SAFMAP MODELS – Level 1 and Level 2

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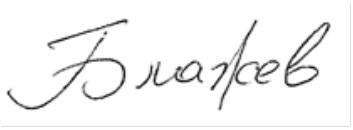
Prepared by: Tzvetomir Blajev NMD/SAF EUROCONTROL	20-11-2025	
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1 Document purpose and scope

The main purpose of this report is to document the SAFety Functions MAPs (SAFMAP) barrier model and describe it at a level of detail commensurate to the current level of model's maturity.

Four SAFMAP configurations applicable to the en-route, approach, landing, taxi, take-off and initial climb phases of flight are described in this report:

- Mid-air collision en-route - defining functions that may prevent mid-air collisions and separation minima infringement in controlled airspace class A, B and C during the en-route phase of fight.
- Mid-air collision TMA - defining functions that may prevent mid-air collisions and separation minima infringement in TMA/CTR airspace class B and C during the en-route, approach or initial climb phases of flight.
- Inadequate separation - defining functions which may prevent mid-air collisions and inadequate separation in airspace class D and E.
- Runway collision - defining functions which may prevent runway collisions and incursions.

The SAFMAP configuration description provides in this document includes the following information:

- The SAFMAPs hierarchical structures;
- The structural relationships between safety functions, and
- The textual explanation of the safety functions. These expanded textual descriptions should not be considered as formal definitions but rather as non-exclusive guidance to support the use of the SAFMAP model. The explanation includes often references and practical examples of the implementation of a given safety function.

Each SAFMAP model is constructed by several hierarchical levels. It is recognised that the development maturity of the various SAFMAP model levels varies considerably and therefore this document defines only levels for which sufficient confidence exists that these have been implemented in the European ATM operational environment. Thus the SAFMAP model levels described in this document are:

- Basic safety functions;
- Level 1 safety functions;
- Level 2 safety functions;
- Level 3 safety functions;
- Level 4 safety functions;
- Level 5 safety functions .

This document provides SFMAP models Level 1 and Level 2.

The SAFMAP model configurations are updated periodically in line with the findings of the analysis of the occurrence data collected within the scope of the European Network Manager collaborative process which seeks to identify operational hazards at network level and use this information to assess overall network safety risk.

2 The SAFMAP concept

2.1 SAFMAP hierarchical structure

The SAFMAPs are barrier models based on a structured documentation of the available defences against particular unwanted accident outcomes. These barriers are either part of the ATM system (ground and/or airborne component) or can impact on the safety performance of ATM and/or aircraft navigation.

Each discrete barrier is considered as a safety function. The functions used are rather generic, for example the function “Detection that entry onto the RWY protected area will be incorrect” does not specify the actual means to implement this function such as stop-bars, runway guard lights or runway entry lights.

Similarly “Prevention of overlooking potentially conflicting aircraft when issuing clearance or instruction” does not specify the actual means to implement this function such as MTCD, ATCO structured scan of their situation display, team member support, short-term conflict probe or Cleared Flight Level (CFL) processing by the STCA. Some functions are provided by procedures, some - by technical systems and others - by a combination of procedures, equipment and humans.

A basic principle applied to the construction of SAFMAPs was to include (describe) all barriers which are available and ‘used by someone’ in the industry. This means that SAFMAPs become a repository of best practices that are not necessarily required by regulations. Examples of such ‘best practices’ are the use of short-term conflict probes, A-SMGCS functions or runway status lights.

SAFMAPs are hierarchical structures in which each higher level structure (function) can be decomposed into several lower level structures (functions). The highest levels are called **basic safety functions**. Each of these basic functions is then decomposed into more detailed Level 1 safety functions and, in the same manner, each of these **Level 1 safety functions** may be further decomposed into several **Level 2 safety functions** and so on. At present, Level 5 is the most detailed specification and not all safety function levels are necessarily decomposed to the same extent. A function is decomposed only if there is a need as demonstrated by the occurrence of several incidents that have illustrated different ways in which a particular function can be implemented and/or challenged.

The following examples are provided as a means to illustrate the hierarchical model structure by using the Mid-air collision SAFMAP. It has 6 basic safety functions. The example below is about the decomposition of the “Tactical Conflict Prevention” basic function:

- “Conflict-free ATC clearances and instructions” is an example of a Level 1 safety function.
- “Prevention of overlooking potentially conflicting aircraft when issuing clearance or instruction” is an example of a Level 2 Safety Function.

Starting with each basic safety function, the progressive decomposition of each safety function level into a more detailed lower level results in the 'mapping' of how the component safety functions at each level collectively provide the redundancy which delivers the higher level safety function.

2.2 Lateral SAFMAP structures

Depicting the components of a safety functions **next to each other** means that failure of any of these components (lower level functions) **would be sufficient** for the failure of a higher-level function, which they are components of. For example, as illustrated in Figure 2-1, the higher-level function ‘Adequate pilot response to ATC collision avoidance instructions' will fail if either ‘Pilot acts promptly to ATC instructions' or 'Pilot follows correctly the ATC instructions' fails. Success of both lower level functions is needed in order for the higher level function to be viable.

Figure 2-1: Lateral SAFMAP structure

2.3 Vertical SAFMAP structures

Depicting the components of a safety function **one above another** means that failure of all depicted components **is necessary** for the higher-level function to fail. For example, as illustrated in Figure 2-2, the higher level function 'Air-ground communication is functional' will fail if all 'Conflict aircraft are on the sector frequency', 'Data link communications' and 'Emergency communication' fail. Success of any of these lower level functions will make the higher level function viable.

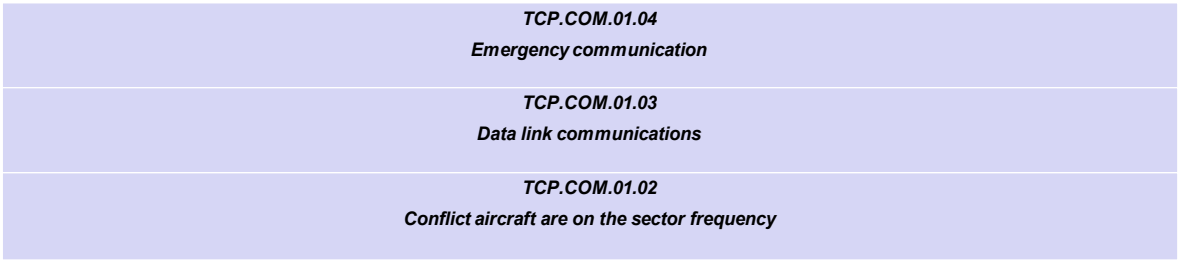

Figure 2-2: Vertical SAFMAP structure

2.4 Definition of terms

Term	Definition
Imminent collision	A situation, in which all basic ATM SAFMAP barriers have failed to resolve an airborne conflict and a collision between two aircraft is impending - almost certain to happen very soon.

2.5 General analysis principles

In situations involving on-the job-training SAFMAPs barrier performance is analysed based on the overall outcome at the level of ATS provision. E.g., if a potential conflict is not detected by the OJT but detected by the OJTI, who did not inform the trainee, the detection barrier is considered failed. Similarly, if the OJTI intervened and suggested plan of action that was implemented by the OJT and worked, the barrier 'plan of work' is considered to have worked (successful).

3 Mid-air collision en-route SAFMAP model

This SAFMAP model describes the available ATM system barriers that may prevent mid-air collision in control areas between flights provided with air traffic control service and separated from each other.

3.1 Basic safety functions

The basic safety functions, often referred to as barriers, are structured sequentially in terms of a functional architecture.

Figure 3-1: Mid-air collision en-route SAFMAP basic safety functions

The basic safety functions (barriers) for the prevention of mid-air collision in en-route control areas between flights that are separated from each other are:

- Tactical Conflict Prevention (TCP): use of design, procedures, technology and human operators to ensure conflict-free flight trajectories in the ATC sectors' airspace.
- ATC Tactical Separation Assurance (TSA): the ATC prevents conflicting trajectories to result in infringement of prescribed separation minima.
- ATC Collision Avoidance (CA_ATC): the ATC prevents infringements of prescribed separation minima to result in mid-air collision.
- Pilot Collision Avoidance – ACAS (ACAS): by following an ACAS RA, the pilot prevents an aircraft proximity to result in a mid-air collision.
- Pilot Collision Avoidance – Visual (CA_V): by taking avoiding action based on visual judgement of the conflict potential, the pilot prevents an aircraft proximity to result in a mid-air collision.
- Providence: the geometry of a conflict results in a closest point of approach sufficient to avoid the collision.

3.2 Mid-air collision en-route Level 1 functions

PROVIDENCE					
IMMINENT COLLISION					
CA_V02 The conflicting aircraft is visible	**CA_V03** Pilot identifies promptly the conflicting aircraft visually	**CA_V04** Pilot's correct collision avoidance decision	**CA_V05** Pilot initiates intended action promptly	**CA_V06** Avoidance action correctly implemented and collision avoided	
CA_V01 – No need for visual collision avoidance – function not challenged					
POTENTIAL COLLISION UNRESOLVED BY ACAS AVOIDANCE					
ACAS02 Visual collision avoidance does not trigger before	**ACAS03** Functional ACAS and transponder	**ACAS04** Correct and timely RA	**ACAS05** RA maneuver is possible	**ACAS06** RA detected, correctly interpreted, and correct decision taken	**ACAS07** Avoidance action correctly implemented and collision avoided
ACAS01 – No need for ACAS RA (The CPA distance is higher than ACAS trigger)					
POTENTIAL COLLISION UNRESOLVED BY ATC					
CA_ATC02 Opportunity for ATC collision avoidance	**CA_ATC03** The need for collision avoidance detected and interpreted by ATCO	**CA_ATC04** Effective ATCO decision and action	**CA_ATC05** Air-ground communication is functional	**CA_ATC06** Adequate air-ground communications	**CA_ATC07** Adequate pilot response to ATC collision avoidance instructions
CA_ATC01 No need for ATC collision avoidance intervention – function not challenged					
SEPARATION INFRINGEMENT					
TSA02 Opportunity for ATC prevention of separation infringement	**TSA03** Conflict detected and interpreted by ATCO	**TSA04** Effective ATCO decision and action	**TSA05** Air-ground communication is functional	**TSA06** Adequate air-ground communications	**TSA07** Adequate pilot response to ATC separation infringement prevention instructions
TSA01 No need for ATC separation infringement prevention – function not challenged					
AIRBORNE TACTICAL CONFLICT					
TCP01 Tactical conflict prevention by ATC tactical planning	**TCP02** Prevention of tactical conflict induced by deviation from clearances or instructions	**TCP03** Prevention of tactical conflict induced by airspace infringement	**TCP04** Conflict-free ATC clearances and instructions	**TCP05** Prevention of tactical conflict involving military flights in shared airspace	**TCP06** Prevention of tactical conflict induced by controlled airspace excursion

Figure 3-2: Mid-air collision en-route SAFMAP Level 1 structure

Each basic safety function (barrier) for the prevention of mid-air collision in control areas between flights that are separated from each other is decomposed into a number of Level 1 safety functions. Each of latter has been assigned a unique identifier comprised of two parts:

- The first part of a Level 1 safety function identifier denotes the basic safety function it supports. For example TSA corresponds to "ATC Tactical Separation Assurance"
- The second, numerical part, defines the unique identifier of the function within the Level 1 model architecture.
- The Level 2 safety functions are, in a similar way, decomposed and associated to a unique identifier. For example TCP02.01 ('Prevention of altitude deviation initiation') denotes:
- TCP - The function belongs to the basic safety barrier "Tactical Conflict Prevention".
- '02' - The function belongs to Level 1 safety function "Prevention of tactical conflict induced by deviation from clearances or instructions".
- '01' – is the unique identifier of the Level 2 safety function 'Prevention of altitude deviation initiation''.

The same principle applies to the components of SAFMAP Level 3 and Level 4 architecture.

3.3 Tactical Conflict Prevention (TCP) barrier

3.3.1 TCP01 Tactical conflict prevention by ATC tactical planning

TCP01.02	*TCP01.03*	*TCP01.04*	*TCP01.05*
Planned flight route conflict is detectable	*Planned flight route conflict is detected timely and correctly interpreted*	*Correct inter-sector or inter-unit coordination when needed*	*Correct implementation of coordinated conflict prevention solution*
TCP01.01 *Pre-tactical de-confliction procedures*			

Figure 3-3: TCP01 structure

Safety Function Level 1	Safety Function Level 2	Description
TCP01 **Tactical conflict prevention by ATC tactical planning**	**TCP01.01** **Pre-tactical de-confliction procedures**	The planned aircraft trajectories are de-conflicted by means of strategic and pre-tactical procedures and traffic constraining measures, such as route availability restrictions, standing level allocations based on entry points or traffic flows, complexity management procedures, etc. Such measures are published in the RAD, LoAs between ATS units, but may also be introduced by the ATS units' supervisors.
	TCP01.02 **Planned flight route conflict is detectable**	There are available, operative and adequate means for traffic awareness sufficient for ATCO to detect the tactical conflict.
	TCP01.03 **Planned flight route conflict is detected timely and correctly interpreted**	Using the available data ATCO detects and correctly interprets the planned route conflict. The function is decomposed further in section 3.3.1.2
	TCP01.04 **Correct inter-sector or inter-unit coordination when needed**	Technical support for inter-sector coordination within the ATS unit and with the adjacent ATS units is provided and is operative. ATCO initiates timely coordination with the adjacent sector/ATS unit to resolve the predicted conflict between planned aircraft trajectories in their AoR. The coordinated solution is appropriate and correctly understood. There is no deliberate ATCO decision not to coordinate but to manage the conflict after aircraft entry into the sector's airspace.

Safety Function Level 1	Safety Function Level 2	Description
	TCP01.05 **Correct implementation of coordinated conflict prevention solution**	The ATCO of the adjacent sector/ATS unit implements timely and correctly the agreed measure and the predicted conflict between planned aircraft trajectories is resolved successfully.

