ASSESSING PUBLIC EXPOSURE IN COMMERCIAL FLIGHTS IN BRAZIL

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1. INTRODUCTION

Exposure to cosmic radiation in aircraft travel is significantly higher than that at the ground level and it varies with the route due to the effect of latitude, the altitude of flight, the flight time, and the year due to the effect of the solar cycle in galactic cosmic ray flux. The world average estimated by UNSCEAR (2010) for the effective dose due to cosmic radiation at ground level is 0.38 mSv per year, about 16% of the average worldwide dose from natural sources.

The computer program CARI-6, developed by the U.S. Federal Aviation Administration Civil Aerospace Medical Institute, calculates the effective dose of galactic cosmic radiation received by an individual (based on an anthropomorphic phantom) in an aircraft flying the shortest route between two airports the world.

The aim of this project is to estimate the contribution of cosmic radiation exposure on commercial flights to the Brazilian population.

2. METHODOLOGY

Some standard flights were selected to assess the variability of parameters affecting flights in Brazil. The simulations for the doses will be made using the model Cari-6 (FAA, 2011).

A database including all routine commercial flights in Brazil is been implemented in Excel spreadsheets, based on data on flights for November, 2011. To assess the uncertainty due to the annual variability on cosmic rays flux, a flight from Rio de Janeiro, RJ, to Porto Alegre, RS, was selected. The distance between the two airports is about 2000 km and flight time is about 2 hours. This flight was simulated at different months within 2011 and annually from 1995 to 2011. To assess the latitude differences within Brazil, doses from flights from Rio de Janeiro, RJ to different locations in Brazil were simulated. The airports locations used in this work are described on Table 1 and shown in Figure 1. Results for assessing latitude effect are presented in µSv per hour at a standard flight altitude of 34000 ft.

Figure 1. Airports included in simulations

Table 1. Location of airports used in this work

City	*IATA code*	*ICAO code*	*latitude*	*longitude*	*elevation (m)*
Rio de Janeiro	GIG	SBGL	22º 48' 36" S	43º 15' 02" W	9
Porto Alegre	POA	SBPA	29º 59' 38" S	51º 10' 16" W	3
São Paulo	GRU	SBGR	23º 26' 08" S	46º 28' 23" W	750
Brasília	BSB	SBBR	15º 52' 09" S	47º 55' 15" W	1060
Salvador	SSA	SBSV	12º 54' 31" S	38º 19' 21" W	20
Manaus	MAO	SBEG	03º 02' 28" S	60º 03' 02" W	80

3. RESULTS

Figure 2 and 3 present the variability predicted for the Rio de Janeiro – Porto Alegre two hours flight, assuming a 15 minutes period for takeoff, up to a 90 minutes average cruise altitude of 34000 ft, and 15 minutes for landing, totalizing 2 hours for each flight.

Figure 2. Doses for flights from Rio de Janeiro to Porto Alegre for the same month in different years.

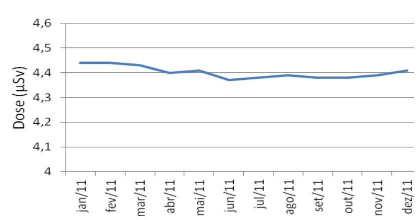

Figure 3. Doses for flights from Rio de Janeiro to Porto Alegre for different months of the same year.

The variability within a single year was much smaller than the variability within a 11 years solar activity cycle.

A statistical summary of the results obtained are presented on Table 2. The results for latitude effects are shown on table 3.

Table 2. Summary results for simulations

source of uncertainty	*flights characteristics*	*average dose (µSv)*	*standard deviation (µSv)*	*coeficient of variation (%)*
seasonal aspects*	monthly flights	4,40	0,02	0,56
solar cycle*	annual flights	4,36	0,11	2,49
altitude*	30000-38000 ft	4,41	1,21	27,31
takeoff and landing**	5 to 15 minutes	4,71	0,32	6,79
time at en route altitude***	100 to 140 min	4,71	0,70	14,93

* 15 min take off and landing, 120 min flight
**120 minutes total flight
*** 10 minutes take off and landing

Table 3. dose rate at en route altitude (34000 ft) for different flights within Brazil

Flight	*dose rate (µSv/h)*
GIG - POA	2,70
GIG - MAO	2,41
GIG - SSA	2,51
GIG - BSB	2,52
GIG - GRU	2,62
POA - MAO	2,46
average	2,54
std.dev.	0,11
CV (%)	4,19

Main cause of variability was the altitude of the flight that depends on the type of airplane and the route. For the latitude effect within Brazil, less then 5% variability on dose rate is expected.

4. CONCLUSIONS

Based on these results, it was decided that the work shall continue using nominal flight time for each route, according to that predicted by airlines. Average altitude to be used for all large airplane (> 80 passengers) flights shall be considered to be 34000 ft. The reference year will be 2011, for which data for all flights are available.

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