A Unified Roadmap for Platform DHS

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Airbus Defence and Space

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This document has been assessed by the following Technical Rater:

Assessed and classified by:: R.Roques **Date classification completed: 2/10/2023**

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2. Expected DHS evolutions
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5. Conclusion and perspectives

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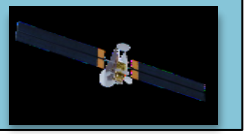
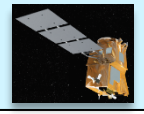
Current DHS product lines 1/2 : classical hirel platforms

	Telecom & Navigation		Earth Observation, Science & Exploration		
S/C Product Line	EUROSTAR NEO 	ONESAT 	S950 Mid-size EO commercial S/C 	Large Institutional EO & Science S/C 	Planetary Exploration S/C 
Avionics Product Line	E-NEO/OneSat Avionics		AstroBus NG	AstroBus NEO	AstroBus derived
OBC	GPAR Mk2 (LEON3)		OSCAR Mk3 (LEON3)	OSCAR Mk4 (LEON3)	OSCAR Mk4 (LEON3)
OBSW	RTEMS PUS-A		RTEMS PUS-A	RTEMS PUS-C	RTEMS PUS-C
Mass memory			Specific	LEON2 PUS-C	In OBC
Remote Interface Unit	In OBC		RIU (standalone)	RIU (standalone)	RIU (standalone)
Security Unit	In OBC or external		IDCU CCSDS	In OBC CCDS EP	In OBC CCSDS EP
Data bus	SpW, CAN, 1553		SpW, CAN	SpW, 1553	SpW, 1553
EEE components	Hirel	Hirel + New Space	Hirel	Hirel	Hirel

- OBC + local processing
- Full redundancy
- Common technologies but distinct implementations
- Mostly hirel EEE so far

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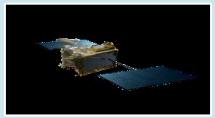
Current DHS product lines 2/2 : new space high quality platforms

Business Domain	Telecom	Earth Observation
S/C Product Line	Telecom LEO Constellations 	S250 Small EO S/C & Constellations 
Avionics Product Line	Arrow	AstroBus SE
OBC	Amethyst (ARM R5)	Amethyst (ARM R5)
OBSW	Hypervisor RTEMS PUS-A	Hypervisor RTEMS, LINUX PUS-A
Mass memory		Payload Management Unit ARM A9, PUS-A
Remote Interface Unit	In OBC	In OBC
Security Unit	In OBC or external	IDCU-C CCSDS
Data bus	SpW, CAN	SpW, CAN
EEE components	New Space	New Space

- Centralized STR & GNSS processing in OBC
- Partial redundancy
- Commercial technologies : ARM (R5, A9), Linux
- Automotive/COTS EEE

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Current spacecraft DHS product lines at Airbus – in a nutshell

- **Two “classical” platform families : ENEO/OneSat and AstroBus NG/Neo**
  - ESA SAVOIR compliant architecture
  - Central OBC with local processing in STR, GNSS and mass memory units
  - Full redundancy
  - Mil-Bus, CAN, SpW, Wizard high speed links
  - Common technologies (LEON2/3, RTEMS) but distinct implementations
  - Hirel EEE. Moving to “new space, high qual” on commercial applications

- **The “new space” LEO platforms : Arrow and AstroBus SE**
  - Central OBC with centralized STR and GNSS processing
    + Mission/payload computer for EO
  - Partial redundancy
  - CAN, SpW, Wizard and optical high speed links
  - Commercial technologies : ARM (R5, A9), Linux
  - Automotive/COTS EEE

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Main Expected DHS evolutions in space programs

Institutional Earth Observation & Exploration

- Significant **data throughput increase** at Instrument interface
  - ►Generalization of optical fibre links
  - ►Larger mass memories
- Full deployment of **ESA standardization** initiatives (SAVOIR, Generic OIRD, CCSDS security, ADHA)
- **File based** operations for platforms and payloads

- But :
  - Hirel EEE to be still required by a majority of programs
  - On-board autonomy still limited (downlink management mainly)

Commercial Earth Observation

- More autonomy. Reduced end-to-end **operations cost**
- **Faster data** delivery from orbit to end user
- And even more :
  - On-board data reduction / processing
  - Permanent access. Up/downlink via relays and/or comms LEO constellations
  - New operations paradigms (user apps up/downloads)

