INTERNATIONAL CIVIL AVIATION ORGANIZATION

WESTERN AND CENTRAL AFRICA OFFICE

Twenty-Fourth Meeting on the Improvement of Air Traffic Services over the South Atlantic (SAT/24)

Luanda, Angola, 5-7 June 2019

Agenda Item 3.3: SAT Area Risk Assessment and LHD Monitoring

3.3.2 ATLANTICO COLLISION RISK MODELING AND LHD MONITORING

(Presented by the CARSAMMA)

SUMMARY
This paper presents the required Tolerable Safety Level (TLS) of 5x10-9 fatal accidents per hour of flight (relative to monitoring the altitude maintenance performance of a representative sample of the aircraft population) and demonstrates that the safety criteria defined in ICAO Document 9574 continue to be satisfied in the RVSM airspace of the Atlantico FIR.
REFERENCE(S): Doc 9574
Related ICAO Strategic Objective(s): **Safety**

1. INTRODUCTION:

1.2 This working paper constitutes the collision risk analysis report for the RVSM airspace in the year 2018 at the Atlantico FIR, and the Collision Risk Modeling (CRM) methodology was used for the airspace safety assessment as recommended by ICAO in space RVSM.

2. DISCUSSION:

2.1 Among the activities of an RMA (such as CARSAMMA) are the constant assessment of the safe use of RVSM airspace using the QUANTITATIVE (CRA) method of collision risk assessment.

For the quantitative evaluation, the REICH Collision Risk Model, as recommended by ICAO, is used. This is an intensive mathematical base model where, at the end of the processing of the air movement data received from the relevant CAR / SAM Regions FIR (sheets containing flight data), the Vertical Collision Risk to be compared to - TLS - Target Level of Safety - of the study flight region, this method being used to determine if the safety of the system is acceptable as an absolute method. Several different calculation tools and databases are needed to complete the work, and the use of many hours of expert analysis.

This report contains the summary of the results of the Safety Assessment (CRM) of the Reduced Vertical Separation Minimum of 300 meters (1000 feet) in the ATLANTICO FIR airspace in 2018.

