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EUROCONTROL Specification for Approach Path Monitor

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Abstract

This document specifies the minimum requirements for the development, configuration and use of Approach Path Monitor (APM) in the ECAC area.

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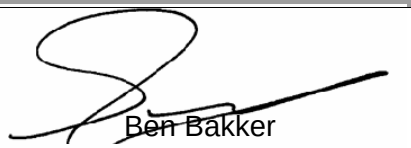
Technical Manager	 Ben Bakker	19-5-2009
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CONTENTS

1. INTRODUCTION

This document is aimed at all Air Navigation Service Providers (ANSPs) in the European Civil Aviation Conference (ECAC) area. It specifies the minimum requirements for the development, configuration and use of Approach Path Monitor (APM). APM is a ground-based safety net intended to warn the controller about increased risk of controlled flight into terrain accidents by generating, in a timely manner, an alert of aircraft proximity to terrain or obstacles during final approach.

This document does not apply to Minimum Safe Altitude Warning (MSAW) which is a separate safety net. Minimum requirements for MSAW are specified in a separate document.

The European Convergence and Implementation Plan (ECIP) contains an Objective (ATC02.7) for ECAC-wide standardisation of APM in accordance with the EUROCONTROL Specification for Approach Path Monitor (this document). This document specifies, in qualitative terms, the common performance characteristics of APM as well as the prerequisites for achieving these performance characteristics.

It should also be noted that Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation) contains *inter alia* the following essential requirements:

- "*Systems and operations of the EATMN shall achieve agreed high levels of safety. Agreed safety management and reporting methodologies shall be established to achieve this.*"
- "*In respect of appropriate ground-based systems, or parts thereof, these high levels of safety shall be enhanced by safety nets which shall be subject to agreed common performance characteristics.*"

The present document facilitates harmonization of the APM elements of the ground based safety nets and sets up the prerequisites for the refinement, in quantitative terms, of the common performance characteristics which might be developed in a further step in response to the requirements of the SES interoperability Regulation.

This document is targeted at stakeholders identified in ECIP ATC02.7, and the requirements are placed on ANSPs. The document is structured as follows:

- Chapter 1 describes the purpose, scope and structure of the document.
- Chapter 2 lists reference documents, explains terms and contains a list of abbreviations.

- Chapter 3 describes the APM concept of operations. It provides the contextual information for interpretation of the requirements contained in Chapter 4.
- Chapter 4 specifies the minimum qualitative requirements that are regarded as necessary for effective APM. It does not prescribe implementation aspects. Only the ***minimum*** requirements that are considered essential for ensuring the effectiveness of APM in the ECAC area are specified. These requirements are necessarily of a qualitative nature considering the implications of local factors that need to be considered. The requirements in this chapter are normative in the sense that:
  - Requirements using the operative verb ***"shall"*** are mandatory to claim compliance with the Specification. Mandatory requirements are explicitly numbered with the prefix "APM-".
  - Requirements using the operative verb ***"should"*** are recommended.
  - Requirements using the operative verb ***"may"*** are optional.
  - Requirements using the operative verb ***"will"*** denote a statement of intent.
- Chapter 5 identifies the comprehensive guidance material available to assist in implementing this Specification.

Use of the word "shall" is avoided in Chapter 3 of this Specification and in the guidance material in order to emphasise the introductory and explanatory rather than normative nature of the information provided.

Some of the terms in section 2.2 and the requirements on procedures in section 4.2 are derived from paragraph 15.7.4 of ICAO Doc 4444. Any differences in formulation are intended to remove ambiguity and not to imply deviation from ICAO provisions. For example, no references to "minimum safe altitude" are included in this Specification. ICAO uses this term but does not provide a definition. Use of the term in this Specification could introduce ambiguity regarding the purpose of APM: the sole purpose of APM is to enhance safety and not to monitor adherence to legal minima.