Table 3-1 TCP01 description

3.3.2 TCP02 Prevention of tactical conflict induced by deviation from ATC clearance or instruction

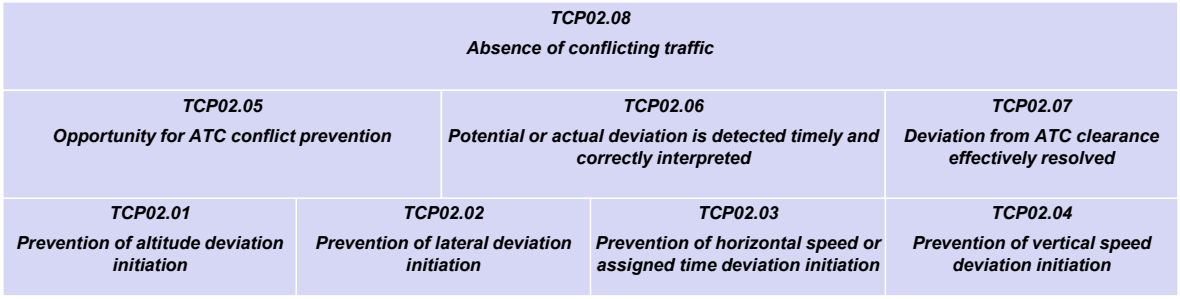

Figure 3-4: TCP02 structure

Safety Function Level 1	Safety Function Level 2	Description
TCP02 **Prevention of tactical conflict caused by deviation from ATC clearance or instruction**	**TCP02.01** **Prevention of altitude deviation initiation**	The initiation of altitude deviation by the pilot or by the aircraft is prevented. The function is decomposed further in section 3.3.2.1
	TCP02.02 **Prevention of lateral deviation initiation**	The initiation of lateral deviation by the pilot or by the aircraft is prevented. The function is decomposed further in section 3.3.2.2
	TCP02.03 **Prevention of horizontal speed or assigned time deviation initiation**	The initiation of horizontal speed or assigned time (time over or time by) deviation by the pilot or by the aircraft is prevented. The function is decomposed further in section 3.3.2.3
	TCP02.04 **Prevention of vertical speed deviation initiation**	The initiation of vertical speed deviation by the pilot or by the aircraft is prevented. The function is decomposed further in section 3.3.2.4

Safety Function Level 1	Safety Function Level 2	Description
	TCP02.05 **Opportunity for ATC conflict prevention**	ATCO is able to detect the potential or actual deviation from the ATC clearance or instruction in time to prevent a potential conflict with another aircraft. The function is decomposed further in section 3.3.2.5
	TCP02.06 **Potential or actual deviation is detected timely and correctly interpreted**	Using the available data ATCO detects and correctly interprets the potential or actual deviation from ATC clearances or instructions. The function is decomposed further in section 3.3.2.6
	TCP02.07 **Deviation from ATC clearance effectively resolved**	The ATCO takes correct and timely action to resolve the deviation situation and prevents a tactical conflict. This function is decomposed further in section 3.3.2.7
	TCP02.08 **Absence of conflicting traffic**	There is no other potentially conflicting traffic in the vicinity of the deviating aircraft.

Table 3-2: TCP02 description

3.3.3 TCP03 Prevention of tactical conflict induced by airspace infringement

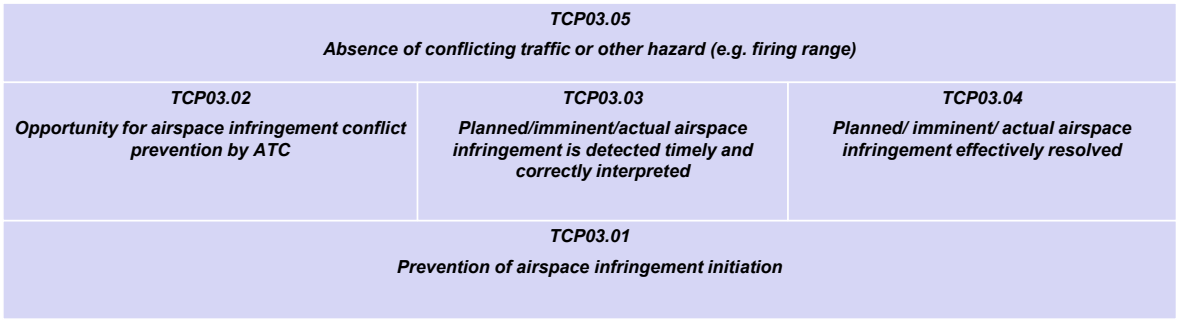

Figure 3-5: TCP03 structure

Safety Function Level 1	Safety Function Level 2	Description
TCP03 **Prevention of tactical conflict induced by airspace infringement**	**TCP03.01** **Prevention of airspace infringement initiation**	There is no imminent airspace infringement. Airspace infringement can occur as a restricted airspace or controlled airspace infringement. This function is decomposed further in section 3.3.3.1.
	TCP03.02 **Opportunity for airspace infringement conflict prevention by ATC**	ATCO is able to detect a planned or imminent airspace infringement in time to prevent a potential conflict: • in case of CAS infringement – with an aircraft within the (about to be) infringed airspace. • in case of restricted airspace - infringement of the restricted airspace or its buffer, as applicable. This function is decomposed further in section 3.3.3.2.
	TCP03.03 **Planned/imminent/actual airspace infringement is detected timely and correctly interpreted**	Using the available data ATCO detects timely and correctly interprets the planned/imminent/actual airspace infringement. This function is decomposed further in section 3.3.3.3.
	TCP03.04 **Planned or imminent or actual airspace infringement effectively resolved**	The ATCO takes correct and timely action to resolve the airspace infringement situation and prevents a tactical conflict. This function is decomposed further in section 3.3.3.4.
	TCP03.05 **Absence of conflicting traffic or other hazard (e.g. firing range)**	There is no conflicting traffic or other hazard that could become a threat to the infringing flight. This includes effective coordination for emergency stop of restricted airspace use in case of pending or imminent restricted airspace infringement.

Table 3-3: TCP03 description

3.3.4 TCP04 Conflict-free ATC clearances and instructions

TCP04.07 *Pilot does not follow incorrect ATC clearance or instruction*						
TCP04.01 *Prevention of tactical conflict induced by inadequate inter-sector and inter-unit coordination communication*	*TCP04.02* *Prevention of overlooking potentially conflicting aircraft when issuing clearance or instruction*	*TCP04.03* *Prevention of ATCO clearing or instructing an unintended aircraft due to visual or mental confusion with another one*	*TCP04.04* *Prevention of tactical conflict induced by inadequate ATCO plan of work*	*TCP04.05* *Prevention of tactical conflict induced by incorrect work plan execution by ATCO*	*TCP04.06* *Prevention of tactical conflict induced by use of inadequate controlling techniques by ATCO*	*TCP.COM.02* *Prevention of tactical conflict induced by inadequate communication of ATC clearance or instruction*

Figure 3-6: TCP04 structure

Safety Function Level 1	Safety Function Level 2	Description
TCP04 **Conflict-free ATC clearances and instructions**	**TCP04.01** **Prevention of tactical conflict induced by inter-sector and inter-unit coordination communication**	The needed inter-sector or inter-centre coordination is correctly communicated, understood and interpreted by both parties.
	TCP04.02 **Prevention of overlooking potentially conflicting aircraft when issuing clearance or instruction**	This safety function prevents situations of ATCO overlooking a relevant aircraft when issuing a clearance or instruction to another one. This function is decomposed further in section 3.3.4.1.
	TCP04.03 **Prevention of ATCO clearing or instructing an unintended aircraft due to visual or mental confusion with another one**	This function includes situations of ATCO visually or mentally confusing an aircraft surveillance position and/or identity with the position and/or identity of another one and issuing a clearance or instruction to the unintended aircraft.

	TCP04.04 **Prevention of tactical conflict induced by inadequate ATCO plan of work**	This safety function includes: • ATCO knowing and recalling from memory the ATC rules and procedures (e.g. the applicable separation and spacing standards), wake turbulence categories and related aircraft separation minima; • application of defensive control (avoiding the instructions and clearances that rely on later monitoring or incorrect flight route assumption); and • devising a plan of work which will not lead to a conflict. • correct, complete, timely, not omitted inter-sector or inter-centre coordination; • standard coordination procedures are applied and LoA are followed. • ATCO adjusting elements of work settings in way not obstructing appropriate control – for example setting surveillance screen scale that allow correct understanding of the traffic situation.
	TCP04.05 **Prevention of tactical conflict induced by incorrect work plan execution by ATCO**	This safety function prevents conflicts caused by controller slips of the tongue, delays in the execution of the work plan, or other deviations from what would otherwise be a safe plan of work. The ATCO actions taken to implement the coordinated changes to aircraft trajectories are correct, appropriate and timely.
	TCP04.06 **Prevention of tactical conflict induced by use of inadequate controlling techniques by ATCO**	This safety function: • prevents misjudgement of traffic situation in horizontal or vertical plane; absolute and relative horizontal speeds; absolute and relative vertical speeds or other aspects of the traffic situation; • ensures that used vectoring, speed or rate of climb/descent techniques do not generate a conflict.
	TCP.COM.02 **Prevention of tactical conflict induced by inadequate communication of ATC clearance or instruction**	A tactical conflict due to inadequate air-ground communication is prevented. The function is decomposed and described in more detail in section 3.3.2.7.2. ***Note***: This function excludes scenarios of aircraft deviation from the intended ATC clearance due to inadequate air-ground communications. These scenarios are addressed by TCP02.
	TCP04.07 **Pilot does not follow incorrect ATC clearance or instruction**	Pilot does not consider the received ATC clearance correct and/or appropriate, and questions it.

Table 3-4: TCP04 description

3.3.5 TCP05 Prevention of tactical conflict involving military flights in shared airspace

TCP05.01	*TCP05.02*	*TCP05.03*
Appropriate airspace use procedures and/or correct and timely civil-military coordination	*Military flights compliance with agreed airspace use conditions*	*Civil flights compliance with agreed airspace use conditions*

Figure 3-7: TCP05 structure

Safety Function Level 1	Safety Function Level 2	Description
TCP05 **Prevention of tactical conflict involving military flights in shared airspace**	**TCP05.01** **Appropriate airspace use procedures and/or correct and timely civil-military coordination**	This function prevents conflicts between GAT and military flights in airspace where the traffic control is exercised by separate civil ATS and military units and/or working positions. This function includes: • appropriate airspace use procedures; • availability of ground-ground communication means between the civil and military units; • appropriate, correct and timely coordination between the concerned civil and military units on the separation of the GAT and military flights; • correct interpretation of the coordinated conditions and actions; • appropriate actions of the civil and military ATS units.
	TCP05.02 **Military flights compliance with agreed airspace use conditions**	Military flights (pilots) comply with the standard civil-military procedures and/or LoA establishing the rules and conditions for the shared use of airspace, and do not deviate from received clearances and instructions.
	TCP05.03 **Civil flights compliance with agreed airspace use conditions**	GAT flights (pilots) comply with the standard civil-military procedures and/or LoA establishing the rules and conditions for the shared use of airspace, and do not deviate from received clearances and instructions.

Table 3-5: TCP05 description

3.3.6 TCP06 Prevention of tactical conflict induced by controlled airspace excursion

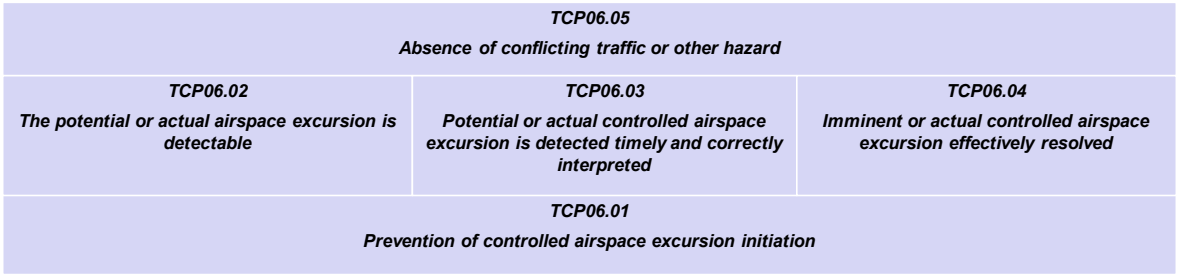

Figure 3-8: TCP06 structure

Safety Function Level 1	Safety Function Level 2	Description
TCP06 **Prevention of tactical conflict being generated by controlled airspace excursion**	**TCP06.01** **Prevention of controlled airspace excursion initiation**	This function prevents the initiation of controlled airspace excursion. It is decomposed further in section 3.3.6.1
	TCP06.02 **The potential or actual airspace excursion is detectable.**	There are available, operative and adequate means for ATCO to detect the potential or actual airspace excursion. It is decomposed further in section 3.3.6.2
	TCP06.03 **Potential or actual controlled airspace excursion is detected timely and correctly interpreted**	Using the available data ATCO detects timely and correctly interprets the potential or actual airspace excursion. It is decomposed further in section 3.3.6.3
	TCP06.04 **Imminent or actual controlled airspace excursion effectively resolved**	The ATCO takes correct and timely action to resolve the controlled airspace excursion situation and prevents a tactical conflict. This function is decomposed further in section 3.3.6.4
	TCP06.05 **Absence of conflicting traffic or other hazard**	There is no other conflicting traffic or other hazards (e.g. firing range) that could endanger the traffic that leaves the controlled airspace.

Table 3-6: TCP06 description

3.4 Tactical Separation Assurance basic safety function (TSA)

3.4.1 TSA01 No need for ATC separation infringement prevention

Safety Function Level 1	Description
TSA01 **No need for ATC separation infringement prevention**	ATC separation infringement prevention function is not challenged. For example, the flight crew may detect the conflict and act promptly to resolve it, or the conflict geometry does not required further action by ATC and/or flight crew (diverging aircraft trajectories).

Table 3-7: TSA01 description

3.4.2 TSA02 Opportunity for ATC prevention of separation infringement

TSA02.01	*TSA02.02*	*TSA02.03*	*TSA02.04*
ACAS or visual avoidance does not activate beforehand	*The tactical conflict is detectable*	*Sufficient time for prevention of separation infringement*	*Separation assurance is ATCO responsibility*

Figure 3-9: TSA02 structure

Safety Function Level 1	Safety Function Level 2	Description
TSA02 **Opportunity for ATC prevention of separation infringement**	**TSA02.01** **ACAS or visual avoidance does not activate beforehand**	The geometry of the encounter and the rate of closure are such that neither ACAS-triggered nor visual avoidance occurs prior to the ATC intervention for prevention of the separation minima infringement.
	TSA02.02 **The tactical conflict is detectable**	There are available, operative and adequate means for ATCO to detect the tactical conflict. It is decomposed further in section 3.4.2.1
	TSA02.03 **Sufficient time for prevention of separation infringement**	The ATCO has sufficient time to detect and prevent the separation infringement. There is no relevant sudden development of the situation (such as an altitude deviation in the presence of horizontally un-separated traffic). The available time is sufficient for the pilot to complete the instructed manoeuvre before the separation infringement or ACAS RA annunciation.
	TSA02.04 **Separation assurance is ATCO responsibility**	Local procedures define that separation assurance is ATCO responsibility for a particular conflict scenario – e.g. in case of airspace infringement.

