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Topical issues of personnel training in the field of unmanned aircraft systems

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Abstract: The legal regulation, and hence, the training system in the field of unmanned aircraft systems (UAS) in the Russian Federation, the European Union and the United States is based on the unmanned aerial vehicles (UAV) rating with respect to UAS maximum take-off weight (MTOW) and their purpose (method of use). In this regard, small-unmanned aircraft (sUAS) are identified – in our country up to 30 kg, in the EU and the USA up to 55 lbs (25 kg) and UAV with larger weight. In the USA and Europe, the training of remote pilots for sUAS is differentiated based on the degree of risk that UAV can represent for public safety. Thus, the training of remote pilots to use UAVs with MTOW less than 25 kg (55 lbs) in a sparsely populated area during daylight hours under the conditions of visual range is conducted in the online format, the result of which is taking tests. In the United States and Europe, the UAV application with MTOW more than 25 kg (55 lbs) or performing UAV operations, presenting a potential risk for public safety, requires more comprehensive and long-term training of remote pilots. In the Russian Federation, UAS personnel training is conducted in educational organizations according to different programs, which vary significantly depending on a specific type of aviation UAVs refers to: State, Civil or Experimental. UAS personnel training programs for various aviation types are not harmonized, which leads to the failure to credit previously received education in training to perform activities in another aviation type. The article describes the analysis results of the international and national experience, perspectives for the development of the UAS personnel training system, as well as formulates the proposals concerning further development of the national system for UAS specialists training.

Key words: unmanned aircraft system, unmanned aerial vehicle, remote pilot, training, personnel training.

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Актуальные вопросы подготовки кадров в области беспилотных авиационных систем

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Аннотация: Правовое регулирование, а значит и система подготовки кадров в области беспилотных авиационных систем, в Российской Федерации, Европейском союзе и США строится исходя из классификации беспилотных

воздушных судов по максимальной взлетной массе и назначению (способу использования) беспилотных авиационных систем. В этом смысле выделяют малые беспилотные воздушные суда – у нас в стране до 30 кг, в ЕС и США до 55 фунтов (25 кг) и беспилотные воздушные суда с большим весом. В США и Европе подготовку внешних пилотов для малых беспилотных воздушных судов дифференцируют исходя из степени риска, которую беспилотные воздушные суда могут представлять для окружающих. Так, подготовка внешних пилотов к использованию беспилотных воздушных судов максимальной взлетной массой менее 25 кг (55 фунтов) в малолюдной местности в дневное время в условиях визуальной видимости проводится в виде онлайн-обучения, итогом которого является сдача тестов. Использование беспилотных воздушных судов максимальной взлетной массой более 25 кг (55 фунтов) или выполнение операций с использованием беспилотных воздушных судов, представляющих потенциальный риск для окружающих, в США и Европе требует иной, более сложной и продолжительной подготовки внешних пилотов. В Российской Федерации подготовка кадров в области беспилотных авиационных систем осуществляется в образовательных организациях по разным программам, которые значительно отличаются в зависимости от принадлежности беспилотных воздушных судов к определенному виду авиации: государственной, гражданской или экспериментальной. Программы подготовки кадров в области беспилотных авиационных систем для различных видов авиации не гармонизированы, что приводит к невозможности зачесть ранее полученное образование при подготовке к выполнению деятельности в другом виде авиации. В статье представлены результаты анализа международного и отечественного опыта, перспектив развития системы подготовки кадров в области беспилотных авиационных систем, а также сформулированы предложения по дальнейшему развитию отечественной системы подготовки специалистов в области беспилотных авиационных систем.

Ключевые слова: беспилотная авиационная система, беспилотное воздушное судно, внешний пилот, обучение, подготовка кадров.

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Introduction

Lately, the growth of the world's market of robotic engineering, including unmanned aircraft systems, has featured an exponential character. Economic branches are increasingly emerging, where the most diverse tasks are solved using UAS¹.

In conformity with various estimates, a range of UAS applications encompasses not less than 1000 proposals in over 20 economic sectors. As the key examples of possible UAS use, one can give:

- monitoring [1–3];
- photogrammetry and aerial photography operation [4, 5];
- cargo delivery [6–8];
- educational objectives and entertainment purposes [9];
- special tasks of government entities [10].

Safety and efficiency of UAS application are substantially specified with special skills of respective specialists: UAV remote pilots and servicing aeronautical personnel. Considering

the above, the process of education and training for UAS specialists takes on particular significance.