2. CONVENTIONS REGARDING TERMS

2.1 Reference Documents

[EURO-HRS]	Guidelines for Trust in Future ATM Systems: Principles, HRS/HSP-005-GUI-03, Edition 1.0, May 2003
[SRC-ESARR4]	ESARR 4: Risk Assessment and Mitigation in ATM, Edition 1.0, 05-04-2001

2.2 Explanation of Terms

alert	Indication of an actual or potential hazardous situation that requires particular attention or action.
altitude	The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL).
approach path monitor	A ground-based safety net intended to warn the controller about increased risk of controlled flight into terrain accidents by generating, in a timely manner, an alert of aircraft proximity to terrain or obstacles during final approach.
ATS surveillance service	Term used to indicate a service provided directly by means of an ATS surveillance system.
elevation	The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.
false alert	Alert which does not correspond to a situation requiring particular attention or action (e.g. caused by split tracks and radar reflections).

final approach	That part of an instrument approach procedure which commences at the specified final approach fix or point, or where such a fix or point is not specified, a) at the end of the last procedure turn, base turn or inbound turn of a racetrack procedure, if specified; or b) at the point of interception of the last track specified in the approach procedure; and ends at a point in the vicinity of an aerodrome from which: 1) a landing can be made; or 2) a missed approach procedure is initiated.
flight level	A surface of constant atmospheric pressure which is related to a specific pressure datum, 1 013.2 hecto-pascals (hPa), and is separated from other such surfaces by specific pressure intervals. *Note 1.– A pressure type altimeter calibrated in accordance with the Standard Atmosphere:* *a. when set to a QNH altimeter setting, will indicate altitude;* *b. when set QFE altimeter setting, will indicate height above the QFE reference datum;* *c. when set to a pressure of 1 013.2 hPa, may be used to indicate flight levels.* *Note 2.– The terms "height" and "altitude", used in Note 1 above, indicate altimetric rather than geometric heights and altitude.*
ground-based safety net	A ground-based safety net is functionality within the ATM system that is assigned by the ANSP with the sole purpose of monitoring the environment of operations in order to provide timely alerts of an increased risk to flight safety which may include resolution advice.
height	The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.
human performance	Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

level	A generic term relating to the vertical position of an aircraft in flight and meaning variously, height, altitude or flight level.
nuisance alert	Alert which is correctly generated according to the rule set but is considered operationally inappropriate.
warning time	The amount of time between the first indication of an alert to the controller and the predicted hazardous situation. *Note.– The achieved warning time depends on the geometry of the situation.* *Note.– The maximum warning time may be constrained in order to keep the number of nuisance alerts below an acceptable threshold.*

2.3 Abbreviations and Acronyms

ADS	Automatic Dependent Surveillance
AGDL	Air-Ground Data Link
ANSP	Air Navigation Service Provider
APM	Approach Path Monitor
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATS	Air Traffic Service
EATMN	European Air Traffic Management Network
EC	European Commission
ECAC	European Civil Aviation Conference
ECIP	European Convergence and Implementation Plan
(E)GPWS	(Enhanced) Ground Proximity Warning System
ESARR	EUROCONTROL Safety Regulatory Requirement
FAF	Final Approach Fix
FUA	Flexible Use of Airspace
GAT	General Air Traffic
HMI	Human Machine Interface
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
MSAW	Minimum Safe Altitude Warning *Note.– Not to be confused with MSA (Minimum Sector Altitude).*

MSL	Mean Sea Level
OAT	Operational Air Traffic
QFE	Atmospheric pressure at aerodrome elevation *(or at runway threshold)*
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
SES	Single European Sky
SRC	Safety Regulatory Commission
VFR	Visual Flight Rules

3. APM CONCEPT OF OPERATIONS

3.1 Purpose of APM

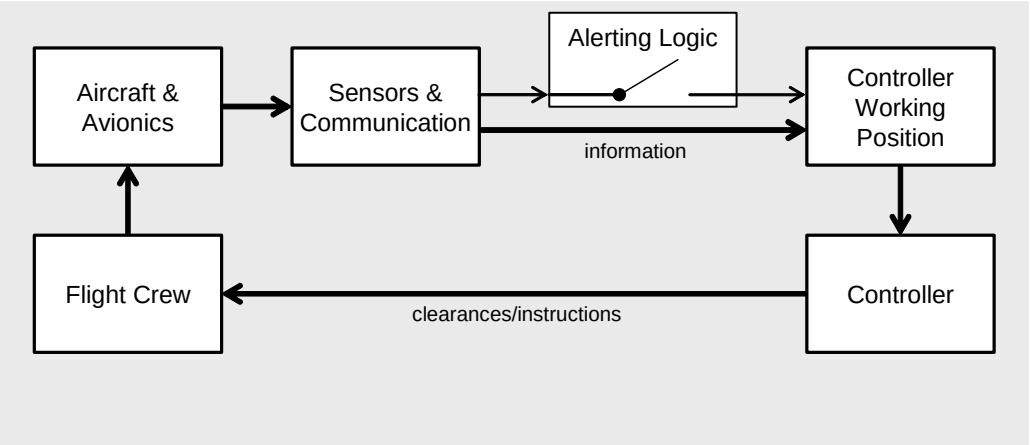

Fig. 1: Simplified ATC Control Loop

As illustrated in Fig. 1, today's ATC system is human centred; based on processing of a continuous stream of information, the controller issues clearances and instructions to prevent or resolve conflicts.

