Highly reliable COTS satellite and launcher computers

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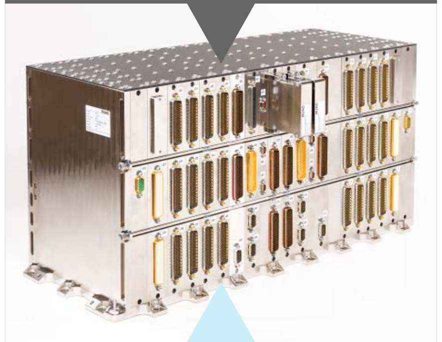
RUAG Space
On-board computer heritage

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

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

GEO telecom on-board computer

Mars Rover on-board computer

LEO constellation Single-Board Computer

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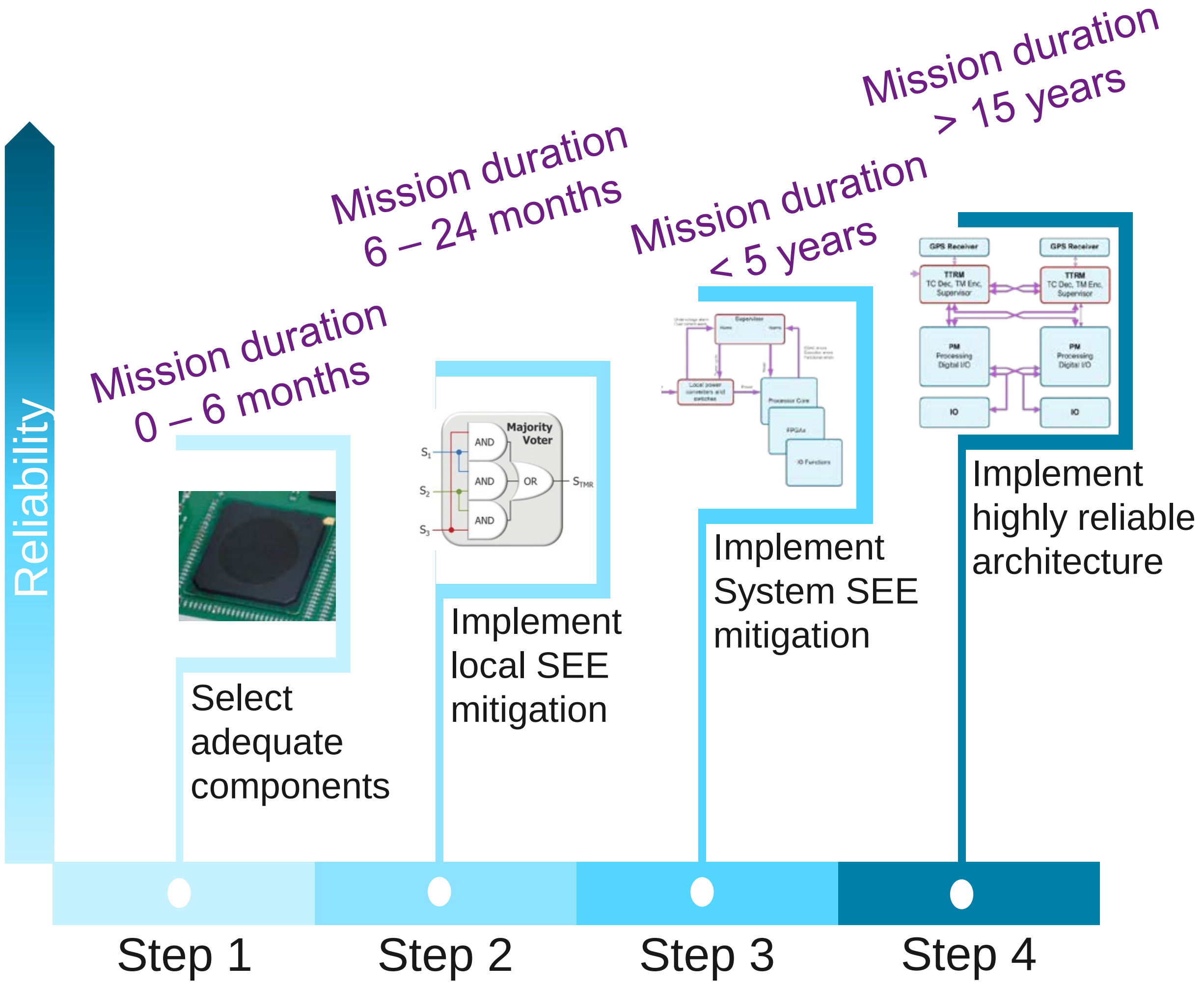
Usage of commercial components in space

