

# Instrument Control & Data Processing

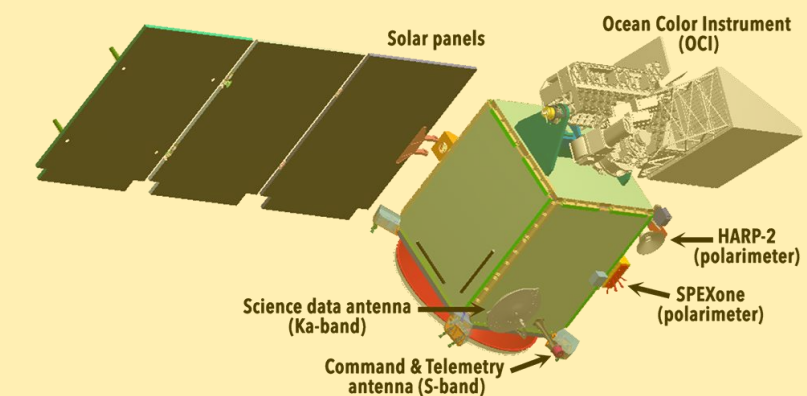
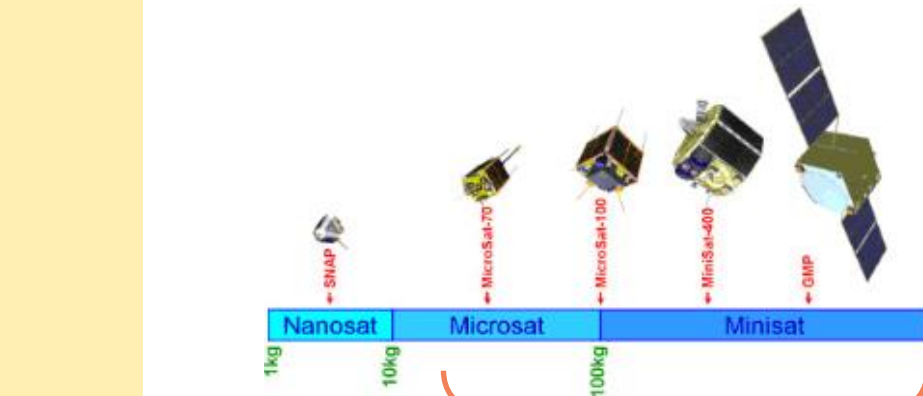
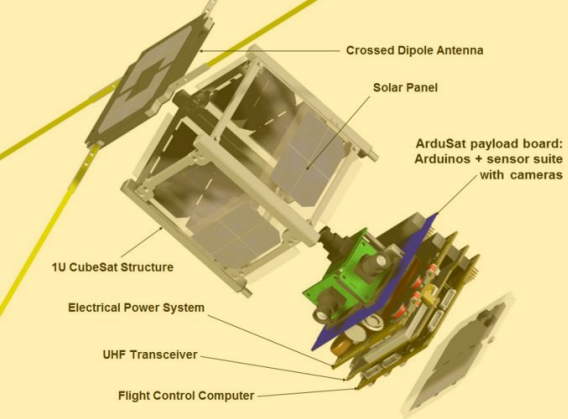
for high-reliable  
'New Space'  
instruments

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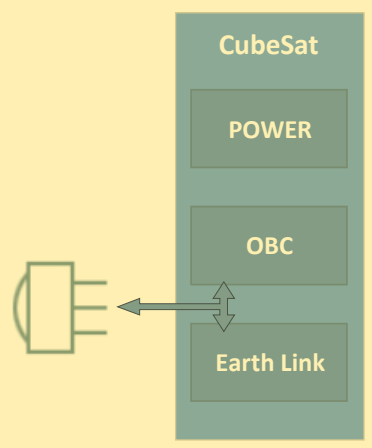


UNIVERSITY  
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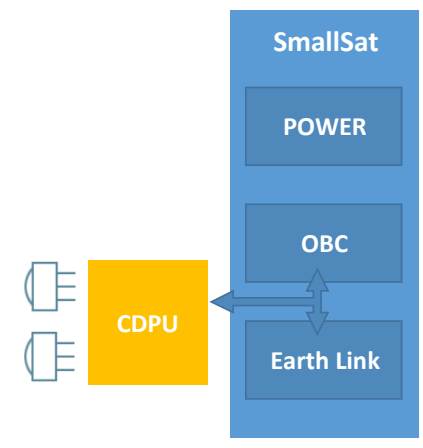




