INTERNATIONAL CIVIL AVIATION ORGANIZATION
South American Regional Office - Regional Project RLA/06/901
Assistance for the Implementation of a Regional ATM System, taking into account the ATM operational concept and the corresponding CNS technological support
Tenth Workshop/Meeting of the SAM Implementation Group (SAM/IG/10)
(Lima, Peru, 1-5 October 2012)

SAM/IG/10-WP/14
09/04/12

Agenda Item 8: Other matters
a) Application of SMS methods to LHD analysis

Study on the Implementation of the Safety Management Systems (SMS) Methodology for the Collection, Preparation, and Analysis of Large Height Deviation (LHD) Reports

(Presented by CARSAMMA)

Summary

This paper presents a summary of large height deviation (LHD) reports received by CARSAMMA in relation to the SMS methodology advocated by ICAO and endorsed at a GREPECAS meeting as a recommendation for application by CARSAMMA in the CAR/SAM Regions.

References
- ICAO SMS Manual.
- Report of Large Height Deviations (LHD) in 2010.

ICAO Strategic Objectives:	**A -** Safety

1. Introduction

1.1. The CAR/SAM Regional Planning and Implementation Group (GREPECAS) entrusted the Caribbean and South American Monitoring Agency (CARSAMMA) the implementation of the SMS methodology for the analysis of LHDs. CARSAMMA is an administrative agency under the *DEPARTAMENTO DE CONTROLE DO ESPAÇO AÉREO* (DECEA), a body that belongs to the Airspace Control System of Brazil (SISCEAB).

1.2. In order to apply the SMS methodology for the analysis of LHDs, CARSAMMA has prepared an "LHD SMS Guide", which appears in **Appendix A** to this working paper, describing step by step the stages to be followed in this analysis. The SMS is used to estimate the system risk value.

1.3. An important addition to the methodology for LHD SMS analysis is the risk assessment and quick identification of trends and critical points where risks occur, which reduces the time required to do the safety analysis of the system.

1.4. The objective of this work is to present a summary of the study on the application of SMS analysis to LHD reports received by CARSAMMA, and document and present safety management as a valid tool for safety assessment in RVSM airspace.

2. Context

2.1. This section offers a brief description of how information is analysed in the LHD SMS model approved by ICAO, which is to be used in the risk assessment process.

2.2. Based on the analysis and assessment of GTE LHDs (Telecon), the SMS risk matrix shows the risk classification at three levels: high, medium, and low, as seen in Figure 1.

HIGH RISK – The risk proposal is unacceptable, cannot be applied until the hazard is mitigated and the risk reduced to a medium or low level.

MEDIUM RISK - The risk proposal is acceptable. It may be implemented, but follow-up and management are required.

LOW RISK - Acceptable, without restrictions or limitations. Hazards do not require active management, but must be documented.

Figure 1 – Risk Acceptance Criteria

3. Discussion

3.1. For the LHD SMS analysis, some parameters must be taken into account, such as the duration of the event, ADS or radar display, weather conditions during the event, and other traffic involved.

3.2. To that end, the following expression is used:

VR=(PxDxG)+R+W+T, where:

VR=risk value

P= probability **R= with /without ATS surveillance**
D= duration **W= weather conditions (VMC or IMC)**
G= severity **T= other traffic**

3.3. CARSAMMA used its database to identify LHDs from 2004 to 2011 inclusive, and LHD reporting frequency. Based on this information, it built a consolidated table, with levels going from 1 (one) to 5 (five), to be used in the LHD probability analysis.

3.4. The values calculated in the LHD analysis were classified as follows:

Low risk - 1 to 20
Medium risk - 21 to 75
High risk - 76 to 100

4. Summary and conclusions

4.1. Based on hazard identification and analysis, LHDs are classified as of low, medium or high risk in order to generate an ICAO/CARSAMMA Safety Management Document (LHD-SMD) containing the number, description, cause, severity, probability, and initial risk value of LHDs.