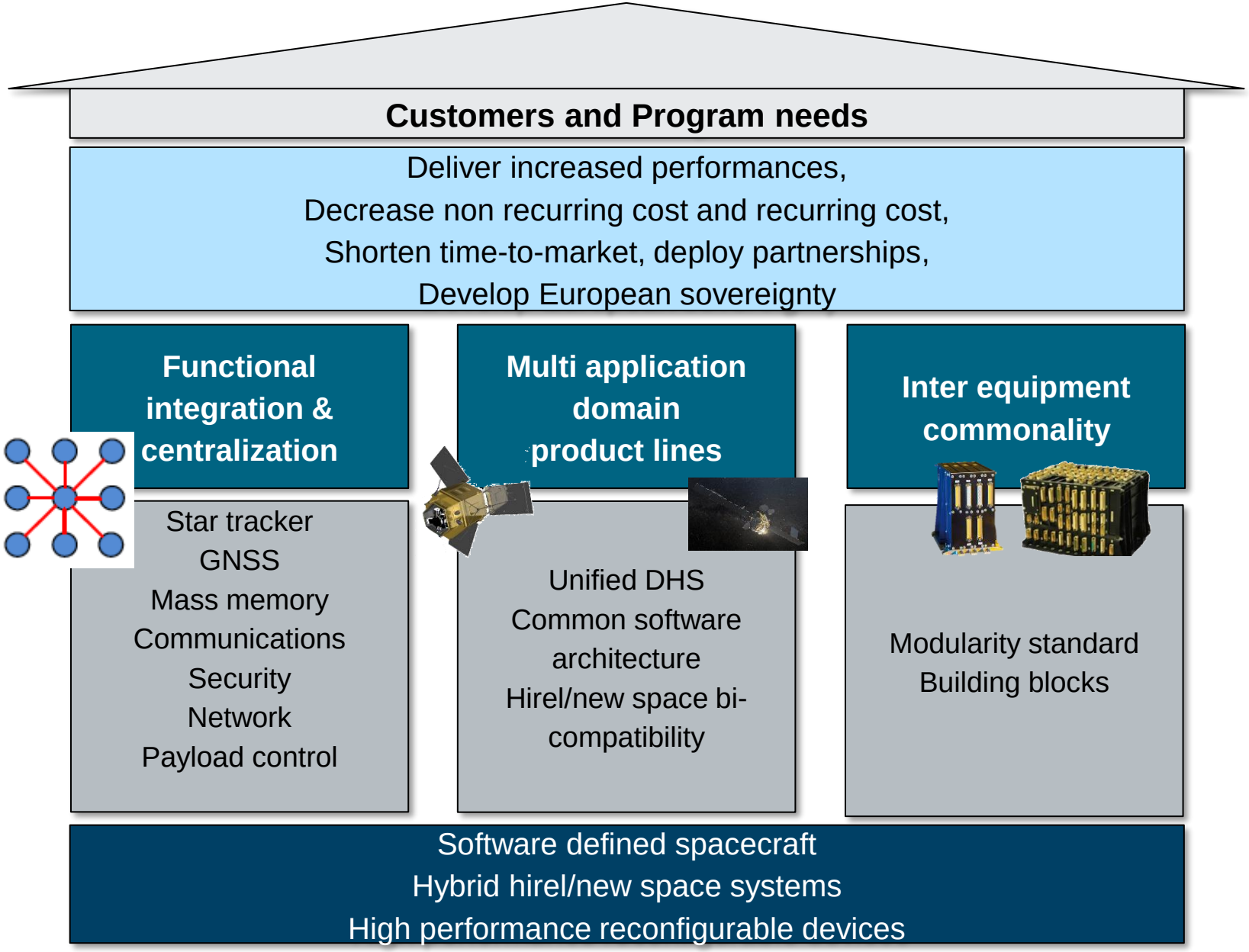
Telecom and Navigation

- Platform hardware cost reduction. Generalization of **“new space high quality”** components on large spacecraft as well
- High performance digital payload interfacing using **commercial IT communication standards** (Ethernet, IP,…)
- **Dependability** (service interrupt minimization)
- **Security** certification according to Ground IT frameworks

Other generic evolutions

- In-orbit **software maintenance and upgrade**, including FPGA bitstreams
  - ►Processing unit architecture impact
  - ►increased uplink data rate
- More stringent Space/Ground security
- Increased number of **situational awareness** units to interface (incl. image analysis, compression, downlink)
- Reinforce **European sovereignty**

