be associated with the media by storing them as a recording on the media in addition to any written or printed information attached to the media.

Lifetime of Removable Archive Media

COM01.69 Removable archive media must be replaced before any deterioration results in the loss of recorded data and any impounded recordings still required by either the CAA or the AAIB must be accurately transferred onto new media if necessary (2264).

COM01.70 **Acceptable Means of Compliance**: The manufacturer's stated lifetime for the archive media together with media usage data from the logbook may be used as an indicator for replacement. Other means may include tape usage data stored on the media itself or data held within the recording equipment.

COM01.71 **Guidance:** Any precautions stated by the manufacturer or supplier of the recording equipment concerning the handling/storage of the archive media are very important in ensuring the integrity of recorded data and achieving the stated lifetimes for the media.

Impounding of Recordings

COM01.72 On receiving a detailed request concerning recorded transmissions from either the CAA or the AAIB, normally within the 30 day retention period, archived data containing the specific recorded transmissions shall be removed from normal storage or extracted from HDD/SDD and placed in a separate and secure quarantine area pending further instructions (999).

COM01.73 Units will be required to impound a minimum of 4 hours data for all audio channels on each side of the occurrence times, i.e. 8 hours in total.

COM01.74 If the system also records surveillance data, then this should be impounded at the same time if possible; otherwise surveillance data can be quarantined locally and made available to produce recordings as required by the CAA or the AAIB (See also CAP 670, Part C, Section 3 SUR 10).

COM01.75 For security reasons, data exported as an 'original copy' to removable media must be in a format that can only be replayed on a dedicated replay machine or original recorder. Secondary copies made for local use only may be in an open format.

COM01.76 Extracts of recorded communications, copied from the original source files contained on HDD/SSD or from a separate archive source to removable media must be demonstrated to be a complete, accurate and verifiable copy of the original recordings (2265).

Note: Manufacturers of ATS recording and replay systems are now able to offer software tools which are capable of meeting this requirement and the ATS provider is encouraged to check whether the CAA will accept the production of "copies on demand" from their particular systems.

COM01.77 In the event of an aircraft accident or serious incident, ATS units are permitted to make one single copy from the original media before the original recording is placed into separate and secure storage (2360). An archive copy will be made from internal storage devices before a local copy is made (2361). Subsequent local replays of the recorded transmissions must only be made from the local copy (2362).

COM01.78 **Guidance**: Original recordings may be impounded for a minimum period of three years in the case of accident investigations.

CAA Access to Recording Equipment

COM01.79 Access to the Recording Equipment shall be permitted to authorised persons from the CAA for the purposes of replaying and making copies of original recordings (1733).

COM01.80 **Acceptable Means of Compliance**: If the recording equipment is unable to replay removable archive media whilst continuing to record communications, another recorder or dedicated replay-only equipment may be required.

Prevention of Inadvertent Loss of Recorded Communications

COM01.81 The inadvertent loss of recorded communications, whilst operating the recording equipment, shall be prevented by means of procedures in conjunction with equipment security functions where available (1734).

Appendix A to COM 01: Minimum Performance Specification for Recording Equipment

Scope

COM01A.1 This document comprises the minimum performance specification for analogue and digital recording equipment used at ATC Units for the recording of voice and data link communications.

General

Equipment Configuration

COM01A.2 The equipment shall be designed with appropriate options to ensure the un-interrupted availability of communications recording (1045).

Note: Options might include the duplication of critical internal units such as electronics modules, power supply units, intermediate and archival storage media drives and the ability to interconnect main and standby recording equipment.

COM01A.3 Where an option to interconnect main and standby equipment is available, an automatic changeover function shall be provided, which operates the main and standby equipment in parallel to ensure continuity of recordings, for an adjustable time period with a recommended minimum of 10 minutes (1046).

Alarm/Status Indications

COM01A.4 The equipment shall provide appropriate local and remote alarm / status indications including an output to indicate the overall operational status of the equipment (1047).

COM01A.5 The remote alarm / status indications shall not be affected by any loss and/or subsequent restoration of electrical power to the equipment (1048).

Note: Urgent and non-urgent alarms may be used to distinguish between problems which require immediate attention, such as failure of the recording equipment, and those which do not, such as an impending recording archival media change.

Time and Date Information

COM01A.6 The equipment shall automatically record time (hours/minutes/seconds) and date (day/month/year) information (1049).

COM01A.7 Co-ordinated Universal Time (UTC) in hours, minutes and seconds of the 24-hour day beginning at midnight shall be used (1050).

COM01A.8 The time shall have an accuracy such that it can be maintained within plus or minus 2 seconds (UTC) (1051), except when data link communications are utilised, when the accuracy shall be plus and minus 1 second (UTC) (1052), within a reasonable period of time and at least for the duration of recording time on a single archival storage media.

COM01A.9 The time shall have a resolution of 1 second (1053).

COM01A.10 Where an external source is used to derive time and date information, the equipment shall incorporate an internal source to be used in the event of failure of the external source or temporary loss of signal from radio time code receivers (1054).

Note: The time and date information may be derived from an internal source or via an external interface with the ATC Unit Master Clock where this exists, another common reference source, or a radio time code receiver utilising terrestrial (e.g. MSF & DCF77) or Global Positioning System signals.

Line Interface

COM01A.11 Line interfaces shall be provided which are compatible with telephone connections made via the Public Switched Telephone Network or private lines (1055).

COM01A.12 Line interfaces shall be provided which are compatible with radio connections made via the Public Switched Telephone Network or private lines to transmitter, receiver and associated control equipment at 2 Wire or 4 Wire level (1056).

Note: Optional modules to provide telephone connection Off-Hook and Ring Detect signals for the contact activation circuits may be incorporated into the line interfaces.

Recording Initiation

Voice Activation

COM01A.13 Voice Activation or Voice Operated Switch (VOX) may be used to initiate recording of telephone signals or other ground-ground communications.

COM01A.14 The sensitivity of the voice activation circuit shall be adjustable (1057).

COM01A.15 An adjustable time delay shall be provided after the voice activation circuit releases before recording stops (1058).

COM01A.16 An adjustable minimum time period shall be provided for the voice activation to prevent spurious responses to noise pulses (1059).

Note: Due to the inherent delay with the voice activation circuit responding to initial syllables of speech and delays due to the mechanical inertia in the magnetic tape transport system of analogue equipment, it is possible that initial syllables of speech may not be recorded. A circuit to buffer the signals to be recorded may be used to reduce this effect.

COM01A.17 The setting of the voice activation sensitivity is more critical for varying input levels, such as radio signals, which may result in communications not being recorded.

COM01A.18 Voice activation is not generally acceptable for radio signals due to these possible effects.

Contact Activation

COM01A.19 Contact activation derived from on/off hook, ring detect or other signalling conditions, may be used to initiate recording of telephone signals or other ground-ground communications.

COM01A.20 Contact activation derived from transmitter push-to-talk (PTT) and receiver squelch or mute lift conditions should be used to initiate recording of radio signals (1060).

Analogue Signal Conditioning

COM01A.21 Options for adjusting or disabling Automatic Gain Control (AGC) for individual inputs should be provided where it is used to compensate for variations in line interface levels (1061).

COM01A.22 Companding (Compression – Expansion) techniques may be used to match the dynamic range of the line interface levels to that of the recording equipment.

Human Machine Interface

Audio Output

COM01A.23 A front panel loudspeaker, volume control and on/off switch shall be provided on the equipment or on a separate remote control panel if this option is provided (1062).

COM01A.24 A front panel standard headphone socket and volume control shall be provided on the equipment or on a separate remote control panel if this option is provided (1063).

Copy Output

COM01A.25 A front panel or easily accessible output connector for making copy recordings shall be provided, which may have a preset output adjustment (1064).

COM01A.26 The output shall comprise one audio channel, which shall be the selected recorded channel, and another audio channel which shall have either a voice synthesised (spoken) time output or tone coded time markers from, or derived from, the time and date information of the original recording (1065).

Security of Recordings

COM01A.27 Techniques shall be used to reduce the possibility of inadvertent erasure of recorded information (1066).

Note: The use of software controlled password, electronic or mechanical keyswitch access or other measures may be appropriate. Where the use of such devices is not feasible, for example with analogue reel to reel magnetic tape recording equipment, the disabling of the recording/erase mechanism may be necessary, which would then require the provision of a separate bulk erase machine. The use of a single action to record without verification or protection should be avoided.

Removable Media

COM01A.28 The recording equipment or systems shall be capable of providing complete, accurate and verifiable copies of the recorded data (see COM 01.76) on removable media (2266). The type of media used and the file format employed must be acceptable for use by the CAA (2267).

COM01A.29 Guidance on the handling and storage of removable media shall be provided, as appropriate, with the equipment documentation (1068).

Replay Functions

COM01A.30 The equipment shall be capable of replaying the original recorded communications on archival media in a continuous 'real time' mode and presenting the time and date information separately from, but synchronised with, the recorded communications (1069).

Note: The capability to replay in a continuous 'real time' mode means that the messages can be replayed continuously without interruption or any manual intervention, with any periods of silence or absence of recorded messages re-inserted.

Analogue Equipment

COM01A.31 Analogue recording equipment is classified as that which records analogue signals in real time directly onto the archival media. Typically magnetic tape reel to reel or cassette transport systems utilising electronic, electrical and mechanical devices are used.

Recording Check

COM01A.32 Devices and/or techniques shall be incorporated to provide a check for successful recording onto archival media (1070).

Note: Magnetic tape transport systems can employ off tape monitoring to establish that successful recording has taken place.

Recording Quality

COM01A.33 When compared with a reference of –10dBm at 1,200 Hz, the amplitude variation from 300 Hz to 3,400 Hz shall not exceed ± 3dB (1071).

COM01A.34 Signal to noise ratio shall be better than 40 dBA (38dB) when the reference signal is replayed (1072).

COM01A.35 Harmonic distortion of the reference signal, replayed at 0dBm, shall not exceed % (1073).

COM01A.36 Crosstalk from adjacent channels shall not exceed 40 dB (1074).

COM01A.37 Wow and Flutter shall not exceed 1% (1075).

Digital Equipment

COM01A.38 Digital recording equipment can be classified as that which encodes and records analogue voice or data communications onto internal storage with the capability to transfer the recorded data into archive storage periodically to achieve the minimum retention criteria or on demand for investigative purposes. Magnetic/optical media or storage drives utilising electronic, electrical or mechanical devices may be used in this process.

Analogue to Digital Conversion

Voice Coding and Decoding (Codec) Techniques

COM01A.39 The recording equipment or system shall employ voice coding techniques which ensure the replay quality of previously archived radio communication messages will achieve a minimum Mean Opinion Score (MOS) of 4.0 (Good) (2268).

COM01A.40 The voice coding scheme shall be able to cope with different types of voice, multiple voices, background noise without any significant deterioration in quality (1077).

COM01A.41 The voice coding scheme should comply with published European or International standards where available (1078).

Note: Voice coding schemes using waveform coding techniques include CCITT G.711 – A/μ-law PCM and CCITT G.726-ADPCM. Codecs using these techniques have been scored in accordance with ITU (T) Recommendation P.862.1. The results obtained from these tests have indicated that the use of codecs which employ either G.711 (at 64 kbit/second) or G.726 (at 32 kbit/second) will meet or exceed the minimum MOS required for the replay of radio communications between ATC and aircraft under their control.

Data Compression

COM01A.42 The amount of data compression applied at the analogue to digital conversion, either as part of the voice coding scheme or as a separate process, shall not significantly degrade the recorded communications (1079).

Note: Based upon trials involving the subjective assessment of data compression of speech for ATC Applications, a minimum MOS of 3.5 is acceptable for the recording and subsequent replay of telephone communications.

Intermediate Storage

COM01A.43 Where an internal storage device is used, the process by which the communications are routinely transferred onto a separate and secure archive storage system, where necessary to meet minimum retention criteria, shall be automatic (not requiring human intervention) (1080) and shall be secure from attempts to select, alter or interfere in any way with the data (1081).

COM01A.44 The information held on the intermediate storage devices shall be transferred to the archive storage system via an appropriate communication system at regular intervals (2269).

COM01A.45 The equipment shall use a safe shutdown mode, in the event of power failure or equipment malfunction, to ensure that intermediate storage data is not lost and that the communications can be replayed normally from the archive storage system (1083).

Archive Storage System

COM01A.46 The equipment shall use a safe shutdown mode, in the event of power failure or equipment malfunction, to ensure that any necessary file management information can be written to the archive storage system, so that the communications can be replayed normally from the archive storage system (1084).

Recording Check

COM01A.47 Devices and/or techniques shall be incorporated to provide a check for successful recording onto the archive storage system (1085).

Note: Read after write verification between the intermediate and archive storage systems can be used.

Recording and Replay Quality

COM01A.48 The voice quality obtained during replay of recorded radio communication between ATC and aircraft under their control shall be equal to or better than the MOS required in COM01.13 (2270).

Note: Manufacturers are encouraged to consult the Recommendations published by the International Telecommunications Union (ITU) as P.862. The technique described in P.862 is an enhanced perceptual quality measurement of voice quality in telecommunications known as PESQ (Perceptual Evaluation of Speech Quality). The PESQ algorithm is protected by patents and was jointly developed by British Telecommunications plc and Royal KPN NV (www.pesq.org).

PESQ provides rapid and repeatable results without the need for the listening panel tests usually needed to establish an MOS.

Several manufacturers are now able to offer test equipment or software based tools capable of determining PESQ but it must be remembered that ATC radio communications usually consist of several brief and rapid exchanges, the quality of which may vary greatly during typical operations. In contrast, the quality of operational telephone conversations that must also be recorded will generally conform to commercial standards.

The latest Recommendation, P.862.1, provides an improved correlation to MOS and in tests conducted using P.862.1, a proprietary codec operating at 8 kbits/second produced consistently better results than a legacy codec operating at 16 kbits/second.

COM 02: VHF Aeronautical Radio Stations

Part 1 Preliminary Material

Introduction

COM02.1 Under the terms of Article 205 of the ANO, any ATS equipment is required to have CAA approval before being established or used in the UK. Under the terms of Article 255 an Aeronautical Radio Station is specifically included in the meaning of ATS Equipment.

Note: The term 'Aeronautical Radio Station' in the definitions contained in the Glossary, is taken to include the terms Aeronautical Station and Aeronautical Mobile Station for the purposes of this document.

Scope

COM02.2 This document sets out the engineering requirements for VHF radio equipment and systems at Aeronautical Radio Stations of the Aeronautical Mobile Service established or used within the UK to provide ATS.

Note: 'Air Traffic Services (ATS)' means the various flight information services, alerting services, air traffic advisory services and ATC services (area, approach and aerodrome control services). One or more of these services may be employed in the En-Route Communications Network, at Area Control Centres, and Aerodromes.

COM02.3 This document applies to fixed, stationary, vehicle, portable and hand held equipment categories comprising transmitter, receiver and transceiver equipment types operating in the VHF Aeronautical Mobile (R) Service allocation 118 MHz to 136.975 MHz, using Double Sideband (DSB) Amplitude Modulation (AM) full carrier with 8.33 kHz or 25kHz channel spacing, intended for analogue voice and data link communications.

Note: In order to further clarify the requirements applicable to Air Ground Communication Services (AGCS) and Radio Communication Services (RCS) reference should be made to the web pages at:

http://www.caa.co.uk/default.aspx?catid=2004&pagetype=90

The precise legal situation with respect to ATS, AGCS and RCS is subject to regulatory developments and the relationship between UK and EU Legislation. Developments will be promulgated to applicants as they occur. Each applicant for approval will receive details of the relevant requirements current at the time of application.

References

1. ICAO Annex 10 Aeronautical Telecommunications Volume III – Communication Systems Part I – Digital Data Communication Systems; Part II – Voice Communication Systems.
2. ICAO Annex 10 Aeronautical Telecommunications Volume V (Aeronautical Radio Frequency Spectrum Utilization).
3. CAA Paper 96006 Co-channel Interference Study (Report prepared by Roke Manor Research Ltd and published by the CAA).
4. EUROCAE ED-67 'Minimum Operational Performance Specification for devices that prevent unintentional or continuous transmissions' April 1991.

Part 2 Requirements

Safety objective

COM02.4 **The equipment and systems at Aeronautical Radio Stations shall provide complete, identified, accurate and uncorrupted voice and data link communications for Air Traffic Services (1002).**

General Requirements

COM02.5 The requirements in this section are applicable to equipment and systems at all ATS Aeronautical Radio Stations operating on Aeronautical Mobile (R) Service frequency assignments.

International Standards

Note: This document incorporates the relevant SARPs from ICAO Annex 10 and Annex 11 together with material from the ITU Radio Regulations.

COM02.6 The equipment, systems, services and facilities shall comply with the applicable international standards, recommended practices and procedures for ANS in Annex 10 and Annex 11 to the Convention on International Civil Aviation (376).

COM02.7 The equipment, systems, services and facilities shall comply with the applicable Radio Regulations of the International Telecommunications Union (377).

Radio Spectrum Management

COM02.8 The equipment and systems shall be designed and constructed to operate within the Aeronautical Mobile (R) Service allocation 117.975 MHz to 137.000 MHz (378). The first and last assignable frequencies being 118.000 MHz and 136.975 MHz. For radiotelephony channel spacing is either 25 kHz or 8.33 kHz using Double Sideband (DSB) Amplitude Modulation (AM) full carrier with ITU emission designator 6K80A3EJN for 25 kHz and 5K00A3EJN for 8.33 kHz channel spacing (379). For data link communications channel spacing is 25 kHz using Double Sideband (DSB) Amplitude Modulation (AM) full carrier with ITU emission designators 13K0A2DAN for ACARS using MSK modulation, 14K0G1D for VDL Mode 2 using D8PSK modulation and 13K0F7D for VDL Mode 4 using GFSK modulation (380).

Note 1: The equipment and systems are only required to be capable of operation in the modes specified by the ANO Approval. However, new equipment may be purchased with options for other modes of operation to cater for future operational requirements.

Note 2: Equipment and systems at specific Aeronautical Stations are required to be capable of operation with a channel spacing of 8.33 kHz to provide an ATC Service.

COM02.9 The equipment and systems shall be installed, operated and maintained in compliance with the terms of specific location dependent or general frequency assignment(s) and the terms and conditions of an ANO Approval granted in respect of the ATS being provided (381).

COM02.10 **Guidance**: The frequency assignments may include parameters such as the DOC, minimum field strength within the DOC, maximum field strength outside the DOC and/or minimum and maximum effective radiated power (ERP). These parameters are designed to support

reliable communications and to reduce the probability of co-channel or adjacent channel interference to other users.

COM02.11 The DOCs associated with the frequency assignments for ATS Communications Facilities and Radio Navigation and Landing Aids at aerodromes, shall be published in the Remarks column of sections AD 2.18 and AD 2.19 of the AIP, respectively (2271).

COM02.12 Frequencies for En-route Navigation Facilities shall have their DOCs published in the AIP section ENR 4.1 under the associated Remarks column (2272).

Note: Aircraft radio transmissions outside of the DOC are a known source of co-channel and adjacent channel interference.

COM02.13 **Recommendation**: The effective radiated power should be such to provide a minimum field strength of 45 dBV/m within the radio service area for Air Traffic Services, or such a minimum field strength or minimum effective radiated power as may be specified by the ANO Approval (383).

[Based on ICAO Annex 10 Aeronautical Telecommunications Volume III § 2.2.1.2. Power and Volume V Attachment A § 2.4]

COM02.14 **Guidance**: The ICAO Annex 10 Volume III §2.2.1.2 recommendation specifies that 'On a high percentage of occasions, the effective radiated power should be such as to provide a field strength of at least 75 V/m (- 109 dBW/m2) within the defined operational coverage of the facility, on the basis of free space propagation.' This field strength has been assumed to be the median (50 percentile) value and to achieve the 'high percentage of occasions' has been adjusted to a 95 percentile value, considered appropriate for Air Traffic Services, by the use of an additional margin of 8dB based on CCIR (ITU) Recommendation 528-2 using the expression [20 log 75 dBV/m + 8 dB]. Further information may be found in reference [3].

WT Act Aeronautical Radio Licence

COM02.15 All Aeronautical Radio Stations shall be suitably licensed under the WT Act prior to any transmissions being made (384).

COM02.16 For new installations that operate on aeronautical frequency assignments, initial applications to establish an Aeronautical Radio Station shall be made to the CAA, which will trigger the process of

issuing a WT Act aeronautical radio licence and ANO Approval for ATS (385).

COM02.17 **Guidance**: The CAA's Directorate of Airspace Policy (DAP) has been appointed by Ofcom as its agent for WT Act aeronautical radio licences.

COM02.18 For established Aeronautical Radio Stations which have ANO Approval, WT Act aeronautical radio licence renewal will be arranged directly between DAP and the service provider.

Note: OFCOM may be contacted at:

OFCOM
Riverside House
2a Southwark Bridge Road
London
SE1 9HA

www.ofcom.org.uk

COM02.19 Failure to renew a WT Act aeronautical radio licence will invalidate the associated ANO Approval. If a Service Provider does not renew their WT Act aeronautical radio licence within a reasonable period of that licence becoming invalid, the associated frequency assignment will be withdrawn. Co-incident with the withdrawal of the frequency assignment the ANO Approval will be withdrawn. Renewal after the withdrawal of the ANO Approval will be treated as a new application, which may lead to delay and Service Provider expense in re-establishing an Aeronautical Radio Station.

Note: All new ATS Aeronautical Radio Stations must have been assessed under the ANO Article 205 by the CAA before a WT Act aeronautical radio licence can be issued.

Inspection of Aeronautical Radio Stations

COM02.20 The equipment and systems at aeronautical radio stations, associated records and WT Act Aeronautical Radio Licence shall be made available for inspection by an authorised person, being a CAA Inspector or an OFCOM Radio Investigation Service Officer (388).

COM02.21 **Guidance**: Demonstration of compliance with the terms and conditions of the ANO Approval and WT Act Aeronautical Radio Licence may be required. This may include measurements to verify transmitter frequency, modulation depth, transmitter output power

and a determination of effective radiated power. The ATS Provider responsible for the operation of the Aeronautical Radio Station would normally be expected to provide calibrated measurement equipment for this purpose.

Note: Where the transmitter output power is not adjustable, and is at a level which may result in the effective radiated power permitted by the ANO Approval being exceeded, a means for reducing the power will be required to be fitted prior to operation of the equipment.

Maintenance of Aeronautical Radio Stations

COM02.22 Maintenance arrangements shall be established for equipment and systems at Aeronautical Radio Stations associated with the provision of ATC Services (390).

Note: Further information is contained in Part B, Section 1 APP 02.

COM02.23 Maintenance procedures shall be established for equipment and systems at Aeronautical Radio Stations associated with the provision of FIS and AGCS. Appropriate actions shall be taken to ensure the continued compliance with the WT Act Aeronautical Radio Licence, ANO Approval and other applicable standards or requirements (391).

COM02.24 **Recommendation**: Regular functional and performance checks, including measurements to verify transmitter frequency, modulation depth, output power and a determination of effective radiated power using calibrated measurement equipment, should be undertaken (392).

COM02.25 A record of any functional test, flight checks and particulars of any maintenance, repair, overhaul, replacement or modification shall be kept in respect of the equipment and systems at Aeronautical Radio Stations, as required under ANO Article 206 (1) in accordance with Part A of Schedule 11 (1006) and the records shall be preserved for a period of one year or longer as directed by the CAA (393).

Specific Requirements

Communications Availability

COM02.26 Adequate safety assurance, risk assessment and mitigation shall be performed by the Service Provider to ensure that the equipment and system design, installation, operation and maintenance ensures availability of communications appropriate for the Air Traffic Services and environment in which it is being provided (394).

COM02.27 **Guidance**: The availability of communications is dependent on the radio system design, including equipment configuration and power supply arrangements. The selection of equipment with the appropriate duty cycle can also reduce equipment failure. The provision of alarm/status indications is also important in ensuring that appropriate actions are taken to restore communications when a failure occurs.

Radio System Design

COM02.28 Communications of a specified quality of service shall be provided within the radio service area appropriate to the services being provided (395).

COM02.29 The maximum field strength outside the DOC, as specified in the frequency assignment, shall not be exceeded (396).

COM02.30 **Acceptable Means of Compliance**: Evidence to demonstrate that the defined quality of service and any other conditions associated with the frequency assignment have been met within the radio service area.

COM02.31 For communications in support of ATC and Traffic/Deconfliction/ Procedural Services, a combination of radio service area predictions and functional tests would be acceptable. For other ATS-limited functional tests would be acceptable.

COM02.32 **Guidance**: Quality of service comprises the two aspects of signal (voice or data) quality and availability. Signal quality can be defined by signal to noise ratio or SINAD for analogue systems and by bit error ratio for digital systems. The availability can be defined in terms of a percentage of time and location.

COM02.33 Where co-channel and adjacent channel interference are the limiting factors, signal quality is directly related to the desired-to-undesired (D/U) signal ratio criteria used in the frequency assignment planning

process, the results of which give a minimum field strength within the DOC which should be achieved and a maximum field strength outside the DOC which must not be exceeded. The signal quality at the receiver can be affected by local noise and interference effects such as man-made noise and precipitation static.

Note: Radio system design includes the consideration of location dependent factors such as a clear radio line of sight, location of antenna, antenna type and transmitter power etc. to ensure reliable radio propagation paths are achieved.

COM02.34 **Recommendation**: The Radio Service Area should be published to provide aviation users with information on the anticipated service volume within which reliable communications may be expected (397).

Note: Where the communications quality of service cannot easily be achieved uniformly over the service volume at the lower height limit of the Radio Service Area, an alternative is to publish the DOC and to identify areas within which the quality of service is not achieved.

COM02.35 The antennas shall be installed such as to provide vertically polarised radiation (398).

Equipment Configuration

COM02.36 The equipment configuration shall be such as to ensure the availability of communications appropriate to the service being provided (399).

Note: The configuration of equipment includes associated antennas, cables, filters, commutation units and other equipment necessary for the operation of the equipment and systems.

Acceptable Means of Compliance:

Air Traffic Control Services – The provision of main and emergency equipment.

UK Flight Information Services:

Deconfliction and Procedural Service – The provision of main and emergency equipment.

Traffic Service – The provision of main equipment only.

Basic Service – The provision of main equipment only.

Aerodrome FIS (AFIS) – The provision of main equipment only.

Note 1: Equipment provided in addition to the above would be considered to be 'Contingency Equipment', formerly known as 'standby equipment', which is installed for business continuity purposes.

Note 2: Wherever a service is provided using main equipment only, it shall be explicitly shown how the risks of ATS radiotelephony failure have been adequately mitigated, taking account of: the local airspace environment, specific ATS task, aircraft characteristics and needs and flight crew procedures. Where appropriate mitigation cannot be demonstrated, it is expected that emergency radiotelephony equipment and/or additional contingency equipment will be provided.

Note 3: It shall also be clearly demonstrated how services will be managed during periods of planned withdrawal of single systems to provide for such things as periodic maintenance.

COM02.37 The equipment type shall be appropriate for the service being provided and be compatible with the equipment configuration (400).

COM02.38 **Guidance**: Whilst it is feasible to use transceivers and separate receivers to derive Off-Air Sidetone for ATC and the output for Voice Recording, the lack of redundancy in the modules within typical transceivers and the likelihood of an intermittent duty cycle restriction on the transmitter and power supply mean that transceivers are not generally suitable for use in ATC Services as main or contingency equipment, although they may be suitable for emergency equipment in particular situations.

COM02.39 For AFIS, a transceiver or separate transmitter and receiver are considered suitable as main equipment, with a hand held or portable transceiver being used for emergency equipment.

Note: Main and contingency equipment may be operated as 'System A' and 'System B' where either may be considered as Main whilst in operational service and the other is considered as contingency, awaiting selection in the event of failure of the Main equipment or when the Main equipment is taken out of service for maintenance.

COM02.40 The planned temporary or permanent simultaneous withdrawal of main and emergency radiotelephony equipment shall be considered a significant safety related change to current operations and the

requirements of CAP 670 Part B, Section 1 APP 01 covering safety assurance and CAP 670 Part A paragraph A88 Change Notification Requirements shall apply.

Duty Cycle – Radio Transmitters/Power Supply Units

COM02.41 The duty cycle for Radio Transmitters and associated Power Supply Units shall be appropriate for the service being provided (401).

COM02.42 **Guidance**: ATC and Traffic/Deconfliction/Procedural Services are likely to generate peaks in use which may exceed the duty cycle of equipment rated for intermittent use and thus continuously rated equipment with a duty cycle of 100% is likely to be required. VHF Radio Transmitters used for ATIS and VOLMET obviously require continuously rated equipment.

Power Supply

COM02.43 The power supply for emergency equipment shall be independent of that for the main equipment (402).

COM02.44 **Acceptable Means of Compliance**: The independence of the power supplies need only be for a known limited period provided that the MATS Part 2 procedures manage the safety issues this introduces.

COM02.45 Users shall be provided with an indication of failure of the power supply to the emergency equipment (403) and instructions shall be provided in MATS Part 2 for user actions in the event of failure (404).

COM02.46 **Recommendation**: For an ATC and Traffic/Deconfliction/Procedural Service a primary and alternative power supply should be provided to increase the availability of power to equipment and systems in the event of an interruption to one of the power supplies (405). Change over between supplies should be on a 'no break' basis (406). The primary and alternative supplies should be independent of each other for a known period of time (407). An indication of failure for each power supply should be provided to the user (408) and corrective action taken in the event of failure (409). MATS Part 2 procedures should instruct the user of actions necessary in the event of failure (410).

[ICAO Annex 10 Aeronautical Telecommunications Volume I Paragraph 2.9 Secondary power supply for radio navigation aids and communication systems.]

COM02.47 **Guidance**: The incorporation of suitable conditioning devices as part of the power supply arrangements may be useful in preventing equipment malfunction due to surges, spikes and noise on the power supply.

Alarm/Status Indications

COM02.48 For an ATC and Traffic/Deconfliction/Procedural Service, the system shall provide an indication of system failure that may have an effect on the service being provided, in a timely manner (411), so that actions can be taken to ensure the safe continued provision, or if necessary, the controlled withdrawal of the service (412).

COM02.49 **Recommendation**: The Significance to the user of the indication of failure should be obvious from the indication given (413).

COM02.50 The failure indication should remain obvious to the user whilst the condition causing the failure indication remains (414). Consideration should be given to providing a power supply to the alarm indication that is not dependent upon the system it is monitoring (415).

COM02.51 Changes in the System's state should attract the operator's attention, without continuing to distract once they are aware of the change of state (416). Attention should be drawn both when failures are detected and when they clear (417). Attention to subsequent status changes should not be masked (418). The attention seeking indication should have both visual and audible elements and the ability for the user to acknowledge that they are aware of the change of state thereby removing the attention seeking element (419).

Interface to Voice/Data Recording Equipment

COM02.52 The system at Aeronautical Radio Stations shall provide all the necessary signals and information to the Voice/Data Recording Equipment in compliance with Article 206 of the ANO (420).

COM02.53 **Acceptable Means of Compliance**: For Aeronautical Radio Stations using a separate transmitter and receiver, the receiver audio output may be used as the signal source for the recording equipment. For Aeronautical Radio Stations using a transceiver, a separate receiver on the same frequency will be required.

COM02.54 **Guidance**: Where a separate transmitter and receiver are used, an 'off-air' sidetone will be present at the audio output of the receiver when the associated transmitter is operated.

COM02.55 Where a transceiver is used, the receiver is normally muted in transmit mode, and sidetone is not present at the audio output. A separate receiver and antenna can be used to derive an 'off-air' sidetone.

COM02.56 If a separate receiver is used to record aircraft station transmissions, the antenna and receiver combination must provide a signal comparable in strength and reception area to that of the main antenna and transceiver.

Provision of Off-air Sidetone

Note: Reference should be made to Part C, Section 1 COM 03 Voice Communications Control Systems.

COM02.57 Where Off-air sidetone is provided for ATS, it shall be a replica of the transmitted voice communications without any degradation of quality such as to cause annoyance or disturbance to the operator (421).

Note: The Acceptable Means of Compliance and Guidance in COM02.52 can be applied as appropriate to the provision of Off-air Sidetone.

Provision of Emergency Frequency 121.500 MHz

COM02.58 The emergency frequency 121.500 MHz shall be provided at area control centres, aerodrome control towers and approach control offices serving international aerodromes and international alternative aerodromes (422).

Note: The aerodromes listed in the table in the AIP GEN 1.2 Appendix C are deemed to meet the criteria for International Airports in ICAO Annex 9 Facilitation.

COM02.59 **Acceptable Means of Compliance**: The equipment configuration shall be consistent with that for ATC Services and shall, as a minimum, comprise of a main transmitter and receiver with emergency equipment providing redundancy, together with system and location dependent redundancy measures.

COM02.60 The coverage provided by the equipment, both main and emergency, should be capable of achieving coverage within the greatest designated operational coverage at the particular unit.

COM02.61 121.500 MHz is an ATS frequency and as such shall be subject to off-air recording.

COM02.62 Guarding/monitoring of 121.500 MHz shall be achieved by means identified in a unit's MATS Part 2 (2255).

COM02.63 Should a unit have an approved arrangement in place whereby guarding is undertaken on its behalf by another unit or facility, then the relevant safety case shall be considered adequate if that guarding can be achieved down to aerodrome circuit altitude. Appropriate written agreements shall be put in place.

Note: Attention is drawn to the CAA Statement on 'Provision and Support of Frequency 121.500 MHz for the Purposes of Supplying an Emergency Aid and Position Fixing Service'. The Policy Statement is available from the CAA website at the following link: http://www.caa.co.uk/docs/33/DAP_ProvisionAndSupportOfFrequency121.pdf

Unintentional or Continuous Transmissions

Note: Reference should be made to Part C, Section 1 COM 03 Voice Communications Control Systems.

COM02.64 The equipment and systems at Aeronautical Radio Stations shall not fail in a manner such as to cause unintentional or continuous transmissions (423).

COM02.65 **Recommendation**: New equipment and systems at Aeronautical Radio Stations should incorporate features to prevent unintentional or continuous transmissions, unless this is contrary to the intended purpose for which they have been designed (424). For existing equipment and systems, consideration should be given to incorporating such devices by retrofit, modification or add-on circuitry where appropriate (425).

COM02.66 The equipment and systems should conform to the 'Minimum Operational Performance Specification for devices that prevent unintentional or continuous transmissions' EUROCAE document ED-67 April 1991 [4], so far as it is appropriate for ground based systems (426).

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COM 03: Voice Communications Control Systems

Part 1 Preliminary Material

Introduction

COM03.1 Under the terms of Article 205 (1) of the ANO, any ATS Equipment is required to have CAA approval before being established or used in the UK.

COM03.2 This document covers Voice Communications Control Systems (VCCS) providing communications facilities for the following categories of service described in ICAO Annex 11 Chapter 6 'Air Traffic Services Requirements for Communications':

- 'The Aeronautical Mobile Service (Air-Ground Communications) which uses radiotelephony and/or digital data interchange for radio communications in the VHF Aeronautical Mobile Band'.
- 'The Aeronautical Fixed Service (Ground-Ground Communications) which uses direct-speech communications and/or digital data interchange over radio communications links and other telecommunications media such as optical fibre and land lines'.
- 'The Surface Movement Control Service which uses two-way radiotelephony communications to provide an aerodrome control service for the control of vehicles on manoeuvring areas, except where communication by a system of visual signals is deemed to be adequate'.

COM03.3 The structure of this document has been arranged to consider these services under the broad heading of 'COMMUNICATIONS FACILITIES'. The Aeronautical Mobile Service and the Surface Movement Control Service are normally provided using radio communications and will be referred to by the description 'radiotelephony communications' abbreviated to 'RTF communications'. The Aeronautical Fixed Service incorporating telephone and interposition communications (Intercom) will be referred to by the description 'Ground-Ground Communications'. The term 'lines of communication' covers both 'RTF communications' and 'Ground-Ground Communications'.

Scope

COM03.4 This document sets out the engineering requirements for VCCS communications facilities established or used at locations within the United Kingdom providing Air Traffic Services.

References

1. ICAO Annex 11 — Air Traffic Services.
2. ICAO Annex 10 Aeronautical Telecommunications Volume III – Communication Systems Part I – Digital Data Communication Systems; Part II – Voice Communication Systems.

Part 2 Requirements

Safety Objective

COM03.5 **The VCCS shall enable direct, rapid, continuous and intelligible two-way voice communications for Air Traffic Services (1087).**

General Requirements

International Standards

COM03.6 The equipment, systems, services and facilities shall comply with the applicable international standards, recommended practices and procedures for air navigation services in Annex 10 [2] and Annex 11 [1] to the Convention on International Civil Aviation (1088).

Communications Facilities

General

COM03.7 The operator shall have clear visual and audible indication of the status of all available lines of communication (1090).

COM03.8 The operator shall have the ability to select or deselect independently lines of communication or facilities in any combination, without affecting the operation of other lines of communication or facilities available at that or any other position (1091).

COM03.9 Where the system configuration can be changed, a means of quickly restoring the last set option configuration before any failure shall be provided (1092).

COM03.10 **Recommendation**: Operator workload should be reduced to a minimum by implementing functions with single keypress operation where practicable (1093).

COM03.11 Headsets shall be provided except at units with very low density operations where loudspeaker and free-standing microphone (i.e. no headset capability) may be authorised (1094).

COM03.12 **Recommendation**: Loudspeaker and headset earphone volume should be audible at the operating position when set to their minimum level (1095).

Note: The air-ground communications may be switchable between headset and loudspeaker as traffic conditions dictate.

COM03.13 **Recommendation**: Headsets are the preferred audio interface equipment and should be configured to operate in split mode (1096).

Note 1: Split headset mode implies the following:

RTF Communications only – Transmissions heard in both earpieces.
RTF Communications and Ground-Ground Communications – RTF transmissions heard in one earpiece and Ground-Ground Communications heard in the other earpiece. When the operator makes an RTF Communications transmission sidetone is heard in both earpieces.

Note 2: Handsets, desk or hand microphone may be used in combination with the desk loudspeaker where the ambient noise or traffic levels permit such operations.

COM03.14 Operating positions shall have a loudspeaker which will allow selected lines of communication to be monitored (1097).

COM03.15 **Recommendation**: Operating positions should have provision for the connection of a number of headsets enabling instructor/student, dual operator and supervisor monitoring facilities (1098).

COM03.16 The instructor/student facility, where provided, shall enable direct communications via headsets (1099).

COM03.17 The instructor/student facility, where provided, shall enable the instructor to interrupt any student communications at any time (1100).

Note: The instructor/student interrupt may be achieved by use of a dedicated instructor PTT Press-To-Talk control incorporating separate switches for RTF Communications and Ground-Ground Communications.

COM03.18 Operating positions shall have provision for at least two momentary action PTT controls, one of which shall permit 'hands-free' operation (1101). The controls shall be used to control RTF Communications transmissions (1102).

Note: Typical PTT controls may be panel mounted switches, headset in-line switches, foot switches, switches incorporated into desk or handheld microphones and handsets.

COM03.19 The audio level of each audio outlet shall be independently adjustable (1103) and any communications shall still remain audible and intelligible to the operator when the minimum level is selected (1104).

COM03.20 Separate controls for the audio level of RTF Communications and Ground-Ground Communications shall be provided with the setting in use being apparent to the operator (1105).

COM03.21 The return path of each communication function shall incorporate an automatic gain control (AGC) function to ensure an acceptable signal to noise level and to minimise the possibility of hearing damage (acoustic shock) by preventing extremely loud signals from being delivered into the ATC headset (1106).

Note: A signal gain path memory or similar feature can prevent distortion of the initial syllables of speech at the beginning of each received message or after pauses in speech. The principle of operation is that the last dynamic gain or attenuation setting is retained for future use.

COM03.22 **Recommendation**: The presence of two or more AGC devices in a signal path could degrade the received audio signal and only one single AGC device or function should therefore be employed in each signal path (1107).

COM03.23 The design and implementation of the voice switch shall be such that any input can be connected to any output without the possibility of blocking occurring (1108).

COM03.24 Where a system provides the capability for instant replay of communications this shall not be made available at operational positions. Where it is not possible to disable the feature its use shall be disallowed by local procedures.

RTF Communications

Note: Reference should be made to Part C, Section 1 COM 02 'VHF Aeronautical Radio Stations' and Part C Section 1 COM 06 'UHF Radio Equipment and Systems' (1109).

COM03.25 Air-ground Communications on appropriate frequencies shall be provided (1110).

COM03.26 Two-way radiotelephony communication facilities shall be provided for aerodrome (surface movement) control service for the purpose of controlling vehicles on the manoeuvring area, except where communication by a system of visual signals is deemed to be adequate (1111).

Note: This communication facility is normally provided by UHF radio equipment and systems but the use of VHF Aeronautical Mobile Service frequencies may be permitted for ground to ground communications in specific circumstances.

COM03.27 **Recommendation**: Where conditions warrant, separate communication channels should be provided for the control of vehicles on the manoeuvring area (1112).

COM03.28 **Recommendation**: VHF air-ground communications should be cross-coupled to UHF two-way radiotelephony communications for vehicles operating on the active runway (1113).

Note: Cross-coupling between the VHF air-ground communications used for the control of aircraft and the UHF two-way radiotelephony communications used for the control of vehicles provides situational awareness for the aircrew, controller and operator of the vehicle. The vehicle operator is aware of any aircraft transmissions by monitoring the cross-coupled VHF Air-Ground Communications and has direct two-way radiotelephony communications with the controller. In some cases the transmissions from vehicles are re-transmitted to

aircraft. As separate transmit and receive frequencies are used at UHF between the base station and vehicles, talkthrough facilities may be used to enable vehicles to hear one another.

COM03.29 RTF communications which have been selected shall always be available irrespective of the state of other lines of communication (1114).

COM03.30 The operator shall be provided with a degree of assurance that Air-Ground Communications transmissions have been successful (1115).

Note: The normally accepted method of implementing this is to provide off-air sidetone to the operator's headset derived from either the radio receiver associated with the transmitter for that radio channel, or from a separate receiver. It is recognised that the future widespread implementation of digital telecommunications systems may mean that off-air sidetone cannot be implemented in all situations, in which case alternative ways of indicating the successful transmissions may be used.

COM03.31 **Recommendation**: The operator should be provided with a degree of assurance that two-way radiotelephony communications for the control of vehicles on the manoeuvring area transmissions have been successful (1116).

Note: The normally accepted method of implementing this is to provide off-air sidetone to the operator's headset. Where UHF Radio Equipment and Systems are used, it may be necessary to provide a separate receiver in addition to the base station receiver, in order to derive the off-air sidetone signal for both directions of transmission.

COM03.32 The operator shall be provided with the facility to select more than one air-ground communications frequency simultaneously (1117). When the PTT control is operated communications shall be transmitted on all selected frequencies to aircraft (1118). When the PTT is released the operator shall be provided with the combined audio signals from all selected frequencies (1119).

Note: The operator will normally be provided with off-air sidetone derived from a combination of all the received audio signals from all selected frequencies. It is recognised that the operator is unlikely to be able to determine whether transmissions on each and every selected frequency have been successful; alternative ways of indicating the successful transmissions may be required. It is also acknowledged that the combination of the received audio signals

may result in distortion of the overall off-air sidetone. Particular attention may be required in the design and implementation.

COM03.33 **Recommendation**: When two or more ATS frequencies are being used by a controller, consideration should be given to providing facilities to allow ATS and aircraft transmissions on any of the frequencies to be simultaneously retransmitted on the other frequencies in use thus permitting aircraft stations within range to hear all transmissions to and from the controller (1120).

Note: The operator will normally be provided with off-air sidetone derived from only one of the received audio signals. This may be arranged such that the signal paths utilise all the cross-coupled transmit and receive communications channels selected.

COM03.34 The operator shall be provided with the facility to select the state of any available radio channel and an appropriate visual/aural indication shall be given to indicate the selection made (1121).

Note: Typical states normally found:

- Channel off.
- Channel receive only.
- Channel transmit and receive.
- Selection of duplicated transmitters and/or receivers.
- Selection of Cross-coupling.

COM03.35 The operator shall be provided with a visual/aural indication of the status of available radio channels (1122).

Note: Typical status reports normally found:

- Aircraft or vehicle call/receiver mute lift.
- PTT operation.

COM03.36 The delay between operating the PTT control and the appropriate electrical or electronic signal being present at the interface with the VCCS shall be as low as practical (1123).

Note: A delay of 20ms or less should be achievable.

COM03.37 The delay between receiving the appropriate electrical or electronic signal at the interface with the VCCS and the activation of any

electrical or electronic device, visual or aural indication shall be as low as practical (1124).

Note: A delay of 20ms or less should be achievable.

COM03.38 When Air-Ground Communications transmissions to aircraft are in progress, Ground-Ground Communications also in progress at the same time shall not be transmitted to the aircraft (1125). An indication shall be given to the other party that Air-Ground Communications are in progress and this may be achieved by relaying the operators' speech (1126).

COM03.39 The VCCS shall not fail in a manner such as to cause unintentional or continuous transmissions (1127).

Note: The equipment and systems should conform to the 'Minimum Operational Performance Specification for devices that prevent unintentional or continuous transmissions' EUROCAE document ED-67 April 1991, so far as it is appropriate for ground based systems.

COM03.40 Anti-Blocking Systems (ABS) – Providers must ensure that the installation and operation of such a system will not be detrimental to the integrity or reliability of the communications system (1128). An isolating switch must be provided at the ATC operating position which will effectively remove the ABS from the RTF system (1129). ABS must not be fitted to an emergency RTF system (1130). The received audio volume to the controller must not be affected by the addition of the ABS (1131).

Note: An ABS prevents transmissions when the associated receiver is in use. The CAA does not currently propose to make installation of ABS a requirement or a recommendation for ATC units.

COM03.41 Comprehensive training shall be provided to both Air Traffic Engineers and Air Traffic Controllers on the possible effects of failures within a communications system which has an ABS fitted (1132). MATS Part 2 and Engineering Instructions are to include this information (1133).

COM03.42 There shall be a visual or other indication to the controller that an ABS system is selected for use (1134).

COM03.43 **Recommendation**: There should be a visual indication to the controller that the ABS is inhibiting controller transmission (1135).

COM03.44 **Recommendation**: The duration of a transmission inhibited by an ABS should be detectable on the associated voice recording (1136).

Ground-Ground Communications

COM03.45 The Provider shall satisfy the CAA that the Aeronautical Fixed Services equipment is adequate for the task for which it is to be used (1137). Among other things, consideration shall be given to reliability, integrity, levels of redundancy, hours of service, classification of airspace and complexity of traffic (1138).

COM03.46 Ground-Ground Communications shall be provided for the telecommunications services required by the ATC unit (1139).

COM03.47 There shall be provision for direct and immediate broadcast and break-in interposition communications (intercom) between supervisors/operators at different positions which shall be possible irrespective of the state of other lines of communication (1140).

Note 1: A broadcast call is used between one position and all others, whereas a break-in call is only between two positions.

Note 2: In some cases it may be necessary to provide an indication of the receipt of an intercom call and to identify the operating position from which the call originated.

COM03.48 Intercom communications shall not be transmitted on any RTF frequency or Ground-Ground Communications (1141).

COM03.49 An adequate number of connection(s) to the public telephone system must be provided (1142).

COM03.50 Other Aeronautical Fixed Services are to be provided as appropriate (1143).

Note 1: They may include a means of communicating:

- Between operational positions within the unit.
- Directly with adjacent ATS units including the parent Area Control Centre.

Note 2: In certain circumstances an automated dialling system may satisfy the requirements. Maximum connection times may be specified by the CAA.

Note 3: The provision of Aeronautical Fixed Services directly into the headsets may be required by the CAA.

COM03.51 Operating positions shall have provision for connection to the Public Switched Telephone Network (1144).

COM03.52 **Recommendation**: In order to achieve a high availability of communications, the Telecommunications Network access should be duplicated and routing/operator diversity used as appropriate (1145).

Note: Access to Telecommunications Network Operators is essential to the implementation of a Ground-Ground Communications network required for the operation of an ATC Unit. Access may be via the Public Switched Telephone Network or via private lines and networks.

COM03.53 **Recommendation**: Where mobile, cellular or personal communications networks are used to fulfil the requirement to access the Public Telecommunications Network, the availability under conditions of congestion should be considered and a priority access facility arranged with the network operator (1146).

Note: The method of access to a Telecommunications Network Operator is not limited to landline connections and may be by means of optical fibre, microwave radio or by mobile cellular or personal communications networks.

Interface to Voice/Data Recording Equipment

COM03.54 The VCCS shall provide all the necessary signals and information to the Voice/Data Recording Equipment in compliance with Article 206 of the ANO (1147).

System Performance

COM03.55 The clarity and volume of communications is to be 'readable' or 'perfectly readable' (see CAP 493 MATS Part 1) (1148).

Voice Transmission Quality – Radio Transmissions

COM03.56 The voice transmission quality of those communications facilities that utilise radio transmissions, the Aeronautical Mobile Service and the Surface Movement Control Service, shall meet or exceed a quality defined by the following:

1. The frequency response shall be such that the gain at any frequency between 300Hz and 3.4 kHz shall be within ± 3dB of the gain at 1kHz (1149).

2. The Total Harmonic Distortion (THD) shall not exceed 2% at any frequency between 300Hz and 3.4 kHz with any gain controls adjusted to give the maximum permitted audio level at the headset or handset (1150).

3. Residual noise and hum on any correctly terminated idle voice circuit shall not exceed -60dBm (1151).

Note 1: The minimum voice channel audio frequency bandwidth for Air-Ground Communications using VHF Aeronautical Mobile radio frequencies has been determined as 400 Hz to 2.7 kHz for 25 kHz channel spacing.

Note 2: The voice transmission quality requirements apply to the voice channel only and do not include microphone and headset characteristics.

Voice Transmission Quality – Non-Radio Transmissions

COM03.57 The voice transmission quality of non-radio transmissions shall meet or exceed those requirements as may be defined in standards for systems which are connected to the Public Switched Telephone Network (1152).

COM03.58 In the absence of any such standards referred to in 7.3.1, the following shall be met:

1. The frequency response shall be such that the gain at any frequency between 300Hz and 3.4 kHz shall be within ± 3dB of the gain at 1kHz (1153).

2. The Total Harmonic Distortion (THD) shall not exceed 2% at any frequency between 300Hz and 3.4 kHz with any gain controls adjusted to give the maximum permitted audio level at the headset or handset (1154).

3. The Crosstalk level on any voice circuit shall not exceed -60dBm when a 1kHz tone is injected into any other circuit at a level of 10dB above nominal test tone level, with all voice circuits correctly terminated (1155).

4. Residual noise and hum on any correctly terminated idle voice circuit shall not exceed -60dBm (1156).

Note: The voice transmission quality requirements apply to the voice channel only and do not include microphone and headset characteristics.

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COM 04: ATC Datalinks

Part 1 Preliminary Material

Introduction

COM04.1 Datalink applications have been available globally for Aircraft Operations Control (AOC) and Aircraft Administrative Control (AAC) functions for many years. The networks, systems and applications providing this functionality are well established, and aircraft equipage is widespread. Since the mid 1990s the systems and networks designed for this function have been expanded to provide limited ATC applications.

COM04.2 Datalink technology is intended to provide enhancements to the processes used within the provision of ATS. In its most simplistic form, the radio communications between ATC and aircraft could be accomplished by digital data transmission using datalink. However the provision of datalink facilities may give rise to significant benefits in the following areas[1]:

- Capacity
- Range
- Reliability
- Speed
- Security

Scope

COM04.3 This document applies to the use of datalink technologies and applications for 'low risk' ATM functions (i.e. those which are not critical in terms of safety and/or time). It is applicable to both Aeronautical Fixed Services and Aeronautical Radio Stations.

1 The benefits listed here are only some of those which have been identified by EUROCONTROL ODIAC Task Force in the EATCHIP Transition Guidelines for Initial Air/Ground Data Communications Services, EUROCAE WG-45 Data Link Applications ED-78, ED-85, ED-89, ED-106, EUROCAE WG-53/RTCA SC-189 Air Traffic Services ED-100 and ICAO Manual of Air Traffic Services Data Links Applications (Doc 9694).

COM04.4 This document covers the use of private networks, such as those provided by ARINC and SITA.

COM04.5 The use of datalink technology for applications other than those detailed within this document will either be the subject of an amendment to this document or a new CAP670 requirement.

Part 2 Safety Requirements

Safety Objective

COM04.6 **To ensure that the level of safety of the ATM function is maintained or improved during installation, transition and operation of datalink equipment, applications and procedures (1003).**

Requirements

COM04.7 A comprehensive safety assessment of the datalink application/system and its interfaces with existing ATC equipment, people and procedures shall be performed and submitted as part of the approvals process (371).

COM04.8 The Safety Assessment for a datalink application/system shall be provided by full and complete adherence to the ATS provider's SMS, if this exists (372).

COM04.9 Provided the Safety Assessment concludes that the datalink system/application is at least tolerably safe, then the use of private datalink networks, which may pre-date the ICAO SARPs, shall be permitted for the following categories[2] of communications messages:

- Meteorological Communications
- Flight Regularity Communications
- Aeronautical Information Service Messages
- Network/Systems Administration (374)

2 These message categories are referenced in the ICAO Manual of Air Traffic Services Data Links Applications (Doc 9694) and the ICAO Manual of Technical Provisions for the Aeronautical Telecommunications Network (ATN) (Doc 9705)

COM04.10 Communications in categories assigned a higher priority than those listed above may be permitted if the ATS provider supplies the CAA with evidence, in addition to the Safety Assessment, proving that:

- The application is not time critical

  and

- Procedures exist for ensuring that the failure of datalink systems has no long term, short term, or immediate effect on the ability of the aircraft or ATSU to complete the communication at an appropriate time (375).

Note: The message categories are referenced in the ICAO Manual of Air Traffic Services Data Links Applications (DOC 9694) and the ICAO Manual of Technical Provisions for the Aeronautical Telecommunications Network (ATN) (DOC 9705).

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Appendix A to COM 04: Acceptable Means of Compliance

Operational Requirements

COM04A.1 The datalink application/system should be demonstrably compliant with its Operational Requirement (OR), produced by the ATS Provider (1157). This OR should form the basis for the collection of evidence that the stable implementation of the application/system is suitable for operational service (1158).

COM04A.2 The OR should include performance and safety requirements pertinent to the application/system concerned (1159).

COM04A.3 The OR should specifically reference any security needs pertinent to the application/system concerned (1160).

Compatibility

COM04A.4 Any datalink system supporting existing functionality should be backwards compatible with any existing ATC methods, procedures and equipment which currently provides all or part of the service for which it is designed (1161).

COM04A.5 Any incompatibilities should be identified, and an impact assessment performed on the ability of the revised systems and procedures to meet the OR of all ATSUs using the datalink system/application (1162).

COM04A.6 The datalink system should be compatible with all levels of aircraft equipment normally expected to be present in the ATSU's operational area of interest (1163).

Guidance

COM04A.7 Guidance on the implementation of datalink applications is available from various national and international bodies. On an application specific basis these documents may be used as part of an acceptable means of compliance. Examples of such documentation are as follows:

EUROCAE	Data-Link Application System Document (DLASD) for the "Departure Clearance" Data-Link Service ED-85A December 2003
EUROCAE	Data-Link Application System Document (DLASD) for the "ATIS" Data-Link Service ED-89A December 2003
EUROCAE	Data-Link Application System Document (DLASD) for the "Oceanic Clearance" Data-Link Service ED-106A March 2004
EUROCAE	Guidance Material for the Establishment of Data Link Supported ATS Services ED-78A December 2000
EUROCAE/ RTCA	Interoperability Requirements for ATS Applications using ARINC 622 Data Communications ED-100A April 2005
ICAO	Manual of Air Traffic Services Data Link Applications Doc 9694

COM 05: Automatic Terminal Information Service (ATIS)

Part 1 Preliminary Material

Introduction

COM05.1 Under the terms of Article 205 (1) of the ANO, any ATS Equipment is required to have CAA approval before being established or used in the UK.

COM05.2 The purpose of an Automatic Terminal Information Service (ATIS) is to reduce ATC workload by the use of a means other than the controller's VHF air-ground communications frequency to convey current and routine meteorological and aerodrome information to aircraft.

COM05.3 ATIS may be implemented by Voice-ATIS or data link (D-ATIS). An aerodrome Voice-ATIS may be provided by an ATS Provider, using either a dedicated VHF transmitter or a CVOR/DVOR transmitter. A D-ATIS may be provided by an ATS Provider, in conjunction with a data link communication Service Provider, using a VHF ground station network or by satellite.

Scope

COM05.4 This document sets out the engineering requirements for Voice-ATIS and D-ATIS used within the UK in support of an ATC Service.

COM05.5 For the purpose of this document, ATIS is only considered to include the collation of meteorological and aerodrome data, the preparation of messages and the transmission of the messages.

COM05.6 The UK Meteorological Authority is responsible for the regulation of meteorological services to aviation. The use and processing of meteorological information within an ATS unit is subject to regulation by the CAA. Further information about the regulatory arrangements for meteorological equipment and services can be found in Part C, Section 4, MET and CAP 746 Meteorological Observations at Aerodromes.

COM05.7 The origination of meteorological reports and other related information is regulated by the UK Meteorological Authority. Automatic Terminal Information Service (ATIS) equipment and the content of ATIS broadcast messages are regulated by the CAA.

References

1. ICAO Annex 11 — Air Traffic Services.
2. ICAO Annex 10 Aeronautical Telecommunications Volume III – Communication Systems Part I – Digital Data Communication Systems; Part II – Voice Communication Systems.
3. ICAO Annex 3 — Meteorological Service for International Air Navigation.
4. ICAO Procedures for Air Navigation Services — Air Traffic Management (Doc 4444-ATM/501).
5. ICAO Manual of Air Traffic Services Data Link Applications (Doc 9694).
6. CAP 746, Meteorological Observations at Aerodromes.

Part 2 Requirements

Safety Objective

COM05.8 **The Automatic Terminal Information Service (ATIS) equipment and systems shall provide complete, identified, accurate and uncorrupted voice/data communication of meteorological and other aeronautical information (1004).**

General Requirements

International Standards

COM05.9 The equipment, systems, services and facilities shall comply with the applicable international standards, recommended practices and procedures for air navigation services in Annex 11 [1], Annex 10 [2] and Annex 3 [3] to the Convention on International Civil Aviation (236).

Interface to Voice/Data Recording Equipment

COM05.10 The equipment and systems used in the provision of a Voice-ATIS or D-ATIS shall provide all the necessary signals and information to the Voice/Data Recording Equipment in compliance with Article 206 of the Air Navigation Order (238).

Note: EUROCAE has published the document ED-93, 'Minimum Operational Performance Specification for CNS/ATM Recording Systems', which includes the ground recording of data-link communications.

Manual of Air Traffic Services Part 2

COM05.11 Appropriate material relating to the operation of the ATIS shall be written for inclusion in the MATS Part 2 (239).

Note: See CAP 670 Part B Section 2 ATC 02 'ATC Documentation' for the requirements and details on the format of MATS Part 2.

Specific Requirements

Voice-ATIS and D-ATIS

COM05.12 The ATIS message shall relate to a single aerodrome (240).

COM05.13 The ATIS message shall be updated immediately a significant change occurs (241).

COM05.14 The preparation and dissemination of the ATIS message shall be the responsibility of the ATS Provider (242).

COM05.15 Individual ATIS messages shall be identified by a letter designator from the ICAO spelling alphabet assigned consecutively in alphabetical order (243).

COM05.16 ATIS shall only be broadcast when the ATC Watch is operational (2327). However, units may be approved to make use of the ATIS frequency to broadcast Auto METAR when the ATC Watch is closed, where the Unit meets the requirements of COM 05 paragraphs COM05.51 to COM05.53 (Broadcast of Auto METAR).

Voice-ATIS

COM05.17 In the UK, ATIS shall only be provided in association with an ATC service (2053).

COM05.18 Voice-ATIS shall be provided at aerodromes where there is an operational requirement to reduce ATC VHF air-ground communications workload (244).

Note: The provision of a Voice-ATIS may be limited by the availability of discrete VHF frequencies which are in short supply.

COM05.19 Voice-ATIS broadcasts shall comprise (245):

1. One broadcast for arriving aircraft or
2. One broadcast for departing aircraft or
3. One broadcast for arriving and departing aircraft or
4. Two separate broadcasts for arriving and departing aircraft where the combined broadcast would be excessively long.

COM05.20 Voice-ATIS shall be provided on a discrete VHF frequency whenever practicable (246).

COM05.21 **Guidance**: As the VHF spectrum is congested and there is a shortage of available radio frequency assignments, any application for the use of a VHF frequency assignment will require a justification of the operational requirements.

COM05.22 When a discrete VHF frequency is not available, Voice-ATIS may be provided on the most appropriate terminal navigation aid (247).

COM05.23 **Guidance**: CVOR or DVOR facilities are considered to be appropriate navigation aids subject to evidence from the ATS Provider of the Voice-ATIS, justifying the choice of navigation aid, taking into account the Designated Operational Coverage, quality of the voice transmissions and any other appropriate factors. The ATS Provider of a CVOR or DVOR navigation aid used for Voice-ATIS would be responsible for demonstrating compliance with Part C, Section 2 NAV 04.

COM05.24 Voice-ATIS shall not be provided on an ILS facility (248).

COM05.25 Voice-ATIS broadcasts, when provided, shall be continuous and repetitive (249).

COM05.26 **Guidance**: In the event of failure of the Voice-ATIS, the air traffic controller may provide the ATIS information using the control VHF frequency or, where the workload prevents this, by opening

of another alternative VHF frequency by an additional air traffic controller or assistant.

D-ATIS

COM05.27 Where D-ATIS is provided alongside the existing availability of Voice-ATIS, the content and format of the information shall be identical (250).

COM05.28 Where D-ATIS is provided alongside the existing availability of Voice-ATIS, when the ATIS requires updating, the Voice-ATIS and D-ATIS shall be updated simultaneously (251).

COM05.29 Where D-ATIS broadcast includes real time meteorological information, which is within the parameters of the significant change criteria reference [3], the content shall be considered identical for the purpose of maintaining the same designator (252).

COM05.30 **Guidance**: In the event of failure of the D-ATIS, the ATIS information can be obtained from the Voice-ATIS. Where both D-ATIS and Voice-ATIS fail, the situation is the same as that for a failure of the Voice-ATIS.

COM05.31 It is likely that interface arrangements will need to be established between the ATS Providers, operating the aerodrome Voice-ATIS, and the D-ATIS data link Service Provider, to ensure compliance with the requirements of paragraphs COM05.27 to COM05.31, which are based on ICAO SARPS.

Note: Guidance material relating to D-ATIS is contained in the document cited at paragraph 3 reference [5]. The technical requirements for the D-ATIS application are contained in Part 1 Chapter 3 of ICAO Annex 10 Vol III, see paragraph 3 reference [2].

Collation of Meteorological and Aerodrome Data

COM05.32 The meteorological data used in the preparation of ATIS messages shall be compliant with ICAO Annex 3 (253).

COM05.33 The meteorological data shall be extracted from the local meteorological routine or special report (254).

COM05.34 Where rapidly changing meteorological conditions preclude the inclusion of a weather report, the ATIS message shall contain information that the relevant weather information will be given on initial contact with the Air Traffic Control Unit (255).

COM05.35 The ATS Provider shall ensure that the accuracy and integrity of the data used in the preparation of the ATIS message is maintained at a level appropriate to the operational requirements (256).

COM05.36 **Guidance**: It is likely that the interface arrangements between the ATS Provider and the Data Link Communications Service Provider will enable the ATS Provider to obtain evidence of compliance with this requirement for the Data Link operations.

Preparation of Messages

COM05.37 Where the Voice-ATIS broadcast messages are not prepared by the aerodrome ATC Unit, the organisation responsible for this task shall immediately make known the information contained in the current broadcast to the ATC Unit (257).

COM05.38 Voice-ATIS broadcasts shall be prepared in the English language (258).

COM05.39 **Recommendation**: The Voice-ATIS broadcast should be prepared to achieve optimum readability consistent with message length, speed of transmission and human factors performance (259).

COM05.40 **Guidance**: The message length should not exceed 30 seconds.

COM05.41 **Recommendation**: The message contents should be kept as brief as possible and information additional to that specified in ICAO Annex 11, 4.3.7 to 4.3.9 should only be included in exceptional circumstances (260).

COM05.42 The message contents shall contain the elements of information as defined in ICAO Annex 11, 4.3.7 to 4.3.9 in the order given (261).

Note: The Appendix A to COM 05 contains a summary of the ATIS message elements in ICAO Annex 11.

COM05.43 **Guidance**: Where the preparation of messages involves recording speech using a microphone, care should be taken to ensure that any background noise does not degrade the quality of the recording. Where the preparation is done automatically, using either synthesised or pre-recorded spoken words or phrases, care should be taken to ensure that the quality and readability of the recording is equivalent to that achieved by manual recording.

Transmission of Messages

Voice-ATIS VHF Transmitter

COM05.44 **Guidance**: CAP 670 Part C Section 1 COM 02 'VHF Aeronautical Radio Stations' contains requirements for all radio equipment including Voice-ATIS VHF Transmitters and VHF Transmitters used for ACARS and VDL Mode 2 data link communications.

Voice-ATIS CVOR/DVOR Transmitter

COM05.45 Guidance: CAP 670 Part C Section 2 NAV 04 'Engineering Requirements for Conventional and Doppler VHF Omni-Directional Range (CVOR/DVOR) Beacons' includes the option of providing Voice-ATIS by using the speech modulation input to the transmitter.

COM05.46 The DOC and frequency assignment terms and conditions must be consistent with both the CVOR/DVOR and Voice-ATIS operational requirements. Radio coverage problems may be found if the CVOR/DVOR is not located on or near the aerodrome providing the Voice-ATIS.

COM05.47 Where the CVOR/DVOR beacon is not the direct responsibility of the aerodrome ATS Provider providing the Voice-ATIS, then a service level agreement or some other arrangement might be necessary to ensure compliance with operational requirements and to cover aspects such as maintenance.

D-ATIS VHF Ground Station Network/Satellite

COM05.48 **Guidance**: CAP 670 Part C Section 1 COM 04 'ATC Datalinks' covers the provision of D-ATIS by ATS Providers. The ATIS may be delivered to aircraft by means of a VHF ground station network and/or earth stations of the mobile satellite service operated by Data Link Communications Service Providers.

COM05.49 If any of the VHF ground stations are located within the UK they will require ANO approval and CAP 670 Part C Section 1 COM 02 'VHF Aeronautical Radio Stations' applies.

Voice-ATIS Telephone Information Service

COM05.50 **Guidance**: Access to the Voice-ATIS may be provided via a PSTN/PBX telephone information service as an additional service to aviation and other users. There is no requirement to record the telephone service.

Broadcast of Auto METAR

COM05.51 Broadcast of Auto METAR, utilising an Automatic Terminal Information Service (ATIS) frequency, shall be in conformity with ICAO Annex 3 and shall be approved for use only at aerodromes where an ATIS facility has been approved and when the ATC Watch is closed. The DOC of the ATIS frequency shall be valid for the Auto METAR broadcast.

COM05.52 The weather report (METAR) shall be prefixed with the word 'AUTO' and only the METAR information shall be included in the broadcast.

COM05.53 Approval to permit aerodrome weather to be broadcast when the aerodrome is effectively closed shall be subject to a safety case assessment. Where an approval is granted the broadcast should state that the aerodrome is closed except to the specific aircraft operation that gave rise to the approval.

Example: xxxxx (Name of Aerodrome) AERODROME IS CLOSED EXCEPT FOR AUTHORISED EMERGENCY SERVICES OPERATORS. AUTO METAR ETC

Appendix A to COM 05: ICAO Annex 11 ATIS Message Elements

Message Elements		Footnote	Arrival & Departure	Arrival	Departure
(a)	name of aerodrome		✓	✓	✓
(b)	arrival and/or departure indicator		✓	✓	✓
(c)	contract type, if communication is via D-ATIS		✓	✓	✓
(d)	designator		✓	✓	✓
(e)	time of observation, if appropriate		✓	✓	✓
(f)	type of approach(es) to be expected		✓	✓	✓
(g)	the runway(s) in use; status of arresting system constituting a potential hazard, if any		✓	✓	✓
(h)	significant runway surface conditions and, if appropriate, braking action		✓	✓	✓
(i)	holding/departure delay, if appropriate		✓	✓	✓
(j)	transition level, if applicable		✓	✓	✓
(k)	other essential operational information		✓	✓	✓
(l)	surface wind direction and speed, including significant variations and, if surface wind sensors related specifically to the sections of the runway(s) in use are available and the information is required by operators, the indication of the runway and the section of the runway to which the information refers		✓	✓	✓
(m)	visibility and, when applicable, RVR	*	✓	✓	✓
(n)	present weather	*	✓	✓	✓

Message Elements		Footnote	Arrival & Departure	Arrival	Departure
(o)	cloud below 1 500 m (5 000 ft) or below the highest minimum sector altitude, whichever is greater; cumulonimbus; if the sky is obscured, vertical visibility when available	*	✓	✓	✓
(p)	air temperature		✓	✓	✓
(q)	dew point temperature	†	✓	✓	✓
(r)	altimeter setting(s);		✓	✓	✓
(s)	any available information on significant meteorological phenomena in the approach and climb-out areas including wind shear, and information on recent weather of operational significance		✓	✓	✓
(t)	trend-type landing forecast, when available; and		✓	✓	✓
(u)	specific ATIS instructions		✓	✓	✓

Footnote	
*	Those elements are replaced by the term "CAVOK", whenever the conditions as specified in reference [4] Chapter 11 prevail.
†	As determined on the basis of regional air navigation agreements. See reference [5].

