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POSSIBILITY OF UPGRADING FIGHTER AIRCRAFT MIG-29 IN THE FIELD OF HELMET-MOUNTED DISPLAY SYSTEMS

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Abstract

The article presents selected results of the analytical work carried out in the Air Force Institute of Technology in the field of information visualization capabilities of helmet-mounted guidance and navigation in fighter aircraft MiG-29. There is presented the SzCz-3UM headset system of target's indication, currently used on-board of MiG-29, which is directly cooperating with the pilot during the combat flight. There was presented that the information from the on-board systems of this aircraft containing analogue devices must be computer-processed into digital form in order to present flight data in the helmet-mounted display system. However, MiG-29 aircraft, used in the Polish Air Force, are equipped with modern digital avionics (integrated avionics system) based on the MIL-1553B digital data buses, which gives the possibility of the new helmet-mounted imaging of flight parameters via the computer data processing from aircraft's devices and on-board installations. To develop guidelines for the construction of the helmet-mounted system for the MiG-29, the SWPL-1 Cyklop flight data-displaying system was adopted (system developed in the Air Force Institute of Technology as avionics system modernization for Mi-17 military helicopters). There are discussed the main problems of scientific and specialist research positions used in the Air Force Institute of Technology to assess the accuracy of the selected equipment components of avionics systems and determine credibility of information provided to the pilot during the flight.

Keywords: *transport, aviation, aircraft glass cockpit systems, helmet mounted display systems*

1. Introduction

A modern military aircraft is an expensive element of equipment of all armed forces worldwide. The use of helmet-mounted digital systems of imaging the piloting-navigational parameters and weapons provides unique opportunities in terms of mobility and flexibility of operation, and is characterised by a kind of universality, which is manifested by the adaptation to perform various operational tasks (missions) in all weather conditions. Thanks to the modern avionics and weapon system, a fighter aircraft becomes a very dangerous tool on the modern battlefield. However, it is crucial to remember that each mission performed by the military aircraft is individually modified depending on the pilot's capabilities, his training and the machine itself. Owing to this fact, it is possible to provide the best conditions for performing the task, obtaining the maximum advantage over the enemy and the possible flexible response to new and unforeseen threats, from both the ground and air.

In case of the Polish Air Force, MiG-29 (Fig. 1) is this kind of aircraft, which thanks to the helmet-mounted data imaging will be a modern platform adapted to present military aircraft of NATO member states and serving the Polish aviation over the next several years [1].

Western avionics systems used in military aircraft to assist the pilot, use the digital systems of helmet-mounted information imaging, guidance and navigation and the aiming and warning of dangerous situations and malfunctions of supervised equipment and installation on board. In Poland, work on the construction of helmet-mounted display of guidance and navigation information system.

Fig. 1. View of the MiG-29 fighter aircraft

In Poland, work on the construction of helmet-mounted display of system information, guidance and navigation was made in the Air Force Institute of Technology in collaboration with the Industrial Optics Centre S.A. Warsaw and Military Aviation Factory WZL-1 S.A. Lodz.

Built on helicopters Mi-17-1V helmet-mounted display system of flight data (marked as SWPL-1 Cyclops) allows piloting the helicopter both during the day and at night (using the night vision goggles) without having to constantly looking at the instrument panels.

However, the basic technical problem that appears in the construction of the system helmet-mounted display of flight data is the need to provide the required continuity and credibility of guidance and navigation information presented.

The idea is that the pilot that controls the flight of the helicopter acquired beliefs to the fact that flying with the use of the system helmet-mounted presentation of the data is as safe as the current method (with looking at the instrument panels), and also gives him the opportunity to focus on the area observation, the aim selection or how to handle the landing.

2. Helmet-mounted data imaging systems for the MiG-29 aircraft

Within the framework of the MiG-29 aircraft modernisation carried out by Wojskowe Zakłady Lotnicze No. 2 Bydgoszcz S.A. (a military aviation facility), the aircraft was equipped with modern digital avionics (integrated avionics system) based on the MIL-1553B digital data buses (Fig. 2).

On the aircraft board, among others, MDP mission computer (Mission Data Processor), EGI navigation platform (INS+GPS), ADC (Air Data Computer), the panel to enter UFCP data, and MFCD multifunctional monitors were installed. The system's open architecture (Fig. 3), allows modifying it, and gives the possibility of the helmet-mounted imaging of flight parameters by the computer data processing from devices and on-board installations [2].

