Highly reliable COTS satellite and launcher computers

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RUAG Space
On-board computer heritage

Command and Data Handling Systems

Delivered to more than 128 satellites in telecom, navigation, science and earth observation applications - Juice, MTG, Rosetta, Galileo, Copernicus, ExoMars Orbiter & Rover

Welcome to our everyday life

Missions ranging from:
- few year in Low-earth orbit
- >15 years in Geo-stationary orbit
- 22 years in deep-space (Solar and Heliospheric Observatory)
Usage of commercial components in space

- Traditionally on-board computers have been built using rad-hard components, immune to radiation effects.
- Modern commercial components provide a good ability to withstand the total dose of radiation that electronics are exposed to in space.
- The use of commercial components to build electronics space products is something that is widely used among most space electronic suppliers today.

- Offering on-board computers using commercial components instead of rad-hard components provides some clear benefits:
  - Lower prices
  - Higher performance, better SWAP (Size, Weight and Power consumption)
  - Shorter lead-times

**Summary:**
Usage of commercial in space is a reality today, offering clear benefits
How do we design highly reliable COTS based space computers?

1. Component selection criteria:
   - Parts reliability
   - Radiation resistance

2. Local SEE mitigations:
   - Latch-Up detection
   - Error Detection And Correction (EDAC) for memories and Triple Modular Redundancy (TMR) for FPGAs

3. System SEE mitigations:
   - Supervisors

4. Highly reliable system architectures
   - Failure correcting links
   - Redundant links
   - Redundant functions

Step 1: Select adequate components
Step 2: Implement local SEE mitigation
Step 3: Implement System SEE mitigation
Step 4: Implement highly reliable architecture
How do we design highly reliable COTS based space computers?

Step 1: Component selection criteria
- Radiation resistance
- Parts reliability
- Radiation testing
- Automotive components

Step 2: Local SEE mitigations
-Latch-up detection
-EDAC
-TMR

Techniques commonly used throughout industry today
How do we design highly reliable COTS based space computers?

Step 3: System SEE mitigations

- Supervisor
- Processor Core
- FPGAs
- IO Functions
- Local power converters and switches
- Undervoltage alarm
- Over current alarm
- EDAC errors
- Execution errors
- Functional errors
- Alarms
- System alarms

Supervisor that detects and corrects module level failures

Step 4: Highly reliable system architectures

- GPS Receiver
- TTRM
- TC Dec, TM Enc, Supervisor
- PM
- Processing Digital I/O
- IO

Architecture with redundant and failure correcting links, cross-strappings between redundant functions
Comparison
RAD-hard vs a LEO Constellation on-board computer

RAD-hard On-board Computer
- Implemented using:
  - Rad-hard components
  - Step 2: Local SEE mitigations
  - Step 3: System SEE mitigations
  - Step 4: Highly reliable system architectures

Total dose: > 100kRAD
Performance: 70 Dhrystone MIPS
Mission life-time:
  > 15 years in GEO
Price: 2M€

Constellation On-board Computer
- Implemented using:
  - Step 1: Component selection criteria
  - Step 2: Local SEE mitigations
  - Step 3: System SEE mitigations
  - Step 4: Highly reliable system architectures

Total dose: 50kRAD
Performance: 1800 DMIPS
Mission life-time:
  < 10 years in LEO
Price: < €200k
Comparison and conclusions
RAD-hard vs a LEO constellation single-board computer

Panther SBC
- Implemented using:
  - Rad-hard components
  - Step 2: Local SEE mitigations
  - Step 3: System SEE mitigations
- Performance: 70 DMIPS
- Total dose: > 100kRAD
- Mission life-time: > 15 years in GEO
- Cost: 500k€

Constellation SBC
- Implemented using:
  - Step 1: Component selection criteria
  - Step 2: Local SEE mitigations
  - Step 3: System SEE mitigations
- Performance: 1800 DMIPS
- Total dose: 50kRAD
- Mission life-time: < 10 years in LEO
- Cost: < €50k

Conclusions:
Modern commercial components are well suited for withstanding the harmful space radiation environment.
The radiation tolerance can be significantly improved designing in additional mitigation techniques.
The reliability can be further improved if designed using a highly reliable architecture.
We listen to make it right.
We stay to make it real.
A promise you can trust.