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FEATURES OF THE IMPORT SUBSTITUTION PROCEDURE IN THE CREATION OF UNMANNED AIRCRAFT VEHICLES TO INCREASE FLIGHT SAFETY

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ABSTRACT

The topic of the study concerns the features of the import substitution procedure in the context of the creation of unmanned aerial vehicles (UAV) in order to improve flight safety. Import substitution is a strategically important mechanism for ensuring the country's independence in the development and production of technologically complex systems, such as UAV. The work examines the key stages of the import substitution procedure in the context of creating UAV and also identifies factors that contribute to increasing the level of flight safety. The incidents, which are currently the most important for the creation of unmanned aircraft systems (UAS) and their integration into a unified airspace, are analyzed: improving of flight safety and efficiency of target control tasks (piloting).

The task of integrating unmanned aviation into a unified non-segregated airspace is largely due to its rapid development and widespread use.

Integration is understood as the performance of flights by unmanned aviation on a regular basis together with manned aircraft in a single airspace with an acceptable level of flight safety.

Considering that such regular flights of unmanned aircraft may threaten the safety of existing civil aviation, International Civil Aviation Organization (ICAO) has assumed the role of coordinator in creating all necessary conditions for the step-by-step solution of the integration problem. The article discusses the strategy for implementing the Global Plan for Flight Safety, as well as the phased plan for integrating drones into Russia's common airspace.

The study also focuses on analyzing the technological and production aspects necessary for the successful implementation of import substitution in the field of UAV. Particular attention is paid to the selection of materials, technical characteristics and safety standards, as well as interaction with Russian suppliers of components and technologies.

The results of the study can be used as recommendations for developers and manufacturers of UAV, as well as for the formation of strategies for government support for import substitution programs in the field of UAV, taking into account the priority of ensuring maximum flight safety.

Keywords: *Import Substitution, Import Independence, Flight Safety; Unmanned Aircraft; Remotely Piloted Aircraft (RPA); Safety Management System (SMS); Manual Control; Manned Aircraft; Aircraft Automation; Human Factor; Unmanned Aircraft System (UAS); Unified Airspace; Artificial Intelligence (AI); Aeromobility*

1. INTRODUCTION

The most important task of creating UAS is to improve flight safety and efficiency in performing target tasks. For this purpose, various means of automation are being widely introduced at present. Strict flight safety requirements are imposed on these means. Thus, in civil aviation the permissible probability of control system failure, leading to an emergency situation, must not exceed 10-9. In spite of the fact that the main source of emergencies is a pilot, and later an external pilot (according to foreign sources [1], up to 70-75% of all accidents occur because of pilot's errors), at present, there is no method of accounting for the human factor

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performing the control process, its errors on the general safety of the piloting process. Under these conditions, requirements for increasing safety are mainly reduced to increasing automation of various stages of flight, leading to replacement of manual by automatic control mode. In case of failure in automatic system and requiring switching to manual control, the process of its development may aggravate due to the fact that the pilot must enter the piloting process and adapt for a certain period of time.

Improving flight safety in the global air transport system is a fundamental and critical strategic goal of ICAO. ICAO works continuously to ensure and improve safety performance globally through the following coordinated activities:

- monitoring of the main trends and indicators in the field of flight safety;
- analysis in the field of flight safety;
- policy and standardization initiatives;
- implementation of programs to address safety-related issues.

It is very important for manufacturers of UAV to quickly resolve the issue of import substitution of critical components of the devices, primarily power plants, software, compensation for the costs of organizing and scaling production, simplifying the certification procedure to achieve the key goals of the state, taking into account the requirements of economic and information security and digitalization of aviation industry.

The methodological issues of creating organizational and economic support for organizing the production of aviation equipment at the facilities of Russian aviation industry in the conditions of import substitution are devoted to the works of such Russian scientists as Afanasyev V.Ya., Babkin V.I., Batkovsky A.M., Bodrunov S. .D., Burdina A.A., Golov R.S., Demin S.S., Jamai E.V., Dmitriev O.N., Zelentsova L.S., Kamchatova E.Yu., Klochkov V.V., Korchak V.Yu., Korshunova E.D., Novikov S.V., Omelchenko I.N., Putyatina L.M., Pushkareva M.B., Siluyanova M.V., Tikhonov A.I., Turovets O. G., Chursin A.A., Fionin V.V., etc.

Issues of import substitution in the Russian economy as a whole are actively discussed in the scientific community. Many authors analyze trends in import substitution and offer their views on optimizing its development. In this area of research, we can note such authors as Asanova S.S., Znamenskaya A.N., Kolotov K.A., Larin S.N., Marchenko Yu.O., Rudakov R.B., Peregorodyeva L.N., Semenov A.M., Stebenyaeva T.V., Streltsova N.V., Chernova V.Yu. and Shefer E.V. Their works trace a strategic approach to the problems of import substitution.

Issues of sustainable development of aviation industry enterprises are considered by a number of Russian authors, among whom are Akulova N.V., Lisitskaya T.S., Kraeva V.M. and Sypalo K.I., however, most authors highlight financial stability of enterprises, almost without affecting production problems, within which an important condition for sustainable development is independence from foreign components and technologies.

