Product lines and standardization – the equipment supplier perspective

ADCSS2020

Patrik Sandin

RUAG Space

October 22, 2020

Together ahead. RUAG

History
Looking back…

- An OBC was specified differently between each program and customer
  - In best case it was the same customer engineering teams @prime and @ESA then there was at least a chance for some commonality
  - Personal opinions of individual system engineers affected the acceptable technical solutions to a large extent
  - Not only mission specifics varied between missions

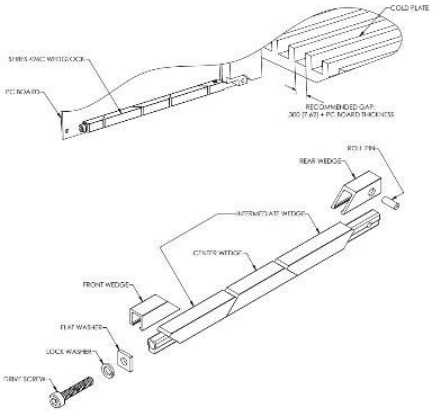
- What happened?
  - SAVOIR was formed and created a reference architecture and reference specifications
  - It is now a well-established foundation for at least ESA satellites
  - Now we have much less variation between missions – of course we still need to do mission specific adaptations
    - It is a competitive advantage to be able to handle mission specifics efficiently

SAVOIR
space avionics open interface architecture

What is the future?

- Is Advanced Data Handling Architecture (ADHA) the future?
  - It is a beginning at least…
- Modular architectures with standardized mechanical and electrical interfaces is the future!
- Is Compact PCI Serial Space the future?
- Is SpaceVPX the future?
- Is wedge-lock the future?
- Remember
  - A fully customized and optimized equipment targeting a specific mission will have better SWaP than equipment built on standardized concepts
    - Total costs will be much higher – is it worth it?

PICMG®



SPACEVPX™

Together ahead. RUAG

Standardization
What is it good for?

Standardization
What is it good for?

- Absolutely nothing
  (Edwin Starr – War)

Standardization
What is it good for?

- **What?**
  - **Electrical interfaces and communication protocols**
    - Both internal and external
  - **Mechanical interfaces**
    - Both internal and external
  - **Functions on a high level**
    - But be careful not to over specify
    - Must allow innovation, competition and evolution

- **Why?**
  - **Increased reuse**
    - Complete crates and modules between units, missions and customers
  - **Focus on what is important** – the mission specifics
    - We do not want to spend valuable time and effort on adapting electrical and mechanical interfaces unless it is necessary
  - **Integration of more functions** in the same unit
    - Reducing DC/DC converters, mechanical housing and harness
  - Develop modules for a **wider customer base**
    - Easy to get started no need to focus on mechanics and backplanes
    - Removing the cost of adapting to each customer
  - Reuse of **qualification status**
    - At least reduce re-qualification efforts between units, missions and customers significantly
  - **Faster, cheaper and better – plug and play**

Together ahead. RUAG

Standardization
What is it **not** good for?

- **What?**
  - **Allocation of functions to modules or units**
    - Customers can have preferences but should not be standardized
    - See Product Lines
  - **Performance**

- **Why not?**
  - It hampers **innovation, competition and evolution**
  - We should **compete on technical solutions and flexibility** as well as **schedule and cost**

