Preliminary Definition Report for Phase 1 (enhance STCA)

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Abstract

This document establishes the Preliminary System Requirements of the Safety Nets adaptation to new modes of operation project.

This project tackles the three steps of the SESAR Concept Story Board.

System Requirments are based on Operational requirements coming from :

- P4.8.1 partners discussion
- Existing Documents exploitation:
  - SPIN SG outcomes
  - PASS project guidelines

This preliminary document deals with the phase 1 of the project. It will be further refined to deal with the step 2 and step 3, as well as to take into account refinements based on the results of the verification and validation of each phase.

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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 preliminary version of Preliminary Definition Report for Phase 1 (Enhance STCA) 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" which provides operational and users requirements.

The purpose of this document is to elaborate a high-level specification of the system requirements applicable for the first development phase of P10.4.3. Nevertheless, the current document will be refined along the project duration. Especially, P4.8.3 "Ground-Airborne Safety Nets Compatibility" will join the project by providing additional operational and users requirements for the third phase of the project:

As well, these requirements will be refined in each successive phase of the project, based on:

- P10.4.3 partners consultation
- P10.4.3 verification results and P4.8.1 validation results
- P4.8.1 and P4.8.3 partners discussion
- Existing Documents exploitation :
    - SPIN SG outcomes
    - PASS project guidelines

System requirements address existing operational requirements coming from SPIN sub-group as well as P4.8.1 recommendations, these requirements being applicable for P10.4.3. The formal new operational requirements provided by P4.8.1 will be taken into account as soon as available in the next versions of system requirements.

P10.4.3 System Requirements are provided with the following assigned attributes:

- ID: Unique identification
- Description of the requirement
- Possibly, supplementary information are provided as notes

Traceability from system requirements to operational requirement is established in the 10.4.3.D02 document "Preliminary Operational / System requirements Synthesis Report for Phase 1 (Enhance STCA)"

1 Introduction

1.1 Purpose of the document

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

The set of requirements will be 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

In this version of the document, only Short Term Conflict Alert (STCA) is fully detailed. Other safety nets: Minimum Safe Altitude Warning (MSAW), Area Proximity Warning (APW) and Approach Path Monitoring (APM) will be detailed in future versions.

The document is structured as follows:

- Section 1 introduces the document.
- Section 2 is the core of the document. It defines the system using the following structure:
    - 2.1 sub section introduces the context in which the system is expecting to operate.
    - 2.2 sub section presents the architecture of the system.
    - 2.3 sub section details the interfaces of the system.
    - 2.4 sub section provides the system functional requirements. This sub section is organised in high-level functions:
        - Short Term Conflict Alert (STCA),
        - Minimum Safe Altitude Warning (MSAW),
        - Area Proximity Warning (APW) and
        - Approach Path Monitoring (APM).
    - 2.5 sub section presents the system capacities and the main parameters that could be used to adapt the system to the desired environment.
- Section 3 deals with the recommendation of the operational system.
- Section 4 will list the open issues.
- Section 5 gives the list of the reference documents used to build this preliminary definition report.

Finally, the appendix A will provide the list of the offline parameters used by the system.

1.2 Intended readership

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

<u>Projects within WP10</u>

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.

P10.10.3 iCWP Human Factors aspects and User Interface Design

Regarding Human Factors and the iCWP for Safety Nets Display.

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. The project will also validate the 10.4.3 prototype that will be developed in line with this release of this document.

1.3 Background

At this stage of the project, focus is on STCA. Even if in this section the other safety nets (MSAW, APM and APW) are introduced, they may be refined in the future steps of the project to be in line with the SESAR expectations. For example, APW will surely be refined to be in line with the military expectations.

1.3.1 Operational Concept of Safety Nets

1.3.1.1 General Objectives

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 or intrusion into areas excluded for air-traffic.The function remains silently monitoring the traffic until an increased risk is foreseen. Then, a timely alert will be released to warning controllers on the near future situation. 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 that may 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 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.

1.3.1.2 STCA Objectives

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, that is, 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.

1.3.2 Consideration on the operational environment

1.3.2.1 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 radar 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.

Radar separation will depend on temporal 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 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 are time-dependent areas (e.g. a military firing range with published hours of operation). These areas are activated and de-activated according to delivered Notice To Air Men (NOTAM) or according to schedules previously published in the Aeronautical Information Publication (AIP). Inside active areas for military use, it will apply some specific rules to detect STCA alerts.

