Presented by

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A380 Integrated Modular Avionics

The history, objectives and challenges of the deployment of IMA on A380

Presentation Topics and Scope

- To explain what IMA is and its background
- To explain how IMA has been deployed on the A380
  - ADCN
  - Modules
- The Future of IMA

Why IMA?

- Since the A300
  - Increasing number of software controlled systems
    - New functionality for performance
      - Flight management systems
      - Fuel management systems
    - New functionality for improved safety
      - Flight envelope protection
      - Ground proximity warning
      - Traffic collision avoidance
    - New functionality for improved maintenance
      - Aircraft condition monitoring
    - New functionality for improved passenger comfort
      - Cabin environment control

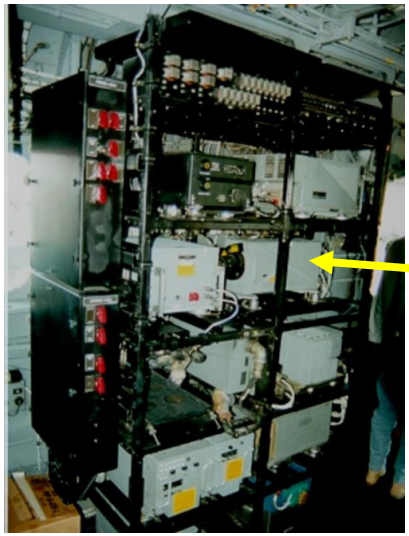
Why IMA?

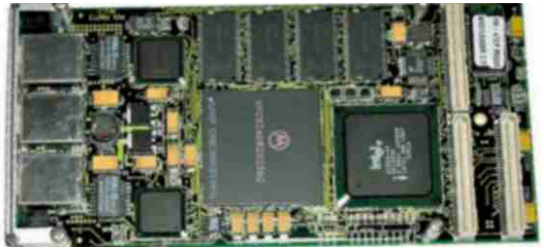
- The Indirect Consequences
  - Every system = 1 or more computers / controllers
  - Every aircraft type = new computers
  - Every computer =
    - Airframer development and management costs
      - Part number costs
      - Documentation
      - More wires
      - More power
      - More sources of unreliability
      - Increased obsolescence risk
    - Airline impact
      - Spares
      - Tooling
      - Increased fault finding

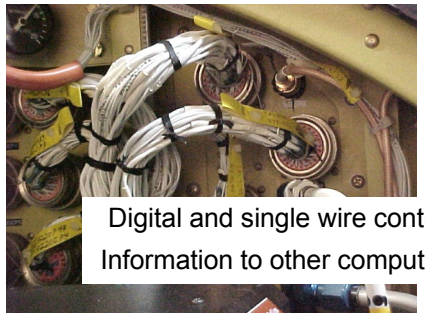
Why IMA? – Traditional LRU

- This implies that quantities of maintenance spares be stored for each fleet at different places.
- During the aircraft life cycle, the cost of modifications, including parts obsolescence mitigation and functional upgrades, becomes even more significant for the airlines.

Why IMA? – Traditional LRU







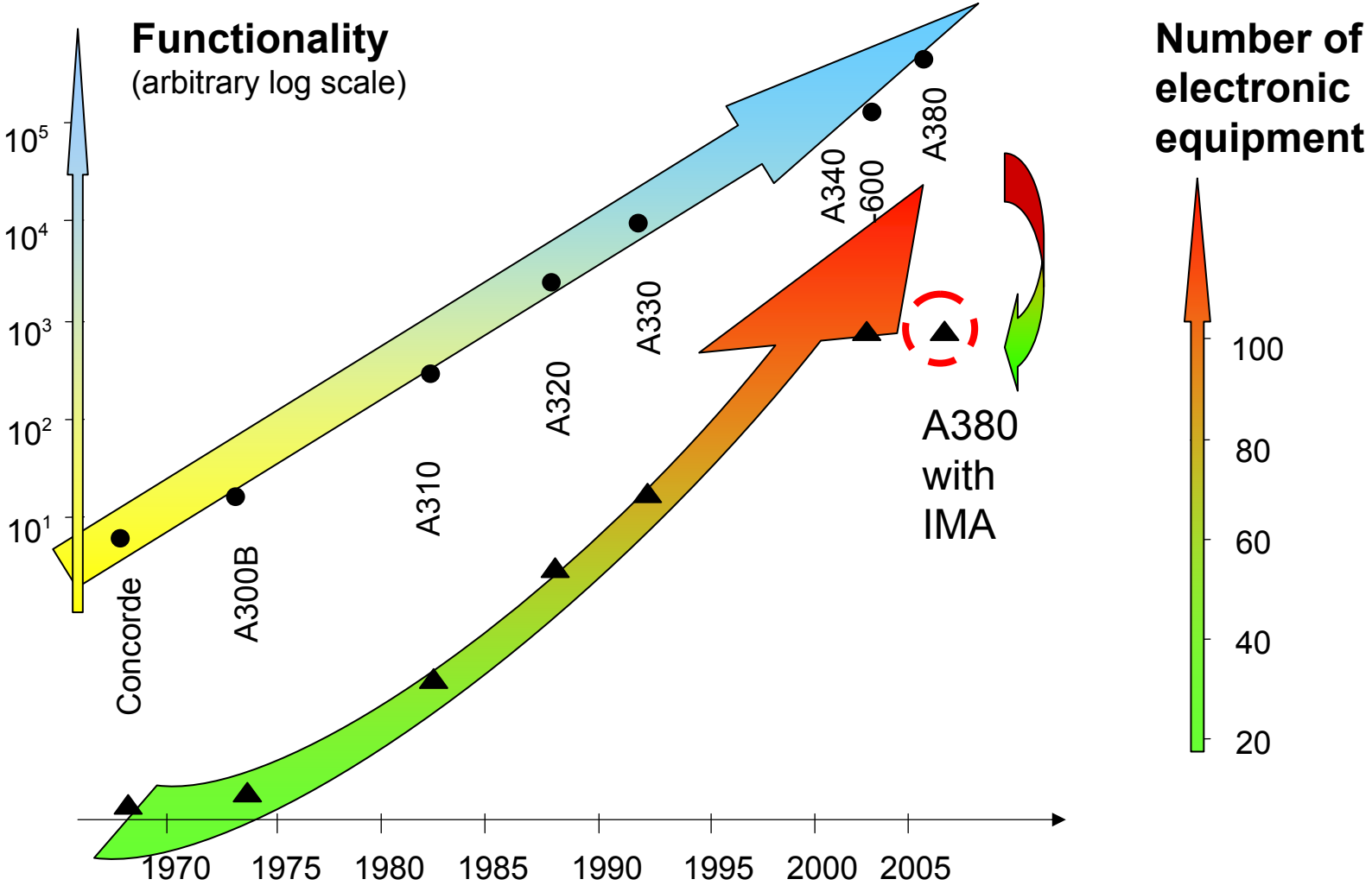
Digital and single wire control
Information to other computers

- Each computer type is uniquely designed for the system and aircraft
  - Application software e.g. fuel control
  - Hardware PCBs
  - Operating System
- Manufactured by system supplier

- Dedicated wiring for each connection
- 100s km cabling per aircraft

Why IMA?

Historical background for the emergence of IMA



Why IMA?

- The response
  - Integrated Modular Avionics
    - Concept
    - Not a specific set of technologies or components
  - Integration =
    - Multiple systems applications executed on the same computer
    - Data communications integrated onto a high speed multiplexed network
  - Modularity =
    - A set of standard non system specific computers
    - Computers that can be configured to provide part of their resources to a particular system application

What is IMA?

- IMA Variations / Proprietary Solutions ?
  - Avionics network
    - ARINC 429
    - ARINC 629
    - AFDX
  - Avionics computers
    - Cabinet of modules, backplane, gateways
      - Honeywell AIMS
    - Cabinet of cards
      - Honeywell Primus EPIC
    - **Independent modules as LRUs**
      - **Honeywell VIA**

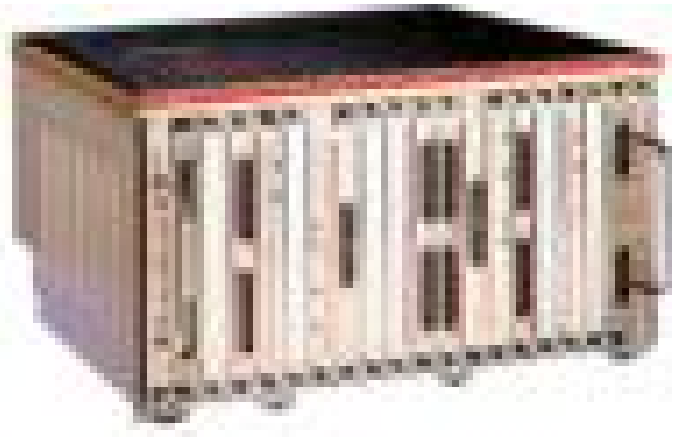
What is IMA?