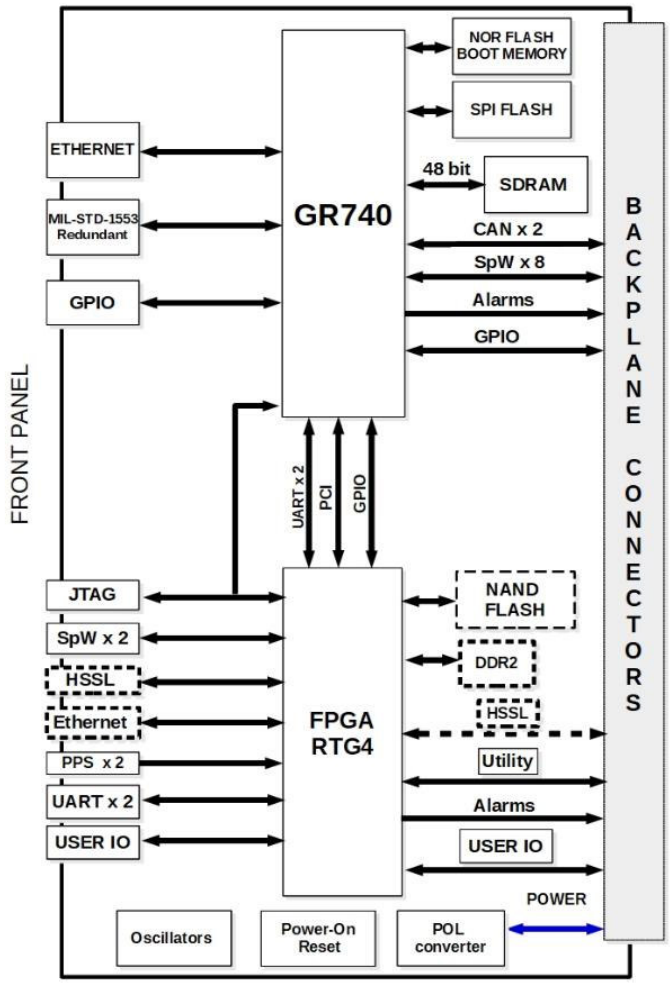
- **Pitfalls**

  Be careful if you standardize every little detail of each module to get drop-in replacements
  - You could believe you get **dual sourcing** advantages on module level
    - But you only get dual manufacturing capability
  - Your suppliers are reduced to **build-to-print shops**
  - Your suppliers can only compete on **lowest manufacturing price**
  - You are not really looking for the **advantages of standardization**

GR740 Single Board Computer
Preliminary datasheet

- A high performance Single-Board Computer based on Cobham Gaisler GR740 Quad-Core 32-bit LEON4FT SPARC V8 processor and Microsemi RTG4 radiation tolerant FPGA.
- The SBC provides an extensive set of memories and redundant interfaces to support the needs of current and future OBC and Data Handling platforms.
- Developed as part of ESA activity “Reference Design and Basic Software for a Single Board Computer based on GR740”

- Features
  - Implemented following the Compact PCI Serial Space backplane standard (CPCI-S.1 R1.0)
    - Dual star, eight SpaceWire interfaces from GR740
    - Multi drop bus, redundant CAN from GR740
    - Full mesh, HSSL (SpFI) from RTG4
    - Multi drop bus, I2C from RTG4
    - Alarms and other utility signals
  - On-board memory
    - SDRAM interfaced with GR740, 512 MIB of accessible data RAM plus ECC check bits
    - Parallel Boot MRAM, 64 KiB interfaced with GR740
    - SPI Flash memory, 32 MiB interfaced with GR740
    - 3D-PLUS NAND FLASH, 8 GiB interfaced with RTG4
    - 3D-PLUS DDR2, 512 MiB of accessible data RAM plus ECC check bits interfaced with RTG4
  - PCI, UART and GPIO interface between GR740 and RTG4
  - Interfaces at front edge of board:
    - Redundant MIL-STD-1553B
    - 2 x SpaceWire
    - Gigabit Ethernet
    - General purpose I/O’s
    - PPS (Pulse Per Second) input for synchronization (SMB)
    - UART/JTAG debug interfaces
  - Form factor
    - 6U (233.5 mm x 160 mm), 5 HP. Mass 1.2 kg (estimate)
  - Power consumption: ~30 W (estimate)



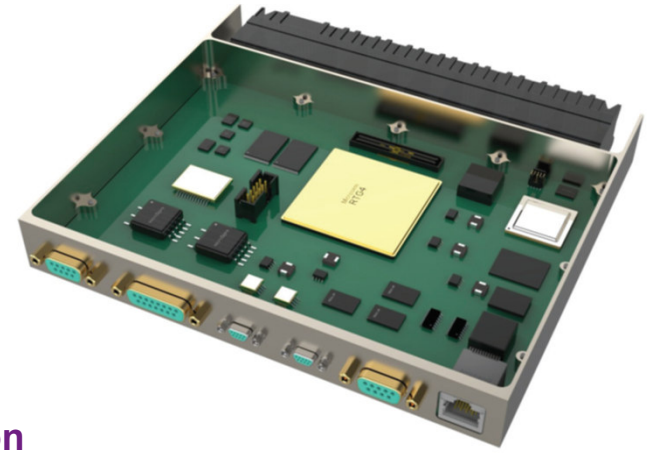
Together ahead. RUAG

High Performance Processing Modules
Lynx (ARM) Single Board Computer (SBC) datasheet

