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REQUIREMENTS AND METHODOLOGICAL APPROACHES TO THE TRAINING OF UNMANNED AERIAL VEHICLE OPERATORS FOR THE UNITS OF THE STATE BORDER SERVICE OF UKRAINE

Based on the generalization of the experience of participation of military units of the State Border Guard Service of Ukraine in performing tasks related to the defense of the state, the article formulates requirements and proposes methodological approaches to training of operators of mini-class unmanned aerial vehicles (FPV-drones), which will make it possible to organize targeted training of FPV-drone operators not only in the training centers of the border guard agencies, but also directly in the units and on the basis of relevant volunteer organizations.

***Keywords**: State Border Guard Service, repelling an armed invasion, command and control and artillery reconnaissance units, mini-class unmanned aerial vehicles, FPV-drones, operators, training, requirements, methodological approaches.*

Statement of the problem. With the beginning of the full-scale invasion of the russian federation on the territory of our country, the Command of the State Border Service of Ukraine (SBSU) made a decision to create mobile border detachments (MBD), which, as a part of the defense forces, carry out the missions related to the defense of the state. These formations comprise various types of units, including command and control and artillery reconnaissance units, which are equipped with unmanned aerial vehicles (UAVs) and conduct aerial and artillery reconnaissance, intelligence, and adjustment of artillery fire in various types of combat. The results of the missions, assigned to these units, depend on many factors, including the level of training of UAV operators and the availability of their professional training programs.

Currently, the training of UAV operators for the needs of the MBDs is carried out mainly on the basis of the Main Personnel Training Center (MPTC) of the State Security Service of Ukraine named after Major General Ihor Momot, which has accumulated considerable experience in training UAV operators of various classes. However, taking into account the dynamics of hostilities and the turnover of personnel associated with it, the training of operators is also carried out directly in the units and on the basis of civilian (volunteer) organizations that have instructors and relevant training experience.

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To ensure targeted training of UAV operators for the military formations of the SBSU, it is necessary to formulate qualification requirements and methodical approaches to the training of UAV operators for units of the SBSU

Analysis of recent research and publications makes it possible to conclude that this issue has been studied by both domestic and foreign scholars. Thus, in publications [1, 2], issues related to the peculiarities of modern wars, the creation of a modern army and weapons, and the use of UAVs for various purposes were considered. In the paper [3], the authors analyzed the experience of NATO member countries in UAV employment, and determined the main direction for further development of UAVs employment in operations as one of the elements of the air component of intelligence, communication, navigation and strike systems. The methods and tactical techniques of employment of first class UAVs are defined and substantiated in the article [4] based on the analysis of the experience of modern armed conflicts, taking into account the experience of conducting combat operations on the territory of Ukraine. Scientific publications [5–9] summarize the experience of employment of UAVs of various classes in modern armed conflicts in which the armed forces of NATO member states were involved. The theory and practice of UAVs (drones) employment in the

conditions of a modern armed conflict is described in the manual [10].

At the same time, the results of the analysis of scientific works and publications related to the researched issues allow us to conclude that the training of UAV operators has not been given enough attention. The transition to the full-scale employment of such means by military formations of the SBSU determined the urgency of the problem of accelerated training of UAV operators, which is carried out not only on the basis of the MPTC, but also directly in the units of the military formations of the SBSU and at numerous volunteer training courses. There are no standard qualification requirements for the training of UAV operators, programs and methods of their training. All these factors determine the relevance of the topic of the article.

The purpose of the article is to formulate qualification requirements and offer methodological approaches to the training of mini-class UAV operators for SBSU units based on the results of the generalization of the experience of Border Service units engagement in repelling an armed invasion.

Summary of the main material. The results of the generalization of the experience of engagement SBSU military formations in repelling an armed invasion indicate the active use of UAVs of various classes, especially mini-class multi-rotor drones, where the technology of transmitting a video signal in real time from the installed video camera to the operator's special goggles or monitor is used. This technology is called FPV (First Person View), and UAVs with such technology are called FPV drones [11].

A great interest in mini-class unmanned aerial vehicles (FPV-drones) is caused by a number of advantages that make detecting and countering such drones not an easy task. The main advantages are: small geometric dimensions, which keep the probability of their damage by anti-aircraft artillery shells at low values; low detection visibility at radar and optical ranges; the use of highly maneuverable flight modes, etc.

The experience of employment of FPV drones by the MBDs demonstrates that they make it possible to receive real-time reconnaissance data, to adjust the fire of weapons on enemy targets, to drop munition to strike a target from the air, etc.