Some authors pay considerable attention specifically to the aviation industry in terms of problems of import substitution, with the emphasis being on the development of measures within the framework of import substitution of components for the aviation industry. Here we can highlight such authors as Mitanova A.I., Prosvirina N.V., and others, including paying considerable attention to the project approach to the implementation of import substitution programs. Such authors as Budnik E.E., Gumerova G.F. and Sitnikova L.V. analyze the impact of import substitution policies on the activities of enterprises and make certain proposals for the formation of import substitution mechanisms, however, at the moment there is no effective adapted mechanism for import substitution of UAV for the sustainable development of enterprises in the aviation industry and increasing flight safety. Therefore, it is necessary to intensify scientific research in this area.

2. THEORETICAL BASIS

RPA systems are a new component of the overall aviation system that ICAO, states and industry organizations are currently studying, defining and ultimately integrating. These systems, based on the latest developments in aerospace technology, can open up new and expanded civil/commercial applications and improve flight safety and efficiency throughout civil aviation. The safe integration of RPA systems into unsegregated airspace is a lengthy process requiring concerted action by many stakeholders, each bringing to the process their expertise in areas such as external

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pilot certification and medical clearance, technologies implemented in detection and prevention systems, data links (including its protection from inadvertent interference or illegal interference), echelon standards relative to other aircraft and dispersion [2].

ICAO first addressed the issue of unmanned aircraft about a decade ago, when the Air Navigation Commission made the general secretary to consult with individual states and international organizations regarding civil unmanned aircraft activities, procedures and operating authorizations. In 2007, ICAO established the Unmanned Aircraft Systems Study Group to develop a regulatory framework for the safe integration of UAS into non-segregated airspace [3].

"Manual on RPA" (ICAO Doc 10019 AN/507) highlights Chapter 7, "Safety Management", which contains information on the safety roles and responsibilities of government aviation organizations and service providers under RPA systems safety oversight system. The areas covered include: State Aviation Safety Program, oversight of SMS of service providers and the authority of RPA systems operators, in particular the authority of contracted service providers to conduct their safety risk management activities within RPA systems operator's SMS [2].

When implementing RPA systems, the potential implications for flight safety performance due to the mutual influences of internal and external actors in the aviation system must be considered. It is important to assess the risk associated with flights performed by RPA systems, especially the potential impact on other service providers. The integration of RPA systems into unsegregated airspace requires a thorough assessment of RPA systems flight safety performance. In this regard, RPA systems operator's SMS should:

a) be established in accordance with the elements of the conceptual framework of SMS;
b) correspond to the scope of the service provider's activities and the complexity of its aviation products and services [4].

Technological development of UAV provides more private development companies. But the government, federal services, regional authorities and local governments are responsible for integrating them into the national economy. Obviously, at this stage, technological progress is far ahead of the legal framework for the use of UAV. In order to eliminate this lag and safely integrate drones into the national economy and the lives, the government issued a corresponding decree on October 5, 2021.

The document approves a step-by-step plan to integrate drones into Russia's common airspace. This integration should be understood as a process of improving the legislation, as well as the introduction of flight control technologies with the necessary level of safety. Issues of UAV flight safety are of absolute priority. They are primarily understood not so much as the safety of unmanned aircrafts, but as the safety of other air traffic participants, people on the ground and ground infrastructure facilities [5, 6].

Despite the seeming infinity of airspace, in many of its areas there is constant and intensive air traffic, and if we talk about flights at low altitudes, then ground infrastructure objects are added to this: high-rise buildings, power lines and other artificial or natural obstacles that complicate the flight of any vehicle. Safety issues are particularly acute when it comes to flying directly over the heads of citizens [7].

For this reason, one of the basic principles of the concept proposed in the document is that the higher the risk, the higher the requirements. Based on this, for example, it is proposed to establish criteria for categorizing unmanned aircraft and UAS, differentiated requirements for aviation personnel and training and airworthiness of drones. The same applies to the developers and manufacturers of UAS.

In parallel with the development and implementation of UAV flight rules, their operational "reconciliation" with manned aircraft in the unified airspace of the country is necessary. Thus, the training and admission of "external" pilots (i.e., pilots outside the aircraft) to perform flights should be carried out according to appropriate developed training programs, including simulator training (as with conventional pilots) [8, 9].

Along with the solution of legal issues, the establishment of rules for the use of UAV and the construction of a control system, it is necessary to solve many issues related to the technological integration of unmanned aircraft into the unified airspace of the country. This will require the creation and certification of systems to observe and prevent aerial collisions of unmanned aircraft with each other and with manned aircraft. This is a huge technological layer of issues, on the solution of which the safety of people will directly depend [10].

3. METHODOLOGY

We analyze manned aircraft flight accidents and identify the common causes.

Figure 1 shows the causes of manned aircraft accidents from 2010 to 2020 [11].

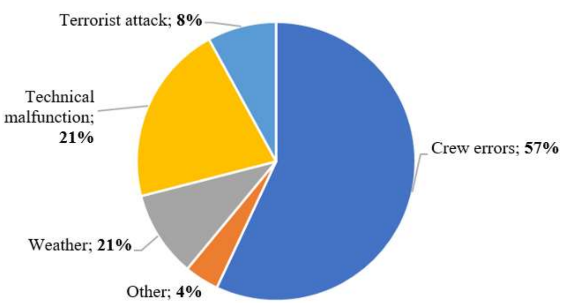

Figure 1. Causes of manned aircraft accidents from 2010 to 2020

The analysis of all these factors given in [12] also shows that the main group of causes is related to the crew. Table 1 identifies the 10 main factors (causes of accidents) and groups of causes that determined them, which led to a fatal accident in the ten-year period from 1997 to 2006 [13].

