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ANALIZA UPOTREBE DRONOVA U VATROGASNOJ SLUŽBI I OČEKIVANI BUDUĆI IZAZOVI

ANALYSIS OF THE USE OF DRONES IN FIRE SERVICE AND EXPECTED FUTURE CHALLENGES

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Abstract – *This paper analyzes the use of Unmanned Aerial Systems (UAS), including Unmanned Aerial Vehicles (UAV), in the European Union, with a case study from the Republic of Croatia. An overview is provided of the level of adoption and implementation of unmanned aerial systems in fire services that, in accordance with European standards, have introduced the use of drones in cooperation with the civil sector. Based on an analysis of the regulatory framework and documents of the European Union Aviation Safety Agency (EASA), safety measures and operational procedures for drone use are proposed, along with recommendations for drone operators regarding compliance with safety standards. Particular emphasis is placed on future investments in advanced solutions involving long-range operations, beyond visual line of sight flights, night operations, and activities requiring the implementation of risk assessment.*

Keywords: *UAS, fire service, drone operation safety*

Apstrakt – *U radu se analizira upotreba bespilotnih vazduhoplovnih sistema (UAS), uključujući bespilotne letelice (UAV), u Evropskoj uniji, sa primerom iz Republike Hrvatske. Dat je pregled stepena primene i implementacije bespilotnih vazduhoplovnih sistema u vatrogasnim službama koje su, u skladu sa evropskim standardima, uvele upotrebu dronova u saradnji sa civilnim sektorom. Na osnovu analize regulatornog okvira i dokumenata Evropske agencije za bezbednost vazdušnog saobraćaja (EASA), predlažu se mere bezbednosti i operativne procedure za upotrebu dronova, kao i preporuke za operatere dronova u pogledu primene bezbednosnih standarda. Poseban akcenat stavljen je na buduća ulaganja u napredna rešenja koja obuhvataju letove na većim udaljenostima, izvan vidnog polja operatera, noćne operacije i aktivnosti koje zahtevaju sprovođenje procene rizika.*

Ključne reči: *UAS, vatrogasna služba, bezbednost operacija dronova*

1. INTRODUCTION

Unmanned Aerial Systems (UAS), commonly referred to as “drones”, were long used exclusively as military technology. After 2015, UAS began to be applied for civilian purposes as well, which led to an exponential increase in their use. Not long after, this type of technology found its application in firefighting. The use of drones in extinguishing large active fires, as well as in search and rescue operations and post-fire assessments, can provide a comprehensive understanding of the situation on the ground and be invaluable for ensuring the safety of firefighting teams. The need to standardize drone operations in Europe was soon recognized in order to establish a unified legal framework for all member states. UAS are regulated by international guidelines for safe integration into civil airspace. The International Civil Aviation Organization (ICAO), through the Manual on Remotely Piloted Aircraft Systems (Doc 10019) [1], defines basic safety and operational requirements, while JARUS - Joint Authorities for Rulemaking on Unmanned Systems develops technical standards and the SORA [2] model for assessing the risks of UAS operations. These guidelines form the basis of EASA regulation, ensuring the coordinated and safe use of UA systems. The European Commission formalized rules and procedures for civil drone operations through the adoption of Delegated Regulation (EU) 2019/947 [3]. The European Union Aviation Safety Agency (EASA) is the body responsible on behalf of the European Commission for civil aviation safety. EASA’s role at the EU level is to regulate the certification of airspace users in cooperation with national regulators, standardize drone usage procedures, conduct investigations, and oversee registered operators. In addition, EASA collects data for safety analysis purposes, which is used to create reports and prescribe safety regulations to promote the safe use of drones and airspace within the EU.

EU member states were required to harmonize their national regulations with this directive, and as of 1 January 2020, a unified framework for drone usage in European airspace has been in effect.

This paper aims to clarify the specific objectives of analyzing the integration of drone technology into firefighting services:

- Objective: Evaluate the level of UAS adoption by Croatian fire services in comparison with established EU standards as outlined by the EASA.
- Methodology: Data analysis was conducted through a literature review, regulatory framework assessments, and comparative studies between Croatian practices and broader EU guidelines. Primary criteria for comparison include regulatory compliance, operational capabilities, training standards for remote pilots, and the effectiveness of safety measures in both contexts.

Analyses were conducted using regulatory documents, industry reports, and selected interviews with representatives of Croatian fire services and training organizations. The comparative framework focused on examining how national regulations align with EU directives, identifying gaps in training and operational practices, and understanding the implementation dynamics of drone technology in emergency response.

