



EDHPC2025 paper presentation:

Modular and Scalable Electrical Architectures for Satellite On-Board Data Handling and Processing – using **ADHA** (Advanced Data Handling Architecture)

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Data Handling Section | **TEC**
ESA/ESTEC | **EDD**

EDHPC 2025 ADHA Session A1
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Presentation Scope and Overview

ADHA has already provided standardisation of some DHS functions (OBC, MM, etc).

An expansion of DHS functions to be standardised under ADHA is currently planned.

This paper presentation aims to provide possible examples of end-to-end data-handling / avionics architectures for representative mission profiles based on ADHA units, and module functions currently considered for standardisation under the ADHA-3 system study activity.

More details are included in the provided technical paper.

Presentation sections:

1. Standardised ADHA data-handling functions
2. Example unit architecture configurations
3. End-to-end data-handling system / avionics architectures based on ADHA units

1. ADHA standardised DHS functions

ADHA standardises DHS functions as Module Functional Requirements Specifications.

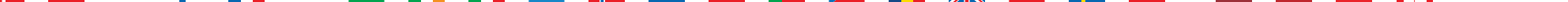
The currently standardised module functions include:

- **Power Module** – provides backplane power buses
 - **OBC Module** – complete SAVOIR-compliant OBC
 - Possible to split over several modules – up to supplier!
 - **Mass-memory** – complete (payload) mass-memory
 - Reference architecture split between MM master module and MM extension (storage) module)
 - **DPM (Data Processing Module)** – for high-end (payload) data processing
 - Can also be provided as for co-processor, off-loading a payload ICU or platform OBC for processing tasks
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Module Type	Module Sub-Type	Slot Profile
Power Module	-	Power Module Slot
OBC Module	OBC Processor Module	System Controller Slot
	OBC Extension Module	System Controller Extension Slot
Mass-Memory Module	Mass-Memory Master Module (MMM)	Extended Peripheral Slot
	Mass-Memory Extension Module (MEM)	Peripheral Module Slot
Data-Processing Module	-	Peripheral Module Slot



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Flexibility in ADHA module design – mezzanines

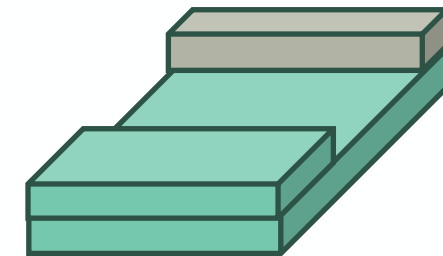
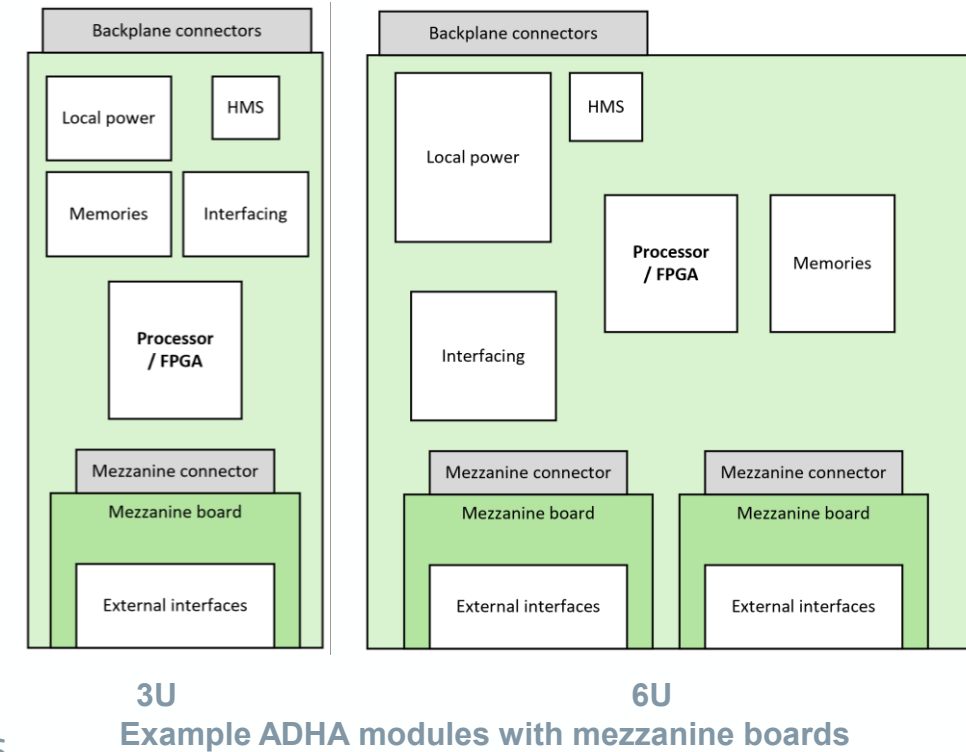
Note that it is possible to support multiple different ADHA DHS functions with a single hardware design!

