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Possibilities for the Implementation of 3D Protocols in the Activities of the Military Law Enforcement Service of the Armed Forces of Ukraine: International Experience and Strategies for National Security under Wartime Conditions

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Abstract. The article is devoted to the development of recommendations on the use of 3D protocols in the activities of the Military Law Enforcement Service in the Armed Forces of Ukraine, taking into account international and Ukrainian experience. The relevance of the research is determined by the need to increase the efficiency of the performance of the main service tasks, including the documentation of criminal and other offences, crime prevention, protection of military facilities, ensuring personnel security, maintenance of discipline and guaranteeing the judicial admissibility of digital evidence at the national and international levels. The aim of the article is the development of a model for the integration of 3D protocols that takes into account the technical, organisational and regulatory features of Ukrainian conditions and contributes to the effective fulfilment of the lawful tasks of the service. A comprehensive approach was applied for the research, providing for the analysis of international experience, the practice of the use of digital technologies in the activities of law enforcement agencies of Ukraine and open sources of recent years. The methodological basis of the research consists in the combination of interdisciplinary approaches integrating the provisions of international law, criminalistics and modern digital technologies. For the comparison of national and international standards in the field of digital forensics, the comparative-legal method was applied, while the systemic approach made it possible to reveal the interrelations between technical and legal aspects. The analysis of regulatory legal acts, protocols and recommendations was carried out by means of the document study method, while content analysis and elements of critical analysis were used to generalise scientific and practical approaches. Technical aspects of photogrammetry and laser scanning were examined, which make it possible to create 3D models of incident scenes with high accuracy within a short time, reducing the duration of investigations and lowering risks for personnel in hazardous areas. The main results include the development of recommendations on the standardisation of digital evidence, optimisation of equipment procurement, training of specialists and the conduct of pilot projects with the assessment of their effectiveness. The practical significance of the work consists in the creation of an implementation model that provides for the integration of artificial intelligence and augmented reality for the automation of data analysis and training, increasing the efficiency of the performance of service tasks and personnel security. The proposed model ensures a comprehensive approach to the admissibility of digital evidence, combining technical solutions, personnel training and legal legitimacy with international recognitio.

Keywords: Military Law Enforcement Service of the Armed Forces of Ukraine, digital evidence, photogrammetry, laser scanning, augmented reality, digital forensics.

Introduction

The war of russia against Ukraine, which has continued since 2014 and escalated with the full-scale invasion in 2022, has revealed significant gaps in crime and emergency incident documentation systems for law enforcement agencies. Traditional recording methods, such as photography and written protocols, are often ineffective in combat zones due to high risks for personnel, limited access to incident sites and the loss of important details [1].

Modern digital technologies, in particular 3D recording protocols that create 3D models of

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incident scenes on the basis of photogrammetry and LiDAR scanning, offer a more accurate alternative. They make it possible to reproduce scenes with high geometric and textural accuracy, increasing the reliability of digital evidence and personnel security [2]. International experience demonstrates the effectiveness of such technologies in countries with developed security systems, in particular in the United States, the United Kingdom, Israel and Australia, where they are used for documenting crimes, accidents and war crimes, as well as for the training of law enforcement personnel [3].

In Ukraine, the use of 3D protocols remains limited due to the lack of a regulatory framework, insufficient technical equipment and the absence of trained specialists [4]. At the same time, the experience of using digital models during the documentation of shelling of civilian facilities, disasters and accidents [5] demonstrates the expediency of their integration into the activities of the Military Law Enforcement Service of the Armed Forces of Ukraine (hereinafter – the Law Enforcement Service) in order to increase the accuracy of evidence and personnel security [6].

Particular complexity is posed by the adaptation of technologies to Ukrainian conditions, where budgetary constraints and the shortage of personnel slow down the introduction of new methods. Areas of active hostilities, such as Donetsk, Kherson and Zaporizhzhia regions, complicate traditional recording procedures, increasing risks for staff [7]. Pilot projects involving the use of three-dimensional protocols will make it possible to test technologies in frontline conditions, assess their strengths and weaknesses, and provide practical training for new specialists [8, 9].

Thus, the scientific novelty of the research consists in a comprehensive study of the possibilities for integrating three-dimensional protocols into the activities of the Law Enforcement Service of Ukraine, taking into account international experience and the conditions of the armed conflict. The relevance is determined by the urgent need for rapid, safe and judicially admissible recording of war crimes and other offences.

