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UNMANNED AERIAL VEHICLES AS TOOLS FOR CONTROLLING SELECTED ASPECTS OF AN ORGANISATION'S SECURITY

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Abstract.

The research niche of this article lies in the insufficiently explored use of Unmanned Aerial Vehicles (UAVs) in enhancing security systems in organisations. The purpose of the study was to determine how and in which security domains UAVs can improve the effectiveness of control and supervision processes while reducing operational risk and safety-related costs. The study addresses the research gap between rapidly developing UAV technologies and their practical integration into organisational safety management systems. The research hypothesis posits that the integration of Unmanned Aerial Vehicles (UAVs) into safety management systems significantly increases the effectiveness and precision of control and supervision processes, resulting in reduced operational risk, enhanced situational awareness, and lower costs of maintaining technical and physical security. The research employed a six-stage methodology, including a review of scientific literature and legal frameworks, an industrial case study, a focus group scenario, qualitative data collection, and in-depth analysis. The results support the proposed hypothesis, showing that UAV deployment improves inspection efficiency, accuracy, and safety by enabling early detection of anomalies, enhancing situational awareness, and reducing human exposure to hazardous environments. UAVs also facilitate real-time infrastructure monitoring and support predictive maintenance. The findings indicate that UAVs complement rather than replace traditional inspection methods. Their effective implementation requires organisational readiness, including trained personnel, defined procedures, and regulatory compliance. In conclusion, UAV integration enhances risk control, operational performance, and system resilience, strengthening security capabilities, particularly in technical and physical security domains.

Keywords:

Unmanned Aerial Vehicles (UAVs); Organisational Security; Technical Safety; Physical Security; Risk Management

Introduction

In recent years, there has been a dynamic development of modern technologies. Technological progress has been entering new sectors, revolutionizing the work environment. During this time, the topic of Unmanned Aerial Vehicles (UAVs), commonly known as drones, has increasingly appeared in public discourse. This technology was originally developed and continues to be advanced within the military sector. Over the past decade, the rapid development and miniaturization of sensors, cameras, batteries, and satellite navigation systems have made commercial drones ubiquitous across various industries and economic sectors.

The safety sector, in particular public services, has been highly successful in utilising the potential of UAVs. Firefighters use drones to monitor large forest fires, enabling rapid situational assessment and more effective coordination of firefighting operations. Police forces deploy UAVs to secure large public gatherings and mass events. The military employs unmanned aerial systems for reconnaissance and as combat tools. However, in the organisational security sector, drones are only beginning to gain wider application.

Many organisations—especially those operating in the energy, transport, and logistics sectors—constitute elements of the national critical infrastructure (critical entities). Their resilience and ability to function during extraordinary circumstances have a direct impact on maintaining the functioning of the state, ensuring effective crisis response, and minimising the effects of disasters or attacks (Ustawa z dnia 26 kwietnia 2007 2023, item 122). According to the Council Directive 2008/114/EC (2008), *critical infrastructure* refers to an asset, system, or part thereof that is essential for maintaining vital societal functions, public health, safety, security, economic or social well-being of people, and whose disruption or destruction would have a significant impact on a Member State due to the loss of those functions. In the literature, safety generally refers to protection from unintentional harm or accidents, whereas security is more commonly associated with protection against intentional threats. The two terms are closely related and often overlap in practical use (Jagusiak 2018).

Efforts to ensure the security of such organisations are implemented across six main areas:

- physical security;
- technical safety;
- personnel security;
- information and communication technology (ICT) security;
- legal safety;
- and continuity and recovery planning (Skomra 2015; NPOIK 2023).

Opportunities for improving security tools can be sought in various branches and processes, yet the most relevant areas for applying UAV technology are physical

security and technical safety within organisations. The goal of physical protection is to prevent unauthorized individuals from entering organisational premises and to detect dangerous tools or substances (Ignac-Nowicka 2010). In turn, technical safety relates to the prevention of disruptions in technological processes within the organisation and should be approached in a broad sense. One of the main elements of technical safety includes environmental management systems and occupational health and safety management systems (Kisilowski et al. 2021).

Therefore, the implementation of technologies such as UAVs into control and inspection processes of physical security and technical safety should be regarded as an essential component of the future direction in the development of organisational security systems.

