Final Technical Specification for Phase 2 (Enhance Safety Nets)

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Abstract

This document is the Final Technical Specification for Phase 2 (Enhance Safety Nets) of P10.4.3 "Safety Nets adaptation for new modes of operation" established in tight coordination with P4.8.1 "Evolutions of Ground-Based Safety Nets"

The purpose of this document is to elaborate a high-level specification of the system requirements applicable for the second phase of P10.4.3. These System Requirements are based on P4.8.1 and P4.8.3 outputs and existing documents from SPIN SG and PASS project guidelines [2].

This document is an update of 10.04.03 D39 where includes the conclusions raised on Release 3 in the validation exercise EXE-04.08.01-VP-239. There will be another update of this document in order to include the conclusions of the validation exercise EXE-04.08.03-VP-066.

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Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

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Executive summary

The 10.4.3 project will tackle the three steps of the SESAR Concept Story Board, it will be shared in three phases:

- Phase 1: Enhanced STCA
- Phase 2: Enhanced Safety Nets
- Phase 3: Safety Nets adaptations

This document is the Final Technical Specification for Phase 2 (Enhance Safety Nets) of P10.4.3 “Safety Nets adaptation for new modes of operation” established in tight coordination with P4.8.1 ”Evolutions of Ground-Based Safety Nets” and P4.8.3 ”Ground-Airborne Safety Net Compatibility which provide operational and users requirements which provide operational and users requirements.

The purpose of this document is to refine the preliminary release of the System Definition (defined in the D39 Preliminary TS for Phase 2 (Enhance Safety Nets including RADP) that includes D11 Preliminary Definition Report for Phase 2 (Enhance Safety Nets)) requirements, using experience gained along the Safety Nets functions development phase as well as the outcomes from validation phase.

These refinements is based on:

- P10.4.3 partners consultation
- P4.8.1 and P4.8.3 partners discussion
- Operational requirements provided by 4.8.1 and 4.8.3 (OSED, SPR and/or INTEROP)
- P10.4.3 verification results and P4.8.1 validation results (EXE-04.08.01-VP239 and EXE-04.08.01-VP066).

1 Introduction

1.1 Purpose of the document

The purpose of this document is to refine the system requirements allocated to the SESAR Project 10.04.03: Safety Nets adaptation to new modes of operation.

The set of requirements have been revised and updated in an iterative process, according to the three phases defined in the Project Initiation Report of 10.04.03 project and aligned with the concept story board steps:

- Phase 1: Enhanced STCA
- Phase 2: Enhanced Safety Nets
- Phase 3: Safety Nets adaptations

1.2 Intended readership

According to the scope of the project the following SESAR projects can be interested in this document:

- Projects within WP10:
  - P10.1.7 ATC System Specification: Project 10.1.7 will provide the consolidated Technical System Requirement set and Architecture Definition including a description of functionality and logical interfaces for conflict management components.
  - P10.10.2 iCWP Human Factors Design: Regarding Human Factors and the HMI requirements for Safety Nets Display.
  - P10.10.3 iCWP Prototyping: providing the HMI prototype supporting the developed concept.

- Projects outside WP10:
  - P4.8.1 Evolution of Ground Based Safety Nets: P.4.8.1 will provide the operational requirements related to safety nets for each step of the SESAR concept storyboard. This operational project has also validated the 10.4.3 prototype that has been developed in line with the release of this document.
  - P4.8.3 Ground-Airborne Safety Net Compatibility: P4.8.3 will provide the operational requirements related to the display of ACAS RA downlinked information to the controller. This operational project will also validate the 10.4.3 prototype that will be developed in line with the release of this document.

1.3 Inputs from other projects

The requirements defined in this document are based on results of previous studies on Safety Nets:

- SPIN SG outcomes
- PASS project guidelines

And operational requirements defined in:

- Deliverable D17 [15] of project 4.8.1 and
- Deliverable D18 [17] of project 4.8.1

- Milestone M110 [16] of project 4.8.3.

1.4 Structure of the document

This document is organised in the following chapters:

- Chapter 1: Purpose and scope; Requirements structure; Functional block purpose and high level overview;
- Chapter 2: General functional block description;
- Chapter 3: Functional block Functional and Non-Functional Requirements
- Chapter 4: Assumptions
- Chapter 5: Referenced documents

1.5 Requirements Definitions – General Guidance

Requirements in this document are developed according to the SESAR Requirements and V&V Guidelines [9]. They follow the layout illustrated below:

[REQ]

Identifier	
Requirement	
Title	
Status	
Rationale	
Category	
Validation Method	
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<Enabler>	Enabler code	<Full>
<SATISFIES>	<ATMS Requirement>	INTEROP or SPR Requirement Identifier	<Full>
<ALLOCATED_TO>	<Functional block>	Functional block Identifier	N/A
<APPLIES_TO>	<Operational Focus Area>	Operational Focus Area Identifier	N/A
<CHANGED_BECAUSE_OF>	<Change Order>	Change reference	N/A
<ALLOCATED_TO>	<Project>	Project Identifier	N/A

Table 1 – Requirements layout

1.6 Functional block Purpose

Safety Nets are background functions of the ATM system whose purpose is warning the controller to prevent collision risks of controlled flights due to loss of separation with other aircraft, dangerous approximation to terrain obstacles, intrusion into areas excluded for air-traffic or extrusion out of specific areas (e.g. military training areas). The function remains silently monitoring the traffic until an increased risk is predicted. Then, an alert will be raised in a timely manner to warn controllers on the predicted hazard. Risks are evaluated by monitoring current positions and estimating the aircraft's predicted path within approximately the next two minutes. Along this time, aircraft conflicts, terrain collision hazards and imminent penetration into excluded areas are probed.

Thus, the controller is alerted in a timely manner of situations for which he might need to issue some avoiding instructions. Notification may include a conflict resolution advice. Safety Nets are not intended to be a mean of increasing ATC capacity.

According to these objectives, the main features to achieve for this function are:

- Alert relevant conflicts, terrain collision hazards and unauthorized penetrations in excluded areas,
- Provide alerts within an adequate warning time,
- Minimize nuisance alerts,
- Avoid false alerts.

In some rare circumstances, Safety Nets may not alert the controller to certain situations that are potentially hazardous. The prediction systems make certain assumptions about an aircraft's likely behaviour. Sudden, extreme manoeuvres may, therefore, result in conflicts, terrain collision hazards or imminent area penetrations that will not be alerted with the required warning time, if at all.

Safety Nets use predicted aircraft paths. Due to uncertainty of prediction it is inevitable that some alerts will be caused by situations that did not in fact entail any risk. In order to ensure that the predictive role of Safety Nets can be fulfilled, it is therefore necessary to accept an effective minimum of nuisance alerts.

Besides the use of predicted aircraft paths, Safety Nets have to be based on some models of traffic movement. The aim of such models is to capture the most probable behaviour of real traffic, but the complexity of real manoeuvres and rules followed by controllers in common practice will inevitably lead to alerts correctly generated according to the models but unnecessary from the point of view of common practice.

The validation method of Safety Nets has to be clearly defined for the particular control site and the airspace it is to cover.

Consequently, a Safety Nets tuning phase on each ATC site is mandatory to reach the best trade-off between false, nuisance and genuine alerts. Moreover, this tuning has to be performed in close collaboration between the Safety Nets manufacturer and the ANSP who must find mutual agreement on the tuning (i.e. parameters setting).

Nuisance alerts have a crucial importance in the acceptance by controllers and should be minimised by means of an optimisation process. The aim of optimisation should be to maximise the proportion of genuine conflicts, terrain collision hazards or imminent area penetrations which are alerted while minimising the number of nuisance and false alerts.

Optimisation has to be planned as a long lasting phase before the Safety Nets are in operation. This phase should start as early as possible and continue during the lifecycle of the system.

Once there is an agreement on the Safety Nets performance between the industrial partner and the ANSP, the optimisation process requires analysing regularly the individual alert conditions and to determine the statistical characteristics of alert generation. Both to facilitate the tuning phase and later to accomplish evolutionary or corrective maintenance activities, some automatic tool should be integrated in the Safety Nets to analyse error sources and evaluate conditions for alert detection using recorded data.

An option is an iterative process executed off-line by designated personnel and based on previously recorded data. Every successive cycle of the off-line process consists of a series of steps: recording of input data and alert data, analysis of generated alerts and tuning of parameters in a realistic environment replaying real or simulated data. As a complement, automatic learning algorithms may be incorporated in the optimisation logic to accomplish this tuning. These algorithms could be based for example on the alert analysis performed by the ANSPs following alerts raised during the safety nets lifecycle. The output of such algorithms requires a regular evaluation by operational experts.

1.7 Functional block Overview

1.7.1 Considerations on the operational environment

1.7.1.1 Regions

Airspace is not a homogeneous medium for air navigation. At any time, airspace is divided in different areas as a mean of assigning particular characteristics to given volumes.

A hierarchical division of airspace is usually considered using the concepts of regions. The function of regions and areas is to provide a mean of assigning particular characteristics to given volumes of airspace. Regions are airspace volumes with specific traffic characteristics. From the operational point of view, the airspace is divided in “en route” and TMA regions, along with the near airport regions Control Terminal Region (CTR) and the own airport volume.

Areas are volumes inside a region with special characteristics. They add a more detailed structure to the overall organisation given by regions. A region may be completely split in different areas (e.g. control sectors), may have only some dispersed areas or may have no areas at all. In the last case, the airspace in the region is considered having no more than the characteristics of the region and with the same value at every point. Multiple areas may be defined for every characteristic and areas may overlay each other if they correspond to different characteristics.

Relevant properties of regions are the horizontal and vertical separations, related with the types of expected manoeuvres in the region. Usually, the same separation is applicable in the whole region, but it could be possible to define some area where a more reduced separation would be applicable. For vertical separation, regions with standard separation and reduced separation for aircraft with Reduced Vertical Separation Minimum (RVSM) equipment are defined.

Separation depends on sensors availability. With full sensors availability normal separation may be applied. When there is some sensor failure, extended separation has to be applied instead. A low availability may be coped with by applying a degraded separation.

Areas may be used to delimit some specific volumes which feature particular types of manoeuvres, such as holding patterns or the final approach areas. The configuration of these areas will vary along time, depending on such factors as airport configuration for landing and take-off or holding operations.

A special case is time-dependent areas (ARES) (e.g. a military firing range with published hours of operation). Since the airspace is not purely civil or military airspace but considered as a continuum, allocated according to user requirements, any segregation is considered temporary, and based on real time usage within a specific period of time.

The Level 1, called Strategic, consists of the definition of national policies and predetermined airspace structures. The day to day allocation, within the framework defined at Level 1, is the Level 2, called Pre-tactical. In this level, it is carried out the communication of airspace allocation data to all the parties concerned. In Level 3, it is activated or deactivated, or reallocated, the airspace previously allocated in Level 2.

The activation of these areas is published in a daily Airspace Use Plan (AUP). If necessary, changes to this pre-tactical airspace allocation is effected by AMCs through the publication of an Updated Airspace Use Plan (UUP). The activation/deactivation of areas is the result of a negotiation between Mil ANSP and Civ. ANSP (FUA Level 1, 2, 3). This negotiation is done by different means from phone/fax up to automated Airspace Management support systems. Some ATM systems already cater the data exchange between the ATFM system and ASM support systems such as e.g. Local And Regional Airspace management system. Inside active areas for military use, specific STCA and APW processing rules may be required.

From a temporary point of view, two types of areas may be considered. Some areas can be activated and de-activated whilst keeping a fixed geometry. Prohibited, restricted and dangerous areas published in AIP pertain to this type. Also control sectors, holding stacks or manoeuvre areas can be included in this group. Besides this, other areas are created and cancelled, having a particular geometry only while they are active. Temporary segregated areas pertain to this type.

Safety Nets make an intensive use of areas. The main one is the Safety Nets region, that is, the region where tracks will be monitored. Nevertheless, Safety Nets may be inhibited from producing alerts involving specific areas inside this region. In the same way, it could be considered desirable to define some regions as ineligible for de-activation. These regions would therefore always be activated when the Safety Nets are in operation and would thus provide a minimum level of cover by preventing the supervisor inadvertently disabling the Safety Net by de-activating the wrong regions.

1.7.1.2 Airspace Boundaries

Different types of airspace are defined as the union of multiple areas and regions. While for most areas, its borders may be crossed without restriction, there are circumstances in which border crossing between some areas is hazardous and unexpected crossing must be alerted. Unexpected crossings can be classified either as excursions from safety area or unauthorized crossings between areas intended for the segregation of different types of operations.

In order to define the limits of the safety area the first factor is the terrain, as the lower limit of airspace. For instrumental flight, it may be considered that there exists a minimum safe surface whose violation could lead to a terrain alert in the cockpit. Then, the controller must be capable to warn the pilot early enough to prevent the GPWS alert issued on board.

Two approaches may be followed to define this minimum safe surface. From an operational point of view, the minimum safe altitude is defined as the lowest minimum altitude that could be applicable among Minimum Radar Vectoring Altitude, Minimum Obstacle Clearance Altitude or Minimum Sector Altitude. In most cases, for terrain collision avoidance, infringements of such a minimum altitude may be considered as nuisance alerts, because these operational altitudes are not tightly fitted to terrain and obstacles. Therefore, to reduce nuisance alerts, a more strict topographic approach may be applied, modelling the minimum safe surface as a surface closely following the terrain. This approach is based on the availability of digital terrain data. Nevertheless, terrain is continuously changing and an additional height margin should be added to the terrain elevation to take account of temporary obstacles (e. g. cranes). Near airports, minimum safe altitude is not applicable for aircraft arriving or departing from the airport. Instead, during final approach manoeuvres, the kinematics conditions of approaching should be monitored to foresee a possible collision against terrain. For every runway and type of aircraft there exists an approach procedure that defines a safe path to runway threshold. In order to assess that the runway will be safely reached, lateral and vertical deviations from this nominal path should be monitored. The nominal path together with the lateral and vertical tolerances defines an approach funnel. Movement of aircraft inside this funnel is monitored.

The approach path monitoring finishes monitoring the flight at about 2 NM away from runway threshold. There are several reasons for this. The first is that, at less than this distance, the controller has not time enough for issuing any instruction for corrective actions before the aircraft touches down. More, this is the critical distance at which the pilot must decide if a missed approach procedure should be initiated. And furthermore, at this distance the height tolerance of the funnel volume is near the precision and accuracy of the surveillance data and nuisance alerts will be provoked.

There are different types of areas intended for the segregation of operations, including prohibited, restricted and dangerous areas. Border crossing for these areas must be authorised in order to maintain the traffic segregation and avoiding collision risks. Therefore, a general function for border crossing protection must be defined.

Several traffic segregations are considered. Civil aircraft are not authorised to enter in military areas while they remain active, and reciprocally, military aircraft are not authorized to unexpectedly leave these areas during military exercises. In the same manner, controlled and uncontrolled traffics are segregated on different sides of controlled airspace border. And finally, the separation of own controlled traffic from traffic controlled by collateral control centres could be considered. In that case, border crossing will be only a safe movement after the flight handover.

A special case of areas whose borders must never be crossed are the not transgression zone (NTZ areas) defined between prolongations of parallel runways with independent operations. So, at airports with independent operations on parallel runways, collaboration between approach path monitoring and border crossing protection is required. With this configuration, the approach manoeuvre should be monitored, but if a transgression of the excluded zone is foreseen, an alert on NTZ infringement should be issued.

1.7.1.3 Current Traffic Picture

The surveillance system provides the current traffic picture shown to the controllers at any time. This set of tracks is also an input to the Safety Nets. In some sense, the main task of Safety Nets is to analyse and anticipate the conflictive positions of these tracks inside the structure of areas and regions.