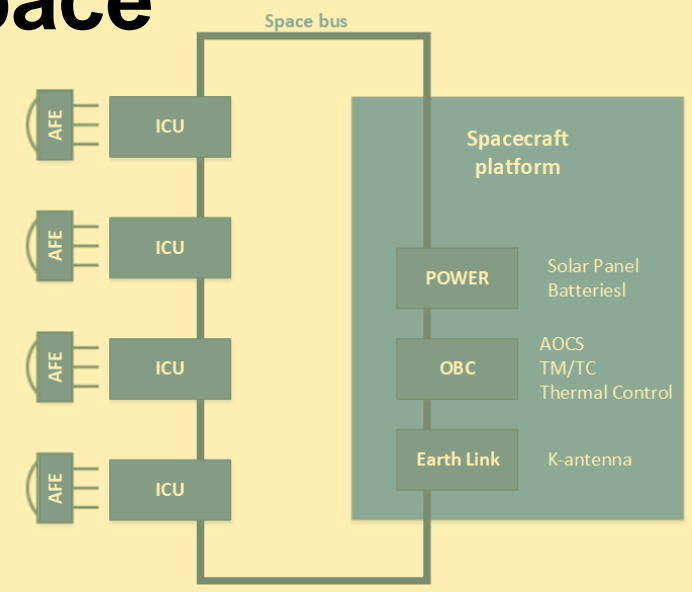
# New Space ↔ Traditional Space



**CubeSat**  
 Single instrument  
 Not Rad-Tolerant

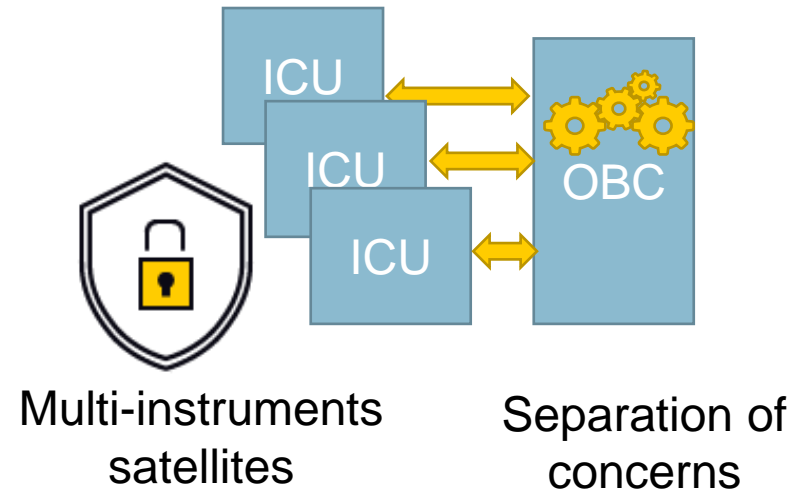
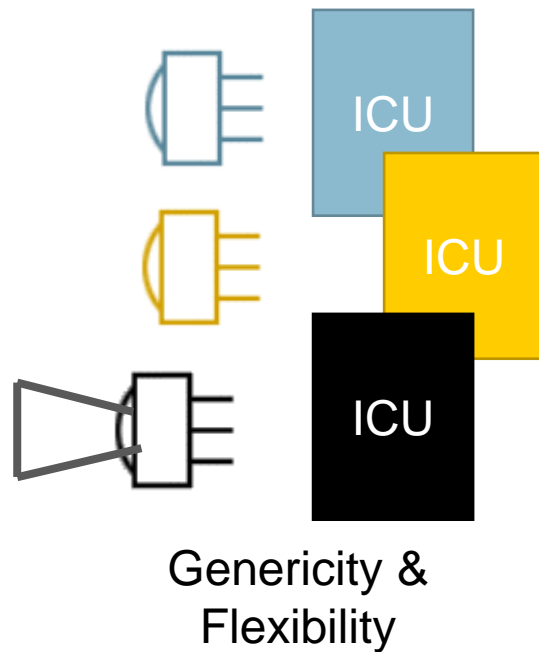
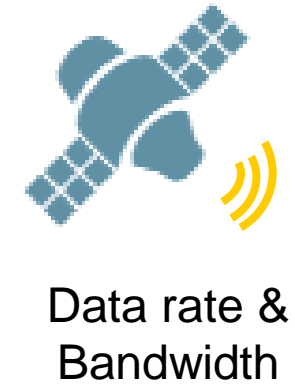
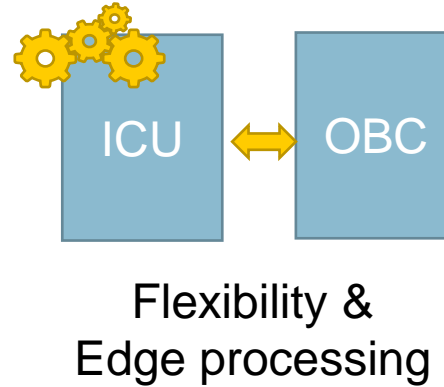
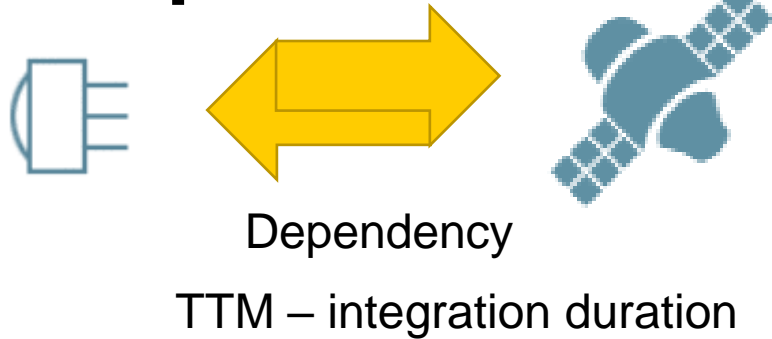