The dynamic development of Unmanned Aerial Vehicle technology has created new possibilities for organisational security control and monitoring. Despite the increasing availability and potential of these systems, their application within the field of organisational safety, particularly in the areas of physical security, and technical safety remains at an early stage of implementation. There is still a lack of clear analyses indicating how and to what extent UAVs can effectively support organisational safety control processes, especially in the context of critical infrastructure, technological risk management, and resource protection.

The research problem addressed in this study concerns the insufficient understanding of how Unmanned Aerial Vehicles can be effectively integrated into organisational security systems to improve the efficiency of control and supervision processes while reducing operational risk and safety-related costs.

Research question: How can the application of Unmanned Aerial Vehicles in organisational security systems enhance the effectiveness of control and supervision activities while simultaneously reducing operational risk and the costs of ensuring technical and physical security?

Research hypothesis: The integration of Unmanned Aerial Vehicles into organisational safety management systems significantly increases the effectiveness and precision of control and supervision processes, leading to reduced operational risk, improved situational awareness, and lower costs of maintaining technical and physical security.

Literature review

Unmanned Aerial Systems (UAS) are characterized by high mobility and the ability to collect data over large areas with relative ease. The visible light and thermal cameras used in modern drones now provide image quality comparable to traditional manual cameras. However, the difference between a manual inspection and a remote inspection is profound. Through unmanned inspections, organisations

can assess technical conditions without exposing workers to risks - regardless of the height or accessibility of the inspected area.

The nature of work in sectors such as energy, telecommunications, transport, and logistics is inherently risky, often requiring operations in open areas and at considerable heights. UAV technology enables environmental monitoring and technical inspections at high altitudes without involving human personnel, thus minimising the risk of accidents.

UAVs are electromechanical systems capable of autonomous flight and various operations. The term refers to all types of unmanned flying units, ranging in size from just a few centimetres to several dozen meters. Different UAV types are designed for specific operational purposes (Balestrieri et al. 2021, pp. 53–63). Implementing UAVs in security-related sectors begins with selecting the appropriate device and integrating it into operational processes. UAVs can be equipped either with fixed sensors or interchangeable modules, depending on the mission requirements.

The most common and fundamental sensor is the RGB camera (Red–Green–Blue), which records visible light. It enables real-time imaging, photography, and video capture. The quality and resolution of optics are particularly important for analytical purposes, especially when inspections rely on photographic documentation. While most commercial drones are equipped with standard RGB cameras, higher-end models allow for interchangeable or enhanced optical systems. Due to the rapid commercialization of the drone industry, high-resolution UAV systems are now available at relatively low prices, though specialised units can cost from several hundred to hundreds of thousands of euros.

For more advanced operations, specialised sensors are required. The LiDAR (Light Detection and Ranging) sensor allows for terrain mapping and the creation of 3D models based on precise laser distance measurements between points (Liang et al. 2023, p. 202). Another important sensor is the thermal imaging camera, which enables thermal inspections of structures, machinery, and installations - particularly useful in detecting overheating, energy losses, or locating missing persons in difficult terrain. The GPS RTK (Real-Time Kinematic) sensor is an equally valuable tool, providing centimetre-level positioning accuracy through satellite navigation and a reference station system. This technology functions similarly to geodetic measurement tools but replaces ground-based equipment with an airborne platform.

All four sensor types: RGB, LiDAR, thermal, and RTK have demonstrated strong potential for use in the security sector. UAVs offer a fast, precise, and safe inspection tool, especially in technically complex or high-risk environments. Their deployment can also reduce operational costs, such as those associated with high-altitude maintenance and rope-access inspections.

In industrial settings, UAVs equipped with optical and thermal sensors can be used for external crane inspections, assessing the condition of structural components that are otherwise difficult to access. By detecting heat anomalies in mechanical parts,

these systems allow for proactive maintenance, preventing failures or hazardous incidents (Łukasiewicz and Niemczyk 2022, pp. 11–16).

Due to their ability to capture high-resolution imagery from elevated positions, UAVs have become valuable tools in building inspections, infrastructure monitoring, and asset protection within both physical security and technical safety domains. Field experiments have confirmed their versatility and practical value in organisational security monitoring (Falorca, Miraldes and Lanzinha 2021).

