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Agenda Item 3: **Review of the Results of Large Height Deviation (LHD) and the Collision Risk Model (CRM) Analysis**

VERTICAL COLLISION RISK ASSESSMENT OF THE CAR/SAM REGIONS IN 2023

(Presented by CARSAMMA)

EXECUTIVE SUMMARY	
This Working Paper presents a summary of the calculation of vertical collision risk in the CAR/SAM Regions in 2023 using the CRM methodology.	
Strategic Objectives:	• Safety
References:	• ICAO Doc 9574 - Manual on a minimum vertical separation of 300 m (1 000 ft) between FL 290 and FL 410 inclusive. • ICAO Doc 9937 - Operational procedures and methods for regional oversight bodies in relation to the use of a minimum vertical separation of 300 m (1 000 ft) between FL 290 and FL 410 inclusive. • Aircraft Movement in the RVSM space in 2023. • Reports of Significant Altitude Deviations (LHD) in 2023.

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 the RVSM airspace of the CAR/SAM Regions.

1.2 This document reports the vertical collision risk analysis in RVSM airspace in 2023 in the relevant Caribbean and South America Flight Information Regions (FIRs) of this Agency.

2. Analysis

2.1 According to Doc. 9574 and Doc. 9937, the assessment should be made to ensure that operations in RVSM airspace do not induce an increase in the risk of vertical collision such that the total vertical risk does not exceed the defined safety objectives.

2.2 For the quantitative assessment, the Reich Vertical Collision Risk Model is used, as recommended by ICAO. This is a model with intense mathematical foundations that, after analysing aircraft movements (spreadsheets containing data on flights carried out in RVSM airspace), calculates the operational safety level (TLS) of the Flight Information Region under study. Various calculation tools and databases are used for the various calculations during the process, as well as several hours of analysis by CARSAMMA experts.

2.3 The RVSM safety assessment covers a period of twelve consecutive months.

2.4 Tools for security assessment:

- ICAO Collision Risk Methodology;
- ICAO Doc. 9574 is used to develop the global system Performance Specification, with the specification and performance requirements for aircraft altitude maintenance;
- All aircraft operating in airspace with reduced minimum vertical separation must be RVSM certified;
- The RVSM certification of the aircraft is current;
- The desired safety level (TLS) of 5 x 10-9 fatal accidents per flight hour (in a representative sample of aircraft) continues to be met;
- There is evidence of stability of the aircraft altimetry system (ASE) error;
- 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;
- Additional effective safety measures are taken to reduce the risk of vertical collision and meet operational safety goals due to operational errors and contingency procedures; and
- Air traffic control procedures continue to be effective.

2.5 The risk model was adapted to take into account:

- Technical risk of the aircraft on the same airway and on the intersection airways; and
- The effect of significant height deviations (LHDs) on system risk.

3. CAR/SAM Airspace

3.1 The RVSM airspace monitored by CARSAMMA is comprised of 34 Flight Information Regions (FIRs) in the Caribbean and South America. Each part of that airspace was treated as an isolated system, with its own statistical parameters.

3.2 Data Traffic Collection - The sample used to evaluate the pass frequency, physical and dynamic parameters of typical aircraft to assess the risk of vertical collision, was collected in the period between December 01 and 31, 2023 from the 31 FIRs of CARSAMMA. In these movement data, in terms of flight hours of the samples collected, 279,534 flight lines were used with 772,172 hours of duration of the aforementioned FIR, being 197,703 hours from the CAR Region (26%) and 574,469 hours from the SAM Region (74%).

3.3 Regarding the occurrence of significant height deviations (LHDs) reported in the CAR/SAM Regions, CARSAMMA received a total of 732 LHDs in 2023. After the analysis and validation carried out through teleconferences with representatives of the ICAO Offices Lima and Mexico, IATA and CARSAMMA, 624 of these LHDs were considered valid in the relevant CAR/SAM Regions in the CRM study.

3.4 Therefore, the total LHDs analysed by the CRM parameters were:

Code	A	B	C	D	E1	E2	F	G	H	I	J	K	L	M	Total
#LHD	**0**	**4**	**0**	**5**	**342**	**213**	**0**	**0**	**0**	**3**	**0**	**0**	**56**	**1**	**624**

Month	# LHD	Duration (min)	Crossed Levels
January	**60**	**48.50**	**80**
February	**71**	**131.50**	**86**
March	**56**	**321.50**	**58**
April	**63**	**143.50**	**72**
May	**73**	**106.95**	**69**
June	**41**	**77.00**	**49**
July	**49**	**76.17**	**59**
August	**29**	**29.18**	**30**
September	**40**	**51.00**	**38**
October	**44**	**53.00**	**44**
November	**45**	**48.00**	**31**
December	**53**	**52.00**	**38**
Total	**624**	**1138.30**	**654**

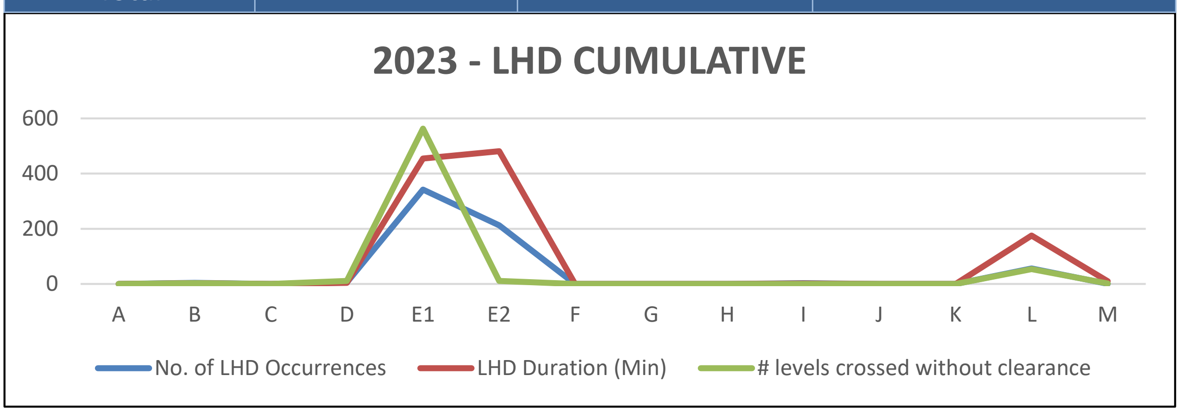

Table 1 – LHD

4. Aircraft movement data collection

4.1 Sample data to estimate pass frequency and physical parameters, as well as the dynamics of a typical aircraft for vertical collision risk assessment were collected from December 1 to December 31, 2023.

4.2 Upon receiving the aircraft movement data, CARSAMMA proceeded to filter and process the data. Table 2 shows one of these products and list the types of aircraft that flew through the CAR/SAM FIRs, with their dimensions and percentage of flight numbers, including a typical aircraft, used as one of the dimension parameters of the vertical collision risk calculation model.

ACFT Type(Top 20)	Lenght λx	Wingspan λy	Height λz	Flights
B738	0.021328	0.018521	0.006749	48571
A320	0.020286	0.018413	0.006350	47435
A20N	0.020286	0.018413	0.006350	26679
B38M	0.021312	0.019395	0.006641	19109
A321	0.024033	0.018413	0.006350	17060
B763	0.019568	0.015507	0.005707	11925
B39M	0.018272	0.018413	0.000635	8542
A319	0.029644	0.025702	0.007559	8365
B789	0.018898	0.018521	0.006749	7709
B737	0.034017	0.034017	0.009179	7116
A332	0.031749	0.032559	0.009395	6752
A21N	0.030778	0.032397	0.009179	6741
E190	0.024033	0.018413	0.006350	6578
B788	0.034395	0.032883	0.009989	6329
A359	0.034395	0.034989	0.010043	4688
B772	0.036123	0.034557	0.009125	3707
B739	0.021328	0.018521	0.006749	3470
B77W	0.025551	0.020788	0.007322	3006
B752	0.025476	0.021823	0.006773	2793
E195	0.019708	0.015605	0.005994	2319
Typical acft	**0.023082**	**0.020762**	**0.006724**	**248,894**

Table 2 – The Top 20 aircraft that flew RVSM in the CAR/SAM FIR in flight terms
(Dimension measurements are expressed in nautical miles)

5. Vertical Collision Risk Estimation (CRE)

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

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

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

Figure 1 – General formula of the REICH Vertical Collision Risk Model

5.3 The source material and quantity used to estimate the values of each parameter of the internationally accepted vertical collision risk model (CRM) used to evaluate the safety of RVSM airspace are summarized in Table 3.

