TDM
Technology Demonstration Module for PROBA-II

A Low Cost and Autonomous Component Space Radiation Effect monitor for space missions

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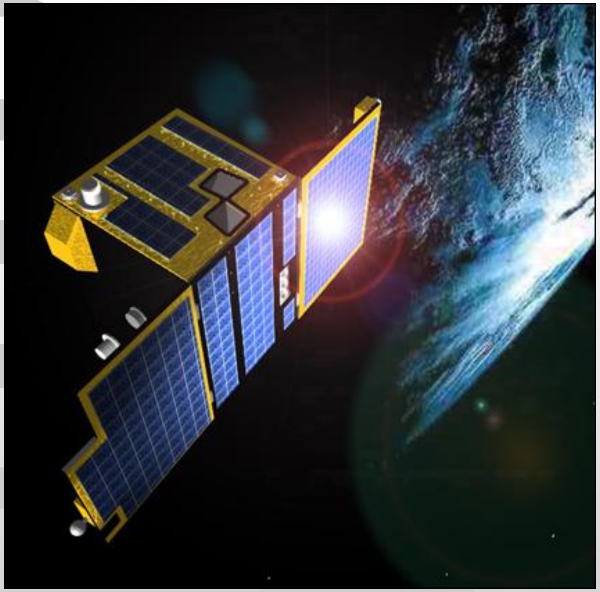


In a contract for the European Space Agency, Verhaert Space developed a Technology Demonstration Module (TDM) for flying on-board PROBA-II.

It is primarily a space radiation effects monitor, measuring Single Event Effects (SEU and SEL) and Total Ionising Dose.
Secondarily it provides an in-space technology demonstration test platform for components.

Introduction (2)

The need?

A low-cost component Test-platform

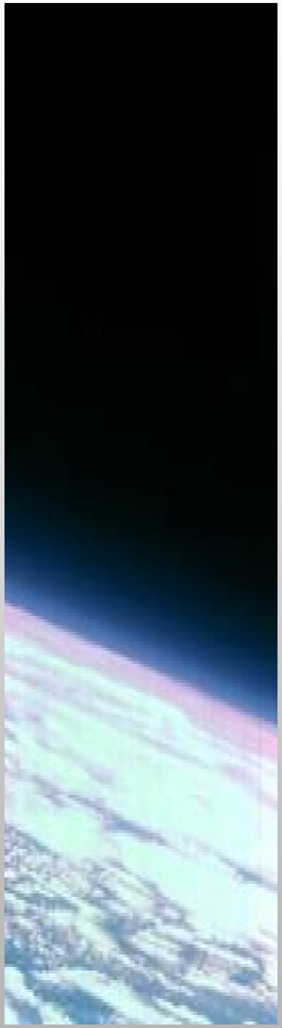
→ to demonstrate in-orbit performance of new technologies

A low-cost radiation SEE monitor

→ to measure in-orbit radiation effects inside existing flight equipments and correlate these measurements with the predictions and measurements performed on ground.

The design goal

- easy integration in satellites and flight equipment
- available as OEM-board or as a self-standing payload
- autonomous payload (minimum management from the spacecraft)
- electrical interfaces compatible with a wide range of satellite-busses.
- low power, mass and volume
- modularity
  - at board-level (easy replacement of component technology)
  - at FPGA-level (easy integration of third-party IP-cores)
- reliability
  - high-reliable part:
    for the radiation monitor, experiment control and satellite interface logic
  - experimental part:
    for the new technologies (lower screened components)



Interface Design

Commonly used interfaces:

- 28V power interface (20-30V input range)
- UART communication interface (configurable baudrate)

Can be delivered as:

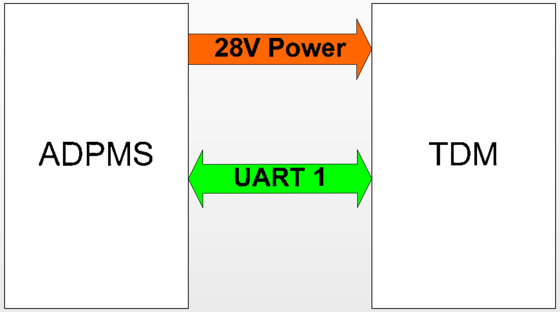
- A board, mountable inside an equipment (ex. ADPMS)
- A self-standing payload