Interest in UAV technology increased significantly during the COVID-19 pandemic, when social isolation, remote work, and restricted mobility created new challenges. These conditions accelerated robotization and digitalisation, bringing unmanned systems into mainstream use. A notable example comes from China, where drones equipped with loudspeakers were used to communicate safety instructions in quarantined zones and to monitor gatherings to enforce social distancing. Similarly, in the United States and Australia, drones were tested for medical supply delivery, disinfection, biological sampling, and remote threat detection. These pandemic-era innovations later found commercial and industrial applications, popularizing UAV-based inspection and monitoring systems (Mohsan et al. 2022, pp. 2–14).

Today, UAV technologies are increasingly used in organisational security monitoring, including:

- Employee supervision – real-time monitoring of work processes to ensure compliance with occupational safety and procedural standards.
- Work environment safety analysis – detecting and eliminating potential hazards to health and life (Savković et al. 2021, pp. 525–550).
- Progress tracking – monitoring project completion and verifying task execution, both internally and by external contractors; for example, warehouse safety is a key concern for many companies (Szymonik 2023).
- Incident analysis – aerial imagery used for documentation and investigation of adverse events (Ewertowski and Ludwiczak 2025, pp. 124).

Integration with other systems – complementing existing safety audits or remote control systems with aerial data (Choi et al. 2023, pp. 2–8).

Situational awareness and geospatial analysis – supporting executive decision-making processes through spatial data (Zaskórski and Miszalski 2021).

Decision-support systems – providing visual and analytical input for security-related management decisions (Ścibiorek and Borucka 2022).

Thus, contemporary organisational safety management is entering a stage of integration between traditional inspection methods and UAV-based technologies. The implementation of unmanned aerial systems as remote auditing and monitoring tools offers significant potential benefits for safety departments, management teams, and external stakeholders, contributing to greater efficiency, improved situational awareness, and enhanced overall resilience of organisations.

Research methodology

The study employed scientific research methods, understood as a set of appropriate, goal-oriented, and model approaches (Czupryński, Wiśniewski and Zboina 2017). The following empirical methods were applied: the case study method and the focus group interview method.

The case study method is a well-established research strategy for investigating complex, context-dependent phenomena within their real-life settings, particularly when the research subject is individual in nature (Korzeniowski 2012). It enables an in-depth, holistic understanding of processes, relationships, and mechanisms by integrating multiple sources of evidence, such as documents, observations, and interviews, thereby enhancing analytical rigor (Czakoń 2015).

Focus group research is a qualitative method based on group discussions led by a trained specialist, the aim of which is to explore participants' perceptions, experiences and shared meanings of the presented topic through interactive communication (Korzeniowski 2012). The method leverages group dynamics to generate rich, nuanced data, as participants respond not only to the moderator's questions but also to each other's perspectives, facilitating deeper insight into collective sensemaking processes (Morgan 1997).

A methodological approach was used in the research, consisting of six stages:

- Analysis of the content of academic literature dedicated to UAVs and organisational security;
- Analysis of the content of current legal acts related to UAVs and organisational security in Poland;
- Case study of the selected organisation;
- Designing a focus group scenario based on insights from the initial stages;
- Conducting a focus group meeting with representatives of the organisation's management;
- Analysis of research results.

The study was carried out in the second half of 2024. The first two stages were described in the introduction and literature review sections. In the third stage, the possibilities of using Unmanned Aerial Vehicles for occupational safety inspections were analysed based on a case study. The case organisation was selected using a purposive sampling strategy combined with an access-based criterion. A formal research proposal describing the objectives, scope, and expected involvement was submitted to five companies operating in the selected region. Only one organisation agreed to participate, which determined the final case selection. While the sampling process was partially constrained by organisational willingness, such access-driven selection is consistent with qualitative case study research, where the depth and quality of data take precedence over representativeness (Yin 2018). The selected case provided a unique opportunity to investigate the research problem within

an authentic organisational setting. The scope of the study included the practical implementation conducted with prior authorization of research and observation within an organisation (enterprise) located in the Greater Poland region.

