RESEARCH AND MEASURING CAPABILITIES OF THE SYSTEM-INTEGRATION LABORATORY EQUIPMENT TO OPTIMIZE INTEGRATED AVIONICS SYSTEMS

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Abstract

The paper has been intended to present research tools used at ITWL to activate and test hardware and software implemented in the integrated avionics systems. Particular attention has been paid to the research stand (built under the R&D project of the Ministry of Science and Higher Education) intended to optimize avionics systems integrated with digital data buses employed (according to, among other things, MIL-1553B and ARINC-429 standards). Specialized research equipment/test devices used to test software, including - apart from other things - test-patterns generators (within the range of display capability of the secondary head-up display (SHUD)) and information efficiency testers (for the SHUD and up-front control panel (UFCP) thereof) have also been presented.

The architecture of a Sextant Avionique's STRATUS-type navigation system, engineering accomplishment of the laboratory stand, the laboratory equipment to optimise integrated avionics systems on the digital data bus MIL-STD-1553B, research capabilities of the laboratory stand and equipment to optimize the integrated avionics system, laboratory stand's panels used in the process of integration, additional research tools for the optimisation of the integrated avionics system, exemplary research tools used to optimise software of the integrated avionics system: the SHUD/UFCP tester), and the Multi-function Display (MFD) tester are presented in the paper.

***Keywords**: integrated avionics systems, research and measuring equipment, optimization of functionality*

1. Introduction

Architectures of integrated avionics systems, in use at the present time, need of a pretty large number of digital connections of various types, depending on the kind of applications that 'operate' particular aircraft subsystems [1]. Among them are the following ones: inertial and satellite navigation central stations, radio navigation systems, weapons control interfaces, airborne radio stations. Without these often very expensive and complicated systems no aircraft, either military or civil, could make full use of their intended and designed potential. On the other hand, any aircraft, the old-generation ones including, with the integrated avionics system built in, has much enhanced functional (operational) capabilities, earlier inaccessible. The construction of such a system does not present nowadays any difficulties as far as the hardware is concerned (especially after Poland had entered the EU and NATO structures, which has made the Western Europe/North America markets open to Polish companies). What remains a real challenge is the software, i.e. the development of sufficiently effective and reliable solutions that meet any requirements of flight safety, and what is more, of using the weapons safely (in military aviation). The true extent of the problem can be illustrated by the fact that there are only a few companies throughout the world, which offer their service in the field of integrating avionics systems (including ITWL, who specialize in the integration of navigation-and-attack, and communications systems).

An exemplary integrated system that satisfies the MIL-STD-1553B standard (Fig. 1) combines sub-systems such as inertial navigation central station and satellite navigation central station (the INS/GPS), air data central station, electronic flight information system, primary flight display, electronic attitude and heading reference system (AHRS), radio altimeter, Doppler radar speed sensor [2]. What is used to provide communication and integration of avionic devices on the bus is a bus controller, a remote terminal that integrates particular avionic subsystems (or a subsystem with a built-in terminal as a stand-alone remote terminal with the inner interface), and a bus monitor (optionally, a bus recorder).