- Cabinet of modules

- Functionality split between modules:
  - Power Supply Modules, Gateways, Processing, IO
- Inter module communications backplane
- ARINC 653 Operating System
- Originally ARINC 629
- Single supplier …. for everything
- Boeing 777

What is IMA?

- Card File



- Semi open architecture – third party hardware
- Processing, IO and gateway cards
- Proprietary DEOS Operating System
- Proprietary backplane
- Business and Regional Jets
  - Embraer, Raytheon, Dornier

What is IMA?

- Independent Modules as “LRU”

- Derivative of AIMS – repackaging
  - Provides processing, IO and PSU in one package

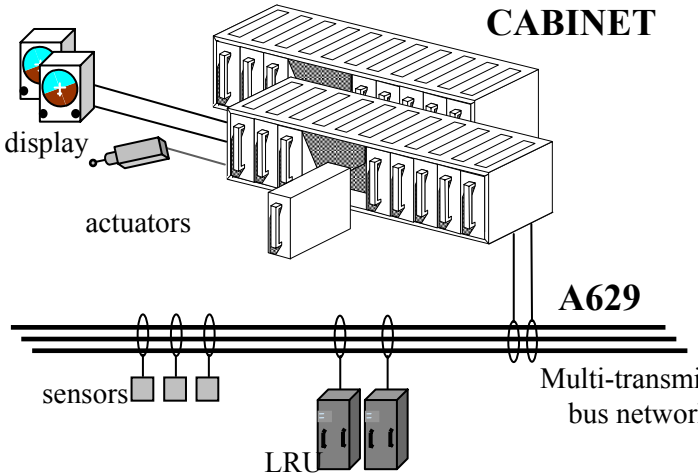
What is A380 IMA?

- Since mid 80s the former Airbus partners have done research on IMA for their systems (PACTS, IDEE3, NEVADA, PAMELA, VICTORIA)
  - With the objective to merge different system design approaches and different procurement approaches
    - Closed loop control systems, data management and processing systems
    - Safety critical and non safety critical
    - Software only functions to full multi-domain systems like fuel
    - Complete design in house, integration of components to fully outsourced

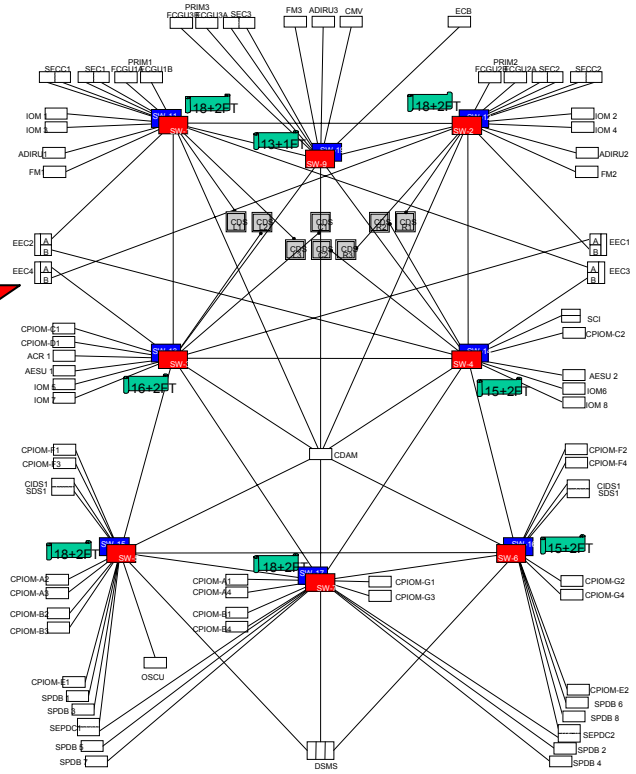
- Therefore the IMA solution had to:
  - Be suitable for different types of systems (I/O needs / Performances / Safety)
  - Be suitable for a large number of systems and their suppliers to allow real competition
  - Compartmentalised to allow parallel developments to be managed

What is A380 IMA?

Integrated Modular Avionics



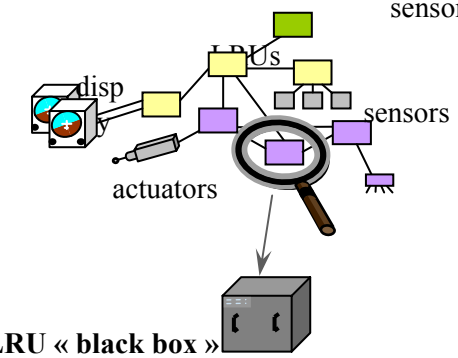
CABINET



MODULE

AFDX NETWORK

« Federated architectures »

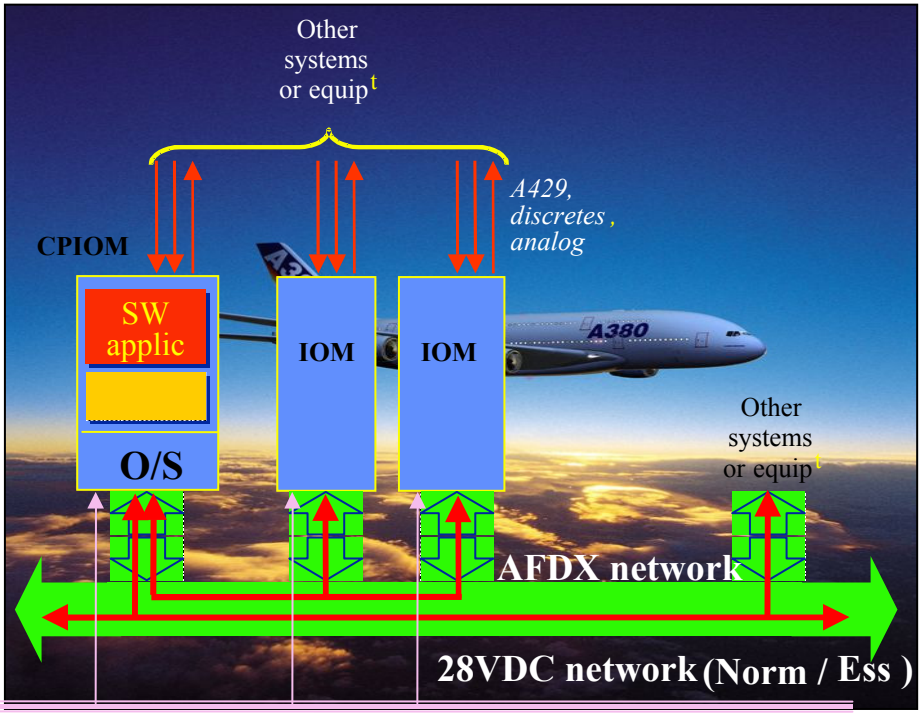


LRU « black box »

CONCEPTS & TECHNOLOGIES EVOLUTIONS

What is A380 IMA? - Airbus Concept

- IMA shared resources are:
  - the avionics communications network: the solution selected is AFDX (Avionics Full Duplex Ethernet), fully compatible with Ethernet network of Open World and based on common switch modules
  - Modules, i.e. Core Processing & Input / Output Modules or CPIOM, Input/ Output Modules or IOM, ,...) for hosting of several applications and signal acquisition/transmission



