29th Congress of the International Council of the Aeronautical Sciences
St. Petersburg, Russia; September 7-12, 2014

ADVANCED AVIONICS EQUIPMENT ON THE BASIS OF SECOND GENERATION INTEGRATED MODULAR AVIONICS

G.A. Chuyanov, V.V. Kosyanchuk N.I. Selvesyuk, E.Yu. Zybin
State Research Institute of Aviation Systems, Moscow, Russia

Keywords: *IMA 2G, SDR, CNS, fault-tolerant, avionics*

Abstract

The presentation describes the perspectives for the development of architecture, components, functional features, principles of safety and fail-safe provided, design technology of the on-board equipment based on the principles of second generation integrated modular avionics, assess the possible development of highly integrated on-board systems and common aircraft equipment.

1 Introduction

A prospect in the avionics equipment development is the integration and generalization of onboard software and hardware on the basis of integrated modular avionics (IMA) [1].

This is due to both economic and organizational-technical backgrounds. On the one hand, there is an increasing need to expand the functionality and scalability of avionics equipment while striving to reduce its development and operating costs. On the other hand, the existing and projected levels of technology and hardware components allows for increasingly integrated in hardware and algorithmic levels [3].

All this allows us to identify promising areas of avionics equipment improvement on the basis of the IMA:

1. Development of a network fault-tolerant architecture of the onboard avionics with a minimum range of unified open standard interchangeable and highly integrated components based on IMA Technologies of 2nd Generation (IMA 2G platform).

2. Development of innovation aircraft systems with built-in remote hubs.

3. Development of complex of multifunctional monosensors (for example, IMA/SDR/CNS airborne radio system).

4. Development of new features and functionality of the onboard avionics and pilot cockpit.

Let us consider these directions.

2 Second Generation Integrated Modular Avionics

2.1 Advanced Architecture

Modern architecture of on-board equipment based on 2nd generation IMA technology links the different aircraft systems into a single complex (Fig. 1).

Implemented architecture is created on the basis of scalable IMA to increase productivity, reliability of information transmission, resistance to interference and reduce the weight characteristics of communication and input-output devices. Advanced communication protocols between the IMA platform features sensors and actuators are applied to ensure the effective construction of dynamic structures with a network organization.

Highly integrated multi-functional systems, such as single software-controlled radio communication, navigation and surveillance must be implemented in this structure. Functions of general aircraft equipment systems should also maximize the overall computing resources of the complex.