Due to the standardised backplane interfaces, the same core hardware configuration can be kept – while adapting for specific DHS functions by:

- Changing the SW and FPGA design
- Adopting the front-panel interfaces

To make updating the front-panel interfaces more affordable – ESA plans to develop and qualify very-high performance (10-25Gbit/s/lane) mezzanine connectors, with high-pin count (>100 pins), for board-to-board configurations

- This allows to change the front-panel interfaces, without impacting the TRL of the core module design (including processor/FPGA, power, backplane interfaces)



2. Example ADHA unit configurations

...including the ones that are considered for future standardisation.

- 1) Central Data Handling Unit (CDHU) – for institutional EO mission
- 2) Fully integrated platform DHS – for integrated platforms
- 3) Payload Data Handling Unit (PDHU)
- 4) Instrument Controller Unit (ICU)
- 5) Data Processing Unit (DHU)
- 6) Integrated instrument electronics



ADHA unit configuration example 1)

12-slot 6U-ADHA Central Data Handling Unit (CDHU)



The following CDHU (Central Data Handling Unit) integrates both platform and payload data handling in a single unit:

- Full platform OBC
- GNSS Receiver
- I/O Modules for AOCS
- Full payload Mass-Memory

Slot #	Module type	Redundancy
0	Power Module	Internally redundant
1-2	GNSS Receiver Module (GNSSRxM)	N+R
3-6	On-Board Computer (OBC)	N+R
7-8	Mass-Memory Master Module (MMM)	N+R
9-10	Mass-Memory Extension Module (MEM)	N+R
11-12	RTU AOCS I/O Module	N+R

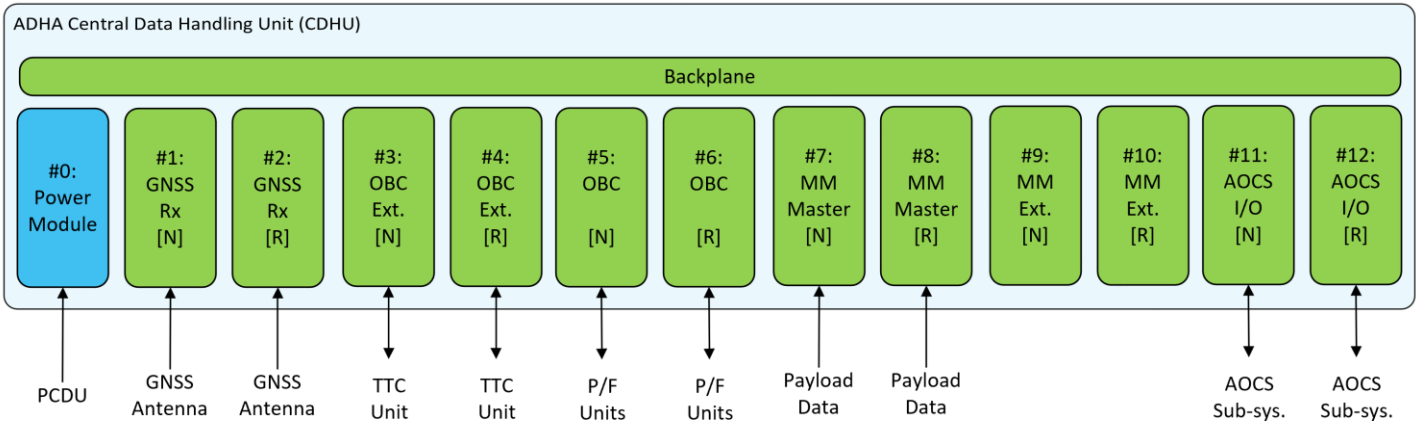
Note: excepts additional external (u)RTU for propulsion sub-system, and thermistor acquisition – if necessary.

Options:

- AOCS I/O can be replaced with e.g. additional MM
- ...or removed for a smaller 10-slot unit.

Possible optimisation:

- N+R GNSSRxM in a single slot (#1) with 2x FCGs
- ...would allow a possibility to add a transponder (also 2xFCGs) in the open slot (#2)