**SmallSat**  
 Single or Multi instrument  
 Instrument autonomy  
 Rad-Tolerant



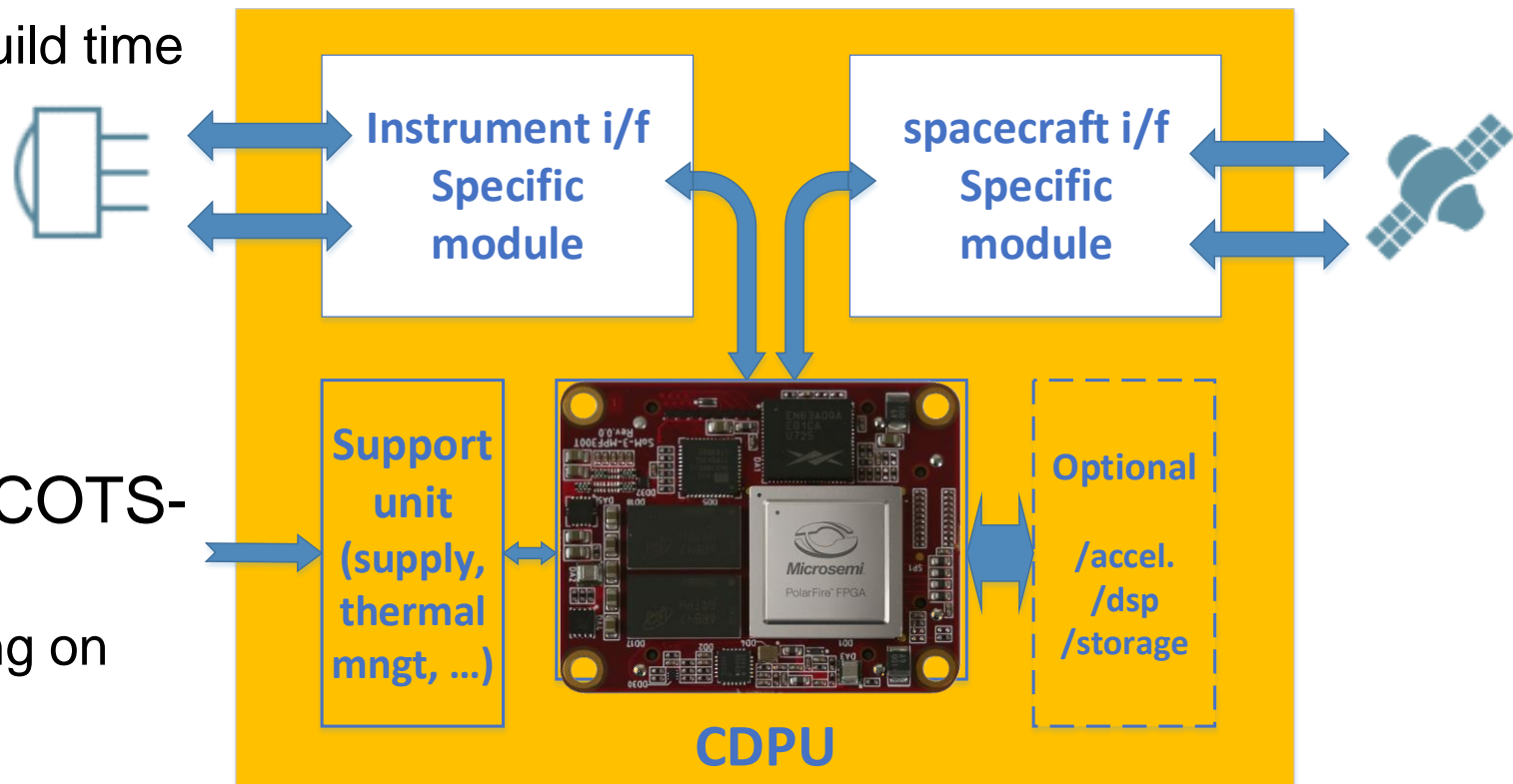
**Science satellite (conventional space)**  
 Multi instrument  
 Custom ICU developed  
 Share Earth link with other instruments

# Problem context: Separation of concerns and standardization in satellites



# Modular electronics to bridge sensor with satellite platform

- Enabling reuse of modules in new projects → NRE cost sharing
- Separation of concerns between satellite platform and instrument developers
  - **Reducing** overall satellite build time
  - **Reducing** instrument development and test time
- **Rapid prototyping**
- Design for rad.-hard (and COTS-equivalent) components
  - Reliability trade-off depending on mission needs



