ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/01.3001.0010.2837

POSSIBILITIES OF VOICE SUPPORTING OF THE PILOT IN MULTI-TASK MILITARY AIRCRAFT

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Abstract

The article presents selected results of the analytical works, carried out in the Air Force Institute of Technology, in the field of possibilities to support the pilot's work in the cabin of the modern multi-task aircraft or military helicopter with the use of the computer voice communication assistant, with automatic recognition of the pilot's voice and speech, which operates in conditions of the lack of time. There are presented the voice systems warning the pilot of the occurrence of an emergency state, as the so-called voice guides, P-591-04 type, used in the MiG-29 multi-purpose aircraft and RI-65 type, used in the Mi-17 and Mi-24 helicopters. As an example of implementation of the concept of a new system supporting the pilot's work, there was selected the voice communication system, constructed in the Air Force Institute of Technology for the W-3PL multi-purpose helicopter with the ZSA integrated avionics system. The main research problems related to the construction of integrated avionics systems, verbally supporting the pilot's work, were discussed, and the specialized tools and research stations used in the Air Force Institute of Technology for the phonoscopic speech and voice studies, were presented. Furthermore, an example of the functional diagram and the system architecture of the pilot's work verbal supporting for a selected emergency situation on the aircraft board were demonstrated, as well as the expected range of that system's applications.

Keywords: *transport, aviation, aircraft voice supporting systems, cockpit voice activated systems*

1. Introduction

One of the avionics systems, dynamically developed in recent years, include the devices for verbal communication with the pilot, which inform him about the occurrence of an emergency situation or provide answers to the questions asked by the pilot [5, 8]. In the Polish military aviation, the voice systems warning the pilot of the occurrence of an emergency state, as the so-called voice guides are used, among others, in the MiG-29 multi-purpose aircraft (P-591-04 type) and the Mi-17 and Mi-24 helicopters (RI-65 type). The applied on-board warning systems use simple devices in the form of tape recorders. In the situation of the emergency state occurrence (e.g. fire on the board), they play back the messages recorded earlier on the magnetic tape, and signal with sound in the form of a bell placed in the aircraft cabin. In the RI-65 voice guide, all the voice information is recorded in the order dependent on the priority, and the device makes it possible to play the recorded warnings twice.

The priority is determined in such a way that the information given through the channel of a lower order number is more important than the one given through the channel of a higher number [1, 2]. More advanced versions of the devices "talking" to the pilot include the systems warning of the air collision possibility (TCAS type) and systems warning the pilot of the possibility of a collision with an obstacle or the ground (TAWS and EGPWS types). These systems currently constitute standard equipment of the military transport aircraft, among others, C-130 Hercules, CASA C-295M and M28B/PT Bryza, operated in the Polish Armed Forces [7].

The devices, which receive the pilot's voice messages, include voice control systems of the VTAS type integrated avionics system, and the VHMI type voice navigation data entry system. These systems are introduced as equipment of the following military aircraft: F-16 Vista, Rafale, JAS-39

Gripen and Eurofighter Typhoon [11]. The most technologically advanced system includes the ADACEL system constructed for the F-35 Lightening II multi-purpose aircraft. In the Polish aviation, there is a lack of any devices of this type.

An example of the military aircraft with advanced devices supporting the pilot in terms of generation of voice messages is F-16 with the VIPER system (Fig. 1). It is a multi-purpose aircraft of increased manoeuvrability with the active flight control system and the MMC module mission computer managing the integrated avionics system operation. Various kinds of sound signals (information and warning), which are recorded by the CVP type on-board recording equipment, are given through the intercom to the pilot's headphones. However, in the version operated in the Polish Armed Forces, the F-16 aircraft does not have a voice system at the level of the verbal communication assistant [8].


Fig. 1. View of the F-16 aircraft (left) and the Viper helmet-mounted imaging and communication system (right)

In a situation threatening the flight safety, the pilot of the modern military aircraft is forced to take quick decisions, the basis of which is an increasing number of information "hidden" in the computer storage and data transmission digital buses within the integrated avionics system. As the research demonstrates [5, 11], clear reduction of time related to obtaining information is possible, among others, by introducing its transmission channel in the form of the pilot's two-way verbal communication with the on-board computer.

With the use of the "human-machine" verbal communication channel, the pilot receives a new tool to control the aircraft on-board systems and a new method of obtaining information necessary for effective piloting and using the integrated avionics system elements, among others, in terms of the on-board weapons [9].