Safety Function Level 1	Safety Function Level 2	Description
		This barrier is considered failed by default in case of restricted airspace infringement.

Table 3-8: TSA02 description

3.4.3 TSA03 Conflict detected and interpreted by ATCO

TSA03.01	*TSA03.02*
Conflict detected timely by ATCO	*Conflict correctly interpreted by ATCO*

Figure 3-10: TSA03 structure

Safety Function Level 1	Safety Function Level 2	Description
TSA03 **Conflict detected and interpreted by ATCO**	**TSA03.01** **Conflict detected timely by ATCO**	The ATCO uses available information to maintain adequate awareness of the traffic situation and detects timely the tactical conflict. It is decomposed further in section 3.4.3.1
	TSA03.02 **Conflict correctly interpreted by ATCO**	The ATCO uses available information to maintain adequate awareness of the traffic situation and correctly interprets the tactical conflict.

Table 3-9: TSA03 description

3.4.4 TSA04 Effective ATCO decision and action

TSA04.01	*TSA 04.02*	*TSA 04.03*	*TSA 04.04*
Adequate ATCO conflict resolution plan - goals	*Adequate ATCO conflict resolution plan - adequate controlling techniques*	*The time available for conflict resolution is not exceeded*	*Adequate conflict resolution plan execution*

Figure 3-11: TSA04 structure

Safety Function Level 1	Safety Function Level 2	Description
TSA04 **Effective ATCO decision and action**	**TSA04.01** **Adequate ATCO conflict resolution plan - goals**	The ATCO correctly decides that action is needed and selects appropriate conflict resolution action that would in principle prevent the separation infringement (do nothing, vector, descent, etc.). This includes knowing and/or recalling the ATC rules and procedures (e.g. separation and spacing standards, standing constraints, coordination and correct communication of the conflict resolution action with the affected sector(s), when needed, etc.).
	TSA04.02 **Adequate ATCO conflict resolution plan - adequate controlling techniques**	This function includes: • awareness of the traffic situation and relevant aircraft performance constraints. • avoiding misjudgement of the traffic situation in horizontal or vertical plane; absolute and relative horizontal speeds; absolute and relative vertical speeds or other aspects of the traffic situation • using vectoring, speed or rate of climb/descent techniques as appropriate to achieve conflict resolution. • Adequate coordinated conflict resolution actions, if other sectors are affected.
	TSA04.03 **The time available for conflict resolution is not exceeded**	The time available for effective resolution is not exceeded by delayed action. There is no impact by: • reluctance to intervene when ATCO is uncertain (waiting), including after late detection of the conflict but when time available after conflict detection would have been sufficient for successful separation assurance; • occurrence of a more serious situation (that will trigger STCA); • ATCO distraction; • lost awareness of a previously identified conflict.
	TSA04.04 **Adequate conflict resolution plan execution**	This function includes correct execution of the correct and efficient ATCO plan of work, preventing slips of the tongue or other deviations from the plan.

Table 3-10: TSA04 description

3.4.5 TSA05 Air-ground communication is functional

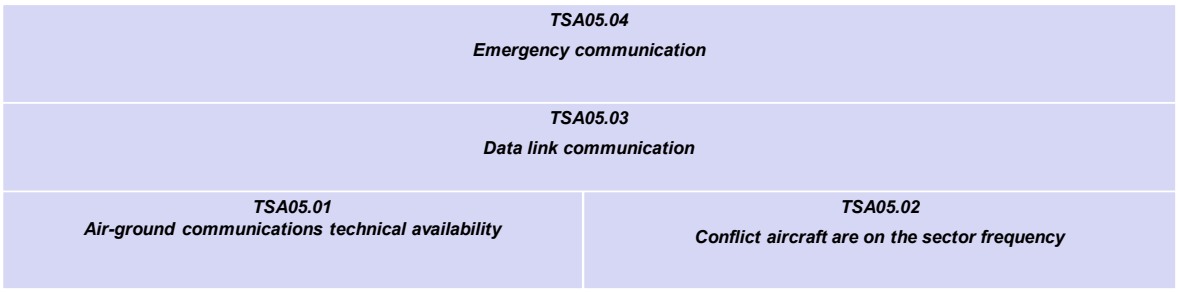

Figure 3-12: TSA05 structure

Safety Function Level 1	Safety Function Level 2	Description
TSA05 **Air-ground communication is functional**	**TSA05.01** **Air-ground communications technical availability**	There is no partial or complete loss, or incorrect operation of the communication equipment and functionalities neither on the ground, nor on board of aircraft involved.
	TSA05.02 **Conflict aircraft are on the sector frequency**	Aircraft involved in the conflict are transferred to the correct frequency and the required radio frequencies or channels are correctly selected by the pilot(s).
	TSA.05.03 **Data link communications**	Air-ground communication is established via CPDLC.
	TSA05.04 **Emergency communication**	Air-ground communication is established on the emergency frequency, or on another frequency or by other means (e.g. ACARS).

Table 3-11: TSA05 description

3.4.6 TSA06 Adequate air-ground communications

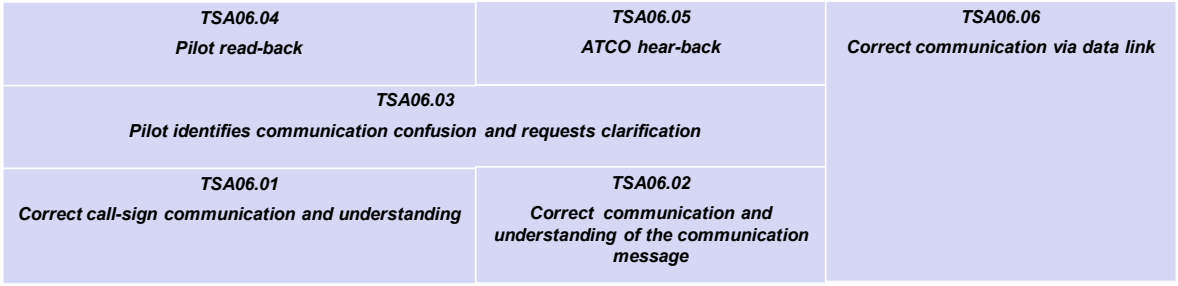

Figure 3-13: TSA06 structure

Safety Function Level 1	Safety Function Level 2	Description
TSA06 **Adequate air-ground communications**	**TSA06.01** **Correct call-sign communication and understanding**	This function, based on R/T exchange, includes: • identifying and preventing the use of similar call-signs; • use of complete and correct call-signs; • controller awareness of call-sign similarity; • adequate articulation of call-signs and clear speech; • special attention (defensive ATC) to the correct reception and understanding of instructions / clearances by potentially higher risk flights (language skill level, airspace familiarity); • correctly hearing and interpreting the call-sign.
	TSA06.02 **Correct communication and understanding of the communication message**	This function, based on R/T exchange, includes: • complete and clear communication of instructions, clearances or other information; • prevention of communication being blocked or subject to interference; • adequate articulation using clear speech which avoids excessive speed of clearance delivery; • special attention (defensive ATC) to potentially higher risk flights or situations (language skill level, airspace familiarity) and use of language likely to be familiar to the pilot; • avoidance of complex, excessively long, ambiguous or additional/confusing information in a clearance or instruction; • correctly hearing the message content; • language comprehension, without mental confusion and avoiding expectation bias.
	TSA06.03 **Pilot identifies communication confusion and requests clarification**	This function, based on R/T exchange, includes: • pilot(s) actively monitoring both the traffic situation and communications, • identification of potential confusion in communications whether intended for them or not; and • promptly informing ATC or requesting clarification • ATCO responds timely and the confusion is resolved.
	TSA06.04 **Pilot read-back**	This function, based on R/T exchange, includes: • pilot(s) providing prompt, complete and understandable read-back of the understood call-sign and communication message which is not blocked or subject to interference; • ATCO requesting pilot read-back when partial or not provided when needed/required.
	TSA06.05 **Controller hear-back**	This function, based on R/T exchange, includes involves: • controller actively listening to read-backs so as to identify communication misunderstandings, • confirmation of hear-back when required; and

Safety Function Level 1	Safety Function Level 2	Description
		• prompt resolution of any communication misunderstandings.
	TCP.06.06 **Correct communication via data link**	The clearances and instructions are correctly communicated to, understood and acknowledged by the pilot by means of data link communication (CPDLC).

Table 3-12: TSA06 description

3.4.7 TSA07 Adequate pilot response to ATC separation infringement prevention instructions

TSA07.04 *ATCO monitoring and resolution of inadequate pilot response to ATC separation infringement prevention instruction*		
TSA07.01 *Pilot acts promptly to ATC instructions*	*TSA07.02* *Pilot follows correctly the ATC instructions*	*TSA07.03* *Pilot does not deviate from normal procedures*

Figure 3-14: TSA07 structure

Safety Function Level 1	Safety Function Level 2	Description
TSA07 **Adequate pilot response to ATC separation infringement prevention instructions**	**TSA07.01** **Pilot acts promptly to ATC instructions**	The pilot does not question the ATC instructions and takes prompt action to implement them.
	TSA07.02 **Pilot follows correctly the ATC instructions**	The pilot implements correctly the ATC separation infringement prevention instructions.
	TSA07.03 **Pilots do not deviate from normal procedures**	Pilots fly the aircraft in accordance with the standard rules of the air and relevant procedures, and there is no additional aggravating deviation from them.
	TSA 07.04 **ATCO monitoring and resolution of inadequate pilot response to ATC separation infringement prevention instruction**	There is ample time for ATCO to monitor, detect timely the inadequate pilot response, interpret it correctly and provide separation infringement prevention instruction that is correctly implemented by the pilot.

Table 3-13: TSA07 description

3.5 ATC Collision Avoidance basic safety function (CA_ATC)

3.5.1 CA_ATC01 No need for ATC collision avoidance intervention

Safety Function Level 1	Description
CA_ATC01 **No need for ATC collision avoidance intervention**	The ATC Collision Avoidance function is not challenged - aircraft are on diverging trajectories after the separation infringement or crossing behind with marginal infringement of the separation standard.

Table 3-14: CA_ATC01 description

3.5.2 CA_ATC02 Opportunity for ATC collision avoidance

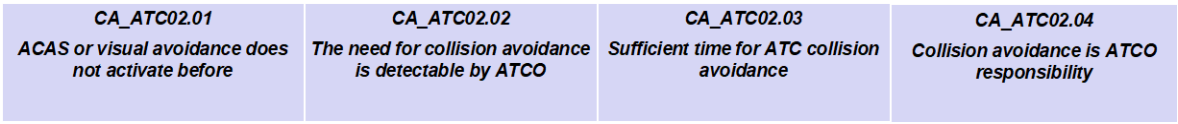

Figure 3-15: CA_ATC02 structure

Safety Function Level 1	Safety Function Level 2	Description
CA_ATC02 **Opportunity for ATC collision avoidance**	**CA_ATC02.01** **ACAS or visual avoidance does not activate before**	The geometry of the encounter and the rate of closure are such that neither ACAS-triggered, nor visual avoidance occurs prior to the ATC collision avoidance intervention.
	CA_ATC02.02 **The need for collision avoidance is detectable by ATCO**	There are available, operative and adequate means for ATCO to detect the need for collision avoidance. It is decomposed further in section 3.5.2.1
	CA_ATC02.03 **Sufficient time for ATC collision avoidance action**	The ATCO has sufficient time to detect and resolve the hazardous aircraft proximity. There is no relevant sudden development of the situation (such as an altitude deviation in the presence of horizontally un-separated traffic). The available time is sufficient for the pilot to complete the instructed manoeuvre before the ACAS RA annunciation.
	CA_ATC02.04 **Collison avoidance is ATCO responsibility**	Local procedures define that collision avoidance is ATCO responsibility for a particular conflict scenario – e.g. in case of airspace infringement.

Table 3-15: CA_ATC02 description

3.5.3 CA_ATC03 The need for collision avoidance detected and interpreted by ATCO

CA_ATC03.03 *Separation infringement detected and interpreted with STCA*
CA_ATC03.02 *Separation infringement detected and interpreted with surveillance data*
CA_ATC03.01 *Separation infringement detected and interpreted with flight plan data*

Figure 3-16: CA_ATC03 structure

Safety Function Level 1	Safety Function Level 2	Description
CA_ATC03 **The need for collision avoidance detected and interpreted by ATCO**	**CA_ATC03.01** **Separation infringement detected and interpreted with flight plan data**	The ATCO correctly associates the flight plan data (e.g. flight trajectory data) with the traffic situation, and detects and correctly interprets the separation infringement.
	CA_ATC03.02 **Separation infringement detected and interpreted with surveillance data**	The ATCO detects and correctly interprets the separation infringement with surveillance data. This includes ATCO adjusting elements of work settings to enable correct situational awareness, for example setting surveillance screen scale that allows correct appreciation of the traffic situation.
	CA_ATC03.03 **Separation infringement detected and interpreted with STCA**	The ATCO correctly associates the STCA with the traffic situation, and detects and correctly interprets the separation infringement.