However, the drive for consistency in cognitive information processing tasks leads to selective perception/exposure, selective attention and selective interpretation. As a result, actual or potential hazardous situations related to aircraft altitude can remain unnoticed.

APM adds independent alerting logic to the control loop in order to avoid controlled flight into terrain accidents by generating alerts of existing situations, related to aircraft altitude during final approach, which require attention/action.

3.2 Operational Context

When APM was first introduced, ATS surveillance services were in most cases provided using mixed (raw radar data supplemented with computer-generated synthetic data) situation displays. In the meantime, the norm for provision of ATS surveillance services has become full-synthetic situation displays in most ECAC States. Decision support tools are gradually being introduced to enable the controller to handle more traffic in order to cope with the ever increasing demand. At the same time, automated support systems have become more robust and trustworthy but also more complex and interdependent. These changes imply a different operational context for APM.

It is essential that individual ANSPs establish a clear APM policy for their particular operational context to avoid ambiguity about the role and use of APM using the following generic policy statements as a starting point:

APM IS A GROUND-BASED SAFETY NET; ITS SOLE PURPOSE IS TO ENHANCE SAFETY AND ITS PRESENCE IS IGNORED WHEN CALCULATING SECTOR CAPACITY.

APM IS DESIGNED, CONFIGURED AND USED TO MAKE A SIGNIFICANT POSITIVE CONTRIBUTION TO AVOIDANCE OF CONTROLLED FLIGHT INTO TERRAIN ACCIDENTS BY GENERATING, IN A TIMELY MANNER, AN ALERT OF AIRCRAFT PROXIMITY TO TERRAIN OR OBSTACLES DURING FINAL APPROACH.

APM is only effective if the number of nuisance alerts remains below an acceptable threshold according to local requirements and if it provides sufficient warning time to resolve hazardous situations, governed by the inherent characteristics of the human centred system.

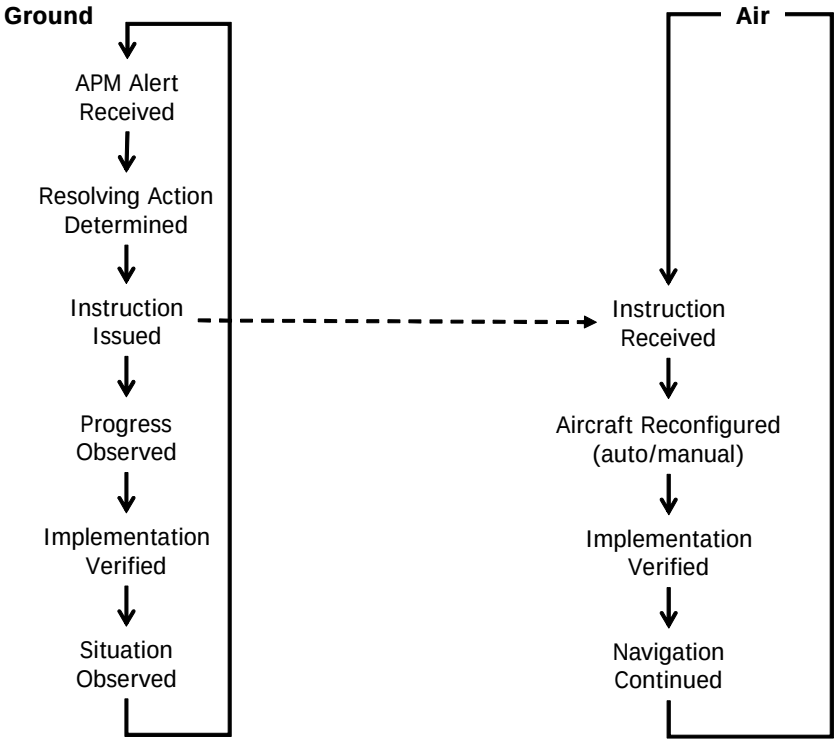

Fig. 2: Expanded ATC Control Loop (triggered by APM)

Fig. 2 illustrates the nominal sequence of events to resolve a particular situation as two loosely loops. Being a human centred system, the Ground loop reflects the states of the controller and the Air loop reflects the states of the flight crew. For each state transition to occur certain preconditions have to be met and actions performed, complicated by many fixed or variable delays and anomalous cases.

