

**APPENDIX A**



**INTERNATIONAL CIVIL AVIATION ORGANIZATION**

**SOUTH AMERICAN REGIONAL OFFICE**

**SAFETY PLAN FOR ATS ROUTE NETWORK  
OPTIMISATION (ATSRO) IN THE SAM REGION**

Version 0.3

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## Executive Summary

1 At the request of the States and International Organizations, the ICAO regular programme in the South American Region has focused, amongst other implementation projects, on the implementation of the global plan initiatives and, particularly, on the optimisation of the airspace structure through the optimisation of the ATS route network (ATSRO) and the implementation of RNAV5.

2 As a result of the aforementioned planning, the ICAO South American (SAM) Regional Office, with the support of Regional Project RLA/06/901, scheduled a workshop for assessing the risks of the system before proceeding with the ATS Route Network Optimisation (ATSRO) in the SAM Region, in order to comply with the safety provisions of Annex 11 before introducing major changes in the aeronautical system structure.

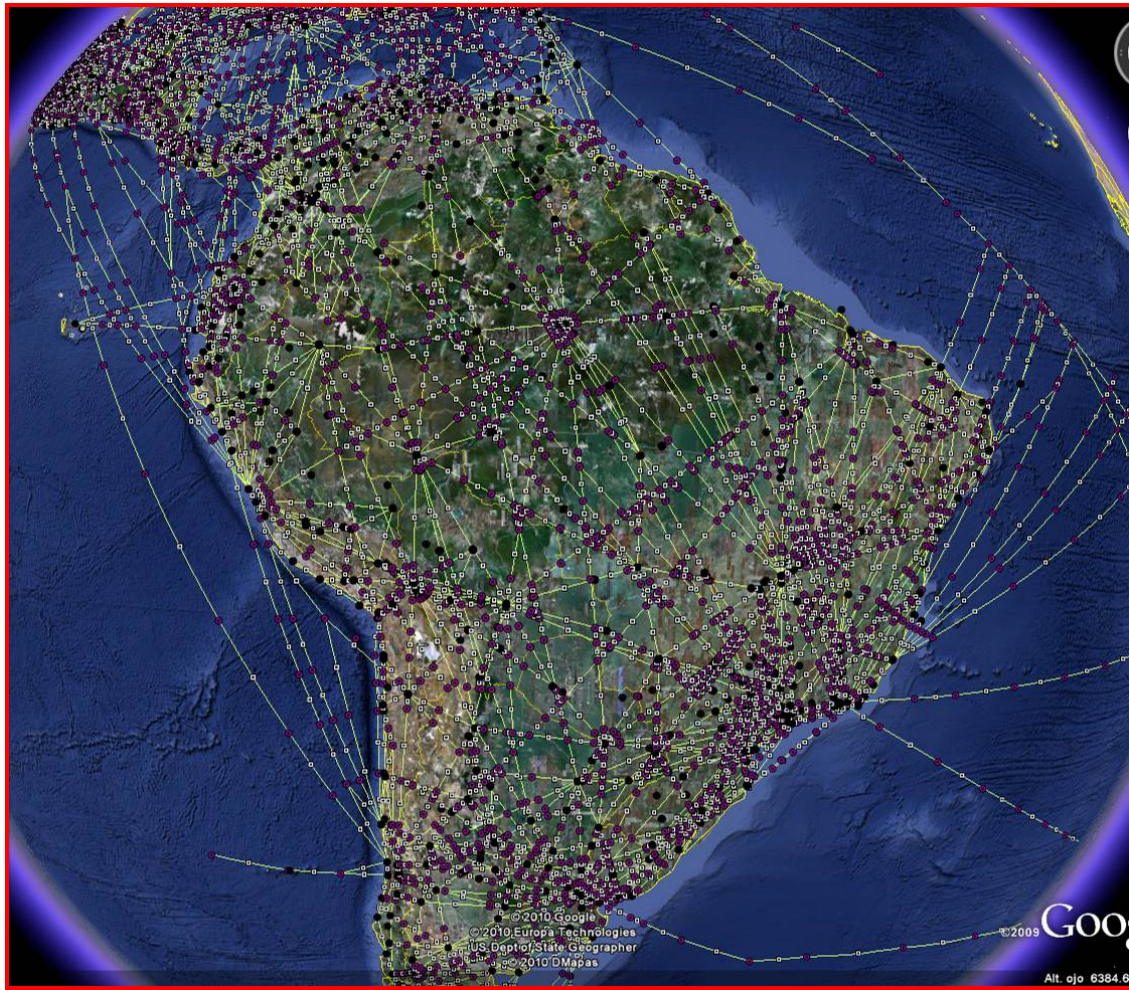
3 This workshop was attended by experts in the various areas of knowledge as well as by civil aviation authorities, air traffic service providers, pilots, operation and airworthiness inspectors, IATA and the CAR/SAM Regional Monitoring Agency (CARSAMMA). With the establishment of this group of experts, it was possible to identify the hazards that might affect or hinder optimisation, assess the consequences in terms of likelihood and severity, and the tolerability of operational risks, and defined the mitigation measures required to improve the resulting level of safety.

4 This multidisciplinary team applied the risk management methodology contained in the Safety Management Manual (Doc 9859) concerning Safety Management Systems (SMS). Accordingly, the operational risks identified were assessed, and the seven stages of the operational risk management process were applied to measure safety levels.

5 This safety study for ATSRO starts with a brief description of the system based on the planning defined for the SAM Region and on the ATS route network optimisation programme. The purpose of this study is to determine the feasibility of the aforementioned optimisation, based on a risk assessment, using the qualitative methodology described in Doc 9859 to ensure the safety of operations within this new scope of application in the SAM Region.

6 This study revealed that the level of risk related to the optimisation of the ATS route network is acceptable and permits the use of the current network and the introduction of modifications without affecting its normal operation, allowing for an orderly transition. Finally, it contains recommendations to the various stakeholders in the Region. In summary, ATSRO in the Region is feasible as shown by this study.

### SAM safety case scenario



## Chapter 1: Preamble

### 1.1 Objective

1.1.1 The purpose of this document is to make a qualitative assessment of the introduction of improvements to the ATS routes in the South American Region under the ATS Route Network Optimisation Programme (Version 1 of the ATS route network), based on a safety assessment following the guidelines established in the regional plan.

1.1.2 The implementation of Version 1 of the ATS route network requires the use of a standard methodology for the identification of hazards and the analysis of their consequences, thus permitting the management of operational risks in the optimisation of the route network (ATSRO). This assessment has been based on the provisions of the Safety Management Manual (Doc 9858).

1.1.3 Taking into account the diversity of scenarios in the SAM Region and the agreements reached at the various work meetings of the SAM implementation group, it was felt that this type of safety case study would be a complex task and should be supported by Regional Project RLA/06/901.

1.1.4 Airspace improvements contribute directly to the achievement of the following ICAO Strategic Objectives:

- **Safety** — *Enhance global civil aviation safety*
- **Environmental protection** — *Minimise the adverse effect of global civil aviation on the environment*
- **Efficiency** — *Enhance the efficiency of aviation operations*

### 1.2 Scope

1.2.1 The safety case study for ATSRO covers the whole SAM Region. The FIRs involved are the following: Antofagasta, Amazónica, Asunción, Barranquilla, Brasilia, Bogota, Comodoro Rivadavia, Córdoba, Curitiba, Ezeiza, Georgetown, Guayaquil, La Paz, Lima, Maiquetía, Mendoza, Montevideo, Panama, Paramaribo, Puerto Montt, Punta Arenas, Recife, Resistencia, Rochambeau and Santiago.

### 1.3 Background

1.3.1 During the CNS/ATM implementation process conducted by the States and the regional planning and implementation groups within the framework of the Global Air Navigation Plan for CNS/ATM Systems (Doc 9750), it was recognised that the technology was not an end in itself and that an integrated global ATM system concept, based on clearly established operational requirements, was needed. This concept, in turn, would serve as a basis for the coordinated implementation of CNS/ATM technologies, also based on clearly established requirements. In order to develop this concept, the ICAO Air Navigation Commission established the Air Traffic Management Operational Concept Panel (ATMCP).

1.3.2 In order to align global planning with the conclusions of the Eleventh Air Navigation Conference, mainly in relation to the Global ATM Operational Concept, as well as to the Industry Roadmap, ICAO began the development of the new Global Air Navigation Plan. In addition to including the Global ATM Operational Concept, the Global Air Navigation Plan focuses on a set of “Global Plan Initiatives (GPIs), providing the necessary conditions for the implementations aimed at attaining benefits for the ATM community in the near and medium term.

1.3.3 At the request of the States and International Organisations, the ICAO regular programme in the South American Region, amongst other implementation projects, has focused on the implementation of these global plan initiatives and, particularly, the optimisation of the airspace structure. In this sense, the meetings of the SAM Implementation Group (SAM/IG) are being held under the auspices of the new project RLA/06/901. One of the purposes of these meetings is the optimisation of the ATS route network (ATSRO) in the South American Region. The first two meetings of the SAM Implementation Group (SAM/IG/1 and SAM/IG/2) reviewed the current status of the route network, identifying several issues that made it difficult to attain the level of effectiveness sought through the optimisation, but which were being mitigated or eliminated, as applicable, through action taken by the SAM States and IATA.

1.3.4 The SAM States have seen the need to improve the airspace structure in order to create an inter-functional air traffic management system that is available to all users during all flight phases, and that meets the agreed safety levels, provides cost-effective operations, is environmentally sustainable and meets national security requirements.

1.3.5 In order to check if the implementation of Version 1 of the route network impaired safety, ICAO was asked to conduct a safety assessment to make sure that no elements that might affect safety were introduced. To that end, a seminar/workshop was held to identify hazards that might result from the implementation, and this document was subsequently prepared based on the information collected at that event.

## Chapter 2 Description of the Air Traffic System in the SAM Region

### 2.1 General status of the SAM ATS route system

2.1.1 The ATS route network is part of the structure and organisation of the airspace. SAM airspace is divided into upper and lower, with a vertical boundary at FL 250. This study is applicable to the ATS route network in the upper airspace.

2.1.2 In general, the development of the SAM route network was always based on the specific requirements of isolated routes, without a global analysis that would take into account the broader operational requirements, and seeking a functional interrelationship amongst the various elements of the airspace structure, such as: ATS routes, control sectors, control areas, TMAs and others.

2.1.3 The work carried out by the States, with the support of Regional Project RLA/98/003, resulted in the implementation of 77 RNAV routes, the modification of 58 route paths, and the elimination of only 7 routes. Although the work done took into account the operational requirements of airspace users, the addition of RNAV routes to the existing airspace structure in some cases resulted in an increased airspace complexity and thus a reduction of ATC capacity.