Table 3-16: CA_ATC03 description

3.5.4 CA_ATC04 Effective ATC decision and action

CA_ATC04.01 *Adequate ATCO collision avoidance plan – goals*	*CA_ATC04.02* *Adequate ATCO collision avoidance plan - adequate controlling techniques*	*CA_ATC04.03* *The time available for collision avoidance is not exceeded*	*CA_ATC04.04* *Adequate collision avoidance plan execution*

Figure 3-17: CA_ATC04 structure

Safety Function Level 1	Safety Function Level 2	Description
CA_ATC04 Effective ATC decision and action	**CA_ATC04.01** **Adequate ATCO collision avoidance plan – goals**	The ATCO correctly decides that action is needed and selects appropriate collision avoidance action that would in principle prevent the collision (do nothing, vector, descent, etc.). This includes effective coordination for emergency stop of restricted airspace use in case of restricted airspace infringement.
	CA_ATC04.02 **Adequate ATCO collision avoidance plan - adequate controlling techniques**	This function includes: • awareness of the situation and relevant aircraft performance constraints; • avoiding misjudgement of the traffic situation in horizontal or vertical plane; absolute and relative horizontal speeds; absolute and relative vertical speeds or other aspects of the traffic situation; • using vectoring, speed or rate of climb/descent techniques as appropriate to achieve collision avoidance.
	CA_ATC04.03 **The time available for collision avoidance is not exceeded**	The time available for effective collision avoidance is not exceeded by delayed action. There is no impact by: • reluctance to intervene when the controller is uncertain (waiting); • occurrence of a more serious situation; • ATCO distraction; • lost awareness of a previously identified conflict.
	CA_ATC04.04 **Adequate collision avoidance plan execution**	This function includes correct execution by ATCO of the correct and efficient collision avoidance plan, preventing slips of the tongue or other deviations from the plan.

Table 3-17: CA_ATC04 description

3.5.5 CA_ATC05 Air–ground communication is functional

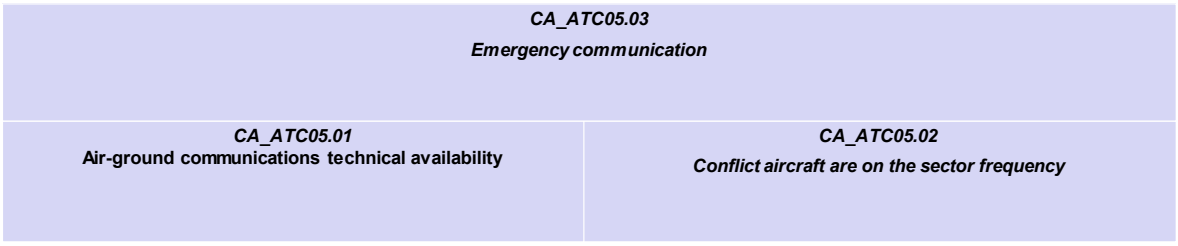

Figure 3-18: CA_ATC05 structure

Safety Function Level 1	Safety Function Level 2	Description
CA_ATC05 **Air-ground communication is functional**	**CA_ATC05.01** **Air-ground communications technical availability**	There is no partial or complete loss, or incorrect operation of the communication equipment and functionalities neither on the ground, nor on board of aircraft involved.
	CA_ATC05.02 **Conflict aircraft are on the frequency**	Aircraft involved in the conflict are transferred to the correct frequency and the required radio frequencies or channels are correctly selected by the pilot(s).
	CA_ATC05.03 **Emergency communication**	Air-ground communication is established on the emergency frequency, or on another frequency.

Table 3-18: CA_ATC05 description

3.5.6 CA_ATC06 Adequate air-ground communication

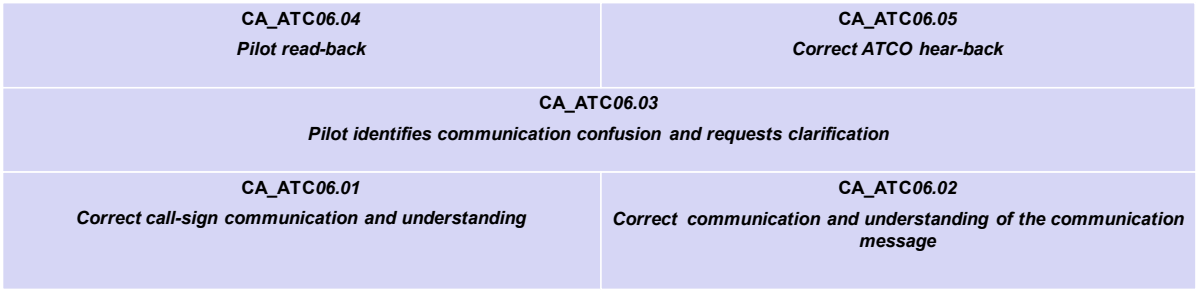

Figure 3-19: CA_ATC06 structure

Safety Function Level 1	Safety Function Level 2	Description
CA_ATC06 **Adequate air-ground communications**	**CA_ATC06.01** **Correct call-sign communication and understanding**	This function, based on R/T exchange, includes: • identifying and preventing the use of similar call-signs; • use of complete and correct call-signs; • controller awareness of call-sign similarity; • adequate articulation of call-signs and clear speech; • special attention (defensive ATC) to the correct reception and understanding of instructions / clearances by potentially higher risk flights (language skill level, airspace familiarity); • correctly hearing and interpreting the call-sign.

Safety Function Level 1	Safety Function Level 2	Description
	CA_ATC06.02 **Correct communication and understanding of the communication message**	This function, based on R/T exchange, includes: • complete and clear communication of instructions, clearances or other information; • prevention of communication being blocked or subject to interference; • adequate articulation using clear speech which avoids excessive speed of clearance delivery; • special attention (defensive ATC) to potentially higher risk flights or situations (language skill level, airspace familiarity) and use of language likely to be familiar to the pilot; • avoidance of complex, excessively long, ambiguous or additional/confusing information in a clearance or instruction; • correctly hearing the message content; • language comprehension, without mental confusion and avoiding expectation bias.
	CA_ATC06.03 **Pilot identifies communication confusion and requests clarification**	This function, based on R/T exchange, includes: • pilot(s) actively monitoring both the traffic situation and communications, • identification of potential confusion in communications whether intended for them or not; and • promptly informing ATC or requesting clarification • ATCO responds timely and the confusion is resolved.
	CA_ATC06.04 **Pilot read-back**	This function, based on R/T exchange, includes: • pilot(s) providing prompt, complete and understandable read-back of the understood call-sign and communication message which is not blocked or subject to interference; • ATCO requesting pilot read-back when partial or not provided when needed/required.
	CA_ATC06.05 **Correct ATCO hear-back**	This function, based on R/T exchange, includes: • controller actively listening to read-backs so as to identify communication misunderstandings, • confirmation of hear-back when required; and • prompt resolution of any communication misunderstandings.

Table 3-19: CA_ATC06 description

3.5.7 CA_ATC07 Adequate pilot response to ATC collision avoidance instructions

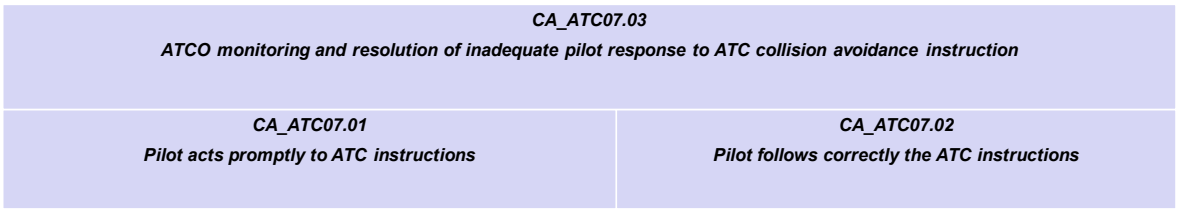

Figure 3-20: CA_ATC07 structure

Safety Function Level 1	Safety Function Level 2	Description
CA_ATC07 **Adequate pilot response to ATC collision avoidance instructions**	**CA_ATC07.01** **Pilot acts promptly to collision avoidance instructions**	Pilot responds promptly to ATC collision avoidance instructions without unnecessary delay and instructions' questioning.
	CA_ATC07.02 **Pilot follows correctly the ATC instructions**	Pilot correctly takes the instructed avoiding action and collision is avoided. The pilot action is not impeded or compromised by an uncoordinated manoeuvre of one of the conflicting aircraft.
	CA_ATC 07.03 **ATCO monitoring and resolution of inadequate pilot response to ATC collision avoidance instruction**	ATCO monitors, detects timely the inadequate pilot responses, interprets it correctly and provides resolution of inadequate pilot response to ATC collision avoidance instruction that is correctly implemented by the pilot.

Table 3-20: CA_ATC07 description

3.6 Pilot collision avoidance - ACAS basic safety function (ACAS)

3.6.1 ACAS01 No need for ACAS RA

Safety Function Level 1	Description
ACAS01 **No need for ACAS RA**	The closest point of approach (CPA) distance does not trigger an ACAS RA.

Table 3-21: ACAS01 description

3.6.2 ACAS02 Visual collision avoidance does not trigger before

Safety Function Level 1	Description
ACAS02 **Visual collision avoidance does not trigger before**	The geometry of the encounter, the rate of closure and the conditions are such that visual avoidance does not occur prior to the ACAS RA.

Table 3-22: ACAS01 description

3.6.3 ACAS03 Functional ACAS and transponder

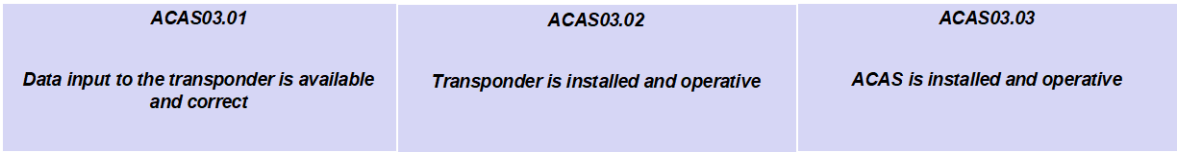

Figure 3-21: ACAS03 structure

Safety Function Level 1	Safety Function Level 2	Description
ACAS03 **Functional ACAS and transponder**	**ACAS03.01** **Data input to the transponder is available and correct**	Data input to the transponder in use is available and input data is correct.
	ACAS03.02 **Transponder is installed and operative**	Transponder (Mode C/S) is installed and is operative on the conflicting aircraft (and on the involved asset in case of encounter in restricted airspace). This includes prevention of deliberate or unintentional deselection of transponder or one of its modes.
	ACAS03.03 **ACAS is installed and operative**	ACAS is installed, operative and is fed with data inputs on at least one of the conflicting aircraft.

Table 3-23: ACAS03 description

3.6.4 ACAS04 Correct and timely RA

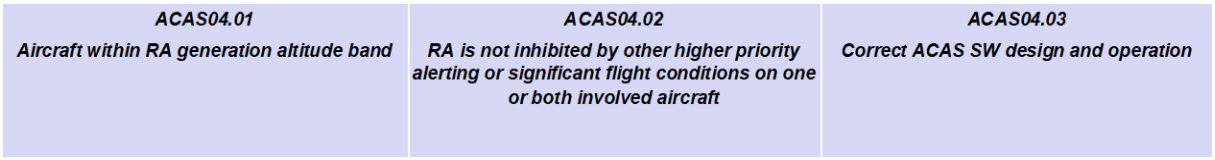

Figure 3-22: ACAS04 structure

Safety Function Level 1	Safety Function Level 2	Description
ACAS04 **Correct and timely RA**	**ACAS04.01** **Aircraft within RA generation altitude band**	The aircraft is at an altitude that is within the RA generation altitude band.
	ACAS04.02 **RA is not inhibited by other higher priority alerting or significant flight conditions on one or both involved aircraft**	Absence of other higher priority alerting as per TCAS MOPS - TAWS (EGPWS) activations and wind-shear warnings that override RA generation ***Note***: 'significant flight conditions' - e.g. stall warning.
	ACAS04.03 **Correct ACAS SW design and operation**	ACAS software design and parametrisation is correct, software operates correctly and generates timely RAs RA sequence for situations with collision risk.

Table 3-24: ACAS04 description

3.6.5 ACAS05 RA manoeuvre is possible

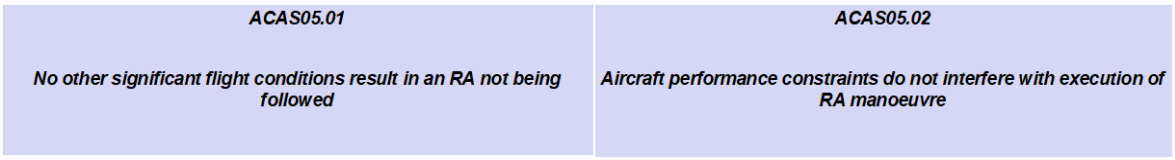

Figure 3-23: ACAS05 structure

Safety Function Level 1	Safety Function Level 2	Description
ACAS05 **RA manoeuvre is possible**	**ACAS05.01** **No other significant flight conditions result in an RA not being followed**	Other concurrent significant flight conditions do not result in pilots failing to follow a TCAS RA. Examples of such conditions are stall warning, stall buffet, negative windshear.

Safety Function Level 1	Safety Function Level 2	Description
	ACAS05.02 **Aircraft performance constraints do not interfere with execution of RA manoeuvre**	Other factors associated with aircraft performance constraints do not lead to flight crew reacting to TCAS RA differently. For example: high climb/descent rate; low climb/descent rate; limited options at high altitude ("coffin corner", aircraft "not clean", heavy etc.); turboprop specific performance issues.

Table 3-25: ACAS05 description

3.6.6 ACAS06 RA detected, correctly interpreted, and correct decision taken

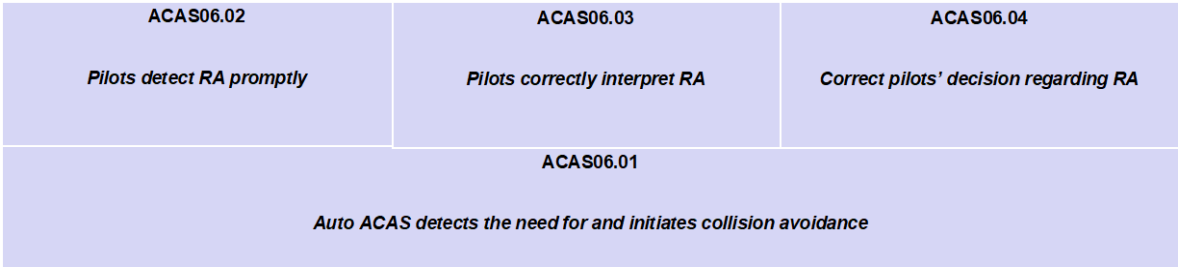

Figure 3-24: ACAS06 structure

Safety Function Level 1	Safety Function Level 2	Description
ACAS06 **RA is detected, correctly interpreted, and correct decision is taken**	**ACAS06.01** **Auto ACAS detects the need for and initiates collision avoidance**	Auto ACAS is installed and functional, autopilot is engaged and auto ACAS detects the need for and initiates promptly the collision avoidance manoeuvre.
	ACAS06.02 **Pilots detect RA promptly**	Pilots detect RA promptly. HMI, annunciations, other warning and expectations/ pilot mind-set do not obstruct RA detection.
	ACAS06.03 **Pilots correctly interpret RA**	Pilots interpret ACAS RA annunciations correctly. Prevailing CRM and/or ineffective training do not impair correct interpretation.
	ACAS06.04 **Correct pilots' decision regarding RA**	Pilots follow RA even if there is a conflicting ATC clearance prior to or after the RA annunciation or sighting of the apparently conflicting traffic. Crew does not ignore RA. For example, pilot does not ignore RA because of not seeing the threat (misjudging the collision risk or identifying the wrong aircraft) or the pilot being distracted or deciding RA is false.