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 can be included in this group control sectors, holding stacks or manoeuvre areas. Besides this, other areas are created and destroyed, 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.

1.3.2.2 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.

1.3.2.3 General Traffic Characteristics

In regions where several airports are close to each other, if some operational procedures can overlap each other or whether aircrafts 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 could appear. In such cases, 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, it will be obtained enhanced surveillance, in the next future.

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

1.3.2.4 Operational Traffic Characteristics

Operational Traffic and General Traffic Organisation is different in each of the nation. It varies from completely independent entities, with civil-military coordination, 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.

Approach name	Approach description
Segregated ATC systems Segregated ATC units	There are different ATC service providers (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 ATC service providers (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.
Single ATC system Co-located operations	There are either two ATC service providers (civil and military) or one ATC civil-military integrated service provider. 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 ATC is responsible for providing the GAT/OAT separation, but this can be returned to the civil ATC in specific circumstances.
Single ATC system One ATC sector, one ATC team	There are either two ANS providers (civil and military) or an ANS integrated service provider. ATC staff are 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).

Table 1 – 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 Traffic Control could request specific handling in the use of the airspace, and in control tasks.

- When controlling Operational 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.

Alert situations for civil control are not alerts for Operational Controllers, whose task is to keep joined aircrafts, and not to separate them as it is expected from the Civil Controllers. For formation flights, no STCA alert is desired. State aircrafts, exempted from the requirement to be RVSM approved, are to be studied to define when they are candidate to STCA.

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 great 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).

1.3.2.5 Operational Characteristics of Alerts

The objective of 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 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.

1.3.3 Support environment

1.3.3.1 Surveillance Data Processing System

The surveillance processing system 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. This data are only managed by the surveillance server and they need not be known by surveillance clients.

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

1.3.3.2 Flight Data Processing System

The Flight Data Processing System (FDPS) 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 data base.

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 processing system in a separated way.

When the surveillance service conforms with 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 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 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 track is not following the route.

1.3.3.3 Aeronautical Environment Processing System

The Aeronautical Environment Processing System (AEPS) 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 AEPS 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.

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 AEPS system from the adaptation data base, the geometry of temporary segregated areas has to be defined on-line in the AEPS system.

1.3.3.4 Working Positions

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

Controller Working Position is in charge of present to the controller those information of interest for him according to the configuration of working position. That is, it may be assumed that the working position knows which operational sectors has been assigned to it and, according to this, it filters what flight plans or alerts have to be displayed to controller. Given that architecture, the Safety Nets do not need to access to the assignation of sectors to working positions.

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 adequate 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.

1.3.3.5 Testing and Maintenance Environment

Tuning of Safety Nets parameters is an important task as it exists 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 Safety Nets processor at recording time. All input and output data of the Safety Nets processor has to be also recorded, including manual actions in the controller working position. This is assumed to be accomplished by others 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 is to work. Starting from this elemental configuration, the tool has to provide ease 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, it would be very useful the generation of some documentation about the built configuration. The output of this tool, apart from reports, will constitute the configuration environment of Safety Nets processor.

1.4 Acronyms and Terminology

1.4.1 Acronyms

Term	Definition
ACAS	Airborne Collision Avoidance System
AEPS	Aeronautical Environment Processing System
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
ANSP	Air Navigation Service Provider
APM	Approach Path Monitoring
APW	Area Proximity Warning
ATC	Air Traffic Control
ATM	Air Traffic Management
B-RNAV	Basic – Area Navigation
CFL	Cleared Flight Level
CNS	Communications, Navigation and Surveillance
CTR	Control Terminal Region
CWP	Controller Working Position
DME	Distance Measurement Equipment
EC	Executive Controller
EDMS	Environmental Data Manager System
E-ATMS	European Air Traffic Management System
FAB	Functional Airspaces Blocks
FDP	Flight-plan Data Processing
FDPS	Flight-plan Data Processing System
FUA	Flexible Use of Airspace
GAT	General Air Traffic
GBAS	Ground-Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

Term	Definition
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
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
PASS	Performance and safety Aspects of STCA full Study
P-RNAV	Precision – Area Navigation
RVSM	Reduced Vertical Separation Minimum
SDP	Sensor Data Processing
SDPS	Surveillance Data Processing System
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
STCA	Short Term Conflict Alert
SSR	Secondary Surveillance Radar
SWP	Supervisor Working Position
TCAS	Traffic Collision Avoidance System
TMA	Terminal Manoeuvring Area
UDP/IP	User Datagram Protocol / Internet Protocol
VOR	VHF Omni directional Range