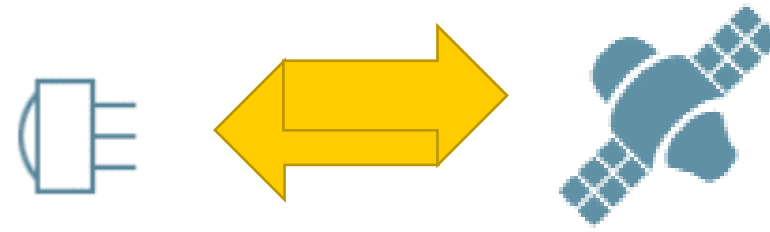
# CDPU: Control & Data Processing Unit

## for SmallSat instruments

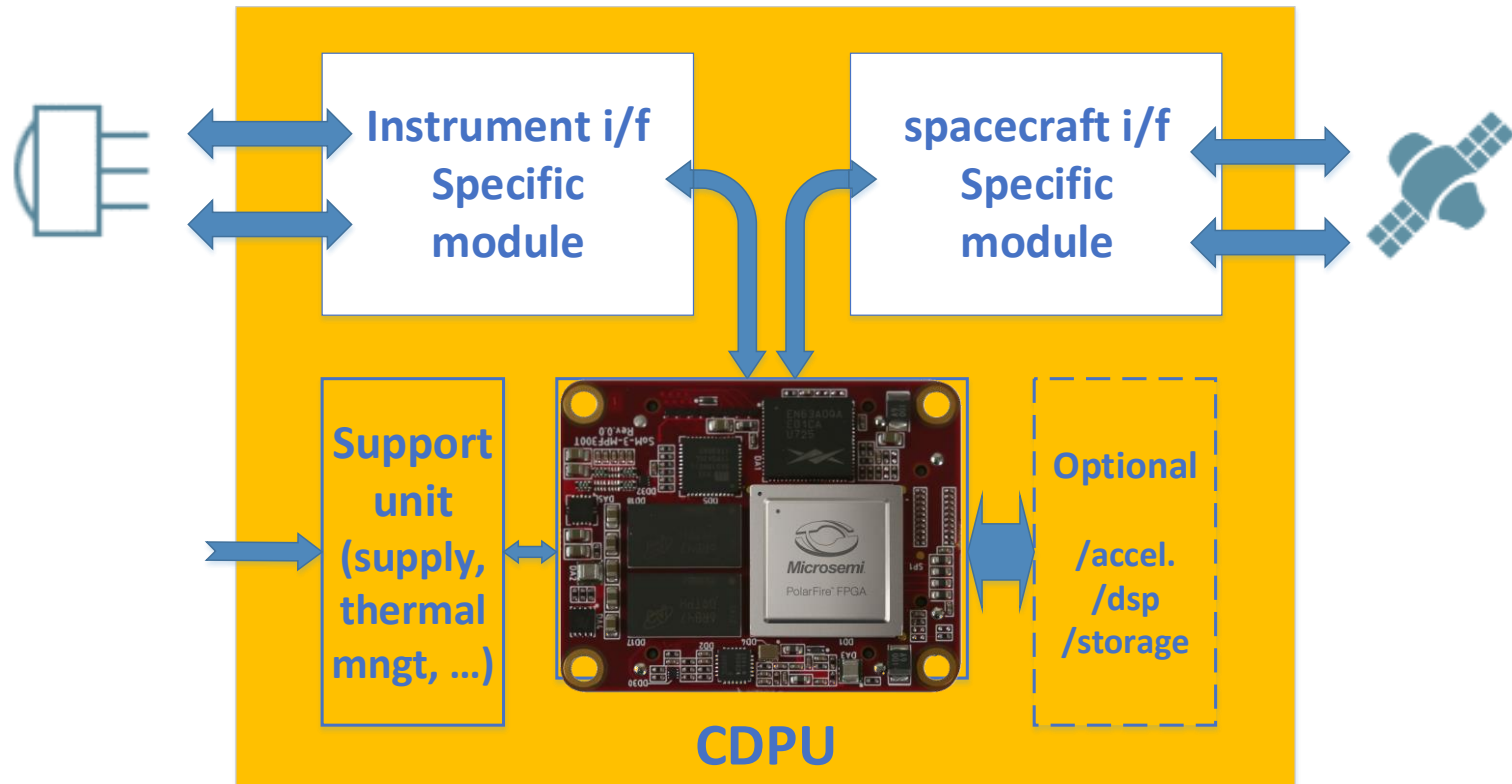
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Space  
Office






**T**  
Technolution



Flexible & reliable integration of sensor and platform



# RISC-V® at Technolution

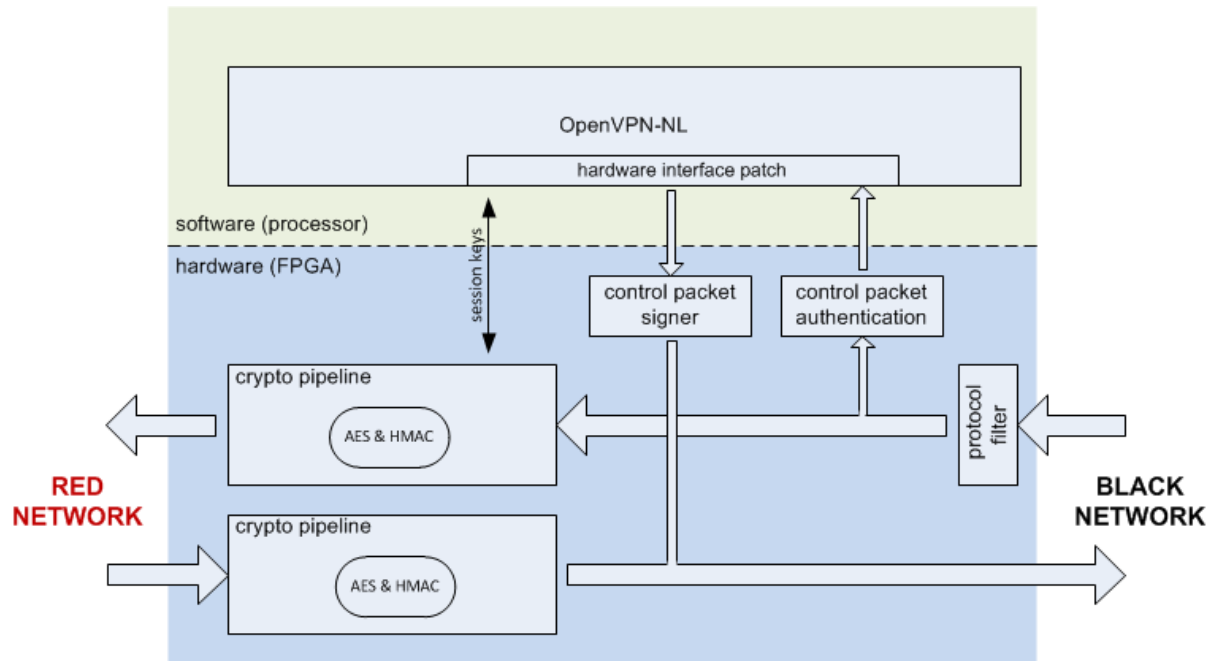
- We develop supplier-independent Programmable Logic designs
  - Implemented in  intel  XILINX  Microsemi  
a MICROCHIP company  NX  
NanoXplore
- FreNox RISC-V IP
  - RISC-V processor family, 100% developed by Technolution
  - No dependencies on open-source implementations
  - Implemented in **NLD/NATO/EU** classified security






# Secure line encryption

- Hardware VPN solution (NLD/NATO/EU restricted)
  - Control flow in software /  RISC-V®
  - Data encryption in hardware logic

