Some Aspects of the Inventory of Emissions from Transport Infrastructure Facilities

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Keywords: Environmental monitoring, transport infrastructure facility, emission of harmful and polluting substances, emission source, inventory of stationary sources, instrumental method, instrument complex for remote measurements.

Abstract: The article discusses some problematic aspects of the inventory of emissions of pollutants into the atmosphere by transport infrastructure facilities in the absence or difficult access to the source of emissions. Based on the analysis of regulatory documentation, problematic aspects of the measurement of emission parameters using methods approved by the current legislation are considered, their analysis is carried out for the objectivity and reliability of obtaining data on measurements of the composition and parameters of emissions. Based on the production practice and personal experience of the author of the article, the current problems arising from the traditional technology of measurements at stationary facilities in conditions of difficult access to the emission source are considered and analyzed, ways to improve the efficiency of experts and ensure their safety are proposed. The advantages and disadvantages of the existing ones are considered and an alternative to the traditional technology is proposed using an instrument complex for remote measurements of the composition and parameters of emissions based on an unmanned aerial vehicle (UAV).

1 INTRODUCTION

Relations in the sphere of interaction between society and nature arising from the implementation of economic and other activities related to the impact on the natural environment are regulated in the Russian Federation by the Federal Law of January 10, 2002. No. 7 FL "On Environmental Protection" and the following number of federal laws defining the state policy for the protection of atmospheric air, land and subsoil, water, biological, forest, etc. resources. These federal documents define the legal framework that ensures a balanced solution to socioeconomic problems, the preservation of a favorable environment, biological diversity and natural resources in order to meet the needs of present and future generations, strengthen the rule of law in the field of environmental protection and environmental safety (On Environmental Protection: Federal Law No. 7FL of January 10, 2002).

The priority concentration of efforts to protect the environment is natural and is based on the constitutional right of every citizen of the country to a favorable environment and the responsibility of the state to ensure this right (The Constitution of the Russian Federation, adopted by popular vote on 12.12.1993 (with amendments approved during the allRussian vote on July 1, 2020). In the conditions of the rapid growth of industry, in particular, transport infrastructure, the negative load on the biosphere in the form of emissions of harmful and polluting substances as a result of industrial and economic activity increases many times (On maximum permissible emissions, temporarily permitted emissions, maximum permissible standards of harmful physical effects on atmospheric air and permits for emissions of pollutants into atmospheric air: Resolution of the Government of the Russian Federation of 09.12.2020 No. 2055, http://publication.pravo.gov.ru).

So, at present, the share of railway transport in the Russian Federation accounts for about 80% of cargo turnover, 40% of passenger turnover of all public transport with 130,000 km of total length of the operational length of the tracks. Such volumes of work are associated with a large consumption of natural resources and, accordingly, significant emissions of harmful and polluting substances into the biosphere. Only stationary sources of transport infrastructure annually emit 197 thousand tons of

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pollutants into the atmosphere, including 53 thousand tons of solids and 144 thousand tons of gases (Populov, 2020). First of all, such facilities include locomotive and car repair plants, boiler houses, depots, fuel depots, sleeper impregnation workshops and other facilities of railway transport enterprises (On Transport Security: Federal Law No. 16FL of 09.02.2007 (as amended on 18.07.2011). These stationary sources of emissions are included in the list of objects of mandatory and continuous monitoring of the state of the environment at various levels of the executive power of the Russian Federation. The basis of monitoring in the field of infrastructure facilities is a mandatory inventory of industrial and economic facilities, including the collection and ordering of all necessary information about the distribution of sources on the territory of the enterprise, the hazard class of emission sources, the amount and composition of emissions of harmful substances into the atmosphere.

2 MATERIALS AND METHODS

The inventory procedure for stationary objects that have a negative impact on the environment is aimed at determining the parameters of emissions for their compliance with established standards. Norms of MPE (maximum permissible emissions) and TAE (temporarily agreed emissions) are strictly regulated and developed for infrastructure facilities being designed, built and put into operation by the calculation method based on project documentation. For existing facilities, such standards are determined only by the results of a mandatory inventory no later than 2 years after the issuance of a permit for commissioning, using special techniques (methods) through the implementation of approved technologies based on measurements, indication and testing.