2. Problems of recognition and speech understanding in the pilot's verbal messages

One of the main problems while constructing the verbal communication system is, among others, the necessity to ensure the pilot's voice correct recognition and the correct understanding of his natural expression [6, 9]. This factor decides about the safety of using this type of system on the aircraft board. It also constitutes an indispensable element for convincing the pilot that the reliability level of such a system is at least equal to the current method of reading indications of the instruments and receiving sound signals, giving him the opportunity to focus on the area observation, select the target or reach the landing field, and also to reduce the time and improve the decision-making comfort.

The effect of the pilot's verbal expressions includes audio files, which, as the measurement signals, are analysed in the speech recognition module of the communication system (Fig. 2).

In order to process the information included in the pilot's voice command, the currently designed and constructed on-board systems use advanced speech recognition algorithms. The algorithms applied in them are based, among others, on the Markov stochastic models, the Kalman optimal filtering and technology of artificial neural networks [6]. Due to the importance of direct use of voice messages to improve the flight safety, the pilot warning systems are used in the civil and military aircraft.

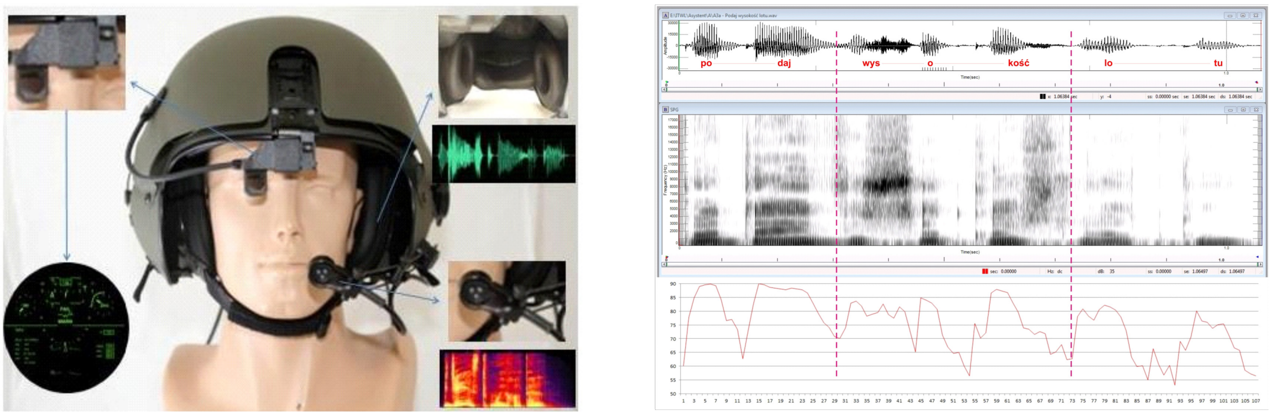

Fig. 2. View of the pilot's verbal communication system elements (left) and the speech analysis capabilities (right)

3. Proposal of the pilot verbal supporting system for the W-3PL helicopter

As an example of implementation of the concept of a new system supporting the pilot's work, the voice communication system, constructed in the Air Force Institute of Technology for the W-3PL multi-purpose helicopter with the ZSA integrated avionics system, was selected [6, 10]. The basic idea of this concept is to create the "assistant" module as a verbal communication system, which is not intended to replace the pilot in his actions, but to support his actions (Fig. 3).

Fig. 3. View of the W-3PL helicopter (left) and the NSC-1 helmet-mounted imaging and communication system (right)

The general schematic diagram of the verbal communication unit connection with the integrated avionics system (Fig. 4) includes digital data exchange buses. They provide the pilot with necessary information about the risks directly resulting from the flight conditions, and about dangerous situations occurring on the aircraft board [10].

The main element of the verbal module of the pilot's "assistant", which integrates the avionics equipment (on-board computer) with the pilot, includes the imaging and voice communication system, which has a built-in interface connecting it with a digital data bus according to the MIL-1553B data transmission military standard. This device is a modified version of the KG-1HC graphic computer (Fig. 4), which is the main element of the NSC-1 helmet-mounted targeting system, developed and constructed for the W-3PL military helicopter [10].