COM 06: UHF Radio Equipment and Systems

Part 1 Preliminary Material

Introduction

COM06.1 Under the terms of Article 205 (1) of the ANO, any ATS Equipment is required to have CAA approval before being established or used in the UK. An Aeronautical Radio Station is specifically included in the meaning of Air Traffic Service Equipment in Article 255 (1).

COM06.2 The definition of 'Aeronautical Radio Station' in Article 255 (1) is considered to include UHF radio equipment and systems at Base Stations and Land Mobile Stations of the Land Mobile Service, where they are used for the purpose of assisting aircraft.

COM06.3 The CAA regulatory responsibility for UHF radio equipment and systems is limited to those aspects associated with the ANO Approval. Ofcom are responsible for WT Act licensing and associated frequency assignments.

Scope

COM06.4 This document sets out the engineering requirements for UHF radio equipment and systems at Base Stations and Land Mobile Stations established or used within the UK in support of ATS aerodrome communications such as those used for ground movement (surface movement) control service, fire service and air traffic engineering.

COM06.5 This document applies to the equipment categories of fixed (Base Station), vehicle, portable and hand held (Land Mobile Station) comprising equipment types of transmitter, receiver (Base Station) and transceiver (Land Mobile Station).

COM06.6 This document applies to UHF radio equipment and systems operating on frequency assignments in the UHF Land Mobile Service allocation 450 MHz to 470 MHz, using Frequency Modulation (FM) with 12.5 kHz channel spacing, for analogue voice communications.

References

1. ICAO Annex 10 Aeronautical Telecommunications Volume III – Communication Systems Part I – Digital Data Communication Systems; Part II – Voice Communication Systems

2. ICAO Annex 11 Air Traffic Services

3. ICAO Annex 14 Aerodromes Volume I – Aerodrome Design and Operations

Note: The Catalogue of ICAO Publications can be found at the ICAO website: www.icao.int.

4. UK Interface Requirement 2001 Private Business Mobile Radio

5. Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity. Official Journal L 091, 07/04/1999 p. 0010 – 0028

6. EUROCAE ED-67 'Minimum Operational Performance Specification for devices that prevent unintentional or continuous transmissions' April 1991.

Note: Information on EUROCAE Publications can be found at the EUROCAE Web Site at www.eurocae.net/. Documents can either be purchased on line or from EUROCAE at the address given below:

EUROCAE
102, rue Etienne Dolet
92240 Malakoff
FRANCE

Telephone: +33 1 4092 7930
Fax: +33 1 4655 6265
E-mail: eurocae@eurocae.net

7. Ofcom information sheets, general publications, licence application forms and guidance forms, and other documents concerning the radio spectrum and other equipment approval can be found at: www.ofcom.org.uk.

Part 2 Requirements

Safety Objective

COM06.7 **The UHF radio equipment and systems shall provide complete, identified, accurate and uncorrupted voice communications for Air Traffic Services Ground to Ground Communications (1005).**

International Standards

COM06.8 The equipment, systems, services and facilities shall comply with the applicable international standards, recommended practices and procedures for air navigation services in Annex 10, Annex 11 and Annex 14 to the Convention on International Civil Aviation (262).

COM06.9 The equipment, systems, services and facilities shall comply with the applicable Radio Regulations of the International Telecommunications Union (263).

COM06.10 Two-way radiotelephony communication facilities shall be provided for aerodrome (surface movement) control service for the purpose of controlling vehicles on the manoeuvring area, except where communication by a system of visual signals is deemed to be adequate (264).

Note: This communication facility is normally provided by UHF radio equipment and systems but the use of VHF Aeronautical Mobile Service frequencies may be permitted for ground to ground communications in specific circumstances.

COM06.11 **Recommendation**: Where conditions warrant, separate communication channels should be provided for the control of vehicles on the manoeuvring area (265).

COM06.12 The driver of a radio-equipped vehicle shall establish two-way radio communication with the aerodrome control tower before entering the manoeuvring area and with the appropriate designated authority before entering the apron (266).

COM06.13 The driver of a radio-equipped vehicle shall maintain a continuous listening watch on the assigned frequency when on the movement area (267).

Note: Guidance on aerodrome vehicle operations is contained in ICAO Annex 14 Attachment A Section 17 and includes operators

qualifications, competency, radiotelephony operating procedures and phraseology.

Radio Spectrum Management

COM06.14 The equipment and systems shall be designed and constructed to operate within the Land Mobile Service allocation 450 MHz to 470 MHz with a channel spacing of 12.5 kHz using Frequency Modulation (FM) with ITU emission designator 11K0F3EJN using semi-duplex operation (268).

Note: The Base Station equipment uses duplex operation and the Land Mobile Station equipment uses simplex operation.

COM06.15 The equipment and systems shall be installed, operated and maintained in compliance with the terms and conditions of an ANO Approval granted by the CAA in respect of the ATS Ground to Ground Communications being provided (269).

WT Act PBR Licence

COM06.16 **Guidance**: A WT Act Private Business Radio (PBR) licence issued by Ofcom will be required prior to the establishment of the Base Station and the installation or operation of equipment and systems. Further information may be obtained from Ofcom.

Note: All new Aeronautical Radio Stations must have been assessed as fit for purpose under the Air Navigation Order Article 205 by the CAA before a radio licence can be issued.

Equipment Specifications

COM06.17 **Guidance**: The minimum equipment requirements comprise the parameters for the licensing of the equipment, contained in the UK Radio Interface Requirement [5] published by Ofcom, in accordance with Directive 1999/5/EC [8] Articles 4.1 and 7.2 and the essential requirements in Article 3.2.

Inspection of UHF Equipment and Systems

COM06.18 The equipment, systems and associated records shall be made available for inspection by an authorised person, being a CAA Regional Inspector, for the purpose of demonstrating compliance with the terms and conditions of the ANO Approval and CAP 670 requirements (270).

COM06.19 **Guidance**: Ofcom may inspect the equipment and systems to ensure compliance with the terms and conditions of the WT Act licence. Further details on the licensing and regulation of PBR may be obtained from Ofcom.

Radio Equipment and Telecommunications Terminal Equipment Directive (R&TTED)

COM06.20 UHF Radio Equipment and Systems shall comply with the R&TTED (1999/5/EC) (271).

Maintenance of UHF Equipment and Systems

COM06.21 Maintenance arrangements shall be established for UHF Radio Equipment and Systems at aerodromes associated with the provision of ATS (272).

Note: Further information is contained in Part B Section 1, APP 02.

Communications Availability

COM06.22 The design, installation, operation and maintenance of equipment and systems shall be such as to ensure an availability of communications appropriate for the ATS being provided (273).

COM06.23 **Guidance**: The availability of communications is dependent on the radio system design, including equipment configuration and power supply arrangements. The selection of equipment with the appropriate duty cycle can also reduce equipment failure. The provision of alarm/status indications is also important in ensuring that appropriate actions are taken to restore communications when a failure occurs.

Radio System Design

COM06.24 Communications of a specified quality of service shall be provided within the radio service area appropriate to the services being provided (274).

COM06.25 **Acceptable Means of Compliance**: Evidence to demonstrate that the defined quality of service has been achieved within the radio service area.

COM06.26 For ATC communications, a combination of radio service area predictions and ground functional tests would be acceptable. For

other ATS radio service area predictions or limited ground functional tests.

COM06.27 **Guidance**: Quality of service comprises the two aspects of signal (voice or data) quality and availability. Signal quality can be defined by signal to noise ratio or SINAD for analogue systems and by bit error ratio for digital systems. The availability can be defined in terms of a percentage of time and location.

Note 1: Radio system design includes the consideration of location dependent factors such as a clear radio line of sight, location of antenna, antenna type, transmitter power etc. to ensure reliable radio propagation paths are achieved.

Note 2: The quality of service within the radio service area includes the consideration of additional propagation loss due to buildings or other structures obscuring the line of sight between the base station and the mobile station.

COM06.28 The antennas shall be installed such as to provide vertically polarised emissions (275).

Equipment Configuration

COM06.29 The equipment configuration shall be such as to ensure the availability of communications appropriate to the service being provided (276).

Note: The configuration of equipment includes associated antennas, cables, filters, commutation units and other equipment necessary for the operation of the equipment and systems.

Acceptable Means of Compliance

COM06.30 Aerodrome Air Traffic Control Services – The provision of main, standby and emergency equipment redundancy.

COM06.31 Flight Information Services – The provision of main and emergency equipment redundancy.

COM06.32 Air-Ground Communication Service – The provision of main equipment is considered sufficient for this level of service.

Note: Main and Standby equipment may be operated as 'System A' and 'System B' where either may be considered as Main whilst in operational service and the other is considered as Standby, awaiting

selection in the event of failure of the Main equipment or when the Main equipment is taken out of service for maintenance.

Power Supply

COM06.33 For an ATC Service, the power supply for the emergency equipment shall be independent of that for the main equipment (277).

COM06.34 **Acceptable Means of Compliance**: The independence of the power supplies need only be for a known limited period provided that the MATS Part 2 procedures manage the safety issues this introduces.

COM06.35 Users shall be provided with an indication of failure of the power supply to the emergency equipment and instructions shall be provided in MATS Part 2 for user actions in the event of failure (278).

COM06.36 **Recommendation**: For an ATC Service a primary and alternative power supply should be provided to increase the availability of power to equipment and systems in the event of an interruption to one of the power supplies (279). Change over between supplies should be on a 'no break' basis (280). The primary and alternative supplies should be independent of each other for a known period of time (281). An indication of failure for each power supply should be provided to the user and corrective action taken in the event of failure (282). MATS Part 2 procedures should instruct the user of actions necessary in the event of failure (283).

[ICAO Annex 10 Aeronautical Telecommunications Volume I Paragraph 2.9 Secondary power supply for radio navigation aids and communication systems.]

COM06.37 **Guidance**: The incorporation of suitable conditioning devices as part of the mains/backup power supply arrangements may be useful in preventing equipment malfunction due to surges, spikes and noise on the power supply.

Alarm/Status Indications

COM06.38 For an ATC Service, the system shall provide an indication of system failure that may have an effect on the service being provided, in a timely manner, so that actions can be taken to ensure the safe continued provision of an ATC Service or if necessary the controlled withdrawal of the service (284).

COM06.39 **Recommendation**: The Significance to the user of the indication of failure should be obvious from the indication given (285).

COM06.40 The failure indication should remain obvious to the user whilst the condition causing the failure indication remains (286). Consideration should be given to providing a power supply to the alarm indication that is not dependent upon the system it is monitoring (287).

COM06.41 Changes in the System's state should attract the operator's attention, without continuing to distract once they are aware of the change of state (288). Attention should be drawn both when failures are detected and when they clear (289). Attention to subsequent status changes should not be masked (290). The attention seeking indication should have both visual and audible elements and the ability for the user to acknowledge that they are aware of the change of state thereby removing the attention seeking element (291).

Interface to Voice/Data Recording Equipment

COM06.42 The equipment and systems at the Base Station shall provide all the necessary signals and information to the Voice/Data Recording Equipment in compliance with Article 206 of the ANO (292).

COM06.43 **Acceptable Means of Compliance**: As the Base Station operates in duplex mode and comprises a separate transmitter and receiver, the receiver audio output may be used as the signal source for the recording equipment for Land Mobile Station transmissions. A separate receiver will be required as a signal source for the Base Station transmissions.

COM06.44 **Recommendation**: Automatic recording facilities should be provided on communications channels used for the control of vehicles on the manoeuvring area (293). [ICAO Annex 11, 6.3.1.2]

Provision of Off-air Sidetone

Note: Reference should be made to Part C Section 1, COM 03 Voice Communications Control Systems.

COM06.45 Where Off-air sidetone is provided for ATS, it shall be a replica of the transmitted voice communications without any degradation of quality such as to cause annoyance or disturbance to the operator (294).

COM06.46 The Acceptable Means of Compliance and Guidance in COM06.15 can be applied as appropriate to the provision of Off-air Sidetone.

Unintentional or Continuous Transmissions

Note: Reference should be made to Part C Section 1, COM 03 Voice Communications Control Systems.

COM06.47 The equipment and systems at Aeronautical Radio Stations shall not fail in a manner such as to cause un-intentional or continuous transmissions (295).

COM06.48 **Recommendation**: New equipment and systems at Aeronautical Radio Stations should incorporate features to prevent unintentional or continuous transmissions, unless this is contrary to the intended purpose for which they have been designed (296). For existing equipment and systems, consideration should be given to incorporating such devices by retrofit, modification or add-on circuitry where appropriate (297).

COM06.49 The equipment and systems should conform to the 'Minimum Operational Performance Specification for devices that prevent unintentional or continuous transmissions' EUROCAE document ED-67 April 1991, so far as it is appropriate for ground based systems (298).

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PART C, SECTION 2

Navigation

Introduction

C2.1 Section 2 of Part C contains engineering requirements for navigation equipment and systems. The approval of flight inspection organisations is included in this section in recognition of their role in the approval and continuing operation of navigational aids. These documents should be used in conjunction with the Generic Requirements and Guidance contained in Part B as appropriate.

Scope

C2.2 The 'ILS' documents cover all aspects of Instrument Landing Systems and some ILS/DME flight inspection and identity keying requirements.

C2.3 MLS 01 covers general requirements for Microwave Landing System (MLS).

C2.4 FLI 02 covers the procedures and requirements for the approval of flight inspection organisations. It is divided into sections covering the approval procedure, flight inspection system for navigational aids in general and specific annexes for ILS, MLS, VHF Omnidirectional Radio Range and Non-Directional Beacon (NDB).

C2.5 The 'NAV' documents cover Instrumented Runway Visual Range systems, MF Non-Directional Beacons, VHF Omnidirectional Range (VOR) flight inspection, Conventional and Doppler VHF Omni-Directional Range Beacons, Distance Measuring Equipment (DME) Transponders and flight inspection requirements for Distance Measuring Equipment.

C2.6 The 'VDF' document covers the flight and ground inspection of VHF Direction Finding Systems.

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ILS 01: ILS Monitors

Part 1 Preliminary Material

Introduction

ILS01.1 Under the terms of Article 205 of the ANO, all ILS installations intended for use at civil airports within the UK require approval by the CAA.

Scope

ILS01.2 This document defines the monitor alarm limits and the method of testing those alarms.

Part 2 Requirements

Safety Objective

ILS01.3 **The equipment shall not radiate guidance signals which are outside the standard operational tolerances.**

Near Field Monitor

ILS01.4 Localisers shall have a minimum of one near field monitor measuring the course centreline (1412).

ILS01.5 Glidepaths shall have a minimum of one near field monitor measuring either the glidepath angle or the displacement sensitivity (1413).

Note: Where multiple monitors are used, the signal from the near field monitor aerial may be split and fed into each set of monitors.

Far Field Monitor

ILS01.6 Category II and III localiser systems shall be fitted with a far field monitor which measures centreline accuracy and displacement sensitivity (1414).

ILS01.7 The monitor shall be installed near the relevant runway threshold (1415).

ILS01.8 The far field monitor shall provide alarms to a remote point (1416), but shall not take executive action (1417).

ILS01.9 A delay shall be incorporated in the monitor to prevent false alarms due to aircraft movement (1418).

ILS01.10 During the time that the ILS is being used to support low visibility procedures, the output of the far field monitor shall be recorded and time stamped (1419). The minimum parameters to be recorded shall be centreline DDM and displacement sensitivity (1420).

ILS01.11 The far field monitor output should be recorded and time stamped at all times when the ILS is operational (1421).

ILS01.12 Means shall be available to replay or present the recorded information (2273).

ILS01.13 Recorded information shall be retained for a minimum of 30 days (2274).

Monitor Correlation

ILS01.14 Any monitors on which the integrity assessment is based shall correlate with changes in the far field (2196). This correlation shall be demonstrated for each new design of ILS transmitter, antenna or monitor system installed in the UK (1423).

Alarm and Warning Settings

ILS01.15 Monitor alarm settings shall not exceed the limits given in Table 1 (1165). This requirement applies to all monitors on which the integrity of the ILS is based (1801).

ILS01.16 On a system where several sets of monitors have been considered in the integrity assessment, the system shall be adjusted to a point where sufficient alarms on those monitors are generated to cause a changeover/shutdown (1172).

ILS01.17 If flight or ground tests show that the change measured in the field exceeds the limits given in Table 1 with the transmitter set to the alarm condition, then the monitor system shall be adjusted to tighter limits than those given in Table 1 (1802).

ILS01.18 Monitor limits shall not be so tight that equipment instability can cause false shutdowns (1167).

Table 1 Monitor Alarm Limits

Parameter	CAT I	CAT II	CAT III
LOCALISER			
Alignment at threshold	±1.5% ddm (15μA) (1803)	±1.1% ddm (11μA) (1804)	±0.9% ddm (8μA) (1827)
Displacement Sensitivity	±17% of nominal input (1828). The ICAO Annex 10 standard that a localiser width angle must not exceed 6° is interpreted as an 'adjust and maintain' limit. The system alarms will still be set to ±17% of the nominal input (1829). Field measurement is of nominal displacement sensitivity (1830).		
	Localiser with no separate clearance system ±10% of nominal input. If clearance in the region between ±10° and ±35° is at any point <170 μA (1831).		
Clearance	±20%of nominal input (1833)		
	Localiser with a separate clearance transmitter ±10% of the nominal clearance input if clearance in the region between ±10° and ±35° is at any point <170 μA (1834)		
Frequency Difference (Dual Frequency)	5KHz to 14KHz (2376)		
RF Level Single Frequency	-3dB provided that coverage is satisfactory when the power is reduced to the alarm limit (1837)		
RF Level Dual Frequency	±1dB Unless tests have shown that a wider limit may be used (1838).		
GLIDEPATH			
Alignment	-0.075Θ (5.5% ddm 47 μA) (2377) +0.1Θ (7.3% ddm 63 μA) (2378)		

Parameter	CAT I	CAT II	CAT III
Displacement Sensitivity	±25% of nominal input (1841) Field measurement is of nominal displacement sensitivity (1842).		
	Glidepath with no separate clearance transmitter: ±20% of the nominal displacement sensitivity. If the 'fly up' signal at 0.3Θ is <200 µA (1843).		
Clearance	±20% of nominal input (1844)		
Frequency Difference (Dual Frequency)	4KHz to 32KHz (2379)		
RF Level Single Frequency	-3dB provided that coverage is satisfactory when the power is reduced to the alarm limit (1847)		
RF Level Dual Frequency	±1dB Unless tests have shown that a wider limit may be used (1848).		

Changeover and Shutdown Times

ILS01.19 The maximum TOTAL time of false radiation shall not exceed the number of seconds shown in Table 2 (1187).

ILS01.20 In the case of a common fault, e.g. the aerial system, in a system configured for immediate changeover, the quoted time is the total time from beginning of the fault until final shutdown of the system.

ILS01.21 For category I and II systems, where immediate changeover is not provided, the delay from the time of shutdown of the main transmitter to the start of radiation from the standby transmitter shall be 20 ±2 seconds (1188).

ILS01.22 For systems having this delay, the figures given in Table 2 shall apply separately to each transmitter of the system (1189).

Table 2 Changeover and Shutdown Times (in seconds)

	CAT I	CAT II	CAT III
Localiser	10 (1856)	5 (1857)	2 (1858)
Glidepath	6 (1859)	2 (1860)	2 (1861)

Alarm Testing

ILS01.23 The alarm points of all monitors shall be checked and recorded at commissioning (2364).

ILS01.24 The alarm points of all monitors shall be checked and recorded at intervals not exceeding 12 months (2365).

ILS01.25 Where it is not possible to establish the amount of change of the transmitted parameter when checking the alarm points, then independent test equipment shall be used (2366).

Commissioning Alarm Conditions

Glidepath

ILS01.26 At commissioning the alarm condition given in Table 3 shall be set and checked by flight inspection (2396).

Localiser

ILS01.27 At commissioning the Alignment and Displacement Sensitivity alarm shall be checked by field or Flight Inspection (2397).

Table 3 Commissioning Flight Inspection Alarm Conditions

GP type	Method	Pass criteria
Sideband reference	Adjustment of relative phase between upper and lower aerials to give sufficient alarms to cause shutdown (2367).	Alignment and Displacement Sensitivity within the limits in Table 1. Below Path Clearance and Coverage within the limits in ILS 02 Table 2 (2370).
Null reference	Adjustment of relative phase between upper and lower aerials to give sufficient alarms to cause shutdown (2368).	
M-Array	Adjustment of the relative phase of the middle aerial, compared to the upper and lower aerials to give sufficient alarms to cause shutdown (2369).	
Alignment and Displacement Sensitivity		
Condition		**Pass criteria**
Width wide and angle low (2325)		Alignment and Displacement Sensitivity within the limits in Table 1 (2380).
Width normal and angle high (1873)		
Width normal and angle low (1874)		
Width narrow and angle normal (1875)		
Width wide and angle normal (1876)		

Routine Monitor Recording

ILS01.28 All equipment monitor readings for all transmitters capable of operating into the aerial shall be taken at monthly intervals or as prescribed by the equipment manufacturer or engineering authority (1882).

Alarm testing following Engineering Work

ILS01.29 Following any engineering work involving the aerial distribution unit, feeder cables, aerials or monitor-combining unit, the following glidepath alarm condition shall be set and checked by flight inspection:

1. Angle low and width wide simultaneously (1867);
2. Phase advance alarm (1868); and
3. Phase retard alarm (1869).

Note 1: If the monitor phase tests are not successful and transmitter adjustments are required, parts of the normal flight inspection will have to be repeated. Guidance on Sideband Reference Phase Testing can be found in Appendix A to ILS 01.

Note 2: On certain systems it is difficult to adjust the aerial phasing so that the system is just at the alarm point. For this reason, it is permissible to make the tests with the monitor near to or just beyond the alarm point. Provided that both the monitors and the flight inspection figures show reasonable symmetry, the behaviour at the alarm points can be calculated.

Calculation of Displacement Sensitivity

ILS01.30 In many cases it is more usual to measure the signal width rather than the displacement sensitivity as defined by ICAO. For example, on a glidepath system the flight inspection will normally measure the angle between 75 µA fly-up and 75 µA fly-down. To convert changes in displacement sensitivity to changes in the angle, the following formulae should be applied:

An X% REDUCTION in displacement sensitivity (decrease in sideband power) will produce a GREATER width angle of (1190):

(nominal angle) ÷ [(100 -x)/100]

An X% INCREASE in displacement sensitivity (increase in sideband power) will produce a NARROWER width angle of (1191):

(nominal angle) ÷ [(100 + x)/100]

Examples

As an example, wide alarm on a standard 3° glidepath,
(25% decrease in displacement sensitivity):
(nominal angle) ÷ [(100 – x)/100] = 0.72 ÷ (75/100) = 0.96°
Similarly, narrow alarm:
(nominal angle) ÷ [(100 + x)/100] = 0.72 ÷ (125/100) = 0.58°

As an example, wide alarm on a 5.8° localiser,
(17% decrease in displacement sensitivity):
(nominal angle) ÷ [(100 – x)/100] = 5.8 ÷ (83/100) = 6.99°
Similarly, narrow alarm:
(nominal angle) ÷ [(100 + x)/100] = 5.8 ÷ (117/100) = 4.96°

Appendix A to ILS 01: Guidance on Sideband Reference Phase Testing

Introduction

ILS01A.1 The sideband reference glidepath characteristics are more susceptible to small phase changes in the transmitting aerial system than any other common glidepath.

ILS01A.2 A simplified way of seeing the problem is to consider the signal from the lower aerial. This signal alone would give twice full scale fly-down on a pilot's indicator. It is only the presence of the upper aerial signal, when combined with the lower aerial signal, which produces the fly-up signal below the glidepath. Any error in the relative phase of the signals from the two aerials will result in the signal from the lower aerial having more effect. This results in weaker fly-up signals near the ground and a lower glidepath angle.

Note: It is not the policy of the CAA to provide precise system adjustment procedures but in view of the high cost of flight inspection some guidelines are offered.

Guidelines

ILS01A.3 The guidelines in this Appendix are arranged as below:

ILS01A.4 **Paragraphs ILS01.A7 to ILS01A.10** describes the faults which may exist if the phase alarm test has been attempted and failed.

ILS01A.5 **Paragraphs ILS01.A11 to ILS01A.15** describes a procedure for adjusting and verifying that the transmitter aerial phasing is correct. If the phasing is verified as described using a repeatable method of de-phasing, the monitor phase alarms can be verified using only ground measurements. If there are any doubts about the accuracy of transmitter aerial phasing, it is advisable to apply the tests detailed in this section.

ILS01A.6 **Paragraphs ILS01.A16 to ILS01A.20** describes the verification of monitor phase alarms based on results from tests in paragraphs ILS01.A11 to ILS01A.15.

Note: Paragraphs ILS01.A11 to ILS01A.20 are only suggested methods of avoiding excessive flying hours. The system operator/ manufacturer may use any method of adjustment to ensure that the system will pass the required tests.

Non-compliance with Monitor Test

ILS01A.7 If the reduced fly-up and glidepath angle in both tests (phase advance and phase retard) are similar, but outside permitted tolerances:

ILS01A.8 This indicates that in the normal condition both the transmitter aerial phasing and the monitor signal phasing are correct. The only adjustment required would be to increase the sensitivity of the monitors. The CAA would not require further flight inspection. The changes in monitor sensitivity can be verified using ground test equipment.

ILS01A.9 If the fly-up and glidepath angle in both tests are not similar:

ILS01A.10 This indicates that either the transmitter aerial phasing or the monitor phasing (or both) are wrong. If, in either test, the fly-up was higher than in the normal condition, an error in the transmitter aerial phasing exists.

Verification of Transmitter Aerial Phasing

ILS01A.11 The transmitter aerial phasing should be adjusted to give the correct phase of signals in the far-field. This is the condition which gives maximum fly-up signals at low angles – the usual measurement point is q.

ILS01A.12 The correct phasing can be verified by altering the transmitter aerial phasing and making a level slice flight inspection. The system is then de-phased by the same amount in the opposite direction and the level slice repeated.

ILS01A.13 The two flight inspection results should be similar and both show a fall in the fly-up at q and a lower glidepath angle.

ILS01A.14 If the de-phasing is done using a calibrated phaser, or by inserting fixed adaptors or extension cables in the aerial fields, it is possible to avoid further flying of the phase alarms. The amount of phase

change used for the tests is not critical, but a value of approximately 40° gives an easily measurable change.

ILS01A.15 When the phasing has been adjusted and verified by this method, the remaining parts of the flight inspection may be completed. Further flight inspection of the phase alarms will not be required.

Adjustment and Verification of Monitoring

ILS01A.16 The monitor may now be adjusted until its response to de-phasing is symmetrical. The same phaser settings or extension links that were used in paragraphs ILS01.A11 to ILS01A.15 must be used for these tests.

ILS01A.17 The monitor response will be adjusted by its phasing controls in the case of an integral monitor, or by its physical position in the case of a field monitor.

ILS01A.18 The final setting of the monitor must be such that identical changes are seen for advance or retard of the transmitting aerial signals.

ILS01A.19 It will be known that the phase link or calibrated phaser setting gives a certain fall in fly-up signals and glidepath angle. This test will also give a monitor change as measured in paragraph ILS01.A18.

ILS01A.20 By applying a suitable scaling factor, it will be possible to calculate whether the system monitors would reach alarm before transmissions were outside specification. The only adjustment then required would be a change in sensitivity which could be verified by ground equipment tests.

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ILS 02: ILS Flight Inspection Requirements

Introduction

ILS02.1 Article 205 (5) of the ANO permits the CAA to include a condition on an Article 205 approval requiring that the equipment be flight checked by an approved person.

ILS02.2 The purpose of this document is to ensure that a system, when flight inspected, is operating within defined limits.

Scope

ILS02.3 This document defines the:

- Flight inspection interval;
- Limits to be applied to all parameters measured; and
- Types of inspection.

Safety Objective

ILS02.4 **The equipment shall provide a complete, identified, accurate and uncorrupted source of guidance information to aircraft.**

Flight Inspection Interval

ILS02.5 For ILS facilities, the prescribed interval between successive inspections is 180 days (2147).

Tolerances

ILS02.6 A tolerance of +20 days is applicable to the prescribed intervals. Operators shall strive to ensure that flight inspection takes place as closely as possible to the prescribed intervals. If the previous inspection lasted more than one day, the interval shall be calculated from the date when the inspection started (1254).

ILS02.7 Flight inspections may be made up to 7 days earlier than the due date without affecting the due date for the next inspection (1257).

If an inspection is made more than 7 days before the due date, the date of subsequent inspections shall be advanced (1258).

Delays due to Adverse Weather

ILS02.8 Occasionally, prolonged periods of adverse weather may prevent an inspection being completed within the permitted tolerance. If this occurs, the system may continue in operation for a further 25 days provided that a reduced flight inspection has been made within the permitted tolerance interval (1264).

ILS02.9 Reduced inspection requirements:

Localiser: part orbit ± 35° at approximately 6 nautical miles for both transmitters (1265).

Glidepath: Level slice starting at the edge of the DOC, at the height normally used for such a flight on the facility, for both transmitters (1266).

Supplementary Flight Inspections

ILS02.10 A supplementary flight inspection must be made 90 days ±20 days after a periodic flight inspection if at that inspection any parameter was found outside the flight inspection tolerances stated in Tables 1, 2 or 3 below and subsequently adjusted (1298).

ILS02.11 This requirement can be relaxed if ground measurement and equipment monitors confirm the changes seen during the periodic flight inspection. In this case it would be acceptable to carry out more frequent ground monitoring and inspection of the equipment monitor records (1886).

ILS02.12 Only the parameters found out of tolerance need to be checked by the supplementary flight inspection (1887).

ILS02.13 A supplementary flight inspection may be requested by the CAA at any time if the following conditions arise:

1. A regional inspector considers that any aspect of maintenance is not being correctly carried out (1888);
2. An inspection of equipment monitor records, which may be requested at any time by the CAA, shows any evidence of instability (1889);

3. Changes have been made within the safeguarded areas (1890); and

4. A periodic inspection has shown any unusual, though not necessarily out of tolerance, aberrations in the course structure (1891).

Field Monitors

ILS02.14 Commissioning flight inspections of localisers and glidepaths shall be made with all field monitors that can have a significant effect on the signal in space installed in their final positions (2148).

Note: An engineering flight inspection may be necessary to establish the position of the glidepath field monitor.

Flight Inspection Organisations

ILS02.15 All flight inspections shall be made by an organisation having CAA approval under the ANO for the specific category of ILS being inspected (1346).

Note: A list of approved flight inspection organisations is available on the CAA website at www.caa.co.uk/flightinspection.

Inspection after Engineering Work

ILS02.16 Certain types of engineering work involving the aerial distribution unit, feeder cables, aerials or monitor-combining unit may require that the system be flight checked before being returned to service. If an operator is uncertain of the type of inspection required, he should contact a Regional Inspector for clarification (1892).

Analysis of Flight Inspection Records

ILS02.17 The ATS Provider shall analyse the flight inspection report at the earliest opportunity for operational systems and prior to entering a facility into operational service, to ensure that the flight inspection requirements are met (2275).

ILS02.18 The ATS Provider shall address any deficiencies or non-compliance to ensure a safe service is provided (2276).

ILS02.19 An ATS Provider may delegate the task of analysing the flight inspection report to a third party specialist organisation. This may be the flight inspection organisation that provided the report. The responsibility for addressing any deficiencies identified remains with the ATS Provider (1894).

ILS02.20 The person who conducts the analysis shall be competent to do so.

Note: This may include training on a specific flight inspection report format (2277).

Flight Inspection Limits

ILS02.21 Flight inspection results shall conform to the limits given in Tables 1, 2 and 3.

Parameters to be Measured

ILS02.22 The following tables give details of the parameters which must be measured at each type of flight inspection.

ILS02.23 In the following tables, DOC is defined in Safety Related Aeronautical Information Circular (AIC) (Pink) 'The use of Instrument Landing System (ILS) Facilities in the United Kingdom'.

Promulgated Procedure

ILS02.24 At commissioning and on an annual basis an Instrument Rated pilot shall check the final turn onto all Instrument Approach Procedures (IAP) (The check does not need to be conducted by a CAA approved Flight Inspection Organisation). During the check the pilot shall observe any other navigational aids that are used to support the procedure. The aim of this check is to ensure that any navigational signals used as part of the procedure, position the aircraft to allow the ILS to be correctly captured. Where several IAP follow the same path only one flight needs to be conducted (2149).

ILS02.25 The pilot shall provide confirmation of the performance of the navigational aids used for the IAP. The ATS Provider shall formally record this confirmation (2150).

Table 1: Localiser Limits

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Alignment Of nominal total angular width	Cat I ± 1.5% (1895) Cat II ± 1.0% (1896) Cat III ± 0.5% (1897)	Cat I ± 5.0% (1194) Cat II ± 2.1.% (2151) Cat III ± 1.4% (1196)	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Displacement Sensitivity Of the nominal displacement sensitivity	Cat I ± 5% (1901) Cat II ± 3% (2152) Cat III ± 3% (1903)	Cat I ± 17% (1904) Cat II ± 10% (2153) Cat III ± 10% (1906)	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Symmetry (either side of courseline) of the measured displacement sensitivity	45% to 55% (1200). In cases of disagreement with the ground figures, the ground measurements at threshold shall be used for assessment (1201)		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Modulation Sum SDM sum of the modulation depths of the navigational tones	39% and 41% (1220). Measured when approaching the facility, where the ddm is approximately zero (1218)	36% and 44% (1219) Measured when approaching the facility, where the ddm is approximately zero (1218)	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Off Course Clearance	Substantially linear increase from the front courseline to an angle where the deflection current is 175 µA (0.18 ddm) (2154). From this angle to 10° on the same side, the deflection current must not fall below 175 µA (0.18 ddm) (2155). From ±10° to ±35° the deflection current must not fall below 150µA (0.155 ddm) (2156). It is desirable that the deflection current in the region between 10° and 35°should not be below 175 µA (0.18 ddm). Wherever possible, systems should be adjusted to achieve this. (2157)		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Coverage	Usable signals at edge of DOC, ±10° from the centreline (2158) Usable signals at 17 NM,±10° to ±35° from the localiser centreline (1213)	Annual only. Usable signals at edge of DOC on the localiser centreline (2159)	Commissioning 1 or 2 Annual 1 or 2 Routine None
	Usable signals between ±35° from the localiser centreline at or beyond 6NM from the localiser (2160).		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
	Usable signals shall be receivable to the distances specified, at and above a height of 2000 feet above the elevation of the threshold or 1000 feet above the elevation of highest point within the intermediate and final approach areas, whichever is the higher (1214). A usable signal is defined as a signal producing localiser flag current of not less than 275 µA and a ddm conforming to the off course clearance requirements. **Ref to Eurocae ED46B.		

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Course Structure	**Cat I** 30 µA (0.031 ddm) Edge of DOC to point A, then decreasing at a linear rate to 15 µA (0.015 ddm) at point B. 15 µA (0.015 ddm) from point B to point C (2161) **Cat II/III** 30 µA (0.031 ddm) Edge of DOC to point A, then decreasing at a linear rate to 5 µA (0.005 ddm) at point B. 5 µA from point B to the ILS reference datum (2162).		Commissioning 1 or 2 Annual 1 or 2 Routine None
	Cat I 30 µA (0.031 ddm) 8NM from the ILS reference datum to point A, then decreasing at a linear rate to 15 µA (0.015 ddm) at point B. 15 µA (0.015 ddm) from point B to point C (1204) **Cat II/III** 30 µA (0.031 ddm) 8NM from the ILS reference datum to point A, then decreasing at a linear rate to 5 µA (0.005 ddm) at point B. 5 µA from point B to the ILS reference datum (1205). Course structure shall have a probability of 95% or better of not exceeding the limits given below, when assessed over a 40 second interval (1203). **Note**: Guidance on structure assessment may be found in Attachment C to ICAO Annex 10 Volume 1		Commissioning 1 or 2 Annual 1 or 2 Routine 1 or 2

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Identification	Clear and no perceptible interference to the basic localiser functions (1221)		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Power ratio Two frequency systems only	On the localiser centreline, the course signal must exceed the clearance signal by a minimum of: Cat I /II 10 dB (2163) Cat III 16 dB (2164)	N/A	Commissioning 1 or 2 Annual None Routine None
Polarisation	Only required at the commissioning of an aerial system which is new to the UK. Polarisation error when the aircraft is in a roll attitude of 20° shall be no greater than: Cat I 0.016 ddm (1215). Cat II 0.008 ddm (1216). Cat III 0.005 ddm (1217).		As required

Table 2 Glidepath Limits

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Alignment Of the promulgated glidepath angle	Cat I ± 1.5% (1910) Cat II ± 1.0% (1911) Cat III ± 1.0% (1912)	Cat I ± 7.5% (2173) Cat II ± 7.5% (2174) Cat III ± 4.0% (1915)	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Displacement Sensitivity Of the nominal displacement sensitivity	Cat I ± 8% (1919) Cat II ± 6% (1920) Cat III ± 5% (1921)	Cat I ± 25% (1922) Cat II ± 20%(1923) Cat III ± 15% (1924)	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Symmetry of upper/lower half sector. Of the measured displacement sensitivity	Cat I 33% to 67%. (1928) Cat II 42% to 58%. (1929) Cat III 42% to 58%. (1930)		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Mod Sum SDM Sum of the depths of modulation of the navigational tones	78% – 82% Measured when approaching the facility, where the ddm is approximately zero (1931).	75% – 85% Measured when approaching the facility, where the ddm is approximately zero (1932).	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Below Path Clearance Normal Operations	The clearance below path should be measured close to the edge of the Designated Operational Coverage (DOC).There shall be a smooth increase in ddm from the glidepath angle to an angle where 190 µA fly-up (0.22 ddm) is reached. This shall occur at not less than 0.3$\underline{\Theta}$ (2165). Where this is achieved at an angle above 0.45$\underline{\Theta}$, the fly-up must not fall below 190 µA (0.22 ddm) between this angle and 0.45$\underline{\Theta}$ or to such lower angle, down to 0.3$\underline{\Theta}$, as required to safeguard the promulgated glidepath intercept procedure (2166). Where coverage between 0.45$\underline{\Theta}$ and 0.3$\underline{\Theta}$ is less than the specified datum, but sufficient current is present to remove the flag alarm, the fly-up shall not fall below 190µA (0.22 ddm) (1230).		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Below Path Clearance Course only **Note:** **This check is to ensure that 2 frequency M- Arrays have been correctly set up and that the clearance transmitter is not hiding a problem**	Cat I Between the glidepath angle and 0.45Θ or to such lower angle, down to 0.3Θ, as required to safeguard the promulgated glidepath intercept procedure, the ddm must remain 150 Hz predominant wherever a useable signal is present. (2167) Cat II/III Smooth increase in ddm from the glidepath angle to an angle where 150 µA fly-up (0.175 ddm) is reached. Between this angle and 0.45Θ or to such lower angle, down to 0.3Θ, as required to safeguard the promulgated glidepath intercept procedure, the ddm must remain 150 Hz predominant wherever a usable signal is present. (2168) **Note**: With clearance signal removed, there is no requirement to meet any coverage (signal strength) specification. Only the value of ddm is being examined.	N/A	Commissioning 1 or 2 Annual None Routine None

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Clearance Below Path (at ±8° azimuth)	During the prescribed level flight, a minimum deflection current of 190 µA (0.22 ddm) must be achieved at 0.45$\underline{\Theta}$ measured close to the edge of DOC. (1234)		Commissioning 1 & 2 Annual 1 or 2 Routine – Alternate from the annual
Clearance Above Path	Smooth increase in fly-down from the glidepath angle to an angle where the fly-down is 190 µA (0.22 ddm). Between this angle and 1.75$\underline{\Theta}$, the fly-down must not fall below 150 µA (0.175 ddm). (1934)		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Coverage	Adequate coverage must exist to the edge of the DOC and down to 0.45$\underline{\Theta}$ or a lower angle down to 0.3$\underline{\Theta}$, as required to safeguard the promulgated glidepath intercept procedure. (2169) Adequate coverage is defined as a receiver input exceeding the equivalent of a 40 µV source of EMF and a total impedance of 50 ohms resistive, together with sufficient current to remove the flag alarm.		Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2

Parameter	Commissioning	Annual/Routine	Transmitter to be checked
Course Structure	Course structure shall have a probability of 95% or better of not exceeding the limits given below, when assessed over a 40 second interval (1238). Cat I 30 µA (0.035 ddm) Edge of DOC to point C. (2170) Cat II 30 µA (0.035 ddm) Edge of DOC to point A, then decreasing at a linear rate to 20 µA (0.023 ddm) at point B. 20 µA from point B to the ILS reference datum. (2171) Cat III 30 µA (0.035 ddm) Edge of DOC to point A, then decreasing at a linear rate to 20 µA (0.023 ddm) at point B. 20 µA from point B to the ILS reference datum. (2172) **Note**: Guidance on course structure assessment may be found in Attachment C to ICAO Annex 10 Volume 1.		Commissioning 1 or 2 Annual 1 or 2 Routine 1 or 2
Biased Structure	The structure of the edges used to calculate the displacement sensitivity should have good correlation with the course structure. (1935)		Commissioning 1 or 2 Annual 1 or 2 Routine None

Table 3 Marker Beacon Limits

Parameter	Commissioning/Annual/Routine	Transmitter
Coverage	The following distances shall be measured whilst on the ILS glidepath and localiser course line: Inner Marker 150 m ± 50 m (2175) Middle Marker 300 m ±100 m (2176) Outer Marker 600 m ±200 m (2177)	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2
Field strength	No less than 1.5 millivolts per metre at the limits of coverage. Rising to at least 3 millivolts per metre (2178)	Commissioning 1 & 2 Annual 1 & 2 Routine 1 & 2

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ILS 03: EU OPS 1 General Requirements

Introduction

ILS03.1 Subpart E of the European Union Commission Regulation (EC) No. 859/2008 (Commonly known as EU-OPS 1) introduces revised requirements for All Weather Operations.

ILS03.2 A key component in Subpart E is the introduction of the concept of "Lower Than Standard Category 1" and "Other Than Standard Category 2" approach operations. In these operations, approved aircraft operators will be able to take advantage of the aircraft's autoland capability or new Head Up Display Landing System (HUDLS) technology when the Runway Visual Range (RVR) is below the conventional limit for Category 1 and with reduced Aeronautical Ground Lighting requirements for Category 2.

ILS03.3 These operations require that the Instrument Landing System meets more stringent requirements based on the ICAO ILS Classification scheme depending upon the minimum RVR value that is intended to be used.

Note: The ICAO ILS Classification scheme is defined in ICAO Annex 10 Volume 1 Radio Navigation Aids Attachment C 4.

ILS03.4 Subpart E also allows suitably approved aircraft operators to benefit from the use of Enhanced Vision Systems (EVS). Operators will be able to conduct Category 1 Precision Approaches and Approaches with Vertical Guidance (APV) in reduced RVR conditions.

ILS03.5 The ATS Requirements Overview web pages (www.caa.co.uk/ATSRequirementsOverview) provide guidance and links to Safety Requirements for ATS providers and Aerodrome Licence Holders wishing to implement Lower than Standard CAT I, Other than Standard CAT II or Enhanced Vision Systems (EVS) Operations.

Scope

ILS03.6 This document defines the ATS requirements for Lower Than Standard Category 1, Other Than Standard Category 2 and EVS approach operations, above and beyond those already published for the normal facility category.

Safety Objective

ILS03.7 The equipment shall provide a complete, identified, accurate and uncorrupted source of guidance information to aircraft, with levels of integrity and continuity of service which are consistent with the category of service provided.

Lower Than Standard Category 1 Operations

ILS03.8 The Localiser offset shall be less than or equal to 3 degrees (2384).

Operations to an RVR between 549 m and 450 m

Note: The following requirements support the ICAO Classification I/T/1.

ILS03.9 The Localiser shall meet the Localiser Course Structure requirement for Category 2 as detailed in ILS 02 Table 1 (2385).

ILS03.10 The Localiser Sensitive Area shall be defined to protect the CAT II course structure requirements of ILS 02 Table 1 (2386).

Operations to an RVR between 449 m and 400 m

Note: The following requirements support the ICAO Classification II/D/2.

ILS03.11 The Localiser and Glidepath shall meet the Category 2 requirements in ILS 01 except for those in Section 5 Far Field Monitor (2387).

ILS03.12 The Localiser and Glidepath shall meet the Category 2 requirements in ILS 02 (2388).

ILS03.13 The Localiser shall comply with ILS10 paragraph ILS10.56 (2389).

ILS03.14 The Glidepath Sensitive Areas shall be defined to protect the CAT II course structure requirements in ILS 02 Table 2 (2390).

ILS03.15 The Localiser Sensitive Area shall be defined to protect the CAT III course structure requirements of ILS 02 Table 1 and ILS 10 paragraph ILS10.41 (2391).

Other Than Standard Category 2 Operations

Operations to an RVR between 450 m and 350 m

Note: The following requirements support the ICAO Classification II/D/2.

ILS03.16 The Localiser shall comply with ILS 10 paragraph ILS10.41 (2393).

ILS03.17 The Localiser Sensitive Area shall be set to protect the CAT III course structure requirements of ILS 02 Table 1 and ILS 10 paragraph ILS10.41 (2394).

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ILS 06: Requirements for ILS and ILS/DME Identity Keying

Part 1 Preliminary Material

Introduction

ILS06.1 ICAO Annex 10 requires that ILS and DME systems shall radiate an identity code when they are operationally available.

Scope

ILS06.2 This document defines the identity keying requirements for all categories of ILS including those systems with an associated DME.

Part 2 Requirements

Safety Objective

ILS06.3 **An operationally available ILS or DME shall radiate an identity code permitting it and its operational status to be positively identified (1327).**

Keying Sequence

Safety Objective

ILS06.4 **An associated ILS and DME shall radiate identity codes which positively identify their association (1328).**

ILS06.5 When a DME is associated with an ILS, the identity keying of both systems shall be synchronised (1329). ICAO Annex 10 refers to this as 'associated' code.

ILS06.6 A complete keying sequence shall occupy approximately 40 seconds (1330).

Note: In the following descriptions the 40 second interval is represented by /4 and the number of times the Morse code is repeated in that interval is shown by the preceding figure, i.e. 1/4 means that the Morse code identity occurs once in each 40 second interval.

Master Equipment

ILS06.7 Unless the DME is also associated with an MLS, either the DME or the ILS may be used as the master identity keyer.

System Operation

ILS06.8 If at any time the master equipment fails, the slave equipment shall revert to totally independent keying (1331).

ILS06.9 If the master keyer is subsequently returned to service, the slave equipment shall automatically return to normal slave operation, with no requirement for manual resetting at the slave equipment (1332).

ILS06.10 When a localiser is acting as slave to a DME it shall key 3/4. The DME keying shall be synchronised to occur where there is an interval in the localiser keying. If the DME fails, the localiser shall revert to 4/4 keying with no gap where the DME identity would have been (1333).

ILS06.11 When a DME is slave to a localiser, it shall key 1/4. If the localiser fails, the DME shall continue to key 1/4, i.e. the DME shall key itself at the correct rate for an independent DME (1334).

ILS06.12 Regardless of which equipment is master or slave, a failure in one equipment shall neither leave the associated equipment without identity (1335) nor cause it to close down (1336).

Slave Monitor Information

Note 1: If the slave equipment fails, there is no requirement for the master equipment to alter its keying sequence.

Note 2: Certain types of ILS and DME equipment, when used as master, have the facility to accept an input from the slave's status monitor. This signal can be used to alter the keying sequence of the master. If this facility exists, it may be used.

ILS06.13 If this system is used, the master equipment shall automatically return to associated keying when the slave equipment is returned to service (1337).

Independent Operation

ILS06.14 An ILS with no associated DME shall always key 4/4, i.e. the Morse code shall be repeated at regular intervals, not less than 6 times per minute (1338).

Use of Letter 'I' Prefix

ILS06.15 If the DME identity code has an 'I' prefix, the DME shall continue to radiate this prefix if the associated localiser fails (1339).

Equipment Out of Service

Note: It is sometimes necessary to radiate signals from equipment which is not available for operational use. This can occur during commissioning tests or engineering investigations.

ILS06.16 Whenever the equipment is not available for operational use, the identity keying shall be suppressed (1340).

Note 1: Radiation of continuous un-keyed tone is permitted.

Note 2: During commissioning and engineering flight inspections, the normal identity code may be radiated for short periods at the navaid inspector's request.

ILS06.17 The use of the code TST for extended periods of testing shall no longer be permitted (1341).

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ILS 08: ILS Radio Noise Monitoring

Part 1 Preliminary Material

Foreword

ILS08.1 This document identifies those specific engineering requirements that must be met to achieve approval for equipment, systems and organisations under the ANO. This document is based upon those relevant and applicable ICAO SARPs. This document supersedes and replaces all earlier versions.

Introduction

ILS08.2 Radio signals from extraneous sources may interfere with the guidance information of an ILS signal. The problem becomes more important for Cat II and Cat III systems, where a higher level of integrity is required than for Cat I.

ILS08.3 Interference monitoring and data recording has been carried out on Cat II and Cat III airfields for many years, allowing trends in the background interference level to be analysed. For this trend analysis to remain valid, it is essential that new monitoring equipment is compatible with the previous system of measurement. For this reason, this document is highly prescriptive in certain areas.

ILS08.4 At present, techniques for monitoring interference on an operational channel are only in the development phase. The existing system assumes that the interference is equally distributed throughout the localiser band. Hence all channels except the active ILS frequency are monitored.

ILS08.5 Advanced equipment may be used which for example, can recognise interference on the operational channel or examine the complete frequency band with no gaps. However, the equipment shall also comply with all requirements in this document.

Scope

ILS08.6 This requirement applies to all ILS localisers operated at Cat II or Cat III.

References

- ICAO Annex 10

Part 2 Requirements

Safety Objective

ILS08.7 **The instrument landing system shall provide an accurate and uncorrupted source of guidance to aircraft (1347).**

Equipment

Note: Throughout this requirement, all references to signal voltages are the voltages measured at the aerial when terminated with 50 W. When calibrating the equipment, due allowance must be made for cable losses.

Automatic Scanning

ILS08.8 Ability to bypass up to 5 channels (1348)

Frequency range

ILS08.9 100 – 110 MHz (1349)

Frequency tolerance

ILS08.10 ± 05% (1350)

Channel spacing

ILS08.11 50 kHz (1351)

IF bandwidth

ILS08.12 The 3dB bandwidth shall be between ±10 and ±15 kHz (1352). The exact figure shall be stated as it is required for analysis calculations (1353).

Receiver sensitivity

ILS08.13 2µV for 10dB (signal + noise)/noise ratio at 50% Mod AM or FM deviation 30% of IF bandwidth (1354).

Modulation detector

ILS08.14 The standard detector shall be for amplitude modulation (1355). For normal monitoring this detector shall provide the output to the audio storage device (1620).

ILS08.15 **Recommendation**: The receiver should also be able to detect frequency modulation (1621).

Note: A receiver which automatically selects the correct detector for the modulation mode may be used. If this is used, the stored records should show the type of detector in use at the time of recording.

Audio bandwidth

ILS08.16 The minimum 3dB bandwidth of the receiver and recording equipment shall be 300 to 3,400 Hz (1356).

Spurious responses

ILS08.17 The receiver shall provide adequate immunity to interference from two-signal third order inter-modulation products caused by signals outside the band being examined (1357). This may be achieved by using a receiver which meets the requirements of ICAO Annex 10 Paragraph 3.1.4.

Dynamic range

ILS08.18 The receiver shall measure signal strengths in the range 2μV to 100μV (1358).

ILS08.19 The receiver shall be capable of detecting modulation when the signal strength is in the range 2μV to 1000μV (1359)

Interval between successive scans

ILS08.20 Between 1 and 2 minutes when no modulation is being recorded (1360). This figure shall be quoted since it will be required for the analysis of data (1361).

ILS08.21 In other cases the total scan time will be determined by the recording time.

Scanning dwell time on each channel

ILS08.22 For signals greater than Threshold 1 but less than Threshold 2: The receiver shall dwell on the channel long enough to allow the time, channel number and signal strength to be logged (1362).

ILS08.23 For signals greater than Threshold 2: The receiver shall dwell on the channel long enough to allow the time, channel number and signal strength to be logged, and for demodulated audio signals to be recorded (1363).

Audio Recording duration

ILS08.24 When a signal exceeds threshold 2, the demodulated audio signal shall be recorded for a continuous period of approximately 20 seconds (1364).

Note: To save recording space, if 10 successive scans have found the same channel with a signal exceeding Threshold 2, modulation recording of that channel may be terminated and only the signal strength need be logged.

Channels to be examined at each scan

ILS08.25 Initially, all except the operational Localiser frequency or frequencies (1365).

Note: If a continuous carrier is detected on one or more of the channels being examined, the scanning may step over those channels provided that the presence of the carrier on that channel has been recorded.

Operational Channel monitoring

ILS08.26 If the equipment can also record interference events on the operational channel. Details shall be provided of:

1. The mask used to remove the ILS signal (1366).
2. The threshold levels used for the noise measurement (1367).

Threshold level

ILS08.27 Threshold 1: Adjustable over the range 2μV to 10μV (1368).

ILS08.28 Threshold 2: Adjustable over the range 10 to 20μV (1369).

Aerial horizontal response

ILS08.29 Omnidirectional (1370).

Aerial polarisation

ILS08.30 Horizontal (1371).

Storage of results

ILS08.31 Channel occupancy data shall be sent either directly to a printer or stored on computer disk or both (1372).

ILS08.32 Modulation information shall be stored on a suitable audio recording device (1373).

Note: Suitable audio devices include such media as standard audio cassettes and solid state digital storage.

ILS08.33 **Recommendation**: The results should be stored in a format which will facilitate further analysis (1374).

Calibration

ILS08.34 Documented calibration procedures shall be applied to all equipment involved in the measurement of radio noise level (1375). All equipment and standards used in the calibration process shall have traceability to national or international standards (1376).

ILS08.35 When any equipment used is claimed to be self calibrating, the internal processes involved shall be clearly defined (1377). This involves showing how the equipment's internal standard is applied to each of the parameters which it can measure or generate. The internal standard shall have traceability to national or international standards (1378).

ILS08.36 Calibration intervals shall be stated in the calibration records (1379). Evidence shall be available to support the quoted calibration intervals (1380).

Standard Settings

ILS08.37 For normal operation, threshold settings shall be:

Threshold 1	μV (1381)
Threshold 2	13μV (1382)

Data to be Recorded

ILS08.38 For each scan across the frequency band, when any signal exceeds threshold 1, the following parameters shall be recorded:

1. The date and time (1383).
2. The frequency or channel number of each channel having a signal exceeding threshold 1 (1384).
3. The strength of all signals exceeding threshold 1 (1385).

Note: For signals greater than 100μV, the absolute signal strength need not be recorded. It is sufficient to state '>100μV'.

ILS08.39 Where the signal strength exceeds threshold 2 and modulation is present, the detected modulation shall be recorded (1386).

Note: Modulation is recorded to assist in identifying an offending transmission.

Location of Measuring Equipment

Horizontal position

ILS08.40 If a single measurement point is used for the complete airport, then the aerial shall be located near the mid-point of the runway (1387). If an alternative location in the approach area is used, the measurements shall only apply to that particular approach (1388).

ILS08.41 Measurements near the mid-point shall only be made with equipment that is immune to blocking from the operational localiser (1389).

Vertical position

ILS08.42 The aerial shall be higher than any obstructions in the immediate vicinity (1390) but shall not be an obstruction to aircraft (1391).

Measurement Interval and Duration of Measurement

Interval

ILS08.43 The measurement shall be made on each Cat II and Cat III runway at intervals not exceeding one year (1393).

Duration

ILS08.44 The total measurement period shall be a minimum of 350 hours in any one year (1394). The measurement need not be made in one continuous period.

Report

ILS08.45 The report shall show the total number of times that each channel has signals present with strengths:

1. Exceeding threshold 1 but not threshold 2 (1395).
2. Exceeding threshold 2 (1396).

ILS08.46 The present acceptance limit is an interference rate equivalent to < 2 x 10-5 events per second. An event being a signal > 13μV. The total rate shall be calculated as an average over the total monitoring time (1397). Submitted results shall show the calculations used in producing the figures for the interference rate (1398).

ILS08.47 Modulation recordings shall be made available on request (1399).

ILS08.48 When measurements show that the interference level exceeds limits, the appropriate CAA engineering inspector must be advised immediately (1400).

ILS08.49 Evidence of the required routine measurements must be available when requested by a CAA engineering inspector (1401).

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ILS 10: General Requirements for ILS

Part 1 Preliminary Material

Introduction

ILS10.1 The ILS provides precision guidance signals to aircraft in the last stages of approach and landing. For this purpose the equipment needs a high level of integrity, accuracy and reliability. Other auxiliary equipment is used to support the main equipment.

ILS10.2 Instrument Landing Systems are classified as Category I, Category II or Category III, in ascending order of accuracy, integrity and reliability.

ILS10.3 Full definitions of these categories may be found in ICAO Annex 10, Volume 1, Chapter 3.1.1.

Scope

ILS10.4 This document sets out the minimum requirements for all categories of ILS service.

ILS10.5 The scope of this document relates only to the performance of the ILS facility. The overall category of a runway is dependent on many other factors.

Part 2 Requirements

Safety Objective

ILS10.6 **The equipment shall provide a complete, identified, accurate and uncorrupted source of guidance information to aircraft, with levels of integrity and continuity of service which are consistent with the category of service provided.**

SARPs Compliance

ILS10.7 In addition to the requirements below, Instrument Landing Systems shall comply with the SARPs in ICAO Annex 10, Volume 1, Chapter 2 General Provisions for Radio Navigation Aids, and Chapter 3, Section 3.1 Specification for ILS (1998).

Note: Where the UK has differences filed to SARPs, these will be published in Supplements to the Annexes and in the UK AIP.

Integrity and Continuity of Service

ILS10.8 The ILS shall meet the ICAO Annex 10 Volume 1 SARPs for Integrity and Continuity of Service found in Chapter 3.1 (1999).

Note: A method of putting an ILS with an established Mean Time Between Outages (MTBO) into service can be found in Appendix A to ILS 10.

ILS10.9 Maintenance shall be prescribed in accordance with the Integrity Analysis (2330).

Serviceability Indicators

ILS10.10 FISOs and/or ATCOs directly responsible for ILS operations shall be provided with information on the operational status of radio navigation services essential for approach, landing and take-off at the aerodrome(s) with which they are concerned, on a timely basis consistent with the use of the service(s) involved (2278).

ILS10.11 Where status information is reliant upon a visual status indicator, then an audible alarm should be provided which indicates that the visual indicator has changed state (2279).

Failure of Status Communications

ILS10.12 Permitting a status communications failure to shut down the ILS without a warning could unnecessarily remove the ILS signal when the aircraft is in a critical phase of the approach.

ILS10.13 Failure of status communication between the ILS equipment and the remote status indicators shall cause an immediate alarm at the remote indicators (2002).

ILS10.14 For Category II and III systems, failure of the status communication shall not cause an immediate ILS close-down (2003).

ILS10.15 For Category I systems, it is acceptable to consider status communication failure as part of the Continuity of Service assessment (2004).

ILS10.16 Following failure of the status communications, only aircraft on final ILS approach shall be permitted to complete the approach (2005). The ILS shall then be withdrawn from service in accordance with a documented procedure (1430).

ILS10.17 If the ILS is configured to close-down the system after a delay following status communications failure, the delay must be long enough for the actions in paragraph ILS10.13 to be completed (2006).

ILS10.18 In the event of a status communication failure, a suitably trained technician may be stationed at the ILS building(s) with a suitable means of communication to ATC (2007). The equipment should then operate in local control, supervised by the system monitors (1624). The monitors shall not be overridden or inhibited (1625). ATC must be advised without delay of any change in status of the ILS (2210).

ILS10.19 A reciprocal ILS shall not be put into service until the system with faulty status communications is positively disabled and cannot accidentally radiate (2008).

Category and Status Unit

ILS10.20 In addition to the normal remote control and other indications, Category III facilities shall be fitted with a unit that accepts signals from the ILS equipment, its monitors and the runway direction switch to automatically provide ATC with indications of the operational category of the ILS (1436).

Note: The precise method of calculation used by the Category and Status Unit will depend on the ILS equipment from which it derives its inputs. The display category will need to be supported by the integrity and Continuation of Service assessment.

ILS10.21 The unit shall have an integrity as determined by hazard analysis (1437).

ILS10.22 Any change of calculated category shall cause an audible alarm to ATC (1439).

ILS10.23 The unit shall have provision to limit the maximum category output to the display (1440).

ILS10.24 If the calculated category falls, then the category must remain at the lower value until upgraded manually by an authorised person except as prescribed in paragraph ILS10.25 (2280).

ILS10.25 If a Far Field Monitor alarm or ILS pre-alarm causes a category fall, then the category may be automatically upgraded as long as no other alarms are present (2281).

ILS10.26 The unit shall only automatically upgrade the category at initial ILS equipment switch-on or runway change (1443).

Interlocking

ILS10.27 Where systems are installed at opposite ends of the same runway they shall be interlocked so that only one system may radiate at one time (1445).

ILS10.28 The interlocking system shall be such that the non-operational system cannot be switched on using either the remote or local control switches (1446).

ILS10.29 The interlocking system shall fail-safe (1447). If the communication link between the systems fails, it shall not be possible to make the non-operational system radiate using the local or remote front panel controls (1448).

ILS10.30 The interlocking shall be considered as part of the integrity and CoS assessment (2009).

Provision of Standby Equipment

ILS10.31 Category III systems shall have dual equipment so that the system is 'fail operational', regardless of proven MTBO (1450). The non-operational transmitter shall radiate into a dummy load and its critical parameters shall be monitored (1451).

ILS10.32 Other categories should have standby equipment with automatic changeover (1452).

Standby Battery Power

ILS10.33 Category II and III systems, including the remote control equipment, interlock and status displays shall be provided with a standby battery power supply (1453). In the event of a mains power failure, this shall be capable of sustaining the normal ILS operation for a minimum of 20 minutes (1454).

ILS10.34 **Recommendation**: Category I facilities should have standby batteries (1455).

ILS10.35 The ATS Provider shall have a procedure for managing the withdrawal and return of the ILS from/to operational service when standby batteries are or have been in use. Consideration should be given to the designed battery capacity and the fact that discharged batteries may take a significant time to recharge to full capacity following a failure (2010).

Localiser Back Beam

ILS10.36 Facilities designed to radiate a back beam are not permitted (1456).

Offset Localisers

ILS10.37 An offset localiser may be installed as required; such an installation shall be a Category I facility (2011).

Field Measurements

Localiser Alignment

ILS10.38 For CAT I, II and III systems, alignment measurements on centreline and as close to threshold as practicable shall be taken as soon as possible after commissioning and flight inspections on all transmitters (2012).

ILS10.39 For CAT I, II and III systems, alignment measurements on centreline and as close to threshold as practicable shall be taken at monthly intervals or as agreed by the CAA in advance on all transmitters (2013).

ILS10.40 Alignment measurements shall comply with the Alignment limits in ILS 02 Flight Inspection Requirements Table 1 Localiser Limits (2331).

ILS10.41 For CAT III systems which provide roll out or take off guidance, measurements of course structure along the runway to ILS point E shall be made at commissioning and at 6 monthly intervals. The commissioning and one check per year should be conducted with an appropriate antenna height consistent with that of an aircraft antenna, e.g. 3 to 8 m above the runway. The second check may be made at 15 m above the runway. (2211).

ILS10.42 Course structure shall have a probability of 95% or better of not exceeding the limits given below, when assessed over a 40 second interval (2332).

0.5% DDM at Threshold to ILS point D increasing at a linear rate to 1% DDM at ILS point E.

Note: Guidance on structure assessment may be found in Attachment C to ICAO Annex 10 Volume 1.

Localiser Displacement Sensitivity

ILS10.43 Displacement Sensitivity measurements shall be made on all transmitters:

1. No closer than half the runway length from the localiser (2371).
2. Between the half and the full sector width points, providing that a proportional relationship is established between that point and the full sector width (2372).

ILS10.44 For CAT I Localisers using 14 or less radiating elements, field measurements may be made approximately 300 m in front of the local transmitting aerial (2017).

ILS10.45 Displacement Sensitivity measurements shall be taken as soon as possible after commissioning, and flight inspections (2018).

ILS10.46 Displacement Sensitivity measurements shall be taken at monthly intervals or as agreed by the CAA in advance (2019).

ILS10.47 Nominal displacement sensitivity for Category I localisers on runway codes 1 and 2 shall be set at ILS point B (2282). Runway codes 1 and 2 are defined in ICAO Annex 14.

ILS10.48 Displacement Sensitivity measurements shall comply with the Displacement Sensitivity limits in ILS 02 Flight Inspection Requirements Table 1 Localiser Limits (2333).

Ground Measurements of Displacement Sensitivity instead of Flight Inspection

ILS10.49 It is permissible to make routine ground measurement of Displacement Sensitivity instead of Flight Inspection.

ILS10.50 At commissioning, the displacement sensitivity shall be measured by flight inspection (1303). If the ground and air measurements differ by more than 5% the disagreement shall be investigated (1304).

ILS10.51 The flight inspection shall still include semi-orbits from which linearity in the course sectors can be examined (1305).

ILS10.52 All airports wishing to use the ground measurements as standard shall submit the following information to the CAA:

1. Position of the ground measurement points (1306); and
2. Details of the equipment to be used for this measurement (1307).

ILS10.53 The localiser displacement sensitivity shall be measured at a time as near as possible to that of the flight inspection (1308). The result of the measurement is needed by the flight inspection organisation as part of the structure measurement calculations.

ILS10.54 The measurements may be made either in DDM or μA deflection current at the measurement points. For standardisation these results shall be converted into localiser full sector width, i.e. the theoretical angle between the points at which 0.155 DDM would occur (1310).

ILS10.55 The airport's ILS maintenance instructions shall show the method of calculating the width angle from the ground measurements (1311).

Localiser Off Course Clearance

ILS10.56 Off course clearance is measured by flight inspection and as such there is not a requirement to measure off course clearance on the ground. Operators may wish to establish a test point in the far field to assist in checking the localiser performance before requesting a flight inspection after engineering work (2020).

Field Test Equipment

ILS10.57 In the event of an accident or incident an airport should do all that is reasonable to ascertain that the ILS is operating correctly. For this reason all aerodromes shall have equipment suitable for making field measurements available within 12 hours (2021).

Glidepath Measurements

ILS10.58 Glidepath field measurements are not mandatory but would be of great help in proving equipment stability. It is recommended that monthly field checks are made on null reference and sideband reference glidepaths (1280).

Field Test Points

ILS10.59 Points at which field measurements are made shall be clearly and permanently marked. These marks shall not present a hazard to aircraft (1463) and shall be immune to disturbance by such operations as grass cutting and snow clearance (1464).

Critical Areas

ILS10.60 Localiser and Glidepath critical areas shall be clearly marked and identified. The marking shall be visible day and night (1465) and shall help ensure that no person or vehicle may enter the areas without the permission of ATC (1466).

ILS10.61 Where fencing is used to mark the critical areas, the operator shall ensure the ILS continues to operate in accordance with the requirements of ILS 02 Flight Inspection Requirements (1467).

ILS10.62 Details of the Localiser and Glidepath critical areas shall be included in the unit MATS part 2 or MAFIS, together with any appropriate procedures (2022).

Sensitive Areas

ILS10.63 Localiser and Glidepath sensitive areas shall be set in relation to the aircraft type that causes the greatest dynamic bends to the course structure, whilst operating at the aerodrome during Low Visibility Procedures. (2334).

ILS10.64 Details of the Localiser and Glidepath sensitive areas shall be included in the unit MATS part 2 or MAFIS, together with any appropriate procedures (2024).

ILS10.65 When defining the Sensitive Area the operator shall be cognisant of any static bends (2335).

Computer Simulation

ILS10.66 Where computer simulation is used to define an ILS sensitive area, or to support a case for a system remaining operational during construction work, the following are required:

1. Proof that the version of software being used is the latest issue, OR recent written confirmation from the software manufacturer that the version being used has no known safety related problems (1469);

2. Proof that the person making the simulation has received formal training in the use of the simulation programme (1470);
3. Evidence to support that the model is suitable for the intended simulation (2025); and
4. Evidence to support the correlation of the modelling tool with far field measurement (2026).