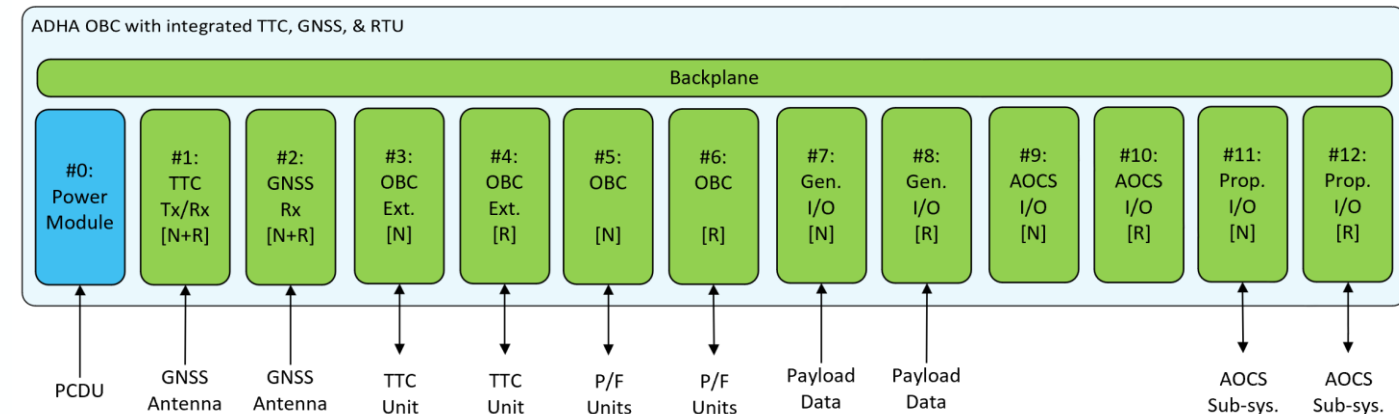


Note: expects payload data to be handled by external unit (e.g. PDHU)

- OBC
- TT&C Transponder
- GNSS Receiver
- RTU functionality – generic I/O, AOCS I/O and propulsion sub-system I/O

Utilises 2xFCGs in slots #1-#2 for TT&C transponder and GNSS Receiver.

Slot #	Module type	Redundancy
0	Power Module	Internally redundant
1	TT&C Module	N+R (2FCGs)
2	GNSS Receiver Module	N+R (2FCGs)
3-6	On-Board Computer (OBC)	N+R
7-8	RTU Generic I/O Module	N+R
9-10	RTU AOCS I/O Module	N+R
11-12	RTU Propulsion I/O Module	N+R



Stand-alone Payload Data Handling Unit (PDHU)

This example PDHU (Payload Data Handling Unit) targets the complete management of payload data

Integrates:

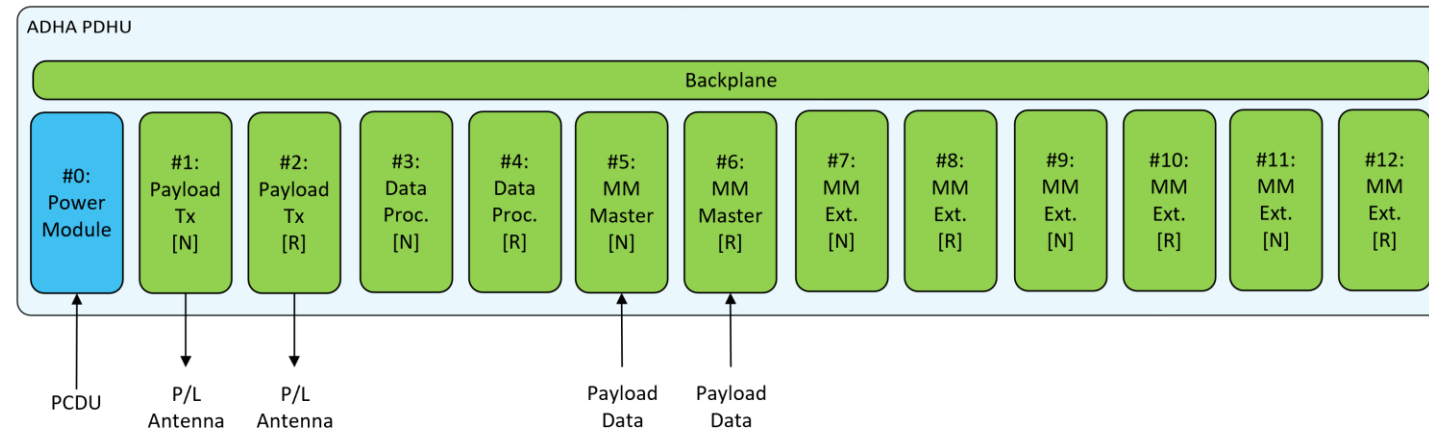
- MM master controller and memory slices
- Data processing module
- Payload transmitter radio

The number of MEM slices and/or DPMs can be adapted for the specific mission need.

Redundancy concept can also be adapted for the reliability: both N and R master-modules, have access to all (six) MEM slices – in principle all can be activated at the same time.

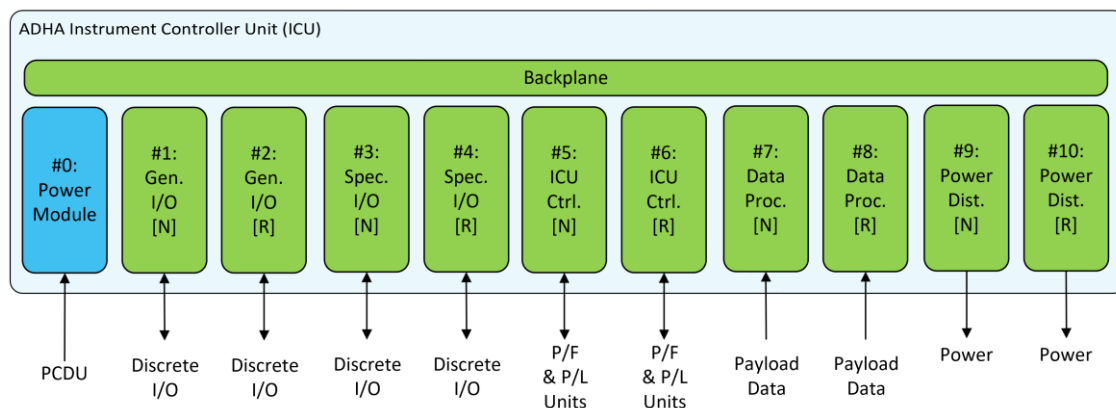
Possible optimisation: data processing can be provided by the MM master module.