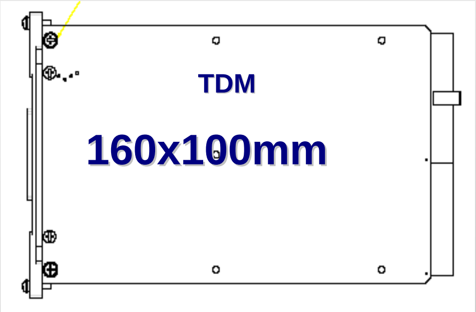
Temperature range from -20°C up-to +60°C

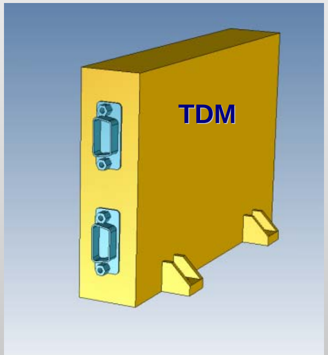
PCB form factor 3U format (single Eurocard)

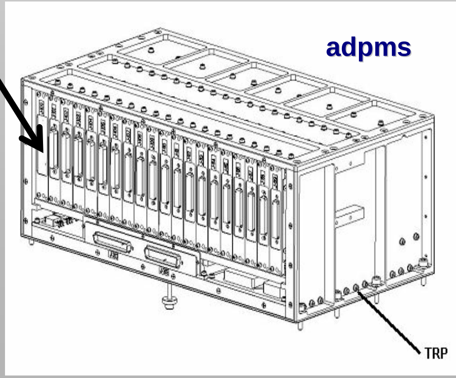
Autonomous operation
Realised with different experiment managers and an autonomous logging facility realised as an FPGA SoC design.
Very little interaction with Spacecraft required (only for start, stop and data retrieval)