CRM Parameter	Description
N_{az}	Number of fatal accidents per flight hour due to loss of vertical separation.
S_z	Vertical Separation minimum.
$P_z(S_z)$	Probability that two aircraft nominally separated by the vertical separation minimum S_z are in vertical overlap.
$P_y(0)$	Probability that two aircraft on the same track are in lateral overlap.
λ_x	Average aircraft length.
λ_y	Average aircraft wingspan.
λ_z	Average aircraft height with undercarriage retracted.
$S\,x$	Length of longitudinal window used to calculate occupancy.
$E_z(same)$	Same direction vertical occupancy.
$E_z(opp)$	Opposite direction vertical occupancy.
$\overline{\|\Delta V\|}$	Average relative along track speed between aircraft on same direction routes.
$\overline{\|V\|}$	Average aircraft ground speed.
$\overline{\|\dot{y}\|}$	Average relative cross track speed for an aircraft pair nominally on the same track.
$\overline{\|\dot{z}\|}$	Average relative vertical speed of an aircraft pair that have lost all vertical separation

Table 3 - CRM Parameter Estimates

5.4 Demonstration of the technical feasibility of RVSM in the CAR/SAM Regions:

- Step frequency Nx;
- Probability of lateral overlap Py (0): and
- Vertical overlap probability Pz (1000).

To demonstrate this, the following objectives were established:
• Build confidence in technical TLS compliance; and
• Certify the stability of the ASE.

5.4.1 Pass frequency, Nx - This is the airspace parameter in which the aircraft is exposed to risk. The equivalent pass frequency was estimated taking into account two aircraft flying in the same direction and in opposite directions, as shown in Table 4.

	Same Direction	Opposite Direction	Equivalent	Flight Hours
Pass Frequency	**0.027476**	**0.094817**	**0.132312**	**772172**

Table 4 – Pass Frequency

5.4.2 The values relate to the CAR/SAM airspace system. It should be noted that the equivalent passage frequency shown in Table 4 (0.132312) has been calculated based on the flight hours of the 31 CAR/SAM FIRs that submitted their movement data.

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

5.4.4 Table 5 contains the sets of physical and dynamic parameters that are estimated in the risk profile, as well as the monitoring of the main parameters for CAR/SAM FIRs. All parameters were determined based on the airspace of each region that is considered an isolated system.

CAR/SAM	Ez (same)	Ez (opp)	V	ΔV (same)	ΔV (opp)
	0.116142	**0.023704**	**434.88 kt**	**28.7538 kt**	**909.5235 kt**

Table 5 – Physical and dynamic parameters

6. Conclusions from the Vertical Collision Risk Estimation (CRE)

6.1 Collision Risk - Figure 2 shows the vertical collision risks calculated for each FIR of the CAR/SAM Regions during the year 2023. The Port-au-Prince, La Paz, Guayaquil, Curacao, Panama and Santo Domingo FIRs were the that SUFFERED risk above the Desired Security Level (TLS).

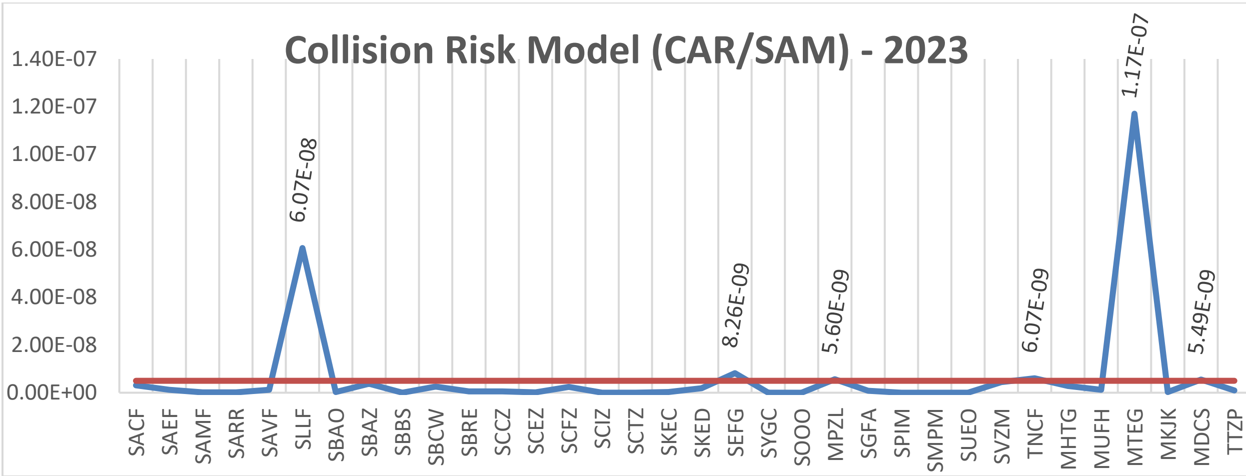

Figure 2 - Collision Risk

6.2 The CARSAMMA Altimetry Laboratory attached to this study a work that indicates the main quantitative parameters that influence the CRM calculation in general, and special considerations to mitigate collision risk factors in the 6 FIRs that exceeded the TLS in the year 2023.

6.3 At the end of this work, we would like to remember some data that make up our calculations:

- 305,381 lines of aircraft movements were received and after processing 279,561 flight records were validated. In relation to previous years, this use is satisfactory.
- In the CRM calculation, a non-certified aircraft using RVSM airspace induces a significant increase in the risk of vertical collision. A greater effort is necessary on the part of the AACs and the PSNAs of the CAR/SAM regions for the correct use of the RVSM space, including the State's aircraft.
- Among the 279,561 validated movements, some aircraft whose registration does not appear in the RVSM approval database were identified at the end of an audit process carried out by CARSAMMA, with the support of the other RMAs and AACs of the CAR\SAM regions. by CARSAMMA.

This may have been caused by:

- ✓ error in filling the F2 (RVSM approval) by the AAC;
- ✓ failure to send the F2 to CARSAMMA by the AAC;
- ✓ error in typing F2 by CARSAMMA in the RVSM database; or
- ✓ that the aircraft is NOT RVSM certified.

- Considering the occurrences in the CAR/SAM RVSM space, 624 LHDs were validated during the teleconferences held during the year by the LHD sector in CARSAMMA.

- The LHD event duration (time) and level crossing parameters also negatively influence the CRM calculation. The FIRs that have areas with an oceanic region, or large distances between mandatory reporting positions, are the most affected in this calculation.

6.4 The technical error of CAR/SAM FIR meets the objective that it should not exceed 2.5 x 10-9 fatal accidents per flight hour due to loss of the standard vertical separation of 1000 feet and all other causes.

- Operational risk does not have a predetermined limit according to ICAO Doc.9574.
- In the case of the CAR/SAM Regions, the estimated risk is 2.371 x 10-9 below the TLS, which is 5.0 x 10-9.

CAR/SAM RVSM airspace – Estimated Flight Hours = 772,172 hours			
Source of Risk	**Estimated Risk**	**TLS**	**Observation**
Technical Error	**0.0709 x 10-9**	**2.5 x 10-9**	**Below**
Operational Error	**2.258 x 10-9**	**-**	-
Risk	**2.371 x 10-9**	**5.0 x 10-9**	**Below**

Table 6 – CAR/SAM Risk

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APPENDIX

VERTICAL COLLISION RISK ANALYSIS

CARIBBEAN AND SOUTH AMERICA RVSM AIRSPACE 2023

Summary

In general, what are the conditions found in the RVSM airspace that may lead to an increase in the level of vertical collision risk

Altimetry & Audit
CARSAMMA

VERTICAL COLLISION RISK – GENERAL CONSTRAINTS

SUMMARY

DEFINITIONS
AAD – Assigned Altitude Deviation
ASE – Altimeter System Error
ATC – Air Traffic Control
CFL – Current Flight Level
FIR – Flight Information Region
FTE – Flight Technical Error
MMR – Minimum Monitoring Requirement
NOTAM – Notice to Airmen
RMA – Regional Monitoring Agency
RVSM – Reduced Vertical Separation Minima
SAA – South Atlantic Anomaly
TVE – Total Vertical Error
TLS – Target Level of Safety

This study was prepared by CARSAMMA, to help the FIRs of the CAR/SAM regions to better understand and in a general way, which conditions found in the RVSM airspace that may lead to an increase in the level of risk of vertical collision, if mitigating measures are not taken satisfactorily.

ATMOSPHERIC WEATHER CONDITIONS

Weather conditions that cause turbulence can be detrimental to accurate height maintenance, and include:

a) gravitational shear waves;
(b) storms;
c) orographic flux;
d) volcanic ash;
e) South America Magnetic Anomaly (AMAS/SAA).

a) Gravitational shear waves are present when the atmosphere is stably stratified, i.e. layers of cold air are situated below layers of warmer air in the troposphere. The interface region between these layers of air of different densities is where the level of equilibrium of vertical movement is, which is the preferred place for the development of gravitational gravity waves, which can cause strong turbulence.

b) When reports of storms with severe turbulence are received, ATC shall verify the aircraft's ability to maintain the CFL.

Upon confirmation that weather conditions are affecting, or are likely to affect, the accuracy of height keeping, ATC should provide alternative separation as soon as possible.

c) Orographic flow, more commonly known as mountain wave activity, has been identified as being particularly detrimental to accurate height maintenance.