The **aim of the research** is the development of a model for the integration of three-dimensional protocols for incident scene recording into the activities of the Law Enforcement Service, taking into account international and national experience, which ensures effective documentation of war crimes, other offences and incidents, increases the speed and safety of investigations, and guarantees the judicial admissibility of digital evidenc.

The research tasks provide for:

analysis of international experience in the use of three-dimensional protocols in the activities of civilian and military law enforcement agencies (the United States, the United Kingdom, Israel, Australia, Germany, Canada) and identification of best practices for adaptation in Ukraine;

study of the technical principles of photogrammetry and LiDAR scanning, assessment of their suitability for rapid and safe creation of digital models of incident scenes in field and combat conditions;

assessment of the regulatory framework and procedural requirements for digital evidence in Ukraine, ensuring their compliance with international forensic standards (ISO 17025, NIST OSAC);

development of recommendations on organisational integration of three-dimensional protocols into the work of the Military Law Enforcement Service of the Armed Forces of Ukraine, including personnel training, preparation of working groups and implementation of pilot projects;

determination of optimal technical solutions for Ukrainian conditions (photogrammetry based on unmanned aerial complexes (UAC) for daytime operations, LiDAR scanning for night-time and complex conditions);

ensuring a comprehensive approach to the implementation of digital evidence that combines technical, organisational and legal aspects, as well as cooperation with international partners for increasing the effectiveness and legitimacy of the evidentiary base.

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Literature Review

The analysis of scientific sources indicates growing attention to the use of three-dimensional technologies in criminalistics and law enforcement activities. The reviewed publications emphasise the effectiveness of photogrammetry, laser scanning and drones for the creation of accurate digital models that increase the quality and speed of investigations and ensure the legal admissibility of evidence. International studies note the successful integration of such technologies into security systems and the use of artificial intelligence and augmented reality for data analysis and the training of specialists. In countries with limited resources and in conflict conditions, sources emphasise the problems of standardisation, personnel training and the legal legitimacy of digital evidence. In general, scientific publications confirm the prospects of three-dimensional technologies for increasing the effectiveness of law enforcement activities and substantiate the need to adapt these solutions to Ukrainian realities [1, 9].

Methodological Framework

The methodological framework of the research is formed by the combination of interdisciplinary approaches covering international law, criminalistics and digital technologies. The comparative-legal method was used for the analysis of national and international standards in the field of digital forensics, the systemic approach was applied to identify interrelations between legal and technical aspects, and the document analysis method (regulatory legal acts, protocols and guidelines) was also used. Content analysis and elements of critical analysis were applied for the generalisation of scientific and practical approaches. Such a combination of methods ensures the objectivity, depth and practical significance of the obtained results.

Results

3D recording protocols are a method of documenting incident scenes by creating three-dimensional models on the basis of processing images obtained by high-resolution cameras or LiDAR (Light Detection and Ranging) sensors [10]. The technology covers photogrammetry, which reconstructs scenes through the analysis of two-dimensional images from different angles, and laser scanning, which forms point clouds for highly accurate geometric reconstruction. Orthophotoplans, as geometrically corrected aerial photographs, and panoramic images provide comprehensive reproduction of the incident scene with accuracy up to 1 cm [21].

Law enforcement agencies use these methods for the recording of crimes, accidents and war crimes, the creation of virtual reconstructions for forensic examination, and the increase of the speed of investigations and training. This applies both to national police bodies and to the Military Law Enforcement Service of the Armed Forces of Ukraine in relation to war crimes and breaches of military discipline.

It should be noted that, under the Criminal Code of Ukraine (Section XIX), military offences are crimes against the order of service committed by servicemen. The object is the order of service, the subject is military personnel. The Section contains nine groups of crimes (Articles 402–433), and these and other offences may be recorded by the Law Enforcement Service in order to subsequently transfer them for investigation to the appropriate pre-trial investigation body.

Digital evidence is a key component of digital forensics, which combines technical and legal instruments for documenting, preserving and analysing information that is relevant to investigations [14]. In this context, 3D protocols are a modern means of recording and reproducing the incident scene.

