DOI 10.15302/J-SSCAE-2021.04.013

Digital Transformation of Emergency Management System: Technical Framework and Policy Path

Zhang Weidong [1], Gao Zhijie [2], Wang Chaoxian [1]

1. Policy and Economics Research Institute, China Academy of Information and Communications Technology, Beijing 100191, China
2. Center for Strategic Research on Frontier and Interdisciplinary Engineering Science and Technology, Beijing Institute of Technology, Beijing 100081, China

Abstract: With the acceleration of the new generation of information technology innovation, the economy and society are showing crucial new digital transformation features. The digital transformation of the emergency management system, an essential part of the economy and society and the concentrated expression of national governance capabilities, is on the agenda. This paper follows the objective laws of technological industry transformation based on the theoretical paradigm of technical and economic management, attempts to portray the characteristics of modern emergency management systems, presents a technical system, and proposes a policy path to promote the digital transformation of emergency management systems. Research shows that the current digital transformation technology system and technical capabilities are improving increasingly, and the emergency management system requires digital transformation. It is necessary to construct a technology system for emergency management digital transformation covering three levels: technology, platform, and management. It is also necessary to promote balanced development of the physical world and social systems, platform support and management decision-making, technological innovation, and integrated applications. Therefore, during the process of subsequent emergency management policy design and the formulation of the "14th Five-Year Plan," it is necessary to strengthen the digital upgrade of emergency management infrastructure, consolidate the foundation of the digital platform for emergency management, and strengthen the integrated application of digital technology in emergency management practices.
Keywords: emergency management system; digital transformation; technology system; integrated application

1 Introduction

Currently, the sci-tech revolution and industrial transformation represented by the new generation of information technology have reached an advanced stage, with the trend of digital transformation in the economy and society becoming increasingly evident. The frequency and transmission speed of emergencies have increased, exposing the economy, society, and people to significant impact and harm. With the acceleration of the technology revolution and people's demands for a safer and more stable life, there is a higher requirement to enhance the innovation of emergency management technology and improve emergency management capacity. However, it is challenging for the current emergency management technology system to meet such needs. Thus, utilizing digital technology tools has become a common choice in all countries to improve emergency management capabilities. The digital,

Received date: April 14, 2021**;** **Revised date:** June 10, 2021
Corresponding author: Gao Zhijie, senior engineering of Beijing Institute of Technology. Major research fields include digital transformation and technological innovation strategy. E-mail: gzj@bit.edu.cn
Funding program: CAE Advisory Project "Research on Smart Emergency Development Strategy (2035)" (2020-XY-03); Beijing Science and Technology Project (Z181100004118003)
Chinese version: Strategic Study of CAE 2021, 23(4): 107–116
Cited item: Zhang Weidong et al. Digital Transformation of Emergency Management System: Technical Framework and Policy Path. *Strategic Study of CAE,* https://doi.org/10.15302/J-SSCAE-2021.04.013

networked, and intelligent transformation of emergency management systems has accelerated, and the construction of technical systems and microlevel policies for the digital transformation of emergency management has been performed steadily.

The technical system of emergency management comprises two categories: general and professional. The former refers to the underlying technological system, such as communications, information, equipment, and digital technology. In contrast, the latter refers to a specific technological system combined with vertical industries, such as mining, electric power, geology, environment, and transportation. As a type of general technology, digital technology mainly serves as the foundation of the underlying technology and empowers professional technology. Recently, the development of digital technology has shown new characteristics, such as the accelerating process of new network deployment, continuous and substantial increase in computing capabilities, significant increase in the intelligent analysis level, and continuous enhancement of technology combination coordination. Therefore, the coordination of multiple technologies, such as perception, transmission, computing, and analysis, has significantly improved the ability to solve practical problems; thus, the technical conditions of the rapid development of emergency management systems tend to be established.

Current research on the integrated application of digital technology in emergency management systems has mainly focused on applying specific digital technology. For example, some researchers have investigated how big data, artificial intelligence (AI), and blockchain are applied in emergency management, such as improving the emergency response speed, enhancing resource allocation efficiency, and treatment effects. However, few comprehensive and systematic studies have been conducted, and a framework analysis is lacking. This study focused on the overall and framework research of the digital transformation of emergency management systems, combined with the industrial characteristics of emergency management systems, with the integrated applications of digital technology and emergency management serving as a starting point.

