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Agenda Item 1: Safety Assessment Post RVSM Implementation

**Safety Assessment of the CAR/SAM Regions
After Three Years of RVSM Application**

(Presented by the CARSAMMA)

Summary

The aim of this document is to show, by means of argument and supporting evidence that, how the criteria defined in ICAO Doc 9574 have been met after three years of RVSM implementation in the CAR/SAM regions and what additional corrective actions are needed.

References:

1. Manual on Implementation of a 300 m (1,000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive, International Civil Aviation Organization, Doc 9574, Montreal, March 1992.
2. Review of the General Concept of Separation Panel, Sixth Meeting, Montreal, 28 November – 15 December 1988, ICAO Doc 9536, RGCS/6, Volumes 1 and 2.
3. Review of the General Concept of Separation Panel, Seventh Meeting, Montreal, 30 October - 20 November 1990, ICAO Doc 9572, RGCS/7.
4. The EUR Monitoring Report 2003. EUROCONTROL, edition 1.1, 2003.
5. AP/ATM/11 Final Report.
6. AP/ATM/12 Final Report.
7. AP/ATM/13 Final Report.

1. Introduction

- 1.1 This report shows the results of a safety assessment relevant to the operational phase of implementation of the Reduced Vertical Separation Minimum of 300 m (1000 ft) in the airspace of the Caribbean and South American regions (CAR/SAM). This phase corresponds to the continuation of implementation strategy of the Manual on Implementation of a 300 m (1000 ft) Vertical Separation Minimum between FL 290 and FL 410 inclusive, ICAO, Montreal, Doc 9574, 1st edition 1992, 2nd edition 2000.
- 1.2 According to Doc 9574 the assessment should be carried out to ensure that the operations in the RVSM airspace do not induce an increase in the collision risk, such that the total vertical risk does not exceed the safety objectives established.\
- 1.3 The methodological procedures used are based on the experiences obtained from the RVSM implementation in the North Atlantic and European airspaces and in the CAR/SAM regions airspace (References 1 to 7).

2.0 Context.

2.1 **On Airspace** – the CAR/SAM regions airspace is constituted by 38 Flight Information Regions (FIR) located in the following States: Antigua and Barbuda, Netherlands Antilles, Argentina, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, El Salvador, Ecuador, United States, Grenada, Guadeloupe, Guatemala, Guyana, French Guyana, Haiti, Honduras, Jamaica, Martinique, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, St. Barthelemy, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay and Venezuela.

2.2 **On Traffic Movement Data Collection** – the sample used to estimate the passing frequency and the dynamic and physical parameters of the typical aircraft for the collision risk assessment was collected in the period from 14 to 27 January 2008, as determined in the AP/ATM/9/13 conclusion, thirteenth meeting, held in Colombia, Bogota, in the period between 09 and 13 July 2008. From among the data received from the 38 FIR of the CAR/SAM regions, the data received from three adjacent control centers (ACC), Havana, COCESNA and Panama from Caribbean region, and four adjacent ACC, Curitiba, Brasilia, Recife and Amazonian from South American region, were treated. The sample consisted, in terms of flight hours, of a total of 26, 924 hours received from all ACC, 8,575 hours (~32%) received from the CAR region and 18,349 hours (~68%) from the SAM region. And as in previous occasions, much of the data received from some States could not be used to advantage by different reason: errors in entrance and exit time (e. g. exit time occurring simultaneously to or before the entrance time), lack of information for identifying and locating routes and waypoint position reporting points, etc.

2.3 **Aircraft Population** – in accordance with the orientation guidance to RVSM implementation it is necessary that 100% of the RVSM approved aircraft population meet the RVSM requirements.

2.4 **Data On Vertical Deviations** – in the absence of appropriate ways of providing aircraft height-keeping monitoring, the statistically representative vertical deviations of less than 300 ft from the North Atlantic region (sent by the CMA agency) were used. The atypical large height vertical deviations AAD, collected from the CAR/SAM regions, were added to the typical vertical deviations from NAT for a new fitting of the AAD probability distribution function. The statistical data (mean and standard deviation) of the ASE distribution functions for each group of aircraft types were obtained from the European RVSM monitoring program and are contained in Reference 4.

3.0 Demonstration of the Technical Feasibility of RVSM Application in the CAR/SAM Regions.

3.1 Conditions that Quantify the Global System Performance Specification.

3.2 **Passing Frequency** – the passing frequency was determined individually for each route segment, each airway, each ACC, for the three adjacent ACC of the Caribbean region and for the four adjacent ACC of the South American region, and for the whole airspace of the CAR/SAM regions represented by all the considered ACC. In the Caribbean region, the peak of the passing frequency occurred in the route segment between waypoints UCA and URSUS of the route UA301, which belong to FIR Havana, for aircraft flying in opposite directions. In South America, the passing frequency peak occurred in the FIR Recife in the route segment between waypoints CONDE and SVD of the UW58 airway. The passing frequencies for the CAR/SAM regions are shown in Table 5.

3.3 The estimate for the vertical occupancy on crossing routes was derived from the traffic samples received from the main 7 CAR/SAM FIR in terms of traffic density. The vertical occupancy is estimated to be 0.5488.

3.4 Aircraft Size

3.4.1 The aircraft length, wingspan and height shown in Table 1 were used in the estimation of risk for the CAR/SAM RVSM safety assessment. These numerical values were estimated from the traffic sample.

Aircraft	λ_z Height (NM)	λ_x Length (NM)	λ_y Wingspan (NM)
Average Aircraft	0.0078381	0.0233009	0.0209562

Table 1 - Aircraft Size Used in the CAR/SAM RVSM Safety Assessment

3.4.2 Estimation of the risk for proximate aircraft pairs at adjacent flight levels on crossing routes requires the diameter of the disk representing the shape of an aircraft in the horizontal plane, λ_h . This value has been taken as 0.0233009 NM for average aircraft in the CAR/SAM airspace.

3.5 Relative Aircraft Speeds.

3.5.1 Table 2 presents the numerical values and sources for estimation of relative aircraft speeds used in the CAR/SAM safety assessment. The numerical values of average relative along-track speed and average absolute aircraft ground speed are those obtained from the analysis of the traffic sample. CARSAMMA used the numerical value of relative cross-track speed already used in the safety assessment of other regions, i.e. 20 knots.

3.5.2 The numerical value for the relative horizontal-plane speed of a pair of aircraft on crossing routes in horizontal overlap was determined from the angle of route intersections in a route system analysed assuming that the speed of an individual aircraft is 450.11 knots.

3.5.3 The numerical value of 1.5 knots for relative vertical speed shown in Table 2 is that used in both the NAT and Pacific RVSM safety assessments.

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
$ \Delta V $	Average absolute value of the relative along-track speed between aircraft on same direction routes	18.25 knots	Estimated from CAR/SAM sample
$ \bar{v} $	Average absolute value of the aircraft ground speed	450.11 knots	Estimated from CAR/SAM sample
$ \dot{y} $	Average absolute value of the relative cross track speed for an aircraft pair nominally on the same track	20 knots	Value used in NAT RVSM safety assessment

Parameter Symbol	Parameter Definition	Parameter Value	Source for Value
$\overline{h(\theta)}$	Average absolute value of the relative horizontal speed during overlap for aircraft pairs on routes with crossing angle varying from 5 to 175 degrees	Depends on the angle of intersection	Corresponds to an average aircraft speed of 448.50 knots
\overline{z}	Average absolute value of the relative vertical speed of an aircraft pair that have lost all vertical separation	1.5 knots (all traffic flows)	Value used in NAT and Pacific RVSM safety assessments

Table 2 - Relative Aircraft Speeds Used in the CAR/SAM RVSM Safety Assessment

- 3.6 **Probability of Lateral Overlap** – CARSAMMA used 0.3 NM as a standard deviation of lateral heading to estimate the numerical value of $P_y(0)$. The result of this estimation is a value of 0.0494.
- 3.7 **Probability of Vertical Overlap Attributable to Technical Height-Keeping Performance** - As noted previously, technical risk is considered to arise from the effects of turbulence, loss of height-keeping as well as from aircraft altimetry and altitude-keeping system performance errors. Hence, the estimation of the probability of vertical overlap must take into account the contributions of vertical errors arising from all of these sources.
- 3.7.1 CARSAMMA has compared the results of monitoring aircraft height-keeping performance in the NAT and CAR/SAM regions and has found them to be similar. As a result, and considering the amount of data available, CARSAMMA has used the estimates of ASE from the NAT region in the technical operational safety assessment.
- 3.7.2 The Task Force has consistently called on ATS providers, airspace users and others to forward monthly reports of all sorts of LHD to CARSAMMA. While not all ATS units have provided these monthly reports, those received by CARSAMMA from January through December 2007 have highlighted just a few significant instances of LHD attributable to turbulence. Because of the important effect of this parameter on vertical collision risk, CARSAMMA has taken a cautious approach to specify its numerical value. The approach considered the LHD from the NAT region added to the LHD from the 7 CAR/SAM FIR, which resulted in the values shown in Table 3.

$P_z(1000)$	$P_z(0)$	$P_y(0)$
5.091×10^{-9}	0.4852	0.0496

Table 3 - Results for the Vertical and Lateral Overlap Probability

- 3.8 **Verification of the Global Height Keeping Performance Specification** – Tables 4.1 to 4.3 show that all *TVE* proportions are met simultaneously, verifying that the Global Height Keeping Performance Specification is in agreement, taking into account the conditions in which the data on deviations have been obtained from the NAT airspace and from the CAR/SAM regions.

