Advanced Data Handling Architecture (ADHA)

EDHPC 2025

ADHA Tutorial – Notes on ADHA modules design

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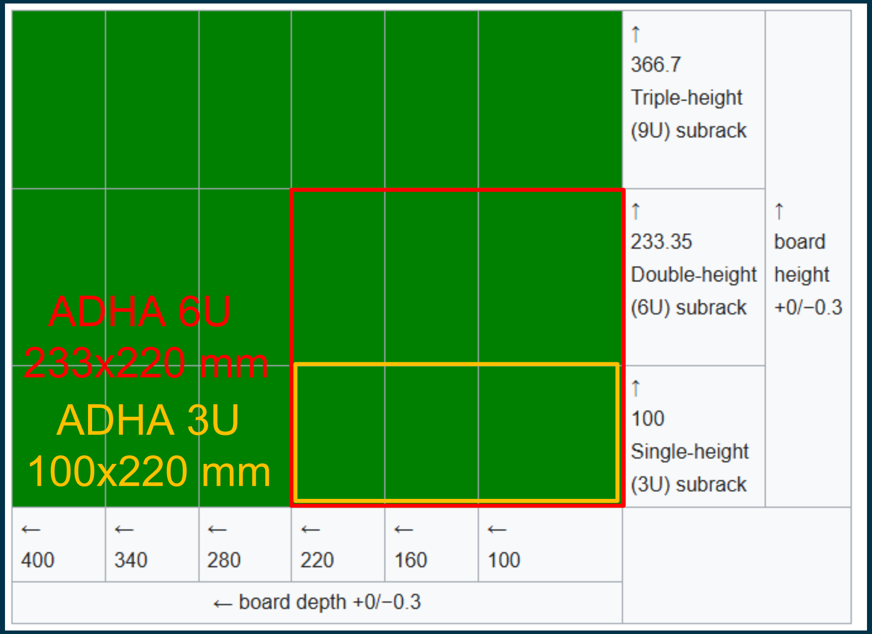
Introduction to ADHA Modules

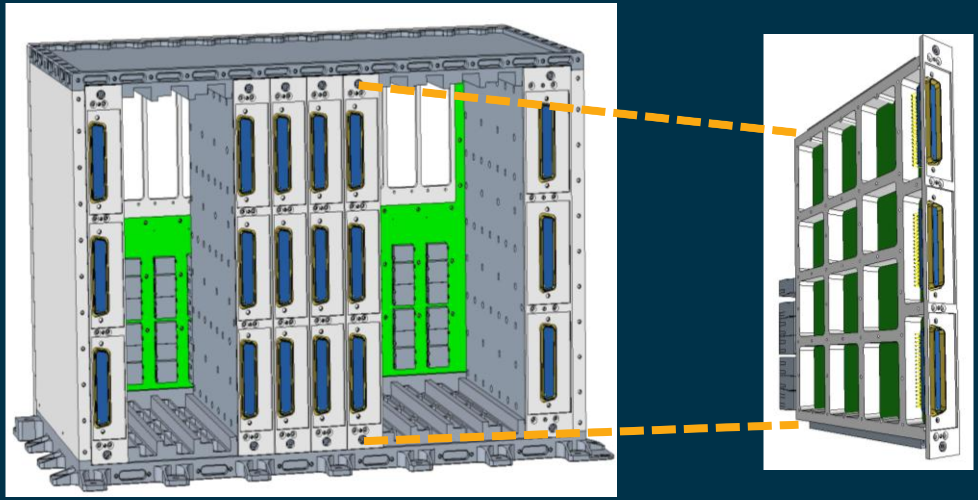
What are the characteristics of an ADHA ***Module*** ?