The modification of the integrated avionics system in the MiG-29 aircraft with the helmet--mounted display of piloting-navigational parameters and the weapon system will mainly result in increasing situational and tactical awareness by the pilot. It will provide clear visualisation of instructions, information given during the flight, complete control over the aircraft and its weapons.

At the time of the combat mission implementation, the pilot will not have to shift his gaze to the instruments in the cockpit, but he will have to focus on the task performance, e.g. detection of threats, observation of the space around the aircraft, as well as tracking, interception and shooting the target.

Fig. 2. View of the MiG-29 aircraft cabin after installation of an integrated avionics system by WZL-2 S.A.

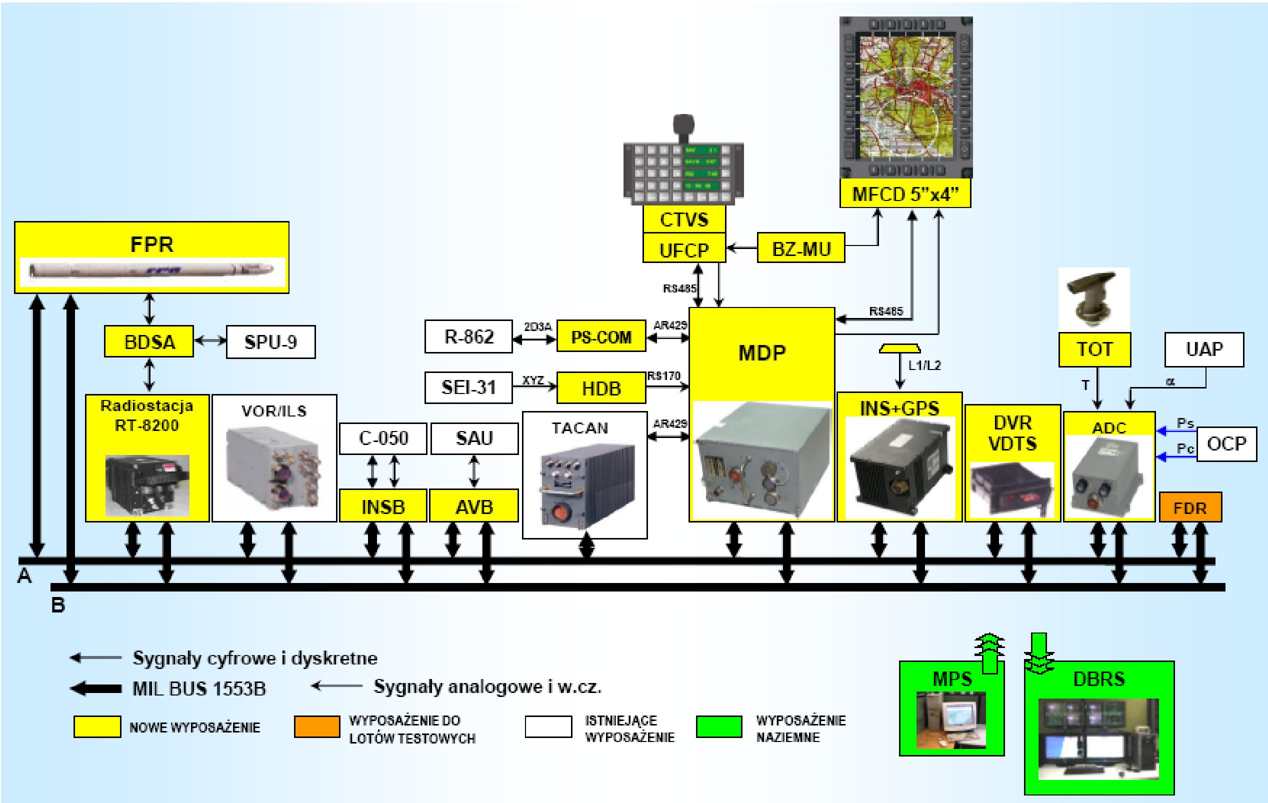

Fig. 3. Organisation of an integrated avionics system on the MiG-29 aircraft board

2.1. The SzCz-3UM headset targeting system

On the MiG-29UB aircraft board, the SzCz-3UM headset system of indicating the target is the one directly cooperating with the pilot during the combat flight (Fig. 4). This system is partly mounted on the pilot's helmet and is intended, as the name suggests, indicating the target with the use of the reticle.

