Advanced Data Handling Architecture (ADHA) – Development Status & Roadmap

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

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ADHA & APA: Executive Summary

The Advanced Data Handling Architecture (ADHA) and Advanced Power Architecture (APA) initiatives specify an end-to-end architecture for data-handling and power sub-systems, based on European standardized and inter-operable electronics modules and units, of common electrical and mechanical form-factors and interfaces.

This level of modularity, interoperability and standardization enables the streamlined and accelerated development, testing, integration and qualification of new configurable data handling units.

The ADHA program was initiated in 2019, in a partnership between ESA and key industry partners (SMEs, LSIs) across ESA Member States.

The Advanced Power Architecture (APA) initiative addresses the same objectives, for the Electrical Power Subsystem (EPS)

- Substantial commonalities and synergies between the ADHA and APA programs.

The aim of the ADHA and APA R&D programs is to deliver a new generation of standardized data-handling and power equipment at TRL6 by 2027, ready for use by institutional and commercial missions and constellations.

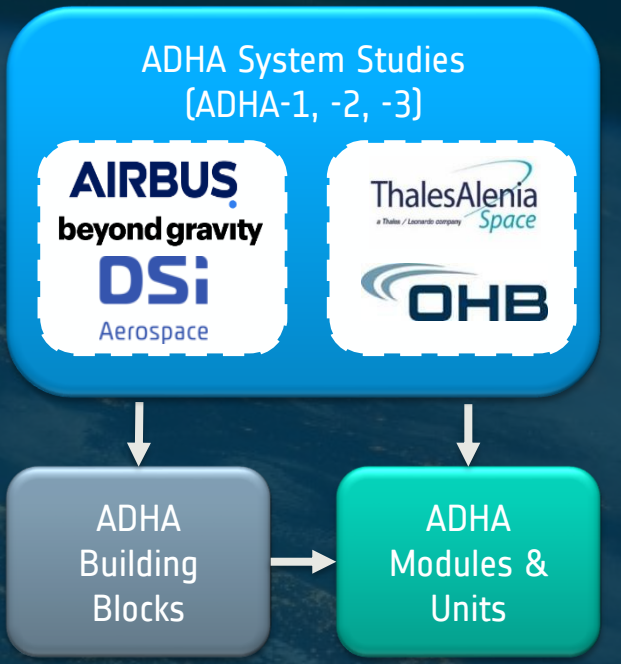
ADHA R&D Programme Organisation

The ADHA Programme is divided into three types of activities:

1. System-level studies (ADHA-1, -2, and -3)
   - Define the requirements specification for ADHA elements
   - Perform 1st ADHA unit-level AIT campaigns
   - Parallel contracts, led by: ADS (DE) and TAS (IT) as primes

2. ADHA Unit and Module hardware development contracts
   - Funded through ESA TDE, Preparation, GSTP, InCubed programs
     - many initiated by industry!
   - In total, 20+ development activities on-going

3. ADHA Building Block activities
   - (e.g. backplane connector development and qualification)



In ESA, ADHA is led by the Data Handling section (TEC-EDD), in close collaboration with other technical domains in ESA D/TEC:

- Power, Microelectronics, Flight Software, Radiation Hardness Assurance, Components, Structures, Thermal, GNC/AOCS, Software Systems

These close collaborations are a real testament to the interdisciplinary nature of ADHA.

ADHA development programme – and ecosystem

The ADHA program has grown to an ecosystem of industrial partners, developing avionics and data handling equipment based on a standardized set of electrical and mechanical specifications.

Indicative statistics:

- 22+ MEuros of capital raised so far by ESA funding programs (as per Q3 2025) –
  - Funded by Future EO, Preparation, TDE, GSTP, InCubed
- 17 industrial partners involved in the ADHA ecosystem, from 13 different countries,
  - Including companies' own capital investments
- 25 activities ongoing, for ADHA module, unit and equipment developments (plus 10+ new activities planned)

In the ADHA ecosystem, we are shaping the future of modular and interoperable avionics, by:

- Fostering cooperation, within industry, and with ESA
- Increasing competitiveness
- Leveraging synergies, between agency and industry, and between technical domains

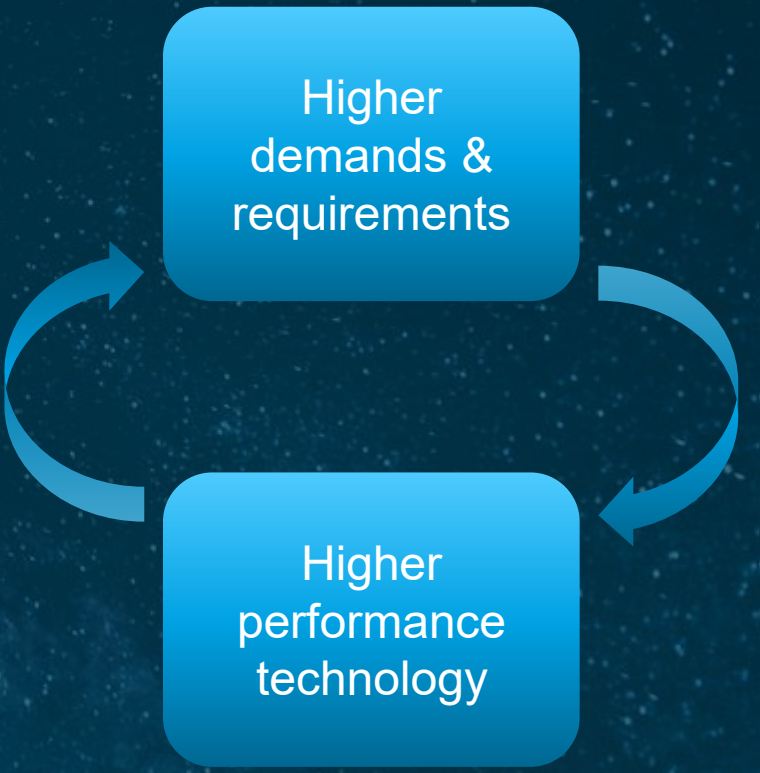
...to advance European leadership and innovation.

ADHA is more than a standard...
It is a foundation for flexibility, scalability, and European autonomy and sovereignty in space avionics systems.

Evolution of OBDH / DHS Equipment

In the last years, the requirements for on-board data handling equipment have evolved:

- Increase in data-rate/performance requirements
  - → More data at faster rate to process and store on-board
  - → More power / thermal dissipation needed
- Increase in the number of missions to serve with a single product
  - → More demanding schedules, and less time for generic product developments
- Higher level of on-board autonomy (e.g. for constellations)
  - → More advanced on-board functions required



At the same time the technology is evolving:

- More advanced high-performance microelectronics and sensors available for space
- Higher acceptance to use COTS components
- Very-high speed payload transmitters and optical transceivers have been demonstrated

ADHA Objectives

ADHA aims to:

- Meet the evolving performance requirements of OBDH / DHS equipment – of the next generation of applications – by utilising the latest technologies (e.g. European UDSM technology)
- Increase European competitiveness, serialisation and non-dependence – and reduce Non-Recurring Engineering (NRE) in Data Handling Systems

ADHA has the following objectives:

- Deliver a new generation of On-Board Data Handling equipment at TRL6 by 2027

- Ensure dual- or multi-sourcing of key On-Board Data Handling Equipment by 2028

...to be available for institutional and commercial missions.
...both large-scale missions (ADHA-6U), mid- and small-sats / constellations (ADHA-3U).

