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The Potential of Unmanned Aerial Vehicles for Use in Crisis Management in Poland

ABSTRACT

The article explores the integration of Unmanned Aerial Vehicles (UAVs) within the Crisis Management System (CMS), highlighting their potential to enhance crisis response and management through operational efficiency. It examines how UAVs can be effectively employed in crisis situations, presenting updates to the CMS that incorporate UAV capabilities. The article details the functions and key components of the CMS, which spans multiple levels of governance, from central to local authorities and executive agencies. The focus is on the preventative role of UAVs in crisis scenarios. Our research demonstrates how UAVs can be utilized to prevent and mitigate the impact of natural hazards such as floods, volcanic eruptions, hurricanes, tornadoes, heavy snowfall, snow avalanches, extreme heat, and frost. The findings suggest that integrating UAVs into the CMS framework can significantly enhance the system's ability to manage and control crises effectively and rationally. The deployment of drones in emergency situations holds significant potential to enhance and optimize relief efforts and operational processes. The article examines how UAVs can play a crucial role in modern crisis management environments, emphasizing their ability to improve emergency response. It also addresses the intersection of CMS with emerging threats such as cyber-terrorism, which is increasingly relevant in the context of cybersecurity and the digital landscape. In summary, we believe that emergency response groups can significantly benefit from the existing capabilities of UAVs. The integration of UAVs into crisis management systems offers substantial value both to affected populations and areas, as well as to disaster responders. UAVs provide a unique network for

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collecting and sharing critical disaster data, thereby enhancing the efficiency and effectiveness of emergency operations.

KEYWORDS: risk managment, unmanned aerial vehicles (UAVs), unmanned operational aircraft (UOA), UAVs flights

STRESZCZENIE

Potencjał bezzałogowych statków powietrznych wykorzystywanych w zarządzaniu kryzysowym w Polsce

W artykule omówiono podstawowe zagadnienia zarządzania kryzysowego (ZK) w odniesieniu do użycia bezzałogowych systemów powietrznych (BSP) w obszarze panowania nad kryzysem oraz zarządzania umożliwiającego efektywne wykorzystanie BSP. Przedstawione rozwiązania aktualizacji ZK w zakresie wykorzystania BSP stanowią istotną część tego opracowania, w którym opisano i podsumowano zasadnicze składowe i funkcje tego systemu. W obszarze ZK funkcjonuje wiele instytucji ustanowionych hierarchicznie od centralnego organu aż po komórki w samorządach lokalnych i siłach oraz środkach realizujących zadania. W opracowaniu podkreśliliśmy, że zadania wykonywane w ramach ZK mają na celu głównie rolę prewencyjną. Przeprowadzone przez nas badanie i uzyskane wyniki pozwoliły na wyciągnięcie wniosków mówiących o możliwych sposobach minimalizowania skutków kataklizmów, np. powodzi, erupcji wulkanów, huraganów, tornad, obfitych opadów śniegu, w tym lawin, ekstremalnych upałów czy mrozów dzięki efektywnemu i racjonalnemu wykorzystaniu ZK. Ponadto, użycie dronów w celach reagowania kryzysowego będzie odgrywać znaczącą rolę w obecnych warunkach i może ułatwić oraz zoptymalizować procesy i przedsięwzięcia pomocowe. Podkreślono nieodłączność wystąpienia ryzyka aktywności terrorystycznej związanej z rozwojem obszaru cyberprzestrzeni i jej bezpieczeństwa jako jednego z czynników związanego z obszarem ZK. W konsekwencji artykuł przedstawia wyzwania ZK w zakresie wystąpienia przyszłych sytuacji kryzysowych w relacji do rozwoju technologii i możliwości użycia BSP. Mając na uwadze wykorzystanie BSP w ZK, zaznaczono konieczność dostosowania procedur do przepisów prawa międzynarodowego i narodowego (szczebel krajowy, resortowy, wojewódzki, powiatowy i gminny). Podsumowując, w naszej opinii dostępne obecnie możliwości BSP zdecydowanie wpłyną korzystnie na wszelkie przedsięwzięcia podjęte w ramach działań zarządzania kryzysowego. Zarządzanie kryzysowe w odniesieniu do BSP jest korzystne zarówno dla dotkniętej kryzysem społeczności, jak i dla udzielających pomocy, np. wykorzystując funkcjonujący do zbierania i przekazywania danych kryzysowych system BSP.