With the implementation of the RVSM, States known to have airspace susceptible to orographic flow must:

- to be responsible for the provision of such conditions; and
- detail the action required by the ATC upon receipt of such forecasts.

d) During the volcanic eruption process, even if it is not very intense, there is the formation of a very specific type of cloud, the **pyrocumulus** or fire cloud, which throws an extensive cloud of debris into the atmosphere, which can cause serious damage to aircraft engines and sensors. This type of cloudiness has intense turbulence, which in turn causes strong gusts of wind on the surface and even lightning can be observed. This is because particles of rocks formed by magma are also released into the atmosphere in the form of ashes. These rocks hit each other and end up generating electrical charges that give rise to lightning.

e) The South Atlantic magnetic anomaly (SAA) affects satellites and spacecraft with orbits at an altitude of a few hundred kilometers and with orbital inclinations between 35° and 60°. In these orbits, the satellites periodically pass through SAA, being exposed for several minutes to the strong radiation that exists there. The International Space Station, orbiting at an inclination of 51.6°, required a special coating to deal with the problem. The Hubble Space Telescope does not make observations while it is passing through the region. Global positioning system (GPS) satellites also experience interference when passing through these positions, notably during solar storms.

SAA undergoes a westward shift, whose travel velocity is 0.3° per year.

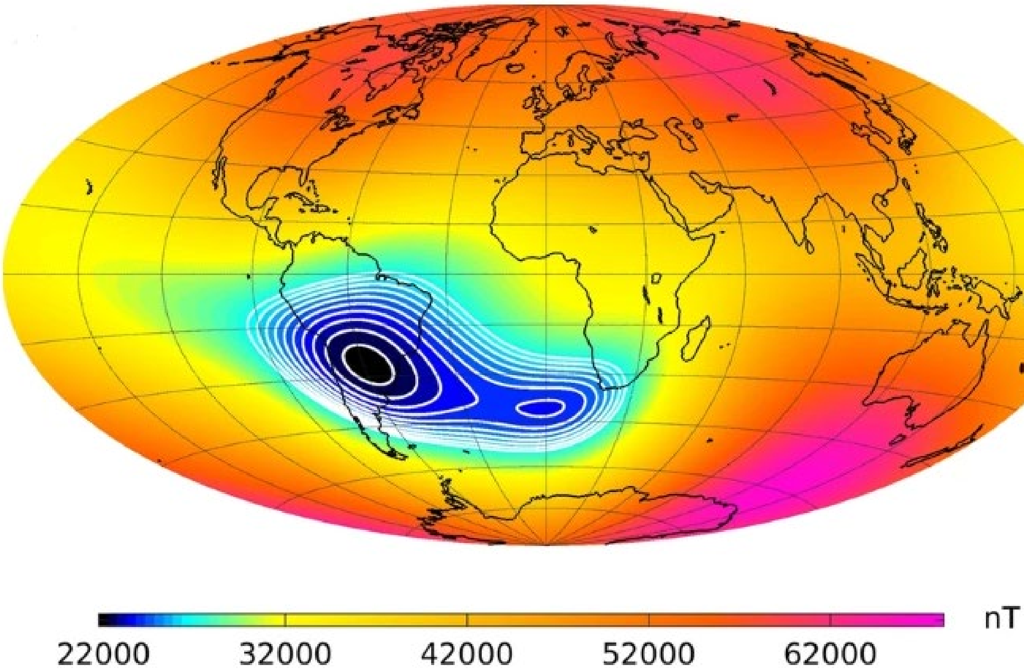


Figure 1 - South Atlantic Anomaly

In addition, when any of the meteorological conditions listed in the above points are expected to prevail over an area for an extended period, the appropriate ATC authority shall consider:

(a) issue a NOTAM specifying the routes or the affected area; and

(b) temporarily suspend the use of 300 m (1,000 ft) of VSM in the affected area.

CONFIRMATION OF THE RVSM CERTIFICATION STATUS OF AIRCRAFT

The continued implementation of the RVSM is contingent on the establishment of an aircraft certification confirmation process, which is intended to exclude aircraft and non-qualified operators from operating in RVSM airspace unless appropriate separation is applied. The process may have regional variations, but the primary responsibility for confirming the certification status of an aircraft/operator shall lie with the State of Operator/State of Registration.

The confirmation process will be facilitated by the application of the following measures:

(a) maintain an exhaustive record of all certifications granted for operations in RVSM airspace;

b) provide the certification records to the regional monitoring agency (CARSAMMA) for inclusion in its regional database of RVSM certifications; and

(c) include a verification of the certification status of aircraft/operators in the schedule of routine in-flight inspections.

At the appropriate level, a secondary responsibility should be borne by the ATS provider States to institute routine certification state checks on aircraft operating in their area of authority and intending to operate in RVSM airspace. In addition to the control activities conducted by CARSAMMA, this responsibility could be fulfilled by:

(a) the control of ATS flight plans;

(b) cross-checking with the regional database of RVSM certifications; and
(c) consult operators suspected of not complying with the requirements of this airspace.

Depending on state regulations, ATC clearances may be withheld for operations that do not comply with RVSM airspace requirements.

Together with the provider States, an additional level of certification confirmation can be carried out by CARSAMMA. This can be achieved by the action of the RMA, following a consultation by an aviation authority, to obtain confirmation of the approval status from the State of Operator/State of Registration of aircraft that are not in a regional database of RVSM certifications.

With the audit work done monthly by CARSAMMA, some aircraft that have used RVSM airspace but are not listed in the global database as RVSM certified are identified. These aircraft, after confirmation of non-certification made by the State of registration or operation, contribute to increase the risk in the CRM study of the FIR overflown.

MAIN PARAMETERS, AIRCRAFT TYPES, MONITORING GROUPS AND TRAFFIC ALTIMETRY SYSTEM ERROR

The traffic samples sent by the FIR CAR/SAM are analysed and various parameters collected for use in the vertical collision risk formula.

Some examples: The various types of aircraft are separated, their dimensions compiled, and with this data a typical aircraft is created that will have its dimension taken into account as being the standard of aircraft that occupied the RVSM space in the FIR.

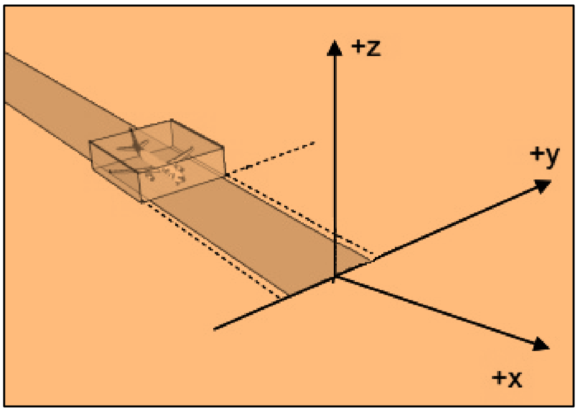


Figure 2 – Aircraft dimensions

If this traffic is flying at a route crossing or on parallel routes, the modeling of the situation will be different, as we see in the figure below.

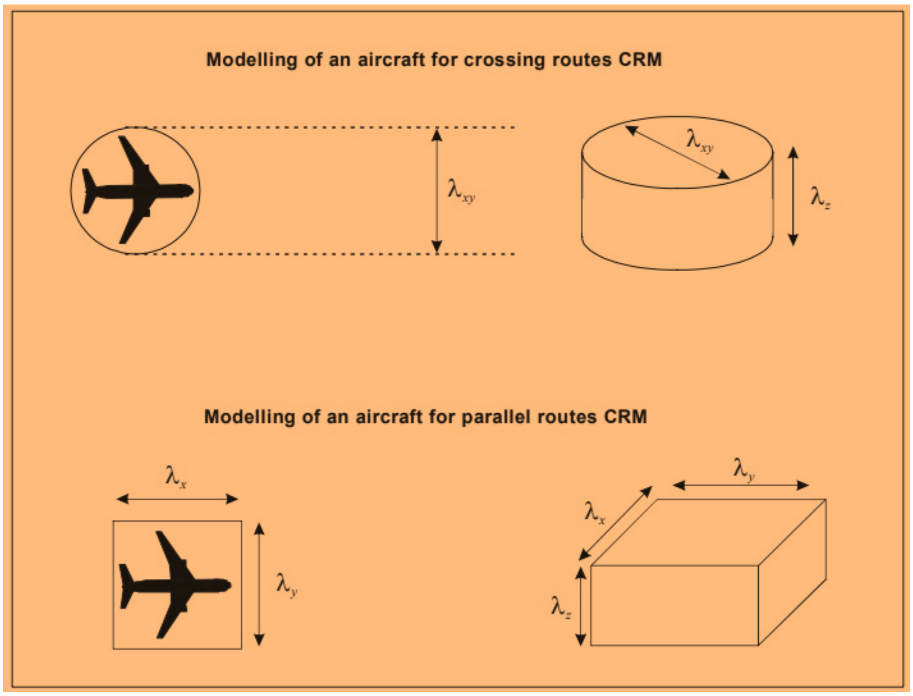


Figure 3 – Aircraft dimensions (crossing/parallel routes)

For each FIR studied, the various types of aircraft were separated and counted, the **monitoring group (MMR**) to which they belong was identified, and the mean **error of the altimetry systems (ASE)** of the sample was calculated. This is done based on the document of the RMAs "***MMR - Minimum Monitoring Requirements***" available on the CARSAMMA Portal, together with the database of the monitoring flights carried out to calculate the errors of the aircraft altimetry system, of the CARSAMMA Altimetry Laboratory, having as limits a maximum altitude variation of more or less 200 feet, The higher this number is, the greater the probability of failure to maintain the aircraft's altitude.