- It implements a self standing function in the frame of the ADHA unit
- It may be realized over one or more ADHA boards (for redundancy or complexity)
- It has its own Specific RS/SoW (in addition to applicable Standard documents)
- It has its own lifecycle (independent from the units' lifecycle)

Interface aspects: mechanical & thermal (1/2)

- ADHA mechanics is compliant with industry standard cPCI and IEEE 1101
- Supported board formats are Eurocard 6U (233x220 mm) or 3U (100x220 mm)
- Pitch 6 HP (30,48 mm) apart from the Power Module which is 8 HP (40,64 mm)
- 6U boards weight 1.4 Kg, for Power Module 2.25 Kg
- Max. thermal dissipation 30 W (standard mounting with wedgelocks)



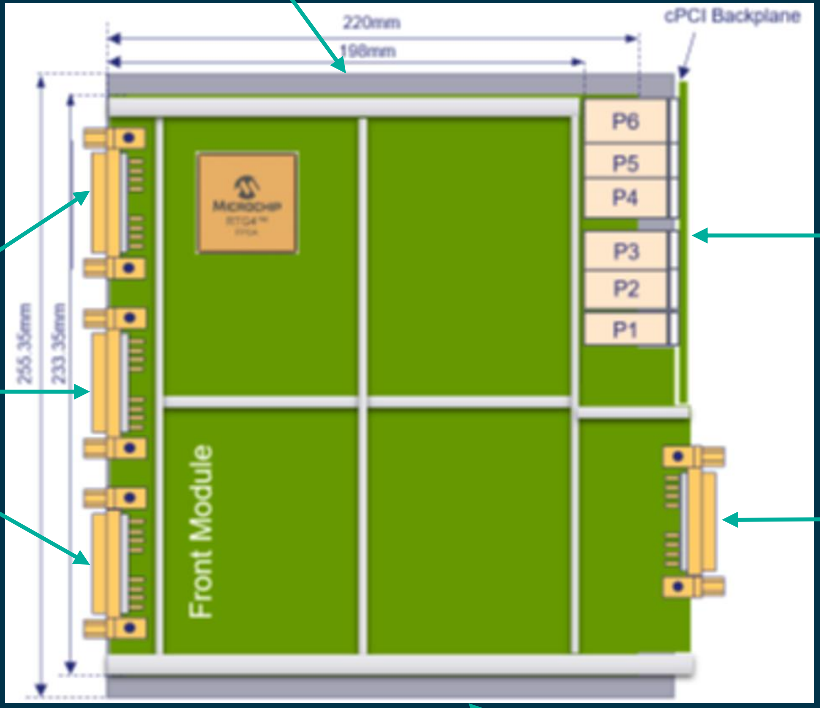


Interface aspects: mechanical & thermal (2/2)

ADHA board mechanical and thermal intefaces

Wedge lock interface

Front panel
external connectors



ADHA backplane
connectors

User defined
backplane connectors
or rear external
connectors

Wedge lock interface

Interface aspects: power supply

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ADHA modules are supplied by the Power Module though the backplane by the following (redundant) lines:

Supply voltages including transients							
Rail	**5V**		**12V**		**28V**		
Vnom	4.93		11.63		27.15		V
Operating Range	4.35	5.50	10.25	13.00	25.00	29.30	V
Failure Case Range	4.20	5.70	10.20	13.40	24.00	30.00	V
Vovp max	6.50		14.70		32.00		V

ADHA board maximum power consumption :

- 0.4 A on the 5 V supply voltage (for unit health monitoring only);
- 1 A on the 12 V supply voltage (main power supply);
- 1 A on the 28 V supply voltage (limitedly to the issuing of HPC pulses)

For 12 boards this corresponds to a power consumption ~200 W

- In line with ADHA Power Module capability

Module Profile vs. Module Kind

It is important to distinguish clearly the difference between boards' ***profile*** vs ***kind*** :

- The ***profile*** refers to the boards' implementation of ADHA-specific features. e.g.:
  - Supervision of unit internal C&C (other modules' On/Off/Reset/Sync, master of the CAN data bus, etc…)
  - Implementation of central switch in SpW and/or SpFi star topology
- The ***kind*** refers to the boards' implementation of Mission-specific features. e.g.:
  - Acting as On Board Computer (OBC), Solid State Mass Memory (SSMM), Instrument Control Unit (ICU), etc…

Module Profiles Short Summary (1/2)

Profile B – System Controller:

- Supervision of unit internal C&C
- SpW and/or SpFi central switch
- Implements mission specific function

Profile C – Extended Peripheral:

- SpW and/or SpFi central switch
- Implements mission specific function

Profile D – Peripheral:

- May host 1 or 2 FCG
- Implements mission specific function

Profile E – Extended System Controller

- May implement part of unit internal C&C on behalf of System Controller board (only if necessary)