SŁOWA KLUCZE: zarządzanie kryzysowe, bezzałogowe statki powietrzne (BSP), bezzałogowy statek powietrzny operacyjny (UOA), UAVs loty bezzałogowych statków powietrznych

Introduction

The number of UAV flights has gradually increased due to the technical, operational, and economic capabilities of these devices. UAVs can be utilized for recreational, commercial, and combat purposes by individuals, companies, organizations, central and local governmental institutions, and even military entities (Routledge, 2016). The advantages of Unmanned Aerial Vehicles (UAVs) and the capabilities of Unmanned Aerial Vehicle Operators (UAVOs) include executing air operations over short and long distances and under ordinary, difficult, and hazardous atmospheric conditions. According to the US Department of Defense (2020), imagery is defined as a likeness or representation of any natural or man-made feature or related object or activity, along with the positional data acquired simultaneously with the likeness or representation. This includes products produced by space-based national intelligence reconnaissance systems and likenesses and representations produced by satellites, airborne platforms, UAVs, or other similar means, excluding handheld or clandestine photography taken by or on behalf of human intelligence collection organizations (US Joint Chiefs of Staff, 2017).

The decision-making process regarding the use of UAVOs for crisis-related tasks in Poland is primarily overseen by central government authorities. However, authority may often be delegated to lower levels within the framework of operational use in specific situations. Key authorities in the crisis management system include the President of the Council of Ministers, the Council of Ministers, the Minister of Regional Affairs, and secretaries of central government institutions responsible for responding to various types of crises. The primary aim of implementing UAVO usage is to prevent or at least minimize the effects of natural disasters such as floods, terrorist attacks, epidemics, chemical or biological incidents, environmental damage, snow avalanches, extreme heat, or frost. The number of UAVOs and their operational capabilities are increasing due to advancements in technical, operational, and economic factors.

Military may take advantage of UAVs by employing them in recognizance, identification of chemical weapons and other substances, but also using them to hit a wide range of targets (e.g., combat units, logistics elements, vehicles, etc.). UAVs operate in the near environment even in locations that are far away, in difficult and harmful environmental conditions. UAVs have a capacity to be extremely useful during cross-sectional reaction plan execution. In such situation the authorities shall be encouraged to prove the employment of UAVs not only in emergency circumstances, natural disasters but also in police and military operations. These activities create an excellent field for research and studies.

General Knowledge on Crisis Management Systems

In the modern world, there is a growing reliance on both robotization and automation. These advanced technologies significantly impact natural environments, social dynamics, economic activities, security protocols, and various other processes. Crisis situations, particularly those that endanger human life, increasingly require the support of sophisticated devices and systems capable of operating in real-time, irrespective of the scale and severity of the threat. A critical element in crisis management is the reaction time, which is contingent on the nature and magnitude of the threats. UAVs and various types of robots, with their advanced capabilities, offer the potential for quicker and more effective responses.

Collaboration within and across agencies is essential in emergency management. Simona et al. (2021) propose a conceptual framework for analyzing technological support for collaborative services in this field. This framework might be based on the 3C Model, which views collaboration services as the integration of three attributes: communication, coordination, and cooperation. It is therefore advisable to continuously seek new capabilities in the crisis management system using these collaborative methods and suitable devices. Such advancements can significantly enhance the decision-making process, allowing for more timely and effective responses to real-time situations. Disaster management comprises many components, and the application of knowledge management (KM) practices across all major phases of the disaster management cycle remains unclear. However, implementing KM in all phases of disaster management can reduce disaster impacts and enhance resilience (Oktari et al., 2020). Hierarchical structures often struggle to be flexible or adaptive enough to address the demands of large and complex disaster environments. Empowerment practices can enhance adaptive performance by enabling operational units in the field to respond effectively to unpredictable aspects of their work environment. Through reliance on their training and improvisational skills, unit members are better equipped to overcome stress and fatigue during complex incidents (Huntsman et al., 2021).