1.4.2 Terminology

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 tracks	Surveillance tracks linked to a flight plan.
Excluded areas	This term is mainly used in section 1.3. At this step of the project it refers to the areas used by the APW function to alert in a timely manner aircraft that are predicted to enter these areas. In step 2, APW will be enhanced to be in line with the EUROCONTROL specifications for APW. At this stage of the project APW will not only alert on areas excluded for air traffic, but also alert on military aircraft that are about to exit a military training area without being authorised or uncontrolled flights entering a controlled area without authorization.
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.
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 SDPS and received by the Safety Nets Server.
Turning area	A turning area is defined as a volume used to enable a turning trajectory prediction for the main hypothesis.

2 Preliminary system definition

2.1 System Context

2.1.1 Global environment

The system context diagram is depicted in the following picture.

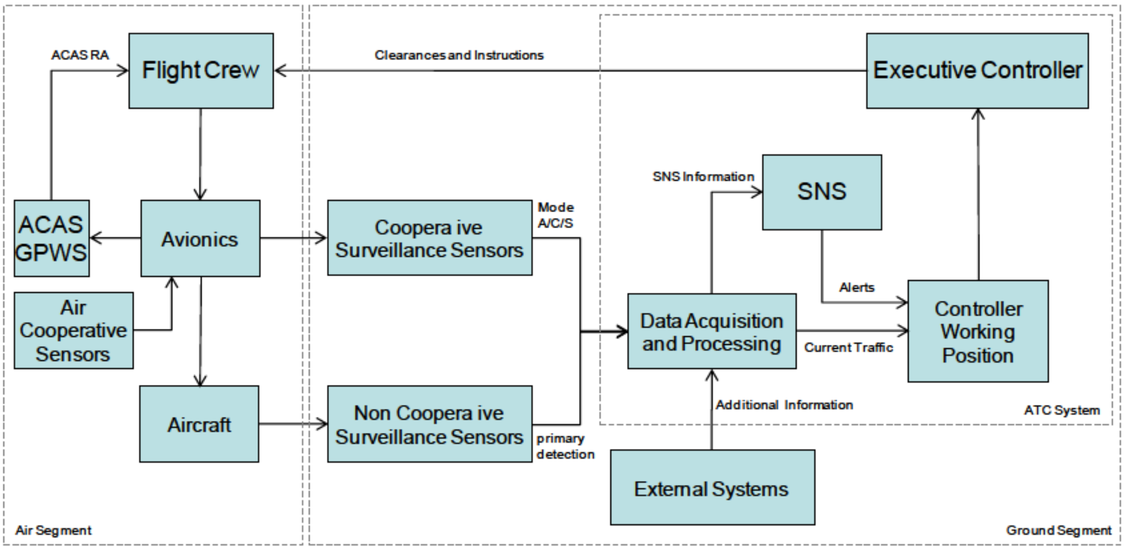

Figure 1 – System context

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 aircraft itself 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, a 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 grand extension 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.

2.1.2 STCA enhancement

Future of STCA is focused on helping with further traffic increases, changing traffic patterns, FUA, changing aircrafts characteristics, further information in the air and in the ground, and the introduction of new concepts. It´s also important to remark new modes of separation as self-separation, in particular when lower separation than minima are considered.

Other changes needed are:

- Correlation of ATC constraints with aircraft intent, in order to further reduce the number of nuisance alerts.
- Increased look-ahead time, and multilevel or different types of alerts.
- Correlation of alerts proceeding from multiple sources (ground and air) to generate combined alerts.

Issues related with STCA, marked by EUROCONTROL, are:

- STCA in TMA:
  - Margin error reduced: controller should be warned quickly
  - STCA must be tuned in adequate manner.
- RVSM should be considered to avoid nuisance alerts when the aircraft had been RVSM before but it isn't yet correlated
- Aircrafts with no altitude information
- CFL implementation.
- Traffic Collision Avoidance System / Airborne Collision Avoidance System (TCAS/ACAS) implementation and combined information with STCA.

Last point is not assumed to be completed in D01. It will be in step 2 of 10.4.3.

Aircraft Derived Data could be used, but using these data is not mandatory in this step.

10.10.3 works on CWP over Safety Nets.

Other points should be, at least in part, considered in this project.

SNS will manage tracks without altitude information, and it should be defined how it will be done. The same comment applies to the use of CFL.