	Profile B System Controller	Profile E (*) Ext. System Controller	Profile C (*) Ext. Peripheral	Profile D (*) Peripheral
P6	**Optional:** - star point of SpFi	**Unused:** - general purpose	**Optional:** - star point of SpFi	**Unused:** - general purpose
P5	**Unused:** - general purpose	**Unused:** - general purpose	**Unused:** - general purpose	**Unused:** - general purpose
P4	**Optional:** - SpW connections - SpFi connections	**Optional:** - SpW connections - SpFi connections	**Optional:** - SpW connections - SpFi connections	**Optional:** - SpW connections - SpFi connections
P3	**Optional:** - star point of SpW	**Unused:** - general purpose	**Optional:** - star point of SpW	**Unused:** - general purpose
P2	**Mandatory:** - PS_ON source - RST source - HMS collector **Optional:** - geographical addressing	**Optional:** - geographical addressing	**Optional:** - geographical addressing	**Optional:** - geographical addressing
P1	**Mandatory:** - Power lines - HMS **Optional:** - CAN bus - Sync - I2C bus	**Mandatory:** - Power lines - PS_ON - RST - HMS **Optional:** - CAN bus - Sync - I2C bus	**Mandatory:** - Power lines - PS_ON - RST - HMS **Optional:** - CAN bus - Sync - I2C bus	**Mandatory:** - Power lines - PS_ON - RST - HMS **Optional:** - CAN bus - Sync - I2C bus

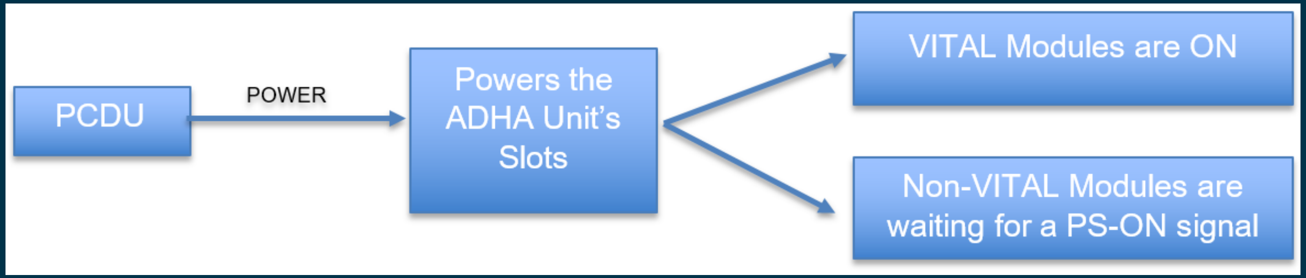
Module Profiles Short Summary (2/2)

- It is important to realize that modules' profile vs kind are orthogonal properties, i.e. often a module of a certain kind may be implemented accordingly to different modules profiles and vice versa.
- Moreover, as already presented in the ADHA Unit Tutorial, nothing prevents that one module may be "under-utilized", e.g. an SSMM Controller capable to operate as System Controller, is utilized instead as Extended Peripheral.

	Integrated OBC + SSMM (ADHA-U1)	SSMM + DPU (PDHU)	ICU + DPU	Integrated OBC + Remote Terminal Unit	Dedicated Remote Terminal Unit
System Controller	OBC	SSMM Controller	ICU	OBC	RTU Controller + Gen IO
Extended Peripheral	SSMM Controller	N/A	DPU	N/A	N/A
Peripherals	SSMM Exp.	SSMM Exp. DPU	Gen I/O boards	Gen I/O boards, AOCS boards, Prop. Boards…	Gen I/O boards, AOCS boards, Prop. Boards…
Extended System Controller	OBC	N/A		OBC	N/A

Modules Switch On: Vital vs. Not Vital

- Spacecraft functions are considered "***Vital***" if "*can cause permanent mission degradation if not executed when it should be, or wrongly executed, or executed in the wrong context*" (ECSS-E-ST-70-11 "Space Segment Operability"). E.g. TC link, attitude control, thermal control…
- ADHA supports the implementation of Vital Function through Vital Modules. These need to be always powered on, hence their connection to the power rails cannot be switched off. E.g. SBT, OBC…
- An ADHA unit which contains a Vital Module (typically the system controller but not only) is called "Vital Unit"
- In ADHA Architecture, once the Spacecraft is in "On" state, it is assumed that a Vital Unit cannot be switched off under any condition, hence it is supplied by the PCDU through an R-LCL (retriggerable).
- On the contrary, Non-Vital Units are power supplied by regularly switched LCL