Methodology and Processes in the Polish Crisis Management System

To effectively address our objective of "to prevent and minimize the effects of natural hazards," we examined the overall response of decision-making bodies, emphasizing both operational flexibility and technological capabilities.

These factors are particularly critical in crisis situations. With the increasing number of UAVs and licensed UAV operators, the airspace, especially over densely populated urban areas, is becoming increasingly crowded. Consequently, it is necessary to discuss conditions under which it may be possible to regulate or limit recreational and commercial UAV flights.

The Crisis Management System in Poland, as outlined in Table 1 and in accordance with the Journal of Laws of the Republic of Poland (2007), is a multi-tiered framework comprising the following components:

- crisis management bodies,
- opinion-making and advisory bodies competent in matters of initiating and coordinating actions taken in the field of crisis management,
- crisis management centers that maintain 24-hour readiness for action.

Table 1. Elements of crisis management at individual management levels

Level	**Administrative grade**	**Crisis management authority**	**Opinion-making and advisory body**	**Crisis Management Center**
1.	National	Council of Ministers, Prime Minister	Government Crisis Management Team (CMT)	Government Security Center
2.	Departmental	Ministers of government, Heads of a central authority	CMT (ministry, central office)	Crisis Management Center (CMC) (ministry, central office)
3.	Provincial	Governor	Provincial CMT	Provincial CMC
4.	District (county)	County Mayor	District CMT	District CMC
5.	Municipal	District Commune Head, Mayor, City Mayor	Commune CMT	Communal (municipal) CMC (Can be created)

Source: own study based on the Journal of Laws of the Republic of Poland, 2007.

The primary coordinating body during crisis events in Poland is the Government Center for Security (GCS). The GCS is tasked with ensuring effective communication and information flow between various administrative levels, including the Council of Ministers, the Prime Minister, relevant ministers overseeing government departments, Governors, County Mayors, and Municipal Mayors (Provosts). State institutions maintain close cooperation with the GCS through various communication channels, including telephone, email, and social networks, all of which are available 24 hours a day to guarantee uninterrupted information exchange.

Pursuant to the Journal of Laws of the Republic of Poland (2007) on crisis management, the Government Center for Security (GCS) provides essential information services to the Council of Ministers, the Prime Minister, and the Government Crisis Management Team. Additionally, the GCS ensures the seamless flow of information between national and international crisis management authorities and structures. The increasing frequency and intensity of natural hazards, coupled with the growing interdependencies among social-technical and ecological systems, are exerting significant pressure on emergency management frameworks. Relying solely on emergency management as a primary adaptation strategy is inadequate, as it fails to address the socio-political drivers of vulnerabilities. Bosomworth et al. (2017) addressed challenges for future strategic-level emergency management: reframing, networking, and capacity-building. These three key suggestions could assist the country's strategic-level emergency management in tackling challenges such:

- Reframing: Developing new perspectives on emergency management that incorporate socio-political dimensions and prioritize reducing vulnerabilities.
- Networking: adopting a network governance approach.
- Capacity-building: further developing the capacities of strategic--level emergency managers.

Crisis situations primarily encompass natural disasters triggered by environmental factors and those stemming from human activity. In a country like Poland, the most perilous and likely events include floods, heavy snowfall and frost, droughts, large-scale fires, hurricanes, chemical disasters, the current SARS-CoV-2 pandemic, and animal diseases. These threats are considered the most dangerous and probable. There is a robust consensus among humanitarian response authorities on the necessity for global action by professional organizations to develop a structured approach for a coordinated international response during sudden-onset disasters. The proposed plan employs a "three-tier approach":

- Tier 1: Immediate disaster response at a national/international level.
- Tier 2: Organization and deployment of healthcare personnel.
- Tier 3: Restoration management of disaster survivors and community reintegration.