In Ukraine, digital evidence obtained by means of 3D protocols and other methods of digital forensics is already recognised as admissible in judicial practice [12]. The use of three-dimensional models, orthophotoplans and point clouds makes it possible to reproduce the incident scene with high accuracy, which ensures the reliability and integrity of evidence [15]. Judicial authorities recognise

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such materials as proper and admissible for the assessment of the circumstances of crimes, accidents or breaches of military discipline. This confirms the effectiveness of 3D protocols for documenting military and civilian offences [4], while simultaneously increasing the speed and safety of investigations. Thus, the use of digital evidence in the activities of the Military Law Enforcement Service of the Armed Forces of Ukraine complies with the requirements of national legislation and international forensic standards.

Technical principles. Photogrammetry [16] uses structure-from-motion (SfM) algorithms [17], which combine a series of images into a 3D model through the identification of common points. LiDAR measures distances by means of laser pulses, creating point clouds with an error of 0.012–0.032 m depending on lighting conditions [18]. In 2025, a study was conducted that assessed the accuracy of the LiDAR sensor in the iPhone 15 Pro Max, achieving 0.012 m when used in combination with RTK equipment such as the viDoc RTK Rover. This indicates the potential of mobile devices for high-precision measurements in field conditions [19]. Photogrammetry, although effective for textural detailing, has limitations under low-light conditions. In particular, the calibration of non-metric cameras is sensitive to poor lighting, which leads to an increase in determination errors [20]. According to information published on manufacturers' websites, unmanned aerial vehicles such as the DJI Mavic Pro are equipped with cameras with a resolution of up to 1 cm per pixel, which makes it possible to create models within 5–10 minutes. However, in order to achieve such accuracy, optimal survey conditions must be ensured, including flight altitude and image overlap.

Software such as Pix4Dmapper and FARO Zone 3D effectively processes data for the creation of digital twins and for the analysis of bullet trajectories or bloodstain patterns. For example, research demonstrates that solutions from Pix4D constitute a reliable alternative for the rapid and accurate documentation of incident scenes, even in complex conditions.

Thus, the integration of mobile LiDAR sensors, unmanned aerial systems and specialised software opens new opportunities for accurate and effective documentation of incidents in law enforcement activities [11].

Hardware and software tools may also be used for 3D modelling, including Microdrones equipped with LiDAR, DJI Mavic for photogrammetry, Leica Cyclone and RealityCapture. They simplify the documentation process.

Requirements for digital evidence. According to Article 100 of the Civil Procedure Code of Ukraine, electronic evidence is digital data on the circumstances of a case, including metadata. 3D models meet these requirements. The requirements for digital evidence include reliability without distortion, integrity against alteration, identifiability of the source, completeness and reproducibility. In accordance with the requirements of Article 85 of the Criminal Procedure Code of Ukraine, admissible evidence is evidence that directly or indirectly confirms the existence or absence of circumstances to be proved in criminal proceedings and other circumstances that are relevant to criminal proceedings, as well as the reliability or unreliability and the possibility or impossibility of using other evidence.

According to the requirements of Article 86 of the Criminal Procedure Code of Ukraine, evidence is recognised as admissible if it has been obtained in the manner established by this Code. Inadmissible evidence may not be used when making procedural decisions, and the court may not refer to it when adopting a judicial decision. This ensures the legal weight of evidence.

Digital evidence obtained through 3D protocols must comply with forensic standards, in particular ISO 17025 and NIST OSAC. The main criteria include reliability (representation of the scene without distortion), integrity (protection against alteration through version control), identifiability of the source (recording of equipment, operator and time), completeness (coverage of all elements of the scene) and reproducibility (possibility of recreating the model). NIST emphasises the standardisation of formats (.las for point clouds) and data backup for judicial admissibility. The Berkeley Protocol highlights the verification of open sources for international courts, which is

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relevant for the documentation of crimes in Ukraine.

Procedural requirements. Recording in accordance with unified protocols, maintenance of action logs containing information on operators and survey conditions, and clear rules of access are necessary for ensuring the admissibility of 3D evidence in legal relations [22], increasing the effectiveness of investigations and guaranteeing personnel security. Hardware and software complexes are used for capturing, processing and visualising data for the creation of 3D models; after appropriate training, they are integrated into operational units for the rapid documentation of incident scenes.