The order and content of the inventory work is determined by the order of the Ministry of Natural Resources and Ecology of the Russian Federation No. 871 dated November 19, 2021 (On approval of the procedure for conducting an inventory of stationary sources and emissions of pollutants into the atmospheric air, correcting its data, documenting and storing data obtained as a result of such inventory and adjustments: Order of the Ministry of Natural Resources and Ecology of the Russian Federation No. 871 dated November 19, 2021). According to the approved procedure and rules, the determination of the qualitative and quantitative composition of emissions from the surveyed atmosphere pollution sources (APS) can be carried out by instrumental or computational methods. At the same time, the applicability of a particular methodology is justified by the developer by confirming the comparability of the emission values obtained using the emission calculation algorithm and the formulas for calculating the emission values included in the methodology with the values obtained as a result of measurements performed in accordance with the legislation of the Russian Federation.

The priority method of measuring the emission indicators of stationary APS in accordance with the current Rules is defined as instrumental, in the implementation of which special technical means (devices) with known metrological characteristics are used as measuring instruments. This priority is objective, since the direct sampling of emissions from APS by special devices, being a direct measurement, allows you to determine objective indicators of pollution, eliminates errors in further calculations while minimizing absolute errors (Markov, 2008).

At the same time, paragraphs 2628 of the Rules define cases when a calculation method is allowed during inventory, which is based on calculations of atmospheric air pollution parameters based on the design data of the enterprise, the material and raw material balance of the technological process, physicochemical patterns of emission generation processes or indicators of specific emission values from the same type of equipment. At the same time, the materials of the justification of the applicability of the calculation method should contain information about the place of research, the technological equipment under study, the operating modes of the equipment during measurements, and more.

The calculation method is also allowed in cases where the direct use of measuring instruments is difficult or excluded due to the high temperature of the gas air mixture of the APS, the high flow rate of the exhaust gases, the ultralow or ultrahigh pressure inside the APS flue. Basically, these are the cases when it comes to the inventory of mobile or unorganized APS.

However, the most common reason for using the calculation method at facilities is, as stated in the Rules, "the lack of practical possibility of sampling", that is, difficult access or lack of access to APS. These are the cases when the location of the APS excludes the possibility of access to it by an expert with the necessary instrumentation or access to it is difficult due to complexity and (or) danger. Unfortunately, such stationary objects include just those, emissions from which make up the majority of the total volume of atmospheric air pollution – highrise pipes of boiler houses, depots, factory workshops, crowns of air

ducts with exits on roofs or vertical walls of buildings located at a considerable height. Of course, the justification for the applicability of the calculation method in such cases is objective, but the final results will not differ in a high degree of reliability. Thus, the calculation method is considered applicable if the emissions values compared by the calculated method differ by an amount determined by the measurement error used to justify the applicability of the calculation method, including when obtaining the initial information necessary for calculations; at the same time, the difference in the values (indicators) of emissions should be in the range of +/ 25% (On approval of the Rules for the development and approval of methods for calculating emissions of harmful (polluting) substances into the atmospheric air by stationary sources: Decree of the Government of the Russian Federation No. 422 dated 16.05.2016). At the same time, when implementing the calculation method during the collection of information and its processing, additional errors may appear dictated by the human factor: starting from unintentional distortion of information, ending with errors in postprocessing of data, their incorrect interpretation. Summarizing this, we can say with confidence that the calculation method with such values of normatively permissible and forced (random) errors does not give an objective picture and is forced.

Thus, the instrumental method of conducting an inventory of stationary objects remains the most reliable in terms of obtaining objective data on emissions of a particular object. This fact is recognized by both domestic and foreign experts in the field of environmental pollution monitoring. Thus, the latter propose to use data on emissions of harmful and polluting substances obtained from orbiting satellites for the purpose of subsequent modeling of their distribution. However, even in this case, the data obtained with the help of satellites must be constantly compared with the actual values of the emission parameters obtained directly using instrumental measurements. This is the only way it becomes possible to calculate the correlation coefficient, the use of which will allow to obtain a model adjusted for reliability (Szymankiewicz, 2021).

3 RESULTS AND DISCUSSIONS

Taking into account the priority of the instrumental method for determining the qualitative and quantitative composition of emissions from the examined APS, expert organizations authorized by executive authorities to conduct an inventory use group of experts equipped with mobile laboratories. At the same time, the mobile laboratory performs, in fact, the function of a vehicle for the delivery of experts and instruments to the territory of a stationary facility. Actions to directly measure the parameters and composition of emissions are carried out by an expert on foot, for which he needs to perform a certain algorithm of actions, which begins with moving to the location of the APS and ends with returning to the starting point. The practice of inventory shows that problems occur already at the initial stage.

