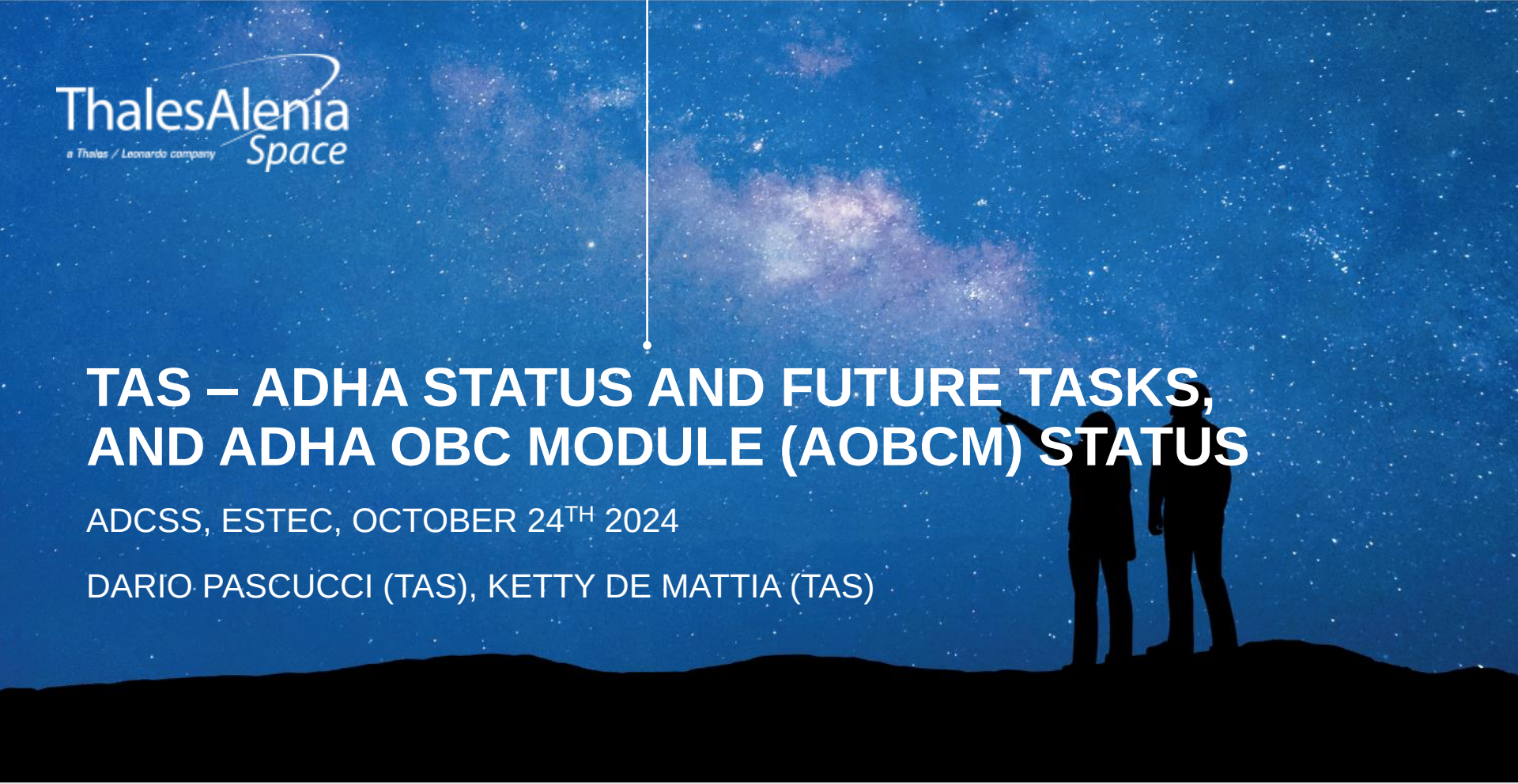

TAS – ADHA STATUS AND FUTURE TASKS, AND ADHA OBC MODULE (AOBCM) STATUS

ADCSS, ESTEC, OCTOBER 24TH 2024

DARIO PASCUCCI (TAS), KETTY DE MATTIA (TAS)

Date: 23/10/2024
Ref: xxxxx
Template: 83230347-DOC-TAS-EN-008

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INTRODUCTION TO ADHA (1/2)

- ESA and Industry initiative to develop a modular, scalable and interoperable DH standard
- TAS & ADS primes of ESA double sourcing contracts, but most of European Space industry is involved (OHB, BG, DSI…):
  - "Advanced Data Handling Architecture (ADHA) Consolidation, Standardisation, and Product Suite Development" -> "**ADHA-2 Frame Contract**"
- Scope of the ADHA-2 Frame Contract is:
  1. Definition of ADHA standardization;
  2. Specification and technical monitoring of first ADHA modules to be developed under TDE:
     - Power Module -> **ADS**
     - OBC -> **TAS**
     - SSMM -> **DSI**
  3. Development by primes (TAS, ADS) of Demostrators at TRL-6 (EM) within 2025:
     - Production of backplane + unit mechanics
     - Integration and testing of ADHA-U1 including Power Module, OBC and SSMM

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INTRODUCTION TO ADHA (2/2)

- Perceived advantages of the ADHA approach:
  - Make possible the assembly of a DH unit starting from standardized modules;
  - Different unit integrators re-use whatever ADHA module without adaptations (both HW and CC/DH level);
  - More compact system (integrates different functions in same box)
  - Implement effective scalability e.g. increase performance and budget by adding extra modules (e.g. SSMM);
  - More efficient implementation of georeturn: board level instead of unit level, no adaptation neded;
  - Easier involvment of SME and New ESA Member States;
  - Capitalization of validation at board level;

- To achieve these objectives the ADHA standardization does not only cover technical aspects, but also fully defines the development process:
  - Standardized SoW and development requirements for units and modules;
  - Standardized documentation tree at unit and module level;
  - Etc.