Below are some parameters found during the collision risk analysis in 2023:

Description	**Value**
Probability of lateral overlap (Py(0))	**0.0616**
Frequency of passage in opposite direction (Nx(opp))	**0.0948**
Frequency of passage in the same direction (Nx(same))	**0.0275**
Crossover Crossing Frequency (Nxy(cross))	**0.0948**
Average length of aircraft (λx)	**0.0231 Nm**
Average width of aircraft (λ y)	**0.0208 Nm**
Average height of the aircraft (λz)	**0.00668 Nm**
Relative average speed of the aircraft in the same direction (|ΔV|)	**28.1 kt**
Average aircraft speed (|V|)	**435 kt**
Average relative speed of aircraft at airway crossing (|y|)	**13 kt**
Average Relative Vertical Speed of Aircraft During Vertical Separation Loss (|z|)	**1.5 kt**

Table A-1. Parameter values used to define the height maintenance performance specification.

It should be borne in mind that with the technological development of new aircraft projects with advanced processes and technologies, the ASE number calculated tends to decrease. That is, older aircraft have a higher ASE number, even if within the desired RVSM parameters, which can influence the risk of vertical collision.

Added to this, we have the aircraft that used this special airspace and whose records were not found in the databases of RVSM certified aircraft, which greatly increases the risk calculated in that flight region.

ESTIMATION OF ASE

The **altimetry system error (ASE)** of an aircraft is expected to vary, within some limits, on some average value that is characteristic of each individual aircraft for a given set of operating conditions. This characteristic means is expected to be largely invariant over many flights, unless there is some intervention, such as damage or repair, that alters the error characteristics. The interval during which ASE remains relatively constant, in the absence of intervention, is not precisely known, but data and experience indicate some moderate increase in ASE magnitude as an altimetry system ages. Data and experience also indicate that the errors of the pilot and co-pilot's independent altimetry systems are not necessarily the same.

The actual ASE of an aircraft at any given time is the difference between its actual TVE and the contemporary real FTE. Given a measure of TVE and a contemporaneous ADD for the aircraft, the difference between TVE and ADD provides an estimate of ASE. The accuracy of this estimate is affected by the granularity of the 30 m (100 ft) quantization inherent in Mode C and by any mismatch between the Mode C return and the altitude display. However, when averaging several repeated samples, this approach should allow a representative value of the ASE to be established.

The age of the fleet in a sample is directly proportional to the ASE number, i.e., the older the fleet, the higher the average ASE found, and this impacts the CRM.

MONITORING THE PASSING FREQUENCY

The proportion of time during which aircraft at adjacent flight levels are exposed to the risk of collision due to loss of vertical separation is accounted for in the overall system performance specification, defining a maximum frequency of oncoming aircraft on the same route. In practice, exposure may occur due to aircraft passing in the same direction or opposite directions on the same route at adjacent flight levels or due to aircraft passing at adjacent flight levels on separate routes at a waypoint.

A closely related and frequently used parameter is "occupancy," which is a measure of the number of aircraft at adjacent flight levels within a specified distance of a typical aircraft. Independent monitoring of system performance requires that the combined effect of the frequency of these various types of passes be estimated using traffic movement data from RVSM airspace., or simulated data prior to RVSM implementation. This should be compared to 2.5 aircraft passes in the opposite direction per hour of flight. These estimates should be determined over the entire airspace being assessed, if it is practical to do so. If the airspace covers a regional area, the airspace of three adjacent FIRs covering the busiest traffic flows in that region or the highest frequency of passing should be assessed in order to address the problem of high traffic flows, where a higher than average risk of collision may occur.

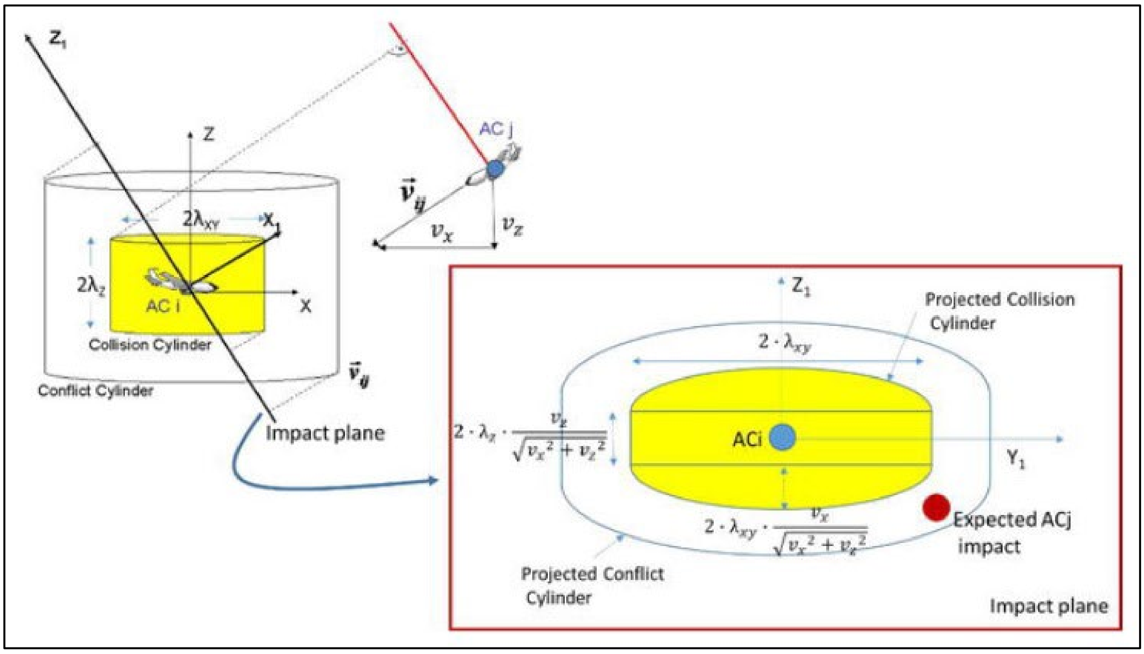


Figure 4 – Projected Conflict cylinder

RECEPTION OF TRAFFIC SAMPLES AND DEBUGGING

For this phase, which CARSAMMA calls “data purification”, a check of the compatibility and consistency of the data sent is carried out, as many times several differences from the requested pattern are found in the traffic samples, such as the lack of precious information for a correct risk assessment, in addition to the non-submission of any data by some FIRs.

Examples of deficiencies or absences found in the submitted data are: unknown airways flown, missing time of entry and exit from RVSM space, levels flown out of RVSM space, unknown aircraft type, etc. Therefore, this debugging takes many hours of work from the RMA to correct, and even so, because of the amount of data that are invalidated by the inconsistencies found during this phase, we may not have a faithful picture of what happens in the airspace of the FIR under study, and the consequent calculation of the vertical risk.

To have a general summary of the deficiencies found, the following were identified:
- The files presented a remarkable amount of information from repeated (duplicate) flights;

- On some flights, there was a reversal of course and fixed departure; this was placed as a fixed entry and vice versa;

- In some FIRs, several times are not ascending, i.e., the time of entry into the RVSM space is greater than the time of exit from this airspace;

- In some flight information there was a change of airways, instead of the X airway, the Y airway was used and vice versa;

- It was observed that several flights were described as flying in one FIR, when in fact they were flying in a neighboring FIR, and did not appear in the other FIR, where they should appear.

It is important to mention that the absence of RVSM air movement data from 03 FIR in the year 2023 will not allow calculating the risk level of these segments of the CAR/SAM airspace, but also that it will have an impact on the calculation of the risk level of the CAR/SAM regions. Therefore, these data have a very important relevance in the CAR/SAM RVSM airspace safety process.

ANALYSIS OF FIR THAT HAVE EXCEEDED TLS

During the calculations of the CRM with the methodology recommended by ICAO, the REICH Formula is used, with intense use of mathematical and statistical definitions and parameters. The main data inputs, as previously stated, are the LHDs received and validated by CARSAMMA, and the air movements in RVSM space sent by the FIR of the Caribbean and South America.