Also available as EM for early compatibility testing





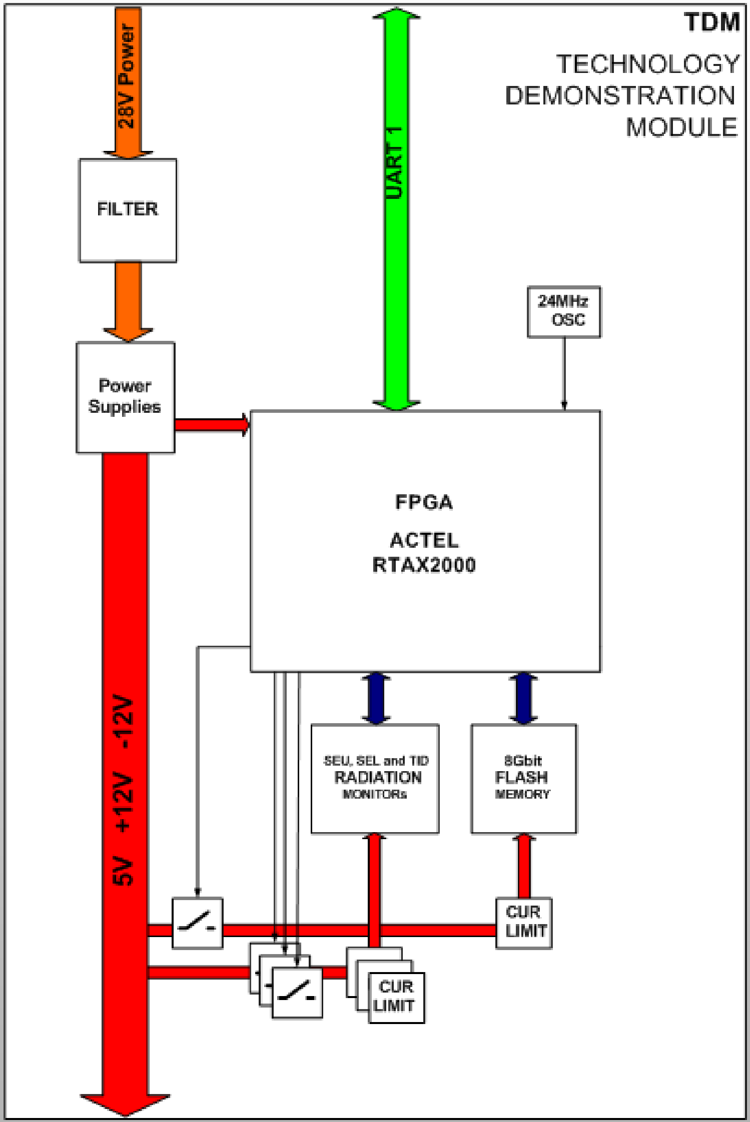




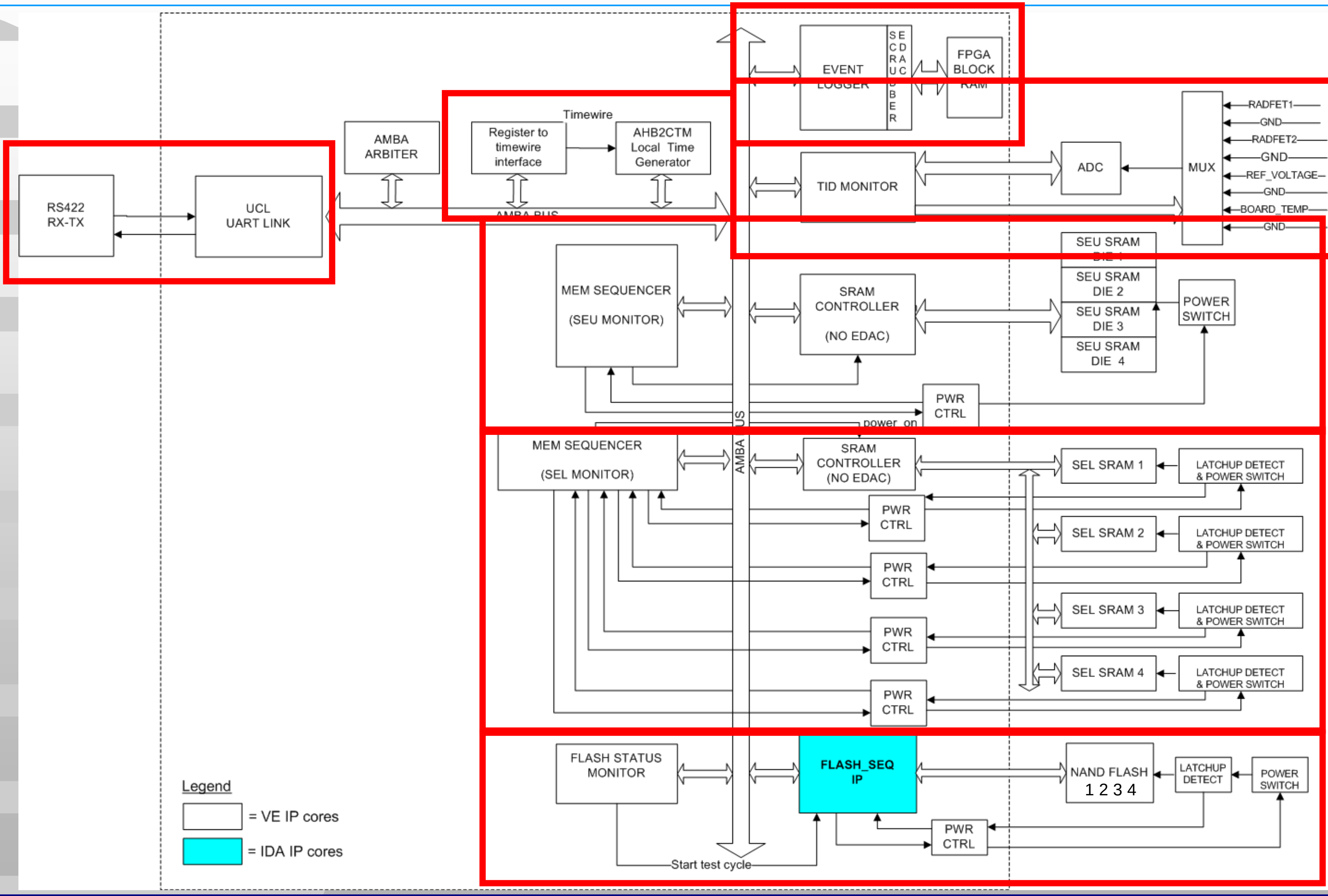
Architectural design

The main blocks:

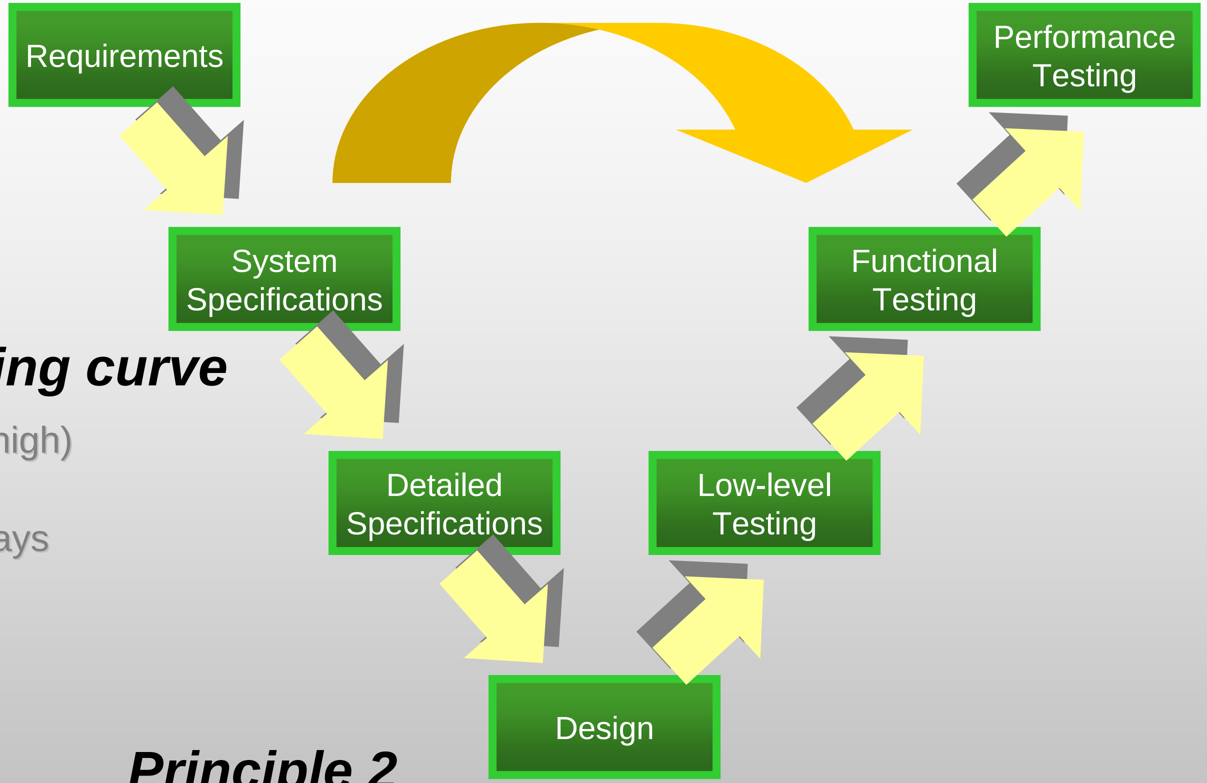
- EMI filter
- Galvanic isolated power supplies (28V → 5V,±12V)
- UART I/F (RS422 electrical levels)
- FPGA RTAX2000 – "The brain"
- Radiation monitors for SEU, SEL and TiD
  - SEU "Multi chip SRAM dev. from Atmel"
    - ***AT68166F (4 x 512Kx8 SRAM)***
  - SEL "SRAM dev. from Alliance Semi, ISSI and Samsung"
    - ***AS7C34096A-12TI (512Kx8 SRAM)***
    - ***IS61LV5128AL-12TI (512Kx8 SRAM)***
    - ***IS62WV20488BLI (2Mx8 SRAM)***
    - ***K6R4008V1D-TI10 (512Kx8 SRAM)***
  - TiD "RADFETs from Tyndall"
    - ***ESAPMOS4***
- Technology Demonstration:
  - 8Gbit NAND-FLASH memories
    - ***K9F8G08U0M-PIB0 (1Gx8 NAND FLASH)***



