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North American, Central American and Caribbean Office

WORKING PAPER

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09/10/20

CAR/SAM Planning and Implementation Regional Group (GREPECAS) Twentieth Scrutiny Working Group Meeting (GTE/20)

Online. 9 – 11 November 2020

Agenda Item 3: Activities and Tasks to be Reported to GREPECAS

2019 VERTICAL COLLISION RISK (CRM) IN THE CAR/SAM REGIONS

(Presented by CARSAMMA)

EXECUTIVE SUMMARY	
This Working Paper presents a summary of the calculation of the vertical collision risk in the CAR/SAM Regions for 2019, using the CRM methodology.	
Action:	Suggested Actions are included in Section 8
Strategic Objectives:	• Safety
References:	• ICAO Doc 9574 - Manual on a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive, AN/934. third edition - 2012 • ICAO Doc 9937 - Operating Procedures and Practices for Regional Monitoring Agencies in Relation to the Use of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive, AN/477. first edition - 2012 • Aircraft movements in RVSM airspace in 2019 • Reports of Large Height Deviations (LHD) in 2019

1. Introduction

1.1 The purpose of this work is to show that the safety criteria defined in ICAO Doc 9574 and Doc 9937 continue to be met in CAR/SAM RVSM airspace.

1.2 This document reports on the analysis of vertical collision risk in RVSM airspace in 2019 in the Caribbean and South America Flight Information Regions (FIRs). The vertical collision risk model (CRM) calculation methodology was used for this analysis, recommended by ICAO for RVSM airspace.

1.3 The CRM calculation process involves two inputs: RVSM Air Movement files of the studied FIRs, and LHD occurrences in these FIRs.

1.4 CARSAMMA, and the FIRs involved, carry out the validation of LHD throughout the year, bringing a better distribution of the analysis work. With the RVSM Air Movement files, there is a concentration of debugging work, since all are delivered at the beginning of the current year. For this reason, all CARSAMMA members are allocated to the work of debugging the files, since most of the collected files are not delivered following the examples requested by this Agency, requiring time and effort to use at least 85% of the received information.

1.5 Note that three packages of FIR Air Traffic Movements (SAEF, SOOO and MKJK) could not be considered, as a substantial amount of information is missing from them.

1.6 Considering the information above, in recent years, CARSAMMA has been adapting proactively to its duties, improving its staff structure with the inclusion of new employees, intensive training and the acquisition of updated tools for its development.

2. Analysis

2.1 According to Doc 9574 and Doc 9937, the assessment is required to ensure that operations in RVSM airspace do not generate an increase in collision risk, so total vertical risk does not exceed the defined safety targets.

2.2 For the quantitative assessment, the Reich vertical collision risk model is used, as recommended by ICAO. This is a model of intensive mathematical fundamentals that, after analyzing aircraft movements (spreadsheets containing data on flights conducted in RVSM airspace), it calculates the level of safety (TLS) of the flight information region under study.

2.3 The RVSM safety assessment covers twelve consecutive months.

2.4 Special attention should be paid to make sure that:

i. All aircraft operating in reduced vertical separation minima airspace are RVSM-certified;

ii. Aircraft certification is current;

iii. The target level of safety (TLS) of 5×10^{-9} fatal accidents per flight hour continues to be met (for follow-up of a representative sample of aircraft);

iv. The use of RVSM does not increase the level of risk due to operational errors and contingency procedures;

v. There is evidence of the stability of the aircraft altimetry system (ASE);

vi. The introduction of RVSM does not increase the level of risk due to operational errors and flight contingencies, following a predefined level of statistical confidence;

vii. Effective additional safety measures are adopted to reduce the risk of collision due to operational errors and contingency procedures and meet safety goals;

viii. Air traffic control procedures continue to be effective.

3. CAR/SAM airspace

3.1 CAR/SAM airspace covers a broad area extending from the Gulf of Mexico to Patagonia, encompassing 34 flight information regions (FIRs) of the following countries: Antigua, Netherlands Antilles, Argentina, Barbados, Barbuda, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, El Salvador, Ecuador, Grenada, Guadeloupe, Guatemala, Guyana, French Guiana, Haiti, Honduras, Jamaica, Martinique, Nevis, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Saint Barthelemy, St. Kitts, St. Lucia, St. Vincent, Suriname, Trinidad and Tobago, Uruguay, and Venezuela.

