International Civil Aviation Organization

CARIBBEAN AND SOUTH AMERICAN RVSM GRUPO DE TABAJO DE ESCRUTINIO (CAR/SAM RVSM GTE)

REFERENCE GUIDE

1. Introduction

1.1. This reference guide is a consolidation of materials describing the construction, purpose and methodology of the CAR/SAM RVSM Grupo de Trabajo de Escrutinio (GTE). It is intended to be used as a basic reference for anyone interested in Scrutiny Group activity.

1.2. It is essential that regional authorities take into account all possible means of ascertaining and reducing the level of risk of collision resulting from operational errors that cause large height deviations (LHD). The CAR/SAM RVSM GTE is the primary group to evaluate and assess the operational aspects of large height deviations.

2. Background

2.1. System Performance Monitoring

2.1.1. Experience has shown that large height deviations, a deviation in the vertical dimension from the cleared flight level whereby established margins of separation may be eroded, of 90 m (300 ft) or greater in magnitude have a significant impact on operational and technical risk in RVSM airspace. The causes of such deviations have been found to be, but are not limited to:

a) an error in the altimetry or automatic altitude control system of an aircraft;

b) turbulence and other weather-related phenomena;

c) an emergency descent by an aircraft without the crew following established contingency procedures;

d) response to airborne collision avoidance system (ACAS) resolution advisories;

e) not following an ATC clearance, resulting in flight at an incorrect flight level;

f) an error in issuing an ATC clearance, resulting in flight at an incorrect flight level; and

g) errors in coordination of the transfer of control responsibility for an aircraft between adjacent ATC units, resulting in flight at an incorrect flight level.

The additional risk associated with operational errors and in-flight contingencies influence the outcome of RVSM safety assessments. A diagram illustrating the LHD contribution to the overall risk assessment is included in Appendix A.

2.1.2. System performance monitoring, as outlined in ICAO doc 9574, is necessary to ensure the continued safe use of reduced vertical separation minimum (RVSM) and that

established safety goals are met. This activity includes monitoring the minimum risk of collision associated with operational errors and in-flight contingencies. The monitoring process is divided into two main categories:

a) Risk associated with the aircraft technical height-keeping performance (technical risk), and

b) The overall risk, i.e. risk due to all causes.

2.1.3. The monitoring process involves the collection and evaluation of operational data. Appropriate methodologies will need to be in place to process this data in order to enable comparison with regionally agreed overall safety objectives.

2.2. Regional Monitoring Agency (RMA) Roles and Responsibilities

2.2.1. ICAO Doc 9574 describes a five-step implementation process for introduction of the RVSM. Among other actions required, the implementation process calls for establishment of a regional monitoring agency (RMA) to act as the safety oversight body. The RMA is required to conduct regular comprehensive safety assessments in order to ensure that the Target Level of Safety (TLS) is met. That is, that the risk associated with the RVSM as estimated by ICAO risk modeling is less than the TLS value. In other words, the RMA determines if the estimated risk of collision, calculated in accordance with ICAO collision risk methodology, is less than the agreed TLS.

2.2.2. A critical component of RVSM safety assessment, as well as a system performance monitoring requirement, is the analysis of large height deviations.

2.2.3. It is the responsibility of the cognizant RMA to establish a program for identifying large height deviations and a mechanism for collecting and analyzing reports of such deviations. It is also the responsibility of the RMA to provide periodic reports of observed height deviations to the appropriate PIRG and/or its subsidiary bodies, in accordance with procedures prescribed by the PIRG.

2.2.4. The Caribbean-South American Monitoring Agency (CARSAMMA) is the regional monitoring agency (RMA) established by GREPECAS to conduct this work for the Caribbean and South American regions.

2.2.5. While the RMA will be the recipient and archivist for reports of large height deviations, it is important to note that the RMA alone cannot be expected to conduct all activities associated with a comprehensive program to detect and assess large height deviations.

2.3. Establishment of a Reduced Vertical Separation Minimum Scrutiny Group

2.3.1. To assist the RMA in analyzing LHDs, a body of experts has been established by GREPECAS. This group of operational, ATC, flight crew and safety experts is called a Scrutiny Group, Grupo de Trabajo de Escrutinio (GTE). The GTE Terms of Reference is included in Appendix B.

3. Composition

3.1. The Scrutiny Group requires a diverse set of subject-matter experts. The Group is composed of subject matter experts in air traffic control, aircraft operations and maintenance, regulation and certification, data analysis, and risk modeling from the involved regions.

3.2. In the CAR/SAM regions, the following organizations are represented in the Scrutiny Group:

a) The Caribbean and South American Monitoring Agency (CARSAMMA)

b) The Federal Aviation Administration (FAA)

c) Dirección Générale de l'Aviation Civile (DGAC)

d) International Federation of Air Line Pilots' Associations (IFALPA)

e) Corporación Centroamericana de Servicios de Navegación Aérea (COCESNA)

f) Corporación Peruana de Aeropuertos y Aviación Comercial S.A. (CORPAC S.A.)

