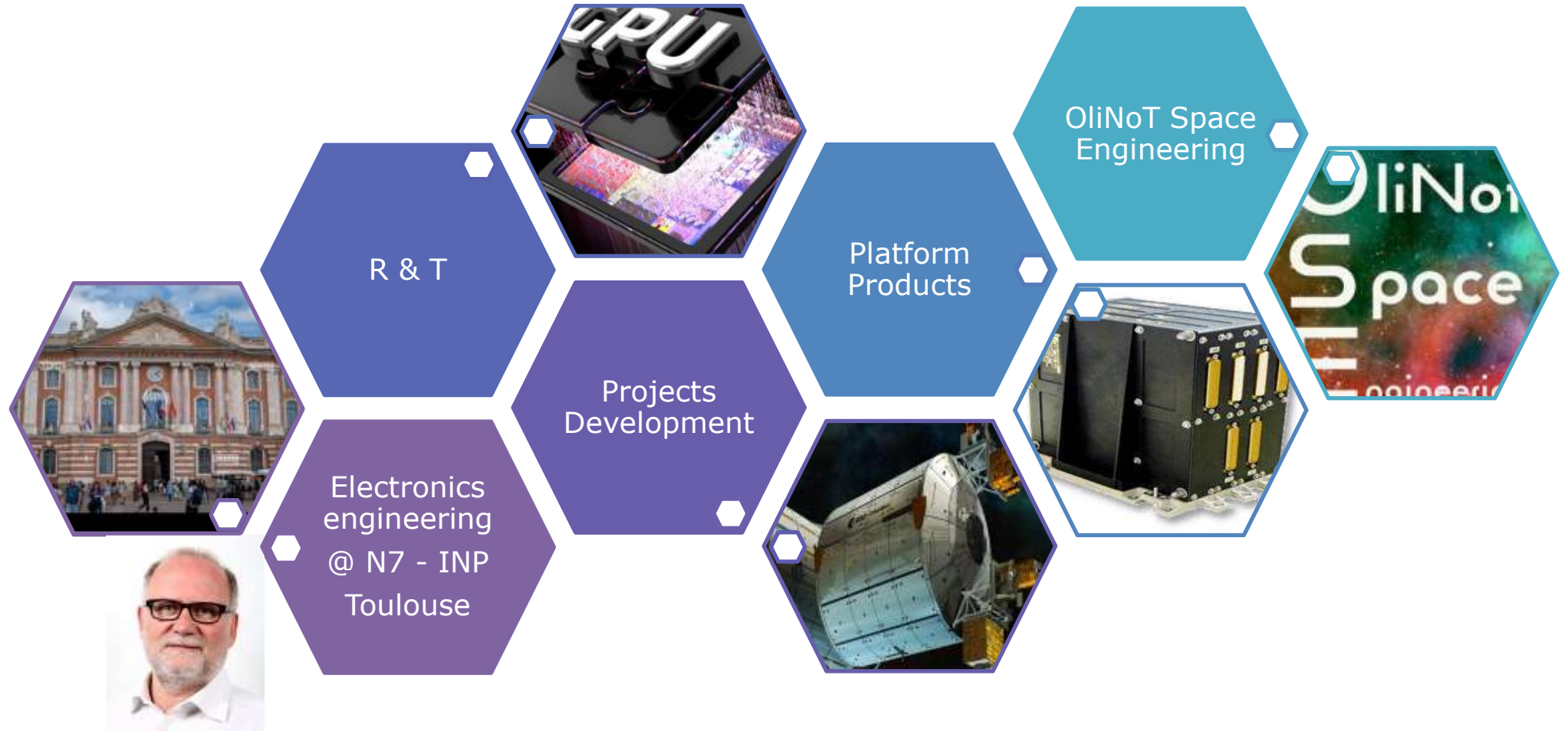


# Impact of LEON on space a revolution ?

Göteborg, February 5<sup>th</sup> 2026

**Olivier Notebaert**  
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# 40 years of Space Data Systems Engineering



Olivier Notebaert

1986 MATRA Espace > Matra Marconi Space > Astrium > Airbus Defence and Space 2022

2023 OliNot Space Engineering

[linkedin.com/in/olivier-notebaert-0a950112/details/experience/](https://www.linkedin.com/in/olivier-notebaert-0a950112/details/experience/)