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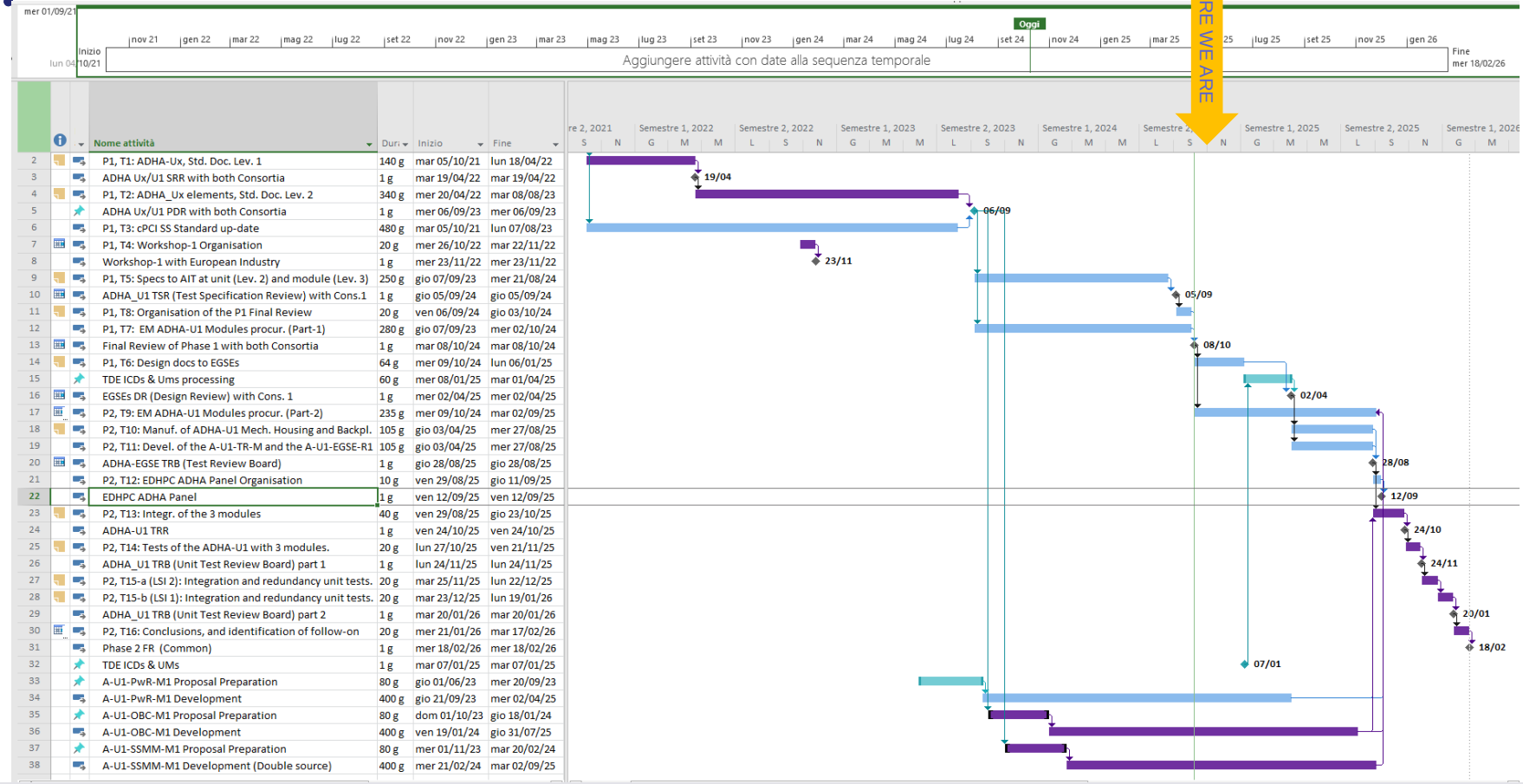
SCHEDULE OF ADHA-2 ACTIVITIES

ADHA-2 Phase-1 Final Review closed 8/10/2024

HERE WE ARE



	Nome attività	Dur.	Inizio	Fine
2	P1, T1: ADHA-Ux, Std. Doc. Lev. 1	140 g	mar 05/10/21	lun 18/04/22
3	ADHA Ux/U1 SRR with both Consortia	1 g	mar 19/04/22	mar 19/04/22
4	P1, T2: ADHA_Ux elements, Std. Doc. Lev. 2	340 g	mer 20/04/22	mar 08/08/23
5	ADHA Ux/U1 PDR with both Consortia	1 g	mer 06/09/23	mer 06/09/23
6	P1, T3: cPCI SS Standard up-date	480 g	mar 05/10/21	lun 07/08/23
7	P1, T4: Workshop-1 Organisation	20 g	mer 26/10/22	mar 22/11/22
8	Workshop-1 with European Industry	1 g	mer 23/11/22	mer 23/11/22
9	P1, T5: Specs to AIT at unit (Lev. 2) and module (Lev. 3)	250 g	gio 07/09/23	mer 21/08/24
10	ADHA_U1 TSR (Test Specification Review) with Cons.1	1 g	gio 05/09/24	gio 05/09/24
11	P1, T8: Organisation of the P1 Final Review	20 g	ven 06/09/24	gio 03/10/24
12	P1, T7: EM ADHA-U1 Modules procur. (Part-1)	280 g	gio 07/09/23	mer 02/10/24
13	Final Review of Phase 1 with both Consortia	1 g	mar 08/10/24	mar 08/10/24
14	P1, T6: Design docs to EGSEs	64 g	mer 09/10/24	lun 06/01/25
15	TDE ICDs & Ums processing	60 g	mer 08/01/25	mar 01/04/25
16	EGSEs DR (Design Review) with Cons. 1	1 g	mer 02/04/25	mer 02/04/25
17	P2, T9: EM ADHA-U1 Modules procur. (Part-2)	235 g	mer 09/10/24	mar 02/09/25
18	P2, T10: Manuf. of ADHA-U1 Mech. Housing and Backpl.	105 g	gio 03/04/25	mer 27/08/25
19	P2, T11: Devel. of the A-U1-TR-M and the A-U1-EGSE-R1	105 g	gio 03/04/25	mer 27/08/25
20	ADHA-EGSE TRB (Test Review Board)	1 g	gio 28/08/25	gio 28/08/25
21	P2, T12: EDHPC ADHA Panel Organisation	10 g	ven 29/08/25	gio 11/09/25
22	EDHPC ADHA Panel	1 g	ven 12/09/25	ven 12/09/25
23	P2, T13: Integr. of the 3 modules	40 g	ven 29/08/25	gio 23/10/25
24	ADHA-U1 TRR	1 g	ven 24/10/25	ven 24/10/25
25	P2, T14: Tests of the ADHA-U1 with 3 modules.	20 g	lun 27/10/25	ven 21/11/25
26	ADHA_U1 TRB (Unit Test Review Board) part 1	1 g	lun 24/11/25	lun 24/11/25
27	P2, T15-a (LSI 2): Integration and redundancy unit tests.	20 g	mar 25/11/25	lun 22/12/25
28	P2, T15-b (LSI 1): Integration and redundancy unit tests.	20 g	mar 23/12/25	lun 19/01/26
29	ADHA_U1 TRB (Unit Test Review Board) part 2	1 g	mar 20/01/26	mar 20/01/26
30	P2, T16: Conclusions, and identification of follow-on	20 g	mer 21/01/26	mar 17/02/26
31	Phase 2 FR (Common)	1 g	mer 18/02/26	mer 18/02/26
32	TDE ICDs & UMs	1 g	mar 07/01/25	mar 07/01/25
33	A-U1-PwR-M1 Proposal Preparation	80 g	gio 01/06/23	mer 20/09/23
34	A-U1-PwR-M1 Development	400 g	gio 21/09/23	mer 02/04/25
35	A-U1-OBC-M1 Proposal Preparation	80 g	dom 01/10/23	gio 18/01/24
36	A-U1-OBC-M1 Development	400 g	ven 19/01/24	gio 31/07/25
37	A-U1-SSMM-M1 Proposal Preparation	80 g	mer 01/11/23	mar 20/02/24
38	A-U1-SSMM-M1 Development (Double source)	400 g	mer 21/02/24	mar 02/09/25