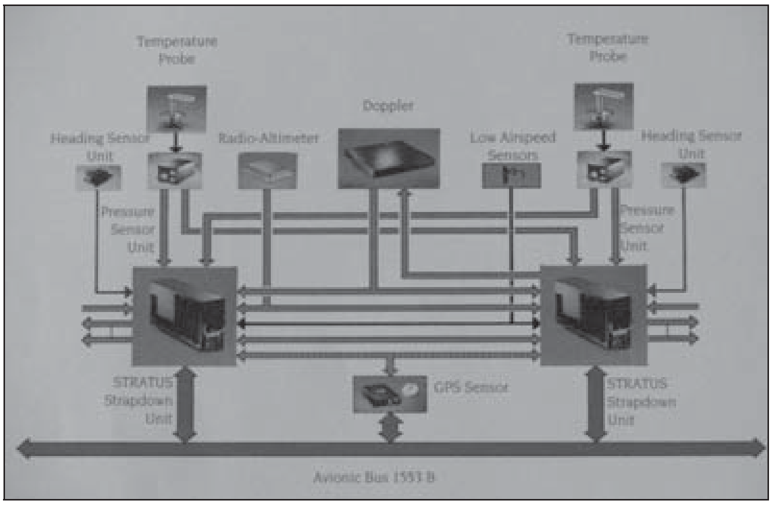

Fig. 1. The architecture of a Sextant Avionique's STRATUS-type navigation system integrated with a digital data bus MIL-STD-1553B

A standard component to support development and testing of the avionics-integrating software used by well-known and respected integrating companies (Fig. 1) is laboratory equipment to, among other things, actuate, test and optimize avionics systems as far as the architecture, organisation, and detailed management of particular modes of operation of the system under integration are concerned. Such equipment in possession of ITWL provides it with capabilities comparable to those of western companies in the field of integrating new avionic devices. A good example to prove this statement is the W-3PL helicopter upgrade project (*Capercaillie*) to satisfy the needs of the Armed Forces of the Republic of Poland.

The construction of the so-called digital glass cockpit is nowadays recognised a perfect solution to the problem of integration. The pilot is actually provided only with information absolutely indispensable to perform a given task. All the information needed is graphically presented on multi-function display (MFD) screens, which provides 'the continuity' of aircraft control capability and the so-called situational awareness [3]. The integration-dedicated laboratory stand), i.e. a research/testing tool to optimise the software of integrated avionics systems is only one among multiple highly significant means to provide such capabilities.

Discussed below are some selected functions performed by the laboratory equipment built at ITWL, as well as some selected problems in the field of optimizing the functionality and reliability thereof, which arose while actuating and testing the developed software to integrate the avionic devices.

2. Engineering accomplishment of the laboratory stand to optimise the integrated avionics system

Specialised research and laboratory tools are used at ITWL in the course of integration-dedicated activities to find optimal solutions. The most essential component to support the research work is the avionics integration laboratory stand (Fig. 2). Originally, the stand was built in the ITWL's Division for Avionics to actuate and test a set of avionic devices for the PZL M96 IRYDA, integrated in the 1990s by the Sextant Avionique.

The 'closed-loop' stand has been furnished with a basic set of devices to compose an integrated avionics system, including: the INS/GPS central station (as a source of flight-control and navigational commands), the secondary head-up display (SHUD) (as a sighting device and, at the same time, a computer for the integrated-avionics-system management), the up-front control panel (UFCP) (as a SHUD-built-in control panel operated by a pilot), the SMD-54 (a smart multifunction display to graphically present SHUD-delivered information), and the SHUD-originated imagery recorder.

Fig. 2. The laboratory equipment to optimise integrated avionics systems on the digital data bus MIL-STD-1553B

The system built on the laboratory stand is of a 'closed-loop' type as far as the tasks, the hardware and the software are concerned (i.e. it is optimised from the point of view of the Tactical-Technical Requirements for a given PZL M96 IRYDA jet trainer). Therefore, to arrive at the 'open-loop' solution (i.e. one expandable in the scope of devices in use, and with modifiable software), the stand has been additionally furnished with the KM-1 mission computer, the MW-1 multi-function display screens (with a keyboard to control the system operation), and the digital data bus terminals intended for attaching some additional devices/subsystems, e.g. radio navigation ones (e.g. the automatic direction finder (ADF), the radio altimeter, the area-referred VOR/TACAN navigation system, and the ILS/MRK/DME landing system. The stand built in this way has become a multi-purpose stand to integrate, actuate, and test the so-called avionic core system for any aircraft (e.g. combat and/or rescue ones, airliners, etc.).