Phases Proportion	VF	OIP	MP-I	MP-II	MP-III	Threshold
Prob{ TVE ≥ 300}	8.55×10^{-5}	6.04×10^{-5}	1.04×10^{-5}	9.43×10^{-5}	9.45×10^{-5}	2.0×10^{-3}
Prob{ TVE ≥ 500}	2.27×10^{-6}	1.48×10^{-6}	3.02×10^{-6}	2.76×10^{-6}	2.77×10^{-6}	3.7×10^{-6}
Prob{ TVE ≥ 650}	2.13×10^{-7}	1.46×10^{-7}	2.84×10^{-7}	2.61×10^{-7}	2.62×10^{-7}	4.7×10^{-7}
Prob{950 ≤ TVE ≤ 1050}	2.19×10^{-9}	1.67×10^{-9}	2.55×10^{-9}	2.41×10^{-9}	2.42×10^{-9}	5.3×10^{-8}

Table 4.1 – Proportions of Height Keeping Errors (CAR Region)

Phases Proportion	VF	IOP	MP-I	MP-II	MP-III	Threshold
Prob{ TVE ≥ 300}	7.12×10^{-5}	4.69×10^{-5}	5.21×10^{-5}	3.81×10^{-5}	3.81×10^{-5}	2.0×10^{-3}
Prob{ TVE ≥ 500}	1.34×10^{-6}	8.69×10^{-6}	7.29×10^{-6}	6.15×10^{-7}	6.16×10^{-7}	3.7×10^{-6}
Prob{ TVE ≥ 650}	9.81×10^{-7}	7.89×10^{-7}	5.91×10^{-7}	5.89×10^{-8}	5.90×10^{-8}	4.7×10^{-7}
Prob{950 ≤ TVE ≤ 1050}	7.53×10^{-9}	8.79×10^{-9}	6.49×10^{-9}	8.34×10^{-10}	8.36×10^{-10}	5.3×10^{-8}

Table 4.2 – Proportions of Height Keeping Errors (SAM Region)

Phases Proportion	VF	OIP	MP-I	MP-II	MP-III	Threshold
Prob{ TVE ≥ 300}	7.86×10^{-5}	5.05×10^{-5}	6.95×10^{-5}	6.051×10^{-5}	6.060×10^{-5}	2.0×10^{-3}
Prob{ TVE ≥ 500}	1.72×10^{-6}	1.05×10^{-6}	1.49×10^{-6}	1.470×10^{-6}	1.472×10^{-6}	3.7×10^{-6}
Prob{ TVE ≥ 650}	1.43×10^{-7}	9.86×10^{-7}	1.34×10^{-7}	1.395×10^{-7}	1.398×10^{-7}	4.7×10^{-7}
Prob{950 ≤ TVE ≤ 1050}	1.31×10^{-9}	1.11×10^{-9}	1.28×10^{-9}	1.462×10^{-9}	1.466×10^{-9}	5.3×10^{-8}

Table 4.3 – Proportions of Height Keeping Errors (CAR/SAM Regions)

- 3.9 **Identification of the causes of Height Keeping Errors Inconsistency** – the causes of deviations correspond to atmospheric turbulence and other possible flight technical errors as autopilot or even to operational conditions of air traffic control not identified in the incident reports.
- 3.10 **Verification of Technical TLS (Technical Risk)** - The goal is to demonstrate that the TLS of 2.5×10^{-9} fatal accidents per aircraft flying hour is satisfied according to a significant level of confidence. The technical risk that represents the CAR/SAM region was evaluated considering the movements of three different adjacent ACC from the CAR region and four from the SAM region, as was done in the precedent safety analysis. The Havana, COCESNA, Panama, Curitiba, Brasilia, Recife and Amazonian ACC were used at that time. In Table 5 below, the parameters of the Technical Collision Risk Model for the operational phases in 2006 (MP-I), 2007 (MP-II) and 2008 (MP-III) are shown for comparison.
- 3.11 The collision risk was assessed separately for the CAR and SAM regions and for the total CAR/SAM airspace, as shown in Table 6 below.
- 3.12 **Effect of the Growing Traffic** - the evolution of collision risk in the period from 2008 to 2017 was estimated for an annual traffic growing rate of 8 % that directly affects the passing frequency numerical value. The forecasts are shown in Figs. 1, 2 and 3, below. Note that, until 2017, the technical risk will be below the limit of 2.5×10^{-9} . In the figures below, a similar projection is presented for the Verification Phase (VP), Initial Operation Phase (IOP) and Operational Phases (MP-I, MP-II and MP-III) scheduled for years 2004, 2005, 2006, 2007 and 2008, respectively.

PARAMETERS	AIRSPACE								
	CARIBBEAN			SOUTH AMERICA			CAR/SAM REGIONS		
	FM-I	FM-II	FM-III	FM-I	FM-II	FM-III	FM-I	FM-II	FM-III
$P_y(0)$	0.0464	0.0493	0.0500	0.0446	0.0512	0.0492	0.0447	0.0504	0.0494
$P_z(0)$	0.4095	0.4494	0.4508	0.3748	0.4487	0.4338	0.3862	0.4485	0.4852
$P_z(1000)$	8.18×10^{-9}	9.94×10^{-9}	8.06×10^{-9}	1.78×10^{-9}	3.15×10^{-9}	2.463×10^{-9}	3.75×10^{-9}	5.82×10^{-9}	5.091×10^{-9}
$\lambda_x (NM)$	0.0224519	0.023812	0.02418663	0.0206317	0.02387	0.0229706	0.021244	0.0238494	0.02330088
$\lambda_y (NM)$	0.0196701	0.020920	0.02120884	0.0186196	0.02171	0.0208620	0.01897	0.0213892	0.02095623
$\lambda_z (NM)$	0.0067274	0.0071437	0.007224062	0.0062421	0.00722	0.0070315	0.006403	0.0071865	0.0078381
$\lambda_h (NM)$	0.0224519	0.023812	0.02418663	0.0206317	0.02387	0.0229706	0.021236	0.0238494	0.0235078
$ \bar{V} (NM / h)$	470.65	464.70	467.68	442.30	437.59	446.93	451.72	448.50	450.11
$ \overline{\Delta V} (NM / h)$	20	20	20	18.42	18.04	19.21	18.44	18.05	18.25
$ \bar{y} (NM / h)$	20	20	20	20	20	20	20	20	20
$ \bar{z} (NM / h)$	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
$N_x(op)$	0.3361	0.2731	0.3351	0.2397	0.1772	0.2293	0.2873	0.2287	0.2838
$N(same)$	0.0	0.0	0.001	0.0139	0.0043	0.01001	0.0139	0.0043	0.01001
$E_z(cros)$	0.3743	0.3240	0.3492	0.9053	0.4637	0.6845	0.7003	0.3973	0.5488
$S_x(NM)$	80	80	80	80	80	80	80	80	80

Table 5 - Summary of the Technical Vertical Collision Risk Parameters

	CAR	SAM	CAR/SAM
FM-I	0.140×10^{-9}	0.036×10^{-9}	0.076×10^{-9}
FM-II	0.152×10^{-9}	0.043×10^{-9}	0.087×10^{-9}
FM-III	0.151×10^{-9}	0.041×10^{-9}	0.093×10^{-9}

Tabla 6. Technical Collision Risk

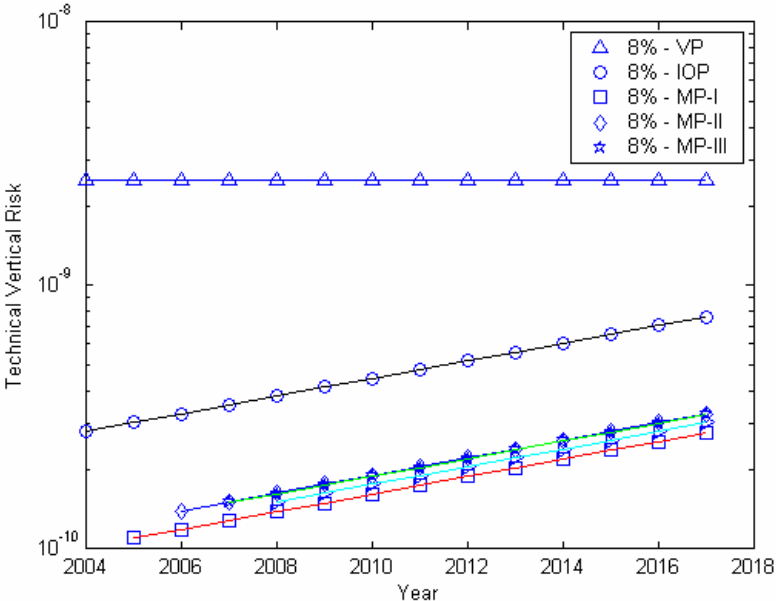


Fig 1 - Technical Collision Risk Forecast for the Caribbean Region

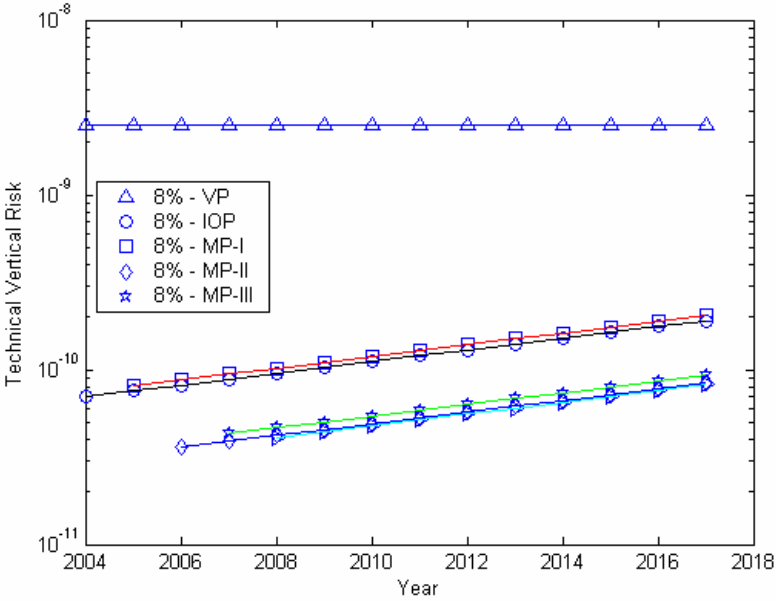


Fig 2 - Technical Collision Risk Forecast for the SAM Region.

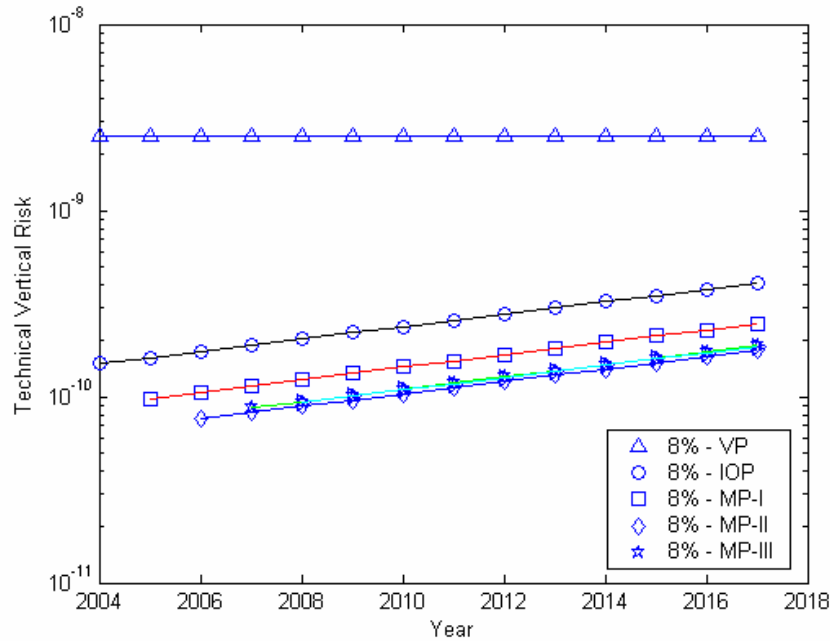


Fig 3. Technical Collision Risk Forecast for the CAR/SAM Regions.