Notes:

1. The implementation of a Safety Management System is the responsibility of the States, and GTE / CARSAMMA play the role of facilitators in this process.

2. *The LHD-SMD will be sent to the ICAO Lima and Mexico Offices for subsequent delivery to each State (FIR) involved in the LHDs analysed, for adoption of any applicable mitigation measures.*

4.2. As a result of the safety analysis of 2011 LHDs, CARSAMMA draws the attention of CAR/SAM States to the following events that had a maximum risk value, with the sole purpose of improving safety in RVSM airspace:

a) Event of longest **Duration**
- LHD 415 – 259min **-** Code N **-** VR = 37

b) Event of greatest **Severity = 5**
- LHD 382 - 12min **-** Code B **-** VR = 27

c) Event with **Probability = 5** and **Risk Value = 40**
- LHD 117, 159, 220, 573, 691 – Code N.
with an average duration of 4 minutes.

d) Events with highest **Risk Value** (=46)
- LHD 171 – 14min **-** Code N

5. Suggested action

5.1. The Meeting is invited to:

a) take note of the information contained herein, and the States willing to do so may use this information as a reference to mitigate LHDs; and

b) use the suggested method for conducting safety analysis, and member States may use it as a guide for the collection, processing, analysis, delivery, and publication of data related to this matter.

APPENDIX A

Risk Management Guide for the Analysis of Large Height Deviations (LHDs) in the CAR/SAM Regions, using the SMS Methodology

PREAMBLE

This guide may be used for SMS safety analysis, applying the methodology recommended by ICAO and endorsed by GREPECAS for application by CARSAMMA in the CAR/SAM Regions. CARSAMMA experts, together with the members of the Scrutiny Working Group (ICAO GTE), used this methodology to analyse the large height deviation (LHD) forms generated in the CAR/SAM Regions.

Since safety management has to be developed and applied in different areas of civil aviation, it was decided that the first part of this guide would contain the principles of the SMS methodology and, in the second part, this methodology would be applied to LHD analysis and the adjustment of tables and documents to the specific characteristics of RVSM airspace.

FIRST PART

SAFETY MANAGEMENT PROCESS

In general, the risk management process has five phases:

- Description of the system;
- Identification and coding of hazards - CARSAMMA;
- Risk analysis - GTE (teleconference);
- Risk assessment – GTE; and
- Risk treatment (mitigation) - State.

DESCRIPTION OF THE SMS

The manual defines a system as "an integrated set of components that combine, or the support given to an operational environment to achieve a given objective. These components include individuals, culture, equipment, information, procedures, facilities, services, and others."

Not all States participating in the system assign the same weight to each threat identified (*e.g.*, loss of power in one engine). For example, the loss of an engine (for multi-engine aircraft) at high speed and altitude does not always result in a catastrophic accident. Many multi-engined aircraft are designed to fly with a single engine in a restricted flight. However, in some States, the loss of a power-unit (at low speed, low height, gross height weight) may result in loss of control or loss of lift. Under these system conditions, the hazard can be catastrophic. The manual requires that consideration be given in the SMS to the worst reasonable case scenario in the system. If so desired, other conditions of the system may be considered, but only as a supplement to the worst-case scenario.

RISK ASSESSMENT

The risk assessment must follow the guidelines of the ICAO SMS Manual.

The SMS Risk Matrix classifies risks at three levels: high, medium, and low. These levels define the SMS as the process to mitigate the risk for each hazard identified, as shown in Figure 1.

HIGH RISK – The risk proposal is unacceptable, cannot be applied until the hazard is mitigated and the risk reduced to a medium or low level.

MEDIUM RISK – The risk proposal is acceptable. It may be implemented, but follow-up and management are required.

LOW RISK – Acceptable, without restrictions or limitations. Hazards do not require active management, but must be documented.