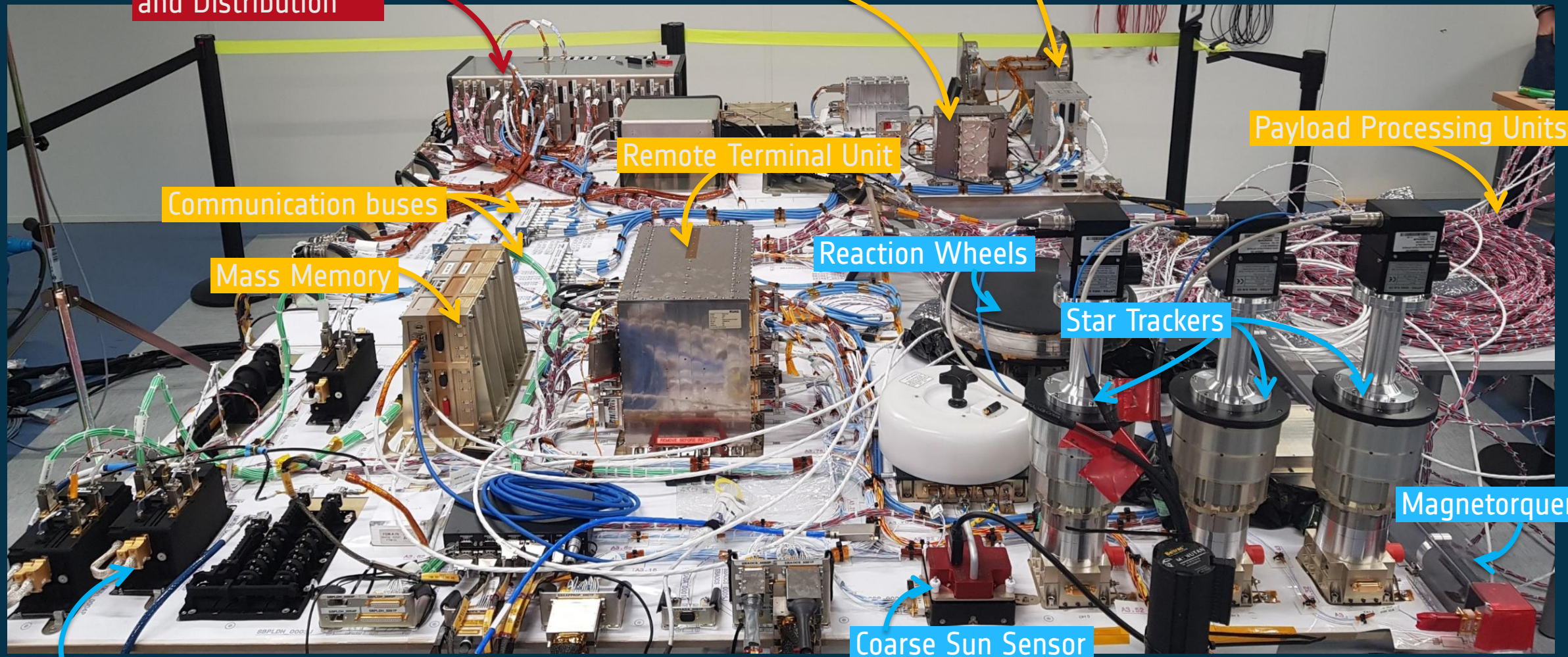
ADHA Technical Perimeter & Scope

The ADHA program defines the following elements:

- An end-to-end data handling architecture
  - To ensure interoperability between data handling units
- A standard backplane electrical interconnect between modules
  - Based on the cPCI-Serial-Space standard
  - To allow interoperability of modules from different suppliers within the same unit
- Standard mechanical form factor and interfaces
  - For uniformity across the OBDH subsystem, more efficient qualification, assembly and integration
  - Compatibility between any ADHA-compliant modules, for faster unit integration and configuration
- A standard procurement and PA (Product Assurance) approach
  - To allow clear requirements based on expectations in different mission classes

All ADHA specifications have been agreed between the ADHA consortia members, including the three LSIs (ADS, TAS and OHB), ensuring that data handling equipment suppliers / SMEs have a consistent set of requirements.

Example DHS Flat-Sat (before ADHA/APA)



MetOp-SG EFM @ Airbus DS Toulouse

ADHA: Benefits at System Level

Interoperability at module level allows integration of multiple functions in same unit

- Overall reduction in harness mass – and fewer electronics boxes per mission
- Uniformity across platform (and payload) units dimensions facilitates placement and harness optimisation within the S/C

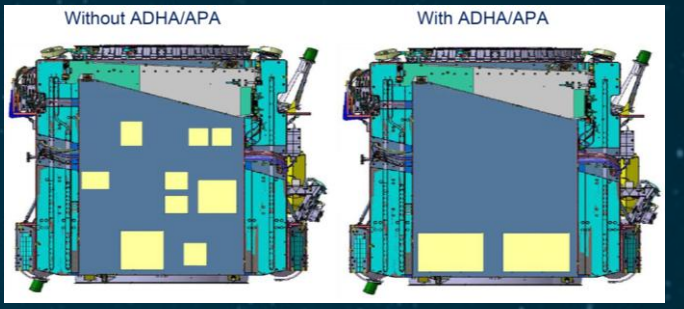


Image source: Airbus, DASIA2024

Use of recurring equipment products lowers project risk

- Allows schedule optimisation and early testing of mission critical functions

Scalability and modularity provide flexibility in unit configuration and allows expansion of functions

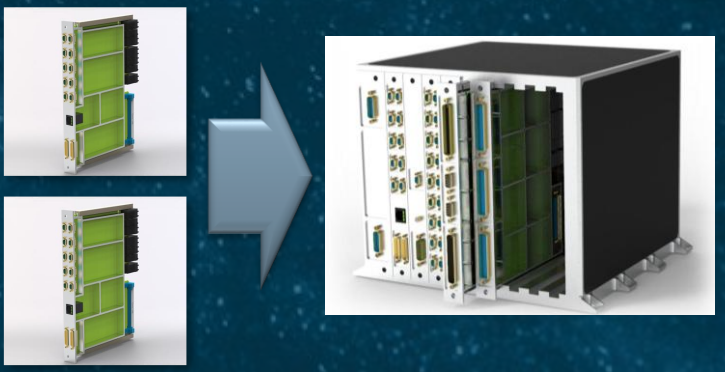
- Allows adoption for specific mission needs, reducing expensive and risky NRE – i.e. less chance of an equipment development being on the critical path of the mission schedule

Flexibility in implementation of georeturn requirements

- Allows dual- and multi-source of same equipment (important for constellations)

Supplier #1

Supplier #2



ADHA: Benefits for Equipment Suppliers (incl. SMEs)

Standardisation of interfaces, functions and verification approach

- Promotes reuse of products across different flight projects/customers

Iterative upgrades of products and use of the latest technology

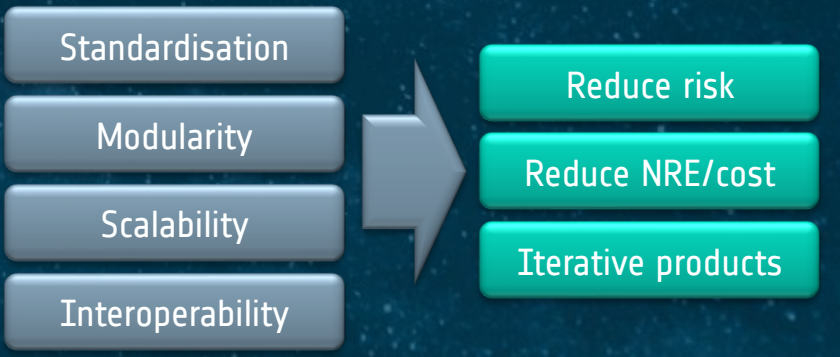
- Modularity allows upgrading of specific functions (e.g. as new microelectronics becomes available) – without losing TRL level of other functions, allowing European companies to stay competitive to increasing data handling requirements to increasing data handling and performance requirements