The SzCz-3UM targeting system operates in the opto-electronic composition of the OFPrNK-29E targeting and navigation system and the RŁPK-29E radiolocation targeting system, is designed to determine angular coordinates of the target visually observed by the pilot by turning the head. On the pilot's helmet, there are three light emitting diodes and a channel of imaging the target information, i.e. the projector and the eyepiece with translucent glass.

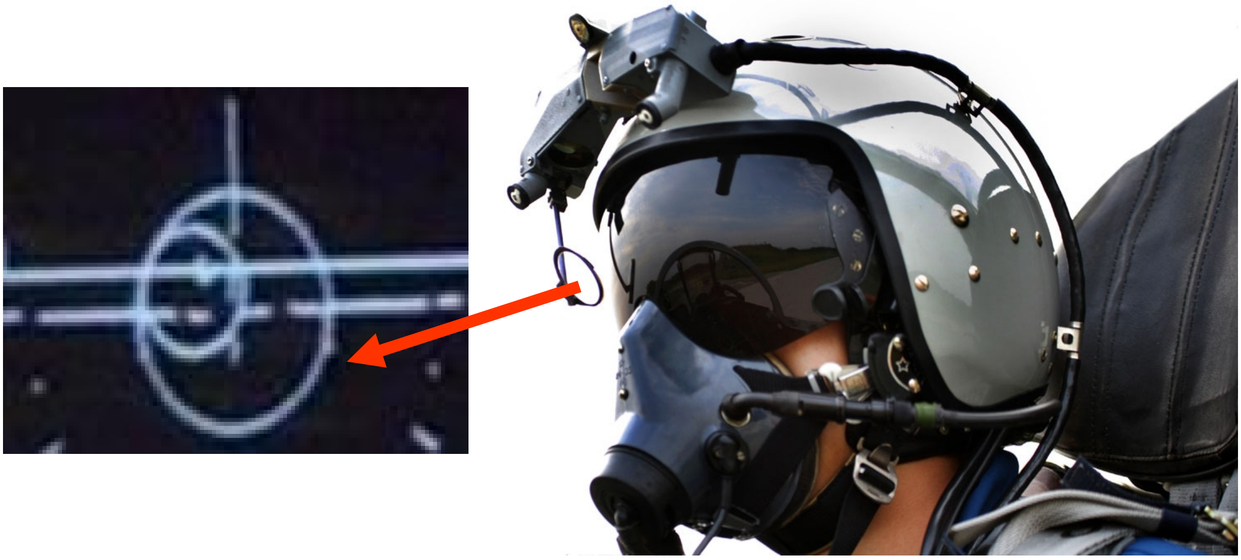

Fig. 4. View of the helmet with the SzCz-3UM targeting system, imaging method

In the cabin, polyhedral prisms (SKAB-A and SKAB-B units) are mounted on the IŁS-31 collimator head. The target indication system sends the code values, which include information on location of the zeroing (sighting-in) line in the aircraft coordinate system, to the on-board computer. In the conditions of the target visual visibility, it provides sending information on location of the zeroing line in the zone corresponding to the cone of a flat angle at the apex of 60^{o} in the aircraft coordinate system, which is limited by the inclination angle to minus 15^{o}. On the eyepiece of the gunsight, the pilot is provided with the imaging in the form of grids, i.e. the ring and cross with solid or dotted lines depending on tracking and interception of the target [3].

2.2. The SWPL-1 helmet mounted display system

The SWPL-1 helmet mounted display system is designed for the crew commander (the first pilot) and the second pilot, enables imaging the selected flight manoeuvre and navigation parameters as well as control of a drive unit operation. This system receives and processes information from the helicopter on-board systems and passes it to the helmet-mounted displays in the form of graphic symbols or in a digital form.

Flight parameters imaging in daylight are performed using the helmet-mounted head-up display DWN-1. At night, flight parameters imaging is performed using the night vision goggles (NVG) and the NWN-1 helmet-mounted night display. The system also allows generation of WARN warning signals about dangerous situation on the helicopter's board and generation of FAIL signals informing the pilot about the failure of the on-board systems (Fig. 5).

The source information from the on-board systems of the helicopter is passed to the UDS-1 signal matching system. In this system, transformation and standardisation of analogue and binary signals as well as implementation of logical functions related to the generation of the WARN and FAIL signals take place. Processed signals are transmitted to the KG-1 graphic computers.