# Revolutions

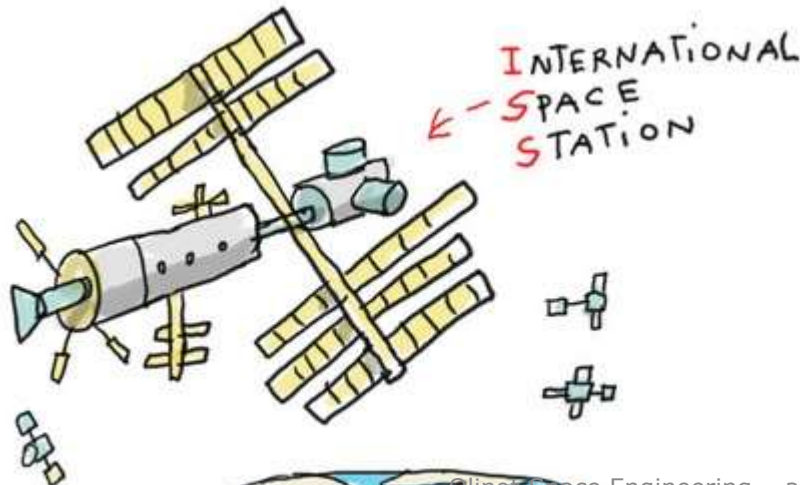
## French Revolution (end 18<sup>th</sup> Century)

### Context

- Social inequality
- Political oppression
- Cultural evolution for more freedom (Age of Enlightenment)

### Triggers

- Bad harvests -> Starvation
- High price peaks
- Eden-Reyneyal treaty -> Economical impact



05/02/2026

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## Space On-board Data systems (end 20<sup>th</sup> Century)

### Context

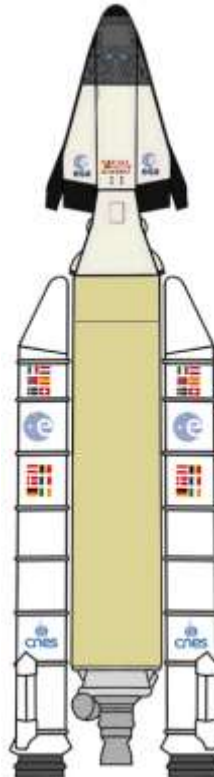
- Inequality between space and ground data systems
- High dependency for space grade parts (8086, 68020, Mil-Std-1750...)
- Determinism dogma prevents the adoption of new data-handling techniques
  - RTOS, tasks priorities and pre-emption, Object Oriented S/W (Ada, C/C++), Pre-fetch, caches, asynchronous I/O's,...

### Triggers

- Parts Obsolescence, increasing costs
- Very ambitious programs requiring technology breakthroughs