The combination of LiDAR scanning and photogrammetry reduces risks in hazardous areas: drones equipped with LiDAR are capable of operating under low-light conditions, while augmented and virtual reality interfaces enable the remote analysis of scenes. The integration of artificial intelligence automates preliminary processing and object identification, accelerating reconstruction and reducing the workload on experts. Hybrid solutions optimise the ratio between cost and accuracy, which is important for deployment in Ukraine. Modern 3D protocols provide for the use of aerial imagery, orthophotoplans and panoramic images in combination with unmanned aerial complexes (UAC) [21] for comprehensive reproduction of the incident scene and subsequent judicial analysis. The trend towards the transition to mobile platforms and cost-effective models (for example, solutions based on Skydio) strengthens the possibilities for operational application in field conditions, while international standards and training programmes increase the level of integration of these technologies into law enforcement activities.

The United States of America. Law enforcement agencies of the United States include federal agencies (for example, the Department of Homeland Security – DHS), local police bodies (police departments) and the military police of the Armed Forces of the United States. US law enforcement personnel use hardware and software complexes from various manufacturers, mainly for the purposes of 3D modelling of accident scenes, crime scenes and search-and-rescue operations. The most widespread among police bodies are FARO tripod scanners and drones produced by Skydio. Examples of use include the San Francisco Police, which uses photographic recording by means of drones for the reconstruction of crime scenes, thereby accelerating investigation timeframes. In Douglas County (Nevada), photographic recording by means of drones is used for organising the оперативне documentation of road traffic accidents, significantly reducing the time spent at the incident scene. The US military police apply similar technologies for documenting offences on military bases [24].

The United Kingdom. Law enforcement agencies of the United Kingdom, in particular Scotland Yard and the National Police, actively use 3D modelling for the documentation of crime scenes and accident scenes. Among the key technologies, Pix4Dmapper software is used, which makes it possible to create highly accurate 3D models of incidents, ensuring the reliability of evidence and the effectiveness of investigations. Drones are widely used for the rapid photographic recording of incident scenes, which significantly reduces the time spent at the scene and increases the оперативність of data collection. For example, in 2023 the London police used drones for the photographic recording of the site of mass unrest, which made it possible to accurately reconstruct events for court proceedings and reduced the time required for forensic examination by 40% [25].

The military police of the Royal Armed Forces use high-precision Leica RTC360 3D scanners for documenting incident scenes on military bases, which makes it possible to effectively record crimes and accidents. The working conditions of the military police are often associated with high risk; therefore, rapid and accurate documentation of incident scenes is critical for subsequent investigation [26].

The use of 3D modelling in British law enforcement agencies increases operational effectiveness, reduces the time required for documenting incident scenes and ensures a comprehensive approach to evidence collection through the integration of drones, laser scanners and

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specialised software. At the same time, the military police adapt these technologies to the specific conditions of military bases, which makes it possible to maintain high accuracy and reliability of investigations even in complex and hazardous situations.

Israel. Law enforcement agencies of Israel, in particular the Tel Aviv Police and the military police of the Israel Defense Forces, actively integrate unmanned aerial vehicles (UAV) with artificial intelligence technologies and hardware and software complexes for the 3D recording of incidents in high-risk areas, including war crimes, which makes it possible to promptly document attack sites and increase the effectiveness of investigations and the accuracy of evidence [27]. The military police use UAV for creating 3D models of incident scenes during operations in high-risk areas, for example during operations in the Gaza Strip in 2024, which facilitated the rapid collection of evidence. The Tel Aviv Police use 3D modelling for documenting accidents and other urban incidents, which makes it possible to create accurate models for analysis and investigation; in particular, in 2020 a 3D model of the city was created. In addition, Israeli law enforcement agencies cooperate with international partners, for example in 2019 with the United States Department of Homeland Security for the implementation of 3D visualisation tools in criminal investigations [28]. Such integration of UAV technologies, artificial intelligence and 3D documentation enables Israeli law enforcement personnel to effectively record incidents in high-risk conditions, increasing the оперативність and accuracy of investigations, and may constitute useful experience for other countries.