- 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?

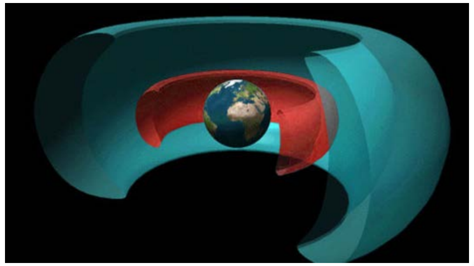


1. Component selection criteria:
   - Parts reliability
   - Radiation resistance
2. Local SEE mitigations:
   - Latch-Up detection
   - Error Detection And Correction (EDAC) for memories and Triple Modular Redundancy (TMR) for FPGAs
3. System SEE mitigations:
   - Supervisors
4. Highly reliable system architectures
   - Failure correcting links
   - Redundant links
   - Redundant functions

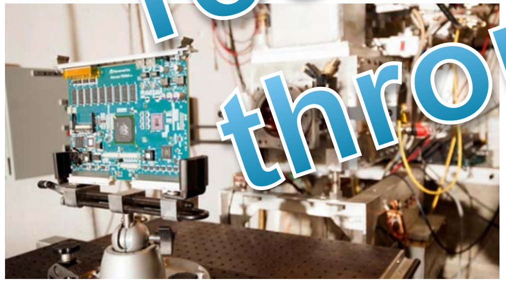
How do we design highly reliable COTS based space computers?