Slot #	Module type	Redundancy
0	Power Module	Internally redundant
1-2	Payload Transmitter Module	N+R
3-4	Data Processing Module (DPM)	N+R
5-6	Mass-Memory Master Module (MMM)	N+R
7-12	Mass-Memory Extension Module (MEM)	3*(N+R)



- ICU control, generic and specific I/O functions (motor control, heaters, thermistors etc), power distribution for external payload units, and payload data processing.

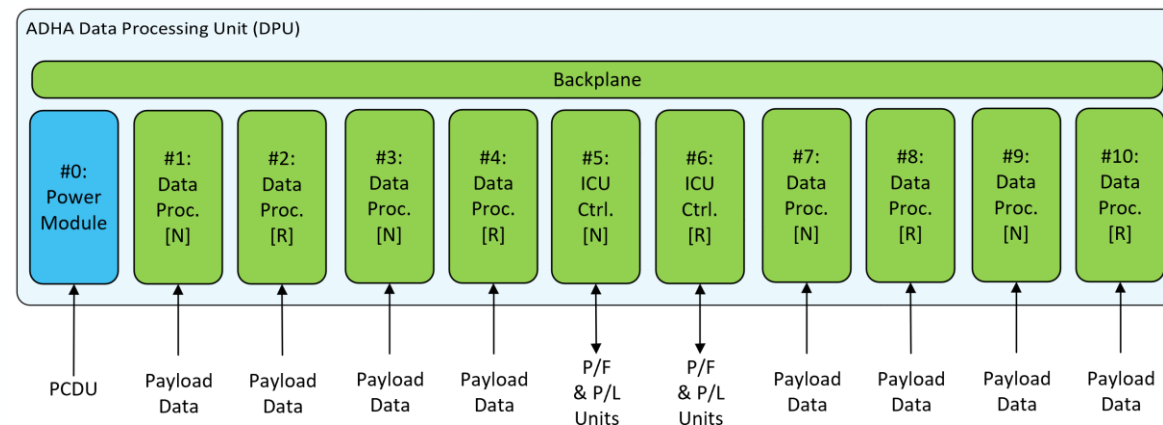
Slot #	Module type	Redundancy
0	Power Module	Internally redundant
1-2	ICU Generic I/O Module	
3-4	Custom payload-specific I/O module	
5-6	ICU Controller Module	
7-8	Data Processing Module (DPM)	
9-10	Payload Power Distribution Module	



- For a very high-throughput payload (e.g. multi-sensor or SAR radar)

Integrates multiple DPMs (data processing modules) – scalable between 1-10 per unit (here shown with 8x).

Slot #	Module type	Redundancy
0	Payload Power Module	Internally redundant
1-4	Data Processing Module (DPM)	$2*(N+R)$
5-6	ICU Controller Module	$N+R$
7-10	Data Processing Module (DPM)	$2*(N+R)$



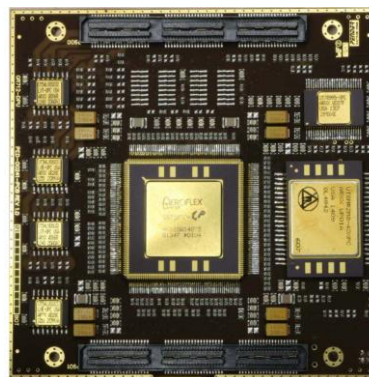
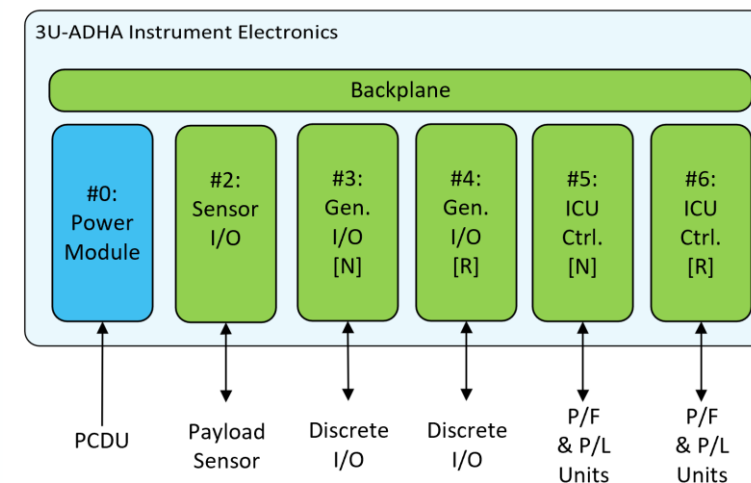
Integrates:

- ICU/DPU module for IASW, control and simpler processing
- Generic I/O for instrument discrete functions (e.g. payload mechanism)
- Specific (non-redundant) sensor I/O

Targets primarily science instruments developed by research institutes for ESA Science missions, as CFIs.