Considering the existing classification [11] and experience of employment of UAVs, the mini-class UAVs (FPV-drones) can include tactical battlefield devices with a take-off weight 2 kg – 15 kg, a flight range up to 10 km, endurance time up to 2 hours, altitude up to 250 m, with a maximum flight speed up to 100 km/h.

The employment of FPV drones to perform the specified combat missions ensures the following: they lower the risk of loss of military reconnaissance and assault groups personnel; they reduce "detect-destroy" cycle of combat control by modern reconnaissance-strike means, which are created in tactical-level units when they perform certain combat missions; they increase the effectiveness of artillery and mortar fire, etc.

Thus, the goal of training FPV drone operators is to master the necessary knowledge and skills of piloting UAVs at the level that will enable them to perform combat missions successfully.

To achieve the goal of training FPV drone operators, in our opinion, the main tasks of training are defined as: studying the structure and controls of modern FPV drones; development of FPV drones piloting skills in close to combat conditions to perform the missions and repel an armed invasion under different weather conditions, day or night (which do not always correspond to the recommendations of the UAV operation manuals); formation of high moral and psychological qualities of operators, which ensure their performance of combat missions.

The analysis of tasks and methods of their execution, as well as the capabilities of FPV drones and countermeasures [6, 7] makes it possible to formulate the qualification requirements for training FPV drone operators, necessary to form up the competence – the ability to operate military UAVs to perform combat missions and combat support tasks.

Thus, after completing the training course, the operator of this UAV class must:

– know: its tactical and technical characteristics and specifications, and the requirements of operation manuals; the procedure for planning and creating a flight route; the pre-flight procedures, selection of means of attack; UAV control bodies; the main methods of combat employment and the order of their execution; the after-flight UAV maintenance;

– be able to: assess the technical condition of the UAV and its readiness for combat employment; conduct the analysis of the meteorological situation and potential malfunctions of the UAV; develop a flight task and a flight plan; launch the UAV, remotely control it and control its flight parameters; prepare means of destruction for combat employment; recognize UAV threats in flight and take measures to ensure its safety; perform after-flight maintenance and fix detected malfunctions;

– to have the skills of: remote control of FPV drones in various flight modes and environmental conditions; assessment of the situation in the zone

(area) of combat employment; search and detection of enemy impact points (targets) to destroy.

The experience of training narrow-profile specialists in this particular category, allows us to claim that for high-quality training, training groups should include no more than 6–8 people (members of the UAV crew) and one teacher (instructor) per each group. Classes should be conducted on the prepared training and material base. The training course of UAV operators should last up to 20 training days, depending on the tasks they will perform in the future. The length of the training day – 7 hours, academic hour – 50 minutes.

If necessary, UAV training course can be limited to 10 – 14 days, the duration of the training day can be increased to 10 hours with a mandatory break for a rest between day and night classes. The sequence and timing of the classes are adjusted according to the training tasks and the level of training of the trainees.

The admission requirements should include the initial vocational aptitude interview, medical and psychological check-ups. Candidates with medical limitations or any deviations from normal behavior will not be admitted to the training course.

According to the gained experience, the complete training course for FPV drone operators includes two stages and finishes with a final certification test.

At the first stage, it is recommended to conduct theoretical classes to study the following: the structure of UAVs, their tactical and technical characteristics and specifications, and components; UAV flight controls (operator's goggles, headset, control panel); pre-flight preparation and methods of employment; safety requirements during the operation of FPV drones.

The main focus of UAV operators theoretical training classes must include: tactical and special training, technical training, reconnaissance and military topography. It is advisable to conduct classes in the classrooms using visual aids (stands, layout, samples of UAVs under study, etc.).

The second stage involves practical classes to master the following skills: piloting on the simulator in different modes (if available); UAV flight control initial level; piloting in the field conditions in various modes of UAVs; dropping munition on the target, etc.

If a simulator is available, training sessions are held on it to familiarize trainees with the skills of controlling the flight of FPV drones from the control panel. The simulator simulates the flight of the UAV in such a way that the operator sees on the monitor screen how the UAV reacts in real time to the commands from the control panel. During such classes, the operator develops basic skills of conducting reconnaissance, adjusting artillery fire and performing a single strike using FPV drones.