2.1.4 There is a close relationship between the route network structure and airspace sectorisation. This relationship must be taken into account even from the planning phase in order to endorse the feasibility of a sectorisation that provides optimum ATC capacity, including ATS delegation. When defining the type of route (unidirectional/bidirectional) and the direction of unidirectional routes, the need for enhanced sectorisation efficiency may be taken into account.

2.1.5 An important aspect has been civil-military coordination, which is essential to ensure route network efficiency. Currently, there is a certain level of coordination that needs to be improved in most of the Region. The concept of a flexible use of airspace (FUA), which is essential to meet the requirements of all airspace users, is not being applied.

2.1.6 Unidirectional routes are used in part of the Region. This is a limiting factor and, except for some few cases, there is no parallel route structure with sufficient spacing between route centre lines to facilitate traffic management and increase airspace capacity. In general terms, the longitudinal separation applied in FIR boundaries is 10 minutes.

2.1.7 Currently, the route network is based on conventional and RNAV routes, where performance-based navigation (PBN) is not yet being used. The implementation of RNAV 5 is expected for late 2010.

2.1.8 In the airspace under study, air traffic services that include route control, flight information and alert services are provided. There are ground/air communications throughout the upper airspace and, to a large extent, a surveillance system is also available. The navigation structure is still based on fixed radio aids (VOR, VOR/DME) but a high percentage of the fleet has autonomous navigation systems that allow them to fly on any desired flight path within the coverage of station-referenced navigation aids, or within the limits of autonomous aids, or a combination of both.

2.1.9 There is also an aeronautical meteorology and information service that meets the standards defined in the corresponding ICAO Annexes. Likewise, all the States of the Region provide search and rescue service.

2.1.10 In case of ATS system failure, there are contingency plans that have been duly agreed upon and harmonised among all the States in the Region. In case of a partial or total interruption of the ATS system and/or related support services, these contingency plans will ensure that air operations will not be interrupted and that the main international air routes will remain open, with due consideration to the agreed safety levels.

## 2.2 **Situation following the implementation of Version 1 of the ATS route network and RNAV 5**

2.2.1 The optimisation of the SAM route network is being carried out by stages in order to obtain the corresponding operational benefits as soon as possible. It was deemed advisable to consider RNAV 5 implementation as Phase 1, the beginning of the route network optimisation programme, taking into account that it is a concept that will facilitate optimisation. This implementation phase will be executed in keeping with the SAM PBN Implementation Programme approved by the SAM/IG/2 meeting and the PBN Roadmap approved by GREPECAS. Starting in Phase 2, the route network version concept will be incorporated, taking into account that airspace structure changes as air traffic movement grows, the shifting of air traffic demand from one Region or airport to another, available technologies, amongst other aspects (see **Appendix 1 to Chapter 2**).

2.2.2 It is expected that the implementation of Phases 1 and 2 of the ATS route network optimisation will promote the necessary conditions for the introduction of substantial improvements in subsequent optimisation phases, and will harmonise the criteria for the approval of aircraft and operators for operations in RNAV routes, while providing the necessary elements for an appropriate route spacing.

2.2.3 Isolated actions by States for the development of domestic ATS route networks must be limited to airspaces that strictly serve domestic purposes. Likewise, such actions normally have a direct and noticeable effect on traffic beyond the area of jurisdiction of the State involved.

2.2.4 The use of unidirectional routes will favour the improvement of airspace structure, which leads to an increase in ATC sector capacity. Most ATS routes will be established on a permanent basis. However, there are cases in which the implementation of temporary routes, based on the existence of special use airspaces (SUA), may permit airspace structure optimisation, either reducing traffic in the main routes or allowing aircraft to fly their most convenient profiles.

2.2.5 It is expected that, during the subsequent phases of the route network optimisation programme, a protected airspace and an appropriate spacing between adjacent ATS routes will be provided. This spacing between parallel centre lines in which PBN applies will depend on the type of RNAV or RNP specified by each State, or on regional agreements, and its application will be assessed according to Doc 9689, taking into account, *inter alia*, the available ATS surveillance capacity and air traffic controller workload.

## **Chapter 3: Hazard Identification Process for SAM ATS Route Network Optimisation (ATSRO)**

### 3.1 **Introduction**

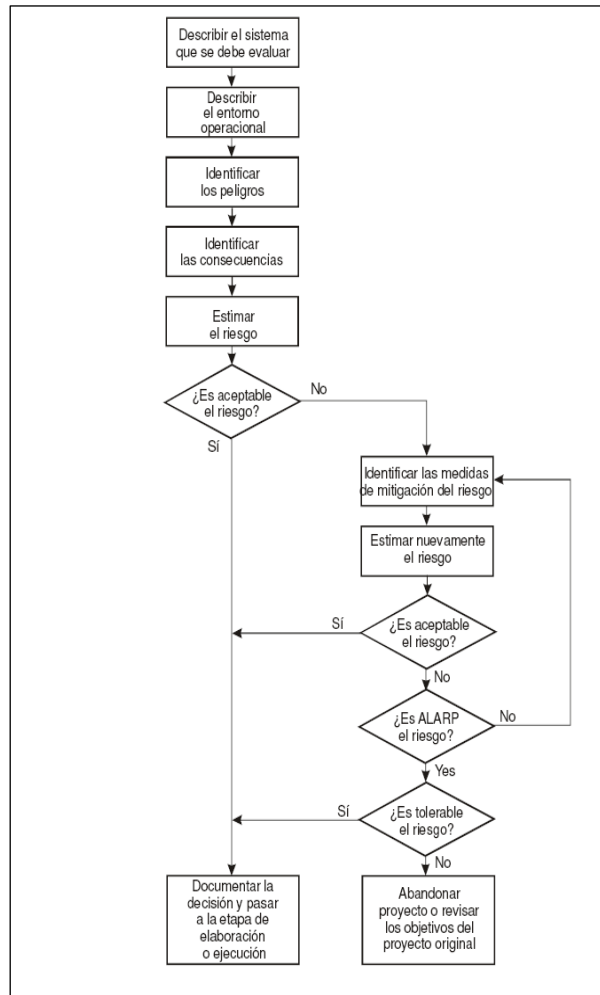
3.1.1 As seen in Chapter 1 of this document, and for the purpose of identifying hazards within the operational scope of ATSRO, a regional workshop (SAMRA/01) was scheduled with the participation of a multi-disciplinary group of experts, which are listed in **Appendix 1 to Chapter 3** of this document. This

multi-disciplinary group identified hazards and linked their consequences to ATSRO. This group of experts identified the hazards and their associated consequences, and determined their level of operational risk for the validation of ATSRO.

3.1.2 For purposes of the analysis in this chapter, hazards are defined as factors that could affect the acceptable level of safety (ALoS); for example, the modification or realignment of an airway and the optimisation of the regional route network, a new scenario involving generic hazards of a natural, technical or economic nature. The occurrence of a hazard generates consequences that affect all operational areas, such as: technical aspects, loss of separation, increase in the workload of services, and others. In the case of natural hazards defined as severe turbulence or volcanic ash, the consequences in terms of damage to aeroplane components will be immediate. Another aspect to consider is the degradation of communication systems, which affects the integrity of the ATM system. With a common understanding of the relationship between hazards and their consequences, we can move to the next stage, in which operational risks are managed, as explained in Chapter 4 of this document.

### 3.2 Analysis of the safety assessment process (hazard identification)

3.2.1 For the safety assessment process, it is advisable to divide it into seven stages or steps, following the guidelines contained in Doc 9859, SMM. The different activities are listed in chronological order, systematically ordering the actions that will permit the identification of hazards as follows:



Step 1:	Drafting (or obtention) of a full description of the system to be assessed and the environment in which the system will operate
Step 2:	Identification of hazards and their consequences
Step 3:	Risk assessment, expressed in terms of likelihood
Step 4:	Risk assessment, expressed in terms of severity
Step 5:	Risk index/tolerability
Step 6:	Risk mitigation
Step 7:	Drafting of the safety assessment documents

3.2.2 The diagram below shows the safety assessment process and the possible need to repeat the process cycle until finding a satisfactory method for the identification of hazards and associate their consequences.

3.2.3 The hazard identification process can only identify hazards within the scope of the described system. Therefore, the boundaries of the system must be sufficiently broad to encompass all possible system repercussions. It is particularly important for the description to include the relationship between the system being assessed and the larger system to which it belongs.

### Diagram illustrating the safety assessment process

3.2.4 The safety repercussions of a possible loss or degradation of the system will determine, in part, the characteristics of the operational environment in which the new scenario or implemented system will be integrated. Therefore, the description of such environment included all the factors that could have a significant effect on safety. These factors will vary from case to case and could include, for example, the specific characteristics of the air traffic system and other related factors.

3.2.5 The description of the regional system includes the contingency procedures and other non-ordinary operations, such as the various types of deficiencies or failures in communications or navigation aids.

3.2.6 The first step in the verification of the safety assessment process is a description of the system or proposed change. Although this was specified in the previous chapter, it is important to recall its systematic relationship, which permits a logical and methodical analytical process. The “system”, as defined for the safety assessment, will always be a sub-component of a larger global ATM system.

### 3.3 Hazard identification methodology for ATSRO implementation

3.3.1 Regarding the previous point, the group of experts attending the SAMRA workshop applied the methodology described in Doc 9859 (SMM) for the identification of hazards in a logical and sequential manner, and a more objective and systemic management or risks, in order to determine the technical feasibility of ATSRO in the SAM Region. **Appendix 2 to Chapter 3** contains the hazard identification and risk management form used for this purpose.

3.3.2 It should be noted that the hazard identification process was carried out in a multi-disciplinary and integrated manner in the Region. This analysis was conducted at the SAMRA/1 workshop. An attempt was made to identify all potential hazards through a series of sessions in which a structured approach was applied. The techniques used in the workshop followed a structured, multi-disciplinary approach that included the following aspects:

- a) Checklists. Review the experience and data available on accidents, incidents or similar systems, and prepare a hazard checklist. Aspects that present a possibility of risk will require a more in-depth assessment.
- b) During the sessions, the team was able to review the hazard checklists, generate ideas on hazards in a more broad and free manner, and analyse potential scenarios in detail. These sessions require individuals with diverse operational and technical experience, and generally follow a guided discussion format. At this SAMRA/1 workshop, a facilitator with knowledge of teamwork techniques was designated for the group sessions.
- c) Representatives accredited by each State of the Region, with knowledge of the relevant areas of the ATSRO project, participated in the workshop. The range of knowledge was broad to make sure that all the aspects of the ATSRO route system were addressed. However, it should also be noted that each team shared its operational experience, which facilitated a qualitative analysis.
- d) During this stage, work was done in plenary sessions, with the participation of all the participants of the workshop, who agreed to, and validated, each of the hazards and the associated consequences. This was recorded in a document for the “safety library” of the Region.

