SECTION 7.
FIRE AND CIVIL SAFETY

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IMPLEMENTING INDUSTRY 5.0 TECHNOLOGIES IN CIVIL SAFETY SYSTEMS FOR INTELLIGENT EMERGENCY MANAGEMENT

The rapid increase in natural, technological, military, and cyber threats, together with the growing complexity of emergency response processes, necessitates the modernization of existing civil safety systems through the implementation of advanced digital technologies. The Industry 5.0 concept provides the foundation for integrating artificial intelligence, cyber-physical systems, digital twins, the Internet of Things (IoT), Edge Computing, and human-centric management, enabling continuous situational monitoring, intelligent analysis of heterogeneous data, prediction of hazardous event development, and real-time decision support. The implementation of Industry 5.0 technologies improves emergency response efficiency, enhances the coordination of civil safety forces, optimizes resource utilization, and increases the resilience of critical infrastructure under multifactorial threat conditions. Therefore, research focused on implementing Industry 5.0 technologies in civil safety systems for intelligent emergency management is highly relevant, scientifically justified, and of significant practical importance for improving public safety and advancing the digital transformation of civil protection systems.

The framework for implementing Industry 5.0 technologies in the civil safety system to enhance the level of intelligent emergency management is presented in Figure 1.

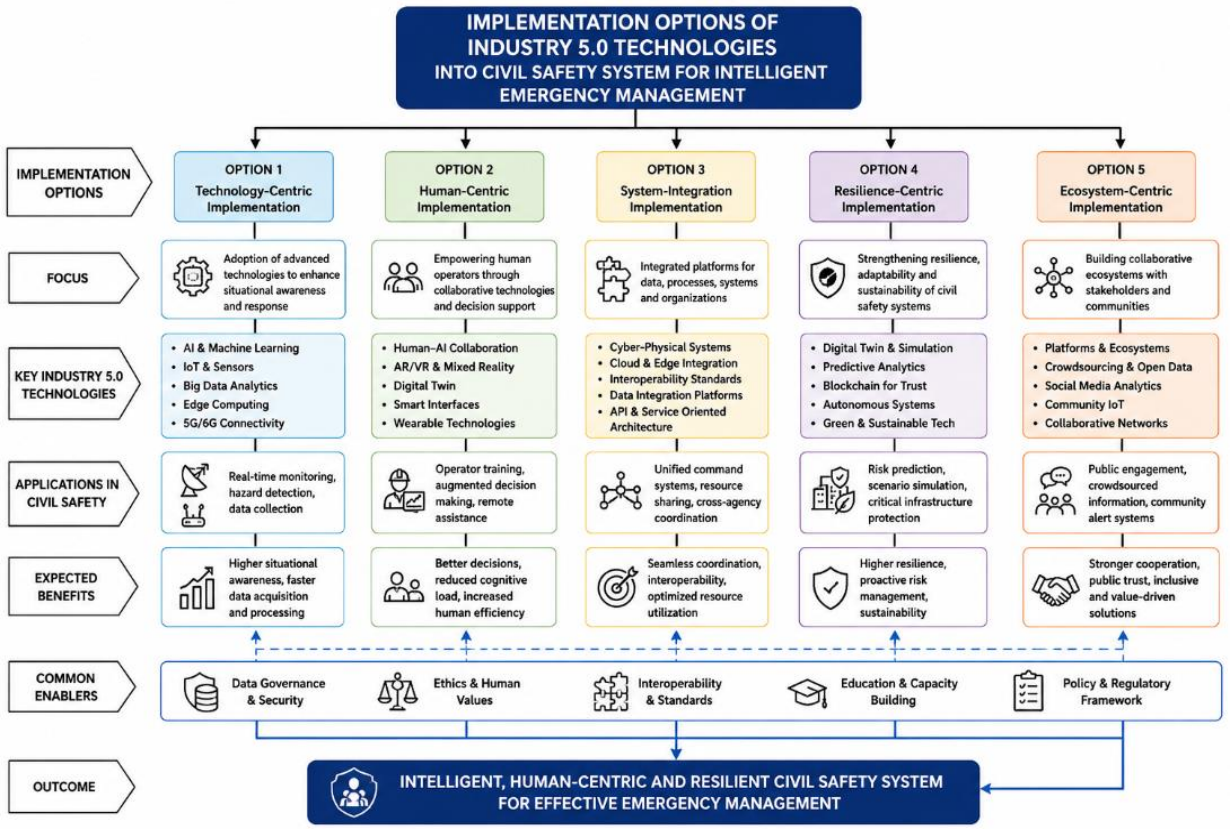

Fig. 1. **Framework for Implementing Industry 5.0 Technologies in the Civil Safety System**

The proposed framework for implementing Industry 5.0 technologies in the civil safety system represents a multi-level conceptual model that covers the entire digital transformation cycle of emergency management, from selecting an implementation strategy to achieving the practical outcome of an intelligent human-centric civil safety system. The key feature of the framework is the integration of five complementary implementation approaches, namely technology-driven, human-centric, integration-oriented, resilience-oriented, and ecosystem-oriented approaches, which enable the digital transformation process to be adapted to the specific operational requirements of various civil safety organizations and emergency response services. Each implementation approach is characterized by its own application domain, Industry 5.0 technologies, functional objectives, and expected outcomes, thereby providing comprehensive support for monitoring, forecasting, decision-making, coordination of emergency response forces and

resources, and effective collaboration among all stakeholders involved in emergency management.

The technological foundation of the proposed framework is based on artificial intelligence, machine learning, the Internet of Things (IoT), digital twins, big data analytics, Edge Computing, cyber-physical systems, cloud technologies, interoperability standards, data integration platforms, predictive analytics, autonomous systems, and advanced digital communication technologies, all of which are integrated into a unified information environment. This approach enables the continuous acquisition, processing, and analysis of heterogeneous information, the creation of a comprehensive situational picture, the simulation of emergency scenarios, and real-time decision support. At the same time, the human-centric approach emphasizes collaboration between humans and artificial intelligence through the use of digital twins, augmented and mixed reality technologies, intelligent user interfaces, and operator support tools, thereby reducing cognitive workload, improving the quality of managerial decisions, and preserving the leading role of humans in accordance with the principles of Industry 5.0.

An important feature of the proposed framework is the inclusion of common organizational and technological components that ensure the coordinated operation of all implementation approaches. These components include data governance mechanisms, cybersecurity, the ethical use of artificial intelligence, interoperability standards, personnel training, and regulatory support, which together establish a unified foundation for the deployment and scalability of the proposed solutions. The interconnection between the individual layers of the framework illustrates a logical progression from the selection of an implementation strategy through the application of appropriate digital technologies and the execution of operational functions to the achievement of measurable outcomes, thereby ensuring a systematic and coherent digital transformation of the civil safety system.

Conclusion: The proposed structural framework is distinguished by its comprehensiveness, modularity, and scalability, enabling the implementation of various deployment scenarios tailored to the specific requirements of individual organizations or regions. The framework integrates the technological, organizational, and human-centric dimensions of Industry 5.0 into a unified architecture, thereby enhancing situational awareness, reducing emergency response time, optimizing resource utilization, improving interagency collaboration, strengthening the resilience of critical infrastructure, and increasing the overall effectiveness of civil safety management. Consequently, the proposed framework provides a scientifically grounded foundation for the further digital transformation

of civil protection systems and the development of intelligent emergency management capabilities.

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