3.2 Each part of the airspace was treated as an isolated system, with its own statistical parameters.

3.3 Collection of traffic data – The sample used for assessing the pass frequency and physical and dynamic parameters of typical aircraft to determine the collision risk was collected from 1 December to 31 December 2019 in the 31 CAR/SAM FIRs. In the sample collected, **347,537** lines of flight records were received from the FIRs mentioned above. All records were purged, leaving **303,760** lines of flight records validated in the process. However, all the data was used in another CARSAMMA product, namely the RVSM airspace audit. As in previous years, a large portion of the data received from some States could not be used in the CRM for various reasons, including errors in the entry and exit times of RVSM airspace (less or equal flight entry time), lack of complete information to identify and locate fixed routes and reports, or even data send beyond the deadline.

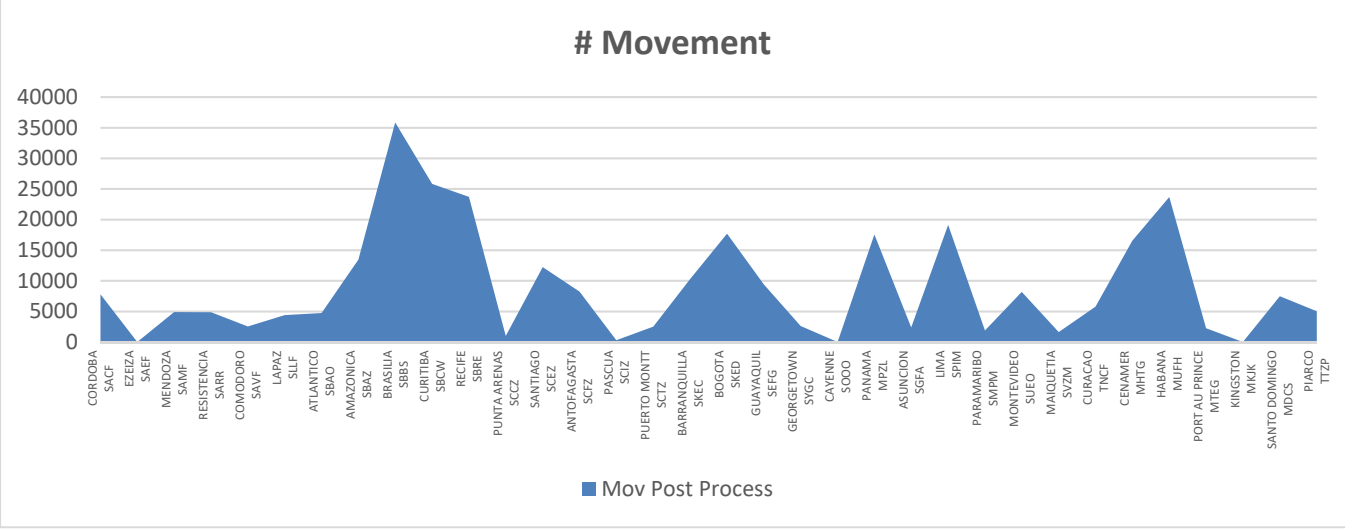

Table 1

3.4 Regarding the occurrence of vertical deviations (LHDs) in the CAR/SAM Regions, **CARSAMMA received a total of 1039 LHD reports in 2019**. **After analysis and validation based on the Risk CRM parameters, 965 of these LHDs were considered valid in the CAR/SAM Regions**.