Interoperability at unit level allows integration of 3rd party products

- Allows expansion of product portfolio beyond in-house products
- Lower entry threshold into programmes with geo-return constraints

All of these benefits contribute to promote less risky and costly NRE per mission

- Freeing up supplier's engineering resources to focus on recurring products



Architecture Overview

The ADHA architecture consists of the following elements:

1. The standardised ADHA Backplane

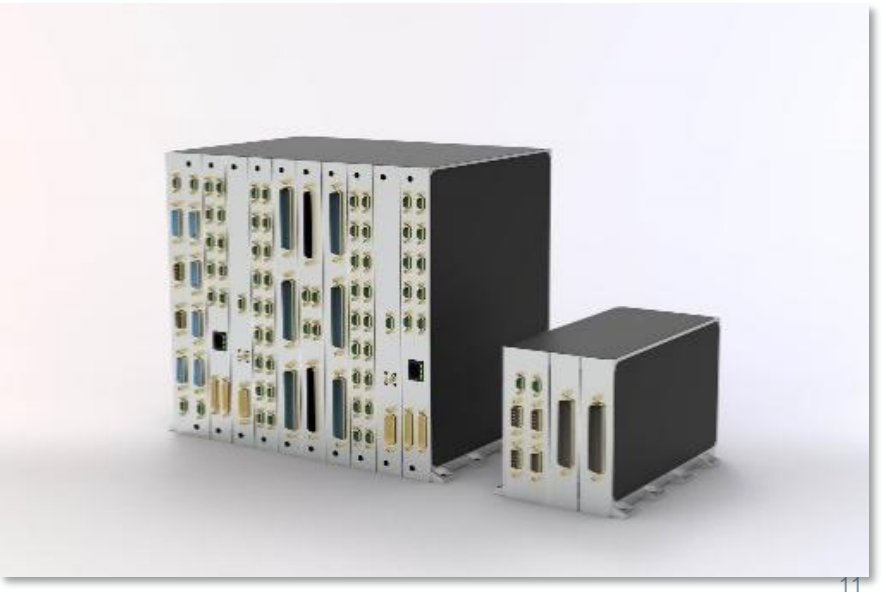
2. ADHA Modules – with standardised functions

3. ADHA Units

Note: ADHA comes in two sizes: 6U and 3U (Eurocard sizes)

- 6U: 220x233mm, 3U: 220x100mm

We show an example using 6U in the next slides



Architecture Overview: ADHA Module (6U)

ADHA Module

Standardised External Interfaces (per module function)

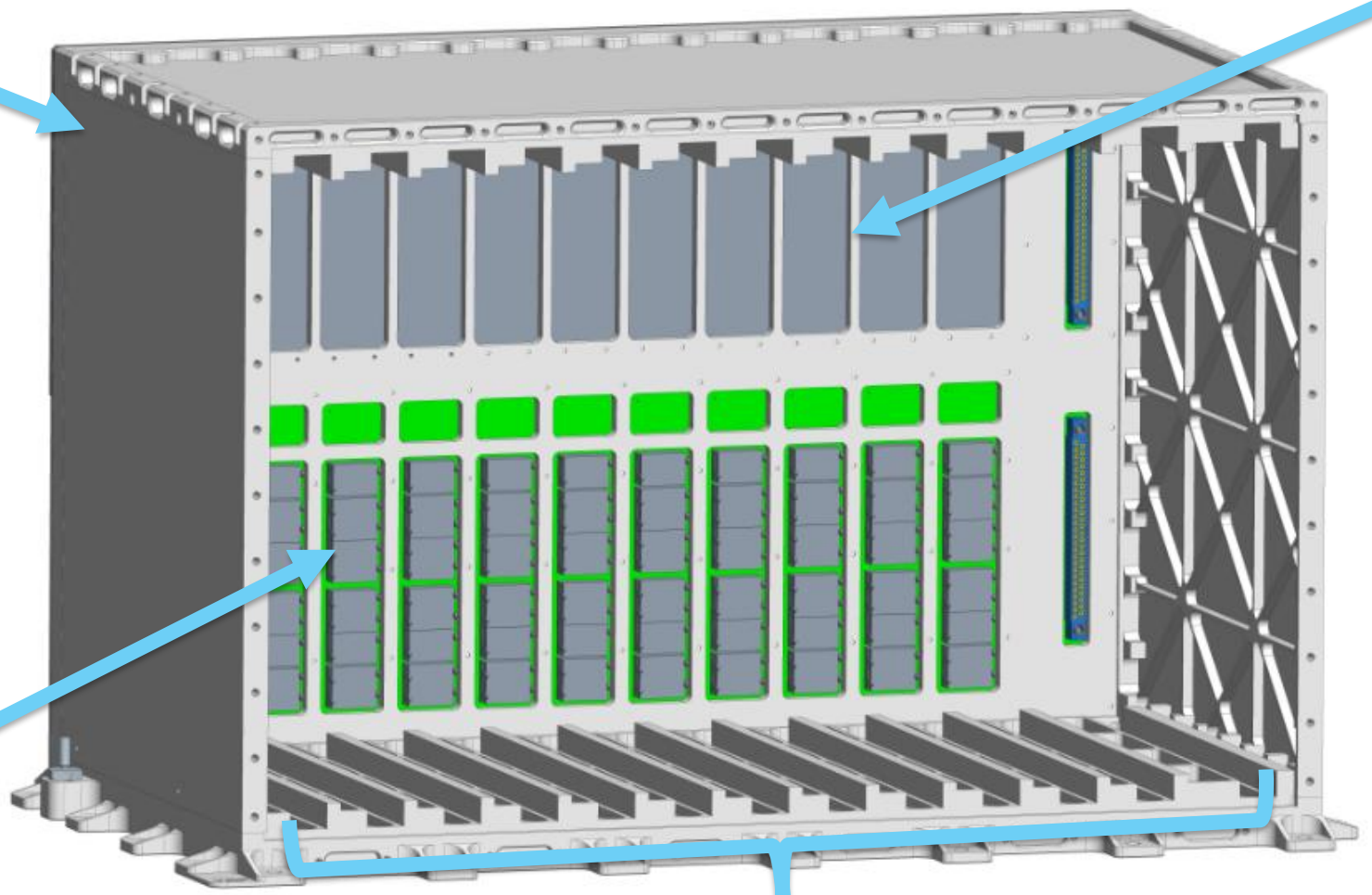
ADHA Modules follow Specification per Function (e.g. ADHA OBC, ADHA mass-memory, etc.)