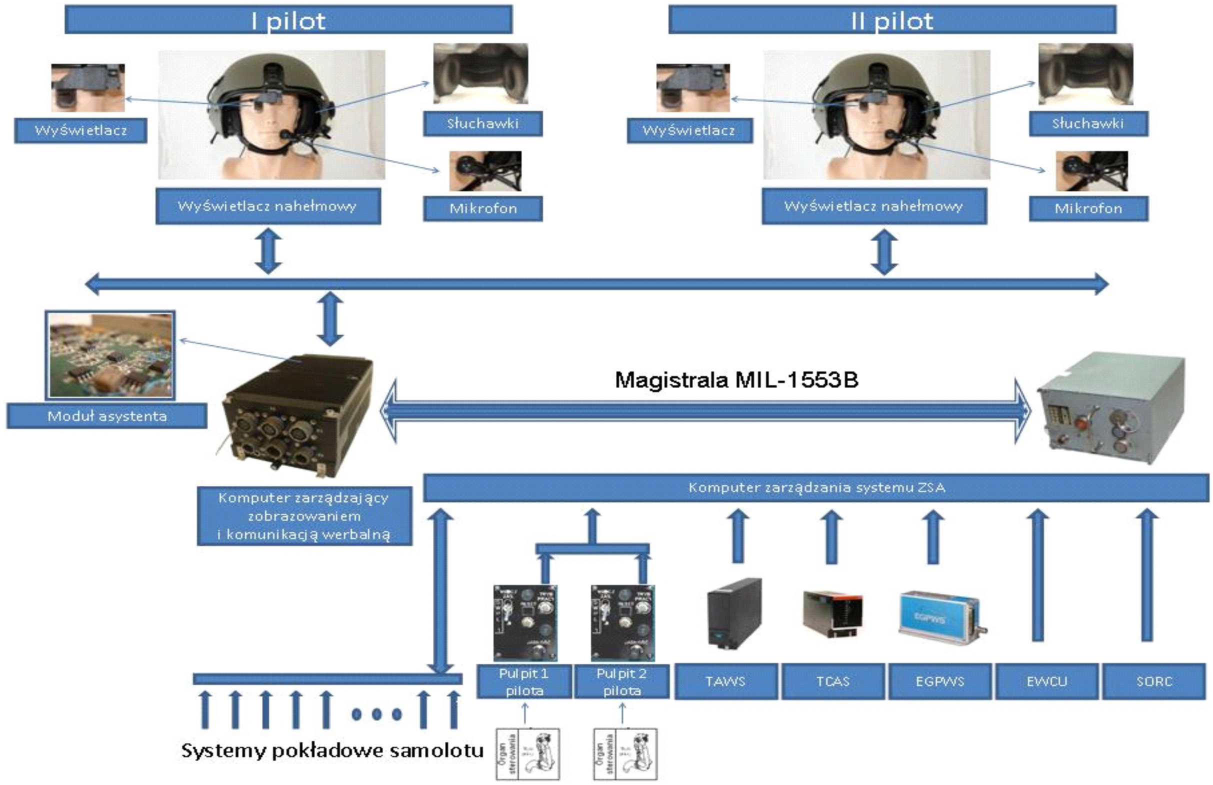

Fig. 4. Example of the method of integrated verbal communication block and avionic system of W-3PL helicopter

4. Proposal of the verbal system supporting the pilot for the MiG-29 aircraft

In the verbal communication system offered for the MiG-29 aircraft (Fig. 5), it was assumed that the module constructed in the Air Force Institute of Technology will cooperate with the pilot in a creative manner, i.e. will "understand" his natural speech and it will be able to use it [11].

Fig. 5. View of the MiG-29 aircraft (left) and the SzCz-3 helmet-mounted imaging and communication system (right)

In the proposal developed for the MiG-29 aircraft with the integrated avionics system (Fig. 6), the KG-1HC modified module, as the imaging and voice communication computer, would fulfil the function of the pilot's "assistant" managing its visual and sound communication with on-board devices [3, 11, 12]. A microphone and headphones located on the pilot's helmet would be the direct voice communication interface. Voice commands issued by the pilot would be recorded and analysed by the speech recognition module, which constitutes the main element of the "assistant" system. This module would consist of the built-in speech recognition algorithms that would use artificial neural networks (as in the system for the W-3PL helicopter). They would check correctness of the recorded command regarding the acoustics and grammar, by comparing it with authority records included in the dictionary of commands [10].