ILS10.67 Due to the difficulty of simulating lattice structures such as cranes, the CAA may require confirmatory flight and/or ground inspections during construction work.

Use of Second Hand Equipment

ILS10.68 Second hand equipment may be installed subject to the following conditions:

1. The equipment shall be examined by the manufacturer's quality representative or by an agent designated by the manufacturer (1473). A written declaration shall show:
   a) The equipment is in a satisfactory state for further service (1474); and
   b) There are no outstanding safety-related modifications (1475).
2. Glidepath aerials shall be brand new or factory refurbished and re-tested to the original factory test specification (1476); and
3. All aerial feeder cables shall be renewed (1477).

Grass Height

ILS10.69 When considering the grass height around the Localiser and Glidepath the operator should refer to CAP 772 Birdstrike Risk Management for Aerodromes, Chapter 4 Potential Effect of Grass Height on Navigational and Visual Aids.

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Appendix A to ILS 10: Method of Putting an ILS with an Established Mean Time Between Outages (MTBO) into Service

Conditions which must be met for this abbreviated method of approval to be used

ILS10A.1 The manufacturer's calculated MTBO meets ICAO SARPs with a 90% confidence level (2198).

ILS10A.2 In service MTBO data meets ICAO SARPs with a 90% confidence level (2199).

ILS10A.3 The system(s) considered as part of the In Service MTBO assessment shall be identical system(s) and cover the range of environmental conditions encountered in the UK (2200).

ILS10A.4 The systems are installed and maintained to acceptable standards (e.g. manufacturer's installation and commissioning specifications) (2030).

ILS10A.5 The organisation making the installation has a good quality record and can provide evidence of staff competence (2034).

If the above conditions are satisfactory

ILS10A.6 Carry out all the necessary tests, e.g. Commissioning, Site Acceptance and flight inspection (2201).

ILS10A.7 Run system continuously for 24 hours for CAT 1 and 300 Hours for CAT II/III, on either transmitter in the case of dual equipment (2202).

ILS10A.8 If there are no outages, put into service at the appropriate Category (2203).

ILS10A.9 Start continuous MTBO monitoring, initialising the figures for:

1. CAT 1 Localiser and Glidepath at 1250 hours (2204).
2. CAT II/III Localiser at 5000 hours (2205).
3. CAT II/III Glide Path at 2500 hours (2206).

ILS10A.10 Continue to monitor MTBO using normal processes. A confidence level of 60% may be used (2207).

Note: 'Outage' in these calculations means a total unplanned loss of signal due to a fault. Automatic changeover to the standby transmitter, after a fixed delay if appropriate, is not classed as a failure.

MLS 01: General Requirements for Microwave Landing System (MLS)

Part 1 Preliminary Material

Introduction

MLS01.1 MLS is a precision approach and landing guidance system which provides position information and various ground to air data. The position information is provided in a wide coverage sector and is determined by an azimuth angle measurement and elevation angle measurement and a range (distance) measurement (ICAO Annex 10 Volume 1 3.11.2.1).

MLS01.2 MLS systems are classified as Category I, Category II or Category III in ascending order of integrity and reliability.

Note: Unlike ILS, the accuracy requirements for MLS are the same for all categories.

Scope

MLS01.3 This document sets out the minimum equipment requirement for all categories of MLS used for ILS type approaches (often referred to as "ILS look-alike" approaches).

MLS01.4 The scope of this document relates only to the performance of the MLS facility. The overall category of a runway is dependent on many other factors.

MLS01.5 These requirements apply to MLS with the following configuration:

- ILS look-alike.
- High rate approach azimuth guidance.
- Clearance not provided by pulses.
- No Out of Coverage Indication (OCI) signals.
- No Back Azimuth.

Part 2 Requirements

Safety Objective

MLS01.6 **The equipment shall provide a complete, identified, accurate and uncorrupted source of guidance information to aircraft, with levels of integrity and continuity of service which are consistent with the category of service provided.**

System Requirements

ICAO SARPs Compliance

MLS01.7 In addition to the requirements below, Microwave Landing Systems shall comply with the SARPs in ICAO Annex 10, Volume 1, Chapter 2 General Provisions for Radio Navigation Aids, and Chapter 3, Section 3.11 Specification for MLS (2212).

Note: Where the UK has differences filed to SARPs, these will be published in Supplements to the Annexes and in the UK AIP.

Integrity and Continuity of Service

MLS01.8 The MLS shall meet the ICAO Annex 10 Volume 1 SARPS for Integrity and Continuity of Service found in Chapter 3.11 (2213).

MLS01.9 Maintenance shall be prescribed in accordance with the Integrity Analysis (2336).

Serviceability Indicators

MLS01.10 FISOs and/or ATCOs directly responsible for MLS operations (e.g. Approach Controllers) shall be provided with:

1. Visual indications showing the serviceability status of all elements of the MLS including power supplies (2214); and
2. An audible alarm indicating when the visual indications have changed state (2215).

Failure of Status Communications

MLS01.11 Permitting a status communications failure to shut down the MLS without a warning could unnecessarily remove the MLS signal when the aircraft is in a critical phase of the approach.

MLS01.12 Failure of status communication between the MLS equipment and the remote status indicators shall cause an immediate alarm at the remote indicators (2216).

MLS01.13 For Category II and III systems, failure of the status communication shall not cause an immediate MLS close-down (2217).

MLS01.14 For Category I systems, it is acceptable to consider status communication failure as part of the Continuity of Service assessment (2218).

MLS01.15 Following failure of the status communications, only aircraft on final MLS approach shall be permitted to complete the approach. The MLS shall then be withdrawn from service in accordance with a documented procedure (2219).

MLS01.16 If the MLS is configured to close down the system after a delay following status communications failure, the delay must be long enough for the actions in paragraph MLS01.15 to be completed (2220).

MLS01.17 In the event of a status communication failure, a suitably trained technician may be stationed at the MLS building(s) with a suitable means of communication to ATC. The equipment should then operate in local control, supervised by the system monitors. The monitors shall not be overridden or inhibited. ATC must be advised without delay of any change in status of the MLS (2221).

MLS01.18 A reciprocal MLS shall not be put into service until the system with faulty status communications is positively disabled and cannot accidentally radiate (2222).

Category and Status Unit

MLS01.19 In addition to the normal remote control and other indications, Category III facilities shall be fitted with a unit that accepts signals from the MLS equipment, its monitors and the runway direction switch, to provide ATC automatically with indications of the operational category of the MLS (2223).

Note: The precise method of calculation used by the Category and Status Unit will depend on the MLS equipment from which it derives its inputs. Guidance material is provided in Appendix A to MLS 01.

MLS01.20 The unit shall have an integrity as determined by a hazard analysis (2224).

MLS01.21 Any change of calculated category shall cause an audible alarm to ATC (2225).

MLS01.22 The unit shall have provision to limit the maximum category output to the display (2226).

MLS01.23 If the calculated category falls, then the category must remain at the lower value until upgraded manually by an authorised person except as prescribed in paragraph MLS01.24 (2337).

MLS01.24 If a Far Field Monitor alarm or MLS pre-alarm causes a category fall, then the category may be automatically upgraded as long as no other alarms are present (2338).

MLS01.25 The unit shall only automatically upgrade the category at initial MLS equipment switch-on or runway change (2228).

Interlocking

MLS01.26 Where systems are installed at opposite ends of the same runway strip they shall be interlocked so that only one system may radiate at one time (2229).

MLS01.27 The interlocking system shall be such that the non-operational system cannot be switched on using either the remote or local control switches (2230).

MLS01.28 The interlocking system shall fail-safe. If the communication link between the systems fails, it shall not be possible to make the non-operational system radiate using the local or remote front panel controls (2231).

MLS01.29 The interlocking shall be considered as part of the integrity and CoS assessment (2232).

Provision of Standby Equipment

MLS01.30 Category III systems shall have dual equipment so that the system is 'fail operational', regardless of proven MTBO (2339).

MLS01.31 The non-operational transmitter shall have its critical parameters monitored (2340).

Standby Battery Power

MLS01.32 Category II and III systems, including the remote control equipment, interlock and status displays, shall be provided with a standby battery

power supply. In the event of a mains power failure, this shall be capable of sustaining the normal MLS operation for a minimum of 20 minutes (2235).

MLS01.33 **Recommendation**: Category I facilities should have standby batteries (2236).

MLS01.34 The ATS Provider shall have a procedure for managing the withdrawal and return of the MLS from/to operational service when standby batteries are or have been in use. Consideration should be given to the designed battery capacity and the fact that discharged batteries may take a significant time to recharge to full capacity following a failure (2237).

Synchronisation

MLS01.35 Failure of the synchronisation link between azimuth and elevation facilities shall cause immediate shut-down of the MLS (2238).

MLS01.36 The synchronisation link shall be included in the calculations for the overall MTBO of the equipment (2239).

Critical Areas

MLS01.37 Azimuth and Elevation critical areas shall be clearly marked and identified. The marking shall be visible day and night and shall help ensure that no person or vehicle may enter the areas without the permission of ATC (2240).

MLS01.38 Where fencing is used to mark the critical areas, the operator shall ensure that the MLS continues to operate in accordance with the requirements of MLS 02 Flight and Ground Inspection Requirements (2241).

MLS01.39 Details of the critical areas shall be included in the unit MATS Part 2 or MAFIS, together with any appropriate procedures (2242).

MLS01.40 Where MLS is co-located with ILS, the MLS critical area will normally be within the ILS critical area and hence need not be separately marked (2243).

Sensitive Areas

MLS01.41 Azimuth and Elevation sensitive areas shall be defined (2244).

MLS01.42 Details of the Azimuth and Elevation equipment sensitive areas shall be included in the unit MATS Part 2 or MAFIS, together with any appropriate procedures (2245).

Note: These areas will normally be defined by the system operator or manufacturer and endorsed by the CAA. This information is required for positioning of hold points, production of ATC instructions, etc.

Computer Simulation

MLS01.43 Where computer simulation is used to define an MLS sensitive area, or to support a case for a system remaining operational during construction work, the following are required:

1. Proof that the version of software being used is the latest issue, OR recent written confirmation from the software manufacturer that the version being used has no known safety-related problems (2246);
2. Proof that the person making the simulation has received formal training in the use of the simulation programme (2247);
3. Evidence to support that the model is suitable for the intended simulation (2248); and
4. Evidence to support the correlation of the modelling tool with field measurements, e.g. Flight Inspection results (2249).

Appendix A to MLS 01: Guidance Material Relating to the Automatic Calculation of MLS Category

Condition	Display
Failure of Azimuth standby transmitter	Cat II
Failure of Elevation standby transmitter	Cat III
Changeover to Azimuth standby transmitter	Cat II
Changeover to Elevation standby transmitter	Cat III
Far Field Monitor alarm	Cat I
Where a single battery is used: Low battery voltage alarm	 Cat I
Where each transmitter has its own battery and warning system: Low voltage alarm on one battery Low voltage alarm on both batteries	 Cat II Cat I
Loss or corruption of data for calculation	MLS not available
Where multiple monitor sets are used: Disagreement between monitors	 Cat III
Reciprocal system on	MLS not available
Status of reciprocal not known	MLS not available
Local control	MLS not available

Note: This information is not exhaustive since the operation of the CSU is dependent on the monitoring system of each type of MLS equipment.

Note: This information relates only to the displayed category. Consequent actions, such as controlled withdrawal from service, are covered by the operator's procedures.

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MLS 02: Microwave Landing System (MLS) Flight and Ground Inspection Requirements

Introduction

MLS02.1 Article 205 (5) of the ANO 2009, as amended, permits the CAA to include a condition on an Article 205 approval requiring that the equipment be flight checked by an approved person.

MLS02.2 The purpose of this document is to ensure that Microwave Landing Systems (MLS) are maintained and operated within defined limits.

Scope

MLS02.3 These requirements apply to MLS with the following configuration:

- ILS lookalike;
- high rate approach azimuth guidance;
- clearance not provided by pulses;
- no Out-of-Coverage Indication (OCI) signals;
- no back azimuth.

MLS02.4 This document defines the:

- inspection interval;
- limits to be applied to all parameters measured; and
- types of inspection.

MLS02.5 Work is ongoing to investigate requirements for checking multipath. Once these have been established, they will be included in this set of requirements.

Safety Objective

MLS02.6 **The equipment shall provide a complete, identified, accurate and uncorrupted source of guidance information to aircraft (2283).**

Inspection Interval

MLS02.7 For MLS facilities, the prescribed interval between successive inspections is 180 days (2284).

Tolerances

MLS02.8 A tolerance of ±20 days is applicable to the prescribed intervals. Operators shall strive to ensure that inspections take place as closely as possible to the prescribed intervals (2285). If the previous inspection lasted more than one day, the interval shall be calculated from the date when the inspection started (2286).

MLS02.9 Inspections may be made up to 7 days earlier than the due date without affecting the due date for the next inspection. If an inspection is made more than 7 days before the due date, the date of subsequent inspections shall be advanced.

Delays due to Adverse Weather

MLS02.10 Occasionally, prolonged periods of adverse weather may prevent an inspection being completed within the permitted tolerance. If this occurs, the system may continue in operation for a further 25 days provided that a reduced flight inspection has been made within the permitted tolerance interval (2289).

MLS02.11 Reduced inspection requirements:

- Azimuth: part orbit ± 40° at not less than 5 NM from Approach Reference Datum (ARD) at Minimum Safe Altitude (MSA) for both transmitters (2290); and
- Elevation: level slice on centre line from 0.3 theta to 1.75 theta, for both transmitters (2291).

Supplementary Flight Inspections

MLS02.12 A supplementary flight inspection must be made 90 days ±20 days after a periodic flight inspection if at that inspection any parameter was found outside the flight inspection tolerances stated in Table 1 or 2 and subsequently adjusted (2292).

MLS02.13 The above requirement can be relaxed if ground measurement and equipment monitors confirm the changes seen during the periodic flight inspection. In this case it would be acceptable to carry out more frequent ground monitoring and inspection of the equipment monitor records.

MLS02.14 Only the parameters found out of tolerance need to be checked by the supplementary flight inspection.

MLS02.15 A supplementary flight inspection may be requested by the CAA at any time if the following conditions arise:

1. A regional inspector considers that any aspect of maintenance is not being correctly carried out;
2. An inspection of equipment monitor records, which may be requested at any time by the CAA, shows any evidence of instability;
3. Changes have been made within the safeguarded areas.

Field Monitors

MLS02.16 Commissioning flight inspections shall be made with all field monitors that can have a significant effect on the signal in space installed in their final positions (2293).

Flight Inspection Organisations

MLS02.17 All flight inspections shall be made by an organisation having a CAA approval under the ANO for MLS flight inspection (2294).

Inspection after Engineering Work

MLS02.18 Certain types of engineering work may require that the system be flight inspected before being returned to service. The ATS provider shall carry out an assessment to ascertain the scope of the flight inspection (2295).

Analysis of Flight Inspection Records

MLS02.19 The ATS Provider shall analyse the flight inspection report at the earliest opportunity for operational systems and prior to entering a

facility into operational service to ensure that the flight inspection requirements are met (2341).

MLS02.20 The ATS Provider shall address any deficiencies or non-compliance to ensure a safe service is provided (2342).

MLS02.21 An ATS Provider may delegate the task of analysing the flight inspection report to a third party specialist organisation. This may be the flight inspection organisation that provided the report. The responsibility for addressing any deficiencies identified remains with the ATS Provider (2343).

MLS02.22 The person who conducts the analysis shall be competent to do so (2344).

Note: This may include training on a specific flight inspection report format.

Inspection Criteria

MLS02.23 Inspection results shall conform to the tolerances given in Tables 1 and 2 (2298).

Parameters to be Measured

MLS02.24 Tables 1 and 2 give details of the parameters that must be measured at each inspection.

Promulgated Procedure

MLS02.25 At commissioning and on an annual basis an Instrument Rated pilot shall check the final turn onto all Instrument Approach Procedures (IAP) (2299). During the check the pilot shall observe any other navigational aids that are used to support the procedure (2300). The aim of this check is to ensure that any navigational signals used as part of the procedure position the aircraft to allow the MLS to be correctly captured. Where several IAPs follow the same path, only one flight needs to be conducted as long as it ensures that all supporting navigational aids are checked.

MLS02.26 The pilot shall provide confirmation of the performance of the navigational aids used for the IAP (2301). The ATS provider shall formally record this confirmation (2302).

Table 1 Azimuth Limits

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Angle Accuracy Runway Coverage Area to Approach Reference Datum (ARD)	Path Following Error (PFE) ± 4.0m Path Following Noise (PFN) ± 3.5m Control Motion Noise (CMN) ± 3.2m or 0.1 degree, whichever is less	Ground check On centreline between ARD and along runway	From plot	Commissioning Both Routine Both
	Mean Course Error (MCE) ± 3.0m **Note**: The ICAO Standard in Annex 10 Volume 1 paragraph 3.11.5.2.5.1 is for ground equipment contribution. Checks in the far field would include the effects of multipath. Due to the similarity with ILS it is assumed that this requirement includes multipath effects. MCE standard needs to be clarified by ICAO.	Ground Check Spot check at the ARD	Direct reading	

Table 1 Azimuth Limits (Cont.)

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Angle Accuracy ARD to limits of coverage	PFE and PFN The PFE and PFN limits, expressed in angular terms at 37 km (20 NM) from the runway threshold along the extended runway centre line, shall degrade linearly to be 2 times the value specified at the ARD	This is a two-part test Level slice on centre line from 20 NM at 0.3 theta to 1.75 theta Note: The requirement for flight to 1.75 theta can be reduced if elevation is not being checked. Fly down from 7 NM on azimuth and elevation to ARD	Plot from 20 NM to the intercept of the glidepath; and Plot from 6 NM to ARD	Commissioning Both Routine Both
	CMN The CMN limit shall degrade linearly from the value at ARD to be 0.1 degree at 37 km (20 NM) from the ARD along the extended runway centre line at the minimum glide path angle			
	MCE The Mean Course Error shall not exceed an error equivalent to ± 3.0m at ARD	Fly down from 7 NM on azimuth and elevation to ARD	Average between 1 NM and ARD	

Table 1 Azimuth Limits (Cont.)

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Angle Accuracy with Azimuth Angle	PFE and PFN The PFE and PFN limits, expressed in angular terms at plus or minus 40 degrees azimuth angle, shall degrade linearly to be 1.5 times the value on the extended runway centreline at the same distance from the ARD The PFE limits shall not exceed 0.25 degree in any region of coverage The PFN limits shall not exceed 0.15 degree in any region of coverage **Note**: When clearance is used, PFE and PFN can only be measured in the proportional guidance area	2 flights, one either side of the centreline, in the vicinity of the edge of the proportional guidance Each flight comprising a level slice from 20 NM at 0.3 theta to a point to intersect the glide path angle and then fly down to ARD	Plot from 20 NM to ARD	Commissioning only. One TX
	CMN The CMN limit, expressed in angular terms at plus or minus 40 degrees azimuth angle, shall degrade linearly to be 1.3 times the value on the extended runway centreline at the same distance from the ARD The CMN limits shall not exceed 0.1 degree in any region of coverage **Note**: When clearance is used, CMN can only be measured in the proportional guidance area			

Table 1 Azimuth Limits (Cont.)

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Clearance Regions	Fly left or fly right clearance information as appropriate from beyond the proportional guidance sector to ± 40 degrees	Commissioning Part orbit at not less than 5NM from ARD at Minimum Safe Altitude (MSA) in both directions Routine Part orbit at not less than 5NM from ARD at Minimum Safe Altitude (MSA) in one direction	Plot from ± 40 degrees about centreline	Commissioning Both Routine Both

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Power Density	In accordance with ICAO Annex 10 Volume 1 paragraph 3.11.4.10.1 for high rate approach azimuth guidance and approach elevation guidance	Commissioning 20 NM ±40 degrees part orbit within coverage at MSA; and Part orbit at not less than 5NM from ARD at MSA Routine Part orbit at not less than 5NM from ARD at MSA	Commissioning Plot of ±40 degrees at 20 NM; and Plot of ±40 degrees at 5 NM Routine Plot of ±40 degrees at 5 NM	Commissioning 20 NM one TX only 5 NM both TX Routine Both
Power Density at ARD	+15 dB above the value in ICAO Annex 10 Volume 1 paragraph 3.11.4.10.1	Ground spot check Antenna extended to ARD	Direct read off ground equipment	Commissioning Both Routine Both

Table 1 Azimuth Limits (Cont.)

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Power Density along runway	Greater than 5 dB above the value in ICAO Annex 10 Volume 1 paragraph 3.11.4.10.1 for one degree or 9 dB for 2 degree or larger beam width antennas at 2.5 m (8 ft) above the runway surface, at the MLS datum point, or at the farthest point of the runway centre line which is in line of sight of the azimuth antenna	Ground spot check	Direct read off ground equipment	Commissioning Both Routine Both
Multipath relative power density Within the MLS azimuth coverage at 60 m (200 ft) or more above threshold	The duration of a reflected scanning beam signal whose power density is higher than 4 dB below the azimuth guidance scanning beam signal power density shall be shorter than one second	Level Slice on centreline from 20 NM at 0.3 theta to intersect a Fly down from 7 NM on azimuth and elevation to ARD	Plot or analysis	Commissioning One TX Biennial One TX

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Multipath relative power density Within the MLS azimuth proportional guidance sector, below 60 m (200 ft) above threshold	The power density of any reflected approach azimuth guidance scanning beam signal shall be less than 10 dB above the power density of the approach azimuth guidance scanning beam signal	Ground check on centreline between ARD and along runway	From plot	Commissioning One TX Biennial One TX

Table 1 Azimuth Limits (Cont.)

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Monitor Verification		Ground check	Spot check	Commissioning Both Routine Both
Identification		Ground check	Spot check	Commissioning Both Routine Both

Table 2 Elevation Limits

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Accuracy at Approach Reference Datum	Mean Glidepath Error (MGE) ± 0.3m **Note**: The ICAO Standard in Annex 10 Volume 1 paragraph 3.11.5.3.5.1 is for ground equipment contribution. Checks in the far field would include the effects of multipath. Due to the similarity with ILS it is assumed that this requirement includes multipath effects MGE standard needs to be clarified by ICAO	Static antenna at the ARD	Direct reading	Commissioning Both Routine Both

Table 2 Elevation Limits (Cont.)

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Angle Accuracy Edge of coverage to ARD	PFE and PFN PFE ± 0.6m at ARD PFN ± 0.4m at ARD The PFE limit and PFN limit, expressed in angular terms at 37 km (20 NM) from the runway threshold on the minimum glide path, shall degrade linearly to 0.2 degrees CMN CMN ± 0.3m at ARD The CMN limit, expressed in angular terms at 37 km (20 NM) from the runway threshold on the minimum glide path, shall degrade linearly to 0.1 degrees Fly up deflection shall exist at all angles between lower limit of coverage and 2.2 degrees, thereafter Annex 10 Volume 1 Standard applies between 2.2 degrees and theta	This is a two-part test Level Slice on centreline from 20 NM at 0.3 theta to 1.75 theta of the elevation Fly down from 7 NM on azimuth and elevation to ARD	Plot from 0.3 theta to 1.75 theta, and; Plot from 7NM to ARD	Commissioning Both Routine Both
	MGE The Mean Glide Path Error shall not exceed: 1.0% of promulgated elevation angle for commissioning 4.0% of promulgated elevation angle for routine	Fly down from 7 NM on azimuth and elevation to ARD	MGE 4 NM to 0.5 NM on approach path	Commissioning Both Routine Both

Table 2 Elevation Limits (Cont.)

Parameter	Tolerance	Profile	Measurement to be made	Transmitter to be checked
Power density	In accordance with ICAO Annex 10 Volume 1 paragraph 3.11.4.10.1 for approach elevation guidance	Commissioning 20 NM ±40 degrees part orbit within coverage at MSA; and Part orbit at not less than 5 NM from ARD at MSA Routine Part orbit at not less than 5 NM from ARD at MSA	Commissioning Plot of ±40 degrees at 20 NM; and Plot of ±40 degrees at 5 NM Routine Plot of ±40 degrees at 5 NM	20 NM one TX only 5 NM both TX
Multipath relative power density Within the MLS elevation coverage	The duration of a reflected approach elevation guidance scanning beam signal whose power density is higher than 4dB below the approach elevation guidance scanning beam power density shall be shorter than one second	Level Slice on centreline from 20 NM at 0.3 theta to intersect a Fly down from 7 NM on azimuth and elevation to ARD	Plot or analysis	Commissioning One TX Biennial One TX
Monitor Verification		Ground Check	Spot check	Commissioning Both Routine Both

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FLI 02: The Approval of Flight Inspection Organisations

Part 1 Preliminary Material

Introduction

FLI02.1 Article 205 (5) of the ANO 2009, as amended, requires that a navigation aid is flight checked by the CAA or a person approved by the CAA, on such occasions as the CAA may require.

FLI02.2 The purpose of this document is to define the conditions for such an approval.

Scope

FLI02.3 This document defines the procedures and requirements for the approval of flight inspection organisations and their equipment.

FLI02.4 It is divided into three sections as follows:

- **Section 1**: Flight Inspection Organisations – Approval Procedure. This section defines the procedure to be followed when requesting approval of a flight inspection organisation.
- **Section 2**: Flight Inspection System – Navigation aids (general).
- **Section 3**: Annexes specific to each navigational aid.

Part 2 Requirements

Note: The requirements in this section apply to the flight inspection of all types of navigational aid. Additional requirements for specific navigational aids are given in the annexes to FLI 02.

Flight Inspection Organisations – Approval Procedure

Safety Objective

FLI02.5 **An approved applicant shall be capable of using flight inspection techniques to measure accurately the signals in space radiated by those navigational aids which they are approved to inspect (1630).**

FLI02.6 Applicants shall submit the required information in a coherent documentary form (1631).

FLI02.7 Applicants shall detail the overall operation in an Exposition document including references to associated documents (1632). See Part 2, paragraph FLI02.17 for details.

Note: The CAA will examine the submitted documentation and may call for further information on certain subjects. For example, the method used to calculate the measurement uncertainty for certain parameters may need to be examined in more detail.

FLI02.8 The applicant may propose an aircraft or system which is new in concept or not in common use for flight inspection. In such a case, the CAA will seek advice from other expert departments and may also initiate a general consultation with the industry.

FLI02.9 If the applicant proposes a new system or aircraft or the organisation does not have a demonstrable history of flight inspection, then practical demonstrations of capability will be necessary.

Note: The tests will be in two parts. Applicants may be required to perform either or both parts:

1. A demonstration of position fixing accuracy. This will be evaluated on an established test range. The precise details of this trial cannot be defined until details of the applicant's system are known.

2. A demonstration of overall system performance. For this trial the applicant will make a simulated commissioning inspection of the selected navigational aid. The trial may require several similar flight profiles to be flown to demonstrate the repeatability of measured results.

FLI02.10 The CAA shall evaluate or require evaluation of the results of these trials (1633).

FLI02.11 If special R/T facilities are required during the trials the applicant shall be in possession of the relevant approvals and licences for their use (1634).

FLI02.12 The applicant shall provide the CAA with a build state document of the measuring equipment (1635), a complete and formalised list of the current issues of all relevant documentation (1636) and an Exposition describing the entire operation (1637). The CAA shall

retain this documentation and require it to be updated to always reflect the current state of the applicant's flight inspection system operation and organisation (1638). If the applicant proposes to make any changes to a flight inspection system, operation, or organisation, the CAA shall approve these changes before the applicant is permitted to make any further flight inspections (1639).

FLI02.13 Where approval for ILS inspection is granted under this procedure it may be limited to the flight inspection of specific categories of ILS.

FLI02.14 The CAA reserves the right to inspect the flight inspection system or organisation at any time and to request regular flight inspection reports.

Note: If the applicant is an organisation which has been making flight inspections for many years under a formal or implicit approval from another Aviation Authority, the submitted documentation may suffice for approval.

FLI02.15 For all applicants the CAA reserves the right to require that a practical demonstration of ability is given.

Organisation and Quality

Safety Objective

FLI02.16 Any organisation intending to perform flight inspection of navigation aids shall satisfy the CAA that it is competent, having regard to any relevant previous conduct and experience, equipment, organisation, staffing maintenance and other arrangements, to produce accurate and adequate flight inspection results in relation to ATS safety aspects (1480).

Exposition

FLI02.17 An Exposition shall be provided to detail the overall organisation and its intended operation (1481). The following aspects shall be included (or referenced to other documents) in the Exposition, or provided in a coherent documentary system (1482).

Identification

- Organisation name, document title, reference number.
- Base location.

- Amendment status, issue number, date, amendment record.
- Approval by the accountable manager.
- Distribution list.
- Exposition administrator.
- Contents list.

Organisation

- Introduction, Purpose of document, General information on the organisation. Interfaces with other organisations and departments. General statements on organisational policy with respect to ATS safety related aspects.

Undertaking

- Scope of tasks. Types of navigational aids to be inspected (For ILS the applicant must state the categories of ILS which he wishes to calibrate).
- Organisational Chart.
- Personnel responsibilities, terms of reference and authority to act.
- Procedures for notifying the CAA of major organisational changes.
- Procedures for notifying the CAA regularly of the latest state of the flight inspection programme.
- Procedures for notifying the CAA of proposed equipment changes and modifications or change of aircraft type.
- Details of the aircraft which the applicant wishes to use for flight inspection.
- Functional description, technical specification and manufacturer's type number for all major items of the flight inspection system. This shall include details of the equipment used for calibrating the system.
- Location, characteristic and type of all measurement aerials on the aircraft.
- Technical description of any parts of the system which the applicant has designed or built.

- The design authority for all equipment shall be stated.
- Procedures for inspection of equipment.
- Details of all uses of software and firmware in the measurement system. Also details of software and firmware support.
- Details of a log or record system for faults and maintenance of the measuring system.
- Spares holding and control.
- Documentation Control. List of documents held and produced.
- Personnel training, competency and recency checking arrangements.
- Details of any internal and external auditing system, e.g. auditing of the organisation by any other organisation not associated with the production of inspection results.
- Details of the quality management system.
- Details of the history of the organisation.
- Details of any formal or implicit approvals which the applicant has received from other Aviation Authorities.
- A list of any navigation aids which the applicant regularly inspects under such a formal or implicit approval. This will include:
  - Type of navigation aid.
  - Location of navigation aid.
  - Category of navigation aid (if applicable).
- Flight inspection operating instructions for the inspector and flight crew.
- A typical or test flight inspection report.
- A typical or test sample structure measurement for those navigational aids where structure measurements form part of a normal flight inspection.
- A statement showing to 95% confidence, the measurement uncertainty which the applicant claims to achieve for each of the measurable parameters.

- Details of statistical methods or interpolative techniques which may be applied.
- Details of AOC (Air Operator's Certificate) related approvals held in respect of aircraft operations.
- Procedures for the control of sub-contractors.
- A statement of compliance with the flight inspection requirements of the CAA.

Aircraft

Safety Objective

FLI02.18 **The aircraft used shall be appropriate for the purpose of flight inspection and shall be operated in a way which ensures accurate measurement of all parameters (1483).**

FLI02.19 The aircraft shall be a multi-engine type capable of safe flight within the intended operational envelope with one engine inoperative, fully equipped and instrumented for night and instrument flight (1484).

FLI02.20 Aircraft conducting Flight Inspection must carry a flight crew adequate in number and description to ensure the safety of the aircraft.

FLI02.21 A cross-wind limit shall be set which will allow measurement accuracies to be within the limits required (1486). This limit shall be shown in the operating instructions (1487).

FLI02.22 The aircraft shall have a stable electrical system with sufficient capacity to operate the additional electronic and recording equipment (1488).

FLI02.23 Measures shall be taken to reduce propeller modulation to an acceptably low level (1489).

Note: As the aircraft may be required to fly abnormal procedures during an inspection, it is normal practice to add markings and/or lights which will increase the visibility of the aircraft against all normal backgrounds.

Equipment

Safety Objective

FLI02.24 **The purpose of the navigation aid flight inspection is to verify that all parameters of the navigation aid meet the requirements specified in Annex 10 to the Convention on Civil Aviation and any other specific requirements of the CAA. The equipment fitted in the aircraft must be capable of measuring all these parameters (1490).**

FLI02.25 The navigation aid measuring equipment shall not interfere with the operation or accuracy of the aircraft's normal navigation and general avionics equipment (1491).

FLI02.26 The flight inspection measurements shall be adequately protected against the prevailing EMC environment internal or external to the aircraft (1492). Abnormal interference effects shall be clearly identified on the inspection results (1493).

FLI02.27 The inspection system shall have the facility for listening to the identity modulation of the navigation aid being inspected (1494).

Position Fixing and Tracking Equipment

FLI02.28 The flight inspection system shall include equipment which can determine and record the aircraft's position in space relative to a fixed reference point (1495). The uncertainty of measurement must be commensurate with the parameter being inspected (1496).

Recording Equipment

FLI02.29 The flight inspection system shall include equipment which can record the measured parameters of the navigation aid being inspected (1497).

FLI02.30 All recordings shall be marked so that they can be correlated with the aircraft's position at the time of the measurement (1498).

FLI02.31 **Recommendation**: Where possible the flight inspection should comply with the guidance and recommendations given in ICAO Doc 8071 Vol II (1499).

FLI02.32 **Recommendation**: As far as is reasonably possible the flight inspection equipment, including associated aerials should be totally independent from the aircraft's operational avionics fit (1500).

Aerials

FLI02.33 The aerials shall be positioned in such a manner that they are not obscured from the signal during any normal inspection flight profiles (1501).

Note: To achieve this may require the use of more than one measuring aerial for one particular function. If duplicated navigation aid measuring receivers are used they may use a common aerial.

FLI02.34 The aerials to be used for tracked structure measurements shall be positioned with due regard to the tracking reference on the aircraft (1502). If the aerials and the reference are not in close proximity, this error must be addressed in the measurement uncertainty calculations and in setting the operational crosswind limit. Alternatively, the errors may be corrected using information from the aircraft's attitude sensors and data concerning movement of the aerial's phase centre (1503).

Spectrum Analyser

Note: It is useful if a spectrum analyser is available for investigating equipment malfunctions and sources of interference. The analyser should have a method of image storage.

Measurement Uncertainty

Safety Objective

FLI02.35 **The measurement uncertainty for any parameter must be small compared with the operational limits for that parameter (1504).**

FLI02.36 The measurement uncertainty to 95% probability must be calculated for each of the parameters to be measured (1505). The method of calculation and any assumptions made must be clearly shown (1506).

FLI02.37 Many measurements are a combination of receiver output and aircraft position. In these cases the figure required is the sum of all the errors involved in the measurement, including aircraft position.

FLI02.38 Where several measurements are combined to produce a single result, these errors should be added by the RSS method (the square-root of the sum of the squares), to give the overall expected measurement uncertainty (1507).

Note: For certain ILS system parameters, the maximum permitted measurement uncertainty depends on the category of the ILS being inspected.

FLI02.39 For measurements which can only be derived from recordings, the accuracy and resolution of the recording equipment shall be included in calculating the expected measurement uncertainty (1508).

FLI02.40 When modifications are made which will affect the uncertainty of measurement of any parameter, new calculations shall be submitted (1509).

Temperature Stability

FLI02.41 The uncertainties stated in Part 3 shall be maintained under the specified environmental conditions for a flight inspection procedure (1510). The operator shall define the environmental conditions (temperature range, humidity range, etc.) (1511).

FLI02.42 Details of measurement uncertainty with respect to temperature shall be available for all the measuring equipment (1512). This may be in the form of test results made by the operator, or manufacturer's specifications. If manufacturer's specifications are quoted, the proposer shall be prepared to produce manufacturer's test results as evidence (1513).

FLI02.43 If the measuring equipment requires any warm-up or cooling time, this shall be clearly indicated in the operating instructions (1514).

Note: If necessary, any temperature dependent apparatus may be fitted in a temperature controlled enclosure. An indicator/alarm shall be fitted to inform the navigation aid inspector of any error in temperature (1515).

Position Marking of Flight Inspection Data

FLI02.44 The accuracy of marking shall be commensurate with the accuracy required in the final figure (1516). Specific requirements are given in paragraph FLI02.36 of the appropriate Appendix to FLI 02.

Inspection Procedures and Standards

Safety Objective

FLI02.45 **All measuring equipment used for flight inspection shall be calibrated to defined standards (1517).**

FLI02.46 Clearly defined inspection procedures shall be applied to all equipment involved in the measurement of parameters in paragraph FLI01.24 of the appropriate annex of FLI 02 (1518). All equipment and standards used in the inspection process shall have traceability to national or international standards (1519).

FLI02.47 When any equipment used is claimed to be self calibrating, the internal processes involved shall be clearly defined (1520). This involves showing how the equipment's internal standard is applied to each of the parameters which it can measure or generate. The internal standard shall have traceability to national or international standards (1521).

FLI02.48 Details of inspection intervals required shall be contained in the inspection records (1522). The proposer shall be prepared to produce evidence in support of the quoted inspection intervals (1523).

Software

FLI02.49 Refer to Part B, Section 3 SW 01.

Operating Instructions

Safety Objective

FLI02.50 The operating instructions shall ensure that all measurements are made to defined and documented procedures (1524).

FLI02.51 This documentation will include concise details of:

1. The flight profile to be used for each individual measurement (1525).
2. Pre-flight inspection of measuring equipment (1526).
3. Siting of any necessary ground tracking or position fixing equipment (1527).
4. Scheduled maintenance and inspection of the measuring equipment (1528).
5. Operation of the measuring equipment (1529).
6. Production of the flight inspection report (1530).
7. Certification (1531).

8. The method of calculating any results which are not directly output by the measuring equipment (1532).

Personnel Training and Qualification Requirements

Safety Objective

FLI02.52 All personnel concerned with the flight inspection shall be adequately trained and qualified for their job functions (1533).

FLI02.53 The proposer must show that all personnel concerned with the flight inspection are adequately qualified for their job functions (1534).

FLI02.54 The proposer must be prepared to submit CVs for all personnel directly concerned with the flight inspection, from which each person's experience and suitability can be determined (1535).

FLI02.55 The organisation must have a procedure for ensuring the competence of its personnel (1536). This procedure must have provision for regular assessment of competence (1537).

FLI02.56 Particularly for the inspection of precision approach aids, the flight crew's familiarity with each location to be inspected is considered to be of importance. The proposer's procedures and instructions must include details of training and familiarisation which will apply to the flight crew (1538).

Flight Inspection Report

Safety Objective

FLI02.57 The flight inspection report shall clearly and accurately document the measured performance of a navigational aid (1539).

FLI02.58 All flight inspection results shall be documented to a report format agreed with the CAA (1540). The minimum information to be provided on the report shall be (1541):

- Station name and facility designation.
- Category of operation.
- Date of inspection.
- Serial number of report.
- Type of inspection.

- Aircraft registration.
- Manufacturer and type of system being inspected.
- Wind conditions.
- Names and functions of all personnel involved in the inspection.
- Results of all measurements made.
- Method of making each measurement (where alternatives are available). These may be referenced to the operating instructions.
- Details of associated attachments (recordings, etc.).
- Details of extra flights made necessary by system adjustments.
- An assessment by the aircraft captain of the navigational aids performance.
- Comments by the navigation aid inspector/equipment operator.
- Details of any immediately notifiable deficiencies.
- Statement of conformance/non-conformance.
- Navigation aid inspector's signature.
- Pilot's signature.
- Signature of the individual who is legally responsible (if different from the two bullet points above).

Records and Graphs

Safety Objective

FLI02.59 Records and graphs shall be produced in a manner which ensures that system parameters may accurately be deduced from them (1542).

FLI02.60 If recordings or graphs are used to derive figures for the inspection report, the scales shall be commensurate with the permitted measurement uncertainty limits (1543).

Note: If the recordings or graphs are only used to show that results are within designated tolerances, they may be presented on a reduced scale.

FLI02.61 The data from which these recordings and graphs are made shall be stored with sufficient accuracy that expanded scale plots can be provided on demand (1544).

FLI02.62 For flights where parameters are evaluated by comparison of the received signal and the output of a tracking device, only the final result need be presented for a normal inspection unless other data has been requested by the customer. Position data and raw signal data shall be recorded or stored and provided on demand (1545).

Note: This will be necessary in cases where further analysis of the results is required; for example, to assess marginal performance or to assist in identifying causes of multi-path reflections.

Identification

FLI02.63 The minimum identification on each record and graph shall be (1546):

1. Serial number.
2. Date.
3. Description of type of flight.
4. Name of airport.
5. Designation of facility being inspected.

Retention of Flight Inspection Data

FLI02.64 Flight Inspection Reports and data required to generate Flight Inspection Reports shall be retained for 1 year (2203).

FLI02.65 The flight inspection organisation shall have means to reproduce Flight Inspection Reports (2204).

Aircraft Operation

FLI02.66 Details shall be provided as to whether the aircraft is being operated as Public Transport or Aerial Work (2205).

Annexes Specific to Individual Navigation Aids

Note 1: The annexes in this section contain requirements specific to the flight inspection of individual navigation aids. They must be read in conjunction with Section 2 of this document.

Note 2: To facilitate cross-referencing, the paragraphs in the annexes have the same numbers as the relevant paragraphs in FLI 02, Part 2.

Annex 1 – Instrument Landing System

Aircraft

FLI02.18 Manual flight control using only the mandatory navigation instruments is not considered sufficiently accurate for inspection of the following types of ILS:

- Category III systems.
- Category II systems.
- Category I systems, which the operator wishes to use for autoland in good visibility.

For inspection of the above systems the aircraft shall be fitted with equipment which will provide repeatable following of the required path (1549). Systems considered suitable to this purpose include telemetry of the ground based tracking system's output to a separate instrument in the aircraft, or an autopilot. If an autopilot is used the CAA shall be satisfied that it is capable of safe operation down to 50 feet above the threshold elevation (1550).

Equipment

FLI02.24 Measurement and Recording Equipment

A normal ILS/DME inspection system shall be capable of measuring and recording the following parameters (1551):

1. Localiser Field strength.
2. Localiser Modulation Sum (SDM).
3. Localiser Difference in Depth of Modulation (DDM).

4. Glidepath Field strength.
5. Glidepath Modulation Sum (SDM).
6. Glidepath Difference in Depth of Modulation (DDM).
7. Marker Beacon Field strength.
8. Marker Beacon Fly-through Time.
9. DME Field strength.
10. DME Distance.

The recording equipment shall be capable of recording any of the ILS parameters listed in paragraph (1552). The equipment shall measure and record beam structure by comparison of tracking data and the ILS signal, from a distance of at least 4 NM from the runway threshold (1553).

It shall be possible to annotate the recordings with comments and any other necessary information at the time of making the recording (1554).

For beam bend measurements, the total time constant of the measuring and recording equipment shall be 9/V seconds where V is the aircraft velocity in kilometres per hour (1555).

If digital sampling/storage is used, the sampling rate shall be compatible with this time constant but never less than 4 samples per second for all parameters which are continuously measured (1556).

The equipment shall be capable of recording a minimum of 4 parameters simultaneously (1557).

Note: Post inspection processing may be necessary to achieve the required accuracy for certain parameters.

Measurement Uncertainty

FLI02.35 Maximum permitted measurement uncertainty at 95% confidence level (1558).

Throughout the following tables, the figure of 2dB for field strength is the permitted uncertainty for repeatability of measurement. It is not a requirement for absolute field strength measurement.

Localiser

	Cat I	Cat II	Cat III
Alignment (average) (related to threshold)	2.0m (2078)	1.0m (2079)	0.7m (2080)
Displacement sensitivity (of the actual figure)	4% (2081)	4.0% (2082)	2.5% (2083)
Field strength (relative)	2dB (2084)	2dB (2085)	2dB (2086)
Off course clearance	3% (2087)	3% (2088)	3% (2089)
Course structure Outer limits of coverage to ILS Point A	6μA (2093)	6μA (2094)	6μA (2095)
Course structure ILS Point A to threshold	3μA (2096)	1μA (2097)	1μA (2098)
Modulation sum (absolute mod depth)	1.6% (2099)	1.6% (2100)	1.6% (2101)
Polarisation	1.5μA (2012)	1.0μA (2013)	1.0μA (2104)

Glidepath

	Cat I	Cat II	Cat III
Angle (of the glidepath angle)	0.5% (2108)	0.3% (2109)	0.3% (2110)
Displacement sensitivity (of the actual figure)	2.5% (2111)	2.0% (2112)	1.5% (2113)
Field strength (relative)	2dB (2114)	2dB (2115)	2dB (2116)
Clearance (of the actual figure)	3% (2117)	3% (2118)	3% (2119)
Course structure	6μA (2120)	4μA (2121)	4μA (2122)
Modulation sum	2% (2123)	2% (2124)	2% (2125)

Marker Beacon

Field strength (relative) 2dB (2129)Distance 10 metres (2130)

Associated DME

Field strength (relative) 2dB (2131)

Distance 60 metres at threshold and point A (2132)

Uncertainty of Position Marking of Flight Inspection Data

Approach Toward a Facility

± 0.1 NM for markings at each nautical mile (2133).
± 0.1NM for marking at ILS point A (2134).
± 0.05 NM for marking at ILS point B (2135).
± 0.1° for marking glidepath slice at 5 x 1.75 (glidepath angle) (2136).
± 20 metres for marking the threshold crossing (2137).

Orbital Flights (1565)

± 1.5 Degree.

Note: A marking accuracy of ±1.5° applies to clearance and coverage inspection, it is not sufficient for measuring displacement sensitivity.

Records and Graphs

FLI02.59 Where chart recordings are used for parameter evaluation, they shall have sufficient resolution for this purpose (1566). The minimum requirements are given below.

Structure Stability Recordings (deviation current) (1567)

Localiser

Minimum sensitivity of 0.5mm per µA.

Glidepath

Minimum sensitivity of 0.5mm per µA.

Structure Measurements (corrected recordings)

Localiser (1568)

Minimum sensitivity of 1mm per μA.

Glidepath

Minimum sensitivity of 0.5mm per μA for the initial part of the recording. For Category II & III systems, it must be possible to show the signal characteristic down to threshold crossing (1569). This may require reduced sensitivity depending on available chart width.

Other Measurements

Many other recordings will need sensitivity changes during the recording to obtain optimum resolution at all times. The chart produced must be capable of displaying at least 450 μA of deflection current without saturation. Sufficient different sensitivities of display must be available to allow signal characteristics to be measured accurately (1570).

Position Annotation

Records and graphs must be annotated to show the position of the aircraft at the time of making the measurement (1571). The minimum requirements are given below. Required accuracies of annotation are given in paragraph FLI02.36.

Approaches Towards a Facility

Every nautical mile (referenced to 0 NM at the threshold), ILS points A, B & C, Threshold.

Glidepath Level Flight (on localiser centreline)

Every nautical mile (referenced to 0 NM at the threshold), and 1.75Θ (2138).

Orbital Flights (1573)

Every 5 degrees.

Annex 2 – Microwave Landing System

Equipment

Receiver

FLI02.24 The receiver used for MLS flight inspection shall:

1. have independent Azimuth and Elevation flag outputs (1578); and
2. be capable of operating with the transmitter basic data word *2 set to 'on test' (1579).

The equipment shall be capable of measuring and recording the relative signal levels of each component (scanning beam, clearance, multipath, OCI, preamble) within a function (1582).

This measurement may be made by examining the receiver output or by the use of separate measuring equipment such as a spectrum analyser.

Measurement and Recording Equipment

An MLS inspection system shall be capable of measuring and recording the following parameters (1586):

- Azimuth Path Following Error (PFE)
- Azimuth Path Following Noise (PFN)
- Azimuth Control Motion Noise (CMN)
- Azimuth Mean Course Error (MCE)
- Azimuth Field strength
- Elevation PFE
- Elevation PFN
- Elevation CMN
- Elevation Mean Glidepath Error (MGE)
- Elevation Field strength.

It shall be possible to annotate the recordings with comments and any other necessary information at the time of making the recording (1589).

The minimum data sampling rate shall be 5 Hz (1590).

The filters used for measurement of PFE, PFN and CMN shall be designed using guidance given in ICAO Annex 10, Volume 1, Attachment G, figure G11 (1591). The filter design shall be compatible with the digital data sampling rate (1592).

Measurement Uncertainty

FLI02.35 Maximum permitted measurement uncertainty at 95% confidence level

Azimuth

PFE	0.8 metres at reference datum
PFN	0.7 metres at reference datum
CMN	0.6 metres at reference datum

At all other places where these parameters are measured, the uncertainty shall not exceed 0.02°

Field strength (Relative) 2dB

Elevation

PFE	0.2 metres at reference datum
PFN	0.1 metres
CMN	0.1 metres

At all other places where these parameters are measured, the uncertainty shall not exceed 0.01°

Field strength (Relative) 2dB

The figure of 2dB for field strength is the permitted uncertainty for repeatability of measurement. It is not a requirement for absolute field strength measurement.

Associated DME (1597)

Field strength (relative)	2dB
Distance	60 metres at threshold and point A

Records and Graphs

FLI02.59 Where chart recordings are used for parameter evaluation, they shall have sufficient resolution for this purpose.

Annex 4 – VHF Omnidirectional Radio Range

Equipment

Measurement and Recording Equipment

FLI02.24 The VOR inspection system shall be capable of measuring and recording the following parameters:

1. Alignment Accuracy (1944);
2. Field strength (1945);
3. 30Hz Modulation depth (1946); and
4. 9960Hz Modulation depth (1947).

It shall be possible to annotate the recordings with comments and any other necessary information at the time of making the recording (1948).

During orbital flights the system shall be capable of measuring and recording every 5 degrees (1949).

Measurement Uncertainty

FLI02.35 Maximum permitted measurement uncertainty at 95% confidence level is given below:

Parameter	Measurement Uncertainty
Alignment	0.4° (1950)
Field Strength	3dB (1951)
Modulation 30Hz and 9960Hz	0.4% (1952)

Records and Graphs

FLI02.59 Where chart recordings are used for parameter evaluation, they shall have sufficient resolution for this purpose (1953).

Records and graphs must be annotated to show the position of the aircraft at the time of making the measurement (1954).

Annex 5 – Non-Directional Beacon (NDB)

Equipment

FLI02.24 Measurement and Recording Equipment

The NDB inspection system shall be capable of measuring and recording the following parameters:

1. Accuracy (2139);
2. Field strength (2140).

It shall be possible to annotate the recordings with comments and any other necessary information at the time of making the recording. (2141)

During orbital flights the system shall be capable of measuring and recording every 5 degrees. (2142)

Measurement Uncertainty

FLI02.35 Maximum permitted measurement uncertainty at 95% confidence level is given below:

Parameter	Measurement Uncertainty
Accuracy	1.0° (2143)
Field Strength	3dB (2144)

Records and Graphs

FLI02.59 Where chart recordings are used for parameter evaluation, they shall have sufficient resolution for this purpose (2145).

Records and graphs must be annotated to show the position of the aircraft at the time of making the measurement (2146).

NAV 01: Engineering Requirements for Instrumented Runway Visual Range (IRVR) Systems

Part 1 Preliminary Information

Introduction

NAV01.1 Under the terms of the ANO 2009, as amended, all ATS equipment at civil facilities within the UK require approval by the CAA. IRVR is considered to be an item of ATS equipment.

Scope

NAV01.2 This document details the performance criteria and safeguarding requirements for IRVR equipment installed in the UK and intended for use in the provision of an ATS.

NAV01.3 The purpose of this document is to ensure that consideration has been taken of those aspects that affect the safety of services provided and supported by an IRVR facility.

Part 2 Requirements

Safety Objective

NAV01.4 **The equipment shall enable the provision of an accurate indication of the runway visual range to be available to the pilot during the take-off and landing phases of flight (1641).**

Technical Requirements

NAV01.5 IRVR shall be measured, over the range appropriate for the approach categorisation, to a minimum accuracy of (1642):

- ±10 Metres from 50 m to 400 m.
- ±25 Metres from 400 m to 800 m.
- ±10 per cent above 800 m.

NAV01.6 All systems shall meet these accuracy requirements over background luminance levels in the range 5 to 30,000 Cd.m-2 (1643).

NAV01.7 For existing systems, IRVR values calculated using 40 per cent of the averaged beam intensity of the specified inner ellipse for runway edge lights (as defined in Appendix 6A of CAP168, "Aeronautical Ground Lighting Characteristics") will be permitted following the submission to the CAA of results obtained by either photometric measurement or following the "block replacement" of those lights (1644).

Note 1: For new and existing systems, the initial de-rating factor of 40% is based upon the minimum serviceability requirements set out in Chapter 6 of CAP 168 (Licensing of Aerodromes) and continuing operation at this level will depend upon satisfactory evidence of on-going inspection and subsequent maintenance programme being presented to the CAA.

Note 2: CAA staff will determine whether continued operation at the initial de-rating factor is justified or whether the de-rating factor can be increased upward toward the ICAO recommended maximum of 80% (Doc 9328 Chapter 6.5, "Light and Light Intensity").

Note 3: The number of inspections required in each calendar year will depend upon the nature and frequency of aircraft operations from that aerodrome but a minimum of 4 photometric inspections (one in each quarter) should be taken during each 12 month period and the results submitted to the appropriate CAA regional office.

NAV01.8 The sensor output shall be sampled at a minimum rate of once per second (1645).

NAV01.9 The equipment shall average the recorded extinction coefficient over a period of 1 minute, to effect smoothing of short-term atmospheric variations in ATS reports (1646).

NAV01.10 The 1 minute averaged IRVR value presented to ATC shall be rounded down to the nearest increment specified in NAV01.28 (1647).

NAV01.11 When RVR is increasing, a hysteresis of 1.5 increments shall be used to prevent unnecessary fluctuations in the displayed IRVR (1648).

NAV01.12 The equipment integrity and reliability shall be such that the number of safety-related failures shall be no more than 10-5 per operating hour, unless otherwise indicated by a formal and documented hazard analysis (1756).

NAV01.13 For METAR, a 10-minute averaging period shall be used for obtaining mean value(s), except when the 10-minute period immediately preceding the observation includes a marked discontinuity in RVR values (2306). Only those values occurring after the discontinuity shall be used for obtaining mean values (2307).

Note: A marked discontinuity occurs when there is an abrupt and sustained change in RVR lasting at least 2 minutes.

Equipment Calibration

NAV01.14 The maintenance and calibration policy, and facilities necessary to maintain performance within the parameters stated in this document, shall be documented and implemented (1757).

Equipment Interfaces

NAV01.15 Technical justification that the safe operation of the equipment is not compromised by any non-passive interfaces installed in or connected to other equipment shall be provided (1651).

Note: The connection of the IRVR system to any existing approved equipment may require the reassessment of that other equipment.

NAV01.16 All interfaces between the IRVR system and other systems shall be designed, constructed, installed and tested to an integrity standard appropriate for the more demanding applicable standard (1758).

NAV01.17 The interfaces to the lighting systems shall be fed with tell-back information only (1653).

NAV01.18 Any tell-back indications from the runway lighting system which indicate that the lighting equipment has malfunctioned or which prevent the status of the runway lighting from being established shall render the IRVR information to be invalid (1759).

NAV01.19 The IRVR system shall be provided with a time source which shall be synchronised to UTC within a tolerance of ±5 seconds (1655).

Monitoring

NAV01.20 All IRVR systems shall be self-monitoring for correct operation (1656).

NAV01.21 Any incorrect operation identified by the monitoring shall render the IRVR information to be invalid (1760).

NAV01.22 Displays in operational positions shall indicate the serviceability status of the system (1761).

Displays

NAV01.23 ATC operational displays shall present the RVR data in an alphanumeric format with indication of trend over successive readings (1658).

NAV01.24 **Recommendation**: All changes in either system status (including blanking of displayed data) or RVR value should be displayed at ATC operational positions within 15 seconds of such changes (1762)

NAV01.25 Where the IRVR value is presented on a display system that is not dedicated to the function (i.e. where information from a variety of sources is displayed on a single display system), all operational ATC positions shall display the IRVR data in the standard alphanumeric format (1763).

NAV01.26 All displays shall be provided with a method of testing the serviceability of the display and backed by procedures to ensure compliance with the stated criticality (1661).

NAV01.27 Where data is transmitted beyond the aerodrome the ICAO station identification shall be included (1664).

NAV01.28 The data shall be displayed with the following resolution:

3. 25 m intervals from 50 to 400 m (1665).
4. 50 m intervals from 400 to 800 m (1666).
5. 100 m intervals above 800 m (1764).

Recording

NAV01.29 IRVR records shall be time stamped against UTC and retained for a minimum period of 30 days (1668). Electronic, magnetic or optical recording devices may be used, but all records must be stored in a readily accessible format. Printed copies of these records shall be available on request (1765).

NAV01.30 The RVR value and status information shall be recorded in the event of the following:

1. Change in RVR or trend from any site (1669).
2. System self test (1670).
3. On detection of change of serviceability status (including nature of the fault) (1671).
4. Change of runway in use (1672).
5. Change in runway lighting intensity (1673).

NAV01.31 **Recommendation**: Change in law used to calculate the given RVR value should be recorded (1674).

NAV01.32 **Recommendation**: Transmittance, Illuminance Threshold (Et) and software version should be recorded (1675).

NAV01.33 **Recommendation**: Runway light intensity used for IRVR computation should be the actual light intensity in use on the runway and RVR should not be computed for a light intensity of 3% or less of the maximum light intensity available (2308).

Siting Criteria

Safety objective

NAV01.34 **Sensor measurements shall be used to derive an RVR value that is representative of the pilot's perspective of the visibility along the runway and in the prevailing weather conditions including background luminance (1766).**

NAV01.35 **One or more background luminance meter (BLM) sensors must be installed at locations which are known to be unaffected by artificial lighting from the runway in use at that time, from the apron area, or from aerodrome and external sources such as road lighting schemes.**

Note: The current state of BLM technology is such that direct sunlight has to be avoided and for this reason, the majority of UK BLMs are aligned to view the north sky at an elevation of 22.5 degrees above the horizon. However, due to the prevailing wind directions in the UK, the majority of precision runways in the UK are constructed in an east-west orientation. This implies that a pilot who is observing the runway against a rising sun or setting sun

may experience a lower RVR than that generally reported by an instrumented system unless the relevant BLM was observing the same portion of brightly lit sky.

NAV01.36 **Recommendation**: IRVR sensors should be positioned not more than 120 m laterally from the runway centreline, but not infringing the obstacle-free zone for precision approach runways. In the touch-down zone (TDZ), sensors should be sited not more than 300 m from the threshold in the landing direction (1768).

NAV01.37 IRVR measurement on a runway operating to CAT I shall be made at one location representing the TDZ area in accordance with the ICAO Recommended Practice (2252).

NAV01.38 **Recommendation**: IRVR should be provided on a runway operating to CAT I in accordance with the ICAO Recommended Practice (2252) and if provided shall be made at one location representing the TDZ area (1769).

Note: Runway Visual Range (RVR) assessment using Human Observers may be permitted for runways operating to CAT I.

NAV01.39 IRVR measurements on a runway operating to CAT II shall be made at two locations, representing the TDZ and midpoint (MID) (1770).

NAV01.40 IRVR measurements on a runway operating to CAT II with a LDA greater than 2000 m are recommended to be made at three locations, representing TDZ, MID and stop end (STP) (1771).

NAV01.41 IRVR measurements on a runway operating to CAT III shall be made at three locations, representing TDZ, MID and STP (1772).

Note: Particular attention should be paid to the design and location of the sensor heads to ensure an effective representation of the required coverage area.

NAV01.42 The sensor housing shall not affect the accuracy of the atmospheric measurement (1682).

NAV01.43 Summary of System Requirements Under Normal Operating Conditions:

IRVR Assessment Site (LDA – Landing Distance Available)	**Category I Rwy less than 2000m LDA**	**Category II Rwy less than 2000m LDA**	**Category II Rwy 2000m or more LDA**	**Category III All Runways**
TDZ	Recommended	Required	Required	Required
MID		Required	Required	Required
STP			Recommended	Required

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NAV 02: Engineering Requirements for MF Non-Directional Beacons

Part 1 Preliminary Material

Introduction

NAV02.1 Under the terms of Article 205 of the ANO 2009, as amended, all Civil MF Non-Directional Beacon (NDB) installations, intended for use in the provision of an ATS, require approval by the CAA.

Scope

NAV02.2 This document sets out the Engineering requirements for MF NDBs intended for use in the provision of an ATS. This document applies to all NDBs including those associated with published Instrument Approach Procedures, also known as Locators, promulgated as NDB(L).

Part 2 Requirements

Safety Objective

NAV02.3 **The system shall radiate a signal which complies with the standard operating parameters and provides correct guidance to users within its rated coverage.**

System Requirements

SARPs Compliance

NAV02.4 In addition to the requirements below, NDB systems shall comply with the SARPs in ICAO annex 10 Volume 1, Chapter 2, General Provisions for Radio Navigation Aids (2038) and Chapter 3 Section 3.4, Specification for non-directional radio beacon (NDB) (2040).

Note: Where the UK has differences filed to SARPs these will be published in Supplements to the Annexes and in the UK AIP.

Transmission Characteristics

Radiated Frequency

NAV02.5 The equipment shall only transmit on the frequency assigned by the CAA and as appears in the schedule to the radio licence issued under the Wireless Telegraphy Act (2041). The assigned frequency shall be maintained within ±0.01% (2042).

Power Output

NAV02.6 The power output shall be adjusted to give a vertical field strength of 70 microvolts/metre at the limit of the rated coverage (2043), and be maintained within tolerances of +2 dB (2044) and -3 dB (2045).

Modulation Characteristics

Identification

NAV02.7 Modulation is by on/off keying of an amplitude modulating tone (2046). Each NDB shall be individually identified by a two or three letter international Morse code group as assigned (2047) and transmitted at a rate corresponding to approximately 7 words per minute (2048). The complete identification shall be transmitted at least 3 times in each 30 second period, equally spaced within that period (2049).

NAV02.8 The facility Identification shall be suppressed when the NDB is not available for operational purposes, e.g. under maintenance (2050).

Note: The normal identity code may be radiated for short periods during maintenance or flight inspection as necessary.

Modulation Frequency

NAV02.9 The frequency of the modulating tone for identification shall be 400 Hz ±25 Hz (2051).

Change of Carrier Power during modulation

NAV02.10 The carrier power of an NDB shall not fall by more than 0.5 dB when the identification signal is being radiated (2052).

Monitoring

Executive Monitor Action

NAV02.11 An executive site monitor shall be provided to switch off the equipment in use and, if applicable, change over to the standby system in less than 1 minute if:

1. There is a change in radiated carrier power of more than +2 dB or -3 dB to that required for the rated coverage (2058).
2. A malfunction or failure of the means of self monitoring of executive parameters occurs (2059).

Non Executive Monitor Action

NAV02.12 A Non-Executive Alarm will be generated within three minutes, if the NDB fails to transmit the correct identification code (2060).

Status Information

NAV02.13 FISOs and/or ATCOs directly responsible for approach, landing and take-off at the aerodrome(s) with which they are concerned shall be provided with information on the operational status of radio navigation services, on a timely basis, consistent with the use of the service(s) involved (2310).

NAV02.14 Where status information is reliant upon a visual status indicator, then an audible alarm should be provided which indicates that the visual indicator has changed state (2311).

Standby Power Supply

NAV02.15 An NDB shall be provided with suitable power supplies and means to ensure continuity of service appropriate to the needs of the service provided (2062).

Maintenance Requirements

NAV02.16 NDB operators must regularly record the field strength of their NDB, as measured at a remote location (2063).

Note: Measurement of field strength at a non-rated remote location is acceptable if correlation to measurement at rated range is traceable.

Flight Inspection

NAV02.17 Commissioning flight inspections shall be made by an organisation having CAA approval for flight inspection of NDBs under the ANO (2064). Additionally, the CAA may, if it becomes concerned that the NDB is no longer performing to the SOC, request a flight check of the NDB, at the Service Provider's expense, by an approved Flight Inspection Organisation.

NAV02.18 Annual flight inspections may be conducted by local pilots (ideally Instructor rated). The pilot shall provide confirmation of the performance of the NDB as described in the table below (2065). The ATS Provider shall formally record this confirmation (2066).

NAV02.19 Pilots should consider the yawing motion of the aircraft when assessing the NDB.

Parameters to be measured

NAV02.20 During commissioning and annual inspection the appropriate parameters in the following table shall be measured and be within limits. These checks need only be done on one transmitter.

Parameter	Limits	Periodicity and Measurement Method
Accuracy within the DOC	ADF needle oscillations <± 10°. (2067) See Note.	**Commissioning** Orbit at the DOC or 15 NM, whichever is the smaller at Minimum Safe Altitude.
Accuracy on Airways	ADF needle oscillations < ± 10°. (2068) See Note.	**Commissioning** Following notified airways. Where an NDB supports many airways, then one airway in each quadrant should be flown.
Accuracy in Holding Patterns	ADF needle oscillations < ± 5°. (2069) See Note.	**Commissioning** Following notified Holding patterns.

Parameter	Limits	Periodicity and Measurement Method
Accuracy on Instrument Approach Procedures	ADF needle oscillations < ± 5°. (2070) See Note.	**Commissioning and Annual** Following Instrument Approach Procedure
Coverage	>70 microvolts per metre. (2071)	**Commissioning** Orbit at the DOC or 15 NM, whichever is the smaller, at Minimum Safe Altitude.
Identification	Correctness, clarity and proper tone. (2072)	**Commissioning and Annual** Throughout the flight inspection.
Station passage	Reversal without excessive ADF needle swing around station passage. ADF needle oscillations <± 10° throughout the remainder of the radial. (2073) See Note.	**Commissioning and Annual** Two radials 90 degrees apart. From 5 NM to 5 NM past the station.

Note: Periods of out of limits are acceptable as long as:

1. they are oscillatory in nature rather than one sided and do not exceed 8 seconds for the check of the DOC, Airways and Holding patterns and 4 seconds for Instrument Approach procedures,
2. the pilot reports that the usability of the NDB is acceptable and that the NDB satisfactorily supports the Airway/Holding Pattern/ Approach Procedure.

Analysis of Flight Inspection Records

NAV02.21 The ATS Provider shall analyse the flight inspection report at the earliest opportunity for operational systems and prior to entering a facility into operational service, to ensure that the flight inspection requirements are met (2345).

NAV02.22 The ATS Provider shall address any deficiencies or non-compliance to ensure a safe service is provided (2346).

NAV02.23 An ATS Provider may delegate the task of analysing the flight inspection report to a third party specialist organisation. This may be the flight inspection organisation that provided the report. The responsibility for addressing any deficiencies identified remains with the ATS Provider (2347).

NAV02.24 The person who conducts the analysis shall be competent to do so (2348).

Note: This may include training on a specific flight inspection report format.

Off-Shore Requirements

NAV02.25 Particular attention shall be given to the design and location of the beacon antenna to ensure an effective coverage pattern (2074).

NAV02.26 The beacon shall be capable of operating on the frequencies laid down in the UK AIP ENR, Chapter 1.15, Off-shore Operations, for both mobile and fixed operations (2075). As frequencies are shared for mobile installations it is imperative that any commissioning or testing of the NDB shall be carried out with due regard to preventing interference to other users (2076).

NAV02.27 Procedures shall exist to prevent simultaneous operation with other co-channel beacons (2077).

NAV 03: VHF Omnidirectional Range (VOR) Flight Inspection Types and Requirements

Part 1 Preliminary Material

Introduction

NAV03.1 It is a requirement that all VOR systems and associated Instrument Flight Procedures are checked by flight inspection at prescribed intervals.

Scope

NAV03.2 This document defines the following:

- Parameters to be measured;
- Profiles to be flown to demonstrate the VOR is suitable to support Instrument Flight Procedures;
- Measurement methods;
- Flight inspection tolerance limits;
- Flight Inspection type and Interval.

Part 2 Requirements

Safety Objective

NAV03.3 **To ensure that the VOR provides an accurate and uncorrupted source of guidance information within the Designated Operational Coverage.**

Parameters to be Measured

NAV03.4 During Commissioning and Routine inspection the parameters in the following table shall be measured for all available transmitters and be within limits:

Parameter	Limits
Alignment	±2° (1955)
Bends	±3.5 ° (1956)
Roughness and Scalloping	± 3° (1957)
Coverage	90 microvolts per metre (1958). At commissioning only, useable signals up to an elevation angle of 40 degrees (1959).
Modulation 30Hz and 9960Hz	± 2% (1960)
Voice	Clear (1961)
Identification	Clear (1962)
Polarisation	± 2° (1963)

Measurement Method

Reference checkpoint

NAV03.5 A checkpoint shall be selected during the commissioning inspection at a point in space where the signal is stable. This checkpoint shall be used in establishing course alignment, 30 Hz Modulation Depth, 9960Hz Modulation Depth and Field Strength to be recorded on the Flight Inspection report (1964).

NAV03.6 The position of the reference checkpoint should be recorded in terms of azimuth, distance from the facility, and the mean sea level (MSL) altitude (1965).