Modules Switch On: Sequence

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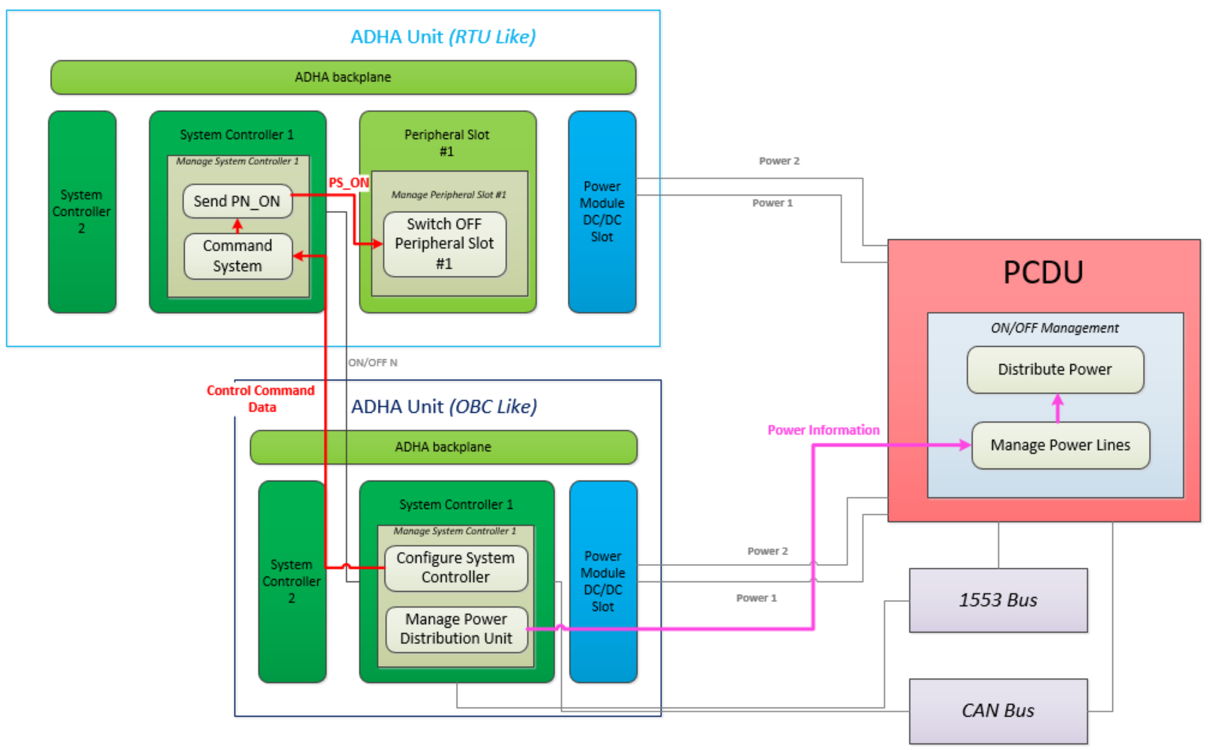
- PCDU powers Vital Units through R-LCL.
- System Controllers on Vital Unit(s) determine autonomously which is the only Master
- The Master System Controller of Vital unit:
    - configures other modules on the same unit
    - powers ON non-Vital ADHA units by PCDU LCL
    - Depending on which power lanes switched for Non-Vital Units → switch ON selected System Ctrl.
- The Master System Controller of Non-Vital ADHA unit
    - configure other modules used in the same unit