Table 1. Main factors of plane crashes and their causes

	Groups of causes	Main factor
1	Crew	Missing action/wrong action
2	Crew	Loss of spatial orientation in the air
3	Crew	Manual control of the aircraft
4	Crew	Poor training
5	Operation	Error in repair or operation
6	Environment	Wind shear/wind gust
7	Crew	Improper loading
8	Crew	Ignorance of instructions
9	Operation/ground equipment	Mistakes when loading cargo
10	Aircraft systems	Failure of display systems/systems

Thus, the greatest number of catastrophes, accompanied by human casualties, is due to crew errors. The main stages of flight in which these accidents occur are landing, glide path and takeoff, i.e., the stages where the pilot is actively involved in control. A significant number of accidents occur as a result of loss of control in flight, in hard landings, underflight, roll off the runway and tail-end collision. Many of these causes are related to so-called unstabilized glide path. Basically, the above mentioned consequences of pilot's errors are determined by the following factors [14]:

- loss of pilot's orientation;
- pilot's improper actions;
- pilot's problems with manual control.

Reducing pilot errors can mainly be achieved in two ways:

- increasing the level of training;
- harmonization of the pilot's actions with the response of the aircraft.

If we project the statistics of aviation incidents in manned aviation to UAS operation, we can note the following.

The "remoteness" of the external pilot of UAS is superimposed on the errors of the crew of the piloted aircraft, which increases the probability of such factors of aviation incidents as missing action/wrong action and loss of spatial orientation in the air, since, in fact, UAS is controlled by instruments from the ground control station.

The likelihood of a technical malfunction of UAS also increases due to the presence of additional control elements: ground control station and data transmission channel.

Due to the relatively small size of UAS, the influence of weather conditions, such as wind shear or icing, also increases.

Aviation safety is the most important aspect of RPA systems operation, and when compared to aircraft with a pilot on board, aviation safety is of a similar, but at the same time specific nature. Since the external pilot station is similar in purpose and design to the cockpit, it must be similarly protected against sabotage and unlawful malicious interference. However, given the fixed and vulnerable nature of the external pilot station (as opposed to the enclosed nature of a commercial aircraft, which is less likely to be penetrated and heavily armed), further consideration should be given to the possible vulnerability of such facilities to acts of unlawful interference. In addition, there is a probability of suppression/interception of ABC data channel by intruders [15].

This leads to the conclusion that additional measures, both technical and administrative, must be applied to ensure the safety of UAS use in non-segregated airspace.

The development of the import substitution procedure when creating UAV and their management system is of strategic importance for national security, economics and technological development. Many countries are seeking to actively develop their own base in this area to ensure sustainability and self-reliance in matters of defense and technological progress. Import substitution reduces the country's dependence on foreign technology companies, prevents risks associated with changes in global politics and economics and reduces the risk of leakage of important confidential information.

4. RESULTS AND DISCUSSION

The laboratory of Moscow Aviation Institute (National Research University) (MAI) analyzed data on 1 200 accidents involving passenger planes from 1980 to 2018 and highlighted a pattern: the percentage of accidents related to pilot error ranges from 52% to 67% of the total. Most fatal crashes occur during descent and landing approach. This phase lasts about five minutes, but this is when the pilot is most actively involved in controlling the aircraft.

General information about the main causes of flight accidents, factors that influence the occurrence of accidents, as well as the distribution and frequency of accidents by flight phases (takeoff, climb, cruise flight, descent, landing approach, landing, departure for the second circle and parking) allowed developing two methodologies for assessing the risk of an accident situation. The first assesses risks associated solely with pilot error, when all aircraft systems are operating in normal mode. In the second one, risks are assessed in case of simultaneous failure of control systems and pilot error.

The methodology is based on the relation between the probability of an emergency situation occurring and the pilot's average estimation, revealed in the course of experiments at MAI flying stand. A special Cooper-Harper Pilot Rating scale was used for this purpose.

There is an opinion that in order to increase flight safety it is necessary to exclude pilot from active control of the aircraft as much as possible, i.e. to turn him into an observer controlling automatics. This will reduce the percentage of errors caused by human factor. However, over the past 25 years, when highly automated passenger aircraft were put into service, the number of accidents caused by pilot error has decreased, but the number of accidents caused by failure of automation has increased. In addition, the number of accidents caused by poor pilot-airplane interaction has increased. That is, the autopilot and the exclusion of the pilot from the flight control loop do not solve the problem of increasing flight safety.

Even when flying in normal mode, the pilot is extremely overloaded with information. And the main problem is that in case of automation failure or control system malfunction the pilot needs from 4 to 6 seconds to adapt to the abnormal situation. Every second of delay can aggravate the process of emergency situation development. Moreover, the need for manual piloting increases the stress situation, which can provoke a decrease in control accuracy and the occurrence of irreversible consequences.

These conclusions can be fully applied to unmanned aviation as well. Many experts believe that the way out of this situation lies in the introduction of AI technologies in automatic aircraft control systems.