All tracks generated by the surveillance system will be processed and monitored by the Safety Nets Server (SNS). When a conflict will be detected, eligibility criteria will be checked to decide whether or not an alert is to be sent to the controller working positions. These criteria will certainly vary from one ANSP to another, and possibly from one safety net to another.

Then, criteria used for safety nets analysis could be:

- tracks coupled with flight plans currently following visual flight rules,
- tracks coupled with flight plans currently belonging to operational category,
- tracks without identification (primary tracks, tracks without flight plan coupling), and
- tracks outside the controlled volume.

A track is a set of kinematics parameters and additional data, including for coupled tracks a link to the flight plan. Some of these properties provide the information required by Safety Nets. Position and altitude are the essential parameters to achieve a basic level of warning. Velocity and vertical rate are required to achieve an acceptable warning time. Additional parameters from track and flight plan may contribute to improve conflict detection.

1.7.1.4 General Air Traffic Characteristics

In regions where several airports are close to each other, if some operational procedures can overlap or whether aircraft are frequently manoeuvring, complex situations regarding Safety Nets functions behaviour (e.g. STCA), or MSAW in case of hunched up terrain configuration or obstacles in final approach, it would be useful to implement multi-model processing allowing conflict decision based on likelihood functions.

Equally, in some major airports with independent runways, controllers could have to manage couple of aircraft separated by less than the authorised radar separation (e.g. two independent runways separated by less than 2 NM). In such typical cases, Safety Nets can propose specific processing using Normal Operating Zones (NOZ) inhibition areas avoiding nuisance alert generation. Inside NOZ, survey on ground and avionics on board assess than minor radar distances still maintaining safety.

Traditional navigation carries the flights from navaid, Distance Measuring Equipment (DME) and/or VHF Omni directional Range (VOR), point to another. The Basic Area Navigation (B-RNAV) uses fixed points not necessarily associated to a navaid, by using VOR/DME, DME/DME or Global Navigation System (GPS).

Further than these concepts, Precision – Area Navigation (P-RNAV) offers much better precision, and is to be used in Terminal Manoeuvring Area (TMA).

By using Ground-Based Augmentation System (GBAS) in the proximity of airports, which uses Global Navigation Satellite System (GNSS) GALILEO technology combined with augmentation on ground, enhanced surveillance will be obtained in the next future.

When more precise data are received by Air Traffic Control (ATC) Systems, Safety Nets will be able to give more accurate alerts, but they will have to analyze the increasing traffic permitted by the airspace of the future.

1.7.1.5 Operational Air Traffic Characteristics

Operational Air Traffic (OAT) and General Air Traffic (GAT) Organisation is different in each of the nations. Civil/military coordination varies from completely separated civil/military entities up to fully integrated entities.

A report (done in 2001) on the status of civil-military coordination in air traffic management identified four types of approaches for the en-route ATC organisational arrangements when handling Operational Air Traffic (OAT) / General Air Traffic (GAT) in controlled airspace between civil and military air navigation service providers. The four types are assumed to be still valid although some countries may have changed their approach. From today's point of view a fifth type could be added: it appears in the last row of the table below.

Approach name	Approach description
Segregated ATC systems Segregated ATC units	There are different ANSPs (civil and military). The military ATC and the Air Defence Control are located in the same operational room and they use the same system. Therefore, there are two ATC architectures with poor data exchange between them. Military and Civil ATC units are located in different places. Military ATC units are responsible for OAT and civil ATC units for GAT. The military ATC unit is always responsible to provide the GAT/OAT separation.
Integrated ATC systems Segregated ATC units	There are two ANSPs (civil and military). Military and ATC units reside in different locations. The military and civil ATC systems have similar functions and the level of data exchange is good. Updated flight plans and controllers intentions are exchanged. Civil and military ATC positions use the same data and have the same display presentation. Active co-ordination is performed directly between the ATC positions involved using telephone or automated tools. The airspace under the responsibility of a civil ACC unit corresponds with the area of responsibility of just one military ATC unit.

Approach name	Approach description
Single ATC system Co-located operations	There are either two ANSPs (civil and military) or one civil-military integrated ANSP. The ATC staff is co-located in the same ATC unit. There is a single ATC system with a good level of data exchange. In general, the OAT flight plans are inputted and updated in the Flight Data Processing system. However controllers' intentions are usually not inputted. The military and civil components of the ATC unit are responsible for the same area of responsibility. There are few military ATC sectors, each of them overlapping few civil sectors. Military ATC sectors are generally responsible for OAT and civil ATC sectors for GAT. However, in some cases traffic may be exchanged between controllers, if required, in order to alleviate the co-ordination tasks. The military ANSP is responsible for providing the GAT/OAT separation, but this can be returned to the civil ANSP in specific circumstances.
Single ATC system One ATC sector, one ATC team	There are either two ANSPs (civil and military) or one integrated ANSP. ATC staff is located in the same operational room of the same ATC unit. There is a single ATC system with a good level of data available. The Flight Data Processing system needs to keep an update of OAT flight plans. There is only one ATC sector, which serves a given block of airspace. Each sector deals with GAT and OAT and the controller may be a single controller rated for handling both GAT and OAT or a team of two executive controllers (usually one civil and one military).
Segregated ATC systems Segregated ATC units Enhanced Data Exchange	There are different ANSPs (civil and military). The military ATC and the Air Defence Control are located in different locations and working on different ATC systems. The level of data exchange between Military/Civil systems is good, traffic intentions are continuously exchanged. Data exchange between Mil ATC and Air Defence is good. Military ATC units are responsible for OAT and civil ATC units for GAT. The military ATC unit is always responsible to provide the GAT/OAT separation.

Table 2 – The different civil-military ATC coordination approaches

OAT consists of flights which do not comply with the provisions stated for GAT and for which rules and procedures have been specified by national authorities.

Since the Single European Sky (SES) will harmonise airspace design and arrangements for airspace use at European level, i. A. through the creation of Functional Airspace Blocks (FAB), the European military community must overcome this national fragmentation to be interoperable with the future ATM Network. EUROCONTROL has been mandated to harmonise European-level OAT arrangements and is progressing this work in three steps.

- Harmonisation of OAT Rules
- Europe-wide OAT-IFR Transit Service (OATTS) Development

- Europe-Wide Use of Military Training Areas

Civil flights such as test-flights can be OAT, when they require some deviation from ICAO rules to satisfy their operational requirements.

Due to these specificities, Operational Air Traffic Control could request specific handling in the use of the airspace, and in control tasks. When controlling Operational Air Traffic, some of the tasks are:

- monitoring OAT frequencies, and performing all R/T communication with OAT;
- identification and acceptance of OAT being transferred from other military or civil agencies/sectors;
- obtaining an ATC clearance from GAT Executive Controller (ECs) for OAT to transit a civil airspace whilst remaining under the authority of the OAT EC;
- coordinating, as required, with GAT ECs;
- providing radar separation between all OAT receiving a service and GAT within the civil airspace;
- issuing clearances for aircraft (OAT and GAT) to enter or transit airspace for which the OAT EC has responsibility;
- initiation of transfers of OAT being transferred to other military or civil agencies/sectors;
- maintaining an awareness of pertinent weather information which might influence the conduct of OAT flights.

By observing the list above, derived questions on STCA have to be considered to decide when STCA have to be issued. It should be necessary modelling, not only the traffic, but the airspace. A case study for Mil STCA has been performed in the SPIN TF. Results are available on the Eurocontrol website.

Alert situations for civil control are not necessarily alerts for Operational Controllers. Examples of this are formation flights: for formation flights, no STCA alert is desired. State aircraft, exempted from the requirement to be RVSM approved, are to be studied to define when they are candidate to STCA.

The main difference between a Mil STCA model and a Civil STCA model is that a Mil STCA model has to take into account:

- High speed manoeuvring traffic
- Formation flights
- Flying Radar in Trail traffic
- Dog fighting
- Non cooperative tracks (not squawking)
- Block Level data (the Lower level and upper level between which an aircraft is performing eg aerobatics)

Formation flights and high speed manoeuvring traffic may cause split tracks where a tracker cannot correctly associate radar plots to existing system tracks.

Flight Data Record provides information of OAT, indicating if it is a military flight, state aircraft and points where the aircraft changes from GAT to OAT along their planned routes.

The aim of the SESAR related projects is to converge towards pan-European airspace, with benefits for both of the users (civil and military). It involves many tasks in order to obtain international agreed standards and norms, including the involvement of the Military in this process.

Two requirements summarize this collaboration:

- Firstly, the understanding and acceptance, by all parties involved in Air Traffic Management (ATM), of both civil and military airspace user requirements.
- Secondly, the joint civil/military pursuit of mechanisms and procedures to ensure the accommodation of those requirements on a fair and equitable basis and in accordance with state prerequisites such as defence requirements.

Some areas of interest derived from the previous requirements will have to be taken into account in the future of Safety Nets in order to model alerts and airspace, and the parameters associated:

- implementation of peacetime airspace organisation rules and procedures under the responsibility of Member States
- ATM issues of common interest during crisis and war
- ATM/CNS (Communications, Navigation and Surveillance) procedures in response to acts of unlawful interference against civil aviation as defined by International Civil Aviation Organization (ICAO).

Military Safety Nets processing may require specific rules, e.g. for high manoeuvring traffic in dense traffic areas, many nuisance alerts will be generated. For MSAW, low flying exercises may trigger many MSAW alerts. Therefore, an OAT controller should have the possibility to turn ON/OFF at console level STCA, APW or MSAW processing.

1.7.1.6 Operational Characteristics of Alerts

The objective of an alert is to attract the attention of controller on a certain situation. This can be achieved by means of visual and / or acoustic signals. In any case, the level of warning must be under some limits in order to avoid excessive stress. Thus, when an acoustic signal is integrated, an option of alert recognition has to be provided to the controller for silencing the alert (depending on the ANSP policy). Every aspect related with the improvement of alert display in the more appropriate manner is an important question.

From the operational point of view, controllers may be impelled to do some manual action on every alert in order to be recognized. Several options may be available to the controller. Two basic options are accept the alert or discard it. According to the action chosen, the system may present in a different form the ulterior alert information.

It is important that controllers are not presented with an excessive number of nuisance alerts that provide unnecessary distraction and reduce the impact of alerts in general as well as a loss of confidence in the system.

When the prediction time is significantly in excess of the required warning time, it may be preferable to delay displaying the alert until several passes through the detection logic have confirmed it. This does reduce the amount of warning time given to the controller but is considered to be a valuable step in preventing nuisance alerts from being displayed.

Surveillance data errors could also generate alerts emphasized by predictive functions, and it is therefore desirable that alerts are not displayed unnecessarily. This delay mechanism will not solve all the nuisance alerts linked to surveillance data errors, but it surely helps in some situations.

In circumstances where there would not be sufficient warning time available following the delay for alert confirmation, the alert must be displayed immediately. The update rate would need to be taken into account in this process.

Once an alert is delivered, the alert has to last a minimum amount of time before being eliminated. That is, even in the case the alert is found false immediately after the first delivery, the alert has to last a minimum time. Intermittent alerts should be avoided because they may cause confusion and stress to ATC Controllers.

1.7.1.7 Downlinked ACAS RA Information

ACAS is the part of airborne Safety Nets intended to prevent midair collisions between aircraft. The current TCAS II implementation tracks aircraft in the surrounding airspace and provides flight crew with vertical RAs when a risk of impending collision is detected. Announced RAs recommend the pilot how best to regulate the vertical speed to avoid the collision.

According to the Safety Nets concept, TCAS II works independently of the aircraft navigation, flight management systems and ATC ground systems. While assessing threats, it does not take into account the ATC clearance, pilot's intention nor autopilot input. Pilots are required to follow the RA indication in any case, even if there is a conflict between the RA and the current ATC clearance. Only stall warning, windshear, and GPWS alerts have precedence over ACAS.

TCAS II relies on replies from the transponders of near aircraft within a range of about 30 Nm. Therefore, aircraft which are not equipped with a transponder or carrying an inoperative transponder are not detected. Additionally, aircraft with a transponder which is not reporting the altitude will not generate RAs. Due to surveillance limitations neither RAs nor TAs will be issued against threats with a closure rate of over 1200 knots or with vertical rates over 10,000 ft/min.

The objective of RAs is to achieve a safe vertical distance from a threat aircraft (from 300 ft to 700 ft, depending on altitude). To accomplish this, two categories of RAs are provided to pilots: corrective advisories, which instruct the pilot to deviate from current flight path; and preventive advisories, which advise the pilot to maintain or avoid certain vertical speeds. When the threat aircraft is also fitted with TCAS II, both systems coordinate their RAs through the Mode S data link in order to provide complementary resolution senses.

Inevitably, some RAs may be perceived by pilots as nuisance and unnecessary; as they are generated when it is believed there is no risk of collision. However, the safety benefit provided by TCAS II takes precedence over an occasional unnecessary RA. Conditions likely to cause in air nuisance alerts occur during closely spaced parallel approaches. Even when these approach procedures are correctly applied, unnecessary RAs may occasionally occur. The same is true for RAs often issued against VFR aircraft moving on the edge of controlled airspace.

On the contrary, TCAS II operation on the airport surface provides no safety benefit. Routine operation of TCAS II on the ground can degrade surveillance performed by airborne TCAS II units and performance of ATC radars. When on ground, the pilots may turn TCAS II on for a short period of time before crossing or entering an active runway to double-check for the presence of any aircraft on short finals.

RAs are time-critical information. They are nominally generated 15 to 35 seconds before the Closest Point of Approach, although shorter generation times are possible in some geometry. Onboard, pilots are required to respond to first RA within 5 seconds and any subsequent RAs within 2.5 seconds. In contrast, RAs are typically reported by pilots to en-route controllers in 30 seconds, on average.

1.7.1.8 Operational Characteristics of ACAS RA Alerts

Presentation of ACAS RA from airborne Safety Nets to the controllers shares most of the operational characteristics of presentation of ground Safety Nets alerts. Like them, operationally relevant RAs must be displayed to controllers while RAs which are not operationally relevant must be filtered according to local factors. Also RA display must attract the controller's attention and the controller must have the possibility to inhibit the display for predefined volumes of airspace and for individual flights. Accordingly, ACAS RA may be presented to controllers as another kind of Safety Nets alerts.

During an RA event, if the RA is not in compliance with the current ATC clearance or instruction, the pilot should, as far as workload permits, report the RA to the controller. However, such pilot reports are often late or inaccurate. Whilst pilot RA reporting by the R/T channel is implemented as a transaction (a pilot report followed by an acknowledgement from the controller), RA display to controllers only concerns one-way provision of information from aircraft systems to CWP, which is additional and independent of the R/T channel.

Thus, RA display in the ATC system is for informative purpose only. But display of too much information may be counterproductive. Controller's situational awareness increases as the amount of information about the encounter increases up to the point where too much information can cause confusion. One reason for potential confusion is the infrequent occurrence of RAs, even in high density, complex airspace.

Presentation of RAs in the CWP is intended to precede pilot RA reports or even to be the only source of such information, thus providing more timely and dependable information about the RAs occurring on board aircraft. But this will be only effective if latency is kept to a minimum.

1.7.2 Supporting environment

1.7.2.1 Surveillance Data Processing

The Surveillance Data Processing (SDP) provides the surveillance service consumed by Safety Nets with the current traffic situation. The surveillance service updates all surveillance tracks periodically.

Advanced servers support the service initiation by request. A refresh period may be specified at request time. The service provided by server will try to meet these requirements up to the possible. With standard servers providing a unique service the client functions will have to adjust to this period. The same occurs with the area of interest. The server may support its selection or it will be only capable of providing all surveillance tracks inside the tracking area. Usually, the tracking period is marked by means of end of cycle messages. An end of batch indicator may also be delivered.

Tracking servers also distribute server status information. Server status may be used to restart the conflict detection process and cancel current alerts when tracking server is detected to be going off or restarted.