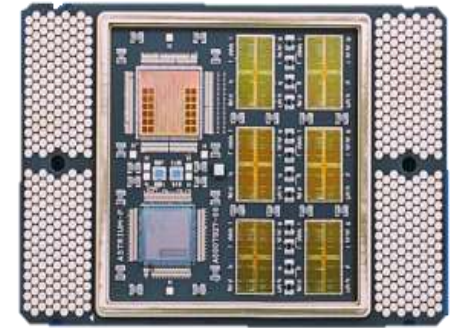


MILITARY STANDARD  
SIXTEEN-BIT COMPUTER INSTRUCTION SET ARCHITECTURE



# 90's : Root Technologies developments

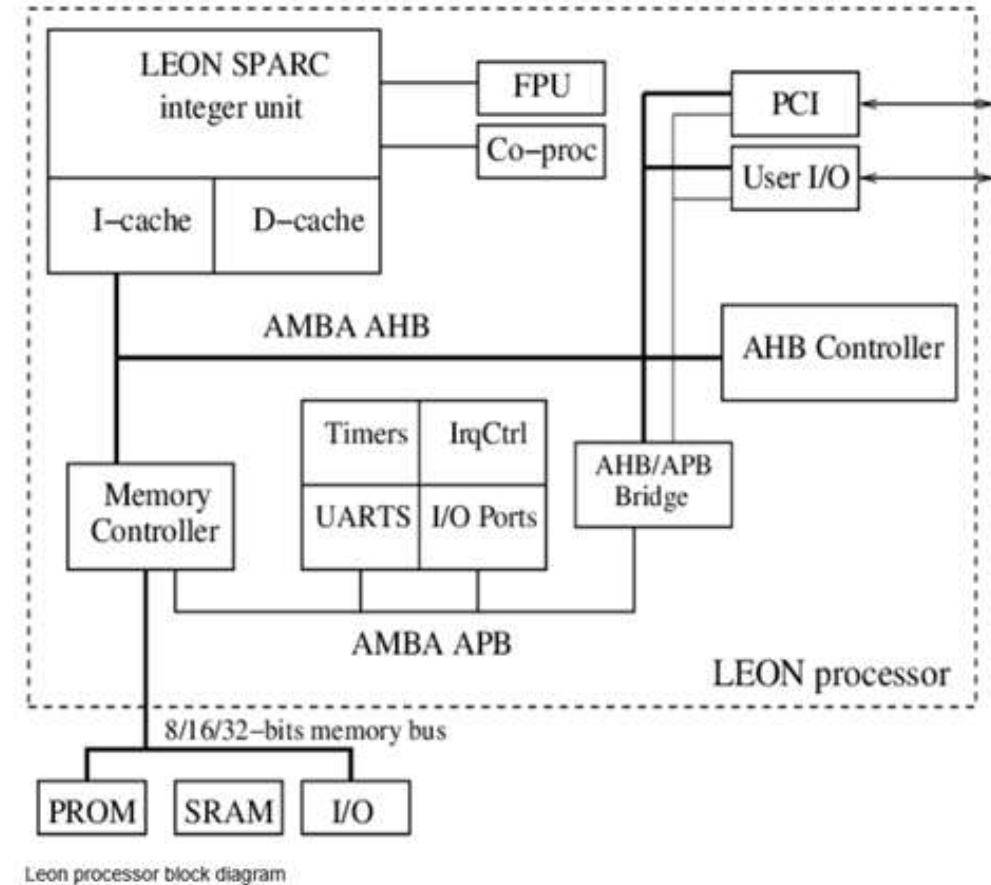
- ✈ **Favourable winds**
  - Technology Readiness Level scale adopted
  - ESA/ESTEC technology development strategy (TRP, GSTP, ARTES, etc...)
  - Strong support from national agencies (CNES, SNSB, DLR...)
- ✈ **Major innovative technologies becomes « flight proven »**
  - ERC-32 (Sparc) on Science, Observation, Space Transportation...
  - RTOS everywhere (ASTRES\_1750, RTEMS...)
  - OO techniques, ADA and C languages
- ✈ **Seeds planted for future OBDH systems**
  - IEEE 1355 preparing SpaceWire
  - Radiation effects knowledge and robustness technologies
  - Leon study
- ✈ **But some crisis**
  - Economic crisis in 93: Hermes abandoned, ISS/Columbus strongly downscaled
  - and a « software crisis »
    - Delays, costs, performances, quality, product assurance issues ...