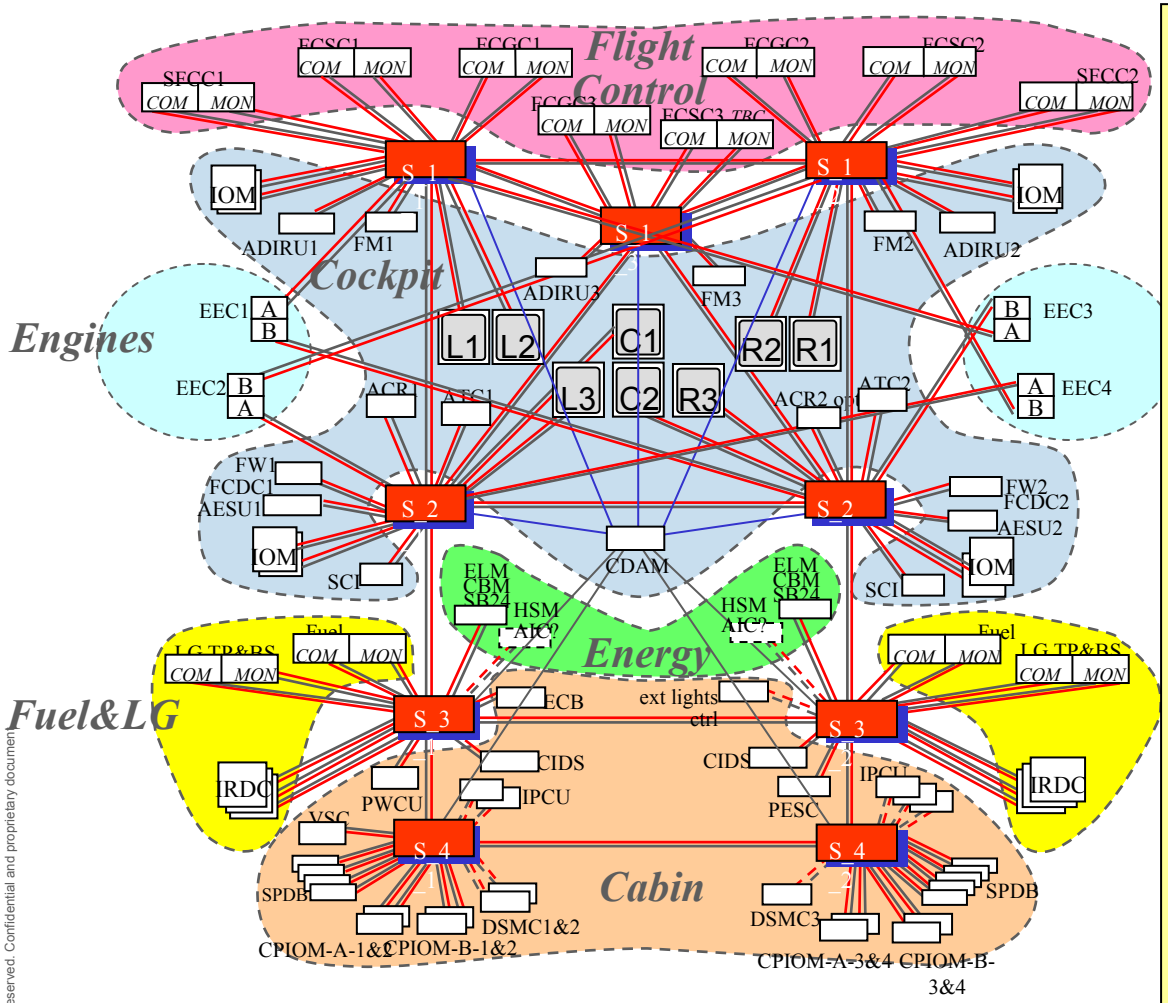
What is A380 IMA? Airbus Concept

- The AIRBUS IMA concept is based on "shared Modules". A module-focused approached has been preferred compared with the previous concept of "Cabinet". Its key features are:
  - ARINC 600 IMA Module packaging connected to AFDX network
  - Robust partitioning in computing resource & communications
  - Determinism of application execution & data exchanges
  - Standardised Application Programming Interface (API) to avoid obsolescence impacts on applications
  - Conventional equipment's mixable

- Resource sharing has a direct impact on the way to design and implement systems since it creates new dependencies between them, both from a technical and a process point of view.

- This concept has been selected as the baseline for systems design on Cockpit, Utility, Energy and Cabin domains and extended globally on all the domains.

What is A380 IMA? - ADCN Network & Topology

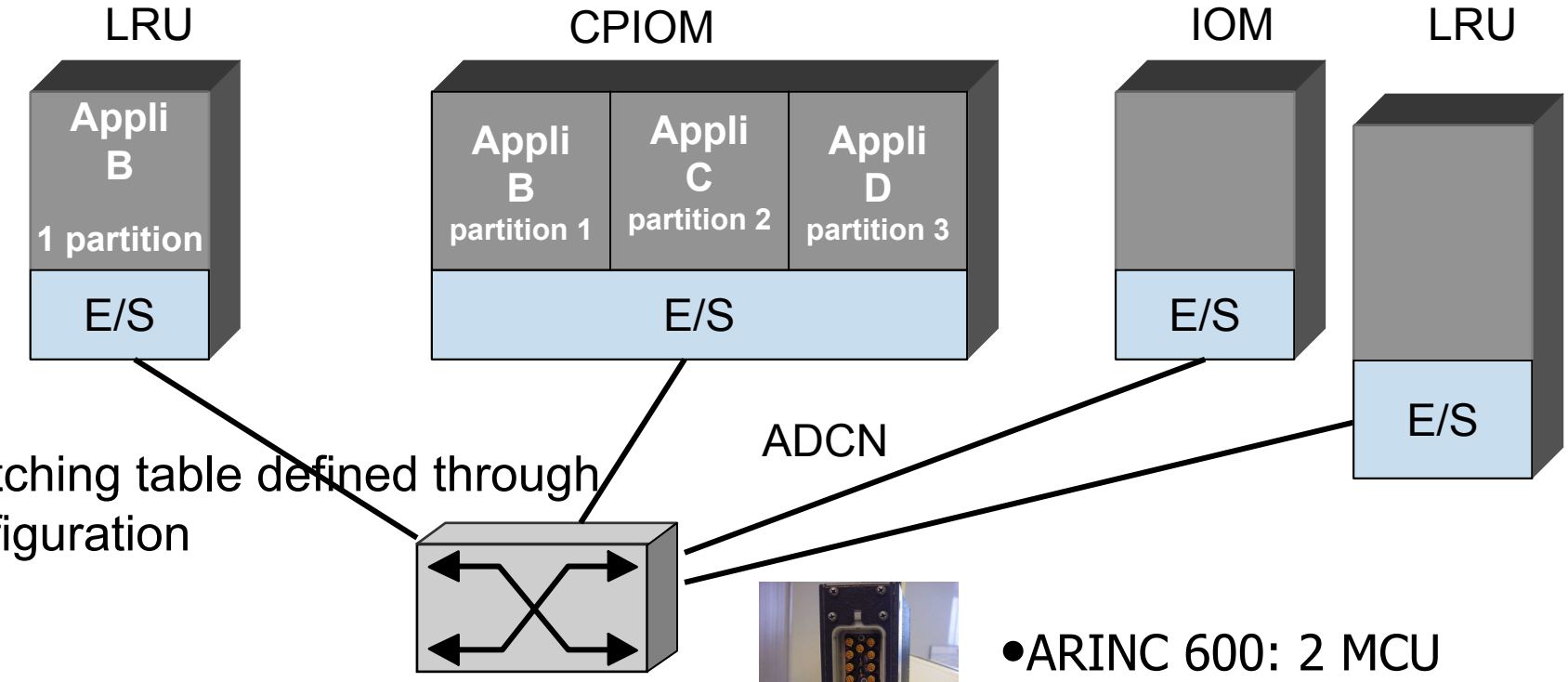


AFDX Network:

- 100 Mbits
- Redundant Network (A&B) with independent alimentation
- AFDX switches = 2 x 8
- NB of ports (connections) possible on each switch (20-24)
- MTBF of the switch is very high (100 000 hours expected)
- Up 80 AFDX subscriber

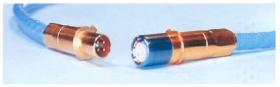
AFDX - Generality

- Freedom of choice for data format (harmonized at aircraft level)
- Integration of LRU, IOM (Input Output Module) & CPIOM (Core Processing Input Output Module)
- Technology based on COTS standards