A desirable feature of surveillance service is the delivery of both the measured altitude (mode C) and the corrected altitude of tracks. The ASTERIX format published by EUROCONTROL provides two different data elements to carry this information. The I062/136 data item is identified as the measured flight level, whilst the I062/135 data item represents the calculated track barometric altitude with QNH correction.

The availability of both altitudes simplifies greatly the acquisition of track data for the Safety Nets analysis. Other advantages are the simplification of adaptation data with QNH covered areas and the isolation from QNH updates. These data are only managed by the surveillance server and they need not be known by surveillance clients.

Safety nets are very sensible to the quality of the altitude input data. When both measured and smoothed altitudes are available, a careful assessment of the characteristics of the vertical tracker has to be accomplished in order to select the more reliable input.

The SNS is not intended to compensate for upstream component errors or lack of data.

1.7.2.2 Downlinked Aircraft Parameters

Downlinked Aircraft Parameters (DAPs) are part of the surveillance data provided to SNS in an environment where Mode S Enhanced Surveillance is available.

Improvement of safety nets derived from the use of DAPs will come from two ways. The first improvement is indirectly derived through the enhancement of the quality of system tracks provided by SDP. Moreover, a second source of improvements is based on their direct use by the functions involved by ground-based safety nets.

For most civil aircraft in Europe, the following parameters are currently mandated to be available for downlink (parentheses indicates the identifier in ASTERIX Category 62):

- Final State Selected Altitude (I062/380/FSS),
- Selected Altitude (I062/380/SAL),
- Roll Angle (I062/380/RAN),
- Track Angle Rate (I062/380/TAR), or otherwise, if not available, True Airspeed (I062/380/TAS),
- Track Angle (I062/380/TAN),
- Ground Speed (I062/380/GSP),
- Magnetic Heading (I062/380/MHG),
- Indicated Airspeed and Mach Number (if aircraft can provide both) (I062/380/IAS),
- Barometric Vertical Rate (I062/380/BVR).

In addition, the following parameters are also usually available, but not mandated:

- True Airspeed (I062/380/TAS),
- Barometric Pressure Setting (I062/380/BPS).

From this set of parameters, Final State Selected Altitude (FSS), Selected Altitude (SAL), Roll Angle (RAN) and Track Angle Rate (TAR) have been identified as the more effective DAPs for use in ground based safety nets.

The nominal meaning of FSS/SAL indicates that aircraft will perform a departure from current level to the selected one in a short period of time. Nevertheless, time delay until starting of manoeuvre can be highly variable. Even, it is common practice of pilots set the FSS/SAL to the missed approach level when aircraft initiate a final approach procedure, so never reaching that altitude. Also, it is possible that the end of the departing level manoeuvre could be away of the selected altitude, passing through their FSS/SAL and levelling at another flight level. The reason for these unexpected behaviors is that this parameter does not indicate an intended level due to autopilot (coupled with the SAL parameter) or manual aircraft flight modes.

A useful application of FSS/SAL is to check the CFL. When a CFL has been issued and the FSS/SAL remains with a different value, a level busts due to incorrect flight level might occur. In any case, if the subscale pressure setting is incorrect, the aircraft will level out below or above the indicated FSS/SAL.

Potential benefits from the use of FSS/SAL are obtained by increasing the warning time and reducing the rate of false alerts. Increase of warning time may be achieved initiating the vertical prediction with an assumed vertical rate when the FSS/SAL indicates an upcoming departure from level flight. On the other hand, false alerts may be avoided improving the vertical prediction with a 'level off' cut instead of using a constant vertical rate throughout the entire vertical prediction look-ahead time.

The Track Angle Rate (TAR) and Roll Angle (RAN) parameters indicate an aircraft turn. While RAN could provide an early indication; it does not provide the turn rate. In exceptional cases, RAN might not indicate a turning manoeuvre, as when the aircraft is experiencing turbulence. The nominal meaning of TAR provides the turn rate, but it may be not always available. Potential use may follow two different strategies. In the most conservative, the TAR parameter is only used to indicate the start of a turning manoeuvre and its value of the rate of turn is not used for prediction. The alternative is to use directly the track angle rate for the lateral trajectory prediction, avoiding the need of an assumed value. In both cases, to achieve a good performance, some kind of filtering of noisy values would be required, such as a minimum threshold.

Potential benefits from the use of RAN and TAR are obtained by detecting turns earlier than otherwise and discarding false turns generated by the tracker.

Validation exercises have clarified that the most promising use of down-linked parameters rely on a multi-hypothesis prediction algorithm, where main hypothesis are based on DAPs, but always in contrast to the backup hypothesis, based on extrapolation of the current kinematics vector.

DAPs may also provide a means for deriving additional pertinent situational information that could be included in new or existing safety net functions. For example, True Airspeed, Ground Speed and True Track Angle could be used to estimate wind data, which could then input into the prediction filters of safety nets.

1.7.2.3 ACAS Monitoring System

The ACAS Monitoring System delivers surveillance information on ACAS RA events to the ATM system in a timely manner to display them to controllers. This system detects RA activity on the ground making use of the communication capabilities of TCAS II based on RA reports, RA broadcast messages and RA coordination messages.

RA reports are downlinked to Mode S ground sensors by using the Mode S data link. When the aircraft is routinely interrogated by Mode S radars, the transponder will indicate in its reply that an active RA is stored. The radar system reads out the data in a further interrogation. This process is referred to as RA downlink and takes place on the SSR reply channel (1090 MHz).

RA broadcast messages with the stored RA information are transmitted on the SSR interrogation frequency (1030 MHz) and can be received by surrounding ACAS systems and receivers on the ground. This broadcast is provided for the first time when an RA is initially displayed to the flight crew and is rebroadcast every 8 seconds. The information content of the RA broadcast partly coincides with the RA report; it includes the stored RA data but own Modes A/C instead of threat related information.

If both aircraft are equipped with TCAS II, the RAs will be coordinated between the two systems. The first aircraft to which an RA is generated transmits an RA coordination message to the intruder that will be responded with a coordination reply. If both aircraft select simultaneously the same RA, the aircraft with the higher address inverts its RA.

The ACAS monitoring system is in charge of merge information from these complementary sources and suppress redundancies when analyzing the received data. This includes redundant information which has already been sent. Additionally, the system filters out technical errors such as empty fields, missing intruder data or undefined data.

Information on RA events is delivered in the ASTERIX Category 4 format. Coverage will include airspace above FL100 and in major TMAs within the defined region. When in an RA event both aircraft are TCAS equipped, separated RA information for both aircraft is provided (if available). In nominal conditions, the monitoring system must provide RA messages to the ATM system within 2 seconds from the annunciation of the RA in the cockpit.

1.7.2.4 Flight Data Processing

The Flight Data Processing (FDP) stores all flight plan information and provides the flight plan data consumed by Safety Nets. Flight data are updated every time a change has been detected. So, clients need to be loaded at start time or to have access to some distributed flight plan database.

The flight data processing system is in charge of coupling tracks with flight plans. For some systems, every time a track is created and correlation achieved, the flight plan related data are filled in a track message and sent to the surveillance service for its subsequent distribution. For others, flight plan data are sent to Safety Nets directly. In the case of Safety Nets, further information could be needed and, therefore, these data have to be obtained directly from the flight data processing system in a separated way.

When the surveillance service conforms to the ASTERIX format an important number of flight plan data elements can be sent for every coupled track. This standard includes in the I062/390 data item such data elements (non-exhaustive list) as the type of flight (GAT/OAT), flight rules, RVSM, Standard Instrument Departure (SID), Standard Terminal Arrival Routes (STAR) and Cleared Flight Level (CFL).

That is, if Safety Nets have access to the flight data processing system, this information can be obtained through two ways. In consequence, a clear strategy has to be defined. If the surveillance server is appropriately updated by the flight data processing system, it is easier to obtain these data from the surveillance service. In fact, it may be valuable to analyse if all required flight plan data can be distributed in the surveillance service. Additional data from the flight plan which may be required for Safety Nets are the flight route or the holding information.

But if the flight data processing system only provides the surveillance server with fixed flight plan data, such as callsign, and does not update variable data, then, the Safety Nets may adopt a different strategy, using only the link between track and flight plan to obtain all required flight plan information from the flight plan processing system.

Another possible function performed by the flight data processing system is the monitoring of track conformance with the established flight plan route. When the coupled track is detected farther from the foreseen route, a route deviation alert may be delivered. If Safety Nets functions use the flight plan route, then these deviations warnings have to be taken into account because they indicate that the track is not following the route.

1.7.2.5 Aeronautical Environment Processing

The Aeronautical Environment Processing (AEP) provides the airspace configuration consumed by SNS. When a client request the airspace configuration service, the current configuration is sent and, starting from this time, airspace configuration changes are received.

The status of prohibited, restricted and dangerous areas is determined by AEP according to received NOTAM from external Aeronautical Information Service (AIS) sources. Also, operators may introduce manually in the system such information as the activation schedule for some area or departure and arrival runways in use at airports of interest. Usually, areas are considered as pre-active, active and de-activated. Activation/deactivation of time depending areas (eg TRAs) may also be the result of a data exchange between ATM and AMP systems.

STCA and APW functions will be active or no depending on each kind of area. Some rules will exist to define this association, nevertheless, such a relation may be also configured manually. The same is true for the geometry of areas. Whilst published areas have a fixed geometry which may be accessed by the AEP from the adaptation data base, the geometry of temporary segregated areas has to be defined on-line.

1.7.2.6 Working Positions

Working positions are the controller working positions and the supervisor positions.

Controller Working Position is in charge of presenting to the controller that information of interest for him according to the configuration of the working position. It may be assumed that the working position knows which operational sectors have been assigned to it and, according to this, it filters what flight plans or alerts have to be displayed to the controller. Given this architecture, the Safety Nets do not need to access to the assignation of sectors to working positions. In addition the configuration of a CWP does not only depend on the sector for which the controller is responsible, but also from the role of the controller.

Alert recognition is an action which may require changes in order to display alerts. For alert display configuration different strategies may be applied. The inhibition of alerts for some particular flight may be done at presentation level or at generation level. Assuming the first option may alleviate the logic of Safety Nets and, what is more important, permit to know all generated alerts without inhibition. Flights with some kind of alert inhibition should be displayed properly to remember this condition.

Actions on the supervisor working position aim to adapt the performance of Safety Nets functions to the current traffic situation during current operation. In this working position, Safety Nets configuration is accomplished in terms of airspace volumes. The problem is to define what kind of volumes are the more convenient: complete regions, individual operational sectors, groups of sectors assigned to a given CWP, configured volumes for the Safety Nets, or on-line defined volumes.

Because the status of safety nets has to be presented in all controller and supervisor working positions, every inhibited volume requires to display the associated area in an appropriate manner.

1.7.2.7 Testing and Maintenance Environment

Tuning of Safety Nets parameters is an important task because there exist as many operational configurations as there are ATC sites. Moreover, ATC environment and available tools for controlling aircraft also impact Safety Nets tuning. It is quite obvious that for a given site and parameters setting, depending on the average traffic density for example, some alerts will be classified as nuisance alerts by some controllers while classified as justified by others.

Reaching this objective will be facilitated by a clear definition of the evaluation method of the Safety Nets behaviour, linked with the use of set of tools (e.g. Recording and Replay tool of simulated or real surveillance data, Display and Analysis tool for typical cases explanation).

The minimum set of tools to accomplish the verification and validation phase are a Recording and Replay tool, a Display and Analysis tool and a Configuration Data Manager. These tools may be considered as components of systems which are external to the Safety Nets server.

The Recording and Replay tool for alert data is assumed to be a component of the Recording and Replay System. This component has to record all alerts distributed by the Safety Nets together with additional information needed for analysis. A recording session will comprise also the configuration environment of the Safety Nets Server at recording time. All input and output data of the Safety Nets Server has to be also recorded, including manual actions in the controller working position. This is assumed to be accomplished by other components of the Recording and Replay System.

The Display and Analysis tool for Safety Nets is assumed to be a component of the Analysis and Maintenance System. This tool has to be capable of recovering a recording session from the Recording and Replay System. Then, alerts should be found and reported using some appropriate format. Individual analysis of alerts has to be supported as well as the statistical analysis of the complete session.

Configuration of Safety Nets functions may be so difficult that a support tool is also necessary to accomplish this task. The configuration data manager is assumed to be a component of the Environmental Data Manager System. The first objective of this tool is to capture the environmental data which defines the airspace where Safety Nets are to work. Starting from this elemental configuration, the tool has to provide easy procedures to create, modify and erase areas, establish relations among area types, assign parameters to areas and give values to this parameters. Some checks could be done automatically, such as detection of area overlaps. Finally, the generation of some documentation about the built configuration would be very useful. The output of this tool, apart from reports, will constitute the configuration environment of Safety Nets processor.

1.8 Glossary of terms

Term	Definition
Backup hypothesis	The backup hypothesis is a straight line trajectory prediction computed by the SNS only if the main hypothesis is not a straight line
Conflict status	Conflict status is computed by the SNS and distributed in a STCA alert.
Coupled RA	RA linked to a surveillance track.
Coupled tracks	Surveillance tracks linked to a flight plan.
Excluded areas	Areas used by the APW function to model Prohibited Areas, Restricted Areas and Danger Areas. The APW function raises an alert when an aircraft is predicted to enter an excluded area.
Latency time	Elapsed time between the first RA annunciation to the flight crew and the first RA display to the controller.
Look ahead time	The number of seconds of the trajectory prediction computed by the SNS.
Main hypothesis	The main hypothesis is the predicted trajectory that the SNS expects the track to follow
NOZ area	NOZ area is a volume aligned on the runway axis of a runway that could be operated in independent approach mode. NOZ areas are used to inhibit STCA alerts for tracks performing parallel approaches on two runways operated in independent parallel approach mode.
Resolution Advisory	An indication given to the flight crew recommending a manoeuvre intended to provide separation from all threats; or a manoeuvre restriction intended to maintain existing separation.
SNS processing area	A SNS processing area is a volume in which the SNS processing applies with a specific set of parameters and a priority.
SNS region	SNS region is the volume in which the SNS operates. The SNS region is a specific SNS processing area associated to the set of parameters with the lowest priority.
STCA alert	A STCA conflict that is distributed to the Controller Working Position (CWPs).
STCA conflict	Predicted or actual infringement of SNS separation thresholds (lateral and vertical) between two aircraft.
STCA conflict age	The age of the STCA conflict is the number of seconds between the first detection of the conflict and the current time.
STCA processing	The STCA processing starts by the creation of a track pair and ends if necessary by the distribution of a STCA alert
Surveillance track	Track provided by the SDP and received by the Safety Nets Server.
Turning area	A turning area is defined as a volume used to enable a turning trajectory

Term	Definition
	prediction for the main hypothesis.