- Note: similar concept for a reference payload DPU reference design was e.g. used on the ESA JUICE mission.

Slot #	Module type	Redundancy
0	Power Module	Internally redundant
2	Mission-specific sensor I/O module	Non-redundant
3-4	ICU Generic I/O Module	N+R
5-6	ICU Controller Module	N+R



JUICE payload DPU reference design
Image source: Frontgrade Gaisler AB

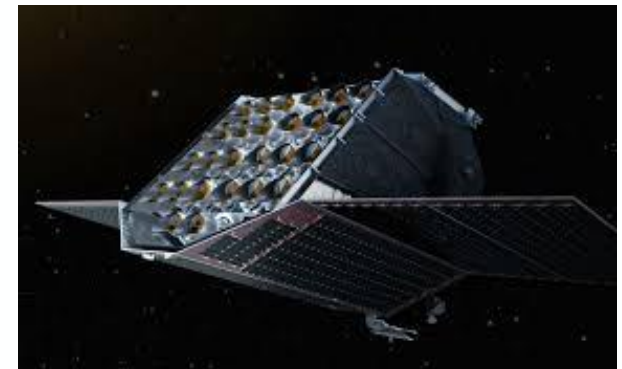
3. End-to-end data-handling / avionics architectures based on ADHA units and modules

End-to-end data-handling / avionics architectures based on ADHA units and modules

In the following slides, we now present some example end-to-end data handling / avionics architectures based on the ADHA units and modules presented in the previous sections.

Examples:

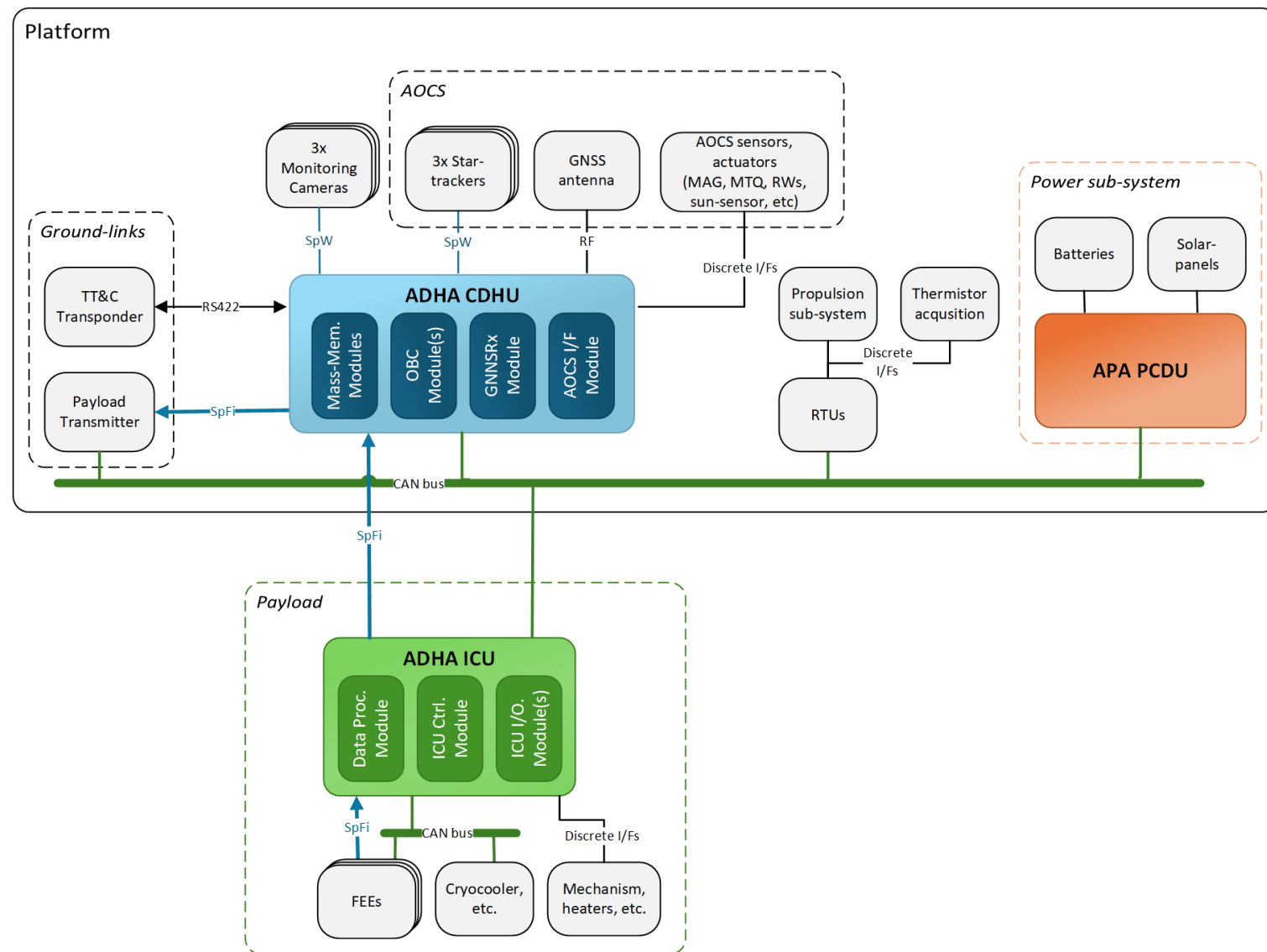
- 1) Institutional EO mission
- 2) Mission with very high-rate remote-sensing payload
- 3) Multi-instrument science mission
- 4) Large-scale space telescope