A special feature of conducting training sessions on the simulator is the training of an entry-level UAV flight control operator. After working out the piloting scenarios on the simulator, the operator learns how to control the flight of an entry-level UAV and practices take-off, altitude hold, flying over a short distance and landing. Training on the simulator is expedient to complete with the test in the form of practical tasks on the entry-level UAVs.

Further, the training of operators is aimed at forming up the skills of preparing and controlling the FPV drone in flight to ensure the accomplishment of the assigned missions. At practical flight training classes, it is advisable to work on the following: pre-flight checklist procedure for UAV functions and readiness and the operator's goggles (headset); such basic techniques as UAV take-off, altitude hold, rotating in place, changing the direction of movement – rolling (front-to-back) and pitching (side-to-side) and landing; UAV flight control without the operator's goggles (headset) in order to observe its dynamics in the process of altitude climb, rotating, rolling and landing; controlling the flight of the UAV in the operator's goggles in order to get a sense of presence in real space and observe its dynamics "from the first person" while it is climbing, rotating, rolling and landing.

So, the main techniques to be performed by operators during practical training on the training ground (rough terrain) are the following:

1) flying 8 figure: take off from the starting point, fly along a pre-marked route around obstacles making 8 figure turns, return to the starting point and land (approximately 3–4 laps);

2) flying around obstacles: take-off, fly along a route, pass around natural obstacles, move left and right to get over them, return to the starting point and fly again, land at the starting point (approximately 3–4 laps);

3) flying over obstacles: take-off, fly through the frames (installed one after another at a distance of 3–4 m from each other with different dimensions of the height and width of the slot) keeping the altitude, turn in the open space and return to the starting place through the frames again (to complicate the drill, the frames can be placed in a random order);

4) flying with the entry into the building (window, doorway): take-off, fly to the building, enter the building through the opening, turn around inside the closed space, exit (approximately 2–3 times).

In addition, it is necessary to conduct classes on practicing the skills of dropping munition on the target. Training grenades are used as a munition payload. To practice the skills of dropping munition on the target, the following drills should be performed:

1) *dropping munition on the target in a hover mode*: take-off, fly along a given route, detect a target, hover over the target at a specified altitude, send the command to drop, control munition leaving the payload release system, return to the starting point, land;

2) *flying to the target at a low speed to drop munition*: take-off, fly along the specified route, detect a target, revisit (if necessary) the target at a low speed and a specified altitude, send the command to drop, control munition leaving the payload release system, return to the starting point, land;

3) *flying to the target at a high speed to drop munition*: take-off, fly along the specified route, detect the target, revisit the target (if necessary) at a specified speed and altitude, send the command to drop, control munition leaving the payload release system, return to the starting point, land;

4) *flying along an enveloping trajectory (right, left) to the target to drop munition:* take-off, fly along the specified route, detect the target, revisit the target from the left/right at a certain speed and altitude, send the command to drop, control munition leaving the payload release system, return to the starting point, land;

5) *flying along an enveloping trajectory (right, left) to the target to drop munition*, *avoiding obstacles*: take-off, fly along the specified route avoiding natural obstacles, detect the target, revisit the target at a certain speed and altitude, send the command to drop, control munition leaving the payload release system, return to the starting point, land;

6) *flying to the target to drop munition from a high altitude in a dive*: take-off, fly along the specified route avoiding natural obstacles, detect the target, revisit the target at a certain speed and altitude, dive on the target, send the command to drop, control munition leaving the payload release system, return to the starting point, land.

These drills are more difficult than practicing UAV piloting skills and they require maximum concentration of attention from the trainees. In order to master dropping munition to fit the dimensions of the target, the drill should be repeated several times.

As the experience has proven, it is expedient to carry out all UAV flights by a crew of a UAV operator and his/her assistant. The assistant is appointed from among the operators who are being trained. The operator prepares the controls, and the assistant prepares the UAV for the flight (employment).

Pre-flight UAV training must be carried out before each flight. It involves: the controls (control panel) check; batteries installation; video transmission channel check, as well as the reliability of the fastening of the payload release system, etc.

On completion of each drill, the teacher (instructor) must carry out After Action Review of a flight, during which he/she should focus on the accuracy of the drill elements, analyze the mistakes made by the trainees, so that the trainees do not repeat them while conducting the other drills.

It is also worth noting that during the training, UAV operators learn how to provide drone maintenance on their own, especially in field conditions.

