# Manual on the Assessment of Large Height Deviations (LHDs) based on an ATS Safety Management System (SMS) for the CAR/SAM Regions

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## 1. INTRODUCTION

The Scrutiny Task Force (GTE) and the CAR/SAM Monitoring Agency (CARSAMMA) have developed a methodology for the analysis and assessment of Large Height Deviations (LHDs), based on a Safety Management System (SMS), with the purpose of increasing the level of safety in CAR/SAM RVSM airspace.

This methodology is used for assessing the level of risk of each occurrence individually, and helps to identify trends and critical points of occurrence.

CARSAMMA will continue calculating the Risk Value using the Collision Risk Model (CRM) established in ICAO Doc 9574 (Manual on implementation of a 300m vertical separation minimum between FL290 and FL410 inclusive), using a TLS of 5 X $10^{-9}$ fatal accidents per hour of flight as reference parameter. The objective is to conduct a quantitative (CRM) and qualitative (SMS) assessment of operations in RVSM airspace and increase the level of safety in the CAR/SAM Regions.

## 2. Background

The GTE recognised the need to analyse LHDs applying a safety management system (SMS) approach, since the Collision Risk Model uses a mathematical formula to calculate the level of risk of the Regions without giving details of the occurrences analysed.

The GTE has been using the SMS methodology to analyse and assess LHDs since 2011. This methodology allows CAR/SAM States and international organisations to analyse, adopt and implement measures to mitigate LHDs in their respective FIRs.

## 3. LHD Analysis and Assessment

During the analysis, the cause of the occurrence is identified using the LHD code table, which is contained in appendix B to this manual.

Following the identification of the causes (LHD code) by CARSAMMA, the GTE must analyse the risks associated to each LHD code that has been identified, assessing their severity and likelihood of occurrence.
For the **Severity Analysis**, the GTE team, based on its experience, applies the Severity Table as follows:

| Effects | Severity of Hazard (LHD) |
|---|---|

| | Catastrophic 5 | Hazardous 4 | Major 3 | Minor 2 | Insignificant 1 |
|---|---|---|---|---|---|
| **ATC** | **Collision with aircraft, ground or obstacle. TCAS (RA) warning** | **Significant reduction of separation or total loss of capacity (ATC zero)** | **Significant reduction of separation or ATC capacity** | **Slight reduction of ATC capacity or significant increase of ATC workload** | **Slight increase of ATC workload** |

Table 1

Each code is associated to an LHD severity based on the impact on safety:

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

Table 2

After determining the severity, the **Likelihood** is established based on statistical data showing the points with higher rates of occurrence in the CAR/SAM Regions, bearing in mind the worst-case scenario. To this end, the following table is used:

| Likelihood | Level of ATC service/system | Operational |
|---|---|---|
| **Frequent 5** | Continuously occurring in the system | Expected to occur every 1-2 days |
| **Occasional 4** | Expected to occur frequently in the system | Expected to occur several times a month |
| **Remote 3** | Expected to occur several times during the lifetime of the system | Occur approximately once every few months |
| **Unlikely 2** | Unlikely, but may be reasonably expected to occur during the lifetime of the system | Expected to occur approximately once very three years |
| **Extremely unlikely 1** | One of them is unlikely but possible in the lifetime of the system | Expected to occur approximately every 30 years |

Table 3

After determining the likelihood, the duration of the occurrence is established based on the following table:

| | |
|---|---|
| **1 Short** | **$d \leq 1$ minutes** |
| **2 Medium** | **$1 < d \leq 2$ minutes** |
| **3 Long** | **$d > 3$ minutes** |

Table 4

Thus, the following expression may be used:

| Likelihood (P) | Duration (D) | Severity (G) |
|---|---|---|
| 5 Frequent | | 5 Catastrophic |
| 4 Occasional | | 4 Hazardous |
| 3 Remote | 3 Long | 3 Major |
| 2 Unlikely | 2 Medium | 2 Minor |
| 1 Extremely unlikely | 1 Short | 1 Insignificant |