- Institutional EO mission with complex instrument, with medium data throughput

- ADHA CDHU – for platform and payload data handling
- APA PCDU – for power conditioning and distribution
- Additional RTU(s) for propulsion etc
- External TTC transponder and payload transmitter

- ADHA ICU – for instrument control, I/O and data processing
- Additional FEEs, cryocooler, mechanism etc



ADHA-based avionics / data-handling architectures 2)

Mission with very high-rate remote-sensing payload

Use-case description:

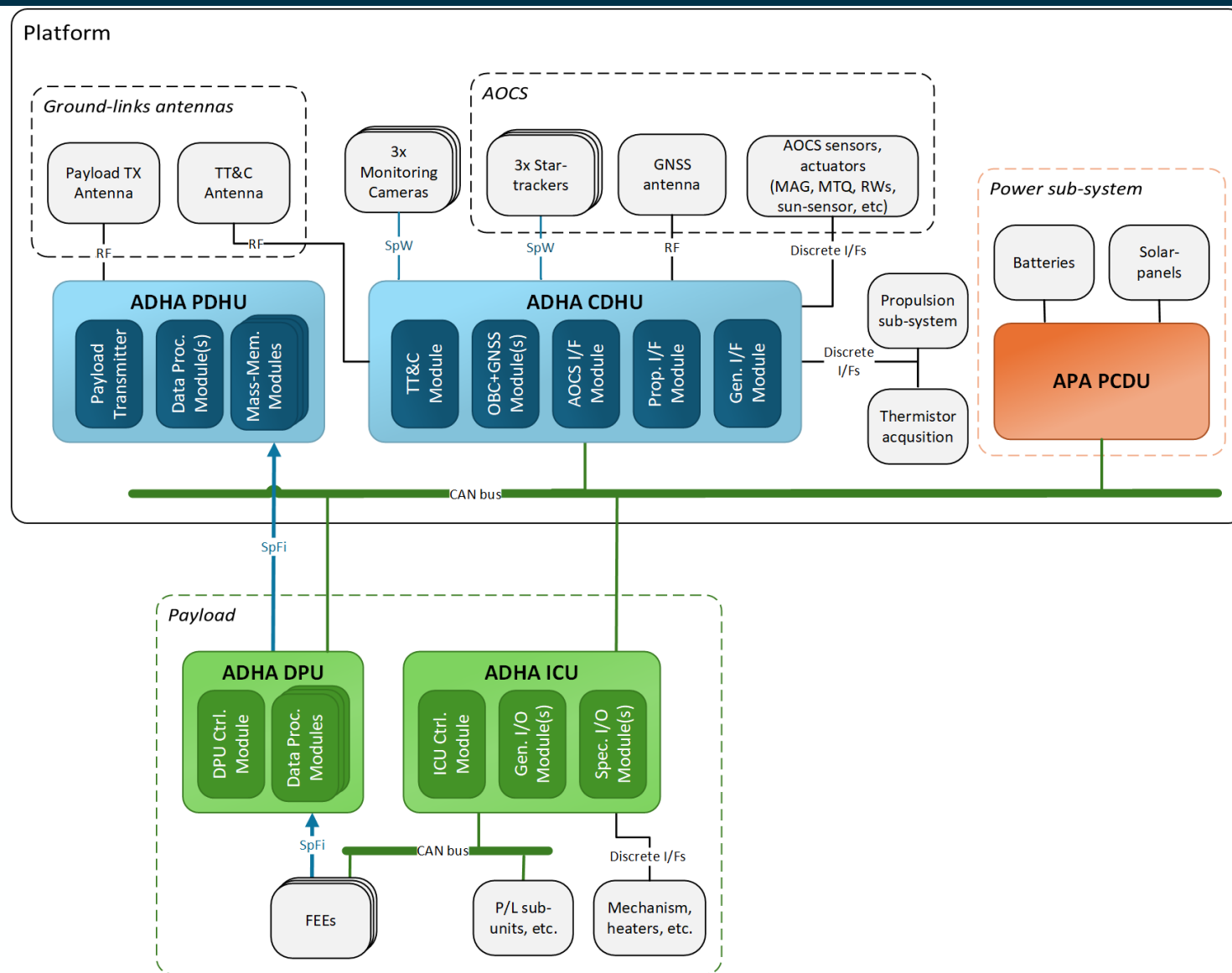
- A very high-rate remote-sensing payload (multi-sensor hyperspectral instrument, or SAR radar)

