On-Board Data Systems

Ph. Armbruster TEC-ED
Email: philippe.armbruster@esa.int
Avionics for multi-mission platforms, hard Facts

- Avionics take an important share of the platform cost
- Many building blocks have a high potential for a recurrent use (especially processor modules, I/Os) provided that:
  - Their development and procurement is performed at program level (not at project level)
  - They are compatible with an open system architecture capable of following technology evolution based on well accepted international standards
- Power and mass minimization are strong constraints
- Avionics are to a large extent independent of the platform structure of the S/C
- Harness minimisation and its control during project advancement is in some cases an important issue.
Future Needs

- Accommodate high resolution instruments: high data rate communication (on-board and TM), high capacity mass memories and high performance on-board processing capability
- Accommodate a set (suite) of very different instruments
- On-board intelligence/autonomy for exploration missions
- Constrained costs (with additional performance and complexity)
Data Systems: cost reduction

- System development cost
  - Standardize the system
  - Define an innovative development process and life cycle
  - Compose the system from building blocks
  - Anticipate the development of the building blocks

- System cost
  - Lower the cost for space access
  - Launcher enhancement
  - Reusable launcher
  - Reduce dry mass
  - Structure
    - Wireless
  - Power
  - Harness
    - Harness optimization
  - Integrated Avionics
    - Integration technologies
    - New processor technologies
  - Enhanced propulsion
  - Enhanced FDIR
    - Autonomous mission management
  - In-flight reprogrammability
    - Autonomous collaboration between systems

26/04/2007
On-Board Data Systems
## Classification of Data Systems

<table>
<thead>
<tr>
<th>System Type</th>
<th>Life Time in Safety Mode</th>
<th>Interruption of Service</th>
<th>Error Detection Coverage</th>
<th>Survival Mode at System Level</th>
<th>Ground Intervention</th>
<th>Future Use</th>
<th>CPU</th>
<th>SW</th>
<th>Used for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Oriented System</td>
<td>10 years</td>
<td>1 second</td>
<td>100%</td>
<td>Full Segregation</td>
<td>Ground intervention not allowed</td>
<td>Safety chain CPU is 1750, Safety chain SW is 512 KB, System chain CPU is ERC32, System chain SW is 4 MB, Used in ATV, ISS</td>
<td>Future use: FLPP, CTV</td>
<td></td>
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</tr>
<tr>
<td>Availability Oriented System</td>
<td>Few hours or days</td>
<td>10 ms</td>
<td>100%</td>
<td>No Survival Mode at System Level</td>
<td>Ground intervention is not possible</td>
<td>CPU is 1750 or ERC32, SW is 4 MB, Not used</td>
<td>Future use: Science and as system chain of safety oriented systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability Oriented System</td>
<td>15 years in orbit</td>
<td>1 minute</td>
<td>90%</td>
<td>Survival Mode at System Level</td>
<td>Ground intervention always possible</td>
<td>CPU is 1750 or ERC32, SW is 4 MB, Used: EO, Telecom</td>
<td>Future use: Science and Next generation on Leon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Technology Oriented System</td>
<td>3 years</td>
<td>Allowed</td>
<td>90%</td>
<td>Switch payload to safe state when error</td>
<td>Ground intervention always required</td>
<td>CPU is ERC32, SW is more than 4 MB, Used: payload for ISS</td>
<td>Future use: Science, Next generation: Leon, PPC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Oriented System</td>
<td>3 years</td>
<td>Allowed</td>
<td>80%</td>
<td>Robust Survival Mode at System Level</td>
<td>Ground intervention always required</td>
<td>CPU is 1750, SW is 512 KB, Used: specific</td>
<td>Next generation: Leon, PPC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
System classification and system architectural design

- Two complementary architectural options:
  - Highly Integrated Control and Data Systems, for small spacecraft Avionics
  - Distributed data and control systems, for medium to large satellites embedding demanding payloads in terms of on-board data processing.

- The two approaches share common building blocks and technologies (Processors, ASICs, Bus and network interfaces, microelectronics devices)
  - Can be made modular and scalable (on-board computers, mass memories)
  - Gap between platform Data Systems and Payload Data processing systems can be bridged (e.g. Astrium Unionics)

- Fault tolerance, Harness minimization, hierarchical networks, standardized interfaces and services (at HW and SW) are systematic objectives underlying all R&D activities in the field of data systems.
Avionics for multi-mission platforms

Platform I/O

Communication with surface element

An example: HICDS extension for Aurora

26/04/2007

On-Board Data Systems
Data Handling systems

Payload Data Handling and Processing systems strategy based on a distributed approach, on-board hierarchical networks (SpaceWire, CAN, sensor bus) and a cautious integration of COTS based functions.

- Memory Module
  - Memory banks
  - Context Saving Memory
- Data Compression Module
- Telemetry Formatter/Encryption Module
- Control Processor module
- Dedicated Processor module
- DSP Processor module
- Spacecraft control bus
- SpaceWire links
- Control bus/line

Notations:
- Modules based on Hi-Rel components
- Modules based on COTS
- Optional Module

Instruments:
- Instrument
- Instrument
- Complex Instrument
- Instrument

Other components:
- HIVAC
- CCD/APS Camera
- RTC
- CAN bus
- optional DPU
TopNet: Pilot activity, decentralised integration

Involvement of different actors (industry, university, agency) in a pilot activity for decentralized integration of SpW-based data handling sub-systems that are geographically separated.