3.3. Scrutiny Groups in other regions have recommended the formation of a Scrutiny Sub-Group. Participation in the Sub-Group is by subject matter experts and specialists. The Sub-Group is responsible for executing the preparatory work for the Scrutiny Group including the analysis and categorization of selected large height events. The Scrutiny Group shall govern the decisions proposed by the Sub-Group. Sub-Group members are drawn from the Scrutiny Group.

4. Objectives

4.1.1. The Scrutiny Group’s work contributes directly to the requirement to provide on-going assessment of factors which affect the estimate of collision risk in RVSM airspaces.

4.1.2. The initial result of the Group’s effort is to examine the “event” reports and produce an estimate of time spent at a flight level other than cleared. This estimate is used as a primary input used in the preparation of an estimate of the operational risk for the implementation of Reduced Vertical Separation Minimum (Appendix A). The Group examines both technical risk (affected by reliability and accuracy of the avionics within the aircraft) and operational risk (affected by the human element) in the development of the safety assessment.

4.1.3. Once the Group has made its initial determination, the data are reviewed to look for performance trends. If any adverse trends exist, the Group may make recommendations for reducing or mitigating the effect of those trends as a part of the RVSM

implementation. Subsequently, the Group will meet to examine the post-implementation record of performance and to assure that operational errors are kept to a minimum. This information is used to assure that the airspace being examined continues to satisfy the requirements of the target level of safety, which is necessary to support continued RVSM operations. New procedures or other mitigation strategies to reduce occurrences of large height deviations may evolve out of this process.

5. Data Collection

5.1.1. It is the responsibility of the relevant RMA, CARSAMMA, to establish procedures for the collection of information concerning large height deviations of 90m (300ft) or greater in magnitude

5.1.2. The primary source for reports of LHDs is the ATC units. Surveillance data collected by ATC units provides the basis for identifying large height deviations. ATC units should be required to submit monthly reports of large height deviations to the cognizant RMA.

5.1.3. CARSAMMA, with the advisement of the GTE, created a LHD reporting form designed to capture the information necessary to accurately assess large height deviations. The form is available in three different languages, Portuguese, Spanish, and English and is accessible on CARSAMMA's web site at the following location: http://www.cgna.gov.br/CARSAMMA/siteUSA/inicial.htm . A sample of this form is included in Appendix C.

5.1.4. Accessibility of LHD reporting materials is essential to encourage the reporting of events by all parties involved in the provision of air traffic services.

5.1.5. The GTE will explore all sources for reports of large height deviations such as State databases of air safety incident reports and voluntary reporting safety databases.

5.1.6. When analyzing reports of large height deviations, the primary concern of the GTE is the impact of such events on the collision risk and on the overall safety of the system. Data collected by the GTE is used for analysis purposes only and all LHD events reviewed by the GTE are de-identified. Confidentiality will be maintained.

6. Data Review and Evaluation

6.1.1. The methodology employed by the GTE is to examine existing databases as well as other sources and analyze events resulting in a large height deviation of 300ft or greater within FL290-FL410. These events are usually the result of Air Traffic Control (ATC) loop errors (the undiscovered misunderstanding of a clearance), instances wherein a controller fails to capture an inaccurate read-back, an altitude over or undershoot, turbulence situations, emergencies, errors in coordination, weather complications or response to an ACAS resolution advisory. The largest source of reports useful for these purposes comes from the established regional safety reporting systems. However, in many instances these reports are designed for other purposes so they may lack the clarity on information that would be desirable to the GTE. Thus, the experience of the members

of the Scrutiny Group is essential in order to infer the effect, if any, the events have on risk in the airspace. All data sources undergo an initial review using key RVSM parameters and all reports of interest are extracted for further evaluation.

7. Methodology

7.1.1. The GTE is tasked with the responsibility of analyzing all reports of interest and assigning parameter values, as defined in the GTE LHD White Paper (Appendix D), that consist of cleared flight level, event flight level, levels crossed, final flight level, duration at unplanned flight level and total vertical deviation. Since the reports are not tailored for the needs of the Scrutiny Group, these values are not typically clearly defined. The GTE must rely on the expert judgment and operational experience of its members to assign these values.

7.2. Parameter Values

7.2.1. Cleared Flight Level

7.2.1.1. The flight level at which the pilot was cleared or currently operating. For example, aircrew accepts a clearance intended for another aircraft and ATC fails to capture the read back error or aircrew conforms to a flawed clearance delivered by ATC.

7.2.1.2. This parameter, in some cases, will require expert judgment and operational experience to assign a value. The Scrutiny Group must take into consideration the controller's plan versus the cleared flight level.

7.2.2. Event Flight Level

7.2.2.1. The event flight level is the flight level of error or the incorrect altitude of operation for an identifiable period of time without having received an ATC clearance

7.2.3. Duration at Unplanned Flight Level

7.2.3.1. The greatest exposure to risk is the time spent level at a flight level other than the cleared level. This parameter value contributes significantly to the calculation of operational risk.