The training of UAV operators ends up with final assessment, for example, in the form of a credit test after which the trainees get admission to fly UAVs independently. Those who have successfully mastered the training program for UAV operators are admitted to the credit test. The final assessment (qualification test) is carried out in the form of a comprehensive testing (if possible, in conditions as close to combat as possible), both the knowledge of theoretical aspects and practical skills of the operators are assessed. The credit test is carried out on a training ground equipped with appropriate targets (trenches, shields, obstacles, target circles).

To determine the level of theoretical knowledge and practical skills, during the final assessment, the following issues are checked: the knowledge of the designation, flight specifications, the procedure of deployment, setting up and preparation of the drone for employment; piloting skills in the open terrain for target reconnaissance (pre-flight preparation, take-off, altitude hold, following the route, landing); piloting skills with dropping munition on a prepared track (dropping a training simulated (combat) grenade into a trench). Control piloting exercises with dropping munition into the trench should be performed with strict adherence to all commands of the operator's assistant and under the supervision of a teacher (instructor). As a rule, dropping a training imitation (combat) grenade is carried out into a trench at a distance of 30–400 m from the starting point from the altitude of 50–60 m.

Conclusions

Therefore, the proposed qualification requirements for operators of mini-class UAVs (FPV-drones) and methodical approaches to their training make it possible to organize targeted training of the specified category of specialists from among the servicemen of the military formations of the SBSU and thus give them an opportunity to carry out the missions related to UAV employment not only in SBSU personnel training centers, but also directly in the units and on the basis of relevant volunteer organizations. The use of methodological

approaches to the organization of training of UAV operators, in our opinion, will contribute to increasing the training course effectiveness and the proficiency of trainees, thus ensuring the skillful employment of UAVs while performing assigned to them missions and combat support tasks.

In order to improve the quality of training of UAV operators, the training program must be based on the most effective ways to employ FPV drones, which have been proven in combat conditions. The development of such relevant training programs makes a prospect for further research.

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КВАЛІФІКАЦІЙНІ ВИМОГИ ТА МЕТОДИЧНІ ПІДХОДИ ДО НАВЧАННЯ ОПЕРАТОРІВ БЕЗПІЛОТНИХ ЛІТАЛЬНИХ АПАРАТІВ ДЛЯ ПІДРОЗДІЛІВ ДЕРЖАВНОЇ ПРИКОРДОННОЇ СЛУЖБИ УКРАЇНИ

На основі узагальнення досвіду участі військових частин Державної прикордонної служби України у виконанні завдань, пов'язаних із захистом держави, сформульовано вимоги й запропоновано методичні підходи до підготовки операторів безпілотних літальних апаратів класу міні (FPV-дрони).

Використання FPV-БПЛА в умовах ведення бойових дій потребує відповідної підготовки операторів, зокрема оволодіння необхідними знаннями й навичками пілотування на рівні, що забезпечує виконання бойових і спеціальних завдань.

Задля цього авторами визначено кваліфікаційні вимоги, запропоновано методичні підходи до підготовки операторів безпілотних літальних апаратів такого класу з метою формування у них відповідної компетентності.

Увесь процес підготовки операторів FPV-дронів має здійснюватись у два етапи і завершуватися підсумковою атестацією. На першому етапі доцільно проводити теоретичні заняття, під час яких вивчаються: будова, тактико-технічні характеристики та обладнання безпілотних літальних апаратів; керування польотом; передпольотна підготовка й методика застосування; вимоги безпеки під час експлуатації. Головний напрям теоретичної підготовки становитимуть тактико-спеціальна, технічна, розвідувальна підготовка та військова топографія.

На другому етапі проводяться практичні заняття для відпрацювання: пілотування на тренажері в різних режимах (за наявності); управління польотом дронів; пілотування в полі у різних режимах; скидання боєприпасів на ціль тощо. Запропоновано основні вправи для виконання операторами під час практичних занять на полігоні (пересіченій місцевості).

Це дасть змогу організувати цільову підготовку операторів FPV-дронів не лише у навчальних центрах прикордонного відомства, а й безпосередньо у підрозділах і на базі відповідних волонтерських організацій. Використання методичних підходів до організації навчання сприятиме підвищенню ефективності навчання та якості підготовки операторів.

Перспективи подальших досліджень передбачають розроблення програми підготовки операторів, зміст якої міститиме найефективніші способи використання безпілотників, що пройшли випробування у бойових умовах.

Ключові слова: *Державна прикордонна служба, відбиття збройного вторгнення, підрозділи управління і артилерійської розвідки, безпілотні літальні апарати міні-класу, FPV-дрони, оператори, навчання, кваліфікаційні вимоги, методичні підходи.*

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