Table 3-26: ACAS06 description

3.6.7 ACAS07 Avoidance action is correctly implemented and collision avoided

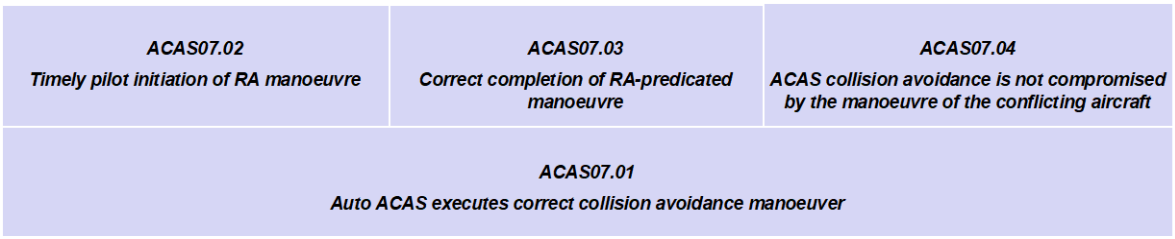

Figure 3-25: ACAS07 structure

Safety Function Level 1	Safety Function Level 2	Description
ACAS07 **Avoidance action is correctly initiated and completed, and collision is avoided**	**ACAS07.01** **Auto ACAS executes correct collision avoidance manoeuvre**	Auto ACAS implements a correct and timely collision avoidance manoeuvre and mid-air collision is avoided.
	ACAS07.02 **Timely pilot initiation of RA manoeuvre**	Pilots promptly initiate the RA manoeuvres (within 5 seconds or 2.5 seconds for any subsequent trajectory reversal RA).
	ACAS07.03 **Correct pilot completion of RA-predicated manoeuvre**	Pilots correctly follow the required RA-predicated manoeuvre until 'clear of conflict' is annunciated or equivalent conditions prevail. This action is not compromised by aircraft performance constraints, prevailing CRM or RA training issues.
	ACAS07.04 **ACAS collision avoidance is not compromised by the manoeuvre of the conflicting aircraft**	The conflicting aircraft do not perform a manoeuvre that compromises the ACAS RA collision avoidance. For example non-ACAS equipped aircraft does not perform a manoeuvre with characteristics that compromises the ACSA RA, including reverse RA.

Table 3-27: ACAS07 description

3.7 Pilot Collision Avoidance - Visual basic safety function (CA_V)

3.7.1 CA_V01 No need for visual collision avoidance

Safety Function Level 1	Description
CA_V01 **No need for visual collision avoidance**	No need for visual collision avoidance – e.g. lack of reaction to RA but after a horizontal or other manoeuvre the collision was avoided prior to the visual avoidance.

Table 3-28: CA_V01 description

3.7.2 CA_V02 Opportunity for visual collision avoidance

Figure 3-26: CA_V02 structure

Safety Function Level 1	Safety Function Level 2	Description
CA_V02 **Opportunity for visual collision avoidance**	**CA_V02.01** **The conflicting aircraft/military asset is visible**	The visibility conditions, situation and dynamic characteristics of the encounter allow for conflict detection. It is decomposed further in section 3.7.2.1
	CA_V02.02 **Sufficient time for visual collision avoidance**	The time available (after the conflicting aircraft or hazard become visible) is more than the minimum needed for decision on and execution of an effective collision avoidance action.

Table 3-29: CA_V02 description

3.7.3 CA_V03 Pilot identifies promptly the conflicting aircraft/object visually

Safety Function Level 1	Description
CA_V03 **Pilot identifies promptly the conflicting aircraft visually**	Pilot promptly sights potential conflicting traffic/object visually and correctly assesses it as posing a risk of collision.

Table 3-30: CA_V03 description

3.7.4 CA_V04 Pilot's correct collision avoidance decision

Safety Function Level 1	Description
CA_V04 Pilot correct collision avoidance decision	Pilot correctly decides that collision avoidance is necessary and decides what that action should be.

Table 3-31: CA_V04 description

3.7.5 CA_V05 Pilot initiates intended action promptly

Safety Function Level 1	Description
CA_V05 Pilot initiates intended action promptly	Pilot promptly initiates visual collision avoidance action without unnecessary delay.

Table 3-32: CA_V05 description

3.7.6 CA_V06 Avoidance action correctly implemented and collision avoided

Safety Function Level 1	Description
CA_V06 Avoidance action correctly implemented and collision avoided	The pilot completes correctly the intended avoidance manoeuvre and the risk of collision is removed.

Table 3-33: CA_V06 description

3.8 Providence basic safety function

Safety Function Level 0	Description
Providence	The geometry of the conflicting flight paths results in separation that is sufficient to prevent a collision.

Table 3-34: Providence barrier description

4 Mid-air collision TMA/CTR SAFMAP model

This SAFMAP model describes the available ATM system barriers that may prevent mid-air collision in TMA/CTR airspace between flights provided with air traffic control service and separated from each other.

4.1 Definitions of terms

Term	Definition
Imminent collision	A situation, in which all basic ATM SAFMAP barriers have failed to resolve an airborne conflict and a collision between two aircraft is impending - almost certain to happen very soon.
Traffic synchronisation	Synchronisation of departing and arriving flights. For arriving flights, the synchronisation phase starts at the initial approach fix (IAF) and includes assignment of published arrival and approach routes (e.g. STAR, RNAV approaches) and/or all tactical actions (e.g. vectoring, speed and altitude management) to establish and maintain correct aircraft sequence for landing, and ends upon aircraft landing or execution of missed approach. For departing flights, the synchronisation phase starts with the assignment of a departure clearance and ends at the last point of the departure scheme (e.g. SID, RNAV departure) or at the last point of the tactical (not based on published procedures) departure clearance.

4.2 Basic safety functions

The basic safety functions (barriers) for the prevention of mid-air collision in the TMA and CTR airspace are identical to the basic safety functions that can prevent mid-air collision en-route.

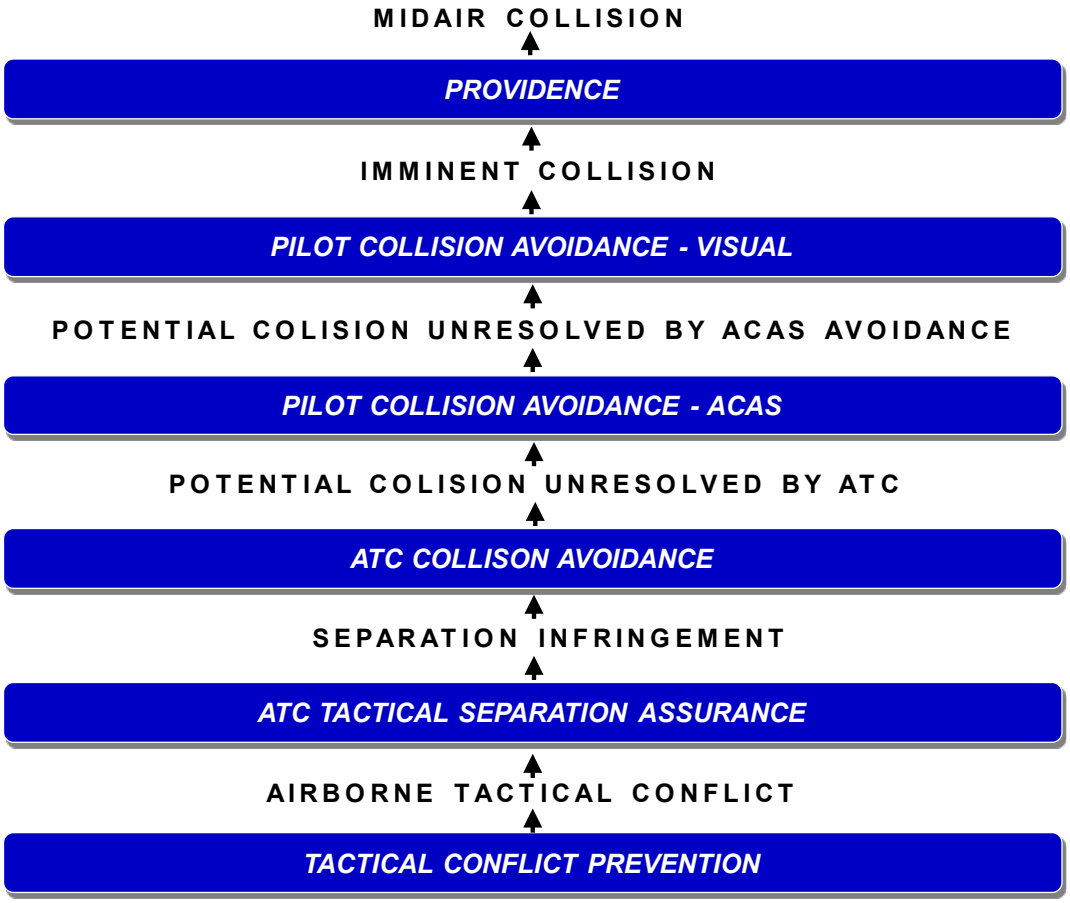

Figure 4-1: TMA/CTR mid-air collision SAFMAP basic safety functions

The basic safety functions (barriers) for the prevention of mid-air collision in TMA/CTR airspace between flights that are separated from each other are:

- Tactical Conflict Prevention (TCP): use of design, technology, procedures (e.g. STAR, SID, coordination) and human operators to ensure conflict-free flight trajectories in the TMA/CTR airspace.
- ATC Tactical Separation Assurance (TSA): the ATC prevents conflicting trajectories to result in infringement of applicable separation minima.
- ATC Collision Avoidance (CA_ATC): the ATC prevents infringements of applicable separation minima to result in mid-air collision.
- Pilot Collision Avoidance – ACAS (ACAS): by following an ACAS RA, the pilot prevents an aircraft proximity to result in a mid-air collision.
- Pilot Collision Avoidance – Visual (CA_V): by taking avoiding action based on visual judgement of the conflict potential, the pilot prevents an aircraft proximity to result in a mid-air collision.
- Providence: the geometry of a conflict results in a closest point of approach sufficient to avoid the collision.

4.3 Mid-air collision TMA/CTR Level 1 functions

PROVIDENCE					
IMMINENT COLLISION					
CA_V02 The conflicting aircraft is visible	CA_V03 Pilot identifies promptly the conflicting aircraft visually	CA_V04 Pilot's correct collision avoidance decision	CA_V05 Pilot initiates intended action promptly	CA_V06 Avoidance action correctly implemented and collision avoided	
CA_V01 – No need for visual collision avoidance – function not challenged					
POTENTIAL COLLISION UNRESOLVED BY ACAS AVOIDANCE					
ACAS02 Visual collision avoidance does not trigger before	ACAS03 Functional ACAS and transponder	ACAS04 Correct and timely RA	ACAS05 RA maneuver is possible	ACAS06 RA detected, correctly interpreted, and correct decision taken	ACAS07 Avoidance action correctly implemented and collision avoided
ACAS01 – No need for ACAS RA (The CPA distance is higher than ACAS trigger)					
POTENTIAL COLLISION UNRESOLVED BY ATC					
CA_ATC02 Opportunity for ATC collision avoidance	CA_ATC03 The need for collision avoidance detected and interpreted by ATCO	CA_ATC04 Effective ATCO decision and action	CA_ATC05 Air-ground communication is functional	CA_ATC06 Adequate air-ground communications	CA_ATC07 Adequate pilot response to ATC collision avoidance instructions
CA_ATC01 No need for ATC collision avoidance intervention – function not challenged					
SEPARATION INFRINGEMENT					
TSA02 Opportunity for ATC prevention of separation infringement	TSA03 Conflict detected and interpreted by ATCO	TSA04 Effective ATCO decision and action	TSA05 Air-ground communication is functional	TSA06 Adequate air-ground communications	TSA07 Adequate pilot response to ATC separation infringement prevention instructions
TSA01 No need for ATC separation infringement prevention – function not challenged					
AIRBORNE TACTICAL CONFLICT					
TCP01 Tactical conflict prevention by traffic synchronisation and ATC tactical planning	TCP02 Prevention of tactical conflict induced by deviation from clearances or instructions	TCP03 Prevention of tactical conflict induced by airspace infringement	TCP04 Conflict-free ATC clearances and instructions	TCP05 Prevention of tactical conflict induced by military flights in shared airspace	TCP06 Prevention of tactical conflict induced by controlled airspace excursion

Figure 4-2: Mid-air collision TMA/CTR SAFMAP Level 1 structure

Each basic safety function for the prevention of mid-air collision in terminal control areas (TMA) and control zones (CTRs) between flights that are separated from each other by ATC is decomposed into a number of Level 1 safety functions.

In this version of the TMA SAFMAP model the only difference to the en-route SAFMAP model is in the structure of Level 1 function TCP01 - Tactical conflict prevention by traffic synchronisation and ATC tactical planning.

The TCP01 safety function has been described in detail in section 4.4 below. The other (identical to the en-route SAFMAP model) safety functions are described in chapter 3 of this document.

Note: The scenario “conflict between a going around aircraft (flying a missed approach procedure (MAP)) and departing aircraft due to pilot deviation from the MAP or assigned route” has been modelled at Level 3 of TCP1 function, hence the barrier TCP01.03.05 shall be used in the SAFMAP analysis of such events but not TCP02.