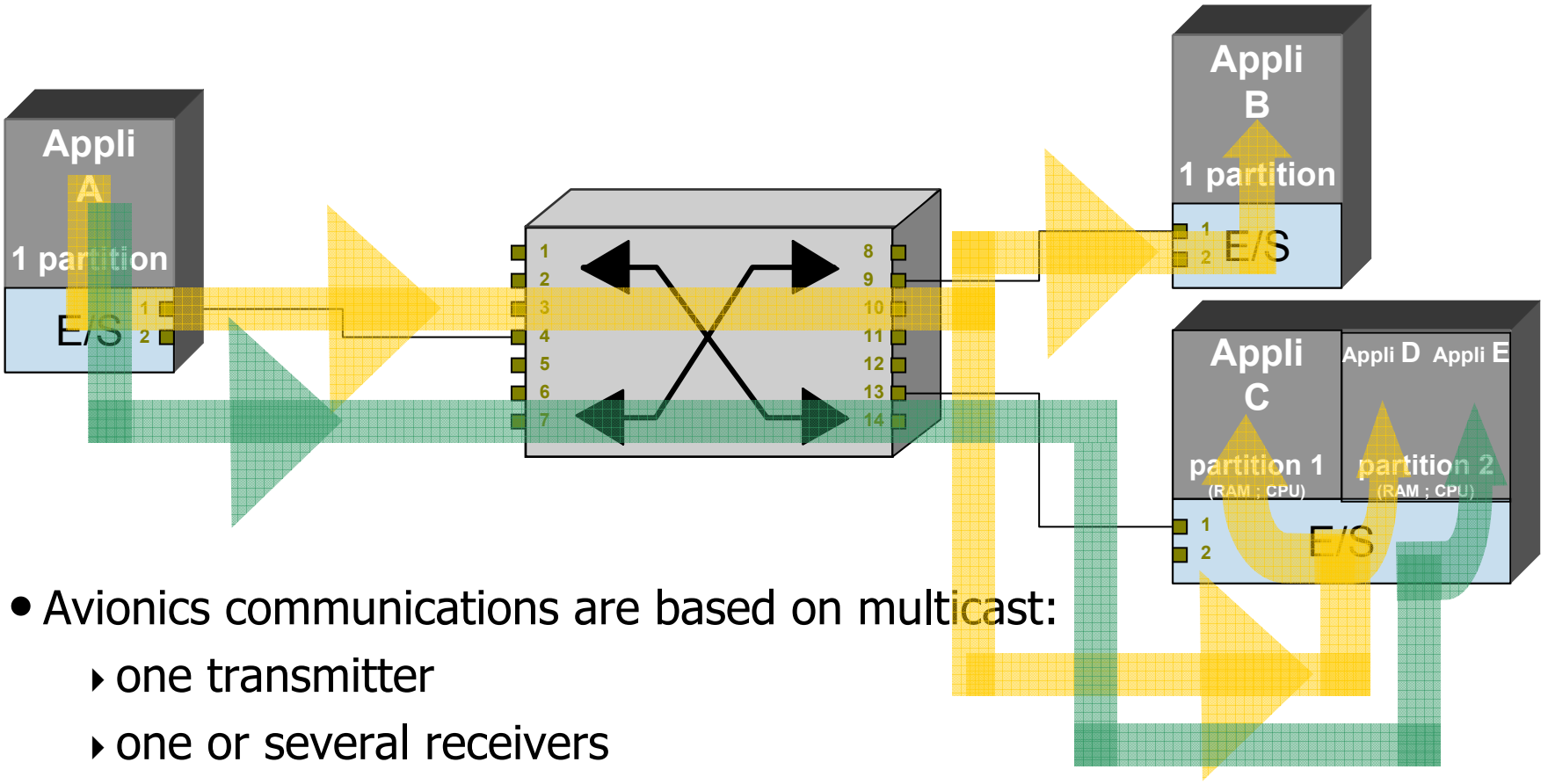
- Switching table defined through configuration
- Traffic policing (enforcement of allocated bandwidth)

- ARINC 600: 2 MCU



QUADRAX Connectors

AFDX technology – Addressing : MAC,IP,UDP



- Avionics communications are based on multicast:
  - one transmitter
  - one or several receivers
- Asynchrony individual clocks
- NO reconfiguration capability in the AFDX network

AFDX: Performances

- Does AFDX sustain expected real time performance:
  - Yes: real time performances were really challenging, both on the ES and the switch (ES wire speed reception ie 200 Mbits/s ; switch wire speed switching, with only bottleneck on output buffer).

- Packet loss percentage:
  - 0 % in the switch by definition (a configuration where the switch cannot guarantee that no frames are lost is not “schedulable” and thus not produced)
  - Nevertheless frame may be lost due to
    - Bit error rate (target 10-8)
    - Failures

What is A380 IMA ? - AFDX Network use

- Switches Configuration process:

System Team

Data base

NCD : VL & Paths

Confcheck → determinism OK

Confgen → Create configuration Loads

Switches Datalaoding

What is A380 IMA?

- Impact on the system development process = Risks
  - At the component level:
    - IMA developed before system > requirements mismatch
    - Maturity of IMA components > impacts multiple systems
    - Technical capability > impacts multiple systems
  - At the Industrial level:
    - Management > Dedicated trans-national IMA team
    - Procurement >
      - Arbitration process,
      - Contractual resources,
      - Change in supplier business model
    - Development > User Groups, Hot Lines, Bi-laterals
    - Certification
    - Support Process > Airbus

What is A380 IMA?

- Pre launch
  - Partner activity to review available solutions and proposals
    - Many suppliers example Smiths, Honeywell, Rockwell Collins, Thales, Diehl, BAe Systems
    - Front runner - Cabinet / rack + ARINC 629
- Joint launch team to define the avionics solution
  - Architecture, scope, key technologies, supplier pre-selection
  - AFDX as the network
    - ARINC 629 future growth, cost ?
  - IMA computers as dedicated LRUs – The “Open Architecture” solution
    - Multiple system suppliers
    - Scalable
    - Multiple IMA suppliers including Airbus make policy for key technology
    - System suppliers able to develop and integrate separately
    - Minimise the management and co-ordination activities to be performed by Airbus – focus on systems

What is A380 IMA? - IMA integration perimeter

Function on A380

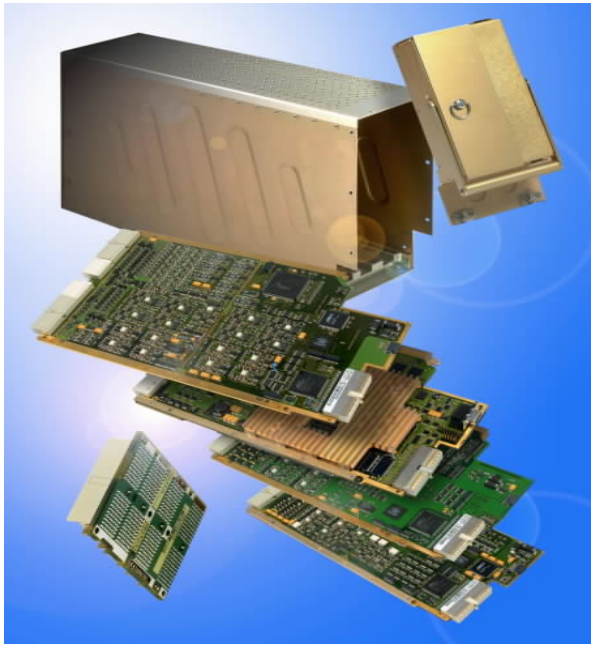
Cockpit
Flight Warning,
FCU Back-Up,
Weight & Balance Back-Up Computation
Flight Control Data Concentrator
Air Traffic Communication

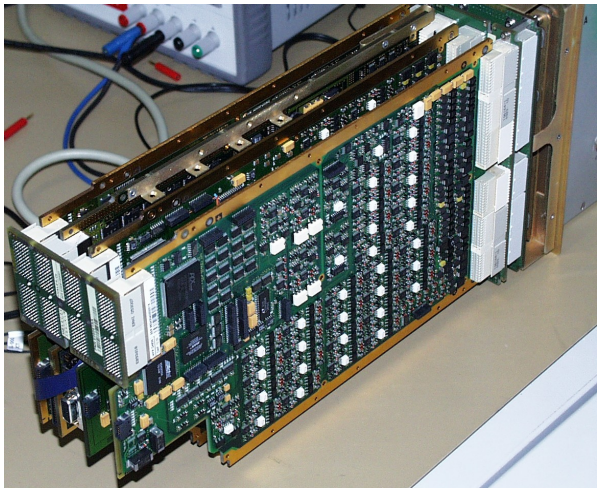
Energy
Electrical Load Management,
Circuit Breaker Monitoring,
ATA 24 BITE

Utility
Fuel Measurement & Management
Braking,
Steering,
Extension/Retraction,
Others (Tyre pressure, etc.)