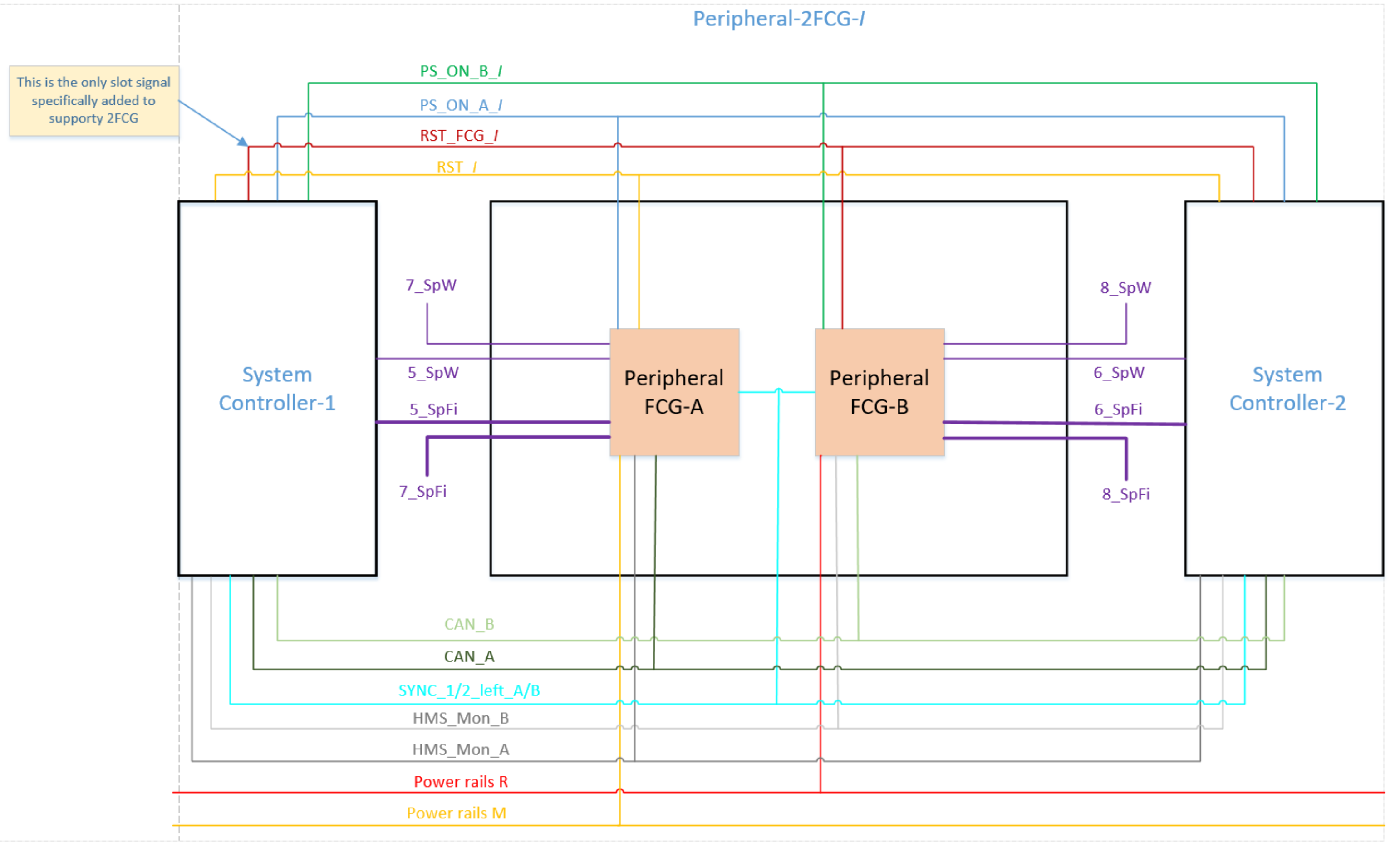


Non-vital System Controllers must not contain any cross strap between the N and R voltage rails. Hence it is possible to select the Master System Controller by powering on the Power Rail #1 or #2.

Non-vital modules for use in any other type of slot may contain cross straps between the N and R backplane voltage rails (not to be populated when the module is used in a system controller slot)

Modules Redundancy Concepts

- Intra-Module redundancy: the backplane has been expanded with additional signals to support 2 Fault Containment Groups to implement nominal and redundant functions within a module;
- Well suited for I/O boards, GNSS…
- 4 slots (1-4) supporting 2 FCGs;
- Support hot redundancy of FCGs;
- Power and CAN bus redundancy accessible by the two FCGs;
- Full configuration commanding of both CFG through PS_ON/RST;
- Full diagnostic observability of both FCGs through HMS;
- SpW/SpFi cross-strapping may be managed through switches.