3.3.3 For the identification of hazards, all possible alternatives were analysed, from the least likely to the most likely scenario, duly considering the “worst” conditions or context. It is also important to note that the hazards identified by this team of experts had to be “credible” and consistent with the operational context and experience of all the participants.

3.3.4 An important point to note is that sometimes it is difficult to establish the difference between the worst-case scenario and one based on coincidence or assumptions, which should not be taken into account. To overcome this problem, the following criteria were applied:

- a) Worst-case scenario: The most unfavourable conditions are foreseen; for example, extremely high traffic levels, disturbance due to extreme weather conditions.
- b) Most likely or credible scenario: This assumes not exaggerating nor expecting a combination of extreme conditions during the operational life cycle of the system.
- c) This type of assessment should always analyse the most critical phase of flight in which the aircraft could be affected by failure of a system considered to be critical, although in general it was not necessary to assume that all failures would occur at the same time. However, the group identified all common or recurrent failures occurring when a single (trigger) event initiates a multiple cause and makes the system collapse.

3.3.5 Upon concluding its discussions, the SAMRA/1 workshop recorded the hazards, describing each of them, as agreed upon and validated by the group of experts. Likewise, it recorded their associated consequences, together with the assessment of their likelihood and severity. This activity permitted an objective risk management and the definition of the necessary mitigation measures, which will be later described. This list was updated whenever new hazards were identified and new scenarios emerged, which

called for an analysis of the required mitigation measures. All the background information gathered during the SAMRA workshop was recorded in the table that summarises the different plenary sessions, shown in **Appendix 1 to Chapter 4**, in relation to the hazards and risks identified during the workshop.

### 3.4 **Analysis of the consequences of hazards in ATSRO implementation**

3.4.1 Based on the hazards agreed upon and recorded and the associated consequences identified for each of them, the task of determining the severity of each of these consequences began. Once this information was approved, the workshop proceeded to the next stage, applying risk management in terms of the likelihood and severity of the events described, with a view to the classification of risks according to the Management Triangle, which will be described in detail in Chapter 4.

3.4.2 Although the assessment of the severity of the consequences will always imply some subjective judgment, well-structured and guided group discussions based on a standard risk classification (Doc 9859), with qualified participants with broad experience in their respective specialties should guarantee an objective and professional result. Once the severity of all the hazards identified was assessed, the results were recorded in the table of hazards, including the justification of the analysis, which appears in Appendix 1 to Chapter 4, referred to the identification of hazards and operational risks during the workshop. The Appendix contains the table summarising the hazards identified and their associated consequences, leading to the next stage, described in Chapter 4, involving the ATSRO safety assessment.

### 3.5 **Identification of hazards in ATSRO implementation**

3.5.1 During the hazard identification stage, all possible sources of system failure were analysed. Depending on the nature and size of the system analysed, the sources were as follows:

- a) Equipment (software and hardware);
- b) Operational environment (*e.g.*, physical conditions, airspace, route design);
- c) Human operators;
- d) Human-machine interface;
- e) Operational procedures;
- f) Maintenance procedures;
- g) External services; and
- h) Others

3.5.2 The experts participating at the 2010 SAMRA workshop followed this hazard identification process, applying the techniques defined in the theory of PhD. James Reason (Doc 9859) to determine the importance of latent or underlying conditions in the system, since latent conditions are not easily manifest and are only evident when an undesired event (accident) occurs. That is why this process seeks to answer questions such as: “how could the personnel misinterpret this procedure?” or “how could a qualified person misuse this new function or this new system (intentionally or not) within the scope of ATSRO?”

3.5.3 The validation and registration of the hazards identified were defined in plenary session and will be described more specifically later. The respective consequences were also assigned in order to proceed to the next stage, involving the assessment of the likelihood and severity and the subsequent adoption of the required mitigation measures. This registration process is a fundamental part of this document, since it summarises the actions assessed. It is also part of the safety assessment concept identified as the “*technical safety library*”, for future verification of the assumptions used in operational risk management, as specified in Doc 9858, SMM. This registry must be updated as new hazards are identified and new proposals are submitted in the Region, serving as a baseline for subsequent analyses. Figure 2 shows the safety information

flow and the safety library structure, as a validated registry for an efficient management of safety assessment methods.



Figure 2. Safety Library - Doc 9859, SMS

### 3.6 Description of the hazards analysed by the group of experts of SAMRA/1

3.6.1 Based on the hazards identified by the group of experts of the SAMRA/1 workshop, different *focus groups* activities were carried out to analyse and identify specific hazards that might affect route network optimisation, and to define the context of these hazards, whether technical, natural or economic. Likewise, the specific hazards were assigned to the different analytical scenarios. Subsequently, the consequences of each hazard were identified, and the results recorded in the table of hazards shown in Appendix 2 to Chapter 3.

3.6.2 In order to identify the hazards related to ATSRO implementation and facilitate the analysis, the hazards previously identified were classified according to the most frequent consequences, defined as recurrent events (number of repetitions). These were defined as: Airprox and Failures, due to the ATC or mechanical reasons, as listed below:

- a) Consequences related to **Airprox** hazards, of which a total of eight (8) similar events of this common component were identified, distributed as follows:
  - i) Inability of the aircraft to maintain the RNAV route
  - ii) Lack of coverage of ground and air navigation aids
  - iii) Degradation of systems, such as GNSS, surveillance and communications
  - iv) Incursion in restricted airspaces and RNAV routes
  - v) Civil/military coordination deficiencies
  - vi) Outdated aircraft database
  - vii) Deviations due to equipment failure or contingencies
  - viii) Increase in ATCO workload
  
- b) Consequences associated to a hazard resulting from an **operator or mechanical (engine) failure**, of which two (2) common events were identified, as follows:

- i) Deviations or route cancellations resulting from adverse meteorological conditions and/or engine failure resulting from volcanic ash.
- ii) Airspace sectorisation inadequate for ATSRO purposes

3.6.3 As to hazards of a specific type with a common criterion, the following were identified:

- a) By type of consequence related to the hazard due to **AIRPROX**:
  - i) Operation with an outdated aircraft database in the ATSRO route network of the SAM Region.
  - ii) Deviation due to equipment failure
  - iii) Deviation due to contingencies
  - iv) Inability of the aircraft to maintain the RNAV route
  - v) Degradation of systems defined as:
    - GNSS satellite navigation
    - Surveillance
    - Communications, such as CPDLC, VHF and HF
    - Incursion in restricted airspace and RNAV routes
- b) By type of consequence related to the hazard due to **Failure**:
  - i) Increased ATCO workload
  - ii) Volcanic ash

3.6.4 As to the classification according to the nature of the hazard, two types were identified: **technical** hazards, which are those related to the operation of the system, and **natural** hazards, defined as meteorological phenomena or others, as follows:

- a) **Technical type**
  - i) Inability of the aircraft to maintain the RNAV route
  - ii) Lack of coverage of ground and air navigation aids
  - iii) Degradation of systems such as GNSS, surveillance and communications
  - iv) Incursion in restricted airspaces and RNAV routes
  - v) Civil/military coordination deficiencies
  - vi) Outdated aircraft databases
  - vii) Deviations resulting from equipment failure or contingencies
  - viii) Increased ATCO workload
- b) **Natural type**
  - i) Adverse meteorological conditions (storms, hurricanes, turbulence, tornados)
  - ii) Volcanic eruptions

3.6.5 With respect to the definition of the consequences associated to the hazards, the group of experts of the SAMRA/1 workshop identified the following possible scenarios:

- a) Hazards derived from aircraft operations on ATS routes were divided into two large groups. The common denominator for **technical** hazards was the *operation of aircraft not certified* to operate on ATSRO routes. Another relevant aspect that was analysed was the *degradation of the capability to operate in the ATSRO route network*. The consequence of both hazards is:
  - i) AIRPROX
- b) In the case of **natural** hazards and their associated consequences, resulting from volcanic ash caused by unexpected eruptions and phenomena caused by solar storms that might affect global navigation systems, the following possible *sequelae* or results were identified:
  - i) Degradation of GNSS, surveillance and communication systems

### 3.7 **Conclusions of the identification of hazards and the analysis of consequences for ATSRO**

3.7.1 Based on the identification of the specific hazards described and their consequences, two constant factors are noted: the inability of aircraft to maintain RNAV, which generates **Airprox** events; and **failures** caused by both **ATC personnel**, which generate an **increased workload** in the system, and by **operator errors**. It is also important to highlight the effects of **nature**, which degrade the systems.

3.7.2 Once hazards have been defined, the risk management process may be started, as described in the next chapter.

## **Chapter 4: Operational risk management process for the implementation of the route network - ATSRO**

### **4.1 Introduction**

4.1.1 In this stage of the process, the background information defined in the previous chapter and by the group of experts of the SAMRA/1 workshop are analysed and compared. After validating this information, the methodology for determining operational risk levels described in the 7-step process is applied as required in the SMM. This stage of the analysis will depend on two variables defined as: the *likelihood* of occurrence of an event, and the worst-case scenario, known as the *severity* of an event. A qualitative analysis is conducted and, finally, operational risk matrices are used, determining what additional actions can be agreed by the group of experts and applied in order to minimise or effectively contain the operational risks in the ATS route network optimisation.