Cabin
Bleed,
Overheat Detection,
Supplemental Cooling
Cabin Pressure & Ventilation Control,
Air Conditioning

IMA – Modules





- 8 different part numbers / 30 modules of CPIOM per chipset developed by 2 suppliers
  - **AIRBUS** (**EYY**):
  - **Thales Avionics**, associated with Diehl Avionik System:

- They host 21 avionics functions developed by 10 suppliers

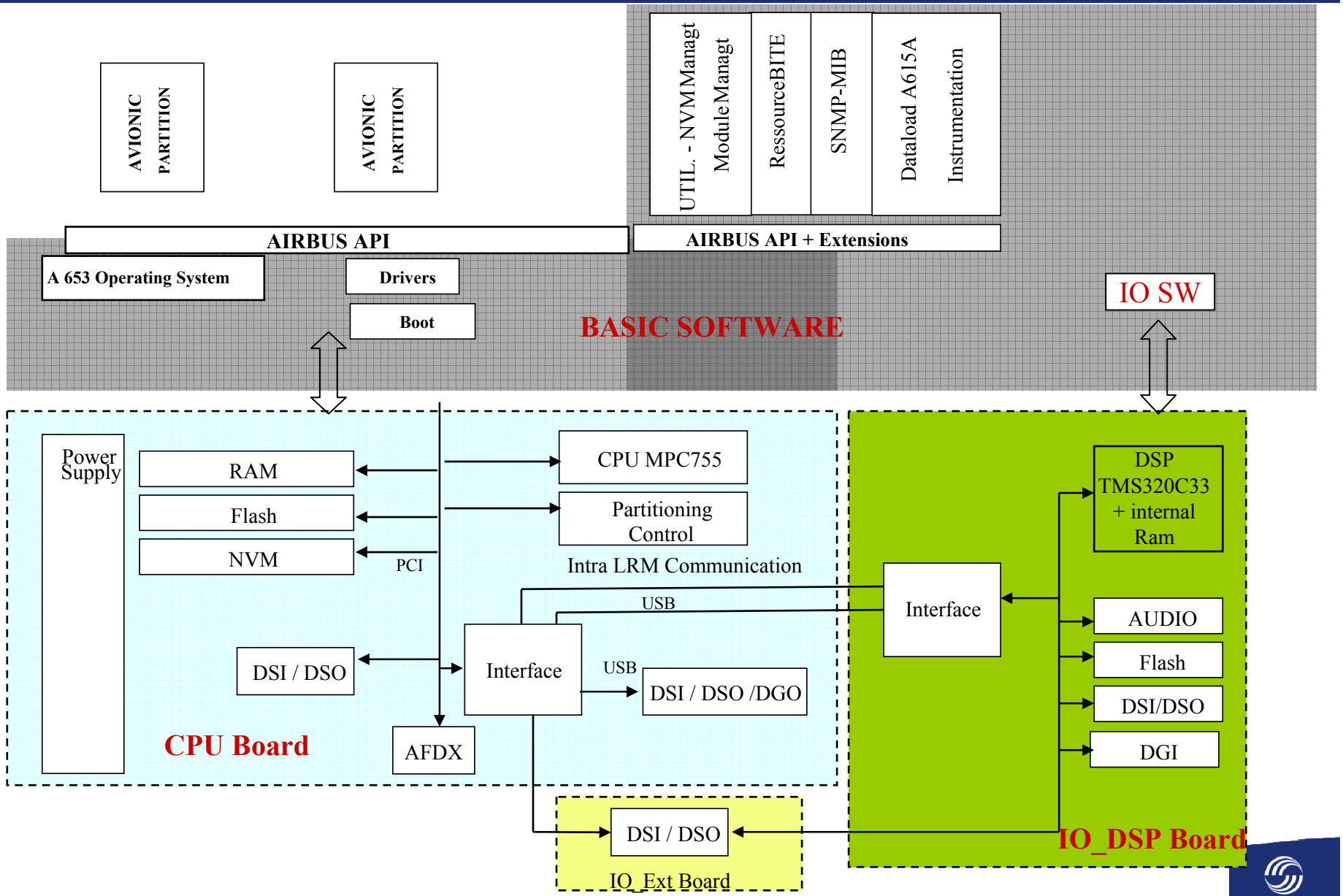
- 1 single part number of IOM called “IOM-A”

- All modules are ARINC600, 3 MCU box, around 4.2 kg, with 50 000 hours MTBF objectives

What is A380 IMA ?

- What makes IMA different ?
  - Standardised Software Environment
  - ARINC 653 Operating System
    - Application software is independent from the hardware
      - Like Windows
      - No direct access to I/O
      - Internal process control services
      - Health Monitoring services
    - Enables Obsolescence protection for system software
      - Software – largest NRC element of systems
      - Production life = 20 years, Aircraft life = 50 years

What is A380 IMA? - CPIOM

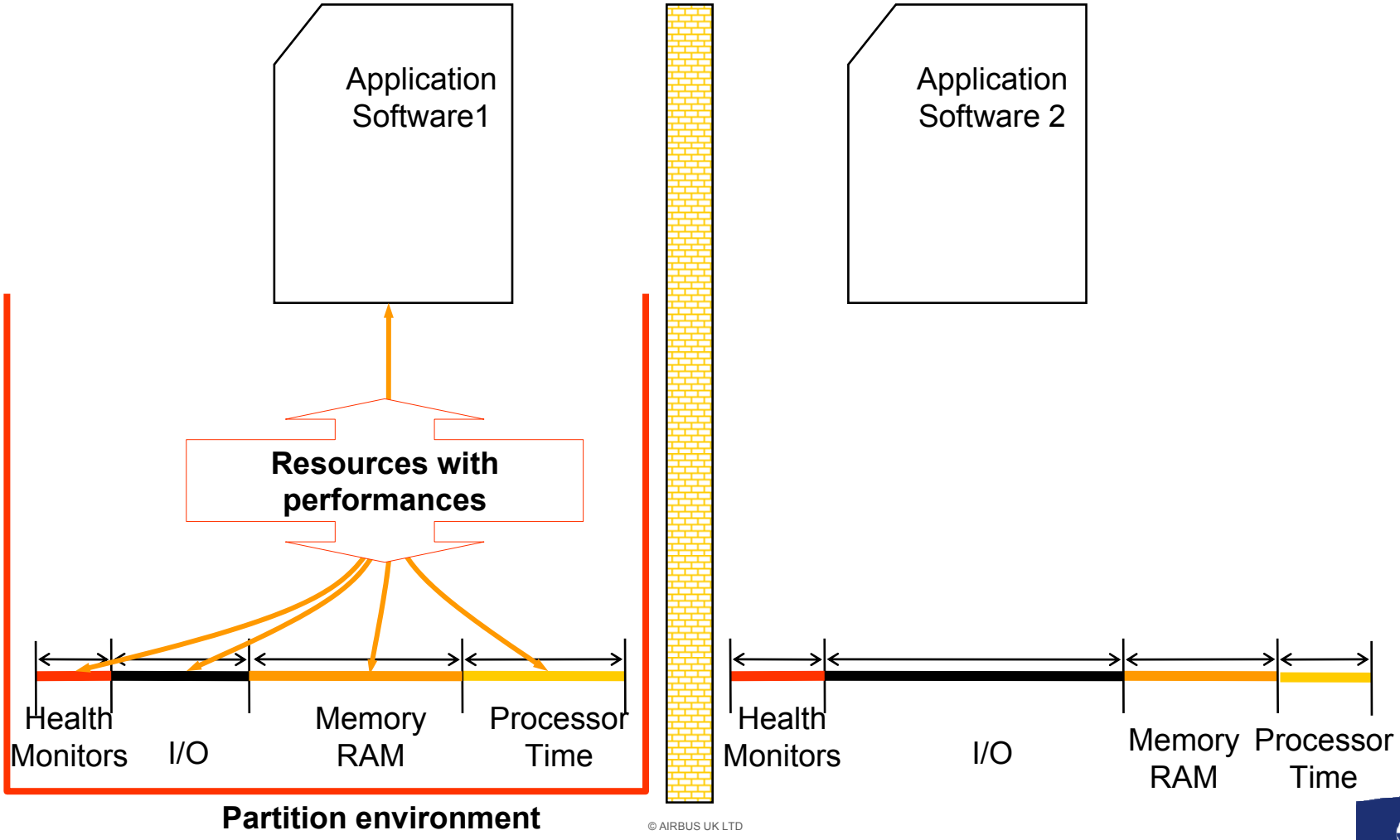


What is A380 IMA ?

