LABORATORY EQUIPMENT TO OPTIMISE INTEGRATED COMMUNICATION SYSTEMS FOR MILITARY HELICOPTERS

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Abstract

What has been presented in the paper is a research/testing tool used in the Air Force Institute of Technology (Instytut Techniczny Wojsk Lotniczych – ITWL) to build, actuate, test, and optimise integrated communication systems as far as both a set of devices the system is composed of and the applied software are concerned. Particular attention has been paid to the so-called integration station (built under the Mi-8, Mi-17, Mi-24 upgrade project), i.e. the laboratory equipment to optimise and unify communication systems integrated on the basis of digital data buses (following the MIL-1553B standard, among other ones). Such equipment has allowed ITWL to integrate new communication devices/systems while upgrading the W-3PL helicopter. Some selected tasks performed with this equipment engaged have been discussed. Also, problems arising while actuating and testing the developed software to integrate communication devices/systems (including digitally controlled radio stations of the RRC, HARRIS, and MR6000 types, communication control panels of the PSŁ-1 type and multi-function displays of the MW-1 type) have been given consideration in the scope of the software functionality and reliability. Presented are also additional monitoring and measuring systems used to test this software, just to mention the M230 rugged laptop computer used to diagnose the system and prepare plans of the radio communication.

Keywords: *integrated communication systems, research/testing station, software optimisation*

1. Introduction

A helicopter is one of the most universal tools of a modern battlefield. It performs missions typical of an aerial weapons platform (a gunship/attack helicopter), destroys the enemy's armour concentrations, provides reconnaissance and patrol flights, and support to friendly forces, including airborne assault/troops landing, close support, and evacuation. Only these few examples show of what significance for the modern armed forces the helicopter can be. It appears [1] that to have missions accomplished precisely and on time it is necessary to provide a suitable radio communication system, which is one of the most essential requirements.

A communication system is one of primary tools on the helicopter. The most essential requirements, i.e. being reliable and covert remain unchanged for many decades. Nowadays, it means protection of any radio transmission against interception and decoding of radio traffic by the enemy. A helicopter usually carries a crew of several people and a dedicated team (e.g. combat troops, a medical team, etc.); on this account the communication system on the helicopter is much more complicated than that on a combat aircraft. The system in question as the so-called intercom has to provide communication for the people on board, whereas the aircrew and the team commander have to keep up communication between the helicopter and other units, e.g. a command & control centre, a convoy, other helicopters, etc.

Modern Western solutions in the field of airborne communications have been based on the computer technology. A typical communication system shows an analogy with a computer system, operation of which is based on a digital data bus that follows some accepted standard (among other ones, the MIL-1553B). To meet these requirements and to improve the so-called situational awareness of the aircrew in the field of radio communication [1], the integrated communication systems of the ZSŁ type have been developed in the ITWL's Division for Avionics. They are a computer-based set of airborne and tactical radio stations essential to successfully perform and accomplish a combat mission. This is what provides the aircrew with communication throughout the whole flight while on board of a military helicopter. To control the system, specialised control panels of the PSŁ-1 type or multi-function displays MW-1 (with internal/external radio-station/ subscriber selecting keys) are used. A communication server that manages radio communication system is the main component of the integrated communication system for aircrews of military helicopters. The communication server consists of control and managing packages furnished with suitable software. The helicopter's crew members control particular components of the integrated communication system via control panels of the PSŁ-1 type (or multi-function displays and radio station dedicated devices). Depending on the military helicopter's assignment and the mission complexity degree, parameters from particular radio stations and radio navigation data (including the so-called special signals) are transmitted to the communication server.

The final task in the process of constructing the integrated communication system, prior to building it into a military helicopter, is the system optimisation that allows the best solution to be found/selected from among the accepted propositions, one that would satisfy criteria resulting from the user's requirements. What supports the process is the so-called integration station [2], which allows of the optimisation of the integrated communication system's architecture components, organisation, and functions under laboratory conditions. This, in turn, enables tests of several solutions, the implementation of which into the helicopter solely for testing purposes would be difficult or too expensive. This integration station may also be used in the processes of unification and optimisation of functions of the software to integrate particular airborne and tactical radio stations. Such being the case, it is used as a monitoring and measuring station intended to verify the ITWL-developed draft versions of software for the communication systems in the areas of the organisation and detailed management of particular modes of operation of the integrated communication system. The integration station has allowed ITWL to integrate communication devices also while upgrading the W-3PL helicopter [3].