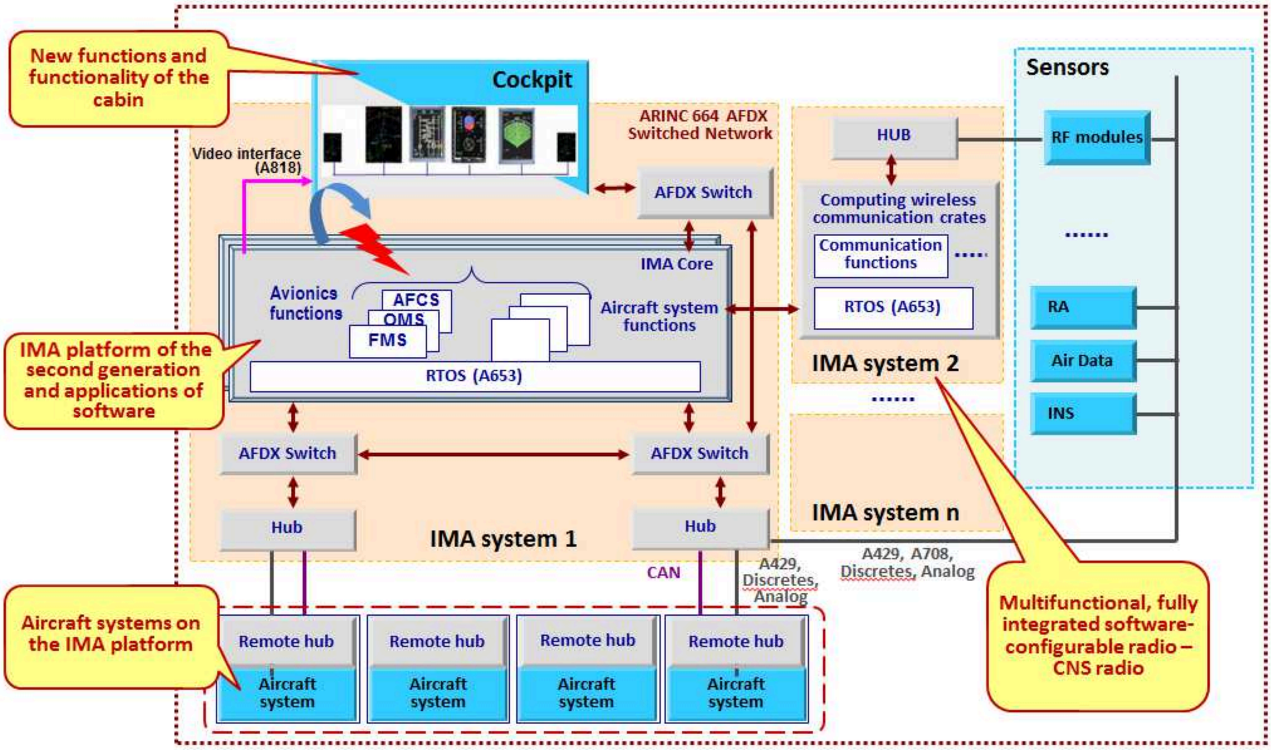

Fig. 1. Network architecture of airborne equipment

Highly integrated multi-functional systems, such as single software-controlled radio communication, navigation and surveillance system, must be implemented in this structure. Functions of general aircraft equipment systems should also make the most use of overall computing resources.

Independent of hardware products are used as the software.

Open architecture involves the connection of various devices according to their functions, such as sensor information via standard hubs to a computing system kernel. Resource allocation functional software is controlled by real time operating system.

Multifunctionality and modularity create the possibility of realization of integrable and modifiable structure of on-board avionics with a significantly lower cost.

An important feature of this architecture is the lack of "hard" connections between the on-board sensors (data channels), and computing platform. This allows for the dynamic reconfiguration of the structure of the avionics complex with the corresponding redistribution of resources. Inside the computing environment are formed (with connection to the necessary information channels of the avionics complex) structure for optimal execution of each function of the avionics complex. Each of these structures is formed only at the time of performing a specified function. Consequently, the overall configuration of a computing environment to dynamically adjusts the operation.

Conceptual areas of development of a new generation of avionics are [5]:

- the creation of a unified series of open adaptable fault-tolerant network architectures of avionics complex based on a scalable IMA in order to increase performance, reliable transmission information, resistance to interference and reduce the weight characteristics of the data lines and input-output devices;
- the use of advanced interfaces (aviation Ethernet, Fibre Channel, RapidIO, Wi-Fi) and communication protocols (TTP) in the integrated modular avionics platform between functions, sensors and actuators, ensuring the effective construction of dynamic structures with a network organization;

- unification of modules and components to reduce the assortment and development time, weight and size characteristics, productivity component base, reliability and fault tolerance;
- implementation of advanced circuit design and construction solutions for the functional modules: multi-core processors, graphics modules to form 3D-images of high resolution, power supply modules with compensation interruption of power, highly reliable network switches, etc.

Implementation of these trends and directions of development of avionics and flight control perspective methods requires the development of the following components to ensure the safety and efficiency of aircraft operation in the next generation of complex multifactorial conditions.

2.2 Components

The main unify components are: crate base support structure, general purpose processing module, network switch module, module signal hub, optical/electrical converter module, power module, indicators with graphical processors and indication panels. The main hardware components of computational kernel are: plug-in module base support structure and graphics controller, mass memory and input/output mezzanines.

Structure of on-board equipment is implemented using a minimum range of unified open standard interchangeable units (modules and systems) with high performance and energy efficiency. Fig. 2 shows the typical unify components of VPX format of the 2nd generation integrated modular avionics platform developed by State Research Institute of Aviation Systems and Scientific Design Bureau of Computer Systems [6].

Embedded electronic systems naturally evolve toward minimization. It makes such equipment parameters as size, weight, power and cost (SWaP-C) to decrease, which offer the great opportunities for future systems, not excepting for systems operating in harsh environments. Creating computer modules with the lower SWaP-C values, without negative affect on the consumer properties and performance, opens up new markets. Such systems are based on VITA 75 standard [4]. Research Institute of Aviation Systems and Ramenskoye Instrument Design Bureau are together exploring the possibility of the implementing of this standard in aircraft.

