Advanced Data Handling Architecture (ADHA)

System architecture and design description

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Contents

Introduction

- The present paper is intended to provide a report of the “ADHA Consolidation, Standardization, and Product Suite Development” (ADHA-2) technical status.
- The purpose of the ADHA standardization is to improve the cost and schedule figures of the DHS procurement, while at the same time improving its technical performances and budgets.
- Hence the ADHA activities are targeted at creating a standardized architecture, as well as an ecosystem of compatible modules that are mutually interchangeable and interoperable between different missions and Large Scale Integrators (LSI).
- The ADHA system is also intended to be highly scalable (from mini to large satellites) just by adapting the multiplicity of integrated modules (e.g. SSMM capacity).
- Besides to the standardization activities, the ADHA-2 project includes the design, production and qualification of the first ADHA-U1 EM unit up to TRL-6.
- ADHA-2 project is currently under execution; the reported results correspond to the status at the Preliminary Design Review (completed in September 2023).

ADHA Documentation Tree

- Level 0 - ADHA System and Top documents
- Level 1: ADHA Unit level Documents
  - Level 1a: Generic Specifications to ADHA-Ux units
  - Level 1b: Specific Specifications for the ADHA-U1 Unit
  - Level 1c: Generic Design Justification files for ADHA-Ux Units
  - Level 1d: Specific Design Justification files for the 6U-ADHA-U1 Unit
  - Level 1e: Specific AIT files for the 6U-ADHA-U1 Unit
- Level 2: ADHA Unit Elements level Documents
  - Level 2a: Specifications Applicable to Elements to build ADHA Ux and ADHA-U1 Units elements.
  - Level 2b: Design Justification files for 6U-ADHA-Ux Unit Elements
  - Level 2c: Design Justification files for 3U-ADHA-Ux Unit Elements
- Level 3: ADHA EGSE Documents
  - Level 3a: Specific AIT files for the ADHA Units EGSEs
  - Level 3b: Specific AIT files for the ADHA modules EGSEs

System Architecture (1/3)

ADHA is conceived to support a wide range of missions (earth observation, telecommunication, scientific, ...), environments (LEO, MEO, GEO, interplanetary, ...) and unit types.

However the first targeted use case is related to Earth observation, hence the applicable System Requirements which come from the Copernicus HPCM Missions:

- The Space Segment Requirements document;
- The Tailoring of the ECSS Engineering standards;
- The OIRD, which is a tailoring of the ESA Generic OIRD (GOIRD);
- The PA and Safety Requirements;
- The Security IRD.

System Architecture (2/3)

ADHA-U1 EM unit requirements in line with Copernicus Extension Missions expected performance:

- Data Hadling Subsystem (DHS) functionality in line with Savoir requirements;
- OBC processing capability of at least 1000 DMIPS / 30 MFLOPS;
- TT&C compatible with X-band performance (TC at least 2 Mbps, TM at least 30 Mbps);
- Security based on CCSDS SDLS Protocol and Extended Procedures;
- SSMM with 32 Tbit for science data storage in basic version but scalable thanks to modularity;
- SSMM science data downlink up to 20 Gbps (using optical transceiver);
- File Based Operation (based on CFDP) for both the TT&C and the Science Data downlink.

System Architecture (3/3)