7.2.3.2. The duration at unplanned flight level is the length of time that an aircraft was level at an altitude (flight level) that was not cleared, or planned, by air traffic control. Duration is recorded in one second increments.

7.2.3.3. The calculation of duration begins once the aircraft is level at a flight level other than the cleared level or planned level by ATC, and terminates once ATC initiates remedial action.

Figure 1 illustrates a large height deviation that has a duration value larger than zero. The duration calculation begins and point A and terminates and point B.

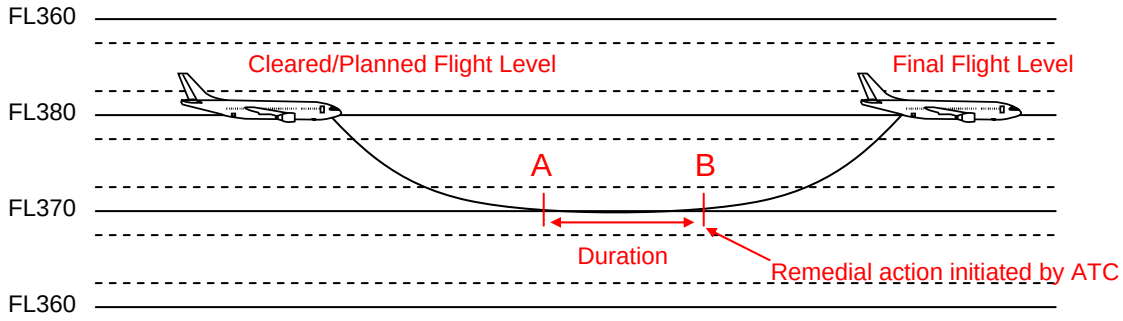


Figure 1.

7.2.3.4. It is important to note that not all large height deviations result in the aircraft being level at a flight level other than that cleared or planned by ATC; therefore, some events are assigned a duration value of zero.

7.2.3.5. It is also important to note the duration value determined or assigned by the GTE of LHDs that occur in a radar environment will vary significantly from that of a non-radar environment.

7.2.3.6. In most cases, LHD reports reviewed by the GTE lack the information necessary to calculate the time spent at incorrect flight level. Thus, the experience of the members of the Scrutiny Group is essential to provide in-depth analysis of each event

7.2.3.7. If the Scrutiny Group is unable to determine the time spent at incorrect flight level, a default value is assigned.

7.2.3.8. The GTE identified the need to establish a default duration value to assign to those events where there is not enough information included in the report to determine the time spent at incorrect flight level. Two default values were established, one for a radar environment and one for a non-radar environment. The default values are included in the GTE LHD White Paper, Appendix D.

7.2.4. Total Vertical Deviation

7.2.4.1. Total vertical deviation is the distance in feet between the altitude of current operation prior to the deviation and the point at which the aircraft is once again under ATC supervision. A deviation that resulted in an increase of altitude will be recorded as a positive number and a deviation that resulted in a decrease of altitude will be recorded as a negative number.

7.2.4.2. Figures 2 and 3 illustrate two large height deviations of different magnitudes. The first example, Figure 2, illustrates a large height deviation with a magnitude of 1000ft. The second example, Figure 3, illustrates a large height deviation with a magnitude of 1300 ft.

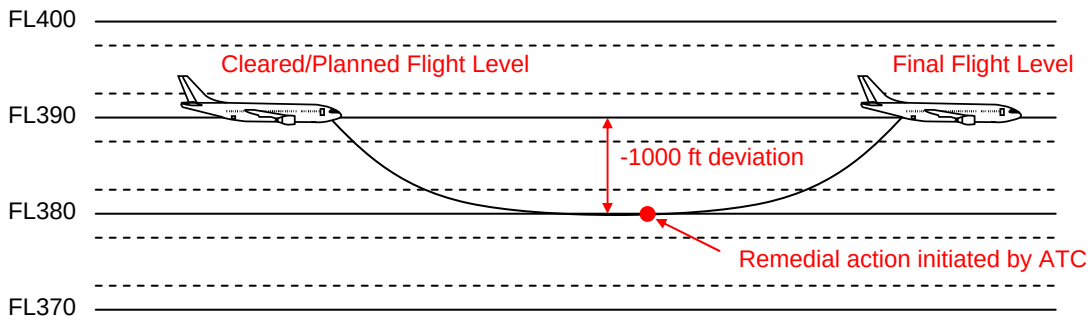


Figure 2.

