New Space era with Controller Area Network

- CAN in Space 2019, Gothenburg/Sweden
- Dejan Gačnik (CTO)

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- New Space is primarily introducing innovations in Space and thus it is opening new frontiers in applications domain.
- It is enabling incremental development, optimising operational costs, it focuses on costs reduction and finally assures that low costs will pay off.
- But practically there was no need for reinventing the wheel, as New Space is inheriting well proven technologies well established technologies used by other industry as automotive, ...
- The main goal is to improve “time to market” and lower the overall satellite costs.
- The New Space on-board architecture is becoming each day more similar to efficient distributed architectures in terrestrial application. To enable a distribution of functions there is an obvious need for diverse availability of microprocessor and microcontrollers, which can in an efficient, but robust way exchange information.

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- CAN has been successfully utilised for Space application already for more then two decades
  - ESA mission (SMART-1 2003, GIOVE-A 2005)
  - SSTL, Saab Space,... satellite platforms used CAN even before
- First production vehicle to feature a CAN-based multiplex wiring system was release 1991

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Why CAN bus

- It supports multi master and multicast features.
- The CAN bus has maximum length of 40 meters.
- The CAN provides the ability to work in different electrical environment.
- It is used to reduce wiring in various applications (primarily automotive). It has single serial bidirectional line to achieve half duplex communication.
- It has standard bus in distributed network.
- It cost is low and lightweight network.
- It allows decent data rate performance with up to 1 Mbps. CAN FD version supports up to 10 Mbps. And then there is a CAN XL coming…
- It has automatic retransmission for message that lost arbitration or they were lost.
- The protocol supports different error detection capabilities such as bit error, ack error, form error, CRC error and stuff error.

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New Space

- Perusing solution that are the most cost effective
  - Reducing development time (simpler interface,...) – faster time to market
  - Reduced number of components (save space and €)
  - Easier integration
  - Availability of code libs/example, testing tools, IF adapters (for EGSE)...
  - New verification methods (Software,...)
  - New manufacturing approaches (capability for series production, automated P&P, AOI, ICT,...)

  On interface level: CAN, SPI, I2C, ETH, ...

- Due to costs constraints COTS are probably the only solution
  - Wide selection of devices (> 2000 MCU with CAN support available and > 120 CAN transceivers)
  - Up-screening required

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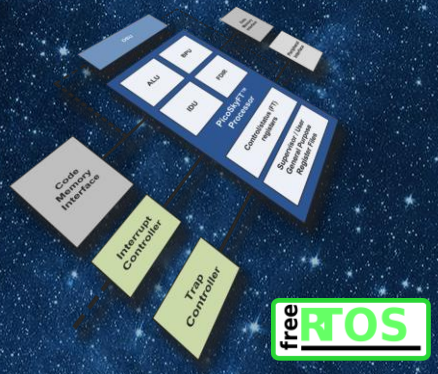
PicoSkyFT soft-core processor

Small footprint, radiation hardened by design processor core



- Small footprint, soft-core and fault tolerant processor core.
- IP Core building block for true SoC architecture implementation and technology independent
- **Architecture**
  - RISC 8/16-bit Harvard architecture
  - Highly deterministic operation
  - Hard real time interrupt response capabilities
  - Low memory footprint of the application code
- **Radiation hardened by design approach** (SEE tolerant)
  - Fully distinguished dual operational mode (supervisor and user mode)
  - Spatial triplication (TMR) on register level (optional temporal redundancy)
  - EDAC protected memory blocks, by Hamming scheme

- **Peripheral units**
  - NVIC
  - DIT
  - DMA
  - MPU
  - CAN
  - SPI
  - I2C
  - UART
  - CRC
  - GPIO

Radiation testing campaigns:

-PSI Proton beam up to 230 MeV

-CERN UHE mono-energy. 40 GeV/n

-ChipIR Neutron beam 10-800MeV

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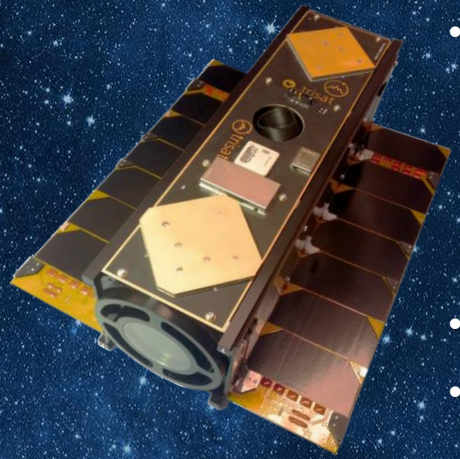
TRISAT NANOsky I platform

New Space approach



TRISAT Satellite PFM

- **Architecture**
  - **Redundant CAN bus** on board @ 125kbps
  - 2 LVDS links @ 20 Mbps (payload – mass storage – SBAND)
  - 6 PicoSkyFT SoC designs
  - 6 Subsystems (13 CAN destination)
- *SEL immunity*
- *Innovative error mitigation techniques*
  - *sophisticated three-level FDIR policy*
- *Redundancy on all critical functions*
- *Thoughtful component selection (+ up-screening) ensure robustness, high reliability and availability of the platform*

NANOimager
Miniaturized multispectral SWIR imager

NANOobc
On-board computer

NANOlink
S-Band SDR transceiver

NANOlink
S-Band SDR transceiver

NANOeps
Electrical Power System

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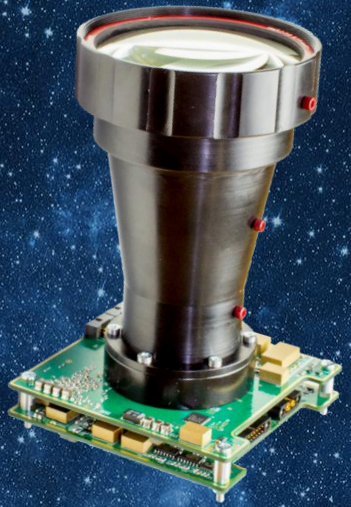
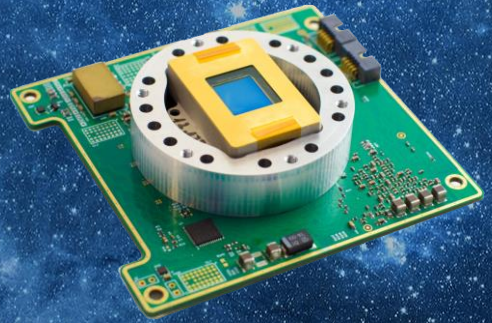
NANOimager

Miniaturized multispectral SWIR imager



- **Architecture**
  - **Redundant CAN bus** on board @ 125kbps
  - 1 LVDS link for payload data transmission
  - 2 FPGA design (ACQ + Processing)

- *Up to 14 non-overlapping multispectral bands*
- *SWIR sensitivity (1100nm – 1700nm)*
- *Resolution 100m@500km*
- *Redundant mass storage*
- *CAN / LVDS interfaces*
- *Comprehensive local subsystem telemetry*



NANOimager
Miniaturized multispectral SWIR imager
(ACQ unit)