So, when measuring the emission of harmful and polluting substances, a number of devices are used that are quite complex in configuration, while some of them have autonomous power sources: bellows aspirator, indicator tubes, digital differential pressure gauge, Pitot tube, PA300M2 aspirator with a battery power supply, a special thermometer, tubes for conducting sampling, filter kits, etc. At the same time, the technology of measurement requires their use in a complex, which involves their transportation to the location of the APS, deployment and use directly at the work site in the vast majority of cases by one operator. Thus, the entire instrument complex, consisting of 3 or more different items with a packing box (case) and a belt (handle) for transportation, with a total weight of up to 1012 kilograms, is carried by the expert. With this load, he needs to get to the located, sometimes at a considerable distance from the laboratory, and sometimes at a considerable height, from the laboratory, overcoming numerous flights of stairs or using a vertical, sometimes without a restrictive fence, ladder.

Arriving at the place of measurements, the expert needs to deploy the instrument complex, connect it to the power supply and measure the emission parameters. After that, write down the parameters in the logbook, put the instrument complex in the case and return to the mobile laboratory.

Successful and safe execution of the entire algorithm of actions in the case of work performed in conditions of difficult access to APS will be ensured by the fulfillment of a number of requirements and conditions by all subjects of the inventory: the expert organization, the management of the object to be inventoried, the expert himself.

So, before the expert organization, in addition to training experts with professional knowledge in the field of measurements and skills of working with equipment, there is a need to provide experts with additional equipment. First of all, with a compact universal container, which, accommodating all the devices and equipment necessary for the work, is

fixed on the back and leaves the expert's hands free. This will allow the expert to comfortably and safely overcome sections of the way to the object of measurements, including stairs with vertical spans, using his hands for insurance. The design of the container should allow carrying devices complete with the necessary attachments, connected to the power supply and ready for operation, with access to their controls. At the same time, the container must have a flat surface area that will be used as a tablet for recording measurement data in the registration log.

It should be noted that the author of the article, taking into account personal experience, tried to implement the above in practice: the container designed by him does not differ in technical perfection and ergonomic appearance, but meets all the above requirements and has proven itself well in practice.

The next element of the expert's equipment in demand by practice is a personal fall arrest system. This equipment must be used by the expert directly when carrying out measuring work at the APS, if the source is located at a significant height, on a plane with a significant slope or an unequipped high-rise site. Prior to the start of measurements, the kit is placed in a compact case, which, in turn, is attached to a container with instruments and equipment so as not to interfere with the expert when moving to the location of the APS.

Of course, the need to use such equipment implies the expert's ability to use it correctly: training in this should also be the responsibility of the expert organization.

In turn, the management of the facility where the inventory work is carried out is obliged to ensure safe and maximally comfortable access of experts to all APS of the production facilities subject to measurements of emission parameters. In addition, it is necessary to equip a work site directly at the point of work, which will allow the expert to place himself at the APS, place devices, make measurements and subsequent records of parameters in compliance with safety and labor protection standards.

The work on determining the qualitative and quantitative composition of emissions from the examined APS in conditions of difficult access to them imposes additional requirements on the professional competencies of the expert. Along with practical skills in using safety equipment and the ability to comply with safety rules when working at height, psychological readiness to perform work in dangerous and difficult situations, the expert must have a sufficient level of physical fitness in order to successfully perform the entire algorithm of the above actions. Often, when the features of the location of APS require the help of a partner, the ability to work in pairs is required.

Of course, compliance with the above requirements and conditions, the solution of all tasks for additional outfit and equipment requires certain organizational and managerial decisions, additional time and material costs for all inventory subjects.

Summing up the above, we can draw the following conclusions:

— the instrumental method of measuring emissions from the APS is the most objective and in demand, since it provides reliable data during the inventory of a stationary object with measurement errors not exceeding the error of the device, provided that the operator (expert) is sufficiently qualified;

— numerous cases of the application of the calculated method of measuring emissions from APS in conditions of difficult access or lack of access to them require the search and development of new technologies and engineering solutions in the field of inventory of stationary objects by the instrumental method.

An alternative to the traditional technology of measuring in conditions of difficult access to the emission point is the equipment of facilities with automatic industrial emission control systems (AIECS) similar to automatic systems for controlling emissions and discharges of hazardous substances to be installed at Category I facilities in accordance with the requirements of Article 67 of the Federal Law "On Environmental Protection". Such systems are installed and operate in accordance with the requirements of legislation to ensure the uniformity of measurements and transmit data on emissions and discharges in accordance with the approved data transmission format. The error is established within the framework of approved standards, and measuring instruments must have pattern approval certificates of measuring instruments.