- 4.0 **Operational Risk** - the CRM for operational risk was developed in connection with the CAR/SAM RVSM implementation. As such, it reflects certain operational characteristics of the CAR/SAM airspace that are not common to other airspaces.
- 4.1 The LHD identified through the reports received by CARSAMMA may be due to operational procedures, adverse meteorological conditions or emergency procedures caused by equipment failures or loss of pressurization and can be divided into four main types of group:
- a) ATC-pilot loop errors and incorrect clearances;
 - b) aircraft contingency events;
 - c) deviations due to meteorological effects; and
 - d) deviations due to ACAS (TCAS).
- 4.2 The definition of errors according to the causes was based on the classification approved by the SWG at AP/ATM/11 (REF. 5) and is presented on the paper related to LHD at that meeting. Tables 9 and 10 below show the large deviations (equal to or larger than 1000ft) for the region analyzed, considered operational and received by CARSAMMA, the types and causes of which are described in the Table 9. In Tables 7 and 8, the last two columns refer to the numbers of crossed flight levels, n^{cl} , in the same (s) and opposite (op) direction of flow.

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
12/01/07	CMP489	B737	DAGUD	390	410	2000	90		M	M	PANAMA/OCEANIC	PILOT	90		1	1
17/01/07	AMX017	B762	DAKMO	360	380	2000	90		M	M	PANAMA/OCEANIC	PILOT / MODE C	90		1	1
19/01/07	ALV512	A315	VKA	300	320	2000	90		M	M	SANTO DOMINGO	PILOT / MODE C	90		1	1
20/01/07	RPB7532	MD80	ALPON	390	370	2000	90		M	M	PANAMA/OCEANIC	PILOT	90		1	1
20/01/07	CMP403	B737	AGUJA	400	400	0	0	90	N	N	PANAMA/OCEANIC	MODE C	90			
23/01/07	SAM8478	MD83	DAKMO	320	340	2000	90		M	M	PANAMA/OCEANIC	PILOT / MODE C	90		1	1
23/01/07	CMP488	B738	8NM SUR BUXOS	380	380	0	0	90	N	N	PANAMA/OCEANIC	PILOT	90			
25/01/07	VEC316	B722	BOGAL	390	370	2000	90		M	M	PANAMA/OCEANIC	PILOT / MODE C	90		1	1
26/01/07	AAL996	B763	ARORO	340	360	2000	90		M	M	PANAMA	MODE C	90		1	1
27/01/07	AAL2133	B738	SELEK	330	370	4000	90		M	M	HAVANA	MODE C	90		2	2
27/01/07	DAL144	B763	ETBOD	320	360	4000	30		M	M	PORT AU PRINCE	PILOT	30		2	2
31/01/07	AVA9776	MD83	DAKMO	360	340	2000	90		M	M	PANAMA	MODE C	90		1	1
31/01/07	CMP302	B737	DAKMO	340	380	4000	90		M	M	PANAMA	MODE C	90		2	2
04/02/07	ARG1365	B735	GELIS	350	330	2000	90		M	M	PANAMA CEANIC	PILOT / MODE C	90		1	1
06/02/07	CMP416	E190	BOGAL	300	300	0	90		N	N	PANAMA/OCEANIC	PILOT / MODE C	90			
09/02/07	TPA410	B762	ILTUR	360	380	2000	90		M	M	PANAMA/OCEANIC	PILOT	90		1	1
12/02/07	CMP824	E190	BITIX	380	340	4000	90		M	M	PANAMA/OCEANIC	PILOT	90		2	2

Table 7 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the CAR Region

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
20/02/07	COA745	B738	(182354N 0883854W)	350	370	2000	90		M	M	CENTRAL AMERICAN	MODE C	90		1	1
21/02/07	DAL516	B752	VESKA	340	350	1000	90		M	M	SANTO DOMINGO	PILOT / MODE C		90		1
25/02/07	AAL932	B752	TOKUT	360	340	- 2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
15/03/07	DAL274	B764	BUXOS	300	320	2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
15/03/07	CMP716	E190	ESEDA	340	340	0	90		M	N	PANAMA	MODE C	90			
19/03/07	TSC174	A310	DUXUN	350	370	2000	90		M	M	PANAMA	PILOT	90		1	1
20/03/07	RPB7512	MD83	KAKOL	320	340	2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
25/03/07	CMP437	B737	ARNAL	370	330	- 4000	90		M	M	PANAMA	PILOT	90		2	2
27/03/07	DAL146	B764	BUXOS	300	320	2000	90		M	M	PANAMA	MODE C	90		1	1
05/04/07	AAL930	B752	DIBOK	360	360	0	15		N	N	KINGSTON	PILOT	15			
08/04/07	LNE539	B763	DAGUD	350	370	2000	90		M	M	PANAMA	PILOT	90		1	1
18/04/07	CMP266	B737	AGUJA	380	400	2000	90		M	M	PANAMA	MODE C	90		1	1
01/05/07	RCH633	K35R	PAPIN	360	360	0	0	90	N	N	PANAMA	PILOT	90			
04/05/07	AAL952	A306	BUXOS	320	340	2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
09/05/07	COA654	B752	TILSO	360	380	2000	90		M	M	PANAMA	PILOT	90		1	1

Table 7 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the CAR Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
09/05/07	CMP300	E190	UKLOS	340	380	4000	90		M	M	PANAMA	MODE C	90		2	2
10/05/07	COA882	B737	ARORO	340	380	4000	90		M	M	PANAMA	PILOT / MODE C	90		2	2
14/05/07	DAL742		2008N 07820W	320	300	- 1000	60		M	I	KINGSTON	PILOT / MODE C		60		1
16/05/07	VPBON			360	380	2000	90		M	M	SANTO DOMINGO	PILOT / MODE C	90		1	1
30/05/07	RPB7540	MD81	KAKOL	320	340	2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
26/06/07	UPS383	B752	UKLOS	360	380	2000	90		M	M	PANAMA	MODE C	90		1	1
27/06/07	CMP874	E190	BOGAL	340	300	- 4000	90		M	M	PANAMA	MODE C	90		2	2
27/06/07	MXA381	A319	ISEBA	350	370	2000	90		M	M	PANAMA	MODE C	90		1	1
29/06/07	AVA060	MD83	DAKMO	340	340		90		N	N	PANAMA		90			
01/07/07	LRC661	A320	PAPIN	370	350	- 2000	90		M	M	PANAMA	PILOT	90		1	1
01/07/07	CCCWK	G150	AGUJA	360	400	4000	90		M	M	PANAMA	MODE C	90		2	2
10/07/07	ALV502	A315		340	300	- 4000	90		M	M	SANTO DOMINGO	PILOT	90		2	2

Table 7 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the CAR Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
18/07/07	AVA060	MD80	DAKMO	320	340	2000	90		M	M	PANAMA	MODE C	90		1	1
18/07/07	N270KA	H25B	BUFEO	350	330	-2000	90		M	M	PANAMA	PILOT	90		1	1
31/07/07	LNE539	B763	DAGUD	350	370	2000	90		M	M	PANAMA	PILOT	90		1	1
17/08/07	XAFLY	LJ60	ILTUR	400	430	1000	90		M	M	PANAMA	MODE C		90		1
22/08/07	RPB7372	MD83	AGUJA	360	360	0	90		N	N	PANAMA	MODE C	90			
05/09/07	RPB7540	MD81	KAKOL	320	340	2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
06/09/07	LCO1100	B763	UKLOS	320	340	2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
07/09/07	UPS382	B752	ARNAL	370	370	0	90		N	N	PANAMA	PILOT	90			
13/09/07	UPS383	B752	UKLOS	320	340	2000	90		M	M	PANAMA	PILOT / MODE C	90		1	1
27/09/07	N800EL	H25B	BUFEO	410	410	0	90		N	N	PANAMA					

Table 7 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the CAR Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)	
03/10/07	COA882	B737	ARORO	360	380	2000	90		M	M	PANAMA	MODE C	90		1	1	
03/10/07	MXA374	A320	15NM south of KASOR (1500n 07940W)	360	360	0	90		D / N	D / N	KINGSTON	MODE C	90				
10/10/07	CMP418	B737	1444N 07747W	380	390	1000	90		M	B	KINGSTON	MODE C		90		1	
23/10/07	AAL912	B752	BUXOS	360	360	0	90		N	N	PANAMA	MODE C	90				
23/11/07	COA 654	B752	TILSO	360	380	2000	90		M	M	PANAMA	MODE C	90		1	1	
24/11/07	LAN584	B763	BUXOS	340	340	0	90		N	N	PANAMA	MODE C	90				
20/12/07	VEC202	B722	PYGBY	320	340	2000	30		M	M	PORT AU PRINCE	PILOT	30		1	1	
25/12/07	AAL939	B738	JOSES	310	390	8000	30		M	M	PORT AU PRINCE	PILOT	30		4	4	
												TOTAL Time (s)		4875			
												TOTAL Time (op)			330		
													TOTAL n(s)			58	
													TOTAL n(op)				62

Table 7 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the CAR Region (Continuation)

VENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLR FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
05/01/07	LAN704	A343	00N 042W	330	350	2000	90		M	M	ATLANTICO	PILOT	90		1	1
13/01/07	DAL145	B763	ILKIT	350	350	0	0	90	N	N	MAIQUETIA	PILOT / MODE C	90			
13/01/07	AAL2943	B763	ESIPO	310	310	0	0	90	N	N	MAIQUETIA	PILOT / MODE C	90			
15/01/07	AAL945	B752	IREMI	350	370	2000	120		M	M	LIMA	PILOT	120		1	1
18/01/07	PUA402	B763	ALBAL	290	390	10000	90		M	M	SANTIAGO	PILOT	90		5	5
20/01/07	ARG1364	B735	MIBAS	340	360	2000	10		M	M	SANTIAGO	PILOT / MODE C	10		1	1
24/01/07	SAA205	A346	24S 010W	310	350	4000	90		M	M	ATLANTICO	PILOT	90		2	2
25/01/07	IBE6833	A346	05N 041W	340	360	2000	90		M	M	ATLANTICO	PILOT	90		1	1
27/01/07	AAL2155	B738	ALCOT	370	390	2000	90		M	M	MAIQUETIA	PILOT / MODE C	90		1	1
01/02/07	TPU135	A319	PLG	340	360	2000	360		M	M	LIMA	PILOT	360		1	1
02/02/07	LPE426	B763	KONRI	360	380	2000	90		M	M	COMOD/RIVAD	PILOT	90		1	1
06/02/07	IBE6833	A346	13N 06037W	320	300	-2000	15		M	M	ROCHAMBEAU	PILOT / MODE C	15		1	1
06/02/07	TUS8411	B763	ILKIT	310	310	0	0	90	N	N	MAIQUETIA	PILOT / MODE C	90			
06/02/07	CUB312	IL62	VSJ	350	350	0	0	90	N	N	MAIQUETIA	PIL/MDC	90			
06/02/07	DAL145	B763	ILKIT	350	350	0	0	90	N	N	MAIQUETIA	PIL/MDC	90			
06/02/07	XBKBE	GLF2	ORTIZ	350	350	0	0	90	N	N	MAIQUETIA	PIL/MDC	90			
06/02/07	CIU308	DC10	GERNI/SKBO	380	370	-1000	90		C	C	ASUNCION	PILOT		90		1
07/02/07	ARG1301	A340	KJFK / SAEZ	400	410	1000	90		D	D	ASUNCION	PILOT		90		1
07/02/07	IBE6847	A346	05N 041W	360	360	0	15		M	M	ROCHAMBEAU	PILOT	15			
08/02/07	CWC463	DC10	VSJ	330	330	0	5		N	N	MAIQUETIA	PIL/ MDC	5			

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
08/02/07	CUB7310	B733	ALCOT	330	330	0	0	90	N	N	MAIQUETIA	PILOT / MODE C	90			
08/02/07	TAP165	A310	NANIK	340	360	2000	90		M	M	ATLANTICO	PILOT	90		1	1
10/02/07	CUB312	IL62	ALCOT	370	370	0	0	90	N	N	MAIQUETIA	PILOT / MODE C	90			
12/02/07	LPE565	A319	ILMUX	340	360	2000	180		M	M	LIMA	PILOT	180		1	1
13/02/07	LPE639	A319	ARI	350	330	2000	90		M	M	ANTOFAGASTA	PILOT	90		1	1
14/02/07	TAM8084	A332	JOBER	350	370	2000	90		M	M	ATLANTICO	PILOT	90		1	1
16/02/07	TAM8075	A320	ESIPO	330	350	2000	240		M	M	MAIQUETIA	PILOT / MODE C	240		1	1
16/02/07	ACA091	B763	ISANI	320	340	2000	90		M	M	MAIQUETIA	PILOT / MODE C	90		1	1
16/02/07	N118MT	CL60	KONRI	370	330	4000	90		M	M	ANTOFAGASTA	PILOT	90		2	2
17/02/07	LAN601	B763	AMERO	350	370	2000	30		M	M	LIMA	PILOT	30		1	1
25/02/07	COA30	B762	KOXAM	320	340	2000	20		M	M	GEORGETOWN	PILOT	20		1	1
25/02/07	BBR1323	B763	KONRI	360	330	3000	90		H / M	H / M	ANTOFAGASTA	PILOT / MODE C		90	1	2
04/03/07	SNTRY82	C141	LIXAS	310	310	0	30		N	N	GUAYAQUIL	PIL/MDC	30			
09/03/07	AFR406	B772	1140N 03642W	340	360	2000	15		N	N	ROCHAMBEAU	PILOT	15		1	1
14/03/07	TAP179	A343	NANIK	360	380	2000	90		M	M	ATLANTICO	PIL/MDC	90		1	1
15/03/07	AER7480		SUR	300	340	4000	90		D	D / N	BOGOTA	PILOT	90		2	2
16/03/07	AAL956	B772	PAKON				90		N	N	MAIQUETIA	PILOT	90			
16/03/07	TPA733	B767	VSJ	370	390	2000	90		M	M	MAIQUETIA	PILOT	90		1	1
16/03/07	BBR1323	B752	KIKAS	350	370	2000	90		M	M	MAIQUETIA	PILOT	90		1	1
20/03/07	LPE627	B767	LIXAS	370	370	0	30		N	N	GUAYAQUIL	PIL/MDC	30			

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
21/03/07	VLO7443	MD11	POS - DEKON	320	340	2000	90		M	M	ATLANTICO	PILOT / MODE C	90		1	1
24/03/07	LAN584	B763	SORTA	320	300	-	2000	30	M	M	LIMA	PILOT	30		1	1
29/03/07	DAL147	B764	SORTA	330	350	2000	30		M	M	LIMA	PILOT	30		1	1
02/04/07	VRG8942	B767	VAGAN	360	380	2000	1200		M	M	MAIQUETIA	PILOT	1200		1	1
02/04/07	ARG1380	A310	VAGAN	380	380	0	900		N	N	MAIQUETIA	PILOT	900			
05/04/07	TPU034	A320	ELAKO	340	360	2000	180		M	M	LIMA	PILOT	180		1	1
08/04/07	LCO11040	B763	GELIS	300	310	1000	30		B	B	LA PAZ	PILOT		30		1
09/04/07	MPD525	A343	13N 030W	360	360	0	15		M	N	ROCHAMBEAU	PILOT	15			
11/04/07	VDA4556	IL76	INCAS	380	300	-	8000	90	M	M	ANTOFAGASTA	PILOT / MODE C	90		4	4
11/04/07	IBE6843	A340	1330N 03730W	340	340	0	15		M	N	ROCHAMBEAU	PILOT	15			
11/04/07	LAN705	A343	10N 036W	320	340	2000	15		M	M	ROCHAMBEAU	PILOT	15		1	1
11/04/07	TAM8099	A342	NANIK	380	400	2000	90		M	M	ATLANTICO	PILOT	90		1	1
11/04/07	IBE6865	A343	1330N 03730W	340	340	0	15		M	N	ROCHAMBEAU	PILOT	15			
11/04/07	AVA025	B762	PULTU	360	380	2000	90		M	M	GUAYAQUIL	PILOT / MODE C	90		1	1
11/04/07	MXA1695	B763	LIXAS	390	390	0	90		N	N	GUAYAQUIL	PILOT / MODE C	90			
11/04/07	AVA025	B763	TERAS	360	380	2000	30		M	M	ASUNCION	PILOT	30		1	1
15/04/07	CMP437	B737	VAKUD	370	390	2000	60		M	M	LIMA	PILOT	60		1	1
19/04/07	CIU329	DC10	ENSOL	410	410	0	90		M	M	GUAYAQUIL	PIL/MDC	90		0	0
21/04/07	N5VS	GLF5	VSJ	450	450	0	90		M	M	MAIQUETIA	PILOT	90			
22/04/07	ARG1364	B735	MIBAS	340	300	-	4000	90	M	M	SANTIAGO	PIL/MDC	90		2	2
23/04/07	TPU035	A320	ILMUX	340	360	2000	90		M	M	LIMA	PILOT	90		1	1

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
26/04/07	COA590	B763	ARNEL	370	390	2000	30		M	M	LIMA	PILOT	30		1	1
26/04/07	LAP707	F100	UMKAL	280	300	1000	90		M	M	SANTIAGO	PILOT / MODE C		90		1
03/05/07	GLG600	B732	BOKAN	350	350	0	90		N	N	GUAYAQUIL	PILOT / MODE C	90			
06/05/07	LAN622	B763	ESDIN	320	320	0	90		M	M	ANTOFAGASTA	PILOT	90			
09/05/07	VEC201	B727	20 NM ANTES DE VSJ	310	330	2000	90		M	M	MAIQUETIA	PILOT / MODE C	90		1	1
11/05/07	DAL061	B767	ILKIT	330	350	2000	90		M	M	MAIQUETIA	PILOT / MODE C	90		1	1
11/05/07	SAM113	F100	BOKAN	320	340	2000	90		M	M	GUAYAQUIL	PILOT / MODE C	90		1	1
14/05/07	LAN501	B763	UGUPI	330	350	2000	90		M	M	GUAYAQUIL	PILOT / MODE C	90		1	1
15/05/07	IBE6652	A346	DIMAS	350	370	2000	15		M	M	ROCHAMBEAU	PILOT			1	1
17/05/07	IBE6843	A346	05N 041W	340	370	3000	15		N	N	ROCHAMBEAU	PILOT		15	1	2
17/05/07	MPD975	A332	IRELA	360	0	0	15		N	N	ROCHAMBEAU	PILOT	15			
17/05/07	MPD525	A343	10N 036W	340	340	0	15		M	N	ROCHAMBEAU	PILOT	15			
17/05/07	MXA1695	B763	LIXAS	390	390	0	90		N	N	GUAYAQUIL	PIL/MDC	90			
17/05/07	VEC201	B727	ALCOT	330	330	0	0	90	N	N	MAIQUETIA	PIL/MDC	90			
20/05/07	DAL335	B764	UGUPI	330	330	0	90		N	N	GUAYAQUIL	PIL/MDC	90			
21/05/07	DLH502	B744	1130N 036W	360	360	0	15		N	N	ROCHAMBEAU	PILOT	15			
25/05/07	LNE7604	B763	ENSOL	360	340	2000	90		M	M	GUAYAQUIL	PILOT / MODE C	90			
26/05/07	AAL1089	B738	VODIN	350	370	2000	90		M	M	MAIQUETIA	PIL/MDC	90		1	1
29/05/07	KLM753	MD11	TERAS	400	400	0	90		M	N	GUAYAQUIL	PIL/MDC	90			