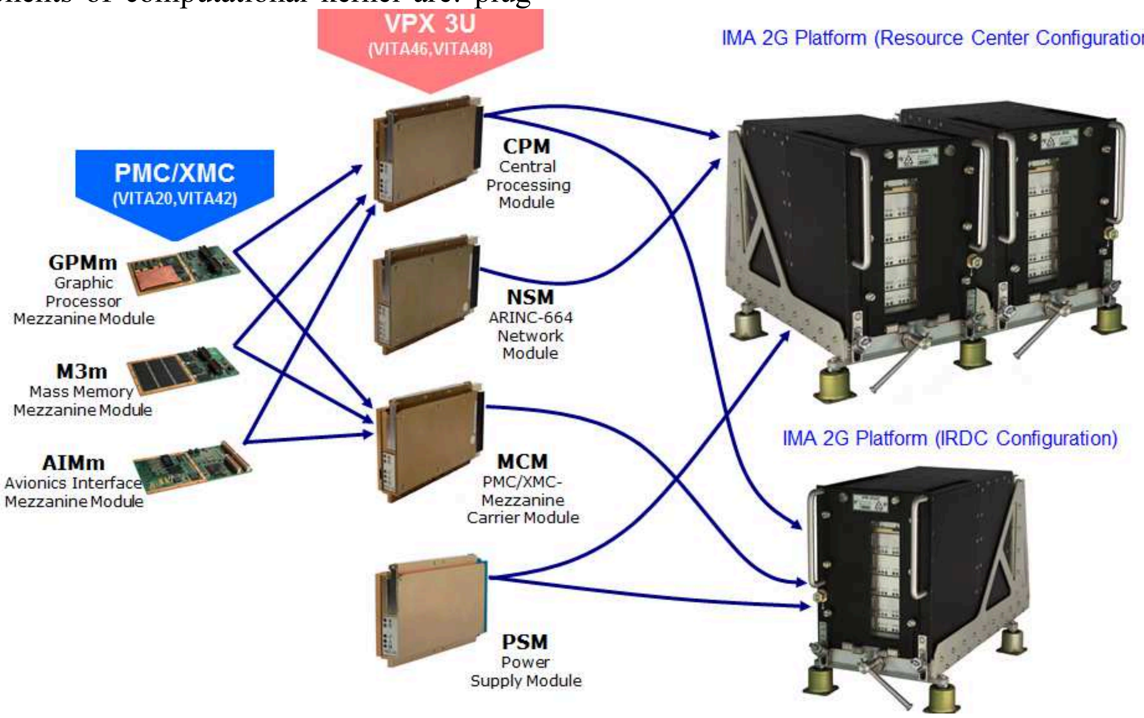

Fig. 2. Typical unify components of VPX format of the 2nd generation IMA platform

VITA 75 is a specification that defines a small form factor (SFF), the case standard, which is based on the customer's requirements. VITA 75 is actually significantly different from the VITA 73 and VITA 74, focuses on the case, both in size and level of resistance to external factors. Internal modules are subject to be determined further, but VITA 73 or VITA 74 modules may be used nowadays.

Fig. 3 shows the blade, stackable and short stackable versions of SFF modules.