Standardised ADHA Backplane Connector* and Interfaces

**Based on commercial cPCI-S-S standard*

Additional External Interfaces

Architecture Overview: ADHA Unit (6U)



Architecture Overview: Example 6U-ADHA Unit

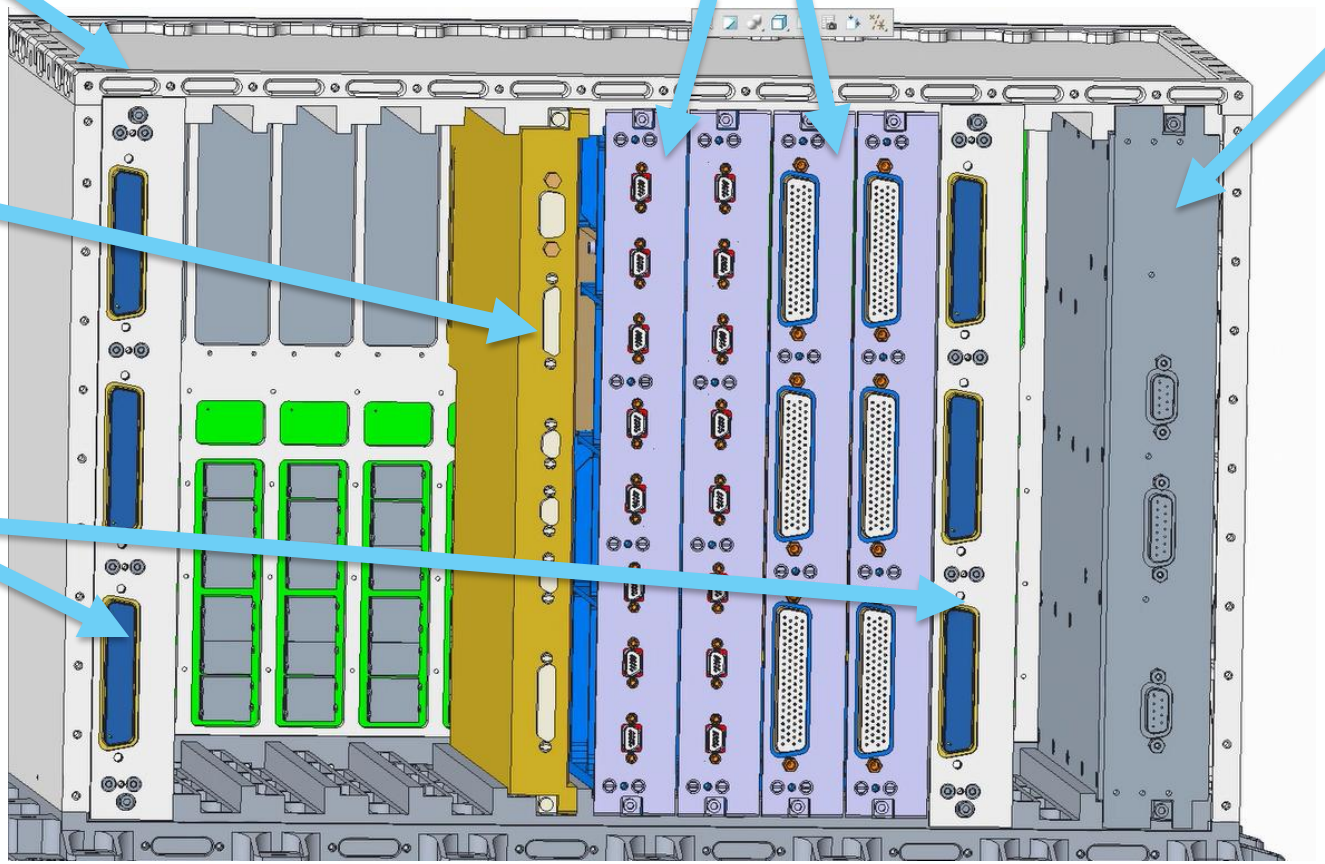
ADHA Enclosure
& Backplane from
(Beyond Gravity)

ADHA On-Board Computer
(Thales Alenia Space)

ADHA Power Module
(Airbus DS)

ADHA Instrument Controller
(Airbus CRISA)

ADHA Reference Modules
(Beyond Gravity)



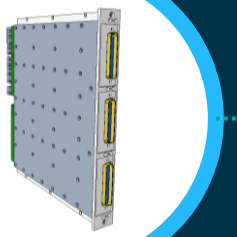
PHASES OF THE ADHA DEVELOPMENT PROGRAM

Advanced Data Handling Architecture

esa

1 Technical and Procurement Requirements Spec.

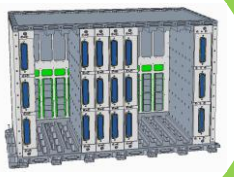
2 Engineering Model (EM) Modules Development



TRL4

We're here

3 Engineering Model (EM) Unit Integration / Testing



TRL5

2026

4 ADHA Unit Qualification

TRL6

2027

5 IOD & Flight Opportunities

TRL7-9

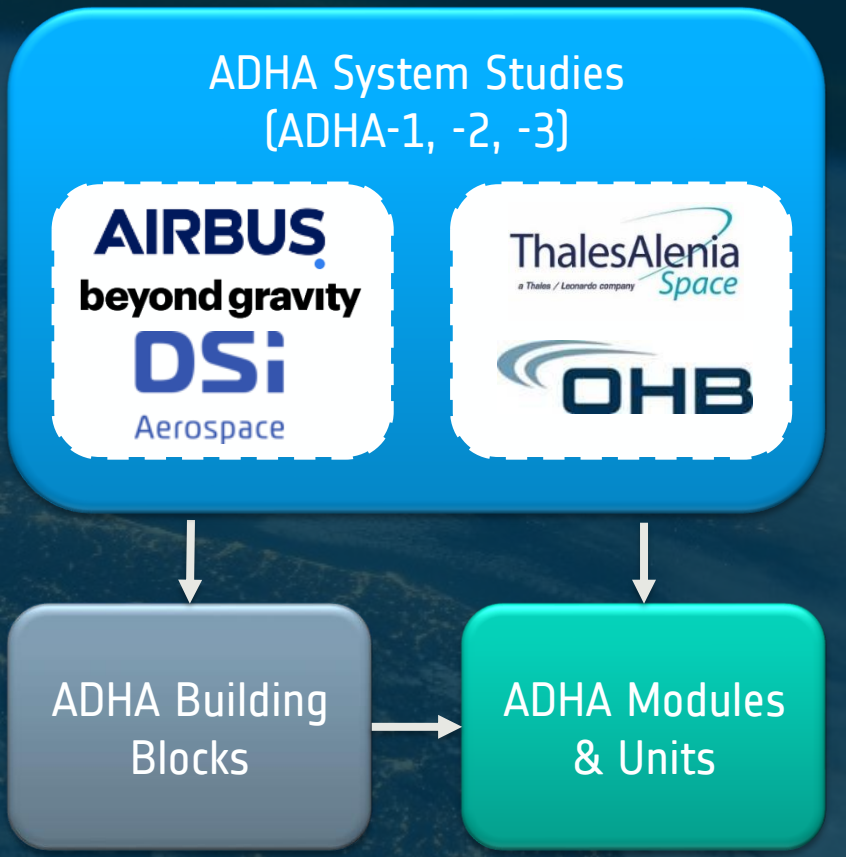
ADHA R&D Programme Organisation

The ADHA R&D Programme is divided into three types of activities:

1. System-level studies (ADHA-1, -2, and -3)
    - Define the requirements specification for ADHA elements
    - Perform 1st ADHA unit-level AIT campaigns
    - Parallel contracts: ADS (DE) and TAS (IT) primes

2. ADHA Unit and Module hardware development contracts
    - Core modules: OBC, MM, Power and GNSS funded through TDE
    - Others funded through GSTP, Incubed, etc - many initiated by industry! In total, ca 20 development activities on-going