The schedule of the external security and safety inspection included the following tasks:

- Identifying potential hazards and irregularities present in the organisation's external areas.
- Conducting a technical inspection of buildings, including the assessment of roof conditions, installed equipment, and identification of infrastructural damage or irregularities.
- Preparation of a comprehensive safety report for the inspected area, containing an analysis of detected irregularities and recommendations for corrective and preventive actions.

The remote external inspection was made possible through the use of a UAV system equipped with optical sensors that enabled photographic documentation of the actual condition of the external areas. Previously, control activities in the analysed environment were conducted manually, involving physical patrols, rooftop access, inspection procedures, and the preparation of inspection reports.

The use of UAVs in inspections can mitigate risks associated with working at heights by substituting human-performed activities with UAV-assisted operations.

The remote inspection was conducted using photo and video documentation collected by the UAV system. Figure 1 presents the initial flight mission plan.



Figure 1. Preliminary flight plan for area inspection

Source: author's own elaboration

The tool required for the implementation of the project was an unmanned aerial vehicle equipped with a high-resolution visible-light sensor. The device's purpose was to document the actual condition of the inspected area by capturing high-quality images and video recordings.

For the conducted study, the DJI Air 2S model was selected, as it met the necessary criteria - it is equipped with a 1-inch camera sensor, enabling the recording of high-resolution photos and videos with satisfactory image quality.

The specification of the device, along with a detailed overview of the requirements for the planned aerial inspection, is presented in Table 1.

Table 1. Analysis of the remote inspection tool

Specification	Technical Data / Description	Source / Reference
Model	DJI Air 2S	Manufacturer data
Weight	595 g	Manufacturer data
Dimensions	180 × 97 × 77 mm (folded), 183 × 253 × 77 mm (unfolded)	Manufacturer data
Battery capacity	3500 mAh – flight time up to 31 minutes	Manufacturer data
Sensor / Camera	1-inch CMOS sensor, max video resolution 5.4K (5472 × 3078)	Manufacturer data
Controller	DJI RC-N1	Manufacturer data
Licencing requirements	UAV weight above 250 g means that flight operations require an open or specific category pilot licence, depending on the mission type.	(Official Journal of the EU L 152, item 45, 11.06.2019)
Regulatory requirements in Polish airspace	The Polish Air Navigation Services Agency must be informed of the intention to perform UAV flights in Polish airspace.	(Journal of Laws of 2023, item 2110, art. 126, dated 04.09.2023)

Source: own study

The flight planning process was aimed at ensuring effective risk and quality management of the operation. A chaotic or unplanned flight could pose hazards and lead to inefficiency. Beginning the operation with low-altitude flights could potentially result in a collision. Therefore, the preliminary analysis of the area was conducted to collect data necessary for planning more detailed missions.

The information gathered during the initial flight was internally reviewed and used to divide the inspection process into smaller operational segments. The study area covered approximately 33,000 m², of which about 19,000 m² consisted of building structures. Due to the extensive size of the organisation's premises, the inspection area was divided into sectors.

Figure 2 presents the layout of the inspection area, divided into nine sections, labelled with letters from A to I.

This division was developed based on the characteristics of the facilities and their surrounding areas. The sector labelling was used in the subsequent stages of the study to locate irregularities within specific areas.

The main remote inspection was then carried out through a series of UAV flight operations performed sequentially over the designated zones. The plan initially assumed completing the entire practical inspection within a single day; however, weather conditions prevented full execution of the task. The collection of photographic documentation was therefore continued on the following day.



Figure 2. Division of the inspection area into sectors.

Source: author's own elaboration

Subsequently, the results and course of the remote inspection were compared with traditional methods, confronting the findings with the opinions of the focus group, which included health and safety specialists and physical security experts who had previously participated in manual safety inspections of the studied area. The analysis of this case study allowed for a practical verification of UAV application possibilities. Conducting the research under real conditions helped illustrate the effectiveness and limitations of such solutions.

The focus group interview (FGI) is a qualitative research method used to gather opinions and insights from a carefully selected group of participants. The main objective of this approach is to collect subjective evaluations and understand how the target group perceives a specific phenomenon. The data obtained through this method enable researchers to identify mechanisms of perception, attitudes, and decision-making related to the studied issue.

Focus group interviews are conducted by a moderator, who guides the discussion toward specific research issues while maintaining an open and natural flow of conversation. The moderator ensures that participants feel comfortable expressing their opinions freely, while keeping the discussion focused on the core research topic.

