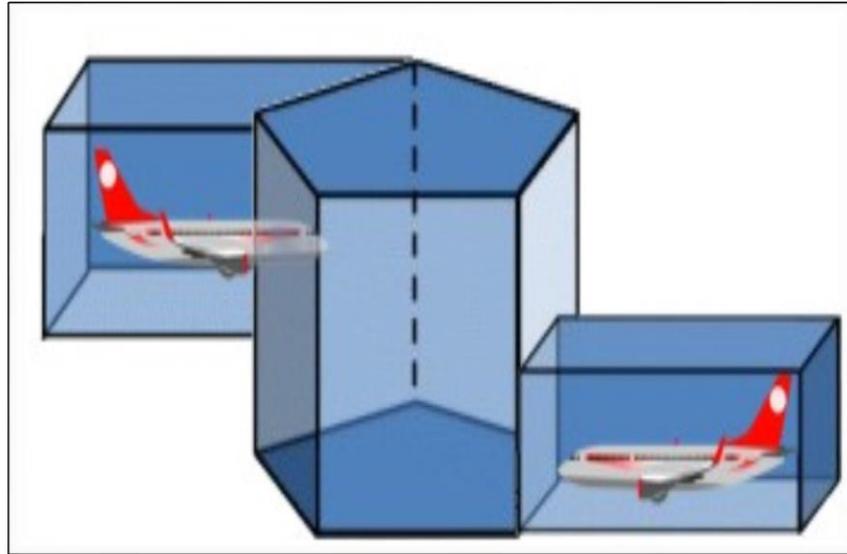


## APPENDIX – F2

### 2018 COLLISION RISK ASSESSMENT AND LARGE HEIGHT DEVIATION (ATLANTICO)



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

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.

**Table 4: CRM Parameter Estimates**

Parameter	Description	Value
$\lambda_x$	Average sample length of aircraft.	<b>0.02635 Nm</b>
$\lambda_y$	Average wingspan of the aircraft sample.	<b>0.02306 Nm</b>
$\lambda_z$	Average height of aircraft sample.	<b>0.00761 Nm</b>
$ \bar{V} $	Average speed of the sample aircraft.	<b>424.106 kt</b>
$ \Delta V $	Relative average speed in the same direction as the aircraft sample.	<b>29.96 kt</b>
$ \bar{y} $	Average speed relative to the cross-sectional approximation of the aircraft sample.	<b>13 kt</b>
$ \bar{z} $	Relative average vertical speed during loss of vertical separation of aircraft sample.	<b>1.5 kt</b>
$P_z(0)$	Probability of two aircraft with the same nominal level are vertically overlap the sample aircraft.	<b>0.2982649</b>

### 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 in the same direction and in opposite directions, as shown in Table 5.

FIR	Pass Frequency		
	Same Direction	Opposite Direction	Equivalent
<b>Atlântico – SBAO</b>	<b>0.010135</b>	<b>0.241099</b>	<b>0.166429</b>

**Table 5 – Pass Frequency**

**Probability of Vertical Overlay, Pz(1000):** The estimated value of Pz (1000) used in our calculations was  $2.46 \times 10^{-8}$ , 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)	$\Delta V$ (same)	$\Delta V$ (opp)	V
Atlântico – SBAO	0.36998	0.060275	0.317703	5.8089	869.6827	424.106
<b>TOTAL CAR/SAM</b>	<b>0.12217</b>	<b>0.03896</b>	<b>0.06281</b>	<b>28.4664</b>	<b>756.13</b>	<b>436.281</b>

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	<b>0.0775E-09</b>	<b>0.0992E-09</b>	<b>0.1767E-09</b>
<b>FIR CAR/SAM</b>	<b>0.0401E-09</b>	<b>2.28E-09</b>	<b>2.32E-09</b>

Table 7: Estimated Risk

The technical risk of ATLANTICO FIR **satisfies** the TLS value of not more than  $2.5 \times 10^{-9}$  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  $0.1767 \times 10^{-9}$  down, hence the TLS, which is  $5.0 \times 10^{-9}$ .

RVSM Airspace ATLANTICO FIR – Estimated <b>annual</b> flight hours = 357,215.28 hours – (note: estimated hours based on December 2018 sample)			
Source of Risk	Estimated Risk	TLS	Note
Technical Risk	$0.0775 \times 10^{-9}$	$2.5 \times 10^{-9}$	below

<b>Operational Risk</b>	<b>0.0992 x 10<sup>-9</sup></b>	-	-
<b>Total Risk</b>	<b>0.1767 x 10<sup>-9</sup></b>	<b>5.0 x 10<sup>-9</sup></b>	<b>below</b>

**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)