Step 1: Component selection criteria

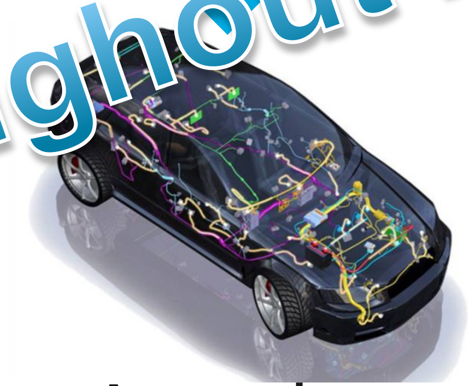
Radiation resistance



Parts reliability



Radiation testing

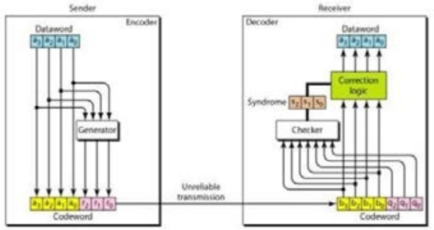


Automotive components

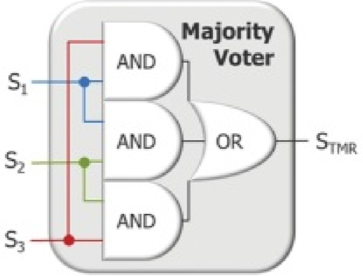
Step 2: Local SEE mitigations

Latch-up detection

EDAC



TMR



Techniques commonly used throughout industry today

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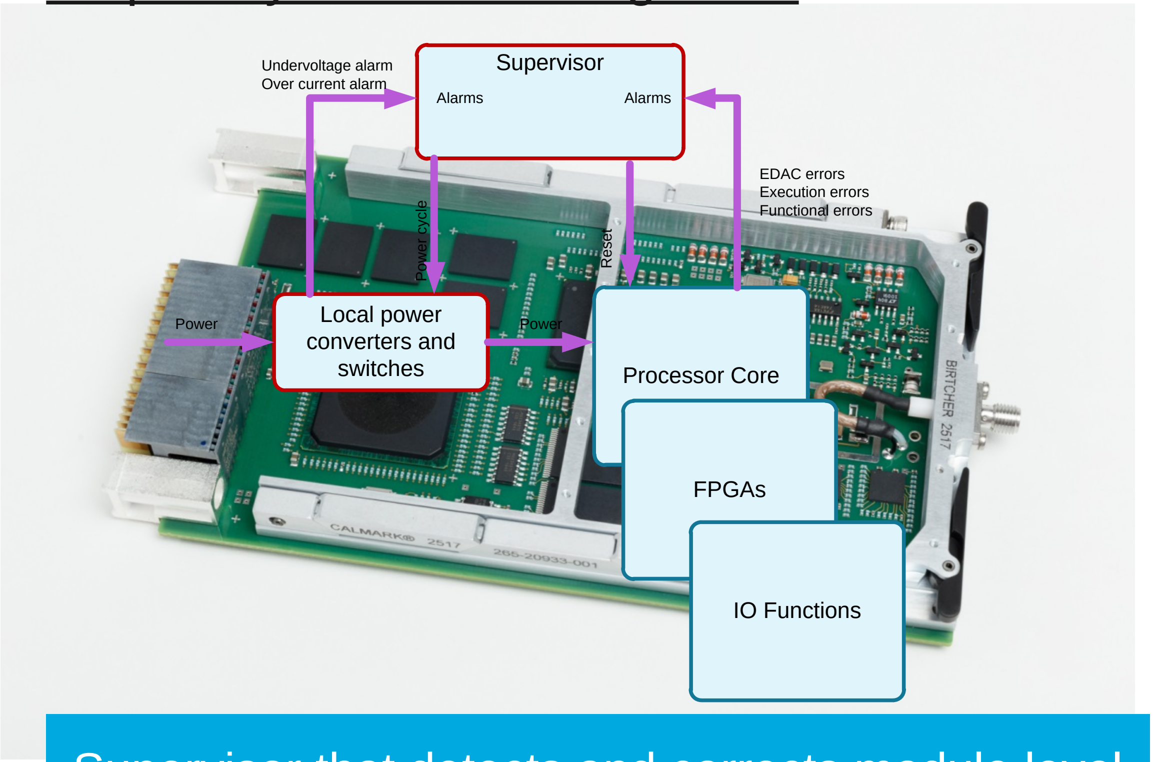
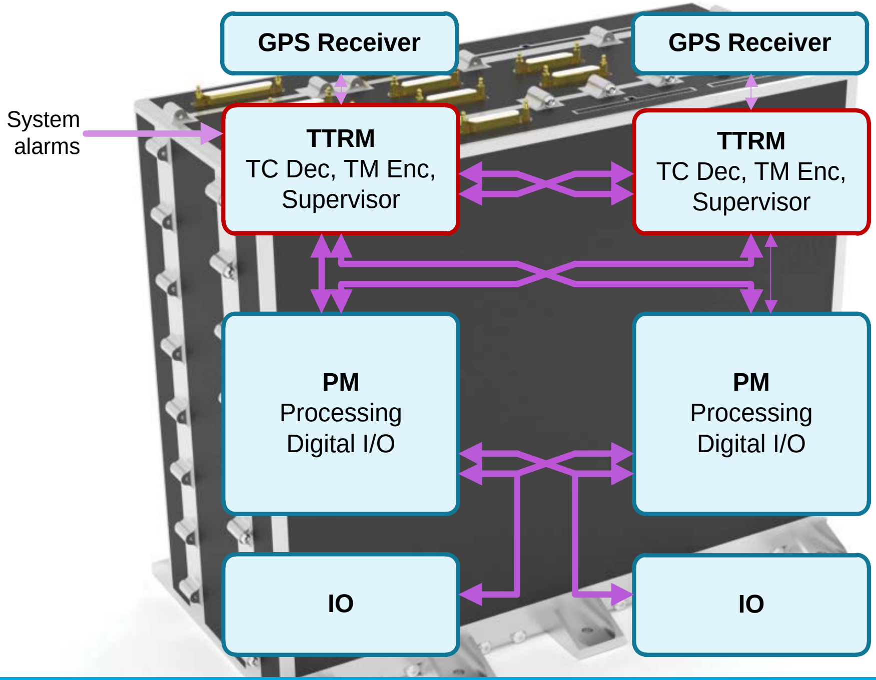
How do we design highly reliable COTS based space computers?