3. ADHA Building Block activities
    - (e.g. backplane connector development and qualification)



The On-Board Data Handling System (DHS/OBDH) – Scope of ADHA System Studies

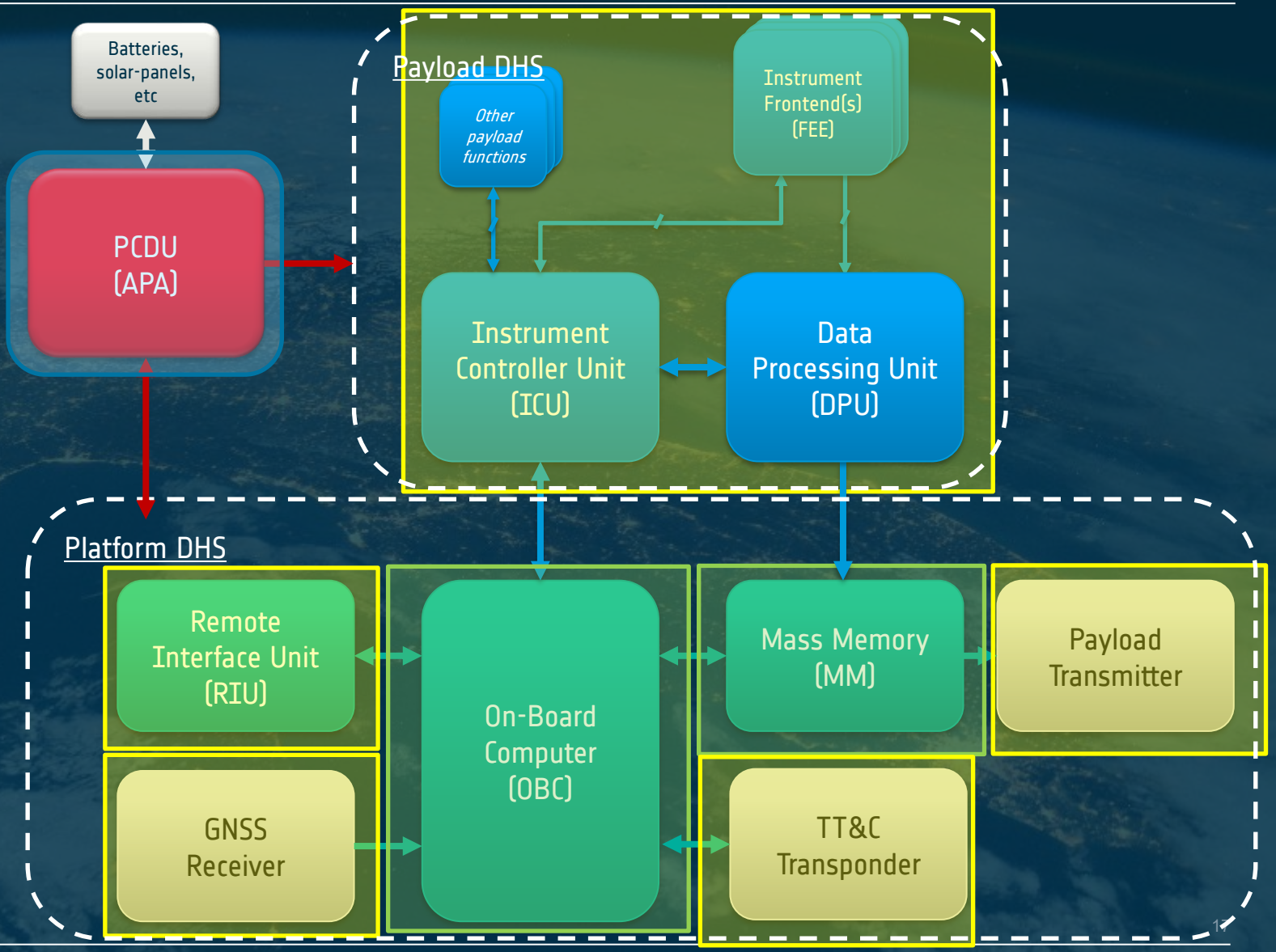
In green:
within the scope of the ADHA-2 System Study

In yellow:
within the scope of the ADHA-3 System Study

In addition ADHA-3 covers:

- Standardisation of software and protocols
- Standardisation of EGSE and module testers
- PA tailoring for Class Gamma/Delta
- ...and other topics

In blue:
within the scope of the APA Study



ADHA-3 Phase-1 Tasks

Task #	Task	Common or single consortia	ADS/DSI/BG consortium	TAS/OHB consortium
1	ADHA-3U Specifications	Common	X	X
1a)	*Class Gamma missions analysis and DHS requirements*	*Lead by TAS consortium*		*X*
1b)	*Update of specifications for 3U*	*Common*	*X*	*X*
2	Payload Module/Unit Specifications	Common	X	X
2a) / 2b)	*Payload mission analysis*	*Lead by ADS consortium*	*X*	
2c)	*Payload module specifications*	*Common*	*X*	*X*
3	Additional ADHA Module Specifications	Common	X	X
4	ADHA Data and Software Interfaces	TAS		X
5	EDS Format and MBSE Architecture	ADS	X	
6	Structural/Thermal Study	ADS	X	
7	ADHA EGSE Architecture	TAS		X
8	End-to-End Use Case Analysis	Common	X	X
9	Industrial Roadmaps	Separate	X	X
10	ADHA Verification approach	ADS	X	
11	ADHA-U1 DHS Use-Case Analysis and FDIR	TAS		X

ADHA: Current Contracts, Industry and Budgets

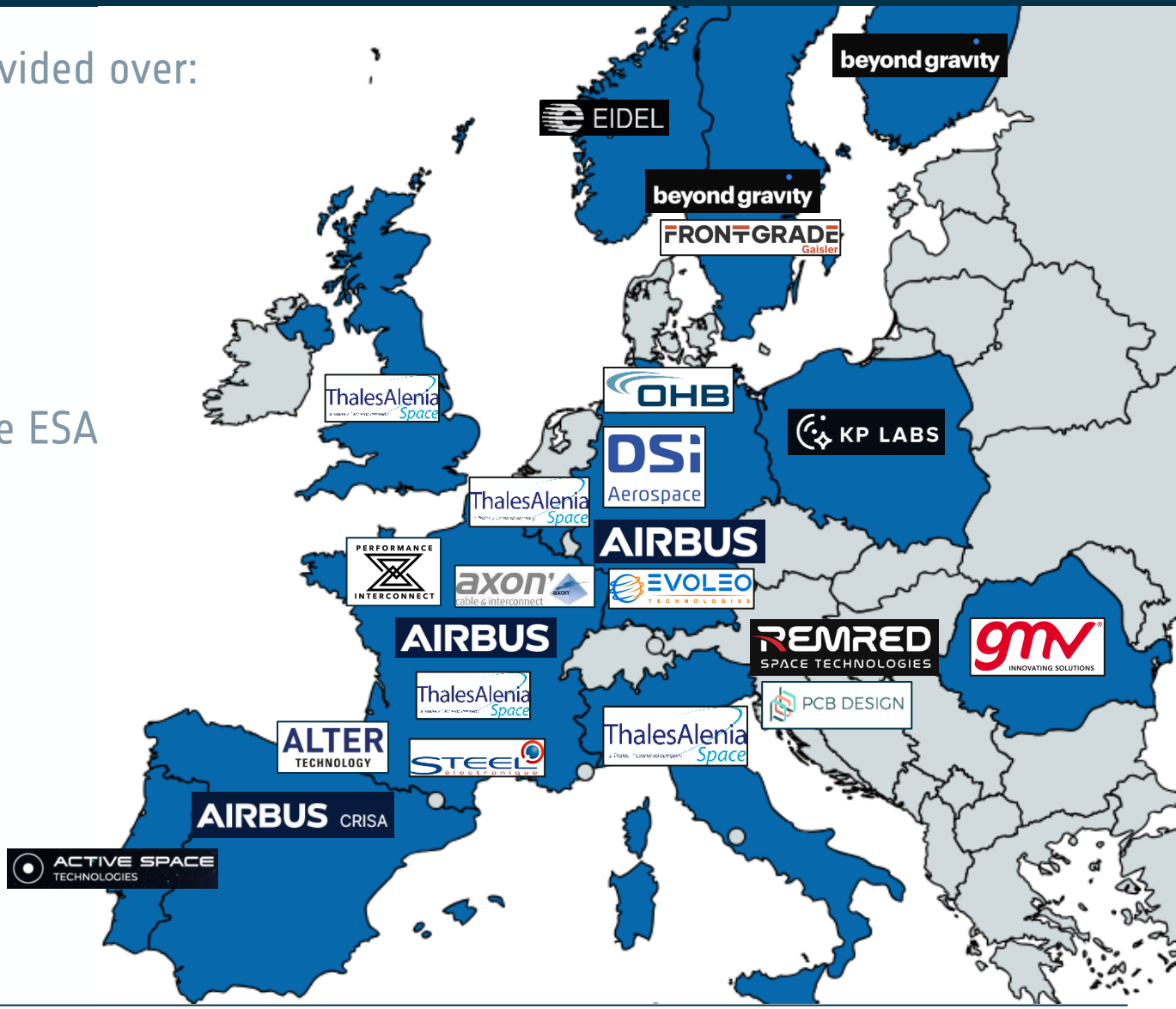
The overall ADHA development ESA activities are divided over:

...18 companies and groups

...in **14 European countries**

...for a **total ESA budget of ca 22MEUR** from multiple ESA funding programs

(FutureEO, Discovery/Preparation, TDE, GSTP, InCubed, ARTES)



ADHA Industrial Working Group (ADHA-IWG)

An ADHA Industrial Working Group (ADHA-IWG) has been initiated

The ADHA-IWG will be responsible for the future maintenance and updates to the standard.

- The ADHA standardisation effort was funded by ESA, and performed by European Industry – and the ADHA standard will be led by industry

Very positive early response from European Industry

- More than 30 entities from 15 different European countries have agreed to participate
- In particular SMEs see the benefit, and savings in effort by adopting the standard

The ADHA-IWG is open to entities in ESA Member States, and will also invite participation from technical experts in national space agencies and technology providers.

ADHA Industrial Working Group (ADHA-IWG) – Members

AIRBUS
beyond gravity
ThalesAlenia Space
a Thales / Leonardo company
DSI Aerospace
OHB
EVOLEO TECHNOLOGIES
KP LABS Mission Complete
gmv INNOVATING SOLUTIONS
EIDELAS
Crisa
AIRBUS DEFENCE & SPACE
STEEL electronique
INGENIArs
ACTIVE SPACE TECHNOLOGIES
EREMS
teletel
OHB LUXSPACE
PCB DESIGN
DELTATEC
FRONTGRADE Gaisler
TELESPAZIO
a LEONARDO and THALES company
RAMON.SPACE
AAC CLYDE SPACE
COROS SPACE
SPiN
Space Products and Innovation
ZAITRA
Aurora Avionics
AROBS Polska
STAR-Dundee
REMRED SPACE TECHNOLOGIES
esa
PERFORMANCE INTERCONNECT
axon' cables & connectors
Positronic
an Amphenol company
cnes
DLR

The ADHA Industrial Supply Chain

Technology, Component, and EEE/microelectronics providers benefit from the standardisation provided in ADHA
→ allowing to promote products towards the ADHA eco-system

Example: backplane/connector suppliers

ADHA Module Suppliers benefit from the standardisation and common functional/interface definitions
→ allowing to promote modules within the ADHA eco-system, to end-users or ADHA unit integrators

Example: mass-memory module suppliers

ADHA Unit Suppliers benefit from the standardisation and reuse of standard modules
→ allowing to promote module/scalable ADHA units towards mission primes

Example: payload data handling unit provider

Note: unit supplier can also be a module supplier

Mission primes benefit from the standardisation – reduces the specification work per mission
→ allowing to procure standard functions from multiple sources

Note: spacecraft bus provider can also be ADHA unit supplier/integrator

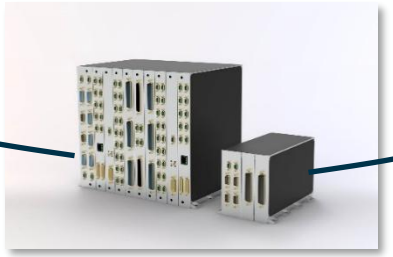
ADHA/APA and ESA Mission Classes

(From ESA/IPC(2024)219)

	Alpha	Beta	Gamma	Delta
Criticality to Agency Objectives, Strategy and Image *Flagship mission, international co-operation, impact on strategic ESA goals and image*	Extremely Critical	Highly Critical	Medium Criticality	Low Criticality
Cost *Cost at completion inc. Phase E1*	> 400 M€	200 – 400 M€	25 – 200 M€	< 25 M€
Mission Lifetime *Nominal mission life duration*	> 7 years	5 – 7 years	2 – 5 years	< 2 years
Mission complexity *Design interfaces, unique payloads, new technology development*	Extremely Complex	Highly Complex	Medium Complexity	Low Complexity

6U-ADHA

3U-ADHA



ADHA EM/EQM Modules – Development Status

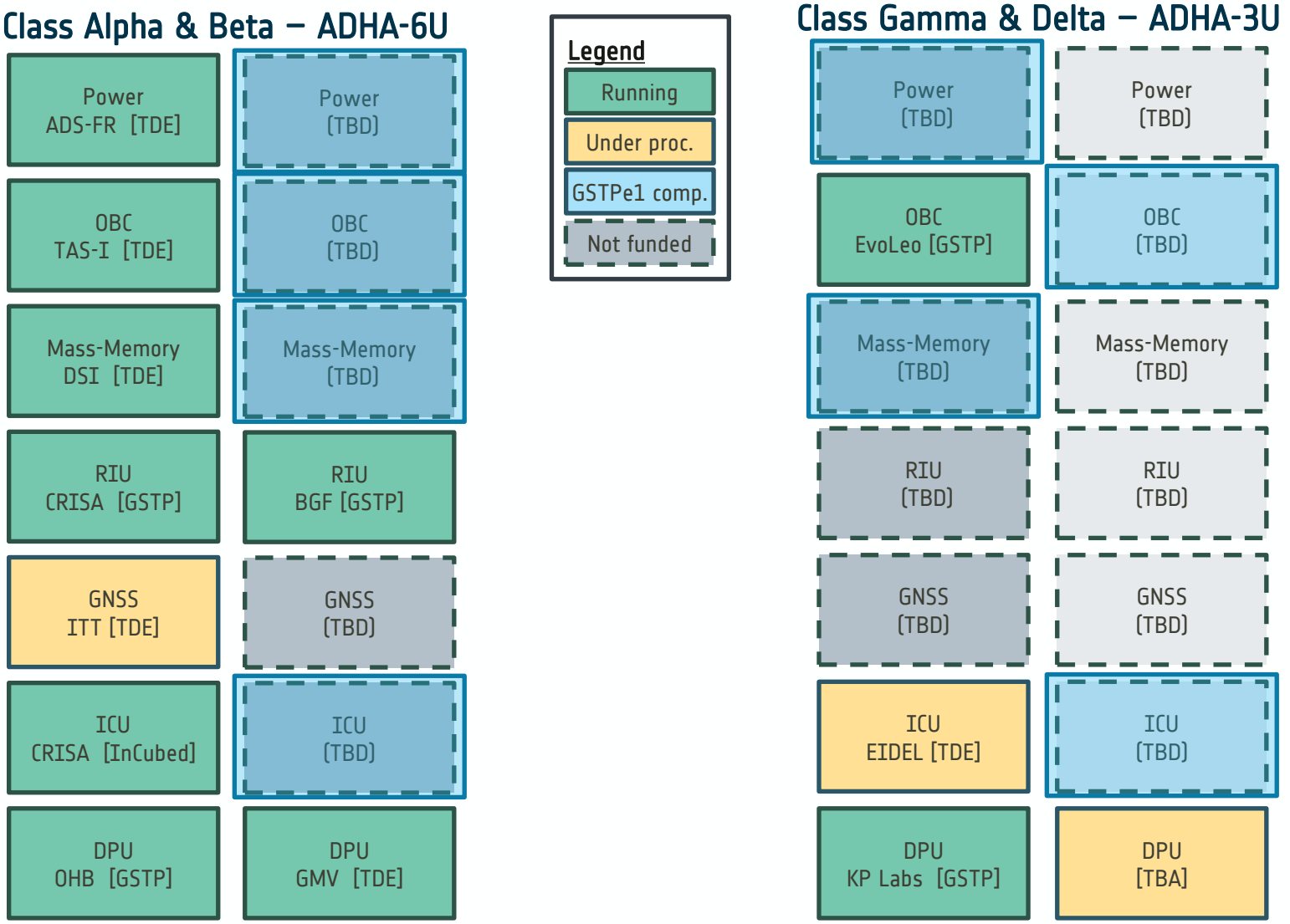
Goal: To have **dual-sourcing** for each of the key modules – for each of the mission class targets.