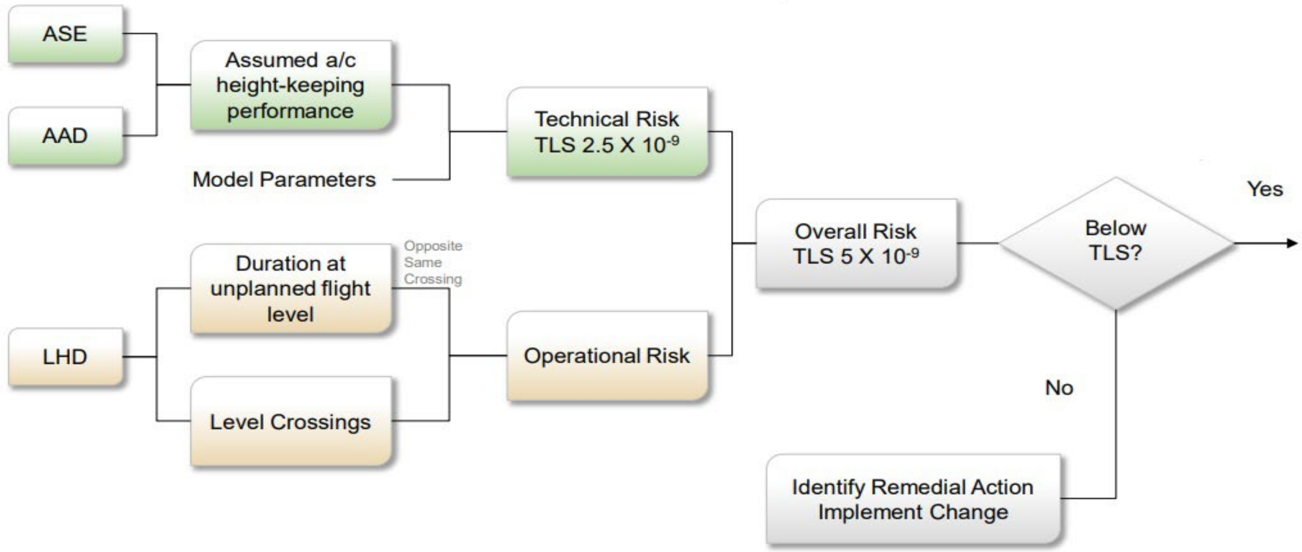


Figure 5 – TLS comparison study flow

- As for the LHD, these are analysed and validated unitarily by CARSAMMA's LHD sector, and the result of this analysis is made available to CARSAMMA's Altimetry Laboratory.

- On the other hand, air movements are received, checked for the correct completion of the data, and debugged as explained in the previous item.

What often happens is that when going through debugging, this data loses several lines of information due to the absence or inaccuracy of the data sent. This may lead to an inaccurate result for the risk calculation of that FIR.

Pz(0) = probability of vertical overlap
Q = time at the incorrect level
Ez(same) = vertical occupation in the same direction
ΔV = relative speed between aircraft in the same direction
Nz(same) = pass frequency between 2 aircraft in the same direction
Nz(0pp) = pass frequency between 2 aircraft in the opposite direction
C1= 1 + λx / ΔV(same) * (Ex(opp) / λy + ΔV(opp) / Ez(same)
C2 = 1 + λx / (2 * ΔV(same)) * (Ex(opp) / λy + ΔV(opp) / Ez(same)

PORT AU PRINCE – TRAFFIC SAMPLE

Type	# flight	Length	Wingspan	Height	Lx	Ly	Lz	ASE	Total ASE
A320	82	0.020290	0.018410	0.006350	1.663780	1.509620	0.520700	65.73	5389.86
B738	78	0.021330	0.018520	0.006750	1.663740	1.444560	0.526500	12.53	977.34
B38M	75	0.021310	0.019400	0.006640	1.598250	1.455000	0.498000	32.56	2442
A321	70	0.024030	0.018410	0.006350	1.682100	1.288700	0.444500	37.76	2643.2
B763	34	0.029640	0.025700	0.007560	1.007760	0.873800	0.257040	-53.28	-1811.52
A319	20	0.018270	0.018410	0.000640	0.365400	0.368200	0.012800	29.26	585.2
A332	20	0.031750	0.032560	0.009400	0.635000	0.651200	0.188000	69.99	1399.8
B789	19	0.034020	0.034020	0.009180	0.646380	0.646380	0.174420	41.31	784.89
A21N	16	0.024030	0.018410	0.006350	0.384480	0.294560	0.101600	70.45	1127.2
B739	16	0.021330	0.018520	0.006750	0.341280	0.296320	0.108000	21.38	342.08
B772	14	0.034400	0.032880	0.009990	0.481600	0.460320	0.139860	32.13	449.82
B77W	12	0.034400	0.034990	0.010040	0.412800	0.419880	0.120480	24.55	294.6
CL60	12	0.011260	0.010590	0.003400	0.135120	0.127080	0.040800	11.17	134.04
A20N	11	0.020290	0.018410	0.006350	0.223190	0.202510	0.069850	55.38	609.18
B733	11	0.017280	0.016200	0.006480	0.190080	0.178200	0.071280	-33.80	-371.8
B788	11	0.030780	0.032400	0.009180	0.338580	0.356400	0.100980	34.10	375.1
E145	11	0.016130	0.010820	0.003650	0.177430	0.119020	0.040150	-14.98	-164.78
B737	10	0.018900	0.018520	0.006750	0.189000	0.185200	0.067500	8.58	85.8
A359	9	0.036120	0.034560	0.009130	0.325080	0.311040	0.082170	-19.04	-171.36
B734	9	0.020290	0.018410	0.006350	0.182610	0.165690	0.057150	-67.56	-608.04
Top 20	540								
					12.643660	11.353680	3.621780	Average ASE	26.88
				Typical ACFT	0.023414	0.0210253	0.006707		
					Lx	Ly	Lz		

LHD were 40: 32 "E1", 1 "E2", 7 “L”.
Occupancy in wrong FL: 58 minutes
FL crossed without authorization: 67
ANV non-RVSM confirmed: 8
ANV non-RVSM unconfirmed: 14
Flights sent by MTEG: 1913 lines
Flights used: 675 lines, 64,5% lost
Sample average ASE: 26.88 Ft.

Main factors in increasing the risk of vertical collision in the MTEG FIR:

- Regarding the **air movement** received by CARSAMMA, we noticed the following differences to what was requested:

04 aircraft with blank Registration;

188 aircraft with Type error or in blank;

04 lines without Origin;

04 lines without Destination;

123 lines with blank or non-existent Airways;

150 lines without a fix;

126 lines with wrong times; and

The loss due to the error in filling out the air movement data (F0) significantly increased the result found for the risk of this FIR.

- The LHD time on a two-way airway and in the opposite direction was **58 min** (high).

- The loss **64.6%** of air movement data during debugging.

- Time at an unauthorized level of the validated LHD crossovers **67.**

- The total time of the LHD, which in the REICH formula is calculated as the probability of total vertical overlap **Pz(0)*Q** = **9.15 E-6** where: **Pz(0)** probability of overlap vertical, and **Q** the total time at the incorrect level.
- Another point of Reich's formula deals with the occupation of the RVSM space, and has a high result in the FIR under study, how:

> **Ez(same)** = **2Th(0) H 0.0384 .** Where: **2** (constant) number of accidents; **Th(0)** time of proximity to aircraft; **H** flight hours of the sample;
> **ΔV** = **1.9** Relative speed between aircraft in the same direction;
> **Nz(same) 0.003** = Frequency of lost separation between 2 aircraft in the longitudinal direction. Or frequency of passage in the same direction;
> **Nz(0pp) 0.1534 =** Frequency of passage in the opposite direction;
> **Nz(equiv) 0.1571** = **Nz(opp) + Nz(same)** **C1 , 11.3845**
> **C2 1.02168**

where:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{\overline{|\dot{y}|}}{|\Delta V|} + \frac{\lambda_x}{\lambda_z}\frac{\overline{|\dot{z}|}}{|\Delta V|}\right]$$

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{\overline{|\dot{y}|}}{2|V|} + \frac{\lambda_x}{\lambda_z}\frac{\overline{|\dot{z}|}}{2|V|}\right]$$

- Attention should be paid to the number of “rogue” **22** aircraft flying over this region.

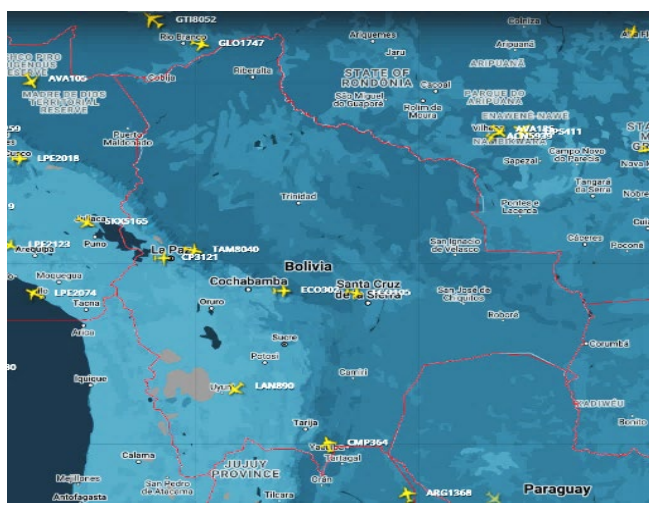
- The passage of traffic control in a small geographical and temporal space requires timely and more accurate coordination.