The selection of participants is a key element in this method. Participants are typically chosen purposefully, based on their expertise and relevance to the research goal. The optimal group size for effective discussion is between 8 and 12 participants, allowing for both diversity of opinions and active engagement of each member.

The focus group process can be divided into the following stages:

- Defining the purpose of the discussion and formulating the main research questions.
- Planning the process: selecting suitable participants and preparing tools such as a questionnaire or interview guide.
- Conducting the session: question-and-answer exchanges, group discussion, and recording the conversation.

Analysing the collected material to develop conclusions and a final report.

This method is particularly effective when analysing expert opinions, as it enables the collection of a large amount of information in a relatively short time. However, it also has limitations - responses may be imprecise or influenced by group dynamics and social factors (Ilczuk 2020, pp. 35–41).

In this study, the focus group consisted of the management team of the selected manufacturing and processing plant, along with personnel responsible for safety and technical matters. This approach allowed for a free exchange of professional opinions, discussion of the conducted UAV inspections, and formulation of conclusions based on the practical experience of the participants.

The focus group methodology was designed to ensure the collection of in-depth, experience-based insights from organisational stakeholders directly involved in safety and security processes. Participants were selected using a purposive sampling

approach, with the organisation delegating individuals representing key functional areas relevant to the research problem. The final group consisted of eight participants, including a health and safety specialist, a security officer, management representatives, and experts from the technical and investment departments, ensuring both functional diversity and domain expertise.

The discussion was moderated by one of the authors, who had prior experience in qualitative research and facilitated the session using a semi-structured approach. A set of guiding questions was developed in advance to ensure consistency and alignment with the research objectives, while still allowing flexibility for participants to elaborate on emerging themes and interact dynamically. The moderator's role was to stimulate discussion, manage group dynamics, and ensure balanced participation among respondents.

The collected data were analysed using thematic analysis, involving iterative coding and categorisation of responses to identify recurring patterns and key themes. The analysis followed a systematic procedure of familiarization, coding, theme development, and refinement, as proposed by Braun and Clarke (2006), enabling the synthesis of individual and collective perspectives into analytically meaningful constructs aligned with the research objectives. The findings from the focus group interview were summarized in a concise report containing the key conclusions and observations expressed by the participants.

Results

The data collected through the UAV inspection were analysed in terms of safety conditions, technical condition, and deviations from the organisation's internal standards. The outcome of the study was a detailed report containing identified nonconformities along with recommended corrective and preventive actions.

The most frequently observed irregularities identified during the inspection were corrosion issues, visible on ventilation chimneys and roof panel surfaces, which lead to structural weakening and an increased risk of failure. Another recurring problem was contamination on skylight surfaces. Limited access to natural daylight may negatively affect the working conditions inside the facility, and can potentially reduce illumination levels below the minimum specified in the PN-EN 12464-1:2012 standard, which defines lighting requirements for workplaces.

Another significant finding concerned workplace organisation and the availability of communication routes. Examples presented in the inspection reports revealed systemic and organisational irregularities related to the use of transport and pedestrian pathways. The blocking of communication routes and improper storage practices generate unnecessary risks.

Regulations also define external areas as an integral part of the enterprise, and the employer's responsibility to maintain order, cleanliness, and proper organisation of transport routes and passages is stipulated in the Regulation of 26 September 1997 on general health and safety provisions.

In view of the identified irregularities, the following corrective measures are recommended:

- Washing and maintenance of roof skylights,
- Regular inspections to prevent further structural degradation and enhance workplace safety,
- Reorganisation of external storage areas,
- Raising employee awareness regarding the obstruction of transport routes and the need for better workplace organisation,
- Inspection and repair of the damaged fence, which currently enables unauthorized access to the premises.

It is also advised to perform periodic checks of the physical security infrastructure and to carry out repairs whenever necessary.

Figure 3 presents examples of the identified irregularities observed during the UAV inspection.

The next step involved internal verification of the results within the organisation to determine the usefulness and applicability of the project. A focus group interview method was employed to collect opinions and discuss the analysed solutions implemented in the studied organisation. The data obtained from the focus group aimed to address the research questions defined for the analysed case study.