Additionally, the Disaster Recovery Committee could play a crucial role in advocacy, training, and accreditation processes for therapy professionals. The significant challenge moving forward is the commitment of countries worldwide to develop a comprehensive, rehabilitation-inclusive approach to ensure the effective delivery of services to at-risk communities (Amatya et al., 2020).

The activity of the crisis management system has been primarily focused on preventing and mitigating the effects of atmospheric phenomena, with less emphasis on addressing failures and catastrophes. However, recent developments suggest a need for reevaluating the classification of epidemic threats within the framework of risk assessment, particularly those related to critical infrastructure. The Polish Government Security Center (2020) previously categorized epidemics as having a possible occurrence with an average impact on national security. This categorization should be reassessed, and the entire chain of potential threats should be reanalyzed. To enhance the effectiveness of crisis management in responding to natural disasters and human-induced catastrophes, it is crucial to have forces and resources capable of providing immediate access to real-time information and alleviating the burdens on personnel working under extremely challenging conditions that threaten health and life. Integrating Unmanned Aerial Vehicles (UAVs) into the crisis management system appears justified, as UAVs can meet these requirements and significantly improve the response capabilities in crisis situations.

The civilian use of drones necessitates the development of the PREDICATE project, which focuses on creating essential methodologies to guide the selection and operational use of Unmanned Aerial Systems (UAS), commonly known as UAVs, in emergency situations. To facilitate UAS selection, the project conducts a comprehensive needs assessment in collaboration with civil protection and law enforcement agencies. This assessment involves a thorough review of currently available technologies and market solutions, resulting in the creation of an online, user-friendly tool designed to support UAS selection based on specific operational requirements. To optimize the use of UAS, PREDICATE develops an intelligent path planning toolkit that automates UAS operations, simplifying their deployment for various civil protection activities. By utilizing these tools, emergency services can gain a better understanding of how to select and effectively employ UAS for monitoring and patrolling disaster-prone regions of interest. This approach aims to enhance the efficiency and effectiveness of emergency response efforts (Huntsman et al., 2021).

When discussing a crisis, it is essential to recognize that crises are characterized by their "unusual" nature for a given area. According to the Act on the State of Natural Disaster, a natural disaster is defined as either a spontaneous event or a technical failure, specifically one that is related to natural forces or technical malfunctions (Journal of Laws of the Republic of Poland, 2002). This definition underscores the distinction between events that arise from natural forces and those resulting from technical failures, both of which can lead to significant disruptions and challenges within the affected region.

Salmoral et al. (2020) highlight a growing interest in employing Unmanned Aircraft Systems (UAS) for flood risk management and response. Despite this, evidence on the structured and strategic utilization of UAS remains sparse. Effective flood response is crucial for saving lives and alleviating suffering. Their study assesses how UAS can be integrated into flood preparedness and response efforts, and formulates guidelines for their deployment at various stages: before, during, and after a flood event. This research aims to optimize the use of UAS to enhance flood management practices and improve overall emergency response efficacy.Natural disasters and technical failures can also be triggered by events in cyberspace and terrorist activities. According to the Journal of Laws of the Republic of Poland (2017), cyberspace is defined as the domain for processing and exchanging information created by information and communication technology (ICT) systems. Specifically, Article 3, point 3 of the legislation addresses the computerization of public entities' activities, including their interactions and connections with users. This highlights the growing importance of cybersecurity in managing and mitigating risks associated with digital threats and cyberattacks.

Sovilj and Sovilj (2017) emphasize the critical need to understand the potential misuse of drones by terrorists. In this context, drones could be employed to transport explosives or other destructive agents, posing significant threats to people, buildings, vehicles, and equipment. They also note concerns about the use of drones for reconnaissance, espionage, and communication to facilitate terrorist activities.