3.3 Operational Concept

3.3.1 Human Performance Considerations

In order to be able to process all available information, the controller must acquire situational awareness and build a mental model of the airspace and traffic pattern. To control the situation and make decisions, the controller has to establish strategies and tactics to handle the traffic flows and conflicts.

Hazardous situations related to aircraft altitude can remain unnoticed by the flight crew and the controller. The controller's workload and priorities may cause an imminent hazardous situation to remain undetected if not alerted by APM.

The use of APM will depend on the controller's trust. Trust is a result of many factors such as reliability and transparency. Neither mistrust nor complacency is desirable; training and experience is needed to develop trust at the appropriate level (see [EURO-HRS]).

For APM to be effective, the controller must have a positive attitude towards APM. This requires that the following aspects are addressed:

- **Appropriateness and timeliness**
  The rule set for generating alerts should be appropriate; dissonance with normal control practices should be avoided.
- **Effectiveness**
  The controller in charge may not notice or recognise the reason for an alert for the same reasons that left the potentially hazardous situation undetected. This should be addressed in HMI design.
- **Comprehensibility and performance monitoring**
  The increasing complexity of APM and the environment in which it is used should be addressed through appropriate training and competence assessment. Practices and controller perception of the effectiveness of APM should be evaluated periodically and following changes to APM. Lessons from particular situations or incidents in which APM was involved should be shared through appropriate mechanisms.

3.3.2 Design Considerations

APM should perform in concert with the airspace design and classification, variety of airspace users and the applicable procedures for air navigation services.

APM should perform for both precision and non-precision instrument approaches. However, for circling approaches, APM should not be expected to operate in circling area/circling prescribed track.

Special consideration should be given to making all ground-based safety nets and controller tools perform in concert.

Dependent on the diversity of these aspects, APM should be capable of using different parameters for generation of alerts. Different parameters may be applied in the case of system degradation (e.g. unavailability of one or more radar stations).

Local instructions concerning the use of APM should be established to ensure that APM is used in a safe and effective manner. Pertinent data should be regularly analysed in order to monitor and optimise the performance of APM.

3.3.3 Technical Aspects

APM is suitable for use in any airspace covered by adequate surveillance.

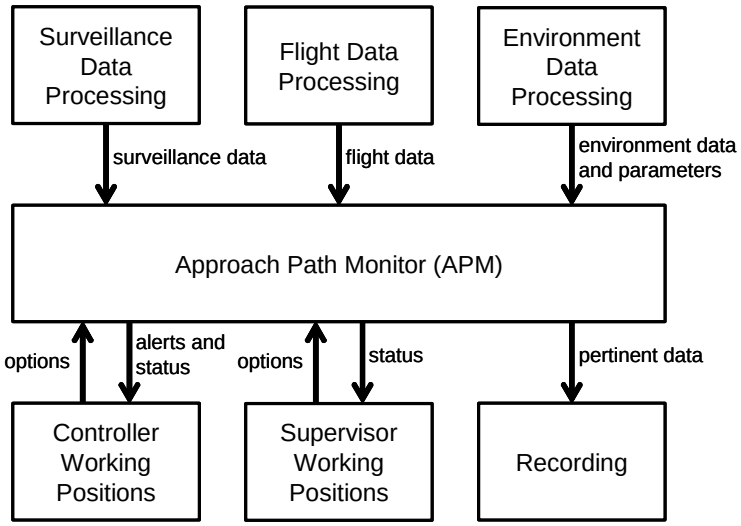

Fig. 3: APM Context Diagram

As illustrated in Fig. 3, APM should obtain information from Surveillance Data Processing, from Environment Data Processing and possibly from Flight Data Processing in order to generate alerts:

- Surveillance data including tracked pressure altitude information should be used to detect hazardous situations
- Flight data should be used as follows:
  - Type/category of flight: to determine the eligibility for alert generation and possibly also the parameters applied
  - Concerned sector(s): to address alerts
- Environment data and parameters should include:
  - Terrain and obstacle data
  - Alerting parameters
  - Additional items (QNH, temperature, etc.)

