Organización de Aviación Civil Internacional
Oficina Regional Sudamericana
Decimoctava Reunión de Autoridades de Aviación Civil de la Región Sudamericana (RAAC/18)
(Sao Paulo, Brasil, 24 al 26 de febrero de 2025)

RAAC/18-WP/43
06/02/25

Item 7A of the Agenda: **Innovation**

OPTIMIZATION OF THE MANAGEMENT OF LARGE HEIGHT DEVIATIONS (LHD) IN THE CAR/SAM REGION WITH REDUCED VERTICAL SEPARATION MINIMUM (RVSM)

Working Paper presented by Colombia, *"The Country of Beauty"*

SUMMARY

The management of Large Height Deviations (LHD) in the RVSM airspace of the CAR/SAM Region is essential for the safety and efficiency of air traffic. The automation of LHD reporting and the adoption of a cascading risk assessment model will improve the identification of patterns, prioritization of corrective actions, and optimization of decision-making.

Effective LHD management requires strengthening notification, analysis, and risk mitigation mechanisms. Currently, reports rely on manual processes and tools that limit the timely detection of incidents. To optimize operational safety, it is proposed to automate reporting through the FDS system and implement a structured risk assessment model. These strategies will enhance event traceability, reduce notification times, and strengthen air traffic managers' decision-making.

States are recommended to implement advanced tools and train personnel to enhance operational safety in the region.

References:

- Doc 9574 – Manual on the Implementation of Reduced Vertical Separation Minimum (RVSM).
- Doc 9937 – Manual on Air Traffic Safety in RVSM Airspace.
- GTE/CARSAMMA Report on LHD deviations.
- SSA Guide – Operational Safety Risk Assessment and Mitigation (MSER-4.0-15-048, Version 01, 07/25/2024).
- ARMS Methodology (Aviation Risk Management Solutions) for ATS risk assessment.

ICAO Strategic Objectives	• *Every Flight is Safe and Secure* • *Aviation is Environmentally Sustainable* • *No Country is Left Behind* • *Economic Development*

1. Introduction

1.1 The management of Large Height Deviations (LHD) in the RVSM airspace of the CAR/SAM Region is essential for the safety and efficiency of air traffic. The automation of LHD reporting and the adoption of a cascading risk assessment model will improve the identification of patterns, prioritization of corrective actions, and optimization of decision-making.

1.2 Effective LHD management requires strengthening notification, analysis, and risk mitigation mechanisms. Currently, reports rely on manual processes and tools that limit the timely detection of incidents. To optimize operational safety, it is proposed to automate reporting through the FDS system and implement a structured risk assessment model. These strategies will enhance event traceability, reduce notification times, and strengthen air traffic managers' decision-making.

1.3 States are recommended to implement advanced tools and train personnel to enhance operational safety in the region.

2. Discussion

2.1. Current Situation of LHD Management in the CAR/SAM Region

2.1.1 The management of Large Height Deviations (LHD) in the CAR/SAM Region faces operational and technological limitations that impact the effectiveness of analysis and corrective actions. ANSPs must report these events to CARSAMMA by the 15th of the following month; however, the information is often insufficient for a detailed analysis of patterns and causes. The lack of precise data restricts the ability to apply mitigation strategies and makes it difficult to identify recurring trends, affecting operational safety in RVSM airspace.

2.1.2 Deficiencies in ATS coordination between area control centers (ACC) create inconsistencies in responsibility transfer and flight level assignment. These problems stem from the absence of standardized procedures, differences in personnel training, and limitations in communication infrastructure. Additionally, human factors, such as communication failures between ATS operators and flight crews, increase the risk of operational errors. The high workload of controllers reinforces the need for automated systems to optimize real-time decision-making.

2.1.3 From a technological standpoint, many ANSPs still operate with manual reporting and analysis systems, making information consolidation difficult and delaying the detection of trends. The lack of interoperability between platforms hinders timely responses to critical incidents. To mitigate these deficiencies, CARSAMMA has promoted the adoption of electronic forms to standardize data collection; however, their implementation has not been uniform across the region. The persistence of manual processes creates inconsistencies in the database and increases the likelihood of transcription errors, affecting the quality of operational safety analysis.

2.1.4 The Civil Aviation Analytics Office developed a geospatial dashboard with CARSAMMA data (first semester 2024), identifying critical LHD areas through a heat map. The location of events was determined by correlating callsign, date, and time, allowing for traceability with ASTERIX Category 62 data. (See https://www.aerocivil.gov.co/analitica/Paginas/LHD_Carsamma.aspx)

2.2 Risk Assessment in LHD Management

2.2.1 The Collision Risk Model (CRM) assesses the severity of LHDs based on collision probabilities, but its static approach limits the ability to anticipate systemic risks. To improve prevention, it is recommended to complement it with predictive analysis tools that detect emerging patterns and generate early warnings. In this context, the Cascading Risk Assessment Methodology offers a more dynamic approach, segmenting events by severity, probability, and recurrence, facilitating efficient resource allocation and more effective corrective measures.