3.5 Therefore, LHDs analyzed according to CRM parameters, were as follows:

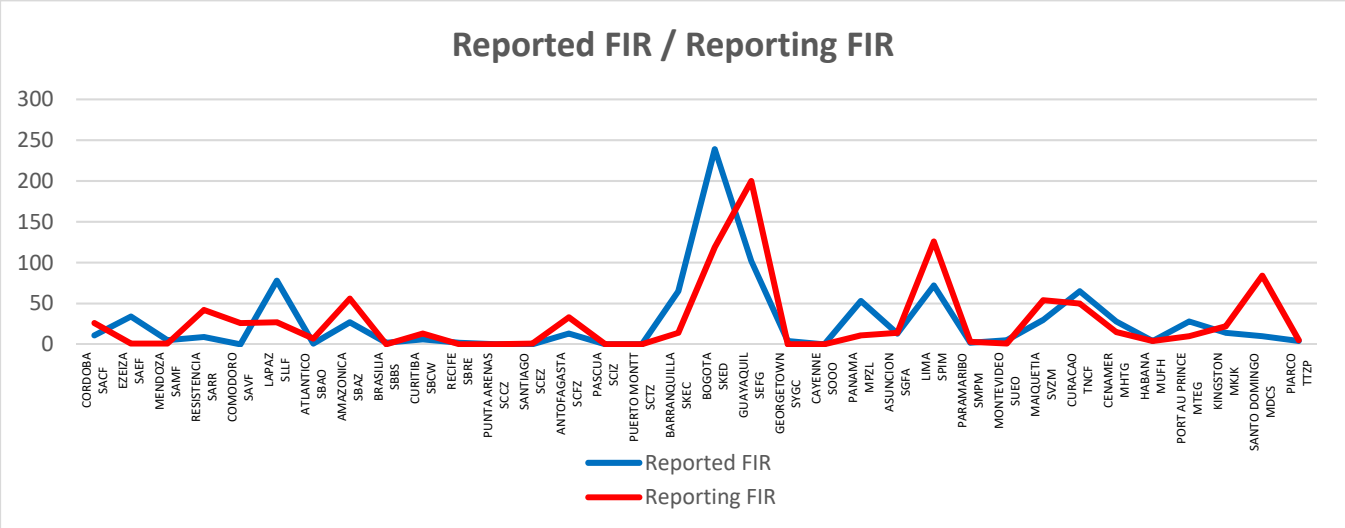

Table 2

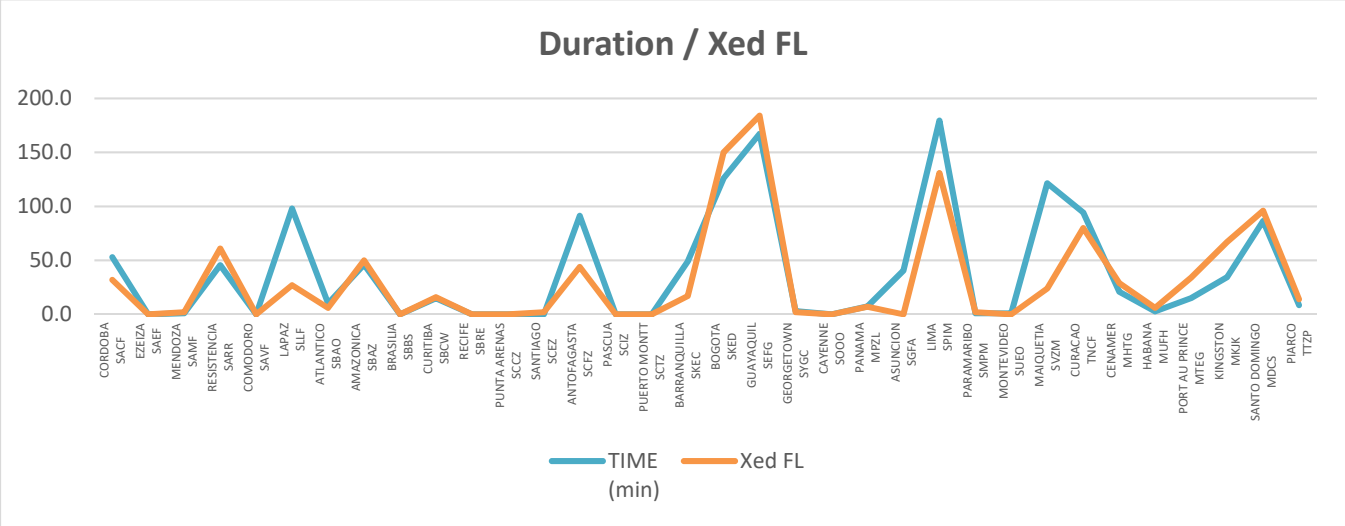

Table 3

4. Collection of aircraft movement data

4.1 The sample data to estimate the pass frequency and physical parameters, and the dynamics of a typical aircraft for the assessment of vertical collision risk, were collected from 1 December to 31 December 2019.

4.2 Aircraft movement data received from the 31 CAR/SAM FIRs were processed and used to assess RVSM airspace safety, as recommended by ICAO.