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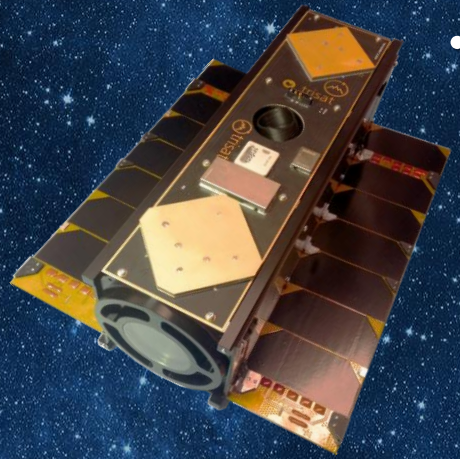
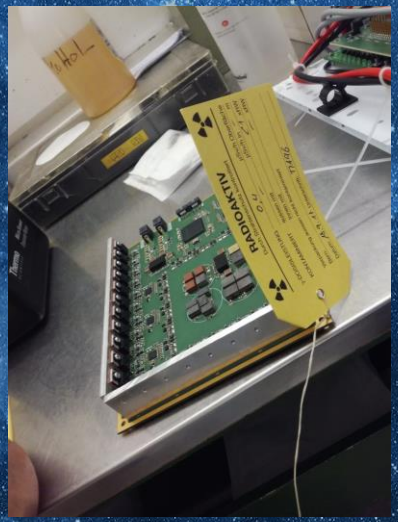
Key enablers for **NANOsky I** platform



TRISAT Satellite PFM

- *LCL – Latching Current Limiters*
  - *Immune to SEE*
  - *Detect the overcurrent event*
  - *Limit the current through the device to a safe level, preventing permanent damage due to thermal runaway*
  - *3 level protection technique*
    - *Component level*
    - *Subsystem level*
    - *System level*
  - *Enhanced telemetry on each system level*
  - *ASIC design starting Q3/2019*
- *Small-foot print FT MCU*
  - *PicoSkyFT processor with complete ecosystem*



LCLs EQM at radiation testing

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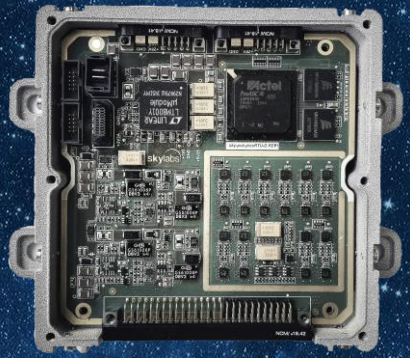
PicoRTU-D system

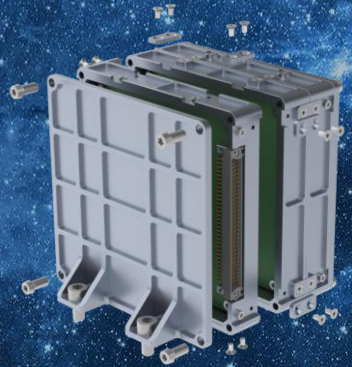
Distributed Remote Terminal Unit



picoRTU-Demonstrator EM

- Distributed RTU system
  - Decentralization
  - Modularity
  - Enhancing European technology independence
- System benefits
  - Saving overall mass,
  - Harness reduction and simplifications,
  - Lower verification efforts and accelerates AIT/AIV
  - Decreases development times of the S/C (RC units)
- Architecture
  - RTUcore – distributed across each unit
  - RTI – Redundant CAN busses (protocol: ECSS-E-ST-50-15C)
  - User interfaces – ECSS-E-ST-50-14C + special user interfaces

picoRTU-D Mock-up
Innovative modular assembly



picoRTU-D Mock-up
Innovative modular assembly
(exploded view)

