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North American, Central American and Caribbean Office

WORKING PAPER

GTE/21 — WP/03
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CAR/SAM Planning and Implementation Regional Group (GREPECAS) Twenty-one Scrutiny Working Group Meeting (GTE/21)

Zoom Meeting, 23 – 27 august 2021

Agenda Item 3: **Activities and Tasks to be reported to GREPECAS**

a) 2020 results of the safety assessment (CRM) in reduced vertical separation minima (RVSM) airspace

2020 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 2020, using the CRM methodology.	
Action:	Monitoring and Documentation
Strategic Objectives:	• Safety
References:	• ICAO Doc 9574 - AN/934. third edition - 2012 • ICAO Doc 9937 - AN/477. first edition - 2012 • Aircraft movements in RVSM airspace in 2020 • Reports of large height deviations (LHD) in 2020

1. Introduction

1.1 The purpose of this working paper 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 2020 in the flight information regions (FIRs) of the Caribbean and South America. The vertical collision risk model (CRM) calculation methodology was used for this analysis, as 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 The validation of the LHD is carried out by CARSAMMA and the FIRs involved throughout the year, bringing with it 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 these files, since most of the collected files are not delivered in accordance with the examples requested by this Agency, requiring time and effort to use at least 85% of information sent.

1.5 However, due to COVID-19 pandemic, that led to a significant drop in air transport activities and several restrictions taken throughout all regions, such as travel bans, travel restrictions, mandatory quarantines, etc., the air movements were significantly impaired, which led to an absence of statistically significant data for the year of 2020. Because of this, exceptionally in 2020 it was requested during Virtual GTE20, to use the average of the movements that occurred in the months of January to December, which was accepted, and implemented thanks to the submission of these data by the FIRs of our regions.

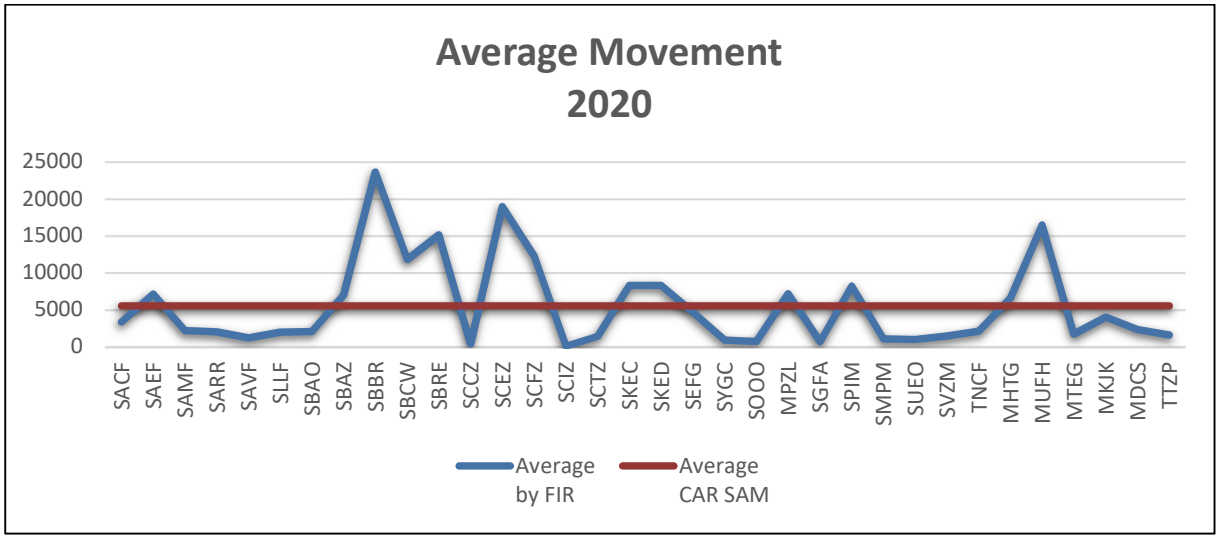

Table 1

Note 1: One FIR RVSM movement could not be considered, due to non-receipt of data by CARSAMMA. It was the FIR SMPM.

Note 2: The RVSM movement from SKED\SKEC took a long time to be debugged by our team, due to the lack of various information, such as entry\exit fix, airways, and time of passage.

Note 3: When 2020 RVSM movement is compared to 2019, scheduled traffic dropped in medium 46.25% in our specifics Regions, as it can be seen in Table 2.