Alignment

NAV03.7 The mean alignment shall be determined by flying a 360 degree orbit of the VOR (1966). The altitude selected for the flight should place the aircraft in the main lobe of the VOR (1967).

NAV03.8 Alignment shall be recorded at the reference check point (1968).

Bends

NAV03.9 Bends shall be determined on all flown radials (1969).

Roughness and Scalloping

NAV03.10 Roughness and Scalloping shall be determined on all flown radials (1970).

Coverage

NAV03.11 Measured as close to the edge of DOC as possible whilst flying either a radial or an orbit (1971).

NAV03.12 Field strength shall be recorded at the reference check point (1972).

NAV03.13 At commissioning useable signals shall be established by two level flights, separated by approximately 90 degrees (1973).

Modulation 30 Hz and 9960 Hz

NAV03.14 The mean modulation depth shall be determined by flying a 360 degree orbit of the VOR (1974). The altitude selected for the flight should place the aircraft in the main lobe of the VOR (1975).

NAV03.15 Modulation shall be recorded at the reference check point (1976).

Voice

NAV03.16 Checked as close to the edge of DOC whilst flying either a radial or an orbit (1977).

Identification

NAV03.17 Checked as close to the edge of DOC whilst flying either a radial or an orbit (1978).

Polarization

NAV03.18 The vertical polarisation effect shall be checked when flying a radial at a distance of 18.5 to 37 km (10 to 20 NM). The aircraft should be rolled to a 30 degree bank, first to one side, then to the other, and returned to a straight level flight. Track and heading deviations should be kept to a minimum. Course deviation, as measured on the recording, is the indication of vertical polarisation effect (1979).

Profiles to be checked

NAV03.19 The following table gives details of the Profiles, which shall be checked.

Profile	Commissioning	Routine
	Transmitter to be checked	
Radials	1 or 2 (1980)	1 or 2 (1981)
Approach Procedures	1 & 2 (1982)	1 & 2 ** (1983)
Cross check radials	1 or 2 * (1984)	None
Intersections	1 or 2 as required (1985)	None
Holds	1 & 2 as required (1986)	None

** For routine inspection of dual transmitter Doppler VORs, where it can be demonstrated that the alignment error between the transmitters is small i.e. ≤0.5 degrees, then only one transmitter needs to be checked.

* Flight inspection of cross-check radials is not required provided there is sufficient flight inspection data to support the use of those radials.

Radials

NAV03.20 A selection of radials, which support Instrument Flight Procedures other than Instrument Approach Procedures, should be inspected (1987).

NAV03.21 The selection should be based on the following:

1. Areas of poor performance indicated by the orbit inspection.
2. Any radials where the coverage may be affected by terrain.
3. One radial selected from each quadrant.
4. The longest and lowest radials.

Instrument Approach Procedures

NAV03.22 Approach radials should be evaluated at a distance that includes the procedure turn, holding pattern and missed approach on commissioning inspections (1988). The approach radial should be flown 30 m (100 ft) below specified altitudes (1989). Commissioning inspections require two additional radials 5° either side of the

approach radial to be flown and analysed with the same criteria as the approach radial (1990).

Holds

NAV03.23 Procedure as published in the AIP (1991).

Cross check radials

NAV03.24 Checked during radial inspection as required (1992).

Intersections

NAV03.25 Adjacent facilities that provide intersections should be inspected to determine their capability to support the intersection. Minimum signal strength should exist for the radial(s) forming the intersection within 7.4 km (4 NM) or 4.5°, whichever is greater, each side of the geographical location of the intersection fix (1993).

Flight Inspection Interval

NAV03.26 The prescribed interval between successive inspections is 1 year. This interval may be extended to 5 years if the Service Provider can demonstrate that the system is stable and that multipath interference does not affect the guidance signals (1994).

Flight Inspection Organisations

NAV03.27 All VOR flight inspections shall be made by an organisation having CAA approval for VOR inspection under the ANO (2009).

Analysis of Flight Inspection Records

NAV03.28 The ATS Provider shall analyse the flight inspection report at the earliest opportunity for operational systems and prior to entering a facility into operational service, to ensure that the flight inspection requirements are met (2349).

NAV03.29 The ATS Provider shall address any deficiencies or non-compliance to ensure a safe service is provided (2350).

NAV03.30 An ATS Provider may delegate the task of analysing the flight inspection report to a third party specialist organisation. This may be the flight inspection organisation that provided the report. The responsibility for addressing any deficiencies identified remains with the ATS Provider (2351).

NAV03.31 The person who conducts the analysis shall be competent to do so (2352).

Note: This may include training on a specific flight inspection report format.

NAV 04: Engineering Requirements for Conventional and Doppler VHF Omni-Directional Range (CVOR/DVOR) Beacons

Part 1 Preliminary Material

Introduction

NAV04.1 Under the terms of Article 205 of the ANO all VHF Omni-Directional Range Beacon (VOR) installations intended for use in the provision of an ATS in the UK require approval by the CAA.

Scope

NAV04.2 This document sets out the Engineering Requirements for all Conventional and Doppler VHF Omni-Directional Range Beacons (CVOR/DVOR) intended for use in the provision of an ATS.

Part 2 Requirements

Safety Objective

NAV04.3 The Beacon system does not radiate a signal which falls outside standard operating tolerances or provide false guidance over its Designated Operational Coverage area (DOC).

System Requirements

SARPs Compliance

NAV04.4 In addition to the requirements below, VOR beacon systems shall comply with the SARPs in ICAO Annex 10 Volume 1 Chapter 2 General Provisions for Radio Navigation Aids (1805) and Chapter 3 Section 3.3 Specification for VHF Omnidirectional Radio Range (VOR) (1806).

Note: Where the UK has differences filed to SARPs these will be published in Supplements to the annexes and in the UK AIP.

Radiated Frequency

NAV04.5 The equipment shall transmit only on the frequency assigned by the CAA and as appears in the schedule to the radio licence issued under the Wireless Telegraphy Act (1807).

Beacon Accuracy

NAV04.6 ICAO Annex 10, Volume 1, section 3.3 gives a measurement distance of four wavelengths from the centre of a CVOR beacon; the equivalent measurement position for a DVOR shall be 300 m from the centre of the DVOR (1808).

Effective Coverage of the Beacon

NAV04.7 The DOC will be determined as part of a standard flight check during the commissioning of the VOR (1809).

Identification

NAV04.8 The Identification shall be suppressed when the VOR is not available for operational purposes, e.g. under maintenance (1810).

Note: The normal identity code may be radiated for short periods during maintenance or flight inspection as necessary.

Speech Modulation

NAV04.9 With the exception of ATIS, no other voice communication channel shall be transmitted via the VOR system (1811).

Standby Power

NAV04.10 Standby power supplies shall be provided commensurate with the service being supported (1812).

Status Information

NAV04.11 FISOs and/or ATCOs directly responsible for approach, landing and take-off at the aerodrome(s) with which they are concerned shall be provided with information on the operational status of radio navigation services, on a timely basis, consistent with the use of the service(s) involved (2312).

NAV04.12 Where status information is reliant upon a visual status indicator, then an audible alarm should be provided which indicates that the visual indicator has changed state (2313).

Flight Inspection

NAV04.13 Flight inspection shall be carried out in accordance with the requirements in CAP 670 Part C, Section 2 NAV 03 (1814).

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NAV 05: Engineering Requirements for Distance Measuring Equipment (DME) Transponders

Part 1 Preliminary Material

Introduction

NAV05.1 Under the terms of Article 205 of the ANO all Distance Measuring Equipment (DME) Transponder installations intended for use in the provision of an ATS in the UK require approval by the CAA.

Scope

NAV05.2 This document sets out the Engineering Requirements for all DME Transponders intended for use in the provision of an ATS.

Part 2 Requirements

Safety Objective

NAV05.3 **The DME Transponder equipment shall not radiate a signal which falls outside standard operating tolerances or provide false information over its Designated Operational Coverage area (DOC).**

System Requirements

SARPs Compliance

NAV05.4 In addition to the requirements below, DME transponder systems shall comply with the SARPs in ICAO Annex 10 Volume 1 Chapter 2 General Provisions for Radio Navigation Aids (1816) and Chapter 3 Section 3.3 Specification for UHF Distance Measuring Equipment (DME) (1817).

Note: Where the UK has differences filed to SARPs these will be published in Supplements to the annexes and in the UK AIP.

Radiated Frequency

NAV05.5 The equipment shall operate only on the frequencies assigned by the CAA and as appears in the schedule to the radio licence issued under the Wireless Telegraphy Act (1818).

Identification

NAV05.6 The Identification signal shall be suppressed when the DME is not available for operational service (1819).

Note: The normal identity code may be radiated for short periods during maintenance or flight inspection as necessary.

Flight Inspection Requirements

NAV05.7 DME shall be flight inspected in accordance with the requirements for DME Flight Inspections contained in Part C, Section 2 NAV 06, Distance Measuring Equipment (DME) Flight Inspection Types and Requirements (1820).

Standby Power

NAV05.8 Standby power supplies shall be provided commensurate with the service being supported (1823).

Use of DME as a Ranging Element with Precision Approach

Note: This includes the use of DME/N with MLS supporting a straight in approach.

NAV05.9 The DME shall be sited to keep the triangulation error at the point at which the distance is required to a minimum (1825).

NAV05.10 Requirements for identification when associated with an ILS are detailed in ILS 06 (1826).

Status Information

NAV05.11 FISOs and/or ATCOs directly responsible for approach, landing and take-off at the aerodrome(s) with which they are concerned shall be provided with information on the operational status of radio navigation services, on a timely basis, consistent with the use of the service(s) involved (2314).

NAV05.12 Where status information is reliant upon a visual status indicator, then an audible alarm should be provided which indicates that the visual indicator has changed state (2315).

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NAV 06: Distance Measuring Equipment (DME) Flight Inspection Types and Requirements

Part 1 Preliminary Material

Introduction

NAV06.1 It is a requirement that all DME systems and associated Instrument Flight Procedures are checked by flight inspection at prescribed intervals.

Scope

NAV06.2 This document defines the following:

- Parameters to be assessed;
- Measurement methods;
- Flight inspection tolerance limits;
- Flight inspection interval.

Part 2 Requirements

Safety Objective

NAV06.3 **To ensure that the DME provides an accurate and uncorrupted source of range information within the Designated Operational Coverage.**

Parameters to be Assessed

NAV06.4 The following parameters shall be assessed for the prescribed transponders and be within limits.

Note: Commissioning checks are required on change of equipment or change of Instrument Flight Procedure (IFP).

Accuracy

NAV06.5 The table below provides the accuracy requirements for the various uses of the DME.

Procedure Supported by the DME	Where and how measurement is made	Interval/ Tolerance	Transponder
DME associated with precision approach	4NM – 1NM from threshold on approach	Comm ±0.03 NM (2179) Routine ±0.1 NM (2180)	Comm both Routine one TXP
DME associated with Instrument Approach Procedures (IAP) that are not precision approaches	4NM – 1NM from threshold on approach	Comm/Routine ±0.1 NM (2181)	Comm both Routine one TXP
IFP	Spot check at ranges promulgated on the procedure	Comm ±0.1 NM (2182)	One TXP
Missed Approach Procedure	Spot check at ranges promulgated on the procedure	Comm/Routine ±0.1 NM (2183)	One TXP
Direct Arrivals	Spot check at ranges promulgated on the procedure The orbit as required for DME general below, may be carried out at the appropriate radius	Comm ±0.1 NM (2184)	One TXP
Hold	Spot check at ranges promulgated on the procedure	Comm ±0.1 NM (2185)	One TXP

Procedure Supported by the DME	Where and how measurement is made	Interval/ Tolerance	Transponder
DME general	An orbit at a radius of 5 NM or greater at an elevation of 2º from the DME site or above MSA.	Comm ±0.1 NM (2186)	A complete orbit on one transponder. Followed by a minimum 20º overlap on the second transponder.
En-Route	During radials flown on any associated facility	Comm/Routine ±0.1 NM (2187)	One TXP

Coverage

NAV06.6 Throughout the inspection whilst within the DOC the DME receiver input shall not fall below –90 dBm (2188).

Identification

NAV06.7 The identification signal shall be clear throughout the flight inspection; additionally, where the ident is synchronised with other equipment, the correctness of the keying sequence shall be checked (2189).

Performance

NAV06.8 False unlocks and instances of interference shall be identified on the Flight Inspection report and investigated by the ATS provider and the appropriate rectification carried out (2190).

Flight Inspection Interval

NAV06.9 For DMEs that support Instrument Approach Procedures the Routine inspection shall be conducted annually. (2373)

NAV06.10 Where there are no associated equipments, inspections shall be made on Commissioning and in line with any flight inspection requirements of Instrument Flight Procedures supported by the equipment (2192).

NAV06.11 For DMEs that support En Route services the Routine inspection shall be conducted in line with the associated equipment. (2374)

Flight Inspection Organisations

NAV06.12 All DME flight inspections shall be made by an organisation having CAA approval for DME inspection under the ANO 2009, as amended (2193).

Analysis of Flight Inspection Records

NAV06.13 The ATS Provider shall analyse the flight inspection report at the earliest opportunity for operational systems and prior to entering a facility into operational service, to ensure that the flight inspection requirements are met (2353).

NAV06.14 The ATS Provider shall address any deficiencies or non-compliance to ensure a safe service is provided (2354).

NAV06.15 An ATS Provider may delegate the task of analysing the flight inspection report to a third party specialist organisation. This may be the flight inspection organisation that provided the report. The responsibility for addressing any deficiencies identified remains with the ATS Provider (2355).

NAV06.16 The person who conducts the analysis shall be competent to do so (2356).

Note: This may include training on a specific flight inspection report format.

NAV 07: ATS Requirements for RNAV (GNSS) Instrument Approach Procedures

Part 1 Preliminary Material

Introduction

NAV07.1 Commission Implementing Regulation (EU) No. 1035/2011 of 17 October 2011 laying down common requirements for the provision of air navigation services requires safety assessment of changes to services including initial provision of a service.

Scope

NAV07.2 This document sets out the requirements for ATS Providers wishing to provide Instrument Approach Procedures supported by Global Navigation Satellite Systems (GNSS) signals. These encompass lateral navigation (LNAV) guidance aspects of Non Precision Approach (NPA) or Approach Procedure with Vertical Guidance (APV). These Instrument Approach Procedures are termed RNAV (GNSS).

Part 2 Requirements

Safety Objective

NAV07.3 **Changes to services provided by ATS Providers including instrument approaches supported by GNSS shall be assessed by the ATS Provider as being adequately safe.**

System Requirements

SARPs Compliance

NAV07.4 In addition to any safety requirements identified by the ATS Provider the GNSS Signal in Space (SiS) must meet the SARPs as defined in ICAO Annex 10 Volume 1, Chapter 3 Table 3.7.2.4-1.

Note: The lateral navigation (LNAV) requirements of APV BaroVNAV procedures are the same as the requirements listed for NPA.

Overview

NAV07.5 The CAA allows, at suitable aerodromes, the provision of published RNAV (GNSS) Instrument Approach Procedures (IAPs), supported by the NAVSTAR Global Positioning System (GPS).

Regulatory Oversight of RNAV (GNSS) IAPs by the CAA

NAV07.6 Applications for an Instrument Flight Procedure (IFP) supported by GNSS should be made in accordance with the requirements in CAP 785 Approval Requirements for Instrument Flight Procedures in UK Airspace (available at www.caa.co.uk/CAP785).

NAV07.7 ATS providers intending to facilitate RNAV (GNSS) IAPs must provide the usual notice of the intended change to the CAA in accordance with CAP 670 Part A Regulatory Framework, paragraph A88 Change Notification Requirements.

NAV07.8 RNAV (GNSS) IAPs must be supported by safety assurance documentation arguing the adequate safety of the proposed IAP in accordance with the proposer's SMS and should be submitted to the appropriate CAA Regional Office in parallel with the application for the IFP referred to in paragraph NAV07.6 above.

Compliance with ICAO SARPs

NAV07.9 An essential aspect to be addressed in the safety assurance documentation is that of the suitability of the performance of the GNSS SiS to support the intended operation. It is recognised that a performance assessment of the GPS SiS is not a trivial task and is unlikely to be achieved by individual service providers in the short term. With this in mind, the CAA will make available data from monitoring carried out over recent years to allow assurance to be gained that the performance of the GPS SiS is suitable to meet ICAO requirements for the support of Instrument Approach procedures. This or other suitable third party data may be used in the development of safety assurance documentation to argue the acceptability of the GPS to support the approach procedure. The data may also be used to ensure the performance of the GPS SiS remains suitable to support the approach procedure.

Note: Real time monitoring of the GPS signal is vested in the RAIM algorithm of the aircraft receiver and is not the responsibility of the ANSP.

NAV07.10 The performance of the EGNOS System is measured and reported on by the European Satellite Service Provider (ESSP). The Monthly reports are available on the ESSP Website at: www.essp-sas.eu/monthly_performance_reports.

Further Guidance

NAV07.11 Further guidance material is available in the GNSS Supported Services area of the ATS requirements Overview pages on the CAA website: www.caa.co.uk/ATSRequirementsOverview.

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VDF 01: Requirements for Flight and Ground Inspection of VHF Direction Finding (VDF) Systems

Part 1 Preliminary Material

Introduction

VDF01.1 Approval under Article 205 of the ANO may be granted for a VDF used in support of ATC operation providing Navigation assistance for aircraft under their control.

Scope

VDF01.2 This document details the minimum requirements for the flight inspection of VDF systems. Additional checks may be required due to poor or difficult siting conditions.

Part 2 Requirements

Safety Objective

VDF01.3 **The VDF equipment shall provide indications of known accuracy to ATC of the magnetic bearing to or from the VDF site of aircraft transmitting on associated aerodrome communication frequencies.**

Functional Requirements

Introduction

VDF01.4 To achieve the safety objective the accuracy and useful service area of the VDF installation shall be demonstrated by Flight Inspection.

VDF01.5 VDF Flight Inspection shall be undertaken on Commissioning of new equipment, replacement of aerial system, relocation of equipment or other major adjustment or modification which may cause the accuracy of the equipment to be compromised, or at any other time as required by an ATS Engineering Inspector.

Note: The method of flight inspection is not specified in this publication, only the parameters to be measured. Examples of methods of flight inspection include:

1. A suitably equipped flight inspection aircraft, using an automatic or semi-automatic positioning or tracking system.
2. Positioning an aircraft over previously surveyed ground checkpoints.
3. Use of a theodolite, sympathetically positioned at the VDF antenna in order to minimise reception induced errors, tracking the target aircraft.
4. Use of Radar positioning of the aircraft in combination with ground surveyed checkpoints.
5. Use of GPS equipped aircraft, in combination with ground surveyed checkpoints.

VDF01.6 Use can be made of any suitable method, providing that the positioning accuracy of the aircraft is better than the required accuracy of the VDF by a factor of 5, i.e. Class A/5 = ±0.4° aircraft positioning accuracy.

Required Procedures

VDF01.7 The following activities shall be carried out during the commissioning of the VDF.

Ground checks

VDF01.8 Checks to confirm the bearing accuracy shall be carried out using suitable test oscillator(s) or portable radio equipment, at previously surveyed ground points around the VDF antenna.

Note: Establishment of accurate test points is necessary in order to provide confidence that the alignment of the VDF is correct prior and subsequent to, flight inspection.

VDF01.9 **Recommendation**: Unless otherwise advised by the VDF manufacturer, ground test points should be located every 10 degrees around the VDF antenna.

VDF01.10 **Recommendation**: Periodic confirmation of the bearing accuracy, using ground checks, should be undertaken in accordance with the equipment manufacturer's recommendations.

Checks using Aircraft

VDF01.11 The flight calibration aircraft shall complete an orbit of the VDF, measuring the actual magnetic bearing from the VDF, which shall be compared with those indicated by the direction finder display.

Note: It may be necessary to complete orbit flights in both directions in order to eliminate any 'lag error'.

VDF01.12 The height and radius for the flight inspection is dependent on the required operational coverage for the VDF. The flight check shall take place at the limit of the required operational coverage and be at an altitude which will maintain radio line of sight, whilst observing any minimum safe altitude criteria.

VDF01.13 Where the operational coverage is not specified then the limits of the VDF, with its associated communications equipment, shall be established.

VDF01.14 Ground and Air checks may need to be repeated if the equipment is adjusted in order to eliminate errors.

VDF01.15 Areas where out of tolerance errors cannot be corrected or where VHF communication was not of sufficient quality shall be subject to further investigation. Any subsequent limitations to coverage shall be published in the UK AIP.

Approach Procedures

VDF01.16 Any proposed VDF Instrument Procedures shall be flown, with confirmation obtained that the indicated bearing is within tolerance throughout the approach.

Frequencies

VDF01.17 The foregoing 'Required Procedures' shall be carried out on the primary VDF frequency.

VDF01.18 Bearing accuracy spot checks and full approach procedures shall be carried out on all other communication frequencies associated with the VDF.

Standby power

VDF01.19 Checks at the ground check points shall be repeated using the standby power source, if installed.

Site Safeguarding

VDF01.20 In the absence of manufacturer's data, refer to the Technical Safeguarding section, CAP 670 Part B, for appropriate guidance.

VDF Categorisation

VDF01.21 The results shall be assessed for categorisation using the following criteria (ICAO Doc. 9426, Air Traffic Services Planning Manual, refers).

Category	Range of Bearing Error
Class A	± 2 degrees
Class B	± 5 degrees
Class C	±10 degrees

VDF01.22 The results and supporting evidence shall then be submitted to the CAA for acceptance and Approval of the facility.

PART C, SECTION 3

Surveillance

Introduction

C3.1 Section 3 of Part C contains safety and engineering requirements for surveillance systems and their constituent elements, including requirements for performance assessment trials. These documents should be used in conjunction with the Generic Requirements and Guidance contained in Part B as appropriate.

Scope

C3.2 The purpose of the 'SUR' sections of CAP 670 is to provide guidance to ANSPs for obtaining approval for surveillance systems and their constituent equipment, which require regulatory approval under Article 205 of the ANO. The equipment subject to regulatory approval includes surveillance systems/equipment used as an essential element for the provision of air traffic services or where such systems/equipment are deemed to be safety-related and used to support the provision of an air traffic service (See Part A, Appendix A for the schedule of equipment to be regulated under Article 205 and 206 of the Air Navigation Order).

C3.3 Surveillance systems which are deployed in an aviation environment to support functions that are not related to air traffic management, such as fleet management, are outside the scope of CAP 670 and the CAA's regulatory responsibility for ATS regulation. The requirements in CAP 670 are also applicable to surveillance data feeds sourced from third parties, e.g. the use of Onward Routed Radar Data.

C3.4 The use of surveillance systems as planning aids or for Secondary Surveillance Radar (SSR) for labelling purposes only is outside the scope of the requirements defined in CAP 670 unless the related planning and labelling functions have safety implications.

Overview of SUR Sections

C3.5 The 'SUR' documents contain guidelines and requirements for surveillance systems and their constituents. SUR 01 provides general guidance on the specific regulatory provisions applicable to air traffic surveillance systems and contains current national policy statements on operational aspects.

C3.6 SUR 02 provides technology independent generic guidance and requirements regarding the derivation of the performance criteria applicable to various surveillance systems. SUR 03 contains requirements to be complied with when using surveillance data from combined sensors or by using multiple techniques. The subsequent SUR sections address technology specific requirements for Primary Surveillance Radar (PSR), SSR, Automatic Dependent Surveillance (ADS) and Multilateration Surveillance (MLAT). These requirements are identified specific to various applications where possible (e.g. en-route and surface surveillance).

C3.7 SUR 08 and SUR 09 identify requirements that are application specific (e.g. Aerodrome Traffic Monitoring and Airport Surface Surveillance) and are independent of the technology being used.

C3.8 SUR 10 and SUR 11 identify requirements applicable to key constituent elements within a typical surveillance system including the recording and replay system, data processing and display systems. SUR 12 addresses requirements applicable for the performance assessment process, which includes pre-operational trials.

C3.9 Annex B to the SUR sections document provides some useful guidance as regards the use of multistatic primary radars which is an emerging non co-operative surveillance technology.

SUR 01: Provision of Surveillance for Civil ATS Operations

Part 1 Preliminary Material

Introduction

SUR01.1 There are international, European and national standards and regulations applicable to ground based surveillance systems in the UK.

Scope

SUR01.2 SUR 01 identifies the ICAO SARPS provisions, European level regulations exclusively applicable to surveillance systems and current national policy on the minimum surveillance coverage requirements required in the UK.

Note: The current European regulations identified in SUR 01 do not mandate specific ground-based surveillance capabilities to be implemented. The national policies on ground-based surveillance strategy and airborne equipage requirements in UK airspace are being reviewed. Further information on the UK approach to surveillance for ATS can be found in Annex E to the SUR Sections.

Part 2 Requirements

General

SUR01.3 The following European level, ICAO level and national legislative requirements must be considered for applicability for all ground based surveillance systems deployed in the UK and relevant provisions shall be complied with as applicable.

SUR01.4 These requirements shall be considered in addition to the generic requirements/legislation applicable to the regulation of all CNS/ATM systems described in Part B of this document.

Single European Sky Legislation (Mandatory)

SUR01.5 ANSPs shall comply with the relevant sections of the following regulations as applicable:

1. Commission Regulation (EU) No. 1207/2011: Surveillance Performance and Interoperability Implementing Rule (SPI IR) – Laying down requirements for the Performance and Interoperability of Surveillance for the Single European Sky.
   - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:305:0035:0052:EN:PDF
2. Commission Regulation (EC) No. 262/2009: Laying down requirements for the co ordinated allocation and use of Mode S interrogator codes for the single European Sky.
   - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:084:0020:0032:EN:PDF
3. Commission Implementing regulation (EU) No. 1206/2011: Aircraft Identification Implementing Rule – Laying down requirements for the Aircraft Identification for the Single European Sky.
   - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:305:0023:0034:EN:PDF

Other European Level Requirements Imposed by the European Commission

SUR01.6 Where applicable, Surveillance equipment is also required to comply with the following EU Directives (refer to CAP 670 Part A paragraphs 39 to A42 for details):

1. Radio and Telecommunications Terminal Equipment Directive (R&TTED) 1999/5/EC (See CAP 670 Part A The Regulatory Framework, paragraph A42 for further information)
   - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1999:091:0010:0028:EN:PDF
2. Waste Electrical and Electronic Equipment Directive (WEED) (2002/96/EC)
3. Restriction of Hazardous Substances (RoHS) (2002/95/EC)

Note: The Commission may also produce regulations or directives to address various aspects of CNS equipment outside the scope of the SES, which are nevertheless applicable to the EU member states.

Note: Furthermore, as the role of the European Aviation Safety Agency (EASA) is expanding to include safety assurance of CNS/ATM systems. Implementing Rules and Certification Specifications relevant to surveillance systems may be generated by EASA in future and this document will be updated accordingly.

Global Level (ICAO) requirements

SUR01.7 **Rationale**: Under the obligations placed on the UK under the Convention on International Civil Aviation, it is necessary to implement the ICAO Standards and Recommended Practices (SARPS) in respect of CNS/ATM equipment. Further details can be found in paragraph A1 of Part A The Regulatory Framework.

SUR01.8 The following SARPS shall be applied to surveillance systems as applicable:

Note: This list will be updated when SARPS are developed by ICAO for surveillance technologies not currently covered.

1. SARPS Annex 10 Volume 4 – Surveillance Radar and Collision Avoidance Systems

Note: Annex 10 Volume 4 contains SARPS for Mode A/C conventional SSR systems, Mode S systems, Mode S Extended Squitter systems and for Multilateration systems.

2. SARPS Annex 10 Volume 3 – Communication Systems

Note: Annex 10 Volume 3 contains SARPS relevant for Automatic Dependent Surveillance Systems.

National Surveillance Coverage Requirements

General

SUR01.9 Primary Surveillance Radar (PSR) is normally the minimum level of equipment necessary to provide Radar Control, Traffic Service or Deconfliction Service. SSR or other surveillance technologies may, to varying extent, be required to supplement PSR in order to safely accommodate increases in traffic complexity or density.

SUR01.10 Failure of surveillance systems must be catered for by provision and publication of operational and engineering contingency arrangements and procedures.

SUR01.11 Non-co-operative surveillance systems shall not be permanently withdrawn from service unless all ATSUs using the system can demonstrate that the traffic demand and complexity can be safely handled using procedural control or remaining surveillance systems.

SUR01.12 The co-operative surveillance system where provided shall not be permanently withdrawn from service unless the demand and complexity of traffic can be safely handled using non-co-operative surveillance alone.

Provision of Surveillance Systems According to Airspace and Air Traffic Services

SUR01.13 The national surveillance coverage requirements applicable to en-route and terminal environment in the UK are listed in Table 1 and Table 2 below.

SUR01.14 Terminal and en-route airspace where non-co-operative surveillance is not mandatory according to Tables 1 and 2, non-co-operative surveillance is required wherever an ATSU providing surveillance based air traffic services identifies that it is probable for non-transponder equipped aircraft, whether identified or not, to present a hazard to operations due to the uncertainty of their positions, which cannot be mitigated by other measures.

SUR01.15 In airspace not identified in Tables 1 and 2, non-co-operative surveillance shall be required wherever an ATCU providing surveillance based air traffic services identifies that it is probable for non-transponder equipped aircraft, whether identified or not, to present a hazard to operations due to the uncertainty of their locations, which cannot be mitigated by other measures.

SUR01.16 In airspace not identified in Tables 1 and 2, if providing services in an environment where there is a mixture of non-co-operative and co-operative targets, where surveillance services are provided exclusively using co-operative surveillance techniques, methods necessary for the safe separation of targets shall be defined and justified.

SUR01.17 The choice of surveillance techniques for the intended application shall be justified based on a hazard identification, considering equipage levels in the operational environment.

Note: The proportion of co-operative and non-co-operative targets and the possibility of presence of co-operative targets with faulty equipment in the intended coverage area must be considered.

Note: The choice of co-operative surveillance techniques could be SSR Mode S, ADS-B or MLAT, where as the choice of non-cooperative techniques is limited to PSR although multistatic radar maybe a feasible option in future.

Table 1 – Surveillance Coverage Requirements in Terminal Environment

	Terminal Environment
Below FL 100	All *Terminal Control Areas* shall have at least a single layer of coverage by a suitable non-co-operative surveillance technique. **Note**: Terminal Control Area is a control area normally established at the confluence of ATS routes in the vicinity of one or more major aerodromes. (ICAO)
	All *Terminal Control Areas* shall also have coverage provided with suitable co-operative surveillance technique/s. **Note**: Co-operative surveillance data may be provided by one or a combination of more than one surveillance technique.
	The co-operative surveillance provision shall contain sufficient redundancy such that the operational requirement for coverage and accuracy to support the Air Traffic Service is met at all times (e.g. Dual SSR coverage or MLAT sensor network with some redundancy).
At and above FL 100	Adequate coverage by SSR or other co-operative surveillance system shall be provided as a minimum in *Terminal Control Areas* (i.e. Non-co-operative surveillance is optional).
	Adequate coverage by SSR or other co-operative surveillance system shall be provided in all Major Terminal Control Areas. **Note**: Major Terminal Control Areas in this document refers to London, Scottish and Manchester TCAs.

Table 2 – Surveillance Coverage Requirements in En-route Environment

<table>
<tr><th></th><th>Areas of high traffic density and/or complexity</th><th>Areas of low traffic density and/or complexity</th></tr>
<tr><td rowspan="3">Below FL 100</td><td>Coverage shall be provided with at least a single layer of coverage by a non-co-operative surveillance technique.</td><td>Coverage shall be provided with data from a suitable co-operative surveillance technique as a minimum

(i.e. non-co-operative surveillance is not mandatory but optional).</td></tr>
<tr><td colspan="2">Coverage shall also be provided with data from a suitable co-operative surveillance technique.</td></tr>
<tr><td colspan="2">The co-operative surveillance provision shall contain sufficient redundancy such that the operational requirement for coverage and accuracy to support the Air Traffic Service is met at all times (e.g. Dual SSR coverage or MLAT sensor network with some redundancy).</td></tr>
<tr><td>At and above FL 100</td><td>In areas of high traffic density ad/or complexity, coverage by a suitable co-operative surveillance technique shall be provided as a minimum</td><td>Coverage shall be provided with data from a suitable co-operative surveillance technique as a minimum

(i.e. non-co-operative surveillance is not mandatory but optional).</td></tr>
</table>

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SUR 02: Generic Requirements for Surveillance Systems

Part 1 Preliminary Material

Introduction

SUR02.1 This section sets out generic data and performance requirements for co-operative and non-co-operative surveillance systems used in the provision of air traffic services. It also introduces the concept of Required Surveillance Performance (RSP).

Scope

SUR02.2 The safety and performance requirements identified in this section are generic safety and performance parameters independent of technology. Where performance criteria have already been developed for specific surveillance applications by ICAO or at a European level, this section also identifies such material as guidance for users.

Part 2 Requirements

Safety Objective

SUR02.3 **To ensure the surveillance system achieves the required level of performance and safety for the intended application independent of the type of surveillance technique or the architecture used.**

Note: Description of surveillance services and applications can be found in Annex C.

Required Performance of surveillance systems

SUR02.4 In order to support a selected ATM application, the surveillance system shall meet a minimum level of performance suitable for the operational requirements of the selected application defined herein as the Required Performance of a surveillance system. These performance criteria shall be appropriate to the chosen application and the air traffic services provided in the airspace concerned.

Note: ICAO has introduced a concept called "RSP-Required Surveillance Performance" for the minimum level of performance of a surveillance system defined above.

SUR02.5 The chosen application and the operational requirements necessary for the application shall be clearly defined.

SUR02.6 The required performance shall be specified and justified for the chosen application and the air traffic service provided in the airspace concerned.

Note: This shall either be derived by the ANSP themselves or be taken from an appropriate Global level/EU level standards document (e.g. A Community Specification).

SUR02.7 Where such minimum required performance is already defined in ICAO SARPS by means of RSP criteria for an application or mandated by law (e.g. SES IRs), the system shall meet the performance criteria defined therein.

SUR02.8 In addition, the national requirements defined later in CAP 670 for particular surveillance systems or applications shall apply.

SUR02.9 Where minimum performance criteria is not mandated in SARPS or in European Law or defined in CAP 670, however are defined in European Specifications or standards that form an acceptable means of compliance to the requirements laid down by European legislation, the ANSP shall endeavour to meet the required performance criteria defined therein. In all other cases the ANSP shall define and justify their own required performance.

SUR02.10 The required performance criteria shall be measurable and verifiable.

Note: Where the required performance is defined for the end-to-end surveillance system containing airborne and ground elements of the surveillance chain, the ANSP shall be able to apportion the performance the ground surveillance sub system must deliver and verify performance of the ground sub system. See Annex A for a schematic diagram of a typical surveillance system.

SUR02.11 Required performance shall be met throughout the coverage volume where the service is provided.

Required Performance – Data Items

SUR02.12 If deployed, all non-co-operative and co-operative surveillance systems shall deliver the minimum required data items as defined in Annex 1 (points 1.1 and 1.2) of Commission Implementing Regulation (EU) No. 1207/2011 Surveillance Performance and Interoperability Implementing Rule (SPI IR).

SUR02.13 Certain surveillance applications may require additional data items depending on the operational requirements (e.g. for safety nets). Data items essential for safe operation and data items that are deemed as beneficial for additional functions (such as safety nets) shall be identified with an indication of their criticality for a safe operation.

SUR02.14 Loss of each data item shall be analysed for operational significance. Where loss of such data has a safety impact (e.g. loss of a safety net) necessary measures shall be in place for maintaining an acceptable level of safety.

Required Performance – Performance Parameters

SUR02.15 When defining performance requirements for the local surveillance sub system, the performance of the data transmission link between the local and the remote sub system shall be taken into account (e.g. latency).

SUR02.16 The following performance parameters shall be defined and justified for the surveillance system supporting a particular application.

Note 1: There may be one or more low level parameters/attributes that contribute to each key performance parameter. Lower level performance metrics may be further defined as necessary.

Note 2: Where performance requirements that are necessary to achieve an acceptable level of safety (e.g. reliability) are chosen from a document with a non-mandatory status (e.g. EUROCONTROL specification), a local safety assessment shall demonstrate that the requirements are adequate and justifiable.

Note 3: The definitions of accuracy, availability, integrity, continuity and timeliness can be found in Article 3 of the SPI IR.

Update period [Example parameters: Scan rate, Probability of update of positional data]

SUR02.17 The update period required for the intended application shall be defined and justified.

Accuracy/Precision [Example parameters: maximum allowable horizontal position error, horizontal position RMS error, Azimuth error, Range error]

Note: The accuracy of a measurement system is the degree of closeness of measurements to the actual/true value. The precision of a measurement is the degree to which repeated measurements under unchanged conditions show the same results.

SUR02.18 The positional accuracy and data precision required for the selected application shall be identified.

SUR02.19 The data precision used shall be consistent with the positioning performance required from the system.

Note: The horizontal position may take various forms depending on the surveillance technique used:

- Range and Azimuth;
- Latitude and Longitude;
- Specific system X and Y co-ordinates.

SUR02.20 An assessment of the horizontal position error shall indicate the surveillance system is capable of meeting the accuracy and resolution requirements for the intended application (refer to SPI IR Annex 1, 2.2).

SUR02.21 The assessment of horizontal position error shall indicate the factors considered for the error calculation and shall be the total error at the time of display.

2D Resolution [Example parameters: Range resolution, Azimuth resolution]

SUR02.22 The system shall be able to resolve two targets having the maximum horizontal position error at any time.

Note 1: Although perfect resolution is desired, the actual resolution achievable is limited by the capability of the surveillance technique being used. However, two aircraft with a maximum horizontal position error shall be resolvable as 2 targets on display. This is

a balance between the practically achievable resolution and the maximum horizontal distance error that 2 aircraft could have in reality.

Note 2: Resolution of techniques such as ADS-B and Multilateration depends on the positional accuracy of the system whereas the resolution of a conventional rotating radar system is typically determined by its pulse width (range resolution) and beam width (azimuth resolution).

Continuity

SUR02.23 The system continuity shall be assessed and justified for the intended application.

Reliability

SUR02.24 The reliability of the surveillance sensor shall be defined and justified.

SUR02.25 The expected reliability either from theoretical analysis or a practical trial shall be demonstrated (508).

SUR02.26 This reliability assessment shall extend to the power supplies and datalinks (509).

SUR02.27 The reliability analysis shall be combined with a hazard analysis to produce a functionally based reliability analysis (510).

Availability

SUR02.28 The factors affecting the availability of the surveillance system suitable to provide service shall be identified.

SUR02.29 The redundancy mechanisms shall be identified. The ANSP shall ensure that safety is not compromised during system unavailability or redundancy.

Latency [e.g. the delay from the detection of a data item to the provision of that item to the display HMI]

SUR02.30 The ANSP shall ensure that the system latency is such that the accuracy of the required data items have not degraded to be unsuitable to use at the time the surveillance data items are used for the intended application.

System Integrity [e.g. undetected incorrect altitude code, undetected incorrect aircraft identification]

SUR02.31 The system shall be capable of achieving the operationally required level of integrity.

SUR02.32 Techniques such as Failure Modes and Effects Analysis (FMEA) shall identify the possible system integrity failures and their effects on the system performance.

Data Integrity [e.g. Navigation Integrity Category (NIC), number of incorrect aircraft identifications]

SUR02.33 The equipment shall contain error detection processes to ensure appropriate data integrity during operation.

SUR02.34 Where processes are employed in the ground system to determine corruption of data these shall be identified and the tolerable rate of undetected errors shall be assessed.

Coverage [e.g. probability of detection, the percentage of actual detections compared to expected detections]

SUR02.35 The required coverage volume in which the selected application will be provided shall be defined (i.e. both horizontal and vertical limits).

SUR02.36 For the intended application, the acceptable number of aircraft of the total number of aircraft in the coverage volume required to be detected and displayed at any update during the operation shall be defined and justified depending on the aircraft equipage and the type of surveillance techniques used in the operational context.

SUR02.37 Probability of detection shall be defined for the intended application. The probability of detection shall meet the operational requirement throughout the required coverage volume, i.e. up to the maximum range and at all operational altitudes.

SUR02.38 If areas with lower than required probability of detection are identified, the ANSP shall clearly identify such areas, and measures for safe operation of aircraft within such areas shall be justified.

SUR02.39 Where services are provided in airspace where carriage of a transponder is mandatory for all aircraft, the co-operative surveillance system shall be capable of exceeding 97% probability of detection.

SUR02.40 **Recommendation**: Probability of detection should be at least 90% for conventional radars and exceed 97% for Monopulse and Mode S radars and other co-operative techniques.

False targets [e.g. density of false targets, rate of false targets, number of false tracks per hour]

SUR02.41 The presence of false targets and targets exceeding the maximum allowable horizontal position error displayed at any update shall be assessed and the maximum criteria shall be defined and justified for the intended operation.

Note: The criteria shall include the false targets including reflections, detection via side lobes of a radar, targets erroneously declared as aircraft targets by plot extractor systems, and erroneous targets exceeding maximum allowable positional error affected on all co operative and non-co-operative techniques being used.

SUR02.42 **Recommendation**: Within any one update, the false target count should be less than 2% of the total target count.

Application Specific Guidance on Performance Requirements

Separation

SUR02.43 Co-operative surveillance systems supporting the separation application shall provide horizontal position, pressure altitude and the identity (aircraft identification or Mode A code) as a minimum.

SUR02.44 The pressure altitude reported to the surveillance data user shall be the most recent pressure altitude received from the aircraft.

SUR02.45 Maximum horizontal position error shall be less than half of the chosen separation minimum minus a specified safety buffer.

Note: This is the maximum error. Other horizontal position accuracy requirements are applicable depending on the actual separation used. See below.

SUR02.46 **Recommendation**: Surveillance systems supporting separation applications should provide ground speed and track information of the aircraft.

Performance Requirements for 3 NM/5 NM Separation Application

SUR02.47 Surveillance Performance criteria have been developed by EUROCONTROL for 3 NM and 5 NM applications for both co-operative and non-co-operative surveillance techniques.

SUR02.48 The values in the following specification may be used as guidance by ANSPs. This document will be updated as new standards are developed by ICAO or European bodies such as EASA or Eurocontrol.

SUR02.49 The ATM Surveillance System Performance Specification is available at:

- www.eurocontrol.int/documents/eurocontrol-specification-atm-surveillance-system-performance

Radio Frequency Characteristics

Interference

SUR02.50 Existing services have operating priority. The existing electromagnetic environment in which the equipment is to operate shall be assessed to ensure that the proposed equipment will comply with all requirements (360).

Note: If, after installation, a new service experiences/creates interference from/to an existing service, modification of the new service must normally take place. The only exceptions are if the other service voluntarily agrees to change, or is in itself deficient and was installed after EMC Directive 89/336 (now replaced by Directive 2004/108/EC) or the Radio and Telecommunication Terminal Equipment (R&TTE) Directive 1999/5/EC came into force.

SUR02.51 Ground-based transmitters shall be subject to spectrum protection requirements stated in Article 5 of the SPI IR (referred in SUR 02 paragraph SUR02.12) and compliant with the R&TTE Directive.

SUR02.52 Where ANSPs have reasonable evidence to believe that their air traffic surveillance systems are subject to interference effects, the ANSP shall inform the relevant CAA ATS Regional Inspectorate.

Note: In addition, any interference effects affecting co-operative systems must also be reported to NISC for investigation as required by Section 3 of CAP 761.

SUR02.53 ANSPs operating 1030 MHz interrogators (e.g. SSR or MLAT) shall ensure that any 1030 MHz transmitter they operate transmits in accordance with National IFF/SSR Committee (NISC) requirements published in CAP 761 Operation of IFF/SSR Interrogators in the UK: Planning Principles and Procedures (www.caa.co.uk/cap761) and the conditions of the NISC Certificate issued for the relevant interrogator.

Note: National aircraft equipage requirements are published in AIP GEN 1.5 Aircraft Instruments, Equipment and Flight Documents.

Frequency Stability of Transmitters, Receivers and Transceivers

SUR02.54 The surveillance system frequency stability shall be sufficient and within tolerance over the expected temperature range and variation in voltage.

Transmitter Output Power

SUR02.55 Transmitter Output Power shall be tested and verified during commissioning of the system.

SUR02.56 The transmitter output power budget shall be sufficient to achieve the required probability of detection throughout the required area of coverage.

Transmitter Unwanted Emissions

SUR02.57 Unwanted transmitter emissions shall be minimised and be within applicable statutory limits.

Note: Transmitter unwanted emissions include out-of band emissions, spurious emissions, and harmonics.

Reducing Spurious Returns

SUR02.58 All spurious return reduction techniques shall be defined and justified (363).

Note: Spurious returns include clutter, garble, spurious reflections etc.

Bandwidth

SUR02.59 The bandwidth required shall be justified (356).

Note: A theoretical or practical evaluation of the frequency components of the output pulse could take the form of a Fourier

transform of the theoretical output waveforms or a practical trial based on a spectrum analysis. In either case the evaluation should include the effects of tolerances on pulse spacing and duration and system non-linearity.

SUR02.60 The equipment shall generate the output pulse patterns to minimise the bandwidth required (357).

SUR02.61 The emission classification as defined in the ITU Radio Regulations Article 4 shall be stated (358)

Siting Requirements

Site Safeguarding

SUR02.62 Refer to the Technical Safeguarding section, CAP 670 Part B Section 4, for appropriate guidance.

Site Restrictions

SUR02.63 Access to the surveillance system and associated equipment shall be restricted such that the availability of the ATS is not compromised accidentally or otherwise (340).

Aerial Support Structure

SUR02.64 The stability of the aerial tower affects the system performance, especially clutter reduction and return position accuracy. The aerial stability limits allocated to the tower shall be justified (341) for sensors requiring an aerial support structure.

SUR02.65 An analysis of the tower structure must show that limits are met at the stated operating wind speed and ice loading (342).

Siting Requirements for Sensors

SUR02.66 Local site obstructions and terrain effects shall be shown to be acceptable for the required coverage (337).

SUR02.67 **Recommendation**: This should be provided by a 360 degree representation giving the elevation (in degrees) of any obstruction versus bearing and a 'line of sight' coverage chart for several target heights based on these obstructions and using the Radar earth curvature (338).

Surveillance Data Processing System Requirements (SDPS)

SUR02.68 Processing equipment shall be able to handle the specified ground station capacity (i.e. the maximum number of targets expected to be processed at any given time).

SUR02.69 The processing system shall not introduce excessive delay between detection and display.

SUR02.70 The surveillance data processing and transmission chain shall not corrupt surveillance data items that are sourced from aircraft systems. Such data items include:

1. Pressure-Altitude (also Barometric Altitude);
2. Aircraft Identity (e.g. Mode A Code; Aircraft Identification);
3. Special aircraft identification data (e.g. SSR Special Position Identification [SPI]);
4. Data indicating emergency conditions;
5. Other Mode S Enhanced Surveillance Parameters; and
6. Surveillance Capability information.

SUR02.71 The tolerable frequency of corruption of aircraft sourced data items shall be derived based on a safety assessment of the significance of the data items to the application.

SUR02.72 The surveillance data processor shall not cause loss or corruption of data.

Environmental Conditions

SUR02.73 The design and testing regime shall demonstrate that the equipment operates as required in the chosen environment (345).

SUR02.74 **Recommendation**: All surveillance transmission equipment should be located in a controlled environment with appropriate heat dissipation and dust control (346).

Interoperability of Surveillance Systems

SUR02.75 Any surveillance interrogator/receiver system using 1030 and 1090 MHz RF band shall comply with the power, spectrum, protocols and formats defined in relevant parts of ICAO Annex 10 Volume 4, Chapters 2, 3, 5 and 6, and Volume 3, Chapter 5 as applicable.

SUR02.76 Surveillance systems shall be subject to Interoperability Requirements in Article 5 of the SES Surveillance Interoperability Implementing Rule referred in SUR 02 paragraph SUR02.12.

Note: Interoperability, in the context of surveillance systems, represents the ability of a local and a remote surveillance sub-system to inter-operate between each other which may be between the ground system and the aircraft transponder or another ground surveillance sub-system.

Performance Monitoring – Remote Control and Monitoring System (RCMS)

SUR02.77 Annex 11 to the International Convention on Civil Aviation requires that a procedure be in place that informs ATS units of the operational status of the equipment used for controlling take-off, departure and approach to land. The system shall report any failures that will put restrictions on the performance or abilities of the equipment (499). How the system achieves this shall be defined and justified (500).

Note: An electronic system or a procedural reporting method from the maintenance department or to ATC can be used.

SUR02.78 If a failure of a sub-system occurs, the remote control and monitoring system or the manual reporting system shall maintain a record of the event (501).

SUR02.79 The RCMS information required depends on the configuration, and the ATS provider's intention to provide service in reduced redundancy. However, the following minimum information shall be available:

1. An indication of present operating configuration (503); and
2. An indication of unavailable sub-systems (504).

SUR02.80 The RCMS shall enable the operator to select the correct course of action. The intended operating procedures shall be submitted for approval (505).

SUR02.81 Any configuration changes undertaken by remote control shall not conflict with local control (506).

Effect of Adjacent Band Spectrum Utilisation

SUR02.82 The operational impact of interference from the adjacent frequency spectrum band shall be assessed.

SUR02.83 The surveillance performance required for the intended application shall not be compromised by the effects of interference or the mitigation mechanisms employed.

Note: The frequency band 2500 MHz to 2690 MHz is likely to become increasingly occupied by mobile communications transmissions in the future following a UK spectrum award and is adjacent to the Primary frequency band 2700 MHz to 3100 MHz (10 cm).

Effects of Wind Turbines on Surveillance Systems

SUR02.84 Where the presence of wind turbines has an operational impact on surveillance systems, suitable mitigation mechanisms shall be applied such that any risks associated with the wind turbine effects are mitigated to an acceptable level.

SUR02.85 The chosen mitigation solutions shall not compromise the surveillance performance required for the intended application.

SUR02.86 Where the solutions involve changes to the surveillance data processing systems or processing data from multiple surveillance sensors, the additional processing mechanisms shall not cause a system overloading or an unacceptable processing delay.

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SUR 03: Requirements for Surveillance Data Transmission Links and Systems Using Combined Surveillance Data

Part 1 Preliminary Material

Introduction

SUR03.1 It is often necessary to combine the surveillance data from multiple surveillance sensors to obtain a complete surveillance picture suitable for the intended application. Certain co-operative ground based surveillance techniques require implementation of many receivers to obtain surveillance capability over the full coverage. It is also often the case that combination of surveillance data from a co operative surveillance technique and a non-co-operative technique is necessary to ensure that all types of targets are displayed.

Scope

SUR03.2 The requirements set in this document apply to surveillance data transmission links (e.g. Copper cable, Fibre optics, RF links, satellite links) from remote or local sensors that provide surveillance data feeds to the data processing systems. It also contains requirements where surveillance data from multiple sensors are used in a combined manner to provide the required surveillance data on the display for the provision of air traffic services.

Part 2 Requirements

Requirements for Surveillance Data Transmission Links

SUR03.3 The local or remote surveillance data feed shall provide complete and uncorrupted data such that the safety of the Air Traffic Service utilising it is not compromised (1718).

SUR03.4 **Recommendation**: Duplicate data transmission links should be implemented to increase the availability where possible (784).

SUR03.5 Where radio links (RF links) are used, the 'line of sight' path of the link shall be safeguarded (786).

Note: Where the radio link is provided by a third party and evidence of safeguarding cannot be provided, then appropriate mitigation for interruption of the link shall be provided.

SUR03.6 **Recommendation**: Radio links should not cross active runways, taxi-ways, railways or roadways. This is due to the change of path characteristics in the presence of aircraft or large service vehicles (787).

The Data Transmission Link performance

SUR03.7 The performance characteristics of the data transmission link shall be capable of meeting the overall performance requirements necessary for the intended application.

SUR03.8 The suitability of the link shall be assessed against the operational requirement (775) and shall include the following aspects:

1. Link integrity and effects of interference (776);
2. Link data rate and capacity (777);
3. Link distortion and effect on accuracy (778);
4. Link delay (latency) (779);
5. Link reliability (780);
6. Link availability and continuity; and
7. Data resolution on link (781).

SUR03.9 The actual performance as regards bit rate, bit error rate, transmission delay and availability shall be defined and justified when compared with the required acceptable performance in the Operational Requirement (782).

SUR03.10 The effects of pick-up of false signals including radio frequency interference, magnetic and electrostatic fields shall be determined (789).

SUR03.11 The link bandwidth shall be determined and shown that it has sufficient capability of transmitting the data required to satisfy the OR (800).

SUR03.12 The worst case data delay through the system shall be defined and be justified as being acceptable (802).

Requirements for Exchange of Surveillance Data between ANSPs/CNS Providers

Unavailability of Surveillance Feeds Supplied by Third Parties

SUR03.13 Where surveillance data is received from a remote supplier, procedures shall be in place that require the remote supplier of surveillance data to supply details to the recipient of any maintenance or planned outages of the source surveillance system that may affect the supplied data (794). Any changes shall be assessed formally to determine the effect on the OR (795).

SUR03.14 If such changes to remote surveillance feeds results in the failure to deliver the required data items and/or the required performance as per the OR, the relevant CAA inspector shall be informed of the change.

Formal Arrangements between ANSPs/CNS Providers

SUR03.15 ANSPs or CNS providers exchanging surveillance data with an ANSP shall establish formal arrangements between them as per the requirements set in Article 5(2) of the SPI IR referred to in SUR 01 paragraph SUR01.5.

Requirements for the Exchanged Surveillance Data Feeds

SUR03.16 Exchange of surveillance data shall be performed in accordance with regulations stated in Article 5(1) of the SES Surveillance Interoperability Implementing Rule referred in SUR 02 paragraph SUR02.12.

SUR03.17 Recommendation: All Purpose Structured EUROCONTROL Surveillance Information Exchange (ASTERIX) format is recommended for data interchange (483).

SUR03.18 Correct operation of all data transformations shall be tested under all data formats used (796).

Combined Surveillance Data from Multiple Surveillance Systems

Co-mounted PSR and SSR Systems

SUR03.19 Where co-mounted PSR and the SSR antenna systems are used to obtain combined target reports, the PSR and the SSR antennas shall be electrically aligned in azimuth with respect to one another either using a computer based plot analysis system or RFMs.

Note: The PSR active reflectors, PSR permanent echoes (PE), or the SSR remote field monitor may be used as the alignment reference depending on whichever system with greater accuracy of geographic alignment.

SUR03.20 In a shared coverage volume of a co-mounted PSR and SSR, the combination rate of target reports shall be suitable to meet the operational requirement.

SUR03.21 Where the PSR active reflectors, PSR PEs or SSR Remote Field Monitors are used as an on-going performance verification technique in a combined PSR/SSR system, appropriate monitoring mechanisms shall still be in place during PSR or SSR unavailability for alignment checking purposes where PSR only or SSR only service will be provided.

Requirements for Systems used for Combining Surveillance Data from Multiple Systems

SUR03.22 The following requirements shall be met as a minimum by systems such as Plot Assigner Combiners and Multi Sensor Tracking Systems that use feeds from multiple systems for the integration of surveillance data.

SUR03.23 The data feeds from the individual surveillance systems used for the combination process shall be defined including the following elements:

1. Update rate of individual data feed;
2. Surveillance data formats before combining;
3. Data items provided by each feed;
4. The position information output format (e.g. range and azimuth) and the reference point for each feed;
5. Accuracy and resolution of each feed; and
6. Surveillance coverage provided by each feed.

SUR03.24 The update rate of each system shall be justified to the required update period output by the system.

SUR03.25 Where feeds from radars (PSR or SSR) located at separate locations are combined (fused), the methodology for slant range correction and azimuth accuracy of the combined positional data shall be justified.

Note: If the radars are not co-mounted, there will be a difference in their slant range measurement of the same target by each radar. Altitude or height information of the target is necessary for the slant range error correction process.

SUR03.26 The output format of positional information of the combined feed shall be defined with the relevant reference point.

Note: E.g. Position information can be displayed as range and bearing with respect to the position of a radar head used as the reference point.

SUR03.27 The methodology for the integration of positional information from different sources to obtain the positional information of the combined position in the format desired shall be clearly defined.

SUR03.28 The methods used to integrate positional information from multiple surveillance sources may introduce features that may impact on the accuracy and the ability to apply a certain separation standard. The impact of these features on the ability to support the defined operation shall be assessed. Such features may include:

- Lag in turns
- Track discontinuities, e.g. across the boundaries between sensor sources
- Track jumps
- Track deviations
- Split Tracks
- False Tracks
- Excessive latency

SUR03.29 The likely wind turbine interference effects or interference of adjacent bands on each individual surveillance source shall be assessed and justified.

Loss of Data Feeds from Individual Surveillance Systems

SUR03.30 The impact of the loss of data from individual surveillance systems on the accuracy and the ability to provide surveillance data to meet the operational requirement shall be assessed.

Note: Loss of one or more feeds used for combining surveillance data may have an impact in terms of accuracy, coverage, and tracking capability.

SUR03.31 Where it is necessary to use surveillance data from multiple surveillance sensors for the continued service provision, the strategy for continued operation including any back up plans in the event of unavailability of a sensor shall be defined and justified.

SUR03.32 Where the unavailability of one or more surveillance data chain(s) results in reduced service levels, or providing procedural service, procedures shall be in place for the safe handling of traffic during the transition period.

Performance Monitoring

SUR03.33 The system shall provide automatically through the display system or procedurally to advise the controller of an overload situation on the links.

SUR03.34 **Recommendation**: Error detection and correction algorithms should be used to check for data corruption (791).

SUR03.35 The system shall provide warning indications for line loss and system status (792).

SUR03.36 Where radar and other type of surveillance techniques are used (e.g. PSR and MLAT) to derive combined target reports, the system shall not be entirely reliant on the availability of either the radar or the other surveillance technique for ongoing performance verification, during unavailability of one system.

SUR03.37 The performance monitoring methods shall be defined and justified.

Using an Additional Surveillance Data Feed as a Redundant Feed

SUR03.38 Where a surveillance data feed is used as a means of redundancy in order to provide continued service in the unavailability of the main surveillance data sources, the back-up feed shall meet the data transmission link requirements listed in paragraphs SUR03.3 to SUR03.12 above.

SUR03.39 The performance of the redundant feed shall meet the operational requirements of the service provided in the unavailability of the main system.

SUR03.40 The unavailability of a redundant feed used as described above shall not impede continued provision of service using main surveillance data feeds and shall have no safety impact.

Note: If the unavailability of a surveillance data feed has an impact on the service provision within the required coverage area, this has to be identified in the safety assessment process by means of a safety requirement.

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SUR 04: Requirements for Primary Radar Systems

Part 1 Preliminary Material

Introduction

SUR04.1 Primary Surveillance radar is the most widely used non-co-operative surveillance technique for Civil ATS applications in the UK. This document sets out safety and performance requirements applicable to such systems.

Scope

SUR04.2 The requirements identified in this document are applicable to all PSR sensors that provide surveillance data for ATS services.

Part 2 Requirements

Radio Spectrum Regulatory Requirements

Primary Frequency Bands

SUR04.3 Within the UK, allocation for radio navigation services and in accordance with ITU Radio Regulations, the following bands are allocated to primary radar services (radio navigation).

1. Long range 23cm (L-band) radar
   - 1215 – 1300MHz Radionavigation (Primary allocation)
   - 1300 – 1350MHz Aeronautical Radionavigation (Primary allocation)
2. Medium range 10cm (S-band) radar
   - 2700-2900 MHz Aeronautical Radionavigation (Primary allocation)
   - 2900-3100MHz Radionavigation (Primary allocation)
3. Short Range Precision 3cm (X-band) radar
   - 9000 – 9200MHz Aeronautical Radionavigation (primary allocation)

- 9300 – 9500 MHz Radionavigation (Primary allocation)

Note: There is a 100MHz span between the 9000-9200MHz and 9300-9500MHz aeronautical radionavigation and radionavigation allocations for which there are no aviation assignment rights.

4. Very Short range (J-band) radar

   - 15.4 – 15.7 GHz Aeronautical Radionavigation (Primary allocation)

Note: The licensing, allocation and assignment of frequencies for civil aviation primary surveillance radar is conducted by the CAA's Directorate of Airspace Policy.

Frequency Tolerance and Frequency Characteristics

SUR04.4 In accordance with Article 3 of the ITU Radio Regulations it is the requirement that radio stations operate within technical specifications to satisfy the provisions of the Regulations stated below.

1. Transmitting stations shall conform to the maximum permitted power levels for out-of-band emissions, or unwanted emissions in the out-of-band domain as specified in the most recent ITU-R Recommendations – Moreover, every effort should be made to keep frequency tolerances and levels of unwanted emissions at the lowest values which the state of the technique and the nature of the service permit.
2. The bandwidth of emissions shall also be such to ensure the most efficient utilisation of the spectrum.

Note: ITU-Radio Regulation Appendix I provide a guide for the determination of the necessary bandwidth.

SUR04.5 In accordance with ITU Radio Regulation Appendix 2 the following transmitter tolerances shall apply.

Frequency bands	Tolerances applicable to transmitters
1250 – 1350 MHz	500 PPM
2700 – 3100 MHz	1250 PPM
9000 – 9200 & 9300 – 9500 MHz	1250 PPM
15.4 – 15.7 GHz	5000 PPM

Level of Spurious Emissions

SUR04.6 In accordance with ITU Radio Regulation Appendix 5 (table II) the following shall apply in determining the maximum permitted spurious domain emission power level:

Attenuation values used to calculate the maximum permitted spurious domain emission power level for radio determination equipment shall be:

43 + 10log (Peak Envelope Power), or 60dB, whichever is the less stringent.

Performance of PSR systems

SUR04.7 The required performance of the PSR system shall be specified.

Note: The performance of a PSR system is dependent on the operational requirement. The safety related performance requirements should be derived based on a risk assessment process. Typical performance requirements of a PSR can be found in the ICAO Doc 8071 Volume 3 – Testing of surveillance radar systems.

Performance Monitoring of PSR

Geographic Alignment

SUR04.8 All PSR systems shall have methods to determine the correct geographical alignment (490).

SUR04.9 Recommendation: The radar should be aligned with geographical north within 0.1 degree.

SUR04.10 The method of alignment checking, reference points, and the direction to which the system is aligned (e.g. true north) shall be specified.

Note: More information on the methods of PSR alignment checking can be found in ICAO Doc 8071 Volume 3, Testing of Surveillance Radar Systems.

Alignment Checking of the Analogue PSR Systems

SUR04.11 For an analogue primary radar, the system shall use appropriate video outputs to check the range/bearing error based on Permanent Echoes (PE) (491).

SUR04.12 The controller or maintenance engineer shall check the error against established tolerances at suitable intervals (492).

SUR04.13 The system shall identify at least one PE in the operational coverage area (493).

Note: It is recommended to have more than one PE. Where more than one PE is used, each PE must be 60° separated from each one:

1. Each PE must be located at a range greater than one third of the standard display range (494).
2. In addition the separation of each PE from other permanent features must be at least 3 degrees in azimuth and ±0.5 nautical miles in range (495).
3. Each PE should not extend over more than 2 degrees of bearing (828).

Alignment checking of the Plot Extracted PSR systems

SUR04.14 For a plot extracted primary radar, one of the following shall be provided for alignment checking purposes:

1. A raw radar feed for calibration purposes. This feed shall be independently aligned with the processed radar feed (532).
2. A PSR active reflector to give a test target (MTI Marker) (533).
3. Areas of radar coverage which are inhibited from processing to enable a PE to be displayed (534).
4. For a PSR used in conjunction with a co-mounted SSR, a procedure in place to determine the collimation error between

the Primary and Secondary data. This can either be achieved by ATC operator checks or equipment monitoring.

Measuring On-going System Performance

SUR04.15 Any methods used for the pre-operational evaluation of performance and on-going performance measurement of the PSR shall be specified (e.g. Built in test methods) along with the parameters (e.g. receiver noise level, transmitter output power) subject to monitoring.

SUR04.16 The performance monitoring of the PSR shall be carried out at sufficiently frequent intervals.

Requirements for PSR and Markers used for Surveillance Radar Approaches

Note: SRAs may be provided using surveillance techniques other than PSR provided that a robust safety argument is presented by the ANSP addressing all risks and the CAA is satisfied.

Update Period

SUR04.17 A primary radar providing the positional data for the following SRAs shall rotate at the following effective minimum turning rates:

1. SRA terminating at 2 NM from touchdown point, a rotation rate of 10 RPM (453);
2. SRA terminating at 1 NM from touchdown point, a rotation rate of 15 RPM (454);
3. SRA terminating at 0.5 NM or less from touchdown point, a rotation rate of 20 RPM (455).

Note 1: Touchdown Point: The point on the runway where it is intended for an approaching aircraft following visual or navigational guidance to intersect the runway surface. This may be the point of the intersection of the glide path with the runway; the point of intersection of the PAPI with the runway; or the point on the runway where a visual indication in the form of an Aiming Point (CAP 168) has been painted.

Note 2: The reference point used for the displayed distances shall be consistent with the distance reference point used in SRA procedures (e.g. In certain airfields the SRA distances may be measured with respect to the runway threshold).

Coverage

SUR04.18 The radar coverage shall be suitable for the SRA termination distance.

Accuracy

SUR04.19 When used for surveillance radar approach (SRA) purpose, the accuracy of the position information shall be justified as suitable for SRA within the range where SRAs are performed.

Marker Requirements for SRA

SUR04.20 When PSR is used for Surveillance Radar Approaches (SRA) with a termination range of less than 2 NM, an appropriate configuration of fixed returns or markers (active test targets/MTI marker) shall be used to confirm the correct position of the SRA approach line.

SUR04.21 The marker configuration shall allow the controllers to confirm the correct position of the SRA approach line.

SRA with a Termination Range of between less than 2 NM and 1 NM from Touchdown Point

1. Centreline markers shall be provided.
2. There is no requirement for bracket markers for SRAs with a termination range of 1NM or more from touchdown point.

SRA with a Termination Range of less than 1 NM from Touchdown Point

1. A set of bracket markers (543):
   - There shall be two permanent markers available that enable the identification of runway touchdown point (544);
   - These permanent markers shall be positioned equidistant from the runway centreline at the instrument touchdown point (545);
   - The distance from the runway edge shall be the minimum commensurate with runway operations but not closer than 15 m from the runway edge (546);
   - Any installation near the runway shall comply with the Obstacle Limitations defined in CAP 168.

2. A set of Centreline markers (538):
   - There shall be two non-permanent markers available (539);
   - These shall be located as follows:
   - Within 2 degrees of the applicable approach centreline (540);
   - Between 3 and 6 NM of the applicable touchdown point (541);
   - Not within 1 NM of each other (542).

Note: For airports with reciprocal approaches, one permanent marker on each approach path may be used.

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SUR 05: Requirements for Secondary Radar Systems

Part 1 Preliminary Material

Introduction

SUR05.1 Secondary Surveillance Radars are the most widely used conventional technique of co-operative surveillance used for Air Traffic Service Applications. SSR systems can be either Mode A/C capable or a Mode S capable system and ICAO have developed SARPS to standardise the use of both Mode A/C and Mode S capable SSR systems. SSR can also be used as a data link for communication between aircraft and ground systems, and SSR signals are also used in other surveillance techniques such as MLAT and ADS-B.

Scope

SUR05.2 This document sets the safety and performance requirements for various aspects of SSR systems that provide surveillance data for the ATS, such as sensor performance, monitoring and implementation.

Part 2 Requirements

SARPS Compliance

SUR05.3 In addition to the requirements below, Secondary Surveillance Radar (SSR) systems, including Mode S surveillance systems shall comply with the SARPs in ICAO Annex 10, Volume IV Chapters 2 and 3.

Note: Where the UK has differences filed to SARPs, these will be published in Supplements to the Annexes and in the UK AIP.

SSR Frequency Requirements

SUR05.4 All SSR systems of Mode A, C and S shall use the 1030 MHz as carrier frequency of the interrogation and control transmissions.

SUR05.5 The carrier frequency of the reply transmission shall be 1090 MHz.

Requirements for SSR systems with Mode A and Mode C Capability

SUR05.6 SSR systems having Mode A and Mode C capability shall comply with the frequency requirements, polarisation, interrogator modes and transmission characteristics mentioned in ICAO Annex 10 Volume 4 Chapter 3, sections 3.1.1.1 to 3.1.1.5 and 3.1.1.8 to 3.1.1.11.

Requirements for SSR systems with Mode S capability

SUR05.7 SSR systems having Mode S capability shall comply with the frequency requirements and transmission characteristics mentioned in ICAO Annex 10 Volume 4 Chapter 3, section 2, and Mode S air-ground data link requirements in Volume 3 Chapter 5.

SUR05.8 All Mode S systems shall also meet compliance with the applicable sections of Commission Regulation (EC) No. 262/2009 laying down requirements for the co-ordinated allocation and use of Mode S interrogator codes for the Single European Sky.