The graphic computer is the main element of the system executing data selection and transformation algorithms and generating information imaging signals to the helmet-mounted head-up display. It also cooperates with the on-board GPS satellite navigation receiver and the on board ADU aerodynamic data system using the bus compliant with the ARINC 429 standard (Fig. 6) [4].

On the board of the Mi-17 helicopter, the SWPL-1 system enables the crew to observe the area and to control the basic flight parameters and the technical condition of the selected helicopter on-board systems at the same time. It has a function of flight parameters visualisation for the first

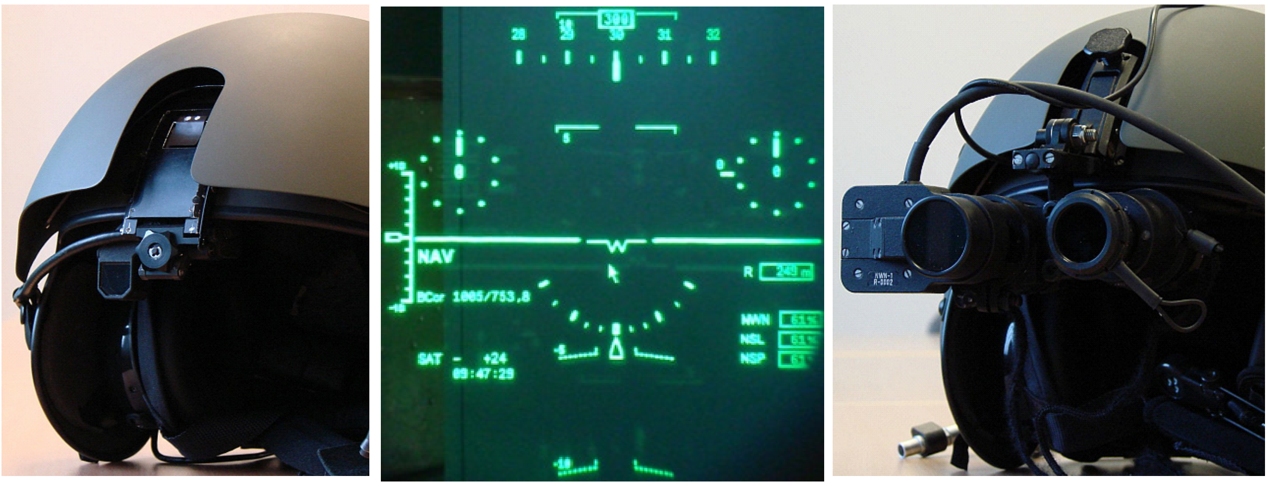

Fig. 5. View helmet mounted display day (left), helmet mounted display night (right)