Australia. Law enforcement agencies of Australia, in particular the Federal Police and the military police of the armed forces, actively use hardware and software complexes based on unmanned aerial vehicles (UAV) for 3D modelling of incidents in remote and hard-to-reach areas, such as the bush. This makes it possible to effectively document fire sites, road traffic accidents and crimes, increasing the accuracy of the evidentiary base and the оперативність of investigations. In particular, in 2022–2024 the New South Wales Police used this technology for the investigation of incidents, which contributed to increasing operational effectiveness. The military police of the Australian Armed Forces also integrate these technologies into training exercises, which demonstrates the versatility of the technology in civilian and military scenarios [29].

Germany. In Germany, the Federal Police (Bundespolizei) and the military police of the Bundeswehr use unmanned aerial vehicles and hardware and software complexes for 3D modelling in counter-terrorism operations and the documentation of accidents: in 2024 the Berlin police used these technologies for the reconstruction of the site of a terrorist attack, which accelerated the identification of suspects, while the military police used them for monitoring violations at training ranges; amendments to the Military Security Strengthening Act adopted in 2025 granted additional powers for the use of UAV, demonstrating Germany's intention to introduce innovative technologies in the field of security and defence [30].

Canada. In Canada, the police, in particular the Royal Canadian Mounted Police, use unmanned aerial vehicles for photographic and video recording of road traffic accident scenes: in the Province of Ontario a combination of heavy Matrice 300 RTK drones and smaller Autel Robotics EVO drones is used, the data from which are processed by specialised software for creating 3D models of incident scenes; the use of such technologies has become an industry standard in the practice of law enforcement agencies in developed countries [31].

russian federation. It should be taken into account that information on russian technologies may be unreliable due to the limited openness of sources and the authoritarian nature of governance in the rf. The hardware and software complex "Filin", first publicly presented in 2024, is intended for creating 3D models of crime scenes and for use by military police in combat zones. Its application includes remote assessment of the situation by means of AR (Augmented Reality) and VR (Virtual Reality) technologies; involvement of remote experts in analysis; use as training material for investigative officers; and minimisation of the influence of the "human factor" during the recording of evidence, which increases the accuracy and objectivity of incident scene documentation.

In Ukraine, there is already experience in the use of photogrammetry and laser 3D scanning of

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incident scenes. The leading institution in the development and application of 3D modelling of incident (crime) scenes is the Kharkiv Scientific Research Forensic Centre of the Ministry of Internal Affairs of Ukraine. Among the most well-known cases is the investigation of the crash of the An-26 military aircraft in Kharkiv region on 25 September 2020; this case became the first public example of the use of 3D modelling in large-scale criminal proceedings in Ukraine.

Since the beginning of the full-scale aggression of the russian federation against Ukraine, Ukrainian law enforcement agencies have initiated investigations into more than 104 thousand war crimes (violations of the laws and customs of war established by international humanitarian law) committed by representatives of the armed forces and the occupation authorities of the rf on the territory of Ukraine.

Through the combination of 3D modelling and OSINT technologies, Ukrainian law enforcement personnel have succeeded in determining the directions of fire and identifying commanders involved in organising these attacks, which were intended to cause an environmental catastrophe in Kharkiv region.

In addition, on the basis of crime scene examinations, the study of craters formed by the impact of submunitions, their angles of fall and the ellipse of their distribution, taking into account the tactical and technical characteristics of the weapons used, investigators and prosecutors, through the use of 3D modelling of the incident, determined the probable area of the launch position of the missile system from which the missile strike had been carried out. A calculation of the possible location of the deployment of a unit of the armed forces of the rf that could have conducted the shelling was made, and as a result of the search carried out in the indicated area, relevant evidence of the crime was found and seized.

The use of high-resolution cameras for recording incident scenes is a fairly widespread practice in the State Emergency Service, the police and scientific centres; however, a standardised methodology and a unified database have not yet been created.

Digital forensics within the Ministry of Internal Affairs: projects are being developed on the use of virtual reconstruction of incident scenes (VR/AR), but no information on systematic implementation has yet been reported; this indicates the existence of isolated innovations without a nationwide strategy.

In July 2023, with the support of the United States Agency for International Development (USAID), the American manufacturing company Skydio transferred nine artificial intelligence-enabled drones for the needs of units of the Office of the Prosecutor General of Ukraine that are engaged in the investigation of crimes under the conditions of armed conflict in frontline regions; this became one of the first examples of international technical assistance in the field of digital forensics.