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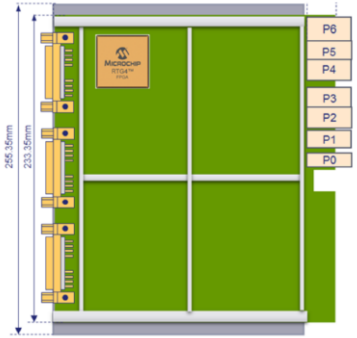
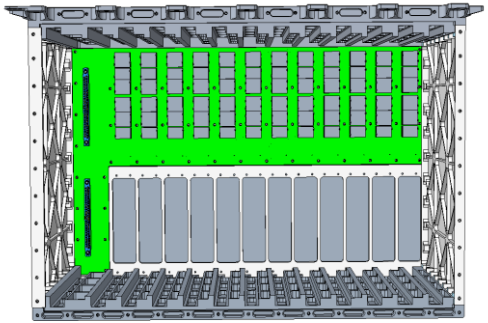
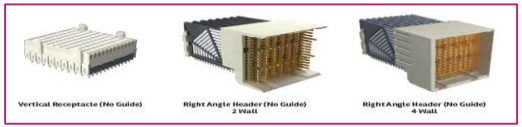
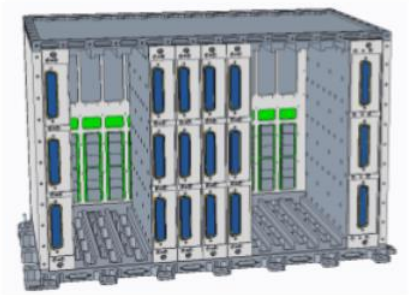
ADHA BASICS (1/4)

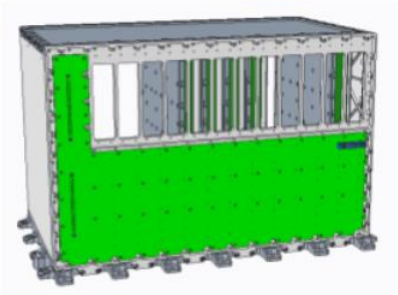
- Based on evolution of cPCI-S-S standard backplane & mechanics (6U and 3U), press-fit connectors (e.g. AIRMAX VS);
- Racked mechanics, to ease the unit assembly and deassembly;
- Fully redundant and cross-strapped system architecture: twin system controllers and redundant links on the backplane (major evolution w.r.t. Compact PCI Serial Space standard) -> Compliant to SAVOIR OBC;
- Boards format 6U extended (length 220 mm) or 3U, the latter specifically for very small single-stream units (e.g. micro-RTU);
- 3U modules may be used in 6U units (possibly through an adapter);
- Up to 12 slots plus Power Module.











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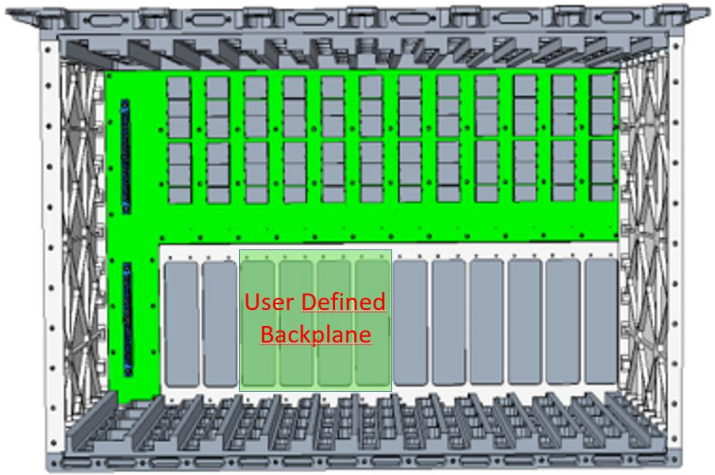
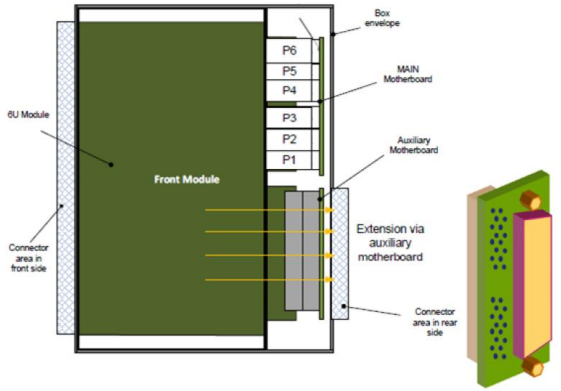
ADHA BASICS (2/4)

- Split Backplane and User Defined Backplanes:
  - Some redundant modules (e.g. the main and redundant boards of the OBC) are connected by a high number of cross-strapping connections;
  - These are much dependent from the specific design of the supplier and are not appropriate to include in the standard backplane;
  - Free space on the lower part of the unit can host one or more User Defined Backplanes;
  - User Defined Backplane is only for specific links between different boards of the same modules; it is not allowed between different kind of modules not to prevent the interoperability of the modules.
  - It is possible to implement additional External Connectors in the rear side of the unit through the User Defined Backplane.





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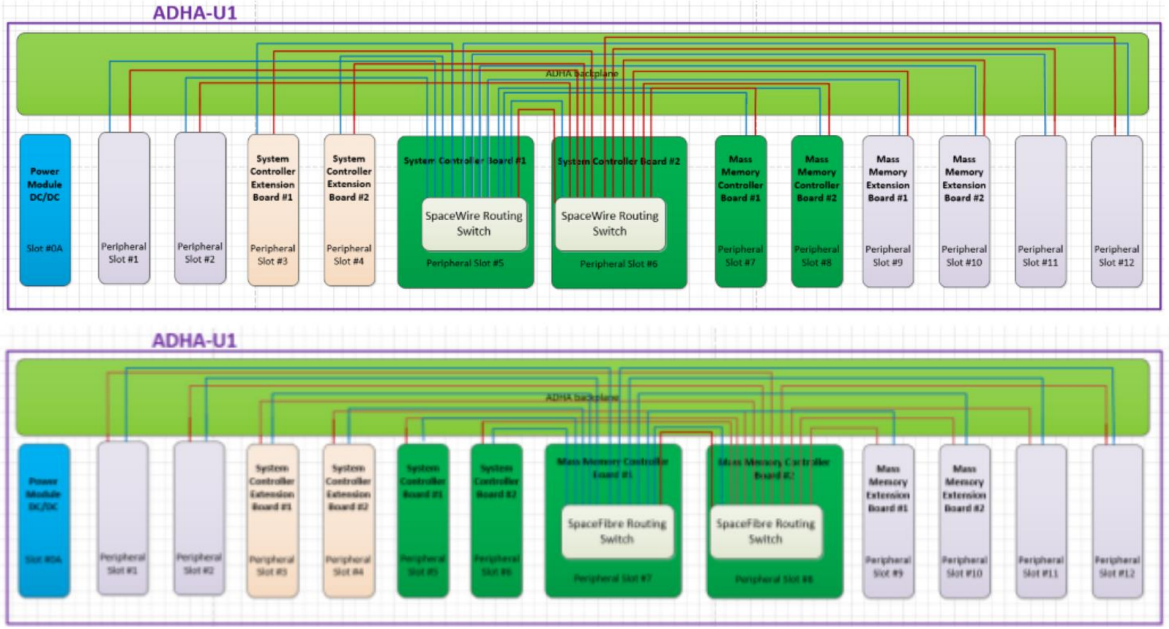
ADHA BASICS (3/4)

- Wide range of links on the backplane, including:
  - CAN Bus for command&control;
  - Spacewire network for command&control and data transfer;
  - Spacefibre network for multi-Gbps data transfer (12.5 Gbps over twin lane point-to-point);
  - Control signals for boards ON/OFF/Reset/Power status;
  - Synchronization signals;
  - Health Monitoring System (HMS) for acquiring vital boards' thermal and power parameters (also from not active boards).
  - Power supply 28V, 12V and 5V.