2. Architecture of some selected integrated communication system (ZSŁ) setup used in the Armed Forces of the Republic of Poland

To make Polish military helicopters (e.g. Mi-8, Mi-17, Mi-24, W-3PL) satisfy the needs of a modern battlefield, an integrated communication system of the ZSŁ type was built into these helicopters while upgrading them. The system was intended to provide communication between helicopters, ground stations, and airspace control stations. It allows the aircrew to select any radio station or subscriber while carrying out internal and external transmissions. The on-board radio communication system also protects the classified and unclassified traffic using frequency coding (the so-called TRANSEC) and speech/data encoding (the so-called COMSEC) capabilities. The range of frequency band was adjusted to suit the User's needs and those of selected radio stations subjected to integration on board of a military helicopter. To determine distinctive features of such a system, analysed was the ITWL-developed integrated communication system built into the above-mentioned helicopters operated by the Polish Land Forces.

The integrated communication system of the ZSŁ type on the Mi-8 and Mi-17 helicopters (Fig. 1) comprises the communication server SK-1, control panels PSŁ-1, airborne radio stations to provide communication between the helicopter and the command & control centre and other aircraft, and VHF/HF tactical radio stations to support the Polish Land Forces and command and control centres at large distances from the radio station. Multi-functionality is a characteristic feature of this system, which means that both the helicopter commander (left station) and the co-pilot/navigator (right station) can use the radio communication system simultaneously and select the mode of operation of radio navigation devices in the range of the so-called navigation signals from the VOR, ARK, TACAN, and MRK systems [4].

Fig. 1. The cockpit with components of the ITWL-developed integrated communication system ZSŁ-1 built into the Mi-8 helicopter

In the Mi-24 combat helicopter, the components of the integrated communication system have been arranged in a different way because of the tandem (with lower and upper pilot seats) cockpit configuration. However, it does not affect the functioning of the whole system.

Fig. 2. The cockpit with components of the communication system in use until now (left) and the ITWL-developed integrated communication system ZSŁ-1 (right) built into the Mi-24 helicopter

To control the integrated communication system on the Mi-8, Mi-17, and Mi-24 helicopters, pilots use control panels of the PSŁ-1 type (Fig. 3), which allow of the selection of a radio station and changes in the settings of performance parameters. The control panel PSŁ-1 includes a colour LCD display, 4 × 3 inches in size, with software of its own. The control-panel display shows, among other things, states of internal and external connections, the type of communication performed, and radio station performance characteristics. A pilot can select an internal subscriber or the radio station via the control panel, the connection being executed by the communication server. The already constructed ZSŁ system can be expanded with additional functions, depending on the user's needs [5].

In the case of the W-3PL helicopter, communication-system control functions are performed by the MW-1 multi-function displays (Fig. 3), 8 × 6 inches in size, of high brightness and resolution. Hence, the helicopter and the aircrew remain operational under all weather conditions, day and night (under different cockpit illumination conditions), and using the night-vision goggles.

To reduce the cost of operating the ITWL-constructed integrated communication system, attention has been paid to the unification thereof. Therefore, components of the system (such as communication server, control panels, the radio station set) are interchangeable and can be used on helicopters of different types. By the way of example, the integrated avionics system (the so-called macro-system) has been built into the W3-PL helicopter; the integrated communication system is one of the components thereof [3]. This one is the most 'expanded' version of the integrated communication system ZSŁ built into a military helicopter operated by the Polish Land Forces. It comprises, among other items, the digitally controlled radio stations of the RRC, HARRIS, and MR6000 types; and three displays of the MW-1 type (for the commander, the co-pilot/operator, and the cargo/troop compartment commander).