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
30/05/07	TAM9537	MD11	DEKON	380	400	2000	90		M	M	ATLANTICO	PILOT / MODE C	90		1	1
30/05/07	LAN621	B763	ESDIN	350	370	2000	90		M	M	ANTOFAGASTA	PILOT	90		1	1
31/05/07	LPE769	B763	LOPES	350	370	2000	90		M	M	ANTOFAGASTA	PILOT	90		1	1
08/06/07	IBE6831	A343	1140N 03642W	340	360	2000	15		N	I / M	ROCHAMBEAU	PILOT	15		1	1
08/06/07	LAN705	A343	1140N 03642W	340	340	0	15		N	N	ROCHAMBEAU	PILOT	15			
12/06/07	AMX010	B762	ESDIN	330	390	6000	420		M	M	LIMA	PILOT	420		3	3
13/06/07	AMX010	B762	KARAZ	390	330	- 6000	90		B / M	M	GUAYAQUIL	PIL/MDC	90		3	3
13/06/07	LAU355	B722	BOKAN	320	360	4000	90		M	M	GUAYAQUIL	PIL/MDC	90		2	2
16/06/07	AFR442	B744	TASIL	340	360	2000	2560		M	M	ATLANTICO	PILOT	2560		1	1
17/06/07	CMP829	B737	ENSOL	390	410	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
18/06/07	CMP307	B737	UGUPI	370	390	2000	90		M	M	GUAYAQUIL	PILOT / MODE C	90		1	1
19/06/07	TPU025	A320	GELIS	330	330	0	0	90	N	N	ANTOFAGASTA	PILOT	90			
20/06/07	LNE517	B763	ENSOL	350	370	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
24/06/07	LRC651	A320	LIXAS	330	350	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
25/06/07	AFR6810	B744	DIKEB	340	360	2000	960		M	M	ATLANTICO	PILOT	960		1	1
03/07/07	MXA1694	B763	KONRI	360	340	- 2000	30		M	M	ANTOFAGASTA	PIL/MDC	30		1	1
04/07/07	LPE581	A319	VAKUD	350	350	0	30	90	M	M	GUAYAQUIL	PIL/MDC	90			
04/07/07	LPE581	B767	VAKUD	390	350	- 4000	30		M	M	LIMA	PILOT	30		2	2
07/07/07	AAL931	B752	ENSOL	370	370	0	90		N	N	GUAYAQUIL	PIL/MDC	90			
13/07/07	LAN503	B763	SORTA	350	370	2000	30		M	M	LIMA	PILOT	30		1	1
13/07/07	LAN503	B763	SORTA	350	370	2000	90		M	M	ANTOFAGASTA	PILOT	90		1	1

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
13/07/07	MXA1691	B763	GELIS	350	370	2000	30		M	M	ANTOFAGASTA	PILOT	30		1	1
14/07/07	LAN501	B763	SORTA	330	350	2000	90		M	M	ANTOFAGASTA	PILOT	90		1	1
16/07/07	AVA075	B762	PULTU	360	360	0	90		N	N	GUAYAQUIL	PILOT / MODE C	90			
16/07/07	COA810	B738	LIXAS	370	370	0	90		N	N	GUAYAQUIL	PILOT / MODE C	90			
16/07/07	ARG1384	A310	GEKAL	300	320	2000	10		M	M	ANTOFAGASTA	PIL/MDC	10		1	1
21/07/07	MPD525	A343	0843N 03527W	340	340	0	15		M	N	ROCHAMBEAU	PILOT	15			
21/07/07	CMP750	B737	SORTA	360	380	2000	30		M	M	LIMA	PILOT	30		1	1
21/07/07	CMP750	B738	SORTA	360	380	2000	90		M	M	ANTOFAGASTA	PILOT	90		1	1
22/07/07	DAL199	B752	ENSOL	330	370	4000	90		M	M	GUAYAQUIL	PIL/MDC	90		2	2
22/07/07	ACA092	B763	SISEL	330	350	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
22/07/07	LAN573	B763	PULTU	340	360	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
22/07/07	LAN573	B767	TERAS	340	360	2000	30		M	M	LIMA	PILOT	30		1	1
22/07/07	CMP750	B737	SORTA	360	380	2000	30		M	M	LIMA	PILOT	30		1	1
22/07/07	CWC463	DC10	BOKAN	360	300	- 6000	90		M	M	GUAYAQUIL	PIL/MDC	90		3	3
23/07/07	GLG603	B732	BOKAN	340	320	- 2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
27/07/07	COA653	B752	VAMOS	350	370	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
27/07/07	TPU029	A319	MIRLO	360	380	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
28/07/07	CMP489	B732	UGUPI	390	390	0	90		N	N	GUAYAQUIL	PIL/MDC	90			
03/08/07	TAM3282	A319	CARDO	350	370	2000	90		M	M	RECIFE	MODE C	90		1	1
05/08/07	AAL2111	A306	UGUPI	290	310	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
07/08/07	IBE6842	A346	MAGNO	370	350	- 2000	120		M	M	ATLANTICO	PILOT	120		1	1

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
08/08/07	SAM112	F100	BOKAN	320	340	2000	60		M	M	GUAYAQUIL	PILOT / MODE C	60		1	1
11/08/07	AVA069	MD83	BOKAN	320	340	2000	180		M	M	GUAYAQUIL	PIL/MODE C C	180		1	1
12/08/07	AFR406	B772	1140N 03642W	340	340	0	15		M	M	ROCHAMBEAU	PILOT	15			
12/08/07	COA810	B738	LIXAS	350	370	2000	180		M	M	GUAYAQUIL	PIL/MODE C	180		1	1
14/08/07	ARG1364	A310	GEKAL	320	330	1000	30		B	B	ANTOFAGASTA	PIL/MODE C		30		1
15/08/07	LPE707	B763	KENOX	340	340	0	15		N	N	ROCHAMBEAU	SBAO ACC	15			
16/08/07	AMX011	B763	KARAZ	380	340	-	180		M	M	GUAYAQUIL	PILOT / MODE C	180		1	1
17/08/07	LPE511	B763	UGUPI	330	350	2000	120		M	M	GUAYAQUIL	PIL/MODE C	120		1	1
17/08/07	KRE2185	B722	ALCOT	320	320	0	90		N	N	MAIQUETIA	MODE C	90			
17/08/07	HCCEZ	E190	NOREX	360	360	0	90		M	M	MAIQUETIA	MODE C	90			
17/08/07	AVA091	MD83	NOREX	320	320	0	90		M	M	MAIQUETIA	MODE C	90			
20/08/07	AMX019	B737	ARNEL	340	360	2000	60		M	M	GUAYAQUIL	PIL/MDC	90		1	1
20/08/07	VPBOZ	F900	NANIK	400	430	1000	300		M	M	ATLANTICO	PILOT		90		1
21/08/07	IBE6845	A346	NANIK	360	380	2000	60		M	M	ATLANTICO	PILOT	60		1	1
22/08/07	LPE429	B763	GELIS	370	390	2000	30		M	M	LIMA		30		1	1
23/08/07	LPE582	A319	TERAS	350	370	2000	120		M	M	GUAYAQUIL	PIL/MDC	120		1	1
28/08/07	ARG1136	B744	POS - FOZ	330	310	-	90		P	P	ASUNCION	PILOT	90		1	1
30/08/07	DLH502	B744	1100N 03630W	340	340	0	15		M	M	ROCHAMBEAU	PILOT	15			
30/08/07	LAN705	A343	0912N 03540W	340	340	0	15		N	N	ROCHAMBEAU	PILOT	15			
30/08/07	CMP273	E190	SISEL	350	370	2000	60		M	M	GUAYAQUIL	PIL/MDC	60		1	1

Table 8. Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
01/09/07	ARG1134	B744	NEURA	330	350	2000	80		M	M	ATLANTICO	PILOT	80		1	1
01/09/07	LNE1447	A320	GELIS	330	350	2000	30		M	M	ANTOFAGASTA	PILOT / MODE C	30		1	1
03/09/07	TAP156	A332	INTOL	370	390	2000	240	90	M	M	ATLANTICO	PILOT	90		1	1
14/09/07	MXA1692	B763	KONRI	360	340	-2000	30		M	M	ANTOFAGASTA	PILOT / MODE C	30		1	1
15/09/07	BW491	B738	EGEMA	410	390	-2000	600	90	M	M	GEORGETOWN	PILOT	90		1	1
16/09/07	TPA601	B763	PUERTO LEGIZANO	380	360	-2000	48		M	M	LIMA	PILOT	48		1	1
22/09/07	DLH504	A343	REGIS	310	350	4000	90		M	B	ATLANTICO	PILOT	90		2	2
28/09/07	FDX44	MD11	ILKUT RUTA RNAV	310	330	2000	90		M	M	MAIQUETIA	PILOT / MODE C	90		1	1
28/09/07	LAU335	B721	NOREX			0	90		N	N	MAIQUETIA	PILOT	90			
29/09/07	CMP273	E190	SISEL	350	390	4000	2580	90	M	M	GUAYAQUIL		90		2	2
01/10/07	CMP279	B738	PLG	330	350	2000	30		M	M	LIMA	PILOT	30		1	1
02/10/07	TPU023	A320	GELIS	350	330	-2000	30		M	M	ANTOFAGASTA	MODE C	30		1	1
02/10/07	MAA6871	B763	URIBI	310	330	2000	180		M	M	MAIQUETIA	PILOT	180		1	1
02/10/07	LCO1731	B767	ESIPO	350	310	-4000	720		M	M	MAIQUETIA	PILOT	720		2	2
06/10/07	LAN621	B763	KARAZ	330	350	2000	30		M	M	LIMA	PILOT	30		1	1
09/10/07	COA653	B752	MOXAS	390	410	2000	1200	90	M	M	GUAYAQUIL	PILOT / MODE C	90		1	1
11/10/07	MPD525	A343	0752N 03505W	320	320	0	15	180	M	N	ROCHAMBEAU	SBAO ACC	180			
12/10/07	LAN531	B763	UGUPI	350	350	0	600		N	N	GUAYAQUIL	PIL/MDC	600		1	1
13/10/07	AAL2111	B763	SISEL	350	370	2000	300		M	M	GUAYAQUIL	PILOT / MODE C	300		1	1
14/10/07	AAL917	A306	UGUPI	270	310	2000	90		M	M	GUAYAQUIL	PILOT / MODE C	90		1	1