Multi-dimension DHS roadmap



Based on 3 pillars :

Centralization

Multi-application domain

Inter equipment commonality

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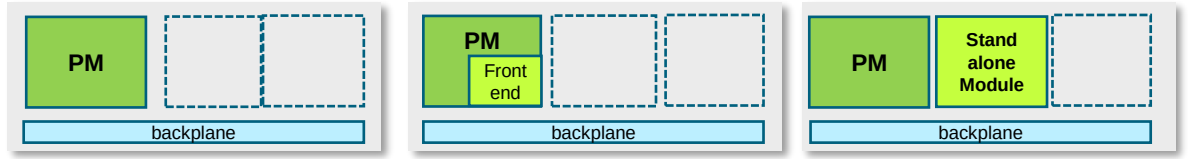
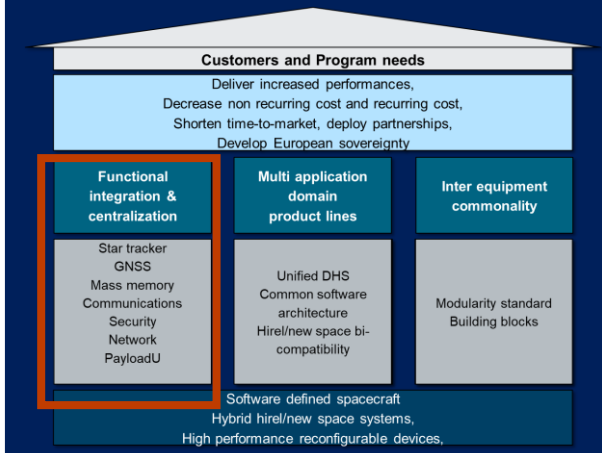
Functional Integration & Centralization



Function	Full centralization	Full centralization with front-end	Mild centralization
	Function runs in **central processing module**	Add'l **specific front-end** required	Add'l **Standalone** module
GNSS		●	●
Star Tracker	●		
Mass memory	●		●
Comms			●
Security	●		●
On-board network		●	●
Discrete I/O (RIU)			●
Payload cmd/ctl		●	●
Payload processing	●		●



Pillar #1

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Unified Design

Align key principles

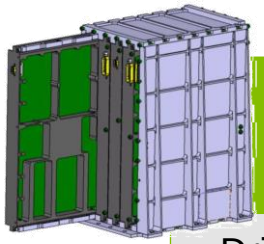
- Processing core selection,
- Unified functional breakdown,
- Data comm architecture
- Reference ops concept
- Reconfiguration strategy
- File-based operations
- Modelling approach

Deploy common SW architecture

- Exec PF SW/ App SW interfaces
- Single middleware
- Automate generation
- Database
- Validation bench

Define Hirel/COTS bi-compatible building blocks

- Smart EEE selection



OBC-Ultra

Classical programs (one-offs, small series)

- Driven by **non recurring cost per project**
- Step-by-step catalogue growth project after project

➔ **Generic standard architecture (ADHA) and physical modularity**

- But : not fully mass/power/volume optimized

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Constellations (large series)

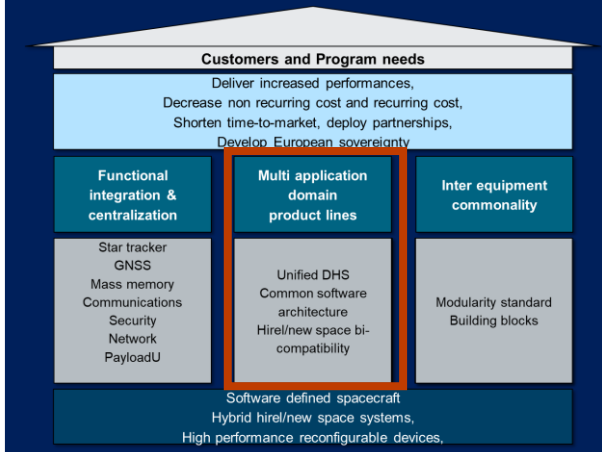
OBC for Constellations

- Driven by **recurring cost**
- Significant specific dev cost can be considered when amortized
- Mass/power/volume optimized

➔ **Generic standard architecture with Physical modularity tailored to a few variability points**