4.1.2 For purposes of standardising the concepts used, risk will be defined as the assessment of the consequences of a hazard (analysed in Chapter 3), expressed in terms of *likelihood* and *severity*. Accordingly, once the hazards and their associated consequences have been defined, based on a given value determined by the likelihood of occurrence of an event and its severity, the matrices defined in the SMM will be used, according to the following formula:

$$\text{Hazard – Consequences} = f [P * S ]$$

where:

**P**= likelihood

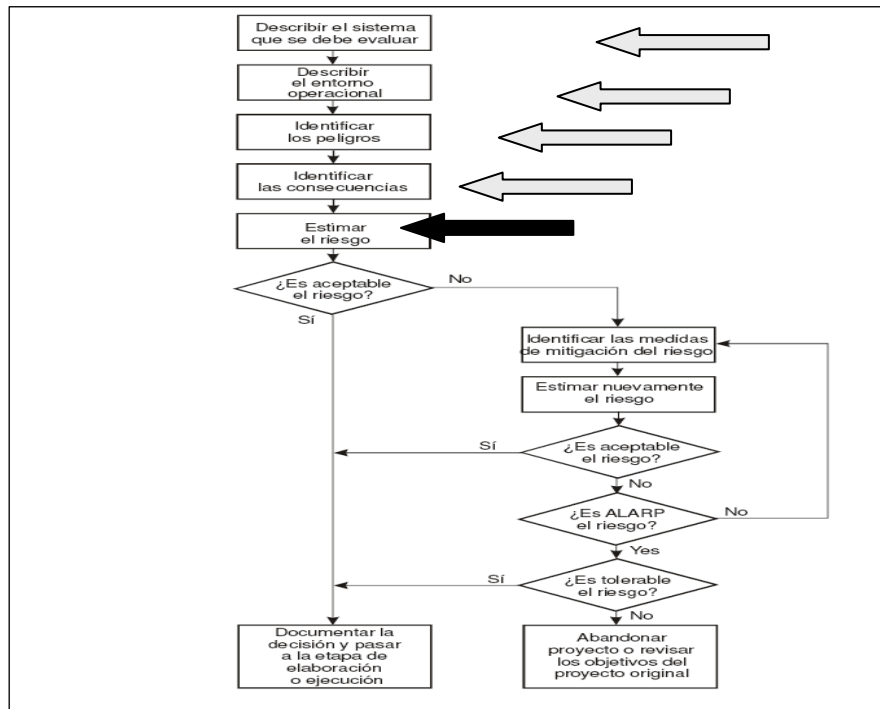
**S**= severity of an event

4.1.3 Accordingly, in this type of analysis, the following steps of the risk assessment process will be completed:

- 3<sup>rd</sup> step: Risk assessment, expressed in terms of **likelihood**
- 4<sup>th</sup> step: Risk assessment, expressed in terms of **severity**
- 5<sup>th</sup> step: Risk index/tolerability for ATSRO
- 6<sup>th</sup> step: Risk mitigation for ATSRO

4.1.4 In order to estimate the *likelihood* of occurrence of an event, an approach similar to the one adopted in the second step is applied. The likelihood will be specified by qualitative category, but certain numeric values will also be assigned, based on the reference matrices, to determine the likelihood related to each condition. Some of the events analysed in this study contained data that was used for direct numerical estimates of the likelihood of failure. For example, data available on component failure rates for several years with respect to system hardware components was relevant for SAM ATS route network flows.

4.1.5 The estimate of the likelihood of occurrence of hazardous events related to human errors will generally involve a degree of subjectiveness, and it should be borne in mind that, even when assessing hardware, there is always the possibility of failure due to human error like, for example, incorrect equipment maintenance procedures. However, as in the previous case, a better definition and assessment of severity is achieved through structured group discussions, with participants with ample experience in their respective specialties. Likewise, a standard risk classification and standard matrices should ensure a more objective, realistic, consensual result.



The graph above shows the analytical stage of Chapter 4

#### 4.2 Aspects taken into account for determining the likelihood of occurrence in ATSRO implementation

4.2.1 For this stage of the study, the matrix contained in the SMM and defined by ICAO as a global risk management analytical tool will be used, as shown below:

**Matrix for determining the likelihood of an event**

	<b>Significado</b>	<b>Valor</b>
<b>Frecuente</b>	Probable que ocurra muchas veces (ha ocurrido con frecuencia)	<b>5</b>
<b>Ocasional</b>	Probable que ocurra algunas veces (ha ocurrido infrecuentemente)	<b>4</b>
<b>Remoto</b>	Improbable, pero posible que ocurra (ha ocurrido raramente)	<b>3</b>
<b>Improbable</b>	Muy improbable que ocurra (no se sabe que haya ocurrido)	<b>2</b>
<b>Extremadamente Improbable</b>	Casi inconcebible que el suceso ocurra	<b>1</b>

4.2.2 Another aspect that must be included in this discussion is the origin of the various values defined for this quantitative analysis. This matrix is based on operational experience worldwide and on the likelihood defined for each occurrence as follows:

- Frequent: 1 to  $10^{-3}$  per hour of flight
- Occasional:  $10^{-3}$  to  $10^{-5}$  per hour of flight
- Remote:  $10^{-5}$  to  $10^{-7}$  per hour of flight
- Unlikely:  $10^{-7}$  to  $10^{-9}$  per hour of flight
- Extremely unlikely:  $+ 10^{-9}$  per hour of flight

4.2.3 The analysis of the hazards identified in the previous chapter showed, with respect to the associated consequences, a similar indicator with a value of “**Occasional**” or **4**. This group of elements was assigned the highest likelihood according to their consequences, as analysed and identified according to the following distribution:

- **Three (3) due to Airprox** (technical type)
- **One (1) due to engine failure** (natural type)

**Occasional, equivalent to a value of “4”**

	<b>Significado</b>	<b>Valor</b>
<b>Frecuente</b>	Probable que ocurra muchas veces (ha ocurrido con frecuencia)	<b>5</b>
<b>Ocasional</b>	Probable que ocurra algunas veces (ha ocurrido infrecuentemente)	<b>4</b>
<b>Remoto</b>	Improbable, pero posible que ocurra (ha ocurrido raramente)	<b>3</b>

4.2.4 All the components of the specific hazards identified were the result of an **outdated database**, deviations due to **equipment failure**, deviations due to **contingencies** and/or the effect of **volcanic ash** or adverse meteorological conditions. This group of hazards had a likelihood of occurrence of **4 (four)**, which, according to the likelihood matrix, translates into effects that occur some times or that have occurred infrequently in the SAM Region.

4.2.5 Regarding the previous analysis and based on the defences existing in this scenario at the time of conducting this analysis, the following defences existed for this scenario: use of the WGS-84 ge-reference system, ATS surveillance services, AIS systems, use of collision avoidance systems (ACAS/TCAS), application of continuous oversight principles, panel meetings (GREPECAS 12/7), safety assessments, previous instructions in the MET/ PIB and ATM areas, application of operations manuals, cancellation of operations on routes affected by meteorological problems, application of the procedures of Doc 4444, publication of NOTAMs, and use of contingency procedures. All of the aforementioned actions seek to contain or minimise the likelihood of risks existing at the time of the analysis.

4.2.6 The group of consequences associated to technical (6) and natural (1) hazards resulted in a likelihood lower than the one previously described, and was assigned an indicator of **3 (three)**, which, according to the matrix, means a **“remote”** likelihood, which is equivalent to **unlikely**. However, it may occur or has rarely occurred in the ATS system. Consequently, the risk assigned to this set of hazards was lower compared to the previous one. The consequences thus identified and analysed showed the following distribution:

- **Six (6) due to Airprox** (technical type)
- **One (1) due to engine failure** (natural type)

**Remote, equivalent to a value of “3”**

	Significado	Valor
<b>Frecuente</b>	Probable que ocurra muchas veces (ha ocurrido con frecuencia)	<b>5</b>
<b>Ocasional</b>	Probable que ocurra algunas veces (ha ocurrido infrecuentemente)	<b>4</b>
<b>Remoto</b>	Improbable, pero posible que ocurra (ha ocurrido raramente)	<b>3</b>

4.2.7 With the **application of the defences existing** in this system, the likelihood was determined by comparing the existing protections in the system, *i.e.*, failure reversal procedures, navigation charts, oversight systems, publication of the AIP, airborne collision avoidance systems (ACAS), autonomous navigation systems (INS/IRS), satellite navigation systems (GNSS), specific contingencies for each natural event (volcanic ash and turbulence), as well as the air crew notification system or NOTAMs. Publication of national documentation based on documents such as Doc. 9613, Doc. 4444 and Annexes 2 and 11.

4.2.8 With respect to the analysis of the hazard resulting from **civil-military coordination failures** between control centres, the panel defined the **incursion in restricted airspaces** in RNAV routes as a specific hazard within the scope of ATSRO, with the consequence of a potential loss of separation or **Airprox**. Based on this, the hazard due to **coordination failures** was considered as **“Remote”**, which, according to the

likelihood matrix, corresponds to a value of “3”, that is unlikely to occur, but may occur or has rarely occurred in the ATS system.

**Remote, equivalent to a value of “3”**

	Significado	Valor
<b>Frecuente</b>	Probable que ocurra muchas veces (ha ocurrido con frecuencia)	5
<b>Ocasional</b>	Probable que ocurra algunas veces (ha ocurrido infrecuentemente)	4
<b>Remoto</b>	Improbable, pero posible que ocurra (ha ocurrido raramente)	3

4.2.9 The analysis of the existing defences in the system showed that it had the appropriate regulations, publication of restricted areas, NOTAMs, AIP, ATC services, ATS surveillance, collision avoidance systems (ACAS), coordination between control centres and the respective FIRs, and letters of operational agreement (LOAs). Consequently, the likelihood of occurrence of an event was considered as “**remote**”. However, the panel highlighted that this item was a latent condition for all control areas in the SAM Region.

**4.3 Aspects taken into account for determining the severity in ATSRO implementation**

4.3.1 It should be noted that this severity analysis completes the fourth step in the operational risk assessment process, based on which the likelihood of an event and its relationship with the severity can be determined. This is the essence of operational risk management.

4.3.2 It is important to point out that, once the severity of an event is determined in general terms, it is difficult to change its value. For example, in the case of a severity classified as “**A**” (catastrophic), even if multiple defences are implemented to reduce the severity to a level “**B**” (hazardous), it is very difficult that it will occur. Thus, reality and operational experience show that it is easier to modify the likelihood of an event, since a series of actions will be required that will normally depend on the availability of resources. In this stage, all hazards and consequences identified in the preceding chapters are analysed to determine the worst-case scenario, and based on that, identify the defences to foster a more robust scenario that is tolerant to operational errors.

4.3.3 In order to determine this important function in operational risk management, the matrix defined in the SMM and shown below will be used:

<b>Severity Matrix</b>		
<b>Severity of the event</b>	<b>Meaning</b>	<b>Value</b>
Catastrophic	Destruction of equipment Multiple deaths	<b>A</b>
Hazardous	Significant reduction of safety margins, physical damage or workload that prevents operators from performing their tasks in a precise and complete manner Serious injury Major damage to equipment	<b>B</b>
Major	Significant reduction of safety margins, reduced ability of the operator to respond to adverse operating conditions as a result of an increased workload or conditions that hinder efficiency Serious incident Injury to individuals	<b>C</b>
Minor	Interference Operational limitations Use of emergency procedures Minor incidents	<b>D</b>
Insignificant	Mild consequences	<b>E</b>

4.3.4 Although the assessment of the severity of the consequences of a hazard will always have some degree of subjectiveness, this is offset by discussions in duly qualified and multidisciplinary groups. With the participation of professionals in each area concerned, as was done in the SAMRA/1 workshop, the result will be a consistent and objective professional opinion for the definition the actions required for risk mitigation.