Chip Design

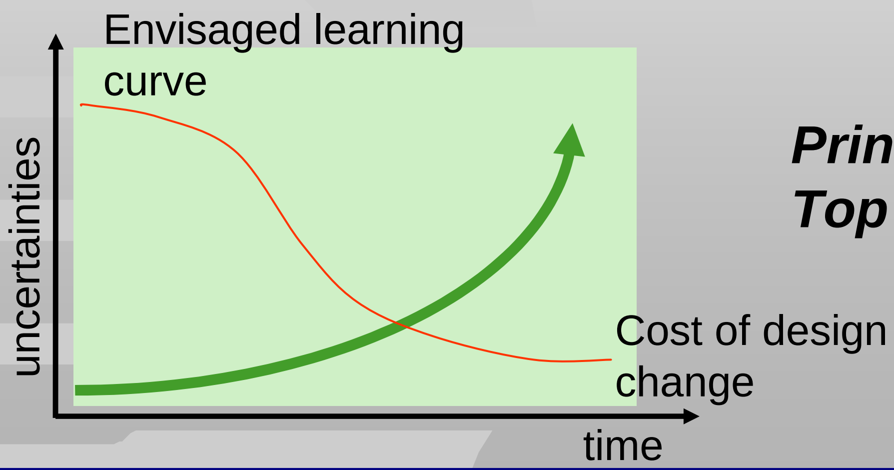

RS422
RX-TX
UCL
UART LINK
AMBA
ARBITER
Timewire
Register to
timewire
interface
AHB2CTM
Local Time
Generator
EVENT
LOGGER
SECURED BUFFER
FPGA
BLOCK
RAM
TID MONITOR
ADC
MUX
RADFET1
GND
RADFET2
GND
REF_VOLTAGE
GND
BOARD_TEMP
GND
MEM SEQUENCER
(SEU MONITOR)
SRAM
CONTROLLER
(NO EDAC)
SEU SRAM
DIE 2
SEU SRAM
DIE 3
SEU SRAM
DIE 4
POWER
SWITCH
PWR
CTRL
power on
AMBA
MEM SEQUENCER
(SEL MONITOR)
SRAM
CONTROLLER
(NO EDAC)
SEL SRAM 1
SEL SRAM 2
SEL SRAM 3
SEL SRAM 4
LATCHUP DETECT
& POWER SWITCH
FLASH STATUS
MONITOR
FLASH_SEQ
IP
NAND FLASH
1 2 3 4
LATCHUP
DETECT
POWER
SWITCH
Start test cycle
Legend
= VE IP cores
= IDA IP cores

Validation Approach



Principle 1
Turning around the learning curve

- Virtual testing prohibits *unexpected* (high) costs at the end + *planning* delays
- Virtual testing = an investment that pays off in one project