In the 12th edition of Annex 1 to the Convention on International Civil Aviation "Personnel Licensing" of ICAO dated from 2018, the requirements, as standards, have already been included for remote pilots, remote student pilots and instructors (further – Annex)², which shall enter into force dated from November 3^d, 2022. For example, in Clause 2.13, Section B of the Annex, the following requirements, regulating the issue of a UAV remote pilot certificate, are formulated:

- an applicant must be not younger than 18 years old;
- an applicant demonstrated proficiency;
- an applicant demonstrated requirements being met for a competence level specified by the adapted model of qualification criteria at the level required to perform duties of a remote pilot-in-command;

¹ The Drone Industry Barometer (2020). Germany, 18 p.

² Annex 1 to the Convention on International Civil Aviation "Personnel Licensing" (2018). 12th ed. ICAO, 148 p.

- an applicant has the 3^d class in effect-Medical Assessment Report (MAR) or the 1st class in effect-MAR.

UAS personnel training is regulated with national regulations in every state.

UAS personnel training in the USA

In the USA, the training of remote pilots for small-sized UAVs (sUAS) with MTOW less than 55lbs (24.95 kg), used for commercial purposes, is conducted under Part 107, Section 14 of the FAA Code of Federal Regulations³.

sUAS remote pilots with MTOW less than 55lbs (24.95 kg) are entitled for flights provided that an applicant:

- is at least 16 years old;
- can read, write, speak and understand English;
- is in a physical and mental condition to safely fly an UAV;
- passed the initial aeronautical knowledge exam.

The Study Guide to prepare for the FAA knowledge exam is posted on the FAA official site. Preparing of the FAA future remote pilots for the test can be done online on the FAA website – faa.psiexams.com.

For recreational pilots, the FAA has developed a Special Manual for a sUAS remote pilot⁴ representing the study material for test-taking to obtain a Remote Pilot Certificate (RPC) with sUAS rating.

If necessary, an applicant can apply to specialized educational institutions for a training course to prepare for a test, the duration of which mainly does not exceed 20 hours. The test, comprising 60 assignments, is conducted as a class-

room-based format in the FAA certified centers of knowledge evaluation.

It should be noted that in the USA, UAS remote pilots are obliged to complete a recurrent training (test) every 24 calendar months as well as the recurring online training to perform night flights.

The FAA focuses on UAV implementation with MTOW more than 55 lbs. If earlier, to operate an UAV with MTOW more than 55 lbs, the RPC was not valid, and a full pilot's certificate under Part 61 FAR was required, at present the situation has changed. In accordance with Section 49USC 44807 a temporary special body for UAS was established which takes a decision to issue the FAA authorization to operate an UAV with MTOW more than 55 lb in the National System of the US air space (NAS) based on the risk-oriented approach. To obtain the authorization, it is necessary to submit a request with the enclosed relevant training program of a remote pilot, developed by an applicant.

The experience of synergies of the USA higher educational institutions and colleges with the aviation authorities and industry is of an active interest. The collaboration is organized and executed under the FAA guidance in the form of the FAA special programs so-called the Initiative programs of university training (Collegiate Training Initiative Program (CTI). The Initiative program of university training UAS-CTI was launched in 2020. Currently, 58 colleges and 26 universities participate in this program. The FAA considers educational institutions concerned as experts in the field of the learning theory and administering academic programs. The program UAS-CTI contributes to schools to develop special education for their students using training programs which prepare students for careers in UAS.

Moreover, the baccalaureate and master's degree programs are implemented in the US aviation universities.

UAS personnel training in Europe

In Europe, based on the EU Regulation 2019/945, which entered into force on Decem-

³ *Operations over people general overview*. (2021). Federal Aviation Administration of the USA. Available at: https://www.faa.gov/uas/commercial_operators/operations_over_people/ (accessed: 27.11.2021).

⁴ *Remote pilot small unmanned aircraft systems study guide*. (2016). Federal Aviation Administration of the USA. 80 p. Available at: https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/remote_pilot_study_guide.pdf (accessed: 27.11.2021).