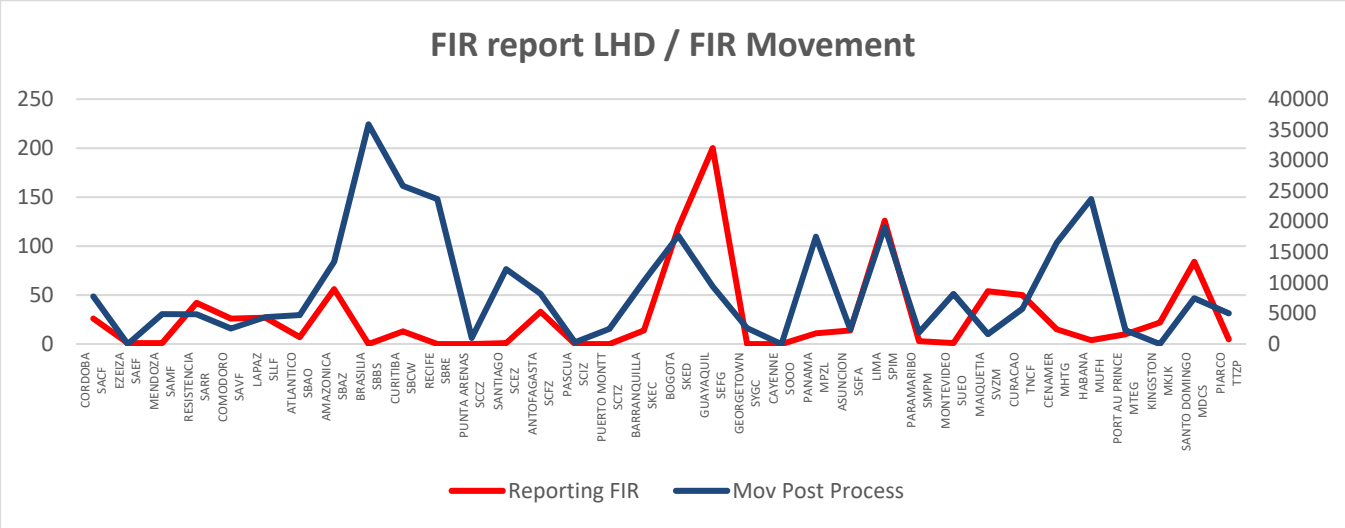

Table 4

4.3 Upon receiving the aircraft movement data, CARSAMMA proceeded to its filtering and processing. Table 4 shows the results and lists the aircraft that flew through the CAR/SAM FIRs, with their dimensions, number, and percentage of flights, including a typical airplane, used as a dimension of the vertical risk calculation model.

Type ACFT	Length	Wingspan	Height	# Flights	% ACFT
B738	0.021328	0.018521	0.006749	77,372	25.47
A320	0.020286	0.018413	0.00635	74,055	24.37
A319	0.018272	0.018413	0.00635	20,266	6.67
A321	0.024033	0.018413	0.00635	18,361	6.04
B763	0.029644	0.025702	0.007559	16,884	5.55
B737	0.018898	0.018521	0.006749	16,607	5.46
E190	0.019568	0.015507	0.005707	14,470	4.76
A332	0.031749	0.032559	0.009395	11,231	3.69
E195	0.019568	0.015507	0.005707	10,109	3.32
B789	0.034017	0.034017	0.009179	8,229	2.70
Others				**36,176**	**11.97%**
Typical	**0.023736**	**0.021557**	**0.00701**	**303,760**	**100.00%**

Table 5 – Aircraft that flew RVSM in CAR/SAM FIRs (Measurements of dimensions are expressed in nautical miles)

5. Collision risk safety assessment (CRM)

5.1 This section analyses the assessment results of the collision risk in the RVSM airspace of CAR/SAM FIRs.

5.2 The internationally accepted collision risk methodology (CRM) has been used for the safety assessment of RVSM airspace in the Caribbean and South America.

5.3 Estimates of the CRM parameter:

$$N_{ax} = 2P_y(0)P_z(0)\left(\frac{\overline{|\dot{x}(m)|}}{2\lambda_x} + \frac{\overline{|\dot{y}_0|}}{2\lambda_y} + \frac{\overline{|\dot{z}_0|}}{2\lambda_z}\right)\frac{2\lambda_x}{\overline{|\dot{x}(m)|}}\frac{1}{T}\sum_s E(s)Q(s)$$

Figure 1 – General formula of the REICH collision risk model

5.4 The material and quantity of the source used for estimating the values of each parameter of the internationally accepted collision risk model (CRM) applied for the assessment of RVSM airspace safety are summarised in Table 6.