Denis Baryshnikov, director of the "Interregional Aviation Cluster" of Russia, gave his comment on how unmanned aviation is developing and when AI will replace flight personnel [16].

Unmanned aviation is developing rapidly; in particular, unmanned technologies are already being actively used to solve tasks of video recording and control of objects in industries such as agriculture, energy and construction.

If we talk about specific forecasts, first of all, it is worth waiting for the use of UAV in the "last mile" segment (the stage of delivery from the distribution center of the logistics operator to the final recipient or destination). First of all, it will be cargo transportation, and we can expect large-scale changes here in the next five years, followed by passenger transportation.

The optimistic scenario is that in about 15 years drone aviation will become a mass phenomenon, and this time is just enough to human

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consciousness adapted to the innovation, people began to perceive unmanned aircrafts as a reliable and safe way to travel. But it is worth bearing in mind that the speed of introduction of drone technology is influenced by a number of factors, the most important of which is the development of a regulatory framework.

Currently, the lack of regulatory documents that integrate UAV into the common airspace is the main factor limiting the development of unmanned aviation. These documents are likely to be a list of rules and zones allowed and prohibited for flights. Experts predict that it will take at least five years for the regulatory documents to catch up with the development of technology.

The second important limiting factor is the need for infrastructure that will protect facilities, including facilities of state importance, from the consequences of the development of unmanned aviation, such as unauthorized flights. After the events in Saudi Arabia, where drones attacked oil refinery, protective technologies began to actively develop.

There is another factor that could theoretically hinder the development of drone technology: technical equipment on the ground. It can hardly be called a "brake" for the industry, since there are no special problems for the creation of ground infrastructure for the development of unmanned aviation.

Safety, which is a major problem for ground transport, is actually a solved problem in the unmanned aviation industry. Unmanned ground transportation needs advanced technology, in particular powerful AI that will allow it to move in a dynamically changing environment where obstacles constantly arise. In addition, there are limited scenarios on the ground for responding to a dangerous situation [16, 17].

In airspace, these problems are virtually nonexistent because there are no obstacles, and if there are, UAV have many echelons (airspace corridors) that allow them to adjust their trajectory.

However, unmanned aircraft only add value to the user when they have the technology to process data quickly without any extra effort in the process. Nowadays, almost every company that does data processing, analytics or "autonomous" flight control claims to use AI, machine learning or deep learning [18].

In general, AI describes the ability of machines to perform complex tasks that have the characteristics of human intelligence and includes such things as reasoning, problem solving, planning, learning, understanding and reading human languages. Currently, the use of AI in relation to machine learning, deep learning and motion programming are hot topics.

The goal of combining unnamed aircraft and AI is to make the efficient use of large data sets as automated and problem-free as possible.

At the moment, the main achievements of unmanned aviation belong to military structures, where UAV are represented by innovative vehicles for monitoring and reconnaissance, as well as heavy unmanned strike systems. The reason for the military industry's significant breakaway is that there are no barriers that restrain commercial projects: they do not wait for the development and harmonization of airspace use rules.

The use of UAS, as a new category of air transport, objectively poses new threats to national security, air traffic safety of manned aviation, as well as new risks of damage to the health of citizens, property of legal entities and individuals, violation of commercial secrets and privacy rights. The key condition for the success of the introduction of unmanned aviation into the economy of the Russian Federation is the joint and compromise of the interests of the state represented by the regulatory regulators (federal executive authorities and certification bodies) and business to develop a mass commercial market for the use of UAS while respecting the established requirements for flight safety.

The implementation of safe and effective integration of unnamed aircraft into the airspace of the Russian Federation will be a systematic and step-by-step work involving all stakeholders in the development of regulatory and technical regulation, creation of new import-independent technologies, development and qualification of airborne and ground equipment, operational procedures for air traffic management, training of air traffic controllers, external pilots and personnel involved in the maintenance of unnamed aircraft.

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Currently, the Ministry of Transport (Russia), Federal Air Transport Agency, Union of Aviation Industrialists of Russia, aviation industry enterprises, research organizations, various business associations and non-profit associations are constantly discussing on the basis of which regulatory requirements and technological solutions to perform safe and effective integration of unnamed aircraft in the airspace of the Russian Federation. There is currently no generally accepted, agreed and approved by state regulators solution.

In this regard, the development of conceptual proposals for the integration of UAS into the airspace of the Russian Federation is timely and urgent task. The scope of the proposed conceptual proposals covers UAS as defined in the Air Code of the Russian Federation and ICAO documents of all classes and categories when flying in uncontrolled and controlled airspace. These conceptual proposals define the main directions of regulatory and technological policy for the integration of unnamed aircraft into the airspace of the Russian Federation, as well as the effective use of airspace by all users in the interests of national security and economic development of the Russian Federation.

The main objectives of the conceptual proposals are:

- ensuring the target level of flight safety in the airspace of the Russian Federation and reducing the risks associated with UAS flights;
- creating conditions for the safe and efficient use of the airspace of the Russian Federation in the interests of unmanned aviation in the short and medium term in order to accelerate the development of the Russian UAS market in the country and in the international market;
- transition to equal access for UAS to Russian manned aviation airspace based on a risk-based approach;
- ensuring the necessary level of aviation security, including cybersecurity and adequate response to threats associated with the illegal use of UAS;
- harmonizing air navigation service rules for UAS flights with international standards and ICAO recommended practices;
- determination of promising areas of technological development in the field of aeronautical service of UAS flights;
- development of a regulatory legal and regulatory and technical framework to ensure the systematic and gradual safe integration of UAS into the airspace of the Russian Federation.