The requirements for automatic systems, the rules for their creation and operation are established by the relevant regulations of the Government of the Russian Federation (On the organization and implementation of production control over compliance with industrial safety requirements at a hazardous production facility: Decree of the Government of the Russian Federation No. 263 dated 10.03.99; On approval of the rules for the creation and operation of an automatic control system for emissions of pollutants and (or) discharges of pollutants: Decree of the Government of the Russian Federation No. 262 dated March 13, 2019). At the heart of the operation of the AIECS is the receipt of reliable information about the

composition and parameters of emissions from an APS object by stationary automatic means of measuring and recording indicators, means of recording and transmitting information to the register of objects that have a negative impact on the environment.

The main advantage of the AIECS is the continuous monitoring of emissions into the environment and the objectivity of the data inherent in the instrumental measurement method. This ensures an increase in the efficiency of regulating technological processes in order to reduce emissions and ensures the effectiveness of state environmental supervision over the fulfillment of the conditions of an integrated environmental permit. Along with this, there is no need for the management of facilities equipped with AIECS to undergo a mandatory inventory with the involvement of an external expert organization.

However, there are a number of problems that complicate the use of automatic systems.

AIECS, like any other, needs maintenance, verification and repair, which requires annual access to the services of third-party service metrological organizations. Moreover, the procedure of maintenance and verification of the system is not only expensive, but also long (standard – up to 28 days), as it requires a stop of production (production line).

The process of equipping facilities with AIECS is very expensive. Category I facilities constitute a relatively small group on a national scale and are, as a rule, large industrial facilities with valid environmental documentation: draft standards for maximum permissible emissions, draft standards for waste generation and limits on their placement, etc. The management of such serious facilities has sufficient resources and capabilities, therefore it has the opportunity to install AIECS (especially since it is regulated by law).

In addition, a full cycle of work on equipping emission sources with automatic measuring and accounting indicators, subsequent examination of documentation and obtaining a certificate of entry into the state register of measuring instruments takes a lot of time. It is no coincidence that according to the current Rules the term of creation of such systems is up to 4 years from the date of receipt or revision of the integrated environmental permit (On Environmental Protection: Federal Law No. 7FL of January 10, 2002).

Along with all of the above, it should be noted that the introduction and use of the AIECS imposes on the management of facilities an additional measure of administrative responsibility, determined from December 2021 by a separate article 8.51 of the Code of Administrative Violations of the Russian Federation (On Amendments to the Code of Administrative Offences of the Russian Federation: Federal Law No. 427FL of 21.12.2021).

Of course, the solution of the abovementioned problematic issues will be very difficult, and sometimes impossible for industrial facilities and transport infrastructure facilities, which are significantly inferior in terms of production scale and financial capabilities to large industrial facilities.

In these conditions, the most promising from our point of view is the development of an instrument complex for remote measurements based on an unmanned aerial vehicle (UAV) for use by an organization carrying out mandatory inventory of objects.

Nowadays, the introduction of UAVs (drones, quadrocopters, flight platforms) into various spheres of life is growing rapidly. So, at present, quadrocopters are on duty on Anapa beach, capable of delivering a special inflatable buoy to a drowning person in the shortest possible time with high speed and accuracy even in stormy wind conditions (Yurkova, 2021). Some well-known companies (Amazon online store, DHL delivery service) are developing and testing technologies for targeted cargo delivery using drones, and the development of domestic unmanned aircraft systems for monitoring overhead power lines is actively underway (The possibilities of using unmanned aircraft systems for monitoring overhead power lines, https://russiandrone.ru/).

Practice shows that existing technologies make it possible to design and very effectively use quadrocopters or so-called flight platforms in various spheres of human activity: in military affairs, in agriculture, in the field of nature protection, in the interests of the Ministry of Emergency Situations, etc. Moreover, the useful weight that the flight platform is able to lift and move targetedly for 3040 minutes, controlled by the operator and with average flight characteristics from those already quite available, is 56 kilograms (Carrying capacity of the quadcopter, https://rclike.ru/).

The developed complex for carrying out inventory of stationary objects in conditions of difficult or lack of access to APS involves placing a set of measuring instruments on an operator controlled drone and conducting measurements remotely, with the control of the complex and transmitting data to the operator via the appropriate software in real time (online).