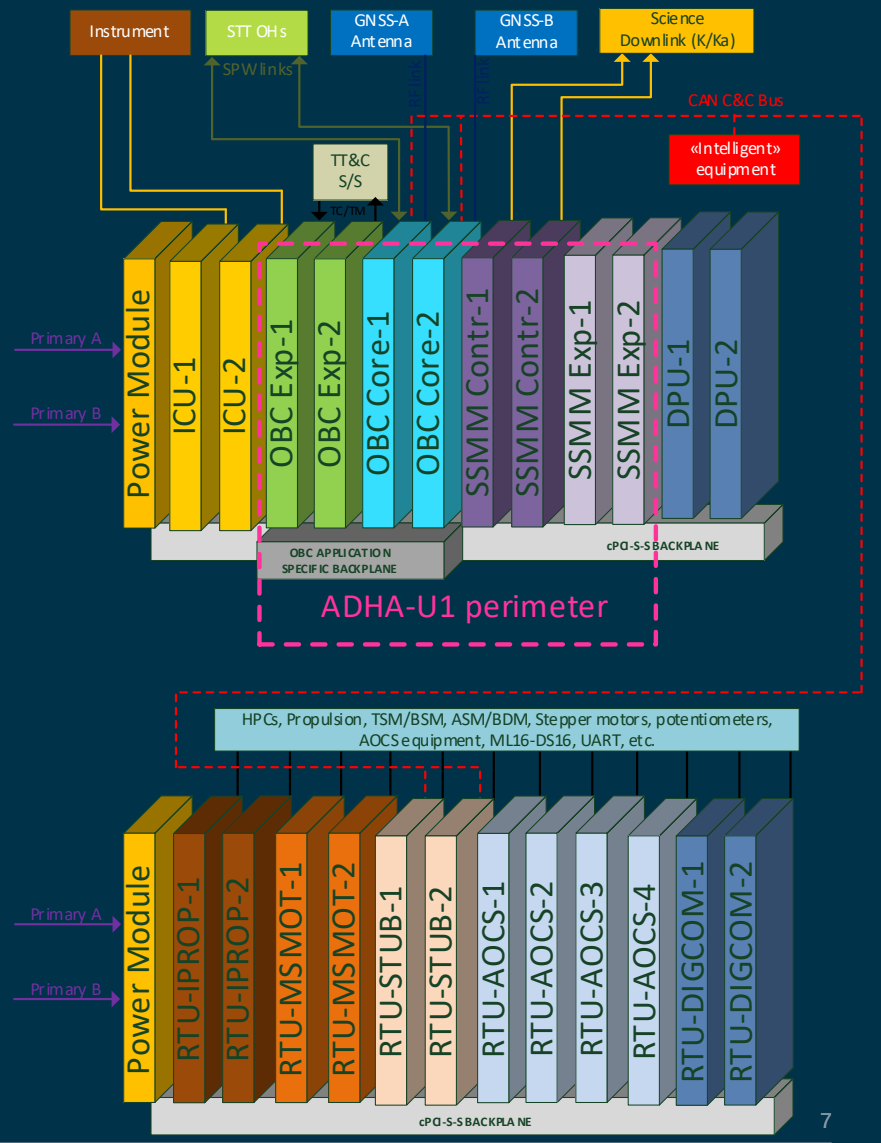
Possible ADHA DHS for future Copernicus Extension missions:

- Vital ADHA box which implements:
  - On Board Computer (OBC) **<– Vital Module**,
  - Solid State Mass Memory (SSMM),
  - Instrument Control Unit (ICU) and
  - optionally the Data Processing Unit (DPU).

  The scalability of the storage capacity is achieved just by integration of additional SSMM modules.
- One Non-vital ADHA box which implements:

  the I/O Remote Terminal Unit. It is composed by:
  - A couple of C&C modules (STUB) located in the system slots;
  - A range of different interface boards.