2. RULES AND PROCEDURES FOR THE OPERATION OF UNMANNED AIRCRAFT

EU Regulation 2019/947 [3] defined three main groups of drone categories (open, specific and certified). The open category is further segmented into 3 additional subdivisions which group the most common types of drones used for both professional and recreational use.
As defined in Article 4 of EU Regulation 2019/947 [3], the Open Category includes numerous limitations, such as a maximum drone mass of less than 25 kilograms, the pilot's obligation not to approach or fly over crowds of people, the requirement to perform flight operations within visual line of sight, a maximum flight altitude of 120 meters above the obstacle overflown, as well as the prohibition of carrying and/or dropping payloads. Figure 1 shows the conditions of drone use classified into subcategories A1–A3 and subcategory A2.

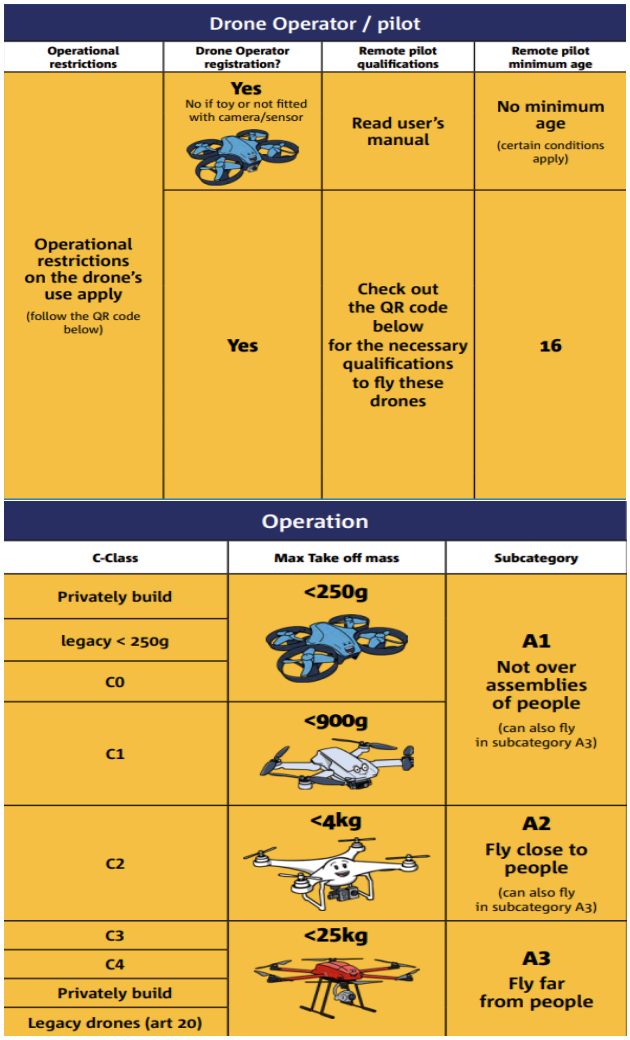

Figure 1. *Conditions and rules for the Open category*

The criteria for determining the category in which a drone operator will request authorization are not defined by the drone's mass nor by the capabilities and performance specified by the manufacturer in the user manual. As shown in Figure 1, in the Open category it is the drone operator's responsibility to independently decide what type of flight operations will be carried out with their drone. If a remote pilot intends to fly beyond visual line of sight and/or close to a group of people, or plans to conduct night operations, they are required to demonstrate the capability to operate at a higher safety level. This capability is demonstrated by passing an examination through the online training platform on the Civil Aviation Agency's website for subcategory A1–A3, or in person for subcategory A2 in cases where advanced flight operations are planned.
A drone operator may be a legal or natural person registered with the Civil Aviation Agency. This is the responsible person who may or may not also be the remote pilot operating the drone. The drone operator is responsible for the registration process, obtaining drone insurance, and preparing an operational manual for the remote pilots who will operate their drone in accordance with the procedures prescribed in the manual. The remote pilot must pass the required exam and submit a copy of their competency certificate to the drone operator. The remote pilot is responsible for complying with the procedures and obligations defined by the drone operator in the operational manual and for maintaining their personal flight logbook in order to record every flight operation. Both the remote pilot's flight logbook and the operator's operational manual are documents that may be requested by the Civil Aviation Agency for the purposes of supervision or in the event of a report of unauthorized drone use by a third party. If the documents cannot be provided or do not exist, penalties may be imposed.