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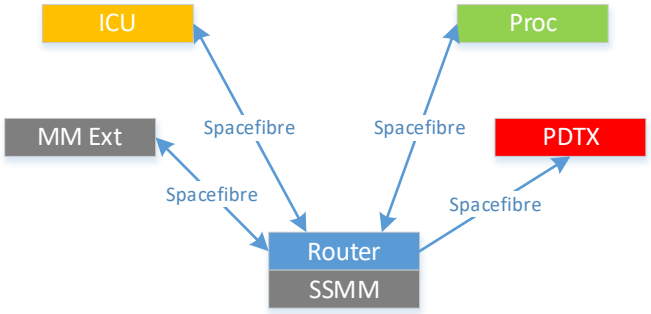
ADHA BASICS (4/4)

- Different modules identified as part of ADHA data processing chain:
  - Solid State Mass Memory (SSMM) including Spacefibre router: is the center of the star topology and can be hosted in the Extended Peripheral or System Controller slots.
  - Mass Memory extension (MM Ext)
  - Instrument Control Unit (ICU): interface to payload modules
  - Processing Module (Proc)
  - Payload Data Transmitter (PDTX)
- ADHA topology supports multiple data processing chain configurations (also at the same time):



ICU -> Proc -> SSMM -> PDTX (real time pre-processing)

ICU -> SSMM -> Proc -> SSMM -> PDTX (off-line processing)

ICU -> SSMM -> Proc -> PDTX (real time post-process.)

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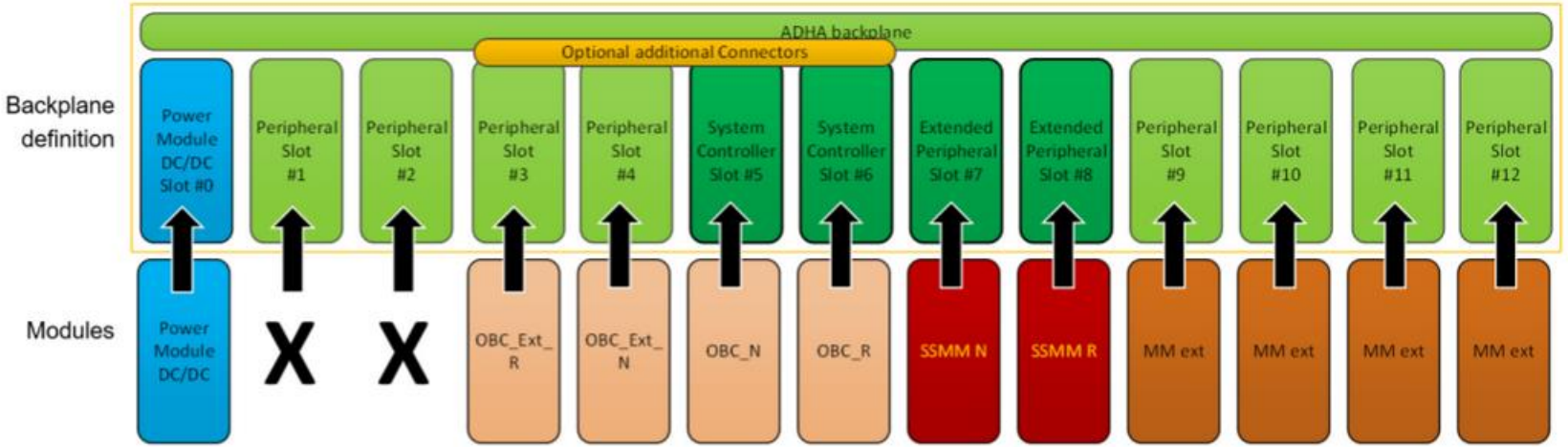
EXAMPLES OF ADHA CONFIGURATIONS (1/3)

- 6U ADHA Unit including OBC and SSMM (corresponding to ADHA-U1 EM)



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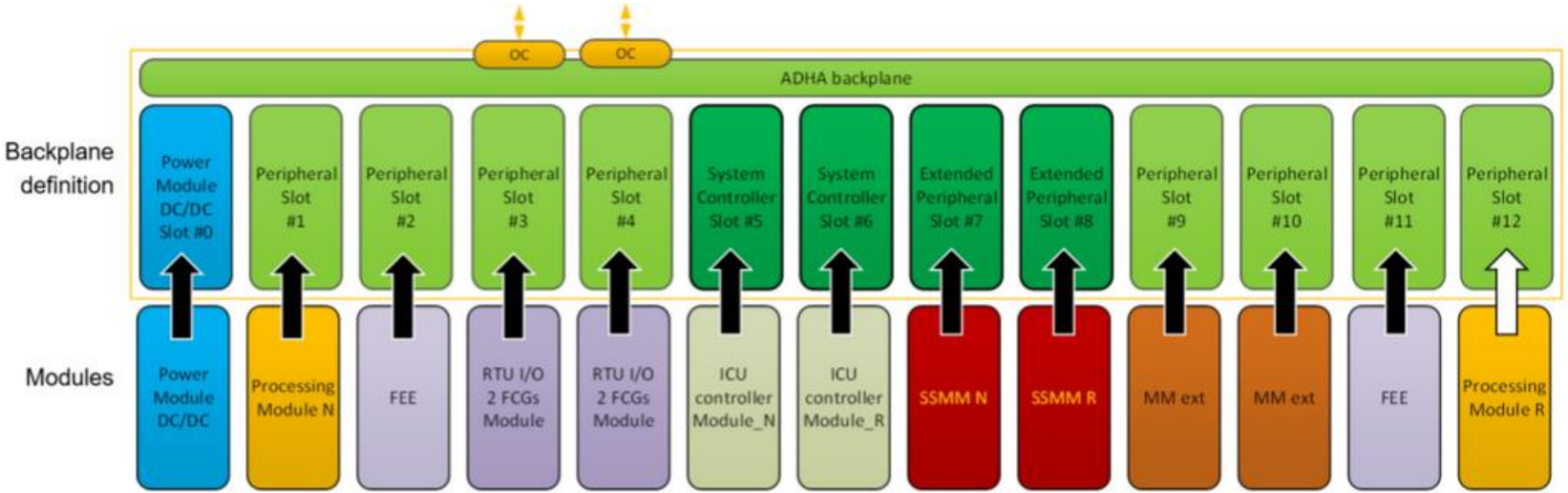
EXAMPLES OF ADHA CONFIGURATIONS (2/3)