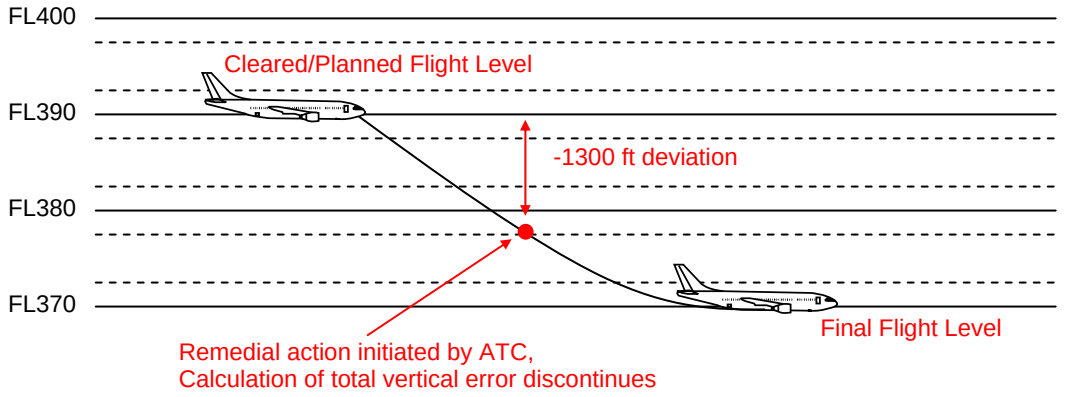


Figure 3.

7.2.5. Levels Crossed

7.2.5.1. The total number of flight levels between the point that the aircraft exits the cleared flight level and is once again under ATC supervision is calculated to determine the number of levels crossed. For example, in the examples provided in figures 2 and 3 in section 7.2.4.2, one level was crossed.

7.2.5.2. The Scrutiny Group must consider the hazard zone when calculating the number levels crossed. The hazard zone is also referred to as the buffer zone.

7.2.5.3. The hazard zone is the minimum physical distance of defined dimensions to accommodate:

a) Variations in an aircraft's flight path due to air movements, etc.;

b) The size of the aircraft;

c) An additional "miss" distance

7.2.5.4. The value of the hazard zone was determined to be ± 90 m (300ft). A brief explanation of the considerations underlying this value is included in paragraph 2.3.6.7 in the *Air Traffic Services Planning Manual (Doc 9426)*. The explanation is also included in Appendix E

7.2.5.5. This buffer zone criterion shall be used to determine that a specific level is occupied by an aircraft. In the LHD illustrated in figure 4, the aircraft penetrates the buffer zone but does not reach the next flight level. Applying the criterion described in paragraph 7.2.5.4, the total number of levels crossed in this example is 1.

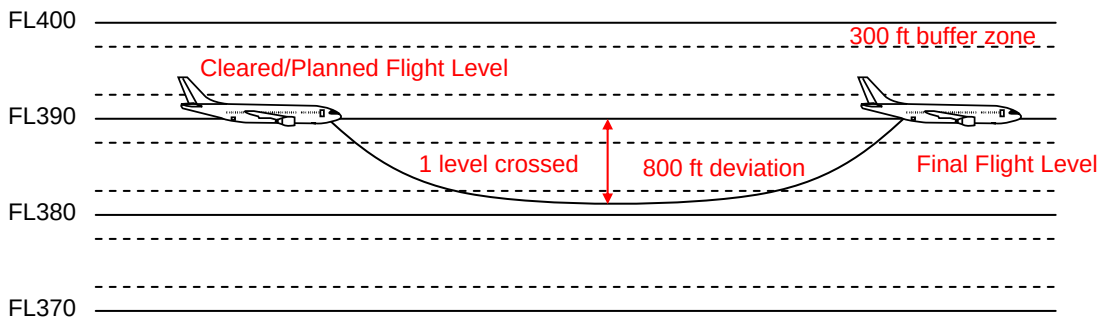


Figure 4

7.2.6. Levels Final

7.2.6.1. The final flight level is the cleared flight level after the error/deviation.

7.2.6.2. Some reports of large height deviations do not contain the final flight level. When this information is not available in the LHD report, the Scrutiny Group relies on operational expert judgment to determine the final flight level. The final flight level of the large height deviation illustrated in figure 5 is 370.

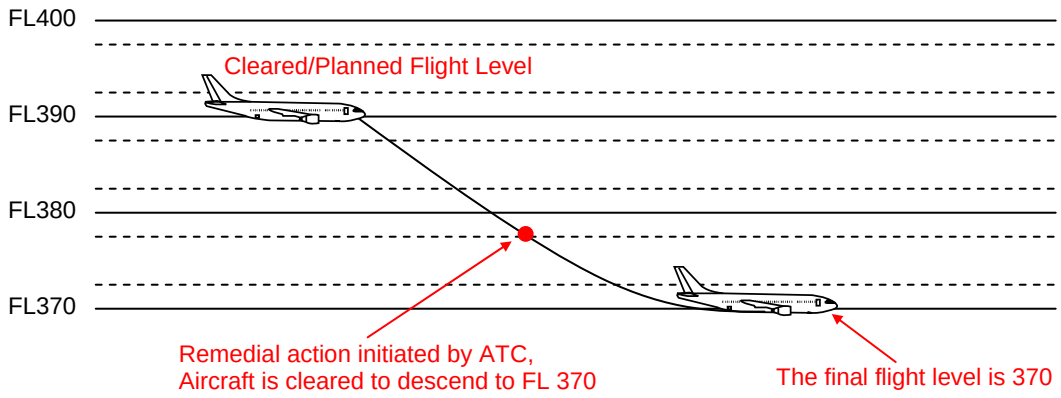


Figure 5.