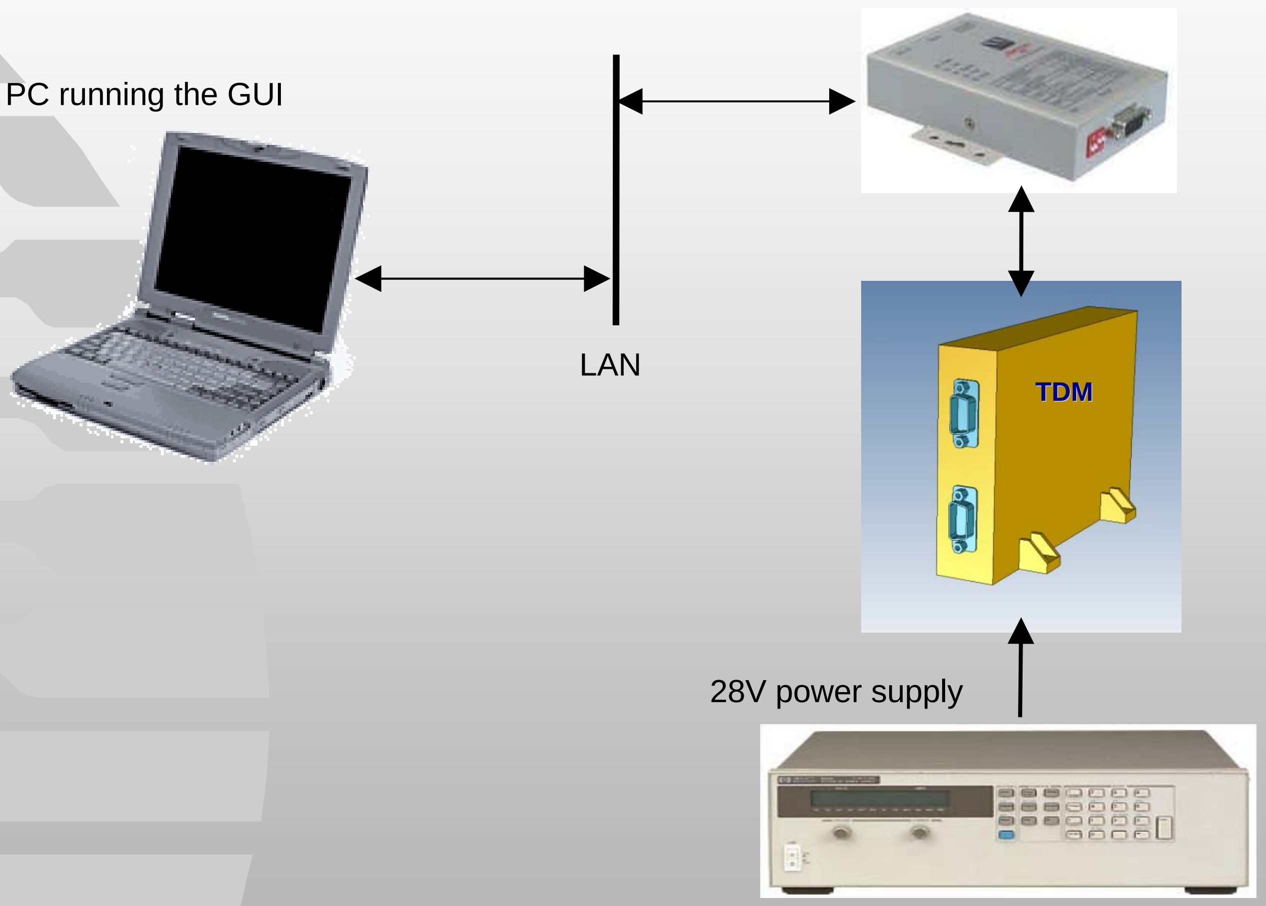


Principle 2
Top down specification, bottom up testing

- The V-model allows to test and re-test all functionality in an efficient way.
- V-model approach = an investment that pays off in one project

Validation Approach (2)

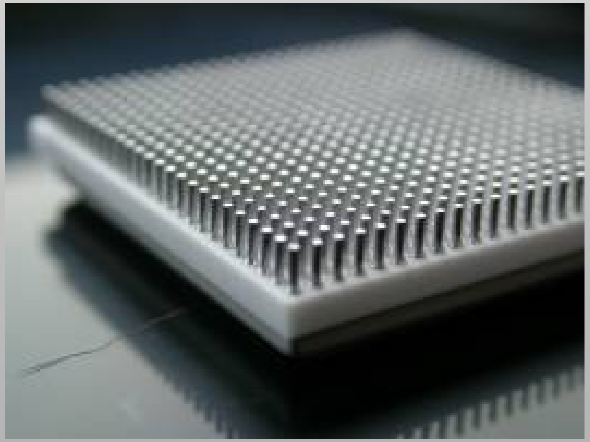
The Test environment….



Critical area's

Herewith a shortlist of the most important difficulties encountered during the TDM development

- **Extra ripple on the supply voltage due to an ACTEL Prototype adaptor**
- **Finding a low voltage DC/DC converter with good efficiency**
- **Estimating the power-consumption of ACTEL RTAX2000 SoC designs**
- **Qualifying the reflow-process for a 624-pin CCGA for use in space**
- **Screening and soldering of RoHS compliant parts**
- **Short development time (1 year from idea-2-FM)**



The Result

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The TDM as developed for the Proba-II satellite offers the following functionality for the following budgets:

SEU monitor
- based on characterised Multi-chip SRAM device
- configurable test patterns
- configurable address range
- continuous logging of results

Component experiment
- Samsung NAND-Flash devices
- SEU/SEL mitigation
- continuous device exercising
- continuous logging of results

SEL monitor
- based on 4 diff characterised SRAM chips
- ***4 LET levels: 3, 6, 8 and 10MeV***
- automatic re-enabling after LU detection
- protection for fast consecutive LU's

<u>Budgets</u>

Mass	**400g**
Volume	**160x100x25mm**
Power	**4 W (operating)**
Temp range	**–20/+60°C**

Power Interface
- Wide input range
- EMI filtering
- Galvanic isolation

Communication Interface
- serial UART
- RS422 electrical levels
- Configurable baudrate

TID monitor
- based on 2 RADFETs
- ***measurement range: 0-3kRAD***
- continuous temperature monitoring
- temperature compensated current supply
- continuous logging of results
- configurable sample rate

Centralised Logging and Timestamping facility
- Time synchronisation with spacecraft
- automatic time-stamping of all events
- configurable level of events
- storage of data

The team

The TDM development has been carried out by

Verhaert Space a leading Belgian small space systems company.

With a track record of more than 30 years Verhaert Space develops advanced small space systems for agencies, large systems integrators and governments. Ranging from advanced small satellites, advanced space mechanisms & structures, and instruments & facilities for micro gravity research in manned and unmanned missions.