6U ADHA Unit including SSMM and Processing Modules



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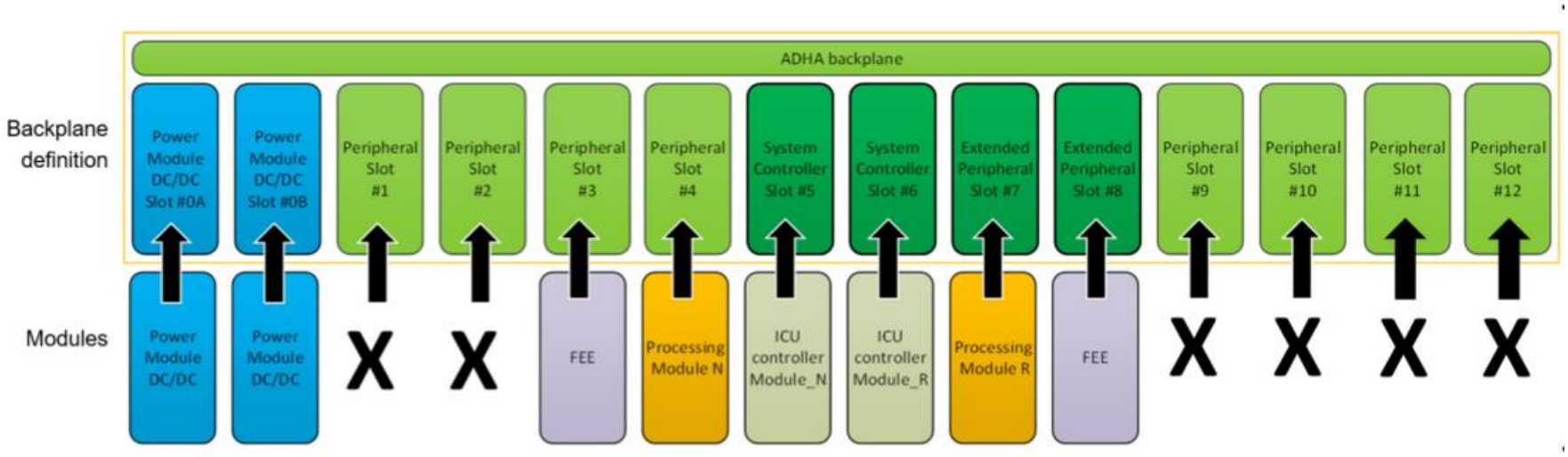
EXAMPLES OF ADHA CONFIGURATIONS (3/3)

- 3U ADHA Unit (non redundant) including I/O (RTU) modules



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M.I.L.A PLATFORM SOLUTION

/// M.I.L.A. is the European Thales Alenia Space platform solution for high performance operational missions.

/// Benefits from Thales Alenia Space legacy

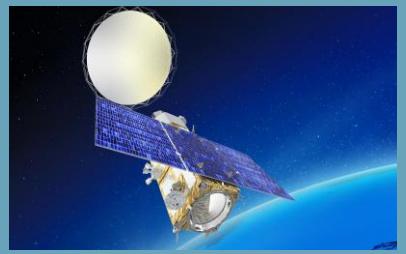
/// Competitive Platform solution with minimum instantiation costs based on tooled product line engineering approach for managing the variability of the Platform solution

/// Current Copernicus missions are based on this new platform solution: CHIME, ROSE-L and CIMR

CHIME

ROSE-L

CIMR



For EARTH SCIENCE mission
And EXPLORATION & SCIENCE of the UNIVERSE

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M.I.L.A PLATFORM SOLUTION

/// Based on a building blocks approach to ensure flexibility and modularity for a wide range of missions

- Variability scheme at platform sub-system level based on alternative, scalable and optional features

/// Compliant to ESA operation requirement (O.I.R.D.)

/// Compliant to space law (LOS) and End of life passivation requirements

/// Available processing for third part application(s)

/// Ensure same operability to customers for whatever the payload (optical, radar, altimeter, …)

Development effort are concentrated on the mission-specific elements, the platform being implemented as a **commodity**

	M.I.L.A Platform
Payload mass	Up to 1.2 T
Payload Data Handling Transmission	• Up to 20Tbits EoL • X-Band or Ka-Band (Optical link optional) • CFDP (Class 1 & 2)
Lifetime	Up to 12.5 years
Avionics Data Handling System	• Multi-partition SW on Leon4FT GR740 SoC • Centralized GNSS and Star tracker processing • PUS-C • File Based Operation / CFDP Class (1 & 2) • Autonomous operations
Attitude Control System	• Sun pointing in Safe Mode through magnetic actuators or Gyrometers & Thrusters • High accuracy 3-axis pointing • Autonomous LEOP sequence • Optional autonomous controlled re-entry
Electrical Power System	Up to 6,5 kW Mono bus 28V Non-Regulated or Dual bus 50V Non-Reg & 28V Reg
Propulsion System	Chemical Uncontrolled or controlled re-entry Passivation
Telemetry, Tracking & Control	S Band or X Band Up to 2Mbps TC Uplink / TM Downlink

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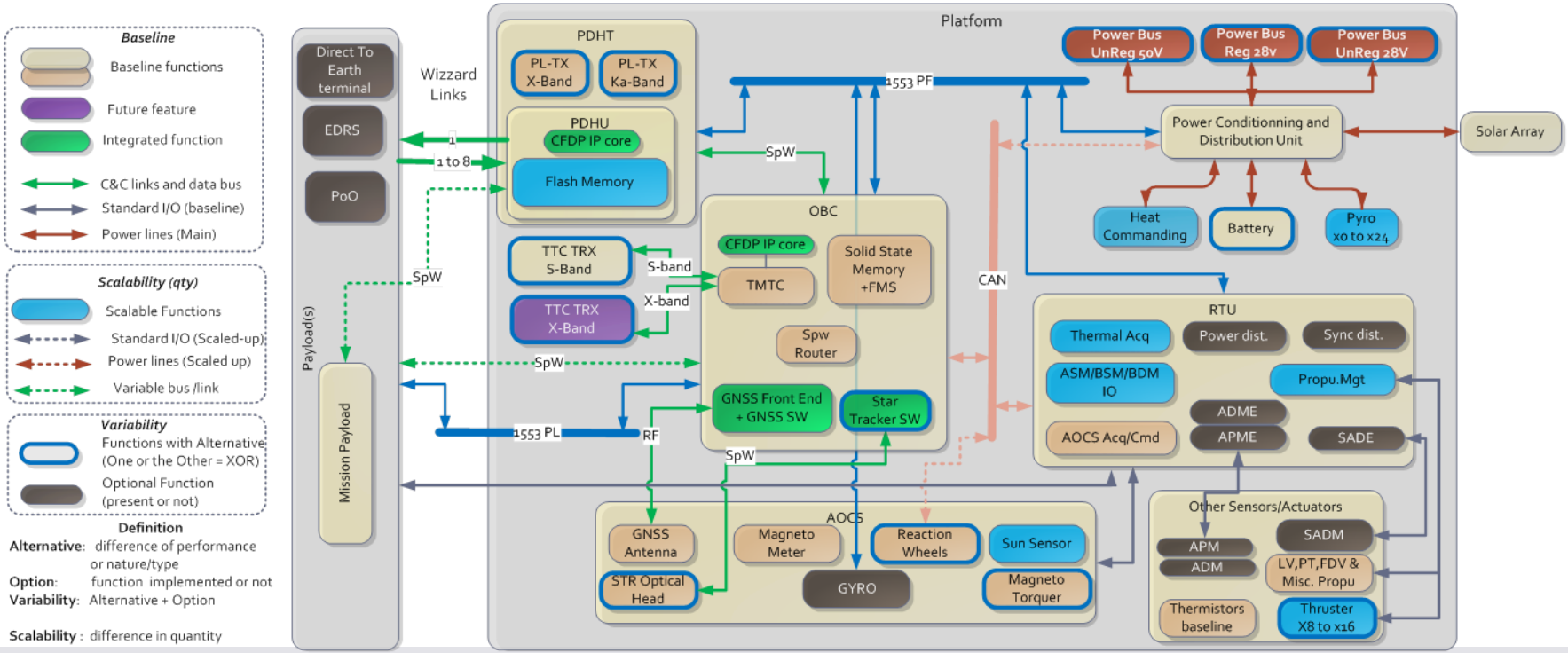
M.I.L.A. ARCHITECTURE AND BUILDING BLOCKS