4.3.5 According to the risk assessment process, once the **severity** assessment of all the consequences of the hazards identified has been completed and the results classified, they must be recorded in the hazard and risk table. Regarding this activity, a brief description of the arguments used to define the worst-case scenario is provided, together with the justification of the severity classification by the work teams.

4.3.6 Based on the analysis of the **severity assigned** to each hazard, eleven (11) hazards were identified by the SAMRA/1 workshop, 10 of which are in the “**Major**”, or “**C**” category. According to the severity matrix, this means a significant reduction of safety margins, a reduced capability of the operator, a response to adverse operating conditions resulting from increased workload or conditions that impair efficiency, personal injuries, or the occurrence of a serious incident. Based on this, most of the hazards in ATSSRO implementation were assigned a value of “**C**”, as shown in the figure below.

Severity is defined as “Major” or “C”

Gravedad del suceso	Significado	Valor
<b>Catastrófico</b>	<ul style="list-style-type: none"> <li>— Destrucción de equipo</li> <li>— Muertes múltiples</li> </ul>	<b>A</b>
<b>Peligroso</b>	<ul style="list-style-type: none"> <li>— Reducción importante de los márgenes de seguridad, daño físico o una carga de trabajo tal que los operarios no pueden desempeñar sus tareas en forma precisa y completa</li> <li>— Lesiones graves</li> <li>— Daños mayores al equipo</li> </ul>	<b>B</b>
<b>Mayor</b>	<ul style="list-style-type: none"> <li>— Reducción significativa de los márgenes de seguridad, reducción en la habilidad del operador en responder a condiciones operacionales adversas como resultado del incremento de la carga de trabajo, o como resultado de condiciones que impiden su eficiencia</li> <li>— Incidente grave</li> <li>— Lesiones a las personas</li> </ul>	<b>C</b>

4.3.7 The hazard entitled “**Inadequate airspace sectorisation for ATSRO**” was assigned a value “**D**” or “**Minor**”, being the only one assigned this severity classification by the group of experts. This is related to the severity of the event, which, based on operational experience, is considered as an event with minor consequences, causing operational interference and limitations, and calls for emergency or contingency procedures, as applicable. It is important to highlight that, of all the hazards analysed, this was the only one classified as “**Minor**”, setting a difference with respect to the rest of the sample analysed.

Severity is defined as “Major” or “D”

Gravedad del suceso	Significado	Valor
<b>Catastrófico</b>	<ul style="list-style-type: none"> <li>— Destrucción de equipo</li> <li>— Muertes múltiples</li> </ul>	<b>A</b>
<b>Peligroso</b>	<ul style="list-style-type: none"> <li>— Reducción importante de los márgenes de seguridad, daño físico o una carga de trabajo tal que los operarios no pueden desempeñar sus tareas en forma precisa y completa</li> <li>— Lesiones graves</li> <li>— Daños mayores al equipo</li> </ul>	<b>B</b>
<b>Mayor</b>	<ul style="list-style-type: none"> <li>— Reducción significativa de los márgenes de seguridad, reducción en la habilidad del operador en responder a condiciones operacionales adversas como resultado del incremento de la carga de trabajo, o como resultado de condiciones que impiden su eficiencia</li> <li>— Incidente grave</li> <li>— Lesiones a las personas</li> </ul>	<b>C</b>
<b>Menor</b>	<ul style="list-style-type: none"> <li>— Interferencia</li> <li>— Limitaciones operacionales</li> <li>— Uso de procedimientos de emergencia</li> <li>— Incidentes menores</li> </ul>	<b>D</b>

4.3.8 For the consequences associated to hazards classified as **Airprox**, this category had the largest number of events, with a total of nine (9), all of which were classified as “**C**” or “**Major**”. In the operational setting, this means a significant reduction in safety margins, a reduced capability of the operator, and a response to adverse operating conditions as a result of increased workload or conditions that impair efficiency, personal injuries, or the occurrence of a serious incident.

**Severity is defined as “Major” or “C”**

Gravedad del suceso	Significado	Valor
<b>Catastrófico</b>	<ul style="list-style-type: none"><li>— Destrucción de equipo</li><li>— Muertes múltiples</li></ul>	<b>A</b>
<b>Peligroso</b>	<ul style="list-style-type: none"><li>— Reducción importante de los márgenes de seguridad, daño físico o una carga de trabajo tal que los operarios no pueden desempeñar sus tareas en forma precisa y completa</li><li>— Lesiones graves</li><li>— Daños mayores al equipo</li></ul>	<b>B</b>
<b>Mayor</b>	<ul style="list-style-type: none"><li>— Reducción significativa de los márgenes de seguridad, reducción en la habilidad del operador en responder a condiciones operacionales adversas como resultado del incremento de la carga de trabajo, o como resultado de condiciones que impiden su eficiencia</li><li>— Incidente grave</li><li>— Lesiones a las personas</li></ul>	<b>C</b>

4.3.9 For hazards resulting from **operator** or **mechanical failures**, this sample analysed three (3), which, like in the previous case, were classified as “**Major**”.

4.3.10 According to operational experience, the lack of **civil-military coordination** had caused the incursion of unauthorised aircraft in the route network of the Region. This activity causes **Airprox** events, and was considered a relevant aspect that needed an in-depth analysis at a regional level in order to establish clear criteria for reducing the impact of this type of failures.

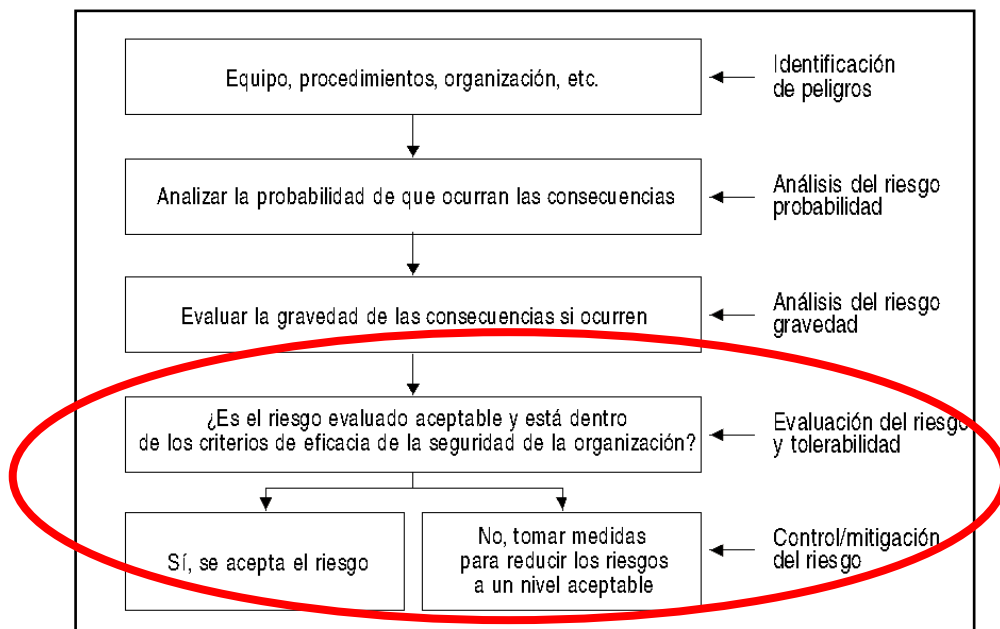
4.3.11 Another important topic that was analysed was the operation with unmanned aircraft of the UAV type. Two States expressed their concern about the increase in the number of operations of this type, which are conducted without the proper coordination with the control centres involved in the Region. The experts also identified as a potential hazard the capacity of these devices to fly and operate above level 290. Therefore, this new scenario can be classified as a potential hazard for ATSR0 implementation and can cause serious injuries and major damage to the equipment. Based on the severity matrix, it was assigned a value of “**C**” or “**Major**”. Finally, UAV operations are increasingly a more likely scenario in the SAM Region, thus tangentially affecting ATSR0 implementation. Therefore, they must be considered in the planning.

## Chapter 5 Operational risk assessment and mitigation for ATSRO

### 5.1 Introduction

5.1.1 As noted in the previous chapters, the potential hazards have been identified and associated to their respective consequences. In this stage of the process, operational risk levels will be determined, defining their acceptability, based on a comparison of the various criteria specified in the matrices, in order to measure the level of risk and assign their respective tolerability index based on the defences applied. In sum, the general concept of this document has been to reduce the operational risk to an acceptable level (ALoS), keeping it realistic and consistent with our potential development. This phase of the study is shown in the figure below.

Analytical Phase of Chapter 5



### 5.2 Operational risk mitigation criteria

5.2.1 The acceptability of a risk will depend on the defences analysed in the proposed scenario. In the case of the ATS route network optimisation, the defences existing in the SAM Region were identified and then the acceptability criteria were applied from a two-dimensional perspective. Acceptability is generally based on the severity matrix of an event and the likelihood of its occurrence. This analysis was based on the SMM manual, using as a reference CAP 670, ATS service requirements, the United Kingdom CAA requirements, adjusted to the operational reality of the SAM Region with respect to risk classification.

5.2.2 In relation to the tolerable risk concept, there is an area between the acceptable risk and the unacceptable risk in which the decision as to the acceptability is not clear or determinant. These latter risks belong to a category in which risk may be tolerable if reduced to a level as low as reasonably practicable (ALARP). When a risk is classified as ALARP, an attempt should always be made to implement mitigation measures (defined as additional defences) that are deemed feasible for the SAM Region. In the case of risks that fall in the intermediate area of the management triangle (shown in the figure below), they are defined as

acceptable, based on risk mitigation. These risk levels may require a decision by management. Risks in this category are not classified rashly as tolerable. Each case must be examined individually, as stated in the previous chapters, taking into account the benefits and costs derived from the implementation of the proposed changes.

**Table of Operational Risk Mitigation Criteria**

Criterios sugeridos	Índice de evaluación del riesgo	Criterios sugeridos
Región no tolerable	<b>5A, 5B, 5C, 4A, 4B, 3A</b>	Inaceptable bajo las circunstancias existentes
Región tolerable	<b>5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C</b>	Aceptable en base a mitigación del riesgo. Puede requerir una decisión de la dirección.
Región aceptable	<b>3E, 2D, 2E, 1A, 1B ,1C, 1D, 1E</b>	Aceptable

5.2.3 The identification of the appropriate risk mitigation measures requires a good understanding of the hazards identified in Chapters 3 and 4 in relation to the factors that contribute to the occurrence of an event of these characteristics, since any effective mechanism for reducing the risk will have to modify one or more of these factors in order to achieve a reduction to an acceptable level or ALoS.

