european space technology harmonisation

Industrial Policy Committee - THAG

AVIONICS EMBEDDED SYSTEMS

Roadmap Issue 4 rev. 2 draft

(adapted for ADCSS2021)

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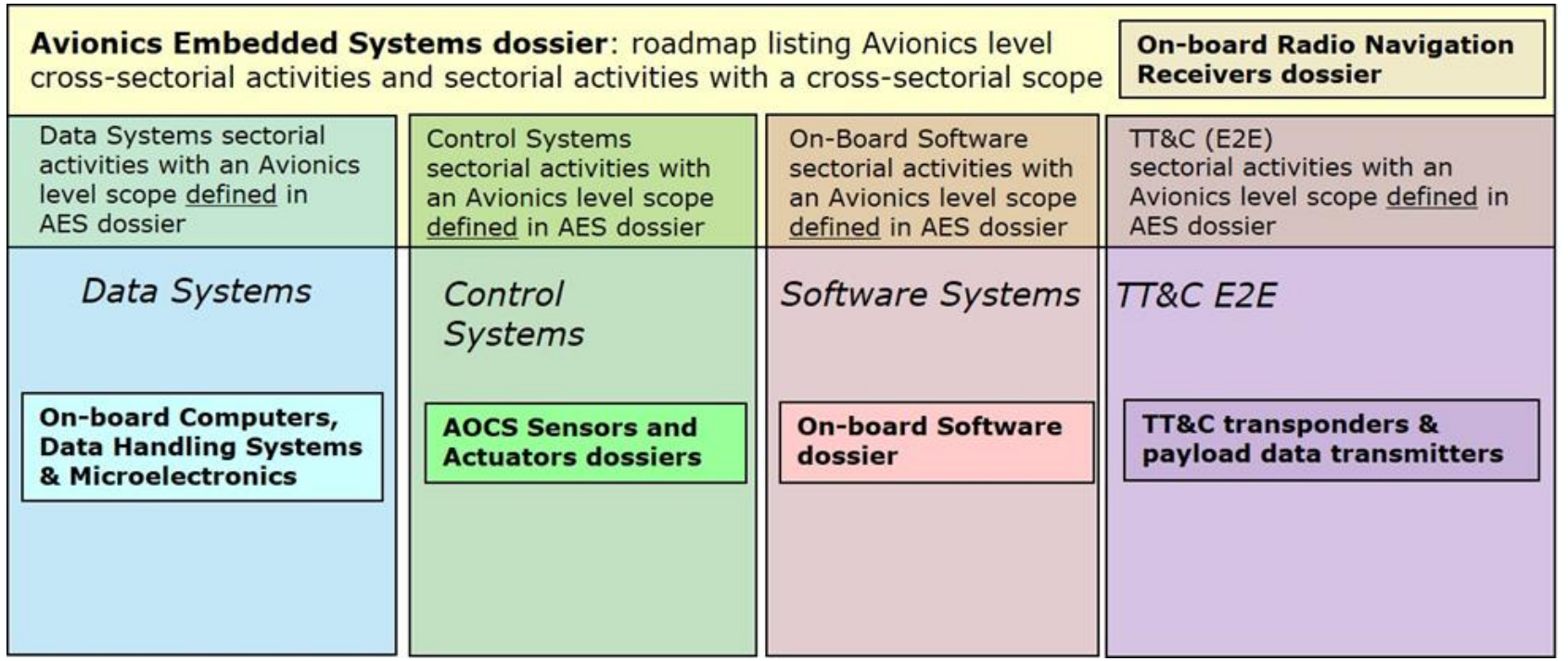
REFERENCE: ESA-TECH-HO- 022126

Technologies Covered



Avionics System functions

o/b communication
o/b autonomy
FDIR
Operability
AOCS/GNC
Space Ground data links
Security
Smallsats

Architecture & Interface

Integrated Modular Avionics
Distributed architecture
COTS enabled systems

Development process

Model based avionics
Advanced control techniques for AOCS/GNC
Evolvable/reconfigurable avionics systems
Avionics verification and validation