Fig. 3. The PSŁ-1 control panel (left) and the MW-1 multi-function display (right) included in the ITWL-developed integrated communication systems

The W-3PL cockpit (Fig. 4) is outfitted with two multifunction displays MW-1 that control the communication system, inform of the operational status of particular radio stations and whether/to what extent other components of the integrated avionics system remain fit for use. Selection of the mode of operation depends on the aircrew decision. Every aircrew member has their own display with a visual representation of a complete set of data essential to perform the mission. All the data are visually represented on these multi-function displays in a fully independent manner.

Fig. 4. The cockpit with components of the ITWL-developed integrated communication system built into the W-3PL helicopter

A general diagram showing how the integrated communication system has been arranged for the above-mentioned military helicopters (Fig. 5) comprises the communication server SK-1, control panels PSŁ-1 (or multifunction displays MW-1), and integrated radio stations.

The communication server provides the on-board communication network with the supervisory control and management. It controls/manages the internal and external communication in both the aircrew- and the troops-dedicated circuits via control panels PSŁ-1 (or multi-function displays MW-1).It also provides the helicopter aircrew with special signals, including the disconnectable navigation signals (e.g. markers) and disconnectable signals – warnings (of, e.g. hazardous flight altitude).

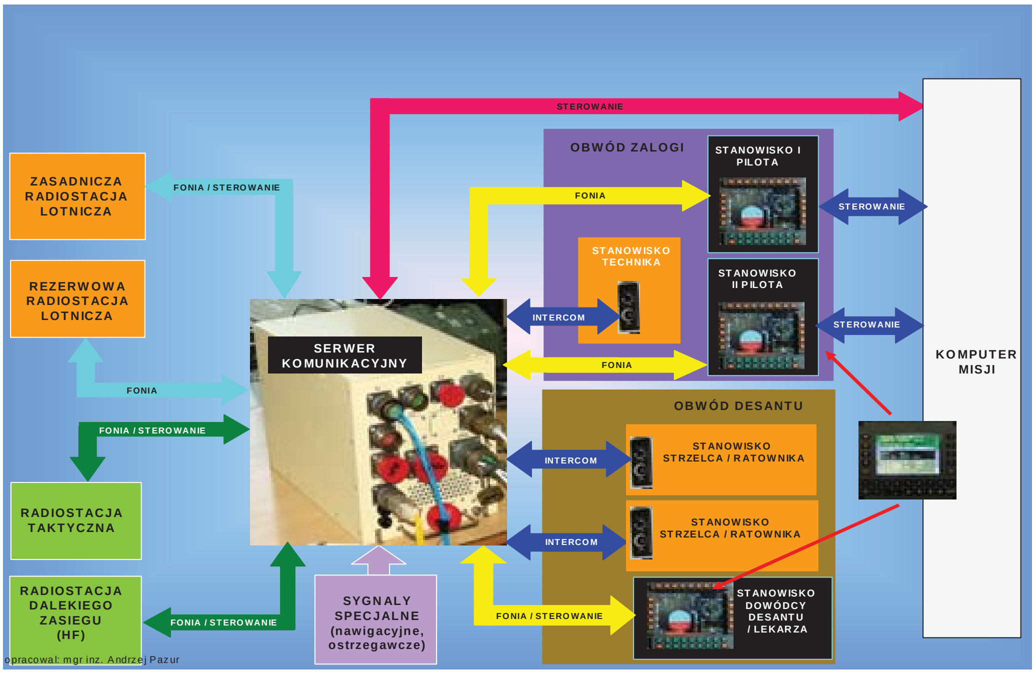

Fig. 5. A general diagram of the organisation of the ITWL-developed integrated communication system ZSŁ-1 built into the Mi-8, Mi-17, Mi-24, and W-3PL helicopters

3. The unification and optimisation of the composition and functions of the ZSŁ

The integrated communication system built into the above-mentioned helicopters provides transmissions via airborne and tactical radio stations, including the selection of a suitable radio station, the subscriber, and the way of communication. The system constructed in this way provides navigation signals and warnings, both kinds essential to the aircrew during any flight. The system upgrade project (carried out at ITWL) has been aimed at providing further operational use of the helicopter fleet up to moment modern aircraft are introduced in service. The optimisation of the system allows the best – from the point of view of the quality criterion assumed – solution to be found using the integration-dedicated equipment/station available; the quality criterion defines, e.g. the range, the number of channels, maintainability, reliability, and cost of the system) [6].