Conversely, drones are also seen as tools for counter-terrorism efforts. Hazelton (2017) argues that U.S. drone strikes, while contributing to security, have had limited political impact. The use of drones is often viewed as a tactical response to specific threats rather than a major strategy in the broader scope of U.S. global interests. As drones become more accessible, including to non-governmental organizations (NGOs), their effectiveness in counter-terrorism may diminish. However, drone strikes can help reduce aggression in non-democratic regimes and strengthen alliances with U.S. partners. Importantly, drone attacks are perceived as a less provocative form of intervention compared to other uses of force, potentially minimizing broader conflict escalation.

Polish National Crisis Management Structure and Tasks

The Polish National Crisis Management structure operates through a highly integrated network, where seamless and uninterrupted cooperation is essential, irrespective of time, day, or season. This coordination

occurs at four distinct levels, with dedicated crisis management teams functioning around the clock to ensure continuous collaboration among all critical entities involved in crisis management. The structure is organized as follows:

- Level 1 (Top Level) includes President of the Council of Ministers (Prime minister), Minister of the Interior and Administration, Government Crisis Management Team, Government Security Center, Crisis Management Teams of Ministries and Central Authorities of Government Administration, and Crisis Management Centers of Ministries and Central Bodies of Government Administration
- Level 2 (Upper Mediate Level) consists of Governor, Provincial Crisis Management Team, and Provincial Crisis Management Center
- Level 3 (Lower Mediate Level) includes District Mayor, District Crisis Management Team, and District Crisis Management Center
- Level 4 (Basic Level) consists of Mayor (City president), Commune – Municipality. Crisis Management Team, and Commune – Municipality Crisis Management Center

We distinguish four phases of crisis management: prevention, preparation, response, and recovery. The activities performed in each phase are logically connected and complement each other. Ideally, preventive measures would be in place to minimize or eliminate the need for subsequent reactions. However, since many natural forces are inherently unpredictable, it is impossible to entirely eliminate threats or prevent the occurrence of hazardous and disruptive events affecting people, animals, and the ecosystem. The phases of crisis management include the following:

- Prevention – actions aimed at eliminating or reducing the likelihood of a crisis through anticipatory measures.
- Preparation – focuses on developing emergency response plans, which detail who will perform specific tasks, when with what resources, and on what legal basis – before, during and immediately after a crisis event.
- Response – triggered when a real threat or event occurs. Its purpose is to implement measures to prevent or minimize damage and, once the crisis has occurred, to carry out rescue operations to aid to the injured and limit secondary damage and losses.
- Recovery – the final phase of the crisis management cycle, during which efforts continue until all systems return to their previous state or achieve a better condition than before the emergency.

Aviation Law (Journal of Laws of the Republic of Poland, 2018a) is the principal document regulating most technical means of flight over land. It is important to highlight that this legislation mandates compliance from all individuals and entities involved in the construction or operation of various types of UAVs. The methods and procedures for operating UAVs are outlined in both international and national legal frameworks.

The Convention on International Civil Aviation (International Civil Aviation Organization, 1944), commonly known as the Chicago Convention, was signed on December 7, 1944, by 52 states. This led to the establishment of the Provisional International Civil Aviation Organization (PICAO), which later evolved into the International Civil Aviation Organization (ICAO) on April 4, 1947. In October of the same year, ICAO became a specialized agency of the United Nations, linked to the Economic and Social Council (ECOSOC). The Rules of the Air (International Civil Aviation Organization, 2018b) apply universally over international waters and national territories, provided they do not conflict with the regulations of the state being overflown.

The pilot-in-command of an aircraft is responsible for ensuring compliance with the rules of the air. An aircraft must be operated in accordance with either the general rules and visual flight rules (VFR) or instrument flight rules (IFR). Flight under visual flight rules is permitted if the flight crew can remain clear of clouds by at least 1,500 meters (5,000 feet) horizontally and at least 300 meters (1,000 feet) vertically, while maintaining a forward visibility of at least 8 kilometers.