Parameter	Description	Values
λx	Mean length of the aircraft sample	**0.023736 nm**
λy	Mean wingspan of the aircraft sample	**0.021557 nm**
λz	Mean height of the aircraft sample	**0.00701nm**
$\overline{\lvert V \rvert}$	Mean speed of the aircraft sample (module)	**458.763 kt**
$\overline{\lvert \Delta V \rvert}$	Relative same-direction speed of the aircraft sample (module)	**12.33 kt**
$\overline{\lvert \dot{y} \rvert}$	Mean speed relative to the transverse approach of the aircraft sample (module)	**13 kt**
$\overline{\lvert \dot{z} \rvert}$	Mean relative vertical speed during loss of vertical separation of the aircraft sample (module)	**1.5 kt**
Pz(0)	Probability that two aircraft with the same nominal level overlap laterally in the aircraft sample	**0.298265**

Table 6

5.5 System performance specifications

5.5.1 Pass frequency, Nx – This is the airspace parameter in which the aircraft is exposed to the vertical collision risk. The equivalent pass frequency was estimated, taking into account aircraft flying in the same direction and in opposite directions, as shown in Table 7.

CAR/SAM Pass frequency	Same direction	Opposite direction	Equivalent	Hours of flight
	0.00858	0.04518	0.067844	1,420,564

Table 7

5.5.2 Values are related to the CAR/SAM airspace system. It should be noted that the equivalent pass frequency shown in Table 7 (0.067844) was calculated based on flight hours in the 31 CAR/SAM FIRs.

5.5.3 The estimated value of Pz (1000) used in our calculations was 2.46 x 10-8.

6. Estimating the collision risk

6.1 Table 8 contains the sets of physical and dynamic parameters estimated in the risk profile, and the follow-up of the main parameters for the CAR/SAM FIRs. All parameters were determined based on the airspace of each Region that is considered as an isolated system.

CAR/SAM	E (same)	Ez (opposite)	Ez	ΔV (same)	ΔV (opposite)	V
	0.015975	0.011294	0.052193	12.0100	428.7624	458.763 kt

Table 8

6.2 Table 9 shows the consolidated collision risk in the CAR/SAM FIRs in for 2019, showing the estimated vertical collision risk by FIR. It must be understood that the FIRs that present an LHD report have a higher risk, but frequently due to failures in the FIRs adjacent to their airspace.