The targeted mission of the in this way understood optimisation of the integrated communication system is to construct a fully functional version of the system, well-suited to the aircrew needs and tasks, together with a specific type of military helicopter dedicated software. The most fundamental criterion (assumed while formulating principles of selecting/adjusting devices to be included in the integrated communication system, and while optimising the devices-dedicated software) is to meet requirements resulting from the architecture and organisation of the system and intended to facilitate successful completion of helicopters-performed combat missions.

The first step in the process is optimisation of the selection of tasks and functions. The intended aim is to determine parameters essential to the completion of tasks and functions, performance parameters, the scope of modernisation (e.g. what should be left as it is, upgraded, or replaced) within the integrated communication system. Owing to the optimisation of the selection of tasks and functions, a suitable level of visual presentations of communication parameters to the aircrew is possible. It is also true for the functions performed via the airborne and tactical radio stations.

The second step is the optimisation of the selection of kinds and types of devices. The task comprises determination of parameters of some selected airborne and tactical radio stations, the kind and type of the radio station that shows the assumed and required parameters (the selection of the type of devices), and the scope of integration (what remains unconnected, what and how should be connected). The optimisation of the selection of kind of devices is carried out by means of analysing offers (including information in catalogues and advertisements) on devices available in the avionics market. The analysis of offers also includes arranging the data into groups according to their subject (e.g. tactical, economic, technical/engineering, computer-science related data, etc.) and determination of the weighting factor (i.e. the importance of a given parameter to satisfying the assumed requirements). Another element is determination of optimum values of a given parameter (or acceptation of the user-formulated requirements ZTT – Technical and Tactical Specifications) and the admissible interval between the best and the worst solution (offer). Calculation of differences in values of parameters for every proposed solution (i.e. differences between the in a given solution proposed values and the optimum ones) enables us to generate a matrix of values of a multi-criteria function by means of attributing corresponding values of the so-called coefficient of parameter to calculated differences. To facilitate the analysis and selection of the optimum solution, the matrix can be subjected to the 'normalisation' operation that consists in bringing values of the selected parameters to suitable values from the interval $\langle 0,1 \rangle$ at the assumption that weighting factors are also brought to values from the interval $\langle 0,1 \rangle$ [5]. Optimisation should be initiated with the selection of values of weights of the same values (equivalued parameters) or pre-set values (following the user's needs, or capabilities to satisfy them) and determination of the so-called boundary conditions, i.e. conditions necessary to be satisfied by the integrated communication system.

The last step in the optimisation process at the stage of laboratory work is verification of the selected propositions on the architectures of the integrated communication systems composed of the earlier analysed devices. The integration station [2] plays a very special part in this case. It allows a number of solutions to be verified, i.e. ones, implementation of which into an aircraft would prove difficult or too expensive.

4. Research/testing capabilities of the station dedicated for the unification and optimisation of the integrated communication system ZSŁ

The completed analyses and the experience gained throughout the research/testing work have facilitated the construction and development of the testing station at the ITWL's Division for Avionics [2]. The station has been designed for the activation and optimisation of communication systems based on the communication server (outfitted with suitable interfaces that are cards for the MIL-1553B-based data exchange bus). Such testing station (Fig. 6) is essential to the testing of 'applications' under development, designed for operating communication system's devices, and hence, for the integration thereof into one compact on-board system. Another advantage of the constructed station is its capability to test the integration-dedicated software and the diagnosing of particular radio stations of the communication system. One of the most fundamental advantages of the station is a capability of simulating some selected radio stations included in the radio communication system, of essential importance when we lack a given device while developing the whole system integrating software.

The major components of the station to optimise the integrated communication system are the communication server built into the station, and airborne and tactical radio stations. Also, there is a kind of a mount with built-in control panels and subscribers plates to connect earphones? to check the whole radio communication system through [6]. Furthermore, there is the M230 rugged laptop computer that '(…) meets and exceeds the standards set by the military and industry (…)' and is used to diagnose the communication server and radio stations included in the integrated communication system [5]. It allows of the feeding and testing software dedicated for particular radio stations and the communication server, and of preparing the radio communication plans. In the program layer the station makes also use of the modified operating system Windows XP implemented into the communication server to, among other things, facilitate the handling of packages and interfaces of integrated devices.