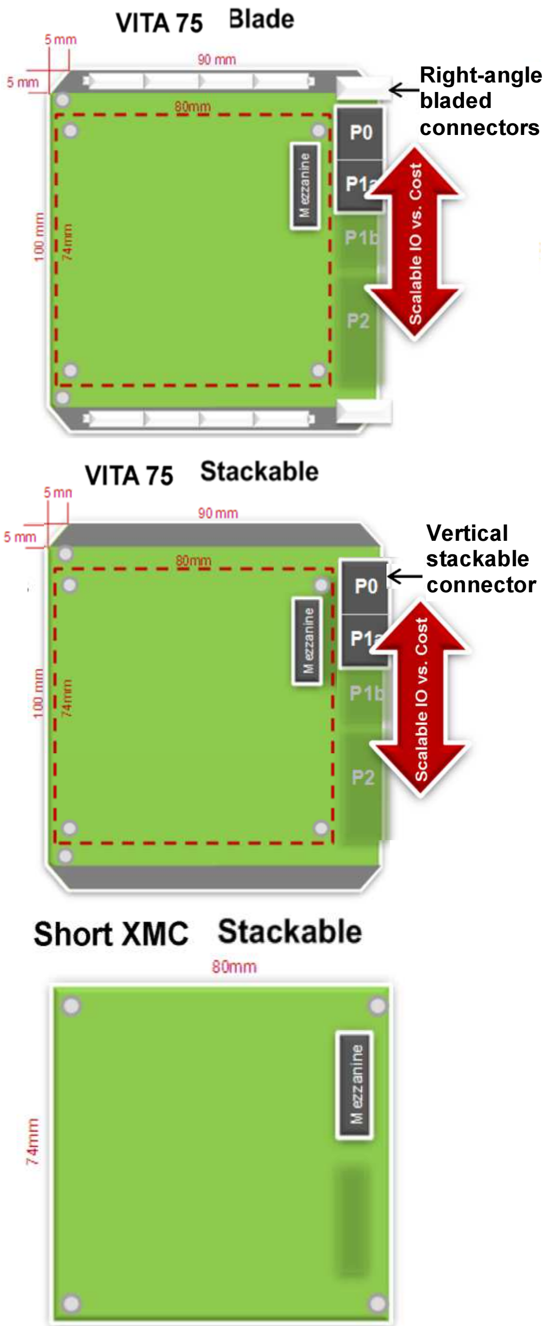

Fig. 3. Blade, stackable and short stackable versions of SFF modules

Second generation integrated modular avionics platform will implements a new schematics and constructive solutions of functional modules, crates and units of integrated modular avionics. Central processing modules will be implemented on the basis of multi-core processors with high performance and low power consumption. Graphic modules will provide the formation of 3D-graphics with a resolution of at least 1920x1200x60 Hz. Network switches will be highly secure and have low power consumption. The effective methods of high energy cooling modules will be implemented based on the standard ANSI\VITA 48.5. Lightweight composite materials for plug-in modules and crates will be used.

3 Aircraft Systems with Built-in Remote Hubs Based on IMA

Aircraft systems with built-in remote hubs based on integrated modular avionics use shared resources, suggesting an increase in inventory systems, aircraft equipment, the functions of which will be implemented in a common computing platform in the form of a corresponding functional software. Moreover, these aircraft systems will be a common information resource onboard computer network.

This will optimize the structure of the onboard avionics according to the following important parameters:

- to improve the weight and dimensions by reducing the number of connecting wires;
- to improve the reliability by reducing the list of external influences that affect the on-board equipment;
- minimize the number of sensors needed to implement the functions of the avionics.

An implementation example of systems with built-in remote hubs based on integrated modular avionics is shown in Fig. 4.

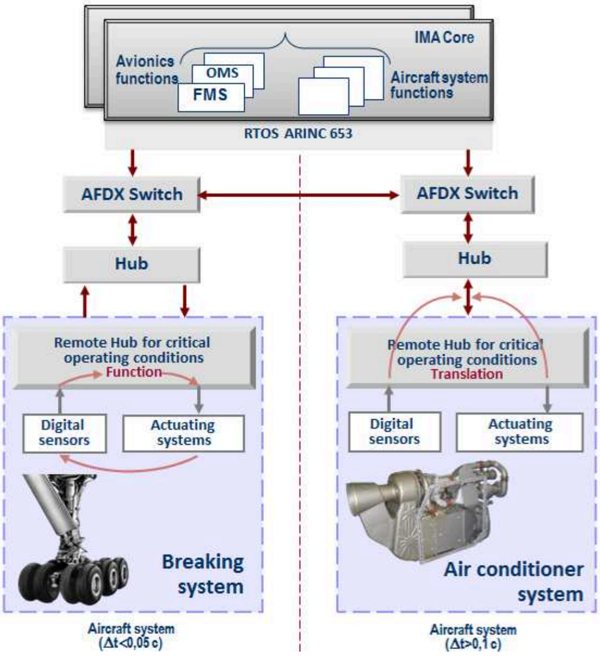

Fig. 4. IMA based systems with built-in remote hubs

The following systems can be considered as such systems: hydraulic, power supply, fuel, landing gear, air conditioning, wheel braking, icing, doors and hatches, the system lights and other.

4 Development of Complex of Multifunctional Monosensors

Promising onboard avionics should have an open network fault tolerant functional-oriented architecture based on a scalable integrated modular avionics using a single computing platform. Functions of avionic systems in this case performed the software applications that share common computing and information resources. In this structure should be implemented highly integrated multi-functional monosensors for basic avionic functions such as IMA/SDR/CNS airborne radio system. Functions of common vehicle equipment also need to maximize the overall computing resources of the complex [7].

Integrated IMA/SDR/CNS softset radio system assumes implementation of various radio signal processing algorithms based on IMA platform (Fig. 5).