Figure 3. Examples of identified irregularities in the area of technical safety and physical security
Source: author's own elaboration

The results of the study are presented in Table 2.

Table 2. Evaluation of the study – comparison of results with the focus group discussion

Question	Answer
Has the organisation previously used UAV technology in any internal processes?	The company has not used drones in its internal processes before. However, it has had experience with outsourced drone services.
Are the research results satisfactory?	The inspection results are satisfactory in terms of assessing the current state of safety. The report provides an excellent basis for planning actions. We were aware of the potential occurrence of some issues; however, addressing them requires significant resources and prioritization. Minor irregularities, such as items left by external companies or damaged fencing, were immediately corrected, confirming the effectiveness of detecting nonconformities during such safety inspections.
How often are external area inspections performed?	External area inspections are carried out every three months or before an audit or a major investment project.
How does the efficiency of the remote inspection performed by UAV compare to the manual one?	Manual inspection is essential and cannot be entirely replaced. However, remote inspections using UAVs can be helpful for visualising problems and quickly providing aerial images of external areas. In summary, UAVs can serve as an effective tool, mainly for specialised tasks or as a supplement to manual inspection. Greater challenges would arise from using drones inside our facilities.
What advantages and disadvantages do you see in implementing UAVs in safety inspection processes?	Advantages include the ability to collect precise data and photographic documentation of areas before implementing various projects. Additional benefits include improved safety and reduced need for work at height, if such tasks can be replaced by UAV use. Disadvantages include the need for manual assessment of most situations. For example, when evaluating roof conditions, there are competitive technologies on the market, such as sensors that monitor structural deflection, which provide more precise data continuously. Additional limitations include legal regulations and the lack of personnel within the organisation holding appropriate licences and operating skills.
In which areas of the company's operations do you see potential applications for UAVs?	This technology may be useful for point and specialised inspections that provide key data, for instance before audits or investment projects. It also performs well in large-area inspections and in checking rooftop installations. We also see potential for using UAVs in the inventory and monitoring of physical security in marshy areas at another company site, where vehicle access is difficult.
What is the company's approach to implementing new UAV-based solutions?	We are open to innovation, and engaging in this collaboration is evidence of that. We are considering the implementation of UAV solutions in some processes, such as inspection and inventory; however, for now, only in cooperation with external service providers.

Question	Answer
Have you noticed any risks or barriers when conducting inspections using UAVs?	Flying drones over people creates risks, and one significant barrier in our case is conducting inspections inside production halls, where confined spaces make such flights risky or impossible. Furthermore, we see technical and organisational barriers to UAV operations. Legal barriers also play a key role, as special permits and licences are required.
What barriers exist to implementing UAVs in internal processes?	At the moment, we have not considered such an option. It would certainly involve implementation costs, staff training, and compliance with legal regulations.

Source: own study

Discussion

The research addressed the problem of insufficient understanding of how Unmanned Aerial Vehicles can be effectively integrated into organisational security systems to improve the efficiency of control and supervision processes while simultaneously reducing operational risk and safety-related costs. The study sought to determine the potential of UAVs to enhance the effectiveness of safety management within organisations, focusing on their application in technical and physical security domains. The findings confirmed the research hypothesis that the integration of UAVs into safety management systems significantly increases the precision and effectiveness of control and supervision activities. The results indicate that UAVs provide measurable benefits in two primary areas: technical safety and physical security.

In the aspect of technical safety, UAVs proved to be particularly effective for infrastructure inspections including roofs, tanks, pipelines, and industrial installations. They allow the early identification of hazards, corrosion, or structural degradation. Their use enhances diagnostic accuracy, minimizes the need for personnel to perform high-risk work at heights, and supports preventive maintenance planning.

In the aspect of physical security, UAVs were found to strengthen monitoring and access control processes by enabling real-time surveillance of external areas, perimeters, and restricted zones. Such applications improve situational awareness and responsiveness to incidents, thereby reducing the likelihood of unauthorized access or operational disruption.

The research also revealed that UAV-based inspections improve the overall efficiency of risk control by expanding the frequency and spatial coverage of monitoring tasks while simultaneously decreasing employee exposure to hazardous conditions. UAVs equipped with high-resolution optical, thermal, or LiDAR sensors facilitate real-time data acquisition and transmission, supporting data-driven decision-making

in safety management. These findings are particularly relevant to high-risk sectors such as energy, transport, and logistics, where inspections are often logistically complex, costly, or potentially dangerous.