7.2.7. Rate of Climb or Descent

7.2.7.1. The rate of climb or descent of an aircraft crossing through an uncleared level also contributes to the estimate of operational risk. In most cases, this parameter value is not included in reports of large height deviations. The GTE must rely on operational expert judgment to determine the rate of climb or descent.

7.2.7.2. The GTE established climb and descent rate default values. The default values are included in the GTE LHD White Paper (Appendix D)

7.2.8. Event Category

7.2.8.1. Classification of each LHD event is necessary for risk assessment purposes and for the identification of adverse trends. Each LHD event is assigned an error type code that identifies the type of event that caused the deviation. The error codes are categorized as operational or technical for consideration in the Collision Risk Model (CRM). A complete list of the error codes is included in table 1.

Table 1. Error Codes

A	Failure to climb/descend as cleared
B	Climb/descend without ATC clearance
C	Entry into airspace at an incorrect flight level
D	Deviation due to turbulence or other weather related cause
E	Deviation due to equipment failure
F	Deviation due to collision avoidance system (TCAS) advisory
G	Deviation due to contingency event
H	Aircraft not approved for operation in RVSM restricted airspace
I	ATC system loop error; (e.g. pilot misunderstands clearance message or ATC issues incorrect clearance)
J	Equipment control error encompassing incorrect operation of fully
K	Incorrect transcription of ATC clearance or re-clearance into the FMS
L	Wrong information faithfully transcribed into the FMS (e.g. flight plan followed rather than ATC clearance or original clearance followed instead of re-clearance)
M	Error in ATC-unit-to-ATC-unit transition message
N	Negative transfer received from transitioning ATC-unit
O	Other
P	Unknown

7.3. Analysis

7.3.1. It is the responsibility of the GTE to summarize their findings and analyze the data with the goal of identifying adverse trends and assess the overall risk.

7.3.2. The benefits of analyzing LHD data over time

7.3.2.1. Maintaining a cumulative summary of analyzed LHD events will allow the GTE to determine the following:

a) The frequency of occurrence

b) Whether errors appear to occur systematically or randomly in time

c) Time between each event

d) Effect of airspace changes, if any, since RVSM implementation

7.3.3. Identify trends

7.3.3.1. The cumulative LHD summary is also used to identify adverse trends. The Scrutiny Group will evaluate grouped event categories and determine whether one particular event type occurs more often than another. This particular analysis can also be applied to geographic regions.

7.3.3.2. The Scrutiny Group will also identify operational trends that may be revealed in the data. If any exist, the Group may make recommendations for reducing the effect of those trends.

7.4. Remedial Recommendations

7.4.1. If adverse trends are identified, the Scrutiny Group will submit recommendations for remedial actions to ensure that operational errors are kept to a minimum and that the airspace being examined continues to satisfy the requirements of the target level of safety, which is necessary to support continued RVSM operations.

7.4.2. It is important to bear in mind that height deviations, as a consequence of operational errors and in-flight contingencies, occur in all airspace irrespective of the separation minimum. The purpose of this monitoring activity is to ensure that operations in RVSM airspace do not induce an increase in the risk of collision from these events and that the total vertical risk does not exceed the agreed overall safety objectives. The actions and measures proposed to reduce risk should not be exclusive to RVSM airspace.