Two mission criticality class targets:

1. **Class Alpha & Beta (Institutional EO & Science Missions)**
   - mainly ADHA-6U

2. **Class Gamma & Delta (Constellations & Commercial Mid- and Small-Sat Missions)**
   - mainly ADHA-3U

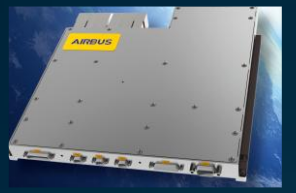
Other functions under proposal: SDR, Security, Payload FEE, Ethernet, EGSE, etc.



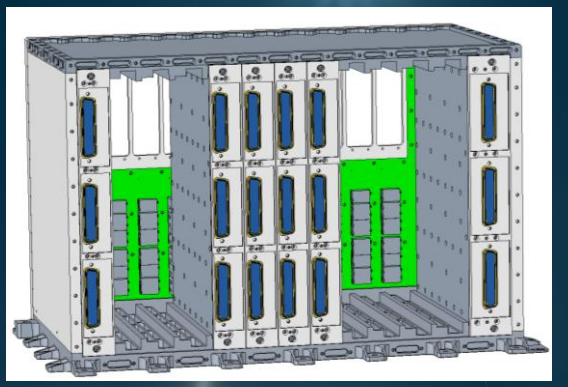
Examples of ADHA modules/units under development