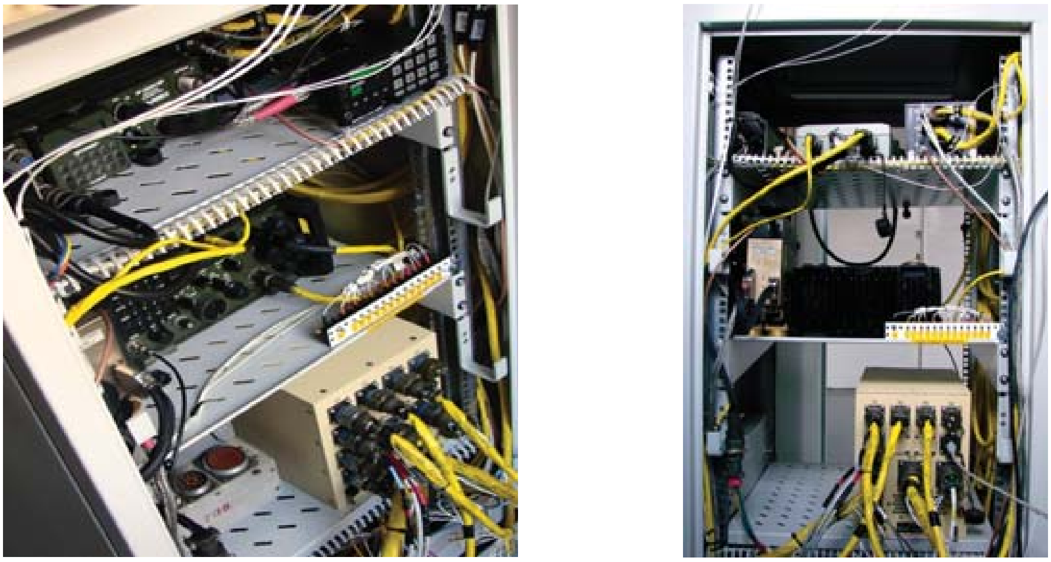

Fig. 6. The testing station with communication system's components (left) and control items (right), constructed and developed at the ITWL's Division for Avionics

5. To summarise ...

Every old-generation helicopter with a modern communication system built in shows much greater operational capabilities, expanded now with applications which up to the present have stayed beyond the engineers' reach. The multi-functionality and capability to operate in the strongly developing network-centric environment are such features [1]. There is no problem with building such a system, i.e. with purchasing the hardware items. What is a real challenge is the development of suitable for the purpose, effective and reliable software that satisfies needs and meets requirements to provide external and internal communication on board of a military helicopter. The ITWL's Division for Avionics took the job upon themselves and was first in Poland to integrate the communication system on board of the upgraded helicopters Mi-8, Mi-17, and Mi-24 of the Polish Land Forces. The integrated communication system of the ZSŁ type is fully operational on military helicopters of the Polish Military Contingent in Afghanistan.

The in ITWL built station to optimise communication systems provides integration of different devices – components thereof (including radio stations), with digital data buses employed and following the accepted standards, e.g. the MIL-1553B. It affords the testing of different functions and formats for data exchange, processing, and visual representation; also, simulation of particular items of the communication system for some selected system architectures. It also permits the communication systems integration following the guidelines included in respective standards and ICAO and NATO rules and regulations, as well as extension thereof with additional functions, depending on requirements of future recipients.

To reduce the cost of operating such systems, a high level unification of applied components and software has been provided. The system components such as control panels (or multi-function displays), the communication server, and stand-alone versions of radio stations are fully interchangeable among different types of military helicopters operated by the Polish Land Forces, with integrated communication systems built in. If (real and fully justified) need be, it is possible to shift the components from one helicopter type to another. Owing to having built the research/testing station that facilitates the optimisation and unification of the integrated communication systems and to the project of upgrading military helicopters flown in the Armed Forces of the Republic of Poland, further operational use thereof in the Polish military aviation has been guaranteed, with high level of compatibility and interoperability in the field of radio communication systems provided.

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