Key Issues

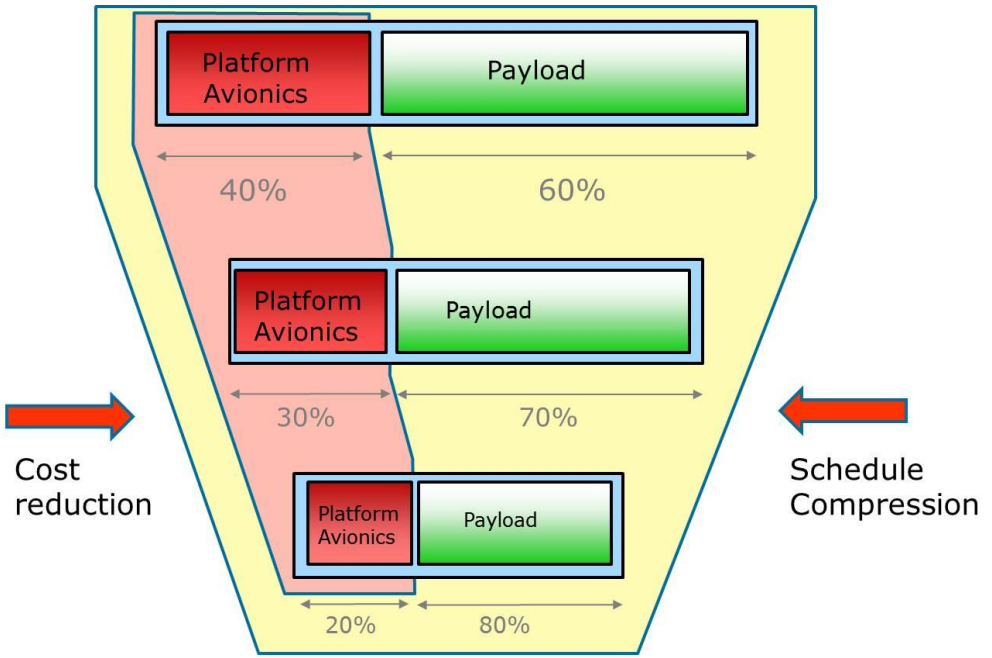
FULFILLING REQUIREMENTS OF HIGH DEMANDING MISSIONS The needs include a higher degree of autonomy, higher on-board data transfer and storage capabilities, high performance real time sensing, and therefore new processors and different software, reliable network, (smart) sensors, cameras, more powerful downlink and uplink.

OBSOLESCENCE and evolution of technologies, in particular for EEE components: the architecture must be adapted to the available components.

“BIG-DATA” challenge starts on-board, by applying a first level of analysis, selection, computation and storage before downlink.

DETERMINISTIC PROTOCOLS multiplexed with asynchronous ones for high data rate transfers.

Impact on the Data Handling system of the COLLISION AVOIDANCE reliability and safe disposal.



More budget dedicated to the actual mission needs implemented by the payload, while decreasing the “infrastructure” cost of the platform.

European Players and Products

It is not possible to list all the avionics players in Europe.

There are generic platforms that the Primes have prepared in the scope of their product lines

There are numerous avionics equipment.

See the respective dossiers:

[AOCSSA] – TECHNOLOGY HARMONISATION DOSSIER - AOCS SENSORS AND ACTUATORS - ESA/IPC/THAG(2020)3

[OBSW] – TECHNOLOGY HARMONISATION DOSSIER - ON-BOARD SOFTWARE - ESA/IPC/THAG(2020)4

[TTPDT] – TECHNOLOGY HARMONISATION DOSSIER - TT&C TRANSPONDERS AND PAYLOAD DATA TRANSMITTERS - ESA/IPC/THAG(2020)12

[OBCDHM] – TECHNOLOGY HARMONISATION DOSSIER - ON-BOARD COMPUTERS, DATA HANDLING SYSTEMS AND MICROELECTRONICS - ESA/IPC/THAG(2021)5

[OBRNR] – TECHNOLOGY HARMONISATION DOSSIER - ON-BOARD RADIO NAVIGATION RECEIVERS - ESA/IPC/THAG(2019)10

Competitiveness and Benchmarking

Specific discipline status can be found in the relevant technical dossiers [AOCSSA], [OBSW], [TTPDT], [OBCDHM], [OBRNR]

