ASHLEY (Avionics Systems Hosted on a distributed modular electronics Large scale dEmonstrator for multiple tYpes of aircraft)

A Step Ahead to the 2nd Generation of Integrated Modular Avionics

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Abstract. The ASHLEY project is a EU 7th Framework Programme under grant agreement no ACP2-GA-2013-605442. It is a valuable asset on the Integrated Modular Avionics Second Generation (IMA2G) path to address future aircrafts program. Innovations are being tackled at different stages with one common objective to improve the current IMA2G distributed platform solution. ASHLEY innovations are validated on the Large Scale aircraft representative demonstrator by integration of a set of representative applications for avionics and open world.

Keywords: Integrated Modular Avionics, Distributed Modular Avionics

1. From the Federated Architecture concept to the IMA1G concept

Early avionics were implemented as a federated architecture, in which each aircraft function (e.g. flight control, flight management, navigation, or systems control) was implemented using dedicated hardware and software.

At the beginning of the 90's, the number of avionics functions increased. This resulted in an increase in size and complexity of the federated architecture (large number of "black boxes" or Line Replaceable Units, of dissimilar sizes and based on different technologies). This in turn increased the cost of overall avionics platform while reducing the efficiency of airline maintenance operations (e.g. number of different spare Line Replaceable Units (LRU) and maintenance procedures, ever-increasing training costs, …).

The Integrated Modular Avionics (IMA) concept was introduced to solve these problems. IMA enables to host on the same platform different functions from different function suppliers using standardised Line Replaceable Modules to reduce the number and types of Line Replaceable Units required.

Contrary to a federated architecture solution which associates an electronic equipment (Line Replaceable Unit) with a system, using dedicated hardware and software, the IMA first generation (IMA1G) introduced the main concept of Line Replaceable Modules (LRM) to replace Line Replaceable Units.

Implementing this key-concept into the avionics platform production scheme led to:

- A LRM-based, standardised implementation environment for system designers;
- A segmentation, resource-sharing approach of the avionics platform;
- A role definition of the IMA actors: Module Suppliers and the Function Suppliers;
- And a definition of their interfaces.

To summarize, the basic principles (or concepts) of IMA1G are:

- Separate roles of Module Suppliers and Function Suppliers;
- Enforce the use of standard interfaces to be used by the Function Suppliers;
- Set-up of a formal process between all IMA actors;
- Guarantee resource segregation for a cost effective certification process.

Fig. 1 shows this evolution from the federated architecture which supported the genesis of avionics, to the first generation of IMA.