2 Concept and implications of digital transformation of emergency management system

The emergency management system is an integrated network managed by the government and other social organizations to respond to emergencies. The emergency management system comprises laws and regulations, administrations and institutions (public and private sectors), mechanisms and rules, capabilities and technologies, and environment and culture [1]. It can also be considered a combination of related elements and the total relationship between them, such as organizations, systems, behaviors, and resources responding to public emergencies [2]. The *CPC Central Committee's Decision on some Major Issues Concerning Upholding and Improving the Socialism with Chinese Characteristics and Advancing the Modernization of China's Governance System and Capacity* describes the goal of emergency management system construction as "to build an emergency management system with unified command and reserves of specialized and regular staff, capable of quick response and effective coordination at different levels to optimize the construction of national emergency management capabilities and systems." Hence, the emergency management system is complex and covers laws, institutions, technologies, and culture.

The digital transformation of the emergency management system refers to improving quality and efficiency to promote and transform the emergency management system by integrating digital technologies, such as the Internet, big data, and AI, with the emergency management system. The digital transformation of an emergency management system involves three main aspects. The first aspect is the transformation of technical tools, such as the application of digital technologies, for example, the Internet, big data, and AI, in the emergency management system and industrialization promoted around emergency management. The second is the transformation of the decision-making mechanism, evolving from the empirical, passive, conventional system to a knowledge-based, proactive, agile system facilitated by digital technologies. The third is the transformation of institutions and culture, characterized by promoting vertical, administrative, and centralized systems and culture adapted for connectivity and collaborative sharing, and establishing a networked, professional, and modernized emergency management system.

3 New characteristics of emergency management systems require digital transformation.

In recent years, emergencies have been significantly influenced by factors in technical and natural environments. The superimposition of conduction and spillover effects has led to ever-increasing harm to people and society. In such a situation, the establishment of a modernized emergency management system is put on a schedule, where digital transformation plays a significant role.

DOI 10.15302/J-SSCAE-2021.04.013

3.1 Integration and holism

Holistic governance is an essential aspect of emergency management [3]. The integrated application of digital technologies is being directed toward cyberization and platformization, helping to overcome the administrative and professional barriers of vertical departments and reflect holistic governance. In emergency management, the integrated management of monitoring, predicting, warning, and responding has become possible by sharing massive amounts of information and data, leveraging the data analysis advantages of the platform, and performing the description, recording, analysis, and reorganization of emergencies for overall descriptions of emergencies. Consider big data technology applied to COVID-19 as an example. The digital application of itinerary cards and health codes integrates communication, medical treatment, transportation, disease control, and other event processes, thus breaking the fragmented governance state of public health. From the holistic governance perspective, it is a new model for epidemic risk prevention and emergency response based on big data [4,5]. The platformization of digital technology systems makes it possible to share data, information, and resources, thus continuously deriving innovations in emergency management models, breaking traditional vertical architectures, and providing vital support for building an integrated and holistic emergency management framework.

3.2 Agility and efficiency

Timeliness is required in emergency management. In the past, humans played a key role in monitoring risk points and sources, and traditional communication was the main method. Thus, the accuracy was insufficient, making it challenging to achieve a real-time response and resulting in an extended lag in feedback and ineffective performance. By using deeply embedded sensing equipment, edge computing capabilities, and the cross-domain direct-connected information transmission system, it is possible to overcome information obstacles between risk points and horizontal departments and vertical hierarchies, and at the same time, improve responsible bodies' speed of response and action through efficient data integration. Through an accurate description of the physical system and the linkage between the virtual and real, the digital twin can analyze and evaluate the risk status of physical systems in real time online, prevent the repetition of emergency actions, and maintain emergency actions in the optimal state from the beginning, significantly improving emergency response efficiency.

3.3 Safety and resilience

The emergency management system may also be affected by uncertainties. The resilience of an emergency management system emphasizes its proactive maintenance and adaptability to effectively respond to external shocks and damages and its ability to self-repair after being damaged [6]. Digital technologies can shorten the information transmission chain and ensure the accuracy of information transmission, strengthen edge processing, and achieve decentralization. Therefore, digital technologies have a unique advantage in ensuring integrity and reliability. In addition, innovations in distributed, small-scale, and diversified models help enhance the recovery and reconstruction efficiency of the emergency management system after a shock.

Overall, digital technologies will become crucial to supporting the modernization of emergency management systems. Given that the complexity and uncertainty of emergency management systems are becoming prominent, strengthening digital technology capabilities and establishing a digital technology support system are fundamental and inevitable topics in establishing a modernized emergency management system. In the future, while the general logic of traditional emergencies from occurrence to applying measures remains unchanged, meeting the various new demands of emergency management system upgrades can only be achieved through digital transformation.