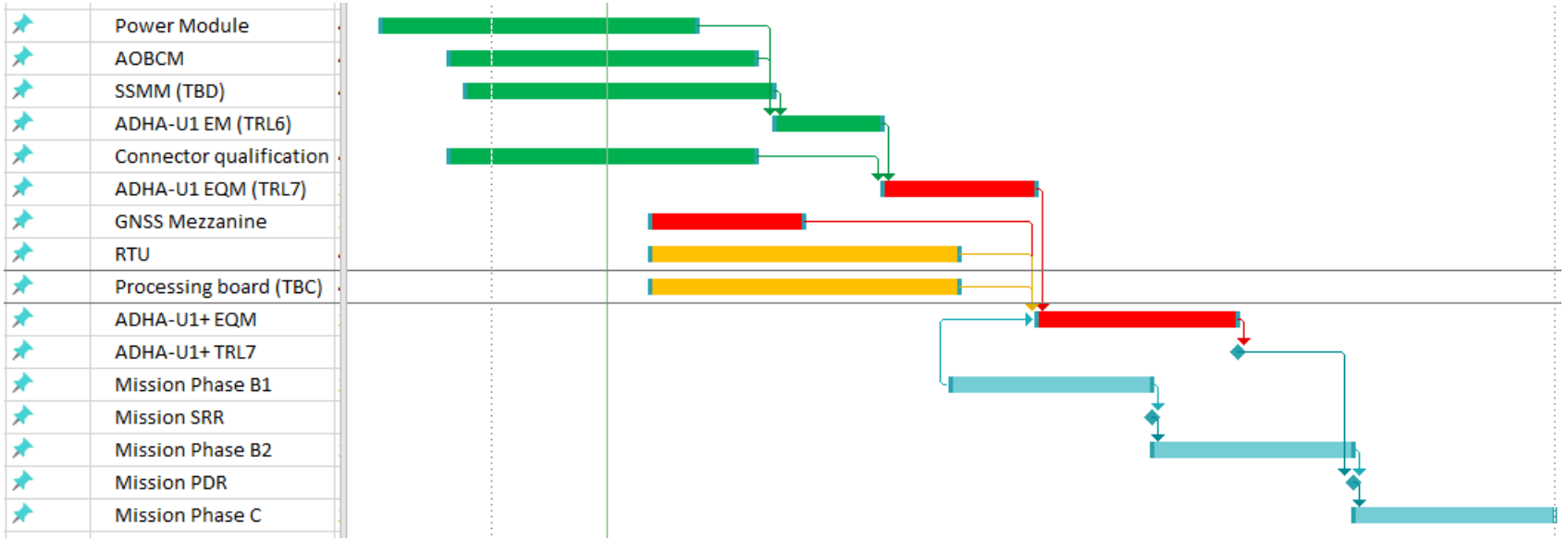
Product Variability

- Functional Architecture at Platform Level, including also Variability and Scalability elements



ADHA TECHNOLOGY DEVELOPMENTS FOR CANDIDATE MISSIONS

/// Developments preparatory for ADHA adoption by Mission, sequence of activities:



- To be identified the possible candidate missions.

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ADHA OBC MODULE (AOBCM) REQUIREMENTS

- **System level requirements**: ADHA is conceived to support a wide range of missions, environments and unit types, however the first targeted use case is related to LEO Earth observation missions. Hence the applicable System Requirements come from the Copernicus HPCM Missions:
  - HPCM Missions System Requirements Documents (SRD);
  - HPCM Operations Interface Requirements Document (OIRD);

- **AOBCM Requirements Specification:** Starting points have been:
  - SAVOIR OBC Specification;
  - OBC Requirements Specifications prepared by the two consortia in ADHA-1 contract, in line with:
    - ➔ applicable system level requirements
    - ➔ companies' heritage

The AOBCM specification is the outcome of extensive coengineering activity of all the Agency and Industry partners (ESA, TAS, ADS, BG);

The final specification has been agreed by all partners after extensive review activity.

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ADHA OBC MODULE (AOBCM) FACT SHEET

- AOBCM functionality and architecture in line with Savoir requirements;
- AOBCM design is evolutive with respect to well established TAS product IPAC/SMU-NG used in various HPCM missions (ROSE-L, CIMR, CHIME), on G2SB1, etc…
- OBC processing capability of at least 1000 DMIPS / 30 MFLOPS;
- Compatible with X-band TT&C performance (TC at least 2 Mbps, TM at least 30 Mbps);
  - Switch from S to X-band for TT&C supports reduction of Ground station
- Security based on CCSDS SDLS Protocol and Extended Procedures (TC authentication);
- File Based Operation based on Class-1 and Class-2 CFDP;
- Optional GNSS receiver;

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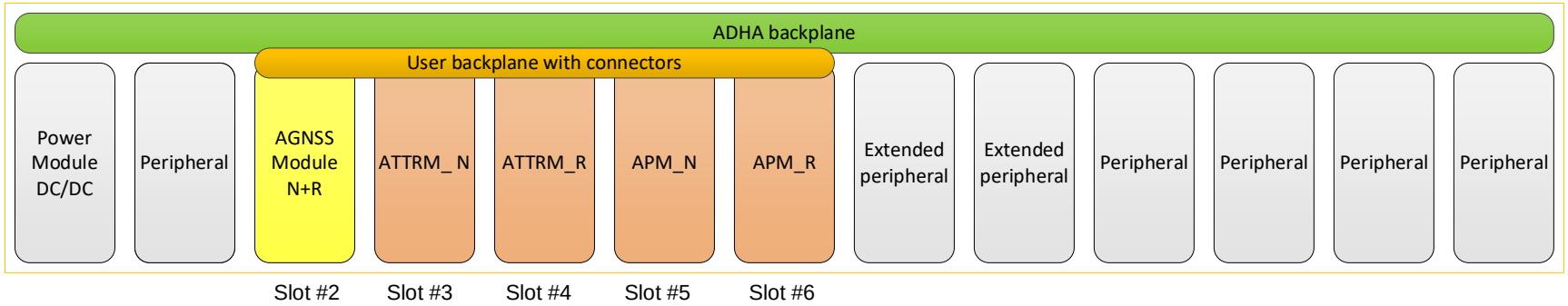
ADHA OBC MODULE DESIGN (1/2)

TASI is in charge to develop the AOBC module for the first engineering model called ADHA U1 unit.