However, the study identified several categories of barriers to UAV implementation. Technical barriers include limitations in flight endurance, vulnerability to adverse weather, and challenges in navigation within confined spaces. Legal and regulatory barriers arise from the need to comply with aviation and data protection laws. Organisational barriers relate to the absence of established operational procedures for UAV deployment, while competency barriers stem from insufficiently trained personnel capable of operating UAVs and interpreting inspection data. Despite these challenges, respondents emphasized the growing institutional readiness and openness to UAV adoption, particularly in contexts where risk reduction and efficiency improvements are strategic priorities.

This study is subject to several limitations, primarily related to the use of a single case organisation and qualitative methods, which constrain the possibility of statistical generalization. The case selection, based on organisational willingness to participate, may also introduce self-selection bias. Additionally, the findings are embedded in a specific organisational and regulatory context, which may limit their direct transferability to other settings. Nevertheless, the results enable analytical generalization (Yin, 2018), offering transferable insights into the mechanisms through which UAVs enhance safety management processes in comparable organisational environments.

Conclusions

The study confirms that the application of UAVs in organisational safety management substantially improves the effectiveness and precision of control and supervision processes, thereby validating the proposed research hypothesis. By improving situational awareness and reducing human exposure to hazardous environments, UAVs contribute to both operational efficiency and occupational safety. Their integration facilitates the digital transformation of safety management systems, enabling organisations to transition from reactive to proactive risk control.

Although UAVs cannot fully replace traditional inspection methods, they function as a powerful complementary tool that strengthens organisational resilience and adaptive capacity. Effective implementation requires a structured approach encompassing regulatory compliance, personnel training, technical standardization, and integration with existing safety management frameworks.

The findings highlight the strategic value of UAV technology within the broader evolution toward intelligent and resilient security systems. The use of UAVs represents not only a technological advancement but also a cultural and organisational

shift toward safety innovation. With proper regulatory and operational frameworks, UAV deployment can deliver measurable benefits in terms of reduced operational risk, optimized safety-related costs, and enhanced organisational resilience in the face of emerging threats.

References

- Balestrieri, E., Daponte, P., De Vito, L. and Lamonaca, F., 2021. Sensors and measurements for unmanned systems: An overview, *Sensors*, 21(4), 8253, DOI: <https://doi.org/10.3390/s21248253>.
- Braun, V., and Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. DOI: <https://doi.org/10.1191/1478088706qp063oa>.
- Choi, H.W., Kim, H.J., Kim, S.K. and Na, W.S., 2023. An overview of drone applications in the construction industry, *Drones*, 7, 515, DOI: <https://doi.org/10.3390/drones7080515>.
- Czakon W. (ed.), 2015. *Podstawy metodologii badań w naukach o zarządzaniu*. Warszawa: Oficyna Wolters Kluwer Business.
- Czupryński, A., Wiśniewski, B. and Zboina, J., 2017. *Nauki o bezpieczeństwie: wybrane problemy badań*, Józef Tuliszkowski Fire Protection Scientific and Research Centre – National Research Institute.
- Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection. Available from: <https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX:32008L0114> [Accessed: 9 October 2026].
- Ewertowski, T. and Ludwiczak, D., 2025. Strategic analysis of implementing UAVs in organisational safety processes. *ZN SGSP*, vol. 2, no. 96, 123–149. DOI: <https://doi.org/10.5604/01.3001.0055.5460>.
- Falorca, J.F., Miraldes, J.P. and Lanzinha, J.C.G., 2021. New trends in visual inspection of buildings and structures: Study for the use of drones, *Open Engineering*, 11(1), 734–743. DOI: <https://doi.org/10.1515/eng-2021-0071>.
- Ignac-Nowicka, J., 2010. *Rozwój technicznych środków zabezpieczeń w obrębie systemów monitoringu wizyjnego miejsc publicznych*. In: Fehler, W. (ed.) *Bezpieczeństwo publiczne w przestrzeni miejskiej*, Biała Podlaska.
- Ilczuk, D., 2020. Kapitał ludzki jako przewaga konkurencyjna przedsiębiorstwa w usługach bankowości detalicznej, *Zeszyty Studenckie Wydziału Ekonomicznego „Nasze Studia”*, (10), 34–41.
- Jagusiak, B., 2018. The Inclusion Processes in the Extent of Welfare Security. *Przeгляд Strategiczny*, 11, 315–328. DOI: <https://doi.org/10.14746/ps.2018.1.22>.