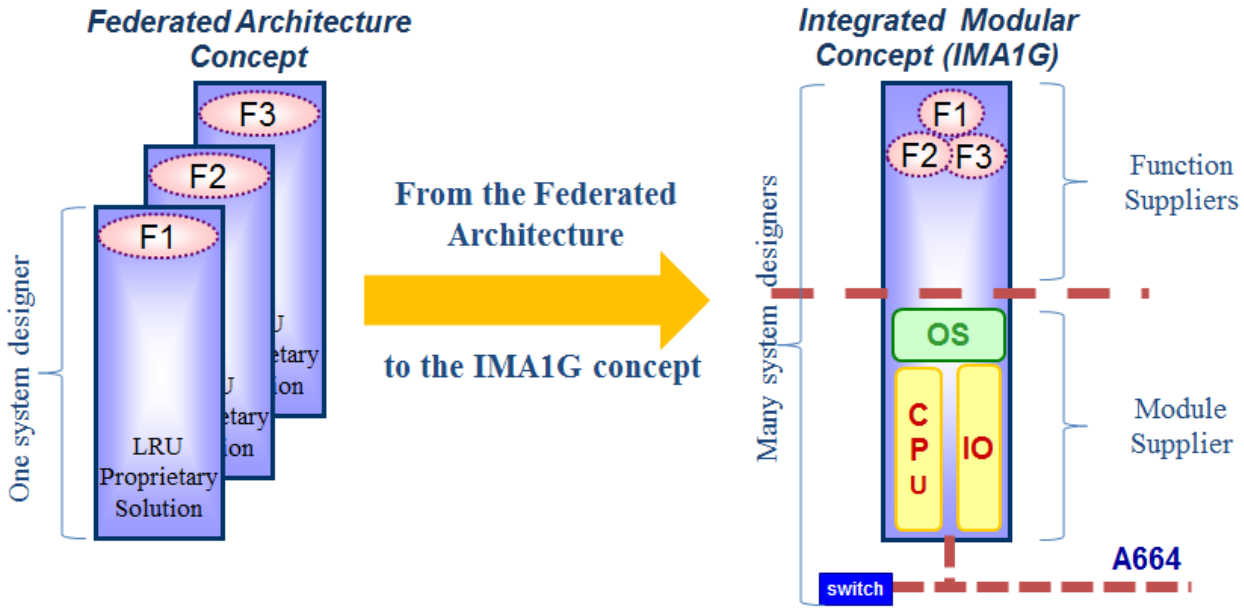

Fig. 1 *The Federated Architecture concept vs. the IMA1G concept*

2. From IMA1G to IMA2G

Fifteen years after the first definition of its concepts, the IMA solution has been chosen in most of the new avionic developments for large Aircraft (A380, A350, B777, B787) to military Aircraft (A400M) and regional category (ATR, SSJ - Soukhoï SuperJet).

We can consider that IMA based avionics is the best environment for competitive solutions for any future avionics platform.

To further the competitiveness of IMA based solutions, Key Competitive Challenges have been defined by the main industrial actors to identify ways forward and needed innovations in the main areas of Industrialization, Modularity, Integration, Certification and Services which are driving the definition of avionics systems.

IMA industrial concept	Wide application of IMA components in programs through universal properties
Modularity	Flexible Module concept with building blocks
Integration	Virtual module concept
Services	Cross-Domain: Provide secured exchange solutions. Platform level properties: Provide new Platform level services (data management). Tools: Provide overall platform level tools to System Designers.
Certification	Achieve standardized way of certification acceptable by authorities

Table 1 *IMA based solutions - Key Competitive Challenges*

While modules, building blocks and technical principles to achieve these Key Competitive Challenges have been successfully developed in the SCARLETT project as the Distributed Modular Electronics (DME) concept, there is a need to define the overarching platform organisation and implementation of those elements. This is one of the main objectives of ASHLEY that will provide a key element in the deployment of IMA2G.

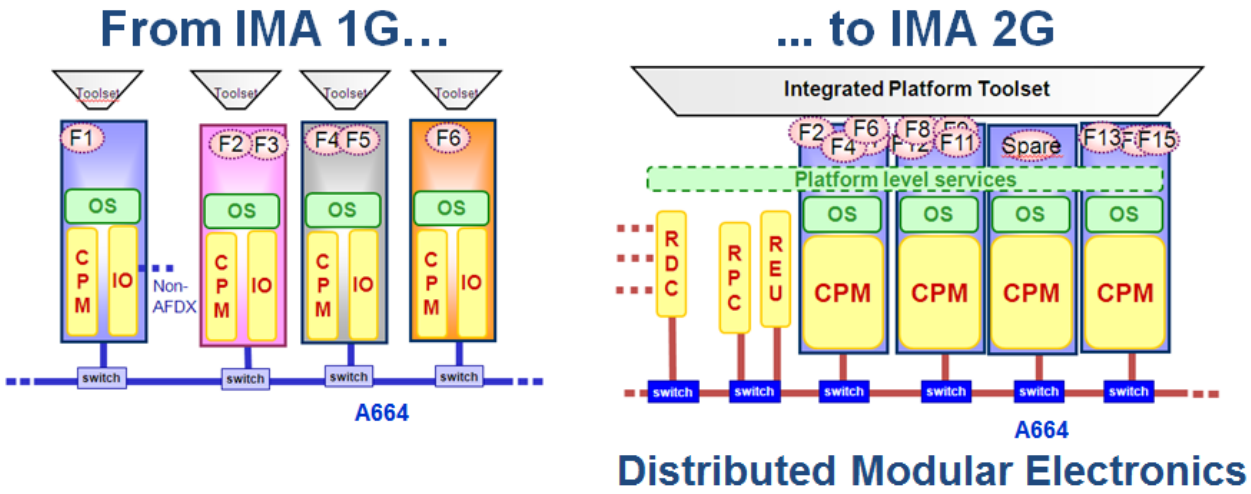

Fig. 2 *Innovation beyond IMA1G – Distributed Modular Electronics*

The Distributed Modular Electronics is a new architectural concept in which the I/O resources (RDC – Remote Data Concentrator, REU – Remote Electronic Units, RPC – Remote Power Control) are separated from the processing resources (CPM – Core Processing Module).