2.2.2 Comprehensive LHD management requires a **regional integrated database** to correlate multi-FIR data, eliminating limitations from fragmented information across different systems. The implementation of predictive tools based on artificial intelligence and big data will strengthen the early identification of trends, optimizing operational response and enabling more informed and proactive decision-making.

2.3 **Proposals**

2.3.1 Implementation of an Automated LHD Reporting Model

2.3.1.1 Dynamic risk assessment based on ARMS and ORA methodologies enables the classification of LHDs according to their severity and recurrence, facilitating the prioritization of critical events and the adaptation of mitigation strategies based on their impact on operational safety (see Appendix D). To complement this approach, a segmentation and classification system for LHD events will be implemented, using operational criteria and risk statistics to differentiate types of deviations and allocate appropriate resources for their efficient resolution.

2.3.1.2 The integration of multi-FIR data and the creation of a unified regional database will strengthen coordination among ANSPs, improving global trend analysis and the identification of recurring patterns. Additionally, the incorporation of simulations and predictive modeling will allow for the evaluation of hypothetical scenarios and the anticipation of potential deviations, optimizing decision-making and the implementation of preventive strategies.

2.3.1.3 Likewise, the implementation of alarms and automatic notifications will enable controllers and ATS operators to receive real-time alerts on significant deviations exceeding established safety thresholds. This will facilitate immediate action and the application of effective corrective measures, contributing to operational safety and risk reduction in the region (see Appendix C – process flow).

2.3.2 Adoption of a Cascading Risk Assessment Model

2.3.2.1 Dynamic risk assessment based on ARMS and ORA methodologies enables the classification of LHDs according to their severity and recurrence, facilitating the prioritization of critical events and the adaptation of mitigation strategies based on their impact on operational safety (see Appendix D). To complement this approach, a segmentation and classification system for LHD events will be implemented, using operational criteria and risk statistics to differentiate types of deviations and allocate appropriate resources for their efficient resolution.

2.3.2.2 The integration of multi-FIR data and the creation of a unified regional database will strengthen coordination among ANSPs, improving global trend analysis and the identification of recurring patterns. Additionally, the incorporation of simulations and predictive modeling will allow for the evaluation of hypothetical scenarios and the anticipation of potential deviations, optimizing decision-making and the implementation of preventive strategies.

2.3.2.3 To ensure the effectiveness of this model, a continuous monitoring system and operational audits will be established, ensuring the periodic review of implemented measures and their alignment with ICAO standards. This will enable continuous improvement in LHD management, fostering a safer, more efficient, and resilient airspace against operational risks.

3. Suggested action

3.1 The meeting is invited to:

a) Urge ICAO to lead the optimization of Large Height Deviation (LHD) management in the CAR/SAM Region, in accordance with the guidance provided in Annex 11, Doc 4444, Doc 9574, and Doc 9937, promoting the automation of event reporting through integration with ATC systems.

b) Encourage CAR/SAM Region States to prioritize investments in improving LHD supervision and analysis through artificial intelligence and big data tools, as well as training air traffic service personnel in the identification and mitigation of risks associated with altitude deviations.

c) Encourage States in the CAR/SAM Region to adopt advanced cascading risk assessment models, including multi-FIR data integration and predictive tools to enhance efficiency and operational safety in RVSM airspace.