Figure 1 – Risk Acceptance Criteria

SECOND PART

LHD FLOW ANALYSIS (SMS)

Application of the SMS Methodology to Risk Identification

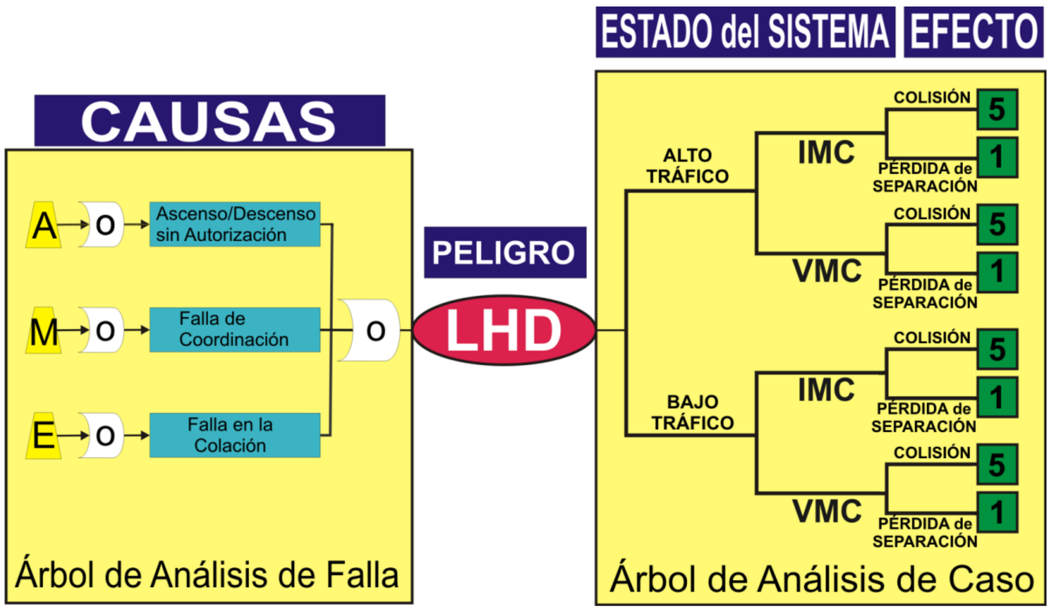

Figure 2 – LHD SMS Flow Analysis

CAUSES		**CONDITION OF THE SYSTEM**	**EFFECT**
Climb/descent with no clearance	**HAZARD**	High traffic	Loss of separation
			Collision Loss of separation
Coordination error		Low traffic	Collision Loss of separation
Readback error			Collision Loss of separation
Failure analysis tree		Case analysis tree	

In this example, the hazard identified is a large height deviation (LHD), the occurrences of which will be listed and coded by CARSAMMA.

Some of the causes of LHDs are identified on the left side of the previous figure. After coding, work starts with the GTE (teleconference). Figure 3 shows, to the right of the hazard, the condition of the system, initially identified as high or low traffic. This condition was later divided into adverse or non-adverse weather conditions.

Each of these conditions results in one of the effects described (mid-air collision or loss of separation). These effects are classified by severity, where 5 is a catastrophic event and 1 is an insignificant effect on safety. The worst case is when an LHD occurs in adverse weather, in both high or low traffic conditions.

Analysis by the GTE (teleconference)

a) The GTE Risk Management Team (teleconference) met to identify the hazards/causes (LHD code)/condition of the system. We are currently using the web-based **GO-TO-MEETING** tool with satisfactory results, in which the risks identified are analysed.

b) Accordingly, Table 1, Hazard Analysis, has been adopted, where fields 1 and 2 are the LHDs, field 3 is to be coded by CARSAMMA, fields 4, 5, and 6 will be the result of the GTE analysis (teleconference), and field 7 is unique to the State of the FIR involved. Field 8 is completed subsequently at the GTE meeting.