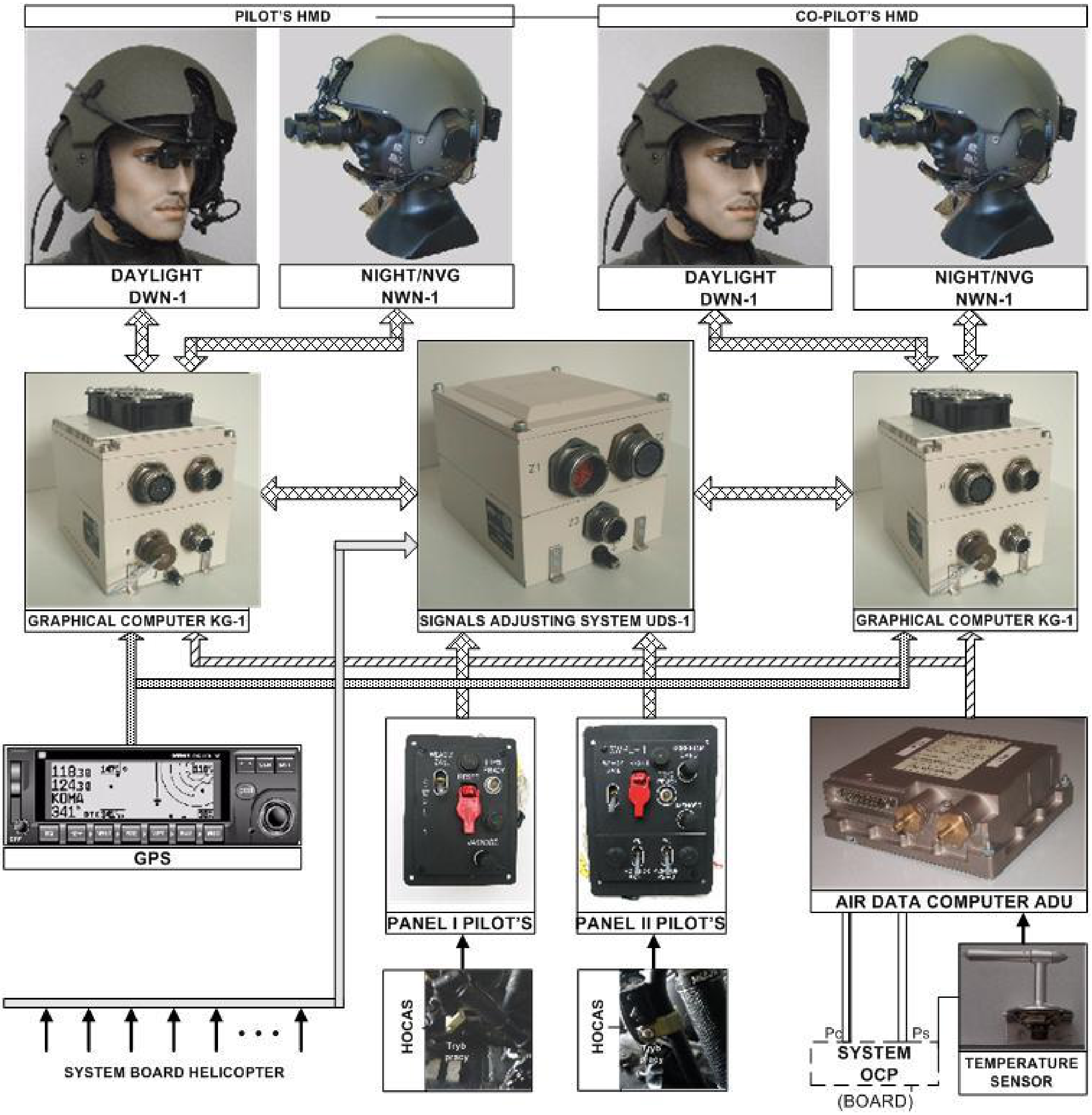

Fig. 6. View system SWPL-1 with a computer graphic KG-1 and signal adjusting system UDS-1

pilot (the commander of the crew) and the second pilot (the pilot/operator) in terms of information necessary for the accomplishment of a combat mission. The pilots have ability of independent selection of an operating mode and the appropriate imaging related to it depending on a current need and executed task. Control of the system operation is possible using dashboards and commutation elements mounted on the steering device [4].

The SWPL-1 system in the version for the Mi-17 helicopter performs imaging of 16 flight parameters in three variants of sets (chosen independently by each of the pilots) and includes 28 emergency states in the warning (WARN) and error signalling (FAIL) system. Before each flight, the system performs automatic diagnosis of the technical condition of the basic modules of the system, with the ability to add corrective and navigation data.

3. Proposal of the helmet-mounted data imaging system for the MiG-29 aircraft developed by the Air Force Institute of Technology

The above presented helmet-mounted targeting and piloting-navigational systems contributed to development of the helmet-mounted data imaging system for the MiG-29 aircraft by the Air Force Institute of Technology. The general functional diagram of the helmet-mounted imaging system includes the following functions: transparent imaging of basic flight parameters and targeting data, and non-transparent imaging with the use of night vision goggles (Fig. 7). Additionally, the information formats of imaging from the KOŁS system transmitters, in the form of symbols or signs, can be displayed [5]. The helmet-mounted system includes a day and night display and a graphic computer with the adjust system.

The graphic computer manages the imaging modes and transmission of communication by the MIL-1553 data bus from the targeting and navigation systems, the adjustment system is used for processing signals from these systems [6].