- More attention should be paid when filling out the F0 form, avoiding excessive data loss during data debugging.

LA PAZ – TRAFFIC SAMPLE

Type	*# flight*	*Length*	*Wingspan*	*Height*	*Lx*	*Ly*	*Lz*	*ASE*	*Total*
B738	1061	0.021330	0.018520	0.006750	22.631130	19.649720	7.161750	*12.53*	*13296.63*
B737	279	0.018900	0.018520	0.006750	5.273100	5.167080	1.883250	*8.58*	*2393.95*
A320	178	0.020290	0.018410	0.006350	3.611620	3.276980	1.130300	*65.73*	*11699.65*
B733	108	0.017280	0.016200	0.006480	1.866240	1.749600	0.699840	*-33.80*	*-3649.97*
CRJ2	96	0.014450	0.011450	0.003360	1.387200	1.099200	0.322560	*-4.59*	*-440.90*
A332	78	0.031750	0.032560	0.009400	2.476500	2.539680	0.733200	*63.06*	*4918.81*
E190	76	0.019570	0.015510	0.005710	1.487320	1.178760	0.433960	*18.92*	*1438.20*
A319	59	0.018270	0.018410	0.000640	1.077930	1.086190	0.037760	*29.26*	*1726.11*
B38M	57	0.021310	0.019400	0.006640	1.214670	1.105800	0.378480	*32.56*	*1855.93*
A20N	53	0.020290	0.018410	0.006350	1.075370	0.975730	0.336550	*55.38*	*2935.37*
B763	40	0.029640	0.025700	0.007560	1.185600	1.028000	0.302400	*-53.28*	*-2131.26*
B789	22	0.034020	0.034020	0.009180	0.748440	0.748440	0.201960	*41.31*	*908.78*
C550	18	0.007770	0.008590	0.002470	0.139860	0.154620	0.044460	*-0.43*	*-7.83*
B734	17	0.019710	0.015610	0.005990	0.335070	0.265370	0.101830	*-67.56*	*-1148.59*
B788	15	0.030780	0.032400	0.009180	0.461700	0.486000	0.137700	*34.10*	*511.51*
F900	11	0.010920	0.010440	0.004070	0.120120	0.114840	0.044770	*15.36*	*168.93*
FA50	7	0.010000	0.010180	0.003770	0.070000	0.071260	0.026390	*55.50*	*388.52*
A333	6	0.034340	0.032560	0.009100	0.206040	0.195360	0.054600	*36.60*	*219.58*
B744	5	0.038180	0.034770	0.010480	0.190900	0.173850	0.052400	*-63.37*	*-316.84*
LJ60	4	0.009654	0.007203	0.002397	0.038616	0.028812	0.009588	*36.21*	*144.86*
Top 20	**2190**								
					45.597426	41.095292	14.093748	***Average ASE***	**15.94**
				Typical ACFT	***0.020821***	***0.018765***	***0.0064355***		
					Lx	***Ly***	***Lz***		

LHD were 45: 1 “B”, 29 “E1”, 10 “E2”, 5 "L"
Occupancy in wrong FL: 95 minutes
FL crossed without authorization: 59
ANV non-RVSM confirmed: 5
ANV non-RVSM unconfirmed: 14
Flights sent by SLLF: 4303 lines
Flights used: 2206 lines, 48.73% loss
Sample average ASE: 15.94 Ft.



Main factors in increasing the risk of vertical collision in the SLLF FIR:

- Regarding the **air movement** received by CARSAMMA, we noticed the following differences to what was requested:

07 aircraft with blank Registration;

15 aircraft without Type;

58 lines with blank or non-existent Airways;

1211 lines without a fix;

2837 lines with wrong times;

428 duplicate lines; and

68% of the file there was no connection between the input RVSM fix and the output RVSM fix.

The loss due to the error in filling out the air movement data (F0) significantly increased the result found for the risk of this FIR.

- The LHD time on a two-way airway and in the opposite direction was **95 min** (high).

- The total time of the LHD, which in the REICH formula is calculated as the probability of total vertical overlap **Pz(0)*Q** = **3.4 E-6** where: **Pz(0)** probability of overlap vertical, and **Q** the total time at the incorrect level.
- Another point of Reich's formula deals with the occupation of the RVSM space, and has a high result in the FIR under study, how:

Ez(same) = **2Th(0) H** **0.0779** **.** Where: **2** (constant) number of accidents; **Th(0)** time of proximity to aircraft; **H** flight hours of the sample;
ΔV = **30.6** Relative speed between aircraft in the same direction;
Nz(same) **0.0107** = Frequency of lost separation between 2 aircraft in the longitudinal direction. Or frequency of passage in the same direction;
Nz(0pp) **0.2424** **=** Frequency of passage in the opposite direction;
Nz(equiv) **0.2597** = **Nz(opp) + Nz(same)** **C1 ,** **1.63071**
C2 **1.02169**

where:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\dot{y}|}{|\Delta V|} + \frac{\lambda_x}{\lambda_z}\frac{|\dot{z}|}{|\Delta V|}\right]$$

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\dot{y}|}{2|\bar{V}|} + \frac{\lambda_x}{\lambda_z}\frac{|\dot{z}|}{2|\bar{V}|}\right]$$

- Attention should be paid to the number of “rogue” **19** aircraft flying over this region.

- This FIR has a long LHD duration, which increases the risk of collision.

- And as this FIR covers a stretch of the Andes Mountains, and may suffer the effects of orographic flow, we recommend that greater attention be paid when accepting traffic from adjacent FIRs (the flight level maybe changed).

GUAYAQUIL – TRAFFIC SAMPLE

Type	# flight	Length	Wingspan	Height	Lx	Ly	Lz	ASE	Total
A320	1694	0.020290	0.018410	0.006350	34.371260	31.186540	10.756900	65.73	111343.86
B763	1106	0.029640	0.025700	0.007560	32.781840	28.424200	8.361360	-53.28	-58929.24
B738	1065	0.021330	0.018520	0.006750	22.716450	19.723800	7.188750	12.53	13346.75
A319	887	0.018270	0.018410	0.000640	16.205490	16.329670	0.567680	29.26	25950.21
A20N	751	0.020290	0.018410	0.006350	15.237790	13.825910	4.768850	55.38	41593.67
B38M	439	0.021310	0.019400	0.006640	9.355090	8.516600	2.914960	32.56	14293.93
B788	423	0.030780	0.032400	0.009180	13.019940	13.705200	3.883140	34.10	14424.46
B39M	419	0.022770	0.019400	0.006640	9.540630	8.128600	2.782160	-0.70	-293.30
B789	403	0.034020	0.034020	0.009180	13.710060	13.710060	3.699540	41.31	16647.28
A21N	298	0.024030	0.018410	0.006350	7.160940	5.486180	1.892300	70.45	20994.10
B735	204	0.016790	0.015610	0.005990	3.425160	3.184440	1.221960	-37.26	-7601.04
B772	204	0.034400	0.032880	0.009990	7.017600	6.707520	2.037960	32.13	6554.52
B744	188	0.038180	0.034770	0.010480	7.177840	6.536760	1.970240	-63.37	-11913.14
A359	163	0.036120	0.034560	0.009130	5.887560	5.633280	1.488190	19.04	3103.52
B752	154	0.025550	0.020790	0.007320	3.934700	3.201660	1.127280	-12.70	-1955.80
A332	147	0.031750	0.032560	0.009400	4.667250	4.786320	1.381800	69.99	10288.53
B77L	97	0.034400	0.034990	0.010040	3.336800	3.394030	0.973880	-0.49	-47.53
B734	92	0.019710	0.015610	0.005990	1.813320	1.436120	0.551080	-67.56	-6215.92
A321	78	0.024030	0.018410	0.006350	1.874340	1.435980	0.495300	37.76	2945.28
B737	58	0.018900	0.018520	0.006750	1.096200	1.074160	0.391500	8.58	497.67
Top 20	8870								
					214.330260	196.427030	58.454830	Average ASE	21.99
				Tipica ACFTl	0.0241635	0.022145099	0.006590172		
					Lx	Ly	Lz		

LHD were 44: 17 "E1", 19 "E2" y 8 "L"
Incorrect FL occupancy: 45 minutes
Unauthorized Cross FL: 28
ANV on RVSM confirmed: 8
ANV on RVSM unconfirmed: 3
Flights sent by SEFG: 9270 lines
Flights used: 9235 lines, loss 0.003%
Average sample ASE: 21.99 Ft.