7.5. Reporting

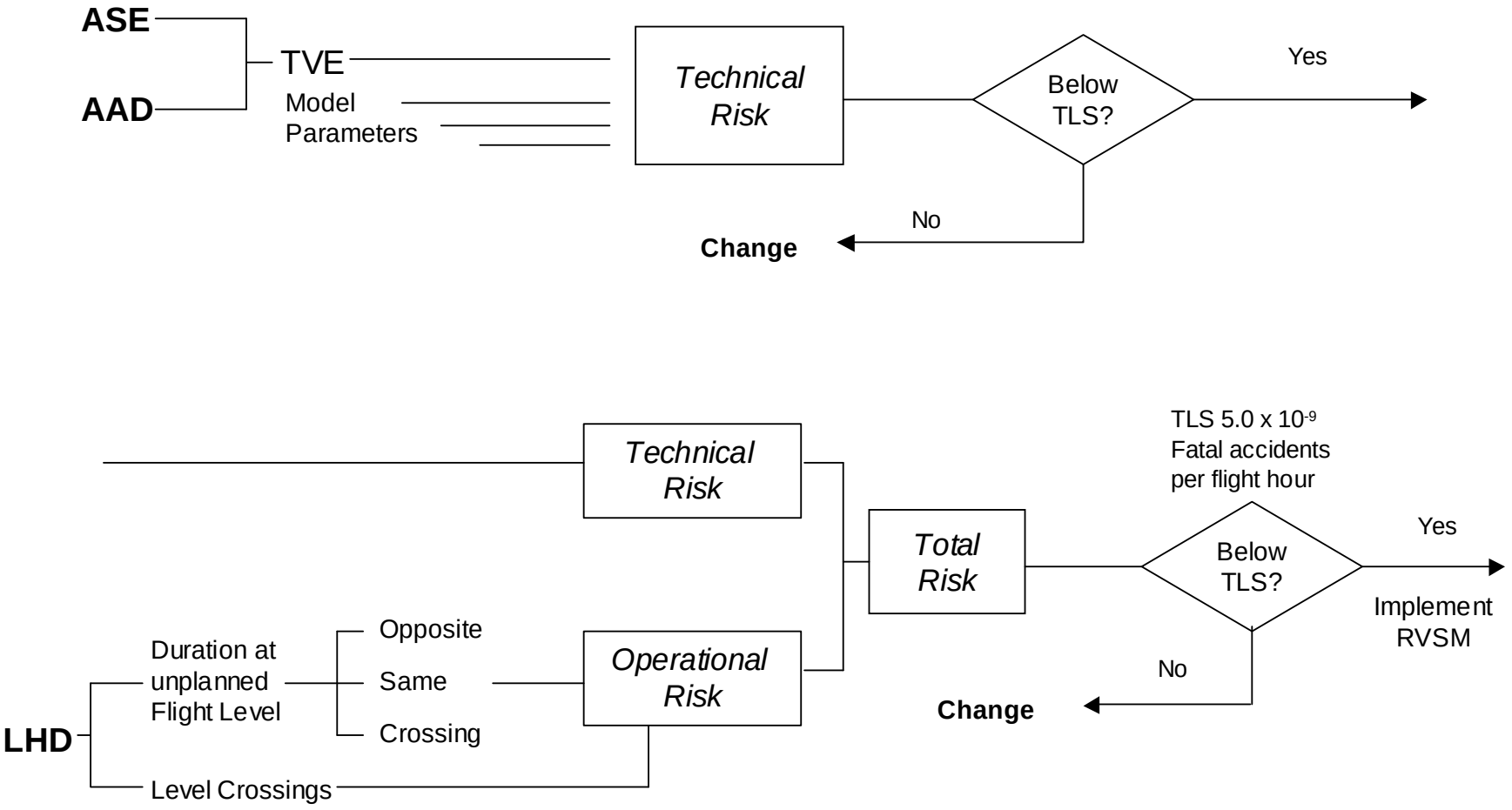
7.5.1. The Scrutiny Group reports annually to the RMA the results of its operational analysis including the identification of performance trends, summary of categories and estimation of duration at incorrect flight level, and recommended measures to reduce the risk in RVSM airspace. The RMA will incorporate the analysis of the Scrutiny Group in its report to the ICAO Regional Planning Group (GREPECAS) for the CAR/SAM regions.

7.6. Meeting Frequency

The Scrutiny Group should meet regularly so that adverse trends due to operational errors that cause large height deviations can be identified quickly and remedial actions can be taken.

Appendix A

RVSM Dataflow and Decision-Making Process Highlighting Scrutiny Activities



Appendix B

Terms of Reference of the CAR/SAM RVSM Grupo de Trabajo de Escrutinio (RVSM/GTE)

a. To assemble subject matter experts, as needed, in air traffic control, aircraft operations and maintenance, regulation and certification, data analysis and risk modeling;

b. To analyze and evaluate large height deviations of 300 ft or greater as defined by ICAO Doc 9574;

c. To coordinate the assembly and review of large height deviation data with the Regional Monitoring Agency;

d. To produce an estimate of flight time away from the cleared flying level to be used a primary input in the preparation of an estimate of risk by the Regional Monitoring Agency;

e. To identify large height deviation trends and to recommend remedial actions in order to improve safety;

f. To report results to GREPECAS through the ATM/CNS subgroup;

g. To accomplish other tasks as directed by GREPECAS.

Composition: 1 State/Organization from the CAR Region, 1 State/Organization from the SAM Region, United States, CARSAMMA, COCESNA, IATA, IFALPA, IFATCA.

Appendix C

CARSAMMA
Caribbean and South American Monitoring Agency

The information contained in this form is confidential and will be used for safety analysis purposes only.