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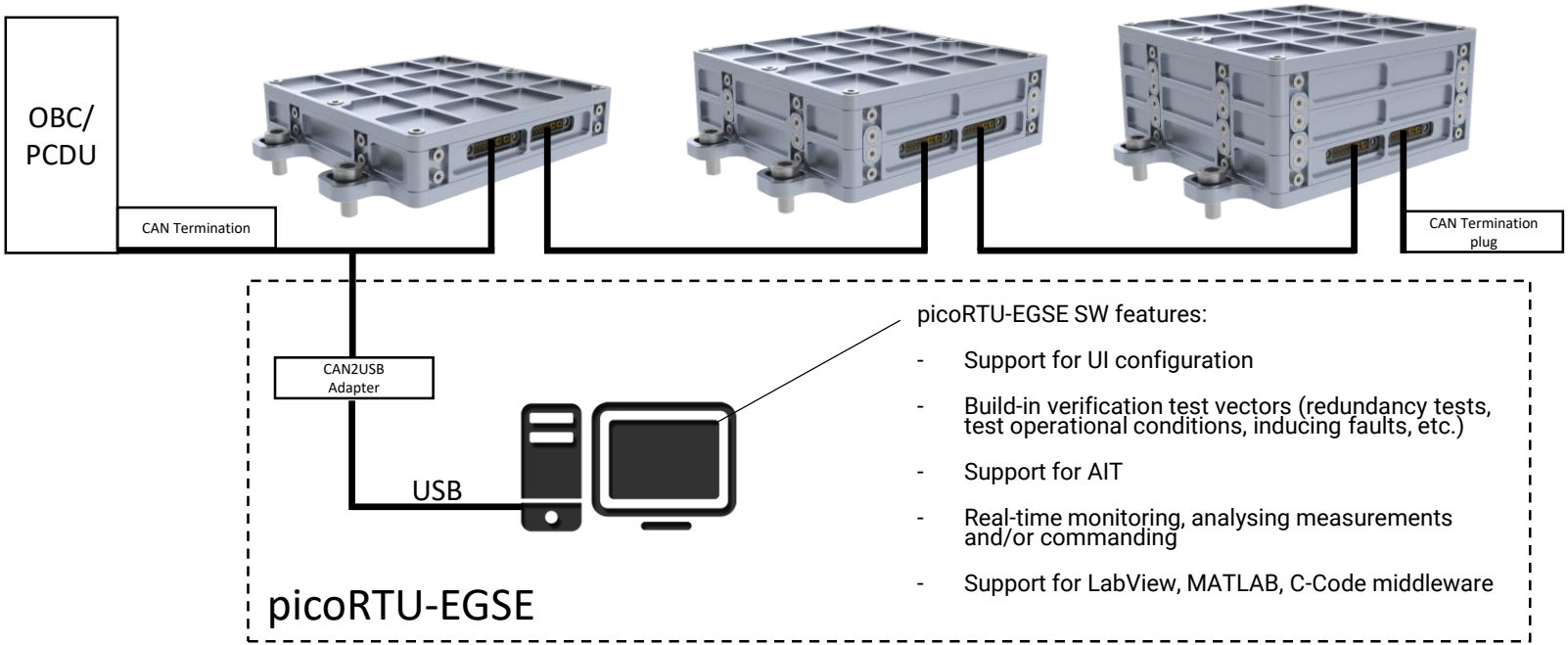
picoRTU System

Distributed picoRTU system ecosystem

- On-board system and supporting environment enables quick assembly, configuration and validation.



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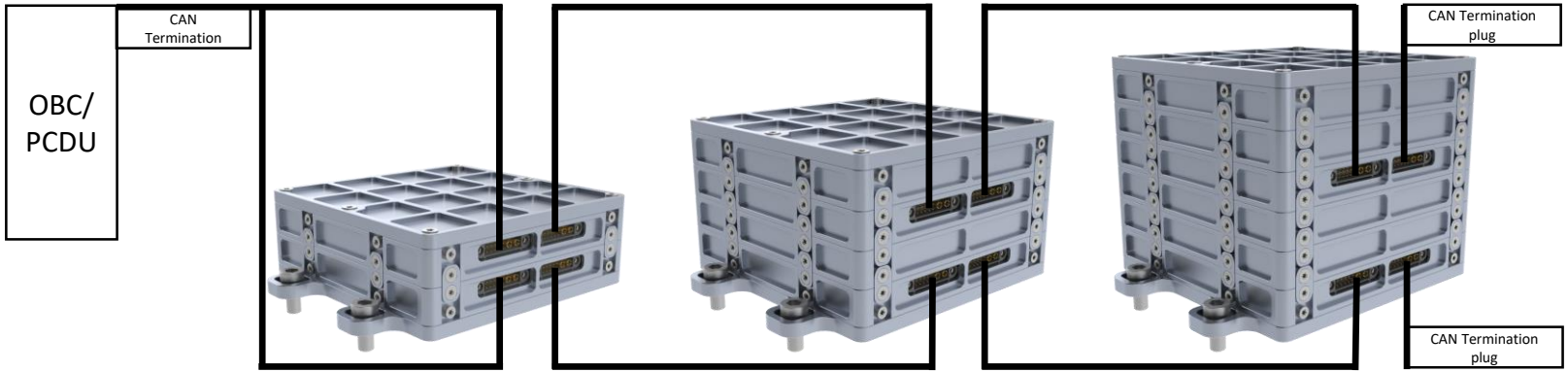
picoRTU System