Table 5

Once the aforementioned values have been obtained, it is determined whether the FIR that is subject to the risk has an ATS surveillance system, if meteorological conditions were VMC or IMC, and whether there was other conflicting traffic, based on which the following values are assigned:

| Surveillance system | Meteorological conditions | Other traffic |
|---|---|---|
| YES = 5 | VMC = 0 | With surveillance = 10 |
| NO = 10 | IMC = 5 | Without surveillance = 10 |

Table 6

## 4. Risk Value Calculation

Once the aforementioned data is obtained, the following formula is applied for calculating the risk value:

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

| Parameter | Description | Value |
|---|---|---|
| VR | Risk value | To be calculated |
| P | Probability of the position | Varies from 1 to 5 |
| D | Duration of the occurrence | Varies from 1 to 3 |
| G | Severity of the occurrence | Varies from 1 to 5 |
| R | With or without ATS surveillance | With=5 or Without=10 |
| W | Meteorological conditions | VMC=0 or IMC=5 |
| T | Other traffic (if any) | 10 |
| | TOTAL | Maximum 100 points |

Table 7

## 5. Target level of safety (TLS)

Once the LHD analysis and assessment process has been completed, the resulting Risk Value for each LHD is inserted in the risk matrix, which is designed to show if the level of risk of each occurrence is above or below the TLS that has been defined as the acceptable level for the CAR/SAM Regions, *i.e.,* 20 points.

| RV | Risk Level | Control |
|---|---|---|
| **76-100** | **HIGH** | **Unacceptable risk, RVSM airspace must be cancelled until the hazard is mitigated and the risk is reduced to the medium or low level** |
| **21-75** | **MEDIUM** | **Acceptable risk, but monitoring and management are mandatory.** |
| **01-20** | **LOW** | **Acceptable without restriction or limitation, hazards do not require active management, but must be documented.** **.** |

Table 8

After defining the level of risk for each LHD, the States and international organisations shall develop and implement mitigation plans, as needed, which shall be presented at face-to-face GTE meetings. The analyses conducted by CARSAMMA and the GTE at the virtual and face-to-face meetings will be presented in a final report to the ICAO Mexico City and Lima Regional Offices and at GREPECAS meetings.

## 6. Terms of Reference (TOR) of the CAR/SAM Regional RVSM Scrutiny Group (GTE)

The Terms of Reference (TOR) of the CAR/SAM Regional RVSM Scrutiny Group (RVSM/SG), known as the GTE, were established with a view to analysing issues affecting the TLS, based on LHD information provided by the States and international organisations.

**Terms of reference**

a) To assemble safety management subject matter experts in air traffic control, aircraft flight operations, regulation and certification, data analysis, and risk modelling;

b) To analyse and evaluate large height deviations of 300 ft or greater as defined in ICAO Doc 9574, Manual on the implementation of a 300 m (1 000 ft) vertical separation minimum between FL 290 and FL 410 inclusive;

c) To coordinate the collection and review of large height deviation data with the CARSAMMA;

d) To determine and validate an estimate of the flight time away from the cleared flight level to be used to estimate the Collision Risk Model (CRM) made by CARSAMMA;

e) To identify safety trends based on the analysis of large height deviations (LHD) reports, recommend mitigation actions in accordance with ICAO SMS provisions, and submit annual reports on safety assessment results to GREPECAS so as to improve safety in the RVSM airspace of the CAR/SAM Regions; and

f) To accomplish other tasks as directed by GREPECAS.

**Composition**:

CAR and SAM States, CARSAMMA, COCESNA, IATA, IFALPA, IFATCA, and the Rapporteur.