3. Research capabilities of the laboratory stand and equipment to optimize the integrated avionics system

The stand has two separated (self-contained) panels to switch on the power supply and to control operation of particular devices of the integrated avionics system (Fig. 3). The panels allow for switching on the power supply for individual devices and to test the system's resistance to any introduced interference in the power supply, which is of particular importance from the standpoint of the so-called electromagnetic compatibility [4].

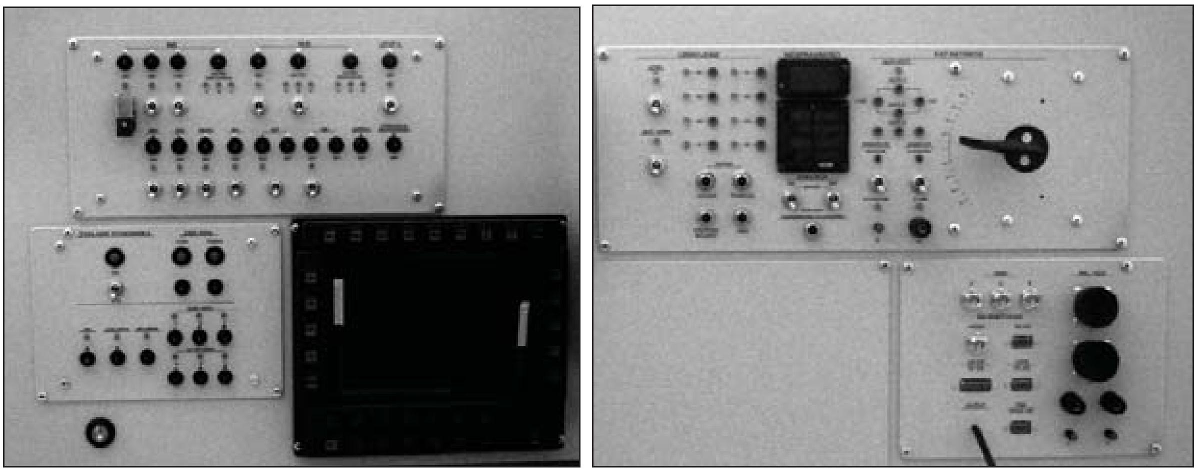

Fig. 3. View of the laboratory stand's panels: to control power supply (left), and warning-signal panel (right) used in the process of integration

The system's software for the 'close loop' version has been contained in the SHUD's memory (the SHUD plays the role of the Master Bus Controller in the integrated avionics system). After the power supply has been switched on (by means of switch-keys of the power-supply panel) the laboratory stand allows for testing (i) the so-called initialisation of the operational system, and then (ii) the correctness of operation of particular applications 'responsible' for the management of the avionic system's devices attached.

Of exceptional usefulness is one of the functions of the research/testing stand with the integrated avionics system, i.e. the Flight/Mission Planning capability. The developed software applications enable flight planning, including waypoints (latitude, longitude, altitude), runway heading, trajectory inclination and flight path angle. The system gives also the date and current flight time, and calculates the time of arrival at the aircraft's destination. Determination of co-ordinates of a current (intermediate) waypoint is a special case of system-performed calculations. The system is also capable of modifying and cancelling the already entered parameters of the waypoints.

As far as the integrated avionics system's health diagnosing is concerned, the implemented software enables the correctness of the system's operation to be continuously monitored (the so-called 'system monitoring'). It consists in the signalling of warning notes, and in cancelling them. The research stand allows for the entering of some selected, pre-set (simulated) failures to different devices. These may include a failure to the INS/GPS central station, the air data computer, the secondary head-up display (SHUD) and its full-colour multi-function display SMD-54. As far as other integrated into the lab stand devices are concerned, it is feasible to introduce a simulated failure to, e.g. the angle-of-attack sensor, the ADF - automatic dirrection finder, and the radio altimeter. The summary of the system-monitoring process is displayed in the form of the so-called System Status. The implemented applications of the system's health monitoring enable also review of the failure history and selection of failure status [5].