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
15/10/07	FDX55	A310	15 NM NORTE FROM VOR/DME VSJ	330	350	2000	240		M	M	MAIQUETIA	MODE C	240		1	1
20/10/07	LRC631	A320	AKNIL	350	370	2000	90		M	M	MAIQUETIA	PILOT	90		1	1
26/10/07	UAL842	B763	LOGON	340	340	0	90		N	N	MAIQUETIA	PILOT	90			
26/10/07	GTI074	B744	IREMI	400	400	0	90		N	N	ANTOFAGASTA	MODE C	90			
27/10/07	UPS382	B752	ENSOL	370	390	2000	300	90	M	M	GUAYAQUIL	PIL/MDC	90		1	1
27/10/07	AFR443	B744	INTOL	310	330	2000	240	90	M	M	ATLANTICO	PILOT	90		1	1
28/10/07	LAN570	B763	ARI	320	340	2000	30		M	M	ANTOFAGASTA		30		1	1
30/10/07	LAN603	B767	KARAZ	330	350	2000	30		M	M	LIMA	PILOT	30		1	1
11/11/07	LXP338	B732	50NM NORTH FROM VTN VOR	320	340	2000	30		B	B	SANTIAGO	MODE C	30		1	1
16/11/07	AMX010	B762	OSELO	330	370	4000	90		M	M	GUAYAQUIL	PIL/MDC	90		2	2
16/11/07	LNE443	B763	GELIS	330	350	2000	30		M	M	ANTOFAGASTA	PIL/MDC	30		1	1
17/11/07	MPH061	MD11	PULTU	320	340	2000	90		M	M	GUAYAQUIL	PILOT / MODE C	90		1	1
18/11/07	LAN621	B767	ARNEL	330	350	2000	30		M	M	LIMA	PILOT	30		1	1
18/11/07	AAL957	B767	VAKUD	350	330	-2000	30		M	M	LIMA	PILOT	30		1	1
19/11/07	ARG1364	B735	MIBAS	300	320	2000	10		B	B	SANTIAGO	MODE C	10		1	1
20/11/07	TPU033	A320	LIXAS	350	350	0	90		N	N	GUAYAQUIL	PIL/MDC	90			
24/11/07	MPD924	A332	BOKAN	350	350	0	90		N	N	GUAYAQUIL	PIL/MDC	90			
24/11/07	CMP436	E190	PADOX	340	360	2000	90		M	M	GUAYAQUIL	PIL/MDC	90		1	1
24/11/07	TPU053	A320	LIXAS	350	350	0	90		M	M	GUAYAQUIL	PILOT / MODE C	90			

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CAR SAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
29/11/07	VLO7441	DC10	JOBER	350	350	0	3600		M	M	ATLANTICO	MODE C	3600			
30/11/07	LPE707	B763	BISUK at FIR boundary	320	340	2000	15		M	M	ROCHAMBEAU					
30/11/07	IBE6651	A346	1018N 04706W at FIR boundary	340	360	2000	15		M	M	ROCHAMBEAU	PILOT	15		1	1
01/12/07	MXA1692	B763	ARNEL	340	360	2000	30		M	M	GUAYAQUIL	PILOT / MODE C	30		1	1
03/12/07	ARG1141	A342	TASIL	340	360	2000	180		M	M	ATLANTICO	PILOT	180		1	1
03/12/07	TAP176	A332	MAGNO	370	390	2000	120		M	M	ATLANTICO	PILOT	120		1	1
05/12/07	SAM181	F100	BOKAN	320	340	2000	20		M	M	GUAYAQUIL	PILOT / MODE C	20		1	1
09/12/07	AAL945	B763	LIXAS	310	330	2000	20		M	M	GUAYAQUIL	PILOT / MODE C	20		1	1
10/12/07	SOO575	B742	SORTA	330	310	-2000	90		M	M	ANTOFAGASTA	PILOT / MODE C	90		1	1
12/12/07	PROPP	H25A	OTONI	400	400	0	15		N	N	ROCHAMBEAU	PILOT	15			
14/12/07	MXA1692	B763	KONRI	320	340	2000	30		M	N	ANTOFAGASTA	PILOT / MODE C	30		1	1
15/12/07	N270KA	HS54	SISEL	350	350	0	30		N	N	GUAYAQUIL	PILOT / MODE C	30			
16/12/07	CMP435	B737	UGUPI	370	390	2000	20		M	M	GUAYAQUIL	PILOT / MODE C	20		1	1
17/12/07	TPU041	A321	LIXAS	330	330	0	20		N	N	GUAYAQUIL	PILOT / MODE C	20			
18/12/07	AFR459	A342	EPODE	350	370	2000	1320		M	M	ATLANTICO	PILOT	1320		1	1
18/12/07	DMJ1005	B737	NANIK	330	320	-1000	3600	90	M	M	ATLANTICO	PILOT		90		1

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)	
19/12/07	LNE1448	A320	PADOX	320	340	2000	15		M	M	GUAYAQUIL	PILOT / MODE C	15		1	1	
19/12/07	MAA6323	B763	MOXAS	350	330	-2000	15		M	M	GUAYAQUIL	PILOT / MODE C	15		1	1	
20/12/07	LAN531	B763	UGUPI	330	330	0	10		N	N	GUAYAQUIL	PILOT / MODE C	10				
20/12/07	KLM753	MD11	PULTU	340	360	2000	30		M	M	GUAYAQUIL	PILOT / MODE C	30		1	1	
21/12/07	IBE6821	A343	NANIK	340	350	1000	1970	90	M	M	ATLANTICO	PILOT		90		1	
23/12/07	TAM8080	A332	KOXAM	360	380	2000	90		M	M	GEORGETOWN	PILOT	90		1	1	
23/12/07	TAP177	A332	NANIK	360	360	0	90		M	M	ATLANTICO	PILOT	90				
24/12/07	MPH664	B763	08N 054W	370	370	0	15		M	N	ROCHAMBEAU	PILOT	15				
25/12/07	PTU024	A320	KONRI	320	340	2000	30		M	M	ANTOFAGASTA	PILOT / MODE C	30		1	1	
26/12/07	CMP273	E190	SISEL	350	330	-2000	15		M	M	GUAYAQUIL	PILOT / MODE C	15		1	1	
27/12/07	LAN531	B763	IREMI	370	370	0	90		N	N	ANTOFAGASTA	PILOT	90				
27/12/07	AVA075	B762	PULTU	360	400	4000	20		M	M	GUAYAQUIL	PILOT / MODE C	20		2	2	
27/12/07	LNE1447	A320	KONRI	340	360	2000	30		M	M	ANTOFAGASTA	PILOT / MODE C	30		1	1	
													TOTAL Time (s)		26298		
													TOTAL Time (op)			705	
													TOTAL n(s)				166
													TOTAL n(op)				176

Table 8 - Operational LHD (Equal to or Larger than 1000ft) Received by CARSAMMA from the SAM Region (Continuation)

Error Type	LHD CAUSE
A	Failure to climb/descend as cleared
B	Climb/descent 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 (ACAS/TCAS) advisory
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)
M	Error in ATC-unit-to-ATC-unit transition message
N	Negative transfer received from transitioning ATC-unit
O	Others
P	Unknown

Table 9 - Classification of the Received LHD

4.3 Classification of errors for risk evaluation

4.3.1 The causes of the group errors were classified and they contribute to two different events:

- *Aircraft levelling at the wrong flight level;*
According to Tables 7 and 8, 272 aircraft levelled at wrong flight levels for 32208 seconds, with an average time of 0.0328922 hours spent in the wrong flight level and nine of them in the opposite direction of the flow.
- *Aircraft climbing/descending through one or more flight levels.*
According to Tables 7 and 8, 462 crossings of flight levels occurred without ATC clearance, 176 of them in the opposite direction of the flow.

4.3.1 All the deviations due to non-severe meteorological effects (larger than or equal to 300ft and lesser than 1000ft) were considered in the AAD distribution.

4.3.2 With respect to the deviations due to ACAS (TCAS), a distribution function formed by the typical and atypical behavior of the deviations was constructed, using a model of double-double exponential form. In this case, the data of the typical behavior were from the NAT region.

4.3.3 The density function $f_{ACAS}^{AAD}(a)$ so obtained was then convoluted with the density function $f^{ASE}(a)$, to generate a $f_{ACAS}^{TVE}(z)$ density function and, finally, to produce an estimate for the vertical overlap probability due to ACAS (TCAS), $P_z(S_z)_{ACAS}$.

4.4 Determination of the appropriate parameter values for each group of classified errors

4.4.1 The calculations were done separately for each region (CAR and SAM) and for the whole CAR/SAM airspace. For both airspaces, the same data (Table 10) of aircraft levelling at wrong flight level n^{wl} , number of flight levels crossed without clearance n^{cl} and average time spent in wrong flight level \bar{t}_{wl} were used. The climb/descent rate $\overline{|\dot{z}_c|}$ was assumed to be 10 kt.

4.4.2 In Table 11 below, the group error parameters are shown, classified according to their application to the CAR/SAM regions. In this table, $P_z^{wl}(1000)$ is the vertical overlap probability due to an aircraft levelling at a wrong flight level and $P_z^{cl}(1000)$ is the vertical overlap probability due to an aircraft that crosses one or more flight levels without ATC clearance. The parameters α^{wl} and α^{cl} refer to the error rates for aircraft levelling at a wrong flight level and aircraft crossing a flight level without ATC clearance, respectively. The product $\alpha^{wl} \times \bar{t}^{wl}$ is the proportion of flying time spent in a wrong flight level.

AIRSPACE									
PARAMETERS	CARIBBEAN			SOUTH AMERICA			CAR/SAM REGIONS		
	MP-I	MP-II	MP-III	MP-I	MP-II	MP-III	MP-I	MP-II	MP-III
n^{wl}	26	61	62	17	52	210	43	113	272
n_{same}^{wl}	24	56	58	17	46	200	41	102	258
n_{op}^{wl}	2	5	4	0	7	10	2	12	14
n_{same}^{cl}	2	9	58	5	0	166	7	9	224
n_{op}^{cl}	4	33	62	9	6	176	13	39	238
n^{cl}	6	42	120	14	6	342	20	48	462
\bar{t}_t^{ne}	0.01811 h	0.02010 h	0.02332 h	0.04118 h	0.08994 h	0.035718 h	0.02723 h	0.05257 h	0.03289 h
\bar{t}_{same}^{wl}	0.01719 h	0.02041 h	0.02335 h	0.04118 h	0.05851 h	0.036525 h	0.02713 h	0.03760 h	0.03356 h
t_{op}^{wl}	0.02917 h	0.01667 h	0.02292 h	0.0	0.29643 h	0.019583 h	0.02917 h	0.17986 h	0.02054 h
t_{same}^{wl}	24.75 min	68.58 min	8.25 min	42.0 min	161.50 min	438.3 min	66.75 min	230.08 min	519.55
t_{op}^{wl}	3.50 min	5.00 min	5.50 min	0.0 min	124.50 min	11.75 min	3.50 min	129.50 min	17.25
t_t^{wl}	28.25 min	73.58 min	86.75 min	42.0 min	286.0 min	450.05 min	70.25 min	359.58 min	536.80
$\left[\dot{z}_c \right]$	10 kt	10kt	10 kt	10 kt	10 kt	10 kt	10 kt	10 kt	10 kt

Table 10 - Operational Errors Data

4.5 Vertical Risk Assessment due to Operational Errors

4.5.1 This section will provide an estimate of the risk associated with all causes connected to RVSM use. The technical and operational risk values are combined to estimate the total risk for the system attributable to all causes.