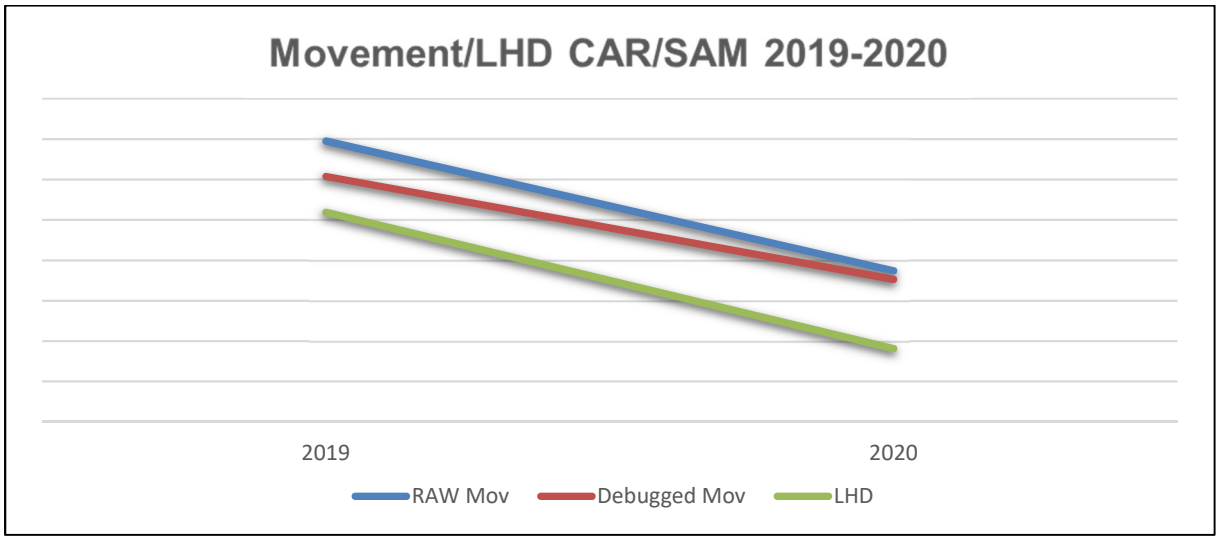

Table 2

2. Analysis

2.1 According to Doc 9574 and Doc 9937, the assessment is required in order to ensure that operations in RVSM airspace do not generate an increase in collision risk, so that 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 a period of twelve consecutive months.

2.4 Special attention should be paid to make sure that:

a) All aircraft operating in reduced vertical separation minima airspace are RVSM-certified;

b) Aircraft certification is current;

c) The target level of safety (TLS) of 5 x 10-9 fatal accidents per flight hour continues to be met (for follow-up of a representative sample of aircraft);

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

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

f) The introduction of RVSM does not increase the level of risk due to operational errors and flight contingencies, in accordance with a predefined level of statistical confidence;

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

h) Air traffic control procedures continue to be effective.

3. CAR/SAM airspace

3.1 The CAR/SAM airspace covers a wide area extending from the Gulf of Mexico to Patagonia, encompassing 34 Flight Information Regions (FIRs) of the countries listed on the table below. Each part of the airspace was treated as an isolated system, with its own statistical parameters.

Table 3 – CAR / SAM Airspace

3.2 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 December 1 to December 31 - 2020 in the 33 CAR/SAM FIRs. In the sample collected, 186,802 lines of flight records were received from the aforementioned FIRs. All records were purged, leaving 176,379 lines of flight records validated in the process. However, all the data sent 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 send data beyond the deadline.

3.3 Regarding the occurrence of vertical deviations (LHDs) in the CAR/SAM Regions, CARSAMMA received a total of 433 LHD reports in 2020. After analysis and validation based in the Risk CRM parameters, 356 of these LHDs were considered valid in the CAR/SAM Regions.

3.4 Just in terms of comparison, we show below a table with the occurrences of LHD divided by the number of air movements per FIR, with the average CAR/SAM being 0.002.

