AVIONICS EMBEDDED SYSTEMS

Roadmap Issue 4 rev. 2 draft
(adapted for ADCSS2021)

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Technologies Covered

### Avionics Embedded Systems dossier
- Data Systems sectorial activities with an Avionics level scope defined in AES dossier
- Control Systems sectorial activities with an Avionics level scope defined in AES dossier
- Software Systems sectorial activities with an Avionics level scope defined in AES dossier
- On-Board Software sectorial activities with an Avionics level scope defined in AES dossier
- TT&C (E2E) sectorial activities with an Avionics level scope defined in AES dossier

### 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:


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


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

<table>
<thead>
<tr>
<th>Telecom</th>
<th>Earth Observation</th>
<th>Navigation</th>
<th>Science (Astronomy)</th>
<th>Exploration (robotics)</th>
<th>Launchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC: low</td>
<td>TC: very low</td>
<td>TC: low</td>
<td>TC: low</td>
<td>TC: low</td>
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<td>O(100 kbps)</td>
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<tr>
<td>Data relay satellite TM/TC</td>
<td>On-board automated commanding</td>
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#### Command & Control (including TM/TC)

- TM: low
- TC: low
- Monitoring: O(100 kbps)
- Security req's
- Data relay satellite TM/TC

#### 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, comm. delay, mission dependent
- On-board automated commanding

#### 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 FDIR Fault tolerant Guidance and Control

#### AOCS / GNC

- Permanent pointing
- Higher accuracy for multi-beam Ka missions
- Orbit transfer management
- Platform CC: <100 Mips
- Data storage: mainly safeguards
- Data transmission: tbc
- Platform CC: <100 Mbps
- Data storage: up to terabits (PL)
- Data downlink: up to gigabit (specific case)
- PL, High data processing performance O(1 GFlops)
- Platform CC: <100 Mbps
- Data storage: up to terabits (PL)
- Data transmission and downlink: up to 10 Mbps
- PL, High data processing performance (1 GFlops)
- Platform CC: <100 Mbps
- Data storage O(100 Gigabits)
- Data downlink Up to 10 Mbps
- TM buffer for later downlink of health data

#### Data Management

- Data Processing
- Data storage
- Data transmission

#### 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; 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