- What makes IMA different?
  - Partitioning
    - The performance of each system must be unaffected by any other
      - To allow systems to be developed, tested and verified separately
      - To allow system faults to be contained
      - To allow new systems to be added post certification

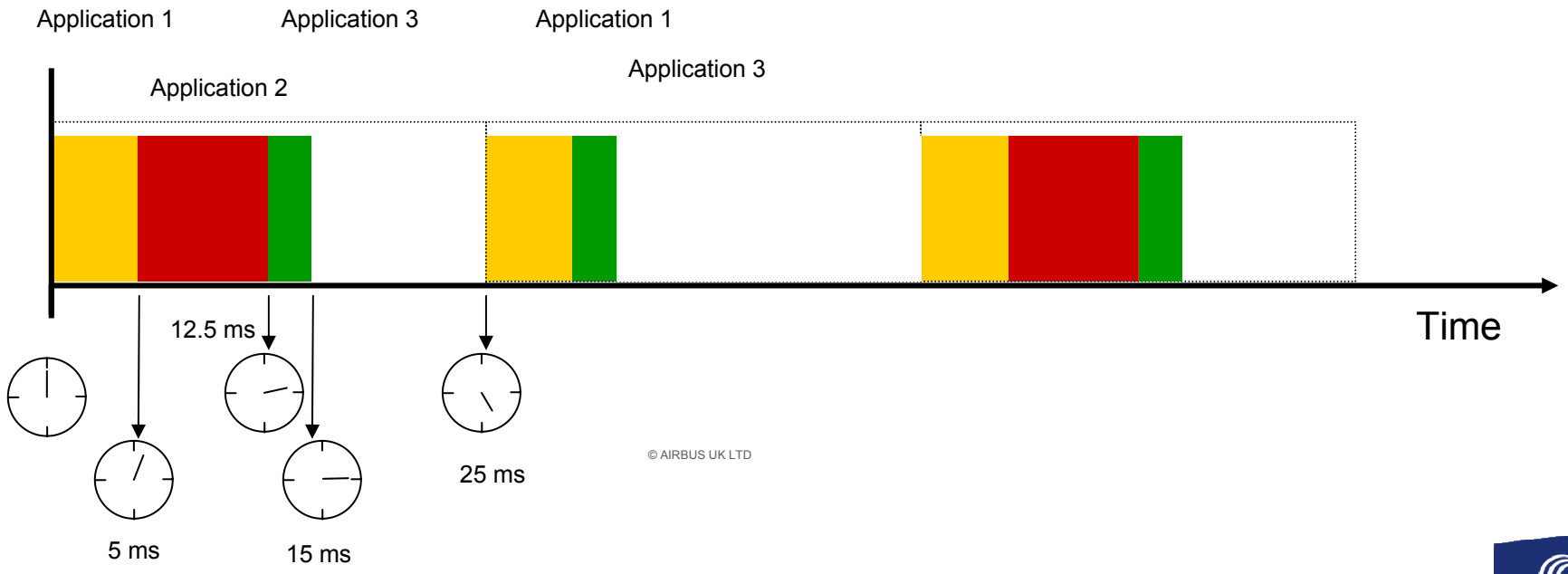
What is A380 IMA ?

- What makes IMA different?
  - Partitioning



What is A380 IMA ?

- What makes IMA different?
  - Partitioning
    - Timing
      - Strict allocation to each system application –
        - Periodic fixed scheduling at application level
        - No prioritisation at application level



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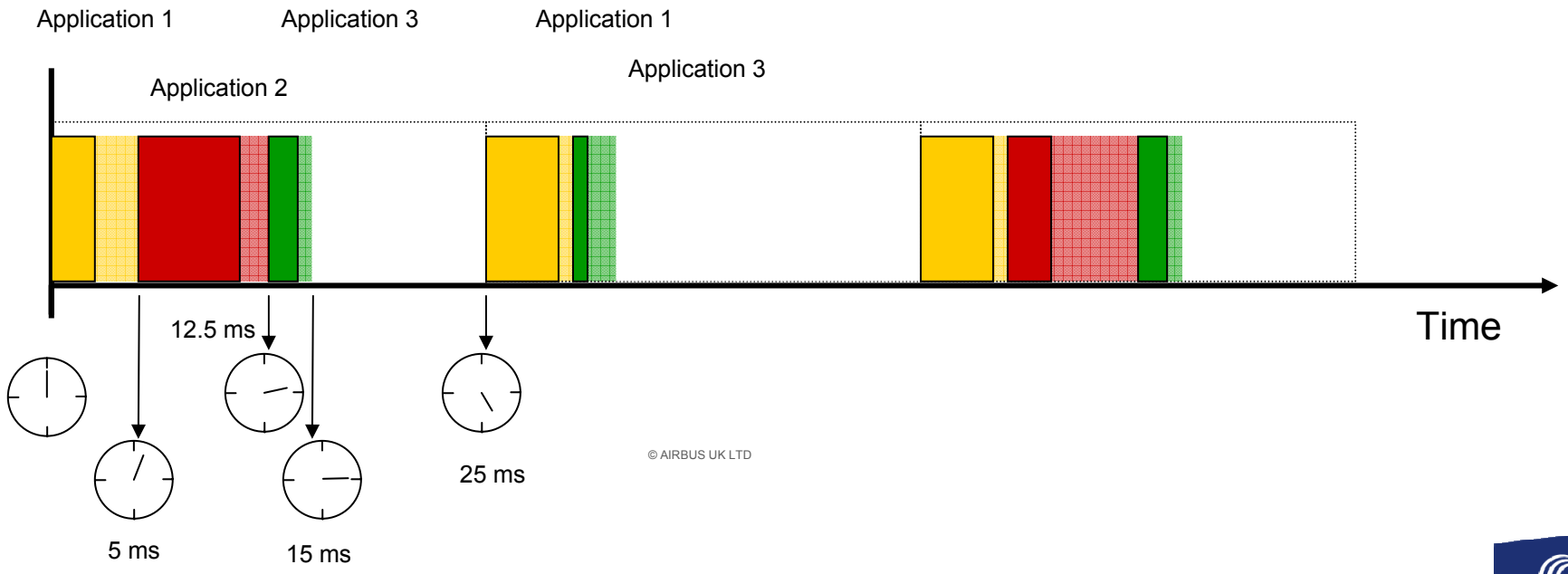