4.5.2 The vertical collision risk was calculated using the Reich Collision Risk Model associated to each group of LHD. Table 12 shows the numerical values of the following components of the risk:

- N_{az}^{tec} , the technical vertical risk;
- N_{az}^{wl} , the vertical risk due to aircraft levelling at a wrong flight level;
- N_{az}^{cl} , the vertical risk due to an aircraft crossing a flight level without ATC clearance;
- N_{az}^{ACAS} , the vertical risk due to ACAS (TCAS) advisories; and
- N_{az} , the vertical collision risk due to all causes or the total risk.

- 4.5.3 As can be seen in Table 12, the total risk for the CAR/SAM region is greater than the agreed TLS.
- 4.5.4 It is important to note that the total risk was strongly influenced by the LHD, most of them due to errors in ATC-unit-to-ATC-unit transition messages and negative transfer received from transitioning ATC-unit.
- 4.5.5 These types of errors are not caused by the RVSM operation.
- 4.5.6 Considering the above remarks, it can be concluded that is necessary to continue to monitor the LHD to keep them inside acceptable limits.

PARAMETER	CARIBBEAN			SOUTH AMERICA			CAR/SAM REGIONS		
	FM-I	FM-II	FM-III	FM-I	FM-II	FM-III	FM-I	FM-II	FM-III
T (hours)	249,264.0	227,736.0	290,607.0	309,264.0	642,528.0	623,170.0	558,528.0	870,264.0	913,777.0
α^{wl}	1.043×10^{-4}	2.679×10^{-4}	2.133×10^{-4}	5.497×10^{-5}	8.248×10^{-5}	3.370×10^{-4}	7.699×10^{-5}	1.310×10^{-4}	2.977×10^{-4}
α_{mismo}^{wl}	9.628×10^{-5}	2.459×10^{-4}	1.996×10^{-4}	5.497×10^{-5}	7.159×10^{-5}	3.209×10^{-4}	7.341×10^{-5}	1.172×10^{-4}	2.823×10^{-4}
α_{op}^{wl}	8.024×10^{-6}	2.195×10^{-5}	1.376×10^{-5}	0.0	1.089×10^{-5}	1.605×10^{-5}	3.581×10^{-6}	1.379×10^{-5}	1.532×10^{-5}
α^{cl}	2.407×10^{-5}	1.844×10^{-4}	4.129×10^{-4}	4.527×10^{-5}	9.337×10^{-6}	5.488×10^{-4}	3.581×10^{-5}	5.516×10^{-5}	5.056×10^{-4}
α_{same}^{cl}	8.024×10^{-6}	3.952×10^{-5}	1.996×10^{-4}	1.617×10^{-5}	0.0	2.664×10^{-4}	1.253×10^{-5}	1.034×10^{-5}	2.451×10^{-4}
α_{op}^{cl}	1.605×10^{-5}	1.449×10^{-4}	2.133×10^{-4}	2.910×10^{-5}	9.337×10^{-6}	2.824×10^{-4}	2.328×10^{-5}	4.481×10^{-5}	2.605×10^{-4}
Q_{same}	7.171×10^{-8}	8.963×10^{-8}	8.034×10^{-8}	1.331×10^{-7}	9.106×10^{-8}	5.861×10^{-8}	4.858×10^{-8}	4.320×10^{-8}	3.673×10^{-8}
Q_{op}	1.170×10^{-7}	7.318×10^{-8}	7.886×10^{-8}	0.0	4.613×10^{-7}	3.142×10^{-8}	5.222×10^{-8}	2.067×10^{-7}	2.247×10^{-8}
$Q = \alpha^{wl} \times \bar{t}^{wl}$	1.889×10^{-6}	5.385×10^{-6}	4.975×10^{-6}	2.263×10^{-6}	7.418×10^{-6}	1.204×10^{-5}	2.096×10^{-6}	6.886×10^{-6}	9.791×10^{-6}
$P_z(0)$	0.4095	0.4494	0.4508	0.3748	0.4487	0.4338	0.3862	0.4485	0.4852
$P_z^{wl}(1000)$	7.736×10^{-7}	2.420×10^{-6}	2.243×10^{-6}	8.484×10^{-7}	3.328×10^{-6}	5.221×10^{-6}	8.097×10^{-7}	3.088×10^{-6}	4.750×10^{-6}
$P_z^{wl}(1000)_{same}$	7.141×10^{-7}	2.255×10^{-6}	2.100×10^{-6}	8.484×10^{-7}	1.879×10^{-6}	5.085×10^{-6}	7.720×10^{-7}	3.089×10^{-6}	4.598×10^{-6}
$P_z^{wl}(1000)_{op}$	5.951×10^{-8}	1.644×10^{-7}	1.421×10^{-7}	0.0	1.449×10^{-6}	1.363×10^{-7}	3.766×10^{-8}	1.112×10^{-6}	1.527×10^{-7}
$P_z^{cl}(1000)$	3.239×10^{-8}	2.635×10^{-7}	5.966×10^{-7}	5.651×10^{-8}	1.347×10^{-8}	7.718×10^{-7}	4.586×10^{-8}	7.928×10^{-8}	7.926×10^{-7}
$P_z^{cl}(1000)_{same}$	1.080×10^{-8}	5.646×10^{-8}	2.884×10^{-7}	2.018×10^{-8}	0.0	3.746×10^{-7}	1.605×10^{-8}	1.486×10^{-8}	3.843×10^{-7}
$P_z^{cl}(1000)_{op}$	2.159×10^{-8}	2.070×10^{-7}	3.082×10^{-7}	3.633×10^{-8}	1.347×10^{-8}	3.972×10^{-7}	2.981×10^{-8}	6.441×10^{-8}	4.083×10^{-7}
$P_z^{ACAS}(1000)$	7.511×10^{-9}	2.895×10^{-9}	6.026×10^{-9}	1.668×10^{-9}	9.132×10^{-10}	1.841×10^{-9}	3.515×10^{-9}	1.692×10^{-9}	3.804×10^{-9}

Table 11 - Parameters of the Classified Operational Error Groups

Risk	AIRSPACE									TLS
	CARIBBEAN			SOUTH AMERICA			CAR/SAM REGIONS			
	MP-I	MP-II	MP-III	MP-I	MP-II	MP-III	MP-I	MP-II	MP-III	
N_{az}^{Tec}	1.4×10^{-10}	1.5×10^{-10}	1.5×10^{-10}	3.6×10^{-11}	4.3×10^{-11}	4.1×10^{-11}	7.6×10^{-11}	8.7×10^{-11}	9.3×10^{-11}	5.0×10^{-9}
N_{az}^{ACAS}	1.3×10^{-10}	4.4×10^{-11}	1.1×10^{-10}	3.4×10^{-11}	1.2×10^{-11}	3.0×10^{-11}	7.1×10^{-11}	2.5×10^{-11}	7.0×10^{-11}	
N_{az}^{wl}	2.6×10^{-9}	5.7×10^{-9}	5.8×10^{-9}	8.2×10^{-9}	27.0×10^{-9}	26.9×10^{-9}	6.1×10^{-9}	2.2×10^{-8}	20.3×10^{-9}	
N_{az}^{cl}	3.9×10^{-10}	3.2×10^{-9}	6.2×10^{-9}	8.8×10^{-10}	1.8×10^{-10}	7.9×10^{-9}	6.7×10^{-10}	9.8×10^{-10}	8.4×10^{-9}	
N_{az}^{Total}	3.3×10^{-9}	9.1×10^{-9}	12.3×10^{-9}	9.0×10^{-9}	27.0×10^{-9}	34.9×10^{-9}	6.9×10^{-9}	23.0×10^{-9}	28.9×10^{-9}	

Table 12 - Collision Risks for the CAR/SAM Regions

4.6 Determination of the limit of time that the aircraft can spend at a wrong flight level when flying in the same direction as another aircraft at the same flight level

- 4.6.1 The proportion of time the aircraft spends at a wrong flight level is defined by the product of the error rate for the aircraft levelling at a wrong flight level, α^{wl} , and the average time spent at the wrong flight level, \bar{t}^{wl} , that is, $\alpha^{wl} \times \bar{t}^{wl}$.
- 4.6.2 Fixing the TLS as the limit for the total risk and using the values of technical risk and the risk due to ACAS (TCAS) advisories calculated on the basis of the data collected, the maximum proportion of time that an aircraft can spend in a wrong flight level, the error rates and the respective maximum tolerances are estimated and shown in Table 13 below for a climb/descent rate of 10 kt. Note that the above error rates refer to errors due to aircraft flying at a wrong level and errors due to aircraft crossing levels without ATC clearance.

Parameters	CAR	SAM	CAR/SAM
<i>Total flying time per year (hr)</i>	290,607	623,170	913,777
$(\alpha^{wl} \times \bar{t}^{wl})_{\max}$	5.597×10^{-7}	6.883×10^{-7}	5.455×10^{-7}
α_{\max}^{wl}	2.400×10^{-5}	1.927×10^{-5}	1.658×10^{-5}
α_{\max}^{cl}	1.683×10^{-4}	1.981×10^{-4}	5.455×10^{-7}
t_{\max}^{wl} (s/ year)	585.55	1.544.20	1794.42
n_{\max}^{cl} (per/ year)	49	123	145

Table 13 Proportion of Time, Error Rates and Maximum Tolerances for Flight Level Crossings Without ATC Clearance and Time Spent at Wrong Flight Levels per Year.

4.7 Remedial Actions.

- 4.7.1 Assuming no flight level crossing without ATC clearance, it can be concluded from Table 13 that about 1,794 seconds per year of aircraft levelling at the wrong level can be tolerated. On the other hand, assuming no aircraft levelling at a wrong flight level, 145 flight-level crossings without ATC clearance with a rate of climb/descent of 10 kt can be tolerated without exceeding the agreed TLS.
- 4.7.2 So, to reduce the risk, the time spent at wrong flight levels and the number of flight levels crossed without ATC clearance must be reduced. Remedial actions must be taken in order to reduce the causes of transition messages between ATC units and negative transfer received from transitioning ATC-unit.

4.8 Risk Assessment for RVSM Operational in the CAR/SAM Regions.

- 4.8.1 This section provides a risk assessment associated with all causes involving the use of RVSM. CARSAMMA has decided to consider that errors of type M and N do not influence in the application of the RVSM, that is, that these kinds of errors, when they occur, will lead to LHDs regardless the value of the RVSM applied. Therefore, in Tables 14 and 15 only the errors that are directly related to the application of RVSM are presented.
- 4.8.2 The calculations have demonstrated that, for this assessment, the consideration above is equivalent to taking corrective actions resulting from the introduction of an efficient program of corrective measures to eliminate the errors in ATC-unit-to-ATC-unit transition message (type M) and in negative transfer received from transitioning ATC-unit (type N).