The main advantage of the complex is the ability to measure emissions at any points that are practically inaccessible when using traditional technology, and there is no need for direct contact of the expert with the APS. This feature makes it possible to remove a number of the problems discussed above and eliminate the need for a variety of organizational and economic decisions by all subjects of the inventory.

In general, the absolute advantages of the complex include:

— high time savings and efficiency in carrying out measurements, obtaining results, processing them and obtaining final data;

— ensuring complete safety for the expert and no need for special outfit and equipment for the expert to ensure his safety and training to work with them;

— the absence of the need for equipment costs for access paths to the APS and equipment of sites for the work of an expert from the management of the facility;

— reliability, simplicity and long service life;

— a relatively short-term training course for the operator of the complex operation;

— relatively low costs for the acquisition of the complex (complexes) by the organization carrying out the inventory, and its (their) maintenance.

4 CONCLUSIONS

A preliminary summary analysis of the economic efficiency and technical solutions for the use of the developed instrument complex based on UAVs allows us to conclude that the introduction of such a complex into the practice of inventory of stationary objects has a number of advantages over the existing (traditional) technology of measuring by the instrumental method and allows solving a number of problems with significant economic benefits.

The introduction of the inventory of stationary objects of the developed instrument complex into practice will certainly require the solution of a number of additional organizational issues and certain costs.

The first and mandatory issue is the training of experts in the management and use of the base of the instrument complex – the flight platform. This requires additional costs and time, but it is assumed that it will be available and possible for an expert organization authorized to conduct an inventory of objects: the cost of services of professional development centers for training UAV pilots currently does not exceed 100 thousand rubles with a training program of 6070 hours (UAV pilot courses in Yekaterinburg, https://proficpr.ru/).

At the same time, the instrument complex, in accordance with the current legislation, requires mandatory registration and, accordingly, registration of a standard flight permit in accordance with the procedure established by the Administrative Regulations of the Federal Air Transport Agency (On Approval of the Administrative Regulations of the Federal Air Transport Agency for the Provision of State Services for the State Registration of Civil Aircraft and the Maintenance of the State Register of Civil Aircraft of the Russian Federation: Order of the Ministry of Transport of the Russian Federation No. 457 dated December 5, 2013). In accordance with the latest amendments to the current legislation, this can be done through a Multifunctional center for the provision of state and municipal services (MFC, which are available in almost every municipality in any region of Russia). At the same time, if the flight height of the measuring platform does not exceed 150 meters, there is no need to obtain a permit in the Unified Air Traffic Management System (Federal Law No. 462FL dated December 30, 2015 "On Amendments to the Air Code of the Russian Federation regarding the Use of Unmanned Aircraft", http://www.consultant.ru/; Decree of the Government of the Russian Federation No. 74 dated February 3, 2020 "On Amendments to the Federal Rules for the Use of the Airspace of the Russian Federation", https://base .garant.ru/). It is assumed that the execution of such documents for an expert organization will not be a big problem.

The issue of coordination between the inventory subjects for permission to use the complex over the inspected objects also needs to be resolved, since most of them are included in the list of standard prohibited zones for any air transport, including unmanned, in the interests of information and antiterrorist security. Such zones, along with military facilities, include industrial facilities, transport infrastructure, residential areas, nature reserves and protected natural areas, recreation areas, and border zones. In addition, it is prohibited to use quadrocopters and flight platforms over operating airfields (closer than 5 kilometers from uncontrolled airfields), over public events and private property objects without the permission of the municipal authorities.

To overcome such a ban, the inspecting organization, which is essentially a user of the airspace, must first obtain permission from the management of the enterprise in whose interests the flight restriction zone is established to use the

instrument complex over the territory of the facility for inventory purposes (Order of the Ministry of Transport of the Russian Federation No. 6 dated January 16, 2012 "On Approval of Federal Aviation Regulations "Organization of Planning for the Use of the Airspace of the Russian Federation". https://base.garant.ru/70153546/?).

The solution of the above issues, of course, requires prior approval, the implementation of certain management decisions and time costs. However, the author of the article assumes that in the conditions of rapid improvement of information and communication technologies and informatization of society, while the priorities of environmental conservation and public health conservation remain unchanged, the developed instrument complex seems to be the most promising both in terms of application efficiency and in terms of economic benefits.

REFERENCES

On Environmental Protection: Federal Law No. 7-FL of January 10, 2002: http://ivo.garant.ru/#/document/12125350/paragraph/849474:0.