Main factors that increase the risk of vertical collision in the SEFG FIR:

- Regarding the **air movement** received by CARSAMMA, we note the following differences with respect to what was requested:

04 aircraft with blank registration;

22 lines with blank or non-existent airways;

617 lines without FIX;

123 lines with wrong times; and

17 duplicate lines.

- The LHD time on a bidirectional and opposite-way airway was **45 min** (high).

- The total time of the LHD, which in the REICH formula is calculated as the probability of total vertical overlap **Pz(0)*Q** = **4.65 E-7** where: **Pz(0)** probability of vertical overlap, and **Q** the total time at the wrong level.

- Another point of Reich's formula has to do with the occupation of the RVSM space, and has a high result in the FIR under study, such as:

Ez(same) = **2Th(0) H** **0.2789** **.** Where: **2** (constant) number of accidents; **Th(0)** time of proximity to the aircraft; **H** sample flight hours;
ΔV = **12.8** Relative speed between aircraft in the same direction;
Nz(same) **0.0207** = Frequency of separation loss between 2 aircraft in the longitudinal direction. Or frequency of passage in the same direction;
Nz(0p) **0.1007** **=** Frequency of passage in the opposite direction;
Nz(equiv) **0.1518** = **Nz(op) + Nz(mismo)** **C1 ,** **1.833529**
C2 **1.021136**

Where:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{\overline{|\dot{y}|}}{|\Delta V|} + \frac{\lambda_x}{\lambda_z}\frac{\overline{|\dot{z}|}}{|\Delta V|}\right]$$

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{\overline{|\dot{y}|}}{2|\overline{V}|} + \frac{\lambda_x}{\lambda_z}\frac{\overline{|\dot{z}|}}{2|\overline{V}|}\right]$$

- Attention should be paid to the number of "NON-RVSM" aircraft flying over this region.

- In the FIR SEFG, greater caution is recommended when accepting the transfer of traffic from adjacent FIRs, along with the possibility of changes in the authorized level without prior notice by the crew due to the instantaneous effects of orographic flows on their geographical location.

CURACAO – TRAFFIC SAMPLE

Type	# flight	Length	Wingspan	Height	Lx	Ly	Lz	ASE	Total
B738	915	0.021328	0.018521	0.00675	19.51512	16.94672	6.175335	12.53	11466.93
A320	582	0.020286	0.018413	0.00635	11.80645	10.71637	3.6957	65.73	38253.91
B38M	560	0.021312	0.019395	0.00664	11.93477	10.86134	3.719223	32.56	18233.72
B788	432	0.030778	0.032397	0.00918	13.2961	13.9955	3.965328	34.10	14731.36
B739	407	0.021328	0.018521	0.00675	8.680496	7.538047	2.746843	21.38	8701.37
A321	402	0.024033	0.018413	0.00635	9.661266	7.402026	2.5527	37.76	15181.37
B737	383	0.018898	0.018521	0.00675	7.237934	7.093543	2.584867	8.58	3286.32
A20N	234	0.020286	0.018413	0.00635	4.746924	4.308642	1.4859	55.38	12959.94
B763	201	0.029644	0.025702	0.00756	5.958444	5.166102	1.519359	-53.28	-10709.56
A332	199	0.031749	0.032559	0.0094	6.318051	6.479241	1.869605	63.06	12549.28
B772	178	0.034395	0.032883	0.00999	6.12231	5.853174	1.778042	32.13	5719.81
B77W	149	0.034395	0.034989	0.01004	5.124855	5.213361	1.496407	24.55	3657.76
B789	146	0.034017	0.034017	0.00918	4.966482	4.966482	1.340134	41.31	6031.02
A359	136	0.036123	0.034557	0.00913	4.912728	4.699752	1.241	-19.04	-2589.78
E190	125	0.019568	0.015507	0.00571	2.446	1.938375	0.713375	18.92	2365.47
A319	113	0.018272	0.018413	0.00064	2.064736	2.080669	0.071755	29.26	3305.95
B39M	103	0.022765	0.019395	0.00664	2.344752	1.997711	0.684071	-0.70	-72.10
MD81	70	0.024352	0.017737	0.00513	1.70464	1.24159	0.35903	-5.50	-385.00
A339	67	0.034341	0.032559	0.0091	2.300847	2.181453	0.609566	0.70	46.75
CRJ2	67	0.014454	0.011452	0.00336	0.968418	0.767284	0.224986	-4.59	-307.71
Top 20	5469								
					132.1113	121.4474	38.83323	Average ASE	26.04
				Typical ACFT	0.024156	0.022207	0.007101		
					Lx	Ly	Lz		

LHD were 27: 17 "E1", 8 "E2" y 2 "L"
Incorrect FL occupancy: 28 minutes
Unauthorized Cross FL: 29
ANV on RVSM confirmed: 0
ANV on RVSM unconfirmed: 2
Flights sent by TNCF: 6420 lines
Flights used: 6339 lines, loss 0.0126%
Average sample ASE: 26.04 Ft.

Main factors that increase the risk of vertical collision in the FIR TNCF:

- Regarding the **air movement** received by CARSAMMA, we note the following differences with respect to what was requested:

19 aircraft with blank registration;

02 lines without a destination; and

14 lines with incorrect times.

- The LHD time on a bidirectional track and in the opposite direction was **27.5 min**.

- The total time of the LHD, which in the REICH formula is calculated as the probability of total vertical overlap **Pz(0)*Q** = **1.10 E-6** where: **Pz(0)** probability of vertical overlap, and **Q** the total time at the wrong level.

- Another point of Reich's formula has to do with the occupation of the RVSM space, and has a high result in the FIR under study, such as:

Ez(same) = **2Th(0) H** **0.01487** **.** Where: **2** (constant) number of accidents; **Th(0)** time of proximity to the aircraft; **H** sample flight hours;
ΔV = **26.2** Relative speed between aircraft in the same direction;
Nz(same) **0.0173** = Frequency of separation loss between 2 aircraft in the longitudinal direction. Or frequency of passage in the same direction;
Nz(0p) **0.1306** **=** Frequency of passage in the opposite direction;
Nz(equiv) **0.1602** = **Nz(op) + Nz(mismo)** **C1** **,** **1.749131**
C2 **1.021759**

Where:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\bar{\dot{y}}|}{|\Delta V|} + \frac{\lambda_x}{\lambda_z}\frac{|\bar{\dot{z}}|}{|\Delta V|}\right]$$

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\bar{\dot{y}}|}{2|\bar{V}|} + \frac{\lambda_x}{\lambda_z}\frac{|\bar{\dot{z}}|}{2|\bar{V}|}\right]$$

- Attention should be paid to the number of "NO RVSM" **02** aircraft flying over this region.

- The recommendation of this Agency (CARSAMMA) for the FIR TNCF is to be more careful when accepting/transferring control of traffic, to return the risk to an acceptable level.

PANAMA – TRAFFIC SAMPLE

Type	# flight	Length	Wingspan	Height	Lx	Ly	Lz	ASE	Total
B738	7051	0.021328	0.018521	0.006749	150.3837	130.5916	47.5872	12.53	88364.28
A320	2645	0.020286	0.018413	0.00635	53.65647	48.70239	16.79575	65.73	173851.5
B39M	2428	0.022764	0.019395	0.006641	55.2724	47.09166	16.12549	-0.70	-1699.60
B763	1201	0.029644	0.025702	0.007559	35.60244	30.8681	9.078359	-53.28	-63990.97
B737	996	0.018898	0.018521	0.006749	18.82241	18.44692	6.722004	8.58	8546.15
A20N	805	0.020286	0.018413	0.00635	16.33023	14.82247	5.11175	55.38	44584.42
B38M	522	0.021312	0.019395	0.006641	11.12491	10.12432	3.466847	32.56	16996.43
B789	390	0.034017	0.034017	0.009179	13.26663	13.26663	3.57981	41.31	16110.27
B752	349	0.025551	0.020788	0.007322	8.917299	7.255012	2.555378	-12.70	-4432.96
B739	315	0.021328	0.018521	0.006749	6.71832	5.834115	2.125935	21.38	6734.48
A332	302	0.031749	0.032559	0.009395	9.588198	9.832818	2.83729	63.06	19044.64
A319	264	0.018272	0.018413	0.000635	4.823808	4.861032	0.16764	29.26	7723.63
A21N	238	0.024033	0.018413	0.00635	5.719854	4.382294	1.5113	70.45	16768.06
A359	175	0.036123	0.034557	0.009125	6.321525	6.047475	1.596875	-19.04	-3332.44
B722	155	0.021922	0.017765	0.005562	3.39791	2.753575	0.86211	48.88	7575.82
B772	126	0.034395	0.032883	0.009989	4.33377	4.143258	1.258614	32.13	4048.86
B744	123	0.038175	0.034773	0.010475	4.695525	4.277079	1.288425	-63.37	-7794.23
B788	113	0.030778	0.032397	0.009179	3.477914	3.660861	1.037227	34.10	3853.34
A321	94	0.024033	0.018413	0.00635	2.259102	1.730822	0.5969	37.76	3549.87
B77W	93	0.034395	0.034989	0.010043	3.198735	3.253977	0.933999	24.55	2283.03
Top 20	18385								
					417.9112	371.9464	125.2389	Average ASE	18.43
				Typical ACFT	0.022731	0.020231	0.006812		
					Lx	Ly	Lz		

LHD were 75: 44 “E1”, 26 “E2” and 5 ”L”
Incorrect FL occupancy: 83 minutes
Unauthorized Cross FL: 141
ANV on RVSM confirmed: 0
ANV on RVSM unconfirmed: 7
Flights sent by TNCF: 19109 lines
Flights used: 19109 lines, loss 0.0 %
ASE sample average: 18.43 ft.