1.9 Acronyms and Terminology

Term	Definition
ACAS	Airborne Collision Avoidance System
ACID	AirCraft IDentification
ADD	Architecture Definition Document
ADD	Aircraft Derived Data
AEP	Aeronautical Environment Processing
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMC	Airspace Management Cell
ANSP	Air Navigation Service Provider
APM	Approach Path Monitoring
APW	Area Proximity Warning
ARES	Airspace REServation/REStriction
ASM	Airspace Management
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
AUP	Airspace Use Plan
B-RNAV	Basic – Area Navigation
CFL	Cleared Flight Level
CHMI	Controller Human Machine Interaction Management [Functional Block]
CNS	Communications, Navigation and Surveillance
CTR	Control Terminal Region
CWP	Controller Working Position

Term	Definition
DAP	Down-linked Airborne Parameter
DME	Distance Measurement Equipment
DOD	Detailed Operational Description
EC	Executive Controller
EDMS	Environmental Data Manager System
E-ATMS	European Air Traffic Management System
FAB	Functional Airspaces Blocks
FDP	Flight-plan Data Processing
FPLD	Flight Plan – Lifecycle Management – Data Distribution [Functional Block]
FUA	Flexible Use of Airspace
GAT	General Air Traffic
GBAS	Ground-Based Augmentation System
GGDC	Ground-Ground Legacy Datalink Communications [Functional Block]
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
LAN	Local Area Network
MSAW	Minimum Safe Altitude Warning
NOTAM	Notice To Air Men
NOZ	Normal Operating Zone
NTP	Network Time Protocol
OAT	Operational Air Traffic
OPSUP	Operational Supervision [Functional Block]

Term	Definition
OSED	Operational Service and Environment Definition
PASS	Performance and safety Aspects of STCA full Study
P-RNAV	Precision – Area Navigation
RA	Resolution Advisory
RADP	RA Data Presentation
RVSM	Reduced Vertical Separation Minimum
SDP	Sensor Data Processing
SES	Single European Sky
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SNS	Safety Nets Server
SPIN SG	Safety nets: Planning Implementation & eNhancement Sub Group
SPR	Safety and Performance Requirements
STAR	Standard Terminal Arrival Route
STCA	Short Term Conflict Alert
SSR	Secondary Surveillance Radar
SUPP	Support Functions [Functional Block]
SUR	Surveillance [Functional Block]
SWP	Supervisor Working Position
TA	Traffic Advisory
TAD	Technical Architecture Description
TCAS	Traffic Collision Avoidance System
TECHSUP	Technical Supervision [Functional Block]
TMA	Terminal Manoeuvring Area

Term	Definition
TP&M	Trajectory Prediction & Management [Functional Block]
TRA	Temporary Restricted Area
TS	Technical Specification
UDP/IP	User Datagram Protocol / Internet Protocol
UUP	Updated Airspace Use Plan
VOR	VHF Omni directional Range

2 General Functional block Description

2.1 Context

2.1.1 Global environment

The system context diagram is depicted in the following picture.

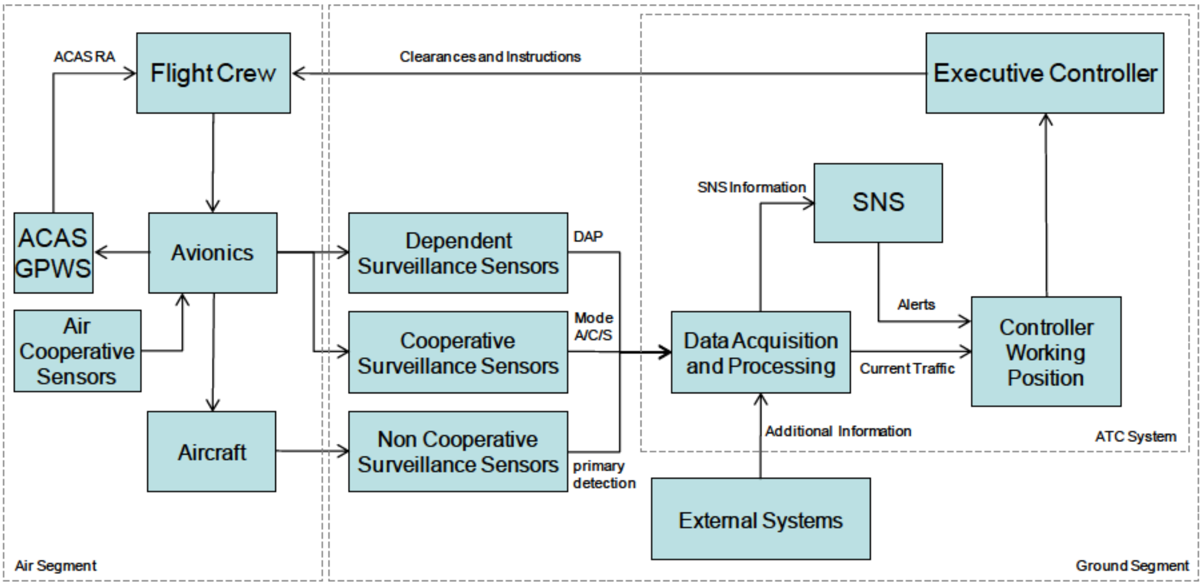

Figure 1 – System context

As illustrated in the figure, the flight crew is involved in two control loops devoted to collision avoidance. One of them is in the air segment, on board the aircraft, and the other one, based on the ground control from an ATC, implies both the air segment and the ground segment.

In the air segment, a traffic situation is elaborated from Mode S emissions coming from near aircraft. The alerting logic of ACAS processes this information searching possible conflicts among the own aircraft with the surrounding traffic. In case of conflict detection, ACAS provides an automatic RA to pilots with a proposal to evade it.

In parallel, aircraft information is gathered by ground sensors and, after processing, the current traffic picture is shown to the executive controller in charge of controlling the flight. The alerting logic of SNS processes this information searching possible conflicts among every pair of surveillance tracks. In case of conflict detection, SNS provides an alert to controller. Once the controller is aware of the conflict and has assessed the situation, an appropriate clearance or instruction will be verbally communicated to pilots.

The current traffic picture depends up to a great extent on the surveillance infrastructure. While an alerting logic based exclusively on non cooperative sensors appears to be unviable, cooperative sensors providing altitude information permit to reach a valuable rate of successful detections.

Dependent surveillance acts as the connecting link between both control loops. This fact has two important advantages. In the first place, intentional data from avionics are available to the ATS system, being particularly important to improve the alerting logic for manoeuvre detection. And second, the RA is carried from the air segment to the ground segment making possible its presentation to controllers.

Unnecessary stress to pilots will be avoided if the ground control is the first loop to detect the conflict and, even best, if controller instructions are consistent with the possible RA issued by ACAS later.

2.1.2 Detailed environment

This paragraph specifies the architecture of the ER/APP ATC system, presenting its context diagram to formalize its *communication links* and *actors*. The view of the system architecture is centred for the Safety Nets.

Communication links identify the interaction (relationships) between the SNS and the other functional blocks.

The system context diagram is depicted in the following picture.

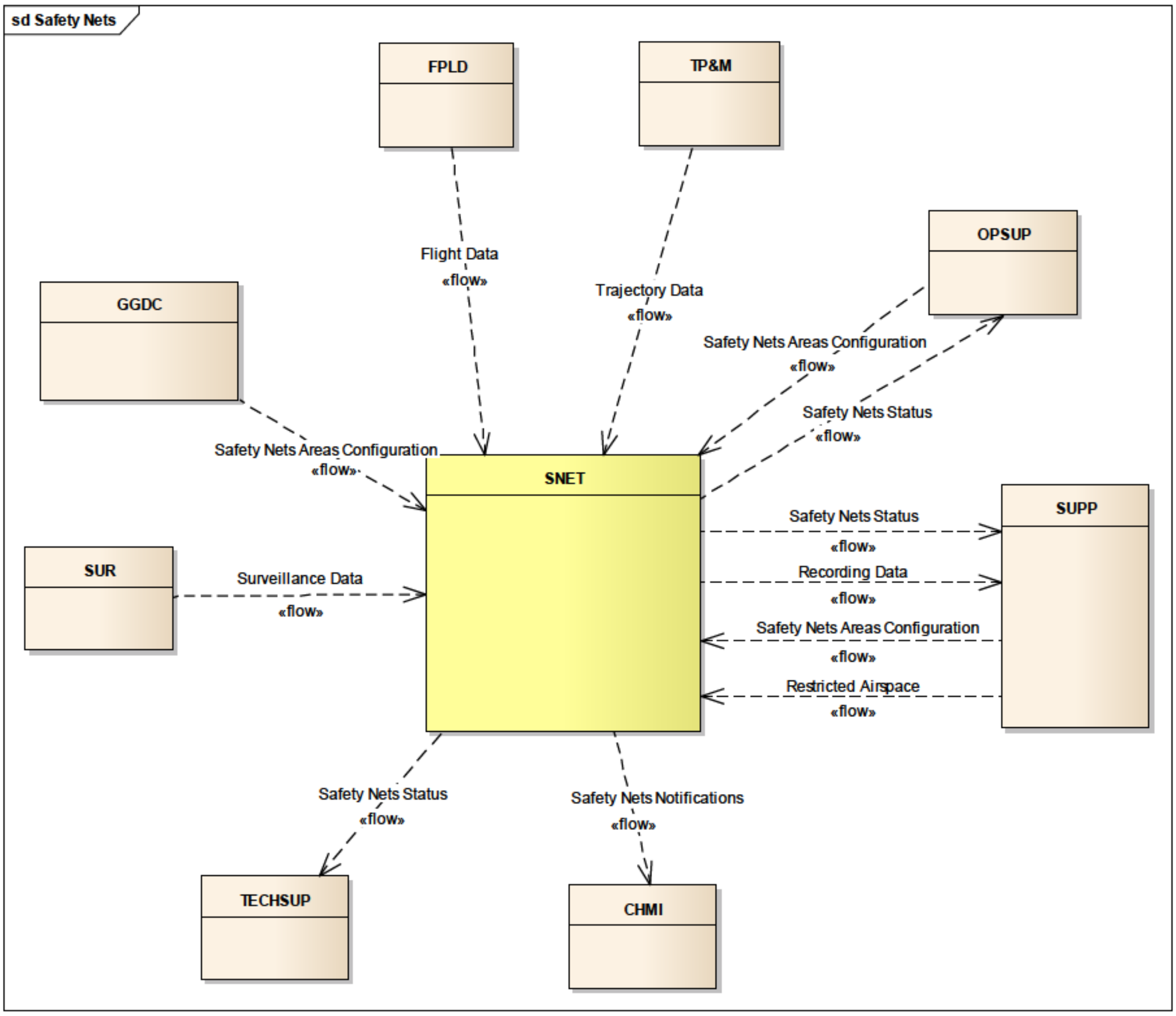

Figure 2 – Safety Nets Server context diagram

2.1.2.1 Surveillance (SUR)

The Surveillance (SUR) Functional Block provides SNS with the following data elements:

- system tracks,
- DAPs,
- surveillance service status information, and

- SDP status information.

Connection is established through an internal Local Area Network (LAN) using the User Datagram Protocol / Internet Protocol (UDP/IP) communication protocol.

Information is delivered according to the **A**ll Purpose **ST**ructured **E**urocontrol Su**R**veillance **I**nformation E**X**change (ASTERIX) protocol issued by EUROCONTROL.

2.1.2.2 Flight Plan – Lifecycle Management - Data Distribution (FPLD)

The Flight Plan – Lifecycle Management - Data Distribution (FPLD) Functional Block provides SNS with the following data elements:

- system flight plan data (SPFL),
- route deviation alerts,
- FDP status information.

Connection is established through an internal LAN using the UDP/IP communication protocol.

Flight plan information is formatted according to the ATS Data Exchange Presentation (ADEXP) format issued by EUROCONTROL. Route deviation alerts are delivered according to the Surveillance Data Exchange (ASTERIX) protocol issued by EUROCONTROL.

2.1.2.3 Trajectory Prediction and Management (TP&M)

The Trajectory Prediction and Management (TP&M) Functional Block provides SNS with the following data elements:

- Trajectory Data.

Connection is established through an internal LAN using the UDP/IP communication protocol.

2.1.2.4 Ground-Ground Legacy Datalink Communications (GGDC)

The Ground-Ground Legacy Datalink Communications (GGDC) Functional Block provides SNS with the following data elements:

- dynamic environment data,
- operational areas configuration (Area Activation/De-activation),
- ACAS RA events.

Connection is established through an internal LAN using the UDP/IP communication protocol.

2.1.2.5 Controller Human Machine Interaction Management (CHMI)

The Controller Human Machine Interaction Management (CHMI) Functional Block provides SNS with the following data elements:

- actions on alerts.

SNS provides it with the following data elements:

- Safety Nets alerts (STCA alerts; MSAW alerts; APW alerts; APM alerts; ACAS RA alerts),
- SNS availability status.

Connection is established through an internal LAN using the UDP/IP communication protocol.

2.1.2.6 Operational Supervision (OPSUP)

The Operational Supervision (OPSUP) Functional Block provides SNS with the following data elements:

- Function and
- areas configuration

SNS provides it with the following data elements:

- SNS availability status.

Connection is established through an internal LAN using the UDP/IP communication protocol.

2.1.2.7 Technical Supervision (TECHSUP)

The Technical Supervision (TECHSUP) Functional Block provides SNS with the following data elements:

- Configuration commands.

SNS provides it with the following data elements:

- SNS elements' status.

Connection is established through an internal LAN using the UDP/IP communication protocol.

2.1.2.8 Support Functions (SUPP)

The Support Functions (SUPP) Functional Block provides SNS with the following functions:

The Managing off-line Environment Data Function provides the SNS with the following data elements:

- Safety Nets areas configuration (static definition of the areas).

The Time Reference function provides the SNS with the following data elements:

- UTC time.

Time reference is distributed using the Network Time Protocol (NTP) protocol.

SNS provides the Recording function with the following elements:

- all output data sent from SNS to others functions, and also,
- SNS areas,
- SNS configuration parameters, and
- additional information on alerts.

Connection is established through an internal LAN using the UDP/IP communication protocol.

2.1.3 Interfaces

The following table describe the data exchange with the other functional blocks of the ER/APP ATC system.

Internal System	To Internal System	From Internal System
Surveillance (SUR)		Surveillance Data
Flight Plan – Lifecycle Management - Data Distribution (FPLD)		Flight Plan Data
Trajectory Prediction and Management (TP&M)		Trajectory Data
Ground-Ground Legacy Datalink Communications (GGDC)		Dynamic configuration of operational areas (Area Activation/De-activation), ACAS RA events.
Controller Human Machine Interaction Management (CHMI)	- Alerts - SNS Availability Status	Interactions on the SNS (depending on ANSP policy / implementation level). Example of possible interactions: - Activation / de-activation of areas - Inhibition of alerts on given flights
Operational Supervision (OPSUP)	SNS Availability Status	Function and Subfunction, Region and Filter activation/deactivation, On-line Data Handling -Geographical airspace volumes and Parameter Handling
Technical Supervision (TECHSUP)	SNS Availability Status	Control & Monitoring
Support Functions (SUPP)	Pertinent Data for Recording	UTC Time, Environment Data, Operational Parameters: -Off-line values of operational parameters (Thresholds, default selections, Regions Handling, eligibility)

Table 3 – SNS internal interfaces

2.2 Functional block Modes and States

N/A

2.3 Major Functional block Capabilities

The SNS is responsible for the following surveillance alerting functionalities:

- Short Term Conflict Alert (STCA)

- Minimum Safe Altitude Warning (MSAW)
- Area Proximity Warning (APW)
- Approach Path Monitoring (APM)

Some functionalities are common to all these functions. The associated requirements are gathered in the function “SNS Common Processing”.

Additionally, the SNS is responsible for the following air-based alerting functionality:

- RA Data Presentation (RADP).

2.3.1 STCA Overview

STCA is a ground-based safety net intended to assist the controller in preventing collision between aircraft by generating, in a timely manner, an alert of a potential or actual infringement of separation minima.

The STCA function will alert for every pair of surveillance tracks involving at least one eligible aircraft whose separation is or is expected to be along a certain time lower than the currently applicable operational separation in the region where tracks are or are going to be, when this infringement of separation implies risk of collision.

The main criterion to assess conflicting aircraft is the separation threshold decided by the Air Navigation Service Provider (ANSP). In the horizontal plane, this separation distance may take different values: normal separation, reduced separation and degraded separation. STCA function needs to rely on the separation threshold because its current value reflects the confidence of controller on aircraft positions. It is a measure of the exactitude of the current traffic picture. In addition STCA function uses also time thresholds to alert the controller on a predicted conflicting situation. These thresholds should be sufficient for the controller to take appropriate action to avoid the conflicting situation, and for the aircraft to manoeuvre.

Another consequence is that the infringement of the separation threshold does not necessarily mean an alert. An example is two tracks with divergent movement.