SUR05.9 SSR interrogators shall be configured to be complied with the requirements and conditions set in the NISC certificate to operate SSR interrogators in the UK. For further details refer to CAP 761 (www.caa.co.uk/CAP761).

Performance Monitoring of SSR

Alignment Checking

SUR05.10 All SSR radar systems shall have methods available to determine the correct geographic alignment.

SUR05.11 The method of alignment checking, reference points, and the direction to which the system is aligned (e.g. true north) shall be specified.

SUR05.12 **Recommendation**: There should be at least one Remote Field Monitor (RFM) to align radar azimuth reference and for integrity monitoring.

General On-going performance Monitoring

SUR05.13 As per ICAO Annex 10 Volume 4 Chapter 3, section 3.1.1.10.1, the range and azimuth accuracy of the ground interrogator shall be monitored at sufficiently frequent intervals to ensure system integrity.

SUR05.14 Methods used for the pre-operational evaluation of performance and on-going performance measurement of the SSR shall be specified (e.g. Built in test methods, RFM) along with the parameters (e.g. receiver noise level, transmitter output power) subject to monitoring.

Receiver Monitoring

SUR05.15 Receiver sensitivity shall be continuously monitored.

SUR05.16 **Recommendation**: in receiver systems that employ monopulse and/or RSLS techniques, the sensitivity of all channels should be monitored.

Interrogator Monitoring

SUR05.17 The following interrogator characteristics shall be monitored on a continuous or a periodic basis for compliance with the limits specified in ICAO Annex 10 Volume 4 Chapter 3:

1. Pulse Intervals;
2. Interrogator relative radiated pulse levels;
3. Interrogator radio frequency;
4. Interrogator pulse duration;
5. Radiated Power; and
6. Spurious radiation.

SUR05.18 The methods of monitoring shall indicate of any fault of the monitored parameters and the failure of the monitoring equipment itself.

SUR05.19 **Recommendation**: For Mode S systems, a test target generator should be used in addition to the test transponder to input test video signals to the Mode S system for simulating replies from Mode S equipped aircraft.

Using a Remote Field Monitor (RFM)

SUR05.20 All SSR systems shall have a RFM for performance monitoring purposes (522).

SUR05.21 The RFM shall have selectable range offset capability.

SUR05.22 **Recommendation**: The Mode S RFM used for performance monitoring should be capable of verifying (Refer to ICAO Doc 8071 Volume 3 Manual of Testing Radio Navigation Aids):

1. Loop tests for all modes of operation used by the interrogator;
2. Mode A/C surveillance – mode A/C only all-call interrogations;
3. Successful lock-out transmission;
4. Reply delay;
5. Transmitter power;
6. Continuous wave inhibitor (failure of a continuous transmission of 1090 signal);
7. Variable minimum Triggering Level;
8. The ability of the sensor to correctly deliver and receive a Standard Length message;
9. The ability of the sensor to correctly deliver and receive a Extended Length message;
10. That Mode A code change is correctly processed by the sensor;
11. Downlink capability report announcement;
12. Flight ID change; and
13. The sensor is working with the correct II/Si codes assigned.

SUR05.23 The RFM shall not generate acquisition squitters to eliminate it being acquired by an ACAS unit.

SUR05.24 The RFM shall be used by the SSR equipment to continuously monitor those radar parameters which affect detection performance, accuracy or resolution (523)

Note: This includes parameters such as the following:

- Target bearing;
- Target range;

- Peak power;
- Side Lobe Suppression; and
- Pulse spacing.

SUR05.25 The RFM shall provide accurate reference information to test the transmission, reception and de-coding characteristics of the SSR service in conjunction with the range and azimuth accuracy of the ground interrogator (1710).

RFM Siting Requirements

SUR05.26 The positioning of the RFM will depend on the use of the equipment.

SUR05.27 **Recommendation**: Where the controller uses the RFM to assess alignment, the RFM should be sited within the range that the controllers can view. The bearing chosen should correspond to an area of airspace commensurate with the operational situation; the position should not conflict with operationally sensitive areas (524).

Note: This does not imply that the controller should continuously check the position, but that a suitable Radar Display range setting should be available to the controller to view the RFM.

SUR05.28 **Recommendation**: Where an equipment sub-system, under the control of the user, uses the RFM to monitor and assess alignment errors, the RFM shall be within the nominal coverage of the radar. If the equipment sub-system is not monitored directly by the controller, a reporting procedure shall be in place (525).

SUR05.29 **Recommendation**: Where a sub-system, not under the control of the user, uses the RFM to monitor and assess alignment errors, the RFM should be within the nominal coverage of the radar. If the RFM position is outside the normal defined area displayed to the remote controller, a reporting procedure should be in place. This procedure should report alarms from the system provider to the service user. The originator of the service, not the remote user, should identify and notify the remote users of any alignment errors determined (526).

SUR05.30 **Recommendation**: The RFM should be located at a range in accordance with manufacturers' requirements.

SUR05.31 The monitor shall not be visible from any other operational radar service (528). Where this is not possible a written agreement to

the installation shall be obtained from the owners of the affected systems (529).

SUR05.32 The Mode A code for the SSR RFM shall be 7777 and/or 7776 unless stated otherwise in the SSR approval certificate.

SSR performance

SUR05.33 For all SSR systems, the following performance requirements shall be stated in addition to the generic performance requirements mentioned in Part C, Section 3 SUR 02. The recommended criteria shall be assessed for suitability for the operational requirement.

Range and Azimuth accuracy

SUR05.34 **Recommendation**: For en-route separation, SSR systems should have a standard deviation of 250 m for range accuracy and 0.15 degrees for azimuth accuracy.

Missing or Invalid Identity and Pressure Altitude Data

SUR05.35 **Recommendation**: The missing or invalid Identity and Pressure Altitude Data should be less than 5% probability in any one scan.

Reports with corrupted Identity and Pressure Altitude Data

SUR05.36 **Recommendation**: Reports with corrupted identity and pressure altitude information should occur with less than 2% probability at any one scan.

False targets

SUR05.37 **Recommendation**: In a full SSR Mode S environment there should be no persistent false targets.

SUR 06: Requirements for Multilateration Systems

Part 1 Preliminary Material

Introduction

SUR06.1 Multilateration is a form of co-operative and independent surveillance system like SSR. Multilateration (MLAT) systems use the time difference of arrival (TDOA) of the existing 1090 MHz transmissions from aircraft, between several ground receivers to determine the position of the aircraft. An MLAT system can be active, passive or both.

SUR06.2 Standards have already been specified for the existing 1090 MHz and 1030 MHz transmissions in ICAO SARPS Annex 10 Volume 4, hence derivation of further Standards will not be pursued with respect to them. However setting requirements for MLAT systems is necessary to ensure that the MLAT systems are compatible with the existing systems, formats and protocols.

SUR06.3 This document sets national regulatory requirements specific for MLAT systems.

Scope

SUR06.4 The requirements in this document apply to all MLAT systems in general. However application specific guidance is provided where possible.

SUR06.5 The Generic requirements in Part C, Section 3 SUR 02 are applicable to all systems including MLAT. The requirements and guidance included in this document are specific to multilateration system implementations. Although multilateration can be applied to many signal types transmitted by aircraft, this document refers to multilateration using 1090 MHz signals.

Part 2 Requirements

ICAO SARPS

SUR06.6 In addition to the requirements below, all Multilateration systems shall comply with the SARPs in ICAO Annex 10, Volume 4 Chapter 6.

Performance Requirements

SUR06.7 MLAT systems used for air traffic surveillance shall have performance to meet the Required Surveillance Performance defined for the operational services supported.

SUR06.8 Where the MLAT system is used as a replacement to radar, the MLAT system shall meet at least the same performance criteria met by the radar system subject to replacement.

Active MLAT System Transmitter Requirements

SUR06.9 The interrogator capability shall be identified and justified with respect to the current and planned aircraft equipage requirements.

SUR06.10 **Recommendation**: Measures should be taken to minimise the effect of active MLAT operation on the 1030/1090 MHz radio frequency environment.

SUR06.11 Interrogations from multilateration systems shall not set "lockout" on any targets.

SUR06.12 The Interrogation rate shall be configured to meet the operational requirement.

SUR06.13 All interrogation types used by the MLAT system shall be defined.

SUR06.14 All active MLAT systems must transmit in accordance with National IFF/SSR Committee (NISC) requirements and conditions specified in the relevant Interrogator Approval certificate.

Active MLAT Systems Capable of Mode-S Interrogation

SUR06.15 Commission Regulation (EC) No. 262/2009: Laying down requirements for the co ordinated allocation and use of Mode S interrogator codes for SES (www.eurocontrol.int/ses/gallery/content/public/docs/pdf/ses/sk_msipdf.pdf) shall apply to all active MLAT systems which have a Mode S interrogator for which at least one of the following conditions is satisfied:

1. the interrogator relies, at least partly, on Mode S all call interrogations and replies for Mode S targets acquisition; or
2. the interrogator locks out acquired Mode S targets in reply to Mode S all call interrogations, permanently or intermittently, in part or totality of its coverage; or

3. the interrogator uses multisite communications protocols for data link applications.

ADS-B capable MLAT systems

SUR06.16 MLAT systems capable of receiving ADS-B messages using Mode S Extended Squitter shall comply with the system characteristics stated in ICAO SARPS ICAO Annex 10, Volume 4 Chapter 5.

SUR06.17 Where an ANSP intends to use ADS-B positional data or other data items transmitted in ADS-B messages, such data items shall be identified with their intended use.

SUR06.18 The ability to de-code ADS-B messages shall be demonstrated as part of commissioning trials. These requirements are identified in Part C, Section 3 SUR 12.

SUR06.19 Where the MLAT system is implemented to detect ADS-B targets, the requirements mentioned in Part C, Section 3 SUR 07 for ADS-B ground systems shall apply to the MLAT ground system capable of receiving ADS-B messages.

SUR06.20 **Recommendation**: It is recommended for all MLAT systems to have the ADS-B message de-coding capability.

Receiver Synchronisation

SUR06.21 The receiver synchronisation method shall be defined and justified as appropriate to the operational requirement.

SUR06.22 **Recommendation**: The synchronisation method should incorporate sufficient degree of redundancy.

SUR06.23 For transponder synchronised systems, the loss of one transponder shall not cause the loss of the entire MLAT system due to synchronisation failure.

Receiver Geographical Distribution

SUR06.24 The geographic distribution of sensor locations shall be such that the required probability of detection and coverage can be obtained at all levels where the service will be provided.

SUR06.25 The system should be installed and optimised such that the loss of data from any single receiver or interrogator does not cause a loss of the required coverage.

SUR06.26 The sensor antennas shall be sited such that at least 4 sensors to have clear line-of-sight simultaneously to the target in the operationally significant coverage area.

Link Performance

SUR06.27 The data transmission links used between the sensors and the central processing system shall be identified along with entities that have operational responsibility.

Note: Various communication links including RF links, satellite links, copper wire links and fibre optics may be used for communications between sensors and the central processing system within the same MLAT system.

SUR06.28 The data link requirements listed in SUR 03 paragraphs SUR03.3 to SUR03.12 shall be applicable to all data transmission links used in the MLAT system.

SUR06.29 The suitability of the data transmission links chosen shall be justified in terms of reliability, availability, continuity and integrity.

SUR06.30 Where such data transmission links are operated by third parties, ANSPs shall have appropriate service level agreements in place for repair, maintenance, accessibility and the performance of the links.

Redundant Sensor Configuration

SUR06.31 The system shall comprise of at least one additional sensor to the minimum number of sensors required for obtaining a 2D or 3D solution throughout the required coverage area.

Note: This additional sensor may be used at all times for improved accuracy, although its use will be essential for deriving position information during a failure of a single sensor.

SUR06.32 The impact on coverage and accuracy in failure of each individual sensor shall be determined through n-1 analysis and shall be demonstrated as acceptable to continue the intended operation.

Note: 'n' is the total number of sensors. This has to be demonstrated via modelling and simulation and during performance assessment trials.

SUR06.33 In the case of more than one sensor failure, the suitability of the system to continue operation shall be decided based upon the

achievable coverage and the accuracy levels. The operational strategy in such situations shall be defined including operational procedures.

SUR06.34 The procedures in such situations shall be clearly documented and the controllers shall be fully trained to handle such event.

MLAT Performance Monitoring

SUR06.35 The MLAT system shall use at least one Remote Field Monitor (SSR site monitor) for on-going system integrity and end-to-end performance monitoring.

SUR06.36 The performance monitoring mechanisms shall be clearly defined with the parameters subject to monitoring by all monitoring mechanisms.

Note: These must include any in-built status monitoring and external monitoring mechanisms.

SUR06.37 The system shall be capable of indicating to controllers when the MLAT system performance is suitable for operational use and when the system performance does not permit its use for providing the intended service.

Note: These may include visual and audible means or both.

SUR06.38 The system shall indicate to the controllers when the system is operating under redundant conditions, if this is deemed necessary.

SUR06.39 The system shall be capable of indicating to the engineering staff the current operational status of the sensor network and any failures.

SUR06.40 Where one or more RFMs are also used for time synchronisation purposes, the impact of the loss of those RFMs to the time synchronisation function as well as to the system status monitoring function shall be assessed and indicated in design assurance documentation.

Sensor Siting Requirements

SUR06.41 The structure upon which the receivers/transmitters, antennas are mounted shall be of sufficient stability to withstand all expected weather conditions in the operational environment, especially with respect to maximum wind speed and icing.

SUR06.42 The maximum wind speed, ice loading, temperature and humidity conditions expected in the operational environment shall be identified.

Note: Typical values for ice loading conditions are up to 10 mm thick, maximum wind speeds during a 3 second period for operation to be no less than 80 knots and 120 knots for survival of the outdoor equipment.

System Interfaces

SUR06.43 The output of the MLAT system shall be a digital data output, using standard communication protocols (e.g. ASTERIX).

MLAT Output and Processing

SUR06.44 The data output rate shall be identified and the MLAT system shall use the data output method that gives the highest quality and positional accuracy of data.

SUR06.45 The processing and tracking system shall be capable of handling the data received by the MLAT receivers and outputting the data at the required rate.

Note: MLAT system may receive a large amount of data depending on the amount of data transmissions occurring on the 1090 MHz frequency at any given time, however the required data rate may be much slower than this (e.g. 4s in a busy terminal environment) depending on the application. Hence the system has to accommodate a processing mechanism that delivers data of best quality and accuracy at the required rate.

Power Supply

SUR06.46 The stability of the power supply to the system shall be consistent with the availability and continuity of service requirements.

Low Level Coverage

SUR06.47 The coverage and the probably of detection in the low levels of altitude shall meet the performance requirements necessary for the intended application in the lower levels of the defined coverage area.

Note: MLAT system coverage and probability of detection can significantly vary across vertical levels. The probability of detection may be lower than the required criteria at lower altitudes.

MLAT Performance

Probability of Detection

SUR06.48 **Recommendation**: The Pd should be at least 97% for the MLAT system.

False Targets

SUR06.49 **Recommendation**: Number of false targets during any update should be less than 1%.

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SUR 07: Requirements for ADS-B Systems

Part 1 Preliminary Material

Introduction

SUR07.1 ADS-B is a form of co-operative and dependent surveillance system. The ADS-B system broadcasts aircraft position and other information to be received by an "ADS B In" capable ground based receiver. The aircraft position, velocity and associated data quality indicators are usually obtained from an on-board GNSS.

SUR07.2 ADS-B messages can be down linked using Mode S Extended Squitter, Universal Access Transceiver or VHF digital link Mode 4. The data link type used in Europe is the Mode S ES using 1090 MHz.

SUR07.3 This document sets national regulatory requirements specific for ADS-B systems.

Scope

SUR07.4 The requirements in this document apply to all ADS-B systems in general. Airborne surveillance using ADS-B IN capability is out of scope of this document.

Part 2 Requirements

ICAO SARPS

SUR07.5 The ground surveillance systems utilising Mode S Extended Squitter capability ADS B) shall comply with the requirements contained in Annex 10 Volume 4 Chapter 5 (the formats and data sources for the squitter massages are defined in ICAO Annex 10 Volume III Part 1, Appendix to Chapter 5).

ADS-B Receiver Requirements

SUR07.6 All ADS-B receiver stations shall be capable of receiving ADS-B messages transmitted via version 2 of the Mode S Extended Squitter message transmission protocol.

SUR07.7 The ADS-B ground receive sub system shall be capable of receiving, decoding, packaging and time stamping the ADS-B messages on the supported data links in the operational environment.

Note 1: If the implementer expect to provide ADS-B surveillance to aircraft that support data links other than Mode S ES (e.g. UAT or VDL), the ground surveillance receivers shall have the capability to support them.

Note 2: In the unlikely event of using data links other than Mode S ES in the UK, additional requirements should be discussed on a case by case basis. In such situations, compliance with the ICAO provisions relevant to UAT and VDL will be expected.

Safety Assessment

SUR07.8 The ANSP shall define the required data items and the specific purpose for which the ADS-B data items will be used.

Note 1: The ADS-B data may be used as the sole means of surveillance, or as the main co-operative surveillance feed, as replacement to existing SSR or as a redundant system.

Note 2: ADS-B ES aircraft equipage requirements are specified in Article 5 of the SPI IR. Annex 10 Part B of the SPI IR specifies the data items that shall be transmitted by the ADS-B Mode S –ES transponders.

Note 3: Mode S-ES transmitting system characteristics can be found in ICAO Annex 10 Volume 4 Chapter 5 section 5.1.

SUR07.9 A comprehensive system safety assessment shall be performed prior to the introduction of ADS-B including identification of failure modes and the probabilities of the ADS-B ground system, and airborne sources providing each required data item to be transmitted in the ADS-B message.

SUR07.10 For all ADS-B ground systems, the requirements for the following shall be derived by conducting hazard identification and risk assessment process:

1. The likelihood that the ADS-B receive sub-system corrupts the ADS-B data;
2. The ADS-B receive sub system does not provide updated ADS-B reports for 1 or more aircraft;
3. The undetected error rates in the ground-ground transmission of ADS-B reports;
4. The rates of undetected errors in the ADS-B messages by the air-ground link;
5. The probability that the ground system creates an undetected error in the vertical position;
6. The probabilities that the ground domain creates an undetected error for each of the Mode A code, Aircraft identification, and ICAO 24 bit address;
7. The probability that the ground domain creates an undetected error in the SPI information;
8. The probability that the ground domain creates an undetected error in the Emergency indicators;
9. The rate of false ADS-B position reports from the ground processing (i.e. false report ratio).

SUR07.11 The ground functions shall detect the loss of data within a period of one refresh cycle (i.e. within the duration of one update period).

SUR07.12 For the airborne system elements from which ADS-B data items are sourced, the following requirements shall be defined:

- The data items and their quality indicator data items;
- The sources providing each data item;

- Data integrity requirements;
- System integrity requirements for sources providing data;
- Continuity;
- Availability.

SUR07.13 The data integrity requirements and system integrity levels for the data sources connected to the transponder shall be in accordance with requirements specified in Annex 2 Part B of the SPI IR.

SUR07.14 The safety assessment for the airborne system elements providing each data item shall include the impact of all elements that interface with the sources providing the data items.

Note: The CAA monitors the GPS performance in support of the aviation applications and safety critical air traffic services that are based on GPS. The performance data can be accessed via www.caa.co.uk/ATSRequirementsOverview and clicking on 'GNSS Supported Services'.

SUR07.15 The ADS-B transponder shall comply with the performance and integrity requirements specified in Annex 2 Part B of the SPI IR.

ADS-B based surveillance services

SUR07.16 ADS-B based surveillance service shall only be provided to targets having certified ADS-B equipment that meet the required performance criteria.

SUR07.17 The suitability of ADS-B surveillance system to be used for the intended purpose shall be assessed and justified taking the following into account:

- the certified equipage levels;
- the quality of data items;
- ability to meet the required performance criteria.

Note: A pre-operational trial period may be necessary to confirm the equipage levels, and for ensuring the performance of the data transmitted by the ADS-B equipment meet the required criteria.

SUR07.18 Where ADS-B is used to support an application that is supported by radar the ADS-B technical performance characteristics shall meet the equivalent radar performance criteria.

SUR07.19 The evidence shall demonstrate the level of equipage, transmitting equipment certification standards, suitability of sources providing data items critical for a safe operation, the performance of the data and the transmitting equipment.

SUR07.20 ADS-B may be used alone as the only co-operative means of surveillance, including in the provision of separation between aircraft, provided that the factors identified in paragraph SUR07.18 are adequate to support the separation minimum.

Update Rate

SUR07.21 The ADS-B system shall maintain a reporting rate that ensures at least an equivalent degree of accuracy, integrity and availability as for a radar system that is used to provide a similar ATC service.

Note: The typical reporting rate from the aircraft is 0.5 seconds, however the rate provided to the situation display may be less than aircraft reported rate provided that the required performance is still met.

Safety Nets

SUR07.22 All safety net features should possess the same responsiveness as equivalent radar safety net features.

Position Accuracy and Integrity Requirements

SUR07.23 The acceptable criteria for the accuracy and integrity of the ADS-B messages required by the ground system shall be determined and justified for the intended application. The accuracy and integrity indicators transmitted by the ADS-B report may consist of:

1. NIC : Navigation Integrity Category
2. NACp: Navigation Accuracy Category for Position
3. NUC: Navigation Uncertainty Category
4. SIL: Surveillance Integrity Level

Note: The types of indicators included may vary depending on the avionics types. The accuracy and integrity indicators above are defined for systems using GNSS as the positional information source.

SUR07.24 The navigation source(s) (e.g. GNSS) that will be used for reporting of aircraft position shall be identified.

Note: The aircraft sending position reports to the ground ADS-B receivers may use GNSS as their positional information source or other sources (such as inertial navigation system).

SUR07.25 An assessment shall determine the likelihood that the position information will not meet the accepted accuracy and integrity criteria for the intended application.

SUR07.26 The availability of the airborne positional data shall be equivalent to that of the radar.

SUR07.27 An analysis shall determine the likelihood that the data of aircraft participating in ADS B surveillance become unavailable during operation or the aircraft sub-system corrupts the ADS-B information.

SUR07.28 For environments expected to receive ADS-B messages from avionics that have not compensated for latency, the determination of required accuracy and integrity criteria shall take the uncompensated latency into account.

Vertical Position

SUR07.29 The vertical position information shall be processed by the ground based surveillance system equivalent to processing Mode C information from SSR.

Note: This is to ensure same level of data integrity is maintained by the ground system when processing altitude information received from ADS-B equipment..

SUR07.30 The vertical tolerances for ADS-B level information should be consistent with those applied to Mode C level information.

SUR07.31 Only barometric altitude shall be displayed to the ATCO for separation purposes.

Note: Some avionics may allow aircraft to transmit geometric height in the ADS-B message although only the barometric altitude is allowed to be used for separation applications.

ADS-B Ground Processing System Requirements

SUR07.32 The availability/continuity of the ADS-B receiving and processing system shall meet the availability/continuity requirements for the provision of intended service.

SUR07.33 The likelihood that the ADS-B ground processing system corrupts information in the airborne ADS-B report shall be determined and justified for the intended service.

SUR07.34 The likelihood that the ADS-B ground processing system does not deliver the ADS-B positional data received from an aircraft shall be determined and justified.

SUR07.35 The ADS-B receive sub-system shall reference all velocity elements to the WGS-84 ellipsoid.

SUR07.36 The ground domain shall not degrade the horizontal position accuracy through loss of resolution, uncompensated latency or other means.

SUR07.37 The resolution of the barometric altitude shall be specified.

SUR07.38 The ground domain shall not degrade altitude resolution to worse than 100 ft.

SUR07.39 Time of applicability in the surveillance report presented to the controller shall have an absolute accuracy of +/-0.2 seconds or less relative to UTC.

SUR07.40 All types of ADS-B surveillance reports shall contain a time of applicability.

SUR07.41 The ADS-B receive sub system shall provide a time field in each ADS-B report, that is translatable to the time of applicability of the data contained in the report.

SUR07.42 The ADS-B receive sub system shall distinctly mark in the surveillance Report whether the altitude/height information contained in the message is derived from a barometric or geometric source.

Quality Indicators

SUR07.43 The quality indicators used/supported by the ground system for determining the suitability of the positional information transmitted by aircraft shall be identified.

SUR07.44 These shall include accuracy and integrity containment parameters and their associated quality indicators from all aircraft using GNSS or non GNSS positional information involved in the ADS-B surveillance application.

Note: GNSS based systems use HPL (Horizontal Protection Limit) or HFOM (Horizontal Figure of Merit) as integrity and accuracy containment parameters. Non GNSS systems may use equivalent accuracy and integrity containment parameters for the derivation of associated quality indicators.

SUR07.45 For aircraft using non-GNSS systems as the source of positional information, the ground systems shall expect an equivalent criteria to that of the GNSS for the accuracy and integrity quality indicators. The accuracy and integrity containment parameters and their associated probabilities shall also be consistent with the HPL/HFOM used in GNSS systems.

SUR07.46 Prior to accepting aircraft with various ADS-B avionics for the provision of ADS-B surveillance, a safety analysis shall be carried out to determine if the risk level is acceptable in the event of unavailability of an integrity containment parameter from aircraft.

SUR07.47 The analysis shall determine the requirement for other means of verifying accuracy and integrity of data by ground monitoring or a strategy to handle such aircraft in a safe manner if additional means of verifying is not provided.

SUR07.48 The ground system shall only use the ADS-B data for the provision of an ATC service if the quality indicators from the participating aircraft meet the required criteria.

Note: See Surveillance Performance and Interoperability Implementing Rule Articles 5, 8 and 11 for the ADS-B equipage requirements imposed under the SES Interoperability regulations and Annex 4 Part B for the list of data items that shall be transmitted by ADS-B transponders to the ground.

SUR07.49 An indication shall be provided to the controller on the display, whether the surveillance quality of a particular aircraft is acceptable for the application, the data is being used.

SUR07.50 The display system shall also indicate whenever the quality of the surveillance data falls below the acceptable criteria for the application.

SUR07.51 Indication that an aircraft is transmitting an emergency status shall be displayed to the controller in a clear and efficient manner.

System Performance Monitoring

SUR07.52 The system shall clearly indicate to the controller if an aircraft fails to meet the required accuracy and integrity criteria during operation (i.e. an aircraft of which initial ADS-B messages were acceptable and used for the provision of service)

SUR07.53 Ground ADS-B receivers shall be subject to status monitoring. The system shall immediately indicate the controller of any failed receivers.

SUR07.54 **Recommendation**: Apart from the quality indicators included in the ADS-B reports, mechanisms should be in place to monitor and verify the accuracy and integrity of ADS-B data.

Degraded Conditions

SUR07.55 In the event of one or more ADS-B receiver failures, a strategy shall be in place either to handle the traffic with back up or additional surveillance data sources, or to reduce coverage where ADS-B based surveillance is provided or to safe transition to procedural control.

SUR07.56 Procedures shall be in place to handle such aircraft that fail to meet the required criteria.

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SUR 08: Use of Surveillance Data for Aerodrome Traffic Monitoring

Part 1 Preliminary Material

Introduction

SUR08.1 The Aerodrome Traffic Monitor (ATM) equipment must be approved by the CAA under Article 205 of the ANO (612). The ATM may use surveillance data from local or remote surveillance sensors or both. The functions of the ATM are described in CAP 493 Manual of Air Traffic Services, Part 1, Section 2, Chapter 1.

Scope

SUR08.2 This document applies to all surveillance sensor equipment providing data in aid of functions performed using the ATM. It also contains requirements for the ATM processing and display equipment.

Part 2 Requirements

Safety Objective

SUR08.3 **The ATM shall provide accurate and uncorrupted data suitable for all the functionalities that will be performed using the Aerodrome Traffic Monitor.**

General Requirements

SUR08.4 The exact functions for which the ATM is used shall be identified as per the description of ATM functionalities contained in CAP 493 MATS Part 1.

Note: ATM must not be used to provide Approach Radar Services.

SUR08.5 In addition to the special requirements that are listed below, the display system requirements and related ergonomic aspects of display systems described in Part C, Section 3 SUR 11 shall apply to ATM display equipment.

Surveillance Sensor Performance Requirements

Accuracy

SUR08.6 The sensors providing data to the ATM shall detect the position of the aircraft with an accuracy sufficient to discriminate between two targets that are separated by the minimum separation distance allowed between aircraft within the area of interest.

Note: The ATM may be used for Air Control Service which includes control over aircraft flying in, and in the vicinity of the ATZ, aircraft taking-off and landing, all movements on active runways and their access points.

Coverage

SUR08.7 The surveillance sensors that provide data for the ATM shall be capable of detecting all targets within a range of 20 NM from runway threshold.

Recording of ATM

SUR08.8 Refer to Part C, Section 3 SUR 10 for ATM recording and replay requirements.

ATM Processing and Display System Requirements

Displayed Range

SUR08.9 In normal operation the ATM shall only display targets within a range in which the functions of the ATM described in CAP 493 MATS Part 1 are applicable.

Note: A range greater than the required range for normal operation may be available for display as and when necessary as a quick look function.

Display Size

SUR08.10 The display shall have a size suitable such that it presents clear unambiguous information of all aircraft within the range of interest to the controllers suitable to perform all functions for which the ATM will be used.

Runway Selection

SUR08.11 The system shall be capable of automatic adjustment of range and centre on runway change (616).

Display Maps

SUR08.12 The display shall show the runway centreline (617).

SUR08.13 **Recommendation**: The system should indicate ranges from the touchdown point in 1 NM increments (618).

Note: See Part C, Section 3 SUR 04 for a definition of the touchdown point. The displayed range may also be measured with respect to the runway threshold. The reference point for the displayed range and that used in the controllers' procedures shall be consistent.

SUR08.14 The display map shall indicate the relevant reference point (i.e. threshold/touchdown point) (619).

SUR08.15 **Recommendation**: If a labelled ATM is provided, handover procedures should positively identify all targets (620).

Resolution

SUR08.16 The equipment shall resolve two targets at the closest separation distance applicable between two targets within the area of interest.

Track Guidance

SUR08.17 **Recommendation**: Prediction vectors or trail dots should be used to indicate approach speed (623).

Display Orientation

Note: The orientation of the picture in relation to the view from the VCR will depend on the complexity of the aerodrome layout and the controller responsibilities.

SUR08.18 At aerodromes (where practically possible) the orientation is to be such that the runway on the ATM is aligned with the view of the runway, from the control position (632). In such cases where this is not possible, Human Factors risks that this may pose shall be addressed in the supporting Safety Assurance Documentation.

SUR 09: Surveillance Systems for Airport Surface Surveillance

Part 1 Preliminary Material

Introduction

SUR09.1 Surveillance sensors play a crucial role in systems used for airport surface surveillance such as SMGCS and A-SMGCS. The surveillance sensors providing data for these systems may comprise of a single non-co-operative sensor such as a Surface Movement Radar (SMR) or a combination of a non-co-operative and multiple co-operative sensors. While ADS-B can be used as a form of surveillance technique for detecting co-operative targets including vehicles, local area multilateration is a popular form of surveillance in surface movement surveillance systems for detecting co-operative targets in the airport environment.

Scope

SUR09.2 According to ICAO SARPS Annex 14 Chapter 9, a surface movement guidance and control system shall be provided at an aerodrome. However, SMR systems and other forms of surveillance sensors may not necessarily be a component in all Surface Movement Guidance and Control Systems (SMGCS).

SUR09.3 The requirements in this document are specially concerning the performance of the surveillance sensors, processing and display of surveillance data, where SMR or other form of surveillance sensors form part of the SMGC system at an aerodrome.

SUR09.4 The requirements in this document apply to all co-operative and non-co-operative surveillance sensors providing data for an airport surface surveillance system. Where possible, special requirements applicable for SMR and co-operative sensors have been identified separately.

Part 2 Requirements

Safety Objective

SUR09.5 **To provide clear and unambiguous surveillance data to aid the guidance, movement and control of airport surface traffic.**

Existing Standards

SUR09.6 The following ETSI standards exist for Advanced Surface Movement Guidance Control Systems which have been identified as "Community Specifications" for application under the SES Interoperability Regulation (EC) No. 552/2004.

- Part 1: ETSI EN 303 213-1: "Community Specification for application under the Single European Sky Interoperability Regulation (EC) No. 552/2004 for A SMGCS Level 1 including external interfaces";
- Part 2: ETSI EN 303 213-2 "Community Specification for application under the Single European Sky Interoperability Regulation (EC) No. 552/2004 for A SMGCS Level 2 including external interfaces";
- Part 3: ETSI EN 303 213-3:"Community Specification for application under the Single European Sky Interoperability Regulation (EC) No. 552/2004 for a deployed co-operative sensor including its interfaces";
- Part 4: ETSI EN 303 213-4:"Community Specification for application under the Single European Sky Interoperability Regulation (EC) No. 552/2004 for a deployed non-co-operative sensor including its interfaces";
- Part 5: "Harmonised EN covering the essential requirements of article 3.2 of the R&TTE Directive for transmitter used in multilateration equipment";
- Part 6: "Harmonised EN covering the essential requirements of article 3.2 of the R&TTE Directive for deployed surface movement radar sensors".

Note: Compliance with the Community Specifications presumes compliance with the Essential Requirements of the SES Interoperability Regulation.

General Requirements

SUR09.7 Where surveillance data from SMR and/or other surveillance sensors are required to support the surface movement surveillance of an aerodrome, the required performance criteria shall be identified based up on the following factors:

1. The minimum visibility conditions the airport normally operates;
2. The traffic density and complexity of the movements;
3. The design and layout of the aerodrome.

SUR09.8 **Recommendation**: The system should be designed to be capable of expansion to accommodate complex operations, larger coverage area and various sizes of aircraft and vehicles that may operate in the aerodrome in future.

Coverage

SUR09.9 The areas of aerodrome surface for which surveillance coverage using SMR or other sensor equipment is required shall be defined.

SUR09.10 The horizontal coverage of the sensor(s) shall extend over the required area of coverage.

SUR09.11 The vertical coverage shall be suitable for monitoring all traffic on the airport surface in the required area of vertical coverage.

SUR09.12 **Recommendation**: The vertical coverage should be at least 60 m above surface level.

SUR09.13 Where the sensors are only required for partial coverage of the aerodrome surface, visible or other means of surveillance shall be in place to monitor traffic on the areas not monitored by surveillance sensor equipment.

Detectability under Adverse Weather

SUR09.14 The Surveillance sensor(s) shall be capable of detecting all surface traffic in the required area of coverage under the worst weather conditions including lowest visibility under which the aerodrome operations shall continue.

Note: All surface traffic shall mean all aircraft and vehicle for a non-co-operative sensor and all co-operative traffic for other means of surveillance such as MLAT and ADS-B.

Mixed Equipage Environment

SUR09.15 Where both co-operative and non-co-operative traffic operate in the required coverage area, sensors shall be implemented to detect both co-operative and non co-operative targets throughout the coverage.

Resolution

SUR09.16 The horizontal resolution of the sensor equipment shall be determined by a safety assessment for the specific aerodrome.

Accuracy

SUR09.17 The accuracy requirement for surface surveillance systems shall be determined by a safety assessment for the specific aerodrome.

Update Rate

SUR09.18 The update rate shall be at least once per second.

SUR09.19 The update rate required shall be decided taking to account the speed of movements between aircraft and vehicles and their dimensions.

Requirements Specific to SMR

SUR09.20 Where SMR is used for airport surface surveillance, SMR shall to the extent possible enable the detection and display of the movement of all aircraft and vehicles on the manoeuvring area in a clear and unambiguous manner.

Note: ICAO Annex 14 Chapter 9 recommends that surface movement radar for the manoeuvring area should be provided at an aerodrome intended for use in runway visual range conditions less than a value of 350 m. In addition, Surface movement radar for the manoeuvring area should be provided at an aerodrome when traffic density and operating conditions are such that regularity of traffic flow cannot be maintained by alternative procedures and facilities.

SUR09.21 Aircraft and vehicle position indications may be displayed in symbolic or non-symbolic form. Where labels are available for display, the capability should be provided for inclusion of aircraft and vehicle identification by manual or automated means.

SUR09.22 The probability of detection for SMR shall be at least 90% for all target sizes expected on the required coverage area.

SUR09.23 Typical performance requirements for a SMR can be found in ICAO Doc 9476 Appendix F. However it should be noted that the required performance from a SMR depends on whether the SMR is used as part of a simple SMGCS or an A-SMGCS in which the requirements may be more stringent.

Requirements Specific to MLAT implementations

SUR09.24 Where multilateration sensors are used in aid of airport surface surveillance, the loss of any one MLAT receiver or interrogator shall not cause a loss of the required coverage.

SUR09.25 The MLAT antennas shall be mounted on strategic locations where each antenna has a clear line of sight to transponder antennas of aircraft or vehicles.

Note: In addition to the requirements listed above, general requirements described in Part C, Section 3 SUR 06 for MLAT systems shall apply to the MLAT systems used for surface surveillance.

Requirements Specific to ADS-B implementations

SUR09.26 Where ADS-B receivers are used in aid of airport surface surveillance, the loss of any one ADS-B receiver shall not cause a loss of the required coverage.

SUR09.27 The ADS-B receiver antenna/s shall be mounted on strategic locations where each antenna has a clear line of sight to transponder antennas of aircraft or vehicles.

SMGCS Requirements

SUR09.28 Where surveillance sensor/s form part of an SMGCS, a local safety assessment shall determine the safety impact in the event of failure of any element of the surveillance system.

SUR09.29 A local safety assessment shall also justify the suitability of the functional and performance requirements of the surveillance system used as part of SMGCS.

Note: General requirements and guidance on Surface Movement Guidance and Control Systems are given in ICAO Doc 9476 – Manual of Surface Movement Guidance and Control Systems.

A-SMGCS Requirements

SUR09.30 Surveillance sensors used for A-SMGCS shall have a vertical coverage up to an altitude to detect missed approaches and where appropriate, low-level helicopter operations.

SUR09.31 The sensors providing data to the A-SMGCS shall detect aircraft from a suitable distance that aircraft approaching to all active runways can be integrated to the ground movements detected and displayed on the A-SMGCS.

SUR09.32 The distance from which it is required to detect approaching aircraft shall be identified.

SUR09.33 The surveillance sensors shall detect any obstacles, and vehicles in the required coverage area and any designated protected areas.

SUR09.34 The A-SMGCS shall be referenced to the World Geodetic System (WGS-84).

SUR09.35 An A-SMGCS shall be designed and operated with due consideration to all of its functional domains. A local safety assessment shall determine the safety impact in the event of failure of any element of the system and confirm the suitability of the functional and performance requirements to the local operational context.

Note: ICAO Document 9830 Advanced Surface Movement and Guidance Control Systems manual contains performance requirements for surveillance, guidance, and control functions for a typical A-SMGCS system. EUROCONTROL has also published an operational Concept and Requirements document for A-SMGCS Level 1 and Level 2 Implementations.

Monitoring and Alerting

SUR09.36 The performance of the surveillance sensors shall be monitored.

SUR09.37 Alerts shall be provided to the users of the system in the following situations;

1. Complete failure of a sensor;
2. Failure of one or more sensors resulting in reduced vertical or horizontal coverage;
3. System malfunction resulting in degraded performance and below the minimum required performance criteria.

Display Requirements for A-SMGCS

SUR09.38 The A-SMGCS shall provide identification and labelling to all authorised aircraft and vehicles on the manoeuvring area, and on other movement areas as required.

SUR09.39 The response time to issue alerts, alarms, or automatically generated instructions shall be suitable such that necessary precautions can be applied to avoid conflicts taking to account:

- The minimum separations between aerodrome movements (aircraft and vehicles);
- The separations between movements from obstacles (ex: buildings, hangers etc.).

SUR09.40 All critical elements of the system shall be provided with timely audio and visual indications of failure.

SUR09.41 Upon re-starting, the system recovery time shall be less than 3 minutes. Upon re-starting, the system shall restore the information on current traffic and system performance.

SUR09.42 Input devices for the controllers shall be functionally simple such that a minimum number of input actions are required from the controllers.

SUR09.43 The display and all the indicators shall be viewable in all ambient light levels in the aerodrome control tower environment.

Processing System

SUR09.44 The processing system shall have sufficient capacity to handle and process the surveillance data at the maximum movement rate at the relevant airfield.

SUR09.45 The allowable error in the reported position shall be consistent with the requirements set by the guidance and control functions.

Recording

SUR09.46 Refer to Part C, Section 3 SUR 10 for recording requirements of surface movement surveillance data.

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SUR 10: Requirements for the Recording, Retention and Replay of ATS Surveillance Data

Part 1 Preliminary Material

Introduction

SUR10.1 The ability to replay recordings of ATS surveillance data is a vital aid to post accident or post incident investigation and to provide location data in the event of search and rescue operations.

SUR10.2 Replayed data can also be used to evaluate and maintain the performance of surveillance systems used to aid the provision of an air traffic service.

Scope

SUR10.3 The term "surveillance data" mentioned in this document refers to all surveillance data obtained from third party providers, en-route or airfield sensors (including approach and surface movement sensors) by radar or other surveillance techniques such as Automatic Dependent Surveillance (ADS) or multi-lateration and wherever such data is used as an aid to air traffic services.

Note 1: The ICAO Standard for "Automatic recording of surveillance data", set out in paragraph 6.4.1 of Chapter 6 in Annex 11 "Air Traffic Services" (Thirteenth Edition, Amendment 43), requires the automatic recording of "surveillance data from primary and secondary radar equipment or other systems (e.g. ADS-B, ADS-C) used as an aid to air traffic services".

Note 2: Surveillance data used "as an aid to air traffic services" shall mean all surveillance data displayed to the controllers either as part of a surveillance display or safety nets for which visual indications will be provided to controllers on screen, derived from surveillance data.

General Requirements

SUR10.4 With effect from 31 December 2012 it shall be mandatory for all ATS Units which use surveillance data as an aid to air traffic services

to have in place surveillance data recording systems for recording operational screens at the glass (ATG) and surveillance data obtained through the wall (TTW) together with the ability to provide a time synchronised replay of voice and surveillance data.

Part 2 General Requirements

Safety Objective

SUR10.5 **To provide data for use in accident and incident investigations either by the Air Accidents Investigation Branch (AAIB) or CAA, and to support search and rescue, air traffic control and surveillance systems evaluation and training (1716).**

Functional Requirements

SUR10.6 All surveillance data used by an ANSP for the purposes of providing an air traffic service shall be automatically recorded and retained by the surveillance data recording system.

SUR10.7 Surveillance data used as an aid to air traffic services shall normally be recorded at two points in the path between the surveillance sensor(s) and the display system with the only exceptions being those described in paragraphs SUR10.16 to SUR10.20 of this document.

1. Through the Wall (TTW): Data obtained from remote or on site sensors or networks.
2. Operational Screens recorded At the Glass (ATG): From a connection (or "tap") as close to each operational display as is practicable.

SUR10.8 The surveillance data obtained ATG shall preferably be recorded using a lossless compression technique with no loss of accuracy or detail. The recording system shall be capable of recording data at a rate (which may be adaptive) sufficient to ensure the successful capture of any changes that occur to the surveillance data displayed to the controller and any system input change made by the controller such as any entries made via either keyboard or mouse/rolling ball..

SUR10.9 The surveillance data recording system deployed at an ATS Unit shall not degrade or otherwise adversely affect the performance of the surveillance processing and display systems employed at that ATS Unit.

SUR10.10 The surveillance data recording system and power supply configuration shall ensure the continued availability of the recording process, without interruption, whenever the ATS Unit is using

surveillance data as an aid to air traffic services (see paragraphs SUR10.35 to SUR10.37).

SUR10.11 Surveillance data recorded either at the ATS Unit or by a third party provider (see paragraphs SUR10.16 to SUR10.20) shall be retained in secure storage for a minimum period of thirty days or longer if the recordings are pertinent to the investigation of an air accident or incident (see paragraphs SUR10.42 to SUR10.45).

SUR10.12 The surveillance recording and replay system at the ANSP facility shall be capable of supporting the time-synchronised replay of voice and surveillance data used by that ATS Unit for the provision of air traffic services.

Part 3 Specific Requirements

Through the Wall (TTW) Recording

SUR10.13 TTW recording includes any surveillance data used by an ANSP as an aid for providing an air traffic service that is either obtained from on site surveillance sensors or in the form of remote surveillance feeds (e.g. ORRDs) provided by a third party (e.g. NATS or MOD). TTW recording shall be recorded at any point in the path between the surveillance sensor(s) and the data processing system and may consist of combined or un-combined feeds or processed or unprocessed surveillance data feeds.

SUR10.14 All surveillance data stated in paragraph SUR10.13 shall be recorded TTW with the exception of data used in the circumstances mentioned in paragraphs SUR10.16 to SUR10.20 which only require recording ATG.

SUR10.15 In circumstances where surveillance data is sourced from a third party (e.g. NATS or the MoD), the remote surveillance data feeds shall be recorded either by the ANSP at the ANSP unit, or by the third party provider of the data. However where such remote surveillance data feeds are not recorded by the ANSP on their premises, ATS Units shall obtain and submit to the relevant CAA Regional Office evidence that the surveillance data will be recorded and retained by the provider of such data.

Note: This evidence should be in the form of a written agreement between the provider of the surveillance data and the ATS Unit.

Circumstances which only require ATG Recording

Analogue Primary Radar Systems

SUR10.16 Data from an analogue primary radar sensor presents an impractical recording requirement as regards bandwidth and subsequent storage of the recorded data.

SUR10.17 In circumstances where the analogue radar data are displayed to the controller in the form of a processed and plot extracted signal, surveillance data shall be recorded from each operational screen ATG.

Surface Movement Surveillance Systems

SUR10.18 Surface Movement control systems including SMR displays and A-SMGCS displays shall be recorded ATG where the information presented on these displays is used by the controllers to provide guidance, information or instructions either by visual or non-visual means that would lead to any movement action of an aircraft or vehicle receiving the service.

Recording of Aerodrome Traffic Monitor (ATM) Displays

SUR10.19 The ATM displays shall be recorded ATG at all times where the ATM display is used to perform any functions listed in CAP 493 MATS Part 1, Section 2, Chapter 1, subject to the conditions listed therein.

Recording of Spare Positions, Duplicate Positions and Surveillance Data in Contingency Visual Control (CVCR) Rooms

SUR10.20 Surveillance data provided for any spare positions, duplicate positions including those positions of any contingency visual control rooms shall be recorded ATG for the entire duration of the event where such positions were used in support of air traffic services including approach or aerodrome control functions.

Accurate and Consistent Timing

SUR10.21 The surveillance recording system shall incorporate time-recording devices or techniques to ensure the accurate "time-stamping" of ATS data.

SUR10.22 Time-recording devices or techniques shall use Co-ordinated Universal Time (UTC) and shall express each time-stamp in hours, minutes and seconds of the 24-hour day beginning at midnight (712).

SUR10.23 A common time-source shall be used to ensure that all recordings made at an ATS Unit or those retained by a third party provider can be time-synchronised in accordance with the minimum requirements set out in paragraph SUR10.12 of this document.

SUR10.24 The recorder time-source shall be automatically updated by reference to an international time standard such as the MSF signal radiated from Anthorn in Cumbria or be subject to regular and documented checks to ensure that the time-stamps are maintained within a tolerance of less than ±2 seconds of UTC (713).

Data Integrity and Continuity of Recording

SUR10.25 Surveillance recording must be maintained during operational hours and measures shall be in place in the event of a loss of a single ATG or TTW data recording capability to restore recording in a relatively short time (e.g. a spare screen capture device or moving to a spare position).

Note: It is likely that the provision of dual-redundant equipment or systems which contain multiple hard disc drives (HDD) or solid state drives (SSD), configured as Redundant Array of Independent Discs (RAID) will be necessary to achieve the required availability.

SUR10.26 In the event of a total loss of ATG or TTW recording, the ANSP shall inform the appropriate CAA Regional Office of the situation and take measures to re-instate the recording capability as soon as practicable.

SUR10.27 The provision of a back-up power supply from either a central battery system or individual Un-interruptible Power Supply (UPS) unit shall ensure the continued availability of power to the surveillance recording system and other essential equipment during all operational hours in the event of an interruption to the main electrical supply (2261).

Recording System requirements

SUR10.28 The recording system shall be capable of recording all TTW surveillance data formats (e.g. ASTERIX, RDIF) used by the surveillance systems at the ANSP unit.

SUR10.29 The recording system shall have the capability to simultaneously record all controller working positions (that use surveillance data) used during all operational hours where air traffic services are provided.

SUR10.30 The recording system shall have the capability to record ATG data at a suitable refresh rate and display resolution and shall faithfully record all the features displayed to the controller at the time of screen capture.

SUR10.31 The recording system shall have the capability to record TTW data at the same link speed and format as the original data source

SUR10.32 Archiving of the recorded surveillance data for the minimum 30 day period shall be an automated process (or with minimal human intervention).

SUR10.33 The system shall have the capability to indicate the failure of the archiving function to ensure no recorded data will be lost during archiving process.

SUR10.34 The ANSP shall be able to demonstrate sufficient storage capacity exists for the storage of surveillance data recorded over a period of 30 days.

Alarm/Status Indications

SUR10.35 Local and remote alarm/status indications of the surveillance recording system, including any additional hardware associated with "screen capture" (ATG), shall be provided to alert ATC and/or Engineering personnel to take such actions as are necessary to ensure the continued operation of the surveillance recording at the ATS Unit (985).

SUR10.36 Remote alarm indications shall be "latching" so that they require positive intervention by ATC or Engineering staff and confirmation of the status of the surveillance recording system by those staff before the alarms are cancelled.

SUR10.37 **Guidance**: Whilst it may be appropriate to able to cancel an audible alarm, another independent visual signal or lamp should continue to alert ATC or Engineering staff until the necessary restorative action has been taken by these staff.

Serviceability and Recording Function Check

SUR10.38 A daily check shall be made of the surveillance recording function. Alternatively the recording system shall contain automatic monitoring to alert the failure of the recording system by visual or audible alarms or indications.

SUR10.39 **Guidance**: Use can be made of any devices or facilities incorporated into the recording equipment to perform automatic checks of the recording function but unless this check is made directly from the hard drive (or drives), a separate replay of pre-recorded data must be made (as determined by local procedures) and the result recorded in the Engineering log book.

Surveillance Data Storage Procedures

SUR10.40 The recorded data shall be retained in secure storage and protected from being erased, corrupted or deleted for a period of at least thirty days.

Note: When the recordings are pertinent to accident and incident investigations, they shall be retained for longer periods until it is evident that they are no longer required (see paragraphs SUR10.46 and SUR10.47).

SUR10.41 Suitable measures and procedures at each ATS Unit shall ensure:

1. All access to the stored data is recorded (728);
2. Authority under which any recorded radar data leaves the site for replay or duplication is recorded (729); and
3. The identity of the person or organisation taking charge of the recorded radar data is recorded (730).

Impounding the Recorded Data

SUR10.42 On receiving a detailed request concerning recorded transmissions from either the CAA SRG Transcription Unit or the AAIB, normally within the 30 day retention period, archived data containing the specific recorded data shall be removed from normal storage or extracted from HDD/SDD and placed in a separate and secure quarantine area pending further instructions.

SUR10.43 If the Surveillance data is recorded on the same system as the audio channels and the system has the capability then the ANSP shall impound a minimum of 4 hours of data either side of the occurrence time, i.e. 8 hours in total. Otherwise surveillance data can be quarantined locally and made available to produce recordings as required by the CAA or the AAIB (see also Part C, Section 1, COM 01).

SUR10.44 The impounding process of the selected data shall not cause any interruptions to the recording and archiving process.

SUR10.45 The ATS Unit, or third party provider of surveillance data, will be permitted to retain one copy of the quarantined data for local use but data retained in the "quarantine" area of the surveillance data recorder must not be replayed, deleted or over-written until written

permission for the release of such data is received from the CAA (725).

Access to Original Records

SUR10.46 In the event that the AAIB request a visual replay of the recorded data (at either the ATS unit or third party provider), the ANSP must be able to provide that visual replay within 24 hours of receiving the request.

SUR10.47 The ANSP shall ensure that appropriate requirements and guidance for ATS personnel are contained in their Manual of Air Traffic Services Part 2.

Replay Functions and Facilities

Replay System Requirements at the ANSP facility

SUR10.48 The recorded data shall be available for replay at a separate (non-operational) position either "on-demand", or as soon as possible, in the case of a replay required to support "search and rescue" at the ANSP facility.

SUR10.49 The use of replay and duplication functions of the replaying system shall not cause a break in the recording function (742).

SUR10.50 It shall be possible to replay audio and TTW or ATG recordings in a time-synchronised manner at the ANSP replay station for any controller position of interest.

SUR10.51 Replay of the surveillance data recorded ATG shall faithfully and correctly identify all of the features displayed at the relevant operational position at the time of screen capture.

SUR10.52 Replay of surveillance data recorded TTW shall faithfully and correctly identify the complete data recorded TTW with no discrepancies to the data recorded TTW.

SUR10.53 The replay system shall have the capability to extract the recorded data for the requested duration by the CAA or the AAIB, in to a suitable removable media (e.g. CD/DVD/memory stick).

SUR10.54 Individual frames/screenshots, from a replay of data recorded ATG shall also be capable of being output as a printed copy when required.

Requirements for Providing Recorded Data by ANSPs to the CAA or the AAIB

SUR10.55 ATS Units and third party providers shall be capable of providing a copy of the surveillance data recorded ATG/TTW for specified dates and times upon request by either the AAIB or the CAA along with the audio recordings for the same time period(as requested).

SUR10.56 The ATS unit shall provide the copied ATG or TTW recorded surveillance data as soon as possible but no later than 72 hours following the arrival of the request.

SUR10.57 It shall be possible to copy the ATG or TTW recording data on to a removal media such as a CD, DVD or memory stick or for the recording to be sent via e-mail as an electronic file which can be replayed to form the air situation picture.

Note: The most appropriate form of receiving these files will be liaised by the CAA or the AAIB.

SUR10.58 TTW or ATG recording data copied to removable media or sent as electronic files (to be replayed to form an air situation picture) shall be produced in a format compatible with the replaying systems used by the CAA and the AAIB (or in the case of ATG recording, standard media player software such as Windows Media Player). If this is not possible, an appropriate replay tool shall be provided with the data.

Note: The types of replaying systems and their capabilities available at the CAA /AAIB may expand, with future upgrades and possible implementation of new systems. It is advised the ANSP check with the CAA /AAIB which types of files are acceptable.

SUR10.59 In addition, a function shall exist to export data from an individual aircraft track of interest, derived from the TTW recording to a text-based file (.TXT or Comma Delimited (.CSV)). The data shall consist of 2D positional data (e.g. radar range and bearing, or latitude/ longitude) and time relative to UTC as a minimum, plus any other available data (SIC, SAC, altitude, squawk code, speed, validity etc).

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SUR 11: Display System Requirements for Surveillance Systems

Part 1 Preliminary Material

Introduction

SUR11.1 When a surveillance data display is intended for use for the provision of ATS it must comply with safety standards.

SUR11.2 This document sets out the technical requirements relating to those safety standards that are concerned with the approved use of surveillance data displays by ATS units.

SUR11.3 Guidance material on issues to consider when changing display technology is available at the following link: www.caa.co.uk/ATSDocuments.

Scope

SUR11.4 This document applies to all types of display equipment used for processing and presenting ATS surveillance data and is subject to approval under the ANO Article 205.

SUR11.5 Part 2 identifies requirements for display system technical characteristics.

SUR11.6 Part 3 sets out requirements on ergonomic aspects of the display systems including a suitable method of specifying and testing the adequacy of the Human Machine Interface (HMI) and its operation.

SUR11.7 The requirements in Part 4 apply to display map generation equipment which is used to produce the fixed display map. These include overhead projection, etched plates, independent display map generators or on-system display maps.

Part 2 Requirements – Display System Technical Characteristics

Safety Objective

SUR11.8 **The display system shall preserve the accuracy, availability and integrity of the input data and reproduce it to present in an unambiguous and clear manner (1712).**

General Requirements

SUR11.9 The environmental requirements for which the display system is designed to operate shall be identified.

Note: These requirements include temperate, humidity, vibration etc.

SUR11.10 System inputs and the data display formats shall be identified.

SUR11.11 Where dual channel systems are used, there shall be no single point of failure in the display system architecture that will result in the loss of the entire system.

SUR11.12 Processing of co-operative and non-co-operative surveillance data shall be designed to minimise the risk of single failure resulting in the loss of both co operative and non-co-operative surveillance data.

SUR11.13 The presence of co-operative and non-co-operative surveillance input signals and code call sign conversation data signals shall be continuously monitored by the system.

SUR11.14 Operators shall be alerted to any detected fault condition of the above.

SUR11.15 System throughput delays shall be minimised.

SUR11.16 The display specification shall be related to the operational requirement both in functional and performance terms (575).

SUR11.17 The display system power supply methods in normal operation and in the event of normal power supply failure shall be identified and justified.

Display of QNH

SUR11.18 The display shall be capable of displaying QNH values (595).

SUR11.19 QNH value input mechanisms shall be identified.

SUR11.20 Manual entry and changes to this value shall be validated by double entry (596).

SUR11.21 When it is possible to change the QNH value automatically, the equipment shall require the change to be drawn to the controller's attention and confirmed on all other displays (597).

Display Configuration Files

SUR11.22 The display configuration files shall be password-protected.

SUR11.23 A rigorous configuration management mechanism of the configuration files shall be in place.

Key Display Technical Features

SUR11.24 The following shall be assessed to determine suitability/ appropriateness for the operational requirement;

1. Screen area and corresponding displayed range (553).
2. The number of display lines (554).
   - **Recommendation**: The number of lines should be greater than 1000*1000 (555).
3. Linearity and screen astigmatism (556).
4. Frame refresh rate (557).
5. Ability to display system status information (560).
6. The chosen display brightness (561).
7. The ambient lighting (562).
8. Maximum response time
9. Maximum number of targets that can be processed and displayed at a given time/capacity
10. Display system typical latency
11. Viewing Angle
12. Matrix type
13. Contrast ratio and luminance

System Parameters

SUR11.25 The following parameters shall be specified and justified in relation to the OR, technical specification and hazard analysis, as appropriate:

1. Resolution (577).
2. Accuracy (578).
3. Precision (579).
4. Max/Min ranges (580).
5. Data load ('analogue' plus 'synthetic') and processing time. If the equipment is subjected to a high data load the operator shall be given a warning of the data that shed (581).
   - **Recommendation**: For systems using remote surveillance data for overlay, data discard should take place progressively from long range (582).
6. The required MTBF (583).
7. Required MTTR (584).
8. Input type. Analogue, data formats, data transmission rates (585).
9. Environmental performance (586).
10. EMC performance (587).
11. Quality standards applicable to equipment design (both hardware and software) shall be stated (588).
12. Correct identification of radar source by validating radar source code (589).
13. Identification of appropriate data input faults. This information shall be indicated within one update interval (590).

Display Range and resolution

SUR11.26 The maximum and the minimum display ranges shall be suitable for the operational requirement.

SUR11.27 The Surveillance Display shall have the capability to select a specific range for each surveillance workstation.

SUR11.28 The display resolution at the maximum and minimum range shall be suitable for the operational requirement.

SUR11.29 Allowable error budgets for the display system shall be calculated and justified in the manufacturers design assurance documentation (576) (e.g. Pixel errors, map projection errors, allowable sensor errors).

Brightness

SUR11.30 The brightness range, both overall and for individual screen elements, shall be restricted to the range determined in the colour assessment trial (600).

Note: It should not be possible to delete radar targets completely by use of this control.

SUR11.31 **Recommendation**: Target and map brightness should be independently variable (601).

Electromagnetic Performance

SUR11.32 The system shall not malfunction from the electromagnetic interference from the other equipment in the operating environment.

SUR11.33 The system shall not emit electro-magnetic interference which will result in malfunction of the other equipment in the operating environment.

SUR11.34 The system shall comply with the European Union Low-Voltage Directive (DIRECTIVE 2006/95/EC).

- http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF

Display Symbols

SUR11.35 The display symbols used for primary only plots, combined plots etc. shall enable the controller to discriminate between various types of target reports, i.e. PSR plots, combined plots etc.

SUR11.36 The symbology set selected shall be assessed for suitability to the OR (567).

Note: The on-screen positioning of menu selection and video map symbology is of particular importance.

SUR11.37 **Recommendation**: The equipment should not display any symbol indicating the position of particular filtered targets (568).

Special Purpose Codes

SUR11.38 The equipment shall draw the attention of the controller by flashing the associate label if it detects one of the emergency codes listed below (569):

- 7700 : SOS
- 7600 : RT FAIL
- 7500 : HIJACK

SUR11.39 **Recommendation**: An audible alarm should also be sounded (570).

SUR11.40 Any audible alarms shall be assessed for distraction and suitability for purpose.

SUR11.41 **Recommendation**: The equipment should display both the emergency code and the previous callsign or code if unconverted (571).

Symbol Size

SUR11.42 **Recommendation**: The symbol size from plot-extracted systems should not vary with displayed range (572).

Note: Some features, map features for example, will be scaled according to their significance on the displayed ranges.

Leader Lines

SUR11.43 Where the display automatically moves the labels to various positions (to prevent label overlapping) the equipment shall provide leader lines (573).

Contrast Control

SUR11.44 **Recommendation**: The ATC staff shall not change the contrast levels set within the system by the engineering staff.

Colour Assessment and Calibration

SUR11.45 Colour calibration checks shall be carried out at intervals appropriate to the system stability (566).

SUR11.46 The colour set shall be assessed as appropriate for the operational requirement (563).

SUR11.47 **Recommendation**: Some colours should be reserved for future requirements (564).

SUR11.48 A system shall be in place that allows the colour set to be calibrated (565).

Readability

SUR11.49 The display shall be readable in all ambient light conditions (625).

SUR11.50 The display shall be readable over a range of viewing angles, both vertically and horizontally (626).

SUR11.51 **Recommendation**: Displays requiring viewing hoods should not be used (627)

Note: High intensity daylight viewing displays and/or brightness controls fitted to the equipment can achieve the same effect.

Colour Display

SUR11.52 Colour alone shall not be the single factor used for distinguishing information between multiple sets of data that are presented in a similar manner on the display. (628).

SUR11.53 The use of colour shall not conflict with the reserved meanings of colour use conventions in ATC displays.

SUR11.54 **Recommendation**: Displays should not use colour for de-cluttering, however if used, it should be ensured that the contrast control is not available in normal use (629)

Map Data Accuracy

SUR11.55 The accuracy which the features are mapped to the system shall be defined.

Functional Parameters

Input Selection

SUR11.56 The system shall be capable of showing the source of all data that the controller has selected for display on the radar display (591).

SUR11.57 **Recommendation**: If a remote SSR data source is used the radar identification code should be decoded and displayed on the screen (592).

SUR11.58 Return to default settings shall be achievable via the 'top level' menu (593).

SUR11.59 The region of the boundary where composite picture processing is being used shall be indicated (594).

Note: This is to indicate the area where track wander may occur.

SUR11.60 **Recommendation**: The system should have the capability for entering annotations for display. A means should be available to distinct annotations from other data.

SUR11.61 The system shall display activation of SPI using a unique indication.

SUR11.62 The following elements shall be available for display as applicable:

1. Map information;
2. Range rings;
3. Time;
4. Selected Surveillance Display range;
5. Selected height filter;
6. Controller jurisdiction indicator;
7. Handoff indication;
8. Range/bearing line (cursor);
9. Indication when the Air Situation Display is not being updated;
10. Selected track presentation mode/surveillance sensor;
11. Special codes;
12. Safety Nets;
13. Track information, including Position symbols, Track history information;
14. Label information.

Target Filtering

SUR11.63 When the display equipment can filter out targets from the situation display, the equipment shall be capable of displaying the parameters of such filters (598).

SUR11.64 **Recommendation**: Display equipment should be fitted with a filter override allowing all targets to be displayed quickly (599).

Note: Target filtering on the display may be based on different criteria including height, area, type, SSR code and other Flight Plan derived data. The requirements and recommendations above apply to all such filtering.

Operator Functions

SUR11.65 **Recommendation**: The equipment should have the following operator functions:

1. Selection of display ranges (602).
2. Display off centre (603).
3. Choice of maps (604).
4. Range rings on/off (605).
5. Choice of leader line length, SSR label block rotation and positioning (606).
6. Prediction data, code/call sign selectivity (607).
7. Choice of character size (608).
8. Menu selection/positioning (609).
9. Acceptance of error/alert messages (610).

SUR11.66 Where surveillance data from multiple surveillance sources (e.g. SSR/MLAT/combined/non combined) are available, the sources from which data to be displayed shall be available as a selectable function.

SUR11.67 Display system shall have the capability to enable or disable track history information in each position.

SUR11.68 The surveillance workstation shall have a capability to select the number of track history positions using a specific symbol.

SUR11.69 The system shall have the capability to re-position any label relative to the position symbol, manually or using an automatic algorithm.

Derived Warning or Alerting Information (Safety Nets)

SUR11.70 ATC Service Providers shall assess the risks to aircraft that can be addressed by deriving warning or alert information from available

surveillance data and, where appropriate, incorporating facilities into surveillance display (or associated) systems (2316).

SUR11.71 Typical warning systems, known as safety nets, include:

- MSAW – Minimum Safe Altitude Warning
- STCA – Short Term Conflict Alert
- APM – Approach Path Monitor
- APW – Airspace/Area Proximity Warning
- RIMCAS – Runway Incursion Monitoring and Collision Alerting System

Note 1: Where safety net systems such as STCA, MSAW, APM and/or APW are deployed, ANSPs shall consider the ATC Contingency Procedures defined in Section 15.7 of ICAO Doc 4444 PANS-ATM in devising procedures applicable to each associated safety net.

Note 2: The effect and contribution of ground based safety nets may be taken into account when an ANSP determines the achieved level of safety. Further information on Safety Nets can be accessed via the EUROCONTROL Safety Net web pages:

- www.eurocontrol.int/safety-nets/public/subsite_homepage/homepage.html

SUR11.72 **Recommendation**: Where installing an STCA, MSAW, APW or APM system it should comply with the Relevant EUROCONTROL Specification accessible via the link given above.

SUR11.73 Where a Service Provider chooses not to install warning facilities where a risk that could be addressed by the use of safety nets is identified (such as Controlled Flight Into Terrain), it is expected that clear evidence that it is impractical to install the system will be provided (2317).

SUR11.74 Where the ground based safety net contribution is necessary in achieving the acceptable level of safety:

1. The integrity, reliability and continuity of the safety net shall ensure that it is capable of supporting the achievement of the acceptable level of safety.
2. Measures shall be in place to ensure the safety of traffic in the event of a complete failure of the safety net.

SUR11.75 Permanent or temporary withdrawal of such a safety net shall only be permitted provided that alternative measures are in place and capable of mitigating the risk to an acceptable level at all times.

SUR11.76 Appropriate training shall be provided to controllers to ensure the safe handling of traffic in the event of failure, withdrawal or limitations of all safety nets.

SUR11.77 Any warning and alerting information derived from surveillance data shall be presented to the controller in a manner (visual or audible) that does not result in any detrimental impact to the routine provision of air traffic control services (2318).

SUR11.78 Measures shall be taken to minimise the presentation of 'nuisance' alerts (2319).

SUR11.79 It shall be possible to silence an audible alert, whilst continuing to present visible information for as long as a hazard exists, so as to avoid any detrimental impact to the routine provision of air traffic control services (2320).

Data Recording Facilities

SUR11.80 See Part C, Section 3 SUR 10 for surveillance data recording requirements.

Part 3 Requirements – Ergonomic Aspects

Safety Objective

SUR11.81 **To ensure the operation of surveillance data displays is unambiguous and does not compromise the safety of the Air Traffic Service (1714).**

The Specification of the Display HMI

Operational Requirement

SUR11.82 The specific operational requirement (OR) for the equipment shall be defined (636).

Evaluation

SUR11.83 A formal ergonomic evaluation shall be carried out to ensure that the safety of the ATS is not compromised (637).

HMI Definition

SUR11.84 The following stages are recommended in the definition of an HMI. In each case, the impact on ATC should be assessed and justified with respect to the OR and the Safety Objective (638).

SUR11.85 **Recommendation**: The activities that the system should perform should be defined (639).

SUR11.86 **Recommendation**: The events that can occur that require a cognitive or perceptive response should be defined (640).

SUR11.87 **Recommendation**: The tasks that the system should accomplish in order to respond to the events and activities should be defined (641).

SUR11.88 **Recommendation**: The tasks should be ranked in order of priority according to the OR (642).

Note: As referred to in CAP 760 (www.caa.co.uk/CAP760), adequate attention must be made to Human Factors, in assessing HMI. The link below provides a list of useful ICAO documents, including Doc. 9758 Human Factor Guidelines for Air Traffic Management (ATM) Systems.

- www.icao.int/anb/humanfactors/Documents.html

Functional and Performance Requirements

Confirmation of Activation

SUR11.89 The input device shall give immediate confirmation of selection (643).

Note: This does not mean that the equipment shall carry out the function selected immediately.

