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Peculiarities of Psycho-Physiological Selection of Operators for Unmanned Aviation Systems

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***Abstract* — World experience in operating unmanned aerial vehicle complexes of operational and tactical assignments showed that the most effective operator team consists of three specialists. First, it is the unmanned aerial vehicle pilot, the one who directly controls the flight. Secondly, the operator of the onboard objectives. He works with sensor systems of various spectral ranges – they serve to monitor the battlefield, search, detect and identify the objects of interest. The same operator makes the decision on aiming and launching weapons. Third, an intellectual support operator with experience in controlling unmanned aerial vehicles, who is competent in the technology of expert systems to assist the pilot and possesses a quick decision-making response.**

Since the errors related to the operator's reliability can lead to the loss of unmanned aerial vehicle, we advise conducting a professional psycho-physiological selection of unmanned aviation systems personnel. Success in a real-world environment is impossible without good preparation. Therefore, the definition and prognosis of the candidate's psycho-physiological state, his ability to the assimilation of necessary knowledge and skills are of great practical importance. Thus, the selection should be made not based on a static assessment of the candidate's general and professional properties, but also on the basis of revealing the dynamics of development of a certain attribute and its tendency to improve during training and professional activity. We designed the three-stage technology of selection and training of UAV operators that provides a high level of unmanned aviation system specialists.

Keywords — unmanned aviation system, unmanned aerial vehicle, operator, psycho-physiological selection, technology.

I. INTRODUCTION

When performing a task by the means of unmanned aerial vehicle (UAV), between the operator at the control point and the UAV two-way communication is supported in real time. The operator monitors not only the telemetry data, the adequacy of UAV behavior, weather conditions, the correctness of the flight task, but also the information coming from the target load, evaluates the data and makes adjustments to the flight task. Automation in the system "operator – UAV" is within from complete control and decision making by the operator to full autonomy of UAV. Observation, recognition, real-time tracking and goal setting can be performed in automatic mode when the operator's function is largely observation. More complex tasks, such as the implementation of electronic reconnaissance, radio-electronic containment, conducting radiation, chemical, bacteriological reconnaissance, containment of air defense systems, the defeat of enemy air and ground targets, may require operator control directly.

The analysis of foreign ex1perience showed that as the automation develops and its reliability increases, the role of unmanned aviation systems (UAS) operators continue to shift towards the activity of an aviation dispatcher [1, 2]. In the absence of non-instrumental information, the problem of synchronization of physical and mental time is usually exacerbated, which leads to an increased risk of the phenomena of desynchronized activity in the piloting process. We consider this as an important argument in favor of introducing the greatest possible UAS automation. Therefore, the interface of the UAS operator's working place must be fundamentally different, focused primarily on the content of the mission, and secondarily on the ability to display and adjust the current flight parameters. Therefore, a high level of automation appears as a fundamental need, which is fully consistent with the level of modern technological capabilities.

II. PECULIARITIES OF OPERATOR ACTIVITY

The complexity of the tasks entrusted to the UAV control operator differs significantly depending, first, on the design and equipment of the UAVs, secondly on meteorological conditions, and thirdly on the purposes of the flight.

However complex and perfect the control equipment may be, there is one nuance in piloting an aircraft from the ground, which can be called "sensory hunger". Staying on the aircraft allows the pilot to receive much additional flight information. The data from the vestibular system and the feeling of overload give a lot of information about the change of position of the aircraft in space. The sound of the engine is also very informative. Much more data is gained by sight: the pilot may, for example, look through the side window of the plane. All this range of sensory signals allows the pilot to quickly become aware of the change of situation and to respond instantly. The UAV operator generally receives only visual information: he sees a coarse-grained image in front of him, typically from a UAV nasal camera that broadcasts with a delay of several seconds if the connection goes through a satellite, plus a map and various digital data on displays that

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need interpretation. Therefore, of course, the reaction of the UAV operator will most often lag behind the reaction of the pilot in a manned aircraft.