Mission Needs and Market Perspectives

Function / Requirement	Characteristics / Mission Drivers for Avionics Embedded Systems					
	Telecom	**Earth Observation**	**Navigation**	**Science (Astronomy)**	**Exploration (robotics)**	**Launchers**
Command & Control (including TM/TC)	TM : low TC : low Monitoring: O(100 kbps) Security req's	TM: low to high TC: low Monitoring: O(100 kbps) Security req's Data relay satellite TM/TC	TM: low TC: low Monitoring: O(100 kbps) Security driven	TM: low / medium TC: low Monitoring: O(100 kbps) On-board automated commanding	TM: low/medium TC: low Monitoring: O(100 kbps) Adaptive, on-board automated commanding	TM: high TC: very low Monitoring: O( )
Autonomy	Low for GEO (permanent link) automated on-board plan execution; autonomy for electric propulsion	New requirements for operational/commercial missions	Survival. Autonomy is important for electric propulsion orbit transfer	No visibility periods, comms delay, mission dependent On-board automated commanding	No visibility periods, high availability autonomous phases; with specific cases for rovers	New requirements to come from future reusable launcher.
FDIR	FDIR driven by quasi-permanent availability	FDIR driven by reliability, availability (for operational programs) and autonomy.	At the constellation level	FDIR driven by reliability and robustness, as well as availability in some cases.	FDIR driven by reliability and robustness, as well as availability in some cases.	Reliable FO/FS High reliability Fault tolerant Guidance and Control
AOCS / GNC	Permanent pointing Higher accuracy for multi-beam Ka missions Orbit transfer management	Pointing accuracy, stability and agility, mission dependent	Medium accuracy pointing	Pointing accuracy, stability, mission dependent	Autonomous rendez-vous and docking; safe precision Entry Descent and Landing	Improved navigation Missionisation
Data Management • **Data Processing** • **Data storage** • **Data transmission**	Platform CC: <100 Mips Data storage: mainly safeguard Data transmission: tbc	Platform CC: <100 Mips Data storage: up to terabits (PL) Data downlink; up to gigabit (specific case) P/L High data processing performance O(1 GFlops)	Platform CC: <100 Mips Data storage: mainly safeguard Data transmission: Tbc	Platform CC: <100 Mips Data storage: up to terabits (PL) Data transmission and downlink; up to 10 Mbps P/L High data processing performance O(500 MFlops)	Platform CC < 100 Mips Data storage O(100 Gigabits) Data downlink Up to 10 Mbps	TM buffer for later downlink of health data
Cost reductions for mission product and Operations	Increased on-board autonomy (automated on-board plan execution; predictive maintenance)	Increased on-board autonomy; Automated file transfer	Increased on-board autonomy	Increased on-board autonomy; Automated file transfer	Increased on-board autonomy; Automated file transfer	Reduction of exploitation costs
Reliability, availability and Safety	Reliability driven (long duration operation, end of life deorbiting), short outage (few minutes)	Mainly Reliability driven. Sometimes also availability (meteorological)	Reliability/Availability (taking into account Satellite level redundancy) Certification	Reliability driven + some high availability phases	Reliability driven + some high availability phases	Availability/ Safety

European Strategic Interest

The following high level European strategic needs can be identified:

To reduce schedule and costs for the development of AES for the operational and commercial missions, e.g. earth observation, navigation and telecom missions.

To enable future missions by providing mature and independent European on-board AES technologies that will support enhanced functionality/performance and reliability as required e.g. for planetary exploration and reusable launchers, at affordable costs.

To strengthen the competitiveness of European space industry and establish synergies to the non-space sectors where Embedded Systems technologies are thriving.

To ensure European technology non-dependence in this domain by supporting and maintaining the building blocks technologies required to meet the needs of future AES.