As shown in Fig. 3, separating Inputs/Outputs (I/O) from computing modules brings several benefits:

- Minimization of the set of module types.
- Easy adaption to aircraft needs in term of I/O and computing power.
- Increased independence of functions from hardware, hence allowing a flexibility of function allocation.
- Reduction of the cable length and weight.

Increasing the computing module performance enables the introduction of a full range of applications (time critical, high performance data distribution, etc), and increases the number of supported function per module (Fig. 4).

Platform level services and related middleware allow isolating aircraft functions from the supporting platform configuration (enhanced application portability) and enable more transparent technological integration for applications (Fig. 5).

Integrated processes and toolset embedding an extensive model-based approach allow allocating a set of applications onto overall platform resources, and enable an early validation and maturity Fig. 6).

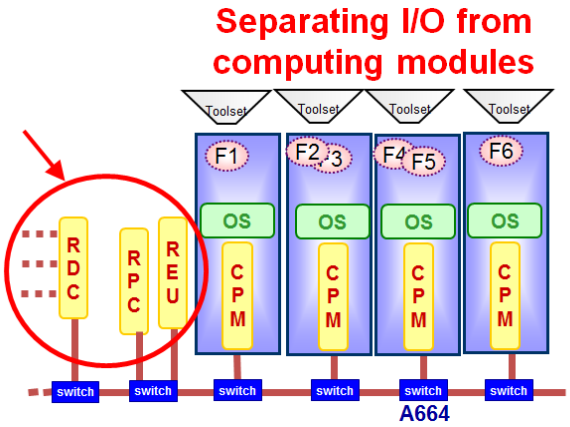

Fig. 3 *Separating I/O from computing modules*

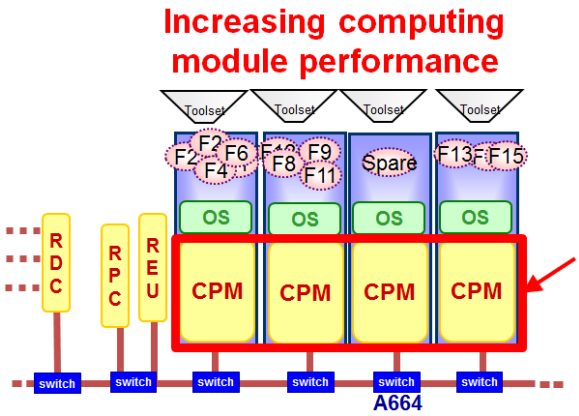

Fig. 4 *Increasing computing module performance*

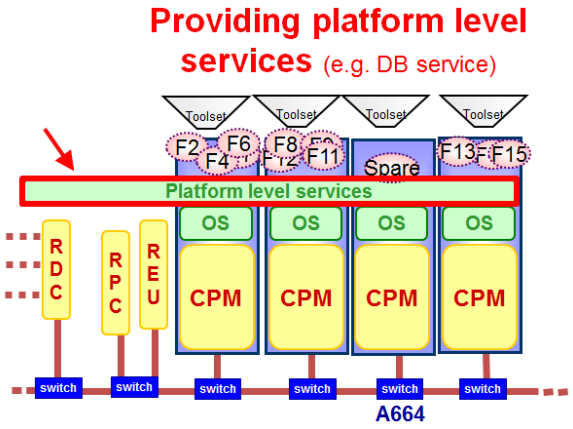

Fig. 5 *Providing platform-level services*

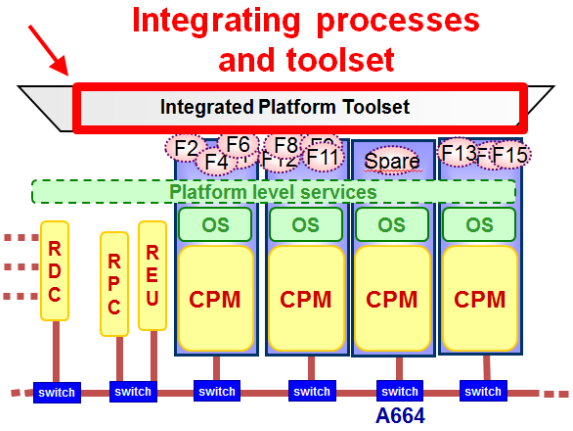

Fig. 6 *Integrating processes and tools*

3. ASHLEY project: context and objectives

On basis of the achievements within the previous projects and the Key Competitive Challenges-driven needed innovations, ASHLEY has the main objective of consolidating and extending the efforts of several independent projects by improving the current IMA2G Distributed Platform Solution. To achieve this overall objective, ASHLEY has the following technical objectives:

Objective 1	To extend the DME concept and set of components over the Open World and Cabin aircraft domains for large aircrafts, regional aircrafts and business jets.
Objective 2	To propose DME remote resources solutions for Secondary Power Distribution and Time Criticality aircraft systems.
Objective 3	To evaluate the benefits of photonics and smart interfaces to sensors and actuators to increase performances of some avionics systems.
Objective 4	To provide Database Services covering both the avionics world and open world to allow for a higher flexibility in avionics systems design.
Objective 5	To decrease avionics (multi-domains) function overall design time thanks to a more system designer oriented tool chain.

Objective 6 To validate the ASHLEY advanced state of the art by implementing a large scale demonstrator consisting of a set of representative aircraft systems onto the DME extended set of components.

Objective 7 To promote DME concepts and innovations to any IMA key stakeholders (industrial, academics, certification and standardization bodies) that will influence existing academia and market and create new ones.

4. ASHLEY expected final results and their potential impacts and use

By reaching all of the above objectives, ASHLEY is a valuable asset on the IMA2G path to address future aircrafts program (Fig. 7).

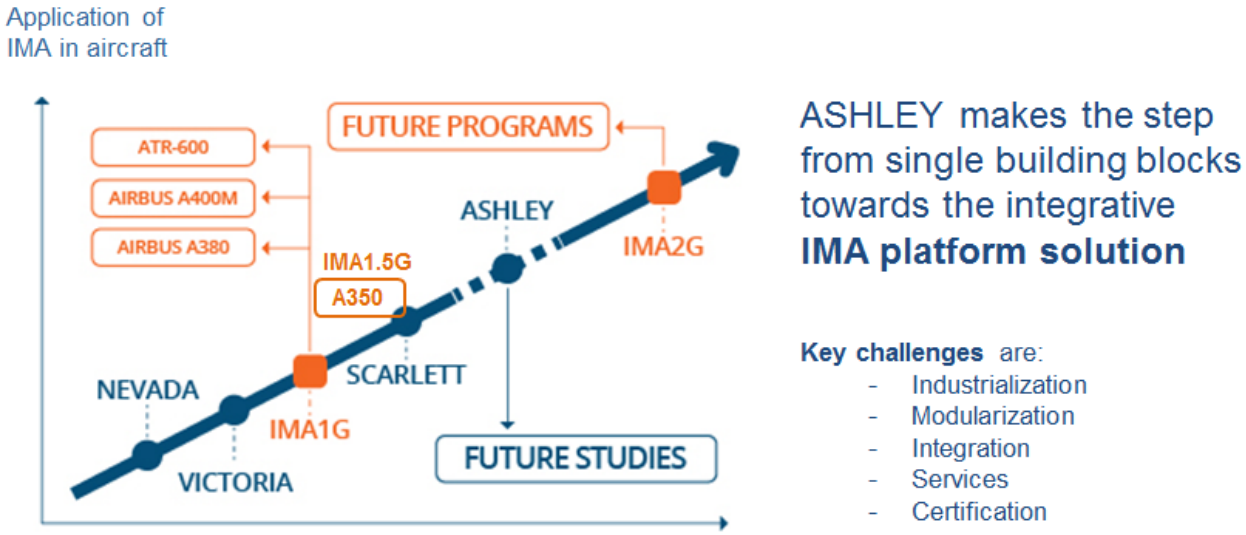

Fig. 7 *ASHLEY on the path of future IMA2G based aircraft programs*

In ASHLEY, innovations are being tackled at different stages with one common objective to improve the current IMA2G distributed platform solution. This IMA2G platform must be "technologically attractive" to cover most of avionics systems needs while improving the aircraft development and its global performance. Main ASHLEY technical innovations are covering the following axes:

- The implementation of the smart components is considered as a real innovation. Indeed, this association of processing intelligence and network connection on a Sensor or Actuator could have a significant impact at the aircraft level (improvement of maintenance diagnostics failure analysis, optimisation of aircraft wiring, simplification of maintenance operations…)

- The introduction of the new passive optical technology requiring no power supply, and the use of Power-by-Light is considered as a real step beyond with the following main advantages: reducing weight at aircraft level, installation simplification (through increase in routing options), higher Mean Time Between Failures, safe behaviour in flammable environment.

- The introduction of a dedicated avionics power line communications solution allows the use of the power distribution system for both power and data thus opening the door for a reduction in weight, volume and complexity of the aircraft wiring along with reduced installation and maintenance costs.

- The properties of the Remote Control Electronics (e.g.: time critical, high integrity…) into the IMA2G architecture are designed to overcome limitations identified for flight safety critical functions, will allow hosting such systems and extend the IMA usage on aircraft.

- Data Bases are mainly used in aircraft systems (Flight Management System, Airport Operation Function, Terrain Awareness Warning System, Flight Warning System…) are often exchanged from one system to another. To avoid any overload on the traffic or data errors, a central Data Base System is being studied and implemented. At first, the ASHLEY project permits deep architecture analysis of this functionality considered as an innovation at platform level. The use of the Data Base Service with representative avionics systems will definitively assess the performance of the concept in a real demonstration.

- Still on the objective to cover the most of avionics systems needs and to reduce the number of Part Number at aircraft level, ASHLEY will innovate by using IMA2G components in domains other than Avionics. Several communications means are available on an aircraft (e.g.: Inmarsat SATCOM, High data rate SATCOM, 3G/4G ground services, other Air-to-Ground network…). ASHLEY permits to develop and test dedicated Open World applications to assess the IMA2G platform communication properties and to improve data security robustness.

- To ensure these new technological concepts will have a chance to be on board of an aircraft, they should also be easily integrated in an industrial organisation. A further Innovation in ASHLEY is in the definition of new process of working, including all the IMA actors, offering efficient tools and an integrating Framework that will permit significant gains on overall design time.

- For innovations which Technology Readiness Level is not mature enough, the ASHLEY project orientates studies on specific topics of particular importance and relevance to the IMA2G platform (including approaches and methods, architectures, techniques and tools from aviation and other domains).

By undertaking research and technology development with a close global market perspective, ASHLEY is a catalyst to the establishment of European leadership in the aviation sector, while leveraging the European position in the harmonisation of standardisation and certification processes globally.

The strong research focus of ASHLEY research activities, using a unique multidisciplinary team, contributes to strengthen the technological and scientific background of Europe. As such, ASHLEY is not only contributing to create an image of Europe as a producer of advanced technological results, but is also creating the leverage for future research works.

ASHLEY public website: http://www.ashleyproject.eu

Abbreviations

ASHLEY	Avionics Systems Hosted on a distributed modular electronics Large scale dEmonstrator for multiple tYpes of aircraft
CPM	Core Processing Module
CPU	Core Processing Unit
DME	Distributed Modular Electronics
IMA	Integrated Modular Avionics
IMA1G	Integrated Modular Avionics First Generation
IMA2G	Integrated Modular Avionics Second Generation
I/O	Input/Output
LRM	Line Replaceable Module
LRU	Line Replaceable Unit
OS	Operating System
RDC	Remote Data Concentrator
REU	Remote Electronic Unit
RPC	Remote Power Control
SATCOM	Satellite Communications
SCARLETT	SCAlable & Reconfigurable elEctronics plaTforms and Tools
SSJ	Soukhoï SuperJet

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