The ADHA OBC functions are implemented on three 6U (220mm x 233 mm) boards:

- ADHA Processor Module (**APM**) boards (N+R) hosted in slots number 5 and 6
- ADHA TC, TM, Reconfiguration and Platform Mass Memory (**ATTRM**) boards (N+R), hosted in slots number 3 and 4
- ADHA GNSS receiver (**AGNSS**) board (N+R in one board), hosted in slots number 2 (optional board)



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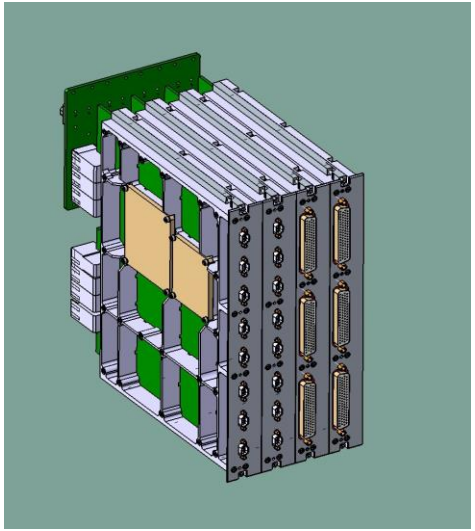
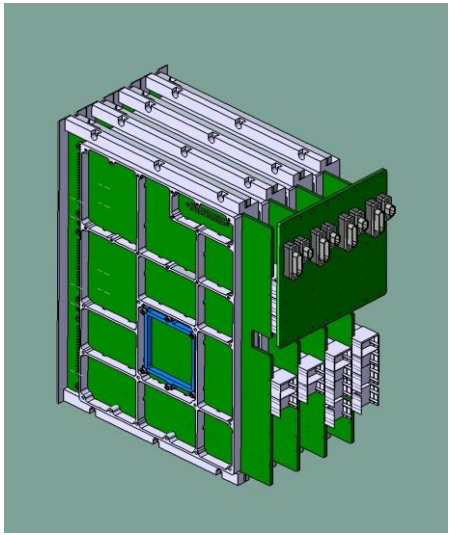
ADHA OBC MODULE DESIGN – USER BACKPLANE

- The AOBCM boards needs to be interconnected by an high number of custom links (matched pair management between RMs, CLCW I/F, PPS from GNSS, interrupts, X-straps, …)
- These links have been implemented through a properly designed **User Defined Backplane**, which host **external connectors** too.
- cPCI connectors are used between the OBC boards an the user backplane (same used in the standard backplane).





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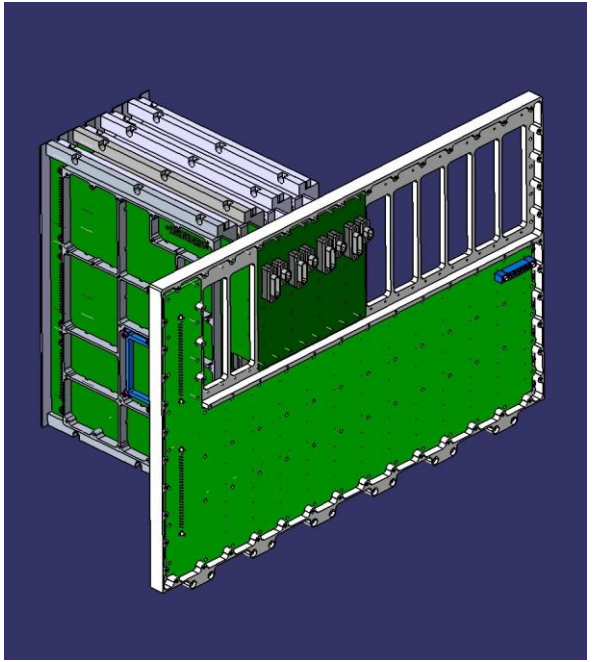
ADHA OBC MODULE - STANDARD BACKPLANE INTERFACE

The OBCM is able to interface the **ADHA standard backplane** and to act as **system controller** to configure, control and manage the entire unit. For these purposes it implements:

- The **SpaceWire router** for the ADHA backplane, acting as the centre of the SpaceWire star networks in the ADHA unit.
- The control functions on the backplane, i.e. **PSON, RST, Health Management System (HMS),** distribution of timing and **synchronisation signals (SYNC),** and bus master on the **CAN busses**.



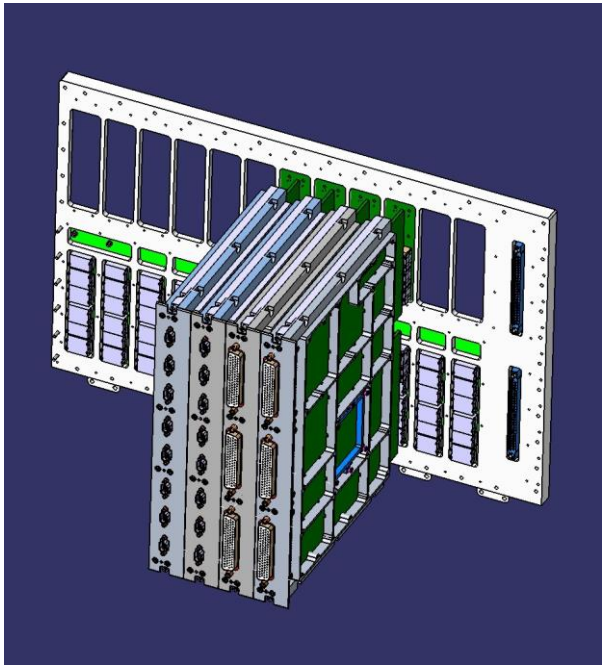
Date: 26/01/2023
Ref: Sp@ceAKademyCTO - New Space Coming Soon "Edge Computing for New Space: OnBoard HPC"
Template: 83230347-DOC-TAS-EN-008

ADHA OBC MODULE - EXTERNAL INTERFACES

Each OBCM redundancy provides :

On the board front panel

- **8 SpW links**
- 1 connector (78 pin) providing **TC input, TM output, PPS input I/F**
- 1 connector (78 pin) providing **external HPTM input, SYNC/ PSS output I/F**
- 1 connector (78 pin) providing **HPC output I/F, ALARM input I/F**



On the rear user backplane

- **CAN BUS I/F**
- **MIL-STD-1553B**
- 1 Test connector to the APM for **maintenance/test purpose**
- 1 Test connector to the ATTRM providing **Configuration Upload Manager I/F and Key Injection Manager I/F**)

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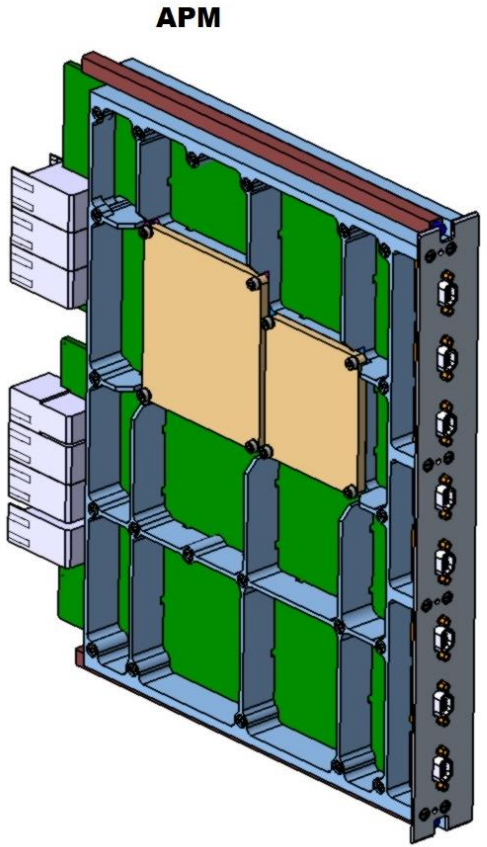
ADHA PROCESSOR MODULE BOARD (1/2)

The **APM** is based on the **GR740** quad-core processor System-on-Chip and the "*Companion*" reprogrammable RTG-4 FPGA, memories, transceivers/drivers/buffers related to various external interfaces and local power distribution devices.