With the use of these drones equipped with modern software, prosecutors are able to conduct crime scene examinations and create 3D models of objects and territories damaged by russian military forces, which significantly reduces risks for personnel and makes it possible to operate in hazardous conditions.

For the systematisation of the proposed measures and the comparison of technical solutions, with a focus on technical solutions, increasing effectiveness and adaptation to wartime conditions, the tables below summarise strategies for the integration of 3D protocols into the activities of the Military Law Enforcement Service of the Armed Forces of Ukraine and compare the capabilities of photogrammetry and LiDAR scanning for ensuring rapid, safe and judicially recognised recording under wartime conditions.

The data presented in Tables 1–2 confirm that photogrammetry based on unmanned aerial complexes (UAC) constitutes an optimal solution for Ukraine due to its low cost and speed. LiDAR is advisable for night-time operations but is limited by budgetary constraints. Compliance with ISO 17025 requirements and training through NATO and EUAM will ensure judicial admissibility. Pilot projects to be implemented by 2026 will make it possible to assess the effectiveness of the technologies without significant financial expenditure, will not require the establishment of new units

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and will allow the practical examination of advantages and potential difficulties in their application.

Table 1. Measures for the integration of 3D protocols into the national security system of Ukraine

Direction	Measures	Відповідальна структура	Implementation deadline	Expected results
Regulatory	Development of digital evidence standards (ISO 17025, NIST OSAC)	Ministry of Internal Affairs of Ukraine, interagency working group	2026	Judicial admissibility in the courts of Ukraine and in the International Criminal Court
Technical	Procurement of unmanned aerial complexes (DJI Mavic, Skydio) and hybrid LiDAR systems (Joli-DAR-1500)	Ministry of Internal Affairs of Ukraine, Military Law Enforcement Service of the Armed Forces of Ukraine, State Emergency Service of Ukraine	2026–2027	Recording incidents within 10 minutes with high accuracy; night-time scanning
Organisational	Training courses for 50–100 specialists	Military Law Enforcement Service of the Armed Forces of Ukraine, European Union Advisory Mission (EUAM), North Atlantic Treaty Organization (NATO)	2026–2027	Trained personnel for work with unmanned aerial complexes and software
International	Cooperation with EUAM, NATO, UNDP	Ministry of Foreign Affairs of Ukraine, Ministry of Internal Affairs of Ukraine, Armed Forces of Ukraine	2025–2027	Funding and standardisation for the International Criminal Court
Pilot	Pilot project within the Military Law Enforcement Service of the Armed Forces of Ukraine	Armed Forces of Ukraine, State Scientific Research Forensic Centre of the Ministry of Internal Affairs of Ukraine	2026–2027	Assessment of effectiveness (70% increase in accuracy)

Table 2. Comparison of 3D documentation technologies for Ukrainian conditions

Parameter	Photogrammetry (unmanned aerial complexes)	LiDAR (hybrid systems)
Cost	2–20 thousand US dollars	50–350 thousand US dollars
Accuracy	1–2 cm (daylight conditions)	2 cm (night-time conditions)
Processing time	5–10 minutes	10–15 minutes
Equipment	DJI Mavic, Skydio	Joli-DAR-1500, Zenmuse L1
Software	Pix4Dmapper, RealityCapture	Leica Cyclone, Faro Zone 3D
Conditions	Daylight	Night-time, complex conditions
Suitability for war	High (cost-effectiveness, speed)	Limited (high accuracy, higher cost)

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At the same time, it is proposed to:

1. Establish a working group composed of representatives of the interested units of the Military Law Enforcement Service of the Armed Forces of Ukraine, with the involvement (if necessary) of representatives of higher military educational institutions of the system of the Ministry of Defence of Ukraine and other interested persons, with the aim of studying the experience of the use of digital documentation technologies both in Ukraine (police, prosecutor's office, the State Emergency Service, etc.) and in the military police of partner countries, as well as intelligence and open-source data on the use of technologies by the adversary; such a working group should include both military and civilian experts (with their consent), and its tasks will includ:

study of the possibility of integrating into the activities of the Law Enforcement Service a hardware and software complex for 3D modelling of incidents into standard protocols for recording war crimes, other offences and incidents, with an emphasis on personnel training;

holding consultations and working meetings with educational institutions that train specialists for the Law Enforcement Service in order to determine the possibility of introducing elements of training in working with digital (electronic) evidence into the educational process.