2.3.2 MSAW Overview

MSAW 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.

This may be either to detect and alert on-time any of the following:

- hazardous aircraft proximity to terrain, or;
- hazardous aircraft proximity to obstacles.

The sole purpose of MSAW is to enhance safety and its presence is ignored when calculating sector capacity.

MSAW is designed, configured and used to make a significant positive contribution to avoidance of controlled flight into terrain accidents.

2.3.3 APW Overview

APW is a ground-based safety net intended to warn the controller about unauthorised penetration of an airspace volume by generating, in a timely manner, an alert of a potential or actual infringement of the required spacing to that airspace volume, which require attention/action. APW warns the controller about unauthorized penetration of flights into controlled airspace, for example:

- penetration of uncontrolled flights into controlled airspace,
- in case of a military ATC system, in addition, penetration of controlled military flights into civil controlled airspace.

2.3.4 APM Overview

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.

2.3.5 RADP Overview

RADP is the presentation to controllers of RAs generated by the airborne safety nets intended to inform the controllers about the RA annunciation in the cockpit in such a way that RA display on CWP precedes pilot's RA report or even is the only source of such information.

Based on this presentation, the controllers acquire a more timely and dependable knowledge about the events of RAs occurring onboard aircraft, while the time interval during which it is possible for them to issue instructions that are unknowingly conflicting with that RA will decrease.

2.4 User Characteristics

Two types of users interact with the SNS:

- Controllers: they receive alerts from the SNS through the CWP. They also have access to the SNS Availability Status.
- Supervisors: they also have access to the SNS Availability Status. Additionally they have the capability to configure the SNS (areas creation, activation…)

2.5 Operational Scenarios

N/A

2.6 Functional

2.6.1 Functional decomposition

N/A

2.6.2 Functional analysis

N/A

2.7 Service View

N/A

3 Functional block Functional and non-Functional Requirements

Some of the requirements in this definition report must be detailed at implementation level. For example the multi hypothesis algorithm has to be detailed at implementation stage depending on the usual traffic in the area.

The logic of the multi hypothesis algorithm will not be the same if the SNS is part of a system where the flight plan route is regularly updated by the controllers. In this situation for example, the hypothesis based on the flight plan route will be privileged in regards to the prediction based on standard approach path.

As a consequence of the above considerations, the multi model algorithm can only be adapted at implementation level.

This definition report introduces a communication link between CWPs and the SNS, for example to activate / deactivate some SNS processing areas. Only essential interactions are presented in this document, and consequently an operational implementation of this specification could enhance these interactions.

The same concept applies to the eligibility criteria of the tracks and the alerts. In section 3.1.2.3.2 for example, the criteria used to declare a track as 'STCA inhibited' are not detailed. They can only be detailed at implementation level, because they could vary from one ANSP to another. What is considered essential in this definition report is that they have to be offline or online adaptable.

Requirement REQ - 10.04.03 - 002.00 introduces a maximum capacity for surveillance tracks. This requirement is essential from a safety point of view. Considering the prototype, it is not essential to specify precisely the behaviour, but it has to be done during an implementation project.

The behaviour of the SNS has also to be clarified when the maximum number of conflicts is reached. This has to be done during an implementation project.

3.1 Capabilities

3.1.1 SNS Common Processing Requirements

Safety net processing is based on prediction of the aircraft position, using extrapolation in a certain predefined look-ahead time. The extrapolation is performed in the horizontal plane and in the vertical plane. It can be linear (straight line) or incorporating some kind of manoeuvring in each plane. Conditions as for which type of extrapolation to use in each case include the following factors: manoeuvring information linked to the track or when an aircraft is located within system areas where the use of manoeuvring extrapolation is defined (e.g. Turning areas or Holding Volumes).

All the information related to altitude or flight level described in the following sections, is an input from the SDP altitude tracking, and expressed as the items defined in ASTERIX CAT062. A general assumption regarding QNH correction: MSAW and APM parameters are specified in terms of altitude (QNH corrected) while STCA and APW are specified in terms of altitude or flight levels (non QNH corrected).

Some requirements below may refer to coupling being required for certain aspects of the SNS. Only system coupling that is received by the SNS within the CAT062 Surveillance tracks is considered.

The SNS enables exclusion of specific tracks from raising any alerts by the SNS. This is done through the use of a Secondary Surveillance Radar (SSR) code, Mode S ID (ACID), a callsign inhibition group, or possibly by selecting a track on the Controller Working Position. Tracks belonging to either of these groups are not expected to raise an alert (except for the STCA case where the other track involved in a conflict does not belong to one of the groups).

3.1.1.1 SNS region

SNS region defines the volume in which the SNS operates. This region is a specific SNS processing area. SNS processing areas are described in section 3.1.1.2.

Identifier	REQ - 10.04.03 - 006.01
Requirement	The SNS region shall be defined as a volume using up to a maximum number of geodetic points in horizontal, and an upper and lower level in vertical (in Flight Level or in QNH corrected altitude).
Identifier	REQ - 10.04.03 - 007.00
Requirement	The SNS region shall be associated to the set of parameters with the lowest priority.

Identifier	REQ - 10.04.03 - 008.00
Requirement	The SNS shall not use surveillance tracks located outside of the SNS region for its processing.

3.1.1.2 SNS processing areas

A SNS processing area defines the volume in which the SNS processing applies with a specific set of parameters. It means that a track within an SNS processing area when a Safety Net processing is initiated is subjected to this processing according to this area's parameters.

Multiple SNS processing areas can be defined. Overlapping between SNS processing areas is allowed. In case a track resides in more than one SNS processing area, a priority has to be determined with regards to which SNS processing area's set of parameters to use.

SNS processing areas are included in the SNS Region but might not fully cover it.

Identifier	REQ - 10.04.03 - 010.01
Requirement	A SNS processing area shall be offline defined as a volume using up to a maximum number of geodetic points in horizontal and upper and lower level in vertical (in Flight Level or in QNH corrected altitude).

Identifier	REQ - 10.04.03 - 011.00
Requirement	Each SNS processing area shall have assigned a set of parameters (offline defined in up to a maximum number of parameter groups).

Identifier	REQ - 10.04.03 - 013.00
Requirement	All SNS processing areas shall be included within the SNS Region.

3.1.1.3 Turning areas

A turning area is defined as a polygon, using several points in the horizontal plane, and an upper and lower level in the vertical plane. In addition, the turning area has an exit point with a heading, used to extrapolate the turning trajectory.

A turning area is used to enable a horizontal multi hypothesis processing for tracks. This means that two different trajectory predictions will be computed for these tracks. It must be possible to define that this horizontal multi hypothesis processing applies only to climbing or descending tracks. The rate of climb / descent received in the surveillance track update message is used to determine if a track is climbing or descending.

Identifier	REQ - 10.04.03 - 014.01
Requirement	A turning area shall be defined as a volume using up to a maximum number

	of geodetic points in horizontal and an upper and lower level in vertical (in Flight Level or in QNH corrected altitude). In addition, it shall have an exit point with an exit heading.

The exit point and the exit heading will be used for the trajectory prediction.

Identifier	REQ - 10.04.03 - 016.00
Requirement	A turning area definition shall have flags enabling the processing to be applied for climbing aircraft, descending aircraft or both.

Identifier	REQ - 10.04.03 - 017.00
Requirement	All turning areas shall be included within the SNS Region.

3.1.1.4 Hypotheses library

The fine filtering processing of Safety Nets functions use multi-hypothesis algorithm. It is likely to implement several hypotheses such as Cleared Flight Level (CFL) limitation, Standard Arrival Routes (STAR), Holding pattern in addition to the straight line or curved hypotheses, either due to tuning process or customer requirements.

When the main hypothesis predicts that the aircraft is going to manoeuvre (that is when the main hypothesis is not a straight line), a backup hypothesis in straight line is always computed. This backup hypothesis allows to detect conflict situations that would occur if the aircraft trajectory does not follow the main hypothesis. This is useful for example in case of a level bust or if a received parameter is invalid.

The multi-hypotheses algorithm is shared between all safety nets.

Identifier	REQ - 10.04.03 - 018.00
Requirement	At each surveillance track reception, the SNS shall compute up to two extrapolations: • The main hypothesis: the trajectory that the SNS expects the track to follow and • The backup hypothesis: a straight line extrapolation (computed only if the main hypothesis is not a straight line).

On the horizontal plane, the main hypothesis computation could be based on (non exhaustive list):

- Flight plan trajectory, or
- Aircraft Derived Data (for example Roll Angle or Track Angle Rate), or
- Holding pattern, or
- Standard Terminal Arrival Route.

On the vertical plane, the main hypothesis computation could be based on (non exhaustive list):

- Flight plan trajectory, or
- Aircraft Derived Data (for example Final State Selected Altitude), or
- Cleared Flight Level, or
- Block Level Limitation.

The SNS should allow to offline activate or deactivate hypothesis used for main hypothesis extrapolation among all hypothesis available in the system.

The Mode S Enhanced Surveillance allows to receive internal parameters of aircraft called DAPs. A study on the use of DAPs in Safety Nets has been carried out by SESAR project 04.08.01. The first results ([13] and [14]) show that the most promising DAP is the MCP/FCU Selected Altitude. The Roll Angle and Track Angle Rate can also have a positive impact on Safety Nets.

These DAPs are transmitted to the SNS by the SDP in ASTERIX Category 062 messages, item 380 Aircraft Derived Data (ADD):

- The DAP MCP/FCU Selected Altitude is received in the subfield #6 Selected Altitude, or if not available in the subfield #7 Final State Selected Altitude,
- The DAP Roll Angle is received in the subfield #15 Roll Angle,
- The DAP Track Angle Rate is received in the field #16 Track Angle Rate.

3.1.1.4.1 CFL Level Off Hypothesis

The CFL (Cleared Flight Level) is the level at which the controller clears an aircraft. This information can be used to predict that a climbing or descending aircraft is going to level off at this CFL.

Identifier	REQ - 10.04.03 - 044.01
Requirement	If the CFL level off hypothesis is activated and if the CFL of the track is available, the main hypothesis extrapolation shall be vertically limited to the value of the CFL.

3.1.1.4.2 Selected Altitude Level Off Hypothesis

The Selected Altitude can be used to improve the vertical prediction. It helps to detect that an aircraft is about to depart from a level or is leveling off.

For tracks under the Transition Level the Selected Altitude is corrected using the Barometric Pressure Setting (BPS) downlinked by the aircraft or the ground based sub scale pression setting information in case the Barometric Pressure Setting is not downlinked, not available or the difference between the Barometric Pressure Setting (BPS) and the ground based sub scale pression setting information exceeds a defined value.

When an aircraft is in final approach, the Selected Altitude value should not be used for prediction. Pilots often select the missed approach altitude once the aircraft is established on final approach. The implementation should take this behavior into account.

Identifier	REQ - 10.04.03 - 046.01
Requirement	If the selected altitude level off hypothesis is activated and if the Selected Altitude field of a track indicates that the track is levelling off, the main hypothesis extrapolation shall be vertically limited to the value of the Selected Altitude, corrected using the Barometric Pressure Setting (BPS) downlinked by the aircraft or the ground based sub scale pression setting information.

When both the Cleared Flight Level and the Selected Altitude are available but different, the implementation shall define the priority of a source over the other. A solution might be not to predict a level off when Cleared Flight Level and Selected Altitude are different.

3.1.1.4.3 Departure from Level Hypothesis

The Selected Altitude can also be used to predict in advance than an aircraft is going to depart from its current level.

Identifier	REQ - 10.04.03 - 047.00
Requirement	If the selected altitude level departure hypothesis is activated and if the Selected Altitude field of a track indicates that the track is about to depart from a level, the main hypothesis extrapolation shall include a start of climb or descend.

The vertical prediction should use a vertical rate defined as an offline parameter. This vertical rate might depend on the aircraft type or on the altitude layer.

When the value of the Selected Altitude changes, aircrafts do not often start immediately to climb or to descend; consequently the implementation should allow to offline define a delay between the change of value of Selected Altitude and start of manoeuvre. This delay might be different between a start of climb and a start of descent.

3.1.1.4.4 Turn Hypothesis

In the horizontal plane, ADD help to identify turns earlier, thanks to the fields Roll Angle and Track Angle Rate. But as the final heading is not available, this information cannot be used to predict the trajectory. On the other hand it might be used to confirm a turn in a turning area.

A filtering of this data is necessary to prevent incorrect predictions due to wrong data. For example a margin might be used: a track is identified as turning if the roll angle is above an offline-defined margin. The same behavior can be applied to the track angle rate.

In the requirement below, the term “Turn Report” refers to the ADD field Roll Angle or the ADD field Track Angle Rate. The implementation should define which fields are used and if necessary the priority of one over the other.

Identifier	REQ - 10.04.03 - 048.01
Requirement	If the turn hypothesis is activated and if a track is inside a Turning Area and its Turn Report indicates that it is turning, the main hypothesis extrapolation shall include a turn to reach the exit point and the exit heading of the Turning Area.

The Turn Report is not used outside of Turning Areas.

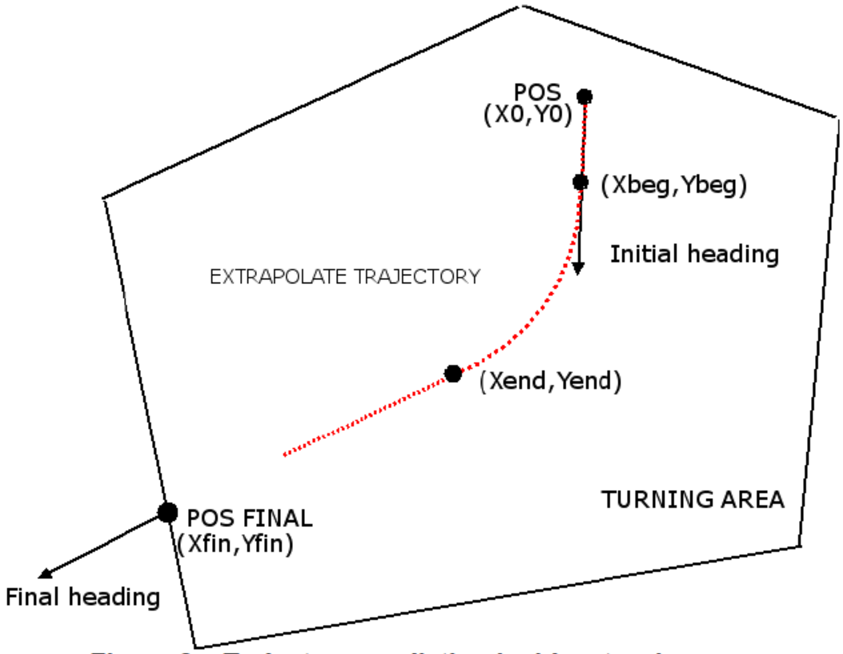

Figure 3 – Trajectory prediction inside a turning area

3.1.1.5 Online modifications

All of the areas defined above are declared through an offline data preparation tool. This tool prepares a set of files that are distributed to the SNS. These files are read by the server during its initialisation phase, but due to some external circumstances, an operational supervisor could decide that the configuration of the server has to change.

This section describes which data could be online modified by an operational supervisor and / or a controller.

Identifier	REQ - 10.04.03 - 019.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate a SNS processing area.

Identifier	REQ - 10.04.03 - 021.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate a turning area.

3.1.2 Short Term Conflict Alert (STCA) Requirements

3.1.2.1 STCA main concepts

The purpose of the STCA is to anticipate positional conflicts and to generate alerts for all eligible surveillance track pairs whose separation distance is or is expected to be lower than the minimum separation requirement. To anticipate these positional conflicts, a trajectory prediction is done for each track. This prediction is limited to a certain time called look-ahead-time both in horizontal and vertical planes.