The FPGA ***Companion*** is intended to:

- support the GR740 in the control of board internal devices
- provide additional interfaces (CAN bus)
- implements the functionality of **GNSS RF front-end**.

Furthermore it implements **ADHA HMS** to acquire ADHA unit boards status.



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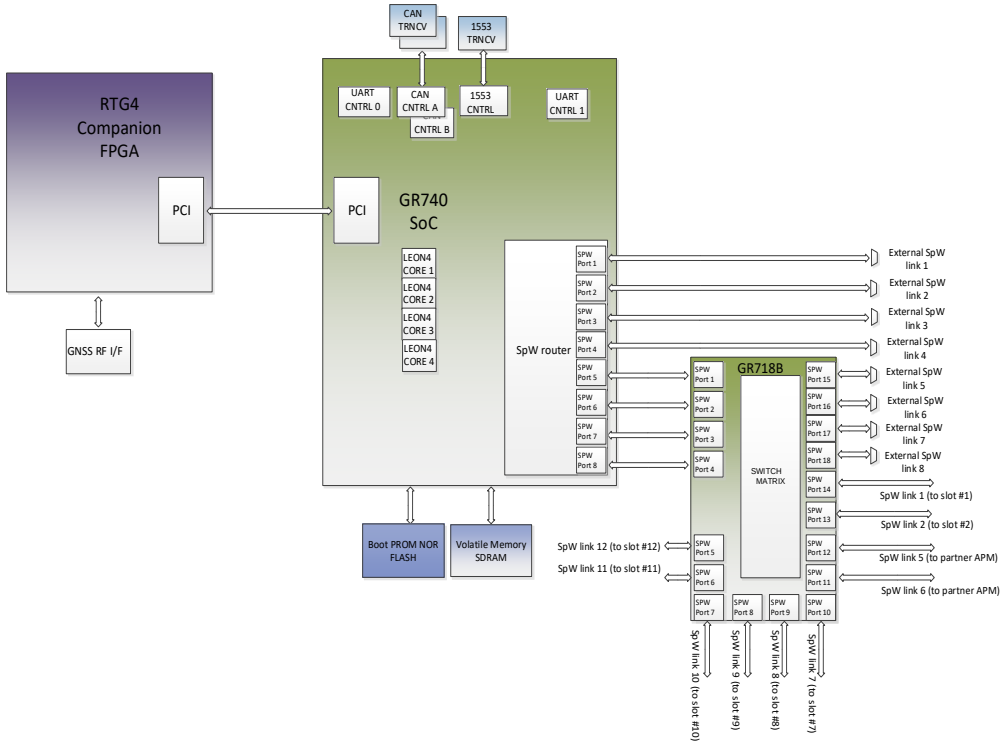
ADHA PROCESSOR MODULE BOARD (2/2)



High number of SpaceWire links are needed in the ADHA system.

The links provided by the embedded **GR740** SoC router are not enough (8 ports).

One additional external FrontGrade Gaisler 18-ports **GR718** SpW router is added to expand the number of SpW links:

- 8 external SpW links
- 10 internal spW links

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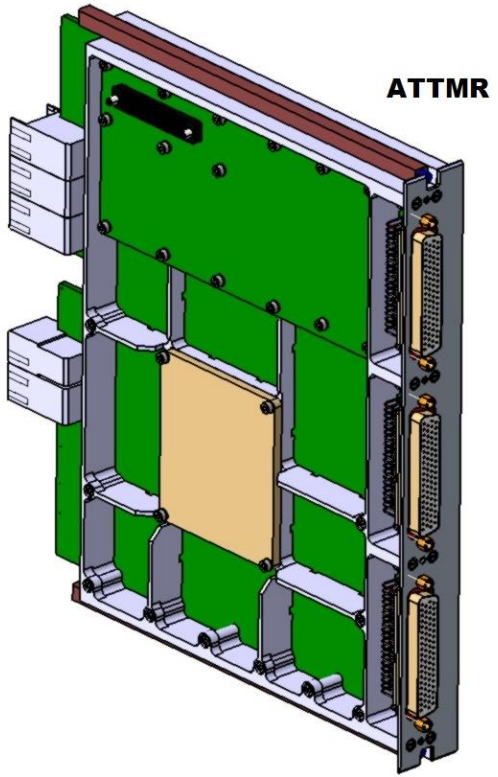
ADHA TTRM BOARD

The **ATTRM** board hosts the ”**Streamer**” FPGA, based on reprogrammable space qualified RTG-4 which includes several functions:

- **TC function**: to receive, decode and handle ground TC.
- **Essential TC function**: the essential telecommands are either OBC internal handled or **dedicated to switch/reset the power status of a module within the ADHA unit** (**PSON/RST** signals) or to release a high-power-command to another external unit.
- **TM / HPTM function**: to send TM and essential TM to ground.
- **Reconfiguration Module (RM) function:** for HW Failure Detection Isolation and Recovery (FDIR).
- **On-Board Time (OBT)** function, for the generation of the reference S/C OBT
- Platform Mass Memory (**PFMM**) function, to provide platform data storage and retrieve.



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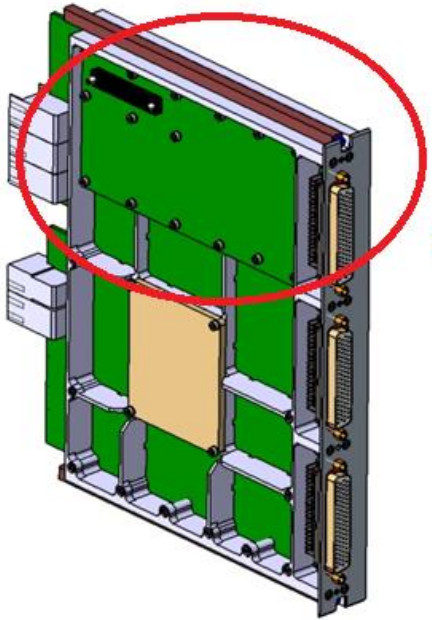
ADHA TTRM BOARD – SECURITY FUNCTIONS

- Security functions are implemented by a dedicated FPGA (RTG-4) called “ADAM” located in a **Security Extension Mezzanine**, plugged on the ATTRM mainboard.
- The implementation for ADHA OBC EM is the ADAM-C as recurrent from Copernicus ROSE-L/CHIME/CIMR which provides TC authentication and TC authenticated decryption (only for OTAR)
- Future full security implementation is possible (CCSDS Authentication, TM Encryption and TC Decryption functions)



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Template: 83230347-DOC-TAS-EN-008

OBC BOARDS DEVELOPMENT STATUS SUMMARY

APM, **ATTRM**, **ASEC** boards status

- schematic design completed
- mechanical design completed
- placement of components completed
- PCB design on-going

The design at now confirms the feasibility to produce an OBC fully compliant with Copernicus HPCM system needs and all the ADHA requirements (6U form factor and specific ADHA functionality).

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