Platform:

- ADHA CDHU – for complete platform data handling (incl. GNSS, TTC, RTU)
- ADHA PDHU – for complete payload data handling (incl. payload transmitter)
- APA PCDU

Payload:

- ADHA ICU – for instrument control
- ADHA DPU – for payload data processing and synchronisation
- Additional front-end/sensor units, and mechanisms



ADHA-based avionics / data-handling architectures 2)

Multi-instrument science mission

Use-case description:

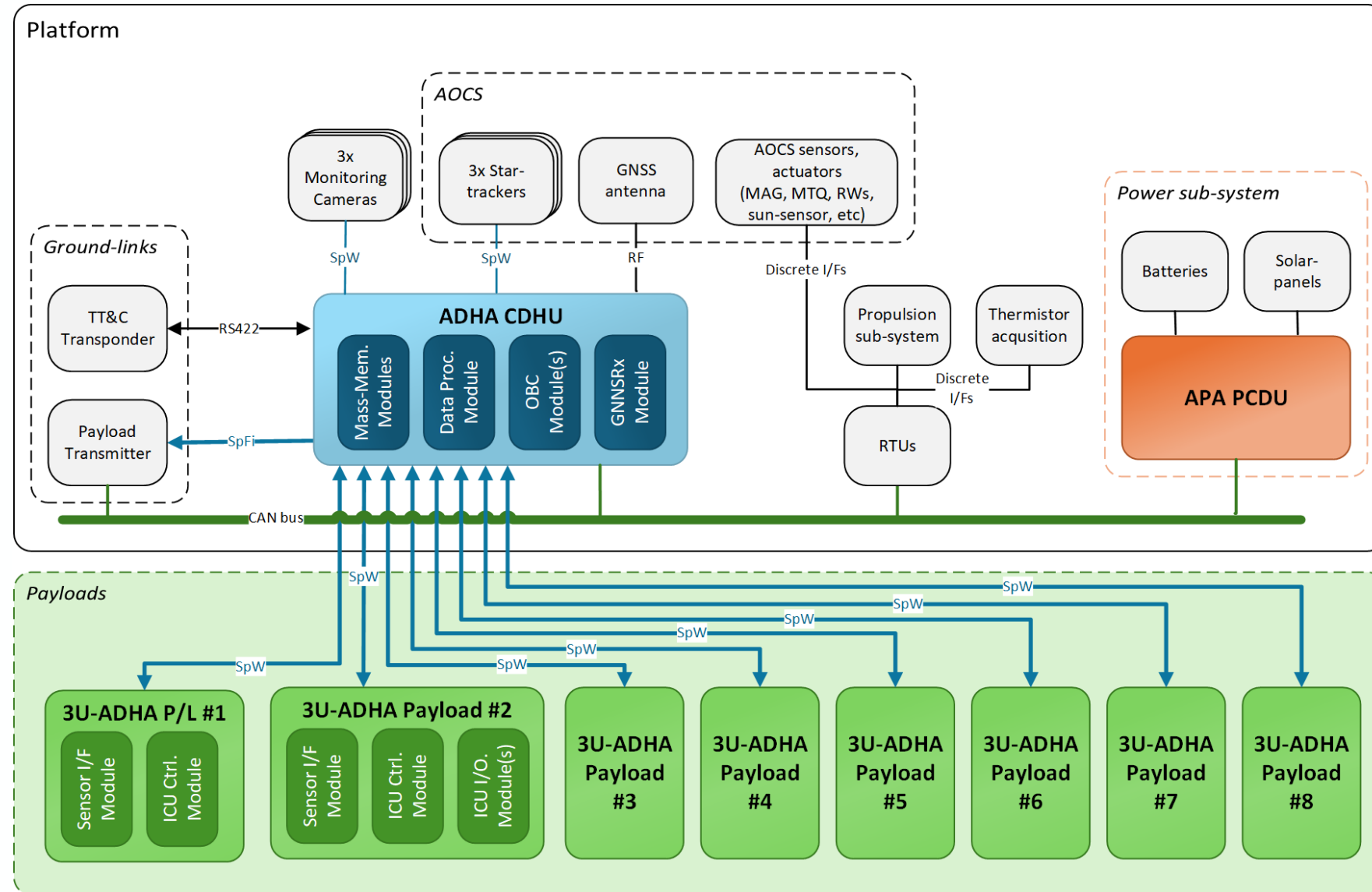
- Large-scale ESA deep-space science mission, with multiple CFI instruments from research institutes (e.g. JUICE, SolarOrbiter, BepiColombo, etc.)