Homogenize STCA in TMA has some task associated. By now the requirements are covering the use of several hypothesis and geometry defined in this airspace.

It should be defined the basis for the use of this hypothesis, the way to assess if non-linear extrapolation is valid or not, etc.

2.2 System Architecture

2.2.1 Environment

This paragraph specifies the system architecture of the ATM 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 subsystems.

The system context diagram is depicted in the following picture.

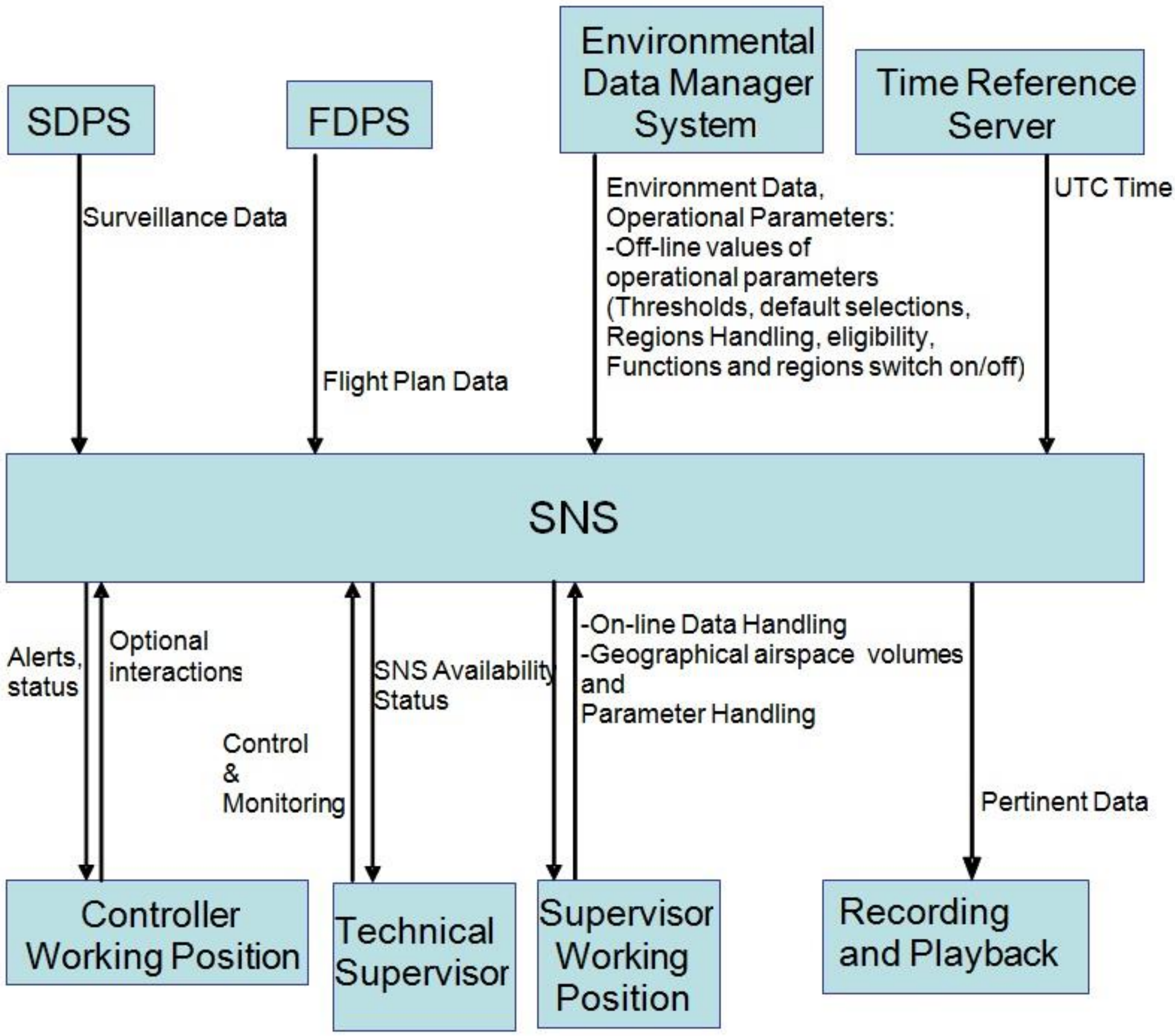

Figure 2 – Safety Nets Server context diagram

2.2.2 Subsystems

2.2.2.1 Surveillance Data Processing System

The Surveillance Data Processing System (SDPS) provides SNS with the following data elements:

- surveillance tracks,
- surveillance service status information, and
- SDPS 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 Surveillance Data Exchange (ASTERIX) protocol issued by EUROCONTROL.