Selection Time

SUR11.90 The selection time shall correlate with the priority level (644).

Note: This is defined as the time between first confirmation of activation and function available.

Wait Indication

SUR11.91 The system shall indicate its indeterminate state during the time between confirmation of activation and function available (648).

SUR11.92 **Recommendation**: All input should be prohibited, except cancellation, during this wait period (649).

Traceability of Device Specification

SUR11.93 **Recommendation**: The mechanical performance of all input devices should be specified to a recognised test standard (650).

Input Devices Technical Requirements

Safety Objective

SUR11.94 **The input devices shall not mislead or hinder the operator or be capable of unintended action (651).**

General

SUR11.95 The following requirements and recommendations are made in respect to specific input devices. These devices shall be appropriate to the task, have consistent performance characteristics and facilitate ease of use (652).

SUR11.96 **Recommendation**: All input devices on the workstation should have appropriate characteristics. Specific regard should be made to the following:

1. Size of input device (653).
2. Separation between input devices (654).
3. Feedback method – aural, tactile or visual, as appropriate (655).
4. Displacement, e.g. push distance (656).
5. Labelling (657).
6. Actuating force (658).
7. Suitability to task (659).
8. Response time (660).

SUR11.97 **Recommendation**: The equipment should not use rotary selection switches to select more than 10 discrete positions (661).

SUR11.98 **Recommendation**: The equipment should not use thumbwheels for high or medium priority controls (662).

SUR11.99 **Recommendation**: Non-tactile switches should activate on the first activation. This is equivalent to the down stroke (663).

Note: Non-tactile switches that have no displacement feedback: Examples include infra-red touch-panels, magnetic pick-up, capacitive pick up etc.

SUR11.100 **Recommendation**: Equipment should not use lever switches to select more than 3 discrete positions (664).

Menus

SUR11.101 All menus shall be appropriately positioned (665).

SUR11.102 **Recommendation**: Menus should not impede the primary task (666).

SUR11.103 **Recommendation**: Equipment should locate each high priority function not lower than the second page of any menu (667).

SUR11.104 **Recommendation**: Equipment should locate each medium priority function not lower than the third page of any menu (668).

SUR11.105 **Recommendation**: Each page should have an available selection to return up one level, return to top level and exit (669).

SUR11.106 **Recommendation**: All functions should be by positive selection (670).

Compliance with Standards

SUR11.107 The relevant ergonomic standards for which the display system has been designed shall be identified.

SUR11.108 **Recommendation**: All display systems used for display of air traffic surveillance data should comply with ISO 9241 standard for display systems.

Part 4 Requirements for Surveillance Display Map Generation

Safety Objective

SUR11.109 **The process of surveillance display map generation shall provide complete and accurate reference data for ATS (1715).**

Procedure for Production and Update of Display Maps

SUR11.110 Display map generation shall be subject to formal configuration management (671).

SUR11.111 Each map or generation of map shall be given a unique identifying label (672).

SUR11.112 The map as displayed on the equipment shall display this label (673).

SUR11.113 In addition, documentation shall use this label to show the origin and contents of the information used on the map (674).

SUR11.114 The individual elements to be included on the map shall be identified and documented in the Operational Requirement (676).

SUR11.115 **Recommendation**: The definition of such elements should be in terms of ATS requirements. These elements should include the following:

1. Visual reporting points (677).
2. Adjacent airfields (678).
3. Adjacent areas of flying activity, for example, hang gliding sites, parachuting sites, etc. (679).
4. Danger areas, prohibited areas etc (680).
5. Limits of controlled airspace (681).
6. Runway extended centrelines (682).
7. Map north marker (683).

Note: For certain ATS units additional points may be required.

SUR11.116 **Recommendation**: A member of the ATC Department should carry out Step SUR11.114 and SUR11.115 (684).

SUR11.117 The map presented shall have specific graphic representation for the following entities as applicable:

1. FIR/UIR borders
2. Lateral limits of sectors
3. Terminal control areas
4. Control zones
5. Traffic information zones
6. Airways and ATS routes
7. Restricted areas

SUR11.118 The identified features shall be referenced to defined geodetic co-ordinates (685). In addition, the procedure shall state the geodetic system used to define these geographical locations (686).

SUR11.119 **Recommendation**: The procedure should define the conversion of the geographical co-ordinates to the system geometry. It should also state the algorithms or processes used to convert this data (687).

Verification

SUR11.120 Provisions shall be made to check the displayed data for accuracy and completeness (689).

SUR11.121 The original production or change request shall be compared with the resulting map information (690).

SUR11.122 **Recommendation**: This should include a procedure for checking the absolute accuracy of the displayed maps (691).

SUR11.123 **Recommendation**: A member of the ATC Department should carry out the verification (692).

Validation

SUR11.124 The final user shall evaluate the whole map prior to introduction to service (693).

SUR11.125 **Recommendation**: A member of the ATC Department should carry out the validation (694).

SUR11.126 A procedure shall exist to ensure that the map always contains all operationally significant information (695).

Responsibilities for Control of Surveillance Display Maps

SUR11.127 The display map documentation shall identify all posts responsible for the control of the video maps (696).

Tolerances on Display Map features

SUR11.128 For a display used for SRA, the accuracy of the map features shall be justified as suitable to the SRA application. The cumulative impact of the sensor error and the map error on the accuracy of the displayed surveillance picture shall be assessed.

Note: The term "SRA" is used for surveillance approaches conducted using any suitable surveillance technique including a primary radar.

SUR11.129 **Recommendation**: For raster scan display systems, all features should be accurate to within the resolution of the display (698).

SUR11.130 On displays used for en-route or approach control services for all features, position accuracy shall be within 450 metres (0.25 NM) (699).

SUR11.131 **Recommendation**: On displays used for surface surveillance, accuracy of all features should be as defined in section 7.3 of EUROCONTROL Functional Requirements for A-SMGCS Implementation Level 1.

Note: Where this cannot be met the ANSP shall define and justify the accuracy criteria used for the application for which the system is used.

Changes to Surveillance Display Maps or SRA Maps

SUR11.132 **Recommendation**: Methods independent of the original source should be used for proof of changes which are independent of the original source (708).

Consideration on Mapping Co-ordinate System

Note: When producing display maps the aim is to place the feature at the position where the radar sensor would place a co-located target. However, as the radar calculates by range and angle, this will not account for the change in angle between grid north and magnetic north. In addition all systems use published geographical co-ordinates to derive the feature position in range and angle. Use of

a different system to convert the geographical co-ordinates from that used to derive the original geographical co-ordinates will produce an error. The procedures in paragraphs SUR11.110 to SUR11.119 and SUR11.128 to SUR11.131 and in Part C, Section 3, SUR 12 will evaluate these errors.

SUR11.133 **Recommendation**: The display maps should be in WGS84 format (709).

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SUR 12: Performance Assessment of Surveillance Systems

Part 1 Preliminary Material

Introduction

SUR12.1 Surveillance systems require performance assessments to be carried out prior to an ANO Article 205 Approval can be granted (803) including flight trials where necessary. Performance assessment may comprise of flight trials, targets of opportunity traffic analysis using both manual and automated means of assessment. It is also necessary to assess the on-going performance of surveillance systems once commissioned and put into service, and when changes are introduced into existing systems.

SUR12.2 The following document details the requirements for such performance assessments and verification tests.

Scope

SUR12.3 This document applies to all surveillance sensor equipment providing data for an ATS and requiring approval under Article 205 of the ANO.

SUR12.4 Although some requirements in the document commonly apply to any test of a similar nature, it does not specify the requirements concerning tests conducted to assess performance of surveillance systems to address a specific problem, e.g. Wind turbine interference, Interference testing.

Part 2 Requirements

Safety Objective

SUR12.5 **To test in a practical manner that the ground based surveillance system meets its Operational Requirement (OR) (1719) on commissioning and during its operational life time.**

General Requirements

SUR12.6 In accordance with the SPI IR Article 7, ANSPs shall assess the level of performance of ground based surveillance chain before putting them into service as well as regularly during the service, in accordance with the requirements set out in Annex V of that regulation.

Note: It is not mandatory to conduct trials or tests to assess system performance for every safety related change to surveillance systems and their constituents. The need for the performance assessment trials upon a safety related change will depend on the nature of the change and the system constituents subject to change (e.g. implementation of an entire surveillance system will require performance assessment trials to be carried out prior to entering operational service, while a replacement of part of a display system may only require a relatively simple performance assessment to be carried out).

SUR12.7 Performance of the surveillance system shall be verified by the ANSP by actual measurement (i.e. not solely by simulation models) using the data available at the output of the surveillance system.

Note: Refer to Annex A to SUR 12 for a schematic diagram of a surveillance system.

SUR12.8 The performance assessment of the surveillance systems shall include performance of all elements in the ground based surveillance chain, i.e. transmitters, receivers, data transmission links, data processing systems, data fusion systems and display systems.

Note: Where an HMI is used, the HMI ideal settings (i.e. display settings such as font style, contrast etc.) may be analysed separately following a Human Factors Assessment.

SUR12.9 Where the HMI performance contributes to the number of hazards or the probabilities at which the hazards occur, the HMI performance shall be justified as suitable for the intended use. This should include where possible, testing and verification of the performance aspects of the HMI that could be tested in a practical manner.

Note: Performance of the HMI can affect the integrity of the data being presented, or to the continuity, reliability, availability of the overall ground based surveillance chain (i.e. integrity safety requirements), hence must be included in the analysis of failure modes.

SUR12.10 Any testing and performance assessment carried out by an ANSP during the performance assessments could only demonstrate a limited range of performance parameters defined in the required performance stated in paragraphs SUR02.4 to SUR02.42 of Part C, Section 3 SUR 02. These can comprise of parameters such as accuracy, resolution, false target rates, processing delays etc. The performance parameters that will be tested during the ANSP performance assessment shall be defined. These must include testing data items critical for safe operation.

Note: Evidence gathering to demonstrate that the system supports the integrity requirements of the ground based surveillance chain via ANSP performance verification testing becomes impractical due to the limited duration and the limited number of circumstances within which the system can be tested in a practical manner. The evidence supporting that a system meets with the integrity requirements must be provided, this may comprise of historical performance data, or based on assurance and evidence provided by the manufacturer regarding the system integrity performance. The ANSP shall seek evidence or choose sample tests to validate a performance prediction model which the manufacturer applied in order to provide performance assurance data.

SUR12.11 Where performance is measured for the complete end-to-end surveillance chain (i.e. including airborne and ground sub systems), it shall be possible to distinguish the performance level attributable to the ground based surveillance chain.

SUR12.12 Where an ANSP relies on airborne systems to provide data items necessary to provide the air traffic services, the suitability of the onboard transmitting equipment and sub systems providing each data item, shall be justified.

Note: The onboard transmitting equipment (e.g. transponder) and other airborne systems providing surveillance data (e.g. GPS signal) may be safety assessed under existing airborne system certification processes.

SUR12.13 The continuity, reliability and availability of such data items transmitted by onboard systems, received by the ground based system shall be safety assessed and justified as suitable for provision of service.

Note: Aircraft manoeuvres, jamming or interference effects can cause loss or corruption of the signal received by the ground surveillance sensor.

Test Targets

SUR12.14 All methods used for test target generation for the purpose of performance assessment shall be specified.

Note: Targets for test purposes could be provided by using a dedicated test flight, Targets of Opportunity Traffic (ToP), In-built test target generators or injected test targets.

SUR12.15 Where, a dedicated test target is used, the target shall have an RCS of approximately 1m2.

SUR12.16 Where ToP traffic is used for performance analysis, the approximate target sizes shall be known for those tests used for probability of detection analysis.

SUR12.17 The suitability of test target type used for the test for assessing the parameter(s) shall be justified.

SUR12.18 Where injected test targets are used evidence shall be provided of the measured target parameters, e.g. Power level.

Performance Assessment Methodology and Techniques

SUR12.19 All techniques and methodologies (both manual and automatic) used for performance analysis shall be specified along with the parameters assessed by each methodology.

Note: Performance assessment could be performed with target counting software, manual observation, manual calculation, or by using special software tools such as SASS.

SUR12.20 Suitability of the performance assessment methodology for assessing the performance of the parameters of interest shall be justified.

SUR12.21 Where results are assessed by manual observation, assessment shall be performed by competent personnel (e.g. ATCOs or Air Traffic Engineers), and the results shall be logged with time of applicability.

Note: Time of applicability may be the time the data item was displayed or a time duration, where the relevant performance parameter being assessed is measured with respect to time, e.g. probability of update or Pd, or delay etc.

Test Environment

SUR12.22 Where ToP or Flight Trials are used for assessing performance of a surveillance system, the performance shall be assessed within the coverage volume where the service is provided using the data from the surveillance system.

SUR12.23 In uncontrolled airspace where services are provided only for the participating aircraft and it is necessary to assess performance parameters involving more than one aircraft, the results shall be verified between aircraft to which the service is provided.

SUR12.24 Performance parameters likely to be affected by the following shall be identified with respect to following in an ANSP specific operational environment:

- Aircraft behaviours (e.g. special manoeuvres, velocity, direction etc)
- Weather Effects (e.g. Rain, snow, wind etc)
- External Interference sources (e.g. phone masts, other radar like transmitters)
- Terrain Effects (e.g. mountains, sea)
- Other noise, clutter or interference sources likely to affect performance (e.g. wind turbines)

Note: The impact these may cause may depend on the specific surveillance equipment used by an ANSP to provide services. Although an ANSP may not have identified all current or future sources that may exist in its environment that affect the performance of their surveillance equipment, any prominent features

listed in categories above should be accurately identified. When establishing performance of a surveillance system, it is important to know the exact conditions in which the surveillance system delivered the measured performance.

Tests for Confirming Performance using Performance Prediction Models

SUR12.25 Where simulated tests are used to assess performance, ANSPs shall ensure the input parameters and assumptions used in the simulated model are valid for the test and the operational context.

SUR12.26 Simulated tests shall be as close an approximation to the real environment as possible in terms of target model, target behaviour, surveillance system, ANSP operational context, weather, terrain etc.

SUR12.27 ANSPs shall identify which specific practical scenarios are used for verifying the prediction model, along with all the parameter settings.

Note: ANSPs may conduct tests for chosen scenarios, to confirm performance predicted based on a prediction model, where testing all such scenarios become impractical or cannot be tested within a practical duration.

Performance Assessment Duration

SUR12.28 The test periodicity or duration shall be justified as adequate to test the parameters subject to assessment.

Positional Accuracy Assessment

SUR12.29 Where accuracy is assessed in comparison to a second surveillance system with a known accuracy, the accuracy of the system used for comparative assessment shall be justified.

SUR12.30 Where accuracy is assessed independently of another surveillance system, the position of the test target shall be recorded by independent and suitable means.

SUR12.31 Positional accuracy assessment shall assess the accuracy of the system in the areas of operational significance.

Coverage Analysis

SUR12.32 Tests shall be conducted to prove the required level of detection within the coverage volume defined by the operational requirement.

SUR12.33 As the system provides a large coverage volume and it might be impractical to conduct practical tests throughout the coverage volume, tests shall at least cover detailed analysis into operationally significant areas.

Note: Such significant areas will include, as appropriate:

- Handover areas.
- Holding areas.
- Typical airway routes.
- Areas with clutter or reflection problems.
- Upper and lower boundaries of operational cover.
- The approach
- For Mode S systems requiring a discrete IC code operation, the validity of the assigned coverage map

SUR12.34 Tests shall contain scenarios to demonstrate:

1. lower vertical boundaries
2. upper vertical boundaries
3. maximum range
4. establish cone of silence area (where applicable) or boundaries of areas of non detection

SUR12.35 Detection at the edge of coverage shall be confirmed with a target of 1 m^2 RCS.

SUR12.36 Coverage analysis shall contain an appropriate series of vertical levels to demonstrate that the surveillance sensors provide adequate coverage in the required coverage volume both in horizontal and vertical dimensions.

SUR12.37 Recommendation: The test should include slices at 1,000, 2,000, 4,000, 6,000, 10,000, and 20,000 ft above the aerodrome reference point and as appropriate to the OR (811).

SUR12.38 Test scenarios shall include target motion in inwards (centripetal) and outwards (centrifugal) directions from any system based on detection by a single sensor (e.g. radar/ADS-B) and scenarios including tangential motion.

SUR12.39 In addition test scenarios shall also include at least one climb and/or descend scenarios ideally from the bottom of coverage through to the top of coverage volume.

SUR12.40 A suitable horizontal test profile covering 360° horizontal coverage of the sensor or the sensor network shall be performed at a level equivalent to the base of the required coverage, the top of the required coverage and at a suitable medium level in between.

SUR12.41 Standard manoeuvres, manoeuvres to test the boundaries of flight path defined by operational procedures, and any special manoeuvres of aircraft operating in the airspace shall be included in the accuracy analysis.

Resolution Check

SUR12.42 The performance assessment shall include tests to check the resolution capability of the system in terms of the minimum separation standards or deconfliction minima as required in the OR (831).

SUR12.43 The resolution capability of the system shall be evaluated in both 'standard' areas and areas of clutter and reflections (832).

False Targets and False Tracks

SUR12.44 The overall system performance assessment calculations shall exclude false targets as much as practically achievable.

Note: False target report is defined as a target report that does not correspond to the actual position of a real aircraft target at the time it was presented to the user, which contains as the minimum the 2D positional data and the time of applicability of 2D positional data.

SUR12.45 The method of identifying false target for manual or automated calculation processes shall be justifiable (e.g. well known clutter areas, reflections etc).

Latency Checks

SUR12.46 The latency introduced by the ground based surveillance system shall be verified during performance assessment tests.

Testing Down-linked Aircraft Parameters

SUR12.47 Performance assessment shall consist of tests to demonstrate successful receipt and decoding of Down-linked Aircraft parameters.

SUR12.48 Any loss, or corruption introduced by the ground system shall be verified through a practical test.

Recording Test Results

SUR12.49 Where the results are not assessed in real time the surveillance data resulted from testing shall be recorded by suitable recording equipment.

SUR12.50 The recording equipment shall meet the recording equipment requirements stated in Part C, Section 3, SUR 10.

SUR12.51 The errors in the collection and recording of data shall be calculated and justified.

Note: This may include:

- The resolution error in any recording devices.
- The error in the equipment used to determine the aircraft position.

SUR12.52 **Recommendation**: Target returns registered in each block of airspace should be recorded and analysed in order to identify areas of anomalous replies (813).

Tracking Performance

SUR12.53 The performance assessment shall determine the following:

1. Missed detections (individual updates)
2. Duration and number of consecutive missed detections
3. Track discontinuities
4. Track seduction
5. Track initiation
6. Track deviations
7. False tracks

SUR12.54 The number of consecutive missed detections that can be tolerated shall be justified.

SUR12.55 The maximum error of the deviated tracks shall not exceed the maximum horizontal position error defined in the required performance criteria.

SUR12.56 Any track initiation problems, track seduction or discontinuities shall be further investigated and shall be justified as acceptable for safe operation.

SUR12.57 For non-plot extracted systems, any track fading effects must be assessed.

Surveillance System Test Configuration

SUR12.58 Where service will be provided with one surveillance technique alone, performance of each surveillance technique operating alone shall be performance assessed for the operational service provided.

Note: For example in normal operation WAM and PSR may be used as the main sources of surveillance data. However PSR alone may be used in WAM failure.

SUR12.59 Where the service is provided by simultaneously using multiple surveillance sources operating as combined or in parallel the simultaneous configuration shall be performance assessed.

SUR12.60 The performance assessment shall assess the surveillance sensor in both its normal mode of operation and in its most degraded mode of continuing operation (807).

SUR12.61 **Recommendation**: All modes of operation of the sensor should be verified.

Note 1: Such configurations may include multiple PRFs, polarisation settings, interrogation patterns, reduced redundancy etc.

Note 2: Such verification may be achieved through a combination of testing and theoretical analysis.

SUR12.62 In situations where the OR requires ground based surveillance sensor to detect replies/squitters of more than one type of co-operative aircraft surveillance equipment, the performance assessment shall demonstrate ability to provide surveillance data from each type.

Note: Some sensors are expected to receive and decode signals from multiple surveillance sources onboard aircraft (e.g. an MLAT

system can detect Mode A/C targets as well as ADS-B targets in an SSR and ADS-B mixed environment).

Performance Assessment for SRA

Accuracy Assessment for SRA Procedures

SRAs terminating at 0.5 NM or 1 NM from touchdown point

SUR12.63 The following accuracy assessment is required for any surveillance system, intended for use for such procedures:

SUR12.64 For each SRA procedure intended, a minimum of 3 aircraft or helicopter tracked approaches shall be carried out (822).

SUR12.65 Where 0.5 NM SRA is proposed, for each approach the target position shall be recorded at threshold, 0.5 NM, 1 NM, 2 NM and 3 NM from touchdown and compared against the controller reported position (823).

SUR12.66 **Recommendation**: For SRAs terminating at 1NM or less from touchdown point, for each approach the target position should be recorded at 0.5 NM, 1 NM, 2 NM and 3 NM from touchdown and compared against the controller reported position (824).

Note 1: To assist in the selection of appropriate range points these ranges can be ± 0.25 NM.

Note 2: The following is a suitable method for obtaining the aircraft position:

- Bearing by use of theodolite tracking of a suitably equipped aircraft using trained operators from an approved flight check organisation.
- Range checking by use of visual reporting points.

Coverage Assessment for SRA

SUR12.67 If SRAs are provided using the surveillance sensors, a dedicated flight trial shall demonstrate the accuracy and Pd, of the surveillance sensor as appropriate, over the SRA approach path up to the SRA terminating distance.

Surface Movement Control Applications

SUR12.68 Surveillance systems implemented for surface movement applications such as SMGCS or ASMGCS, the tests shall demonstrate adequate vertical and horizontal coverage, accuracy and resolution.

SUR12.69 The critical areas shall be identified (e.g. manoeuvring area on the runway) and the tests shall demonstrate that the system is capable of achieving the required coverage, accuracy and resolution over these areas.

SUR12.70 Where the surface movement application also requires coverage over the aerodrome surrounding airspace (e.g. for A-SMGCS) tests (dedicated flying or ToP) shall demonstrate the surveillance system achieves the required vertical and horizontal coverage according to the operational requirement.

Systems using ADS-B data

SUR12.71 For systems using ADS-B position data the positional accuracy can only be affected by the on-board latency, data link latency, and during ground system processing and transmission.

SUR12.72 The performance assessment shall demonstrate the range performance (vertical and horizontal coverage) of the ADS-B ground station is adequate to the required operational coverage.

Note: The ADS-B receiver sensitivity and the power of the transmitted signal by the airborne equipment are key to the range performance.

SUR12.73 A flight trial may be necessary to demonstrate the coverage of the ADS-B ground station (e.g. Mode S ES) depending on whether or not the coverage of the ADS-B receiver station has been demonstrated previously over the required coverage area (e.g. If the coverage of MLAT receivers capable of receiving ADS-B reports is already proven over the required coverage area, it is not necessary to trial its range performance again.).

SUR12.74 The ground system processing and transmission performance's effect on the accuracy of the positional information can occur by delays, losing or corrupting data. Where the ADS-B receiver ground station coverage has already been demonstrated, the performance of the ground system processing and transmission can be demonstrated by simple trials based on the ground or by simulation.

Systems using MLAT data

SUR12.75 For Mulltilateration systems that are implemented for applications other than surface movement applications, flight trials shall demonstrate that the system is capable of achieving required coverage in the required operational levels.

Note: MLAT systems providing data for an A-SMGCS where detection is necessary in the aerodrome surrounding airspace (e.g. within 5 NM), a flight trial shall be necessary to demonstrate the coverage and accuracy.

SUR12.76 Any areas with lack of detection and/or degraded accuracy within the operationally required area of coverage shall be identified.

SUR12.77 The flight trials shall comprise of a flight flying over the lower vertical and horizontal boundaries of the expected coverage area to determine accuracy and coverage.

N-1 Analysis

SUR12.78 MLAT performance assessment trials shall also comprise of trials to demonstrate the achievable coverage upon failure of a receiver in the system covering multiple scenarios.

SUR12.79 In a system with many receivers it may be impractical to trial every scenario of a failure of each receiver. In such cases the most critical scenarios shall be trialled.

SUR12.80 Where the implementer has decided to continue service upon failure of two or multiple receivers, the trials shall demonstrate that the system is capable of achieving the required accuracy and coverage upon failure of the receivers.

Detection of Mode A, C, S and ADS-B Targets

SUR12.81 MLAT systems that are expected to receive and process Modes A/C, S and ADS-B positional information, the performance assessment trials shall demonstrate that the system is capable of receiving and processing targets having Mode A/C, S SSR transponder types and ADS-B targets.

SUR12.82 Trials shall also demonstrate that in a mixed environment where targets with varying co-operative techniques are expected, the system is capable of receiving and processing them simultaneously and presented to the user in a standard update rate.

Note: Various techniques may have differing rates of update, e.g. ADS-B may send information every 0.5 seconds while a radar may update information every 4 seconds only. The trial should demonstrate that the targets received at varying update rates are presented to the user in a correct and a usable manner according to the required update rate.

Assessment of Maps and Remote Field Monitors

SUR12.83 As part of the performance assessment tests the accuracy of the display maps shall be confirmed (825).

SUR12.84 A number of significant map features shall be chosen and a suitable reference shall be determined for each feature (826).

Surveillance Display Maps

SUR12.85 Where new RDP and display systems are implemented, at least three features of new display maps shall have the accuracy assessed as part of the flight trial for the equipment (700). The tolerance on this accuracy shall be better than 900 metres (0.5 NM) (701).

SUR12.86 **Recommendation**: These features should, wherever possible, be in three quadrants of the display (702).

Note: A new video map has no predecessor. Sites which have new radar or map generation equipment produce new maps.

SUR12.87 **Recommendation**: The accuracy assessment should ensure that the features shown correspond identically to those displayed at adjacent ATC units (703).

Note: Co-ordination between adjacent units is an important ATC function.

SUR12.88 **Recommendation**: Co-ordination should be evaluated whenever opportunity occurs (704).

New Surveillance Radar Approach (SRA) Maps

SUR12.89 New SRA maps shall be assessed for bearing and range error at 6 NM, 3 NM, 2 NM, 1 NM and 0.5 NM as appropriate to the intended SRA termination range (705). The assessment shall be by use of an aircraft with independent positioning equipment on board an aircraft or fixed ground mounted reflection sources (706).

SUR12.90 **Recommendation**: Internal or external positioning equipment may be used to determine aircraft position, for example, theodolite or INS etc (707).

SUR12.91 The trials shall also include the verification of performance of the remote monitors such as Permanent echoes and Test Transponders.

SUR12.92 The assessment of Remote monitors shall include as a minimum the verification of horizontal position information accuracy and end-to-end system delay.

Ongoing Performance Analysis and Verification

SUR12.93 Measurements shall be in place to ensure continued satisfaction of the system performance.

SUR12.94 All types of techniques including Remote Field Monitors, BITE and external monitoring methods employed for on-going performance monitoring shall be identified with the distinct purpose of each type of monitoring mechanism.

SUR12.95 Any partial or complete reliance on external monitoring mechanisms for on-going performance monitoring shall be identified.

SUR12.96 Any dependency on other surveillance systems being available for on-going performance monitoring shall be identified.

SUR12.97 Any system status indications provided to controller by means of visual or audible means shall be clearly defined.

SUR12.98 Any instances of failures to meet the required performance criteria determined via the on-going performance monitoring mechanisms or by controller observation shall be recorded.

Note: Such instances may be either recorded in monitoring systems and retrievable when necessary or shall be logged in written form in the case of controller observations.

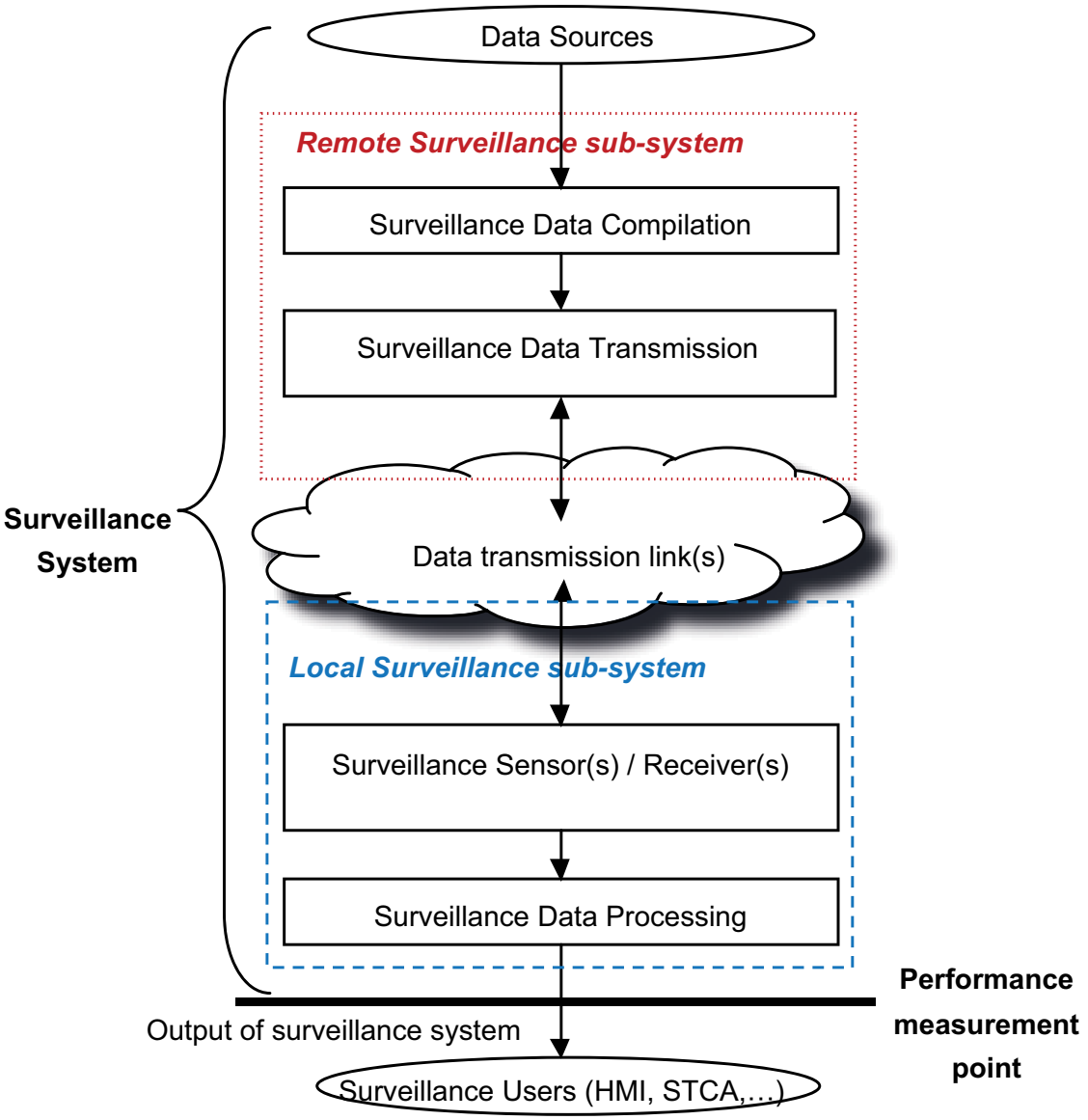
SUR12.99 Complete loss or failure of the surveillance sensors, ground-based data transmission links, processing systems, display systems, HMIs, recording systems and ground based system components such as power supply units, vehicle identification units, external monitoring devices shall be logged/recorded.

SUR12.100 **Recommendation**: Where practicable a SASS-type performance analysis should be performed at sufficient intervals to assess

that the system meets the operational requirements during its operational lifetime.

SUR12.101 Where such on-going performance assessment determines that required performance is not met for a safe operation, the relevant Regional Office Inspector shall be informed and appropriate course of action shall be agreed.

Annex A to SUR 12: A Schematic Diagram of a Surveillance System



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Annex B to SUR 12: Guidance for the use of Multistatic Radar Systems in ATS Applications

Introduction

SUR12B.1 Multistatic is an emerging concept that is becoming an increasingly popular method of providing surveillance data for Air Traffic Service applications. It is being trialled in several European countries to prove the concept and ANSPs are becoming increasingly enthusiastic on multistatic techniques as it provides an alternative to traditional PSR for the detection of non-co-operative targets.

SUR12B.2 These systems may use transmitters of opportunity like radio and television broadcast stations and mobile telephone base stations. Alternatively, dedicated transmitters can be specially deployed to avoid relying on third party illuminators. The signal received via the reflected path is cross correlated with the direct signal from the transmitters in order to locate the position of the target reflecting the signals which is the same principle used in multilateration systems. Similar to MLAT systems, MSPSR systems can also be active or passive depending on whether or not the system uses dedicated transmitters.

Active Multistatic Systems

SUR12B.3 Where the existing level of transmissions do not meet the required performance or are not sufficient to achieve coverage over the entire coverage are required by the operational requirements, transmitters may be added to achieve the level of coverage and to ensure the required performance is met by the multistatic surveillance system.

SUR12B.4 The active Multistatic systems shall be subject to frequency licensing and transmitter requirements.

SUR12B.5 The amount of transmissions shall be kept to the minimum possible level. Such transmissions shall be subject to spectrum protection requirements in Article 5 of the SES Surveillance Performance Interoperability regulation mentioned in Part C, Section 3 SUR 01 paragraph SUR01.6.

Performance Requirements

SUR12B.6 Where a multistatic system is used to replace an existing PSR, the multistatic system shall as a minimum demonstrate to meet the equivalent radar performance.

SUR12B.7 The requirements in Part C Section 3 SUR 06 shall be applicable to the Multistatic systems.

Pre-operational Trials

SUR12B.8 Prior to entering operational service the system shall be subject to a period of pre-operational trial which tests and verifies the overall system performance throughout the required area of coverage.

Annex C to SUR 12: Introduction to Surveillance Applications and Services in the UK

The purpose of this Annex is to introduce the Current Surveillance Based Air Traffic Services in the UK and explain the terms "Services", "Applications" and "Functions" used in the scope of CAP 670 Part C Section 3 Surveillance section.

General

SUR12C.1 Surveillance is used in civil aviation for many purposes, including ATM, weather reporting, terrain avoidance, and search and rescue.

SUR12C.2 Data derived from surveillance systems/equipment can be used directly or as an aid for the provision of various air traffic services defined for inside the controlled airspace and for those in uncontrolled airspace known as ATSOCAS services.

Air Traffic Services based on Surveillance Data

SUR12C.3 In the UK, traditionally the type of surveillance based Air Traffic Services are as follows:

Type of Airspace	Surveillance Service
Controlled Airspace Radar Control Service	Radar Control Service
Outside Controlled Airspace	Deconfliction Service or Traffic Service

Surveillance services provided outside controlled airspace (Deconfliction Service and Traffic Service) are detailed in Section 1 Chapter 11 of CAP 774 UK Flight Information Services.

Applications based on Surveillance Data

SUR12C.4 The term application is used to define a specific use for which surveillance data is used. Whilst the Air Traffic Service officially declared can be categorised as a Radar Control Service, or a Traffic Service, surveillance data can be used for a specific utilisation that directly or indirectly supports the provision of the Air Traffic Service.

SUR12C.5 For example, Radar Control service can be provided in en-route airspace or in an approach environment for the purpose of separation. In the en-route airspace this may be 10NM distance based separation or a time based separation. In the approach environment this may be 5 NM or 3 NM distance based separation.

SUR12C.6 Following are some examples of such applications:

- **In an approach environment**
  - 3 NM distance base separation
  - Surveillance Radar Approaches
- **On an Aerodrome environment**
  - For Air Traffic Monitor (ATM)
  - For Surface Movement Guidance and Control System (SMGCS), or an Advanced SMGCS which is a tool used for providing aerodrome control service.

Surveillance data related functions

SUR12C.7 A function describes a specific task that can be performed using surveillance data. There are many functions for which surveillance data can be used for. The systems designed for various applications described above may have one or more specific functions that use surveillance data:

- Separation of arriving, departing and en route traffic;
- Vectoring;
- Flight path monitoring;
- Position information to assist in the navigation of aircraft;
- Monitoring traffic to provide information to the procedural controller;
- Assistance to aircraft crossing controlled airspace;
- Information on the position of aircraft likely to constitute a hazard;
- Avoiding action;
- Information about observed weather for pilots and other controllers;

- Assistance to aircraft in emergency;
- Surface surveillance;
- Detection of foreign object debris;
- Safety Nets e.g. Short Term Conflict Alert (STCA/RIMCAS/APM).

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Annex D to SUR 12: List of useful ICAO Documents on Ground Based Surveillance Systems

The following ICAO Documents and circulars are useful sources of information for the planning and implementation of various surveillance techniques.

Documents

1. ICAO Doc 9924 – Aeronautical Surveillance Manual
2. ICAO Doc 9871 -Technical Provisions for Mode S Services and Extended Squitter
3. ICAO Doc 9861 – Manual on the Universal Access Transceiver (UAT)
4. ICAO Doc 9830 – Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual
5. ICAO Doc 9694 – Manual of Air Traffic Services Data Link Applications
6. ICAO Doc 9688 – Manual on Mode S Specific Services
7. ICAO Doc 9684 – Manual on the Secondary Surveillance Radar (SSR) Systems
8. ICAO Doc 9476 – Manual of Surface Movement Guidance and Control Systems (SMGCS)
9. ICAO Doc 8071- Manual on Testing of Radio Navigation Aids Volume 3 (Testing of Surveillance Radar systems)

Circulars

1. ICAO advisory circular 174 – Secondary Surveillance Radar Mode S
2. ICAO Circular 212 – Secondary Surveillance Radar Mode S Data Link
3. ICAO Circular 226 – Automatic Dependent Surveillance

4. ICAO Circular 256 – Automatic Dependent Surveillance (ADS) and Air Traffic Services (ATS) Data Link Applications
5. ICAO Circular 326 – Guidelines for Implementation of ADS-B and Multilateration Systems
6. ICAO Circular 21 – Timed Approaches and Utilisation of Radar in Spacing of Aircraft on Final Approach

Annex E to SUR 12: UK Approach for Provision of Surveillance for ATS

SUR12E.1 The purpose of this Annex is to make ANSPs aware of the regulatory approach the CAA, as the National Regulator, has taken regarding the approval of Air Traffic Surveillance Systems, and regarding the ongoing activities concerning the future of surveillance infrastructure in the UK.

SUR12E.2 The UK surveillance infrastructure has been mainly based on PSR and SSR to date and these techniques were included as mandatory requirements in CAP 670 Part C, Section 3 Surveillance. The national airborne equipage carriage requirements are published in the UK AIP GEN1-5 section 5.3 and is currently limited to SSR transponder Equipment.

SUR12E.3 There is increasing interest in other co-operative systems such as Multilateration, ADS-B and ADS-C and non-co-operative techniques such as Multistatic radar amongst countries worldwide including the UK. Standards such as SARPS have already been developed for such systems.

SUR12E.4 As a member state of the European Union, the UK must comply with the European law mandated by the European Commission, in the form of regulations such as SES Interoperability IRs. As such any provisions mandating specific technologies for airborne equipment and ground surveillance systems must be complied with.

SUR12E.5 In addition to technologies prescribed by the European law, the National Supervisory authorities can impose national requirements in terms of airspace, airborne equipage and ground surveillance infrastructure. The CAA has initiated work reflecting the Future Airspace Strategy (FAS) and other related Government imperatives to determine the best options for the surveillance infrastructure within the UK. Cost efficiency, energy efficiency and spectrum efficiency are some of the important factors that are key to this decision making process.

SUR12E.6 In recent years both the ICAO and EUROCONTROL approach has been focused on developing standards based on the required

performance instead of the conventional approach of defining prescriptive standards specific for each surveillance technology.

SUR12E.7 As such the CAA recognises the benefits of adopting an approach that provides greater flexibility to ANSPs on the choice of surveillance technologies to be implemented provided that safety standards are not compromised.

SUR12E.8 Whilst prescriptive requirements may still be necessary to address security and safety concerns in certain types of airspace, the CAA views that the deployment of surveillance systems/equipment will be predominantly based on the required surveillance performance that is a technology independent approach that encourages the adoption of emerging new surveillance technologies.

SUR12E.9 Work has begun both by ICAO and EUROCONTROL to define required surveillance performance standards. Under the performance-based approach, the technical performance parameters are defined specific to each application for which the surveillance data is used.

SUR 13: Requirements for Implementation of Wind Turbine Interference Mitigation Techniques

Part 1 Preliminary Material

Introduction

SUR13.1 Interference caused by Wind turbines is becoming an increasing issue in the UK and in the rest of the world for Air Traffic Primary Surveillance Radars and potentially on other types of surveillance systems.

Scope

SUR13.2 The requirements and policy statements stated in this document are limited to the impact of wind farm interference on Air Traffic Surveillance Systems. The requirements and policy statements in this document address various mitigation techniques and issues associated with the implementation and integration of such techniques. A discussion and further details on the issues of concern are detailed in Annex A to SUR 13.

Part 2 Requirements

General

SUR13.3 ANSPs are reminded that as per the existing SES Regulation, Commission Regulation (EC) No. 1035/2011 and its amendments, providers of air traffic services, in accordance with their SMS, must ensure that hazard identification as well as risk assessment and mitigation are systematically conducted for any changes to the ATM functional systems and supporting arrangements. All planned safety related changes must be notified to the National Supervisory Authority (CAA).

SUR13.4 Any wind turbine effects that are known to be affecting the surveillance services provided by an ANSP, shall be informed to the relevant CAA regional inspector.

SUR13.5 Where an ANSP has reasonable doubt that wind turbine interference is likely to affect their radars from existing or planned wind farm installations, a Line Of Sight Analysis shall be conducted.

NOTE: The CAA have the authority to review the ANO approvals granted to previous mitigation solutions in circumstances where subsequent wind turbine installations are known to have a safety related impact on the ANSP's surveillance services.

SUR13.6 A local safety assessment shall justify the mitigation methods applied.

Compliance with Regulatory Provisions

Statutory Requirements

SUR13.7 The equipment used for the provision of ATS in the UK must comply with the relevant statutory requirements and EU Directives as stated in SUR01.6.

Single European Sky Regulations

SUR13.8 Generic requirements/legislation applicable to the regulation of all CNS/ATM systems are described in Part B of CAP 670.

SUR13.9 In addition, all ground based surveillance sensors must comply with the relevant provisions of Commission Implementing Regulation (EU) No. 1207/2011 Surveillance Performance and Interoperability Regulation (SPI IR).

SUR13.10 If relevant, secondary surveillance sensors shall also comply with relevant provisions of the SES IRs that are listed in SUR01.5 in CAP 670.

SUR13.11 ANSPs implementing new ground based equipment are required to submit the relevant Interoperability files including a Declaration of Verification (DOV) and Technical Files.

NOTE: The new equipment may include surveillance sensors, processing systems, plot assigner combiner systems, multi sensor tracking systems etc.

SUR13.12 The manufacturers of such equipment are required to issue Interoperability declarations including Declaration of Conformity (DC) or Declaration of Suitability for Use (DSU).

ICAO Requirements

SUR13.13 Any secondary surveillance systems used by the ANSP as mitigation to wind turbine interference effects shall comply with the relevant ICAO SARPS provisions listed in SUR01.7 of CAP 670.

CAP 670

SUR13.14 Any Primary Radar systems used as in-fill sensors shall comply with the frequency assignments and transmitter characteristics requirements identified in CAP 670 SUR 04.

SUR13.15 Any in-fill radar implementation shall comply with the appropriate frequency assignments and conditions attached to the frequency assignments issued by the CAA and the WTA Act Licence certificate as a minimum.

SUR13.16 Any co-operative surveillance sensors including SSR Mode S, MLAT, and ADS-B systems shall comply with the relevant SUR sections in CAP 670 and shall comply with conditions attached to the NISC Interrogator Approval.

SUR13.17 For solutions involving software, compliance with SW 01 in CAP 670 is also required.

SUR13.18 In addition, compliance to the above provisions shall be declared in the DSU to be issued by manufacturers of surveillance equipment under the Interoperability regulation of Single European Sky, as well as in the relevant technical files and Declaration of Verifications to be issued by the relevant ANSPs.

Performance of Solutions Involving Additional Equipment

SUR13.19 The overall ground based surveillance system shall meet the required performance necessary for all applications for which the system is intended.

NOTE: Detailed discussion on performance of mitigation techniques can be found in Part 6 of Annex A to SUR 13.

Operational Mitigations

Tolerating Clutter

SUR13.20 Where wind turbine effects are tolerated, a local safety assessment shall justify the ability to provide the service in a safe manner without the need to apply special procedures or mitigation techniques.

SUR13.21 The human factors considerations shall be given due consideration.

SUR13.22 The following shall be taken into account in the assessment:

1. The nature and the extent of the effects
2. The operational significance of the area affected
3. Controllers' ability to provide service in an area of known clutter/ false targets
4. The changing nature of the effects
5. The degree of confidence on the completeness of the identified effects
6. Consequences of the delay to accurately recognise targets.

Controlled Airspace

SUR13.23 In controlled airspace, the need for a procedural mitigation shall be assessed based on:

1. Level of transponder carriage
2. The likelihood of aircraft suffering from radio contact failure
3. Controller workload
4. The risk of infringers coming into conflict with controlled traffic
5. Military aircraft activity

SUR13.24 Any procedures to be applied shall be defined and documented in the unit MATS Part 2.

Uncontrolled Airspace

SUR13.25 Where re-routing around the clutter or the wind farm area is applied, a minimum separation distance of traffic from the clutter shall be specified and justified.

SUR13.26 Any limitations applied to the surveillance service shall be clearly stated and the appropriate procedures shall be mentioned in the unit MATS Part 2 (e.g. informing pilot of the aircraft receiving the service, that the service is being degraded due to clutter, making the pilot aware of the possibility that late or indeed no notification of conflicting traffic may be given).

Transponder Mandatory Zones and Surveillance by Co-operative Ground Sensor

SUR13.27 Where surveillance by a co-operative sensor is selected as a mitigation mechanism, the ANSP shall:

1. Only provide a service provided that the airspace concerned is a Transponder Mandatory Zone or where aircraft within the affected area are transponder equipped
2. Assess the likelihood of faulty transponders causing non-detection of some targets
3. Assess wind turbine effects on the chosen co-operative surveillance display (e.g. false targets caused by wind turbine reflections on SSR)
4. Where the co-operative sensor is used in combination with a PSR, the clutter level from the PSR shall not affect in a manner that data from the co-operative sensor is not clearly visible on the display.

Adjusting Radar Antenna Elevation

SUR13.28 Where antenna beam tilt is adjusted in order to mitigate wind turbine effects, flight trials or targets of opportunity traffic analysis shall confirm the performance of the radar meets the operational requirement.

SUR13.29 Low level coverage loss shall be assessed and suitable measures shall be in place to detect and manage traffic over the area of coverage loss resulting from antenna beam tilt (e.g. all aircraft are SSR equipped and coverage from an SSR sensor exists).

Plan the Location of the Radar to Make use of Terrain Shielding

SUR13.30 The effects on the surveillance service shall be assessed, taking into account the geographical locations of the radar, the wind turbine/s and the terrain shielding effects.

SUR13.31 The assessment period shall be agreed with the relevant CAA regional inspector.

SUR13.32 The evidence of the assessment shall justify the mitigation measure, by indicating the effects are not experienced or meet the minimum operational requirement following implementation of such charges.

Changing the Wind Farm Location or its Characteristics

SUR13.33 Where changes are made to the wind farm to minimise the wind farm effects on radars, the effects on the surveillance service shall be reassessed following implementation of such changes.

SUR13.34 The assessment period shall be agreed with the relevant CAA regional inspector.

SUR13.35 The evidence of the assessment shall justify the mitigation measure, by indicating the effects are no longer persistent or meet the minimum operational requirement.

Physical or Terrain Masking/Clutter Suppression Fence

SUR13.36 The use of a clutter suppression fence or other objects to mask the radar from seeing the wind farm shall be justified and only used where low-level coverage masked from detection does not compromise the operationally required converge.

SUR13.37 Where a clutter suppression fence is used, the size, angle and location of the fence shall be carefully designed not to cause adverse

effects to the radar receiver, radiation pattern, reflections and masking of undesired areas.

SUR13.38 The effects of the clutter suppression fence shall be justified by a performance assessment following implementation.

SUR13.39 The effects of such a clutter suppression fence on an SSR co-mounted with a PSR shall be considered.

PSR Sector Blanking or Range-Azimuth Gating (RAG)

SUR13.40 PSR sector blanking for the purposes of mitigating wind turbine effects on a controller's display shall only be permitted where the ANSP provides a robust safety argument that total loss of all surveillance data on the blanked areas would cause no safety related impact.

SUR13.41 Where air traffic services are provided in the areas masked on the controller's display, the strategy for managing traffic shall be specified and justified.

SSR only or Co-operative only Operation

SUR13.42 Any co-operative only surveillance provision shall be provided in accordance with the national coverage requirements published in CAP 670 SUR 01 and shall be liaised with the appropriate CAA Regional Inspector.

Use of Amplitude Thresholds

SUR13.43 Where amplitude thresholds are applied, for mitigating wind turbine effects, the chosen amplitude threshold shall not cause non-detection of the smallest targets in the ANSP's airspace that were previously detectable with the Primary Radar.

SUR13.44 The threshold set shall take in to account the radar cross section of the largest wind turbine in the area affected, the largest fixed clutter (other than turbine), and a $1m^2$ target likely to fly within the area of interest.

SUR13.45 The chosen threshold shall be justified and shall meet the Pd operationally required in the airspace concerned or the Pd that was previously achieved with the PSR system.

SUR13.46 The likelihood of loss of target detection shall be assessed by a comparison of targets detected prior to and after the threshold implementation.

SUR13.47 The probability of detection and false target rate and any effects on processing shall be assessed by a suitable performance assessment method (e.g targets of opportunity study, flight trial).

SUR13.48 The assessment period shall be agreed with the relevant CAA regional inspector.

SUR13.49 The results of the assessment shall justify the use of threshold, by indicating the effects are no longer persistent and meet the minimum operational requirements.

Constant False Alarm Rating Thresholds/Temporal Threshold Processing

SUR13.50 The same requirements identified for amplitude thresholds shall apply.

Use of Clutter Maps

SUR13.51 The use of clutter map technique shall be justified with respect to the characteristics of the radar system involved. Any limitations to clutter map processing shall be clearly identified.

SUR13.52 Where the clutter map technique is the only mitigation applied to overcome wind farm clutter on a surveillance display, the clutter map shall remain accurate and valid throughout the changing nature of wind turbine clutter characteristics such as not to conceal a true target.

SUR13.53 The probability of detection and false target rate shall be assessed by a suitable performance assessment method (e.g targets of opportunity study).

SUR13.54 The assessment period shall be agreed with the relevant CAA regional inspector and shall cover all areas of the display where the clutter mapping technique is applied.

SUR13.55 The results of the assessment shall justify the use of clutter maps, by indicating the Pd and the false target rate meets the minimum operational requirements.

SUR13.56 Any clutter mapping technique applied shall not conceal the smallest aircraft targets i.e 1m^2 in the ANSP's airspace affected.

Application of Automated Tracking Techniques

Tracking criteria

SUR13.57 Where a specific criteria is designed and applied for the automated tracking process in order to address wind turbine interference, the criteria applied shall be clearly defined and justified (e.g. if the criteria is based on a speed, level or a track angle).

SUR13.58 The applied criteria shall not cause discontinuation of already initiated tracks outside the wind farm area, or non-detection of true tracks, within the wind farm area.

Display of Predicted Target Reports/Updates

SUR13.59 In tracking radars, where temporary loss of detections are experienced, and if predicted target positions are displayed for track maintenance, such predicted position reports shall be clearly distinguishable from the non-predicted targets on the controller's screen by means of a different symbol or a colour.

SUR13.60 The maximum number of predicted positions chosen to display shall be specified and justified.

Track Termination

SUR13.61 Track termination criteria (e.g. number of consecutive missed detections) shall be specified and justified.

SUR13.62 The maximum number of consecutive missed detections before the track is terminated shall be operationally acceptable and be justified.

Special Aircraft Manoeuvres over the Wind Farm Area

SUR13.63 The ANSP shall identify the potential aircraft manoeuvres including special manoeuvres over the wind farm region.

SUR13.64 The effect of the identified manoeuvres over the wind farm region, on position prediction method applied by the tracking radar shall be assessed.

SUR13.65 Special tracking and prediction capabilities of the radar to detect such manoeuvres shall be identified e.g. Use of a Kalman Filter.

Track Initiation

SUR13.66 In tracking radar, track initiation criteria shall be specified.

SUR13.67 Suppression of track initiation shall only be accepted following an assessment of the:

1. Likelihood of an aircraft first appearing in the range azimuth cells of wind turbine area where suppression will be applied,
2. Where there is a strong likelihood of new tracks being generated caused by reflections from wind turbines (e.g. split or duplicate tracks generated in wrong azimuth)
3. The likelihood of non transponding, low RCS targets such as light aircraft or helicopters flying in the area

Use of Adaptive Moving Target Indication (MTI) Techniques

SUR13.68 The likelihood of loss of detection of small targets and slow moving targets shall be assessed using adaptive MTI techniques.

SUR13.69 The probability of detection and false target rate and effects on processing shall be assessed by a suitable performance assessment method (e.g targets of opportunity study, flight trial).

SUR13.70 The assessment period shall be agreed with the relevant CAA regional inspector.

SUR13.71 The results of the assessment shall justify the use of adaptive MTI by indicating the effects are no longer persistent or meet the minimum operational requirements.

Integration of In-fill Radar Target Positions to the Main Primary Radar Display

Slant Range Error

SUR13.72 The slant range errors in the co-ordinate conversion process shall be corrected and the methodology used for the slant range error correction shall be specified.

SUR13.73 The accuracy of the slant range error correction process shall be justified.

SUR13.74 Where a default altitude setting is used for the slant range correction process, the accuracy of this process shall be demonstrated and justified.

Coverage

SUR13.75 The coverage of the in-fill radar shall be adequate to provide coverage over the full volume of operational airspace above the wind farm region.

SUR13.76 **Recommendation:** the in-fill radar should have coverage extending to the precise area of the wind farm. The extended coverage should not result in target positions being duplicated, but rather lead to a smooth integration process across the boundary.

SUR13.77 The range and azimuth cells covering the wind farm region, removed from being displayed in the main radar display shall not include areas over the wind farm not detected by the in-fill radar.

SUR13.78 The removal of the wind farm region from the main PSR display shall not result in duplicate target positions or lost target detections on the display.

Locating the In-fill Sensors

SUR13.79 When locating an in-fill radar the following factors shall be taken into account:

- the need for slant range correction
- the maximum range performance of the in-fill radar
- the size of the wind farm region
- in-fill radar's susceptibility to nearby interference sources and potential for the in-fill radar to suffer from interference effects from nearby electromagnetic sources
- the need to have extra range coverage for smoother integration
- terrain effects
- safeguarding considerations

Performance Monitoring of the In-fill Radar

SUR13.80 All primary in-fill radars shall have methods of alignment checking.

SUR13.81 There shall be methods of on-going performance monitoring of the in-fill radar system.

SUR13.82 All methods of on-going performance verification of in-fill sensors shall be specified.

Timeliness of In-Fill Data

SUR13.83 Where absolute time stamping is used by the main radar and the in-fill radar, using a common time source is recommended.

SUR13.84 As reference for time stamping a standard time source should be used.

Plot or Track Correlation across the Boundary of In-fill Area

SUR13.85 Where both main radar and in-fill radar are PSR sensors and outputs tracks, the track correlation method across the boundary of the in-fill region shall be specified.

SUR13.86 Where the in-fill primary data is not provided by the in-fill sensor as track data but as plot data, and the main PSR is a tracking radar, the track continuation/data fusion algorithm or architecture shall be specified.

SUR13.87 The tracking function shall not cause a noticeable track jump of the positions of target tracks when transitioning to and from in-fill regions to non in-fill regions.

Accuracy

SUR13.88 The accuracy of the positional information following the implementation of the in-fill data shall be demonstrated and justified as suitable to the operational requirement.

Differences in Update Rates/Scan Rates

SUR13.89 The update rate of the in-fill radar shall be at least as same as the main PSR.

SUR13.90 The update rates of each surveillance sensor shall be specified and the accuracy of the output position be justified.

SUR13.91 The required data update rate shall be met throughout the coverage volume by the main PSR as well as the in-fill radar/s.

NOTE: If the update rates of the in-fill radar/s is slower than the main primary radar being used for the provision of services, it may still be possible to integrate the in-fill radar data into the main radar picture. However depending on the operational significance of the area subject to wind turbine interference, the required update rate must be met and therefore a slower update rate may not be acceptable.

Processing Capacity

SUR13.92 An ANSP shall:

1. Consider the additional processing capacity required for in-fill radar data integration or advanced tracking processes.
2. Consider the likelihood of requiring more in-fill radars in future, in order to mitigate wind turbine clutter and the ability of the system to process the various feeds simultaneously.

SUR13.93 The maximum number of target reports that can be processed simultaneously by the processing equipment shall be specified and tested.

Processing Delay/Latency (in-fills/filter software/work-rounds)

SUR13.94 The processing delay shall not be significant enough to impact the validity/timeliness of the data being presented to a controller at any time.

SUR13.95 The processing delay shall be tested as part of the site acceptance testing of any wind farm mitigation solution that requires additional processing.

Data Formats of an In-fill Radar and the Required Processing System Capability

SUR13.96 The radar data output formats output by the main PSR and the in-fill sensors and/or track processors shall be specified and be compatible.

SUR13.97 The processing system shall also be able to accept and process the in-fill radar data into the same format used by the main airfield PSR.

Display Aspects

SUR13.98 The need to make in-fill areas/wind farm regions visible on the controller's display shall be considered based on whether:

1. The controllers feel it is necessary or useful in performing their tasks to know the boundaries of the in-fill areas
2. It is necessary to mark such areas for the controllers to be able to notice the area affected by a failure of an in-fill source

3. It is helpful to make the in-fill areas visible on the controller's display to apply contingency measures in the failure of an in-fill (e.g. apply a work -round or procedural control over the affected area or to switch to a secondary only remote feed to cover the in-fill area etc.)

SUR13.99 Where the outcome of this assessment indicates that it is necessary to mark the boundaries between in-fill areas and the main PSR areas on the controller's display, a human factors assessment shall be carried out to ensure the colour schemes used are appropriate and the changes are up to the controllers' satisfaction.

Mitigations against Failures of Mitigation Techniques Including In-Fill Radars

SUR13.100 The strategy to mitigate the wind turbine effects in the event of a failure of an in-fill source or the mitigation technique shall be identified.

SUR13.101 Fall back procedures or contingency measures to be applied in the unavailability of the in-fill data shall be specified and shall be included in the unit MATS Part 2 as a documented process.

SUR13.102 Where advance tracking systems or processing techniques are used, methods shall be in place to indicate processor overload situation.

SUR13.103 Where mitigation techniques involve integrating additional equipment to the ground based surveillance system, all failure modes of such systems shall be identified by a failure mode analysis.

Indication of Failure of Wind Turbine Mitigation Technique

SUR13.104 Methods shall exist to indicate to the controller the failure of the in-fill radar or other automatic mitigation technique in a timely manner.

SUR13.105 The alarms and indications used shall be justified considering:

1. Colour schemes used
2. Duration of any audible alarms
3. Level of potential distraction to the controller
4. Frequency of the alarms

Impact of Using Automatic Mitigation Techniques on Safety Nets

SUR13.106 The impact of loss of in-fill radar data or the failure of the mitigation techniques on the safety nets functionality shall be identified.

SUR13.107 Where the contribution of safety nets is required in order to achieve an acceptable level of safety, the risks from the loss of safety net functionality over the wind farm affected area shall be mitigated by suitable means.

Support and Maintenance of Mitigation Equipment

SUR13.108 Where an in-fill radar is not owned by the ANSP providing the air traffic service, and is owned or maintained by a third party, appropriate contractual agreements shall be in place.

SUR13.109 Such agreements shall indicate the:

1. Availability of spare equipment supplied to the ANSP
2. Time to repair the equipment
3. Contact points
4. Any remote accessibility by the ANSP to configure the system
5. Physical accessibility to the equipment
6. Maximum outage periods tolerated by the ANSP

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Annex A to SUR 13: Guidance on Wind Farm Mitigation Techniques

Introduction

SUR13A.1 The purpose of this document is to provide supplementary guidance regarding the implementation of wind-turbine mitigation solutions affecting the performance of the Air Traffic Surveillance Radars or surveillance systems.

SUR13A.2 The effects discussed in this document are limited to effects that impact Air Traffic Surveillance Systems. This document addresses the regulatory guidance on producing a safety argument for a safety related change driven by wind warm interference, description of wind turbine effects, an overview of mitigation techniques and technical issues associated with implementation and integration of such techniques.

Background

SUR13A.3 Interference caused by wind turbines is becoming an increasing issue in the UK and in the rest of the world for Air Traffic Primary Surveillance Radars.

SUR13A.4 It is thought that wind turbines also have the potential to cause interference to other CNS systems such as VORs, radio communications, and ILSs, however the most obvious issue encountered on civil air traffic systems to date is the presence of false targets on primary radar systems.

SUR13A.5 ANSPs are responsible for assessing the safety impact of wind turbines on all aspects of ATM operations to ensure the validity of their overall safety argument. This paper focuses on the known effects of wind turbines on surveillance services and provides guidance on the typical issues to be considered when conducting such safety assessments.

SUR13A.6 Whilst co-operative surveillance systems such as SSR, multilateration and ADS-B are either less susceptible or unsusceptible to wind farm interference, the wind farm issues on primary surveillance radars remain a significant issue in the UK due to the high usage of PSR technology in the UK air traffic

environment. Whilst there are several initiatives to explore other possibilities such as utilising Multistatic primary radars and to review the UK surveillance strategy, the role of PSR as an essential element of air traffic surveillance infrastructure is unlikely to change before 2020. The problem of wind turbines interfering with ATC PSR has been identified in the rest of Europe, although there appears to be a reduced impact compared to the UK due to the greater reliance on SSR.

SUR13A.7 As manufacturers around the world are trying to develop various wind farm mitigation solutions, and as UK ANSPs start implementing these various solutions, the CAA must provide safety oversight to ensure that the mitigation solution is acceptable.

SUR13A.8 This document aims to:

- Gather information and form a discussion paper as regards the various guidance material published to date.
- Raise awareness and share knowledge regarding the Wind Farm mitigation techniques the CAA are so far aware of.
- Discuss each type of technique and understand the advantages and disadvantages of each type.
- Identify areas of concern with regards to each implementation which must be considered when producing a robust safety argument.
- To provide safety assessment guidance with regards to effects from wind turbines.

Part 1: Safety Oversight of Wind-farm Mitigation Techniques Implemented by ANSPs

This section contains regulatory guidance regarding the production of a credible safety argument for the safety related changes made to achieve an acceptable level of safety, following implementation of mitigation techniques to address wind turbine interference effects.

Safety Argument – General Discussion

SUR13A.9 Wind Turbine interference is an external effect that has the potential to cause a safety related impact on CNS systems. Wind turbines can also cause physical barriers to operations if situated close to an airfield. Such external interferences can directly or indirectly contribute to an accident or an undesired consequence.

SUR13A.10 As per the Single European Sky regulation, "Risk" means the "*combination of the overall probability, or frequency of occurrence of a harmful effect induced by a hazard and the severity of that effect*".

SUR13A.11 Therefore, hazards caused by wind turbine interference may increase the overall risk in two ways:

1. By increasing the frequency of occurrence of the harmful effects that could be caused as a direct or indirect result of the hazards caused by wind turbine interference, or
2. By increasing the severity of an effect that could have resulted as an effect of lesser severity in the absence of the wind turbine effects.

SUR13A.12 Wind turbines can introduce new hazards that were not identified previously in the absence of wind turbines near an airfield. These new lower level hazards (assessed at an equipment level, or controllers display level) may contribute to and result in an increased frequency of occurrence of hazards identified at a higher level. Hazards can be identified at any level which can be defined. For example the hazards of the overall ground based surveillance system may have been identified at the display level. One such hazard may be loss of target data. One could define hazards caused by the wind turbines at an equipment level. For example, one of the wind turbine interference effects is the loss of receiver sensitivity. Loss of receiver sensitivity could be identified as a hazard at equipment level. This hazard has a direct link to the hazard "loss of data" identified for

the overall surveillance system at a display level. Therefore the rate of occurrences of degradation of receiver sensitivity will impact the rate of occurrence of the loss of targets.

SUR13A.13 Clearly if the effects caused due to the presence of wind turbines near an airfield introduce hazards or contribute to the existing hazards to the surveillance services provided by an airfield, this will result in an overall increase in the risk. The exact increase in risk directly attributable to the wind turbines may be theoretically estimated. This is only possible provided that the ANSP is aware of the level of risk in the absence of wind turbines, the wind turbine hazards have been accurately identified on all areas and the assumptions/predictions about the frequency of occurrence of these hazards are realistic.

SUR13A.14 However following the risk assessment, it may be evident that the effects (i.e. those effects that cannot be regarded as negligible) caused by the wind turbines result in a difference in a performance attribute that can be tangible and measurable using either statistical measurements or by the judgement of human intellect. For example, the only effect that might occur as a result of presence of wind turbines near an airfield might be an increased level of false targets (clutter) on a surveillance display. Number of false targets is part of the performance criteria that must be met by the ground based surveillance system to meet the operational requirement. If this outcome is certain to be the only effect, since the number of false targets is a measurable effect, the ANSP could argue that the risks caused by this effect is mitigated if the level of false targets prior to the presence of wind turbines were achieved following the implementation of a mitigation technique. Another example is the appearance of a 'twinkling' effect on the display that would cause discomfort to controller's sight as a result of wind turbine interference. Although there is no directly measurable defined performance criteria to this effect, it is a tangible effect to the human eye, hence if the twinkling effect was controlled to the level such that the controllers were comfortable looking at the screen, the hazards caused by this effect could be addressed. In such circumstances, the increased level of risk due to wind turbine interference can be addressed by addressing the effects that were caused by such interference without having the need to numerically quantify the overall increase in the risk.

SUR13A.15 Most effects caused by wind turbines are measureable, or verifiable, therefore without calculating their exact contribution to the overall hazards and the increase in probabilities of the hazards attributable to wind turbines (i.e. total increase in risk due to wind turbine effects) acceptable levels of safety can be achieved by mitigating such effects and their rates of occurrences back to the original level. The acceptable level of safety is therefore the currently existing level of safety without the presence of wind turbines.

SUR13A.16 This can only be achieved provided that all such effects and the likelihood of their occurrence are accurately identified, valid and complete. Although the common effects of wind turbines on ATC primary radars have been broadly identified, the exact effects affecting a particular ANSP site depends on numerous factors that affect the wind turbine, radar and target relationship.

SUR13A.17 In most implementations it has been evident that the vast majority of wind turbines affect ATC primary radars although a considerable level of impact may also be possible on Navigation aids such as VORs, DMEs or communications equipment.

SUR13A.18 The mitigation of risk by addressing the effects back to the normal level without the need to numerically quantify the total increase in risk due to the presence of wind turbines can only be achieved if the methods of mitigating such effects do not have any impact to the elements of the system being considered within its defined system boundary. Such an argument could only be true if the ANSP manages to mitigate all effects caused by wind turbine interference without affecting or changing any element of the ground based surveillance system. In such a scenario, there will be no introduction of new risks by the mitigation technique, or there is no possibility for the mitigation technique to change the existing hazards or their rates of occurrences.

SUR13A.19 Eliminating the wind turbine effects or mitigating such effects to an acceptable level may not often be achieved without making a modification to the ground based surveillance system or affecting its hazard rates. Where such modifications are necessary, such modifications should be considered for their overall impact on the safety of the ground based surveillance system. This requires the ANSP to identify the impact to the overall risk budget allocated or that should be achieved and maintained by the system.

SUR13A.20 It is highly important to note that an introduction of a mitigation mechanism may bring new hazards, and as such may also contribute to increasing the overall level of risk. In most circumstances the solution may involve installation of new equipment (e.g. in-fill radar) or modifying the existing equipment (e.g. wind farm filter solution). The affects of this change on existing people, equipment (e.g. radio interference of an in-fill radar to an existing surveillance or comms equipment) and procedures also need to be assessed for any safety related impact.

SUR13A.21 Therefore, introduction of mitigation techniques, whilst helping to mitigate the effects on a surveillance display to meet the required performance criteria will also have an impact on the overall surveillance system integrity performance. Since the level of risk is the risk of the overall ground based surveillance system, merely demonstrating that the effects have been controlled to meet the required performance criteria is not sufficient to demonstrate that the system maintains an acceptable level of safety.

SUR13A.22 The strategy for demonstrating an "acceptable level of risk" therefore depends on whether the wind turbine effects were addressed with or without making a change to the existing system. Where such effects are mitigated without making a change to the surveillance system, one could argue that provided no other systems are affected by the wind turbines, the effects on the surveillance system are mitigated by controlling the effects to meet the required performance criteria (e.g. % of false targets).