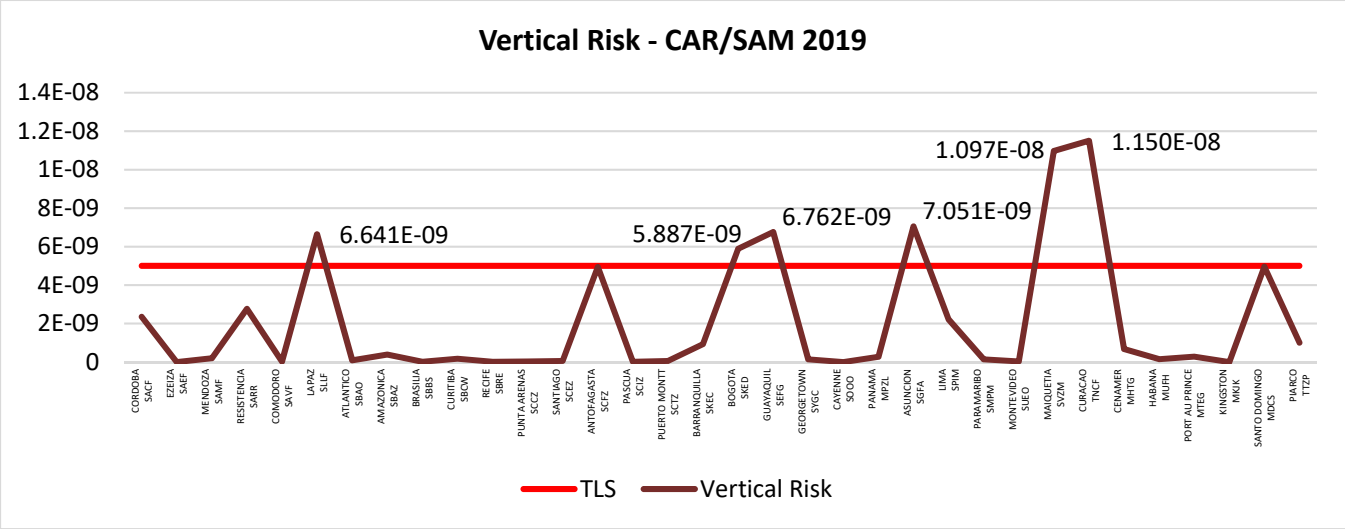

Table 9

7. Conclusions of the safety assessment (CRM)

7.1 The risk was estimated based on the FIR values presented in Table 10, which were obtained after processing all data received, compiled, and processed in the specific CRM software.

STATE	FIR	Reporting FIR	Reported FIR	TIME (min)	Xed FL	Vertical Risk
ARGENTINA	CORDOBA - SACF	26	11	53,0	32	2,357E-09
	EZEIZA - SAEF	1	34	0,0	0	0,000E+00
	MENDOZA - SAMF	1	5	1,0	2	1,954E-10
	RESISTENCIA - SARR	42	9	45,5	61	2,770E-09
	COMODORO - SAVF	26	0	0,0	0	2,583E-11
BOLÍVIA	LAPAZ - SLLF	27	78	98,0	27	6,641E-09
BRASIL	ATLANTICO - SBAO	7	1	10,2	6	8,672E-11
	AMAZONICA - SBAZ	56	27	46,0	50	3,873E-10
	BRASILIA - SBBS	0	2	0,0	0	1,489E-11
	CURITIBA - SBCW	13	6	14,8	16	1,717E-10
	RECIFE - SBRE	0	2	0,0	0	1,931E-11
CHILE	PUNTA ARENAS - SCCZ	0	0	0,0	0	3,578E-11
	SANTIAGO - SCEZ	1	0	0,0	2	5,699E-11
	ANTOFAGASTA - SCFZ	33	13	91,3	44	4,950E-09
	PASCUA - SCIZ	0	0	0,0	0	1,248E-11
	PUERTO MONTT - SCTZ	0	0	0,0	0	6,036E-11
COLOMBIA	BARRANQUILLA - SKEC	14	65	49,0	17	9,279E-10
	BOGOTA - SKED	119	239	126,0	150	5,887E-09
ECUADOR	GUAYAQUIL - SEFG	200	102	167,3	184	6,762E-09
GUYANA	GEORGETOWN - SYGC	0	4	3,0	2	1,364E-10
FRENCH GUYANA	CAYENNE - SOOO	0	0	0,0	0	0,000E+00
PANAMA	PANAMA - MPZL	11	53	7,4	7	2,751E-10
PARAGUAY	ASUNCION - SGFA	14	13	40,5	0	7,051E-09
PERU	LIMA - SPIM	126	72	179,5	131	2,223E-09
SURINAM	PARAMARIBO - SMPM	3	2	1,0	2	1,405E-10
URUGUAY	MONTEVIDEO - SUEO	1	5	1,0	0	3,106E-11
VENEZUELA	MAIQUETIA - SVZM	54	30	121,5	24	1,097E-08
NETHERLANDS ANTILLES	CURACAO - TNCF	50	65	94,3	80	1,150E-08
CENTRAL AMERICA	CENAMER - MHTG	15	28	21,0	29	6,689E-10
CUBA	HABANA - MUFH	4	4	2,8	6	1,498E-10
HAITI	PORT AU PRINCE - MTEG	10	28	15,0	34	2,825E-10
JAMAICA	KINGSTON - MKJK	22	14	34,5	67	0,000E+00
DOMINICAN REPUBLIC	SANTO DOMINGO - MDCS	84	10	86,5	96	4,961E-09
TRINIDAD & TOBAGO	PIARCO - TTZP	5	4	8,5	14	1,003E-09
TOTAL CAR/SAM		965	926	1318,63	1083	1,540E-09
MOUNT PLEASANT	EGYP	0	15			
TOTAL		965	941	1318,63	1083	1,540E-09

Table 10

7.2 The technical risk of the CAR/SAM FIRs meets the TLS value, not exceeding 2.5 x 10^{-9} fatal accidents per flight hour due to loss of the standard vertical separation of 1,000 ft and all other causes.