2.2.2.2 Flight Data Processing System

The Flight Data Processing System (FDPS) provides SNS with the following data elements:

- flight plan data,
- route deviation alerts,
- FDPS 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.

2.2.2.3 Environmental Data Manager System

The Environmental Data Manager System (EDMS) provides SNS with the following data elements:

- environment data (e.g. coordinates of reference points),
- operational areas (e.g. prohibited, restricted and dangerous areas, control sectors, airport area),
- operational parameters (e.g. transition altitude).

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

2.2.2.4 Time Reference Server

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

- UTC time.

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

2.2.2.5 Controller Working Position

The Controller Working Position (CWP) provides SNS with the following data elements:

- actions on alerts.

SNS provides CWP with the following data elements:

- alerts,
- SNS availability status.

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

2.2.2.6 Supervisor Working Position

The Supervisor Working Position (SWP) provides SNS with the following data elements:

- Function switching, and
- Function and regions configuration.

SNS provides SWP with the following data elements:

- SNS availability status.

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

2.2.2.7 Recording and Replay System

SNS provides the Recording and Replay System with the following elements:

- all output data sending from SNS to others systems different from the recording system, 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.

2.3 System interfaces

The SNS is in charge of providing alerts to the controllers in dangerous or prohibited situations, in order to do that they exchange data with other systems.

The following tables describe the data exchange with external and internal ATM systems respectively.

External System	To External System	From External System
Controller	Alerts, SNS Availability Status	Interactions on the SNS (depending on ANSP policy)
Supervisor	SNS Availability Status	Function and Subfunction, Region and Filter activation/deactivation, and configuration
Time Reference Server		UTC Time

Table 2 – SNS external interfaces

Internal System	To Internal System	From Internal System
Multi Radar Tracker		Surveillance Data
Flight Data Processor		Flight Plan Data
Controller Working Position	- Alerts - SNS Availability Status	Interactions on the SNS (depending on ANSP policy / implementation level). Example of possible interactions: - Action / de activation of areas - Inhibition of alerts on given flights
Supervisor Working Position	SNS Availability Status	Function and Subfunction, Region and Filter activation/deactivation, On-line Data Handling -Geographical airspace volumes and Parameter Handling
Environment Data Manager		Environment Data, Operational Parameters: -Off-line values of operational parameters (Thresholds, default selections, Regions Handling, eligibility, Functions and regions switch on/off)

Technical Supervisor	SNS Availability Status	Control & Monitoring
Recording & Playback	Pertinent Data	

Table 3 – SNS internal interfaces

2.4 Functional requirements

The SNS function receives and processes multi sensor surveillance tracks, flight plan data and environmental data. The purpose of the SNS is to provide alerts to the controller in cases where the SNS detects or predicts that without the controller intervention, dangerous or even prohibited situations may occur.

The SNS is responsible for the following surveillance alerting functionalities:

- STCA (Short Term Conflict Alert) - This function determines all the possible surveillance track pairs for which the predicted minimum separation between the two tracks will be lower than the predefined authorised separation within a predefined conflict time interval.
- MSAW (Minimum Safe Altitude Warning) - This function informs the Responsible Controller if one aircraft is going to infringe one of the predefined MSAW areas within a predefined time interval.
- APM (Approach Path Monitoring) - This function informs the Responsible Controller if an aircraft is not going to follow the published approach path within a predefined time interval.
- APW (Area Proximity Warning) - This function informs the Responsible Controller if any aircraft is going to infringe one of fixed or temporary danger areas within a predefined time interval.

2.4.1 Input / output data

REQ - 10.04.03 - 001.00

The SNS shall receive surveillance tracks in ASTERIX CAT 062 format.

#

REQ - 10.04.03 - 002.00

The SNS shall be capable of handling up to a maximum number of surveillance tracks.

#

REQ - 10.04.03 - 003.00

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.

REQ - 10.04.03 - 004.00

The SNS shall receive the mode of operation of the parallel runways.

#

REQ - 10.04.03 - 005.00

The SNS shall distribute safety net alerts in ASTERIX CAT 004 format.

