DOI 10.36074/grail-of-science.24.07.2026.021

INTELLIGENT SITUATIONAL AWARENESS SYSTEMS FOR CIVIL SAFETY BASED ON INDUSTRY 5.0 TECHNOLOGIES

Vladyslav Yevsieiev
Doctor of Engineering Science, Professor,
Professor of Department of Computer IntegratedTechnologies,
Automation, Robotics and Safety Engineering
Kharkiv National University of Radio Electronics, Ukraine

Tatyana Stytsenko
Candidate of technical sciences, Associate Professor,
Associate Professorof Department of Computer Integrated Technologies,
Automation, Robotics and Safety Engineering
Kharkiv National University of Radio Electronics, Ukraine

The research problem lies in the insufficient effectiveness of traditional civil safety systems in the timely detection, analysis, and prediction of emergency situations under conditions of increasing volumes of heterogeneous data, dynamic threats, and a high level of uncertainty. Existing approaches often fail to provide comprehensive situational awareness because information obtained from sensors, video surveillance systems, unmanned platforms, IoT devices, geographic information systems, and emergency response services is processed in a fragmented manner and is not always integrated into a unified information environment. Therefore, there is a need to develop intelligent situational awareness systems based on Industry 5.0 technologies that combine artificial intelligence, cyber-physical systems, digital twins, Edge Computing, and a human-centric approach to support real-time decision-making. The implementation of such systems will improve the timeliness of emergency response, enhance the accuracy of risk assessment, increase the efficiency of civil safety force coordination, and strengthen the resilience of critical infrastructure.

An intelligent situational awareness system in the field of civil safety, according to the Industry 5.0 concept, is a human-centric cyber-physical system that provides continuous data acquisition, integration, intelligent analysis, and forecasting from heterogeneous information sources to create an up-to-date operational picture and support real-time managerial decision-making. The implementation of such a system enables the timely detection of potential threats, risk assessment, prediction of emergency scenario development, and coordination of civil safety forces by

integrating the capabilities of artificial intelligence, digital twins, cyber-physical systems, and human expert knowledge.

The proposed intelligent situational awareness system for civil safety offers several advantages over existing systems. A comparative analysis of the advantages of the intelligent situational awareness system for civil safety based on Industry 5.0 technologies is presented in Table 1.

Table 1

Comparative Analysis of the Advantages of an Intelligent Situational Awareness System for Civil Safety Based on Industry 5.0 Technologies

Evaluation Criterion	Existing Civil Safety Systems	Intelligent Situational Awareness System (Industry 5.0)	Advantage of the Proposed Approach
1	2	3	4
Data Acquisition	Data are collected from a limited number of sources	Integration of data from IoT devices, UAVs, satellites, video surveillance, digital twins, GIS, and social services	Provides a comprehensive operational picture.
Data Processin	Predominantly manual or partially automated analysis.	Automated analysis using artificial intelligence and machine learning.	Reduces data processing time and improves analysis accuracy.
Situational Awareness	Primarily focused on assessing the current situation.	Generates a dynamic situational picture in real time.	Improves the completeness and timeliness of information.
Threat Prediction	Limited use of predictive models	Intelligent prediction of emergency development based on AI and digital twins.	Enables early detection of potential threats
Risk Assessment	Performed using predefined scenarios	Adaptive risk assessment based on big data analytics and intelligent algorithms.	Improves the reliability and accuracy of risk assessment.
Decision Support	Largely depends on the operator's experience.	AI-driven recommendation generation while maintaining human oversight and control.	Reduces the impact of the human factor and improves the validity and reliability of decision-making.
Coordination of Civil Safety Forces	Limited information exchange between operational units.	A unified information environment with synchronized communication among all emergency services	Enhances the efficiency of interagency coordination and collaboration
Resource Management	Resource allocation is predominantly performed manually	Automated optimization of personnel and resource allocation.	Ensures rational utilization of human and material resources.

Continuation of table 1

Evaluation Criterion	Existing Civil Safety Systems	Intelligent Situational Awareness System (Industry 5.0)	Advantage of the Proposed Approach
1	2	3	4
Adaptability to Changes	Requires manual adjustment of system parameters.	Self-adaptation of models based on new data and continuous feedback mechanisms.	Increases resilience to dynamic and evolving threats.
Use of Digital Twins	Digital twin technology is rarely or not utilized.	Simulation of emergency scenarios within a digital environment using digital twins.	Enables the assessment of potential consequences before implementing operational decisions.
Human-Centricity	The operator independently performs most analytical and decision-making tasks.	Collaborative interaction between humans and artificial intelligence in accordance with the Industry 5.0 paradigm.	Improves the quality of managerial decisions while preserving meaningful human oversight and control.