- Kisilowski, M., Skomra, W., Smagowicz, J., Wiśniewski, M. and Szwarc, K., 2021. *Zarządzanie bezpieczeństwem infrastruktury krytycznej i ciągłości usług kluczowych państwa*, Warszawa: Oficyna Wydawnicza Politechniki Warszawskiej.
- Korzeniowski, L.F., 2012. *Podstawy nauk o bezpieczeństwie*, Warszawa: Difin.
- Liang, H., Lee, S.C., Bae, W., Kim, J. and Seo, S., 2023. Towards UAVs in construction: Advancements, challenges, and future directions for monitoring and inspection, *Drones*, 7(3), 202. DOI: <https://doi.org/10.3390/drones7030202>.
- Łukasiewicz, G. and Niemczyk, P., 2022. Drony w służbie bezpieczeństwa, *Dozór Techniczny*, (4), 11–16.
- Mohsan, S.A.H., Zahra, Q.U.A., Khan, M.A., Alsharif, M.H., Elhaty, I.A. and Jahid, A., 2022. Role of drone technology helping in alleviating the COVID-19 pandemic, *Micromachines*, 13, 1593, DOI: <https://doi.org/10.3390/mi13101593>.
- Morgan, D.L., 1997. *Focus Groups as Qualitative Research*. 2nd Edition, Sage Publications, Thousand Oaks. DOI: <https://doi.org/10.4135/9781412984287>.
- Narodowy Program Ochrony Infrastruktury Krytycznej (2023) Tekst jednolity. Available from: <https://www.gov.pl/web/rcb/narodowy-program-ochrony-infrastruktury-krytycznej> [Accessed: 9 October 2026].
- Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft (Text with EEA relevance.) (OJ L 152, 11.6.2019, 45–710). Available from: <https://eur-lex.europa.eu/legal-content/PL/ALL/?uri=CELEX:32019R0947> [Accessed: 9 October 2026].
- Savković, M., Dasic, M., Djapan, M., Vukicevic, A., Macuzic, I. and Stefanovic, M., 2021. *Improving workplace safety using advanced industry 4.0 technologies*, Conference Paper: XI International Conference Industrial Engineering and Environmental Protection 2021 (IIZS 2021) October 07-08, 2021, Zrenjanin, Serbia, 545–552. <https://scidar.kg.ac.rs/bitstream/123456789/18502/1/IIZS2021Proceedings.pdf>, [Accessed: 9 October 2026].
- Skomra, W. (ed.), 2015. *Metodyka oceny ryzyka na potrzeby zarządzania kryzysowego*, Warszawa: Belstudio.
- Szymonik, A., 2023. Determinants of Warehouse Safety – Theory and Practice, *Military Logistics Systems*, 59(2), 37–54. DOI: 10.37055/slsw/186389.
- Ścibiorek, Z. and Borucka, A., 2022. Information in the decision-making process, *Military Logistics Systems*, 56(1), 147–160. DOI: <https://doi.org/10.37055/slsw/155072>.
- Ustawa – Prawo lotnicze (Dz.U. z 2023 r. poz. 2110 art. 126) z dnia 4 września 2023 r. Available from: <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20230002110> [Accessed: 9 October 2026].
- Ustawa z dnia 26 kwietnia 2007 r. o zarządzaniu kryzysowym (Dz.U. z 2023 r. poz. 122). Available from: <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20230000122> [Accessed: 9 October 2026].

- Yin, R. K., 2018. *Case Study Research and Applications: Design and Methods* (6th ed.). Thousand Oaks, CA: Sage.
- Zaskórski, P. and Miszański, W., 2021. Logistic business continuity in terms of information efficiency, *Military Logistics Systems*, 55(2), 173–192. DOI: <https://doi.org/10.37055/slw/145860>.

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