2. Develop a regulatory framework for the use of the technology, harmonised with international standards (for example, ISO standards for forensic examination) (for example, digital evidence standards ISO/IEC 27037, as well as standards of the European Network of Forensic Science Institutes – ENFSI), taking into account the experience of implementation within the Ministry of Internal Affairs, the prosecutor's office and other bodies; this will contribute to the unification of practice and ensure the recognition of evidence by international courts.

3. Study judicial precedents in civil and criminal proceedings, and initiate the introduction of the use of digital (electronic) evidence in inspections and investigations involving specialists of the Law Enforcement Service.

4. Organise cooperation with international partners (the military police community) for the exchange of experience, in particular with NATO programmes on digital forensics.

5. Ensure the technical equipping of the Law Enforcement Service with hardware and software complexes for incident scene documentation and conduct personnel training; such training should include both technical and legal aspects of the use of digital evidence.

6. Develop pilot projects within the Law Enforcement Service for recording violations, in particular in areas where intensive hostilities are ongoing or have recently taken place, with subsequent assessment of effectiveness. Within 3–6 months, this will make it possible to adapt the technology to wartime realities and assess its suitability in field conditions.

Discussion

The results of the research demonstrate the high potential of the use of 3D protocols in the activities of the Military Law Enforcement Service of the Armed Forces of Ukraine; however, their implementation is accompanied by a number of difficulties.

Firstly, technical and organisational constraints, such as limited access to combat zones, a shortage of high-precision equipment and insufficient personnel training, remain key barriers. These challenges are confirmed by data from international and Ukrainian sources, where similar problems were identified during the use of digital technologies in law enforcement activities and under wartime conditions.

Secondly, the comparative analysis shows that countries with developed security systems, such as the United States, the United Kingdom and Israel, successfully integrate 3D technologies for the rapid and accurate documentation of incident scenes. In Ukraine, however, adaptation of these solutions to wartime conditions is required, where the priority is the safe and prompt creation of an evidentiary base. At the same time, ISO 17025 standards and laboratory accreditation do not always take into account the specific nature of combat operations.

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The third aspect of the discussion concerns the integration of artificial intelligence and augmented reality. International experience demonstrates the effectiveness of these technologies in the automation of analysis and training; however, in Ukraine their implementation requires a phased approach, including pilot projects and the training of specialists. In addition, issues arise regarding the admissibility of digital evidence in court proceedings, which requires legal standardisation and compliance with international norms.

Thus, it is necessary to achieve a balance between the technological potential of 3D protocols and the practical constraints of Ukrainian conditions, as well as the integration of international experience in order to increase the effectiveness and legitimacy of the evidentiary base under wartime conditions.

Conclusion and Recommendations

3D protocols constitute an instrument for the protection of truth under wartime conditions. 3D recording protocols, which combine photogrammetry and LiDAR scanning, significantly increase the accuracy and speed of investigations, making it possible to create three-dimensional models of incident scenes with an error of up to 1 cm within 5–10 minutes. The international experience of the United States, the United Kingdom, Israel, Australia and Germany demonstrates that these technologies reduce the time required for forensic examinations by 40–70% and lower risks for personnel in hazardous areas, which is critical for Ukraine under wartime conditions. For example, the use of drones for the remote documentation of war crimes, such as shelling of civilian infrastructure, complies with the standards of the International Criminal Court, ensuring the judicial admissibility of evidence. In Ukraine, where physical access to incident scenes is often limited due to hostilities, such technologies are indispensable for the Military Law Enforcement Service of the Armed Forces of Ukraine.

The main obstacle remains the adaptation of technologies to Ukrainian realities. Budgetary constraints make photogrammetry based on available unmanned aerial complexes (DJI Mavic, Skydio) an economically justified alternative to expensive LiDAR systems. However, the absence of a regulatory framework that complies with ISO 17025 and NIST OSAC limits the legal force of digital evidence. Pilot projects proposed for the Law Enforcement Service may become the basis for testing technologies in frontline areas.

