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ELECTROMAGNETIC PLATFORM FOR LIGHTWEIGHT INTEGRATION/INSTALLATION OF ELECTRICAL SYSTEMS IN COMPOSITE ELECTRICAL AIRCRAFT

COSMIC RADIATION IN-FLIGHT MEASUREMENT FOR ELECTRONIC SYSTEMS

OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES (ONERA)

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https://ec.europa.eu/programmes/horizon2020 http://caric.aero http://www.nserc-crsng.gc.ca

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- Introduction
- Aircraft Exposure to Cosmic Radiations
- About Cosmic Radiations
- Aircraft structure shielding against Cosmic Radiations
- Regulation for aircraft systems certification for radiative environment
- Purpose of Data collection Project

OUTLINES TO BE CONTINUED

- Cosmic Ray interaction with Matter
- Consequences of SEE
- SEE (Soft Error) on Aircraft Electronic System
- SEE (Hard Error) on Aircraft Electronic System
- Effective Dose Calculation
- Conclusion

INTRODUCTION

Nowadays aircraft transportation becomes a common way of travelling and some categories of commercial aircraft can now fly at very high altitudes and whatever the latitudes. The Bombardier Business Jet *Global 7000/8000* belongs to that family of aircraft.

However :

1. Altitude: The higher the aircraft will fly, the higher the exposure to radiations. The exposure to radiation energy approximatively doubles with every 6ooo feet of increased altitude.
2. Latitude: The farther the aircraft will fly away from equator , the greater the dose of radiation energy
3. Duration: The longer the aircraft will stay aloft, the greater that dose

AIRCRAFT EXPOSURE TO COSMIC RADIATIONS

Geographical Coordinates	Altitude (feet)	Effective dose rate (µSv/h)
$0^o, 20^0\ E$	0	0.028
	20,000	0.54
	30,000	1.6
	40,000	3
$40^o\text{N}, 20^0\ \text{E}$	0	0.037
	20,000	0.74
	30,000	2.3
	40,000	4.5
$80^o\text{N}, 20^0\ \text{E}$	0	0.041
	20,000	1.1
	30,000	4
	40,000	8.8

Effective dose calculated in 1998 by CARI-6

ABOUT COSMIC RADIATIONS

Cosmic radiations consist of:

- ✓ *solar component and*
- ✓ *galactic component*

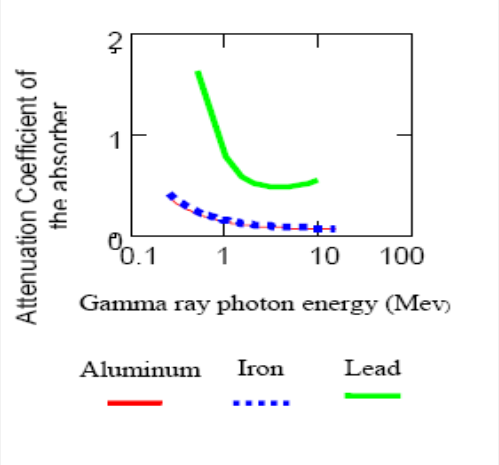
Radiation phenomenon generates a transfer of an energy from a given source to a given receiver. It may be in the form of:

- ✓ *electromagnetic waves* (x-rays and gamma rays)
- ✓ *particles*: neutrons and protons

Assuming that energy penetrates any matter then:

- ✓ The matter becomes "ionized" and its basic composition may change
- ✓ It may affect or even damage an electronic system

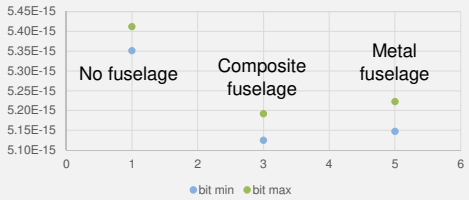
Aircraft structure shielding against Cosmic Radiations



ACCELERATED TESTS AT TRIUMF

- Impact of fuselage
  - Without any
  - Metal fuselage
  - Composite fuselage
  - About 4% loss

95% Confidence Interval Cross-Sections; 1 = no cover, 3 = composite, 5 = metal; loss ≈ 4%



- Metric:
  - Cross section (cm^2) = Nb of errors/Fluence
  - Fluence = Particles /cm^2 = Flux * time
  - Flux = Particles /(sec * cm^2)