➔ Steered by SAVOIR

SAVOIR

Software reference architecture

Time and Space Partitioning **Finalised**

Sensor/Actuator Electrical interface **Finalised**

Sensor/Actuator Functional Interface **Finalised**

MAss Storage Access Interfaces and Services Finalised

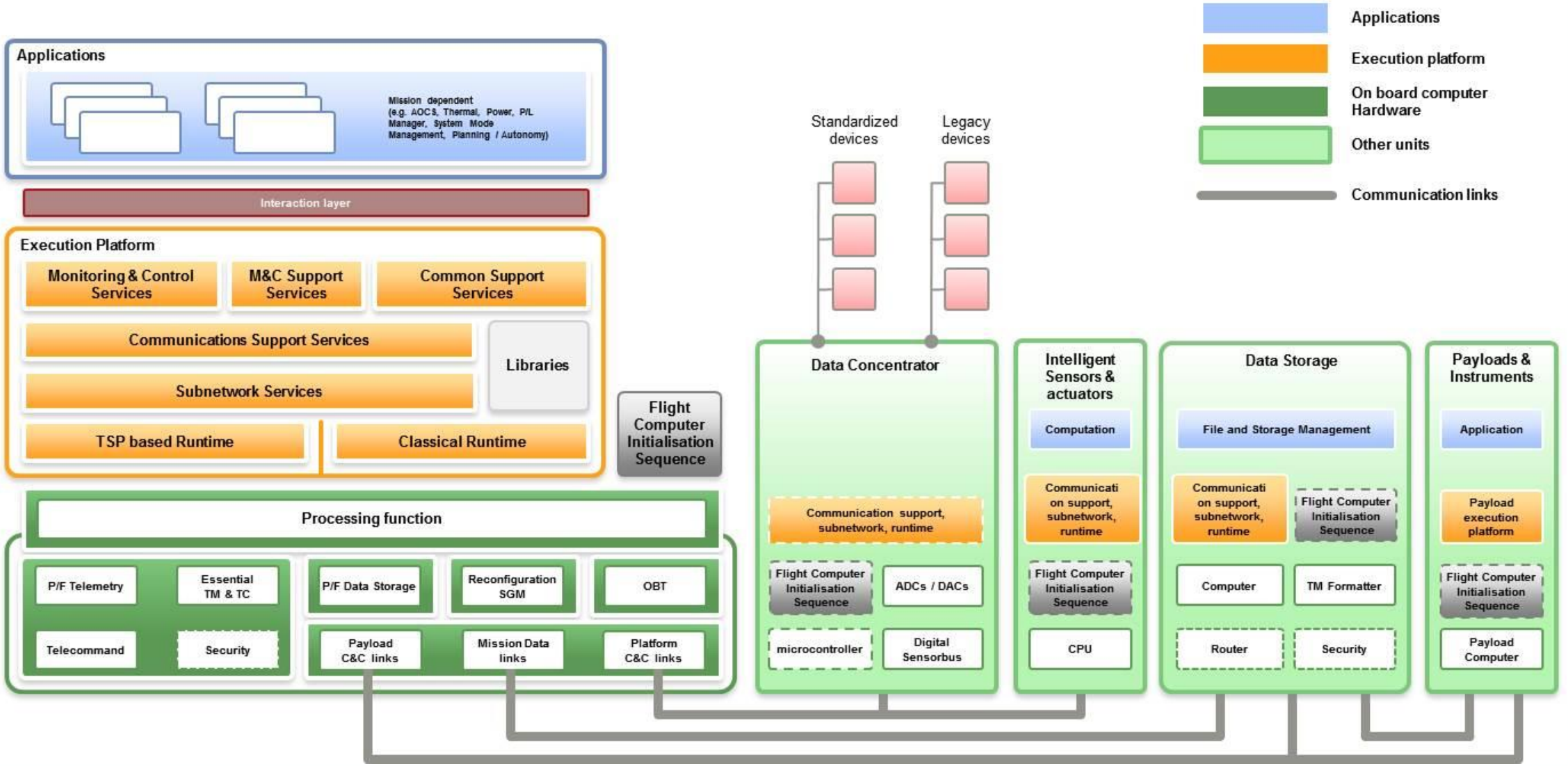
Functional links Finalised

Fault Detection, Isolation, Recovery Finalised, starting version 2

Automatic code generation Finalised

Avionics Power interface New

SAVOIR Reference Architecture



Recap of Mapping Meeting

- **Electronic Data Sheets** (EDS) are relevant for several Harmonisation topics (e.g. AVES, Model Base 4 System Engineering). The interface has not yet been defined, but EDS should be used to define mode-based interface. EDS, most probably, will at some point transition from avionics to systems, also because its scope will be enlarged beyond avionics, e.g. mechanics
- Automation of system processes shall be further analysed as proposed, in particular in the scope of **model based**, the importance of which has been mentioned by several Delegations, e.g. for trade-off between space and ground.
- **AI** appeared in many presentation. It has been recognised as important. Aspects related to **on-board AI** are addressed in the On-Board Software and On-Board Computers, Data Handling Systems and Microelectronics topics.
- Push for **micro-satellites** has been recognised by the Executive, who invited in particular the FR companies to put forward their needs towards nano-sats. This topic will be discussed again in SAVOIR.
- Aspects related to Innovation and Spin-in (for example, drones and new-space) will be evaluated.
- A need for **reprogrammable cryptography algorithms** has been confirmed.
- The importance of the notion of functional architecture is recognised. It is related to the avionics validation and the model philosophy, the proposed topic of "**design to validation**" will be addressed in SAVOIR (including in relation with AOCS/GNC) and impacts reuse and product lines.

Proposed Development Approach

AIM A: Develop Avionic Systems Architectures and Building Blocks

- **Reference Architectures**
- **Interface**
- **Communication network**
- **Integrated Modular Avionics**
- **COTS enabled systems**

AIM B: Pre- Development and Maturation of Advanced Functions

- **Autonomous Functions**
- **FDIR/RAMS**
- **Evolvable/Reconfigurable H/W and system**
- **Operability**
- **Security**
- **AOCS/GNC/Control techniques**

AIM C: Improve the Avionics Development Processes Methods and Tools

- Model-Based (Avionics) Systems Engineering
- Hardware/Software Co-design
- Avionics verification & validation
- Avionics Test Means

AIM D: Develop Technology Demonstrators / Pilot Applications

Conclusions

- This dossier addresses the common system elements of the sectorial data, control, TT&C, and software systems.
- Some key issues are to fulfill the requirements of high demanding missions, and to manage product lines to reduce non recurring costs.
- The strategic European interest is to reduce schedule and costs, to enable future missions, to strengthen the competitiveness and to ensure European technology non-dependence.
- SAVOIR is the reference for the activities and act as a continuous harmonization process to steer the technologies
- Model based avionics engineering is a key to benefit from the configurability of FPGAs

Thank you for your attention