Key Features
- Lynx SBC is a high-performance general-purpose single board computer with flexible communication and interface capabilities
- Processing capability provided by a quad core ARM processor delivering more than 30.000 DMIPS
- IO capability implemented in a reprogrammable FPGA allowing late tailoring to a specific program need (without hardware redesign) and hardware accelerated functionality.
- Designed for 15 years in GEO orbit
- RUAG has an extensive single-board computer heritage:
  > 3000 failure free equipment years in orbit
  > 300 Launcher On-Board Computers
  > 120 Satellite Data Handling Systems

Budgets
- Form factor 6U-160, 5 HP, 234 x 160 x 25.4 mm
  Mass 1 kg incl. frame
- Power consumption 10-25 W

Radiation Tolerance
- Latch Up protected
- All memories with error correction
- Sustain total dose up to 15 years in GEO orbit



Specification
- ARM processor with 4 x CPU cores
  - >30.000 DMIPS
  - 32 KiB L1 instruction cache, 32 KiB L1 data cache, 2 MiB L2 cache
- 4/8 GiByte DDR4 processing memory with ECC
- 4/8/16 GiByte Flash memory with ECC
- 512 MiByte DDR2 communication memory with ECC
- Gigabit Ethernet Debug Link
- Interfaces:
  - Front connectors: 4 x SpaceWire, 2 x UART, 16 x GPIO (configurable), debug interfaces
  - Back-plane, cPCIss: 5 x HSSL @ 3 Gbps, 10 x SpaceWire, 2 x I2C, 6 x SPI, 2 x UART, 32 x GPIO
  - Mezzanine: Interfaces mezzanine (optional)
    - 2 x M1553B (optional), 2 x CAN (optional)

Product lines
What is it?

Very complex… or really simple…

- **Collection of different functions**
  - **expected to be delivered from a supplier**

  or
  - **provided by a supplier matching customer needs**

  with defined and described features
    - Not standardized

- **Can be**
  - **A hardware module**
  - **A mechanical crate with a backplane**
  - **A complete unit**
    - Crate, backplane and modules
  - **Software or gateware module or package**
  - **A subsystem**

- **Pitfalls** (same as for standardization)
  - Too **rigid definitions** of product lines from higher level entities will hamper **innovation and competition**
  - Product lines must allow **different implementations and evolution**

- **SAVOIR reference architecture**
  - A good example of how to standardize functions and use as a basis for product lines
  - Physical allocation is not defined – which is good

- **Equipment data sheet => Customer product line database/catalogue**

Equipment supplier role
Standardization and product lines

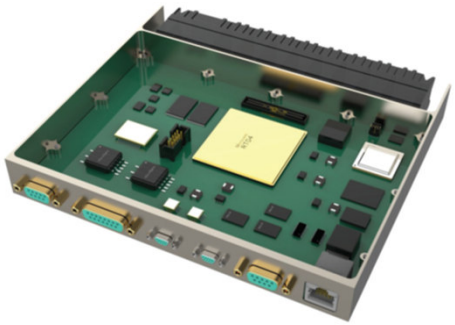
- **Equipment suppliers will be reduced to module suppliers**
  - Both ESA and prime have aired such thoughts in the scope of ADHA
  - This is a big misconception

- **Equipment suppliers will**
  - Continue to deliver efficient and cost-effective solutions for units and subsystems
  - Take advantage of the standardization
  - Build units and sub-systems from standard crates, backplanes and modules
  - Compete on technical solutions and flexibility as well as schedule and cost

Conclusion

- **Modular architectures with standardized mechanical and electrical interfaces is the future!**

- Standardize
  - **Electrical interfaces and communication protocols**
  - **Mechanical interfaces**
  - **Functions on a high level**



- Allow **evolution**, **competition** on **innovation** and **implementation**

- **Equipment suppliers** will continue to deliver **efficient** and **cost-effective units** and **sub-systems**

Together ahead. RUAG