The International Civil Aviation Organization (2020) is responsible for establishing airspace structures, units, and services necessary to promote a safe, orderly, and efficient flow of air traffic. UAV flights within airspaces defined by the ICAO and the European Union's European Union Aviation Safety Agency (EASA) must adhere to specific regulations and rules, whether for recreational, commercial purposes, or crisis management (European Union, 2019c).

To harmonize UAV regulations, the European Parliament passed Regulation (EU) 2018/1139, and the Commission Implementing Regulation (EU) 2019/947 on rules and procedures for the operation of UAVs entered into force (European Union, 2019b). Additionally, the Commission Delegated Regulation (EU) 2019/945 of March 12, 2019, on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, was established (European Union, 2019a).

The entry into force of the aforementioned legal acts will unify the regulations governing the use and performance of air operations involving UAVs. Prior to these legal acts, the lack of a uniform position by international institutions led individual countries, with EASA's approval, to introduce their own regulations for UAV (Unmanned Aerial Vehicle) flights with a Maximum Take-off Weight (MTOW) of up to 150 kg. These regulations included certain exemptions, allowing UAV flights up to a height of 150 meters Above Ground Level (AGL).

Above this height, UAV flights are conducted in segregated airspace structures to ensure separation from other air operations involving manned aviation. The Polish Ministry of Infrastructure has established that safety within these airspace structures is the responsibility of the entity authorized or designated to provide services in each airspace class or structure (Journal of Laws of the Republic of Poland, 2018b).

In segregated airspace structures, UAV operations are typically carried out based on a Flight Plan (FPL) and must meet the requirements for airworthiness and equipment necessary for operations in the designated airspace class. To ensure safety, it is crucial for the Air Traffic Service (ATS) and, in some cases, military operational services, to have information about the location, type, and nature of the UAV flight. This coordination allows for the ongoing management of airspace use and ensures the safety of all airspace users.

While this requirement might complicate the execution of tasks in crisis situations, it is important to remember that crises have specific priorities and often necessitate the use of ad hoc airspace.

Performing unmanned flights is becoming increasingly popular. Table 2 highlights significant progress in issuing UAVO (Unmanned Aerial Vehicle Operator) certificates, notably in 2015 and 2017. The surge in certifications was driven by changes in legal regulations for both recreational and commercial purposes. Permission for Visual Line of Sight (VLOS) operations is common among private operators who navigate UAVs, often drones. To maximize efficiency, Beyond Visual Line of Sight (BVLOS) flights, which enable drones to cover greater distances, require a license. BVLOS flights allow operators to navigate drones beyond their visual range, enhancing operational capabilities. Drone pilot instructors must possess INS permissions to conduct training.

UAVs offer numerous advantages and are becoming serious competitors to manned aviation. They are cost-effective, environmentally friendly, and highly valuable for national security tasks. The current threats of terrorism and the dramatic development of epidemic situations highlight the need for advanced technologies like Deep Neural Networks (DNN) for 3D object recognition. Using DNNs, systems can automatically classify

objects captured in video frames with high accuracy, as demonstrated by Miyazato et al. (2019).

In civilian environments, UAVs are used for a variety of purposes, including forest patrolling, agritourism, environmental monitoring, observing dangerous events, traffic monitoring, pipeline patrolling, responding to natural disasters, and delivering shipments to hard-to-reach areas. Traditional manned transport for these tasks is often difficult, limited, time-consuming, and sometimes impossible. UAVs have been utilized in crisis management by the State Fire Service (SFS) and police for a long time.

Current UAV-borne photogrammetry provides highly effective methods for acquiring up-to-date knowledge of various environments and situations. Their effectiveness is attributed to their ability to operate in challenging conditions known as triple-D areas (Dull, Dusty, Dangerous) and the advanced remote sensing capabilities inherent in photogrammetry (Caroti et al., 2017).