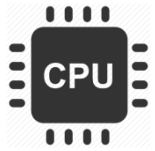


# Secure line encryption

- Hardware VPN solution (NLD/NATO/EU restricted)
  - Control flow in software /  RISC-V®
  - Data encryption in hardware logic
- ⇒ Full understanding of our custom implementation
- ⇒ Transparency for customer/evaluator
- ⇒ Lifecycle management (transparency & portability)



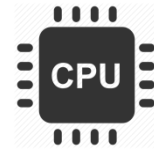




# FreNox-E

## Embedded processor

- hardware
  - RV32I(MA)
  - 32bits, mul/div
  - 5 stages - Harvard arch
  - cache or internal RAM
  - IO space
- software
  - Bare metal (C, embedded Rust)
  - FreeRTOS
  - ThreadX



# FreNox-S

## Application processor

- hardware
  - RV32IMA (S-mode)
  - 32bits, mul/div, atomic, supervisor
  - 5 stages - Harvard arch
  - iMMU, dMMU (1 - 128 entries)
  - 8 way associative cache (4 - 32k)
  - cache coherency (DMA)
  - IO space
- software
  - Linux
  - Buildroot

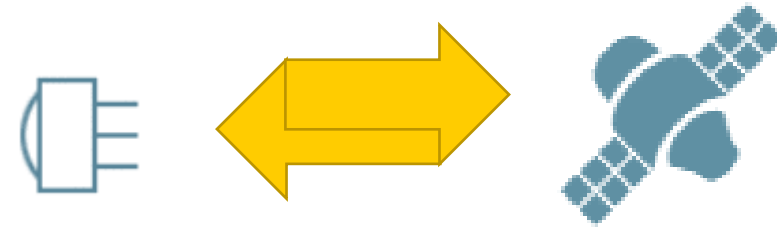
# CDPU: Control & Data Processing Unit

## for SmallSat instruments

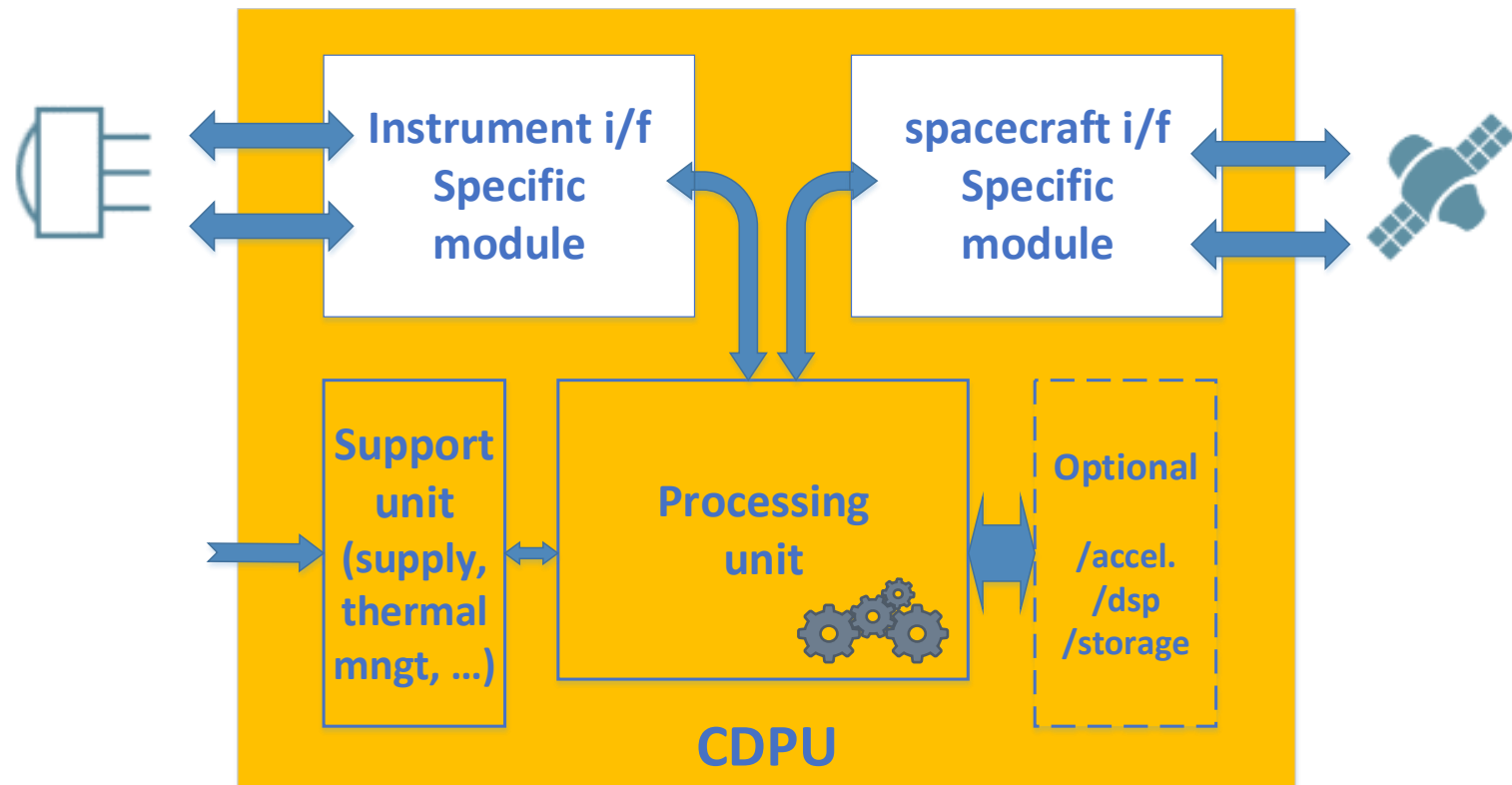
Netherlands  
Space  
Office



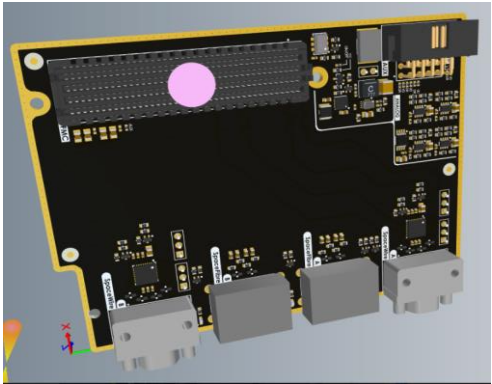
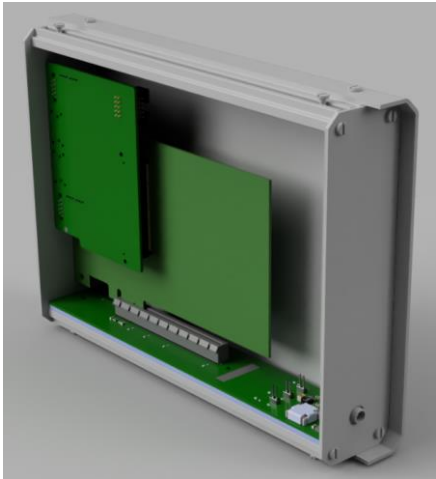
**T**  
Technolution



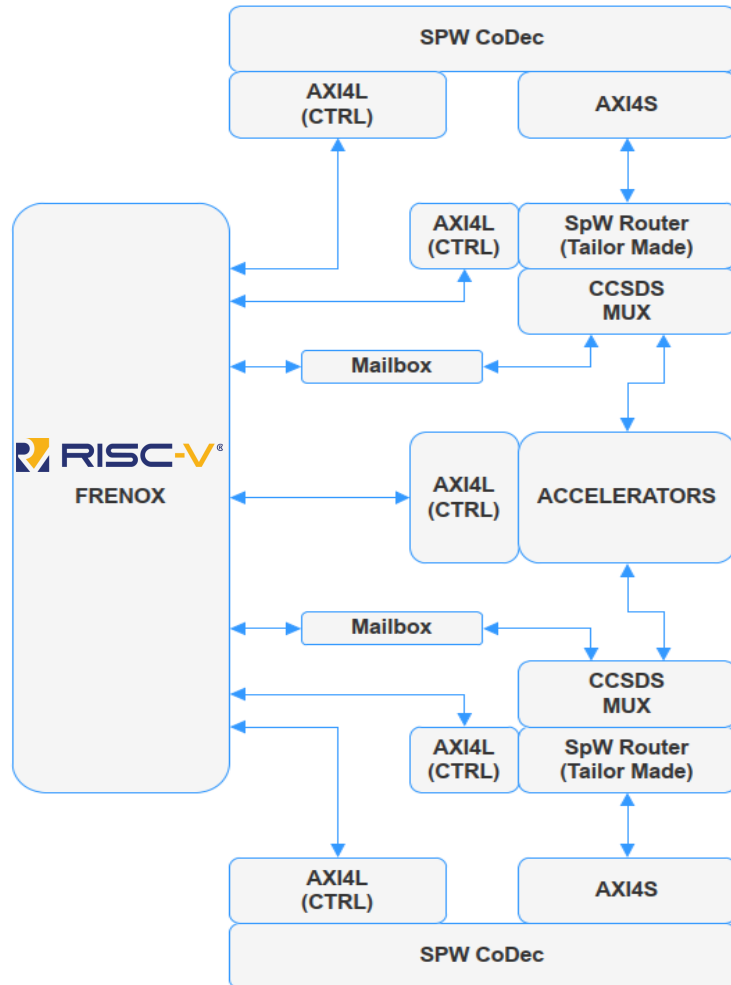
Flexible & reliable integration of sensor and platform