Main factors that increase the risk of vertical collision in the MPZL FIR:

- Regarding the **air movement** received by CARSAMMA, we noticed that the FIR RVSM movement data file was separated into 30 daily spreadsheets, different from those requested.

- LHD time in a bidirectional and opposite-direction airway was **83.0 min**.

- The total time of the LHD, which in the REICH formula is calculated as the probability of total vertical overlap **Pz(0)*Q** = **3.71 E-7** where: **Pz(0)** probability of vertical overlap, and **Q** the total time at the wrong level.

- Another point of Reich's formula has to do with the occupation of the RVSM space, and has a high result in the FIR under study, such as:

Ez(same) = **2Th(0) H** **0.01711 .** Where: **2** (constant) number of accidents; **Th(0)** time of proximity to the aircraft; **H** sample flight hours;
ΔV = 38.3 **Relative speed between aircraft in the same direction;**
Nz(same) 0.0300 = Frequency of separation lost between 2 aircraft in the longitudinal direction. Or frequency of passage in the same direction;
Nz(0p) 0.0270 = Frequency of passage in the opposite direction;
Nz(equiv) 0.0714 = **Nz(op) + Nz(mismo) C1 , 1.513153**
C2 1.022488

Where:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{\overline{|\dot{y}|}}{\overline{|\Delta V|}} + \frac{\lambda_x}{\lambda_z}\frac{\overline{|\dot{z}|}}{\overline{|\Delta V|}}\right]$$

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{\overline{|\dot{y}|}}{2\overline{|V|}} + \frac{\lambda_x}{\lambda_z}\frac{\overline{|\dot{z}|}}{2\overline{|V|}}\right]$$

- Attention should be paid to the number of "NON-RVSM" **07** aircraft flying over this region.

- In the case of the MPZL FIR, due to the high volume of traffic and the absence of losses during the authorization of air movements, it caused a "dilution" of LHD occurrences, which kept the risk above and close to TLS.

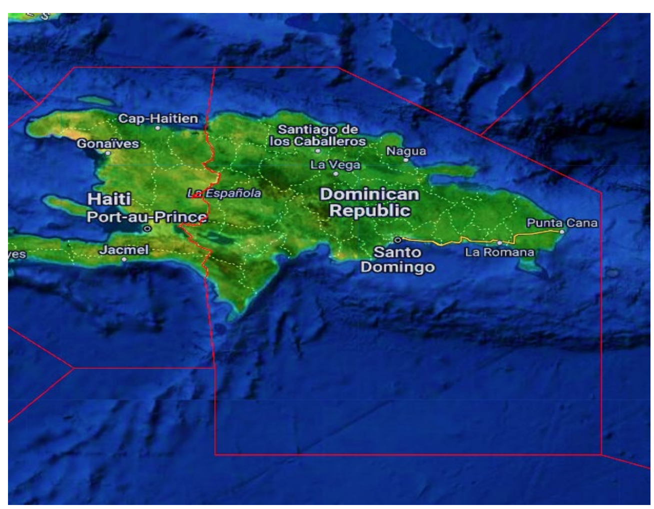
- The recommendation of this Agency (CARSAMMA) for the FIR MPZL is to be more careful when accepting/transferring traffic control, to return the risk to an acceptable level.

SANTO DOMINGO – TRAFFIC SAMPLE

Type	# flight	Length	Wingspan	Height	Lx	Ly	Lz	ASE	Total
B738	1979	0.021330	0.018520	0.006750	42.212070	36.651080	13.358250	12.53	24796.87
B38M	1211	0.021310	0.019400	0.006640	25.806410	23.493400	8.041040	32.56	39430.16
A320	955	0.020290	0.018410	0.006350	19.376950	17.581550	6.064250	65.73	62772.15
A321	729	0.024030	0.018410	0.006350	17.517870	13.420890	4.629150	37.76	27527.04
B739	715	0.034020	0.034020	0.009180	24.324300	24.324300	6.563700	21.38	15286.7
A20N	564	0.020290	0.018410	0.006350	11.443560	10.383240	3.581400	55.38	31234.32
E190	439	0.019570	0.015510	0.005710	8.591230	6.808890	2.506690	18.92	8305.88
B737	419	0.018900	0.018520	0.006750	7.919100	7.759880	2.828250	8.58	3595.02
A332	319	0.031750	0.032560	0.009400	10.128250	10.386640	2.998600	63.06	20116.14
B763	283	0.029640	0.025700	0.007560	8.388120	7.273100	2.139480	-53.28	-15078.2
B752	248	0.025550	0.020790	0.007320	6.336400	5.155920	1.815360	-12.70	-3149.6
B789	225	0.034020	0.034020	0.009180	7.654500	7.654500	2.065500	41.31	9294.75
A21N	223	0.024030	0.018410	0.006350	5.358690	4.105430	1.416050	70.45	15710.35
CRJ2	170	0.014450	0.011450	0.003360	2.456500	1.946500	0.571200	-4.59	-780.3
B39M	162	0.022770	0.019400	0.006640	3.688740	3.142800	1.075680	-0.70	-113.4
A319	158	0.018270	0.018410	0.000640	2.886660	2.908780	0.101120	29.26	4623.08
B772	151	0.034400	0.032880	0.009990	5.194400	4.964880	1.508490	32.13	4851.63
MD82	94	0.024350	0.017710	0.004890	2.288900	1.664740	0.459660	-15.76	-1481.14
B77W	70	0.034400	0.034990	0.010040	2.408000	2.449300	0.702800	24.55	1718.5
MD81	70	0.024352	0.017737	0.005129	1.704640	1.241590	0.359030	-5.50	-385
Top 20	9184								
					215.685290	193.317410	62.785700	Average ASE	27.03
				Typical ACFT	0.0234849	0.0210494	0.006836		
					Lx	Ly	Lz		

LHD were 47: 43 "E1", 02 "E2" y 2 "L"
Incorrect FL occupancy: 33 minutes
Unauthorized Cross FL: 27
ANV on RVSM confirmed: 2
ANV in RVSM unconfirmed: 15
Flights sent by MDCS: 10302 lines
Flights used: 10291 lines, loss 0.001%
Sample Average ASE: 27.03 Ft.

Main factors that increase the risk of vertical collision in the FIR MDCS:



- In relation to the air movement received by CARSAMMA, 301 routes are direct, i.e. without airways included in the AIP. This leads to work on the creation of new virtual routes, which requires additional time and work on the part of CARSAMMA experts.

- LHD time in a bidirectional and counter-directional airway was **33 min** (high).

- The total time of the LHD, which in the REICH formula is calculated as the probability of total vertical overlap **Pz(0)*Q** = **2.88 E-7** where: **Pz(0)** probability of vertical overlap, and **Q** the total time at the wrong level.

- Another point of Reich's formula has to do with the occupation of the RVSM space, and has a high result in the FIR under study, such as:

Ez(same) = **2Th(0) H** **0.1309** **.** Where: **2** (constant) number of accidents; **Th(0)** time of proximity to the aircraft; **H** sample flight hours;
ΔV = **7.3** Relative speed between aircraft in the same direction;
Nz(same) **0.0041** = Frequency of separation loss between 2 aircraft in the longitudinal direction. Or frequency of passage in the same direction;
Nz(0p) **0.0962** **=** Frequency of passage in the opposite direction;
Nz(equiv) **0.1117** = **Nz(op) + Nz(mismo)** **C1 ,** **3.699827**
C2 **1.021096**

Where:

$$c_1 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\dot{y}|}{|\Delta V|} + \frac{\lambda_x}{\lambda_z}\frac{|\dot{z}|}{|\Delta V|}\right]$$

$$c_2 = \left[1 + \frac{\lambda_x}{\lambda_y}\frac{|\dot{y}|}{2|V|} + \frac{\lambda_x}{\lambda_z}\frac{|\dot{z}|}{2|V|}\right]$$

- Pay attention to the number of **17** "NON-RVSM" aircraft flying over this region.

- The FIR MDCS is located between routes with a high volume of traffic, and its geographical extension is relatively small, which leaves little time to receive messages and make decisions, with this Agency (CARSAMMA) recommending that greater attention be paid to coordination at the transfer communication points (TCP).

— END —