Modules Redundancy Concepts

- Inter-Module redundancy:
  - N+R module redundancy: the modules are always dual, this means that there is a nominal module and a redundant module (each on a single board) within the unit
  - N+1 module redundancy for the I/O modules: applicable when N out of N+1 degraded configuration is acceptable (i.e. 3 out of 4 RWs or 2 out of 3 thermistors)

- Unit-level redundancy:
  - The ADHA concept allows to build units containing no redundancy
  - This can be used to implement:
    - a redundant system composed of nominal and redundant ADHA units
    - a single stream system (e.g. redundancy at Spacecraft level in large constellations)

Health Monitoring System (1/3)

- The HMS is an original monitoring system of ADHA modules not part of cPCI-SS
- It is designed to minimize the PCB's room and the power consumption (<0,5W)
- Four parameters monitored for each module or each section of a 2FCG. Default:
  - the current of main power line (+12V); this is the main power line
  - main voltage 3.3V of the POL; this voltage is derived from +12V supply
  - two temperatures; one of the POL (hotspot) and the second relative to an hotspot defined by the module manufacturer.

Add1	Add0	Parameter
0	0	The current of the main power line (+12V)
0	1	The module main voltage (e.g. locally derived voltage from the 12V input)
1	0	Temperature #1 (e.g. main dissipating component, FPGA or processor)
1	1	Temperature #2 (e.g. main power converter)

Health Monitoring System (2/3)

- Capability 64 monitors: 4 parameters * (8*1FCG + 4*2FCG)
- Monitored modules -> 4 pins of the P1 connector
- System controllers -> 16 pins of the P2 connector + 4 pins of the P1 connector
- The HMS system is always active in all the modules (both On and Off)
- Supplied with the “OR” of +5V_A and +5V_B.
- Furthermore its faults are isolated and cannot propagate to the ADHA’s modules.
- The HMS system is managed by the System controller Master but the monitors can also be concurrently acquired by the System controller Partner.

Health Monitoring System (3/3)

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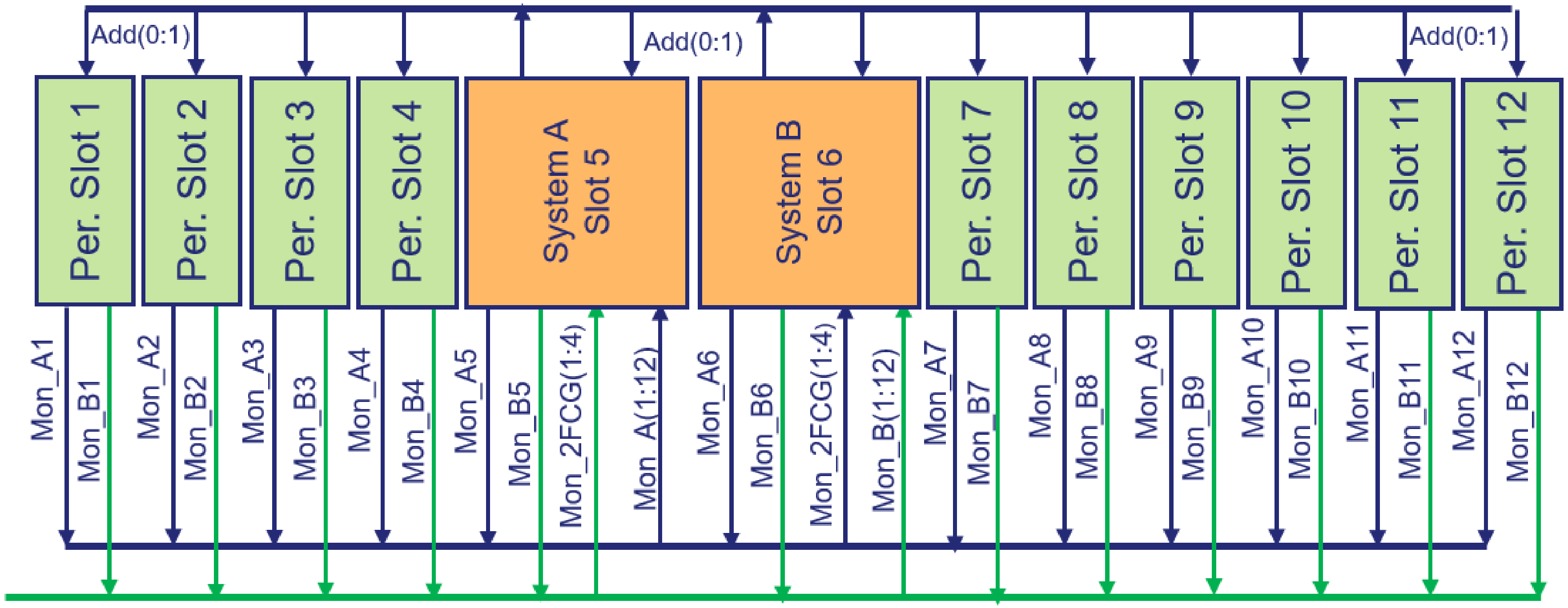
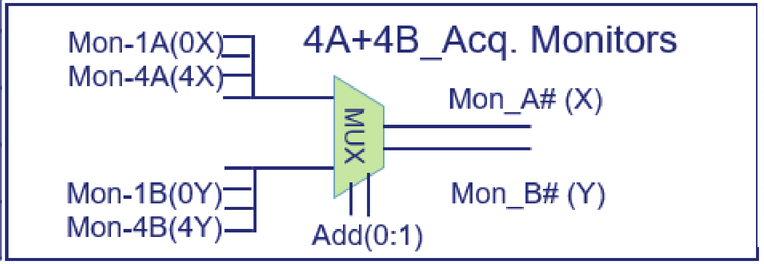
HMS Functional Diagram