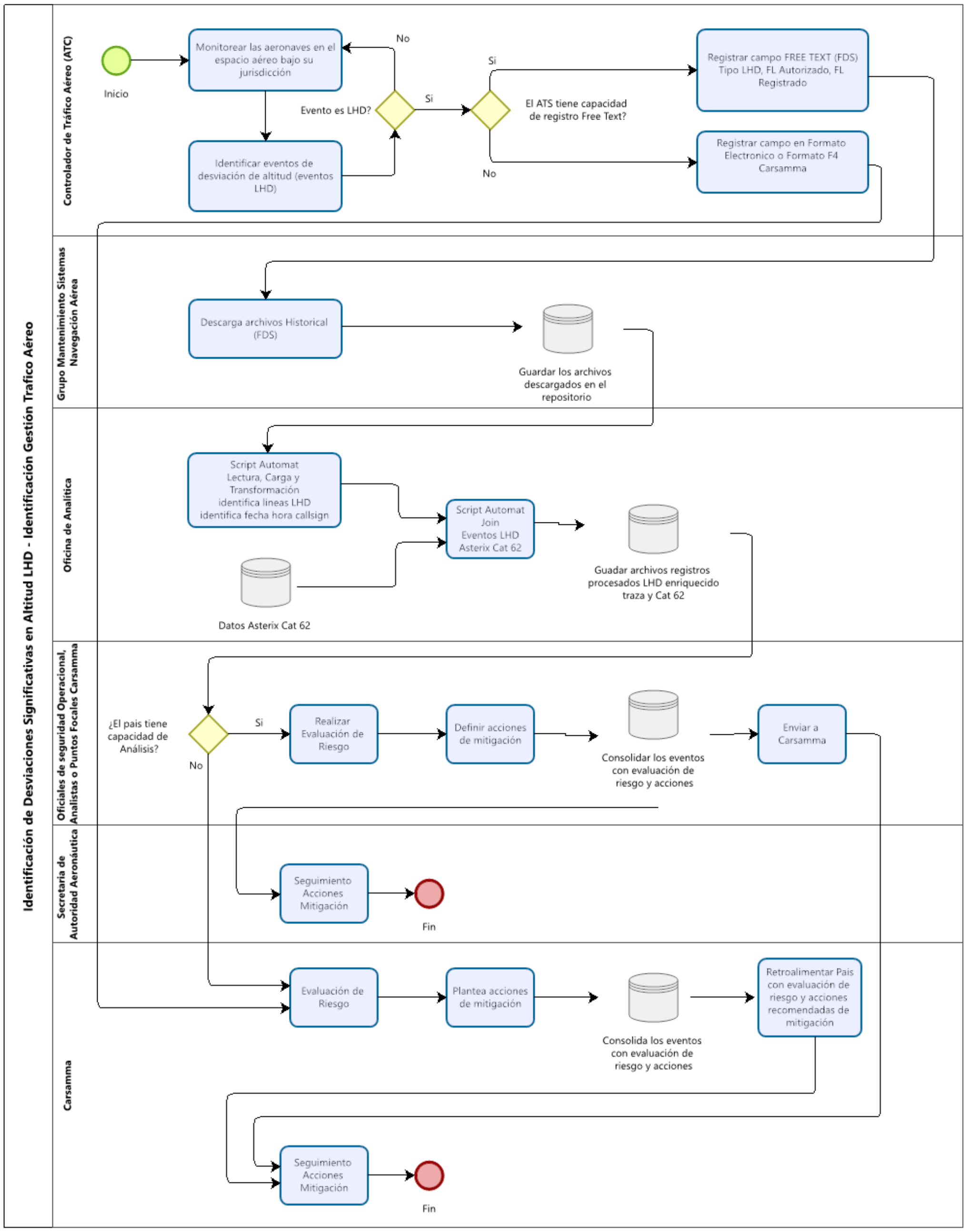
d) Encourage ICAO and States to include these initiatives in the CAR/SAM Regional Air Navigation Plan, contributing to strengthening operational safety and optimizing airspace use.

e) Urge States to develop continuous monitoring mechanisms and operational audits to assess the effectiveness of implemented measures, ensuring continuous improvement in LHD management.