5.2.4 In this particular case of safety assessment, the following possible measures to mitigate the operational risks and apply a mature ALoS have been studied:

- a) Revision of the system design;
- b) Modification of operational procedures;
- c) Organisational changes;
- d) Training of personnel in the SAM Region; and
- e) Use of information and communication technologies.

### 5.3 Description of operational risk management for ATSRO in the SAM Region

5.3.1 Based on the analyses conducted in the previous chapters and the background information and conclusions of the SAMRA/1 workshop, in this stage of the process, operational risk management will be applied and the proposed scenario for the Region will be analysed.

5.3.2 In order to facilitate the analysis, three different groups have been established, based on the likelihood of occurrence ordered from “major” (4) to “minor” (2), explaining the defences required to manage risks at an acceptable level. The summary of the indices identified for a hazard and the respective mitigating measures based on additional actions is shown below:

a) **For technical failures**

Hazards classified as technical failures have been defined as:

- Outdated databases
  - ACC-to-ACC coordination failures
  - Equipment failures and contingencies
  - Inability of aircraft to maintain the RNAV route
  - Lack of coverage of ground and air navigation aids
  - Degradation of systems such as GNSS, surveillance and communications
  - Incursion in restricted airspaces and RNAV routes
  - Deficiencies in civil-military coordination
  - Outdated aircraft databases
- The consequences associated to these hazards were:
    - Airprox
    - Operator and mechanical failures
  - The risk management criterion was:
    - **4**, equivalent to an “**occasional**” likelihood
    - **C**, equivalent to a “**major**” severity
  - The combination of hazard **likelihood** and **severity** is equivalent to:
    - **4 C**, which means acceptable, based on risk mitigation; may require a decision by management.

b) **For the operation of aircraft in ATSRO**

Natural hazards have been defined as:

- Volcanic ash
  - Meteorological effects
- The consequences associated to these hazards were:
    - Airprox
    - Operator or mechanical failure
  - The risk management criterion was:
    - **4**, equivalent to an “**occasional**” likelihood
    - **C**, equivalent to a “**major**” severity

- The combination of hazard **likelihood** and **severity** is equivalent to:
    - **4 C**, which means acceptable, based on risk mitigation; may require a decision by management.
- c) **Regarding civil-military coordination**
- Hazards due to lack of coordination have been defined as:
- Inadequate airspace sectorisation for ATSRO
- The consequence associated to these hazards was:
    - Increased ATCO workload
  - The risk management criterion was:
    - **3**, equivalent to a “**Remote**” likelihood
    - **C**, equivalent to a “**Major**” severity
  - The combination of hazard **likelihood** and **severity** is equivalent to:
    - **3 C**, which means acceptable, based on risk mitigation; may require a decision by management

**Safety Risk Assessment Matrix**

Probabilidad del riesgo	Gravedad del riesgo				
	Catastrófico A	Peligroso B	Mayor C	Menor D	Insignificante E
Frecuente 5	<b>5A</b>	<b>5B</b>	<b>5C</b>	<b>5D</b>	<b>5E</b>
Ocasional 4	<b>4A</b>	<b>4B</b>	<b>4C</b>	<b>4D</b>	<b>4E</b>
Remoto 3	<b>3A</b>	<b>3B</b>	<b>3C</b>	<b>3D</b>	<b>3E</b>
Improbable 2	<b>2A</b>	<b>2B</b>	<b>2C</b>	<b>2D</b>	<b>2E</b>
Extremadamente improbable 1	<b>1A</b>	<b>1B</b>	<b>1C</b>	<b>1D</b>	<b>1E</b>

5.3.3 Based on the identification and detailed description of hazards, and on the assignment of operational risks defined in the previous paragraphs, it is possible to assess and determine the feasibility of ATSRO implementation in the SAM Region. Furthermore, based on the risk matrix indices shown above, it

is possible to create an overall risk map and study the various alternatives (additional defences) to minimise or mitigate risks in ATSRO.

5.3.4 Based on the above, it may be stated that the resulting average level is “**Occasional**”, which is equivalent to “**4**”, with an average value of 4C for the combination defined as the worst-case scenario. Therefore, the operation in an optimised ATS route network is acceptable, based on risk mitigation, and it will eventually require a decision by management. Based on the application of defences to reduce the risk and the resulting index, the operational risk level achieved through the application of the various mitigation measures can be reduced to a value of **2 C**, which means **acceptable based on risk mitigation**, and which might require a decision by management.

5.3.5 The additional actions required within the operational context of the SAM Region will be explained below. These include technological measures, regulatory action or changes, training and continuous supervision of personnel. To this end, the following actions for the efficient implementation of ATSRO in the SAM Region are proposed.

5.3.6 The strategies aimed at mitigating the operational risks of **technical hazards**, such as the degradation of navigation capability, are as follows:

a) **Technical hazards**, with their *Airprox consequence*:

- Outdated databases
- Failures in ACC-to-ACC coordination
- Equipment failure and contingencies
- Inability of the aircraft to maintain the RNAV route
- Lack of coverage of ground and air navigation aids
- Degradation of systems such as GNSS, surveillance and communications
- Incursion in restricted airspaces and RNAV routes
- Deficiencies in civil-military coordination
- Effect of deviations due to solar storms
- Outdated aircraft databases
- 

**Additional defences**

- In the **technological** field
  - Accessibility and availability of the SAM data bank
  - Data exchange through the Internet
  - Data link
  - Implementation of ICT solutions
  - Anonymous on-line reporting system
  - Real-time monitoring
  - RAIM monitoring and alerts
  - Implementation of the digital voice data recording and monitoring programme
- In the **regulatory** field
  - Publication of ATSRO manuals and procedures
  - Establish effective FPL control procedures
  - Operational approval of non-approved aircraft to operate in ATSRO
  - Contingency procedures

- Implement and certify ISO: 9001:2008 QMS quality management programmes in MET/AIS
- Use of lateral deviation forms
- Define the alternate routes by area of operation
- Publish in the AIPs the areas with no navaid coverage
- In the **training** field
  - Updating of training programmes
  - Continuous SMS training for service providers
  - Training of service providers in the role of SSP
  - Holding of NOSS seminars/workshops
- In the **supervision** (continuous oversight) field
  - Define the control of the FPL oversight programme
  - Establish compliance of USOAP non-conformities

5.3.7 Consequently, risk management indices vary from an initial risk level of **4C to a level of 2C** and the likelihood of occurrence drops.

- **Entities responsible for this action:** SAM States  
ANSPs  
CARSAMMA

5.3.8 Strategies to mitigate the operational risks related to natural hazards:

- a) **Meteorological effects and volcanic eruptions on ATSRO routes, with the consequences of Airprox and system degradation:**

**Additional defences**

- In the **technological** field
  - Satellite observation
  - Determine ATC sector/ATFM capacity
  - Satellite observation alerts
  - Information *via* data link
- In the **regulatory** field
  - Publication of ASHTAMs
  - Determine ATC sector/ATFM capacity
  - Air traffic re-planning procedures
  - Certify the ISO: 9001:2008 QMS quality management programmes in MET/AIS
- In the **training** field
  - Training for continuous implementation of contingency procedures
  - Determine ATC sector/ATFM capacity
  - Air traffic re-planning procedures

- SMS training
- In the **supervision** (continuous oversight) field
  - Implement oversight services
  - Implement SSP
  - Verify the publication of alert NOTAMs
- Risk management varies from an initial risk level of 3 C to a risk level of 2C; the severity drops as a result of the additional actions.
- **Responsible entities:** ACCs of the SAM States, operators, ANSPs

5.3.9 Strategies for mitigating the operational risks due to hazards related to civil-military coordination:

a) Civil-military coordination failures that affect ATSRO, resulting in Airprox:

**Additional defences**

- In the **technological** field
  - Updating of chart displays
  - NOTAM data bank
  - Integration of data link technologies
  - Implementation of the regional data bank
  - Use of fast simulation
  - Implementaion of level “D” simulation
  - Determine ATC sector capacity
- In the **regulatory** field
  - Updated and applicable publications
  - Publication of committees
  - ACC-to-ACC coordination regulations
  - Civil-military memorandum of agreement
  - Civil-military coordination (LOAs)
  - Specific contingency procedures for this phenomenon
  - Contingency procedures
  - Air traffic re-planning procedures
  - Publication of alert NOTAMs
- In the **training** field
  - Training of ATCOs, pilots and civil-military managers
  - Seminar/workshop on civil-military coordination of Airprox
  - Training of high-level officials in the SMS concept
- In the **supervision** field
  - Verify the LOAs
  - Implement the continuous monitoring committees (CRM)

- Compliance with the SSP
  - Risk management varies from an initial risk level of **3 C to a risk level of 2C**, and only the likelihood drops
  - **Responsible entities:** Aeronautical authorities, ACCs and air navigation service providers (ANSPs) of the SAM Region.

## Chapter 6 Conclusions of operational risk assessment and mitigation for ATSSRO

### 6.1 Introduction

6.1.1 This chapter summarises the background information gathered during the risk assessment, with the purpose of defining the average risk level for ATSSRO. It also analyses the arguments required to determine the acceptable level of operational risk (ALoS) for the optimisation of the ATS route network in the SAM Region. Finally, it contains recommendations derived from this study to support the ATS route network optimisation programme approved for the SAM Region.

6.1.2 Chapter 2 of this document analysed the qualitative methodology for assessing risk management with respect to ATSSRO, based on the description of the system, in keeping with the guidelines of the corresponding optimisation programme.

6.1.3 Chapter 3 summarised the hazard identification process for ATSSRO and explained the methodology used. It also mentioned the regional workshop (SAMRA/1) that was held with the participation of a multidisciplinary group of experts. The workshop identified the hazards and assessed the consequences in order to determine the resulting operational risk level.

6.1.4 Chapter 4 covered aspects related to operational risk management, analysing the background information defined by the SAMRA/1 workshop, the identification of hazards and their consequences. This information was validated by the workshop, and the methodology for determining the level of the operational risks described in the seven-step process was applied, following the data processing required in the SMM manual. In this analytical stage, the two variables defined--likelihood and severity of an event--are analysed, always making reference to a qualitative analysis. Finally, risk matrices are applied in order to determine what applicable additional action could be agreed by the expert workshop to minimise and efficiently contain the operational risks in ATSSRO.