Step 3: System SEE mitigations



Supervisor that detects and corrects module level failures

Step 4: Highly reliable system architectures



Architecture with redundant and failure correcting links, cross-strappings between redundant functions

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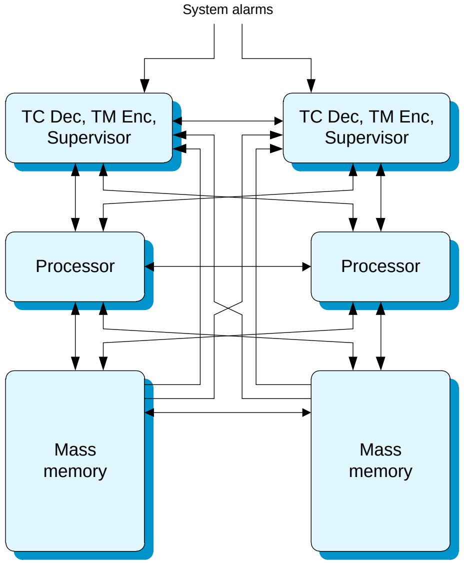
Comparison
RAD-hard vs a LEO Constellation on-board computer

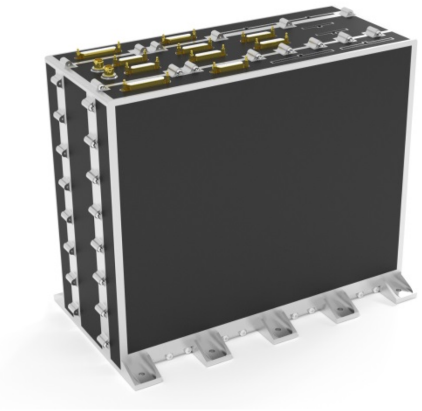
RAD-hard On-board Computer

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:
> 15years in GEO
Price: 2M€

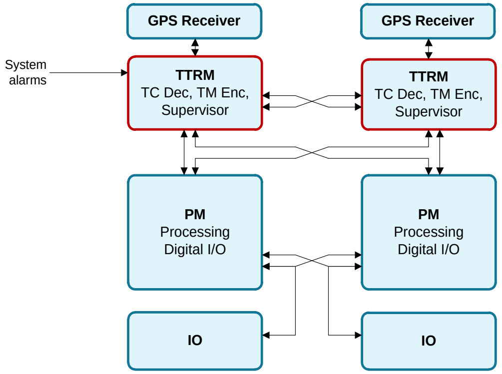


Constellation On-board Computer



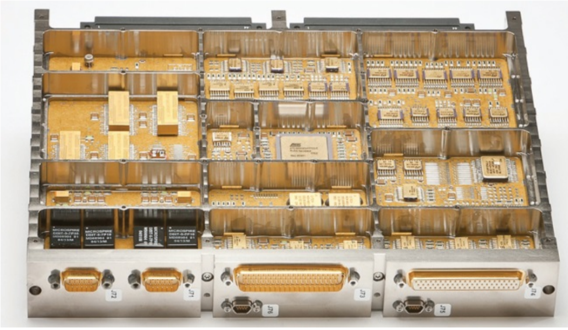
Implemented using:
- Step1: Component selection criteria
- Step 2: Local SEE mitigations
- Step 3: System SEE mitigations
- Step 4: Highly reliable system architectures

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: > 15years in GEO
Cost: 500k€

Constellation SBC

Implemented using:
- Step1: 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.