SUR13A.23 However, where a modification has been made to the ground based surveillance system, the acceptable level of safety must not only meet the required performance criteria, but also the overall level of risk must be acceptable. For an existing system this could be the level of safety that is currently achieved by the system or a lower risk than the current level, if achievable.

SUR13A.24 A single mitigation solution may not address all identified effects. The ANSP may decide the best mitigation techniques that are capable of mitigating the effects. Mitigation techniques should therefore be carefully considered such that all effects can be appropriately addressed.

SUR13A.25 In addition to the ability to meet an acceptable level of safety and the required performance criteria, ANSPs may have other reasons in favour of the mitigation solution chosen such as:

- The mitigation uses minimum bandwidth
- Requires low power
- Flexibility to expand if necessary in future
- Easy to maintain
- Extremely high reliability
- Favourable to RF environment

which would make a stronger argument as to why the chosen solution is best for an ANSP's circumstances.

Safety Argument – Validity of the Assessment of Impact caused by Wind Turbines

SUR13A.26 The ANSP must first establish if the wind turbines cause, or are likely to cause, any safety related impact to the operations of an airfield or to the services (CNS) provided.

NOTE: Methods of such impact assessment are out of scope of this document.

SUR13A.27 For **surveillance systems**, ANSPs must identify all effects (e.g. display effects/processing system effects etc) caused by wind turbines **within the line of sight of the radar**.

NOTE: Discussion and guidance on assessment of impacts caused by wind turbines on radars from existing wind turbines and planned wind turbine installations can be found in CAP 764 Appendix 2 "Radar Assessment Methodology".

SUR13A.28 All existing and potential wind turbine effects on CNS systems must be correctly identified that would contribute to **existing** hazards or that would cause **new** hazards. This must include identifying the probability of occurrence of such hazards.

SUR13A.29 The assessment of hazards introduced by the wind turbine interference on all CNS equipment must be complete and valid.

SUR13A.30 The related consequences must be identified. The consequences must be traceable to the hazards. The impact assessment on the

consequences must focus on the severity as well as the likely increase in rates of occurrence of the consequences.

SUR13A.31 Impact to the required performance criteria for the services provided using the CNS equipment must be assessed (e.g. increase false target rate and decreased Pd on radars).

SUR13A.32 The scope or the boundaries of the individual systems affected by wind turbine interference must be clearly defined. Where there are other systems reliant upon the system/s directly affected by wind turbine effects, they should also be identified and their boundaries must be defined (e.g. ORRD feeds supplying data for other parties).

NOTE: These dependant systems may not necessarily be used to provide the same service.

SUR13A.33 Where safety related impact to the service is identified, claims made in the safety argument must indicate that;

- The safety impact has been assessed in a satisfactory manner
- The ANSP is satisfied with the outcome of this assessment
- No other effects have been identified on the system and to the ANSP's knowledge this list is complete and valid.

SUR13A.34 The evidence must indicate the process used to identify such effects and the competency of those who conducted the assessment.

Safety Argument – Validity of the Selected Risk Mitigation Strategy

SUR13A.35 Depending on the outcome of the safety assessment, the ANSP must identify the increased level of risk that should be mitigated, and the performance parameters that are affected which must be met by the operational requirement in order to provide the service using the systems affected.

THE REQUIRED PERFORMANCE CRITERIA FOR THE SERVICE PROVIDED SHALL BE MET BY THE SYSTEM IN ORDER TO PROVIDE THE SERVICE FOR WHICH THE SYSTEM IS USED.

NOTE: The ANSP may adopt various risk mitigation strategies. It may be that the ANSP wishes to provide a limited service or a different service (e.g. such as procedural mitigation or increasing the separation minima). Whichever means are used, as long as the

surveillance equipment are used to provide the service, the required performance for the chosen service must be achieved by the system.

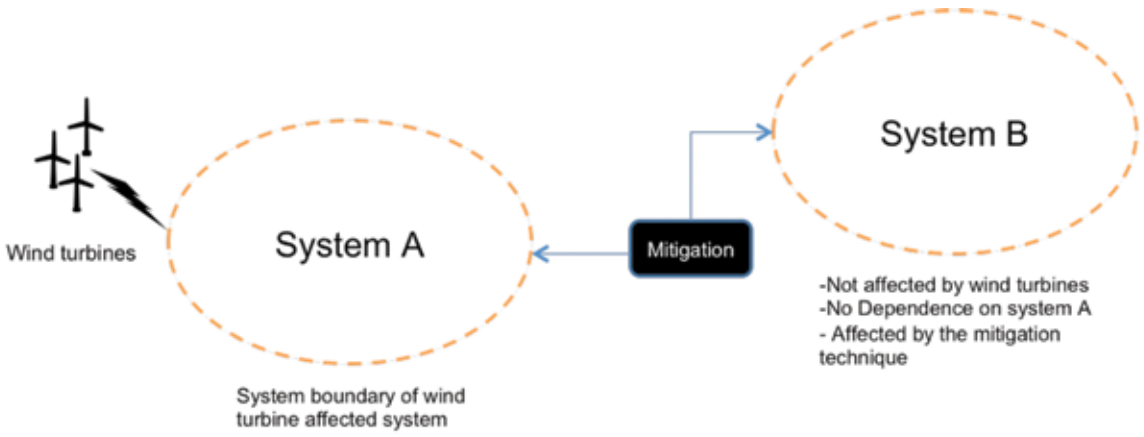
SUR13A.36 Once such effects are correctly identified, the risk mitigation strategy must be clearly defined.

SUR13A.37 The mitigation technique or techniques chosen shall be clearly identified. The suitability of the mitigation technique/s must be justified.

SUR13A.38 The mitigation technique or techniques chosen shall be capable of mitigating the level of risk increased as a result of wind turbine interference.

NOTE: The mitigation technique may or may not involve making a modification internal to the system being considered (e.g. ground based surveillance system). The mitigation may only involve making a modification external to the system (e.g. a clutter fence). Although no internal modification is made to the CNS system, the mitigation technique itself may impact other systems that are not necessarily part of the system that was affected by wind turbine interference, for example, having a clutter fence might affect a SSR that is co-mounted with the affected PSR.

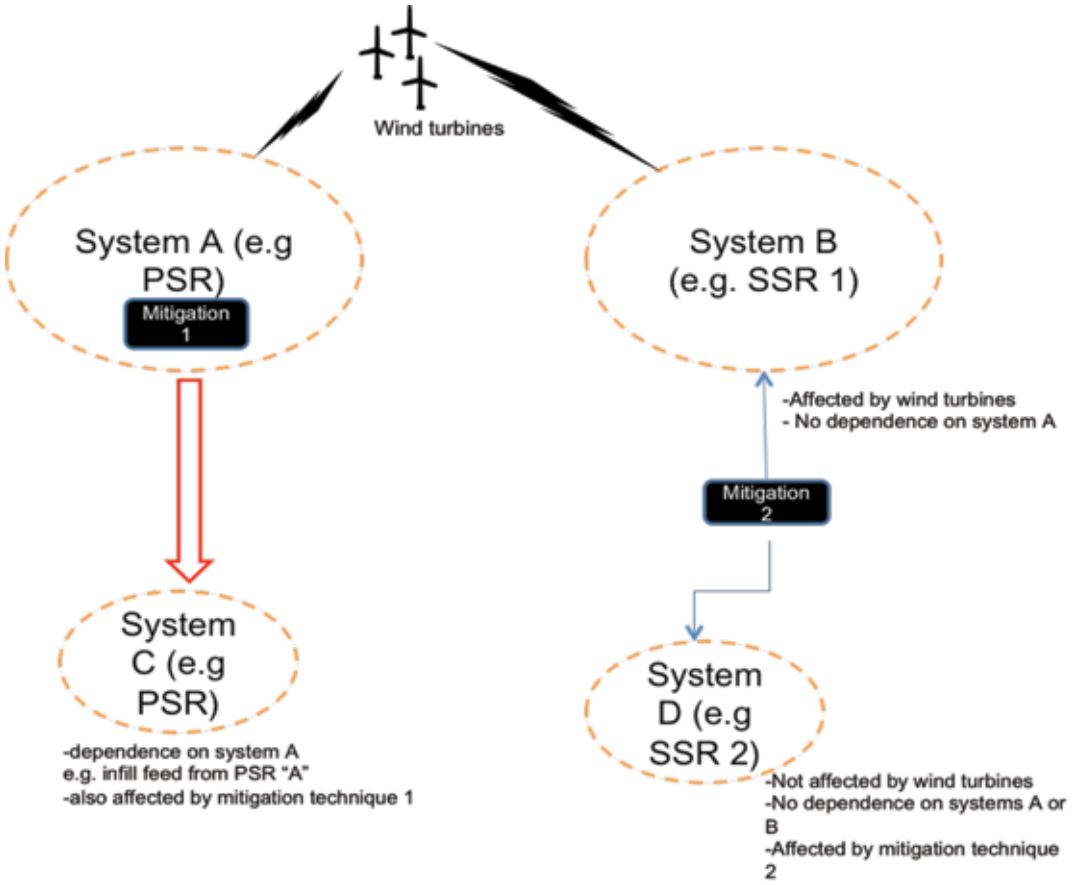
SUR13A.39 Where no other systems are affected (outside the defined system boundary) and the mitigation technique does not require a modification internal to the system being considered (e.g surveillance system), it must be demonstrated that:



- The mitigation technique has mitigated the increased level of risk to a tolerable level and required performance criteria is met by the overall system

- The mitigation technique has not had a safety related impact on any other services or airfield operations or,
- If the mitigation technique has had an impact on other services outside the system, evidence must also demonstrate that any risks caused by the mitigation technique on airfield operations or other services (i.e outside the boundary of the system being mitigated) have been addressed by suitable mitigation methods.

SUR13A.41 Where other systems are known to be affected in addition to the system being considered and the mitigation technique requires an internal modification to the system being considered (e.g.PSR) it must be demonstrated that:



- The mitigation technique/s has mitigated the increased level of risk to a tolerable level and required performance criteria are met by the individual systems affected
- The modification's (mitigation technique) impact to the overall safety budget of the system being considered showing the acceptable level of safety is achieved

- Modification's impact to the safety budget of the other systems which are reliant on the system affected
- If modifications have been made to the other systems, the interdependencies between the systems affected, dependencies by other systems on the affected systems, and the impact of the mitigation technique to such systems

SUR13A.43 The service, or any alterations to the service provided by the ANSP, shall be clearly defined along with any change to the required performance criteria.

SUR13A.44 The argument must be made that the required performance criteria is met by the ground based system following the implementation and integration of the wind turbine mitigation solution/s.

SUR13A.45 Evidence must consist of performance assessment data demonstrating the performance of the ground based surveillance system, which must meet the required performance for the service being provided.

SUR13A.46 Claims must indicate that the impact of the mitigation technique on other services and airfield operations (including people, equipment and procedures) have been assessed and any hazards identified.

SUR13A.47 The safety argument for the implementation of the mitigation mechanism must also indicate the mitigation solution introduces no new risks or increases the existing level of risk.

SUR13A.48 If such risks have been identified, the argument must extend to cover that those risks have also been addressed by various mitigation measures implemented, reduced to an acceptable level and for the suitability of these mitigation measures.

SUR13A.49 Such mitigation techniques may affect the failure rates, reliability, availability and continuity of the ground based surveillance system, hence when demonstrating that an acceptable level of safety is maintained or achieved the impact on the performance of the overhaul system must be essentially considered.

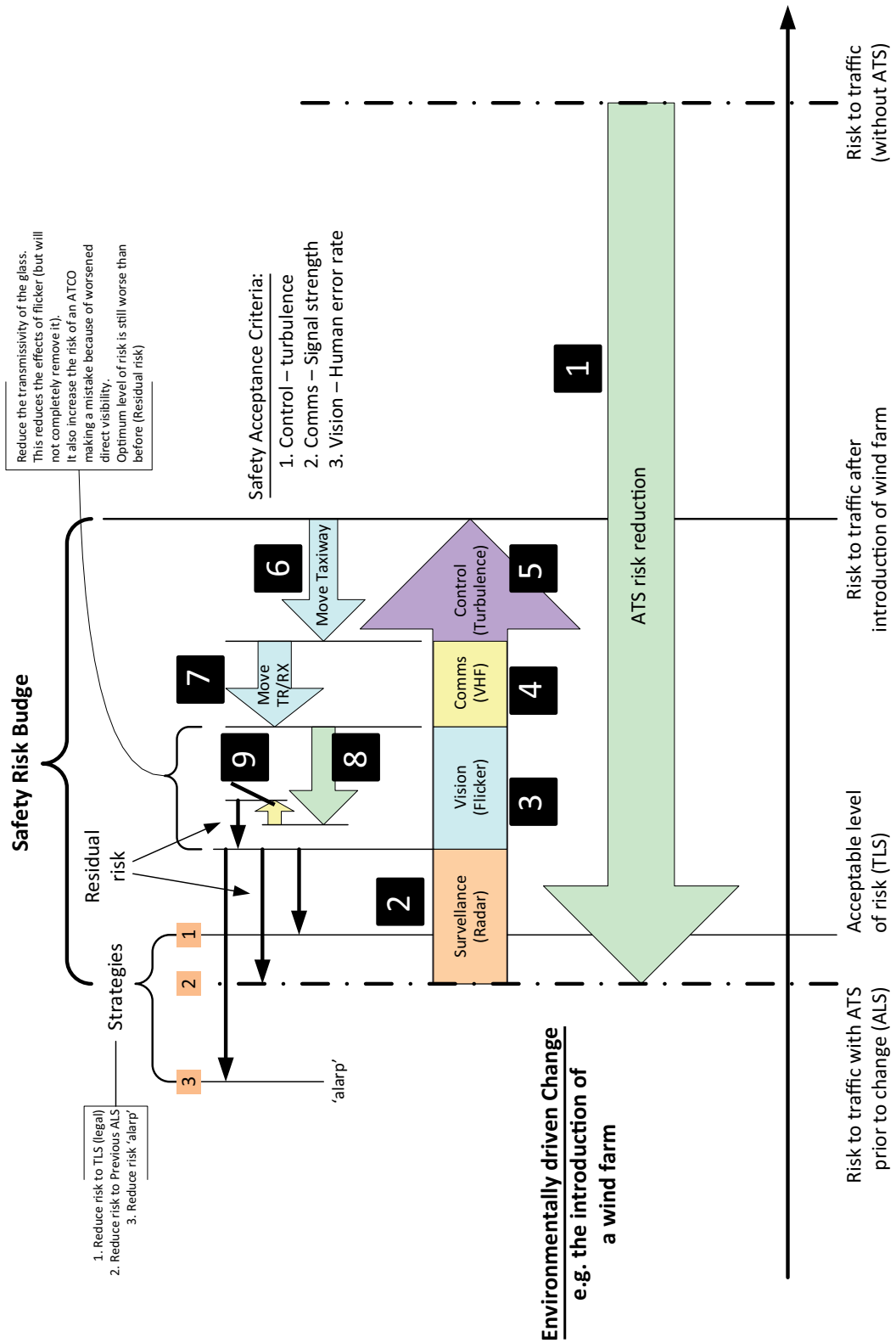
Discussion on an Example Scenario

SUR13A.50 The following figure illustrates an example scenario, where the wind farm is situated close to an airfield and where the wind turbines may cause effects such as flicker on the controller's display etc. It is not representative of all possible effects that could be induced by

wind turbines in a given context. The range of effects that has to be considered depends on a number of factors identified in a later part of this document.

SUR13A.51 Arrow 1 represents the total reduction of risk achieved by the ATM system. Arrows 2, 3, 4, and 5 represent the increase in risk caused by wind turbine interference effects on surveillance, communications and to airfield operations. Arrows 6 and 7 represent the reduction in risk achieved by the mitigations to the effects caused to communications and airfield operations by the wind turbines. These are work-around methods which have not required an internal modification to these areas. Arrow 8 is however a mitigation technique applied to address the effect of flicker on the display system. This involves a modification to the display system. As can be seen by the small arrow (arrow 9), this modification has introduced some risks, which has driven the risk up again by a level represented by arrow 9. Furthermore this modification has not fully mitigated the level of risk increased to the safety budget of this system, hence further mitigation mechanisms are necessary to reduce the risk further down to achieve at least the level of safety that is deemed as acceptable.

SUR13A.52 No mitigations have been applied to address the increased risk levels caused by wind turbines on surveillance systems in the illustrated scenario. However various risk mitigation techniques can be applied to reduce this risk and there would be both up and down arrows representing the amount of risk reduced by such techniques and any additional risks introduced by such techniques.


Safety Risk Budge
Residual risk
Strategies
1
2
3
1. Reduce risk to TLS (legal)
2. Reduce risk to Previous ALS
3. Reduce risk 'alarp'
'alarp'
Reduce the transmissivity of the glass.
This reduces the effects of flicker (but will not completely remove it).
It also increase the risk of an ATCO making a mistake because of worsened direct visibility.
Optimum level of risk is still worse than before (Residual risk)
Safety Acceptance Criteria:
1. Control – turbulence
2. Comms – Signal strength
3. Vision – Human error rate
Move Taxiway
Move TR/RX
Surveillance (Radar)
Vision (Flicker)
Comms (VHF)
Control (Turbulence)
ATS risk reduction
Risk to traffic (without ATS)
Risk to traffic after introduction of wind farm
Acceptable level of risk (TLS)
Risk to traffic with ATS prior to change (ALS)
Environmentally driven Change
e.g. the introduction of a wind farm

Part 2: Wind Turbine Effects on Surveillance Systems

Introduction

SUR13A.53 The following section describes the various effects that wind turbines have caused on ATC primary radars during the trials conducted as part of many research projects around the UK and the rest of the world.

SUR13A.54 ANSPs must therefore consider the possibility that their ATC radars be affected by each of these phenomena as a result of wind turbines within the coverage range of their surveillance systems.

Twinkling Appearance/Blade Flash Effect

SUR13A.55 Rotating wind turbine blades can impart a Doppler shift to any radar energy reflecting off the blades. The radar's MTI processor may – depending on the thresholds set in the processor – detect this as a non-static target and therefore display it as a return on the radar screen. Variation in the wind direction at the turbine, the precise position of the blade in its rotation as the radar beam illuminates it, the pitch of the blade and other factors may cause the amplitude and size of the return to fluctuate from one antenna rotation to another. At sites with single turbines, any radar return from the rotating turbine blades will stay in one location on the screen. However at sites with more than one turbine, the radar may illuminate a blade or blades from one turbine on one antenna sweep, then illuminate the blades of a different turbine on the next sweep. This can create the appearance on the radar screen of returns moving about within the area of the wind farm over time, sometimes described as a "twinkling" appearance or blade flash effect.

SUR13A.56 The extent to which this will happen will depend on, amongst other factors, the radar's range and azimuth resolution – the minimum distance between objects which the radar can detect.

Masking of True Targets by Increased Clutter on Display

SUR13A.57 Wind turbines can cause a significant increase in the level of clutter on the primary radar displays which are unwanted primary radar returns. The reflected signal from the tower can be removed by stationary clutter filter in radars. However the Doppler Effect from the turbine blades are not filtered by stationary clutter filters and

cause unwanted detections that would appear in different forms on both plot extracted systems and non-plot extracted radar systems.

Non-plot extracted systems

SUR13A.58 The presence of clutter can mask the actual target detections from display. On a non-plot extracted system showing unprocessed data, wind turbine clutter can appear as large blips on the screen and when aircraft flying directly overhead the wind farms are detected, the blips indicating the target detection can be completely masked by the larger cluttered area on the display.

Plot extracted systems

SUR13A.59 On plot extracted radar systems, clutter can appear as a sporadic distribution of individual primary radar target reports over the wind farm area. These can mask any actual detections and can also lead to tracking problems which are discussed in a separate section.

Increase in False Targets or False Aircraft Tracks

SUR13A.60 The blade movement of the wind turbines cause a Doppler shift, thereby defeating the moving target processing of the primary radars. The tips of rotating blades can move at similar speeds to aircraft such that the wind turbines may appear as targets on the display similar to an aircraft.

SUR13A.61 It has been observed that within the confines of the wind turbine clutter that primary returns can appear to move around and can often appear very similar to those that would be produced by a light aircraft.

SUR13A.62 For example, temporal threshold processing works by gradually increasing the clutter threshold for each temporal cell until the moving target within that cell is deleted. The wind farm rotors however move in the azimuth plane every two or three minutes to face the strongest wind source, in which case the temporal threshold processor will reset to zero and start again. This then gives the effect of showing a moving target which moves about within a small area. Wind farms therefore tend to appear and/or disappear as the temporal threshold processing realises that they are not moving, and then reappear as the turbine moves in the azimuth plane as it searches for the strongest wind. A separate processing board can be installed that can modify the temporal cells to extremes, which

would effectively give the option of displaying wind farms constantly or deleting the wind farms from the display entirely. Both options are flawed as the former creates more clutter and the latter creates a hole in radar cover.

SUR13A.63 Appearance of multiple false targets can generate false aircraft tracks. False tracks can appear on both plot extracted and non-plot extracted systems where multiple and consecutive false primary returns occur due to wind turbines blade movement.

Receiver Saturation

SUR13A.64 Radar receivers require a large dynamic range in order to detect the reflected energy from both large and small aircraft. However, if an obstacle such as a wind turbine reflects a significant amount of power, the receiver can be pushed beyond its dynamic range and can become saturated. This effect is not limited to wind turbines and can be caused by any large obstacle; however, it is dependent upon the size and range of the obstacle from the receiver. It is acknowledged that the likelihood of wind turbine generated receiver saturation is low; however, any possibility of receiver saturation should be taken into consideration.

Receiver De-sensitisation causing Loss of Targets with Small RCS

SUR13A.65 Trials have shown that the large RCS of wind turbines and the blade flash effect have lead to a decrease in radar sensitivity. Reduced receiver sensitivity increases the minimum detectable signal by a radar receiver, therefore loss of small targets and the maximum range at which the smallest targets can be detected can be reduced as a result. Radar's clutter suppression circuitry uses noise thresholds which increases as the average noise levels increase leading to lack of receiver sensitivity.

SUR13A.66 Since wind turbines can have relatively high RCS they can obscure other targets in the same resolution cell, and so when an aircraft flies over a densely packed wind farm, the turbines' RCS will tend to be higher than that of the aircraft as it passes through the same resolution cell seen by the radar and so the aircraft is obscured.

Loss of Targets due to Adaptive Moving Target Indication (AMTI) Techniques

SUR13A.67 The AMTI processing assesses the background Doppler returns being received in each of its range cells and sets a velocity for which returns are 'notched out'. As the tip speed of the turbines can reach speeds similar to aircraft, it is possible that aircraft detected in the same AMTI range cell as a rotating turbine may fall into the AMTI Doppler notch and be discarded. It is, therefore, possible for some aircraft returns to be lost due to the presence of an AMTI Doppler notch in radars having such capability.

Shadowing behind the Turbines caused by Physical Obstruction

SUR13A.68 Trials have indicated that wind turbines also create a shadow beyond the wind farm so that low flying aircraft flying within this shadow go undetected. The magnified shadows of the turbine blades and the moving rotors are visible on the radar screens of weather and ATC radars [Reference 3]. However recent trial measurements have indicated that the shadow region behind the wind turbines would last only a few hundred meters and would hide only very small objects.

SUR13A.69 The wind turbine's tower and nacelle components present a large physical obstruction in the radar coverage areas in the same way as any other structure, such as a large building. The presence of a physical obstruction with a large Radar Cross Section (RCS) in the path of the radar beam creates a region behind the turbine farm within which aircraft would not be detected. The shadow region behind a wind turbine farm within which primary radar contact is lost by interference with the propagation of the radar beam is believed to be defined by a straightforward geometric relationship between the radar and the wind turbine farm. The shadow region is a result of diffraction of electromagnetic waves. Diffraction is phenomena that occurs when radio waves encounter obstacles. Diffraction occurs with all propagating waves, including sound waves, waves on water, waves in materials and electromagnetic waves. On encountering an obstacle during propagation in a homogeneous medium, a radio wave changes in amplitude and phase and penetrates the shadow zone, deviating from a straight path. The effect of the diffraction penetration of a radio wave into a shadow zone depends on the ratio between the dimensions of the obstacle and the wavelength.

Degradation of Tracking Capabilities

SUR13A.70 When the bulk of the wind turbine structure reflects sufficient energy to swamp any reflected energy of an aircraft in the same area, it causes the receivers to be de-sensitised and the false alarm thresholds to be raised, causing loss of ability to detect aircraft below the threshold level. It was also stated that Doppler Notch in Adaptive MTI radars can also lead to loss of targets.

SUR13A.71 Also, if the wind turbines are within radar line of sight, then the Doppler shift in reflected energy from the blades may defeat any moving target processing and display the blades as targets or tracks that could be mistaken for aircraft.

SUR13A.72 These may result in tracking anomalies in the radar:

1. False targets and False tracks
2. Long gaps (lost consecutive plots) in a track
3. Track Jitter or Track jumps

   Tracks deviating between true and false targets can cause potential track jumps.
4. Tracks over the wind farm area to be false, deviated or discontinued

   Presence of clutter and false targets can cause radars' tacking algorithms to be confused and the track to be discontinued. The exact nature of the effects depends on the tracking algorithms used by particular radar.
5. Track Seduction

   Track seduction is when a plot other than that produced by the source of the track is selected as the update and has the effect of steering the track away from the actual path of the source. If on subsequent scans further 'alternative' plots are available to sustain the deviated path then the track is said to have been seduced. Track seduction is another effect on ATC displays that can be caused due to wind turbine effects. This effect can also lead to split tracks, where an additional (false) track is initiated and seduced away from the true track, leading to confusion as to which the true target is.

SUR13A.73 The tracking algorithms in a radar associates the plots confirmed as targets, in to individual tracks it believes to be from the same target. The false declarations of targets caused by wind turbines can

confuse the tracking algorithms and the plot association function in a plot extracted radar, causing the effects described above.

Degradation of Target Processing Capability

SUR13A.74 Most modern ATC primary radars are fitted with a plot extractor. The plot extractor takes the output of the signal processor, i.e. the hits generated across the beam width, and declares a plot position which may also include course and radial speed information. Plot extraction ranges from a simple position declaration to advanced hit processing, which takes the output of an MTI filter bank and generates plots taking account of amplitude information and Doppler information. There is normally a maximum number of targets the radars processing systems can handle at any one time. Therefore, if a radar experiences a large number of clutter and false plots returned by wind turbines, its processing capacity may be reached and the processing capability can be affected as a result. This may lead to errors and processing delays.

Effects on Secondary Surveillance Radar

Physical blanking and diffraction effects

SUR13A.75 Wind turbine effects on SSR can be caused due to the physical blanking and diffracting effects of the turbine towers depending on the size of the turbines and the wind farm. These effects are only a consideration when the turbines are located very close to the SSR, i.e less than 10 km.

Reflections causing false targets

SUR13A.76 SSR energy may be reflected off the structures in both the uplink and downlink directions. This can result in aircraft, which are in a different direction to the way the radar is looking, replying through the reflector and tricking the radar into outputting a false target in the direction where the radar is pointing, or at the obstruction.

Introducing range and azimuth errors

SUR13A.77 Monopulse secondary radar performance is also affected by the presence of wind turbines (Theil & van Ewijk, 2007). The azimuth estimate obtained with the monopulse principle can be biased when the interrogated target emits its response when partially obscured by an large obstacle such as a wind turbine.

Part 3: Impact of Wind Turbine Interference Effects on Surveillance Performance Parameters

Display Effects/HMI Performance

SUR13A.78 The twinkling effect caused by wind turbines is related to effects on the display and associated human factors considerations as to what this effect might cause to the controller.

SUR13A.79 Increased clutter levels on the HMI can also make the controller's task difficult and cause an increase in controller workload.

False Target Rate or Probability of Alarms

SUR13A.80 Increased level of false plots on both plot extracted and non-plot extracted systems could exceed the operationally acceptable false alarm rates for which the radar was originally designed to achieve.

Probability of Detection

SUR13A.81 Effects such as masking true detected targets from the display due to increase clutter levels, reduction in receiver sensitivity, creation of a shadow region and receiver saturation could all contribute to an overall reduction in the probability of detection of wanted targets.

Surveillance System Integrity

SUR13A.82 The existence of false tracks or false position information or loss of detections means that the data integrity and the system integrity is compromised. If the radar receiver completely saturates due to interference, effects from wind turbines this means targets will no longer be detected by the radar under saturated conditions effecting system continuity.

Position Accuracy of Targets

SUR13A.83 Existence of false targets mean that tracks can be deviated from their actual path and also position information could be related to targets that are non-existent. In SSR, reflections can also cause actual targets to appear in a skewed position with either range or azimuth errors. This affects performance parameters such as RMS value of position accuracy, maximum horizontal position accuracy, track accuracy etc.

Latency

SUR13A.84 As stated previously, a large number of clutter and false plots could confuse the tracking algorithms used in radars using tracking algorithms to display processed target information. The processing capability of the radars may be affected, introducing additional processing delays.

Low Level Coverage

SUR13A.85 Existence of a shadow region means the radar's ability to detect targets directly behind the wind turbines can be affected. Since a shadow region is thought to exist only a few kilometres behind a wind farm and the size is believed to be defined by a straightforward geometric relationship between the radar and the wind turbine farm, only the low level coverage is affected.

Human Factors Considerations

SUR13A.86 The wind farm effects described in earlier sections, such as twinkling effects and increased amount of clutter on the display, may cause undesired display effects that would cause discomfort or affect a controller's ability to visually interpret the surveillance picture in an accurate manner. For example, the controller becoming over familiar with false returns on a display can lead to automatically making assumptions that such returns are simply wind turbine clutter, even when true targets appear within that region. Increased clutter increases controller workload.

Part 4: Overview of Mitigation Techniques

SUR13A.87 It appears that the mitigation techniques can be categorised in to several key types. This section identifies each category and includes a discussion around each topic.

Work-rounds

SUR13A.88 Work-rounds are interim measures which are easy to implement solutions adopted by an ANSP which would enable the ANSP to continue providing service using surveillance radar, under reduced operational efficiency or an increased level of risk, which may be deemed acceptable whilst a long-term full mitigation solution is being progressed. Such measures inherit limitations which makes it only suitable for a limited period or a limited set of circumstances and are likely to avoid such effects rather than addressing the effects experienced by radar.

SUR13A.89 Work-rounds include moving the locations of the wind turbines (where this is feasible and in planning stage), introducing sector blanking, re-routing traffic such that all aircraft fly around the wind farm rather than over it, moving any other operational areas of the airfield, or remove PSR and use SSR only etc. These measures may not be sufficient in the long term as the number of wind turbines is likely to increase over time and are therefore temporary measures rather than a permanent fix to the problem.

SUR13A.90 PSR sector blanking is the means of ensuring that clutter caused by a wind turbine development is not presented to the controller by deliberately masking fixed areas on the radar display. Such a solution can only be viable when the operational use of the radar is such that completely removing all radar coverage on specified radials at certain levels is deemed operationally acceptable.

SUR13A.91 Some ANSPs have also looked in to the possibility of finding temporary measures to overcome the wind farm interference by adjusting the false alarm thresholds (CFAR) and the slow speed filters in their PSR systems. Typically a filter exists within the ATC PSR that will filter from the air traffic controller's screen any objects moving slower than 30 mph (or a defined limit). The filter also removes any static signals it receives leaving only moving objects over 30 mph on the screen.

Advantages

- Less costly
- May be relatively quick to implement

Disadvantages

- May become unsuitable in the longer term
- May not completely eliminate the interference
- May only be suitable under specific circumstances

In-Fill Radars

SUR13A.92 In-fill radars appear to be a popular form of mitigation under consideration by many ANSPs in order to overcome wind farm interference on their primary radars. Several manufacturers are known to have developed in-fill solutions specifically designed for the purpose of wind farm mitigation on ATC radars. This either involves combining the target data from a radar that does not have line-of-sight to the wind farm so that the area on the ATC display that is affected by a particular ANSP's radar, can be filled in by the use of an external feed from a different radar or by implementing a radar with a smaller coverage area that is situated somewhere within the wind farm or where the wind farm is within its within-line-of-sight such that the airspace above the wind farm area can be monitored using the in-fill radar, therefore a complete air situation picture can be produced by combining the two results.

SUR13A.93 In-fill radars involve either 2D or 3D radar solutions.

Advantages

- Has the potential to be a complete solution that can eliminate all of wind farm clutter over a given area

Disadvantages

- Increased cost due to purchasing, operating and maintaining an additional radar.
- May be subject to spectrum availability limitations
- Planning permission and restrictions make deploying green field solutions difficult
- Potential increase in spectrum charges

- May need several in-fill radars as wind farm areas grow in size over time
- Need for additional equipment, maintenance, by the ANSP or a third party
- Processors are required for plot combination therefore additional equipment and room will be required
- Potential to increase additional processing delays, and increase plot loading

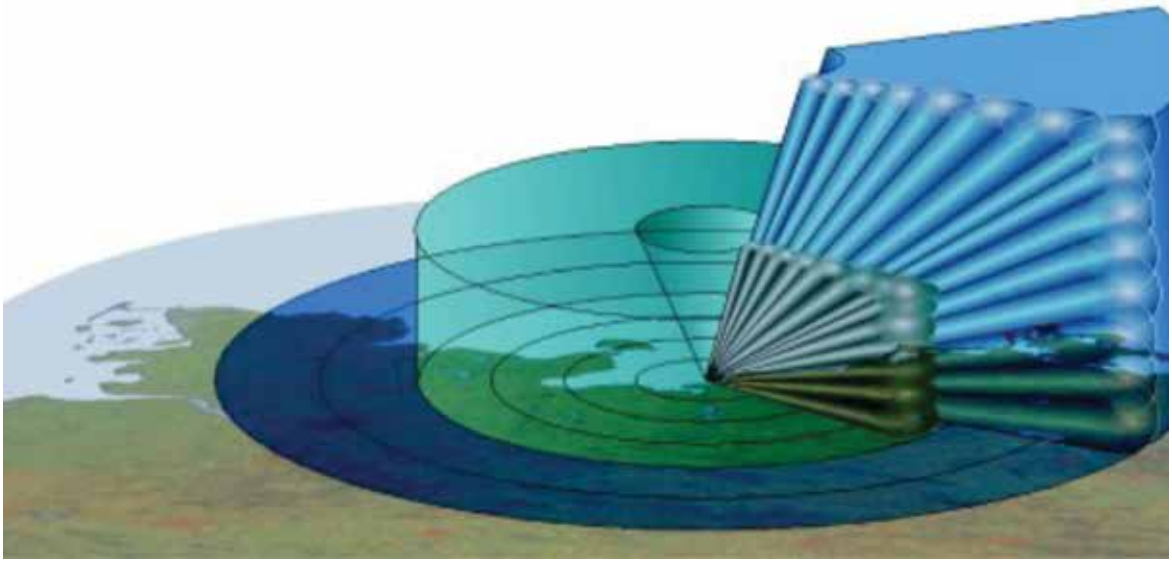
3 Dimensional (3D) Radars

SUR13A.94 Traditional ATC primary radars measure only the range and bearing of the target and do not measure altitude data. They are therefore classed as two dimensional radars. Hence 2D PSRs can only display range and bearing information on the controller's display. An SSR on the other hand obtains pressure altitude data from aircraft transponder responses in the form of a Mode C reply, thus allowing a controller to be made aware of the targets vertical position as well as range and bearing.

SUR13A.95 Some PSRs can provide 3D information by using multiple beams of radio waves at two or more elevation angles allowing the elevation of the target to be derived by measuring the strength of the returns from each beam. Typically these are used as air defence radars, allowing 3D tracking of non-transponding aircraft.

SUR13A.96 3D radars can therefore be used as in fill radars above wind farm affected areas and could be the ideal solution to the wind farm interference issues on primary radars.

Figure 1: An image of a typical 3D radar



Advantages

- Have the potential to be a complete solution that can eliminate 100% of wind farm clutter over a given area
- Slant range error correction is possible and much easier with the height information available

Disadvantages

- Potentially costly
- May need several in-fill radars as wind farm areas grow in size over time
- Need for additional equipment, maintenance, by the ANSP or a third party
- Processors are required for plot combination therefore additional equipment and room will be required
- Potential to increase additional processing delays, and increase plot loading

High PRF Radars

SUR13A.97 Some manufacturers have also developed radars that utilise a high transmitter Pulse Repetition Frequency. This technique makes it possible to discriminate between aircraft and wind turbines by analysing their Doppler signatures and remove the turbine clutter from the display. Such radars may be used as in-fills or, if sufficient range is achievable, the radar may be used as an alternative to a conventional Primary Surveillance Radar.

Advantages

- Have the potential to eliminate most if not all wind farm clutter from the ATC displays

Disadvantages

- Could lead to increased RF pollution due to the number of in fill radars likely to be required
- Increased spectrum utilisation
- High power necessary to achieve longer ranges
- May require several radars to cover a large wind farm or several wind farm areas impacting several areas on display
- Could be costly
- If used as an in-fill, disadvantages of an in-fill solution apply

Use of Spectrum Filters

SUR13A.98 Some manufacturers have attempted to develop a solution that is based on modifying their existing (in service) radars by incorporating a software based spectrum filter to compare the target Doppler signatures whilst maintaining the same (relatively low or normal) PRF with the aim of giving the system the ability to discriminate between turbines and aircraft in a similar way to the high PRF radars discussed above. The discrimination is achieved by carefully analysing the Doppler signatures that exhibits specific spectral characteristics returned by a wind turbine as opposed to an aircraft by using multiple advanced processing algorithms used by the software.

SUR13A.99 The success of such a solution depends on how accurately such a filter can perform and process the Doppler signatures. The various processing algorithms are used to perform this function.

Advantages

- If successful, easy to implement solution as this would require a spectrum filter software upgrade
- No need for in-fill radars
- Can be rolled out to all radars of the same type without having to implement new radars

Disadvantages

- Additional processing capacity required (this may involve additional processing hardware)
- May increase processing times
- May not be able to eliminate 100% of wind turbine clutter
- May not work for all radars in all locations

NOTE: As yet it is unknown weather this can be made to work as it is still under research and development phase.

Predictive and Multi-sensor Trackers (Data Fusion from Multiple Sensors)

SUR13A.100 There have been proposals to employ specialist tracking systems to overcome the impact of wind turbine farms on radar. Such solutions offer the addition of plot extraction and predictive tracking to any compatible radar. Although this may not provide a complete solution to address all potential effects they may offer some potential for the radar processing system to make a semi-intelligent assessment of returns from the vicinity of a wind turbine farm in order to distinguish clutter, including that induced by turbines, from aircraft. If such a system proved to be sufficiently robust then thresholds could be lowered and detection of aircraft over turbines improved. A sufficiently comprehensive fused picture also has the potential to address the issue of shadowing.

Use Alternative Technologies less Susceptible to Wind Turbine Interference

SUR13A.101 Wind farm interference has been one of the key drivers forcing ANSPs to look at alternative technologies for air traffic surveillance. However current CAP 670 SUR 01 states:

"Primary surveillance radar (PSR) is the minimum level of equipment necessary to provide Radar Control, Traffic Service or Deconfliction Service. SSR or other surveillance technologies may, to varying extent, be required to supplement PSR in order to safely accommodate increases in traffic complexity or density."

SUR13A.102 Therefore a means of non-co-operative surveillance is necessary for the detection of non-co-operative targets in areas at least where the environment is not fully co-operative. Although SSR only operation is allowed in special circumstances such as during PSR failures, surveillance with co-operative only techniques is accepted in limited circumstances depending on the airspace type as stated in SUR 01. The CAA has initiated work, reflecting the Future Airspace Strategy (FAS) and the spectrum release programme which aims to release, from 2.7-2.9MHz (which is currently used by S-Band Primary Surveillance Radar (PSR)) by reviewing how non-co-operative surveillance can be best delivered to meet the operational and safety requirements of ANSPs. In parallel, there is an aspiration to use this opportunity to develop a strategic approach to wind farm mitigation in how non-co-operative surveillance is deployed.

Multistatic Primary Radar

SUR13A.103 A key solution that would overcome the need for a PSR that is able to detect non-co-operative targets is Multistatic radars, which are believed to be less susceptible to the effects of wind farm interference. However multistatic systems are not currently widely used or produced by manufacturers in a civil air traffic environment. It is anticipated that Multistatic primary radars will bring greater advantages to the civil ATM infrastructure over the coming years.

Multilateration or SSR only Operation

SUR13A.104 Co-operative only surveillance may be viable in areas where full or the majority of the airspace comprises co-operative targets. However, current CAA policy has to be reviewed in order to permit SSR only or co-operative only surveillance in circumstances other

than in situations where PSR is temporarily unavailable due to failures. Multilateration, SSR or ADS-B are some of the co-operative techniques that can detect co-operative targets despite the presence of wind farms.

Stealth Solutions

SUR13A.105 These techniques try to develop radar absorbing materials (RAM) as well as to design new wind turbines with reduced radar cross section, preserving the efficiency of turbines in terms of electricity production and construction costs. RAM may consist of ferrite paints or polymer layers incorporating crystalline graphite which are coated onto the wind turbines to reduce the RCS.

Part 5: Analysis of Mitigation Techniques

General

SUR13A.106 It should be noted that any mitigation solution that is deemed acceptable under the circumstances at the time of approval may no longer be acceptable if the ANSP's circumstances change in future. The number of wind turbines affecting an ANSP's surveillance services may change in future such that the ANSP might experience more wind turbine effects, previously not experienced or considered as negligible, due to new wind turbine installations. As such, mitigation solutions such as sector blanking may no longer be feasible. This section identifies the various mitigation techniques and provides guidance regarding the potential issues of using such techniques and where possible policy statements relating to the use of such techniques.

SUR13A.107 ANSPs are also reminded that the mitigation mechanisms listed here are guidance only and must not be regarded as mitigations that are recommended or endorsed by the CAA. The decision regarding the most appropriate mitigation mechanism must be made by the ANSP, following a hazard identification and risk assessment as per the SMS of individual ANSPs. It may be that a combination of more than one mitigation mechanism is necessary to overcome wind turbine interference effects. The CAA has no reason to raise objections to any wind turbine mitigation solution, provided that an acceptable level of safety is maintained and the air traffic service being provided is safe under the conditions at the time approval. Hence approval of a mitigation solution must not be regarded as an approval that assures safety of the air traffic service in a future environment which could have potentially more wind turbine effects with different severity levels where further mitigations may be necessary. Where further effects are experienced by future wind farm installations, the CAA will revise the approvals under the new circumstances and take an appropriate course of action.

SUR13A.108 ANSPs are advised that when choosing a mitigation solution, all current and planned wind turbine installations (if known) in the ANSP's coverage volume are considered and a thorough assessment is conducted prior to choosing the appropriate solution, to avoid business risks. Addition of further mitigations in the future will require production of safety cases, reduced ability to continue service in the airspace given the circumstances (until problems are

fixed), potential cost to purchase and implement more mitigation solutions (i.e. 2nd in-fill radar, additional processing capacity).

Operational Mitigations

SUR13A.109 Increased levels of clutter, false targets and false tracks on the surveillance display can lead to an increased risk of the controller not detecting conflicting traffic, delay in aircraft being identified and placed under an ATS and increase in controller workload.

SUR13A.110 The ANSP may decide to apply operational mitigations where practicable. The controllers may be able to tolerate the effects, if not re-route traffic, reduce the information provided or limit the level of service provided. Consequently, guidance on how air traffic controllers should or should not apply radar services in proximity to clutter is generic and is covered in CAP 493 (Manual of Air Traffic Services (MATS) Part 1) Section 1 Chapter 5 and in unit-specific MATS Part 2 documents.

Tolerating Clutter and/or Other Effects

SUR13A.111 Radar clutter can be created by a large number of sources, not just by wind turbines and, in some circumstances, its effects can be tolerated. The effects can take different forms on processed and unprocessed surveillance displays. Although the effects may seem tolerable, consideration must be given to the effects that are not apparent on the surveillance display, and human factors considerations such as controllers becoming over familiar with the effects and making erroneous assumptions.

Re-routing Air Traffic

SUR13A.112 Subject to existing airspace restrictions (including environmental constraints), air traffic controllers may be able to tactically re-route aircraft to avoid overflight of wind turbine clutter, thereby maintaining aircraft identity at all time and enabling safe ATS provision. However, re-routing aircraft has the potential to: impair service provision; reduce efficient airspace use; create 'choke points' of high intensity use within unregulated Class G airspace; increase controller workload; and increase both fuel burn and emission levels. If permanent re-routing measures are considered, service providers (in consultation with wind energy developers) must fully adhere to CAP 725 (Airspace Change Process (ACP)) where required. The ACP is a lengthy and complex process, giving full consideration to all airspace

users, so early consultation with the ACP sponsors (the CAA) is essential to ensure a smooth process.

Limiting ATS or Reducing the Surveillance Information Provided

SUR13A.113 The existence of clutter may necessitate limiting the air traffic service, or air traffic services to be reduced below the level requested by the pilot. For example limitations may be applied to the coverage volume where the service is provided or available. Equally, in uncontrolled airspace the traffic information that can be provided may be reduced, and there may be reduced ability to provide deconfliction advice. The procedures for providing air traffic services in the event of clutter appering on the situation display, listed in MATS Part 1 Section 1 Chapter 5 are stated below for information.

Controlled Airspace

SUR13A.114 Most air traffic inside controlled airspace is flying according to Instrument Flight Rules (IFR) and are provided with standard separation from other IFR traffic by air traffic controllers. In the majority of cases, separation is provided by means of radar. In controlled airspace it is a controlled environment within which flight is only possible subject to ATC clearance; hence an unauthorised aircraft should not exist within the airspace boundaries. All aircraft are supposed to be in radio contact with the air traffic service. However aircraft may suffer from loss of radio contact and traffic from outside the controlled airspace may infringe separation by coming into contact with controlled traffic.

SUR13A.115 In the event of clutter or false targets being present on the situational display the radar service shall not be limited, nor the air traffic service terminated.

SUR13A.116 Controllers should consider the extent of the effects and if necessary take the following actions:

1. The controller may vector the aircraft around the affected area; however, this might not be practicable due to traffic density, airspace availability and/or the requirement to follow specific arrival or departure tracks.

2. If the intensity of the clutter or false targets is such that the controller is not able to clearly see the aircraft's PSR or SSR

position symbol, radar separation shall not be used to separate it and other controlled aircraft.

SUR13A.117 The controller remains responsible for providing separation from aircraft that are considered to be infringing controlled airspace. Therefore, the controller should consider the nature of the clutter including any observed movement, relative speed and track and track consistency, and take appropriate action if a detection is considered to be an unknown aircraft.

Uncontrolled Airspace

SUR13A.118 In uncontrolled airspace, aircraft may fly without contacting any air traffic control agency. Therefore traffic in uncontrolled airspace have the option to participate in a surveillance based service or not. Currently deconfliction service and traffic service are the surveillance based services that are provided in uncontrolled airspace. Whilst most aircraft prefer to receive a surveillance based service from the units providing ATSOCAS services, the targets appearing on PSR can contain both known and unknown traffic.

SUR13A.119 In the event of clutter or false targets being present on the situational display controllers should consider the nature and extent of the clutter/false targets and if necessary take the following actions:

1. For aircraft in receipt of a Deconfliction Service, controllers should inform the pilot of the extent of the clutter and where practicable offer a reroute. However, this may not be possible due to traffic density, airspace availability and/or the requirement to follow specific arrival or departure tracks. The extent of such a re-route should where possible aim to achieve the planned lateral deconfliction minima from the observed clutter. However, it may still be necessary to reduce traffic information/deconfliction advice from the direction of the clutter as detailed at Section 1 Chapter 11 of CAP 493.

2. For aircraft in receipt of a Traffic Service, and those aircraft under a Deconfliction Service that are not re-routed as above, controllers shall inform pilots of a reduction in traffic information/ deconfliction advice as detailed at Section 1, Chapter 11, of CAP 493. If the controller cannot maintain aircraft identity, the service shall be terminated.

3. For all surveillance services, in order to maintain track identity of aircraft being vectored to final approach, if re-routing around the clutter is not practicable for the reasons specified above, an alternative type of approach may need to be conducted.

Surveillance Radar Approaches In all Classes of Airspace

SUR13A.120 Where the increased levels of clutter or false targets affect the surveillance display for aircraft intending to make a radar approach, procedures described in CAP 493 Section 1 Chapter 5 must be applied.

Transponder Mandatory Zones and Surveillance by Co-operative Ground Sensor

SUR13A.121 Under current UK regulations or proposals, not all UK airspace will require a transponder to be fitted and used by aircraft. However it is recognised that in certain circumstances and in certain areas, mandatory transponder carriage can provide significant safety benefits. The CAA has regulatory powers to create Transponder Mandatory Zones (TMZ) for a number of reasons; one of which may be to help mitigate the wind turbine effects on a primary radar. Further details on TMZs can be found in CAP 764.

SUR13A.122 ANSPs may choose to provide surveillance by a suitable co-operative sensor over the wind farm area, in addition to the main PSR, as a mitigation to the wind farm clutter on a surveillance display.

Adjusting Radar Antenna Elevation

SUR13A.123 Evidence suggests that wind turbine clutter may be avoided by raising the antenna beam elevation angle. However the obvious effect of this is a reduction in low-level radar coverage.

Plan the Location of the Radar to make use of Terrain Shielding

SUR13A.124 It may be possible that if a new radar or a replacement radar is likely to be affected, to plan the location of the radar to provide some shielding from the wind turbines using existing terrain surrounding the area.

Moving Airfield Operational Areas

SUR13A.125 Although a highly unlikely scenario, some ANSPs may find that it is viable to move the locations of some operational areas of the airfield where detection is affected by wind farm clutter. Where such an option is being considered, the aerodrome standards aspects must be liaised with the CAA.

Changing the Wind Farm Location or its Characteristics

SUR13A.126 Some ANSPs, in collaboration with the operators of a planned wind turbine installation, may find through careful planning and pre-modelling that adjustment to the wind farm is possible in order to minimise the predicted effects of a wind farm on an ATC surveillance radar. For example, careful spacing between the turbines and the shape of a wind farm can significantly reduce its RCS as seen by the radar hence causing minimal effects on a surveillance system. This option is obviously possible only prior to the implementation of a planned wind farm.

SUR13A.127 Also, clutter suppression techniques and advanced digital tracking described in this document may reduce the effects of wind turbines on radars that use Doppler processing. However, not all radar systems have advanced signal processing algorithms. Hence where it is possible, the RCS of turbines should be reduced.

Physical or Terrain Masking/Clutter Suppression Fence

SUR13A.128 In certain circumstances, and where low level radar coverage in the area of wind turbine development is not required, it may be possible to use either existing terrain or a man-made object to prevent a radar from seeing the wind turbines.

SUR13A.129 Reflections from nearby mountains and other large clutter can sometimes be of such magnitude that it is not practical to completely suppress their undesirable effects by either MTI or range gating. One technique for reducing the magnitude of such large clutter seen by a fixed radar is to erect an electromagnetically opaque fence around the radar or between the radar and the clutter source to prevent the radar from viewing the clutter directly. The two way isolation provided by a typical fence with a straight edge might be about 40 dB, where the isolation is given by the ratio of the clutter signal in the absence of a fence to that in the presence of the fence. The isolation is limited by the diffraction of

the electromagnetic energy behind the fence. Greater isolation than that provided by a straight-edge fence can be had by incorporating two continuous slots near to, and parallel with, the upper edge of the fence to cancel a portion of the energy diffracted by the fence [Reference 9].

SUR13A.130 A fence can suppress the clutter seen by the radar, but it produces other effects not always desirable. It will limit the accuracy of elevation-angle measurement because of the blockage of the fence and the error caused by the energy diffracted by the fence. Energy diffracted by the fence also interferes with the direct path from the radar to cause multipath lobbing of the radiation pattern in the angular region just above the fence. Radar energy backscattered from the fence can sometimes be large enough to damage the receiver front-end.

PSR Sector Blanking or Range-azimuth Gating (RAG)

SUR13A.131 This process identifies particular range-azimuth cells, or groups of cells, within which returns are suppressed. RAG usually involves suppression of all returns from the identified cells, creating a hole in the radar cover. Certain radar systems have the ability to blank out configurable areas to prevent the radar from processing returns from those areas. However other methods simply involve masking the affected areas on the controller's display. In the latter situation the clutter is still generated but simply masked from display. Regardless of the means of enabling PSR blanking, it is important to note that all radar returns i.e. legitimate aircraft as well as wind turbine clutter, are prevented from being presented to the air traffic controller. Therefore, this mitigation can only be used in areas in which the ATS provider or ANSP deems a total loss of data to be acceptable.

SSR only or Co-operative only Operation

SUR13A.132 Currently co-operative/SSR only operation is allowed within certain parts of the en-route airspace as specified in CAP 670 SUR 01. SSR only service may also be permitted on a temporary basis in the event of failure of a primary radar. However it may be justifiable to use SSR only to maintain detection of aircraft within a limited part of a surveillance display that is affected by wind turbines.

Alternative Non-co-operative Techniques less Susceptible to Wind Turbine Interference

SUR13A.133 There is a growing enthusiasm amongst aviation industry stakeholders as well as the UK government to look into alternative surveillance technologies that could replace primary radar systems that are capable of detecting non-co-operative targets. As such a number of research institutes as well as some radar system manufacturers are looking in to the possibility of using Multistatic primary surveillance systems, where as the legacy PSR systems are monostatic systems where the receiver and the transmitter are co-located.

SUR13A.134 There is strong evidence to suggest that multistatic primary systems could be an ideal replacement for PSR systems which will be far less susceptible to wind turbine interference whilst able to detect non-co-operative targets. Some manufacturers have already developed prototype multistatic systems to be tested for civil air traffic surveillance. Although not near term it is anticipated that multistatic primary radar systems are likely to be implemented by manufacturers in the UK as a replacement to PSR in the longer term.

SUR13A.135 Once there is sufficient level of confidence in the technology, appropriate standards and regulatory guidance will be developed and incorporated into CAP 670 SUR section concerning the ANO approval of such systems.

NOTE: Guidance on the approval of multistatic systems is included in Appendix B to the CAP 670 SUR section introduced as part of the third issue).

Use of Amplitude Thresholds

SUR13A.136 If unwanted targets (such as rain or birds) are expected to have a lower radar cross-section than the desired targets, the amplitude of the unwanted returns can be expected to be lower than that of the genuine targets. A voltage threshold can be set in the radar causing returns below a given amplitude to be ignored. However, wind turbines can have radar cross sections larger than aircraft targets so this method has very limited utility.

Constant False Alarm Rating Thresholds/Temporal Threshold Processing

SUR13A.137 A development of the amplitude threshold method is to apply thresholds which will maintain a constant false alarm rate (CFAR). This process, also known as temporal threshold processing, is designed to maintain radar performance in areas where there is clutter. A threshold is set for a group of range-azimuth cells. If the largest return from that area in one antenna sweep is of greater amplitude than the largest return from the previous antenna sweep, the threshold is increased to try to eliminate the clutter.

SUR13A.138 This process is quite effective in removing shifting clutter returns from the radar screen. However, if a desired target within the area has a weaker return than the clutter, or if it stays within the area for several antenna sweeps (as for example a hovering or slow-moving helicopter might), the clutter threshold will eliminate that genuine target as well as the clutter.

Use of Clutter Maps

SUR13A.139 Point clutter such as buildings, towers, chimneys and radio masts, and much ground clutter, is predictable and unchanging. Rather than requiring the radar to analyse and detect this clutter and process it on every antenna sweep, using up processor power, the clutter characteristics can be stored in a memory circuit, which is then accessed on each sweep to remove that clutter from the signal. This is known as a clutter map.

SUR13A.140 Some radars have numerical limits on the number of range-azimuth cells which can be used for clutter mapping or RAG techniques. The total number of cells available may not be sufficient to accommodate processing of all clutter sources visible to the radar, especially where extensive wind farms are involved [Ref 1].

Application of Automated Tracking Techniques

SUR13A.141 Most modern radars display aircraft tracks made of plots confirmed as aircraft plots rather than displaying the unprocessed raw video. This is based on analysis of successive returns from a target to determine the direction and speed of its movement. Such automatic tracking radars will display only targets meeting the specified track criteria hence, for example, returns which do not match the speed characteristics of an aircraft will not be displayed.

SUR13A.142 Enhanced target tracking techniques can be used after detection. For example Feature Aided Tracking (FAT) identifies features from signals and process them in a probabilistic manner. The tracker would incorporate special processing techniques such as adaptive logic, map aided processing, processing prioritisation, enhanced tracking filters or classification algorithms.

Display of Predicted Target Positions in Tracking radars

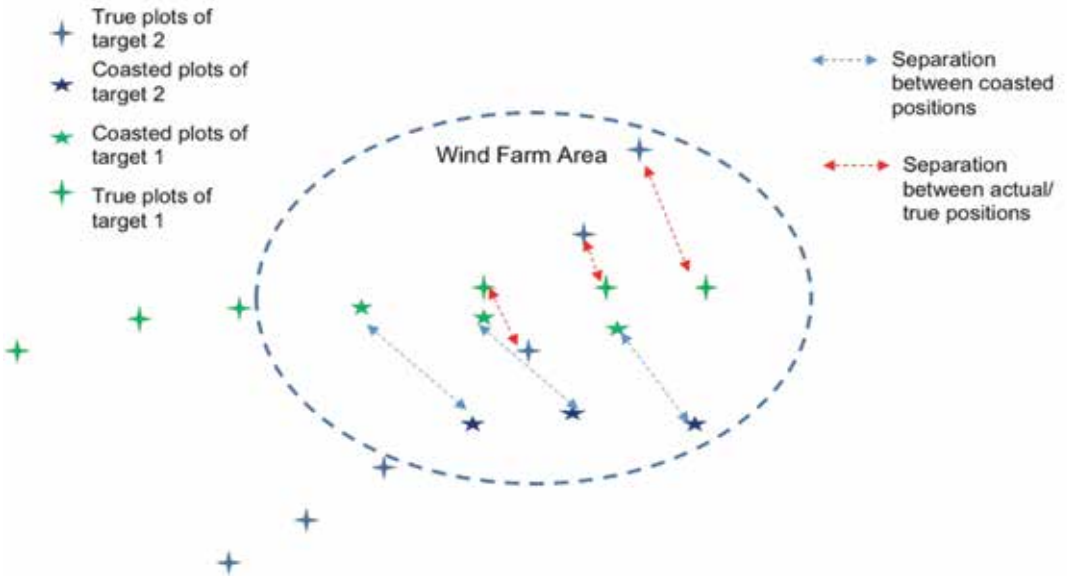
SUR13A.143 Automatic tracking processes can also involve the track processor predicting where the next plot from the aircraft will be, given its track history in terms of speed and direction. Prediction of target positions and therefore display of predicted positions can therefore allow tracking to continue over areas where the radar may not actually be illuminating the aircraft.

SUR13A.144 In a tracking radar, when a new detection is received, an attempt is made to associate it with existing tracks. Over the wind farm area, the next target position in a track could be based on an actual target position or a false wind turbine plot. This can lead to track deviation and target position inaccuracy.

SUR13A.145 The predicted positions are displayed when no target detection is made. Since the tracker may take into account some false wind turbine detections into the predicting mechanism, the predicted tracks may also be erroneous and misleading.

SUR13A.146 As illustrated in the diagram below, the difference between horizontal positions of the predicted target positions and the true target position may be unknown and may be less than the separation minima applied.

Figure 2: Effect of track coasting over a wind farm area on a ATC display



Suppression of Track Initiation Over Wind Farm Areas

SUR13A.147 Tracking processors can also suppress track initiation in selected areas. This will reject any track which first appears in a selected area (such as a range-azimuth cell containing a wind turbine) but will retain pre-existing tracks which have entered that cell from elsewhere [Reference 1].

Use of Adaptive Moving Target Indication (MTI) Techniques

SUR13A.148 MTI processes several consecutive returned pulses. The output of this process identifies any object with zero Doppler, i.e. which is static, and can then eliminate that object from the radar display. Basic MTI can only eliminate static objects. Adaptive MTI (AMTI) not only filters out the fixed clutter, but also estimates the predominant Doppler value of the remaining moving clutter in each range-azimuth cell, and filters it out. AMTI can therefore cancel out moving as well as fixed clutter [Reference 1].

Use of an In-fill Radar

SUR13A.149 The use of "In-Fill" radars is a popular mitigation technique currently considered by many aviation stakeholders to address the wind turbine interference issues on primary radars. The word "In-Fill" implies filling in part of the surveillance picture with the aid of a different surveillance source. Hence the idea of an in-fill radar is to

feed data from a different surveillance source to the areas on the surveillance display affected by wind turbines.

SUR13A.150 These surveillance sources may take various forms. As discussed in sections above, it may be that providing data with a co-operative surveillance sensor is feasible in the airspace controlled a particular ANSP. It may be a primary radar which simply does not see the wind farm since the wind farm is not in its vicinity due to where it is located.

SUR13A.151 However there are in-fill radars particularly designed to have the capability to detect targets in the presence of wind turbines when both the wind turbines and targets are in its coverage. There are a number of issues to be considered when assessing the suitability of a mitigation solution including in-fill radars and any equipment based solutions that are discussed in the following section.

Part 6: Issues to be Considered when Assessing the Suitability of Wind Turbine Mitigation Techniques for ATC Radars

SUR13A.152 This section identifies aspects that must be considered when using and implementing various wind turbine mitigation techniques. Whilst most issues highlighted in this section are relevant to in-fill solutions, other techniques must also be considered for applicability.

S Band In-fill Radars – Wimax Interference Protection

SUR13A.153 Any S-band in-fill radar solution must take in to account the Wimax interference on S-band radars which could cause safety related issues to surveillance services in a future Wimax environment. It is therefore expected any manufacturer of S-band in-fill radars to be aware of the Wimax interference issue and to ensure this has been taken into consideration within the design of the equipment. Wimax interference on S-band radars could result in data output by those radars being unsuitable for use. Further information on the effects of Wimax interference on S-band radars can be provided by the CAA upon request. Furthermore, where transmissions from S-band radars cause interference effects to Wimax stations this could result in alteration or revocation of the licence issued under the Wireless Telegraphy Act by Ofcom.

SUR13A.154 From a safety perspective, an S-band in-fill radar might not be affected by Wimax interference at the time of its ANO approval, due to the absence of a Wimax environment at the time. Moreover the CAA does not currently have a policy statement or a requirement where ANSPs must claim that the transmitters are suitably designed to operate safely in the presence of Wimax signals. In which case should a transmitter become susceptible to Wimax interference effects, and is thought to be suffering from such effects, the CAA will make necessary steps to review the ANO approval, attach new conditions or in the worst case scenario revoke the ANO approval until the interference issues are resolved by a suitable mechanism.

SUR13A.155 ANSPs must be aware that the effects of interference on a surveillance display may not be obvious and may take a long period to identify. There is potential to lose targets, reduce the maximum range that the radar can detect targets etc. which may not be easily detectable. As a consequence, if an in-fill radar is subject to interference effects, it may well be undetected and unknown by the

ANSP. The data fed by the in-fill radar may therefore be unsuitable for use.

SUR13A.156 Future licences to operate primary radars in S-band may therefore be subject to limitations with conditional terms that the transmitters must be Wimax compliant once such an environment exists.

SUR13A.157 From an Ofcom perspective, necessary steps will be taken by Ofcom in order to cease the operation of those S-band transmitters that do not comply with Ofcom's requirements which must be complied with by end of 2015.

SUR13A.158 Any CAA approvals for S-band in-fill radars will take the Wimax interference issue in to account.

Performance of Solutions Involving Additional Equipment

SUR13A.159 Whilst some mitigation solutions are completely software based, or involve changes external to the surveillance system (i.e. traffic/wind farm/environment/clutter suppression fence), some mitigation solutions involve making modifications to the ground based surveillance system. This mainly includes in-fill radar solutions and any solutions that require additional processing capability, data transmission links, data from other surveillance sources or equipment such as plot assigner combiners for data fusion.

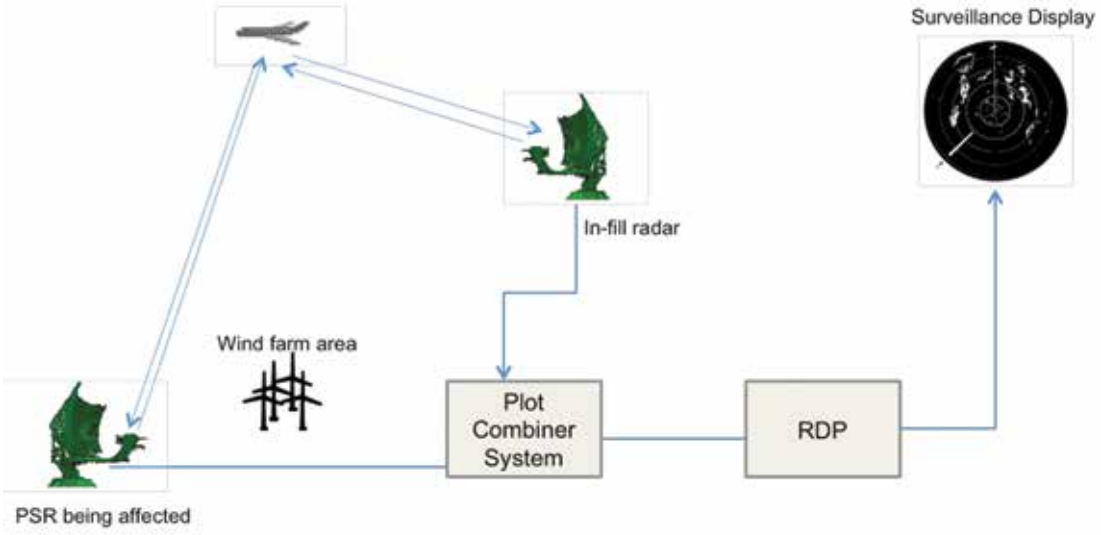
SUR13A.160 This section focuses on guidance on how an ANSP should consider any modifications to the ground based surveillance system from a safety perspective.

SUR13A.161 The complete ground based surveillance system includes sensors, any data transmission links, power supplies, data processors, data fusion systems, display systems (HMI)s, redundant feeds, safety nets and servers, including people and procedures involved.

SUR13A.162 Implementation of a wind turbine mitigation solution could mean adding surveillance sensors, power supplies, data transmission links, additional processing equipment and introducing additional procedures etc. Any modification made to the elements of the "ground based surveillance system" should be considered as a safety related change.

SUR13A.163 The following diagram illustrates a scenario where an in-fill solution is introduced as a mitigation resulting in the ground based surveillance system being modified.

Figure 3: Ground based surveillance system following integration of in-fill radar



SUR13A.164 In the illustrated scenario, introduction of the mitigation technique has resulted in more equipment involving the in-fill radar itself, data transmission links and plot combiner systems being added into the existing ground based surveillance chain. Prior to focusing on the performance of individual elements in the system such as the in-fill radar, it must be remembered that the data will be used for the same surveillance application (e.g. 3 NM separation). The objective is to maintain the acceptable level of safety that is currently achieved or achieve better safety levels by further reducing the risks where possible.

SUR13A.165 Any added components to the surveillance system must be considered as elements or components of the overall ground based surveillance system. The performance that must be delivered by the "ground based surveillance system" is the minimum performance that the surveillance system shall meet that is suitable for the operational requirements of the selected application defined herein as the Required Performance of a surveillance system.

SUR13A.166 The required performance of a surveillance system is defined in CAP 670 SUR 02. The required performance includes the following performance related parameters:

1. Surveillance data items
2. Update period
3. Accuracy/Precision
4. Resolution
5. Continuity
6. Reliability
7. Availability
8. Latency
9. System integrity
10. Data integrity
11. Coverage
12. False targets etc.

SUR13A.167 The required performance depends on the application for which the ANSP wishes to use the surveillance data, and the operational requirements in the context in which the ANSP provides the services. Whilst some of the performance parameters are required to perform the application, the system integrity requirements must be derived through a hazard identification and a risk assessment process. Once the safety integrity requirements necessary to achieve an acceptable level of safety is known, these can be further apportioned to individual lower level system elements. This means that the failure modes, their effects and rates of occurrences (probabilities) must be identified through a risk assessment process. For example the in-fill radar's failure rates and associated data transmission links failures can contribute to the overall hazard rates. However the consequence of such failures may not be severe enough or the ANSP may not have to lose the entire surveillance system as a result. The failure modes, their effects, their rates, the resulting consequences and severity levels are essential to be identified in the risk assessment process.