There is a psychological, moral and legal problem, which is not easy to solve. If all the actions will be performed by a person, then he or she will bear all responsibility for the drone strike. Leaving the automatics in a large area of action may cause senseless casualties or failures in occasions of errors. If the UAV operator is forced to kill or damage without endangering his/her own life, that may become a source of serious psychological suffering, e. g. post-traumatic syndrome.

The goal of this paper is to reveal the peculiarities of human-machine interaction in UAS that should be considered when developing UAV operator training technology.

III. HUMAN-MACHINE INTERACTION IN UAS

In many cases, when there is a threat of disruption of crew activity as a manifestation of the human factor, the deficiency of the quality of human heuristic activity can be noted as the basis of this threat. It is thanks to the ability of a person to act in the face of information deficiency and to find non-standard solutions in the face of unforeseen situations, it remains a key link of ergatic systems, despite the fundamental possibility to automate virtually all components of the control process. In our opinion, the further development of aviation control systems will consist not in displacing a person at the periphery of control processes and replacing various components of its activity by means of automation, but in directing automatics to information support of human heuristic potential in the context of scenario forecasting, understanding of multifaceted situations, determination of expedient actions, decision making when information is incomplete, etc.

It is not just a matter of unloading a person at the operator's workplace, but of assisting him or her directly in the process of solving heuristic problems.

Therefore, we predict the emergence of the verbal component in the human-machine interaction, whose volume growth will obviously occur at the expense of the activity components, not so much procedurally-operational as tactical. The most important element of the system of assistance to a person in overcoming flight problems can be a subsystem of realization of verbal interaction of the machine and the person, such as our system of IVSS (Intelligent Voice Support System) [3].

Assuming that attitude toward speech systems of interaction is defined by the individual characteristics of the cognitive sphere, we compared the groups of pilots who were most positive and most negative about such systems. The comparison was made in terms of individual cognitive styles, verbal-logical thinking, and creativity. In particular, a cognitive style questionnaire (A. Harrison and R. Bremson, adaptation by A. Alekseev) was used to assess the degree of individual propensity for synthetic, idealistic, pragmatic, analytical, and realistic styles, as well as methods for assessing verbal and logical thinking. verbal creativity [4]. It is found that groups of pilots who are positive and negative about the prospect of widespread use of language systems in human-machine interfaces differ significantly in terms of propensity for analytical cognitive style (pilots who are more positive about the use of speech systems of human-machine interaction were higher in analytical style scores). There were no significant differences in other styles, as well as verbal-logical thinking and verbal creativity.

Also, it has been found that pilots who give more positive assessments about the feasibility of introducing systems in which machine-to-human voice interactions will be implemented also find it more interesting to work in a highly automated cabin. This fact, as well as the revealed coherence of the attitude of pilots to automation and speech human-machine interaction, we can interpret as evidence that the idea of the development of interactive speech systems in human-machine interfaces is consistent with the pilots understanding of the general tendencies of cabs automation and it does not contradict their professional psychological outlook.

Psycho-physiological monitoring systems pave the way for the introduction of adaptive interfaces as an effective means of preventing the operator's overloading. The adaptive function may be based on the current instrumental assessment of the psycho-physiological "price of work" of the operator. One of the implementations of this approach is the Cognitive Adaptive Man-Machine Interface (CAMMI) [5].

We have proposed an alternative but CAMMI-compatible approach, which is to adjust the human-machine interface to the typological features of a particular operator [6]. For the practical implementation of this approach, the regularities of interference of different psychic functions, as well as the individual-typological differences of such interference, should be investigated and formalized. Establishing these patterns will allow not only to carry out an ongoing assessment of the reliability of the operator but also to implement adaptive information models aimed at ensuring a real minimization of the risks of erroneous actions associated with information overload.

Features of the activities of the operators of unmanned aviation complexes and systems (UAS) require their special consideration when solving the tasks of organizing workplaces, creating information display systems, regulating the process of ground crew activity, as well as psychological selection and training programs.

Engineering and psychological research aimed at developing intelligent voice support systems and individualized interfaces at the operator's workplaces of aviation ergatic systems, according to their ideology, correspond to the world trends and are in line with the modern world experience in optimizing the functioning and ensuring the effectiveness of the crews and operator teams [7, 8]. At the same time, the expediency of using these developments in modern and perspective unmanned aeronautical systems requires further experimental verification.