Mon1A	12V current
Mon1B	12V current
Mon2A	3.3V POL
Mon2B	3.3V POL
Mon3A	Temp. POL
Mon3B	Temp. POL
Mon4A	Temp. HS
Mon4B	Temp. HS



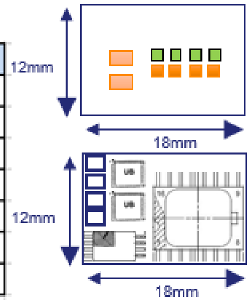
TRUTH TABLE (HC4052)

INPUT STATES			"ON" CHANNELS
INHIBIT	B	A	
L	L	L	0X, 0Y
L	L	H	1X, 1Y
L	H	L	2X, 2Y
L	H	H	3X, 3Y
H	X	X	NONE

X: DON'T CARE

Parts	Qty	Note
Resistor 0603	4	SC protection
Resistor 0402	2	thermistor bias.
Cap. 10nF 0402	4	thermistor cap.
HC4052	1	Mux
2N2222A	2	used as diode
cap.1uF 0805	2	Filtering cap
Zener 3.3V	1	Ref. Thermitors

Rear side

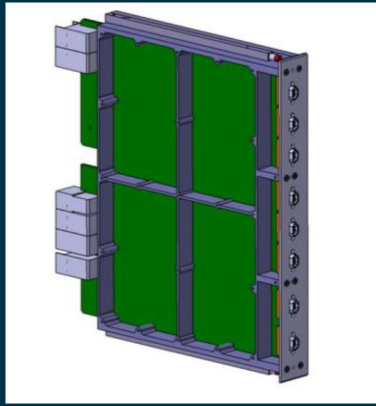


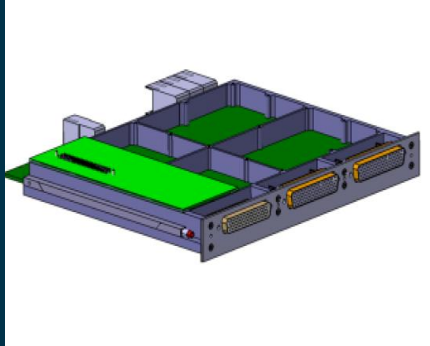
Front side

ADHA On Board Computer Module

- Mission functions allocation:
  - Accordingly to Savoir (6U): processing, TM, TC, Reco, OBT, SGM, P/F MM …
  - Candidate for evolution (esp. for 3U)

- Relevant development:
  - 6U AOBCM for ADHA-U1 (TAS)