A pair of tracks in conflict means that both horizontal and vertical minimum separations are simultaneously infringed.

ATC controller must be warned of the conflict in advance. The warning time is the time before which the ATC controller has to be alerted. The warning time is the amount of time between the first indication of an STCA alert up to the predicted hazardous situation.

The STCA examines aircraft paths and detects conflicts based on the predicted paths or current proximity of an aircraft pair. The most well-established prediction mechanism assumes that aircraft fly in straight lines, nevertheless, recent developments include the ability to take account of turning aircraft or levelling aircraft.

3.1.2.2 STCA geographical definition

Traffic patterns vary between different types of airspace and it is important that the STCA is capable of being adapted to the different requirements placed on it. For example, a linear prediction filter looking for horizontal separation of less than 5 NM within the next two minutes might be acceptable in en route airspace but would be unsuitable for the final approach sector at a busy airport.

It is therefore necessary for the STCA to be capable of using different parameters in different regions. At the simplest level, STCA needs to know whether aircraft are in controlled or uncontrolled airspace. At the next level, STCA needs to know the type of controlled airspace so as to use the correct separation criteria. In more sophisticated systems, a large number of regions, of different types, can be defined so that parameters may be tuned according to the use of individual sections of airspace.

For STCA processing, the airspace is shared in five kinds of areas:

- One SNS region,
- One or several SNS processing areas,
- One or several turning areas.
- One or several STCA inhibition areas,

- One or several pairs of NOZ,

SNS region, SNS processing areas and turning areas are described in section 3.1.1.

NOZ areas are defined by pair. Their goal is to inhibit STCA alerts generated by aircraft aligned on parallel runways.

A NOZ area is an area which an aircraft can fly in when it performs independent parallel approach. When independent parallel approach is in place, two NOZs are defined (one for each runway). While an aircraft is situated within one NOZ area, STCA is not raised in relation with another aircraft which is situated in the other NOZ.

Identifier	REQ - 10.04.03 - 024.01
Requirement	STCA inhibition areas shall be defined as volume using up to a maximum number of geodetic points in horizontal and upper and lower level in vertical (in Flight Level or in QNH corrected altitude).

Identifier	REQ - 10.04.03 - 025.00
Requirement	All STCA inhibition areas shall be included within the SNS Region.

Identifier	REQ - 10.04.03 - 027.01
Requirement	NOZ areas shall be defined as a volume using a given number of geodetic points in horizontal and an upper level in vertical (in QNH corrected altitude).

Identifier	REQ - 10.04.03 - 028.00
Requirement	All NOZ areas shall be included within the SNS Region.

3.1.2.3 STCA processing

Identifier	REQ - 10.04.03 - 029.00
Requirement	The STCA processing shall be initiated at each surveillance track reception.

3.1.2.3.1 STCA parameters determination

Identifier	REQ - 10.04.03 - 030.00
Requirement	If a track is located in several overlapped SNS processing areas, the SNS shall apply the set of parameters of the SNS processing area with the highest priority.

Note: The priority of the parameter sets is derived from their order of declaration.

Identifier	REQ - 10.04.03 - 031.00
Requirement	When a pair of surveillance tracks is located in different SNS processing areas, the set of parameters to be used shall be the one with the higher priority.

Identifier	REQ - 10.04.03 - 032.00
Requirement	A set of STCA parameters shall be composed of two types of parameters: • Standard parameters: These parameters (separation thresholds and warning times) are used when checking conflict with main hypothesis. They are sized to fulfil with the separation protection philosophy of Safety Nets. • Reduced parameters: These parameters (separation thresholds and warning times) are used when checking conflict with backup hypothesis. They are sized in a way near the collision avoidance philosophy.

Each type of parameter is composed of (non exhaustive list):

- Look-ahead time
- Warning time

- Imminent time
- Planar separation
- Vertical separation for low airspace
- Vertical separation for high airspace
- Priority rank

Identifier	REQ - 10.04.03 - 033.00
Requirement	The minimum vertical separation threshold to be used for a specific conflict is determined according to the following conditions: • If both aircraft are at or below the RVSM lower limit, then the low vertical separation threshold shall be used. • If both aircraft are RVSM-approved then: o If one of the tracks is above the RVSM lower limit and below the RVSM upper limit, and the other track is at or below the RVSM upper limit, then the low vertical separation threshold shall be used o If one of the track is flying level 1000 feet below the RVSM upper limit, and the other track is above the RVSM upper limit, then the low vertical separation threshold shall be used. • In all other cases, the high vertical separation threshold shall be used.

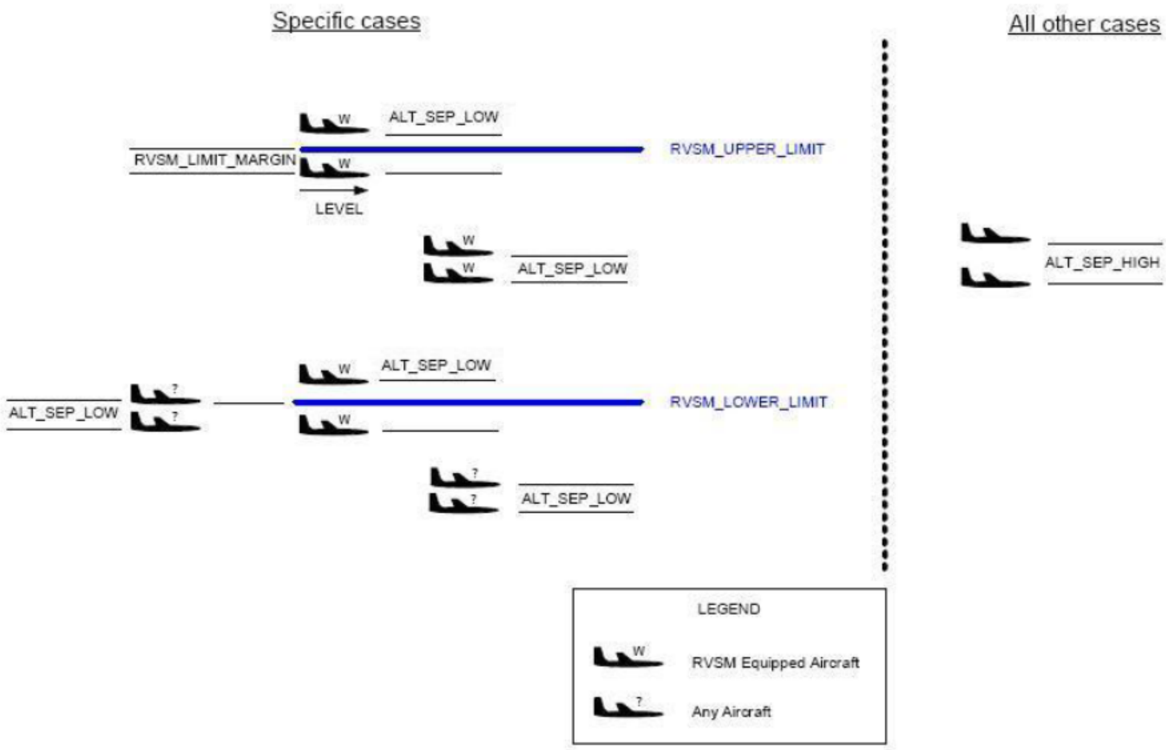

Figure 4 – Minimum vertical separation

3.1.2.3.2 STCA inhibited tracks

The SNS has to provide a capability to inhibit some tracks from raising a STCA alert. This inhibition could be based for example on:

- SSR code (Mode A),

- callsign,
- Mode S ID (ACID),
- correlation status,
- flight rules of track pair (inhibition of conflicts between IFR and VFR flights, between IFR and IFR, or between VFR and VFR).

These inhibition criteria are linked to a SNS Processing Area. This allows to have different criteria in different portions of airspace.

The inhibition criteria are offline defined and might be online modifiable depending on local implementation.

Identifier	REQ - 10.04.03 - 009.01
Requirement	The SNS shall provide a capability to inhibit STCA alerts for some tracks.

Identifier	REQ - 10.04.03 - 045.00
Requirement	Inhibition criteria for STCA shall be restricted to a specific SNS Processing Area.

Note: A 'STCA inhibited track' is not necessarily discarded from the processing.

3.1.2.3.3 STCA online modifications

This section describes which data impacting the STCA processing could be online modified by an operational supervisor and / or a controller.

Identifier	REQ - 10.04.03 - 020.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate a STCA inhibition area.

Identifier	REQ - 10.04.03 - 022.00
Requirement	The SNS shall handle a request to dynamically change the criteria used to declare a track as 'STCA inhibited'.

3.1.2.3.4 Conflict Detection

STCA processing is performed for a pair of tracks. Each track among the pair has a main hypothesis and an optional backup hypothesis.

Identifier	REQ - 10.04.03 - 034.00
Requirement	A conflict situation for a surveillance track pair shall occur if at a given time within the look ahead time the following occurs simultaneously: • The minimum horizontal separation is infringed, and • The minimum vertical separation is infringed.

Identifier	REQ - 10.04.03 - 035.00
Requirement	A conflict shall be detected if: • Both tracks have only one main hypothesis o A conflict situation is detected using main hypotheses and standard parameters • Both tracks have one main and one backup hypothesis o A conflict situation is detected using main hypotheses and standard parameters, or

	◦ A conflict situation is detected using backup hypotheses and reduced parameters • Only one track have both hypothesis ◦ A conflict situation is detected using main hypotheses and standard parameters, or ◦ A conflict situation is detected using main hypothesis versus backup hypothesis and reduced parameters

3.1.2.3.5 Conflict Handling

When a conflict has been detected, it is internally monitored, and a conflict quality is determined. An alert is generated as soon as the conflict status requires controllers to be warned.

STCA conflicts are handled in two ways:

- By mean of a conflict quality.
- By comparison between the time to conflict and the warning time (minimum time to solve the conflict: it includes the sum of reactions times of controller, pilot, aircraft)

Identifier	REQ - 10.04.03 - 036.01
Requirement	Conflict quality shall be determined using the number of conflict detections against the total number of detections and non-detections since the first detection of the conflict. Q = nb detection / (nb detection + nb non-detection)

Identifier	REQ - 10.04.03 - 037.00
Requirement	When a conflict has been detected, the STCA function shall determine the conflict status. Conflicts status can be: • Impending: When the time to conflict is greater than the off-line configurable STCA warning time threshold. • Actual: When the time to conflict is lower than the off-line configurable STCA warning time threshold and the conflict has the following characteristics ◦ Conflict quality is above an off-line configurable STCA quality threshold ◦ Conflict detection number is above an off-line configurable STCA counter threshold • Close: time to conflict lower than the off-line configurable STCA imminent time threshold. • Real: Time to conflict is 0. It corresponds to an effective violation of separation in horizontal and vertical of the off-line defined required separation. • Solved: ◦ If the relative minimum distance between conflicting tracks is greater than the separation threshold (in the horizontal and in the vertical planes) with a last detection age greater than the STCA miss threshold, or ◦ If conflicting tracks are horizontally diverging and the distance between the tracks is greater than the diverging separation threshold with a last detection age greater than the STCA miss threshold.

A conflict is considered resolved after its status becomes “Solved”.

3.1.2.4 STCA output

The STCA function may discover conflicts that should not be presented to the controller. Therefore, upon specific criteria, the SNS must inhibit the distribution of conflicts at the last stage of the processing. If an alert message had previously been distributed for this conflict, the SNS will distribute a solved alert, but will continue to monitor the conflict internally. For example, if a conflicting pair enters an active inhibition area, the SNS will distribute a “fake” solved alert when both tracks will be inside the inhibition area. If the conflict is resolved while the tracks are still inside the inhibition area, the genuine solved will never be distributed.

Identifier	REQ - 10.04.03 - 039.00
Requirement	STCA alerts shall be generated at: • Each conflict detection, when the conflict status is actual, close, real or solved, or • Each update period (SDP cycle) if the conflict has not been detected in the last update period.

Identifier	REQ - 10.04.03 - 041.00
Requirement	The SNS shall inhibit conflict distribution in the following cases: • Both tracks involved in the conflict are in an active STCA inhibition area. • The conflict comprises of a pair of tracks both being flagged as STCA inhibited.

Identifier	REQ - 10.04.03 - 042.00
Requirement	The SNS shall inhibit conflict distribution for the tracks located in NOZ areas if: • Heading gap between each aircraft and the runway axis is lower than a maximum allowed threshold and, • The considered pair of runways is operating in an “independent parallel approach” mode and, • Each track is located within a different NOZ associated with the “independent parallel approach” pair of runways and, • The runway assigned to each track matches the runway linked to the NOZ where the track is located.

3.1.3 Minimum Safe Altitude Warning (MSAW) Requirements

3.1.3.1 MSAW main concepts

MSAW monitors the altitude of aircraft towards terrain and obstacles. When the altitude of an aircraft is detected or predicted to be lower than the applicable minimum safe altitude, the MSAW function generates an alert to the ATC Controller.

As MSAW processing is done close to the ground, MSAW uses the QNH corrected altitude of tracks and the upper limit of the MSAW objects is defined as an altitude above Mean Sea Level.

3.1.3.2 MSAW geographical definition

3.1.3.2.1 MSAW Surface

MSAW uses a surface that defines the minimum safe altitude. Depending on the implementation, this surface can be described by:

- Polygon volumes with an altitude limit: used to model terrain and obstacles,

- Cylinders with an altitude limit: used to model obstacles (e.g. towers, radio masts),
- Digital terrain data: provides the most precise terrain definition.

The MSAW surface is included in the SNS Region but might not fully cover it.

A vertical margin might be added above digital terrain. Lateral and vertical safety margins might also be added around polygons and cylinders definition.

Identifier	REQ - 10.04.03 - 049.00
Requirement	MSAW shall use a surface defining the minimum safe altitude. This surface shall be included in the SNS Region.

3.1.3.2.2 MSAW Inhibition Areas

MSAW Inhibition Areas allow to define areas where the MSAW processing of tracks is inhibited.

Identifier	REQ - 10.04.03 - 050.00
Requirement	An MSAW Inhibition Area shall be defined by: • a name, • a polygon defined by a maximum number of geodetic points in horizontal, • an upper and a lower altitude in vertical, • an activation state. It shall be included in the SNS Region.

3.1.3.3 MSAW processing

Identifier	REQ - 10.04.03 - 051.00
Requirement	The MSAW processing shall be initiated at each surveillance track reception.

3.1.3.3.1 MSAW Inhibited Tracks

The SNS has to provide a capability to inhibit specific tracks from raising a MSAW alert. This inhibition can be based for example on:

- SSR code (Mode A),
- callsign,
- Mode S ID (ACID),
- correlation status,
- flight rules of the track (IFR or VFR).

These inhibition criteria are linked to a SNS Processing Area. This allows to have different criteria in different portions of airspace.

The inhibition criteria are offline defined and might be online modifiable depending on local implementation.

Identifier	REQ - 10.04.03 - 052.00
Requirement	The SNS shall provide a capability to inhibit MSAW alerts for specified tracks.

Identifier	REQ - 10.04.03 - 053.00
Requirement	Inhibition criteria for MSAW shall be restricted to a specific SNS Processing Area.

3.1.3.3.2 MSAW Online Modifications

This section describes which data impacting the MSAW processing can be online modified by an operational supervisor and / or a controller.

Identifier	REQ - 10.04.03 - 054.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate a MSAW Inhibition Area.

Identifier	REQ - 10.04.03 - 055.00
Requirement	The SNS shall handle a request to dynamically change the criteria used to declare a track as 'MSAW inhibited'.

3.1.3.3.3 MSAW Alert Detection

The MSAW processing uses the track extrapolation described in 3.1.1.4. The local implementation might use specific algorithm extrapolations, for example to add a specific behaviour for tracks descending with a slow vertical rate.

If a track infringes or is predicted to infringe the MSAW surface, an alert is raised.