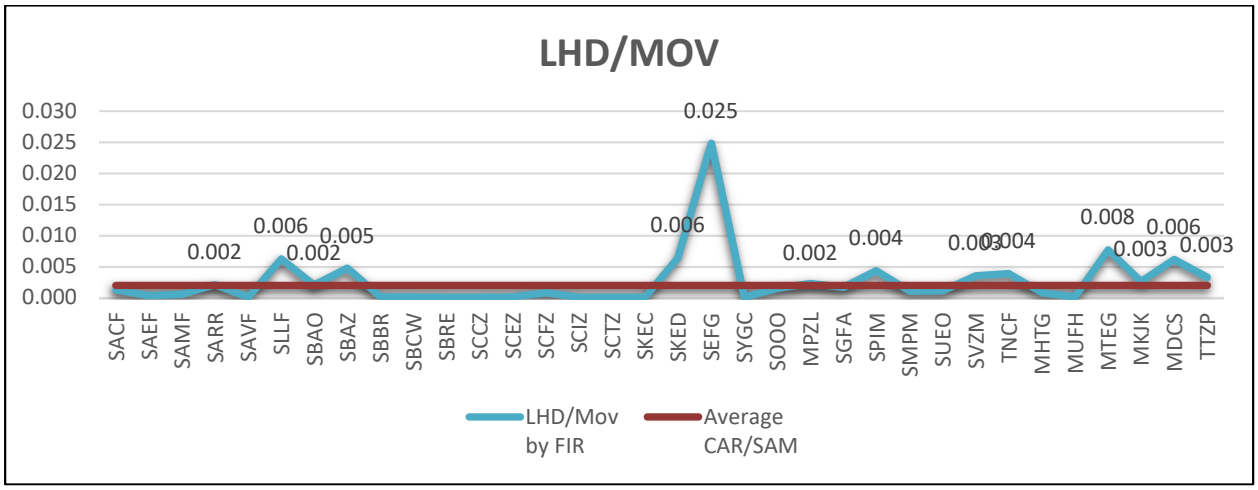

Table 4

4. Collection of aircraft movement data

4.1 The sample data to estimate the pass frequency and physical parameters, as well as the dynamics of a typical aircraft for the assessment of vertical collision risk were collected from 1 December to 31 December 2020.

4.2 Aircraft movement data received from the 33 CAR/SAM FIRs were processed and used to assess RVSM airspace safety, as recommended by ICAO.

4.3 Upon receiving the aircraft movement data, CARSAMMA proceeded to its filtering and processing. Table 5 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	0.00674	33631	21.42
A320	0.020286	0.018413	0.00635	28009	17.84
A20N	0.020286	0.018413	0,00635	10065	6.41
B763	0.029644	0.025702	0.00755	8453	5.38
A321	0.024033	0.018413	0.00635	8204	5.22
A319	0.018272	0.018413	0.00635	6157	3.92
E195	0.019568	0.015507	0.00570	5380	3.43
B789	0.034017	0.034017	0.00917	4494	2.86
B737	0.018898	0.018521	0.00674	3554	2.26
A332	0.031749	0.032559	0.00939	3503	2.23
B77W	0.034395	0.034989	0,01004	3001	1.91
E190	0.019568	0.015507	0.00570	2905	1.85
B788	0.030778	0.032397	0,00917	2830	1.80

B752	0.025551	0.020788	0,00732	2017	1.28
B772	0.034395	0.032883	0,00998	1992	1.27
Others				32835	20.92
Typical	**0.029081**	**0.027894**	**0.008577**	**157030**	**100.00%**

Table 5 – Aircraft that flew RVSM in CAR/SAM FIRs

5. Collision risk safety assessment (CRM)

5.1 This section analyses the results of the assessment of the collision risk in 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 summarized in Table 6.

λx	Mean length of the aircraft sample	0.029081 nm
λv	Mean wingspan of the aircraft sample	0.027894nm
λz	Mean height of the aircraft sample	0.008577 nm
$\lvert V \rvert$	Mean speed of the aircraft sample (module)	447.656 kt
$\lvert \Delta V \rvert$	Relative same-direction speed of the aircraft sample (module)	31.57 kt
$\lvert \dot{y} \rvert$	Mean speed relative to the transverse approach of the aircraft sample (module)	13 kt
$\lvert \dot{z} \rvert$	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
	0.009937	**0.083167**	**0.058727**

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 (0.058727) was calculated based on flight hours in the 33 CAR/SAM FIRs.

5.5.3 The estimated value of Pz (1000) used in our calculations was 2.46×10^{-8}.

6. Estimating the collision risk

6.1 Table 8 contains the sets of physical and dynamic parameters estimated in the risk profile, as well as 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	Ez (same)	Ez (opposite)	Ez	ΔV (same)	ΔV (opposite)	V
	0.08277	**0.02079**	**0.04113**	**31.5762**	**886.344**	**447.656 kt**

Table 8

6.2 Table 9 shows the consolidated collision risk in the CAR/SAM FIRs in for 2020, 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.