Distributed system scenario 3 cont'd

- Configuration scenario: Redundant RTU system in single stack (N+R) – redundant power bus



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picoRTU-D

Preliminary verification

- 164 Technical specifications defined (following SAVOIR RTU TS)
- 103 Preliminary testing procedures defined and successfully tested
  - functional,
  - electrical characteristics
  - environmental,
  - mechanical, ...

Figure 1: TVC Thermal vacuum chamber testbench

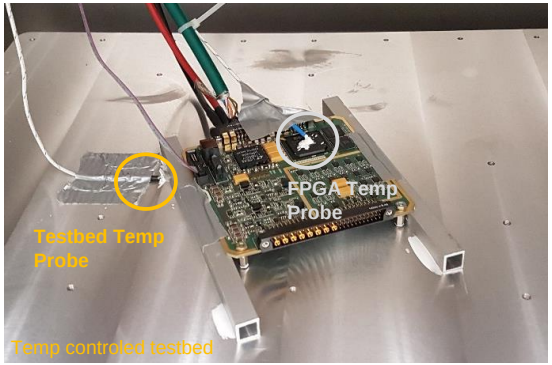
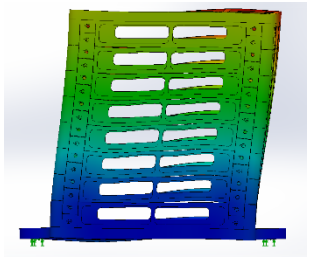


Figure 2: DUT - PicoRTU-D on thermal testbed



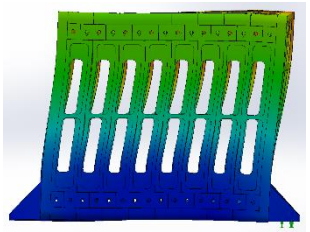


Figure 4: FEM simulation to verify structure vibration resistance compliance

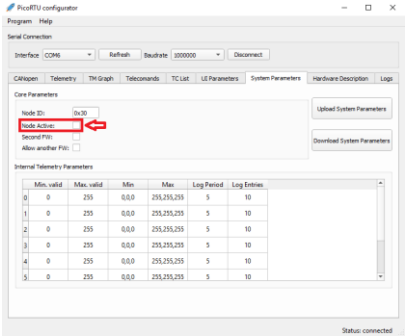
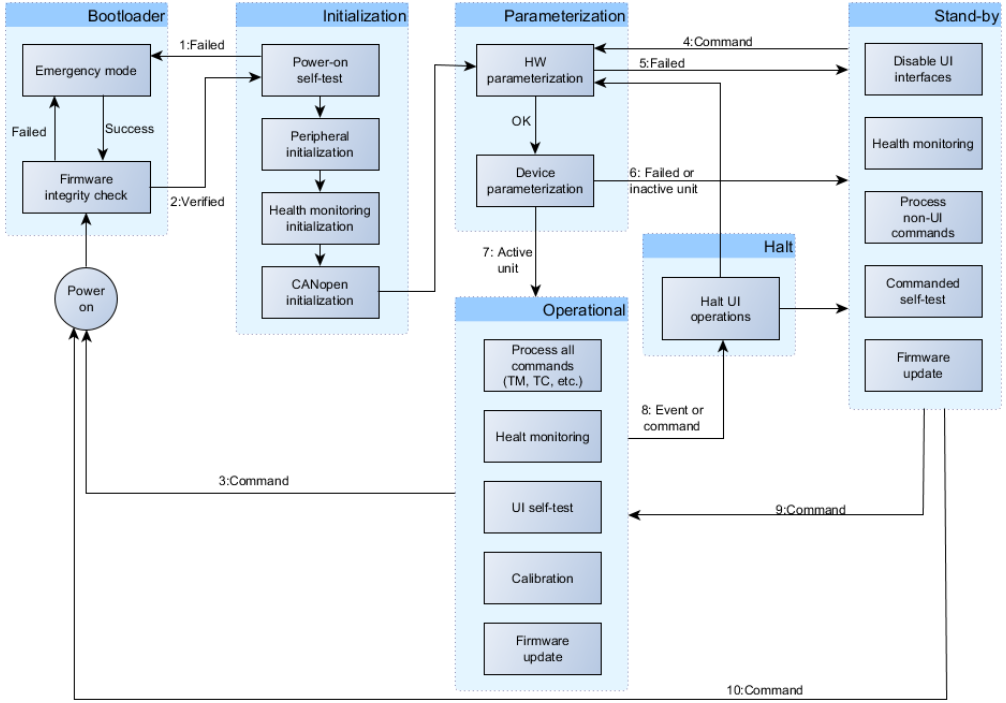