The Constitution of the Russian Federation, adopted by popular vote on 12.12.1993 (with amend-ments approved during the all-Russian vote on July 1, 2020), http://publication.pravo.gov.ru/Document/View/0001202007040001.

On maximum permissible emissions, temporarily permitted emissions, maximum permissible standards of harmful physical effects on atmospheric air and permits for emissions of pollutants into atmos-pheric air: Resolution of the Government of the Russian Federation of 09.12.2020 No. 2055, http://publication.pravo.gov.ru/Document/View/0001202012150010.

Populov, D.A., 2020. Ecology on railway transport: *Materials of the student scientific forum "Ecology on Railway transport 2020"*, https://files.scienceforum.ru/pdf/2020/5dd535dca58f9.pdf .

On Transport Security: Federal Law No. 16-FL of 09.02.2007 (as amended on 18.07.2011), https://legalacts.ru/doc/federalnyi-zakon-ot-09022007-n-16-fz-o/.

On approval of the procedure for conducting an inventory of stationary sources and emissions of pollutants into the atmospheric air, correcting its data, documenting and storing data obtained as a result of such inventory and adjustments: Order of the Ministry of Natural Resources and Ecology of the Russian Fed-eration No. 871 dated November 19, 2021, https://docs.cntd.ru/document/727251276?marker=6540IN.

Markov, V.V., 2008. *Methods and means of measurement, testing and control: a textbook.* OrelSTU..

On approval of the Rules for the development and approval of methods for calculating emissions of harmful (polluting) substances into the atmospheric air by stationary sources:Decree of the Government of the Russian Federation No. 422 dated 16.05.2016, http://www.consultant.ru/document/cons_doc_LAW_198019/92d969e26a4326c5d02fa79b8f9cf4994ee5633b.

Szymankiewicz, K., Kaminski, J.W., Struzewska, J., 2021. Application of Satellite Observations and Air Quality Modelling to Validation of NOx Anthropogenic EMEP Emissions Inventory over Central Europe. *Atmosphere. MDPI AG*, Vol. 12, № 11, p. 1465.

On the organization and implementation of production control over compliance with industrial safety requirements at a hazardous production facility: Decree of the Government of the Russian Federation No. 263 dated 10.03.99, https://normativ.kontur.ru/document?moduleId=1&documentId=69594.

On approval of the rules for the creation and operation of an automatic control system for emis-sions of pollutants and (or) discharges of pollutants: Decree of the Government of the Russian Federation No. 262 dated March 13, 2019, https://base.garant.ru/72197616/.

On Amendments to the Code of Administrative Offences of the Russian Federation: Federal Law No. 427-FL of 21.12.2021, http://publication.pravo.gov.ru/Document/View/0001202112210012.

Yurkova, A., 2021. Drone to the rescue. Rescue drones are on duty in Anapa, *Rossiyskaya Gazeta – Federal,* Issue No. 121(8472).

The possibilities of using unmanned aircraft systems for monitoring overhead power lines, https://russiandrone.ru/publications/vozmozhnosti-primeneniya-bespilotnykh-aviatsionnykh-sistem-dlya-monitoringa-vozdushnykh-lep/?.

Carrying capacity of the quadcopter, https://rc-like.ru/gruzopodemnost-kvadrokoptera.

UAV pilot courses in Yekaterinburg, https://profi-cpr.ru/katalog-programm/upravlenie-bespilotnyimi-vozdushnyimi-sudami/.

On Approval of the Administrative Regulations of the Federal Air Transport Agency for the Pro-vision of State Services for the State Registration of Civil Aircraft and the Maintenance of the State Register of Civil Aircraft of the Russian Federation: Order of the Ministry of Transport of the Russian Federation No. 457 dated December 5, 2013, https://base.garant.ru/70614450/.

Federal Law No. 462-FL dated December 30, 2015 "On Amendments to the Air Code of the Rus-sian Federation regarding the Use of Unmanned Aircraft", http://www.consultant.ru/document/cons_doc_LAW_191538/3d0cac60971a511280cbba229d9b6329c07731f7/.

Decree of the Government of the Russian Federation No. 74 dated February 3, 2020 "On Amend-ments to the Federal Rules for the Use of the Airspace of the Russian Federation", https://base .garant.ru/73501661/.

Order of the Ministry of Transport of the Russian Federation No. 6 dated January 16, 2012 "On Approval of Federal Aviation Regulations "Organization of Planning for the Use of the Airspace of the Russian Federation". https://base.garant.ru/70153546/.