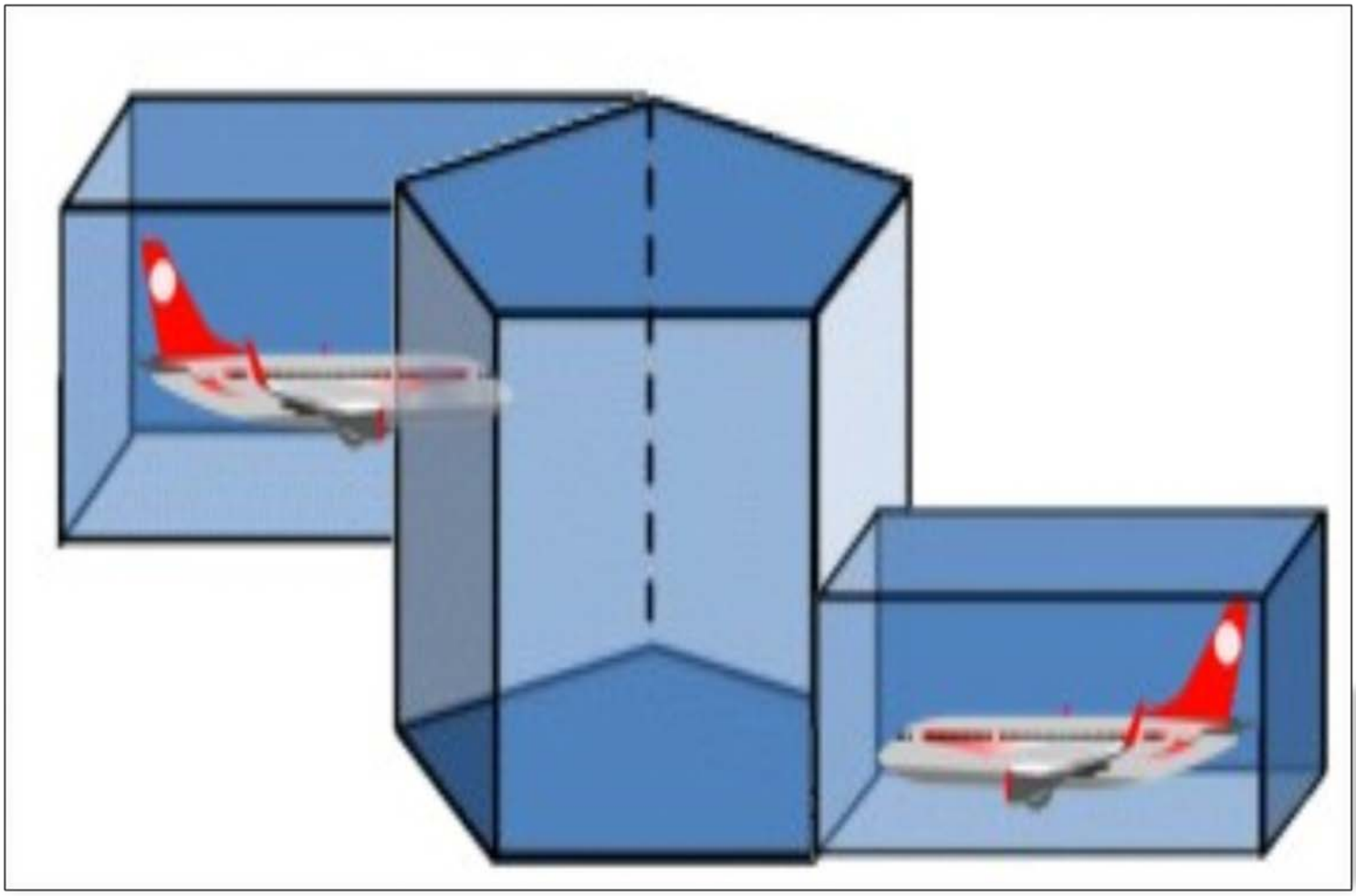
2.2 This section finalizes and estimates the results of the RVSM airspace safety assessment at the ATLANTICO FIR.

At this stage of the data analysis on the screen, a massive use of data processing is used, aiming to know the results of the Collision Risk Model. We will briefly describe how the treated data from the air movement sample together with validated LHD data are used and fused.

2.3 The data of the Large Height Deviation (LHD) issued during the year 2018 by the ATLANTICO FIR are compiled and analyzed during the monthly Conference calls that took place with the participation of experts from the FIRs involved, plus the officers the ICAO Offices of Lima and Mexico, and CARSAMMA.

2.4 During the Teleconferences, the LHDs are analyzed and validated, with the parameter values found, merged and inserted into the General Formula of the Reich Collision Risk Model, shown in the next chapter.

In Figure 2 below, a view of the RVSM airspace is described geometrically in which two aircraft are kept separated by 1000 feet within their safety envelope.



Estimates of CRM Parameters.

$$N_{az}^{T} = P_z(S_z)P_y(0)\left\{N_x(mismo)\left[1+\frac{\lambda_x|\overline{\dot{y}}|}{\lambda_y|\overline{\Delta V}|}+\frac{\lambda_x|\overline{\dot{z}}|}{|\overline{\Delta V}|\lambda_z}\right]+N_x(op)\left[1+\frac{\lambda_x|\overline{\dot{y}}|}{2\lambda_y|\overline{V}|}+\frac{\lambda_x|\overline{\dot{z}}|}{2|\overline{V}|\lambda_z}\right]\right\}.$$

Figure 3 – General Formula of the Reich Collision Risk Model

The value and source of material uses used to estimate values of each of the parameters inherent to the Internationally Accepted Collision Risk Model (RCM) used to perform the safety assessment for RVSM airspace are summarized in Table 4.