REGULATION FOR PROTECTION AGAINST COSMIC RADIATIONS

- International Directive requirements about limitation of aircrew members' exposure to cosmic radiations exist and *Member States* were required to implement that Directive by 13 May 2000.
- **However no clear requirement** for aircraft certification exists for now , except SEE's one for some electronic components which even is not mandatory

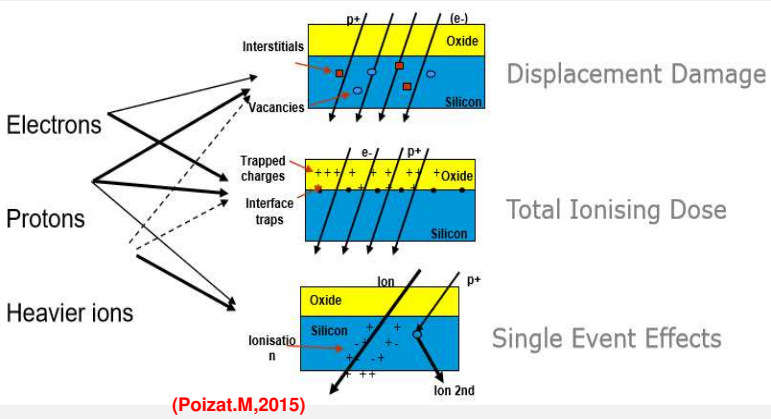
✓ *This is the main reason which that brings together Bombardier and some partners to collect actual data on board Global 7000*

DATA COLLECTION PURPOSE

1. Collect cosmic radiation real data aboard the Global 7000
2. To allow Bombardier to contribute to the very next certification regulation to be released by FAA, TCCA and EASA, for aircraft exposure to cosmic radiation

COSMIC RAY INTERACTION WITH MATTER

- In the micro-electronic circuits: the radiation can generate 3 kinds of failures



(Poizat.M,2015)

CONSEQUENCES OF SEE

- The SEE results from a single particule that deposits sufficient energy on electronic equipment to cause a momentary or permanent change in the state of a device. Most often failures are non-destructives.
- SEEs are instantaneous and transients
- Triggering destructive and non-destructive dis-functions
- Generating errors
- Change of bit values, signal deterioration and information
- Creation of currents that can be destructive

SINGLE EVENT EFFECTS (SOFT ERRORS) ON AIRCRAFT ELECTRONIC SYSTEM

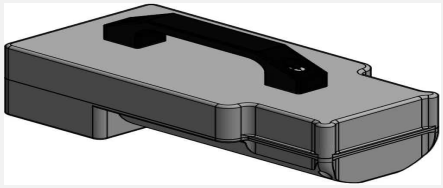
SEE	Phenomenon Explanation	Consequence
SEU (Single Event UpSet)	Collected charge created by an incident energy particle is greater than the critical load of the node.	-Modification of the storage elements: memory cells (SRAM and DRAM). -Rewrite this element is enough to eliminate this effect
MBU (Multi bit UpSet)	-	UpSet in several bits in the same word
MCU(Multi Cell Upset)	An incident particle interacts with several memory cells	Several UpSets bits of an integrated circuit at the same time

SINGLE EVENT EFFECT (HARD ERRORS) ON AIRCRAFT ELECTRONIC SYSTEM

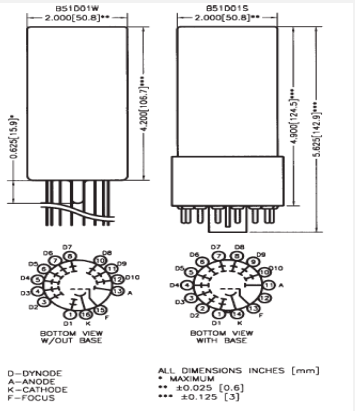
SEE	Phenomenon Explanation	Consequence
SEL (Single Event Latch up)	A highly energetic particle strikes the integrated circuit of the thyristor of a parasitic structure PNPN, with a CMOS (Complementary metal oxide-Semiconductor)	-A short circuit between the power supply and the circuit ground -A transient pulse current is created, causing a considerable heating in the circuit, which can cause a failure or a lock in the device -Stop power is needed to correct this event
SEB (Single Event Burnout)	It is manifested in power devices equiped with Mosfets (Metal Oxide Semiconductor Field Effect Transistor) and BJT (Bipolar Junction Transitor) at high voltages. These devices must also interact with an ionizing particle	Significant currents and temperatures, even destroying the device