Figure 3: picoRTU-EGSE - PicoRTU-D configurator tool

picoRTU System

Software architecture

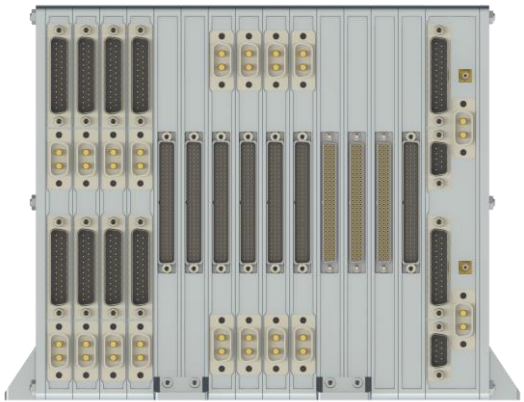
- Software architecture according to SAVOIR Functional and Operability Requirements

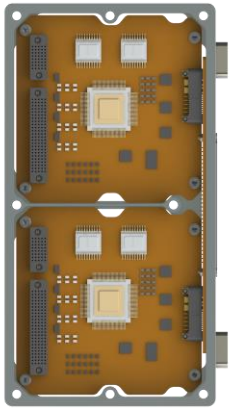


picoRTU System development

picoRTU mock-up for EO
(Space Grade Components)

- SkyLabs will KO product development of picoRTU system
  - System is primarily designed to cope with UI variation between different mission
  - X-strapping on UI
  - Standard user interface (TSM, ASM, BSM, HV-HPC, SS...)
  - Special user interfaces (FCV, LV, Pyro, ADPM, heaters,...)
- ESA GSTP contract for delivering PFM unit for ESA mission
- Primes are cordially invited to join the project for requirements consolidations





picoRTU mock-up for EO – Side and top view

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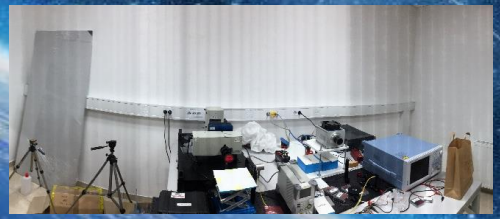
SkyLabs at glance

- **TVC – up to 27U nanosat form factor**
- **SDGS - operates on VHF, UHF S and C bands**
- **Clean room ISO 8 grade - AIV**
- **X-Ray - HW inspection**
- **Other R&D and telecommunication equipment**

SkyLabs Vision

We are innovating the aerospace market with SkyLabs disruptive technologies, products and solutions to change the layout of space.



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