7.3 The operational risk does not have a predefined limit, in accordance with ICAO Doc 9574.

7.4 The estimated total risk for the assessed FIRs is 1,540 x 10-9 below the TLS (5.0 x 10-9).

7.5 Following on from the reports presented by the Secretariat during GTE 19, we show below tables / graphs with the evolution of data for 2019.

GTE	GTE 14	GTE 15	GTE 16	GTE 17	GTE 18	GTE 19	**GTE 20**
Year of the analysis	2013	2014	2015	2016	2017	2018	**2019**
Anual hours	944,628	967,135	1,044,378	1,392,732	2,555,136	1,038,066	**1,420,564**
Risk value	4,62 E-09	1,85 E-09	1,29 E-09	1,41 E-09	2,32 E-09	2,32 E-09	**1,54 E-09**

Table 11

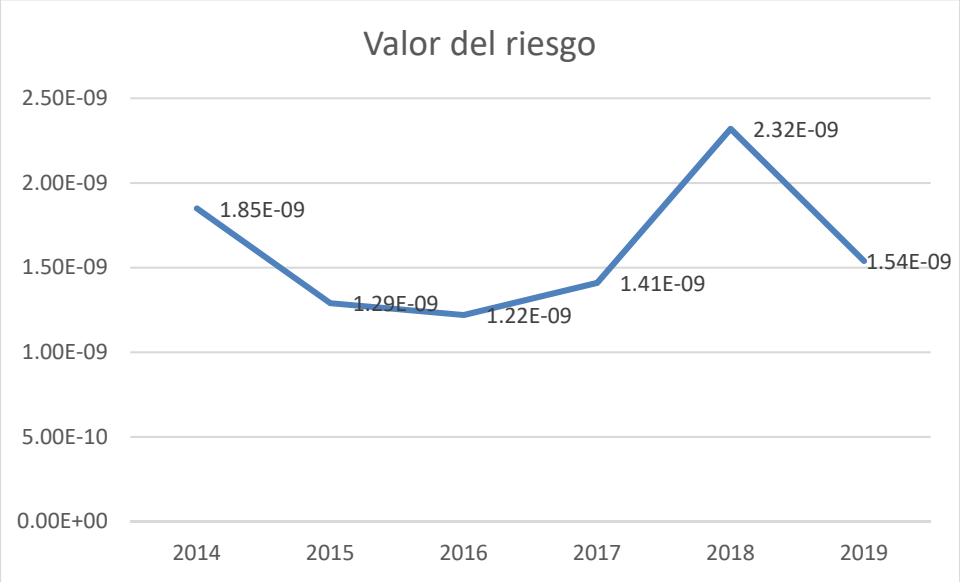

Figure 2

FIR	RVSM SPACE	2016 GTE17		2017 GTE18		2018 GTE19		2019 GTE20			
		RISK	# LHD	RISK	# LHD	RISK	# LHD	RISK	# LHD	no RVSM	Mov (hour)
CURACAO	TNCF	7,15E-09	69	8,2E-09	66	1,86E-08	72	1,15E-08	50	1	12942
SANTO DOMINGO	MDCS	2,82E-09	24	4,13E-09	99	5,6E-09	58	--	--	--	--
LA PAZ	SLLF	0,189E-09	37	3,79E-09	13	114,0E-09	35	6,64E-09	27	--	31767
GUAYAQUIL	SEFG	0,0307E-09	144	7,13E-09	123	5,61E-09	108	6,76E-09	200	6	36276
ASUNCION	SGFA	0,0405E-09	12	3,94E-09	12	10,4E-09	13	7,05E-09	14	1	9317
MAIQUETIA	SVZM	0,029E-09	20	1,84E-09	17	6,54E-09	21	1,10E-08	54	1	13682
BOGOTA	SKED	--	--	--	--	--	--	5,89E-09	119	4	7990

Table 12

8. Suggested action

8.1 The Meeting is invited to:

a) note and review the contents of this working paper;

b) share experiences and comment on CARSAMMA actions on this matter; and

c) use this information to reduce LHDs and improve the safety level in the airspace of CAR/SAM FIRs.

— END —