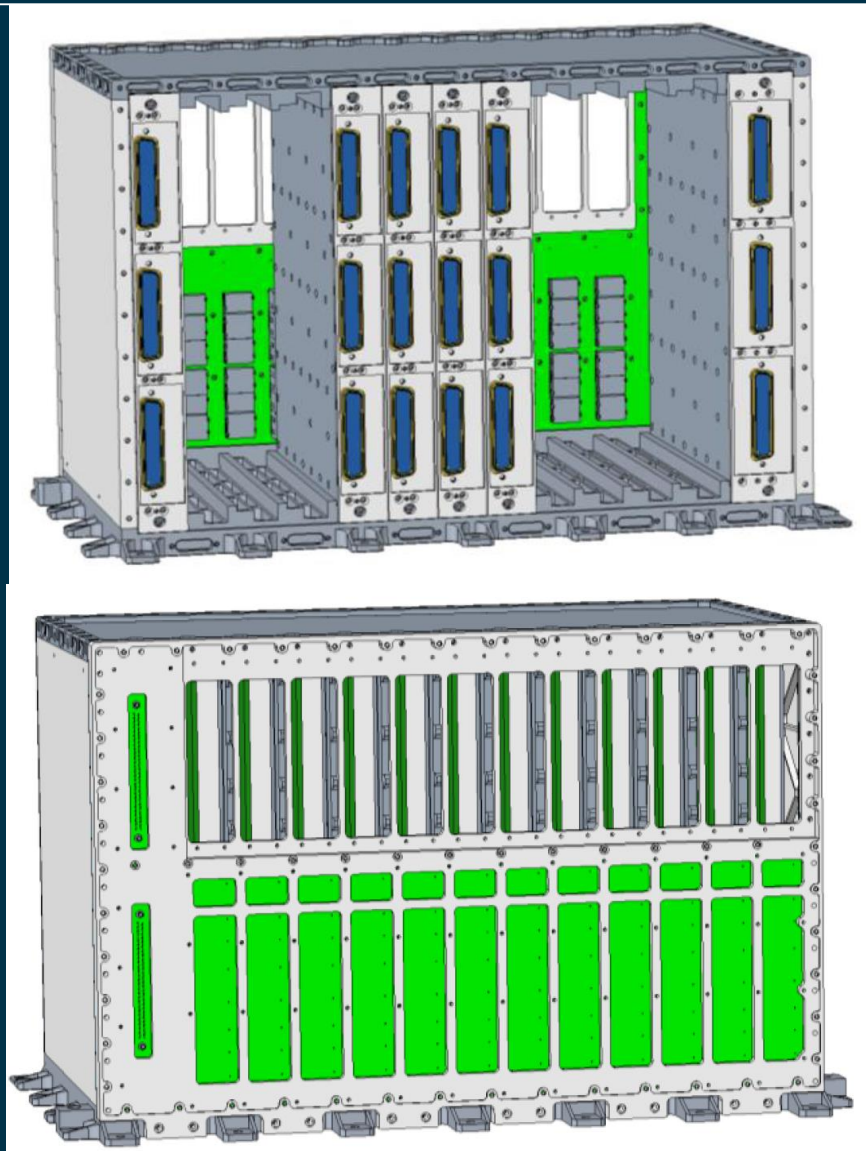
  Each kind of interface board is scalable to accomodate different I/O budgets.



Unit Architecture (1/2)

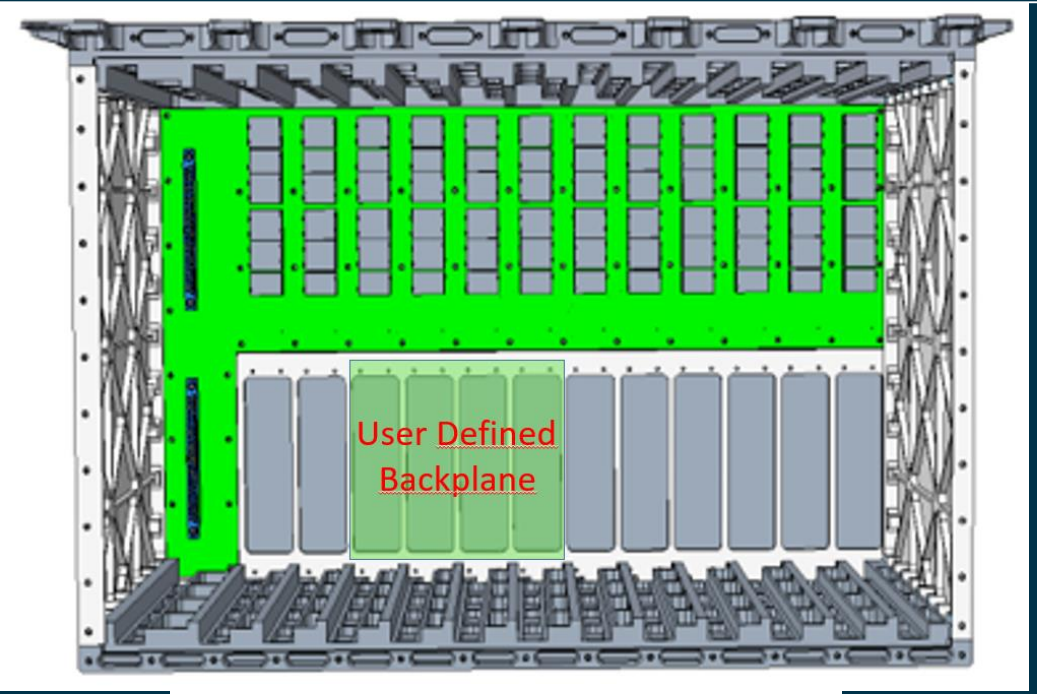
The ADHA architecture is based on the ”Compact PCI Serial Space” (cPCI-S-S) standard, tailored to comply with System Requirements. The most relevant features of the ADHA unit architecture are the following:

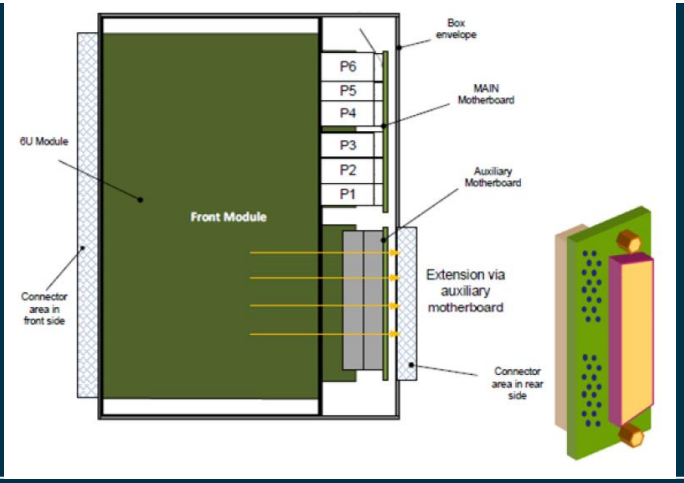
- Racked mechanics, to ease the unit (de)assembly;
- Boards format 6U extended (length 220 mm) or 3U;
- Boards pitch extended from 5HP to 6HP (for mounting the DSUB-78 pin connectors);
- Fully redundant and cross-strapped system architecture (twin system slots and redundant links on the backplane);
- Standardized power module on dedicated slot;
- Wide range of links on the backplane.



Unit Architecture (2/2)

- 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 unit 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.





Slot Profiles (1/2)

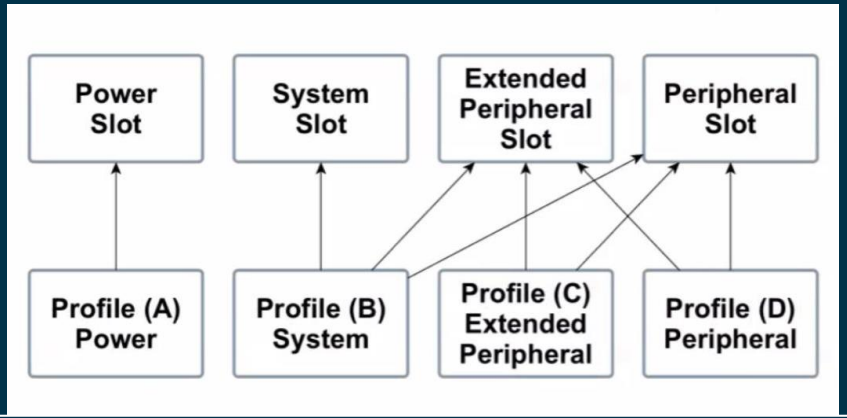
ADHA slots profiles:

- Slot 0: Power module slot:
  - Supplies the internal secondary voltages;
- Slot 1-4: Peripheral slot (with 2 FCG):
  - implement application functionality except the C&C of the ADHA unit;
  - May host boards with internal redundancy thanks to duplicated on/off and reset signals;
- Slot 5-6: System slot:
  - implement application functionality including the C&C of the ADHA unit;
  - May act as hub in Spacewire and/or Spacefibre star network;
- Slot 7-8: Extended Peripheral slot:
  - implement application functionality except the C&C of the ADHA unit;
  - May act as hub in Spacewire and/or Spacefibre star network;
- Slot 9-12: Peripheral slot:
  - implement application functionality except the C&C of the ADHA unit;