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- What makes IMA different?
  - Partitioning
    - Timing
      - Strict allocation to each system application –
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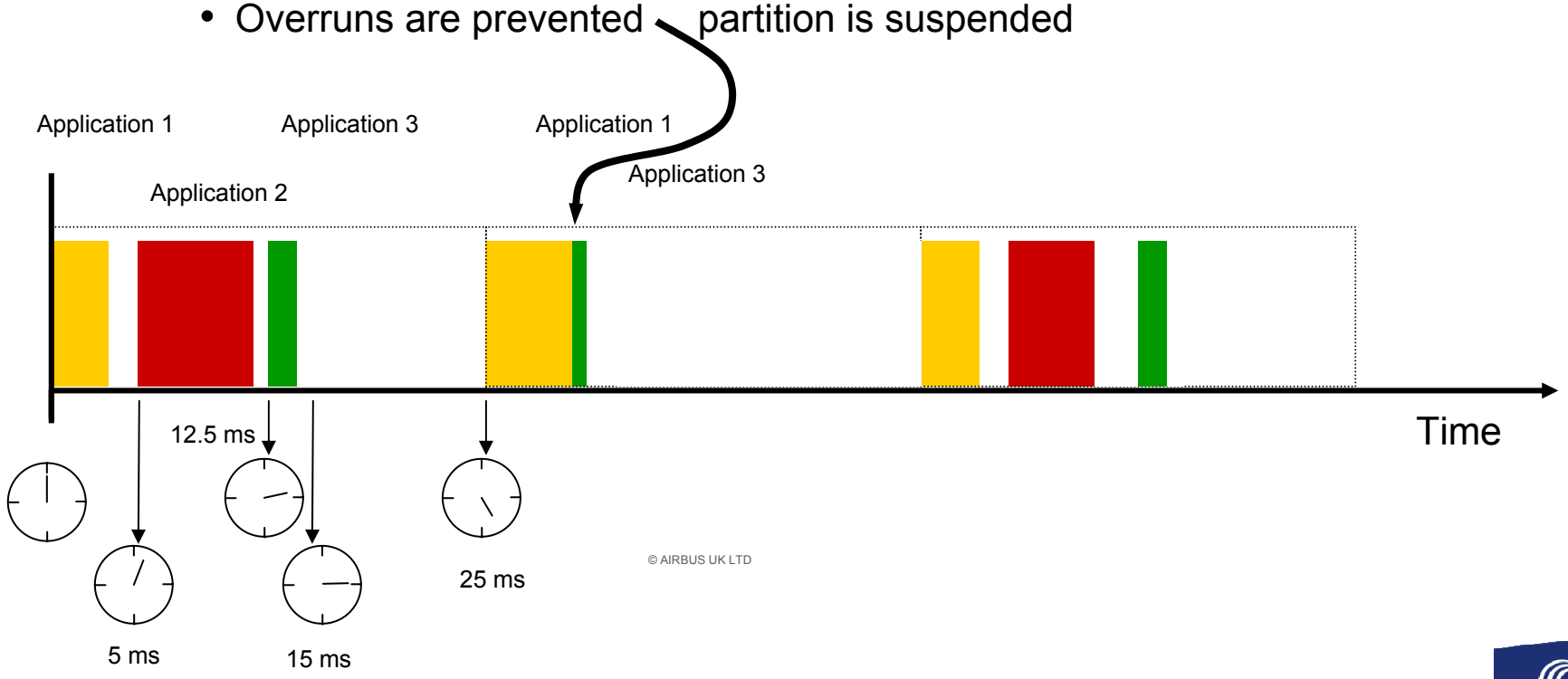
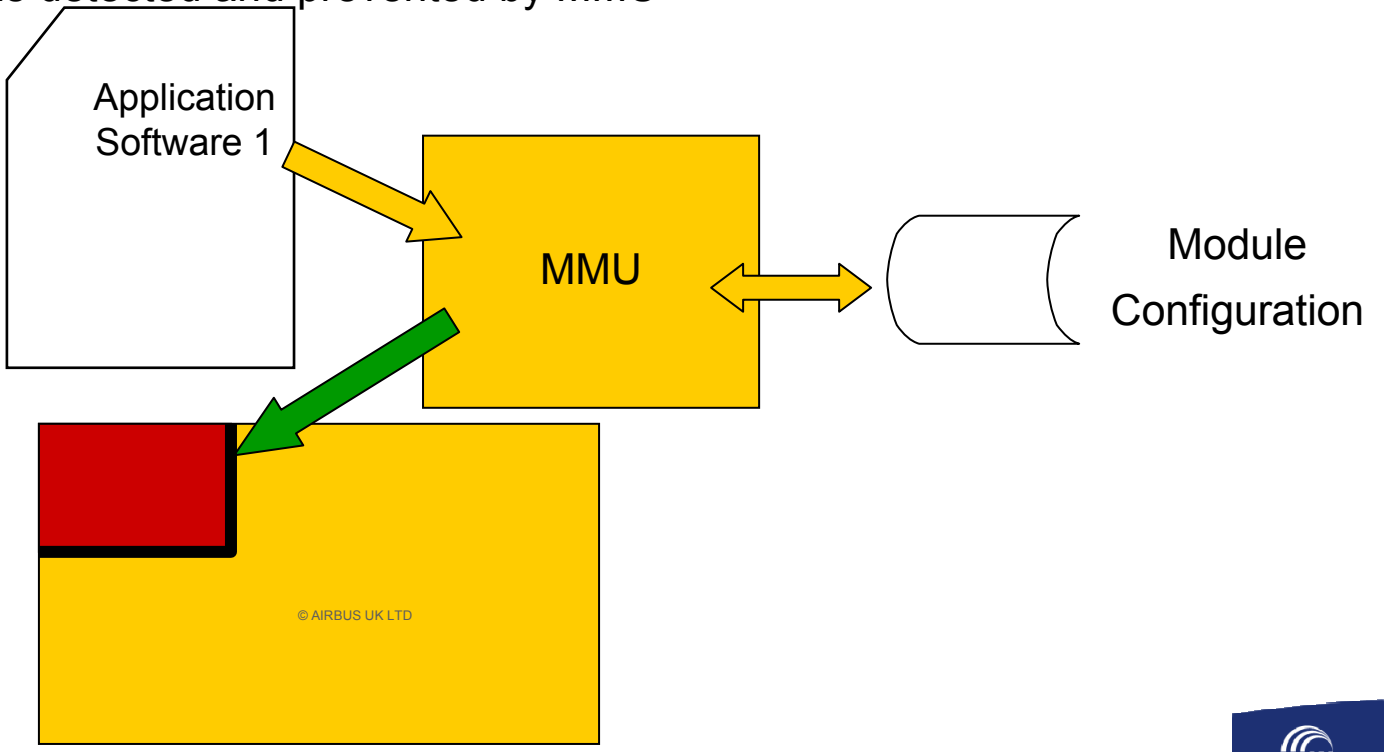
        - No prioritisation at application level
      - Overruns are prevented → partition is suspended



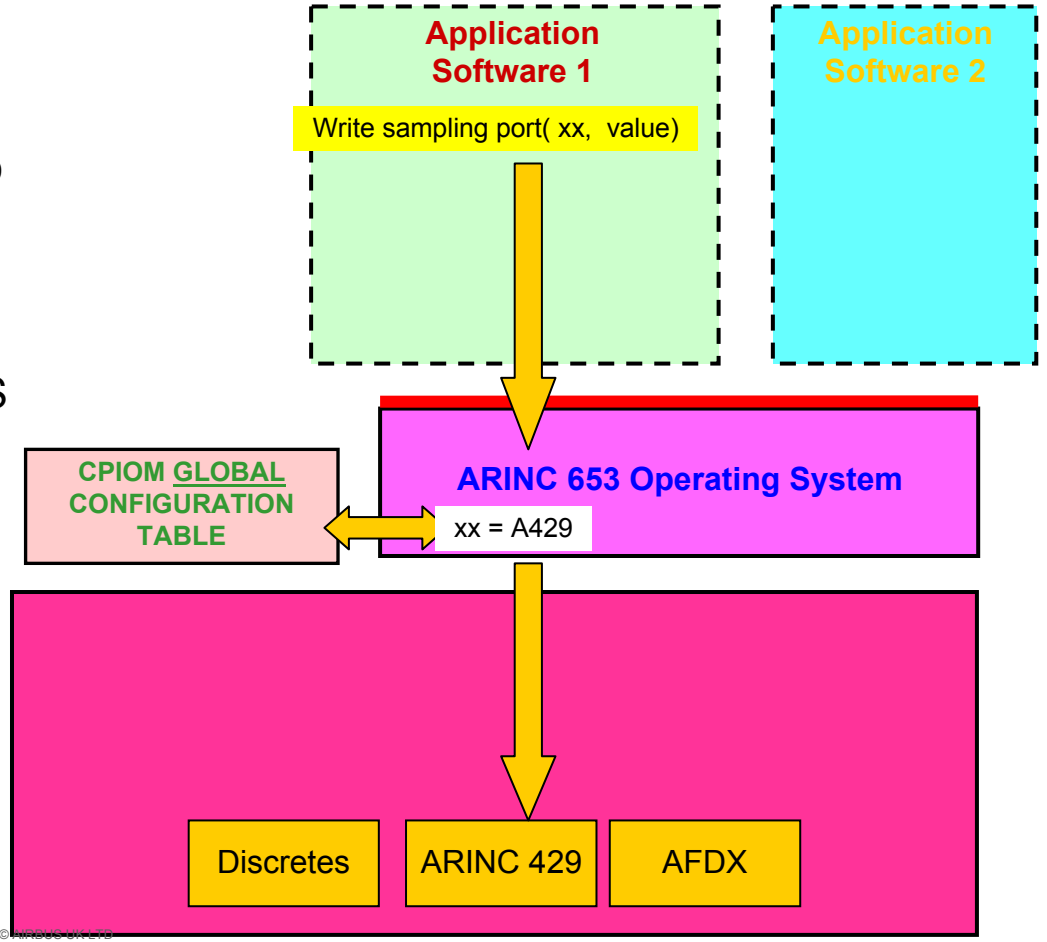
What is A380 IMA ?

- What makes IMA different?
  - Partitioning
    - Memory
      - Segregated allocation to each application
      - Configuration is linked to design I.e. application accesses only the memory configured for it
      - Violations detected and prevented by MMU



What is A380 IMA ?

- What makes IMA different?
  - Partitioning
    - I/O
      - Segregated allocation to each system application
      - Some shared input data e.g. ARINC 429
      - All access is through OS calls



What is A380 IMA ?