Alerts should be generated at least at a Controller Working Position of the control sector working the aircraft. Status information regarding the technical availability of APM is to be provided to all Working Positions. Selectable options of APM related to eligibility, configuration and technical availability may be available at Controller and Supervisor Working Positions.

All pertinent data for offline analysis of APM should be recorded.

3.4 Safety Aspects

It is assumed that EUROCONTROL Safety Regulatory Requirements are effectively implemented. It is recommended to put emphasis on [SRC-ESARR4] and its guidance material for the implementation of, and changes to, APM applications.

3.5 Future Directions and Need for Change

APM will have to meet future demands imposed by, amongst other things, further traffic increase, changing approach procedures, changing aircraft characteristics, further automation in the air and on the ground and, potentially, the introduction of new concepts.

The compatibility of APM and other ground-based and airborne safety nets, in particular (E)GPWS, needs to be maximised.

Availability of improved or new aircraft information through Mode S, ADS and AGDL will offer new opportunities to improve APM.

This could amongst others lead to changes in the following aspects of APM:

- Correlation of ATC constraints with aircraft intent in order to further reduce the number of nuisance alerts;
- Correlation of alerts from multiple sources (on the ground and in the air) to generate combined alerts.

4. SPECIFIC REQUIREMENTS

4.1 Policy, Organisational Clarity and Training Requirements

4.1.1 Policy

APM-01 The ANSP ***shall*** have a formal policy on the use of APM consistent with the operational concept and safety management system applied to avoid ambiguity about the role and purpose of APM.

The policy ***should*** be consistent with the generic policy statements in section 3.2 of this Specification but may contain more detail or additional aspects called for by local factors.

The policy ***should*** be communicated to all relevant staff in order to ensure consistency of all design, configuration, operational use and monitoring activities in compliance with the intended use of APM.

4.1.2 Responsibility for Management of APM

APM-02 The ANSP ***shall*** assign to one or more staff, as appropriate, the responsibility for overall management of APM.

It ***should*** be possible for other staff in the organisation to identify the assigned staff. The assigned staff ***should*** seek advice from the APM manufacturer, as appropriate.

4.1.3 Training and Competence

APM-03 The ANSP ***shall*** ensure that all controllers concerned are given specific APM training and are assessed as competent for the use of the relevant APM system.

Note.– The primary goal of the training is to develop and maintain an appropriate level of trust in APM, i.e. to make controllers aware of the likely situations where APM will be effective and, more importantly, situations in which APM will not be so effective (e.g. close to the runway threshold).

4.2 Requirements on Procedures

4.2.1 Local Instructions

APM-04 Local instructions concerning use of APM ***shall*** specify, *inter alia*:

a) the types of flight (GAT/OAT, IFR/VFR, etc.) which are eligible for generation of alerts;

b) the runways for which APM is implemented;

c) the method of displaying the APM to the controller;

d) in general terms, the parameters for generation of alerts as well as alert warning time;

e) the runways for which APM can be selectively inhibited and the conditions under which this will be permitted as well as applicable procedures;

f) conditions under which APM alerts may be inhibited for individual flights as well as applicable procedures.

4.2.2 Controller Actions

APM-05 In the event an alert is generated in respect of a controlled flight, the controller ***shall*** without delay assess the situation and if necessary the flight ***shall*** be given appropriate instructions to avoid terrain.

4.2.3 APM Performance Analyses

APM-06 APM performance ***shall*** be analysed regularly.

4.2.4 Statistical Analyses

The appropriate ATS authority ***should*** retain electronic records of all alerts generated. The data and circumstances pertaining to each alert ***should*** be analysed to determine whether an alert was justified or not. Non-justified alerts, e.g. during visual approach, ***should*** be ignored. A statistical analysis ***should*** be made of justified alerts in order to identify possible shortcomings in airspace design and ATC procedures as well as to monitor overall safety levels.

4.3 Requirements on APM Capabilities

4.3.1 Alerting Performance

APM-07 APM ***shall*** detect operationally relevant situations for eligible aircraft.

APM-08 APM ***shall*** alert operationally relevant situations for eligible aircraft.

Note.– Situations are operationally relevant when covered by the adopted rule set and optimisation strategy. The rule set and optimisation strategy should be determined taking into account the relevant local factors. APM should not be expected to alert all operationally relevant situations.