Table 1

Requirements for the training of remote pilots of the "open" category in Europe

UAV MTOW	UAV subcategory of the "open" category	UAV remote pilot expertise	Remote pilot's minimum employment age
< 0,25 kg		No preparation is required	No age limit
< 0,5 kg	A1 (can also fly in A3) – flights over people, but not over populated areas	<ul style="list-style-type: none"> • It is required to learn the UAV operational manual • It is necessary to undergo training, pass an examination and obtain the Confirmation about completing online training for subcategory A1/A3 of the "open" category 	16 years old
< 2 kg	A2 (can also fly in A3) – flights close to people	<ul style="list-style-type: none"> • It is required to learn the UAV operational manual • It is necessary to undergo training, pass an examination and obtain the RPC for subcategory A2 of the "open" category 	16 years old
< 25 kg	A3 – flights far away from people	<ul style="list-style-type: none"> • It is required to learn the UAV operational manual • It is necessary to undergo training, pass an examination and obtain the Confirmation about completing online training for subcategory A1/A3 of the "open" category 	16 years old

ber 31st, 2020, the remote pilot training is differentiated and based on an extent of risk, which UASs can pose for public safety, and it basically depends on UAV MTOW. By reference to an extent of risk, the following UAV classification can be given:

- "open" – specifies performing operations with the least risk for public safety;
- "special" – specifies performing operations with a higher risk;
- "certified" – specifies performing operations with a high risk.

The European regulator (the European Aviation Safety Agency (EASA)) has developed the relevant methodical recommendations, which are in the public domain on the official website⁵, where all the required information is available to

obtain a certificate to operate the "open" – category sUAS of subcategories A1/A3 and A2 (Table 1). A process of completing an exam to obtain these certificates takes place in the online mode.

In accordance with the EU Regulation EC 2019/947⁶, for operating UAVs with MTOW more than 25 kg or performing flights to carry out more risky missions, an authorization from the concerned National Department of Civil Aviation, in which UAVs are registered, is required. But if an operation is routine for the UAS application, it is necessary to only notify the National Department of Civil Aviation.

Currently, the routine standards concern:

- missions performed by class C5CE UAVs within a zone of direct visibility at a maximum

⁵ Easy access rules for unmanned aircraft systems (Regulation (EU) 2019/947 and Regulation (EU) 2019/945). (2019). EASA. Available at: <https://www.easa.europa.eu/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulation-eu> (accessed: 27.11.2021).

⁶ Commission implementing regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft. (2019). EASA. Available at: <https://www.easa.europa.eu/document-library/regulations/commission-implementing-regulation-eu-2019947> (accessed: 27.11.2021).

height 120 m over a densely populated area (routine scenario STS-01);

- missions performed by class C6CE UAVs beyond direct visibility in the distance of not more than 2000 m from a remote pilot over a sparsely populated area in the presence of air space observation scouts (routine scenario STS-02).

To operate a special category UAV to perform missions of routine scenarios, a remote pilot must run an online training course successfully and obtain the certificate of theoretical operation knowledge based on routine scenarios (RPC) and the accreditation to undertake on-the-job training. The RPC is valid for 5 years.

To perform UAV flights of the category “certified” to carry out high risk missions, a remote pilot must have a Commercial Pilot License.

Both in the EU and the USA, the training is conducted in accordance with master’s degree programs. For example, the program “Master of Science in Unmanned Systems” is announced by one of the oldest universities of Spain – the University of Santiago de Compostela (Universidade de Santiago de Compostela, USC) in the city of Santiago de Compostela as well as in one of the largest universities of Rome – the State University of Tor Vergata (Università degli Studi di Roma Tor Vergata). The similar programs are available in the universities of Hungary “Wageningen University & Research” and the Netherlands “University of Twente”.

UAS personnel training in the Russian Federation

In the Russian Federation, specialists take the UAS professional education and training in different educational institutions under various programs which substantially differ depending on the specified aviation classification⁷: State, Civil or Experimental. The training for UAS specialists to oper-

ate and apply UAS for State Aviation is conducted in 924 State Center of Unmanned Aviation of the Ministry of Defense (924 Center), the Military Educational and Scientific Center of Zhukovsky and Gagarin Air Force Academy.

The training for civil UAS specialists is conducted within the framework of the further vocational education (FVE) and secondary vocational education (SVE) programs. In addition, it is planned to start specialists training to operate UAS under the higher education (HE) programs in 2022.

UAS specialists training for Experimental Aviation (remote test pilots, test operators of control facilities of payload) is conducted in Fedotov Test Pilot School of Gromov Flight Research Institute (FRI).

UAS personnel training for State Aviation in the Russian Federation

Currently, in the Russian Federation Armed Forces, the priorities for UAV systems are [11]:

- object striking;
- the execution of aerial reconnaissance;
- the target indication and fire correction;
- a radio-electronic attack of radio-electronic systems of objects;
- retransmission of control commands.