#

2.4.2 SNS common processing

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 two dimensions - horizontal and vertical, and can be linear (straight line) or incorporating some kind of manoeuvring in each dimension. Conditions as for which type of extrapolation to use in each case include the following factors: manoeuvring information included in the flight plan data 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 SDPS altitude tracking, and expressed as the items defined in ASTERIX CAT062. A general assumption regarding QNH correction - MSAW 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 an Secondary Surveillance Radar (SSR) code, mode S id, or a callsign inhibition group. 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).

2.4.2.1 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 2.4.2.2.

REQ - 10.04.03 - 006.00

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.

#

REQ - 10.04.03 - 007.00

The SNS region shall be associated to the set of parameters with the lowest priority.

#

REQ - 10.04.03 - 008.00

The SNS shall not use surveillance tracks located outside of the SNS region for its STCA processing.

#

2.4.2.2 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 have to be determined with regards to which SNS processing area's set of parameters to use.

REQ - 10.04.03 - 010.00

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.

#

REQ - 10.04.03 - 011.00

Each SNS processing area shall have assigned a set of parameters (offline defined in up to a maximum number of parameter groups).

#

REQ - 10.04.03 - 012.00

The SNS shall use less than a maximum number of SNS processing areas.

#

REQ - 10.04.03 - 013.00

All SNS processing areas shall be included within the SNS Region.

#

2.4.2.3 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 trajectories 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.

REQ - 10.04.03 - 014.00

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 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.

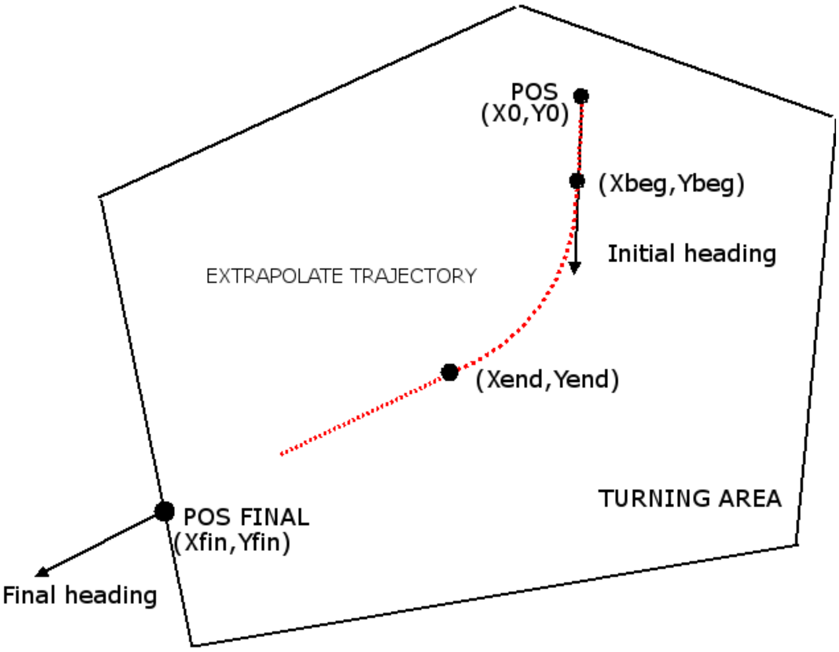

Figure 3 – Trajectory prediction inside a turning area

REQ - 10.04.03 - 015.00

The SNS shall use less than a maximum number of turning areas.

#

REQ - 10.04.03 - 016.00

A turning area definition shall have flags enabling the processing to be applied for climbing aircraft, descending aircraft or both.

#

REQ - 10.04.03 - 017.00

All turning areas shall be included within the SNS Region.

#

2.4.2.4 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 limitation (CFL), Standard Arrival Routes (STAR), Holding pattern in addition to the straight line or curved hypotheses, either due to tuning process or customer requirements.

REQ - 10.04.03 - 018.00

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 plan, the main hypothesis computation could be based on (non exhaustive list):

- Flight plan trajectory, or
- Aircraft Derived Data, or
- Holding pattern, or
- STAR.

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

- Flight plan trajectory, or
- Aircraft Derived Data, or
- Cleared Flight Level.

The aircraft derived data that could be used for trajectory prediction are:

- Trajectory intent data
- Selected Flight Level

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

2.4.2.5 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.

REQ - 10.04.03 - 019.00

The SNS shall handle a request to dynamically activate or deactivate a SNS processing area.

#

REQ - 10.04.03 - 021.00

The SNS shall handle a request to dynamically activate or deactivate a turning area.

#

2.4.3 Short Term Conflict Alert (STCA)

2.4.3.1 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 plans.

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.

2.4.3.2 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 2.4.2.