The psychological selection system for UAS operators should be built taking into account their technical characteristics and the level of automation. It is more expedient to use existing test batteries for the professional psychological selection of air traffic control specialists than for pilots, as a basis for perspective development of test

batteries for assessing the professional suitability of unmanned flight crew members. The increasing weight of the tasks of administration of modern unmanned systems against the background of minimizing the piloting component due to the rapid spread of automation means that it is expedient to consider the addition of test batteries to the UAS operators selection methods aimed at the study of individual features of decision-making, that are used for psychological selection of managers. The weight of psychological criteria for professional suitability to work in the UAS ground crews related to informational human-machine interaction at the operator's workplace in its traditional sense (interaction with the visual indication of instrumental data, wheels, joysticks, etc.) will decrease.

In the long flight, physical fatigue is caused by the characteristic sitting, small and precisely coordinated movements of the fingers. Exercise mainly involves the back and lumbar muscles that support the working posture. The mental load is first and foremost related to the considerable strain of vision and attention. When operating in a mobile control point, UAV control operation can be carried out in conditions that disrupt the normal functioning of the operator. Noise, vibration, high or low temperature, excessive or insufficient light may be the interfering factors.

The purpose of selection is to predict two groups of characteristics of the individual: first - the ability to successfully learn the profession, and second - the effectiveness of the actions in a real environment with all possible complications and changes in the situation. Success in a real-world environment is impossible without good preparation. Therefore, identifying and predicting a candidate's "learning characteristic", ease of learning the necessary knowledge and skills are of great practical importance. On this basis, selection should be made not on the basis of a static assessment of the candidate's general and individual properties, but also on the basis of revealing the dynamics of development of a given quality and its tendency to improve during training [7, 9].

People who do not have sufficient capacity for a particular activity not only take longer and greater difficulty master this activity but also perform worse than others: more often they make mistakes and miscalculations, become the culprits of accidents and generally have less reliability in work. Therefore, it is advisable to spend efforts, time and money precisely on the selection of candidates for training, and not on training people whose efficiency will be minimal.

Ukrainian official list of occupations that need some professional selection (DNAOP 0.03-8.06-94) contains paragraph 10 "Jobs related to nervous and emotional stress (air traffic controllers, controllers for the movement of railway transport, operators of energy systems" and paragraph 9 "Jobs related to the control of land, underground, air and water transport". Although UAV control is carried out using the remote piloted method and the UAV is not used as a traffic transport, the professional activity of the UAV control operator possesses the features of both mentioned points. Thus erroneous actions of the operator in the event of an accident can lead to losses in lives and property. UAV may fall onto the settlement, collide with an aircraft, plane or helicopter, the weapon may be used in a wrong way. Psycho-physiological indicators for professional selection in accordance with paragraphs 9 and 10 of DNAOP are:

- orientation in space;
- reaction to the moving object;
- attention;
- speed of switching of attention;
- memory (visual and auditory);
- emotional resilience and anxiety;
- resistance to stress;
- sensorimotor reactions;
- fatigue;
- ability to make decisions and act in extreme conditions;
- resistance to monotony.

IV. Process of UAS operator training and selection

The need of the Ukrainian Armed Forces for tactical-exploring UAVs is estimated at approximately 400 units [10]. Unfortunately, there is still no government program for the development and operation of UAVs, so there is no overall strategy for the development of unmanned aircraft, there is some confusion in the technical and permitting documentation, terminology, problems of training and selection of operators remain unsolved. Individual manufacturers resolve these issues at their discretion.

Unmanned aviation complex (UAC) "Furia" A-1 C is in service with the National Guard, and will eventually arrive at the Armed Forces of Ukraine. In each complex include ground control station and three UAVs. The complex is served by two to four people, the deployment time of the complex is about 4 minutes. UAV is launched from a catapult, landing by parachute. The control unit is equipped with two monitors. The first monitor is designed to track the geo-information system with binding to the coordinates and GPS positions of the glider, the second is used for monitoring through the optical camera, the image is transmitted in real-time. UAV has a flight range of up to 100 km, stays in the air for up to 4 hours. The cost of the UAC is from $ 10,000 to $ 22,000. Operator training is conducted on the basis of the manufacturer.