4.4 TCP01 Tactical conflict prevention by traffic synchronisation and ATC tactical planning

TCP01.01	*TCP01.02*	*TCP01.03*	*TCP01.04*
Tactical conflict prevention by synchronisation of arrivals	*Tactical conflict prevention by synchronisation of departures*	*Tactical conflict prevention by synchronisation of arrivals and departures*	*TMA/CTR tactical conflict prevention by ATC tactical planning*

Figure 4-3: TMA/CTR TCP01 structure

Safety Function Level 1	Safety Function Level 2	Description
TCP01 **Tactical conflict prevention by traffic synchronisation and ATC tactical planning**	**TCP01.01** **Tactical conflict prevention by synchronisation of arrivals**	Correct and timely information is made available at the APP/TWR CWP about the inbound arriving aircraft, weather, runways in use, etc. ATCO prevents potential tactical conflicts between the arriving to land aircraft by synchronisation of their approach trajectories using standard (4D) arrival schemes, instrument approach procedures, ATC techniques (e.g. vectoring, speed control) and separation standards. This includes synchronisation of aircraft arriving to adjacent or parallel runways. This function is further decomposed in section 4.4.1.
	TCP01.02 **Tactical conflict prevention by synchronisation of departures**	Correct and timely information about the departing aircraft is made available to the APP/TWR ATCO managing the departures. ATCO prevents potential tactical conflicts between successive departures by coordination with the adjacent TWR/TMA/en-route sectors/positions and application of appropriate ATC techniques and separation standards. This includes prevention of conflicts between departures from adjacent or parallel runways. This function is further decomposed in section 4.4.2.
	TCP01.03 **Tactical conflict prevention by synchronisation of arrivals and departures**	Correct and timely information about the arriving and departing aircraft is made available at the APP/TWR ATCO(s) managing the arrivals and departures. ATCO prevents potential tactical conflicts between arrivals and departures, and between departures and aircraft going around by coordination with the adjacent TWR/TMA/en-route sectors/positions and application of appropriate ATC techniques and separation standards. This function is further decomposed in section 4.4.3.

	TCP01.04 **TMA/CTR tactical conflict prevention by ATC tactical planning**	The planned aircraft trajectories are de-conflicted by means of strategic and pre-tactical procedures (e.g. standing level allocations based on entry points or traffic flows). Using the flight route information provided in the system flight plans and/or on the paper/electronic strips and/or surveillance data, ATCO detects timely the planned conflicts between flights entering or leaving the TMA/CTR and prevents them. The function includes correct provision of the ATS service in accordance with the applicable airspace class (e.g. C, D) and type of flight (VFR, IFR). This function is further decomposed in section 4.4.4.

Table 4-1: TMA/CTR TCP01 description

5 Runway collision SAFMAP model

This SAFMAP model describes the available ATM system barriers that may prevent runway collision at a controlled aerodrome between flights provided with air traffic control service.

5.1 Definitions of terms

Term	Definition
Runway collision	Collision of an aircraft with another aircraft, ground vehicle, person, animal, obstacle, while on a surface designated for landing or take-off of aircraft (includes helipad/helideck).
Imminent runway collision	A situation, in which all basic SAFMAP barriers have failed to resolve a runway conflict and a collision between two aircraft or aircraft and vehicle or between aircraft and person/animal/obstacle is impending - almost certain to happen very soon.
Potential runway collision	An unresolved by the ATC Runway Collision Avoidance basic barrier conflict between two aircraft or between aircraft and vehicle(s), or between aircraft and person/animal/obstacle.
Runway conflict	In case of ***landing aircraft*** - conflict occurs at the time: (1) an aircraft with or without landing clearance passes a defined distance (e.g. 2NM) from the runway threshold, and the runway protected area is occupied by a traffic (aircraft or vehicle), pedestrian or animal, or an obstacle is present on the runway protected area; or (2) a traffic (aircraft or vehicle), pedestrian or animal enters the RWY protected area in front of a landing aircraft that is on the RWY protected area or within a defined distance (e.g. 2NM) from the runway threshold. ***Note***: A runway conflict involves simultaneous presence on the runway protected area and convergence.
	In case of ***taking-off aircraft*** - conflict occurs at the time: (1) an aircraft starts its take-off run and the RWY protected area is occupied by a traffic (aircraft or vehicle), pedestrian or animal, or an obstacle is present on the runway protected area; or (2) a traffic (aircraft or vehicle), pedestrian or animal enters RWY protected area in front of the departing aircraft that has started its take-off run. ***Note***: A runway conflict involves simultaneous presence on the runway protected area and convergence.
Incorrect presence on runway	An occurrence at an aerodrome involving unsafe, unauthorised or undesirable presence or movement of an aircraft, vehicle, person (pedestrian), animal or obstacle on the protected area of a surface designated for the landing and take-off of aircraft.
traffic	An aircraft or vehicle, including tug towing an aircraft or group of vehicles with a leader.

5.2 Basic safety functions

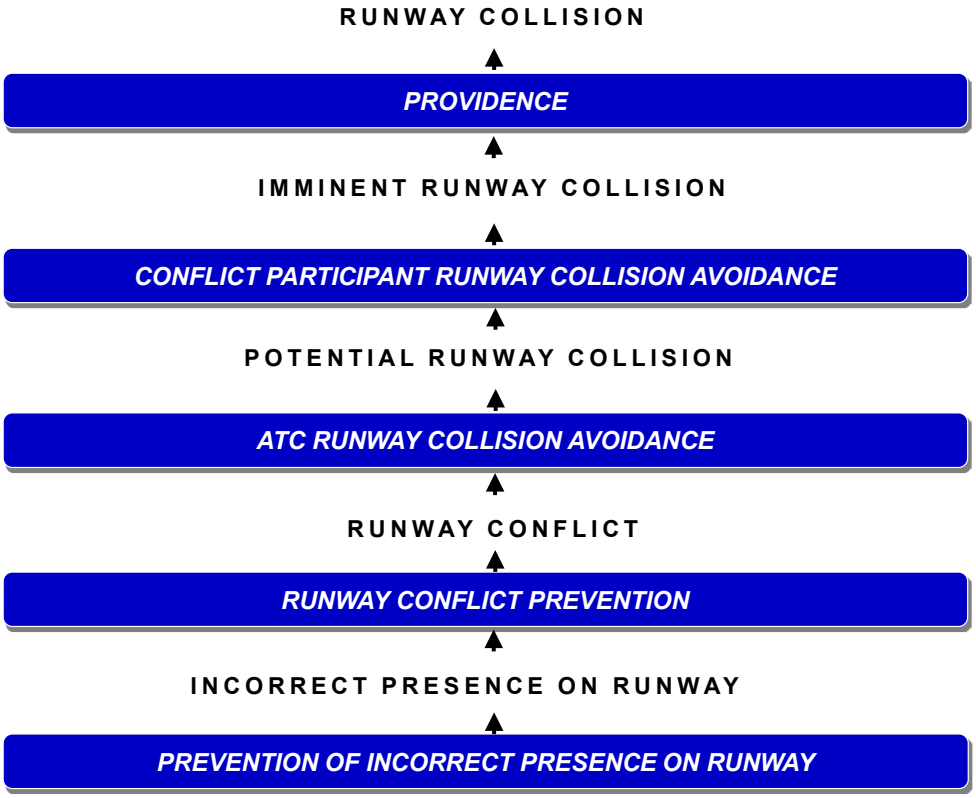

Figure 5-1: Runway collision SAFMAP basic safety functions

The Basic Safety Functions for the prevention of runway collision are:

- Prevention of Incorrect Presence on Runway – use of design, procedures, technology and human operators to prevent the incorrect presence of an aircraft, vehicle, person (pedestrian), animal or obstacle on the protected area of a surface designated at that time for the landing and take-off of aircraft.
- Runway Conflict Prevention – ATC or the participating in the potential conflict pilot /vehicle driver / person (pedestrian) prevents an incorrect presence on the runway to result in a runway conflict (conflicting trajectories).
- ATC Runway Collision Avoidance - ATC prevents a runway conflict to result in a runway collision.
- Conflict Participant Runway Collision Avoidance – the participating in the runway conflict pilot / vehicle driver / person prevents the runway conflict to result in a runway collision.
- Providence - the geometry of a runway conflict results in a closest point of approach sufficient to avoid a runway collision.

5.3 Runway collision SAFMAP Level 1 functions

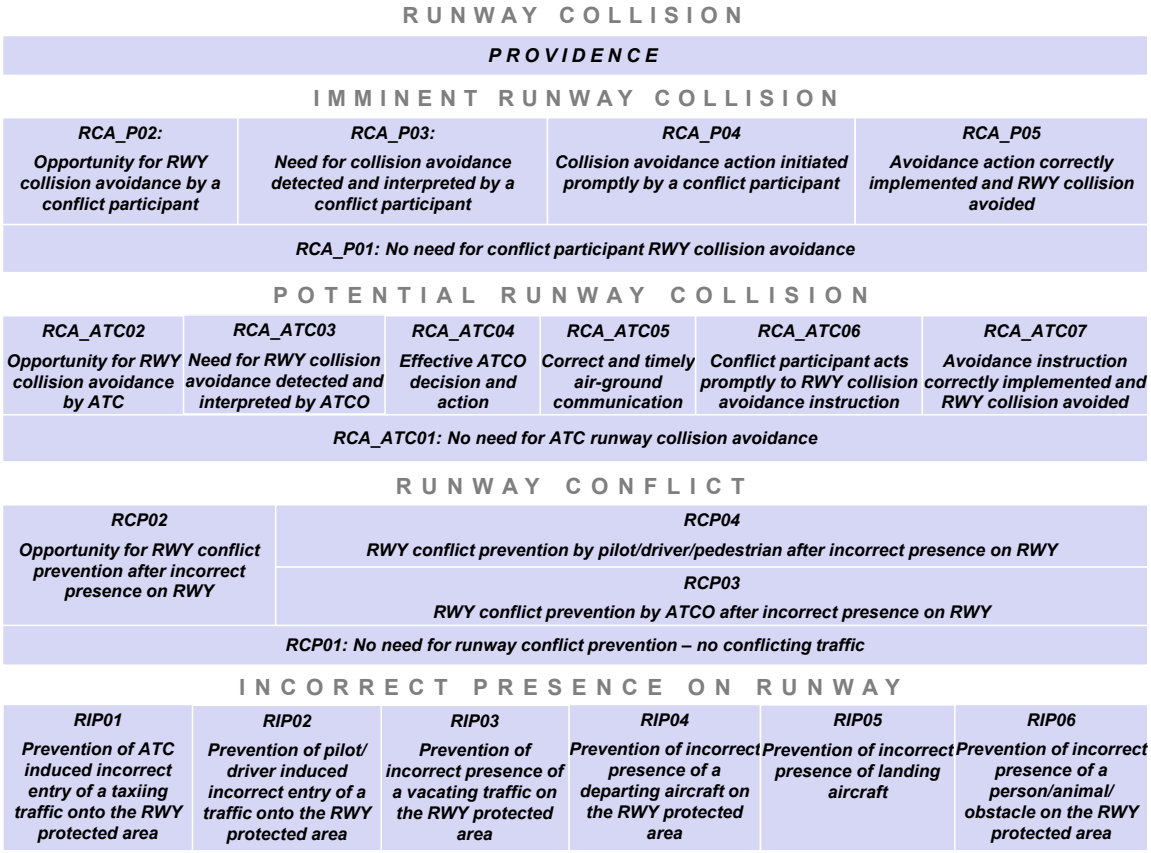

Figure 5-2: Runway collision SAFMAP Level 1 structure

Each basic safety function for the prevention of runway (RWY) collision is decomposed into a number of Level 1 safety functions. Each of these is associated with a unique identifier comprised of two parts:

- The first part of a Level 1 safety function identifier denotes the basic safety function it supports. For example RIP corresponds to "Prevention of Incorrect Presence on Runway".
- The second, numerical part, defines the unique identifier of the function within the basic function architecture.

The Level 2 safety functions are, in a similar way, decomposed and associated to a unique identifier. For example, RIP02.02 denotes:

- RIP - the function belongs to the basic safety barrier “Prevention of Incorrect Presence on Runway”.
- ‘02’ - The function belongs to Level 1 safety function “Prevention of pilot/driver induced incorrect entry of a traffic onto the RWY protected area”.
- ‘02’ – Unique identifier of the Level 2 safety function “Prevention of positional confusion after adequate taxi information”.

The same principle applies to the components of SAFMAP Level 3 and Level 4 architecture.

5.4 Prevention of Incorrect Presence on Runway basic safety function (RIP)

5.4.1 RIP01 Prevention of ATC induced incorrect entry of a taxiing traffic onto the RWY protected area

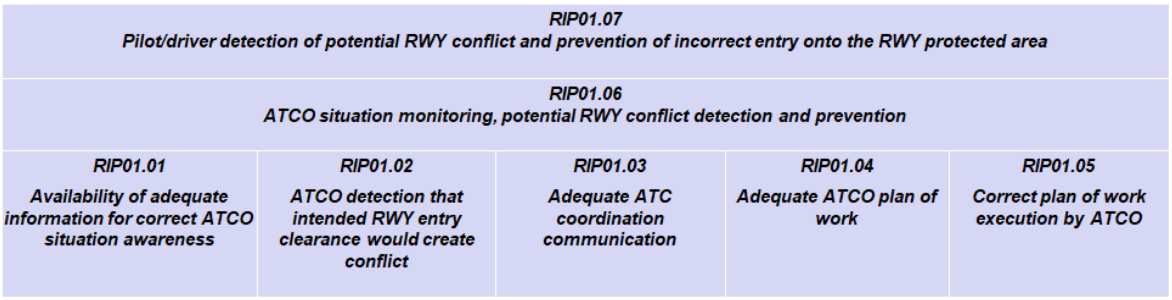

Figure 5-3: RIP01 structure

Safety Function Level 1	Safety Function Level 2	Description
RIP01 **Prevention of ATC induced incorrect entry of a taxiing traffic onto the RWY protected area**	**RIP01.01** **Availability of adequate information for correct ATCO situation awareness**	There are available and functional means for traffic and operational context awareness in the control TWR. Situation awareness means include, but are not limited to: • Good visibility of the manoeuvring area from the ATC TWR; • visual monitoring; • flight data (including RWY designators on strips); • position reports by pilots and/or vehicle drivers; • CCTV; • surveillance data (incl. SMGCS); • RWY/manoeuvring area configuration data; • RWY status information (e.g. memory aids).
	RIP01.02 **ATCO detection that intended RWY entry clearance would create conflict**	Prevention of a conflicting or potentially conflicting traffic from being overlooked by the ATCO while issuing a clearance or instruction. The function is decomposed further in section 5.4.1.1
	RIP01.03 **Adequate ATC coordination communication**	The coordination between the TWR positions (e.g. AIR, GMC), and between the TWR and approach (APP) or apron control provided by the aerodrome operator is correctly communicated, understood and interpreted, and does not lead to incorrect entry of a traffic (aircraft or vehicle) onto the RWY protected area. This function includes correct position handover by ATCOs.