- END -

APPENDIX A

PROPOSED PROCESS FLOW FOR LHD REGISTRATION IN FREE TEXT



Source: Aerocivil - Analytical Office
own elaboration

APPENDIX B

HISTORICAL FILE, EXAMPLE WITH DETAIL

LHD RECORD IN FREE TEXT

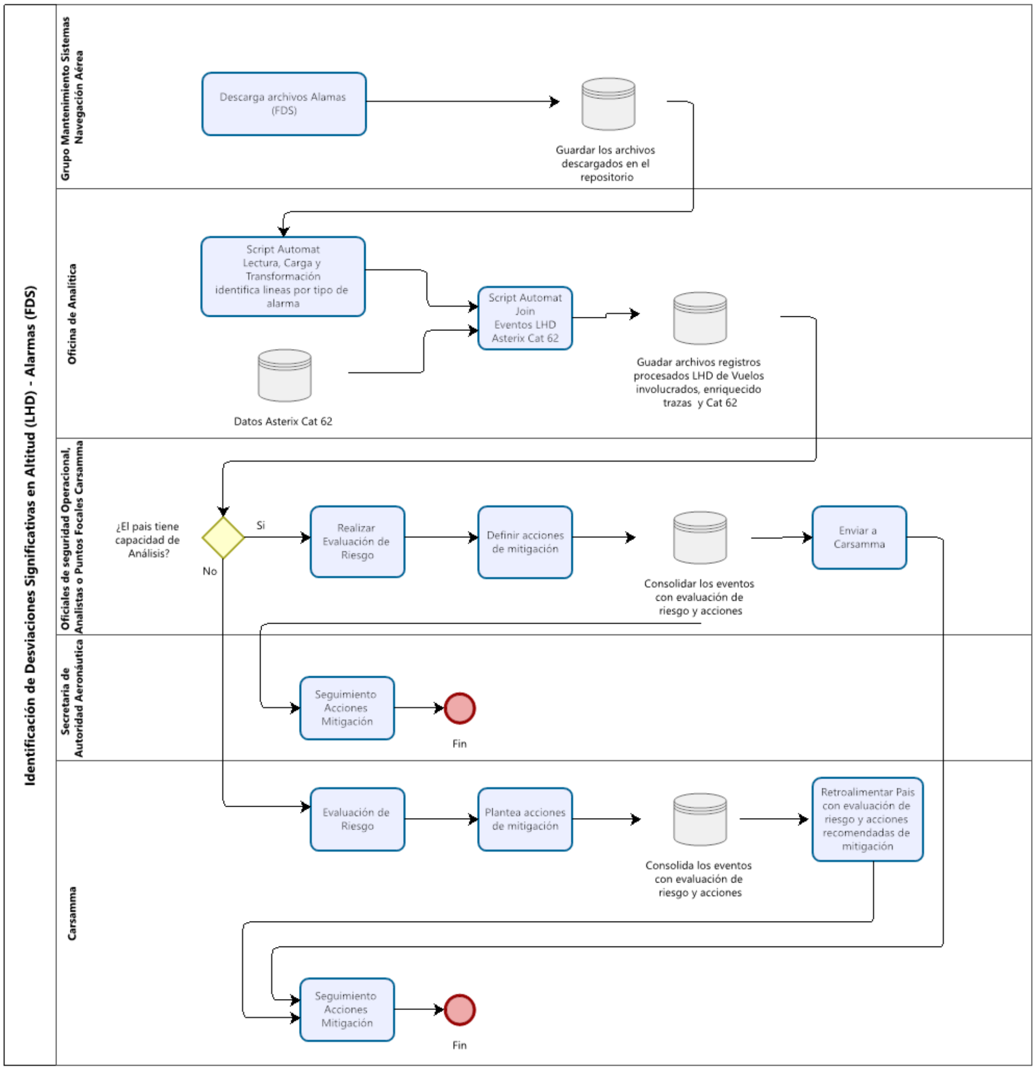
```
********* CMP352_MPTO_241222_1801_MDPC
FPL CORRECTION/FDD2/22-12-24 15:24:02
BQX3669 221521
FF SKBQFDBA
221521 MPTOCMPO
(FPL-CMP352-IS
-B737/M-SDE1E2E3GHRWIZ/HB1
-MPTO1801
-N0438F370 DCT EGETA DCT AGUJA/N0440F380 UM597 PALAS PALAS2B
-MDPC0207 MDSD
-PBN/B1C1D1S2T1 NAV/RNP2 SUR/260B DOF/241222 REG/HP1378
 EET/SKEC0030 TNCF0107 MDCS0131 SEL/CPBQ CODE/0C200C OPR/CMP PER/C
 RMK/TCAS)

CREATION/FDD2/22-12-24 15:24:02
CMP352   IS B737/M SWDE1E2E3GHRIZ/HB1 MPTO 241222 1801 MDPC 2008
N0438F370  ** EGETA/H1805 DCT AGUJA/H1823 N0440F380 ESKOR NESMO SIPOK
 OSUBO ERIKO OROSA IRBAR LIDOL PUTAR MASEN ++ A319 PALAS PALAS2B **
HP1378  EQ MDSD
PBN/B1C1D1S2T1 NAV/RNP2 SUR/260B SEL/CPBQ OPR/CMP PER/C RMK/TCA

SEGMENT (1) INITIAL

RECEIVED ABI/22-12-24 18:09:17
BQX4757 221809
FF SKBQFDBA
221809 MPZLZQZX 2.001517-4.241222180915-5.3F78-
(ABI-CMP352/A0133-MPTO-AGUJA/1833F370-MDPC-8/IS-9/B737/M
-10/SDE1E2E3GHIRWZ/B1H
-15/N0438F370 EGETA DCT AGUJA/N0440F380 DCT PALAS PALAS2B
-18/PBN/B1C1D1S2T1 NAV/RNP2 SUR/260B DOF/241222 REG/HP1378
 EET/SKEC0030 TNCF0107 MDCS0131 SEL/CPBQ CODE/0C200C OPR/CMP
 PER/C RMK/TCAS)
(...)

STATUS_CHANGE/SFN/22-12-24 19:21:28
CORR  MODE S

STATUS_CHANGE/SFN/22-12-24 19:24:12
LOST

STATUS_CHANGE/SFN/22-12-24 19:25:16
CORR  MODE S

STATUS_CHANGE/SFN/22-12-24 19:25:52
LOST

STATUS_CHANGE/SFN/22-12-24 19:26:44
CORR  MODE S

CWP TEXT/CWP11/22-12-24 19:27:54
TEXT : LHDE/380/340

STATUS_CHANGE/SFN/22-12-24 19:29:30
LOST

CANCEL/EVENT/22-12-24 19:37:14
FP TERMINATED
```