Stages of integration are the following:

1. Implementation of basic UAS flight and traffic management principles (electronic registration, electronic identification and strategic geoprotection);
2. Support of UAS operations (planning and provision of pre-flight preparation, airspace clearance, monitoring of UAS location and dynamic airspace data);
3. Advanced UAS operations support (capacity management, conflict detection (ground and airborne assets));
4. Integrated interaction with manned aviation.

According to ICAO Circular 328-AN/190 [19], the specific characteristics of these aircraft affecting aerodrome operations will need to be considered to facilitate the integration of UAS into the existing flight environment. Some of the issues to be considered are the following:

a) acceptability of aerodrome signs and markings for RPA systems;
b) movement of RPA systems with aircraft with a pilot on board in the aerodrome maneuvering area;
c) aspects related to RPA systems' ability to prevent collisions during maneuvering;
d) aspects related to the ability of RPA systems to comply with policy instructions in the air and in the maneuvering area;
e) applicability of instrument landing approach minimums when performing RPA systems flights;
f) need for policy observers at aerodromes to assist the outside pilot in preventing collisions;
g) influence on aerodrome certification requirements of RPA systems infrastructure, such as approach aids, ground support vehicles, landing aids, launch/return aids, etc.;

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h) requirements for rescue and firefighting services for RPA systems (and external pilot station, if necessary);
i) launch/return of RPA systems in places other than airfields;
j) ensuring joint flights of RPA systems and aircraft with a pilot on board in the vicinity of the aerodrome;
k) implications for aerodromes related to specific facilities for RPA systems (e.g., external pilot stations).

ICAO Manned Remotely Aircraft Systems Manual (Doc 10019 AN/507) highlights Chapter 10 “Detection and Avoidance”, which defines it as "the ability to see, perceive or detect nearby aircraft and other hazards and to take appropriate action. This capability is designed to ensure the safe flight of Detection and Avoidance and full integration into all classes of airspace with all airspace users [2].

Appropriate technology and/or procedures may be required for RPA systems to provide capabilities similar to those available to pilots on board an aircraft that use one or more of their senses (e.g., vision, hearing and touch) and appropriate cognitive procedures to do so. Appropriate actions are aimed at preventing dangerous situations (e.g., caused by nearby aircraft) and achieving safety objectives in a particular airspace of a particular class or type of flight.

RPA systems may be equipped with a variety of systems and sensors to detect and prevent various types of hazards. Some of these systems may utilize multiple sensors, providing the ability to reliably detect hazards in a variety of operating conditions. Where Detection and Avoidance are equipped with multiple Detection and Avoidance systems (to detect different types of hazards), they should generally be interoperable, ensuring that appropriate coordinated (if necessary) preventive measures can be taken when different types of hazards (e.g., aircraft creating conflicts, difficult terrain or obstacles) are present simultaneously.

In airspace where the separation between aircraft is provided by policy authority and procedures, flight crew procedures and aircraft equipment requirements (e.g. transponder) are already in place to maintain safe intervals. However, other classes of airspace and hazards other than airborne collision (AAC) may also require Detection and Avoidance equipment and procedures. Detection and Avoidance flight safety level should be similar or higher than that of aircraft with pilots on board.

Full integration of Detection and Avoidance into unsegregated airspace and airfields will require hazard mitigation measures. Air traffic management will help reduce the risk posed by these hazards (e.g., incompatible airspace activities) to Detection and Avoidance and other aircraft. However, Detection and Avoidance may require capabilities or other mitigations (e.g., operational procedures) to limit the risk posed by hazards such as:

a) aircraft creating conflict situations;
b) terrain and obstacles;
c) dangerous meteorological conditions (i.e., thunderstorms, icing and turbulence);
d) ground operations (aircraft, vehicles, structures and people on the ground);
e) other hazards in the air, including trail turbulence, wind shear, birds or volcanic ash.

The conflict management approach to Detection and Avoidance is implemented at three levels, similar to those used to prevent aircraft with a pilot on board from entering hazardous conditions. This approach can be used to prevent collisions with conflict-creating aircraft and avoid other hazardous conditions. It involves three steps:

a) strategic conflict management phase. Typically, this phase is considered the planning phase, which ensures that sufficient data are available to perform the flight;
b) echelon assurance phase. In this phase, actions are taken by all participants to ensure the safe execution of the flight, taking into account the classification of the airspace. In this case, echelon is provided by policy and pilots/external pilots through "safe distance maintenance";
c) collision avoidance phase. In this phase, extreme measures are taken or maneuvers are performed to eliminate conflict situations, if the strategic or tactical phases mentioned above have failed to avoid sources of danger.

The strategic conflict management phase raises awareness of each type of hazard and assists pilots in planning mitigating measures as appropriate, but

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this phase is not considered an active element of implementing Detection and Avoidance function.

The Figure 3 shows how the conflict management process for Detection and Avoidance purposes can be specifically applied to implement the Detection and Avoidance function of danger posed by other aircraft [2].