But could also be realised thanks to a good support from ESA

Mr. Reno Harboe-Sorenson (ESA, NL)

And by a teaming with some renomated experts in their specific field

Mr. Aleksandar Jaksic (Tyndall, IE)

Mr. Hagen Schmidt (IDA, DE)

Pictures

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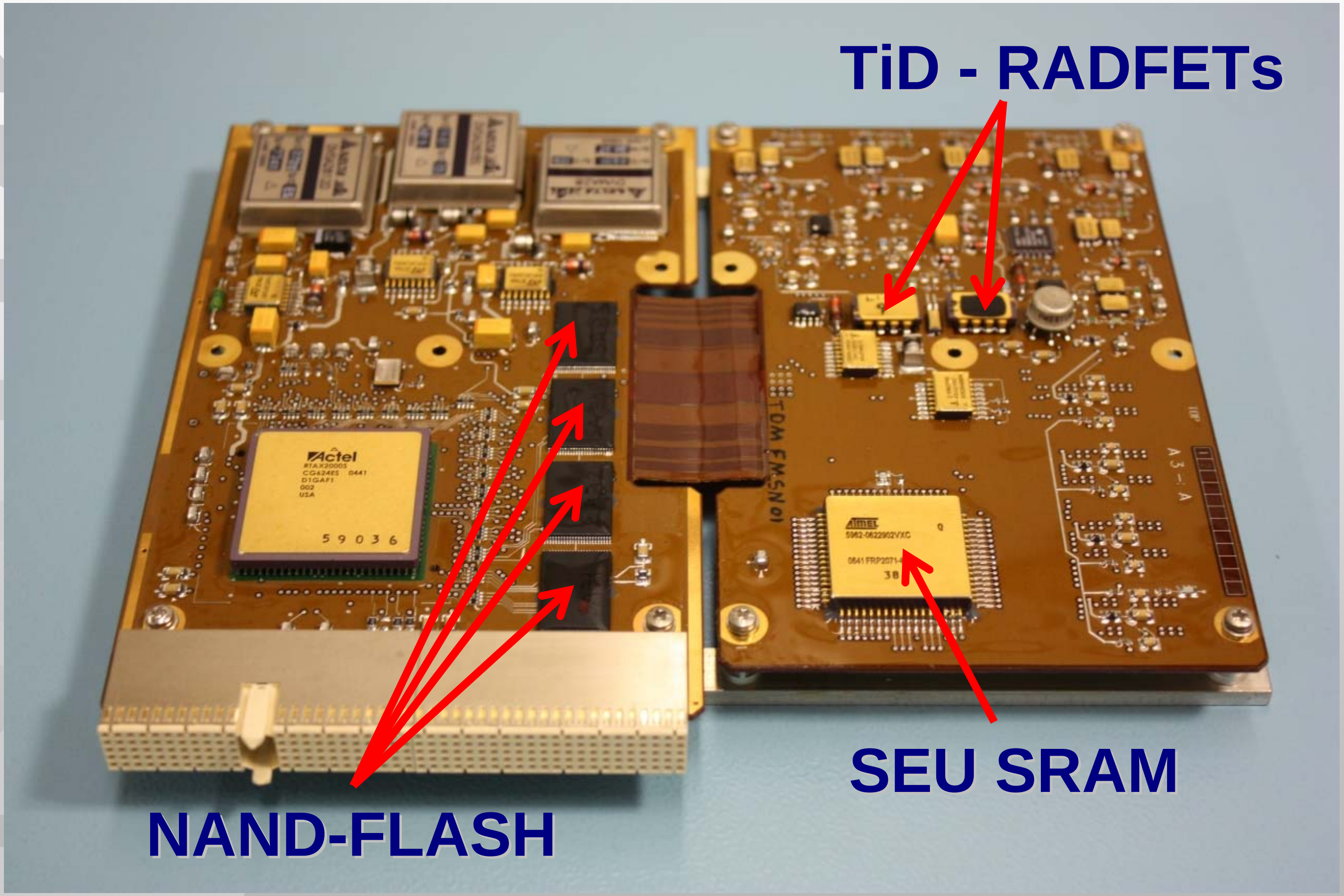
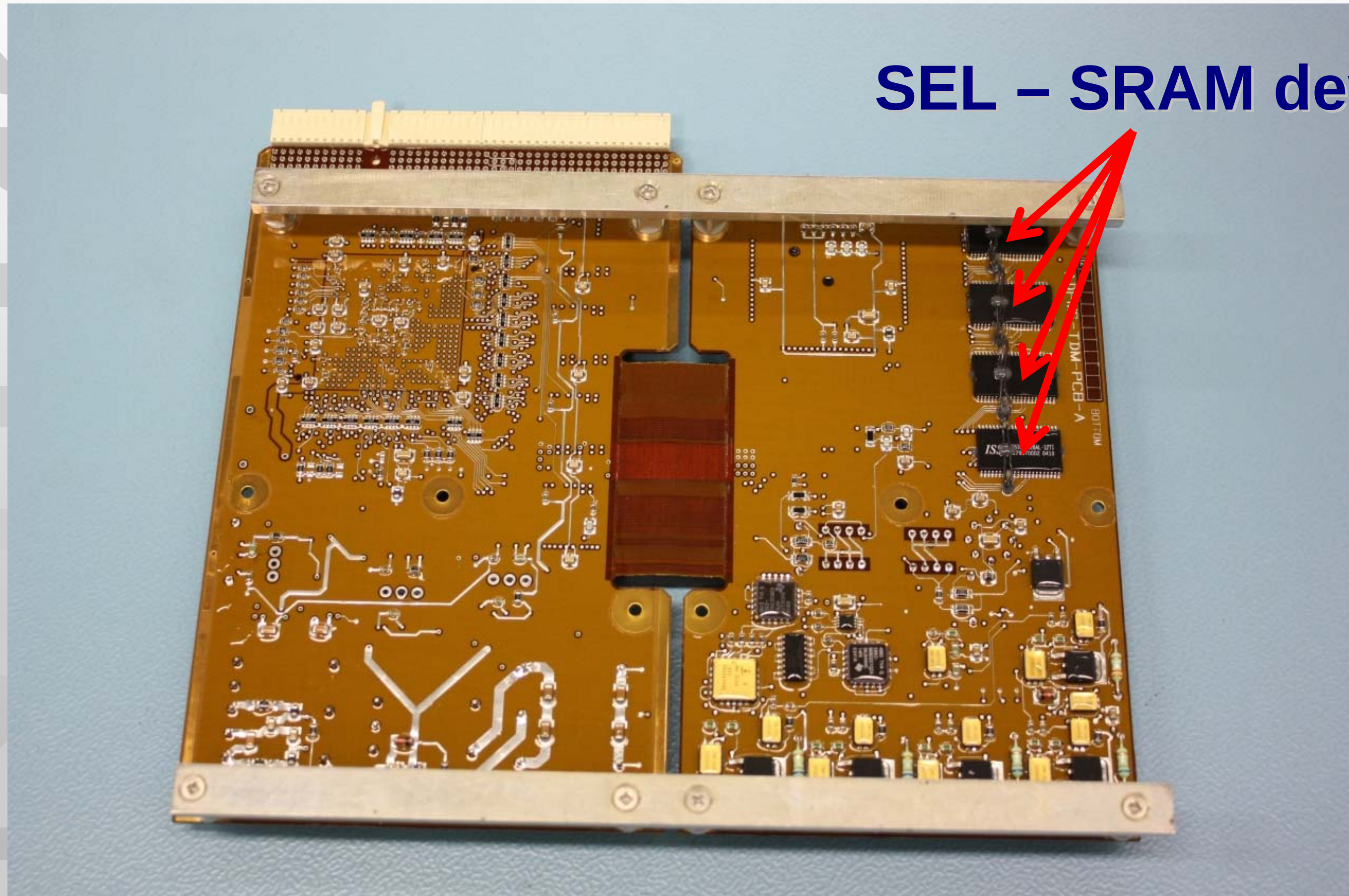