Material for Collecting Light Pulses

1. Scintillator +Photomultiplier (*)



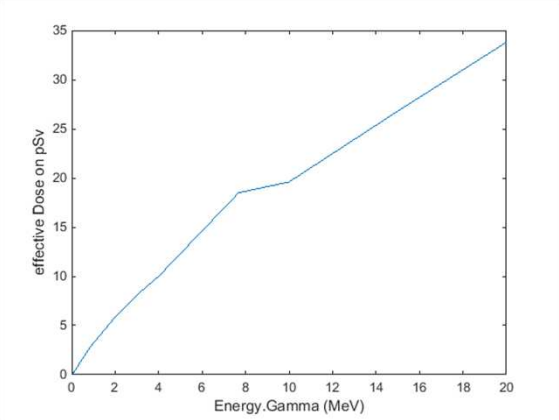
3. Measuring system package (*)



2.Dimensions of the photomultiplier tube (*)

(*) Measuring system is provided by Bubble Technology Industries, Canada

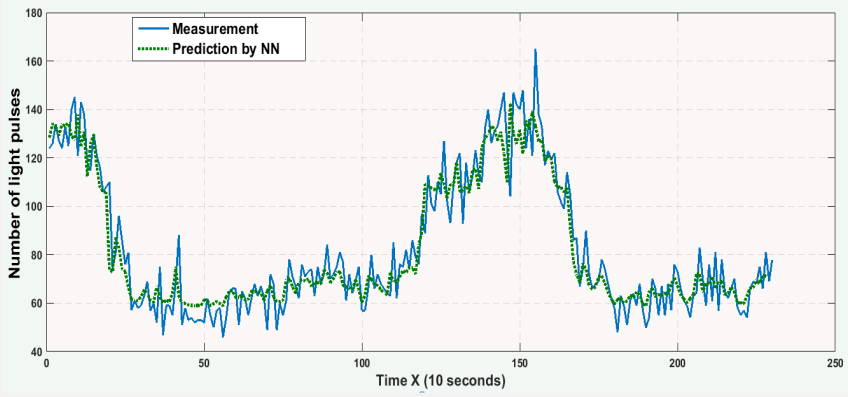
The effective dose for the photons according to the energy (ICRP annals)



- The effective dose for the photons according to the energy **for one point of the flight trajectory** (ICRP annals) and our calculation = 2.92pSv
- The effective dose for the photons according to the Expacs (ONLY THE SAME ENERGIES) and using the the exposition duration (10seconds) = 3.75 pSv
- The relative error = 22% (35% with 05 energies)

RESULTS AND ANALYSIS OF MODELING BY PARTICLE TYPE

Comparison of gamma ray light pulses number



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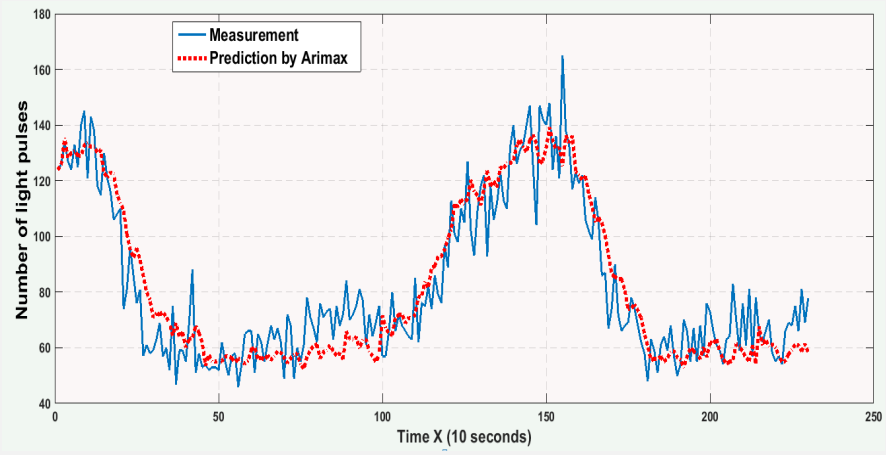

CONCLUSION & FUTURE WORK

- **Results analysis** ARIMAX and Neurons Network (NN) provide a good prediction of gamma rays and neutrons light pulses number

- **Future work** to get the flux of cosmic radiations from the light pulses number prediction, we have to use the mathematical methodologies such as deconvolution models and typical responses for our scintillator type

THANK YOU

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