ALTITUDE DEVIATION FORM

Report to the CARSAMMA of an altitude deviation of 300ft or more, including those due to TCAS, Turbulence and Contingency Events

Today's date:	Reporting Unit:		
INCIDENT DETAILS			
Operator Name:	Call Sign:	Aircraft Type:	Mode C Displayed:
Date of Occurrence:	Time UTC:	Occurrence Position (lat/long or Fix):	
Cleared Route of Flight:			
Cleared Flight Level:	Estimated Duration at Incorrect Flight Level (seconds):		Observed Deviation (+/- ft):
Other Traffic Involved:			
Cause of Deviation (*brief title*): (Examples: ATC Loop Error, Turbulence, Weather, Equipment Failure)			

AFTER SEPARATION RESTORED:		
Observed/Reported Final Flight Level*: *Please indicate the source of information – ModeC/Pilot	Mark the appropriate box Is the FL above the cleared level: ❑ Is the FL below the cleared level: ❑	Did this FL comply with the ICAO Annex 2 Tables of Cruising Levels? ❑ Yes ❑ No

NARRATIVE
Detailed Description of Incident (*Please give your assessment of the actual track flown by the aircraft and the cause of the deviation.*)

CREW COMMENTS (IF ANY)

When complete please forward the report(s) to:

Management Center Of Air Navigation Caribbean and South American Monitoring Agency (CARSAMMA)
Av. Brig. Faria Lima, 1941
São José dos Campos, SP
Cep: 12227-000 Brazil
Telephone: (55-12) 3904-5004 or 3904-5010
Fax: (55-12) 3941-7055
E-Mail: carsamma@cgna.gov.br

Appendix D

Grupo de Trabajo de Escrutinio (GTE) Large Height Deviation (LHD) White Paper

Description of Criteria

Note: *The following terms, expressions and definitions are not approved by the ICAO's Council and should be used for analysis of Large Height Deviation purpose only.*

Cleared Flight Level – the flight level at which the pilot was cleared or currently operating (eg, Aircrew accepts a clearance intended for another aircraft and ATC fails to capture the read back error or aircrew conforms to a flawed clearance delivered by ATC)

Reference Flight Level – The altitude that would have provided at least the minimum separation (vertical or horizontal) required

That flight level from which the Height Deviation is calculated; this level may be different from the Cleared Flight Level and must often be determined by the Scrutiny Group operational experts from the data in the Large Height Deviation report

Event Flight Level – the flight level of error, the incorrect altitude of operation for an identifiable period of time without having received an ATC clearance

Height Deviation – any altitude variation of 300ft or greater from the assigned altitude, these variations can be the result of turbulence, equipment malfunction, ATC loop errors, etc.

ATC Loop Errors – any incident where there is a misunderstanding between the pilot and the controller, failure to properly coordinate altitude information or unable to maintain situational awareness

Total Deviation – the total amount of feet between the altitudes of current operation prior to the deviation and the point at which the aircraft is once again under ATC supervision, a deviation that resulted in an increase of altitude will be recorded as a positive number, a deviation that resulted in a decrease of altitude will be recorded as a negative number

Hazard Zone – 300ft buffer zone above and below each flight level (Diagram 1-A)

Duration - length of time that an aircraft was level at an altitude that was not cleared by air traffic control, duration will be recorded in one second increments (Diagram 1-A), if the Scrutiny Group is unable to determine the time spent at incorrect flight level, a default value is assigned. The default values are included in Table 1.

Table 1. Duration Default Values

Radar	**Non-Radar**
90 s	90 s

Levels Crossed – the total number of flight levels between the point that the aircraft exits the cleared flight level and is once again under ATC supervision (Diagram 1-A)

Levels Final – the cleared flight level after the error/deviation

Code – a category and a subcategory assigned to each event (Diagram 1-B)

Rate of Climb or Descent – the climb and descent values are included in Table 2.

Table 2 Climb and Descent Values

Rate of Descent		**Rate of Climb**	
Drift	1000 ft per minute	Minimum	500
Normal	1500+ ft per minute	Normal	750
Rapid	2500+ ft per minute	Expedite	1250