6.1.5 In Chapter 5, a risk acceptability analysis was conducted, based on the defences analysed in the proposed scenario, identifying the defences associated to ATSSRO that existed in the SAM Region. Subsequently, criteria were applied to judge the acceptability from a two-dimensional perspective.

### 6.2 Final summary of the risk case study within the scope of the ATS route network optimisation

6.2.1 Based on the analysis of the safety case study and the action taken and the proposed additional defences, the average operational risk level has a likelihood of occurrence of **2**, which defines it as **Acceptable** with a severity **C** or **Major**, which means a significant reduction in safety margins, a reduced ability of the operator to comply with the safety margins, which translates into a global risk level of **2 C**. The conclusion is that it is within an acceptable range, according to the management triangle described in Chapter 5 **item 5.2.2** and, in some cases, would potentially require a decision by management and monitoring of the operation in the SAM Region.

6.2.2 In summary, based on the analysis made, it may be concluded that, with the current action taken, the implementation of the ATSSRO route network does not face any problems and will not generate additional hazards in the current airspace structure. The implementation of the additional measures identified in this document and listed in the following chapter will optimise the safety of operations in the new

operational environment, thus contributing to the achievement of the strategic objectives of the global ATM plan. In sum, safety in the Region is at an acceptable level of operational risk, averaging **2 C**, which falls within the concept of controlled risk.

## **Chapter 7 Recommendations resulting from the operational risk assessment for ATSRO**

### **7.1 Introduction**

7.1.1 This chapter lists the recommendations derived from the qualitative study conducted in order to determine the operational risk levels for the ATS route network optimisation in the SAM Region.

### **7.2 Recommendations of the safety assessment for ATSRO**

7.2.1 Based on that described and analysed in this safety study, it may be stated that the commitment of the States of the Region has been a fundamental factor in the achievement of the safety level. However, it should be noted that, as a result of the detailed analysis of the regional system, there are opportunities for improving and preserving the level achieved. Consequently, the States must strengthen and take actions to comply with the optimisation programme in the Region.

7.2.2 **The States** of the Region will provide support in the technological field, through the incorporation of information and communication technologies (ICTs), in keeping with the need to promote the exchange of safety data at the regional level, providing relevant information to define and promote the performance indicators for the Region and record lateral deviations that affect the national and regional ALoS. In the regulatory field, the States will update and publish the changes required for operating on ATSRO routes, and will continue promulgating the different contingency plans and programmes required for the implementation of this system. Regarding training, the States shall encourage knowledge about the application of, and operation on, ATSRO routes, as well as the implementation and monitoring of the SMS phases with respect to the operation of the ATSRO system. The States shall promote continuous training in the requirements operating on ATSRO routes in the short term. Finally, they shall apply the safety oversight and continuous monitoring tools, based on the eight critical elements defined by the SSP.

7.2.3 **The operators** shall promote and carry out the exchange of safety data at regional level to start a performance indicator database for the Region, and will provide the necessary information to determine lateral deviations (hot spots) that affect the ALoS of the Region. Regarding regulations, the operators shall update the contingency plans and programmes required to operate in an optimised ATS route environment. In terms of training, they shall encourage recurrent training for operations on ATSRO route, using navigation system (RAIM) failure simulation and practices in order to identify, on a timely basis, the failures that affect or could affect ATS route capacity. They shall also implement safety management systems (SMS) and, finally, promote continuous training for an efficient operation of the ATS route network, including contingency procedures for each case.

7.2.4 **The ATS/ANSPs** shall exchange safety data at regional level in order to establish the validated indicators for measuring performance in the Region and provide information on the identification and establishment of lateral deviations (hot spots) that affect the ALoS of the Region. Regarding regulations, they shall update, within the ACCs, the contingency plans and programmes required for operating in an optimised ATS route environment. For purposes of training, they shall encourage recurrent training for operating on optimised ATS routes, using simulation with standard scenarios and contingency programme practices, with a view to identifying, on a timely basis, the failures that might affect the capacity of the units. As to the SMS concept, those ATSPs that are already in the implementation phase, shall continue with the planned implementation, encouraging the application of proactive processes in the NOSS programme, and finally, promoting continuous training for operating in the ATSRO route environment. The ATSPs that have not done so yet, shall start, as a matter of urgency, the implementation of SMS. Finally, they shall incorporate

and promote supervision based on the eight critical indicators of continuous oversight, based on the requirements proposed for the interaction between the SMS and the SSP of the States.

7.2.5 **The ICAO South American Regional Office** will include in its planning the holding of the SAMRA/2 workshop, with a view to assessing ATSRO following the optimisation, improving the competencies of experts, and bridging any gaps that may arise. The Regional Office should designate focal points and request the participating States to permit their periodic participation. This type of training will enhance the level of knowledge and will provide positive synergies to preserve the safety levels in the SAM Region.

7.2.6 Finally, the observations and conclusions of this safety case study for ATSRO should be part of the safety library of the Region, creating a baseline that will permit the recording of any proposed improvements in the future concerning risk management and the safety level achieved in the SAM Region.

## APPENDIX 1 TO CHAPTER 2

## AIR TRAFFIC MOVEMENT BETWEEN FL 290 AND FL 410

## Air Traffic Movement in ATS Routes

Air traffic movement between FL 290 and FL 410, by FIR, and percentage of flights in the main ATS routes Period: 13 to 28 January 2008				
Country	FIR	Amount of air traffic in the sample	Percentage of flights in the main ATS routes	Number of ATS routes
Argentina	Córdoba	1769	92%	13
	Comodoro Rivadavia	713	96%	9
Bolivia	La Paz	684	97%	13
Brazil	Amazónica	4085	67%	13
	Brasília	11333	50%	12
	Curitiba	10499	44%	13
	Recife	3418	66%	13
	Sao Paulo (TMA)*	1911	100%	4
Chile	Antofagasta	1480	89%	10
	Easter Island	164	100%	4
	Puerto Montt	412	94%	6
	Punta Arenas**	281	98%	7
	Santiago	2109	89%	13
Guyana	Georgetown	187	97%	9
Panama	Panama	1389	70%	14
Paraguay	Asunción	605	90%	14
Peru	Lima	3599	69%	14
Suriname	Paramaribo	369	98%	11
Uruguay	Montevideo***	892	100%	12

\* Provides ACC services in the segment between Río de Janeiro and Sao Paulo. There is a significant volume that does not appear in the sample because it flies below FL 290.

\*\* 91% in ATS route UT 100.

\*\*\* There is a significant volume that does not appear in the sample because it flies below FL 290.

**Table 2 – Air traffic movement between FL 290 and FL 410, by FIR, and percentage in the main city pairs**

<b>Air traffic movement between FL 290 and FL 410, by FIR, and percentage in the main city pairs Period: 13 to 28 January 2008</b>				
<b>Country</b>	<b>FIR</b>	<b>Amount of air traffic in the sample</b>	<b>Percentage of flights of the sample in the main city pairs</b>	<b>Number of city pairs</b>
Argentina	Córdoba	1769	51%	14
	Comodoro Rivadavia	713	65%	13
Bolivia	La Paz	684	60%	14
Brazil	Amazónica	4085	27%	14
	Brasília	11333	28%	17
	Curitiba	10499	28%	16
	Recife	3418	31%	16
	Sao Paulo (TMA)*	1911	76%	15
Chile	Antofagasta	1480	70%	15
	Easter Island	164	89%	11
	Puerto Montt	412	94%	10
	Punta Arenas**	281	92%	8
	Santiago	2109	58%	13
Guyana	Georgetown	187	79%	10
Panama	Panama	1389	48%	15
Paraguay	Asunción	605	53%	13
Peru	Lima	3599	39%	16
Suriname	Paramaribo	369	71%	15
Uruguay	Montevideo**	892	75%	11

## APPENDIX 1 TO CHAPTER 3

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**APPENDIX 2 TO CHAPTER 3**

**HAZARD IDENTIFICATION AND RISK MANAGEMENT FORM**

**Hazard Identification and Risk Management Form**

<b>Type of operation or activity</b>	<b>Generic hazard</b>	<b>Specific component of hazard</b>	<b>Hazard-related consequence</b>	<b>Current risk control defences and risk index</b>	<b>Further action to reduce risk and the resulting risk index</b>	<b>Responsible party</b>

**APPENDIX 1 TO CHAPTER 4  
SUMMARY TABLE OF HAZARD IDENTIFICATION AND RISK MANAGEMENT**

**Hazard Identification and Risk Management Form - ATSRO**

<b>Generic hazard 1</b>	<b>Specific component of hazard</b>	<b>Hazard-related consequence</b>	<b>Current defences to control risk and the risk index</b>	<b>Further action to reduce risk and the resulting risk index</b>	<b>Responsible party</b>
<p>Non-RNAV aircraft flying on RNAV routes</p>	<p>Inability of the aircraft to maintain RNAV route</p>	<p><b>Loss of separation</b></p>	<ul style="list-style-type: none"> <li>• Integrated Aeronautical Information System (AIP, NOTAM, AIP, AIC Supplement and others)</li> <li>• FPL</li> <li>• En-route navigation charts</li> <li>• ATS surveillance service</li> <li>• ACAS/TCAS</li> <li>• Operational manuals of the operator and the ANSP</li> </ul> <p align="center"><b>3C</b></p>	<ul style="list-style-type: none"> <li>• Direct access of ATS units to updated database of RNAV-approved aircraft</li> <li>• Improve surveillance in the necessary areas (implement VHF, HF, ADS-CPDLC, ADS-B, Radar and other types of communications)</li> <li>• Direct access of ARO/AIS units to updated database of RNAV-approved aircraft</li> <li>• Training of operators and air navigation service providers</li> <li>• Applicable contingency procedures upon identifying a non-RNAV aircraft on an RNAV route</li> <li>• Designate a responsible party in each State to maintain the database of RNAV-approved aircraft</li> <li>• Updating and, if applicable, development of the Operational Manuals of the ANSP, incorporating the appropriate procedures</li> </ul> <p align="center"><b>2C</b></p>	<p align="center">States Operators ANSPs</p>

Generic hazard 2	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
Loss of RNAV capacity on board	Inability of the aircraft to maintain the RNAV route	<b>Loss of separation</b>	Alternate “conventional” navigation equipment  Reversal to “conventional” navigation procedures  ATS surveillance service  ACAS <ul style="list-style-type: none"> <li>• Operational manuals of the operator and the ANSP</li> </ul> <p style="text-align: center;"><b>3C</b></p>	Standardisation of operator procedures in case of loss of RNAV capability;  Improve surveillance in the necessary areas (implement VHF, HF, ADS-CPDLC, ADS-B, Radar and other types of communications)  Applicable contingency procedures upon identifying an aircraft that has lost RNAV capability  Training of operators, including training of the crew in the application of contingency procedures  Training of air navigation service providers  ATC simulations  RNAV system integrity oversight plan <p style="text-align: center;"><b>2C</b></p>	States Operators ANSPs