ERC-32

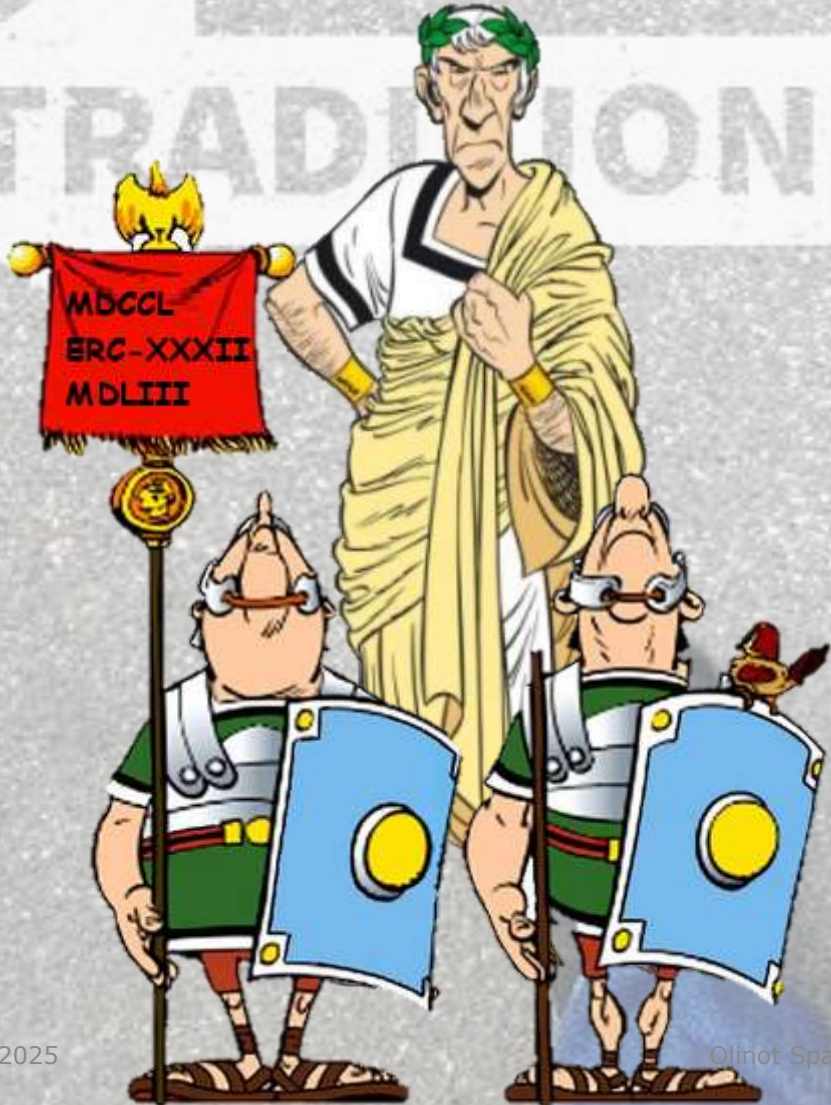
# 1997 : The LEON project

- a kind of “garage” team in ESTEC Lab involving very few people
- **A break-through project !**
  - Modular architecture enabling extensions and evolutions
  - Decision to release the design as an open-source
  - Way for an European  $\mu$ P successor to the ERC-32
- **First functional version of the LEON processor at the turn of the century**



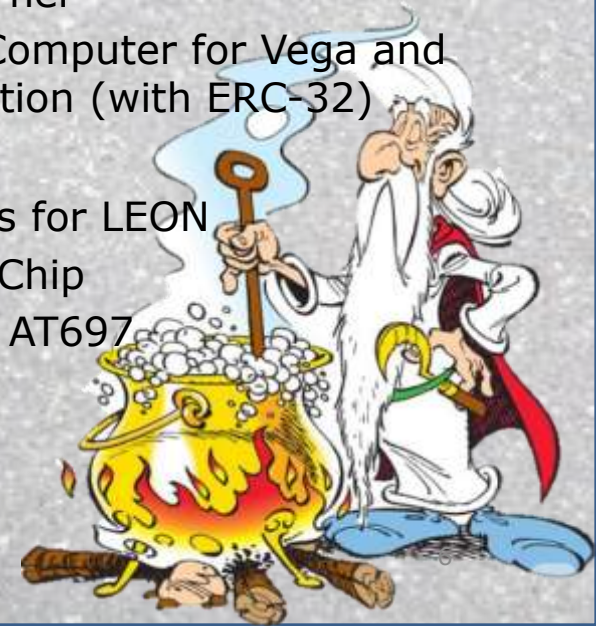
# 2000's : REUSE and EXPLORE

- ✦ Mil-Std-1750, MIL-Std-1553 and ERC32 become THE standards

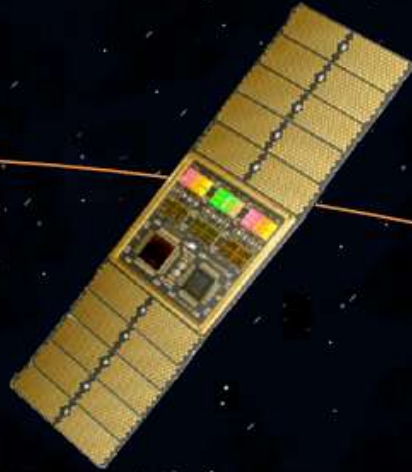


- ✦ **Technology maturation with ESA and agencies support**

- Generic OBDH architecture, functions and interfaces
- Technologies exploration for sensors bus (Can, wireless...)
- Interfaces standardisation (ECSS) and products development
  - SpaceWire, Can bus, 1553 protocols, PUS...
- Future Launchers Avionics
  - ALF -> I/O Kernel
  - Single Board Computer for Vega and Ariane 5 evolution (with ERC-32)
- LEON Maturation
  - VHDL functions for LEON
  - Systems on a Chip
  - LEON2 FT and AT697