Safety Function Level 1	Safety Function Level 2	Description
	RIP01.04 **Adequate ATCO plan of work**	The intended ATCO plan of work is not going to lead to incorrect entry of a traffic onto the RWY protected area. This includes: • correct and adequate goals and interpretation of the information; • identification of corrupted information; • correct interpretation of the traffic situation and constraints; • adequate (correct, timely) coordination with adjacent positions/units (e.g. GMC, clearance delivery, approach control, military); • no misjudgement of RWY traffic separation; • no use of closed RWY or TWY; • no deliberate instruction to cross lit red stop bars; • respecting the clearance limits. This function excludes mis-communication during coordination, which is covered by RIP01.03.
	RIP01.05 **Correct plan of work execution by ATCO**	This function includes provision of clear, unambiguous instructions and clearances, highlighting any difference from standard or routine operations; correct communication of the clearances and absence of slips of the tongue or other deviations from the otherwise effective plan of work.
	RIP01.06 **ATCO situation monitoring, potential RWY conflict detection and prevention**	By continuous monitoring of aerodrome traffic the ATCO identifies own incorrect/inappropriate clearances that may create a RWY conflict and takes timely action to resolve the potential safety issue. The function is decomposed further in section 5.4.1.2
	RIP01.07 **Pilot/driver detection of potential RWY conflict and prevention of incorrect entry onto the RWY protected area**	Situation monitoring enables the pilot/driver to identify potential RWY conflicts induced by incorrect/ inappropriate ATC clearance and to prevent an incorrect entry onto the RWY protected area, which would create the RWY conflict. The function is decomposed further in section 5.4.1.3

Table 5-1: RIP01 description

5.4.2 RIP02 Prevention of pilot/driver induced incorrect entry of a traffic onto the RWY protected area

RIP02.05 ***Pilot/driver situation monitoring and prevention of incorrect entry onto the RWY protected area***			
RIP02.04 ***ATCO situation monitoring, detection and resolution of non-conformity with ATC clearance***			
RIP02.01 ***Correct pilot/driver positional awareness***	***RIP02.02*** ***Lack of RWY entry clearance not omitted by pilot/driver***	***RIP.COM.02*** ***Adequate air-ground communications (taxi route and RWY entry clearance)***	***RIP02.03*** ***ATC clearance correctly followed***

Figure 5-4: RIP02 structure

Safety Function Level 1	Safety Function Level 2	Description
RIP02 **Prevention of pilot/ driver induced incorrect entry of a traffic onto the RWY protected area**	**RIP02.01** **Correct pilot/driver positional awareness**	The pilot /driver has established and maintains correct positional awareness using aerodrome signage (e.g. 'Runway Ahead" signs), markings (e.g. holding position markings), lighting (e.g. RWY guard lights), or on-board technical systems and ensure compliance with the received taxi and/or RWY entry clearance and avoids incorrect entry onto the RWY protected area. The function is decomposed further in section 5.4.2.1
	RIP02.02 **Lack of RWY entry clearance not omitted by pilot/driver**	The potential entry onto the RWY protected area without a valid clearance is prevented by: • the pilot/driver's awareness of the fact that he/she has not yet received a RWY entry clearance, or • the absence of confusion whether a RWY entry clearance has or has not been received.
	RIP.COM.02 **Adequate air-ground communication**	There is no misunderstanding of the cleared taxi route and of the RWY entry clearance. The communication exchange ensures complete, clear and unambiguous instructions, correct read-back and hear-back. The function is decomposed further in section 5.4.2.2
	RIP02.03 **ATC clearance correctly followed**	The pilot/driver correctly follows the received ATC clearance. For example: there is correct identification of other traffic in case of conditional clearance; correct handling of aircraft/vehicle movement; correct helicopter hoovering; correct identification of the RWY Holding Point; correct crew communication.

	RIP02.04 **ATCO situation monitoring, detection and resolution of non-conformity with ATC clearance**	By maintaining continuous watch of the aerodrome traffic and making correct use of the available and operative system support, the ATCO detects the (potential) pilot/driver non-conformity with the ATC clearance. The ATCO resolves successfully the potential safety issue and prevents incorrect entry onto the RWY protected area. The function is decomposed further in section 5.4.2.3
	RIP02.05 **Pilot/driver situation monitoring and prevention of incorrect entry onto the RWY protected area**	Situation monitoring by pilot/driver enables them to identify correctly the RWY protected area and prevent an incorrect entry onto it. The function is decomposed further in section 5.4.2.4

Table 5-2: RIP02 description

5.4.3 RIP03 Prevention of incorrect presence of a vacating traffic on the RWY protected area

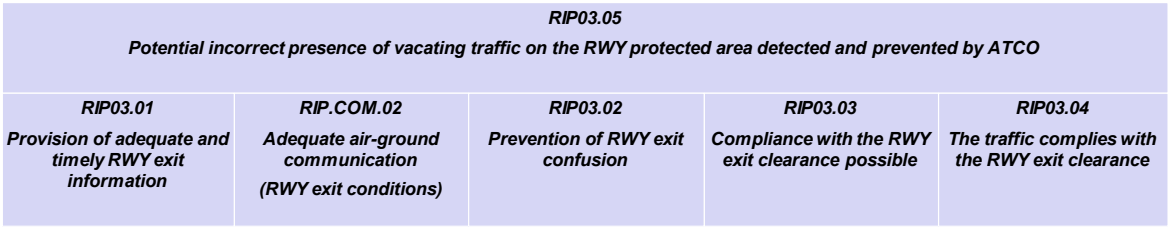

Figure 5-5: RIP03 structure

Safety Function Level 1	Safety Function Level 2	Description
RIP03 **Prevention of incorrect presence of a vacating traffic on the RWY protected area**	**RIP03.01** **Provision of adequate and timely RWY exit information**	The ATCO provides to the pilot/driver timely and correct RWY exit information (e.g. time, RWY exit, taxi-in route).
	RIP.COM.02 **Adequate air-ground communication**	There is no misunderstanding of the RWY exit instruction and cleared taxi-in route. The communication exchange ensures complete, clear and unambiguous instructions, correct read-back and hear-back. The function is decomposed further in section 5.4.2.2

Safety Function Level 1	Safety Function Level 2	Description
	RIP03.02 **Prevention of RWY exit confusion**	The pilot/driver correctly identifies the RWY exit assigned by ATC clearance. The RWY design, signage, markings and lighting do not contribute to RWY exit confusion.
	RIP03.03 **Compliance with the RWY exit clearance possible**	There is no restricting condition at the assigned RWY exit (e.g. blocked path, work in progress) or relevant aircraft malfunction. The RWY vacating turn at the assigned RWY exit is feasible (e.g. there is no overshoot, pilot is able to decelerate, etc.).
	RIP03.04 **The traffic complies with the RWY exit clearance**	The traffic complies with the exit instructions/ guidance provided by the ATCO. In the absence of specific RWY exit information, the traffic vacates the RWY at an exit appropriate to the prevailing traffic situation. The pilot/drivers' RWY vacation report, when required, is correct, i.e. reporting RWY vacated while still on the RWY protected area (due to confusion, signage misplacement, etc.) is prevented.
	RIP03.05 **Potential incorrect presence of vacating traffic on the RWY protected area detected and prevented by ATCO**	The ATCO detects timely the potential incorrect presence of a vacating aircraft or vehicle on the RWY protected area by RWY traffic monitoring (using visual scanning, system support and memory aids) and prevents it.

Table 5-3: RIP03 description

5.4.4 RIP04 Prevention of incorrect presence of a departing aircraft on the RWY protected area

RIP04.05 *Pilot/driver autonomous detection and prevention of the potential RWY conflict*				
RIP04.01 *Take-off clearance for correct RWY and aircraft*	*RIP04.02* *Prevention of conflicting take-off clearance*	*RIP.COM.02* *Adequate air-ground communication (take-off clearance)*	*RIP04.03* *Pilot correctly follows the take-off clearance*	*RIP04.04* *Prevention of take-off initiation without clearance*

Figure 5-6: RIP04 structure

Safety Function Level 1	Safety Function Level 2	Description
RIP04 **Prevention of incorrect presence of a departing aircraft on the RWY protected area**	**RIP04.01** **Take-off clearance for correct RWY and aircraft**	The ATCO issues the take-off clearance to the correct aircraft and for the intended (correct) RWY.
	RIP04.02 **Prevention of conflicting take-off clearance**	The issued by ATCO take-off clearance is correct and ensures that the RWY is not and will not be occupied by another traffic during the take-off. This function includes: • availability of adequate flight data; • correct use of RWY occupancy memory aids; • monitoring of RWY traffic by visual scanning; • monitoring of RWY traffic using surveillance data; • monitoring of RWY traffic by means of pilot/driver position reports; • detection (visually or with system support) and resolution of clearance non-conformity (e.g. route deviations, high speed taxiing towards the holding point, etc.). The function is decomposed further in section 5.4.4.1
	RIP.COM.02 **Adequate air-ground communication**	There is no misunderstanding of the RWY use and/or take-off clearance. The communication exchange ensures complete, clear and unambiguous instructions, correct read-back and hear-back. The function is decomposed further in section 5.4.2.2
	RIP04.03 **Pilot correctly follows the take-off clearance**	The pilot correctly follows the take-off clearance. For example, does not delay the take-off beyond the applicable time tolerance.
	RIP04.04 **Prevention of take-off initiation without clearance**	The pilot does not commence take off without clearance or does not take-off from a TWY or from a different RWY to the one communicated in the ATC clearance (pilot has received clearance for the correct RWY). The function is decomposed further in section 5.4.4.2
	RIP04.05 **Pilot/driver autonomous detection and prevention of the potential RWY conflict**	By autonomous monitoring the pilot/driver detects the potential RWY conflict and prevents the take-off initiation. The monitoring includes: • monitoring of air-ground communication exchange; • visual traffic observation • traffic observation on ACAS display; • use of autonomous pilot interpreted systems, such as take-off hold lights.

Table 5-4: RIP04 description

5.4.5 RIP05 Prevention of incorrect presence of landing aircraft

RIP05.01	*RIP05.02*	*RIP.COM.02*	*RIP05.03*
Sufficient RWY traffic spacing	*Prevention of conflicting landing clearance*	*Adequate air-ground communication (landing clearance)*	*Prevention of landing initiation without clearance*

Figure 5-7 : RIP05 structure

Safety Function Level 1	Safety Function Level 2	Description
RIP05 **Prevention of incorrect presence of landing aircraft**	**RIP05.01** **Sufficient RWY traffic spacing**	The landing aircraft does not continue its approach without having received landing clearance (e.g. due to ATC omission or notification to expect late clearance) beyond the applicable RWY spacing limits or does not enter the RWY protected area while the RWY is still occupied. There is sufficient spacing between successive landing aircraft, and between landing and departing aircraft, which ensures that the applicable spacing limits (distance and/or time) are not violated. (The spacing limits are locally defined and could be 4NM, 1NM, RWY threshold, distance from RWY threshold when the clearance to land is issued, etc.). Sufficient RWY traffic spacing is ensured by means of (list non exhaustive): • adequate sequencing plan supporting achievement of the required spacing intervals, • appropriate approach speed management, • pilot compliance with ATC speed restrictions (published or instructed), • timely issue of ATC take-off clearance, • prompt aircraft take-off following the ATC clearance (no take-off delay by the pilot). The prevention of spacing limit violation is supported by: Time To Touch (TTT) system functionality; anticipation of the “readiness state for departure”, timely cabin secure announcement call. The function includes timely identification and resolution of inadequate spacing. ***Note***: In the context of this function the violation of the spacing limit by a landing aircraft is considered incorrect presence in the protected area of the runway.
	RIP05.02 **Prevention of conflicting landing clearance**	The issued by ATCO landing clearance is correct and ensures that the RWY protected area is not and will not be occupied by another traffic during the landing. This function includes: • availability of adequate flight data; • correct use of RWY occupancy memory aids; • monitoring of RWY traffic by visual scanning; • monitoring of RWY traffic using surveillance data; • monitoring of RWY traffic by means of pilot/driver position reports. • Correct and timely coordination between the TWR and APP, in line with existing procedures and when needed. The function is decomposed further in section 5.4.5.1

	RIP.COM.02 **Adequate air-ground communication**	There is no misunderstanding of the landing clearance (e.g. RWY to be used for landing). The communication exchange ensures complete, clear and unambiguous instructions, correct read-back and hear-back. The function is decomposed further in section 5.4.2.2
	RIP05.03 **Prevention of landing initiation without clearance**	The incorrect initiation of landing without clearance by the pilot is prevented. The function includes prevention of landing initiation without clearance after: • loss of communication in non-compliance with promulgated procedures; • RWY confusion; • communication misunderstanding; • pilot omitting the lack of a landing clearance, or initiation of deliberate landing without clearance. The function is decomposed further in section 5.4.5.2

Table 5-5: RIP05 description

5.4.6 RIP06 Prevention of incorrect presence of a person/animal/obstacle on the RWY protected area

Safety Function Level 1	Description
RIP06 **Prevention of incorrect presence of a person/animal/obstacle on the RWY protected area**	The incorrect (authorised or unauthorised) presence of a pedestrian or the presence of an animal or obstacle on the RWY protected area is prevented by proper design, inspection and maintenance of the manoeuvring area, signage, markings, lighting system, correct ATC instructions and clearances and by measures for improved awareness, movement control and airport perimeter physical security control.

Table 5-6: RIP06 description

5.5 Runway Conflict Prevention basic safety function (RCP)

5.5.1 RCP01 No need for runway conflict prevention

Safety Function Level 1	Description
RCP01 **No need for runway conflict prevention**	The Runway Conflict Prevention safety function is not challenged, i.e. the incorrect presence of traffic or pedestrian(s) or animal(s) or obstacle on the RWY protected area is not followed by a RWY conflict. For example, an unauthorised entry of a traffic onto the RWY protected area does not lead to a conflict due to absence of other traffic (RWY is not occupied) or the unauthorised entry of a traffic is behind the landing or departing aircraft.