- **LHDE** (LHD E) Errores de coordinación en la transferencia ATC-a-ATC de la responsabilidad del control como resultado de factores humanos
- **380** nivel de vuelo autorizado
- **340** nivel de vuelo registrado

Source: Aerocivil - Analytical Office
own elaboration

APPENDIX C

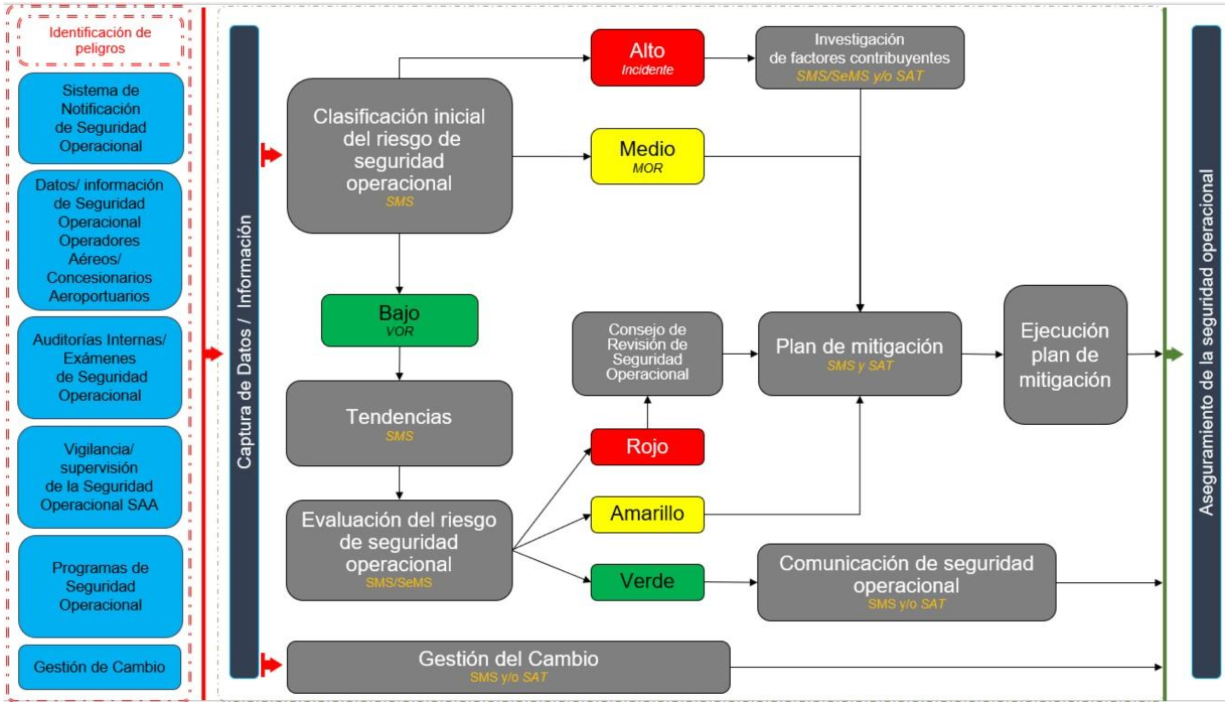
ALARMS ARCHIVE, EXAMPLE WITH DETAIL LHD IDENTIFICATION



Source: Aerocivil - Analytical Office
own elaboration

APPENDIX D

GENERAL OUTLINE OF THE GRSO



Source: ARMS Model, adaptation Aerocivil - Grupo SMS/SeMS

More details of the model at https://isolucion.aerocivil.gov.co/Isolucion/BancoConocimiento4AERONAUTICAPro/c/caea92efd5ba47d8b82d48dd3c03e7c8/MSER-4.0-15-048SSAGuaEMRSOVr.1_17-09-2024_RFC_17-09-2024.pdf

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