In the production of drones, one of the key components is systems for remote control and communication with UAV. However, during the development or mass production of such equipment, deviations from the required characteristics may occur, so the creation of our own import-independent control equipment is critically important for the industry. Russian scientists and engineers have created a licensed domestic control and measurement complex that can monitor the quality of characteristics in the production of components for UAV communication systems. The created complex is based on a vector network analyzer, which measures the amplitude and phase characteristics of the elements of the communication system - these parameters make it possible to estimate the speed of reception and transmission of information. All equipment uses domestic software specially developed for these tasks. In terms of its functions, domestic equipment is at the level of global manufacturers at a lower cost. Today, when the world's main manufacturers of control and measuring equipment have left the Russian market, it has become possible to ensure import substitution in this industry.

The aviation industry, including the production of UAV, is among the priority areas of state support aimed at increasing the level of localization of production. It is possible to achieve Russian technological sovereignty in the production of UAC within two to four years; this requires active work on import substitution in related industries. Currently, the average industry localization of production is about 60%, in some cases it is up to 70-80%. In terms of software for drones and unmanned infrastructure, localization can reach up to 100%. The percentage of localization of drone production now varies from 0% to 85%, depending on the type of UAV. The percentage of localization in the production of key components is minimal: such as microelectronics, motors, batteries, engines, etc. To increase it, co-financing of end-to-end R&D is needed from the state. It is difficult for developers to engage in fundamental developments with their own money in conditions of a shortage of funds without confirmation of the return on investment. One way to quickly create an industry of component suppliers is through government orders, but for this we need to determine the percentage and localization rules by year. An increase in the level of localization could be facilitated by subsidizing Russian production and operation of Russian UAS. It is also necessary to liberalize legislation regarding the use of drones, which would contribute to the development of the market

The Government is currently introducing additional measures to support domestic enterprises to help them produce the necessary components in order to strengthen technological sovereignty. For this purpose, a special register of projects will be created that contribute to the structural adaptation of the economy and are aimed at increasing the level of localization and reducing “critical dependence” on suppliers and buyers from unfriendly states. In 2021, the Russian unmanned aircraft market exceeded 13 billion rubles, and by 2030, the Russian UAV market could reach 120 billion rubles.

5. CONCLUSIONS

The article analyzes and classifies cases of accidents in the process of piloting highly automated aircraft, allowing establishing the main causes of flight accidents and the stages of flight, during which the most frequent accidents occur. It also analyzed the prospects for the development of UAS and their integration into a unified airspace.

The import substitution procedure in creating safe aircraft and their integration into a single airspace is an important aspect for ensuring flight safety and compatibility with international standards:

- flight safety: monitoring the compliance of air systems with certain safety standards, which is important to ensure flight safety in national and international airspace;

- technological aspects: creating safe aircraft requires the use of advanced technologies and equipment. The import substitution procedure allows building systems that include our own developments and technical solutions, which contributes to the development of the national technological base;

• integration into a single airspace: compliance with international standards and requirements ensures the harmonious interaction of national air systems with global airspace, facilitating safe and efficient integration into the global flight system;

• national security and independence: the import substitution procedure allows building security systems based on your own national developments and decisions, which strengthens the country's independence and national security.

Russian government has approved the concept of phased integration of drones into a single Russian airspace by 2030, which includes the following stages:

An organizational period will last until 2023, during which measures will be developed to simplify procedures and remove restrictions on the flight of unmanned aircraft. Also at this stage special services for electronic registration and accounting of unnamed aircrafts will be introduced, and the rules for the preparation and execution of such flights will be established.

The second stage (until 2027) provides for the development and implementation of technologies to ensure the safety of unmanned aircrafts' flights and the creation of the necessary infrastructure for communications, navigation and surveillance systems. At the same time, legislative work will go on. For example, technical requirements for systems and equipment that will ensure flight safety will be approved, and procedures for the use of airspace by joint flights of unmanned and pilot aircraft will be adopted. At the same stage, test flights in the common airspace will begin.

During the third stage (until 2030) it is planned to complete the creation of technical infrastructure to ensure the safety of unmanned aircraft flights, to introduce digital technologies in terms of managing the flights of unmanned and manned aircraft in the common airspace and to adopt normative legal acts that will regulate this sphere [20-24].

The implementation of this concept is very important, because the opening of the market of services using unmanned aircraft requires coordination of various kinds of participants (customers of these services, operators, drone manufacturers and regulators), and regulatory and legal barriers in this area are primarily related to flight safety and protection of life and health of citizens.

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REFRENCES

[1]. International Air Transport Association: Safety Report 2020 Edition 55. https://libraryonline.erau.edu/online-full-text/iata-safety-reports/IATA-Safety-Report-2020.pdf (2018). Accessed 21 November 2023.

[2]. International Civil Aviation Organization: Doc 10019. AN/507. Guide to Remotely Piloted Aircraft Systems. http://aeronav.spb.ru/files/DPAS.pdf (2015). Accessed 21 November 2023.

[3]. International Civil Aviation Organization: The state of aviation safety in the world. Flight safety. https://www.icao.int/safety/State%20of%20Global%20Aviation%20Safety/ICAO_SGAS_book_RU_SEPT2013_final_web.pdf (2013). Accessed 21 November 2023.

[4]. Prosvirina, N.V., Tikhonov, A.I., Kuzmina-Merlino, I.: Organization of Production in Drone Development. *Russ. Eng. Res.* 42, 105–108 (2022).