Pictures (2)



SEL – SRAM devices

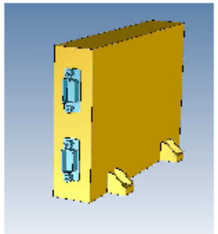
Commercial Flyer

TDM
Technology Demonstration Monitor

A low cost and autonomous component space radiation effect monitor for space missions

Verhaert Space, Component Space Radiation Effect Monitor, an off-the-shelf autonomous unit to measure and characterize radiation effects in a space environment.
Developed in close cooperation with ESA.

- **TID Monitor**
- **SEU Monitor**
- **SEL Monitor**
- **Technology demonstrator (NAND FLASH)**



Main technical data

Dimensions:
- Length = 170mm
- Width = 30mm
- Height = 110mm

Mass properties
- 500gram

Power interface:
- Supply Voltage between 20 and 30 Vdc
- Consumption less than 4 Watt
- Galvanic isolation available on supply voltage
- D-Sub standard density 9pins male connector

Data interface:
- Serial UART communication I/F with RS422 electrical levels
- Baud-rate configurable
- D-Sub standard density 9pins female connector

Environmental Conditions:
- Operating Temperature between –20℃ and +60℃
- Designed for a LEO environment

Quality standard
- Radiation tolerant control circuitry (based on Actel RTAX, …)
- Component selection performed according to ECSS-Q-60 class 3

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Thank you for your attention