4. Additional research tools for the optimisation of the integrated avionics system

Another group of research tools in use at ITWL is the apparatus to test parameters of built-in devices, and software to manage operation thereof. These include: test-pattern generator PM5415/PM5418 to generate test patterns on the SMD-54 dispaly, the SHUD's (and the up-front control panel's (UFCP's)) software tester, and the SMD's-54 software tester. The MIL-1553B data bus that integrates, following the 'open-loop' approach, the radio navigation system, the communications system, the weapons system, and the data-recording system, etc. is tested using the simulator-and-tester's card of the type BU-6557011-300.

The card enables emulation – at the same time – of the so-called data bus controller, 31 remote terminals and the data bus display. Furthermore, it can be used throughout the process of the control-protocol testing, and this owing to the function of introducing errors in the data transmission. Under projects carried out at ITWL, methods of testing the correctness of data processing in avionic systems integrated on the basis of the MIL-1553B data bus, with the oscilloscope employed [6].

Among functions performed by the SHUD tester (Fig. 4) there are the following ones: checks of the correctness of SHUD displays in different operating ranges (display modes), and the SHUD's software testing. The tester is furnished with three specialised panels: for the MIL-1553B data bus address adjustment and even-parity bit checking, for the introduction of control signals, and for diplaying responses in the form of signal lamps. The tester enables generation of signals of feeding the modified software (DOWNLOAD) and erasing it (RES4 and RES5).

Fig. 4. Exemplary research tools used to optimise software of the integrated avionics system: the SHUD/UFCP tester (left), and the Multi-function Display (MFD) tester (right)

Next, the tester of the SMD-54 multi-function display as the so-called repeater of the SHUD (Fig. 4) enables the display correctness checks for particular operating ranges thereof, and comparison of their consistency with information displayed on the SHUD. Apart from the address panels (A1 ÷ A5 switches) and responses in the form of signal lamps (OUT2 ÷ OUT7) the tester contains cut-outs of control signals in the range of video signal selection (VIDEO-SEL) and software downloading (DOWNLOAD). The tester has also the video-signal output joint in the from of the RVG and NTSC sockets, which in turn allows for copying the image from the SMD-54 display to another (additional) display or recorder.

5. To recapitulate...

Modern integrated avionics systems for military aaplications comprise very complex, functionally complicated, computerised sub-systems and terminals, including navigation, communication, and weapons control/ management ones. Integrating them with digital data buses (e.g. the MIL-1553B) employed needs suitable research tools, just to mention the so-called integration-dedicated stand (laboratory equipment) and software testers used to successfully accomplish optimisation thereof.

The in this way built avionic system can operate in the navigational, landing-approach, weapons engagement (e.g. air-to-ground, air-to-air missile lauching), and training modes. Furthermore, such a system 'usually' performs continuous equipment-components monitoring and analyses consequences of failures/damages to every item of the equipment. The above-mentioned components of the integrated avionics system located on the integration stand built at ITWL and different modes of operation provide capabilities of testing the correctness of their operation and resistance to fluctuations in power supply voltage, electromagnetic effects of particular devices upon each other, and validation of the implemented software. Capability to emulate selected devices within the avionic systems, indispensable if a given device is missing while software to integrate the avionic system is developed, proves a great advantage of the ITWL-developed stand. If the stand is developed further on, the development being based on the so-called model set of devices, for the range of flying-and-navigation systems (with mission computer, multi-function displays and the so-called signal concentrator units taken into account), it will be possible to continue with the integration comprising radio navigation, communications, weapons, airframe and engine control systems, etc.

The research/testing stand forms the ITWL's laboratory assets to develop and test the software for the integrated avionics systems under construction, or already built but requiring validation or optimisation. The ITWL-used research/testing tools offered support the process of testing the correctness of operation while actuating and operating the avionic systems integrated on digital data buses. In particular, they offer good grounds for developing the so-called 'digital technology demonstrator' (including the MIL-1553B and ARINC-429 simulators) data buses operational simulator to satisfy the training/operating needs as far as the information/data processing in airborne avionic systems is concerned.

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