# A Spacecraft Controller on a Chip with a LEON 3 !!!



I had a dream



# The SCoC3\* story at Astrium°

## 🚀 New platform AstroSat

- Our proposal for On Board Data Handling
  - Develop a **Spacecraft Controller on a Chip**
  - Target all future spacecraft needs
    - Observation, Science, Telecom...
- Use the modularity and flexibility of the LEON
  - Software compatibility with ERC-32
  - Leon 3 commercial library by Gaisler Research
  - Flexibility for purchasing and/or developing modules from different sources for other VHDL functions and interfaces
    - TM/TC and reconfiguration
    - I/O protocols not only for 1553 but also for SpaceWire and Can bus
  - Goal > 100 Mips + integrated I/O efficiency vs. current slow coprocessors
  - Make a robust ASIC using 0.18µm RH from ATMEL
  - Port and further develop the DHS S/W Core library for SCoC3



# The SCoC3 story at Astrium

## But...

– AstroSat requirement is: **The  $\mu$ P SHALL BE an ERC32**

– Lack of trust in the technical solution:

- Changing the processor is too risky (« software crisis » trauma)
- The cost is very high
- LEON is not “flight proven”
- System on a Chip ?
- Open-source ??
- Can bus ???
- Seriously ????????

**our proposal is rejected**





# With a little help from my friends

## ● Saab Space (Beyond Gravity)

- was the Astrium's preferred supplier for ERC-32 OBC
- Pleiades OBC was the ERC-32 baseline for Astrosat
- Saab Space developed a LEON breadboard OBC based on Pleiades specification and interfaces



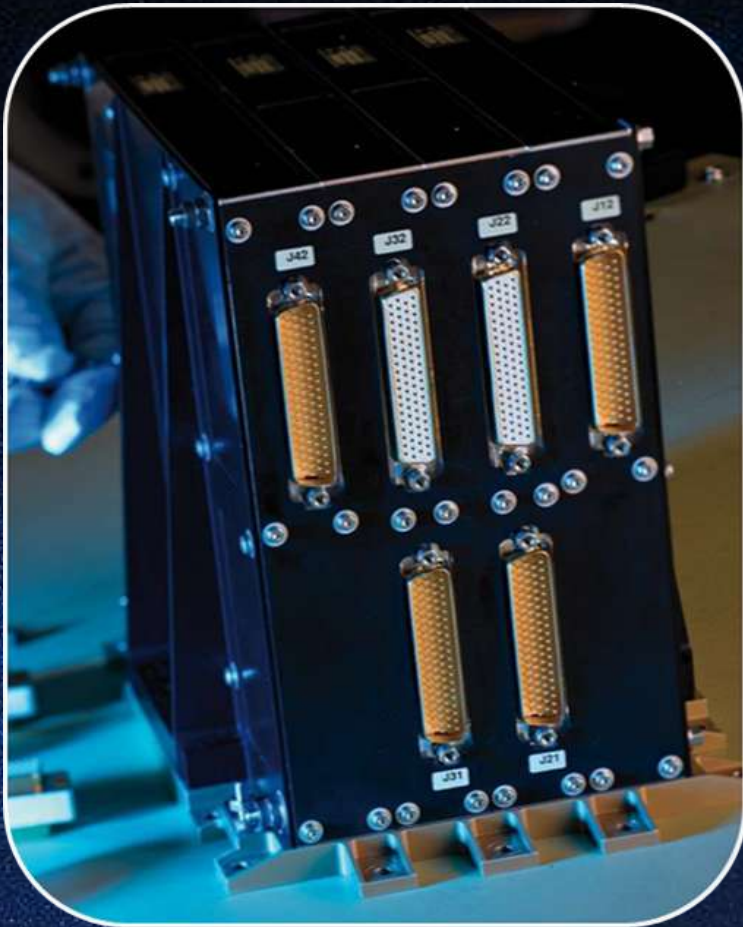
Olaf Grossebaf

## ● I explained my difficulties to get LEON accepted

- Saab Space lend me the LEON board for a few weeks in exchange for Pleiades use-case evaluation results
  - We ported the Pleiades software on the Leon board
  - We tested it successfully using the Pleiades tests facilities
    - With 2 engineers in less than a month







**OSCAR**  
(Observation, Science...)



**Astrix**  
(Fibre Optic Gyroscope Electronics)



**CDMU**  
(Telecom)

# Permanent revolution



**ST 65nm Bulk CMOS Technology**

- High performance / low power consumption
- Fault Tolerant design → robustness in space environment

**GR740 – Quad-Core LEON4FT designed for multi-processing**

**High performance for data processing**  
**Standard interfaces for spacecraft control**

- 4 x LEON4 FT with dedicated MMU and FPU
- 8-port SpaceWire Router
- PCI, Ethernet, 1553, CAN bus
- 64-bit PC100 SDRAM memory I/F