Diagram 1-A

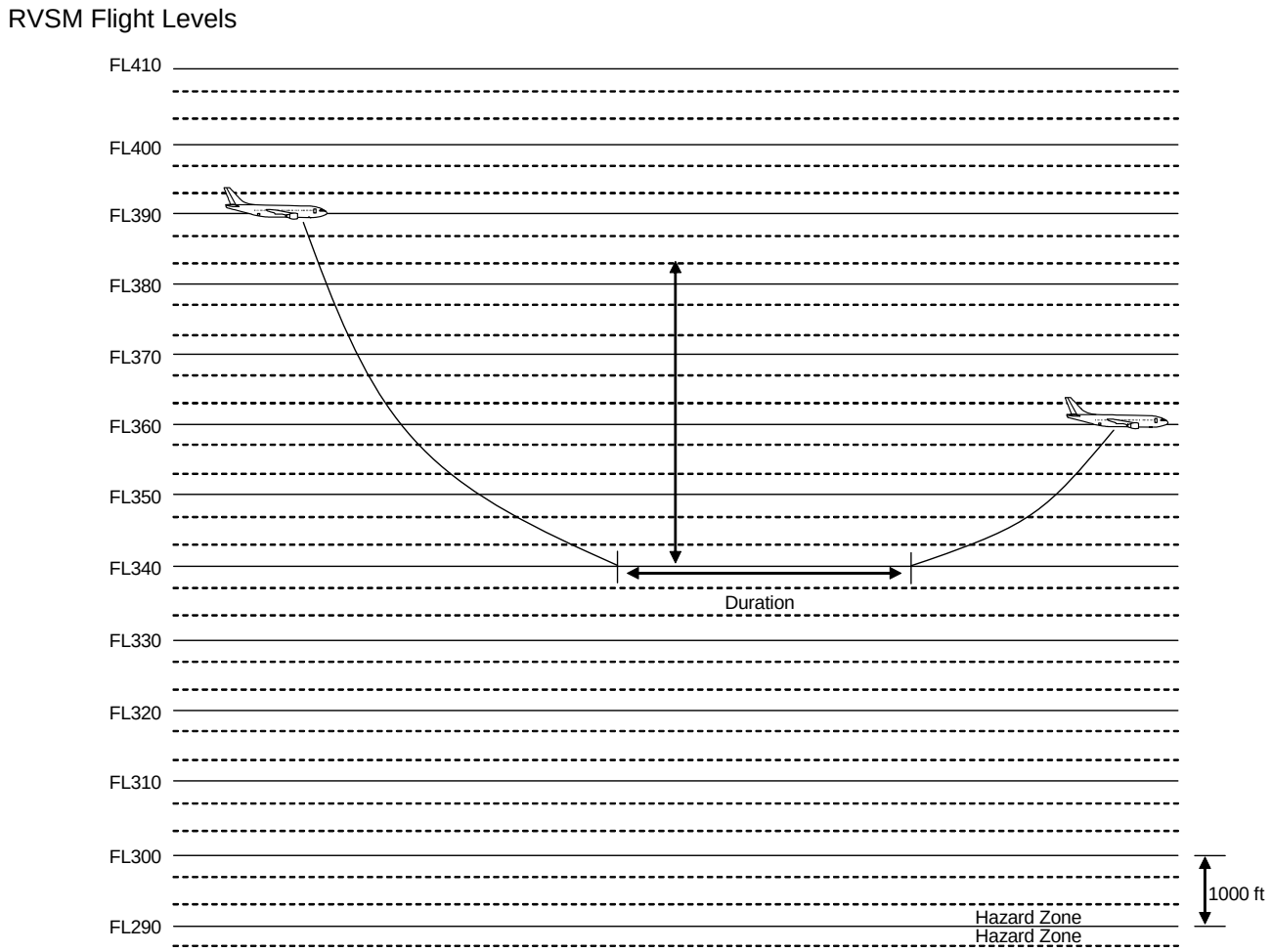

RVSM Flight Levels
FL410
FL400
FL390
FL380
FL370
FL360
FL350
FL340
FL330
FL320
FL310
FL300
FL290
Duration
1000 ft
Hazard Zone
Hazard Zone

Diagram 1-B

Error Codes

Code	Cause of Large Height Deviation
A	Failure to climb/descend as cleared
B	Climb/descend without ATC clearance
C	Entry into airspace at an incorrect flight level
D	Deviation due to turbulence or other weather related cause
E	Deviation due to equipment failure
F	Deviation due to collision avoidance system (TCAS) advisory
G	Deviation due to contingency event
H	Aircraft not approved for operation in RVSM restricted airspace
I	ATC system loop error ; (e.g. pilot misunderstands clearance message or ATC issues incorrect clearance)
J	Equipment control error encompassing incorrect operations of fully functional FMS or navigation system (e.g. by mistake the pilot incorrectly operates INS equipment)
K	Incorrect transcription of ATC clearance or re-clearance into the FMS
L	Wrong information faithfully transcribed into the FMS (e.g. flight plan followed rather than ATC clearance or original clearance followed instead of re-clearance)
M	Error in ATC-unit-to-ATC-unit transition message
N	Negative transfer received from transitioning ATC-unit
O	Other
P	Unknown

Appendix E

2.3.6.7 *Accuracy of SSR Mode C data*

2.3.6.7.1 The use of SSR Mode C data must take account of the following errors affecting accuracy:

a. Correspondence error, reflecting discrepancies between level information used and the level information encoded for automatic transmission. The maximum value of this error has been accepted to be f ± 38 m (125 ft) (95 per cent probability) (cf. ICAO Annex 10, Volume I, Part I, 3.8.7.12.2.5);
b. Flight technical error, reflecting inevitable deviations by aircraft from intended levels as a reaction to flight control operations, turbulence, etc. This error, when related to manually flown aircraft, tends to be larger than that for aircraft controlled by automatic pilots. The maximum value of this error used so far, based on a 95 per cent probability, is ± 60 m (200 ft) (cf. *Report of COM/OPS Divisional Meeting (1966)*, Item 9, page 9-35, 4.2). However, it should be noted that a number of factors contributing to this value have been improved since.

2.3.6.7.2 The mathematical combination of the non-related errors in a) and b) above results in a value of ± 72 m (235 ft) (based on a 95 per cent probability) and it is therefore believed that a value of f ± 90 m (300 ft) constitutes a valid decision criterion to be applied in practice when:

a. Verifying the accuracy of SSR Mode C data;
b. Determining the occupancy of levels.