APM-09 APM alerts ***shall*** attract the controller's attention and identify the aircraft involved in the situation; APM alerts ***shall*** be at least visual.

An audible element ***should*** be included to improve the systems ability to draw the controller's attention to the alert as appropriate (e.g. in Control Towers). If a continuous audible element is included, an acknowledgement mechanism ***may*** be provided to silence an alert.

APM-10 The number of nuisance alerts produced by APM ***shall*** be kept to an effective minimum.

Note.– Human factors and local circumstances determine what constitutes an effective minimum.

APM-11 The number of false alerts produced by APM shall be kept to an effective minimum.

Note.– Local circumstances determine what constitutes an effective minimum.

4.3.2 Warning Time

APM-12 When the geometry of the situation permits, the warning time ***shall*** be sufficient for all necessary steps to be taken from the controller recognising the alert to the aircraft successfully executing an appropriate manoeuvre.

Note.– Warning time may be insufficient close to the runway threshold.

APM-13 APM ***shall*** continue to provide alert(s) as long as the alert conditions exist.

4.3.3 Alert Inhibition

APM-14 APM ***shall*** provide the possibility to inhibit alerts for specific runways and for individual flights.

Note.– It may be necessary to inhibit alerts for specific runways (e.g. when reserved for military operations) to suppress unnecessary alerts. It may be necessary to inhibit alerts for specific flights (e.g. Calibration Service Aircraft on a defined flight pattern) to suppress unnecessary alerts.

APM-15 Alert inhibitions ***shall*** be made known to all controllers concerned.

4.3.4 Status Information

APM-16 Status information ***shall*** be presented to supervisor and controller working positions in case APM is not available.

4.3.5 Adaptability

APM ***should*** be adaptable for the procedures in use in all distinct volumes of airspace.

APM ***may*** need to take into account the type of flight, in order to apply appropriate parameters. Different parameters ***may*** be applied in the case of system degradation (e.g. unavailability of one or more radar stations).

4.3.6 Data Recording

APM-17 All pertinent APM data ***shall*** be made available for off-line analysis.

Note.– Off-line analysis may need access to other data sources as well (surveillance data and voice recordings) for complete analysis.

5. GUIDANCE MATERIAL

5.1 Structure of the Guidance Material

Comprehensive guidance material to assist in implementing this specification covers the full APM lifecycle:

- Definition of objectives
- Implementation or change
- Tuning and validation
- Operating and monitoring

The guidance material consists of a document titled **EUROCONTROL Guidance Material for Approach Path Monitor** with several appendices. Most appendices can be used as stand-alone documents for particular purposes. Table 1 shows the structure of the guidance material.

Title	**Purpose**
EUROCONTROL Guidance Material for Approach Path Monitor	General description of the full APM lifecycle, aimed at staff with responsibility for overall management of APM.
Appendix A: Reference APM System	Detailed technical explanation of typical implementation details of APM with emphasis on parameterisation and performance optimisation. Optimisation concepts are also covered in detail.
Appendix B: Safety Assurance	A set of three documents that can be used as starting point for APM safety assurance work in a particular local context.
Appendix B-1: Initial Safety Argument for APM System	ANSPs may find it convenient to present the safety argument as a stand-alone document initially, as is the case with this document. However, the argument will ultimately become part of the safety case document and the stand-alone version will then become defunct.
Appendix B-2: Generic Safety Plan for APM Implementation	Describes what safety assurance activities should be considered at each lifecycle phase, who should do them, and what the criteria for success are.

Appendix B-3: Outline Safety Case for APM System	Addresses in detail the assurance and evidence from the System Definition stage and outlines the likely assurance and evidence for the later stages.
Appendix C: Cost Framework for the Standardisation of APM	Assists in identifying potential financial implications of standardisation of APM in compliance with the EUROCONTROL Specification for Approach Path Monitor.
Appendix D: Case Study	A document describing the (partial) application of the optimisation and safety assurance guidance material in a demanding environment.
Appendix D-1: Enhancement of APM for Geneva	Identifies potential alternative solutions for APM for Geneva and other airports.

Table 1: Structure of the guidance material

5.2 Availability and Feedback

The guidance material is freely available at www.eurocontrol.int/safety-nets and regularly updated based on feedback received.

Feedback and questions can be addressed to the contact listed in each document and to safety-nets@eurocontrol.int .

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