SPARC Compliant

Courtesy of COBHAM  
www.Cobham.com/Space  
AIRBUS

**SPINAS computer (OBC-SA project)**

Monday @ 14:30  
Wednesday @ 15:20

**On-Board Computer System Architecture project (DLR)**

- Objective**
  - Open Modular Architecture (Space cPCI Serial)
  - Modular S/W with Time and Space Partitioning (PikeOS)
  - High performance multicore processing for resource sharing
  - Miniaturisation (3U boards, <5kg)
- Features**
  - High reliability SPARC V8 CPU (GR740)
    - 4 cores @ 250 MHz
    - 459 DMIPS per core
  - 256 MB SDRAM (+EDAC)
  - 2x Gigabit Ethernet
  - 8x SpaceWire up to 300Mbit/s
  - Redundant MIL-STD-1553B
  - 2x CAN, 2x RS422
  - Watchdog for system reliability

LEON4 Processor Board Bottom View

SPINAS EQM Computer Box

AIRBUS

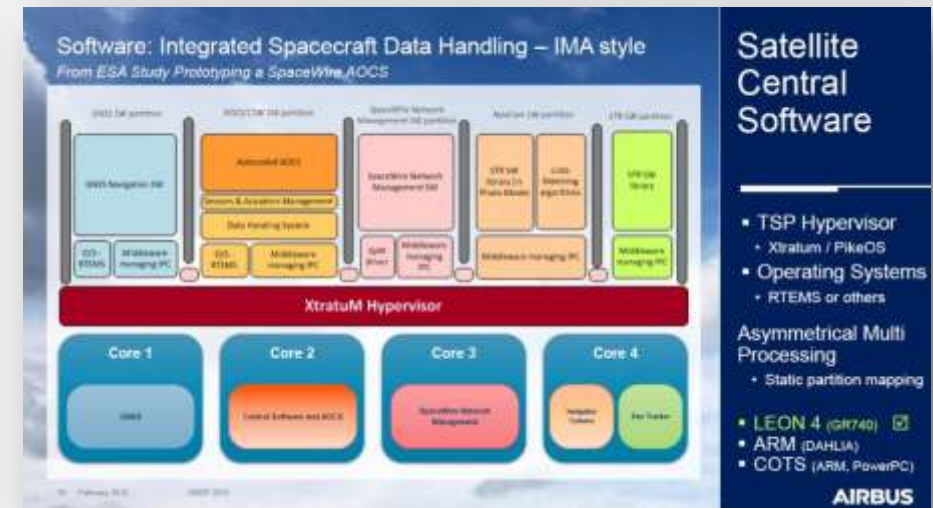
**HP4S – High Performance Parallel Payload Processing for Space**  
ESA Study with the Barcelona Supercomputing Center

- SW parallelisation with OpenMP
  - selection of suitable MC targets
  - Adaptation/development of OpenMP
  - Application benchmarks
- Main criteria's for target selection
  - Technology robustness vs. radiation
  - HW compatibility with the OpenMP
  - Evaluation kit availability
  - SW ecosystem and porting effort
  - Range of applications
- Evaluation benchmarks / use cases
  - ESA generic P/L processing benchmarks
  - GAIA VPU
  - Image processing
  - active mirrors
  - Robotics: disparity map, inverse kinematics

Target	Supplier	Type	Application	RH
GR740	Orion-Genier	Quad Core Leon GPP	General purpose	Yes
MPPA	Kalray	80 cores clustered Processor Array (Cookidge)	General purpose with intensive Data flow	No
Zynq	Xilinx	Quad Core ARMv7 on MPSoC	General purpose with internal FPGA accelerator	No
RC64	Rambus/Alip	64 DSP cores NoC	DSP	Yes
HPDP	Airbus-DS	40 cores Processor Array	Data flow intensive processing	Yes

AIRBUS

**Software: Integrated Spacecraft Data Handling – IMA style**  
From ESA Study Prototyping a SpaceWire AOCSS



**Satellite Central Software**

- TSP Hypervisor
  - Xrtatum / PikeOS
- Operating Systems
  - RTEMS or others
- Asymmetrical Multi Processing
  - Static partition mapping
- LEON 4 (GR740)
- ARM (DAHLIA)
- COTS (ARM, PowerPC)

AIRBUS



Thank you !