Table 2. Report on the issue of UAVO qualification certificates

Type of qualification certificate	Authorization	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020
UAVO qualification certificate	with VLOS permission	5	296	1560	3311	5389	8220	8507	8310
	with BVLOS license	2	53	152	192	692	948	1247	1312
	with INS permission	2	27	32	45	67	184	247	357
Total	Service along with sport and recreation using	9	376	1744	3548	6148	9332	10001	9979

Source: own processing with use of: Civil Aviation Authority, 2020 and data from previous years.

Police departments across the United States are increasingly integrating new visual monitoring technologies, such as unmanned aerial vehicles (UAVs or "drones") and body cameras, into routine practices. While these technologies hold significant potential for both proactive and reactive policing, public attitudes toward their use are mixed. Building on previous research, the current study utilizes a national survey to examine how individuals' perceptions of police legitimacy, effectiveness, and other criminal justice attitudes influence public receptivity to and opposition toward police use of UAVs in various contexts (Heen et al., 2018).

When planning air operations with UAVs, it is essential to consider technical parameters such as operating radius, range, optimal flight level, speed, and flight destination. These factors, combined with the use of permanently installed and/or suspended response sensors, facilitate the successful execution of the planned aviation mission.

In crisis management, UAVs offer the advantage of long-term direct information transmission from monitored areas. UAV operators can alternate tasks with other personnel over specified periods, conducting missions through continuous control or autonomously based on pre-planned flight profiles. This flexibility allows UAVs to be effectively utilized in emergencies for real-time area monitoring, air sampling, mapping, and delivering various materials and medical resources during natural and man-made threats.

Electric drones, in particular, provide a reliable alternative for the emergency transport of medical equipment, essential supplies, communication devices, and more. They can perform reconnaissance, locate hot spots, and facilitate quicker access to emergency sites. Additional approaches, such as e-bikes and e-stretchers, further enhance emergency response capabilities (Wankmuller et al., 2020).

Human and financial considerations, along with the efficiency of unmanned aerial vehicles (UAVs), suggest that UAVs will soon become increasingly prevalent in managing and mitigating crisis situations. Their widespread adoption is anticipated to enhance the effectiveness and sustainability of crisis response efforts. Currently, there are no unified regulations governing the integration of manned and unmanned aerial vehicles within shared airspace. To address this, it is essential to implement separation measures for flights above 150 meters AGL (Above Ground Level) by establishing designated airspace zones, such as restricted zones (R zones). These restrictions should be informed by the specific location of UAV operations and may be guided by the provisions outlined in Annex 15 of the International Civil Aviation Organization (ICAO, 2018a). This annex mandates that Notices to Airmen (NOTAMs) be issued and disseminated when there are potential dangers or threats to air navigation.

By utilizing these provisions, it is possible to establish restricted areas where manned and unmanned aerial vehicles operate separately, tailored to operational needs and the threats faced. To ensure the efficient functioning of the crisis management system, it is crucial that UAVs be readily available to the relevant personnel and institutions involved. UAV operators must possess appropriate UAV operator qualifications and engage in ongoing education and training that closely simulates real-world conditions.

Summary

From a legislative perspective, Poland has enacted the necessary regulations to align with international standards for the utilization of UAVs. The increasing deployment of UAVs in crisis management demonstrates their significant benefits. The crisis management system relies on efficient communication between authorities and organizations responsible for managing and mitigating crisis situations, and UAVs play a crucial role in enhancing this capability.

To facilitate smooth and effective information flow and decision-making, institutions collaborate closely with the Government Center for Security (GCS). This cooperation aims to prevent or minimize the impacts of crises such as volcanic eruptions, tsunamis, hurricanes, tornadoes, epidemics, chemical or biological disasters, heavy snowfall, avalanches, extreme heat, or frost.

Traditionally, crisis response relies heavily on manned aviation, which has its limitations. UAVs, however, offer modern technology that allows for extended operations in disaster areas and real-time image transmission, without the need for extensive infrastructure.

The use of UAVs in crisis management is expanding due to their operational advantages. To accommodate this growth and ensure safety, UAV operations should be conducted in designated airspace structures, either in conjunction with or separate from manned aviation, based on the specific threats, needs, and operational requirements of the crisis management efforts.

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