Identifier	REQ - 10.04.03 - 056.00
Requirement	A conflict situation for a track shall occur if at a given time within the look ahead time the track infringes the minimum safe altitude.

3.1.3.3.4 MSAW Alert Handling

When a conflict is detected, it is internally monitored. An alert is generated as soon as the conflict status requires controllers to be warned.

Identifier	REQ - 10.04.03 - 057.00
Requirement	When a conflict has been detected, the MSAW function shall compute the conflict status. Conflict status can be: • Predicted: the time to conflict is greater than the MSAW warning time threshold and the number of detections is below the MSAW detection threshold, • Close: the time to conflict is below the MSAW warning time threshold or the number of detections is above the MSAW detection threshold, • Actual: the time to conflict is 0. There is an effective infringement of the MSAW surface. • Solved: The conflict is no longer detected.

A conflict is considered as resolved when its status becomes "Solved".

3.1.3.4 MSAW output

The MSAW function may discover conflicts that should not be presented to the controller. Therefore, upon specific criteria, the SNS must inhibit the distribution of conflicts at the last stage of the processing. If an alert message had previously been distributed for this conflict, the SNS will distribute a solved alert, but will continue to monitor the conflict internally. For example, if a track enters an active inhibition area, the SNS will distribute a "fake" solved alert when the track will be inside the inhibition area. If the conflict is resolved while the track is still inside the inhibition area, the genuine solved alert will never be distributed.

Identifier	REQ - 10.04.03 - 058.00
Requirement	MSAW alerts shall be generated at: • Each conflict detection, when the conflict status is Predicted, Close,

	Actual or Solved, or • Each update period (SDP cycle) if the conflict has not been detected in the last update period.

Identifier	REQ - 10.04.03 - 059.00
Requirement	The SNS shall inhibit the conflict distribution in the following cases: • the track is in an active MSAW Inhibition Area, or • the track is flagged as MSAW inhibited.

3.1.4 Area Proximity Warning (APW) Requirements

3.1.4.1 APW main concepts

APW monitors the behaviour of aircrafts. The main goal of APW is to warn the controller in a timely manner that an aircraft is predicted to infringe or is infringing a specific airspace volume without authorisation.

APW warns the controller about unauthorized penetration of flights into controlled airspace, for example:

- penetration of uncontrolled flights into controlled airspace.
- in case of a military ATC system, in addition, penetration of controlled military flights into civil controlled airspace.

3.1.4.2 APW geographical definition

APW needs to know if a region (processing area) is a controlled airspace or a excluded airspace. For this reason, APW shall be capable of using different parameters in different areas in order to adapt its processing.

For APW, the airspace is divided in the following kinds of areas:

- One SNS region
- One or more APW Controlled Areas
- One or more APW Excluded Areas. An APW Excluded Area can represent a Restricted Area, a Dangerous Area or a Prohibited Area.

Identifier	REQ - 10.04.03 - 060.00
Requirement	APW Controlled Areas shall be defined by: • A name • A polygon defined by up to a maximum number of geodetic points in horizontal • An upper and a lower level in vertical • An activation status.

Identifier	REQ - 10.04.03 - 061.00
Requirement	APW Excluded Areas shall be defined by: • A name • A polygon defined by up to a maximum number of geodetic points in horizontal • An upper and a lower level in vertical • An activation status.

Identifier	REQ - 10.04.03 - 062.00
Requirement	All APW controlled areas shall be included within the SNS Region.

Identifier	REQ - 10.04.03 - 063.00
Requirement	All APW excluded areas shall be included within one APW controlled area.

3.1.4.3 APW processing

Identifier	REQ - 10.04.03 - 064.00
Requirement	The APW processing shall be initiated at each surveillance track reception.

3.1.4.3.1 APW Inhibited Tracks

The SNS has to provide a capability to inhibit specific tracks from raising an APW alert. This inhibition can be based for example on:

- SSR code (Mode A),
- callsign,
- Mode S ID (ACID),
- correlation status,
- flight rules of the track (IFR or VFR).

These inhibition criteria linked to an APW Controlled Area of an APW Excluded Area. This allows to have different criteria in different portions of airspace.

The inhibition criteria are offline defined and might be online modifiable depending on local implementation.

Identifier	REQ - 10.04.03 - 065.00
Requirement	The SNS shall provide a capability to inhibit APW alerts for specified tracks.

Identifier	REQ - 10.04.03 - 066.00
Requirement	Inhibition criteria for APW shall be restricted to a specific APW Excluded Area or APW Controlled Area.

3.1.4.3.2 APW Online Modifications

Identifier	REQ - 10.04.03 - 067.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate an APW Controlled Area.

Identifier	REQ - 10.04.03 - 068.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate an APW Excluded Area.

Identifier	REQ - 10.04.03 – 069.00
Requirement	The SNS shall handle a request to dynamically change the criteria used to declare a track as 'APW inhibited'.

3.1.4.3.3 APW Alert Detection

The APW processing uses the track extrapolation described in 3.1.1.4.

When a track infringes or is predicted to infringe an APW Controlled Area or an APW Excluded Area, an alert is raised if particular conditions occur.

The eligibility of tracks to the two types of alert detections should be defined by the implementation. For example:

- For conflicts with an APW Excluded Area, it is usual that only tracks that are correlated with a flight plan are processed.
- For conflicts with an APW Controlled Area, it is usual that only tracks that are not correlated with a flight plan are processed. A list of SSR Codes might also be used to filter eligible tracks.

The link with Flight Plans should be defined by the implementation.

Identifier	REQ - 10.04.03 - 070.00
Requirement	The SNS shall arise a conflict when an eligible flight infringes or is predicted to infringe within the look ahead time one APW Excluded Area.
Identifier	REQ - 10.04.03 - 071.00
Requirement	The SNS shall arise a conflict when an eligible flight enters, at the present instant, one APW Controlled Area.

3.1.4.3.4 APW Alert Handling

When a conflict is detected, it is internally monitored. An alert is generated as soon as the conflict status requires controllers to be warned.

Identifier	REQ - 10.04.03 - 072.00
Requirement	When a conflict has been detected, the APW function shall compute the conflict status. Conflict status can be: • Predicted: the time to conflict is greater than the APW warning time threshold and the number of detections is below the APW detection threshold, • Close: the time to conflict below the APW warning time threshold or the number of detections is above the APW detection threshold, • Actual: the time to conflict is 0. There is an effective infringement of the APW Controlled Area or the APW Excluded Area, • Solved: The conflict is no longer detected.

A conflict is considered as resolved when its status becomes “Solved”.

3.1.4.4 APW output

The APW function may discover conflicts that should not be presented to the controller. Therefore, upon specific criteria, the SNS must inhibit the distribution of conflicts at the last stage of the processing. If an alert message had previously been distributed for this conflict, the SNS will distribute a solved alert, but will continue to monitor the conflict internally. For example, if a track becomes inhibited, the SNS will distribute a “fake” solved alert . If the conflict is resolved while the track is still inhibited, the genuine solved alert will never be distributed.

Identifier	REQ - 10.04.03 - 073.00
Requirement	APW alerts shall be generated at: • Each conflict detection, when the conflict status is Predicted, Close, Actual or Solved, or • Each update period (SDP cycle) if the conflict has not been detected in the last update period.

Identifier	REQ - 10.04.03 - 074.00
Requirement	The SNS shall inhibit the conflict distribution if the track is flagged as APW inhibited.

3.1.5 Approach Path Monitoring (APM) Requirements

3.1.5.1 APM main concepts

APM monitors aircraft positions during landing to check if an aircraft deviates from the nominal approach path of the runway on which it is landing. When an aircraft deviates from the approach path, APM generates an alert to the ATC Controller.

As APM processing is done close to the ground, APM uses the QNH corrected altitude of tracks and all vertical limits are defined as an altitude above Mean Sea Level.

3.1.5.2 APM geographical definition

APM uses volumes describing nominal approach paths.

Identifier	REQ - 10.04.03 - 075.00
Requirement	An Approach Path shall be defined by: • An identifier (airport and runway), • A volume describing the limits of the nominal final approach path.

When using MSAW and APM in the same airspace, the boundary between the two functions should be carefully defined in order to clearly specify where MSAW should be active, where APM should be active, where both should be active and where neither should be active. For example this can be achieved by defining MSAW Inhibition Areas around runways.

3.1.5.3 APM processing

Identifier	REQ - 10.04.03 - 076.00
Requirement	The APM processing shall be initiated at each surveillance track reception.

3.1.5.3.1 APM Inhibited Tracks

The SNS has to provide a capability to inhibit specific tracks from raising an APM alert. This inhibition can be based for example on:

- SSR code (Mode A),
- callsign,
- Mode S ID (ACID),
- correlation status,
- flight rules of the track (IFR or VFR).

These inhibition criteria linked to a SNS Processing Area. This allows to have different criteria in different portions of airspace.

The inhibition criteria are offline defined and might be online modifiable depending on local implementation.

Identifier	REQ - 10.04.03 - 077.00
Requirement	The SNS shall provide a capability to inhibit APM alerts for specified tracks.

Identifier	REQ - 10.04.03 - 078.00
Requirement	Inhibition criteria for APM shall be restricted to a specific SNS Processing Area.

3.1.5.3.2 APM Online Modifications

This section describes which data impacting the APM processing can be online modified by an operational supervisor and / or a controller.

Identifier	REQ - 10.04.03 - 079.00
Requirement	The SNS shall handle a request to dynamically change the criteria used to declare a track as 'APM inhibited'.
Identifier	REQ - 10.04.03 - 090.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate APM processing on a specific Runway.

3.1.5.3.3 APM Alert Detection

APM processing applies on tracks on final approach to a runway. It uses the current position of tracks. Its goal is to detect if a track is deviating, vertically or laterally, from the volume defining the nominal approach path.

As soon as a deviation is detected, an alert is raised.

Identifier	REQ - 10.04.03 - 080.00

Requirement	The SNS shall raise an APM alert on a track on final approach:
	• If the track is in lateral deviation from the approach path and the detection of lateral deviation is activated
	• If the track is in vertical deviation from the approach path:
	    o If the track is below the approach path and the detection of vertical deviation below the path is activated
	    o If the track is above the approach path and the detection of vertical deviation above the path is activated.

3.1.5.4 APM output

As soon as an APM alert is detected, it is sent to the controller. This alert sending is inhibited when the track fulfils an APM inhibition criterion.

Identifier	REQ - 10.04.03 - 081.00
Requirement	APM alerts shall be generated at: • Each conflict detection, or • Each update period (SDP cycle) if the conflict has not been detected in the last update period.

Identifier	REQ - 10.04.03 - 082.00
Requirement	The SNS shall inhibit the conflict distribution if the track is flagged as APM inhibited.

3.1.6 RA Data Presentation (RADP) Requirements

3.1.6.1 RADP Main Concepts

The purpose of the RADP is to anticipate pilot's RA report when an RA is announced by the onboard TCAS II system.

In the ATC system, the RA is shown in the CWP associated to the track which represent the own aircraft in the current traffic picture. In this picture, the RA is displayed as an additional kind of alert in the track label.

The beginning and termination of an RA announcement are considered critical events whose presentation to the controller is subject to precise timing requirements.

3.1.6.2 RADP Geographical Definition

For RADP processing, the airspace is divided in the following kinds of areas:

- One SNS region,
- One or several SNS processing areas,
- One or several RA inhibition areas.

The SNS region is defined in previous section 2.9.1.1 while the SNS processing areas are defined in previous section 2.9.1.2. RA inhibition areas are defined in next section.

3.1.6.2.1 RA Inhibition Areas

RADP allows defining areas where the RA presentation is inhibited.

Identifier	REQ - 10.04.03 – 104.00
Requirement	RA inhibition areas shall be defined as volume using up to a maximum number of geodetic points in horizontal and upper and lower level in vertical (in Flight Level or in QNH corrected altitude).

Identifier	REQ - 10.04.03 – 105.00
Requirement	All RA inhibition areas shall be included within the SNS Region.

3.1.6.3 RADP Processing

The RADP function processes input messages in ASTERIX Category 4 coming from the ACAS Monitoring system. These messages contain one or more RAs which must be coupled to the surveillance tracks matching the own aircraft identifier of RAs.

Identifier	REQ - 10.04.03 – 090.00
Requirement	The SNS shall receive ACAS RA in ASTERIX CAT 004 format.

Identifier	REQ - 10.04.03 – 091.00
Requirement	The coupling of ACAS RA to tracks shall be attempted at each ACAS RA reception.

3.1.6.3.1 RADP Coupling

When the own aircraft identifier of an ACAS RA matches the identification of one surveillance track, the ACAS RA is considered as being coupled to the track. Thus, the ACAS RA coupling process results in the detection of tracks with current RA event annunciation.

Identifier	REQ - 10.04.03 – 092.00
Requirement	An ACAS RA shall be coupled with the track matching the same identification obtained from Mode S identifier or callsign.

Identifier	REQ - 10.04.03 – 093.00
Requirement	ACAS RA shall be eliminated if one of the following conditions occurs: • it does not match the identification of any track, or • a new ACAS RA is coupled to its track, or • after a time parameter since the alert time of a termination RA, or • after a time parameter since the alert time of the last ACAS RA coupled to that track different of a termination RA.

RA presentation is intended to inform the controller on the RA occurrence in aircraft in the current traffic picture. Basically, the controller needs only to know the beginning and the end of the onboard RAs. This may be best accomplished using two states, one informing that the RA is ongoing and other indicating that the RA is just finished.

Nevertheless, it may be convenient to allow the possibility of having available some more information on the content of RA, such as its sense. Thus, the level of detail of displayed RA alerts is left to be configured in the HMI according to local preferences. This allows configurations ranging from the simple presentation level with two states (RA/COC) through the most complex presentation levels with several states, showing additional content.

Identifier	REQ - 10.04.03 – 094.00
Requirement	The identified RA categories shall be the following: • Climb, • Descend, • AVS (Adjust Vertical Speed / Level Off), • MVS (Monitor / Maintain Vertical Speed), • COC (Clear of Conflict).

A track with a coupled ACAS RA is considered as supporting an RA event. Controllers are informed on such RA event by means of RA alerts, if the RA alert presentation is not inhibited for that track.

An RA event starts when an ACAS RA is coupled to a track with no previous RA and lasts until a termination condition occurs. Normal termination happens when the termination RA is coupled and, after the presentation of the COC alert during a configurable time parameter, the RA alert display is eliminated. Changes of the ACAS RA along the RA event are treated as RA alert updates.

Identifier	REQ - 10.04.03 – 095.00
Requirement	An RA event shall be created and associated to a track when an ACAS RA is coupled to a track without prior RA event and it is not a termination RA (COC).

Identifier	REQ - 10.04.03 – 098.00
Requirement	An RA alert shall be delivered for a track at RA event creation and RA event update, if there is not RA alert inhibition for that track.

Identifier	REQ - 10.04.03 – 096.00
Requirement	A new RA alert shall be associated to an RA event whenever an ACAS RA is coupled with the track and the ACAS RA category is different from the current RA alert.

Identifier	REQ - 10.04.03 – 097.00
Requirement	An RA event shall be eliminated when the coupled ACAS RA or the track is eliminated.

3.1.6.3.2 RADP Inhibited Tracks

The SNS has to provide a capability to inhibit specific tracks from raising RA alerts. This inhibition can be based on individual track identifiers or airspace categories, as in the case of ground safety nets.

Inhibition criteria are linked to a SNS Processing Area. This allows having different criteria in different portions of airspace.

Identifier	REQ - 10.04.03 – 099.00
Requirement	The SNS shall provide a capability to inhibit RA alerts for some tracks.

Identifier	REQ - 10.04.03 – 100.00
Requirement	Inhibition criteria for RA shall be restricted to a specific SNS Processing Area.