Comm EO | Telecom | Navigation

Multi application domain product lines



EO, Science, Exploration
Telecom
Navigation

Pillar #2

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Building blocks

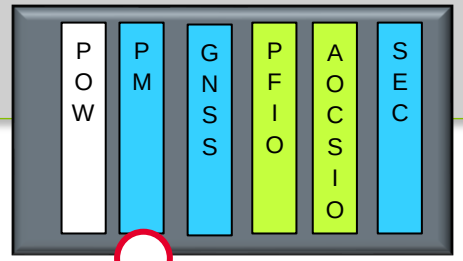
- Processing Module (PM)
- Central power Module
- High speed processing Module
- Discrete I/O modules
- Modular rack
- TBD

Middleware

Numerical simulator

DHS Central Unit

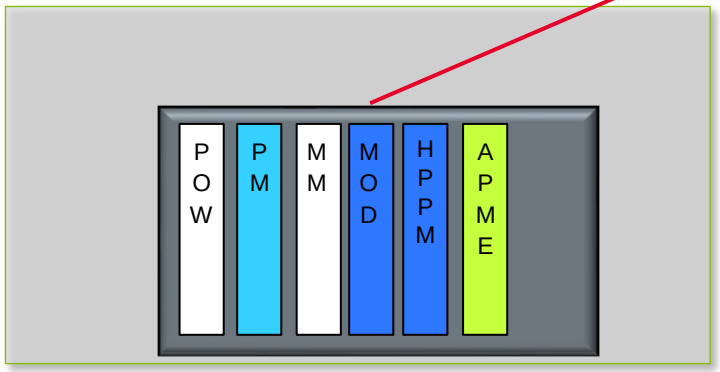
Generic PM for :
Central OBC function
Security function
Discrete I/O subset



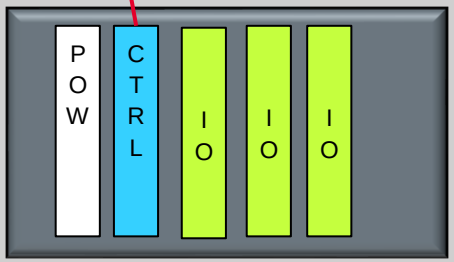
PM Customization via i/f mezzanines

High speed network

Mass memories and Payload management units

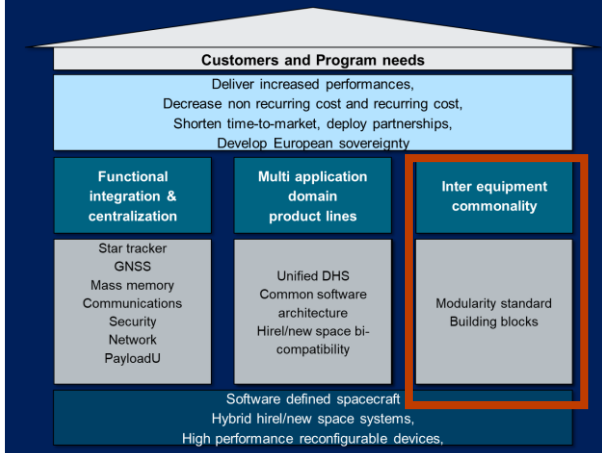


Example of Remote Interface Unit :