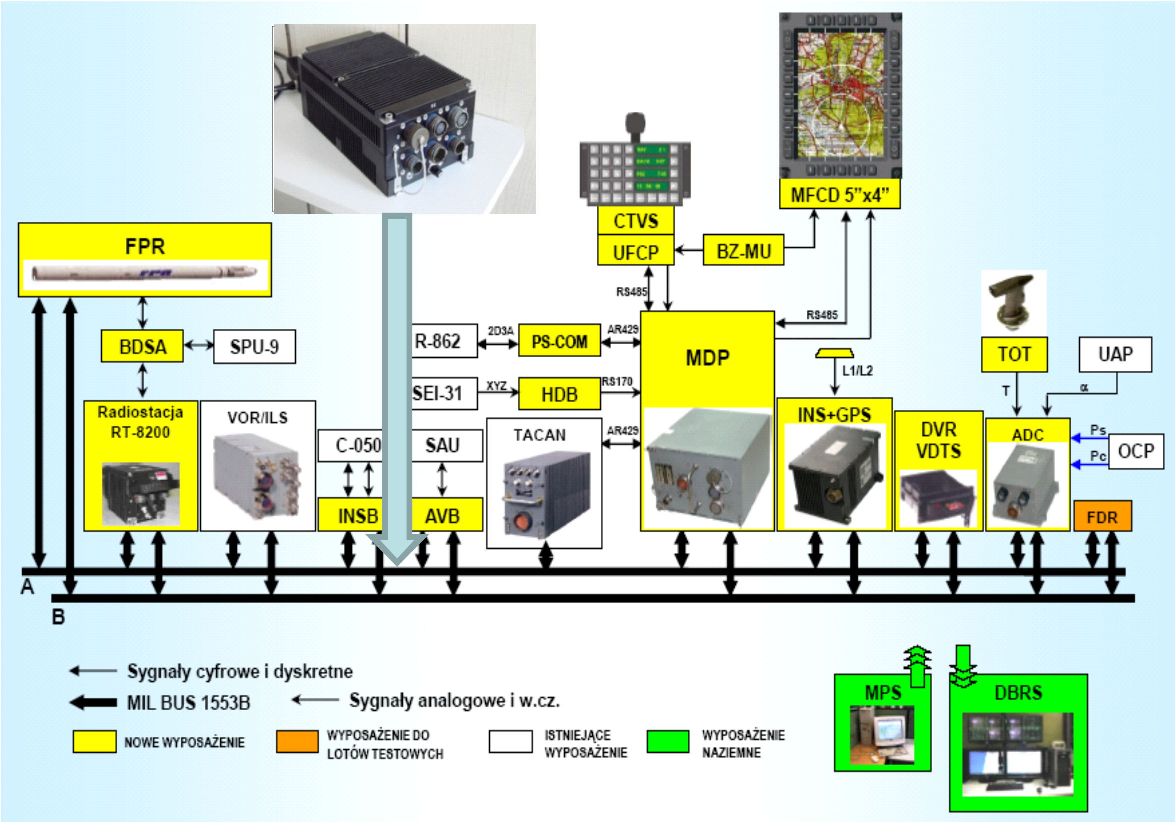

Fig. 6. Example of the way of integration of the verbal communication with the MiG-29 aircraft avionics system

One of the basic conditions imposed on the verbal communication system, is the requirement that a new system maintains the capabilities of the already used systems, in terms of independent data collection and monitoring their changes in order to inform the pilot about danger. An additional advantage of the proposed system would be the ability to verify the pilot, based on the analysis of the voice characteristics, the manner of speech, and knowledge resources in order to determine the powers and customisation of the base of commands that will be used by the pilot [9].

The main functions of the system in terms of receiving voice commands issued by the pilot would include, among others, setting the system operating modes, entering route points to the navigation system, setting the autopilot operation parameters, controlling the position of the chassis, flaps and airbrakes, setting the operating parameters of communication systems, and the mission computer programming (selection of operating modes and introduction of new applications). The task of such a system would be also to organise the so-called "paths" for transmission of commands and emergency sounds on the basis of warning signals, e.g. from the radio altimeter, the "own – foreign" identification system, and the detection system of failures and dangerous situations [12]. These signals should be given a higher priority in terms of imaging and sounds, in relation to the signals from the radio navigation systems, e.g. (ARK, VOR, TACAN).

5. Summary

The existing voice supporting systems for the pilot can be divided into the voice systems warning of danger of the DVO type (Direct Voice Output) and the systems receiving and interpreting the pilot's voice commands of the DVI type (Direct Voice Input).

Currently, the main devices, which use voice communication, include the DVO type systems that warn the pilot by voice commands about the occurrence of dangerous situations on the aircraft board. However, it becomes necessary to introduce a system with the possibilities of two-way verbal communication, as the pilot's "assistant" in terms of operation of the devices being part of the integrated avionics system.

It is expected that the system implementation in terms of verbal communication of the pilot with the aircraft on the basis of algorithms with the technology of artificial neural networks (e.g. in the form developed in the Air Force Institute of Technology), should reduce the disadvantages of present solutions, and accelerate the introduction of DVI systems using speech components to communicate with the aircraft on-board equipment and control of its operation. The system installation in the aircraft will contribute to the improvement of the flight safety level and expansion of probabilities and efficiency of the tasks carried out by the pilot.

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