ADHA 6U Instrument Control Unit (ICU)
ADS CRISA

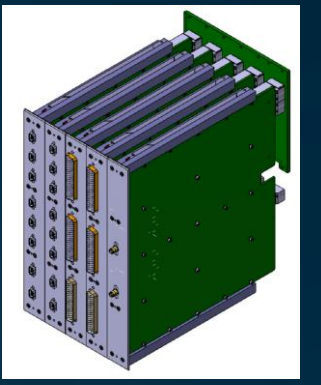
ADHA 6U RIU module,
Airbus CRISA



ADHA 6U Payload Control Module (PCM),
Airbus CRISA



ADHA 6U Unit,
Beyond Gravity

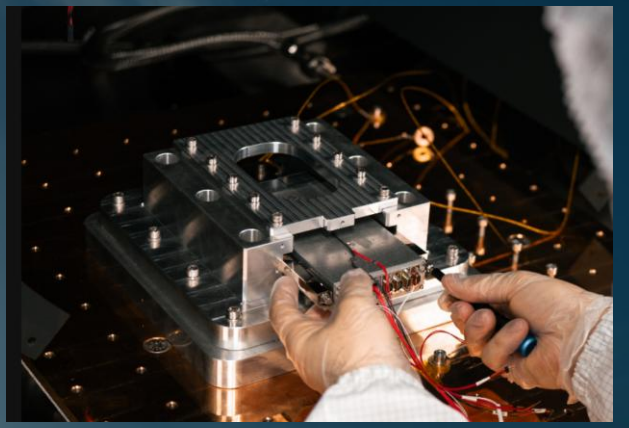


ADHA 6U OBC,
Thales Alenia Space

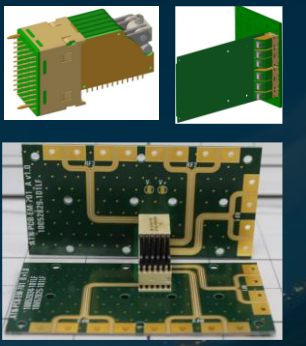
ADHA Backplane Connector, Axon

ADHA 3U bread-board, EVOLEO

ADHA 3U avionics suite, EVOLEO



Lion DPU, KP Labs



ADHA Backplane Connector, Alter / Performance Interconnect

ADHA Activities Roadmap Overview – Current activities

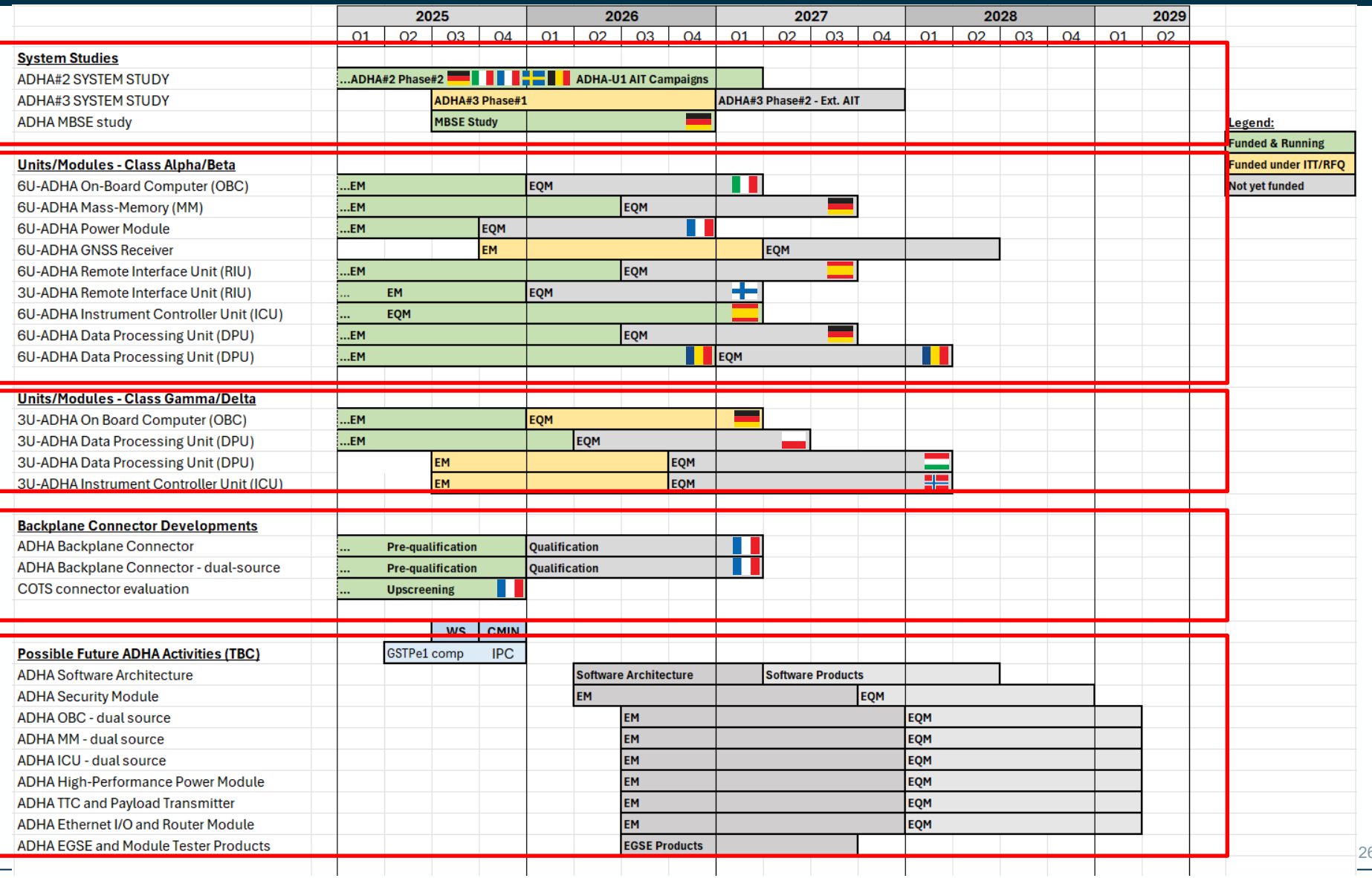
1. System-level study activities

2. Class Alpha/Beta hardware developments

3. Class Gamma hardware developments

4. Key building blocks

5. Future activities (dual-sources)

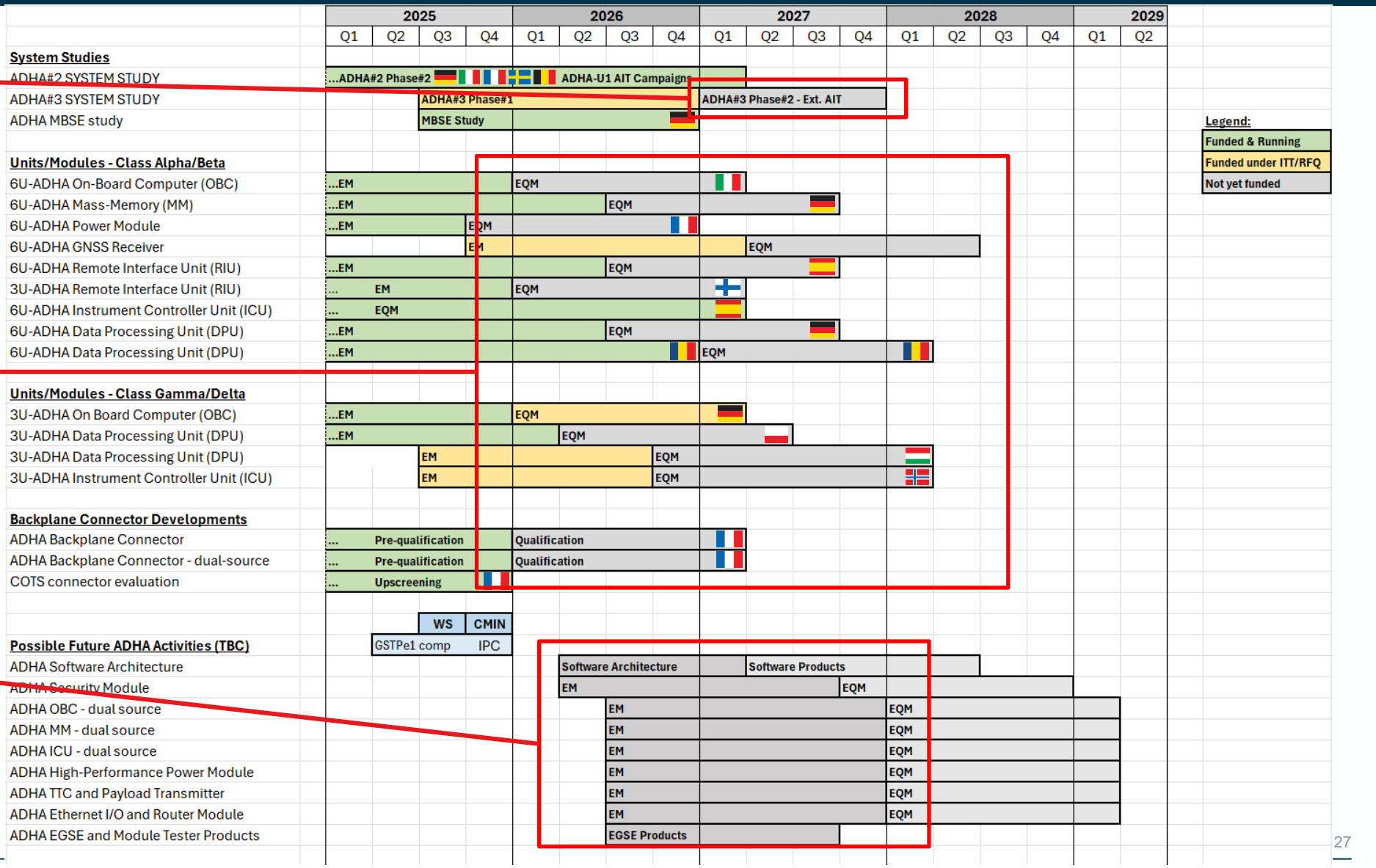


ADHA Activities Roadmap Overview – Current activities

1. Extended AIT campaign
   - CCN to ADHA system study contracts, under GSTP
   - Open to ADHA equipment suppliers

2. EQM developments & hardware qualification
   - Proc. policy: DN
   - Same suppliers as EMs
   - Estimated total budget 15-20MEUR 2025-2027

3. Future TDE/GSTP activities (TBC)
   - Proc. policy: ITTs (open competition)
   - Activities TBC (pending internal ESA evaluation)



ADHA Future Activities – GSTP Element 1 Compendium

Dual-source and additional EM activities:

- Either: open ITTs through GSTPe1 (compendium)
- …or industry-initiated through optional programme(s)
- Estimated required budget (2026-2027): ca 8.3 MEUR
- Parallel activities are desirable for dual sourcing of functions

GSTP Element 1 Compendium includes both:

- 2nd source activities (OBC, Mass-Memory, Instrument Controller)
- …and new functions under standardisation (e.g. TTC module and payload transmitter module)

Advanced Data Handling Architecture (ADHA)

Avionics & EEE

Programme Reference	Activity Title	Budget (k€)
GT1M-800ED	ADHA on-board computer	1,500
GT1M-801ED	ADHA instrument controller unit	1,500
GT1M-802ED	ADHA mass-memory modules and unit integration	1,500
GT1M-803ED	ADHA EGSE and common module testing products	800
GT1M-804ED	ADHA Ethernet I/O and router module	1,000
	Total ADHA - Avionics & EEE	**6,300**

RF Payloads & Technology

Programme Reference	Activity Title	Budget (k€)
GT1M-805EF	ADHA TTC transponder and payload transmitter module(s)	1,200
	Total ADHA - RF Payloads & Technology	**1,200**

Power Systems, EMC & Space Environment

Programme Reference	Activity Title	Budget (k€)
GT1M-806EP	ADHA high-performance power module	800
	Total ADHA - Power Systems, EMC & Space Environment	**800**

Total Advanced Data Handling Architecture (ADHA)	**8,300**

ADHA Status & Roadmap Summary

- The growing ADHA ecosystem, and increasing number of industrial partners interested in developing ADHA -compliant equipment creates new opportunities

- Requirements of different mission criticality classes can be addressed via different ADHA unit formats and configurations (6U/3U, etc).

- Expanding the target applications beyond EO will further enhance the business opportunities: Science, Exploration, Navigation, etc.

- ESA has clearly and actively demonstrated the support in the ADHA program
  - Significant and continuing investments in ADHA program by ESA programs
    - Future EO, Discovery/Preparation, TDE, GSTP, InCubed
    - 22 MEuros in total, as per Q3 2025

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

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

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TEC
EDD