Decentralized units

Intra DHS synergies



Pillar #3

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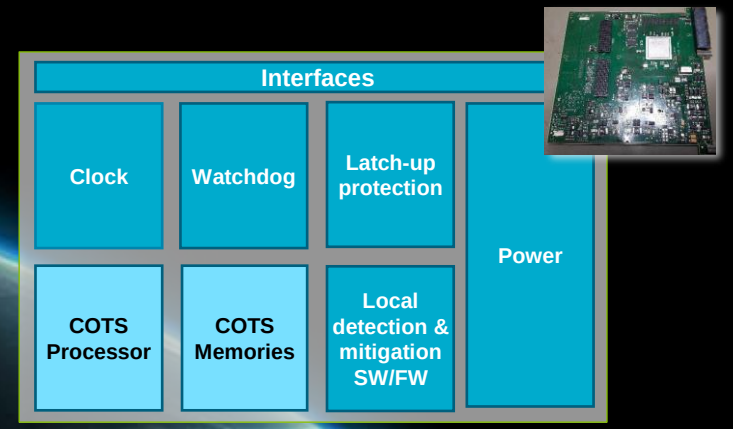
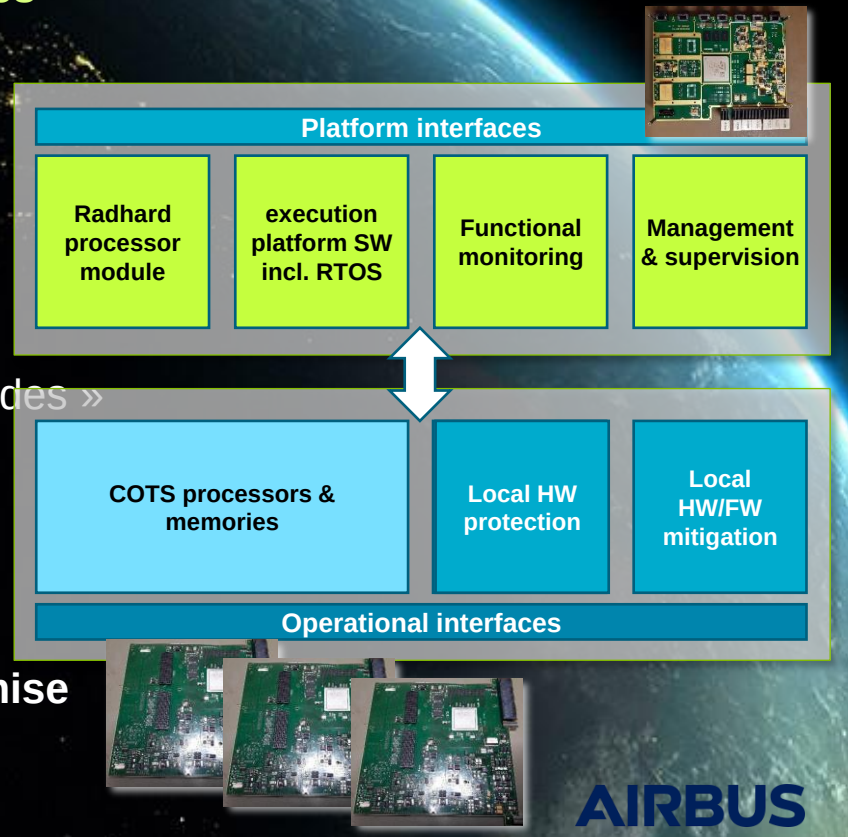
Technological enabler #1 : Hybrid hirel/COTS DHS systems

- **Electronic module level ➔ usual space design techniques**
  - To accommodate COTS components on flight designs (mostly for perf reasons)
  - HW level : detect/correct memory errors, avoid destructive HW effects,…
  - Low level FW/SW mitigation techniques : local triple modular redundancy, local fault symptom monitoring,…



- **Unit/DHS level ➔ Independent supervisor based failure mitigation architectures**
  - Principle : a Hirel/rad hard function monitors/manages a COTS implemented one
  - Initially for highly safe systems now to increase availability of COTS based systems
    - Minimise end-user operational service interrupt delays **: accurate detection** with independent functional monitoring
    - **Safer critical modes** (e.g. initialisation, reprogramming, maintenance) : minimise functional interrupt probability
    - Provide **software diversity** : minimise software execution platform « common modes » e.g. RTEMS module + Linux module
  - Can be adapted to requested fault tolerance levels (graceful degradation, FO, FO/FS,…)



- **Characterization of failure modes effects is key to select the best compromise**

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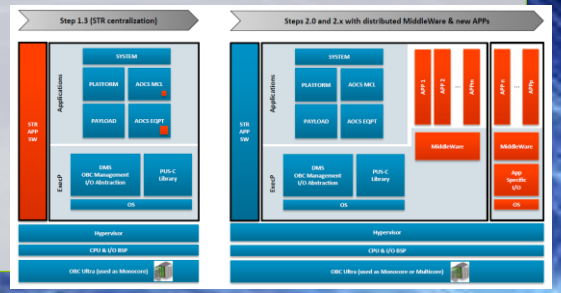
Technological enabler #2 : European sovereignty challenges in DHS area

Design tool suite for European MPSoC

- More efficient resource usage
- Constraint-based place & route for complex incremental designs
- Time driven design support
- In combination with other FPGA-agnostic commercial tools

MPSoC SW ecosystem

- Complete qualification of basic elements : hypervisor, SW development invironment, boot SW
- Improve multicore support (SMP)