3.1.6.3.3 RADP Online Modifications

Inhibition criteria are offline defined and might be online modifiable depending on local implementation.

Identifier	REQ - 10.04.03 – 101.00
Requirement	The SNS shall handle a request to dynamically activate or deactivate an RA inhibition area.

Identifier	REQ - 10.04.03 – 102.00
Requirement	The SNS shall handle a request to dynamically change the criteria used to declare a track as 'RA inhibited'.

3.1.6.4 RADP Output

RA alerts are actually distributed for an RA event if the coupled track is not inside a volume where RA presentation for this track has been inhibited.

Identifier	REQ - 10.04.03 – 103.00
Requirement	The SNS shall inhibit RA event distribution when the track is inside an RA

	inhibition area or when the track is matching the RA inhibition criteria inside a processing area.

3.2 Adaptability

N/A

3.3 HMI Requirements for Safety Nets

3.3.1 HMI for RADP Functionality

Information derived from RADP Functionality is processed in order to be displayed to ATCOs giving a complete picture of the traffic situation.

Identifier	REQ - 10.04.03 – 109.00
Requirement	The CWP shall display RA Alerts associated to a track in a permanent and visible manner, at least in the Track label.

		REQ-04.08.03-OSED-H-ACAS-RA.0010	

Identifier	REQ - 10.04.03 – 110.00
Requirement	CWP shall stop displaying an RA Alert when: • The RA Alert is not received from SNS, or • End of Conflict is received from SNS for the corresponding RA Alert.

Identifier	REQ - 10.04.03 – 111.00
Requirement	The CWP shall reject all the RA alerts associated to a flight for which the RADP functionality is inhibited.

Identifier	REQ - 10.04.03 – 112.00
Requirement	The CWP should display highlighted information in the label for an inhibited flight in the RADP functionality.

Identifier	REQ - 10.04.03 – 113.00
Requirement	CWP shall display information about the availability and the status of global RADP functionality.

Identifier	REQ - 10.04.03 – 114.00

Requirement	CWP should display the RA alerts that have been acknowledged by ATCO in a specific way in the track label.

Identifier	REQ - 10.04.03 – 115.00
Requirement	CWP shall allow configuring audible alerts associated to current RA alerts.

Identifier	REQ - 10.04.03 – 116.00
Requirement	CWP shall remove the associated audible alert after an RA alert acknowledgement.

3.4 Performance Characteristics

3.4.1 Common Performance Characteristics

Identifier	REQ - 10.04.03 - 002.00
Requirement	The SNS shall be capable of handling up to a maximum number of surveillance tracks.

Identifier	REQ - 10.04.03 - 012.00
Requirement	The SNS shall use less than a maximum number of SNS processing areas.

Identifier	REQ - 10.04.03 - 015.00
Requirement	The SNS shall use less than a maximum number of turning areas.

3.4.2 STCA Performance Characteristics

Identifier	REQ - 10.04.03 - 023.00
Requirement	The number of STCA inhibition areas shall be limited to a maximum value.

Identifier	REQ - 10.04.03 - 026.00
Requirement	The number of NOZ areas shall be limited to a maximum value.

Identifier	REQ - 10.04.03 - 038.00
Requirement	The SNS shall manage a maximum number of STCA conflicts defined by a system capacity.

3.4.3 MSAW Performance Characteristics

Identifier	REQ - 10.04.03 - 083.00
Requirement	The number of MSAW Inhibition Areas shall be limited to a maximum value.

Identifier	REQ - 10.04.03 - 084.00
Requirement	The SNS shall manage a maximum number of MSAW alerts defined by a system capacity.

3.4.4 APW Performance Characteristics

Identifier	REQ - 10.04.03 - 086.00

Requirement	The number of APW Controlled Areas shall be limited to a maximum value .

Identifier	REQ - 10.04.03 - 085.00
Requirement	The number of APW Excluded Areas shall be limited to a maximum value.

Identifier	REQ - 10.04.03 - 087.00
Requirement	The SNS shall manage a maximum number of APW Alerts.

3.4.5 APM Performance Characteristics

Identifier	REQ - 10.04.03 - 088.00
Requirement	The number of APM Approach Paths shall be limited to a maximum value.

Identifier	REQ - 10.04.03 - 089.00
Requirement	The SNS shall manage a maximum number of APM alerts defined by a system capacity.

3.4.6 RADP Performance Characteristics

Identifier	REQ - 10.04.03 - 106.00
Requirement	The number of RA inhibition areas shall be limited to a maximum value.

Identifier	REQ - 10.04.03 - 107.00
Requirement	The SNS shall manage a maximum number of RA alerts defined by a system capacity.

Identifier	REQ - 10.04.03 - 108.00
Requirement	Delay time between reception of incoming ACAS RAs and its display as graphic RA alerts in CWP shall be within 2 seconds in 95% of cases.

3.4.7 Performance parameters

The following table describes the software parameters used by the SNS. These parameters have a direct impact on system performances, consequently they are not adaptable through offline configuration.

Definition	Value
The maximum number of points used to describe the horizontal boundary of an area.	16
The maximum number of NOZ areas managed by the SNS	30
The maximum number of surveillance tracks that can be processed by the SNS.	2000
The maximum number of points used to describe the horizontal boundary of a NOZ area.	4
The maximum number of SNS processing areas defined in the SNS.	100
The maximum number of groups of parameters defined in the SNS.	40
The maximum number of turning areas defined in the SNS.	10
The maximum number of STCA inhibition areas managed by the SNS.	15

Definition	Value
The maximum number of STCA conflicts managed by the SNS at a given time.	200
The maximum number of MSAW Inhibition Areas	15
The maximum number of MSAW alerts managed by the SNS at a given time.	100
The maximum number of APW Controlled Areas	10
The maximum number of APW Excluded Areas	100
The maximum number of APW alerts managed by the SNS at a given time	100
The maximum number of APM Approach Paths	15
The maximum number of APM alerts managed by the SNS at a given time.	50
The maximum number of RA Inhibition Areas	15

Table 4 – SNS software parameters

3.5 Safety & Security

N/A

3.6 Maintainability

N/A

3.7 Reliability

Identifier	REQ - 10.04.03 - 040.00
Requirement	The SNS shall provide an alive message at each update period (SDP cycle).

3.8 Functional block Internal Data Requirements

All decisions about internal data are left to the implementation.

3.9 Design and Construction Constraints

Identifier	REQ - 10.04.03 - 043.00
Requirement	The SNS shall be able to replay its input recorded data for offline analysis purpose.

3.10 Functional block Interface Requirements

The SDP could transmit tracks in different distribution modes: in batch mode or clockwise. The SNS should use the same acquisition mode as the SDP to prevent issues of adaptation.

Identifier	REQ - 10.04.03 - 001.00
Requirement	The SNS shall receive surveillance tracks in ASTERIX CAT 062 format.

Identifier	REQ - 10.04.03 - 003.00
Requirement	The SNS shall process surveillance tracks with at least the following data:

	position, ground speed, altitude and rate of climb or descend.

Other input data could be used by the SNS, some of them possibly provided by the flight plan system (e.g. CFL, coupling status, mode A code, aircraft id).

The way to acquire this flight plan data is not detailed in this document as it is dependant from local implementations.

Identifier	REQ - 10.04.03 - 004.00
Requirement	The SNS shall receive the mode of operation of the parallel runways.

Identifier	REQ - 10.04.03 - 005.00
Requirement	The SNS shall distribute safety net alerts in ASTERIX CAT 004 format.

4 Assumptions

N/A

5 References

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[4] **P10.4.3** 10.04.03-PIR-Part 2-00.01.04.xls 26/05/2010

[5] **P10.4.3** 10.04.03-D01-Preliminary Definition Report for Phase 1 (enhance STCA), edition 00.01.00

[6] **P10.4.3** 10.04.03-D02-Preliminary Operational System requirements Synthesis Report for Phase 1 (Enhance STCA), edition 00.01.00

[7] **P10.4.3** 10.04.03-D11-Preliminary Definition Report for Phase 2 (Enhance Safety Nets), edition 00.01.00

[8] **P10.1.7 TAD**

[9] **SESAR** Requirements and V&V Guidelines 02.00.00

[10] **B0.1** Integrated Roadmap DataBase (v1.03b)

[11] **P04.08.01** 4.8.1-D05-VR-TMA-STCA-V3, Preliminary Definition Report for Phase 2 (Enhance Safety Nets), edition 01.00.00

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[13] **P04.08.01** 4.8.1-D13-VR-Benefits-DAP-STCA-V2, Evaluation of safety and performance benefits from the use of existing down-linked parameters in STCA, edition 00.01.01

[14] **P04.08.01** 4.8.1-D14-VR-Benefits-DAP-Other-G-SNET-V2, Evaluation of safety benefits from the use of Existing Downlinked Parameters in Ground-based Safety Nets (other than STCA), edition 00.01.01

[15] **P04.08.01** 4.8.1-D17-OR-DAP-G-SNET-V2, Preliminary OR for the use of DAP in G-SNETs.Preliminary operational requirements for the use of down-linked aircraft parameters in ground based safety nets, edition 01.00.00

[16] **P04.08.03** 4.8.3-M110- Interim OSED deliverable to be used for V2 validation

[17] **P04.08.01** 4.8.1-D18-SPR-DAP-G-SNET-V2, Preliminary Safety and Performance Requirements for the use of down-linked aircraft parameters in ground-based safety nets (Step 1) edition 00.01.00

Appendix A Offline Parameters Description

The purpose of this section is to introduce and describe major parameters available for the Safety Nets Server.

A.1 Global Parameters

Identifier	Definition	Unit
System Parameters		
SDPUpdatePeriod	SDP update period	Seconds
SystemCenterLatitude	System centre latitude	Latitude
SystemCenterLongitude	System centre longitude	Longitude
CFLHypothesisActivated	If true, the main hypothesis extrapolation will be vertically limited to the value of CFL, if available	Boolean
SelectedAltitudeLevelOffHypothesisActivated	If true, the main hypothesis extrapolation will be vertically limited to the value of the Selected Altitude, if available	Boolean
SelectedAltitudeDepartFromLevelHypothesisActivated	If true, the main hypothesis extrapolation will include a start of climb or descent if indicated by Selected Altitude, if available	Boolean
TurnHypothesisActivated	If true, the main hypothesis extrapolation will take into account the rate of turn, if available	Boolean
BPSQNHThreshold	Absolute value of the difference between the Barometric Pressure Setting downlinked from the aircraft and sub scale pression setting on the ground below which the Barometric Pressure Setting can be used to correct Selected Altitude (MCP/FCU) for tracks under the Transition Level.	Integer
SNS processing area parameters		
Name	SNS processing area name	String
ParameterGroup	SNS processing area parameter group ID	Integer
2D Area	Array of latitude and longitude describing the shape of the STCA	Array of latitude /

Identifier	Definition	Unit
	processing area	longitude
UpperLevel	SNS processing area upper bound	Feet/Flight level
LowerLevel	SNS processing area lower bound	Feet/Flight level
DefaultQNH	SNS processing area default QNH value	hPa
DefaultTransitionLevel	SNS processing area default transition level value	Feet/Flight level

Table 5 – Global offline parameters

A.2 STCA Parameters

Identifier	Definition	Unit
STCA Global Parameters		
AltitudeSeparationThreshold	Threshold above which AltitudeSeparationHigh is applied as separation otherwise AltitudeSeparationLow is applied	Feet/Flight level
RVSMLowerLimit	RVSM lower bound	Feet/Flight level
RVSMUpperLimit	RVSM upper bound	Feet/Flight level
STCAProcessOnlyCoupled	If true, only the conflicts involving at least one track coupled to a flight plan will be sent to CWP	Boolean
STCA Parameter Group		
ParameterGroupId	Parameter group identification	Integer
STCALookAheadTime	Prediction time	Seconds
STCAWarningTime	Warning time	Seconds
STCAImminentTime	Imminent time	Seconds
FinePlanarSeparation	Minimum separation	Nautical miles
STCADivergingThreshold	Separation norm for diverging tracks	Nautical miles
AltitudeSeparationLow	Vertical separation applied below AltitudeSeparationThreshold	Feet/Flight level
AltitudeSeparationHigh	Vertical separation applied above AltitudeSeparationThreshold	Feet/Flight level
STCAConflictQualityThreshold	Threshold of quality under which conflict	Float

Identifier	Definition	Unit
	is not displayed	
STCAConflictCounterThreshold	Conflict counter	Integer
ConflictMissThreshold	Number of successive loss of conflict for an already detected conflict	Integer
STCA inhibition area parameters		
Name	STCA inhibition area name	String
ActiveFlag	Activate the STCA inhibition area	Boolean
2D Area	Array of latitude and longitude describing the shape of the STCA inhibition area	Array of latitude / longitude
UpperLevel	STCA inhibition area upper bound	Feet/Flight level
LowerLevel	STCA inhibition area lower bound	Feet/Flight level
NOZ area parameters		
Name	NOZ area name	String
2D Area	Array of latitude and longitude describing the shape of the NOZ area	Array of latitude / longitude
UpperLevel	NOZ area upper bound	Feet/Flight level
MaxDeltaHeading	The allowed gap between runway axis and current track heading.	Degrees

Table 6 – STCA offline parameters

A.3 MSAW Parameters

Identifier	Definition	Unit
MSAW global parameters		
MSAWProcessOnlyCoupled	If true, only coupled tracks are processed by MSAW	Boolean
MSAWLookAheadTime	Prediction time for MSAW	Seconds
MSAWWarningTime	Warning time for MSAW	Seconds
MSAWDetectionThreshold	Number of detections before raising an alert	Integer
MSAWTerrainMargin	Safety margin above terrain	Feet
MSAW inhibition area parameters		
Name	MSAW inhibition area name	String

Identifier	Definition	Unit
ActiveFlag	MSAW inhibition area activation status	Boolean
2D Area	Array of latitude and longitude describing the shape of the MSAW inhibition area	Array of latitude / longitude
UpperLevel	STCA inhibition area upper altitude	Feet/Flight level

Table 7 – MSAW offline parameters

A.4 APW Parameters

Identifier	Definition	Unit
APW global parameters		
APWLookAheadTime	Prediction time for APW	Seconds
APWWarningTime	Warning time for APW	Seconds
APWDetectionThreshold	Number of detections before raising an alert	Integer
APW Controlled Areas		
Name	APW Controlled Area name	String
ActiveFlag	APW Controlled Area activation status	Boolean
2DArea	Array of latitude and longitude describing the shape of the APW Controlled Area	Array of latitude/longitude
UpperLevel	APW Controlled Area upper level	Feet/Flight Level
LowerLevel	APW Controlled Area lower level	Feet/Flight Level
APW Excluded Areas		
Name	APW Excluded Area name	String
ActiveFlag	APW Excluded Area activation status	Boolean
2DArea	Array of latitude and longitude describing the shape of the APW Excluded Area	Array of latitude/longitude
UpperLevel	APW Excluded Area upper level	Feet/Flight Level
LowerLevel	APW Excluded Area lower level	Feet/Flight Level

Table 8 – APW offline parameters

A.5 APM Parameters

Identifier	Definition	Unit

Identifier	Definition	Unit
APM global parameters		
APMProcessOnlyCoupled	If true, only coupled tracks are processed by APM	Boolean
APMVerticalDeviationBelow	Activate below approach path alerts	Boolean
APMVerticalDeviationAbove	Activate above approach path alerts	Boolean
APMLateralDeviation	Activate lateral deviation alerts	Boolean

Table 9 – APM offline parameters

A.6 RADP Parameters

Identifier	Definition	Unit
RADP global parameters		
ClearOfConflictValidityTime	Duration of the display of the End of Conflict RA	Seconds
LastACASRAUpdateValidityTime	Duration of the display of any RA, different from End of Conflict, when there is no subsequent ACAS RA updates	Seconds

Table 10 – RADP offline parameters

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