Unmanned Aircraft Systems of the Ministry of Defense of the Russian Federation [12] are classified depending on the operation radius:

- a short range (up to 100 km);
- a close range (up to 250 km);
- a medium range (up to 500 km).

The training system for UAS specialists of the Ministry of Defense is represented in Figure 1 [13].

In 924 Center, the training for UAS specialists is conducted in compliance with the following FVE programs regarding the professional recurrent training and skills enhancement of military specialists [14]:

- groups for skills enhancement in 4 specializations, the duration of a study course – 1 month (flight management, UAS crew guidance, cryptanalysis of special information);

⁷ *The Aviation Code of the Russian Federation*. (1997). Dated from March 19th, 1997, № 60-FZ (ed. February 18th, 2020). Available at: http://www.consullant.ru/document/cons_doc_LAW_13_744/ (accessed: 27.11.2021).

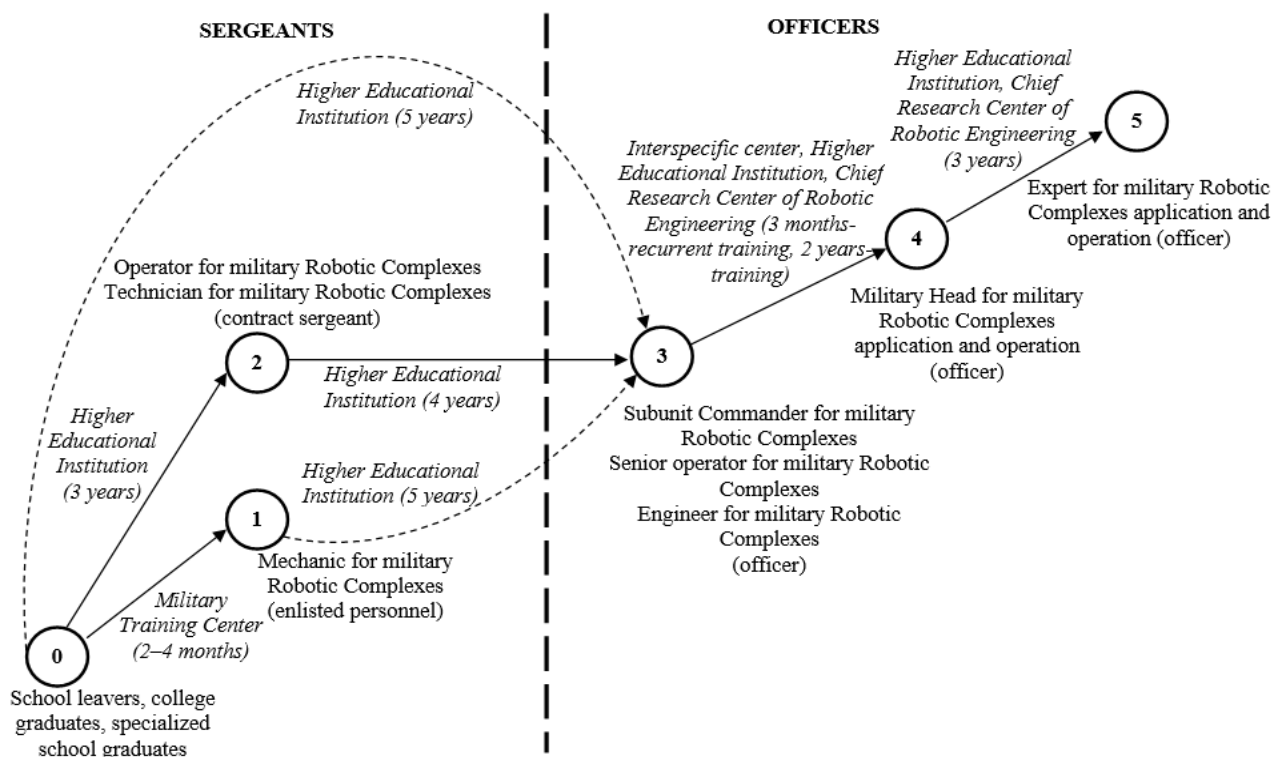


Fig. 1. Architecture of personnel education and training of the military-purpose robotic systems (option)

- groups for the recurrent training in 8 specializations, the duration of a study course – 2...4 months (UAS application and operation).