The comparative analysis demonstrated that the proposed intelligent situational awareness system for civil safety significantly outperforms existing systems through the comprehensive integration of heterogeneous data sources and the application of artificial intelligence, digital twins, cyber-physical systems, and Industry 5.0 principles, enabling continuous monitoring, emergency prediction, adaptive risk assessment, and the generation of well-founded recommendations for real-time decision support. The proposed approach enhances situational awareness, improves the coordination of civil safety forces, optimizes resource utilization, and increases the resilience of critical infrastructure while preserving the leading role of humans in decision-making in accordance with the human-centric principles of Industry 5.0. The obtained results confirm the feasibility of implementing intelligent situational awareness systems as a promising technological foundation for the digital transformation of civil safety and for improving the effectiveness of responses to complex contemporary threats.

References:

[1] Jia, Q., Xiao, J., Bai, L., Zhang, Y., Zhang, R., & Feroskhan, M. (2025). Space situational awareness systems: Bridging traditional methods and artificial intelligence. Acta Astronautica, 228, 321-330. https://doi.org/10.1016/j.actaastro.2024.11.025

[2] van der Lee, M., Peters, C., van Berlo, M., Unzueta, L., Ríos, D., Toivonen, S., ... & Vrochidis, S. (2026). A holistic framework for assessing the uptake potential of EU-funded security research and innovation project results. Open Research Europe, 5(115), 115. https://doi.org/10.12688/openreseurope.19711.2

[3] Alhalalmeh, A., Al-Tarawneh, A., Murshed, A. A., Alrahamneh, A., & Al-Badawi, M. (2026). Strengthening Social Security Systems Through Economic Policy Innovations: Governance Challenges and Solutions. In Artificial Intelligence for Sustainable Innovation Management and Risk Management: A Systems (and Network) Perspective (pp. 1607-1620). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-95310-1_115
[4] Giedraitytė, V., & Miežanskienė, R. (2026). Strategies for Enhancing Civil Participation in National Security: Case of Lithuania. In Democratic Resilience in the Baltics, Vol. 2: Societal Resilience as a Defensive Power (pp. 69-89). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-032-10146-4_4
[5] Nevliudov, I., Yevsieiev, V., Baker, J. H., Ahmad, M. A., & Lyashenko, V. (2020). Development of a cyber design modeling declarative Language for cyber physical production systems. J. Math. Comput. Sci., 11(1), 520-542. https://doi.org/10.28919/jmcs/5152
[6] Hamdan, M., Abu-Jassar, A., Essa, M. A. B., Maksymova, S., Yevsieiev, V., & Lyashenko, V. (2026, April). Hybrid Navigation Model of a Mobile Manipulator Robot: Combination of Global Planning and Local Dynamic Optimization. In 2026 International Conference on Artificial Intelligence for Sustainable Engineering and Innovation (AISEI) (pp. 518-524). IEEE. https://doi.org/10.1109/AISEI68628.2026.11572980
[7] Industry 5.0 та колаборативна робототехніка: динамічний опис навколишнього середовища роботів-маніпуляторів з використанням мови Python: монографія / І. Ш. Невлюдов, В. В. Євсєєв, С. С. Максимова. – Харків : Видавництво Іванченка І. С., 2026. – 279 с. https://doi.org/10.30837/978-617-8332-95-2

ІНТЕЛЕКТУАЛЬНІ СИСТЕМИ СИТУАЦІЙНОЇ ОБІЗНАНОСТІ ДЛЯ ЦИВІЛЬНОЇ БЕЗПЕКИ НА ОСНОВІ ТЕХНОЛОГІЙ ІНДУСТРІЇ 5.0

Vladyslav Yevsieiev
доктор технічних наук, професор, професор кафедри комп'ютерно-інтегрованих технологій, автоматизації, робототехніки та інженерії безпеки
Харківський національний університет радіоелектроніки, Україна
Tatyana Stytsenko
кандидат технічних наук, доцент, доцент кафедри комп'ютерно-інтегрованих технологій, автоматизації, робототехніки та інженерії безпеки
Харківський національний університет радіоелектроніки, Україна