4 Technical frameworks for digital transformation of emergency management system

4.1 Key points for digital transformation of emergency management system

4.1.1 Essentials of digital transformation of emergency management system depend on management level

In contrast to the digital transformations of the industry, agriculture, and services, the digital transformation of emergency management systems is not only in production, operation, and other technical processes but also emphasizes management. Specifically, it focuses on the digitalization of management processes, such as contingency plans, organization and coordination, and process control related to emergency activities. In contrast, decision-making in traditional emergency management is mainly based on experience. However, crises and emergencies are almost nonrepetitive (each is entirely new), and the knowledge system that supports decision-making is constantly tested. In a risk society, emergency decisions made by such knowledge systems based on stereotypes of thinking and behavioral inertia may severely undermine the actual emergency management effects. From a practical viewpoint, high-quality emergency management decisions are still the shortcomings of national emergency causes, restricting the efficiency of emergency resource allocation and the accuracy and effectiveness of the emergency response. Currently, the core tasks of the digital transformation of emergency management systems should focus on improving the ability to identify emergency risks and intelligent level of emergency plans beforehand, enhancing the efficiency and agility of emergency response during the event, and strengthening the abilities to subsequently recover and learn lessons after the event. Only by comprehensively upgrading the digital and intelligent emergency management system can we abandon the potential deficiencies of expert empirical judgments and administrative decision-making by managers and achieve scientific decision-making based on data.

4.1.2 Social systematic risk is a vital aspect of digital transformation of emergency management system

The digital transformation of industries and trades generally focuses on physical systems. Through the digital and intelligent upgrading of physical systems, such as manufacturing, product materials, and logistics supply, the production and operation decisions are optimized, and the efficiency and quality of the production process are improved. However, emergency management systems not only need to deal with natural disasters, forest fires, industrial accidents, aviation accidents, environmental emergencies, and other emergencies that occur in physical systems but also need to fully consider the risk points in social systems, such as public health and public safety incidents. Therefore, it is necessary to accelerate the construction and improvement of a digital emergency system for social life based on the digital transformation of the physical system, forming an emergency management system with complete functions and extensive coverage (Fig. 1).

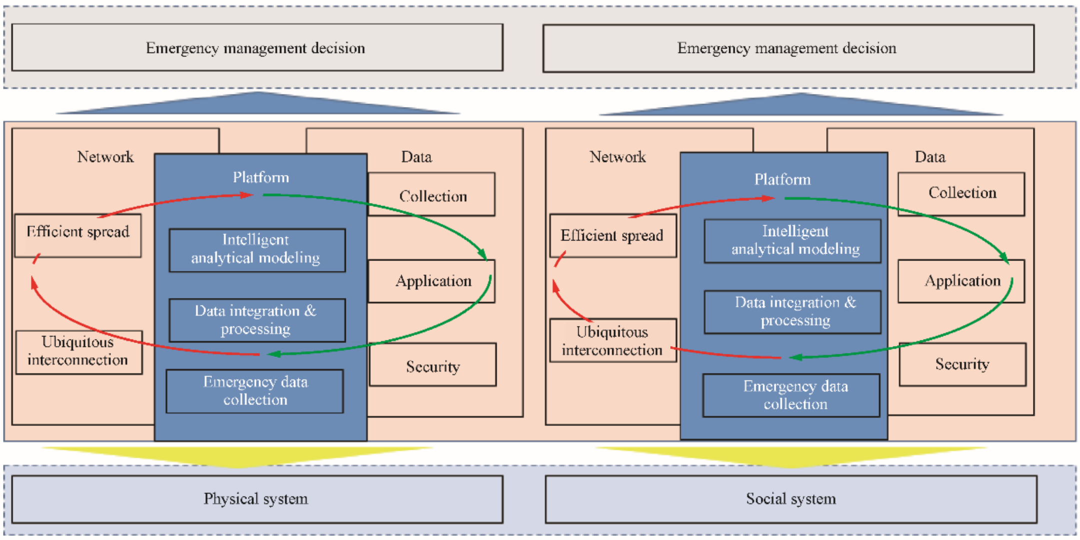

Fig. 1. Framework of digital transformation of emergency management system.

4.1.3 Collaboration, interconnection, and interoperability are basic criteria for digital transformation of emergency management system

Collaboration and interoperability are significant challenges in building an emergency management system. From an organizational perspective, responses to large-scale catastrophes generally require resources and capabilities beyond any organization. Consequently, emergency management participants typically have different organizational backgrounds, making it critical to break the organizational barriers of participants and coordinate the corresponding organizations. From the perspective of information and data, traditional emergency management receives information from risk points but cannot exchange data. The "data chimney" has become a significant obstacle to emergency management in the risk society, and it is time to strengthen collaboration and interoperability of heterogeneous and decentralized information and data to establish an efficient and synchronized emergency management system. Because of the lack of data, information, and knowledge for emergency management decision-making, integrated solutions such as digital platform construction and interoperability enhancement are necessary to overcome barriers and achieve collaboration, interconnection, and interoperability.