## 7. Terms of Reference (TOR) of CARSAMMA

Duties of CARSAMMA:

a) Maintain a central registry of RVSM-approved operators and aircraft of each State/Territory that use CAR/SAM RVSM airspace;

b) Facilitate the transfer of approved data to and from other RVSM Regional Monitoring Agencies (RMAs);

c) Establish and maintain a database containing the height-keeping errors and height deviations of 300 ft or more within CAR/SAM RVSM airspace;

d) Submit timely information for State civil aviation authorities (CAAs) on changes or monitoring status of aircraft type classifications;

e) Submit the results of the monitoring flight using the GPS global monitoring system (GMS);

f) Provide the means for identifying aircraft non-RVSM approved operating in the CAR/SAM RVSM airspace, and notify the appropriate State civil aviation authority (CAA) accordingly;

g) Develop the means for summarising and communicating the content of relevant databases to the RVSM Scrutiny Group (GTE) for the corresponding safety assessment; and

h) Conduct the assessment of the collision risk level (CRM) in the RVSM airspace of the CAR/SAM Regions, in accordance with ICAO Doc 9574 and Doc 9937.

**Acronyms:**

| | |
|---|---|
| GTE: | Scrutiny Group/ Grupo de Tarea de Escrutinio |
| LHD: | Large Height Deviation / Grande Desviación de Altitud |
| CAR: | Caribbean / Caribe |
| SAM: | South América / Sur América |
| RVSM: | Reduced Vertical Separation Minimum / Separación Vertical Mínima Reducida |
| CARSAMMA: | Caribbean and South American Monitoring Agency / Agencia de Monitoreo del Caribe y Sur América |
| SMS: | Safety Management System / Sistema de Gestión de la Seguridad Operacional |
| CRM: | Collision Risk Model / Modelo de Riesgo de Colisión |
| FIR: | Flight Information Region / Región de Información de Vuelo |
| VMC: | Visual Meteorological Conditions / Condiciones meteorológicas de vuelo visual |
| IMC: | Instrument Meteorological Conditions / Condiciones meteorológicas de vuelo por instrumentos |
| TLS: | Target Level of Safety / Nivel de Seguridad Operacional |
| ICAO / OACI: | International Civil Aviation Organization / Organización de Aviación Civil Internacional |
| GREPECAS: | CAR/SAM Regional Planning and Implementation Group |
| TOR: | Terms of Reference / Términos de Referencia |

# Appendix B

## LHD Code Table

| LHD CODE | LHD Code Description |
|---|---|
| **A** | Fail to climb/descend the aircraft as cleared. |
| **B** | Climb/descent without ATC clearance. |
| **C** | Incorrect operation or interpretation of airborne equipment (*e.g.*, incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance, etc.) |
| **D** | ATC system loop error (*e.g.,* ATC issues incorrect clearance or flight crew misunderstands clearance messages) |
| **E** | Coordination errors in the ATC to ATC transfer or control responsibility as a result of human factors issues (*e.g.,* late or non-existent coordination, incorrect time estimate/actual, flight level, ATS route, etc., not in accordance with agreed parameters) |
| **F** | Coordination errors in the ATC to ATC transfer or control responsibility as a result of equipment outage or technical issues. |
| **G** | Deviation due to aircraft contingency event leading to sudden inability to maintain assigned flight level (*e.g.,* pressurisation failure, engine failure) |
| **H** | Deviation due to airborne equipment failure leading to unintentional or undetected change of flight level |
| **I** | Deviation due to turbulence or other weather related cause |
| **J** | Deviation due to TCAS resolution advisory, flight crew correctly following the resolution advisory |
| **K** | Deviation due to TCAS resolution advisory, flight crew incorrectly following the resolution advisory. |
| **L** | An aircraft being provided with RVSM separation is not RVSM approved (*e.g.,* flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan) |
| **M** | Other – this includes situations of flights operating (including climbing/descending) in airspace where flight crews are unable to establish normal air-ground communications with the responsible ATS unit. |