Integrated Modular Avionics

The way ahead for aircraft computing platforms?
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The Need
The need for IMA

- Federated Avionics view of the world

Diagram:

- Flight Deck Control and Display Devices for System 1
- LRU-1 (Dedicated)
- Equipment Under Control

- Flight Deck Control and Display Devices for System 2
- LRU-X
- Equipment Under Control

- Flight Deck Control and Display Devices for System n

Diagram by Silver Software
The need for IMA

◆ Federated Avionics

- Each supplier generally has proprietary hardware (LRU) increasing cost of supply/repair chain and aircraft weight
- All software in a LRU/card must be developed to the same DO-178B safety level even, if this is not strictly necessary from a SHA viewpoint, and is dedicated to that LRU
- If the hardware platform changes the whole product needs to re-verified by licensing authority (JAA – Europe, FAA – USA)
The need for IMA

🔹 Technology Drivers

← Speed of computing has risen dramatically
← Computing platforms/software are a significant cost in modern aircraft development – upwards of 60%
← General commercial trend to open systems
← Desire to use COTS computing platforms
← Desire for reuse where possible
← Desire to restrict re-certification costs due to changes the hardware platform
The need for IMA

IMA – An Answer

- Makes use of spare computing capacity to run multiple independent applications in a central processing network – fewer equipment racks therefore less weight
- Application software is independent of an open architecture core executive – therefore it is platform and location independent
- Application software can be validated independently of the core executive and hardware
- Application software is location independent of the IO (Desirable but not always the case)
The need for IMA

- **IMA view of the world**

  - Flight Deck Control and Display Devices
  - Core Module 1
  - Core Module \( n_p \)
  - AFDX or Ethernet Bus
  - Remote Data Concentrator 1 – Acting as LRU
  - Remote Data Concentrator \( n_{RDC} \)
  - \( LRU_x \)
  - Equipment Under Control
  - Equipment Under Control
The need for IMA - Standards

- ARINC 653 – Avionics Application Software Standard Interface (IMA API Standard) Part 1-3
- ARINC 651 – Design Guidance for Integrated Modular Avionics – Discusses various architectural concepts
- IMA Operating System developed to DO-178B Category A
- Software may be written in either Ada or C
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Structure and Services
IMA – Core Processing
Partitions are highest level of Application Programming

Each partition has its own memory and time slice allocation – these are robustly protected by the O/S

Allocation of resources are agreed between the system integrator (SI) and the function supplier (FS) – The results of which are captured in a configuration table

System integrator has overall responsibility of how resources are divided between FS

Partitions are regularly scheduled
MAF – MAjor Frame – The intrinsic repeat cycle of the Core Module
◆ Application software deals with external data from logical ports only (what the form the transport layer of that data is of no concern of the application)

◆ The configuration table allows physical data to be mapped to/from the logical data but this is done in the core (Via Virtual Links).

◆ Partitions can share IO sources

◆ All IO data that crosses a partition’s boundary becomes external to the Core Module
Internal Services Provided

◆ Multiple Prioritised Processes
   ← Inc 1 Partition Error Handler (Highest Priority process)
◆ Inter-process communications (4 Mechanisms)
◆ Log books & Non Volatile Memory
◆ Exception handling
◆ I/O Resources via API
◆ An Initialisation/Operational mode change
Internal Services Not Provided

- Timer Services
- Interrupts
- Internal memory Control
- Application Error Handling
- All internal items must be developed to the same Software Integrity Level
Designing Using IMA – Timing

- APIs do not provide timing functionality for a partition/processes so this functionality must be provided by the FS
- Designer must understand the how their partitions operate in the context of MIF and MAF to operate timers
- Designers need to be aware of how the refresh rate of data impacts their design, as continuous monitoring is not possible
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Design Using IMA
Design Using IMA - General

- Does not remove from the developers the responsibility of using normal techniques associated with safety critical software.
- Still requires that software is developed in accordance with DO-178B for the appropriate safety category.
- Developers do not need to concern themselves with development of drivers, CLE etc.
- Code must be developed to be portable.
BITE has a hierarchy

An application’s BITE is restricted to the system it monitors/controls

Controlled RDC/LRU have their own low-level BITE

A System BITE correlates faults – normally 1 per application

An application does not perform BITE on the Processor Module resources
Health Monitoring (HM) is provided by the Processor to monitor the Health of the Processing Module’s resources.

HM may monitor BITE output of application partitions to determine its own fault conditions.
Design Using IMA - Concerns

- It does not save us any time?
  - Focus is on the whole lifecycle cost
  - Platform can change without affecting the application
  - Obsolete items do not need to be stored over 30 years (Aircraft design life)
  - Easier to deal with planned obsolescence
  - Fewer spares need to be held by airlines
  - Increases aircraft availability through use of common components.
Design Using IMA - Additional Issues

- Who provides allowance for spare capacity
- Certification based on system certification not generic platforms within the whole aircraft
- Alters the relationship between FS and SI
- Diversity Issues
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Related Subjects
Programmes using IMA

- Airbus A380
- Airbus A330 – Multi-Role Tanker Transport
- Airbus A400-M
- Boeing 777 (MMA made by Honeywell)
- Boeing 787 - Dreamliner
- Boeing 767 Tanker
- C130 (Modernization Program)
- Sikorsky S-92 Helicopter
Other Uses

- Can be used where robust partitioning is important
- Armed Forces – used in partitioning secure systems - Multiple Independent Levels of Security (MILS) – Looking to be used on C130, F22, F35, GPS systems, etc.
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Conclusion
An Avionics Paradigm Shift?
In reality the SI now controls the tools chain – It can therefore save money by doing providing certification evidence for all on the platform

SI should mandate/control common components

To achieve higher savings SI need to analyse whole system to extract out common elements as FS do not see the whole aircraft
IMA - Paradigm Shift?

- Why design software systems so targeted at a perceived system?
- Split systems along SIL lines – Why incorporate low SIL items in with High Integrity Systems?
- Use partitions to create more SIL focused applications – i.e Complexity is the enemy of:
  - Safety
  - Cost
If you always do the same type of thing –
you always get the same type of result
Useful Links

- **www.arinc.com** – ARINC Website
- **http://www.arinc.com/aeec/general_session/gs_reports/2003/presentations/Session%201/03_APEX.pdf** - Presentation on 653 development
- **http://www.ghs.com/** - Greenhills Website
- **http://www.windriver.com/portal/server.pt** - Windriver Website
- **www.avionicsmagazine.com** - publication
References

- ARINC 653 – Avionics Application Software Standard Interface
- ARINC 651 – Design Guidance for Integrated Modular Avionics
- DO-178B/ED-12B – Software Considerations in Airborne Systems and Equipment Certification
- IMA 380 CPIOM User’s Manual and Usage Domain and Definition
- Avionics Magazine®
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