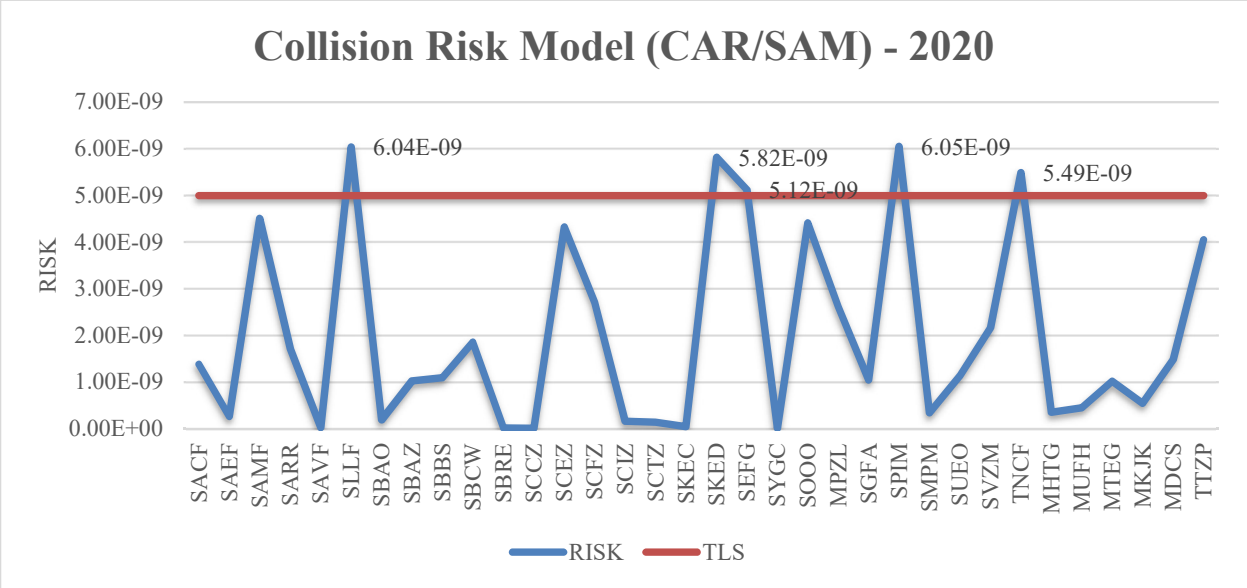

Table 9

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	Vertical Risk
ARGENTINA	**CORDOBA - SACF**	**1.38E-09**
	EZEIZA - SAEF	**0.26E-09**
	MENDOZA - SAMF	**4.51E-09**
	RESISTENCIA - SARR	**1.71E-09**
	COMODORO - SAVF	**0.24E-09**
BOLIVIA	**LAPAZ - SLLF**	**6.04E-09**
BRASIL	**ATLANTICO - SBAO**	**0.19E-09**

	AMAZONICA - SBAZ	**1.02E-09**
	BRASILIA - SBBS	**1.10E-09**
	CURITIBA - SBCW	**1.86E-09**
	RECIFE - SBRE	**0.20E-09**
CHILE	**PUNTA ARENAS - SCCZ**	**0.12E-09**
	SANTIAGO - SCEZ	**4.33E-09**
	ANTOFAGASTA - SCFZ	**2.71E-09**
	PASCUA - SCIZ	**0.16E-09**
	PUERTO MONTT - SCTZ	**0.14E-09**
COLOMBIA	**BARRANQUILLA - SKEC**	**0.46E-09**
	BOGOTA - SKED	**5.82E-09**
ECUADOR	**GUAYAQUIL - SEFG**	**5.12E-09**
GUYANA	**GEORGETOWN - SYGC**	**0.11E-09**
FRENCH GUYANA	**CAYENNE - SOOO**	**4.41E-09**
PANAMA	**PANAMA - MPZL**	**2.62E-09**
PARAGUAY	**ASUNCION - SGFA**	**1.05E-09**
PERU	**LIMA - SPIM**	**6.05E-09**
SURINAM	**PARAMARIBO - SMPM**	**0.34E-09**
URUGUAY	**MONTEVIDEO - SUEO**	**1.14E-09**
VENEZUELA	**MAIQUETIA - SVZM**	**2.17E-09**
NETHERLANDS ANTILLES	**CURACAO - TNCF**	**5.49E-09**
CENTRAL AMERICA	**CENAMER - MHTG**	**0.35E-09**
CUBA	**HABANA - MUFH**	**0.45E-09**
HAITI	**PORT AU PRINCE - MTEG**	**1.02E-09**
JAMAICA	**KINGSTON - MKJK**	**0.54E-09**
DOMINICAN REPUBLIC	**SANTO DOMINGO - MDCS**	**1.49E-09**
TRINIDAD & TOBAGO	**PIARCO - TTZP**	**4.05E-09**
TOTAL CAR/SAM		**1,78E-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 our 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 1,78 x 10-9 below the TLS (5.0 x 10-9).

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 level of safety in the airspace of CAR/SAM FIRs.

— END —