[5]. Tikhonov, A.I., Prosvirina, N.V., Kretov, A.S.: Economics of Drone Monitoring of Ground Objects. *Russ. Eng. Res.* 43(2), 215–220 (2023).

[6]. Soyuzmash: Organization of the movement of unmanned aerial systems. Union of machine builders of Russia. https://soyuzmash.ru/docs/prez/prez-kap-070918-1.pdf (2018). Accessed 21 November 2023.

[7]. Kraev, V.M., Alekseeva, P.A., Tikhonov, A.I. Drones in Labor Management. *Russ. Eng. Res.* 42(10), 1093–1096 (2022). DOI: 10.3103/S1068798X22100136

[8]. Serebryakov, A., Raduntsev, M., Prosvirina, N., Zamkovoi, A.: Strategies for Passing Regulatory Procedures during the Operational Phase of Unmanned Aircraft Systems. *Dron.*, 7(2), 116 (2023).

[9]. Gusarov, R.: Law for the sky: how to make drones safe. RBC. Available at https://www.aex.ru/fdocs/1/2021/10/20/32545/ (2021). Accessed 21 November 2023.

[10]. Dyachkov, D.V., Zolotarev, O.V.: Analysis of air crash statistics based on the study of multiple factors. In *Physical and technical informatics*, 289-320 (2020). https://vestnik.astu.org/temp/e68b4a0ccacf47d06cb7f3b3d8e71c1c.pdf Accessed 21 November 2023.
[11]. Civil Aviation Authority: CAP 1036 Global Fatal Accident Review 2002 to 2011. https://publicapps.caa.co.uk/docs/33/CAP%201036%20Global%20Fatal%20Accident%20Review%202002%20to%202011.pdf (2013). Accessed 21 November 2023.
[12]. Moscow Aviation Institute: The Moscow Aviation Institute is creating a system that will reduce the likelihood of air crashes. (2020). https://mai.ru/press/news/detail.php?ID=116347 Accessed 21 November 2023.
[13]. Akhmedova, A.: Aircraft without a pilot. When artificial intelligence will replace the man at the helm. Company's secret. (2020). https://secretmag.ru/technologies/samolet-bez-pilota-kogda-iskustvennyi-intellekt-zamenit-cheloveka-za-shturvalom.htm Accessed 21 November 2023.
[14]. Tikhonov, A.I., Prosvirina, N.V.: Assessing Projects for Drone Development. *Russ. Eng. Res.* 43(4), 490-492 (2023).
[15]. Russian Drone: Drones and Artificial Intelligence. Russian Drones (2019a). https://russiandrone.ru/publications/drony-i-iskusstvennyy-intellekt-ii-/ Accessed 21 November 2023.
[16]. International Civil Aviation Organization: Cir 328, AN/190. Unmanned Aircraft Systems (UAS) (2011). https://www.icao.int/meetings/uas/documents/circular%20328_en.pdf Accessed 21 November 2023.
[17]. Neupokoeva, E.: UAVs are being integrated into Russian airspace. Comnews (2021). https://www.comnews.ru/content/216856/2021-10-12/2021-w41/bespilotniki-integriruyut-vozdushnoe-prostranstvo-rossii Accessed 21 November 2023.
[18]. Experts evaluate plans to achieve sovereignty in the production of drones (2023). https://www.vedomosti.ru/technology/articles/2023/04/17/971221-dostizheniya-suvereniteta-vipuske-bespilotnikov 21 November 2023
[19]. LETI, together with the manufacturer, replaced imported quality control systems for UAVs (2023). https://tass.ru/ekonomika/19314877 21 November 2023
[20]. Tikhonov, A.I., Sazonov, A.A., Kuzmina-Merlino, I.: Digital Production and Artificial Intelligence in the Aircraft Industry. *Russ. Eng. Res.*, , 42(4), 412–415 (2022).
[21]. Tikhonov, A.I., Prosvirina, N.V., Sazonov A.A.: *Organizational and economic mechanisms for increasing the competitiveness of aviation industry enterprises under the conditions of sanctions pressure from foreign countries: monograph*. Moscow: Znanie-M (2023).
[22]. Tikhonov, A.I., Siluyanova, M.V., Prosvirina, N.V.: Development of a mechanism for assessing a multi-level import substitution system at aviation industry enterprises. *Aerosp. Instrum.*, 6, 40-50 (2023).
[23]. Kraev, V.M., Alekseeva, P.A., Tikhonov, A.I.: Drones in Labor Management. *Russ. Eng. Res.*, 42(10), 1093–1096 (2022). DOI: 10.3103/S1068798X22100136
[24]. Tikhonov, A.I., Prosvirina, N.V.: Production of Machine Tools for the Aircraft Industry: Import Substitution. Russ. Eng. Res., 43(8), 1033–1036 (2023).