Table 5-7: RCP01 description

5.5.2 RCP02 Opportunity for RWY conflict prevention after incorrect presence on runway

RCP02.01	*RCP02.02*	*RCP02.03*
Clearance for the intended RWY use has not been given yet	*It is possible to detect the conflict after RWY clearance issue*	*Sufficient time for RWY conflict prevention*

Figure 5-8: RCP02 structure

Safety Function Level 1	Safety Function Level 2	Description
RCP02 **Opportunity for RWY conflict prevention after incorrect presence on RWY**	**RCP02.01** **Clearance for the intended RWY use has not been given yet**	An ATC clearance for use of the RWY subject to the incorrect presence has not been issued prior to the incorrect entry onto the RWY protected area, i.e. a runway conflict is not yet created.
	RCP02.02 **It is possible to detect the conflict**	The situation provides for timely detection of the RWY conflict - the traffic or pedestrian or animal/obstacle that created the conflict is detectable and the environment conditions support conflict detection by visual observation and/or with system support.
	RCP02.03 **Sufficient time for RWY conflict prevention**	The time available after the incorrect entry/presence on the RWY protected area is more than the minimum needed for decision on, communication and execution of an effective RWY conflict prevention action.

Table 5-8: RCP02 description

5.5.3 RCP03 RWY conflict prevention by ATCO after incorrect presence on RWY

RCP03.01	*RCP03.02*	*RCP03.03*	*RCP03.04*
ATCO detects timely and interprets correctly the potential RWY conflict	*Correct and timely ATCO action for RWY conflict prevention*	*Correct and timely air-ground communication*	*Correct and timely implementation of conflict prevention instruction by pilot/driver*

Figure 5-9: RCP03 structure

Safety Function Level 1	Safety Function Level 2	Description
RCP03 **RWY conflict prevention by ATCO after incorrect presence on RWY**	**RCP03.01** **ATCO detects timely and interprets correctly the potential RWY conflict**	The ATCO detects timely and interprets correctly the potential RWY conflict by using the available means or with third party support. The function is decomposed further in section 5.5.3.1.
	RCP03.02 **Correct and timely ATCO action for RWY conflict prevention**	The ATCO takes timely and correct decision and modifies or does not issue the intended RWY use clearance, or undertakes another timely action to prevent the potential RWY conflict. ***Note***: Modifying or cancelling a RWY use clearance while delivering it or immediately after (e.g. cancelling an incorrect take-off clearance immediately after its delivery and before the aircraft starts the take-off run) is considered as a prevented conflict.
	RCP03.03 **Correct and timely air-ground communication**	The (modified, cancelled) RWY use clearance is issued timely to the correct aircraft/vehicle and is understood and acknowledged correctly by the correct crew/vehicle driver. The function is decomposed further in section 5.5.3.2.
	RCP03.04 **Correct and timely implementation of conflict prevention instruction by the pilot/driver.**	The conflict participant takes prompt action and correctly completes the instructed manoeuvre to prevent RWY conflict. The function is decomposed further in section 5.5.3.5.

Table 5-9: RCP03 description

5.5.4 RCP04 RWY conflict prevention by pilot/driver/pedestrian after incorrect presence on runway

RCP04.01	*RCP04.02*
Pilot/driver/pedestrian detects timely and interprets correctly the potential RWY conflict	*Pilot/driver/pedestrian takes timely and correct action and prevents the RWY conflict*

Figure 5-10: RCP04 structure

Safety Function Level 1	Safety Function Level 2	Description
RCP04 **RWY conflict prevention by pilot/driver /pedestrian after incorrect presence on RWY**	**RCP04.01** **Pilot/driver/pedestrian detects timely and interprets correctly the potential RWY conflict**	The participant in the potential conflict (pilot or driver or pedestrian) detects timely and interprets correctly the potential RWY conflict. The function is decomposed further in section 5.5.4.1.
	RCP04.02 **Pilot/driver/pedestrian takes timely and correct action and prevents the RWY conflict**	The participant in the potential conflict takes timely and correct decision and action and prevents the potential RWY conflict. Examples: • pilot/driver requests clarification before proceeding further; • pilot vacates or does not enter the RWY protected area despite of having received a RWY clearance; • pilot does not commence the take-off run despite of having received the respective ATC clearance); • pilot performs go around after observing that the RWY protected area is occupied, • pedestrian identifies the landing aircraft on short final and leaves the RWY protected area.

Table 5-10: RCP04 description

5.6 ATC Runway Collision Avoidance basic safety function (RCA_ATC)

5.6.1 RCA_ATC 01 No need for ATC RWY collision avoidance

Safety Function Level 1	Description
RCA_ATC01 **No need for ATC RWY collision avoidance**	The ATC Runway Collision Avoidance safety function is not challenged – e.g.: • conflict participants are on diverging trajectories and no risk of collision from the moment the conflict occurred. • conflict that was created by very early (premature) landing clearance issue is resolved before the landing aircraft passes 3 NM from touchdown.

Table 5-11: RCA_ATC01 description

5.6.2 RCA_ATC 02 Opportunity for ATC runway collision avoidance

RCA_ATC02.01 *RWY conflict detectable by ATCO*	*RCA_ATC02.02* *Sufficient time for ATC RWY collision avoidance*

Figure 5-11: RCA_ATC 02 structure

Safety Function Level 1	Safety Function Level 2	Description
RCA_ATC02 **Opportunity for ATC runway collision avoidance**	**RCA_ATC02.01** **RWY conflict detectable by ATCO**	The situation provides for timely detection of the RWY conflict - the traffic or pedestrian/animal/obstacle that participate in the conflict is detectable and the environment conditions support conflict detection by visual observation and/or with system support. The function is decomposed further in section 5.6.2.1.
	RCA_ATC02.02 **Sufficient time for ATC RWY collision avoidance**	The time available (after the conflict start and before the occurrence of CPA/ RWY collision) is more than the minimum needed for decision on, communication and execution of an effective collision avoidance action.

Table 5-12: RCA_ATC 02 description

5.6.3 RCA_ATC 03 Need for RWY collision avoidance detected and interpreted by ATCO

RCA_ATC03.01 *Runway conflict detected timely*	*RCA_ATC03.02* *Runway conflict correctly interpreted*

Figure 5-12: RCA_ATC03 structure

Safety Function Level 1	Safety Function Level 2	Description
RCA_ATC03 **Need for RWY collision avoidance detected and interpreted by ATCO**	**RCA_ATC03.01** **RWY conflict detected timely by ATCO**	The ATCO detects timely the RWY conflict (i.e. identifies the need of runway collision avoidance) by visual observation and/or by using the available system support means.
	RCA_ATC03.02 **RWY conflict correctly interpreted by ATCO**	The ATCO correctly interprets the available information about the runway conflict and the need for runway collision avoidance action.

Table 5-13: RCA_ATC03 description

5.6.4 RCA_ATC 04 Effective ATCO collision avoidance decision and action

RCA_ATC04.01 *Correct and timely ATCO collision avoidance decision*	*RCA_ATC04.02* *Correct and timely ATCO collision avoidance instructions*

Figure 5-13: RCA_ATC03 structure

Safety Function Level 1	Safety Function Level 2	Description
RCA_ATC04 **Effective ATCO collision avoidance decision and action**	**RCA_ATC04.01** **Correct and timely ATCO collision avoidance decision**	The ATCO selects timely a workable collision avoidance solution that can be implemented by the conflict participant(s) and the RWY collision avoided.
	RCA_ATC04.02 **Correct and timely ATCO collision avoidance instructions**	The time available for effective RWY collision avoidance is not exceeded by delayed ATCO action or hesitation and the collision avoidance solution is not compromised by unintentional deviation, e.g. slips.

Table 5-14: RCA_ATC03 description

5.6.5 RCA_ATC 05 Correct and timely air-ground communication

RCA_ATC.COM.01 *Air-ground communication is functional*	*RCA_ATC.COM.02* *Adequate air-ground communications (collision avoidance instruction)*

Figure 5-14: RCP05 structure

Safety Function Level 1	Safety Function Level 2	Description
RCA_ATC05 **Correct and timely air ground communication**	**RCA_ATC.COM.01** **Air-ground communication is functional**	At least one conflict participant (pilot, driver) and the ATCO are able to communicate with each other. The function is decomposed further in section 5.6.5.1
	RCA_ATC.COM.02 **Adequate air-ground communication**	There is no misunderstanding of the collision avoidance instruction by a pilot and/or driver. The communication exchange is not delayed and ensures complete, clear and unambiguous instructions, read-back and correct hear-back. The function is decomposed further in section 5.6.5.2.

Table 5-15: RCP03.03 description

Safety Function Level 1	Safety Function Level 2	Description
RCA_ATC.COM.02 **Adequate air-ground communications**	**RCA_ATC.COM.02.01** **Correct communication and understanding of the call-sign**	This function includes: • identifying and preventing the use of similar call-signs; • use of complete and correct call-signs; • ATCO awareness of call-sign similarity; • adequate articulation of call-signs and clear speech; • special attention (defensive ATC) to the correct reception and understanding of the ATC clearance by potentially higher risk flights or vehicle operations (language skill level, airspace familiarity); • correctly hearing and interpreting the call-sign.
	RCA_ATC.COM.02.02 **Correct communication and understanding of the communication message**	This function includes: • use of language that is familiar to the pilot/driver and they can understand the instructions/ clearances; • complete and clear communication of the conflict prevention instructions or other information; • prevention of communication being blocked or subject to interference; • adequate articulation using clear speech which avoids excessive speed of clearance delivery; • special attention (defensive ATC) to potentially higher risk flights or situations (language skill level, airspace familiarity) and use of phraseology that is likely to be correctly understood and interpreted by the pilot/driver; • avoidance of complex, excessively long, ambiguous or additional/confusing information in a clearance or instruction; • correctly hearing the message content; • language comprehension, without mental confusion and avoiding expectation bias.
	RCA_ATC.COM.02.03 **Conflict participant identifies communication confusion and requests clarification**	This function includes: • pilot/driver actively monitoring both the traffic situation and communications, • identification of potential confusion in communications whether intended for them or not; and • promptly informing ATC or requesting clarification • ATCO responds timely and the confusion is resolved.

	RCA_ATC.COM.02.04 **Conflict participant read-back**	This function includes: • pilot/driver providing prompt, complete and understandable read-back of the understood call-sign and communication message, which is not blocked or subject to interference; • ATCO requesting pilot/driver read-back if partial or not provided when needed/required.
	RCA_ATC.COM.02.05 **Correct ATCO hear-back**	This function includes involves: • ATCO actively listening to read-backs and identifying missing parts or communication misunderstandings; • prompt resolution of any communication misunderstanding; • hear-back confirmation when required.

Table 5-16: RCA_ATC.COM.02 description

5.6.6 RCA_ATC 06 Conflict participant acts promptly to RWY collision avoidance instruction

Safety Function Level 1	Description
RCA_ATC06 **Conflict participant acts promptly to RWY collision avoidance instruction**	The conflict participant initiates the instructed by ATCO RWY collision avoidance action without unnecessary delay or hesitation.

Table 5-17: RCA_ATC06 description

5.6.7 RCA_ATC 07 Avoidance instruction correctly implemented and RWY collision avoided

Safety Function Level 1	Description
RCA_ATC07 **Avoidance instruction correctly implemented and RWY collision avoided**	At least one of the conflict participants correctly completes/executes the required manoeuvre/action and the RWY collision is avoided.

Table 5-18: RCA_ATC07 description

5.7 Conflict Participant Runway Collision Avoidance basic safety function (RCA_P)

5.7.1 RCA_P01 No need for conflict participant RWY collision avoidance

Safety Function Level 1	Description
RCA_P01 **No need for conflict participant RWY collision avoidance**	The Conflict Participant Runway Collision Avoidance safety function is not challenged – e.g. the CPA does not necessitate a collision avoidance action; diverging trajectories and no risk of collision from the moment the conflict occurred.

Table 5-19: RCA_P01 description

5.7.2 RCA_P02 Opportunity for RWY collision avoidance by a conflict participant

RCA_P02.01 *RWY conflict detectable by a conflict participant*	*RCA_P02.02* *RWY collision avoidance manoeuvre feasible*

Figure 5-15: RCA_P02.01 structure

Safety Function Level 1	Safety Function Level 2	Description
RCA_P02 **Opportunity for RWY collision avoidance by a conflict participant**	**RCA_P02.01** **RWY conflict detectable by a conflict participant**	The situation provides for timely detection of the RWY conflict - the traffic or pedestrian/animal/obstacle that participates the conflict is detectable and the environment conditions support conflict detection by visual observation and/or with system support. This function is further decomposed in section 5.7.2.1
	RCA_P02.02 **RWY collision avoidance manoeuvre feasible**	The relative speeds, geometry of the encounter and the time from the moment the RWY conflict became detectable provide opportunity for effective collision avoidance action by at least one RWY conflict participant.

Table 5-20: RCA_P02 description

5.7.3 RCA_P03 Need for collision avoidance detected and interpreted by a conflict participant

Safety Function Level 1	Description
RCA_P03 **Need for collision avoidance detected and interpreted by a conflict participant**	A conflict participant detects timely the need for collision avoidance by visual observation and/or monitoring of the R/T exchange or with system support, and correctly interprets the information as a collision risk threat.

Table 5-21: RCA_P03 description

5.7.4 RCA_P04 Collision avoidance action initiated promptly by a conflict participant

Safety Function Level 1	Description
RCA_P04 **Collision avoidance action initiated promptly by a conflict participant**	A conflict participant initiates a timely RWY collision avoidance action without any unnecessary delay or hesitation.

Table 5-22: RCA_P04 description

5.7.5 RCA_P05 Avoidance action correctly implemented and RWY collision avoided

Safety Function Level 1	Description
RCA_P05 **Avoidance action correctly implemented and RWY collision avoided**	The conflict participant correctly completes/executes the needed manoeuvre/action and RWY collision is avoided.

Table 5-23: RCA_P05 description

5.8 Providence basic safety function

Basic function	Description
Providence	The geometry of the encounter results in a distance between the involved conflict participants that is sufficient to avoid the RWY collision.

Table 5-24: Providence basic function description

==End of document==

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