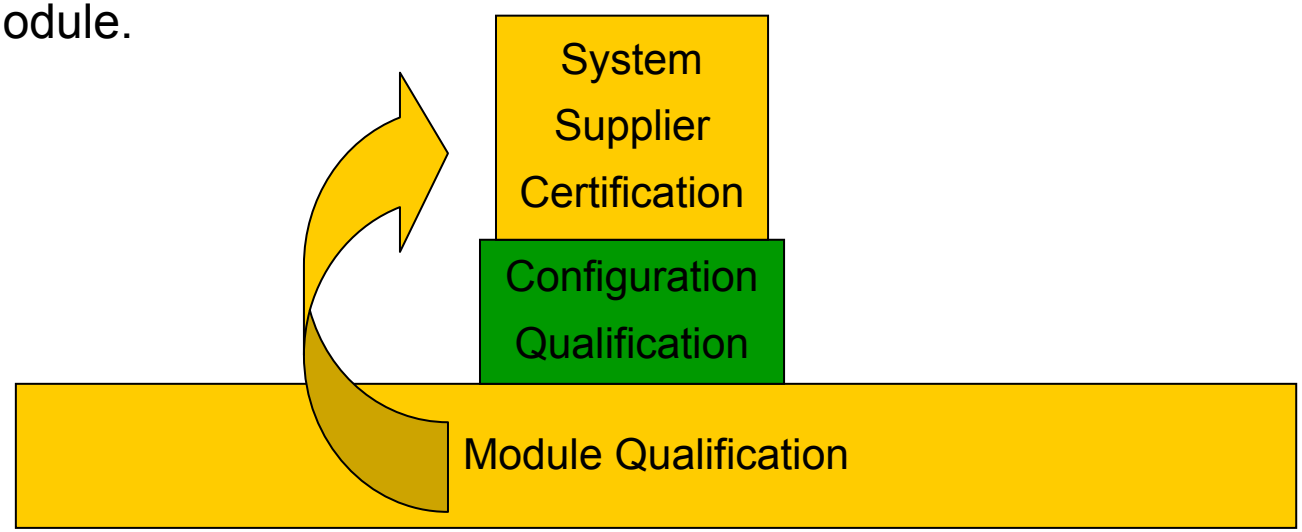
- Partitioning enables:
  - System independence
    - Systems of different DAL(A,B,C) level can be developed at their DAL level
    - Systems can be integrated and tested to separately
  - Incremental Qualification
    - Modifications to one application have no effect on other applications
      - Qualification activities following a modification are limited
- Configuration Parameters Partitioning and Configuration
  - IMA must be configurable
    - Resources – Time, Memory and I/O
    - Implemented with Configuration Tables - loadable
  - Two groups of tables:
    - Tables managed by Airbus – have a global effect
    - Tables managed by the Function Supplier – only have a local partition

What is A380 IMA?

- Qualification of the module within a usage domain represented by the set of configuration parameter ranges
- Usage Domain
  - Represents guarantees on
    - Functionality
    - Performance – e.g. service call times
  - For the range of configurations the module can be used in

What is A380 IMA ? - IMA Modules Qualification

- Qualification and system certification are major parts of IMA
  - The objective of the qualification approach is to give System Suppliers “credit” to be used as part of their system certification
  - Based on credit
    - The function / system supplier takes “credit” from the qualification activities of Module Manager and Module Supplier
    - Does not have to prove functionality, performance and behaviour of the module.



What is A380 IMA?

- New Industrial Roles - the biggest change with IMA
  - Introduce a new role in system development
    - IMA Manager
      - Control the use of module resources
        - Provides resources against user system requirements
        - Maintain spares margins
        - Support the prediction and verification of resources
      - Provide resource configuration tables
        - Develop configuration tables
      - Perform confidence testing on the Integrated Module
      - Perform qualification activities for the module configuration

What is A380 IMA ? - Avionics Functions

- Integration:
  - integration tests are performed
    - on HBOSS
    - again on HBOSS with instrumented code for structural coverage analysis
    - then on TBOSS for target compatibility verification and for providing certification evidences
  - Additional unit tests may be identified to achieve all coverage objectives
  - The whole process is automated to ease non-regression testing between HBOSS and TBOSS

The future

The future of IMA

- A380 IMA reused on A400M/A350 :
  - Mature avionics hardware available immediately
  - NRCs, risks minimised

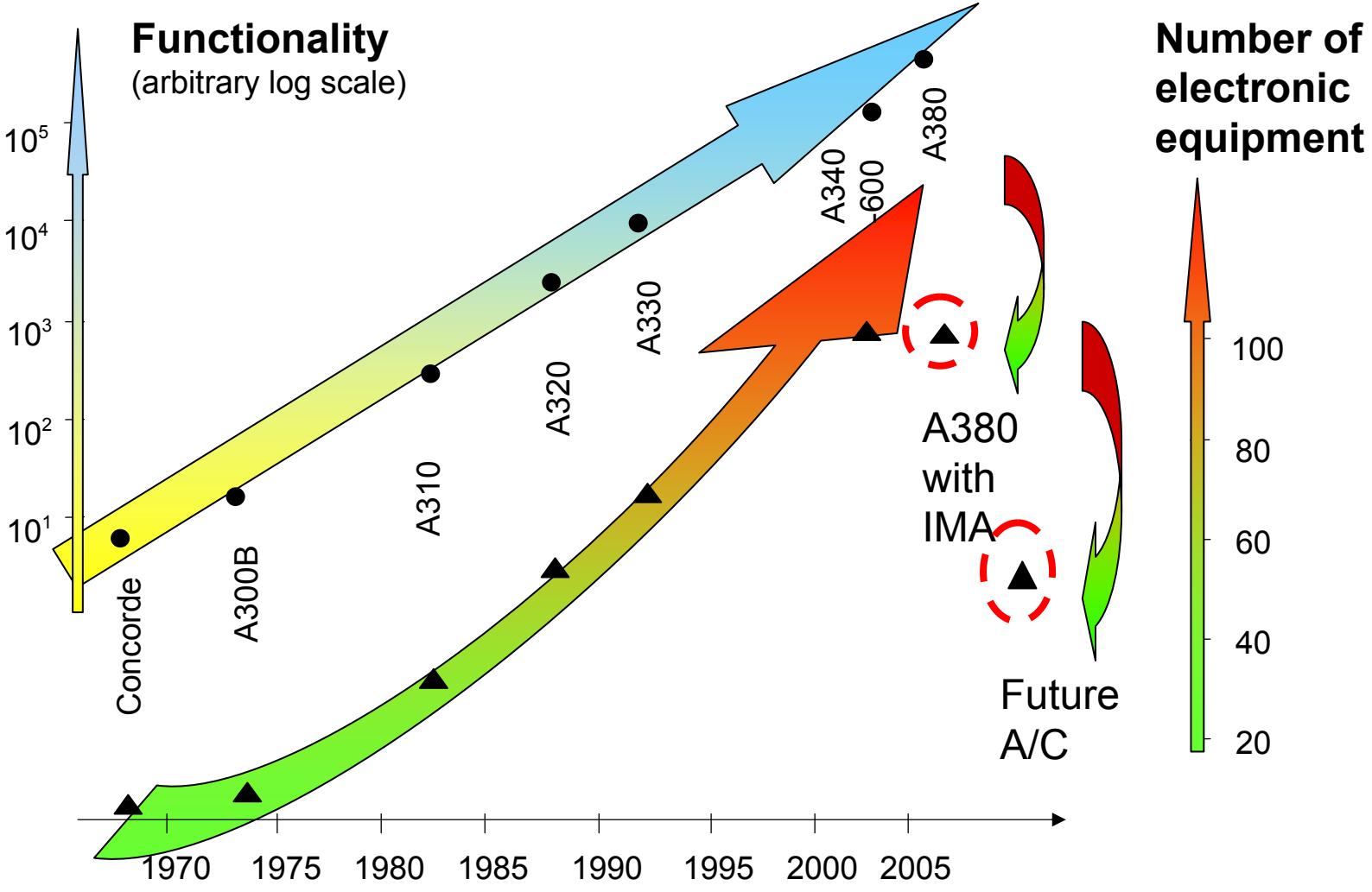
- Next Aircraft – *IMA2G*:
  - Extend the scope of IMA
    - Flight controls, Open world
  - Increase the flexibility of IMA – “Generic Secure Platform”
    - Optimise the IMA architecture
      - Decentralised I/O / Smart sensors
      - Reconfiguration
    - Enable more systems to be integrated within IMA
      - High Critical to Low Critical
    - Enable greater levels of integration on single IMA units

The future of IMA

- Change in technologies:
  - AFDX :
    - greater bandwidth solutions,
    - low cost solutions
    - greater integration
    - All protocols supported
  - IMA
    - Cabinet, Card File ? all have advantages
    - Faster processors – Multi-processor – inevitable
    - New OS – possibly, parallel for Open World
    - New Fields buses technologies ?
  - Tools - greater integration & Industrialisation
    - Platform Architecture definition
    - Avionics configuration
    - Application development, validation and verification
    - Fast ramp up – Technologies choice for Resources industrialisation
    - Fast FAL Integration – Auto test

The future of IMA

Historical background for the emergence of IMA



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