The current Professions Classifier DK 003:2010 contains the profession "Operator of ground-based unmanned aerial vehicle control" (code 3144), which is sufficient for the use of small UAVs. Under the conditions of using more sophisticated UAVs, other specialists will be needed - the operator of onboard radio-electronic equipment, UAV maintenance technicians, etc.

A wide variety of general and specific techniques used in occupational physiology are used to study physiological parameters. The complex of research also includes methods of studying the physiological state, namely excitability and lability of analyzers (visual and auditory [11]), cardiovascular system (electrocardiography, pulse, blood pressure), biochemical parameters of blood, tremorography.

It is important to develop a methodological framework for professionals who will perform the professional selection of UAV operators in order to systematize and unify basic selection techniques. The choice of techniques, some of which are interchangeable, depends on the availability of appropriate laboratory equipment. Unification of the techniques used by different specialists will ensure the identity of the results.

At one time, many teams that were responsible for the control of unmanned vehicles were selected from the mobilized soldiers. Therefore, the common situation was that the UAV was not involved in the activity of military units after the demobilization of those people. Therefore, military specialists and unmanned aerial system designers agreed that the priority should be given to the process of selection and training of specialists, primarily to officers and contract servicemen with a certain technical level of knowledge and understanding of the role of unmanned aircrafts in the Armed Forces of Ukraine.

The UAV operator training course at the Development Center of Radio Engineering Complexes, Systems and Devices "Heavenly Valley" at Vinnytsia national technical university includes three stages: ground training (10–15 weeks); training on simulators (4 weeks); practicing UAV control skills and performing operational tasks (5–6 weeks).

During the first stage – ground training – students learn a number of documents and theoretical disciplines on the basics of using unmanned aviation systems, such as:

- general basis of the organization of the use of UAV;
- functional duties of officials assigned directly to the organization and operation of flights;
- construction and operation of UAV complexes of various types;
- basics of air navigation;
- basics of security in the organization and conduct of UAV flights;
- UAV tactics in different conditions.

In the second stage – training on simulators – future UAV operators get the initial skills to work with the equipment of ground complexes of flight control of these vehicles, in UAV control techniques, as well as conducting aerial reconnaissance in different conditions and situations. The training is conducted under the guidance of a platoon sergeant or a specially designated UAV operator, who also undergo additional training to work with the simulator. During the study 15–20 hours are given to train the practical skills of each student.

During the third stage, military personnel is working out their practical skills to control unmanned aerial vehicles and to obtain intelligence from their board.

Annually, about 200 servicemen undergo training at the "Heavenly Valley" center on the training program for UAV operators RQ-7 “Shadow-200” and 40-RQ-5 “Hunter”. In the Air Force, the selection for retraining of both engineering staff and junior technical personnel (aviation technicians, mechanics) is carried out from among military personnel who have specialized education and practical experience in operating aviation equipment of various types.

The training program for a new specific type of unmanned aerial vehicle is designed for four months. Classes are held on the basis of the training and aviation wing of the Air Force Training and Training Command. During the first two weeks, the engineering staff listens to review lectures on the organization and basics of combat use of units that operate unmanned aviation systems. Subsequently, there is a division into streams according to the UAV types studied, where the students are introduced to the design of a specific aircraft.

Further, within three months, specialized training of specialists (aircraft-engine, avionics, radio-electronic equipment and aviation weapons) is carried out. During this period, systems, units and blocks, technical regulations are studied in detail, as well as practical training on educational training complexes. The final stage of UAV operators' retraining involves the control of the theoretical knowledge of the trainees and testing practical skills in aviation engineering.

V. Conclusion

The designed technology of UAS operator selection and training and its informational support showed good results and provide Armed Forces with high-level specialists. Further studies are to assess the efficiency of the technology.

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