Platform:

- ADHA CDHU for platform + payload data handling
- APA PCDU
- Additional RTUs, TTC transponder, payload transmitter

Payload:

- 8x 3U-ADHA based payloads
- All based on reference design



ADHA-based avionics / data-handling architectures 4)

Large-scale deep-space telescope

Use-case description:

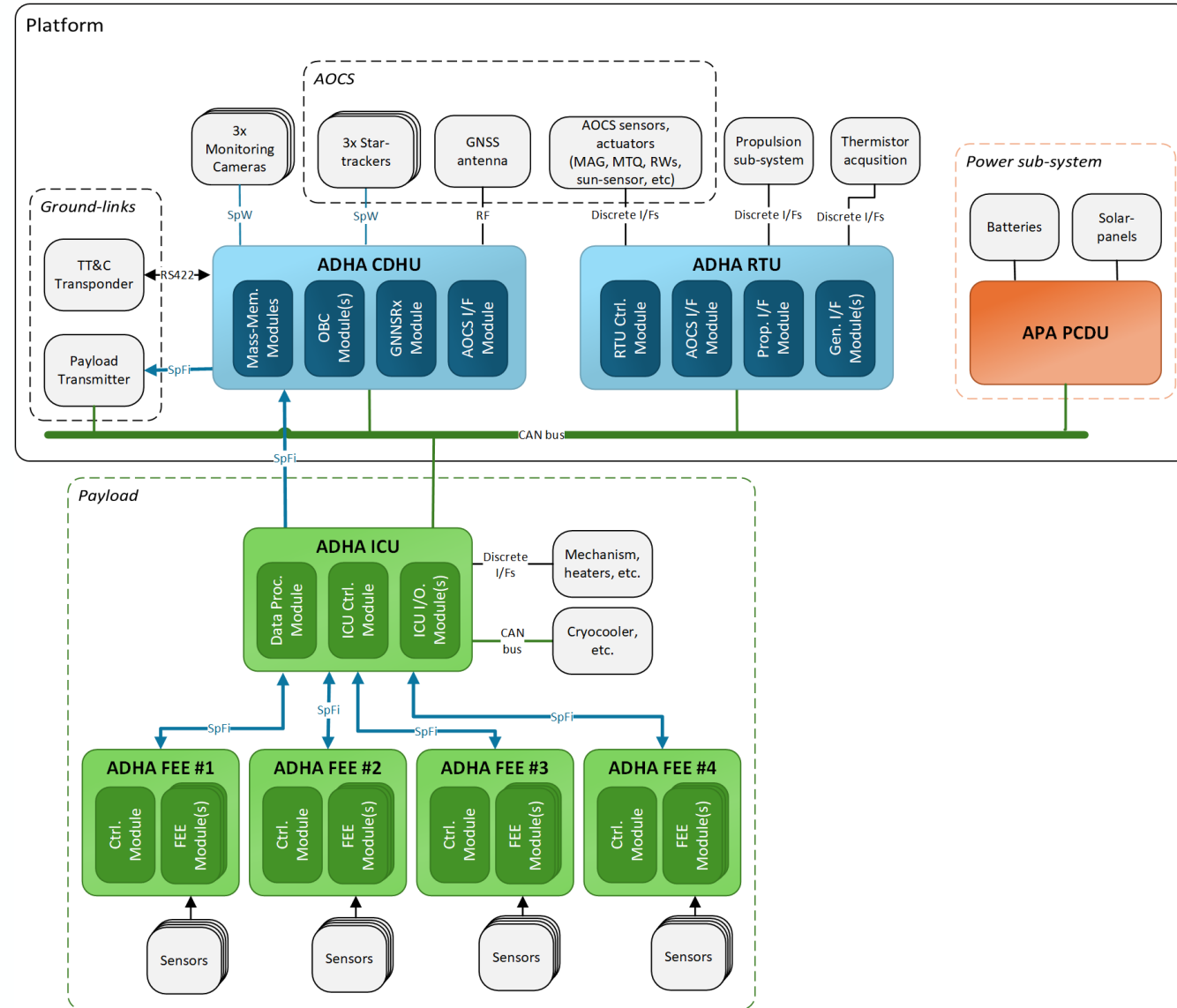
- Large scale ESA deep-space telescope (e.g. Plato, Euclid, etc.)

Platform:

- ADHA CDHU – for platform and payload data handling
- ADHA RTU – for AOCS, propulsion, discrete I/O
- APA PCDU

Payload:

- ADHA ICU – for instrument control and data processing
- 4x ADHA FEEs – for readout of multiple sensors per FEE, and data pre-processing





Advanced
Data
Handling
Architecture

- The new planned DHS specifications allows to derive different ADHA unit configurations.

- We've shown different DHS / avionics architectures based on the ADHA units and modules.

- This shows that ADHA is flexible to enable different DHS / avionics configurations – pending on the preferences and designs of different satellite primes, and for different

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Advanced Data Handling Architecture (ADHA): Project Status, Background and Roadmap

"Working towards a European solution for standardized Data Handling Systems"

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