- ADHA implementation:

Twin board
Processing board +
TM/TC/MM/RM

System Controller
(switch + HMS)
Sys. Ctrl. Extens (Vital)
(Ctrl signals)

State of the art
Alfa/Beta missions

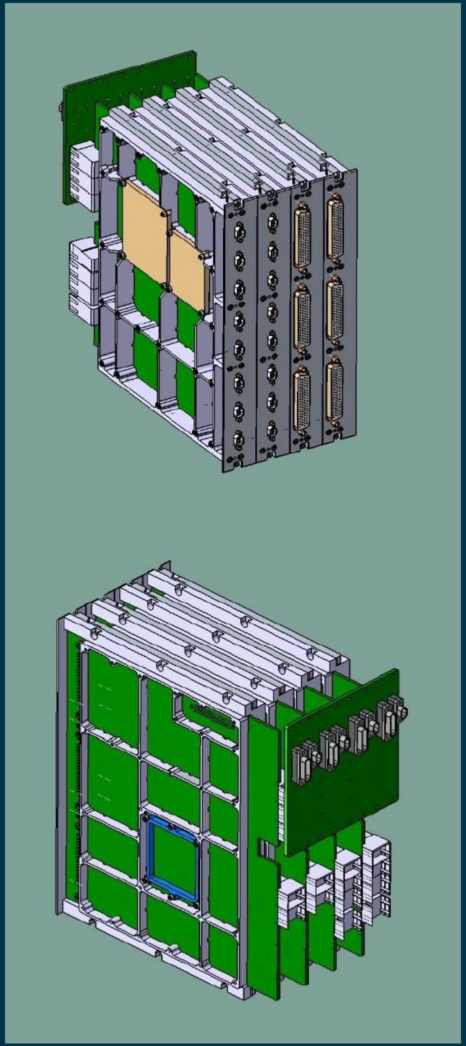
Single board

System Controller (Vital)
(switch + HMS +
Ctrl signals)

For Class.Gamma,
Future developments

6U AOBCM for ADHA-U1 (TAS)

- AOBCM specification agreed by ESA and Industry Consortia and in line with HPCM
- Evolutive design from TAS SMU-NG used on HPCM missions CHIME/CIMR/ROSEL
- Based on quad-core GR740 processor (1700 DMIPS, 30 MFLOPS)
- Compatible with X-band TT&C (2 Mbps TC, 30 Mbps TM)
- Full support to File Based Operations (FBO) including CFDP in Class-1 and Class-2
- Socket for Security mezzanine board (for flexibility to mission security requirements)
- User Defined Backplane to manage :
    - OBC internal connections and X-straps not predefined on ADHA backplane, e.g.:
        - Signals between the two Reconfiguration Modules;
        - Telecommand X-straps with Processing and TM (CLCW);
        - Telemetry X-straps with Processing and internal resources;
        - Etc. etc… > 100 signals
    - Additional external connectors (on rear panel):
        - FPGA programming ports;



ADHA MASS MEMORY

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- Mission functions allocation:
  - Implement input and output interfaces
  - Optionally, implement data processing
  - Store mission data in files
  - Support transfer protocols (e.g. CFDP)

- Relevant development:
  - 6U A3M for ADHA-U1 (DSI)

- ADHA implementation:

Twin board
Master Module +
Extension Modules

Extended Peripheral
(switch, extensions mng, external interf, data proc.)
Peripheral
(Store data, CFDP)

State of the art
Alfa/Beta missions

Single board
(Extension Module)

Peripheral

Less demanding missions, direct interfacing to OBC

6U A3M for ADHA-U1 (DSI)

- A3M specification agreed by ESA and Industry Consortia and in line with HPCM
- Highly scalable system (1-6 6U modules)
- Up to 40 Gbps data rates and 104 Tbit storage
- PUS C&C for both MMM and MEM
- Memory Master Module (MMM):
  - Typically 1 or 2 for redundancy;
  - Controls up to 4 MEM;
  - Backplane SpFi switch (high speed data chain) and SpW switch;
  - High speed (optical) front panel interfaces.
- Memory Extension Module (MEM):
  - Mission data storage on Flash memory as files;
  - Backplane SpFi and SpW interfaces;
  - CFDP protocol management.

Questions?