In the Military Educational and Scientific Center of Zhukovsky and Gagarin Air Force Academy, the training for UAS specialists is conducted in compliance with the following programs of higher vocational education (HVE) and FVE for skills enhancement of military specialists:

- an area of expertise “Application and Operation of Systems with Unmanned Aerial Vehicles”, the duration of a study course – 5 years, engineer proficiency;
- an area of expertise “Application of Aerial Navigation Systems with Unmanned Aerial Vehicles”, the duration of a study course – 5 years, engineer proficiency;
- specializations in 3 areas of expertise, the duration of a study course – 5 years, engineer proficiency;
- groups of officers’ skills enhancement of unmanned aviation services, the duration of a study course – 1 month.

The training of attendees of the Military Educational and Scientific Center of Zhukovsky and Gagarin Air Force Academy for UAS is conducted in compliance with 4 Federal State Educational Standards of Higher Vocational Education (FSES HVE):

- FSES HVE 25.05.04 “Flight Operation and Application of Aviation Systems”;
- FSES HVE 11.05.03 “Application and Operation of Facilities and Systems of Special Monitoring”;
- FSES HVE 25.05.01 “Maintenance and Repair of Combat Vehicles and Engines”;
- FSES HVE 25.05.03 “Maintenance of Aircraft Radio Facilities”.

It should be noted that currently, the uniform FSES HVE for UAV systems has not been developed. In the meantime, The Military Academy of Strategic Rocket Forces named after Peter the Great has developed FSES HVE 15.05.02 “Military and Special-Purpose Robot Engineering”, the duration of a study course – 5 years (specialist), engineer proficiency. The specialization “Special-Purpose Unmanned Aircraft Sys-

tems” is stipulated within the framework of FSES HVE 15.05.02.

The high-qualified specialists training for UAV systems is conducted in military educational institutions and research institutes of the Ministry of Defense of the Russian Federation mainly on the specializations 20.02.14 “Weapons and Military Equipment. Military-Purpose Complexes and Systems” and 20.02.12 “System Analysis, Simulation of Combat Operations and Military-Purpose Systems, Computer-Aided Technologies in the Military Arts”.

Let us highlight the key issues in the sphere of personnel training to apply and operate UAS for State Aviation [14]:

- lack of a sufficient number of military servicemen applying to undergo recurrent training to take up military posts as operators, engineers, technicians;
- the requirement of specialists training on a regular basis for subunits of unmanned aviation for taking up posts by compulsory-duty servicemen;
- discrepancy in regulatory requirements and thus in programs of civil and military-purpose specialists training, and consequently, the problem for civilian readjustment of armed forces personnel upon the completion of a military service.

UAS personnel training for Civil Aviation in the Russian Federation

As per 21 Article of The Aviation Code of the Russian Federation, the aviation used to cater to the public and economics needs is referred as Civil Aviation.

Civil UAS can be applied for both the personal use and aerial application such as:

- aerial distribution of agricultural chemicals;
- aerial survey;
- aerial forest protection;
- construction and mounting, cargo handling work;
- medical assistance;

- aerial checks of on-ground facilities of flight radio-technical support, aeronautical telecommunication and systems of lighting navigational aids of civil aerodromes.

Moreover, in conformity with the common approach, the use of civil UAS can be segmented into the groups of consumers and branches of application [15].

Currently, we can attribute a variety of UAS of domestic and foreign production with a wide range of performance to civil UAS. A consumer segment of the Russian market is represented with UAS manufactured by DJI, Zala Aero, Geoskan, Unmanned Systems, Ptero, Copter Express, etc.

Civil UAS specialists training is conducted in more than 10 professional educational institutions within the framework of FSES of secondary vocational education on the specialization 25.02.08 “Operation of Unmanned Aircraft Systems” (The Order of the Ministry of Education and Science of the Russian Federation dated from December 9th, 2016, № 1549) on the specializations:

- “Operator of Ground Control Facilities of an Unmanned Aerial Vehicle”, the duration of a study course – 4 years (primary general education) or 3 years (secondary general education), intermediate-level specialist proficiency;
- “Aeronautical Instruments Repair Mechanic”, the duration of a study course – 4 years (primary general education) or 3 years (secondary general education), intermediate-level specialist proficiency.

In different educational institutions, in compliance with the professional standard “Specialist on Operation of Unmanned Aircraft Systems, Integrating One or Several Unmanned Aerial Vehicles with MTOW 30 kg and Less” (The Order of the Ministry of Labor and Social Protection of the Russian Federation dated from July 5th, 2018, № 447n), the activity is conducted on the professional and further vocational training for the positions:

- 10005 “Aviation Engines and Airframe Mechanic (Technician)”;
- 10008 “Aviation Instrument and Electrical Engineering Mechanic (Technician)”;

- 18529 “Aviation Radio Facilities Mechanic (Technician)”;
- 24331 “Operator of Ground Control Facilities of an Unmanned Aerial Vehicle”.