Slot Profiles (2/2)

ADHA module profiles:

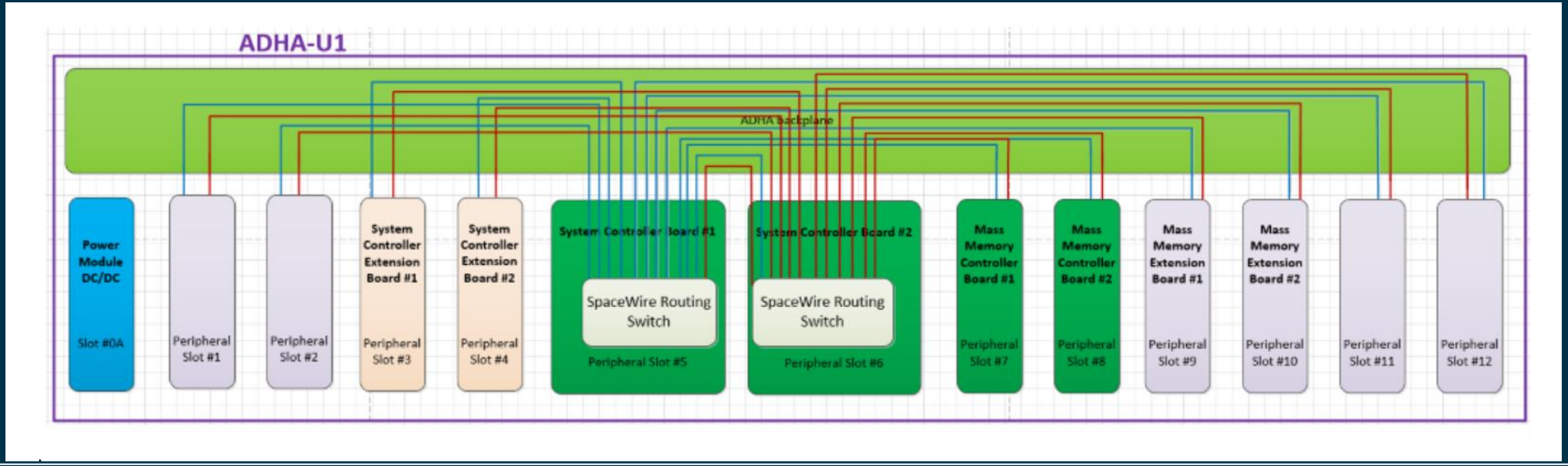
- Module Profile A (power type):
  - compatible with the power module slots.
- Module Profile B (system controller type with possibly SpW/SpFi Hubs):
  - compatible with system slots, extended peripheral slots and peripheral slots.
- Module Profile C (SpW/SpFi Hubs):
  - compatible with peripheral slots and extended peripheral slots.
- Module Profile D (peripheral with 1 or 2 FCGs):
  - compatible with peripheral slots and extended peripheral slots.



Backplane Description (1/2)

Power and Command & Control links:

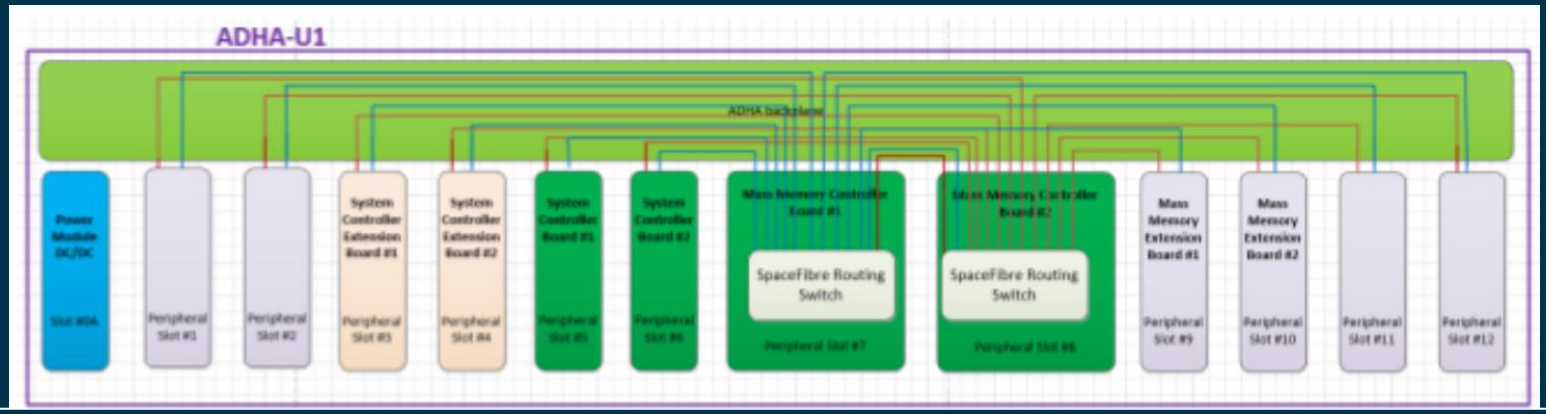
- Power module on dedicated Slot 0 providing internal redundant secondary voltages: +28V, +12V and +5V;
- Modules' on/off/reset managed by dedicated links (PS_ON, Reset) connecting any of the two modules in System Slots (5-6) with any other module;
- Sync-Signals on dedicated lines for precise modules' time synchronization:
- Internal C&C of the unit is based on redundant CAN Bus and point-to-point SpW links connecting any of the two modules in System Slots (5-6) with any other module (double star topology);

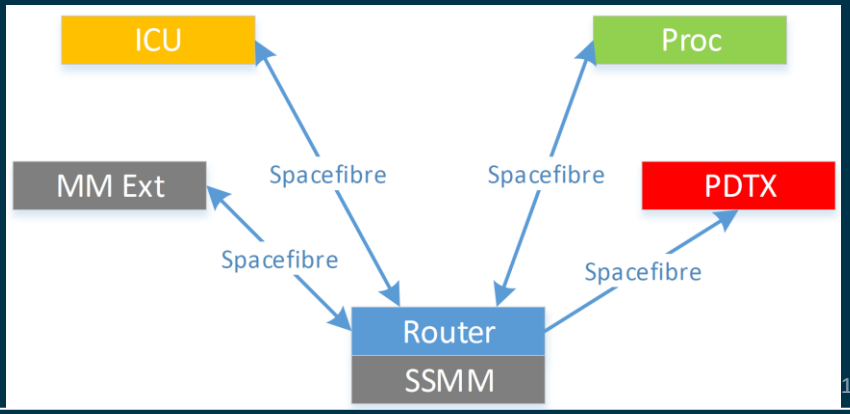


Backplane Description (2/2)

High Speed Data Processing Chain:

- Based on SpFi double star centered on Slots 7-8 (or alternatively 5-6);
- Net data rate for the SpFi links is 10 Gbps (over twin lanes, in advance to 8B/10B encoding);
- Central hub continuous throughput 40 Gbps data rate;
- Data rate to PDTX may reach 20 Gbps if directly connected to the central hub through optical transceiver
- Support different processing paradygms:
  - Real time pre-processing: ICU -> Proc -> MM Ext -> PDTX
  - Off-line processing: ICU -> MM Ext -> Proc -> MM Ext -> PDTX)
  - Real time post-processing: ICU -> MM Ext -> Proc -> PDTX)





Preliminary Power, Mass and Volume Budgets (1/2)

- Power Budget for the different voltages:
  - The worst case power consumption on 12V is 105W which is below the maximum of 150W with a 30% margin.
  - The 5V line will be mainly use by the HMS. It can deliver 5A hence 25 W. The HMS power needs is only 0,5W, so the available power of 2W per board is enough.
  - The 28V line is used to generate the HP commands, 1A is sufficient to guarantee a driving capability > 700mA. The margin on that line is then 30%.