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.

The processing associated with these areas is defined in 2.4.3.4.1.

REQ - 10.04.03 - 023.00

The number of STCA inhibition areas shall be limited to a maximum value.

#

REQ - 10.04.03 - 024.00

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.

#

REQ - 10.04.03 - 025.00

All STCA inhibition areas shall be included within the SNS Region.

#

REQ - 10.04.03 - 026.00

The number of NOZ areas shall be limited to a maximum value.

#

REQ - 10.04.03 - 027.00

NOZ areas shall be defined as a volume using a given number of geodetic points in horizontal and an upper level in vertical.

#

REQ - 10.04.03 - 028.00

All NOZ areas shall be included within the SNS Region.

#

2.4.3.3 STCA processing

REQ - 10.04.03 - 029.00

The STCA processing shall be initiated at each surveillance track reception.

#

2.4.3.3.1 STCA parameters determination

REQ - 10.04.03 - 030.00

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.

#

REQ - 10.04.03 - 031.00

When a pair of surveillance tracks are located in different SNS processing areas, the set of parameters to be used shall be the one with the higher priority.

#

REQ - 10.04.03 - 032.00

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

REQ - 10.04.03 - 033.00

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:
  - 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
  - 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.

#

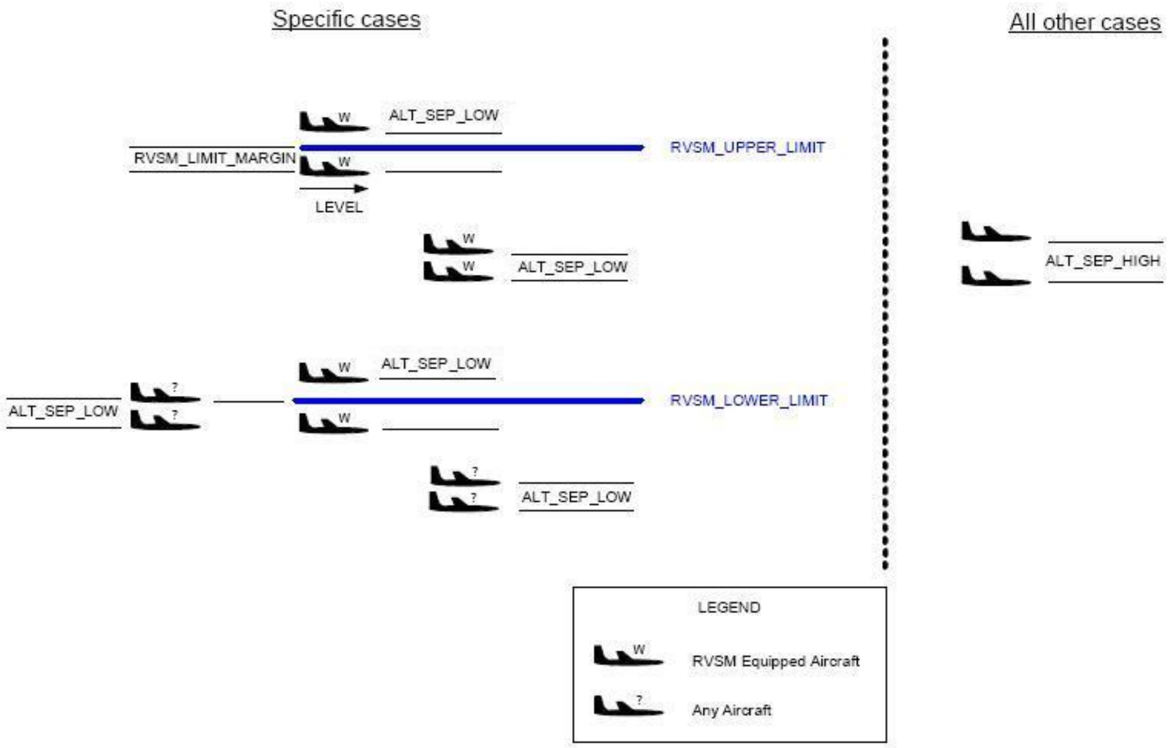

Figure 4 – Minimum vertical separation

2.4.3.3.2 STCA inhibited tracks

The SNS has to provide a capability to inhibit some tracks from raising a safety net alert. It could be online modifiable depending on local implementation.

This inhibition could be based for example on SSR code, callsign or mode S id.

REQ - 10.04.03 - 009.00

The SNS shall provide a capability to inhibit STCA alerts for some tracks. The criteria used to declare these track as 'STCA inhibited' will be offline adaptable.