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
14/05/07	DAL742		2008N 07820W	320	300	- 1000	60		M	I	KINGSTON	PILOT / MODE C		60		1
03/10/07	MXA374	A320	15NM south of KASOR (1500n 07940W)	360	360	0	90		D / N	D / N	KINGSTON	MODE C	90			
10/10/07	CMP418	B737	1444N 07747W	380	390	1000	90		M	B	KINGSTON	MODE C		90		1

TOTAL Time (s)		90		
TOTAL Time (op)			150	
	TOTAL n(s)			0
	TOTAL n(op)			2

Table 14 - Large Operational Errors in the CAR Region, Without Errors of the Types M and N

EVENT DATE	FLIGHT IDENT	ACFT TYPE	POSITION	CLRD FL	EVENT FL	HT LHD	DURATION	DUR GTE	CODE	COD GTE	FIR	SOURCE	Time (S)	Time (Op)	n (S)	n (Op)
06/02/07	CIU308	DC10	GERNI / SKBO	380	370	- 1000	90		C	C	ASUNCION	PILOT		90		1
07/02/07	ARG1301	A340	KJFK / SAEZ	400	410	1000	90		D	D	ASUNCION	PILOT		90		1
25/02/07	BBR1323	B763	KONRI	360	330	- 3000	90		H / M	H / M	ANTOFAGASTA	PILOT / MODE C		90	1	2
15/03/07	AER7480		SUR	300	340	4000	90		D	D / N	BOGOTA	PILOT	90		2	2
08/04/07	LCO11040	B763	GELIS	300	310	1000	30		B	B	LA PAZ	PILOT		30		1
08/06/07	IBE6831	A343	1140N 03642W	340	360	2000	15		N	I / M	ROCHAMBEAU	PILOT	15		1	1
14/08/07	ARG1364	A310	GEKAL	320	330	1000	30		B	B	ANTOFAGASTA	PILOT / MODE C		30		1
28/08/07	ARG1136	B744	POS - FOZ	330	310	- 2000	90		P	P	ASUNCION	PILOT	90		1	1
22/09/07	DLH504	A343	REGIS	310	350	4000	90		M	B	ATLANTICO	PILOT	90		2	2
11/11/07	LXP338	B732	50NM NORTH FROM VTN VOR	320	340	2000	30		B	B	SANTIAGO	MODE C	30		1	1
19/11/07	ARG1364	B735	MIBAS	300	320	2000	10		B	B	SANTIAGO	MODE C	10		1	1
												TOTAL Time (s)	325			
												TOTAL Time (op)		330		
												TOTAL n(s)			9	
												TOTAL n(op)				14

Table 15 Large Operational Errors in the SAM Region, Without Errors of the Types M and N

4.8.3 **Results** – Table 16 below presents the numerical values of the risks due to errors that are directly related to the application of the RVSM, that is, without including errors of the types M and N.

Risk	CARIBBEAN	SOUTH AMERICA	CAR/SAM REGIONS	<i>TLS</i>
N_{az}^{Tec}	1.5×10^{-10}	4.0×10^{-11}	9.3×10^{-11}	5.0×10^{-9}
N_{az}^{ACAS}	1.1×10^{-10}	3.0×10^{-11}	7.0×10^{-11}	
N_{az}^{wl}	1.3×10^{-9}	1.3×10^{-9}	1.4×10^{-9}	
N_{az}^{cl}	1.9×10^{-10}	5.8×10^{-10}	5.3×10^{-10}	
N_{az}^{Total}	1.7×10^{-9}	1.9×10^{-9}	2.1×10^{-9}	

Table 16 - Collision Risks for the CAR/SAM regions

5 Conclusions

- 5.1 This paper provides estimates of the technical, operational, and total risks for the RVSM operation in the CAR/SAM airspace, and also for all kinds of errors present in the reports.
- 5.2 The number of hours flown that is considered for the risk analysis of the CAR/SAM regions corresponds to the total of flight hours for the ACC Havana, COCESNA and Panama of the Caribbean region, together with the ACC Curitiba, Brasilia, Recife and Amazonian of the South American region. In short, the SAM region contributes with 68% of the total flight hours and the CAR region with 32%.
- 5.3 With respect to data on traffic movement, vertical deviations (*ASE* and *AAD*) and lateral deviations, the same conclusions and recommendations in the report of the latest assessment (AP/ATM/13) remain valid.
- 5.4 All the proportions of the TVE are satisfied simultaneously, demonstrating that the global height-keeping performance specification is in agreement with the values published in ICAO Doc 9574.
- 5.5 The technical vertical collision risk for the Caribbean region, South American region and for all airspace of the CAR/SAM regions was evaluated separately. All regions show numerical values of the technical risk below the TLS, under the same assumptions used in the report presented in the AP/ATM/13 meeting.
- 5.6 As can be seen from the values presented above (Table 6), the technical risk estimated three years post implementation of the RVSM is 0.093×10^{-9} . This estimate satisfies the agreed TLS value of no more than 2.5×10^{-9} fatal accidents per flight hour due to the loss of a vertical separation standard of 1000 ft established correctly.

- 5.7 The evaluation of the technical risk for the CAR/SAM regions due to the air traffic growth was carried out for annual growth rates of 8% a year until 2017. The forecast shows that the technical risk will be below the TLS of 2.5×10^{-9} until 2017.
- 5.8 However, the total vertical collision risk due to a combination of technical height-keeping errors and operational errors, evaluated in number of fatal accidents per flight hour, is above the tolerable maximum limit. For the CAR region it is equal to 12.3×10^{-9} , for the SAM region 34.9×10^{-9} , and for the CAR/SAM regions about 28.9×10^{-9} . In order to reduce these values, corrective actions are necessary. The suggested action is to reduce errors of types M and N.
- 5.9 The main operational errors (LHD) collected from the CAR/SAM regions in the period from January to December 2007 are related to transition messages between Air Traffic Control (ATC) units (197 errors of type M), negative transfer received from transitioning ATC unit (63 errors of type N). The other errors can be seen in the Table 17.
- 5.10 The States of the CAR/SAM regions should be aware that each Large Height Deviation (LHD) error corresponds to a warning of danger. As a consequence, remedial actions should be applied independently of whoever holds the responsibilities and independently of the results of the risk evaluation. Therefore, additional remedial actions must be taken to eliminate errors of the following types:
- A - Failure to climb/descend as cleared;
 - B - Climb/descent 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 (ACAS/TCAS) advisory;
 - 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);
- 5.11 The evolution of large errors presented in Table 17 corroborates the conclusions on the collision risk possibilities. Therefore, strong efforts are needed to motivate the States to apply additional safety corrective actions.

LHD Type	VF [*] 2004	IOP 2005	MP-I 2006	MP-II 2007	MP-III 2008
A	2	2	2	-	1
B	3	6	-	1	8
C					1
D					6
E					2
F	-	-	1	-	2
H	-	-	1	-	1
I	-		6	31	2
M	16	4	56	76	197
N	-	-	-	1	63
O	-	-	-	1	-
P	-	-	3	3	1
TOTAL	21	12	68	113	284

* VP – Verification Phase (2004); IOP – Initial Operational Phase (2005);
 MP-I – Monitoring Phase-I (2006); MP-II – Monitoring Phase-II (2007); MP-III – Monitoring Phase-III

Table 17 - Evolution of Large Height Deviations (LHD)

6.0 Special Recommendation

- 6.1 To comply with the resolution of the Fifth Meeting/Workshop of the Scrutiny Group GTE/5, which is transcribed below:
- 6.2 *Taking into consideration that the Scrutiny Group (SG) in analyzing the LHD, verified that errors are not caused by RVSM operation but for common procedures in aircraft transference from an ATC unit to another one. For this reason, new corrective actions at short and mid term were proposed, therefore, GREPECAS/13 considered that these measures are additional to those contained in Conclusion 13/61.*
- 6.3 *In addition to the short-term actions, to find a solution to the identified LHD cause, GREPECAS encouraged States and International Organizations to implement a safety management system and as far as possible, as a technological defense, to gradually implement data communications between ATS (AIDC).*
- 6.4 *On the other hand, GREPECAS/14 considered that in order to significantly reduce the occurrence of this type of errors, CAR/SAM States and International Organizations should, as an urgent matter, commit to adopt the measures referred in Conclusion GREPECAS 13/61 "Measures to reduce operational errors in the ATC coordination loop between adjacent ACC", and particularly the error prevention programme in ATC coordination cycle between adjacent ATS units, associated to the referred conclusion and additional measures previously described (See **Appendix B** to this part of the report).*

7.0 Additional Recommendations

- 7.1 All the recommendations made in the assessment of 2007, which are transcribed below, remain valid:
- 7.2 The recommendations described in this section have the objective of helping in the efforts that will be required by the next tasks associated with the collision risk evaluation after the RVSM implementation in the CAR/SAM regions.
- 7.3 **Data on the Traffic Flow** – approximately 40% of the received data could not be treated due to different reasons: from lack of understanding on how the data should be transcribed to the spreadsheets to inconsistency of data. It is advisable that, before the collection of data, States pay attention to the guidelines developed for this procedure and approved by the RVSM TF.
- 7.4 **Data on Technical Vertical Deviation** – a planning effort should be made to define the best methodology of data collection on technical vertical deviation. Additionally, a work program should be elaborated to show that the Altimetry System Error (ASE) for RVSM-approved aircraft remains steady. This task could be carried out along with the implementation of a monitoring program of the aircraft altimetry system performance. Such program will have to foresee the

monitoring of the mentioned system of altimetry at least each two years or after 1000 flight hours per aircraft (whichever occurs later).

- 7.5 **On Altimetry System Monitoring** - the CAR/SAM regions will have to establish a program for implantation of monitoring units for the verification of aircraft altimetry system. This program will have to be composed of a system of independent monitoring units (AGHME) installed in positions strategically located in the areas of higher traffic flow density. The objective is to monitor the largest possible number of aircraft for verification of the stability of the altimetry system error (ASE) and to check if the technical risk remains compatible with the agreed TLS of 2.5E-9.
- 7.6 **Data on Vertical Deviations due to Operational Errors** - Information on these types of events is obtained through ATC or pilot's reports. Unfortunately important data on these deviations, like number of crossed flight levels and time spent at non-authorized flight level, are rarely informed. As these deviations are consequences of errors or contingency actions, States should develop a work plan to obtain these data with a high level of confidence and share them with CARSAMMA.
- 7.7 States/International Organizations and airlines should continue to apply their best efforts toward obtaining and informing to CARSAMMA of LHD events.