Implementation of these principles in the near future will provide world leadership of national aviation in this area. To create a unified on-board radio system based on IMA it is necessary [2]:

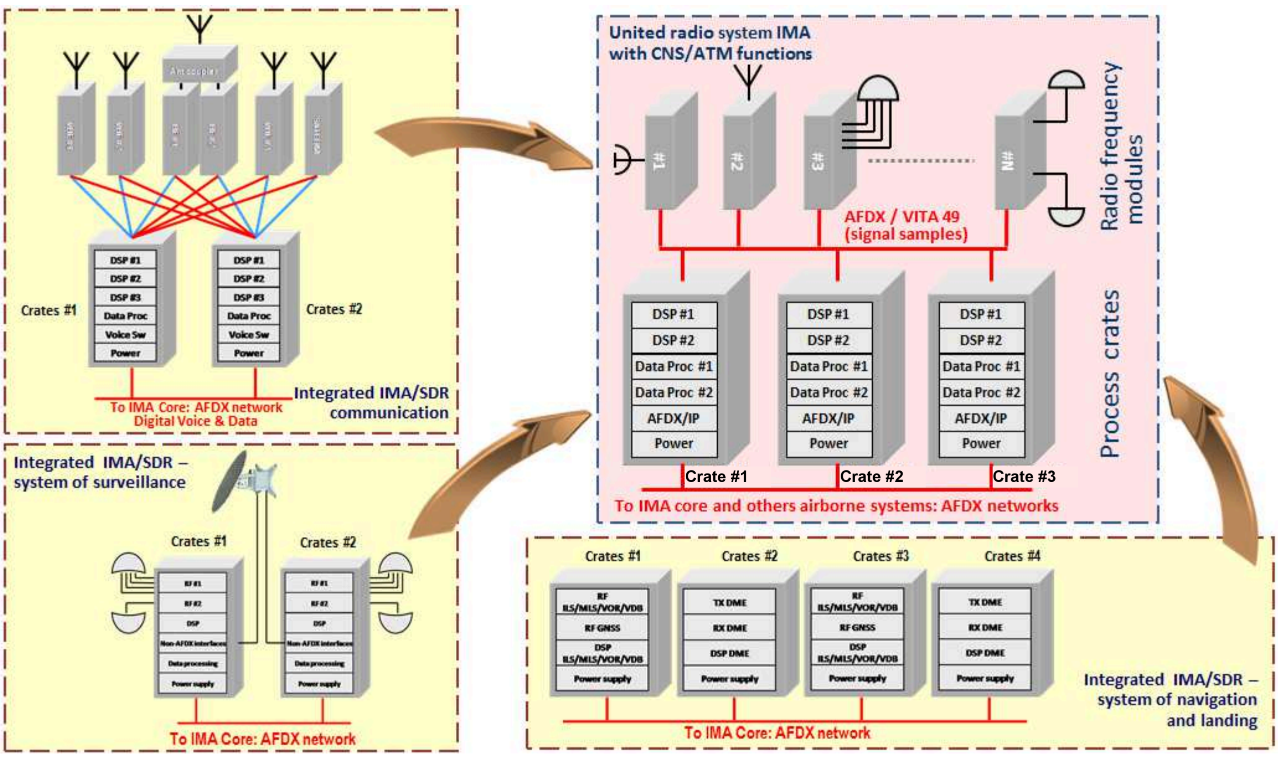

Fig. 5. Integrated IMA/SDR/CNS radio system

- to make the unification of the system modules (processors, routers, broadband radio blocks and active antenna systems);
- to develop communication protocols for combined radio components;
- to implement functions of combined radio system on a single computing platform with the unification of software modules.

Benefits of a unified IMA/SDR/CNS radio system are: improved weight and size, increased reliability and fault tolerance, reduced power consumption, reduced the number of antennas and feeders, possibility of software upgrades.

5 Development of New Features and Functionality of Onboard Avionics and Pilot Cockpit

Development of new features and functionality of the onboard avionics includes the following areas.

Development the aviation systems of improved, synthesize and integrated vision.

Development the new observation functions: detection conflicts board system with procedure of rerouting, conflict detection, superior visual overview, etc.

Expanding the functionality of existing features:

- navigation and flight management software;
- integrated maintenance software;
- electronic flightbook software, etc.

Optimization the information-controlled field of pilot cabin with a view to:

- the transition from the instrument type of flight data to visual presentation of information on the widescreen;
- introduction of more effective ways of control, which use the graphic interface, and the device of control of course (touch panel, joystick, trackball);
- introduction of new functions of crew information support.

6 Conclusion

The implementation of the on-board aircraft equipment based on IMA will significantly improve the efficiency and reduce the cost of on-board equipment development.

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