ADHA Power Module Capacities (N + R)

Overall capability is 200 W

OUTPUT CURRENT Max on 5V line (Aux)	5 A
OUTPUT CURRENT Max on 12V line [A]	12,5 A
OUTPUT CURRENT Max on 28V line [A] (used for HP commands emission)	1 A
VIN Min	21 V
VIN Max	37 V
Efficiency Min	0,95
INPUT CURRENT Max	10,2 A

Power consumption for an ADHA unit in Full Configuration

Slot number	Board type	Power consumption
1	SSMM extension 1	30 W
2	SSMM extension 2	30 W
3	OBC extension N (T2MR)	7,5 W
4	OBC extension R (T2MR)	5,5 W
5	OBC N (MCPM+GPS)	5+3= 8 W
6	OBC R (MCPM+GPS)	0 W
7	SSMM controller N	9 W
8	SSMM controller R	0 W
9	Processor Module N	7 W
10	Processor Module R	0 W
11	RTU I/O N	8 W
12	RTU I/O R	0 W
Total		**105 W**

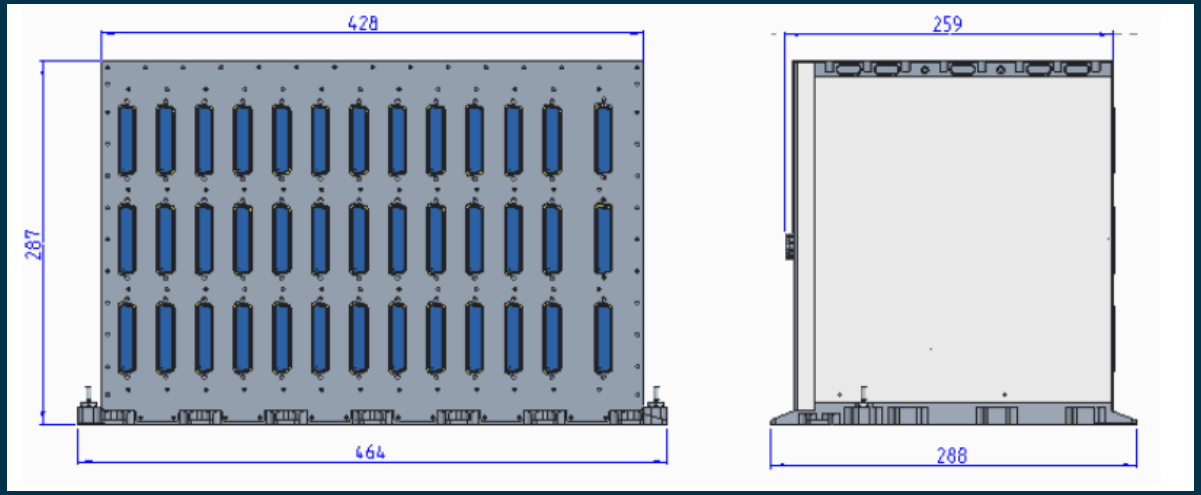
Preliminary Power, Mass and Volume Budgets (2/2)

- Mass Budget:
  - Mass budget depending on the modules' power dissipation, which at this stage is based on data from existing boards.

Rack Unit Assembly (13 Modules)	Mass [grams]
Rack Unit	10000
Modules	19000
Sum Rack Unit Assembly	**29000**

  - The worst case is determined under conservative assumptions and is to be considered very preliminary
  - It is expected to be improved in the next iterations of the design.

- Volume budget:
  - The dimensions of the 6U ADHA unit (length x height x width) are 259 x 287 x 428 mm



Questions?

About ADHA

This document is one of the series of ADHA documents intended to be applied together for the management, engineering and product assurance for developing and using ADHA products in space projects and applications. It can be publicly distributed by ESA and the AHDA industrial teams (ADS, TAS, and Beyond Gravity).

ADHA is a cooperative effort of the European Space Agency and European industry associations for the purpose of developing and maintaining ADHA products. This Document has been prepared by the ADHA Working Group in the frame of the study **“Advanced Data Handling Architecture (ADHA) Consolidation, Standardisation, and Product Suite Development”** (also called ADHA-2 study).

PROPRIETARY INFORMATION