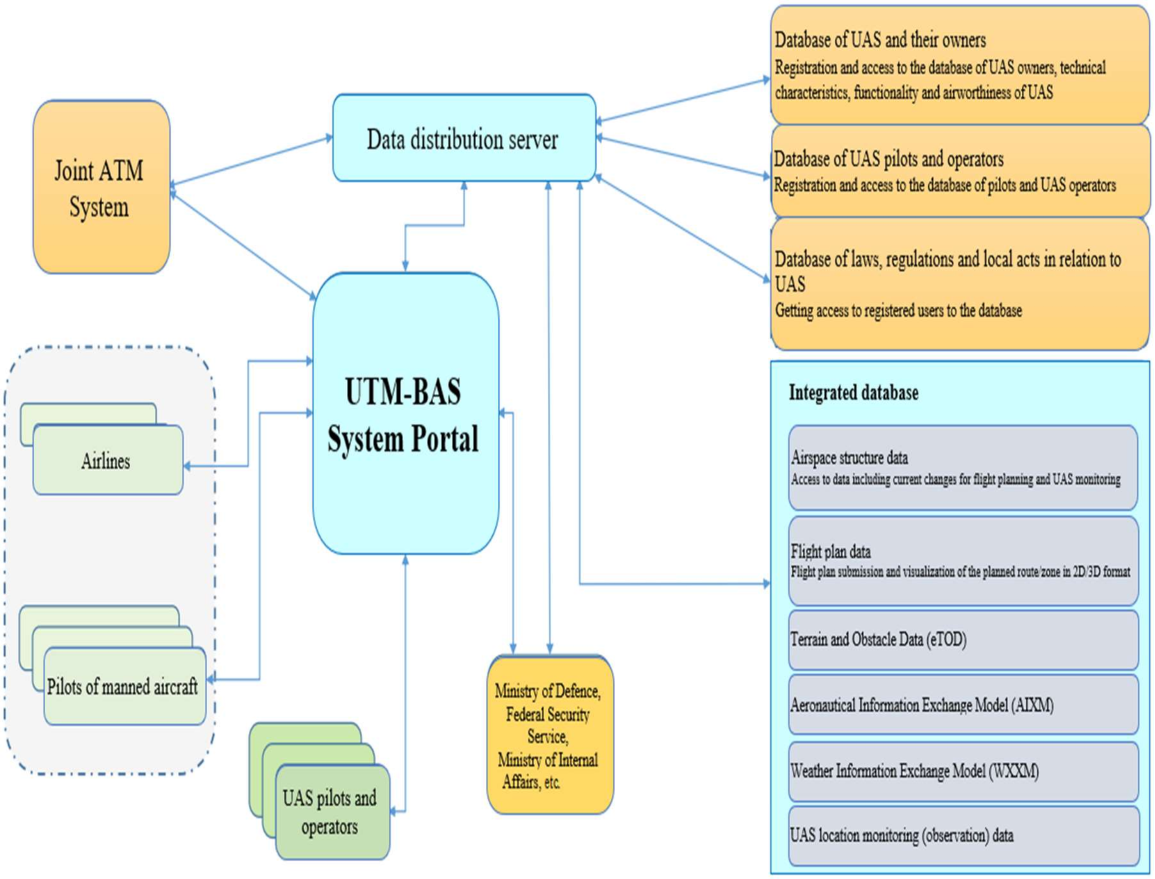

Figure 2. Traffic management system UAS (UTM-UAS)

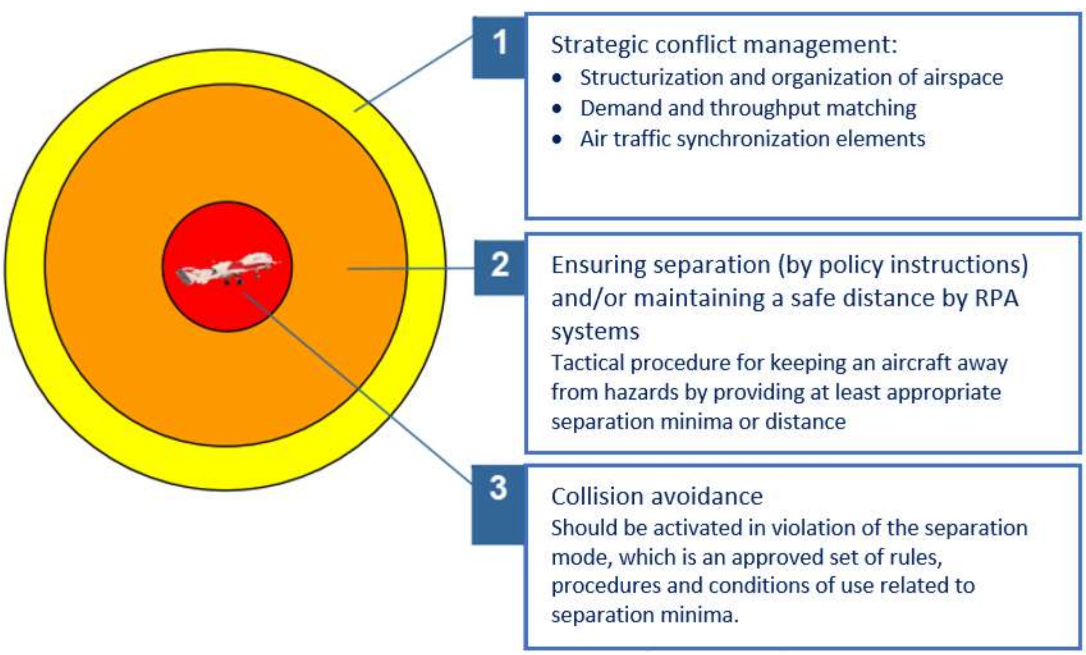

Figure 3. Protection levels