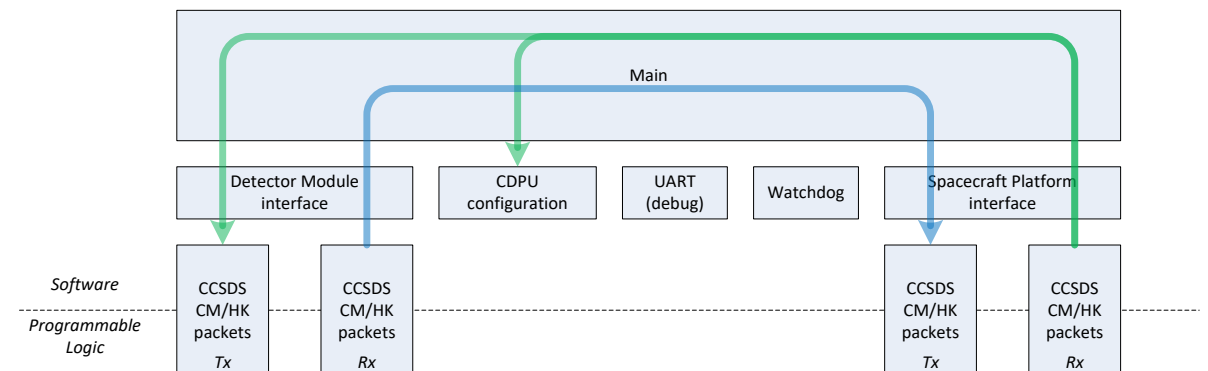
# CDPU Evaluation Kit



# CDPU FPGA Functional Design

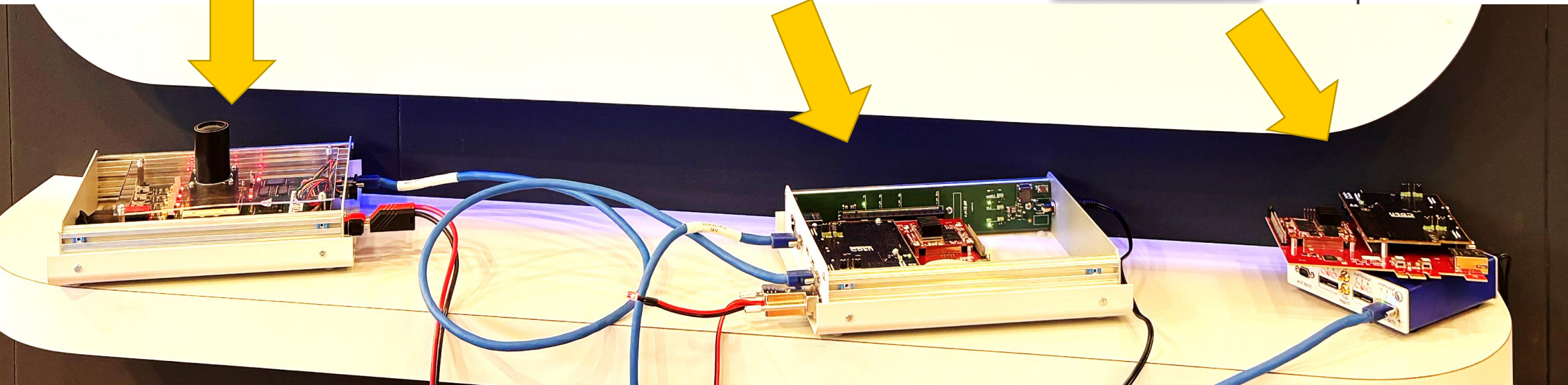
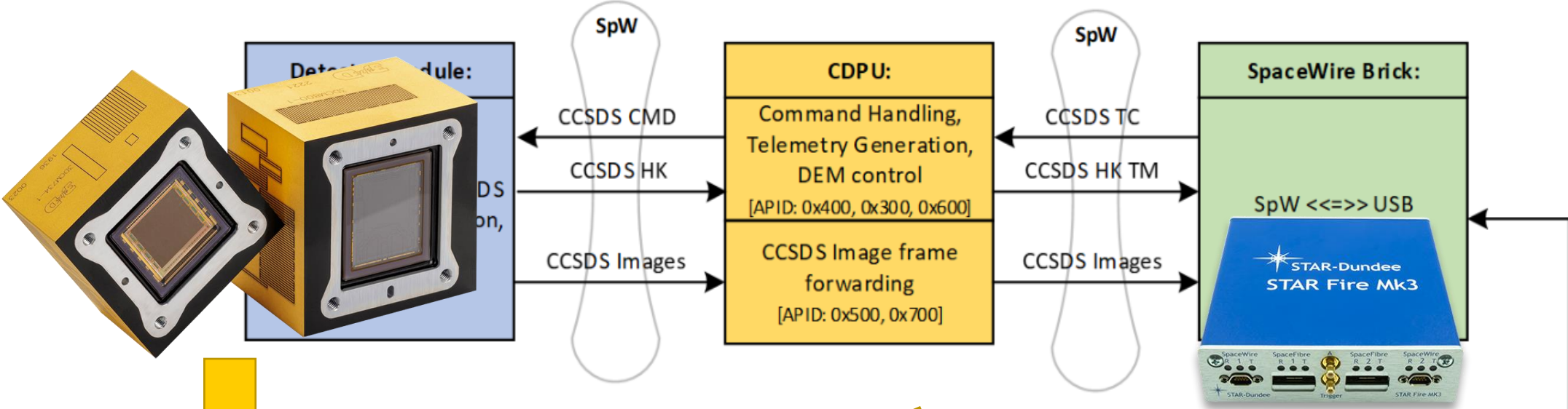


- Programmable logic design
  - FreNox RISC-V
  - SpW interface IP
  - SpFi interface IP
  - Interconnect infrastructure; accelerator extensions
- Embedded software design
  - TC/TM handling





# CDPU Demo – Instrument Integration





Chips JU European R&D



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irdeto Protect. Renew. Empower.



Netherlands Space Office

NSO SBIR Phase 2

AIRBUS s[&t] SRON Netherlands Institute for Space Research

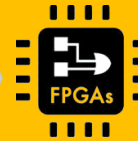


Supported by Instrument Developers (Airbus/SRON)

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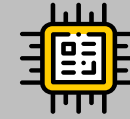
Technolution