3. TRAINING PROGRAMS REQUIRED BY THE CATEGORY IN WHICH FLIGHT OPERATIONS ARE CONDUCTED

The training and examination requirements for remote pilots and other personnel are defined in the regulatory document UAS-UPUTE-005 [4]. In this way, the Croatian Civil Aviation Agency prescribes minimum competencies, verification procedures, and responsibilities. The training program must be documented, with a clearly stated syllabus and accessible records of the completed training. Remote pilots must be familiar with: the basic components of an unmanned aircraft, the remote control system, controls and safety functions, procedures for take-off, flight, hovering, and landing, as well as maintenance instructions and the safety checklist to be completed before each flight operation.
In addition to practical training, the online training for the A1–A3 subcategory includes theoretical knowledge in the areas of air traffic safety, human limitations, meteorology, altitude restrictions, and the protection of privacy and personal data of individuals in accordance with EU Regulation 2016/679. The remote pilot must correctly answer at least 75% of the questions on the online exam in order to obtain the certificate of competency. Practical

self-training for the A2 subcategory is defined by the Croatian Civil Aviation Agency through documents AMC1 and AMC2 UAS.OPEN.030 [4]. Self-training focuses on developing flight skills, risk assessment, and the proper application of theoretical knowledge. Pilots must perform take-off, flight, and landing exercises in controlled conditions, simulate emergency situations, and acquire the ability to take manual control in case of technical malfunctions.

The matrix shown in Table 1. [4] defines the following conditions that must be met in advance:

(1) Only if operating an aircraft of class C1.

(2) The prerequisite for obtaining the Remote Pilot Competency Certificate is completing the training and examinations in the following order: Online training, 40-O Exam, Evidence, Practical self-training, Declaration, 30-O Exam.

(3) Training and examinations may be conducted by bodies and organizations authorized by the Croatian Civil Aviation Agency. Certificates and accreditation may be issued only by bodies or organizations authorized by the Croatian Civil Aviation Agency.

(4) The declaration is issued by the remote pilot.

(5) The competency certificate is issued by the Croatian Civil Aviation Agency.

(6) The remote pilot may acquire the knowledge required for the examination by attending training with an approved training organization or through self-study, online or otherwise.

Table 1. *Applicability matrix of training requirements for remote pilots in specific categories of operations*

Training	Open Subcategory			Specific Category		
	A1	A2	A3	STS-01 PDRA-S01	STS-02 PDRA-S02	PDRA-G01 PDRA-G02 PDRA-G03 SORA
Familiarization with the manufacturer's user manual	X	X	X	X	X	See footnote 7
Online training[4]	X[1]	X	X	X	X	
40-O Exam	X[1]	X	X	X	X	
Evidence	X[1]	X	X	X	X	
Practical self-training		X		X (opt)	X (opt)	
Declaration[4]		X		X (opt)	X (opt)	
30-O Exam[6]		X		X (opt)	X (opt)	
Certificate[5]		X[2]		X (opt)	X (opt)	
40-S Exam				X[3] (for A1/A3)	X[3] (for A1/A3)	
30-S Exam				X[3] (for s A2)	X[3] (for A2)	
Certificate-S				X[3]	X[3]	
Practical training-S				X[3] (no subject (d))	X[3]	
Accreditation				X[3]	X[3]	
Theoretical and practical training-G						

4. USE OF DRONES IN FIRE SERVICE

Integrating data gathered by UAV enables the development of procedures that can reduce casualties and save human lives, while ensuring a significantly higher level of safety during the intervention itself. Compared with traditional methods, this approach offers a range of additional, immeasurable advantages. Ultimately, the goal is to merge human expertise with advanced technology and create a true synergy between the two. Effective fire defence demands the strongest and highest-quality engagement of both human and technological factors, where the capabilities of deployed technologies directly enhance human performance and translate into measurable outcomes — from preserved assets to saved lives.

Firefighters began actively integrating drones into operational needs in 2017. In 2019, the Rijeka-based startup U-space Consulting won third place in the 11th generation of the Startup Incubator Rijeka for its idea “Training Center for Drone Pilots”. During the idea development phase, in cooperation with the Firefighting Association of Primorje-Gorski Kotar County and the Public Fire Brigade of the City of Rijeka, the company developed the first training program for remote drone pilots in Croatia. The program lasted 10 days and included theoretical and practical training in accordance with EU Regulation 2019/947 [3] for the Open Category (A1–A3). Six pilots were trained, all of whom successfully passed both national and EU exams and became certified remote pilots in firefighting. The knowledge gained enabled further development of standard operating procedures for advanced flight operations (e.g., night flights, beyond visual line of sight operations, flights in hazardous materials incident zones, use of thermal cameras, and live video transmission).

The result of years of development and training was the realization of EU-funded projects, such as “CICERON” in the City of Labin, where U-space Consulting trained 15 remote pilots from the Public Fire Brigade, volunteer fire departments, and the Red Cross. Participants were later encouraged to join the association “Unmanned Systems in Crisis Situations (BSKS)”, which today has nearly 100 members and is recognized as a partner of the Civil Protection Directorate. These practical experiences in firefighting operations provide a relevant context for understanding the safety challenges and risk areas identified at the European level by EASA.