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

#

2.4.3.3.3 STCA online modifications

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

REQ - 10.04.03 - 020.00

The SNS shall handle a request to dynamically activate or deactivate a STCA inhibition area.

#

REQ - 10.04.03 - 022.00

The SNS shall handle a request to dynamically change the criteria used to declare a track as 'STCA inhibited'.

#

2.4.3.3.4 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.

REQ - 10.04.03 - 034.00

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.

#

REQ - 10.04.03 - 035.00

A conflict shall be detected if:

- Both tracks have only one main hypothesis
  - A conflict situation is detected using main hypotheses and standard parameters
- Both tracks have one main and one backup hypothesis
  - 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

#

2.4.3.3.5 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)

REQ - 10.04.03 - 036.00

Conflict quality shall be determined using the number of conflict detection against the age of the conflict:

Q = nb detection / conflict age

#

REQ - 10.04.03 - 037.00

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 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”.

REQ - 10.04.03 - 038.00

The SNS shall manage a maximum number of STCA conflicts defined by a system capacity.

#

2.4.3.4 STCA output

2.4.3.4.1 Alert suppression

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 track are still inside the inhibition area, the genuine solved will never be distributed.

REQ - 10.04.03 - 039.00

STCA alerts shall be generated at:

- Each conflict detection, when the conflict status is actual, close, real or solved, or
- Each update period (SDPS cycle) if the conflict has not been detected in the last update period.

#

REQ - 10.04.03 - 040.00

The SNS shall provide an alive message at each update period (SDPS cycle).

#

REQ - 10.04.03 - 041.00

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.

#

REQ - 10.04.03 - 042.00

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.

#

REQ - 10.04.03 - 043.00

The SNS shall be able to replay its input recorded data for offline analysis purpose.

#

2.4.4 Minimum Safe Altitude Warning (MSAW)

This chapter will be completed in step 2 of the SESAR Concept Story Board.

2.4.4.1 MSAW geographical definition

2.4.4.2 MSAW processing

2.4.4.3 MSAW output

2.4.5 Area Proximity Warning (APW)

This chapter will be completed in step 2 of the SESAR Concept Story Board.

2.4.5.1 APW geographical definition

2.4.5.2 APW processing

2.4.5.3 APW output

2.4.6 Approach Path Monitoring (APM)

This chapter will be completed in step 2 of the SESAR Concept Story Board.

2.4.6.1 APM geographical definition

2.4.6.2 APM processing

2.4.6.3 APM output

2.5 System Capacities and 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

Definition	Value
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
The maximum number of STCA conflicts managed by the SNS at a given time.	200

Table 4 – SNS software parameters

3 Recommendations of Operational Product System

Some of the requirements in this preliminary 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 preliminary 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 2.4.3.3.2 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 preliminary definition report is that they have to be offline 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 STCA conflicts is reached (REQ - 10.04.03 - 038.00). This has also to be done during an implementation project.

4 References

[1] **SPIN** : EUROCONTROL Specification for Short Term Conflict Alert 1.1 19/05/2009

[2] PASS : Final report – Synthesis and Guidelines 1.1 17/11/2010

[3] **P10.4.3** 10.04.03-PIR-Part 1-00.01.04.doc 26/05/2010

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

Appendix A: Offline Parameters description

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

Identifier	Definition	Unit
System Parameters		
SDPSUpdatePeriod	SDPS update period	Seconds
SystemCenterLatitude	System centre latitude	Latitude
SystemCenterLongitude	System centre longitude	Longitude
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
WarningTime	Warning time	Seconds
ImminentTime	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
ConflictQualityThreshold	Threshold of quality under which conflict is not displayed	Integer
ConflictCounterThreshold	Conflict counter	Integer
ConflictMissThreshold	Number of successive loss of conflict for an already detected conflict	Integer

Identifier	Definition	Unit
STCA processing area parameters		
Name	STCA processing area name	String
ParameterGroup	STCA processing area parameter group ID	Integer
2D Area	Array of latitude and longitude describing the shape of the STCA processing area	Array of latitude / longitude
UpperLevel	STCA processing area upper bound	Feet/Flight level
LowerLevel	STCA processing area lower bound	Feet/Flight level
DefaultQNH	STCA processing area default QNH value	hPa
DefaultTransitionLevel	STCA processing area default transition level value	Feet/Flight level
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 5 – Safety nets server offline parameters

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