LHD N° (1)	**Description (2)**	**Causes LHD code (3)**	**Severity (4)**	**Probability (5)**	**Level of risk (6)**	**Mitigation measures (7)**	**Residual risk foreseen (8)**

Table 1 – Hazard analysis

LHD RISK ANALYSIS AND ASSESSMENT

Once the causes have been identified (LHD code) by CARSAMMA, the GTE must analyse the risk associated to each LHD code identified, assessing the severity and probability of occurrence. Each code must have an LHD severity associated to it, for example:

5	**4**	**3**	**2**	**1**
F	B, D, E, G, M, N	A, C, I, J, K, L	H	O, P

Table 2 – Severity/Codes

For the **Severity Analysis**, the experience of the GRSO/GTE team members is taken into account, using Table 3, Severity Analysis, as follows:

Effects	**Hazard Severity (LHD)**				
	Catastrophic 5	**Hazardous 4**	**Major 3**	**Minor 2**	**Insignificant 1**
ATC	Collision with an aircraft, terrain, or obstacle, TCAS alert (TA/RA)	Reduction of separation or total loss of ATC capability (zero ATC)	Significant reduction of separation or ATC capability	Slight reduction of ATC capability or significant increase of ATC workload	Slight increase of ATC workload

Table 3 – Severity analysis

After determining the severity, the **Probability** of occurrence of a hazard is defined, taking into account the worst-case scenario. Once again, based on the knowledge and experience of GRSO/GTE staff, the qualitative method for classifying probability must be applied, using the following table:

Probability	**Level of ATC services/system**	**Operational**
Frequent 5	Occurring constantly in the system	Expected to occur every 1-2 days
Occasional 4	Expected to occur frequently in the system	Expected to occur several times per month
Remote 3	Expected to occur several times throughout the life of the system	Occur about once every few months
Improbable 2	Improbable, but may be reasonably expected to occur during the life of the system	Expected to occur about once every 3 years
Extremely Improbable 1	Improbable but possible during the life of the system	Expected to occur at least once every 30 years

Table 5 - Probability

To this end, Table 6 below may be used, together with the risk value expression:

PROBABILITY	**DURATION**	**SEVERITY**
5 FREQUENT		5 CATASTROPHIC
4 PROBABLE		4 HAZARDOUS
3 OCCASIONAL	3 LONG (d > 6 min)	3 MAJOR
2 IMPROBABLE	2 MEDIUM (2 < d ≤ 6 min)	2 MINOR
1 EXTREMELY IMPROBABLE	1 SHORT (d ≤ 2 min)	1 INSIGNIFICANT

Table 6 – Analysis of parameters

VR = risk value

VR=(PxDxG)+R+W+T, where:

P = probability R=with/without ATS surveillance (with=5, without=10)
D =duration W = weather conditions (IMC=5 or VMC=0)
G =severity T = other traffic (0-10)

Once each LHD has been assigned a **VR** by the GTE, use Table 7 to classify the level of risk. And report the level of risk to the DGSO.

VR	LEVEL OF RISK	CONTROL
76-100	**HIGH**	Unacceptable risk, RVSM airspace must be cancelled until the hazard is mitigated and the risk reduced to a medium or low level
21-75	**MEDIUM**	Acceptable risk, but follow-up and management are mandatory.
01-20	**LOW**	Acceptable without restrictions or limitations, hazards do not require active management, but must be documented.

Table 7 – Level of risk

SUMMARY:

Responsibility	Issuance phase	Assessment phase	Analysis phase I	Mitigation phase	Analysis phase II
FIRs involved					
ICAO Office					
CARSAMMA					
TELECON team					
States and International Organisations					
GTE					

Notes:

1. The implementation of the Safety Management System is the responsibility of the States, and GTE/ CARSAMMA play the role of facilitators in this process.

2. The LHD-SMD will be sent to the ICAO Lima and Mexico Offices, and subsequently to each State (FIR) involved in the LHDs analysed for implementation of applicable mitigation measures.

To try the LHD (SMS) analysis methodology, CARSAMMA followed all the steps of this process in 2010 and 2011, the final result of which was a qualitative safety assessment of RVSM airspace.