Parameter	Description	Value
λ_x	Average sample length of aircraft.	**0.02635 Nm**

λ_y	Average wingspan of the aircraft sample.	**0.02306 Nm**
λ_z	Average height of aircraft sample.	**0.00761 Nm**
$\overline{\lvert V \rvert}$	Average speed of the sample aircraft.	**424.106 kt**
$\overline{\lvert \Delta V \rvert}$	Relative average speed in the same direction as the aircraft sample.	**29.96 kt**
$\overline{\lvert \dot{y} \rvert}$	Average speed relative to the cross-sectional approximation of the aircraft sample.	**13 kt**
$\overline{\lvert \dot{z} \rvert}$	Relative average vertical speed during loss of vertical separation of aircraft sample.	**1.5 kt**
$P_z(0)$	Probability of two aircraft with the same nominal level are vertically overlap the sample aircraft.	**0.2982649**

Table 4: CRM Parameter Estimates

Total System Performance Specifications

7.1 Pass Frequency, Nx

It is the airspace parameter that characterizes the aircraft's exposure to vertical collision risk. The estimation for the equivalent frequency of passage was made considering aircraft flying innthe same direction and in opposite directions, as shown in Table 5.

FIR	Pass Frequency		
	Same Direction	Opposite Direction	Equivalent
Atlântico – SBAO	0.010135	0.241099	0.166429

Table 5 – Pass Frequency

7.2 Probability of Vertical Overlay, Pz(1000)

The estimated value of Pz (1000) used in our calculations was 2.46 x 10-8, according to the CRM methodology.

7.3 Probability of Lateral Overlay, Py(0)

According to ICAO Doc 9574, the probability of lateral overlap must be evaluated periodically.

In order to evaluate the operational collision risk, it was considered that Py (0) does not exceed **0.058** according to ICAO Doc 9574.

7.4 Collision Risk Calculation Parameters

Table 6 shows the groups of physical and dynamic parameters estimated with the Reich Collision Risk Model, as well as the main monitoring parameters of the ATLANTICO FIR.

All parameters were determined considering each region of airspace as an isolated system.

FIR	Ez(same)	Ez(opp)	Ez(cross)	ΔV(same)	ΔV(opp)	V
Atlântico – SBAO	0.36998	0.060275	0.317703	5.8089	869.6827	424.106
TOTAL CAR/SAM	**0.12217**	**0.03896**	**0.06281**	**28.4664**	**756.13**	**436.281**

Table 6: Physical and dynamic parameters used in the Reich Collision Risk Model

8 Conclusions of the Safety Assessment (CRM)

Operational Risk had its values estimated by FIRs presented in Table 7, which were obtained at the end of the processing of all data received and compiled and processed in the specific CRM software.

FIR	Technical Risk	Operational Risk	Risk
Atlântico – SBAO	0.0775E-09	0.0992E-09	0.1767E-09
FIR CAR/SAM	0.0401E-09	2.28E-09	2.32E-09

Table 7: Estimated Risk

The technical risk of ATLANTICO FIR **satisfies** the TLS value of not more than **2.5 x 10^{-9}** fatal accidents per hour of flight due to loss of standard vertical separation of 1,000 feet and all other causes.

Operational risk does not have a default value limit according to ICAO Doc 9574.

The total estimated risk is in the case of the ATLANTICO FIR of 0.**1767 x 10^{-9}** down, hence the TLS, which is **5.0 x 10^{-9}**.

RVSM Airspace ATLANTICO FIR – Estimated annual flight hours = 357,215.28 hours – *(note: estimated hours based on December 2018 sample)*			
Source of Risk	**Estimated Risk**	**TLS**	**Note**
Technical Risk	**0.0775 x 10^{-9}**	**2.5 x 10^{-9}**	**below**
Operational Risk	**0.0992 x 10^{-9}**	-	-
Total Risk	**0.1767 x 10^{-9}**	**5.0 x 10^{-9}**	**below**

Table 8: Annual Risk Estimates at the RVSM Airspace of ATLANTICO FIR

In summary, the RVSM airspace at the ATLANTICO FIR has an estimated annual Collision Risk below the TLS recommended by ICAO (**TLS = 5**) considering the CRM methodology (Table 8)

3. ACTION BY THE MEETING:

3.1. The meeting is invited to:

a) take note of the contents of this paper.

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