5. ANALYSIS OF THE EU AVIATION SAFETY AGENCY REPORT (European Plan for Aviation Safety, “EPAS 2021–2025”)

The EASA document *European Plan for Aviation Safety (EPAS 2021–2025)* [5] complemented by the 13th edition of EPAS 2024 [6] defines ten key risk areas in aviation. The identified risks also include challenges associated with the growing presence of drones in airspace and the need to improve the Safety Management System (SMS).

The ten key risk areas include:

- Airborne Collision – collisions between aircraft or between an aircraft and other objects in the air.
- Aircraft Upset – unexpected flight conditions that may lead to uncontrolled impact with the ground.
- Collision on Runway – collision between an aircraft and another object or person on the runway.
- Excursion – when an aircraft leaves the runway surface without taking off.

- Fire, Smoke and Pressurisation – events that compromise crew and passenger safety.
- Ground Damage – damage caused during ground operations.
- Obstacle Collision in Flight – contact with objects such as antennas, power lines, or trees.
- Other Injuries – events that result in injuries not covered by other categories.
- Security – unlawful acts or sabotage against civil aviation, including cyber threats.
- Terrain Collision – impact with terrain without loss of aircraft control, often due to visual illusions or reduced visibility.

The report [6] recommends strengthening competencies, improving communication between regulatory authorities and operators, and proactively identifying emerging threats, including those arising from the increased presence of drones in airspace.

The report also highlights additional safety risks related to: Crosswind, Damage Tolerance to UAS Collisions, IFR/VFR Deconfliction, In-flight Decision-making, Intentional Low Flying, Knowledge of Aircraft Systems, Pre-flight Planning, Training and Competence and Turbulence.

The conclusion of the analysis is that the rapid growth in the number of drones requires additional monitoring and integration of risk-management systems to maintain the existing level of safety in European airspace. Drone operators who, over a period of six months, demonstrate compliance with safety standards while conducting advanced flight operations will meet the prerequisites for obtaining a trust-based exemption certificate. This trust-based exemption should be understood as a recommended regulatory approach described in EASA safety planning documents, rather than as a fully formalized certification scheme. The purpose of the trust-based exemption is to motivate drone operators to make maximum effort, comply with all regulations, and demonstrate the ability to safely conduct one type of advanced flight operation, and then apply the same good practices to other types of operations. As of now, based on available data, there is no widely documented example of a drone operator in the Croatian firefighting sector holding advanced operational authorizations. The majority of registered drone operators and remote pilots operating within the firefighting system currently hold A1–A3 certificates. Although some occasionally fly beyond the visual line of sight, they still need to pass the A2 exam and meet the remaining requirements for the Specific category.

Considering that firefighters will increasingly use drones for advanced flight operations, additional investments in training and the establishment of a safety management system can be expected.

6. CONCLUSION

The use of unmanned aircraft systems in firefighting has been proven to increase the efficiency and safety of operations. Drones enable rapid situational assessment, precise identification of fire hotspots, and a reduction in risks to human life. However, their use also brings a number of challenges—from regulatory limitations to technical and operational risks.

This paper provides an expert contribution by analyzing the application of unmanned aircraft systems in firefighting in accordance with the European regulatory framework, identifying key safety and operational challenges and offering guidelines for their safe and standardized future integration.

The greatest future challenges relate to the integration of drones into airspace and flight-control systems, the standardization of training and certification for remote pilots, the establishment of unified communication protocols between emergency services, the protection of privacy and data security, and the maintenance of systems in line with rapid technological developments.

It is necessary to develop a comprehensive risk-management system that includes pre-flight risk assessment, clear definition of responsibilities and command chains, continuous training and certification of pilots, maintenance and flight-log documentation, regular joint exercises with other services (police, civil protection, mountain rescue, etc.), and incident analysis as an example of good practice or experience exchange, providing feedback for improving procedures.

The success of integrating unmanned systems into firefighting services will depend on cooperation between regulatory authorities, manufacturers, educational institutions, and field operators. Systematic and safe application of drone technology can significantly enhance the operational capacities of firefighting units and increase the level of public safety. Future investments in new solutions are expected to range from a few thousand to several tens of thousands of euros, depending on the operational scope and technical requirements. Therefore, it is recommended that future investors and/or drone operators plan in advance for investments in safety, training, and regulatory compliance, thereby further safeguarding their investment.

7. LITERATURE

[1] Doc 10019, Manual on Remotely Piloted Aircraft Systems (RPAS)

[2] JARUS guidelines on Specific Operations Risk Assessment (SORA)

[3] Commission Implementing Regulation (EU) 2019/947

[4] UAS-UPUTE-005, Civil Aviation Agency, Croatia, Amendment No. 3 / 08 January 2025

[5] European Plan for Aviation Safety 2021–2025, Vol. Three Final, EASA, 15 January 2021

[6] European Plan for Aviation Safety (EPAS) 2024, 13th Edition, 23 January 2024

Short Biography:

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