The duration of a study course can vary from 1 week to several months.

There is also a big number of organizations which conduct a training process for skills enhancement (expansion of learning competencies) related to UAS operation, maintenance, payload. The duration of a study course can vary from 1 week to several months.

Let us highlight the key issues in the sphere of personnel training to operate civil UAS:

- there are no rules for training and the procedure for conducting appraisal of specialists on civil UAS operation;
- there are no general routines to train specialists for UAS operation approved by an authorized body in Civil Aviation, and documents of a standard form which should be issued upon the study completion according to general routines;
- there are no requirements to the Aviation Training Centers which conduct the training for specialists to operate civil UAS and are authorized to issue documents of a standard form to confirm expertise of a crew member when the UAS operator’s certificate is obtained.

It is worth noting that several months are left prior to the development and approval of the stated above documents, since in concordance with the Order of the Ministry of Transport of the Russian Federation dated from November 19th, 2020, № 494, Clause 2.7 FAR-494, setting new standards for the employment of UAV remote pilots shall enter into force from March 1st, 2022. Thus, from March 1st, 2022, an operator, carrying out aviation UAV operations including one with MTOW 30 kg and less, must employ or engage specialists under an independent contractor agreement to do a job. It concerns specialists who completed the academic training according to training programs, approved by an authorized body, exercising functions to render government services in the field of Civil Aviation.

UAS personnel training for Experimental Aviation in the Russian Federation

As per 23 Article of The Aviation Code of the Russian Federation, the aviation used to carry out research, development (R&D), experimental operations as well as test operations of aeronautical equipment and other engineering is referred as Experimental Aviation.

The experimental aircraft are classified into the prototype, modified, aircraft laboratories, production-standard and support vehicles.

Regarding UAS for Experimental Aviation, it should be emphasized that currently, only aircraft laboratories, developed on behalf of the Ministry of Defense of the Russian Federation, have been designed and registered. Notably, a peculiar situation has arisen when the organizations, developing civil UAV prototypes with MTOW more than 30 kg, bypassing Experimental Aviation, give requests for the certification of the stated UAVs to the Federal Air Transport Agency.

UAS personnel training for Experimental Aviation is conducted by Fedotov School of Test Pilots of Gromov FRI in compliance with the FAR “Requirements to specialists as per the list of specialists of aeronautical personnel of Experimental Aviation. The procedure of aeronautical personnel training of Experimental Aviation. The requirements to the procedure of development, approval, content of programs for training specialists as per the list of specialists of aeronautical personnel of Experimental Aviation” (the Order of the Ministry of Industry and Trade of the Russian Federation dated from April 20th, 2018, № 1570) on the specializations:

- a remote test pilot of UAV, the duration of a study course – 2 months;
- a test operator of control facilities of UAV payload, the duration of a study course – 2 months.

The programs of aeronautical personnel training for Experimental Aviation on these specialties were approved by the Order of the Ministry of Industry and Trade of the Russian Federation dated from February 25th, 2019, № 532.

Let us highlight the key problems in the sphere of personnel training regarding UAS tests for Experimental Aviation:

- a training and methodology center of Fedotov School of Test Pilots of Gromov FRI requires technological upgrading including the delivery of state-of-the-art UAV of different types, simulators, and associated training devices;
- instructional staff of Fedotov School of Test Pilots of Gromov FRI requires reinforcement of specialists who have the test experience of different-type UAS.

Conclusion

The given above analysis revealed a host of issues regarding personnel training in the field of UAS in the Russian Federation. The solution of these problems requires the conduction of special research to formulate scientifically valid solutions and implementation of events aimed at the most expeditious development of the competitive and high-tech UAS sector. Among the overriding priorities, let us note the urgency of the development of a new methodology for personnel training in the field of UAS operation which addresses:

- a variety of UAS types, a vast array of UAS take-off weight, a potential of UAS operation both in the segregated and not segregated air space;
- the requirement in a multi-level system of training that covers work force ranging from secondary school students to highly trained staff to ensure flexibility to meet the state interests and economic demands of the Russian Federation;
- the relevancy in the unifying requirements for training aids of aviation training centers, conducting UAS personnel training for different types of aviation;
- foreign experience regarding a differential approach to UAS personnel training depending on the extent of UAS perceived risk for public safety.

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