Next gen MPSoC

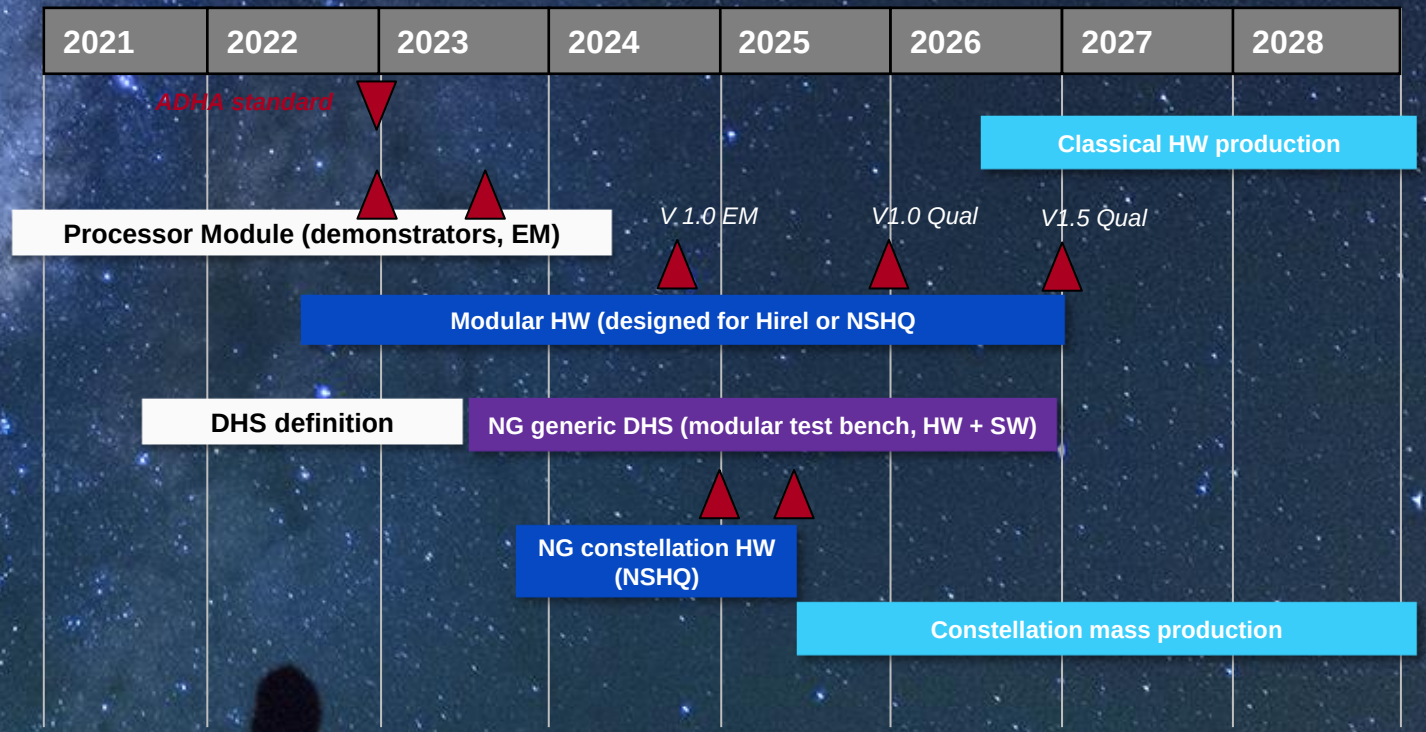
- MPSoC architecture for the end of the decade
- Processing cores selection strategy to be defined
- Could feature more hardwired general purpose functions than current NG-Ultra ➔ to make appropriation by space industry easier)
- European space-compatible industrial flow (7nm and below) to be set up

Integrated power supply elements

- Power cell elements
  - Central DHS racks up to 250 W range (ADHA)
- Point-of-load regulators
  - GaN technology to supply MPSoCs
  - Fully European supply chain still to be developed
- Useful for both full Hirel and hybrid digital architectures

Conclusion and perspectives

- Cross domain **unified product lines** well underway at Airbus
- Latest European technologies make « Hirel space world » and « commercial/constellation space world » unification possible and affordable
- ESA modularity standard (**ADHA**) will shape future DHS equipment product lines
- European technology next steps :
  - Institutional & industry collaboration to be continued to reach full maturity
  - Next gen of European highly integrated devices to be initiated



Next gen Unified DHS development schedule targets

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