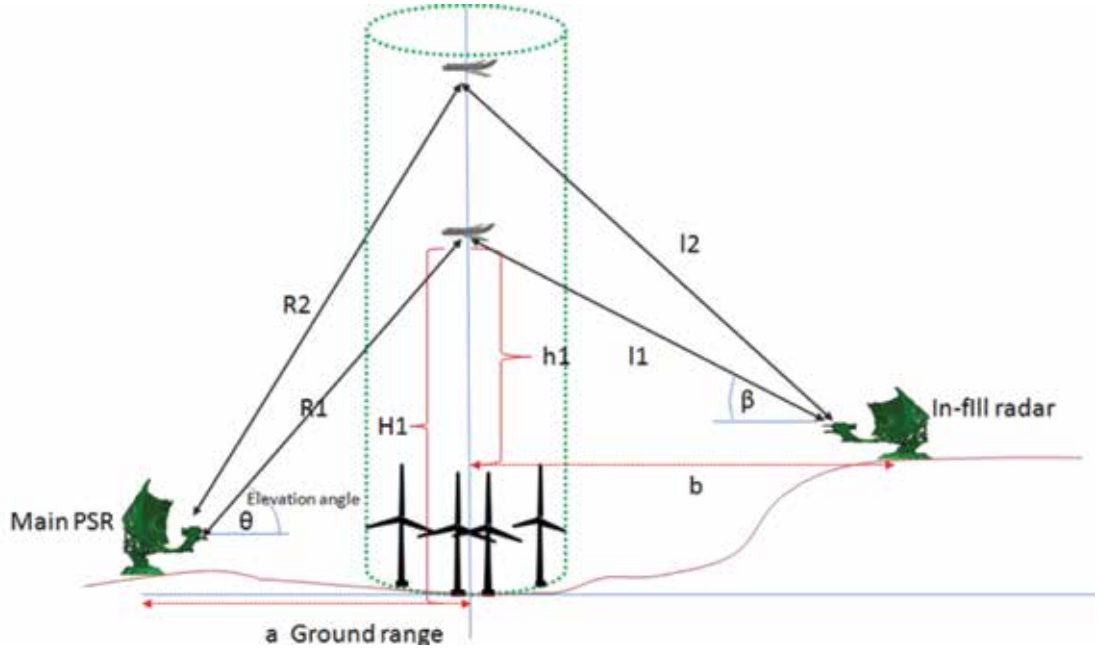
SUR13A.168 A systematic risk assessment process will enable the ANSP to derive the performance required from the individual components in the system including but not limited to in-fill radars, power supplies, redundant feeds, data links, or any other mitigation requiring additional equipment to be integrated to the system.

SUR13A.169 The underlying requirement is that the overall ground based surveillance system shall be able to deliver the required performance necessary to provide service.

Integration of In-fill Radar Target Positions to the Main Primary Radar Display

SUR13A.170 This section describes a common issue associated with translating range and azimuth data measured by a two dimensional radar to range and azimuth measurements with respect to the reference point of another radar known as the slant range error.

Figure 4: Slant Range Difference when measured by two radars



SUR13A.171 Typically primary radar position information is presented as a range and bearing value on the controller's display with reference to the position of the radar head. The measured range is the slant range rather than the ground range. When accepting an in-fill radar feed from a radar situated at a different location to that of the main PSR, the position information output by the in-fill sensor has to be expressed with reference to the main primary radar on the

controller's display in order to have a common reference point for integration of range and bearing data.

SUR13A.172 For example the main PSR and the in-fill radar illustrated in the diagram measures R1 and I1 range information and bearing of the target. The elevation angles Θ and β are unknown since the radars do not measure elevation. For a given range, and an azimuth, the aircraft could be anywhere in the vertical plane, depending on the elevation angle at which the aircraft is precisely located. Unless the two radars are located symmetrically from the location of the target at the same height, the slant range measured by the two radars will always be different. The I1 slant range value given by the in-fill radar must be converted to the slant range with respect to the location of the main radar to be able to display target data from both radars on the same surveillance display measured with respect to a common reference point. This is impossible without the height information of the target from at least one source. The height information applied for this correction may be height information measured by a 3D radar, or Mode C information available from SSR data or, when such data is unavailable, an assumed value in some cases.

SUR13A.173 For example the slant range and azimuth detected by the in-fill radar can be transformed to ground range and position in X, Y, Z co-ordinates if the elevation is known. If the relative positions of the main primary radar and the in-fill radars are known, the X, Y, Z co-ordinates can then be transposed to ground range, and position in X, Y, Z co-ordinates with respect to the main primary radar origin. The height data can then be applied to covert the Cartisian X, Y, Z co-ordinated to range and azimuth polar co-ordinates with respect to the origin of the primary radar.

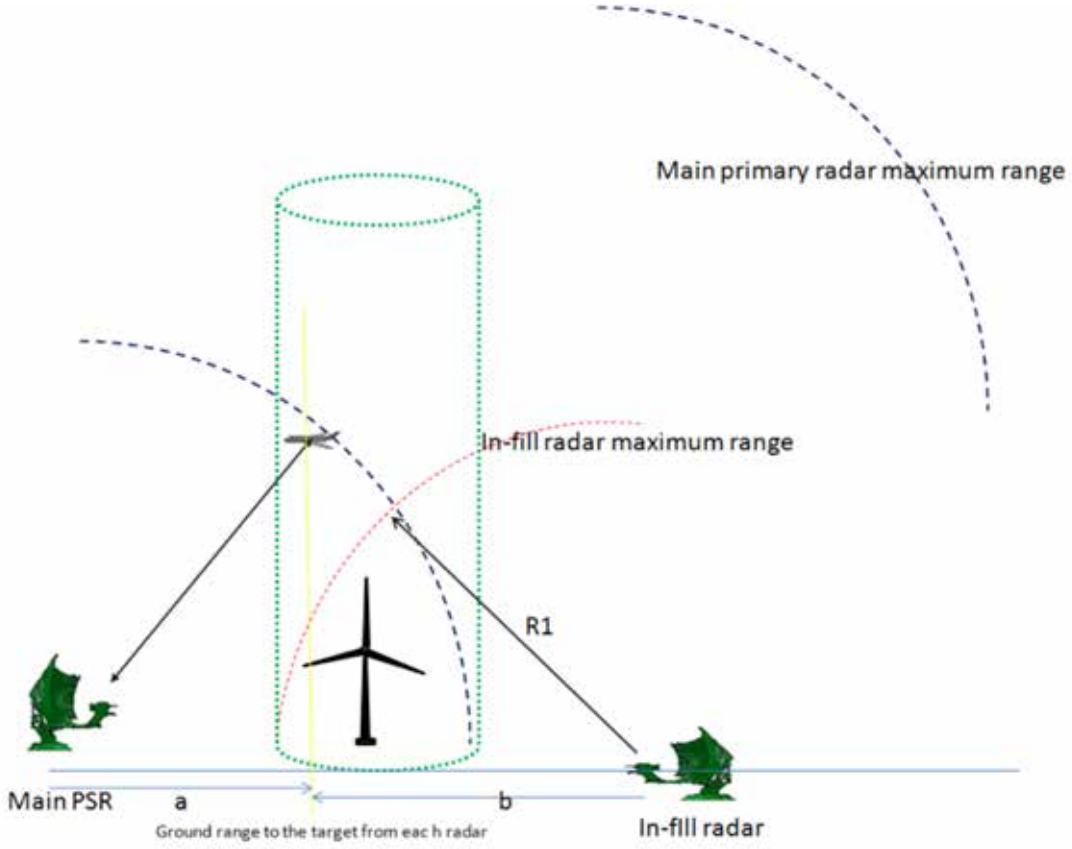
SUR13A.174 The slant range correction process becomes easier if the in-fill radar is a 3D radar which contains an accurate height information, or if the Mode C information is available from at least one surveillance feed. In the absence of this information, the height information applied will be an estimated value depending on the method used by the integration mechanism and the in-fill radar involved.

SUR13A.175 An alternative solution to the slant range error problem is to co-locate the two surveillance sensors or locate them as close as possible, although this may not be always feasible.

Replacing In-fill Radar Data with Main Primary Radar Data

SUR13A.176 Often the output from the in-fill radar are integrated into the main primary radar, by removing the cluttered area of wind turbines detected by the main primary radar and replacing this area with the output from the in-fill radar. Since the display consists of range and azimuth cells, removal of range and azimuth cells consisting of wind turbine area requires careful identification of the area that requires removing from the existing surveillance picture and needs replacement.

Figure 5: Illustration of potential to lose targets by the in-fill process

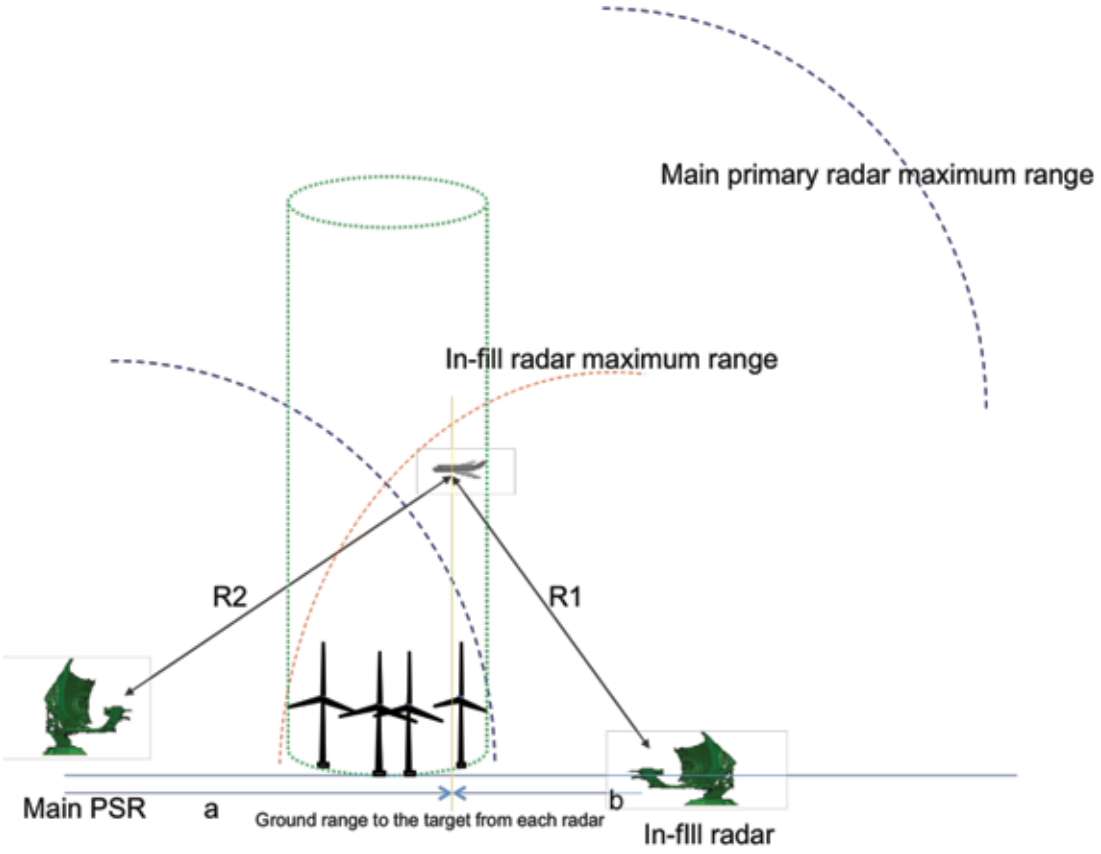


SUR13A.177 Typically most in-fill radars have shorter maximum range than the approach primary radars. For example a typical approach primary radar has a range of about 40–60 NM coverage. In the illustration above, the maximum range of in-fill radar is R1, whilst the maximum range of the main radar is much more beyond R1. All aircraft flying in the cylindrical volume of airspace above the wind turbine are likely to be affected by wind turbine interference on the controller's display. The maximum range of the in-fill radar may be just about enough to cover the farthest point of the wind farm region from the in-fill

radar at the ground level. However since targets are above ground level, the slant range to the target exceeds the maximum coverage range of the in-fill radar at the upper layers of airspace. The target is therefore not seen by the in-fill radar. The target is detected by the main PSR, however as the range covering the cylindrical volume of airspace above the wind farms is removed from the main PSR picture, there is potential for this target to disappear from the display making it completely undetected. The in-fill radar coverage should therefore be enough to reach aircraft in the farthest and upper most levels of vertical coverage in the operational coverage volume. Similarly the area removed by the main PSR should not result in gaps of coverage by both radars where aircraft will not be displayed.

SUR13A.178 Similarly if the aircraft is within the coverage of both the main and the in-fill radar however outside of the area (range) which is removed by the main radar, the target will appear twice on the surveillance display.

Figure 6: Illustration of potential to duplicate targets by the in-fill process



Coverage of Surveillance Sources Providing Coverage over the Wind Farm Region

SUR13A.179 Depending on the mitigation mechanism chosen by the ANSP, service may be provided based on surveillance data from a co-operative sensor or a primary radar in-fill sensor or by having duplicate coverage on full or part of the surveillance display including the wind farm region by an additional primary sensor. Whilst the in-fill sensor must provide complete coverage over the full volume of airspace within the operational boundaries above the wind farm, its range may further extend. Similarly any other sensor providing coverage over the wind farm region may not only have coverage just above the wind farm but extended beyond that. ANSPs may wish to have this additional coverage for added benefits such as increased redundancy and contingency measures.

SUR13A.180 The range of the in-fill radars specifically designed to address wind turbine interference normally have a shorter range than the normal primary radars used for air traffic surveillance. However, the greater the coverage the greater may be the benefits for the ANSPs that receive in-fill data. Also limited coverage of in-fill radars could mean that several in-fill sensors are necessary to address various areas on the display affected by wind turbines including new infrastructure to support each time an in-fill is added.

SUR13A.181 It may also be that the in-fill radar requires coverage outside the precise wind farm area to enable it to smoothly integrate the targets with the targets from main radar. In the case of a co-operative sensor providing coverage over the wind farm region, having extended coverage could mean that combined data could be presented with increased confidence regarding the target position.

Locating the In-fill Sensors

SUR13A.182 As described in paragraph SUR13A.143, in-fill sources can take many different forms. Some in-fill radars are specifically designed with sufficient range coverage to cover only the area of a wind farm. Whilst others may have a bigger range, that can be used for additional redundancy in the system. Some in-fill solutions are designed to be located within the wind farm whilst others can be located outside of the wind farm.

Performance Monitoring of the In-fill Radar

SUR13A.183 Any surveillance sources providing surveillance data to form the overall surveillance picture affects the performance of the entire surveillance system. This section focuses on performance monitoring of primary in-fill radars.

SUR13A.184 Although the in-fill system may be tested and its performance demonstrated at the commissioning of the in-fill system, all surveillance systems must have methods of monitoring the on-going performance.

SUR13A.185 All primary radars, whether plot extracted or non-plot extracted, have methods of alignment checking. This normally involves permanent echoes or active reflectors (MTI Markers). These can either be displayed on the controller's display and or used in the BITE/RTQC for automatic detection of mis-alignment.

SUR13A.186 In addition to alignment checking Built In Test Equipment (BITE) and Real Time Quality Control (RTQC) functions within modern systems check the on-going performance of the system.

Timeliness of In-Fill Data

SUR13A.187 "Timeliness" of data is defined as the difference between the time of output of a data items and the time of applicability of the data items in the SES Interoperability Regulations (SPI IR).

SUR13A.188 Any delays introduced either by the inaccuracies or inconsistencies of the time stamping process, the measurement and processing equipment can lead to the data being invalid and inaccurate at the time the data items are actually used.

SUR13A.189 Surveillance reports should be time stamped at the radar site either by absolute time stamp, or by time-in-storage. Accuracy of this time stamping is determined by the difference between the reported time of measurement and the actual time of measurement of the target position. As aircraft are normally moving when a radar position measurement is taken, accurate reporting of the target position requires the measured range, measured azimuth and the time of measurement.

SUR13A.190 The accurate time stamping is very important for the plot association by the two radars for the same target. The time stamping process used by the in-fill sensor and the main radar may be different, but any temporal inconsistencies must be identified and be minimised.

Plot Correlation Process

SUR13A.191 Some ANSPs use an additional surveillance feed simply for overlaying data. Plot combination is also easy when the two radars are co-located since and the rotation is synchronised. Also plot association and combination from two co-operative sensors become an easier process due to the availability of identification data.

SUR13A.192 However in-fill radars may not always be co-located with the main PSR or be rotating type. The difficulty with the in-fill data is that the data from the two sensors must be presented as if they were measured from the main radar in a timely and accurate manner. Whether the plots within the wind farm region are displayed as combined or reinforced plots, some form of time correlation is necessary, otherwise the picture shown within the wind farm region of the display will be the surveillance picture at a different point in time than the data shown on the rest of the display. This will result in the position data shown in the wind farm region having a position error relative to the error in measurements by the main radar. Also especially around the boundary of the wind farm region plots in and out from the wind farm region must be correlated to those plots detected by the main radar to continue tracks.

SUR13A.193 Also due to the differences in position error at the boundary of the wind farm region, greater separation may also be necessary as a precautionary measure.

SUR13A.194 Such a correlation process requires a tracking process in order to estimate the current position of a target detected by the main radar at the time of detection of the same target by the in-fill radar.

Accuracy

SUR13A.195 Surveillance data displayed to the controller must always meet the required horizontal position accuracy regardless of whether the surveillance data is obtained from a single sensor or multiple different sensors. The position accuracy is the accuracy with which the radar system provides the true position of the aircraft at a given time. Accurate reporting of the aircraft position requires reporting of measured range, measured azimuth and time of measurement.

SUR13A.196 The accuracy is expressed in terms of maximum positional errors which are categorised as systematic errors, residual errors and jumps.

SUR13A.197 There are many factors that impact the accuracy of the positional information measured by a radar. These are applicable to both the main radar and the in-fill radar. The systematic errors are bias errors for each radar in position and time with respect to an absolute reference system. These for example can be caused by bad north alignment of the radar. These can be corrected if known. Residual errors are the deviations in position which exist between the measured target report position and the trajectory at the time of the target report, after correcting any systematic errors. Residual errors can be caused by phenomena such as occasional beam distortion, small timing errors, quantisation noise etc.

SUR13A.198 The accuracy of the reported position information by the in-fill surveillance system may be predicted by the performance prediction models used by the manufacturers of such systems. However the accuracy of the positional information reported by the overall ground based surveillance system following the implementation and integration of in-fill radar data must be demonstrated through practical performance assessment tests.

Co-ordinate Conversion Process

SUR13A.199 In a radar data processing system that uses target reports from a number of sensors, all measured plot positions have to be transformed into one common co-ordinate system. Sometimes the latitude/longitude co-ordinates of a radar system are not accurate, causing systematic offsets in the calculated X, Y variables. Additional errors may be caused by the inaccuracy of the co-ordinate conversion algorithm. Since all such errors are mixed with the errors in the measured range and azimuth variables, they can only be properly estimated by a tool that uses very accurate co-ordinate conversion algorithm and a reliable earth model such as WGS-84.

Differences in Update Rates/Scan Rates

SUR13A.200 Scan time is the mean time between successive measurements of the same target. For a rotating radar, this is the revolution rate. The update rates between the main PSR and the in-fill system may not be the same. The in-fill radar may scan at a faster rate on a target than the main PSR. However the update rate required by the operational requirement may be that of the main radar.

SUR13A.201 A higher scan rate of the in-fill radar means that more up-to-date and more accurate position information is available from the in-fill radar

than the main radar. It is however up to the ANSP to decide whether the most recent position by the in-fill radar must be used each time data is updated on the controller's screen, or whether an averaged position or a position corresponding to the time of measurement by the main radar is to be output.

Processing Capacity (In-fills/filter software/work-rounds)

SUR13A.202 Any infill solution requires additional processing in order to integrate the positional data from an in-fill radar to the main radar picture correctly and accurately.

SUR13A.203 The ANSP may need to implement additional processing equipment in order to enhance the processing capacity of the system.

SUR13A.204 Also an ANSP may be affected by more than one wind farm in the operational area of the screen so that it may be necessary to integrate more than one in-fill radar feed in order to mitigate clutter from all wind turbines affecting the ANSP's PSR coverage.

SUR13A.205 The ANSP should consider the capacity of their existing systems or new systems to process the in-fill feed/s, additional equipment and facilities required for such equipment and identify any limitations.

Processing Delay/Latency (in-fills/filter software/work-rounds)

SUR13A.206 Any additional level of processing required by various wind farm mitigation techniques, be it either an in-fill solution or a spectrum filter software based solution, has the likelihood of increasing the processing delay.

Data Formats of an In-fill Radar and the Required Processing System Capability

SUR13A.207 When using an in-fill radar as a mitigation solution it must be possible to integrate the in-fill radar data into the main PSR data used by the airfield. Most modern radars use the ASTERIX format including all NATS en-route radars. However older systems within the UK may still use formats such as RDIF. In order to be able to integrate an in-fill radar data, the infill radar must have the capability to output the target data in the same format that is used by the ANSP surveillance system.

Analogue Radar Sources as In-fill Radars

SUR13A.208 Although most modern primary radar systems are plot extracted systems, there still exist a number of non-plot extracted primary radar systems in the UK that are used for providing civil air traffic services.

SUR13A.209 It is also possible that radar feeds are provided from such non-plot extracted PSRs as in-fill feeds to other primary radars that suffer from wind turbine effects simply due to the fact that the radar providing the feed does not see the wind farm due to terrain effects. However the primary radars that are specially designed as in-fill radars to address wind turbine effects are modern systems and are therefore likely to be plot-extracted systems.

SUR13A.210 There are additional issues specifically related when trying to combine data involving non-plot extracted systems.

SUR13A.211 Where an analogue PSR is being used as an in-fill radar to be integrated into a plot-extracted system, the data from the analogue must be plot extracted in order for it to be possible to integrate the analogue radar data into a plot extracted radar picture. A plot extractor must then be fitted at the radar head of the analogue radar to make such integration possible. The plot extractor must then output the plot data in an appropriate format.

SUR13A.212 Equally when using a plot-extracted in-fill feed to be integrated into a non-plot extracted system, the two areas on the display would look significantly different whereby the area on the display with the in-fill data would look as confirmed tracks or plots, and the rest of the area on the display would display the raw video.

SUR13A.213 From a display point of view this is not a recommended practice. Radar Displays are the coupling link between radar information and the operator. By using processed radar data on the display the display technique is optimised to improve the information transfer to the operator, whereas an unprocessed display showing the raw video has a different degree of information transfer to the operator leaving the operator to do the processing through his visual sensors.

SUR13A.214 Also, when trying to correlate target data of an aircraft transiting the boundary of the wind farm region, the track correlation and integration becomes an impractical process due to the different levels of processing in the two types of data.

SUR13A.215 Although it is highly unlikely and technically possible to combine analogue in-fill data feed into an analogue primary radar, the unprocessed video from the two radars of the same target may look very different both in size and intensity, hence combining two analogue feeds is not an ideal situation.

PSR/SSR Combined In-fill Feeds

SUR13A.216 An ANSP might choose a remote surveillance data feed from a combined PSR/SSR system that does not see the wind farm, but is capable of detecting the targets within the same area of airspace affected by wind turbine for the local primary radar. For example the current NATS Cromer feed to Norwich is populated with Combined and SSR-only target reports.

SUR13A.217 If the in-fill is a combined feed it is also possible to use a combined in-fill feed as long as the message formats from the combined feed are compatible with the message formats used by the main primary radar and the processing systems that are used to integrate the in-fill sources and the main PSR source.

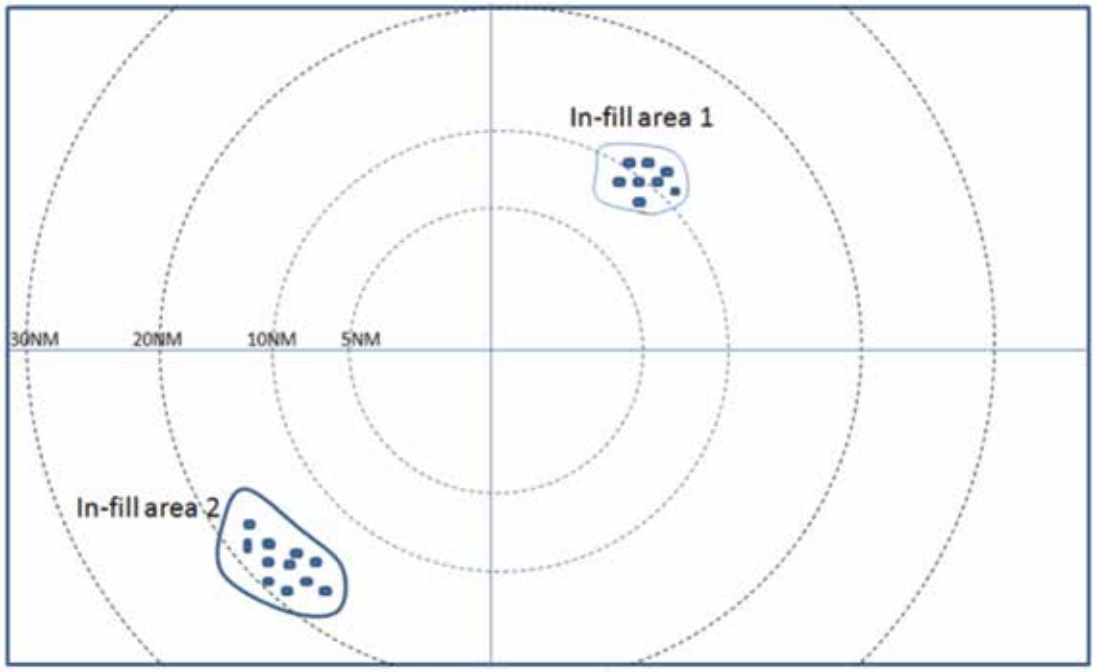
SUR13A.218 Having SSR Mode C altitude information can be an added benefit to the slant range correction process described in a previous section.

SUR13A.219 SSR only or other co-operative only in-fill data may be acceptable in circumstances where the ANSP could provide a valid safety argument that all targets within the airspace that is affected by wind turbines on the controllers display, are fully equipped with transponders.

Display Aspects

SUR13A.220 It is also necessary to consider how the in-fill areas are integrated into a surveillance display system (HMI) and how the in-fill areas impact the controller's display.

Figure 7: Multiple In-fill areas on a surveillance display



SUR13A.221 It is expected that rather than feeding completely independent individual feeds into the display system, some combination process will be applied prior to the display system to correlate and combine target reports where necessary.

SUR13A.222 There may be more than one in-fill area on a controller's display for which additional processing mechanisms have been applied to the data received by various in-fill sources.

SUR13A.223 The co-ordinate conversion process and the timeliness of data discussed in previous sections are also important in ensuring that data displayed on the HMI are valid and accurate.

SUR13A.224 It is important to consider how the in-fill areas or wind turbine affected areas are displayed to the controller both in normal operating conditions and in the failures of the in-fill radar or other mitigation solution applied to the surveillance data over the wind farm area.

SUR13A.225 In normal operation, displaying the in-fill region can be advantageous as a method of on-going performance verification by manual observation by the controller. For example the controller would be aware that the data over the wind farm region are fed in from an in-fill sensor or special processing techniques are applied over this

region. Hence track continuity, track jumps or losses can be noted over this area.

SUR13A.226 In the case of a failure of a wind farm mitigation technique, depending on the system configuration, this region may appear as a totally blank area, or filled in with wind turbine clutter making the failure more obvious to the controller.

SUR13A.227 Also, in the failure of the in-fill radar, or other mitigation techniques applied, ANSPs must also consider means of mitigating the risks arising from this failure. It may be that the controller has to either switch and choose a different in-fill source or apply special procedures to mitigate by procedural control.

Use of Height Information from 3D Radars or Mode C Information from PSR & SSR Combined in-fill Feeds

SUR13A.228 As described previously, the slant range error must be corrected when integrating data from a radar located in a different location than the main primary radar. The height information is necessary for applying this correction. This is often done either by using height information from a 3D radar where the in-fill radar used is a 3 dimensional radar, or where SSR information is available, by using the Mode C pressure altitude information.

SUR13A.229 When neither of these altitude information sources are unavailable, and the main radar and the in-fill radars are not co-located, normally a configurable default altitude setting is applied for the slant range correction process where the default value can be selected to best suit the particular circumstances around the enhancement areas, the type of in-fill radar and the use of the airspace.

Mitigations Against Failures of Mitigation Techniques including In-Fill Radars

SUR13A.230 A mitigation technique is applied to mitigate any risks that arise due to the effects of wind turbine interference. Therefore the failure of a mitigation technique including an in-fill radar would mean that the increased level of risk exists upon its failure.

SUR13A.231 In the event of a failure of an in-fill source (or other mitigation process), the following options may be considered:

- To tolerate the cluttered area until the in-fill radar is re-instated in service

- apply a work-round such as sector blanking if this is a feasible option (no targets at all in the in-fill area)
- use a different surveillance source such as a remote SSR feed to cover the in-fill area if this is feasible in the airspace concerned
- switch to complete procedural control without the use of display

SUR13A.232 In each situation, the appropriateness of these various options depends on a number of variables in the specific context of operation. These include:

- the availability of other in-fill sources or secondary only sources (e.g. SSR or WAM)
- the transponder equipage of aircraft in the affected area
- operational significance of the affected area
- ability of the processing systems to configure to switch to various sources and modes of operation
- the approximate time to repair the in-fill source and re-instate it
- controller's overall ability to adopt to each situation

Indication of Failure of Wind Turbine Mitigation Technique

SUR13A.233 The failure of an in-fill radar or other automated processing technique used may be indicated by the controller using an audible alarm or a visual indication or both. Otherwise the failure of the in-fill source may only be visible to the controller by the continuous absence of any target data on the display.

Impact of Using Automatic Mitigation Techniques on Safety Nets

SUR13A.234 The use of an in-fill radar or other automatic mitigation techniques may also have an impact on the performance of safety nets. The current ground based safety nets policy is stated in CAP 670 under Display System Technical Requirements.

SUR13A.235 Depending on the mitigation technique applied, it may not be possible to operate the safety nets over the wind farm area. Also in the failure of an in-fill radar, the absence of positional data would mean that the safety net function cannot be applied during this outage period. Whilst the safety nets must not be relied upon to achieve an acceptable level of safety, ANSPs may have taken the

contribution of the safety nets into account when achieving an acceptable level of safety. In such circumstances risks of losing the safety nets functionality must be addressed by appropriate mitigation means.

Reliance on In-fill Radars as a Back up Surveillance Coverage Method

SUR13A.236 Although highly unlikely it is possible for an ANSP to rely on an in-fill radar to provide coverage over a greater range beyond the wind farm affected area, to use as a fall back surveillance layer, in the event of a failure of a main Primary Radar. In some in-fill solutions the range may be configurable to depending on the operational requirement. It is known that some wind farm mitigation primary radars have the ability to adjust its range beyond 20 NM.

SUR13A.237 If this is the case, the wind farm mitigation radar could perform two roles:

- to act as a mitigation of wind farm clutter on the display that is an essential part of the main surveillance system used primarily under normal circumstances
- to act as a contingency measure (a redundant feed) in the event of a failure of the main PSR

SUR13A.238 In such circumstance the ANSP's safety case must identify the in-fill radar's contribution both as a mitigation (i.e. a barrier) in the event tree analysis and also in assessing the failure modes of the main surveillance system including the entire ground based surveillance chain. Hence the failure rates of an in-fill radar and the rates of failures would affect the main surveillance system as well as the availability of a barrier that would act as a mitigation in the failure of the main PSR.

Support and Maintenance of Mitigation Equipment

SUR13A.239 The support and maintenance requirements for the in-fill radars (or other equipment based solutions) is another area which should be considered by the ANSPs in selecting the appropriate mitigation solution. It is possible that the in-fill radar may be maintained under separate contractual arrangements by a 3rd party. Effective maintenance and repairing processes increase the availability and the reliability of the in-fill radar, hence is a contributory element in

providing a robust safety argument for the reliability and availability of the in-fill solution.

Approval of In-fill service Providers as ANSPs or CNS Providers

SUR13A.240 Currently where an in-fill radar is not operated by the user of the data, that operator is considered to be an 'operating organisation', as defined in Commission Implementation Regulation 1035/2011 Article 2(8).

"operating organisation means an organisation responsible for the provision of engineering and technical services supporting air traffic , communication, navigation and surveillance services."

SUR13A.241 The user of the data provided by the operating company is considered to be the CNS provider and will be a certificated ANSP. Typically, in the UK there are no 'stand alone' CNS providers. All certificated CNS providers are associated with the provision of an Air Traffic Service or an Air Ground Communication Service.

SUR13A.242 However providers, or potential providers, of in-fill service data should be aware that the CAA is considering redefining providers of such surveillance services as CNS providers, which would require the provider's organisation or company to obtain certification as an Air Navigation Service Provider (ANSP), providing CNS services, in accordance with Regulation 550/2004 Chapter II, the Service Provision Regulation. This would require the provider to demonstrate compliance with Commission Implementation Regulation 1035/2011 Annex I, Annex II and Annex V.

Part 7: Existing Guidance Material

SUR13A.243 The CAA has published CAP 764 "CAA Policy and Guidelines on Wind Turbines" which contains further guidance and safeguarding considerations.

SUR13A.244 The Eurocontrol Wind Turbine Task Force has also developed some guidance material for assessing wind turbine effects on ATC radars which can be accessed via the following link:

www.eurocontrol.int/sites/default/files/content/documents/single-sky/guidelines/20100609-impact-wind-turbines-sur-sensors-guid-v1_1.pdf

SUR13A.245 CAP 670 GEN 01 contains generic high level requirements and guidance on the safety assessment of wind turbines near ATC radars.

Part 8: References and Further Reading

1. BWEA Report; Wind Turbines and Radar- Operational Experience and Mitigation Measures
2. The Operational Effects of Wind Farm Developments on ATC Procedures for Glasgow Prestwick International Airport.
3. www.ontario-sea.org/Storage/26/1787_Wind_Turbine_Interference_with_Air_Traffic_Control.pdf
4. www.eurocontrol.int/sites/default/files/content/documents/nm/guidelines-_impact-of_wind-turbines-surveillance-sensors_v1_1_web.pdf
5. NTIA Technical Report TR-08-454; Asessment of the Effects of Wind Turbines on Air Traffic Control Radars.
6. Wind Farms Impact on Radar Aviation Interests – Final Report by Gavin J Poupart
7. Introduction to radar systems by Merrill I. Skolnik (2nd edition)
8. Manual on testing radio navigation aids volume 3, ICAO Doc 8071

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PART C, SECTION 4

Meteorological

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MET 01: Use of Meteorological Information in ATS Units

This document should be read in conjunction with CAP 746 Requirements for Meteorological Observations at Aerodromes (www.caa.co.uk/CAP746).

Introduction

MET01.1 The origination of meteorological reports and other related information is regulated by the UK Meteorological Authority, Room K6, CAA House, 45-59 Kingsway, London, WC2B 6TE, telephone: 020 7453 6526.

MET01.2 The use, display and processing of meteorological data within an ATC unit is regulated by the CAA's Safety Regulation Group.

MET01.3 Where applicable, IRVR data is also presented to ATC in dynamic (real-time) form. In these circumstances, the equipment used to derive this information and to present it to ATCO working positions within an ATC unit is regulated by the CAA's Safety Regulation Group.

MET01.4 The equipment that is used to derive the surface wind information may be the same as that used to originate the meteorological report for the aerodrome. In this case, only the equipment used to display (and, if appropriate, to process the data specifically for presentation to the air traffic controller) is regulated by the CAA's Safety Regulation Group.

MET01.5 Automatic Terminal Information Service (ATIS) equipment and the content of ATIS broadcast messages are regulated by the CAA's Safety Regulation Group.

Supply of Meteorological Data

MET01.6 Although it is recognised that much meteorological data (typically routine and special reports) is generated by staff who have other primary responsibilities (such as the provision of air traffic control and supporting services), for the purposes of safety regulation the meteorological service is considered to be separate from the air traffic control service.

MET01.7 Suitable training for ATS staff in the use of meteorological equipment and their displays must be provided.

Processing and Display of Meteorological Data

General

MET01.8 When received, meteorological data shall be presented to the air traffic controller (and other users within the ATC unit) without any unnecessary delay and without affecting the integrity of the data supplied (1776).

MET01.9 The equipment used to display meteorological information shall be designed in such a way as to draw the attention of the user to significant changes in the displayed meteorological information (1777).

MET01.10 Numeric or graphical displays used to display meteorological information shall indicate clearly the meaning of any item of information that might be ambiguous or confused with any other item (1778).

MET01.11 A suitable method for testing the correct operation of the display equipment shall be provided (1779).

MET01.12 A suitable method for controlling the display luminance (and other adjustments that can aid readability of the displayed data) shall be provided (1780).

MET01.13 Where meteorological data is broadcast on ATIS the displays in operational control positions shall indicate the code letter used to identify ATIS broadcast (1781).

Surface Wind Data Display

MET01.14 The two-minute mean direction and the two-minute mean speed of the surface wind are to be displayed (51). In addition, the extremes of direction and speed (gust and lull) during the past 10 minutes shall be displayed (52).

Note: A facility to provide an instantaneous surface wind speed and direction should be available to support pilots who request it, particularly at aerodromes supporting the primarily the operations of aircraft whose maximum total weight authorised is 5,700 kg or less (66).

MET01.15 The extremes in direction and speed (gust and lull) should be derived from the 3 second rolling average of the wind speed samples (1784).

MET01.16 The wind direction shall be displayed relative to magnetic North and shall take account of the discontinuity at 0°/360° (1786).

MET01.17 The technical requirements for sensors used to provide dynamic surface wind information at operational control positions are detailed in CAP 746 Requirements for Meteorological Observations at Aerodromes.

Wind Speed and Direction Sensors

Note: Additional information on wind speed and direction sensors can be found in CAP 746 Requirements for Meteorological Observations at Aerodromes.

MET01.18 Since in practice, it is difficult to measure the surface wind directly on the runway, surface wind observations for take-off and landing should be the nest practicable indication of the winds that an aircraft will encounter during take-off and landing (53).

MET01.19 For reports for take-off, the surface wind observations are the be representative of conditions along the runway (54), and for reports for landing the observations are to be representative of the touchdown zone (55).

MET01.20 At aerodromes where the topography or prevalent weather conditions cause significant differences in surface wind at various sections of the runway, additional sensors are to be provided.

MET01.21 Where separate sensors are required as specified above, the indicators shall be clearly marked to identify the runway and section of runway monitored by each sensor (62).

MET01.22 Where multiple sensors are installed, the two minute averages and significant variations in the surface wind direction and speed from each sensor used in reports for take-off and landing are to be monitored by automatic equipment (76).

RVR Data

MET01.23 RVR data derived by Instrumented Runway Visual Range equipment shall be derived and displayed as described in Part C, Section 2, NAV 01 (1787).

MET01.24 RVR data derived by the Human Observer method shall be displayed in operational positions as a distance (measured in m) determined from conversion tables approved for the purpose (1788).

MET01.25 The procedures for converting the human observer reports into RVR values shall be described in the unit MATS Part 2 (1789).

Multi-function Displays

MET01.26 If a single data display is used to display both meteorological and other information it shall not display erroneous information because of the failure or incorrect operation of those other information sources (1790).

Contingency Arrangements

MET01.27 ATS Providers shall identify the effect of equipment failure (or other cause of the loss of meteorological information) on the provision of the air traffic control service (1791).

MET01.28 Wherever practical, alternative sources of information or other mitigation measures shall be identified and the associated operational procedures documented (1792).

Recording

MET01.29 **Recommendation**: The data displayed at control positions should be recorded and the records should be retained for at least 30 days (1799).

MET01.30 **Recommendation**: It should be possible to recreate reliably the appearance of the data display at an operational position from the recorded data (1800).

PART C, SECTION 5

Information and Alerting Systems

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IAS 01: Information and Alerting Systems

Part 1 Preliminary Material

Introduction

IAS01.1 Information and alerting systems used in the provision of an ATS are required to be approved for use under the terms of Article 205 of the ANO.

IAS01.2 This document may be used in isolation or in conjunction with other requirements documents published by the CAA.

Scope

IAS01.3 This document sets out the safety requirements for information and alerting systems used at locations within the UK providing ATS.

Part 2 Requirements

Status Indicators

IAS01.4 Any equipment or facility which has a direct effect on aircraft safety shall have a display showing its status, if not readily apparent, visible to the controller (205).

Recommendation: Where indications of system failures are presented at multiple controller work stations, an adequate safety assessment should be undertaken related to the effects of multiple audible or flashing indicators, the cancellation process for multiple alarms including the cancellation of alarms in other remote locations, the need to cancel alarms at unmanned positions, and any distraction that may be caused to operational tasks.

Data Display Systems (DDS)

IAS01.5 Providers must satisfy the CAA that the system is adequate for its purpose by design or by procedural mitigation (210).

Note: If the system is not capable of demonstrating the required level of safety, for example, because integrity or reliability is not as predicted, then it will be acceptable to include procedures in MATS Part 2 which mitigate deficiencies to ensure that a failure (total or

partial) is not hazardous. Included in these procedures will be details of alternative sources of safety-related information.

IAS01.6 All systems on which information is displayed to ATC for operational use should be designed, installed, configured and maintained in a manner which ensures the integrity of the information (211). As the hazard to aircraft of passing incorrect, misleading, corrupt or anomalous information can vary according to its phase of flight, the integrity requirements will vary accordingly.

IAS01.7 DDS for operational use by controllers should be easily visible from relevant control positions (212). The display should be clear and free from reflections (213). Systems should not divert the attention of controllers at operational positions unless specifically designed to do so (214).

Flight data display

IAS01.8 Flight data displays (such as flight progress strip boards or pinboards) are to be provided (204). Approval may be given for shared displays (for example where two radar controllers work side by side with the data display between them).

Flight Data Processing (FDP) and Electronic Flight Progress Strips (EFPS) Systems

IAS01.9 The following text includes salient points derived and interpreted from the relevant EC Regulations. **To ensure full compliance with these Regulations they should be read in full.** Links to the source material are provided in this section. They apply to Units providing services to General Air Traffic.

Software

IAS01.10 Software related aspects of FDP and EFPS Systems shall comply with Part B, Section 3 SW 01 Regulatory Objectives for Software Safety Assurance in ATS Equipment (1755).

Records

IAS01.11 FDP and EFPS systems shall comply with requirements for retention of records as detailed in CAP 493 Manual of Air Traffic Services Part 1, Section 8, Chapter 1 and Section 6, Chapter 1 (www.caa.co.uk/cap493).

General Issues of Particular Note for FDP and EFPS Systems

IAS01.12 It is recommended that the following issues are considered as part of the system and safety assurance development:

Note: This list is not exhaustive.

- The provision of hand written strips arrangements as backup in case of system failure;
- Timely printing of flight progress strips well before aircraft boundary arrival time;
- Adequate training of operators in human machine interfaces including interaction with directly displayed information and lower level information that needs to be retrieved from other sources, general use of system controls, generation and handling of strips, understanding of warning messages and particular attention to inadvertent closing of displays and processing systems (with resultant time displays to restart applications, as much as 30 seconds);
- Arrangements for procedural control and separation in case of FDP system failure (including TRUCE etc.);
- Lack of changed flight plan/routing information being promulgated to Controllers;
- Adequate alerting of VFR flights to all relevant ATC units, in case systems only forward IFR related data;
- Incorrect assumption of wake vortex category if aircraft type is not recognised to system;
- Two flight plans in the system for the same flight;
- Incorrect identification of aircraft types;
- Mixing of messages between aircraft relating to two aircraft messages being received or input at the same time;
- Planned outages or maintenance not being synchronised with unusual circumstances such as bad weather and flight delays to numerous aircraft;

- Inadequate Service Level Agreements with external (e.g. Airport) Authorities affecting related devices such as servers resulting in un-serviceability of systems/links and hence a need for manual intervention; and
- Ability of strips to display sufficient information or provision of easy access to additional information (strip message space limited).

Flight Plans in the Pre-flight Phase

IAS01.13 For ATS Units having the capability and responsibility for generating flight plans, FDP and EFPS Systems shall ensure adequate checking of data format, data conventions and accuracy and shall indicate acceptance of flight plans.

IAS01.14 Such systems shall ensure adequate communications between all affected ATS Units, operators and their agents, pilots and their agents.

IAS01.15 Changes to flight plans shall be communicated adequately to all stakeholders to ensure safe conduct of flights.

IAS01.16 ANSPs shall ensure that personnel involved in flight planning are fully aware of the relevant provisions of Commission Regulation (EC) No. 1033/2006 of 4 July 2006.

IAS01.17 To facilitate this, ANSPs shall develop and maintain operations manuals, working methods and operating procedures. ICAO provisions specified in Commission Regulation (EC) No. 1033/2006 are:

1. Chapter 3, paragraph 3.3 (Flight Plans) of ICAO Annex 2 – Rules of the Air (10th edition – July 2005);
2. Chapter 4, paragraph 4 (Flight Plan), and Chapter 11, paragraph 11.4.2.2. (Filed flight plan messages and associated update messages) of ICAO PANS-ATM Doc 4444 (14th Edition – 2001); and
3. Chapter 3 (Flight Plans), and Chapter 14, paragraph 14.1.4 (Flight information region boundaries estimates) of Regional Supplementary Procedures, Doc 7030/4 – EUR, Part 1, Rules of the Air, Air Traffic Services and Search and Rescue (Fourth edition – 1987, incorporating Amendment No. 210).

Note: As ICAO documents are updated, the latest version will be referenced in the EC Regulations. Furthermore, certain ICAO documents themselves are being transposed into EC Regulations and developments in this area will be communicated to via CAA Information Notices and on the CAA Website.

Flight Data Exchange between ATC Units using Automatic Systems

IAS01.18 Data exchanged between units shall be recorded.

IAS01.19 Such automatic systems shall comply with the conformity and verification requirements of the Interoperability Regulations. Details regarding compliance with the Interoperability Regulations can be found on the CAA website at www.caa.co.uk/SESInteroperability.

IAS01.20 It is recommended that the following points should be used to derive systems specifications and testing regimes (as derived from Annexes in Commission Regulation (EC) No. 1032/2006 of 6 July 2006):

Note: This list is not exhaustive.

- Information handling;
- Warnings of failures and anomalies;
- Recording of data;
- Information content;
- Data revision and change input arrangements;
- Transfer communications;
- Crossing intention notification;
- Crossing clearance request;
- Crossing counter-proposal;
- Crossing cancellation;
- Quality of service and data including availability, reliability, data security and data integrity. Reliability for a system information link shall be at least 96%;
- Processing times. Such times shall be bilaterally agreed;

- Providing a simulated operational and technical environment that reflects the operational environment; and
- Assessment of Conformity or Suitability for Use of Constituents and Verification of Systems (These being generally standard aspects of Interoperability Regulation Compliance).

IAS01.21 The aforementioned Annexes do not provide prescriptive quantitative requirements other than the figure of 96% quoted for information link reliability. ANSPs are advised to define quantitative requirements as driven by relevant safety requirements particular to the operation and stakeholder requirements related to quality, capacity and business needs specifications.

Flight Message Transfer Protocol

IAS01.22 FDP and EFPS Systems used by ATC units shall employ a protocol for electronic communication comprising message formats, their encoding for interchange and sequence rules used for the information exchanges between flight data processing systems that comply with the requirements of Commission Regulation (EC) No. 633/2007 of 7 June 2007.

IAS01.23 Such systems shall comply with the Interoperability Regulations as mentioned previously (Assessment of Conformity etc.).

IAS01.24 The following points shall be used to derive systems specification and testing regimes for automatic systems (as derived from an Annex in Commission Regulation (EC) No. 633/2007 of 7 June 2007):

Note: This list is not exhaustive.

- Each flight message transfer peer entity shall have an identifier;
- An identification function shall ensure that communications can take place only between authorised flight message transfer peer entities;
- A connection management function shall establish and release connections between flight message transfer peer entities ensuring that flight data transfer can be achieved only during the lifetime of a connection;
- A data transfer function shall send and receive flight data messages between connected flight message transfer peer entities;

- A monitoring function shall verify the continuity of service of a connection between flight message transfer peer entities; and
- All functions exchanged between flight message transfer entities shall use Transmission Control Protocol over Internet Protocol, IP version 6.

Reference Material

1. Commission Regulation (EU) No. 1035/2011 Common Requirements (for hazard identification, risk assessment and mitigation); and
2. The SES Interoperability Regulations (for Essential Requirements relating to Seamless Operation and New Concepts of Operation).

IAS01.25 For details related to Flight Data, Flight Plans and Flight Message Protocols:

1. Commission Regulation (EC) No. 1033/2006 of 4 July 2006 laying down the requirements on procedures for flight plans in the pre-flight phase for the Single European Sky;
2. Commission Regulation (EC) No. 1032/2006 of 6 July 2006 laying down requirements for automatic systems for the exchange of flight data for the purpose of notification, co ordination and transfer of flights between air traffic control units.
3. Commission Regulation (EC) No. 633/2007 of 7 June 2007 laying down requirements for the application of a flight message transfer protocol used for the purpose of notification, co-ordination and transfer of flights between air traffic control units.

IAS01.26 Full details can be found on the CAA website at www.caa.co.uk/ATSRequirementsOverview and www.caa.co.uk/SESInteroperability.

Clocks

IAS01.27 A clock which is easily visible from each control position is to be provided (206). UTC shall be shown in hours, minutes and seconds (207) and is to be accurate to within ±15 seconds per day (208).

IAS01.28 Each control position should have a clock (209).

Aeronautical Ground Lighting (AGL) Control and Monitoring Equipment

Definition

IAS01.29 Aeronautical Ground Lighting (AGL) is defined as 'Any light specifically provided as an aid to air navigation, other than a light displayed on an aircraft.' (ICAO Annex 14).

Scope

IAS01.30 This section refers to Aeronautical Ground Lighting installations at licensed aerodromes only.

Safety Objective

IAS01.31 **The AGL Control and Monitoring System shall enable the selection of the required display of lights and provide an indication of the lights displayed to the aerodrome control position.**

IAS01.32 An indication, easily visible from the aerodrome control position(s), showing the actual serviceability status of AGL services (as opposed to the switch position), shall be provided (215). The equipment shall indicate when failure or abnormal operation of the AGL service selected for use falls below levels required by the aerodrome licence (216). These levels are outlined in CAP 168.

IAS01.33 Modern AGL equipment is capable of providing highly detailed system performance information. The serviceability status information required to be passed to pilots shall be readily established from the indications visible from the aerodrome control position(s) (217).

Note: CAP 168 Licensing of Aerodromes describes the technical requirements for AGL control and monitoring equipment.

IAS01.34 All projects concerning AGL shall be referred in the first instance to the appropriate Aerodrome Standards Inspector (1754).

Software

IAS01.35 Software related aspects of an AGL CMS at ATC units shall comply with Part B, Section 3, SW 01 Regulatory Objectives for Software Safety Assurance in ATS Equipment (1755).

Landing Clearance Indicator (LCI)

IAS01.36 When Surveillance Radar Approaches terminating at a distance of less than 2 NM from touchdown are conducted, a landing clearance indicator of approved design must be provided (219).

IAS01.37 The LCI enables reliable, instantaneous, non-voice communication between the aerodrome controller and the radar controller carrying out the SRA. It usually takes the form of a panel of coloured, lighted buttons at each control position.

IAS01.38 The system should incorporate a means by which the aerodrome controller can indicate to the radar controller that an aircraft is to be instructed to make an immediate go-around (220). An audio alert should be associated with this indication (221).

IAS01.39 At units where an LCI system is installed instructions on its use must be included in the MATS Part 2 (222). Details on the interpretation of the various indications are important, particularly at aerodromes where flying training involving planned go-arounds takes place.

Visual Signalling

IAS01.40 A signal lamp with interchangeable coloured lenses (white, red and green) and spare bulb shall be provided (226) and must be accessible to the controller (227). The lamp must enable control of aerodrome traffic as laid down in the Rules of the Air Regulations 2007 (incorporating The Rules of the Air (amendment) Regulations 2009) (228). The light must be visible from all points of the manoeuvring area (229) and from all points within the aerodrome visual circuit.

IAS01.41 Shining the lamp through tinted glass or blinds can affect the perceived colour of the signal.

Emergency Services Alerting

IAS01.42 An audible method of alerting airfield emergency services shall be provided as a primary means of callout (231). A standby means of alerting airfield emergency services, independent of the primary method, shall be identified (232).

Note: Advice and information on suitable devices or methods can be sought from the CAA.

IAS01.43 A means of communicating with other emergency services shall be provided (233).

IAS01.44 Check-lists of actions to be carried out in the event of an emergency (one check-list for each category of emergency) shall be provided (234). These are to be easily accessible to the controllers likely to use them (235).

IAS01.45 Approval of the aerodrome's Emergency Orders is the responsibility of the CAA.

PART D

Human Resources

Part 1 Unit Staffing and Rostering

Staffing Requirements and Duty Hours

D1 The number of operational positions, period of operation and limitation of duty hours dictate the minimum number of validated controllers required at a unit.

D2 The CAA must be satisfied that the unit maintains sufficient qualified controllers to provide safe air traffic control services. Consideration will be given to the regularity of the Air Traffic Control Service in determining whether a service is safe. There must be no possibility that users will be confused as to which service they are receiving because the type of service changes from day to day or hour to hour. Careful consideration will also be given to the provision of more than one service simultaneously before approving a unit.

D3 Although conditions at different units may vary an approximation for the calculation of the minimum number of controllers required is given using the following formula:

Total number of valid controllers, $C = \frac{ND}{365 - R}$ rounded up to whole number

Where:

- 'N' equals the number of controllers required to attend for duties, including a relief to give breaks, each day. This will depend on the number of operational positions and the period for which they are scheduled to open.
- 'D' equals the number of days the unit provides services in a year.
- 'R' equals the number of days a controller is not available for duty, i.e. rest days, annual leave, public holidays in lieu, allowance for sickness and training etc.

Example 1

A unit comprising Aerodrome Control and a combined Approach and Approach Radar Control open seven days a week between 0600 hrs and 2200 hrs. Both positions manned at all times.

N = 6 (i.e. 2 early duties
2 late duties
2 relief duties)

D = 365

R = 120 (i.e. rest days – 3 x 2½ x 12 = 90
leave = 21
public holidays = 9)

Therefore C = $\frac{6 \text{ x } 365}{365 - 120}$ = (8.9) 9 controllers

Example 2

A small unit without radar able to provide a combined Aerodrome and Approach Control service at certain times of the day. Open 6½ days a week between 0600 hrs and 2200 hrs for 6 days and 0800 hrs to 1600 hrs on the half day.

N = 4 (i.e. 1 early duties
1 late duties
1 duty to split positions (max 10 hrs)
1 relief duties)

D = 338

R = 120 (as example 1 above)

Therefore C = $\frac{4 \text{ x } 338}{365 - 120}$ = (5.5) 6 controllers

Certain assumptions have been made in the calculation of 'N' in the examples above. There are many ways of deploying staff and managers may use other criteria in arriving at 'N'. Whatever method is used, the critical factor will be the regulation of hours scheme.

D4 In neither example has any allowance been made for sickness or other duties. If a controller at the unit in the first example became ill and was absent for any length of time this could result in controllers breaching the hours limitations. As this might require some restriction to the operation of the unit it might be prudent to make such allowance.

D5 There is scope in the second example for sickness, training etc. If an allowance of 10 days per controller is assumed, 'R' is increased to 130 and 'C' becomes 5.75. The rounded up figure is still 6 controllers.

Watch Rosters

D6 Providers shall meet the rostering limitations specified in the Scheme for the Regulation of Air Traffic Controllers' Hours set out in Part 2.

D7 Providers shall notify the CAA of formal rostering arrangements of a repetitive nature only once. However, details of the roster actually worked showing variations due to unforeseen circumstances may be required at the discretion of the CAA, particularly where there is a slight shortfall of staff and overtime is likely.

D8 Providers who are unable to set a regular pattern of attendance for ATCOs shall supply to the CAA a copy of the prepared roster at least 30 days before it is due to come into force together with details of each month's, or each four week period's, roster actually worked.

D9 Rosters supplied to the CAA shall indicate where they meet the various rostering limitations specified in the Scheme for the Regulation of Air Traffic Controllers' Hours set out in Part 2.

Ancillary Tasks

D10 An ancillary task is any task in an operational control room which is not directly associated with the provision of an Air Traffic Control Service.

D11 A person must have an Air Traffic Controller's licence to provide an Air Traffic Control Service.

D12 Providers shall not normally require controllers to carry out ancillary tasks while they are providing operational Air Traffic Control services.

D13 Exceptionally, where such ancillary duties are unavoidable, the CAA must be satisfied that controllers will not be distracted from their primary function or placed under undue pressure. These duties and the person responsible for discharging them must be clearly identified in the unit's MATS Part 2.

Operational Support Staff

D14 Controllers may delegate some of their responsibilities to adequately trained support staff (i.e. Air Traffic Service Assistants) provided they do not include duties for which an Air Traffic Control licence is required. These responsibilities fall into two categories:

1. Air Traffic Control related duties are those closely associated with the safety of aircraft (e.g. Telephone messages concerning flight data and clearances). These duties and the person responsible for discharging them must be clearly identified in the unit's MATS Part 2.

2. Other duties of an administrative nature.

D15 Adequate support staff shall be provided. The number and disposition of support staff will depend on the complexity of the unit. The Provider shall arrange appropriate training and shall be responsible for the continued competence of such staff. The CAA may require to be given details of the training that support staff have received.

Management Functions and Responsibilities

D16 The provider shall identify the key personnel responsible for the safe operation of the Air Traffic Control unit. Their positions, responsibilities, functions, accountabilities and authority must be clearly defined in writing and an organisational chart indicating the specific responsibilities must be provided. Changes in these personnel must be notified to the CAA.

Air Traffic Control Licences

D17 All licensed ATCOs must comply with the requirements laid down in CAP 744 Air Traffic Controllers – Licensing.

Part 2 Scheme for Regulation of Air Traffic Controllers' Hours (SRATCOH)

Purpose

D18 The purpose of SRATCOH is to ensure, so far as is reasonably possible, that controller fatigue does not endanger aircraft and thereby to assist controllers to provide a safe and effective service. In all cases the management of controller rostering should be sympathetic to this purpose and where there is any doubt as to the application of these regulations guidance should be sought from the appropriate ATS Regional Manager in the case of Airports or the Head of En-route and College Regulation in the case of Area Control Centres.

D19 The provisions of SRATCOH shall be applied to students and trainee air traffic controllers undertaking live traffic OJT as if they were watch-keeping air traffic controllers.

Definitions and Associated Limitations

Period of Duty

D20 The period between the actual commencement of and the actual end of a shift during which an air traffic controller whose licence contains a rating valid at the unit exercises, or could be called upon to exercise, the privileges of the licence at that unit, and includes prescribed breaks, time spent on other duties such as training, airfield inspection, meteorological observations, collection of landing fees, administration and any extension of duty.

Maximum Period of Duty

D21 Except where other limits are defined within these regulations no period of duty shall exceed 10 hours. Within 720 consecutive hours (30 days) the aggregate of periods of duty and on call duties shall not exceed 300 hours provided that periods of duty do not exceed 200 hours.

Intervals between Periods of Duty

D22 There shall be an interval of not less than 12 hours between the conclusion of one period of duty and the commencement of the next period of duty. This interval may only be reduced (and only by

a maximum of 1 hour) with the approval of the controller concerned and in any individual case such a reduction will be permitted no more than once in a period of 720 consecutive hours (30 days).

Limit on and Interval following Consecutive Periods of Duty

D23 Upon the conclusion of six consecutive periods of duty within 144 consecutive hours (6 days), or upon consecutive periods of duty within 144 consecutive hours (6 days) reaching a total of 50 hours, whichever is the earlier, there shall be an interval of a minimum of 60 hours before the commencement of the next period of duty. This interval may be reduced in accordance with paragraph D24.

D24 Within 720 consecutive hours (30 days) there shall be not fewer than three intervals between the conclusion of one period of duty and the commencement of the next period of duty. These intervals shall total not less than 180 hours with the minimum interval being not less than 54 hours.

Operational Duty

D25 The period during which an air traffic controller is actually exercising the privileges of the controller's licence at an operational position.

Breaks in Operational Duty

D26 No operational duty shall exceed a period of two hours without there being taken during, or at the end of, that period a break or breaks totalling not less than 30 minutes during which period a controller does not exercise the privileges of their licence.

D27 Breaks shall include all measures necessary to ensure that controllers will not be suffering, to any extent as a consequence of their duties, mental or physical fatigue whilst exercising the privileges of their licence. Such measures are expected to include a certain detachment from the operation, e.g. rest areas, some of which shall afford the individual 'quiet space' and facilities for adequate refreshment.

D28 At units where workload for any part of the day is judged to be low and the activity is spasmodic rather than continuous, periods of operational duty, at these times, may be extended to a maximum of four hours, provided that the following break is taken pro-rata (e.g. 45 minutes after 3 hours or 60 minutes after 4 hours).

Note: Judgements on unit workload are to be made by unit managers in consultation with the appropriate ATS Regional Manager in the case of Airports or the Head of En-route and College Regulation in the case of Area Control Centres.

Night Duty

D29 A period of duty wholly or partly within the period of 0130 and 0529 hours.

Limits on Night Duties

D30 Not more than two night duties may be worked in immediate succession. In all cases the maximum night duty period shall not exceed 9.5 hours and the night duty must conclude no later than 0730 hours.

Interval After Night Duties

D31 Upon the conclusion of a single night duty, or two consecutive night duties, there shall be an interval of a minimum of 54 hours before the commencement of the next period of duty.

D32 Providers may, in exceptional circumstances and with the approval of the controller concerned, offer a controller a 48-hour minimum interval between the end of a single night duty and the commencement of the next period of daytime duty. This allowance is not permitted when planning for, or as part of, the published unit roster and is expected to be utilised only to cover short-notice staffing difficulties.

On Call Duty

D33 A period during which, by prior arrangement, a controller is required to be available to report at his place of work with the intention of providing an Air Traffic Control Service.

Limits for On Call Duties

D34 The maximum On Call period of duty, where the controller does not attend the place of work, shall be 20 hours. For the purpose of this particular limitation, all On Call Duty time spent in attendance at the place of work shall count double. For example, if a controller attends the place of work ten hours after commencing an On Call Duty the 20-hour maximum On Call period of duty will be reached when the controller completes five hours at the place of work [10 hours + (5 hours x 2 = 10 hours) = 20 hours].

D35 Not more than two On Call duties shall be worked in a period of 144 hours (6 days).

D36 Prior to commencing an On Call duty controllers are to be rested in accordance with the scheme's regulations and, if called in, will be subject to the minimum interval between duty periods as specified in paragraph D22. An On Call duty controller who is not called in during an overnight On Call duty shall not be utilised before midday on the day the overnight On Call duty finished.

D37 Normally only one attendance at the place of work per On Call duty shall be permitted. Units needing to operate in exceptional circumstances outside these limitations may seek modification by the CAA in accordance with paragraphs D49 to D51.

Early Start

D38 An early start is a period of duty that commences between 0530 and 0629 hours.

Limits on Early Starts

D39 Not more than 2 early starts shall be worked in a period of 144 hours. Consecutive early start duties shall not be permitted where both duties commence before 0600 hours. An early start commencing before 0600 hours shall count as two morning duties when considering the limitations on consecutive morning duties in paragraph D43.

D40 The early start maximum duty period shall be 8 hours.

D41 At units where the two hour maximum duty period is reduced to 1.5 hours by enhanced relief, all operational duty periods for a controller on an early start commencing **before 0600** shall be limited to hours (on any operational position whether designated

for enhanced relief, or not). For a controller on an early start commencing **at or after 0600** (on any operational position whether designated for enhanced relief, or not) the first operational duty period shall be limited to 1.5 hours.

Morning Duty

D42 A morning duty is a period of duty that commences between 0630 and 0759 hours.

Limits on Morning Duties

D43 A maximum of 5 consecutive morning duty periods shall be permitted. For the purpose of this calculation early starts shall be counted and those commencing before 0600 hours shall count double. The maximum morning duty period shall be 8.5 hours.

Additional Limitations

Reduction of Intervals for Handover

D44 In this scheme, where an interval of a minimum of 60 hours or 54 hours between periods of duty is stipulated, that interval may be reduced by up to 30 minutes solely for the purpose of orderly shift Handover.

D45 The time taken for orderly handover/takeover before a shift start, up to a maximum of 15 minutes, shall not be considered to form part of the oncoming controller's period of duty.

Holidays

D46 During any calendar or leave year not fewer than 10 days of total holiday entitlement shall be taken in periods of not less than five consecutive days of booked leave (excluding rostered days off).

Simulators

D47 Operational and Emergency Continuation Training on simulators and other simulator activity, which may affect a controller's licence, shall be counted the same as operational duty when considered for the purposes of the scheme.

D48 Trial and evaluation simulations which take place within periods of duty, or in place of operational duties, may be conducted within the overall limitations of Periods of Duty. However, trial and evaluation

simulations which take place within the normal 60 hour or 54 hour intervals between periods of duty shall have an interval of 48 hours between the end of the simulation and the commencement of the next period of duty, or alternatively an interval of 24 hours shall immediately precede and immediately follow such periods of simulator duty.

Note: Simulations which are part of Air Traffic Controller rating training at Air Traffic Control Training Colleges are not subject to the requirements of this scheme.

Modification of Limitations

By the CAA

D49 The CAA may at its discretion modify any Limitation through and by authorised members staff, such as ATS Inspectors. Modifications may be made as a requirement of the CAA, or in exceptional or extraordinary circumstances, on the application of a Provider of Air Traffic Control Services. Application may be communicated in any manner to the CAA and must be confirmed in writing within the following 24 hours.

D50 Modification may be made or granted upon such terms and for such duration as the CAA shall specify. It may be communicated in any manner and will be confirmed in writing with reasons within the following 48 hours.

D51 In exercising its discretion to make or grant a modification, the CAA shall have regard to:

1. the amount, type and complexity of recent and anticipated traffic handled by the unit and position concerned;
2. the published operational hours of the unit;
3. the pattern of shifts in operation at the time of any shift involved;
4. the qualifications and availability of support and supervisory staff;
5. exceptional temporary staffing problems;
6. the equipment in use at the unit;
7. exceptional temporary equipment problems;
8. the type of operating position at the unit;

9. factors which may compensate for, or benefits which may arise from, any modification; and

10. such other matters as the CAA considers to be relevant.

By the Provider of Air Traffic Control Services

D52 In exceptional circumstances a Provider at a unit may in its discretion modify any Limitation through persons exercising its authority. Such modifications may only be made to overcome short-term, temporary and unforeseen difficulties at the unit and, having regard to SRATCOH, may only be made if the safety and effectiveness of Air Traffic Control will be maintained. The CAA will require to review the circumstances of each such modification and for this purpose a report and full details of the modification shall be notified in writing, using form SRG 1410, Report of Operational Duty in Excess of SRATCOH (available from the CAA website at www.caa.co.uk/SRG1410). The completed form should be submitted to the CAA within 24 hours of the modification taking effect.

Review of Modifications

D53 A Provider who objects to the refusal, or to the terms of modification of a Limitation, by the CAA may, according to Regulation 6 of the Civil Aviation Authority Regulation 1983, request that the issue be decided by the CAA.

Notification of Roster Details

D54 At the request of the CAA, the Provider at a unit shall supply to the CAA:

1. Not less than 30 days before it is due to come into force, a copy of any proposed working roster and, without request as early as possible, details of any proposed change.

2. Not more than 30 days after receiving a request, details of a roster as actually worked including records of the periods of duty worked.

Guidance on Minimum Rest Facilities

D55 At all units the minimum rest facilities should consist of a separate room, which is remote from the operations room and reasonably

quiet. There should be sufficient and adequate furniture for the number of staff likely to be on a fatigue break at one time.

D56 Facilities for obtaining refreshments should be available within a reasonable distance of the unit or appropriate facilities should be provided for the storage and preparation of food and drinks.

Guidance on Secondary Employment

D57 Although the CAA has no direct legal powers to require that ATCOs do not undertake secondary employment, it may be helpful to clarify how the requirements of SRATCOH and the ANO affect the management of such activity.

D58 Any employment that involves exercising the privileges of an ATCO licence is subject to SRATCOH and should be considered together with any secondary employment that involves exercising of the same privileges, for the purposes of the scheme's requirements.

D59 Article 193 of the ANO 2009 (as amended) places a responsibility on each holder of an ATCO licence not to act as an ATCO whilst suffering from fatigue to the extent that it may endanger the safety of any aircraft to which the controller is providing a service. Controllers who engage in secondary employment within required SRATCOH rest periods are at risk of failing to meet this responsibility. Fundamentally, controllers should not present themselves at work for the purposes of exercising the privileges of their ATCO licence if for any reason they are likely to suffer from fatigue during the period of duty.

D60 In order to a Designation for the provision of air traffic control services, the CAA requires to be satisfied that the Provider is competent, having regard to his organisation, staffing, equipment, maintenance and other arrangements, to provide a service that is safe for use by aircraft. The CAA would not be satisfied in this respect if the Provider did not have measures in place to ensure that secondary employment of their staff that involves exercising the privileges of an ATCO licence is notified to them and is considered in conjunction with primary employment exercising the same privileges for the purposes of SRATCOH.