PoC



EFM



Implementation EM HW



EM Qualification



FM



Flight Model

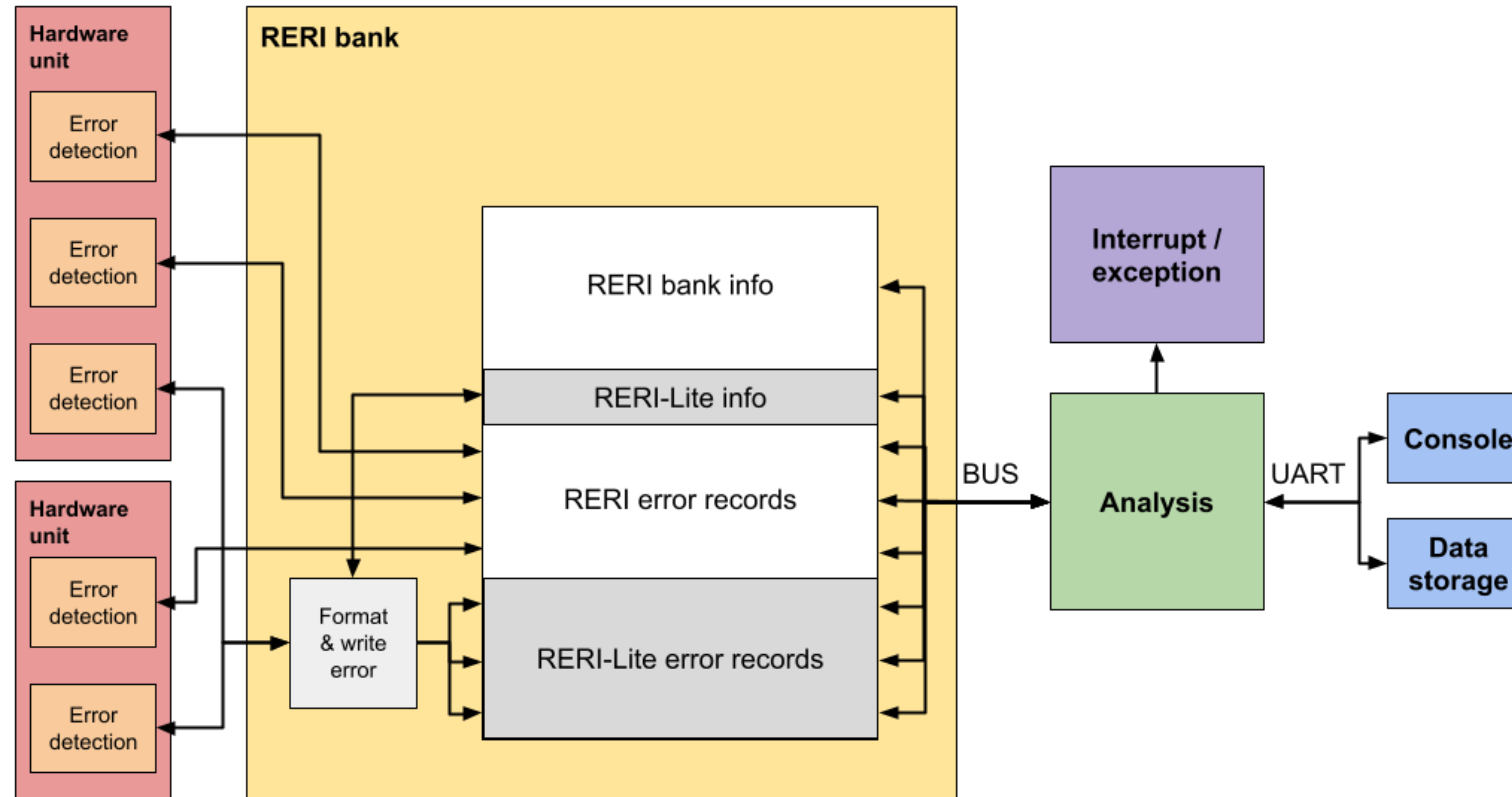
- FreNox-E SoC demonstrated in NG-Medium RH-FPGA
- FreNox-E SoC demonstrated in PolarFire FPGA



→ all-European components CDPU



# Innovation & collaboration



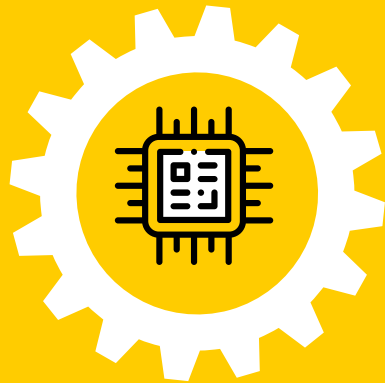
- Joint research with University of Twente & European Space Agency on (reduced) RERI, checkers and radiation testing



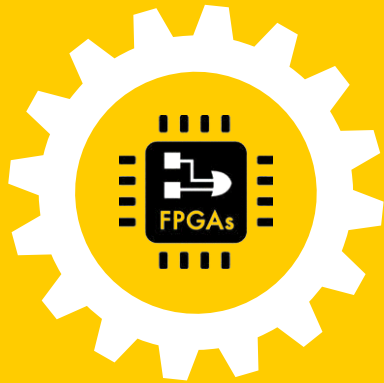
# Conclusion: advanced electronics and embedded systems



Software



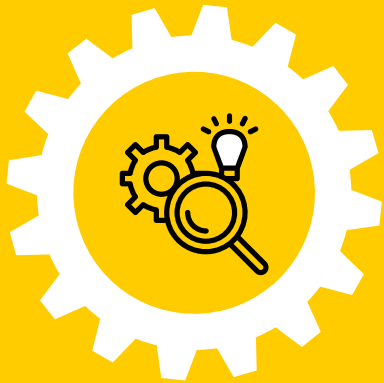
Electronics



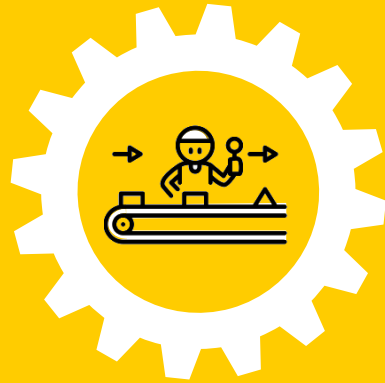
Programmable  
Logic



Services



Research &  
Development



Trusted  
Assembly

**Modular electronics** enable re-use

Modularity gives **reduced instrument development & test time**

**Benefit from standardization:** transparency, portability & flexibility

We build high-security & high-reliability systems using  **RISC-V**® (since 2014)