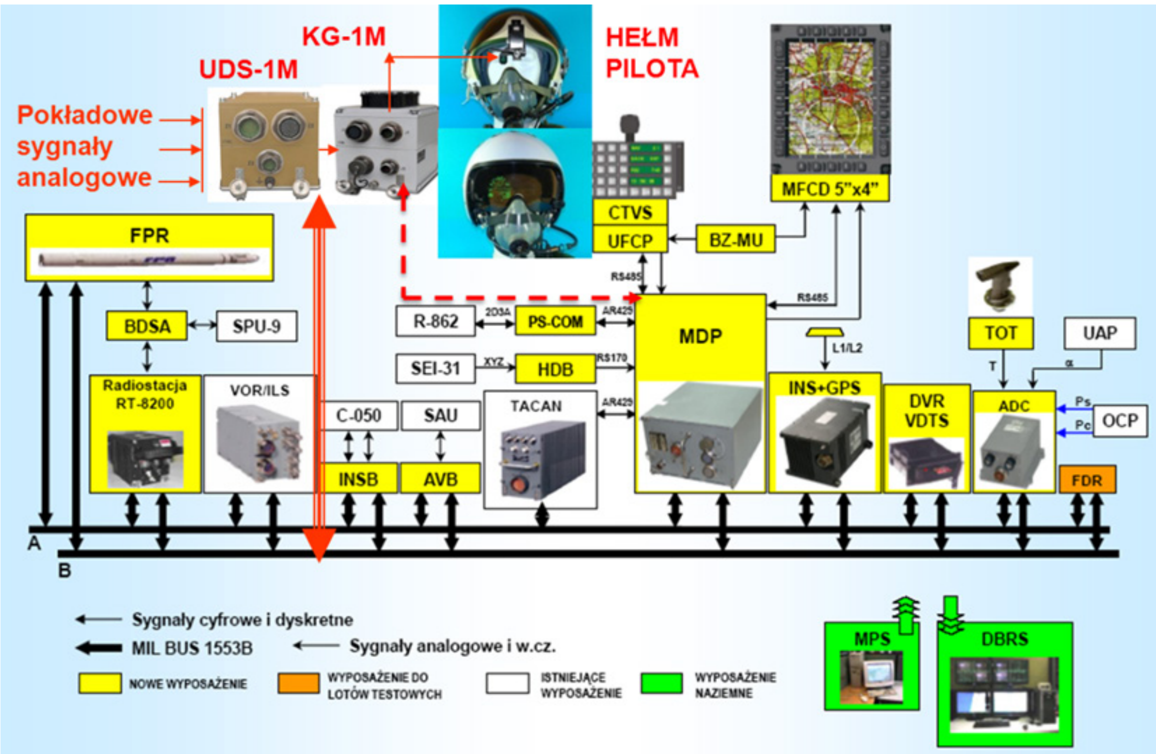

Fig. 7. Integrated Avionics System architecture with the helmet-mounted navigation and targeting data system

In order to select the system's operating mode, the control panel, which will be installed in the MiG aircraft cabin, is provided. The transparent imaging of the helmet-mounted system in the “piloting-navigational” mode contains graphic elements compatible with symbols of the HUD (Head-Up Display) indicators e.g. indication of selected operating parameters of the engine, altimeter or armed mode. At the same time, the commands related to the occurrence of malfunction or failure is displayed from the on-board system during the flight (Fig. 8). The non--transparent imaging includes the use of the image obtained from the observation and targeting head using a set of day and night cameras or the image from the radiolocation station. In the mode of “indication of the target”, the pilot is provided with the imaging, which includes graphic elements from the on-board weaponry and electronic warfare systems, on the maps [7, 8].

Fig. 8. Imaging method for the helmet-mounted navigation and targeting system

4. Conclusion

The MiG-29 aircraft equipment modification made by WZL-2 S.A. is based on the so-called “glass cockpit” with the installed integrated avionics system. The advantage of this system architecture is that it is open, the use of the MIL-1553B bus, which allows for further expansion, among others, the installation of the modern helmet-mounted navigation and targeting system. The helmet-mounted navigation and targeting system offered for the MiG-29 aircraft, in terms of integration, is based on the SWPL-1 Cyklop helmet-mounted flight parameter display system constructed in the Air Force Institute of Technology.

The acquired knowledge and experience at the SWPL-1 construction showed that it is possible both to construct this kind of system for a new aircraft with digital avionics and to adjust it to the existing avionics equipment for the MIG-29 aircraft.

The implementation of the helmet-mounted imaging system on the aircraft board will significantly improve tactical and situational awareness of the pilot in various flight phases, increase the scope of use, i.e. in aerial warfare with the use of modern weapons, which allows to introduce the aviation personnel to the advanced combat training and to cooperate with other aircraft of NATO member states in all conditions in the enemy territory.

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