Generic hazard 3	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
Lack of GND NAVAID coverage	Inability of the aircraft to maintain RNAV route	<b>Loss of separation</b>	<ul style="list-style-type: none"> <li>• GNSS</li> <li>• IRS/INS</li> <li>• ATS surveillance</li> <li>• Integrated Aeronautical Information System (AIP, NOTAM, AIP Supplement, AIC, etc.)</li> <li>• NOTAM concerning satellite health</li> <li>• ACAS</li> <li>• Operational manuals of the operator and the ANSP</li> <li>• Operational manuals of the operator and the ANSP</li> </ul> <p style="text-align: center;"><b>3C</b></p>	<p>Standardisation of procedures for operators in case of inability to maintain the route;</p> <p>Ensure an appropriate coverage by:</p> <ul style="list-style-type: none"> <li>a) Implementing the required GND NAVAIDs; or</li> <li>b) Changing from a “conventional” route to an RNAV route, establishing the air navigation system requirements to fly the route.</li> </ul> <p>Improve surveillance in the required areas (implement VHF, HF, ADS-CPDLC, ADS-B, Radar and other types of communications)</p> <p>Training of operators and air navigation service providers</p> <p>Updating and, if applicable, drafting of the operational manuals of the ANSP, incorporating the appropriate procedures</p> <p style="text-align: center;"><b>2C</b></p>	States Operators ANSPs

Generic hazard 4	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
<p>NAVAID coverage failure</p>	<p>Inability of the aircraft to maintain RNAV route</p>	<p>Loss of separation</p>	<ul style="list-style-type: none"> <li>• Reversal procedures:                             <ul style="list-style-type: none"> <li>a) GNSS, in case of failure of GND NAVAIDs, for equipped aeroplanes</li> <li>b) Failure of IRS/INS, GND NAVAIDs, for equipped aeroplanes</li> <li>c) GND NAVAIDs, in case of GNSS and INS failure</li> </ul> </li> <li>• Maintenance of GND NAVAIDs</li> <li>• NOTAM concerning satellite health</li> <li>• Flight inspection</li> <li>• Contingency procedures of the operator and the ANSPs.</li> </ul> <p style="text-align: center;">3C</p>	<p>Standardisation of operator procedures in case the aircraft cannot maintain its route;</p> <p>Specific procedures to be applied in case of degradation of the navigation capability of the aircraft;</p> <p>Compliance with the Maintenance plan for the verification of ground radio aids;</p> <p>Updating and, if applicable, drafting of the operational manuals of the ANSP, incorporating the appropriate procedures</p> <p>Disseminating information about solar storms that might affect the satellite and HF systems</p> <p style="text-align: center;">2C</p>	<p style="text-align: center;">States ANSPs Operators</p>

Generic hazard 5	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
Adverse meteorological effects	Large deviations	<b>Loss of separation</b>	<ul style="list-style-type: none"> <li>• NOTAM</li> <li>• MET/PIB/VOLMET briefings</li> <li>• ATM briefings between ATFMUs</li> <li>• AIREP</li> <li>• Contingency plan</li> <li>• ACAS</li> <li>• Operational manuals of the operator and the ANSP</li> </ul> <p style="text-align: center;"><b>4C</b></p>	<ul style="list-style-type: none"> <li>• Updating of LOAs between MET/ATM services</li> <li>• Alternate routes</li> <li>• QMS/MET/AIS</li> <li>• Updating of the operational manuals of the operator and the ANSP</li> </ul> <p style="text-align: center;"><b>2C</b></p>	States Operators ANSPs



Generic hazard 7	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
Discrepancy of aeronautical information concerning the route network	Lack of integrity of the data published by the States	<b>Loss of separation</b>	<ul style="list-style-type: none"> <li>• Use of WGS84</li> <li>• ATS surveillance service</li> <li>• Integrated aeronautical information system (AIP, NOTAM, AIP Supplement, AIC, etc.)</li> <li>• ACAS</li> </ul>	<ul style="list-style-type: none"> <li>• Implement quality management system (QMS) in AIS</li> <li>• Comply with AIRAC cycles</li> </ul>	States ANSPs
	Outdated airborne navigation database, if used		<ul style="list-style-type: none"> <li>• Coordination between the States and the navigation database providers</li> <li>• Agreements between operators and navigation database providers</li> <li>• AIRAC cycles</li> </ul> <p style="text-align: center;"><b>4C</b></p>	<ul style="list-style-type: none"> <li>• Comply with AIRAC cycles</li> <li>• Improve and/or formalise coordination between States and navigation database providers</li> <li>• Publish specific navigation database regulations</li> <li>• Schedule operator inspections</li> <li>• Comply with navigation database regulations established by the States</li> </ul> <p style="text-align: center;"><b>3C</b></p>	States Operators

Generic hazard 8	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
<p>Inadequate civil/military coordination</p>	<p>Unauthorised entry of civil aircraft in restricted airspaces Unauthorised entry of military aircraft from restricted airspaces into ATS routes</p>	<p><b>Loss of separation</b></p>	<ul style="list-style-type: none"> <li>• Civil/military LOA</li> <li>• Civil/military coordination committee</li> <li>• Integrated aeronautical information system (AIP, NOTAM, AIP Supplement, AIC, etc.)</li> <li>• Operational manuals of the ANSP</li> <li>• Video charts</li> <li>• Annex 2 and 11</li> </ul> <p>Application of the procedures foreseen in Chapter 16 (16.1) of Doc 4444</p> <ul style="list-style-type: none"> <li>• ACAS</li> <li>• ATS surveillance</li> </ul> <p style="text-align: center;"><b>3C</b></p>	<ul style="list-style-type: none"> <li>• Updating of video charts</li> <li>• Updating of LOAs and general civil/military ATM procedures</li> <li>• ATFM</li> <li>• Training of ATCOs and pilots</li> <li>• Restructuring of segregated sectors/airspaces</li> <li>• Optimise or, if applicable, implement a civil/military coordination committee</li> <li>• Flexible use of airspace</li> <li>• Updating and, if applicable, drafting of the operational manuals of the ANSP, incorporating the procedures foreseen in Chapter 16 (16.1) of Doc 4444 and the standards and recommended practices of Annex 2 and 11.</li> </ul> <p style="text-align: center;"><b>2C</b></p>	<p>States ANSPs</p>

Generic hazard 09	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
Inadequate airspace design	Increased ATCO workload	<b>Operational error of ATCO</b>	ATM/Airspace planning ATS surveillance  Training of ATCOs  SMS implementation standards (paragraph 2.27 of Annex 11)  Capacity management (paragraph 3.1 of Doc 4444)  <p style="text-align: center;"><b>3D</b></p>	<ul style="list-style-type: none"> <li>• Analyse sector workload after route optimisation</li> <li>• Provide a sufficient number of air traffic controllers</li> <li>• Drafting of the safety plan for sectors</li> <li>• ATFM</li> <li>• Updating of ATCO training</li> <li>• Analysis of airspace capacity after RNAV route optimisation</li> <li>• Airspace redesign applying continuous descent operations (CDO)</li> <li>• Implementation of RNAV SIDs/STARs</li> </ul> <p style="text-align: center;"><b>2D</b></p>	<p style="text-align: center;">States  ANSPs</p>

Generic hazard 10	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
Navigation deviations due to technical errors	Deviation due to engine failure	<b>Loss of separation</b>	<ul style="list-style-type: none"> <li>• ATS surveillance</li> <li>• Safety assessment</li> <li>• Operational manuals of the operator and the ANSP</li> <li>• Aircraft and operator approval process</li> </ul> <p style="text-align: center;"><b>4C</b></p>	<ul style="list-style-type: none"> <li>• Use of the lateral deviation (LD) reporting form</li> <li>• Monthly delivery of LD data to CARSAMMA</li> <li>• Training of ATCOs in the completion of the lateral deviation reporting form</li> <li>• Use of data available in CARSAMMA for visualising potential technical errors</li> <li>• Operator inspection programmes</li> <li>• Implement ATC system alarms to detect lateral deviations</li> </ul> <p style="text-align: center;"><b>2C</b></p>	States ANSPs Operators
	Deviation due to a contingency				

Generic hazard 11	Specific component of hazard	Hazard-related consequence	Current defences to control risk and the risk index	Further action to reduce risk and the resulting risk index	Responsible party
<p>Navigation deviations due to operational errors</p>	<p>Lack of coordination between ACCs</p>	<p><b>Loss of separation</b></p>	<ul style="list-style-type: none"> <li>• Measures to reduce operational errors in the ATC coordination loop between adjacent ATCs (GREPECAS15/36)</li> <li>• ATS surveillance</li> <li>• Safety assessment</li> <li>• LOA</li> <li>• Operational manuals of the ANSP</li> </ul> <p style="text-align: center;">4C</p>	<ul style="list-style-type: none"> <li>• Implement measures to reduce operational errors in the ATC coordination loop between adjacent ACCs (GREPECAS15/36)</li> <li>• Use of the lateral deviation (LD) reporting form</li> <li>• Investigation of each LD, taking the necessary risk mitigation measures, and monthly delivery of LD data to CARSAMMA</li> <li>• Training of ATCOs in the application of procedures to avoid ATC coordination errors and completion of the the lateral deviation reporting form</li> <li>• Use of data available in CARSAMMA to visualise potential errors</li> <li>• Updating and, if applicable, drafting of the operational manuals of the ANSP, incorporating procedures to reduce operational errors in the ATC coordination loop between adjacent ACCs</li> <li>• Implement ATC system alarms to detect lateral deviations</li> <li>• Implement AIDC</li> </ul> <p style="text-align: center;">2C</p>	<p>States ANSPs</p>

<b>Generic hazard 12</b>	<b>Specific component of hazard</b>	<b>Hazard-related consequence</b>	<b>Current defences to control risk and the risk index</b>	<b>Further action to reduce risk and the resulting risk index</b>	<b>Responsible party</b>
Outdated operational manuals of operators/ANSP	Erroneous application of procedures	<b>Loss of separation</b>	RNAV 5 approval procedures Safety oversight  Audits and inspections <b>(4C)</b>	Implement SMS <b>(2C)</b>	States Operators ANSPs