The prospects for the development of 3D protocols in Ukraine are associated with the integration of artificial intelligence (AI) and augmented reality (AR). The experience of Israel shows that AI algorithms automate the analysis of 3D data, increasing the accuracy of object identification, such as fragments of weapons. In 2025, Axon forecasts the use of AI for training simulations, which may be adapted for the preparation of relevant specialists of the Law Enforcement Service. AR interfaces, similar to the russian complex “Filin”, make it possible to examine scenes remotely, reducing dependence on physical presence. These technologies, supported by initiatives such as EUAM and NATO programmes, may be implemented in Ukraine by 2027 with the support of international partners.

International cooperation is decisive for technology transfer and training. Programmes of the NATO Military Police Centre of Excellence offer training in 3D documentation that Ukraine may adapt for the Military Law Enforcement Service of the Armed Forces of Ukraine. UNDP grants aimed at digital forensics may finance the procurement of equipment and the training of 50–100 specialists. Cooperation with the International Criminal Court will contribute to the standardisation of evidence for international investigations of war crimes, which constitutes a strategic priority for Ukraine. Further research should focus on the economic efficiency of hybrid systems and the development of national standards for forensic examination.

In summary, it should be noted that 3D protocols constitute a promising instrument for strengthening the national security of Ukraine, especially under wartime conditions. Their

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implementation requires coordinated efforts in the development of a regulatory framework, technical equipping, training and international cooperation. The implementation of pilot projects in 2026–2027 will make it possible to assess their effectiveness and to form a strategy for scaling up for the Military Law Enforcement Service and other law enforcement agencies.

Conflict of Interest

The authors declare that they have no competing interests related to the subject of the article.

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Можливості впровадження 3D-протоколів у діяльність Військової служби правопорядку у Збройних Силах України: міжнародний досвід і стратегії для національної безпеки в умовах війни

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Анотація. Статтю присвячено розробленню рекомендацій щодо використання тривимірних протоколів у діяльності Військової служби правопорядку у Збройних Силах України з урахуванням міжнародного та українського досвіду. Актуальність дослідження

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обумовлена потребою підвищення ефективності виконання основних завдань служби, серед яких документування кримінальних та інших правопорушень, запобігання злочинам, охорона військових об'єктів, забезпечення безпеки персоналу, дотримання дисципліни та гарантування судової прийнятності цифрових доказів на національному та міжнародному рівнях. Ціллю статті є розроблення моделі інтеграції тривимірних протоколів, що враховує технічні, організаційні та нормативні особливості українських умов та сприяє ефективному виконанню законних завдань служби. Для дослідження застосовано комплексний підхід, що передбачає аналіз міжнародного досвіду, практики застосування цифрових технологій у діяльності правоохоронних органів України та відкритих джерел останніх років. Методологічну базу дослідження складає поєднання міждисциплінарних підходів, що інтегрують положення міжнародного права, криміналістики та сучасних цифрових технологій. Для зіставлення національних і міжнародних стандартів у галузі цифрової форензики застосовано порівняльно-правовий метод, а системний підхід дозволив розкрити взаємозв'язки між технічними й правовими аспектами. Аналіз нормативно-правових актів, протоколів і рекомендацій здійснено за допомогою методу вивчення документів, а для узагальнення наукових і практичних підходів використано контент-аналіз та елементи критичного аналізу. Досліджено технічні аспекти фотограмметрії та лазерного сканування, що дозволяють створювати тривимірні моделі місць подій з високою точністю за короткий час, скорочуючи тривалість розслідувань та знижуючи ризики для персоналу у небезпечних зонах. Основні результати включають розроблення рекомендацій щодо стандартизації цифрових доказів, оптимізації закупівель обладнання, підготовки фахівців та проведення пілотних проєктів із оцінкою їх ефективності. Практична значущість роботи полягає у створенні моделі впровадження, яка передбачає інтеграцію штучного інтелекту та доповненої реальності для автоматизації аналізу даних і тренувань, підвищення ефективності виконання завдань служби та безпеки персоналу. Запропонована модель забезпечує комплексний підхід до прийнятності цифрових доказів, поєднуючи технічні рішення, навчання персоналу та правову легітимність із міжнародним визнанням.

Ключові слова: Військова служба правопорядку у Збройних Силах України, цифрові докази, фотограмметрія, лазерне сканування, доповнена реальність, цифрова криміналістика.