DOI 10.15302/J-SSCAE-2021.04.013

4.2 Technical architecture of digital transformation of emergency management system

4.2.1 Digital transformation of emergency management systems involves three major categories of technology

Digital technology mainly refers to fifth-generation mobile communication technology (5G), the Internet of things (IoT), big data, cloud computing, AI, and other forms of information communication technology, covering a wide range of aspects, such as perception, transmission, computing, and modeling. For example, the rapid development of IoT is significant for enhancing the ability to perceive risk events. With the advancement of smart-sensing technologies and reduction in the price of technology products, sensing devices with various front-end data collection functions can be widely utilized, covering the entire field of natural disasters and safety, such as geologic disasters, floods, hazardous chemicals, and mining. Therefore, emergency management decision-making can improve the accuracy of first-hand mass data. IoT, combined with highly reliable, low-latency transmission networks and intelligent analysis methods, can fully support the digital upgrading of emergency management, such as prejudgment, imminent disaster forecasting, and impending prediction.

Integrated technology mainly refers to the integration of digital and emergency technologies, and it is divided into integration with general emergency technologies and integration with professional technologies. The former refers to integration with general technologies, such as communication, detection, and searching during emergency management (typically represented by emergency communication technology). The latter comprises integration with emergency technologies supporting various professional fields (such as geological disasters and floods) and corresponding rescue techniques (such as intelligence of rescue equipment). The digital transformation of emergency communication technology is a typical example of integrated digital and general emergency technologies. Current emergency communication methods are relatively singular, and the degree of digitalization and intelligence is not high. It is necessary to consider relying on 5G, Wi-Fi, optical fiber networks, and other commercial communication network facilities to actively upgrade emergency communication, improve emergency communication networks, and enhance emergency communication capabilities with full coverage and connectivity. Moreover, comprehensive emergency equipment with communication functions, such as aerostats and high-altitude long-endurance drones, can be deployed to facilitate air-and-space integration and enhance resilience and anti-destroy capabilities in regional emergency communications. Such comprehensive communication facilities can further supplement functions, such as remote sensing of perception and high-precision maps. Thus, emergency communication devices can be used for disaster monitoring, disaster identification, postdisaster assessment, reconstruction monitoring, and other scenarios. The digitalization of emergency equipment is a typical example of integrated digital and professional emergency technologies. Rescuers' personal equipment is expected to integrate wearable computing technologies, data collection technologies, and protection technologies; in the future, wearable digital rescue equipment may become the core equipment for emergency rescue, combining functions such as internal and external perception, wireless communication, data transmission, and on-site positioning. Firefighting robots, excavation equipment, and drones integrating AI can exhibit self-learning, self-adaptation, and self-improvement, autonomously assessing disaster levels, conducting disposal operations, and performing stand-alone or local automatic rescue missions [7].

Managerial decision-making technology mainly refers to the emergency management information system, which typically exists as a big data platform to support decision-making in emergency management. Digital platform technology focuses on data mining and value conversion, providing additional support for decision-making in emergency management, including analysis, description, diagnosis, prediction, guidance, and application development. These functions can somewhat achieve intelligent automatic decision-making. The analysis function mainly relies on various models and algorithms to promote the explicitness of the massive and complex data information collected by the front-end and supports the diagnosis, prediction, and optimization functions in the next step. Widely used data analysis methods include statistical mathematics, big data, and AI. The description function demonstrates the status and problems of the current emergencies based on data analysis and comparison and visualizes the state of emergency to clarify the emergency. The diagnosis function helps evaluate the current situation and disaster readiness, promptly identify problems, and provide data analysis solutions. Warnings can be issued immediately when accidents and risks occur, prompting rescuers to adopt scientific and rational rescue plans. The prediction function is used to predict the future state of accidents and risks based on data analysis and intervene prospectively, for example, predict the probability of geological disasters based on meteorological data, issue timely warnings, and carry out response and prevention in advance. The guidance function refers to data analysis for identifying and improving unreasonable and inefficient stuff in the physical environment and social operations.

4.2.2 System of digital transformation technology

The digital transformation of an emergency management system is a complex system engineering, and its technology system covers general, perception, edge-processing, platform, software, standards, supporting, and integrated application technologies. Core technologies include IoT, blockchains, cloud computing, and big data mining. It is critical for various technologies to cooperate to constitute an efficient technical system (Fig. 2).

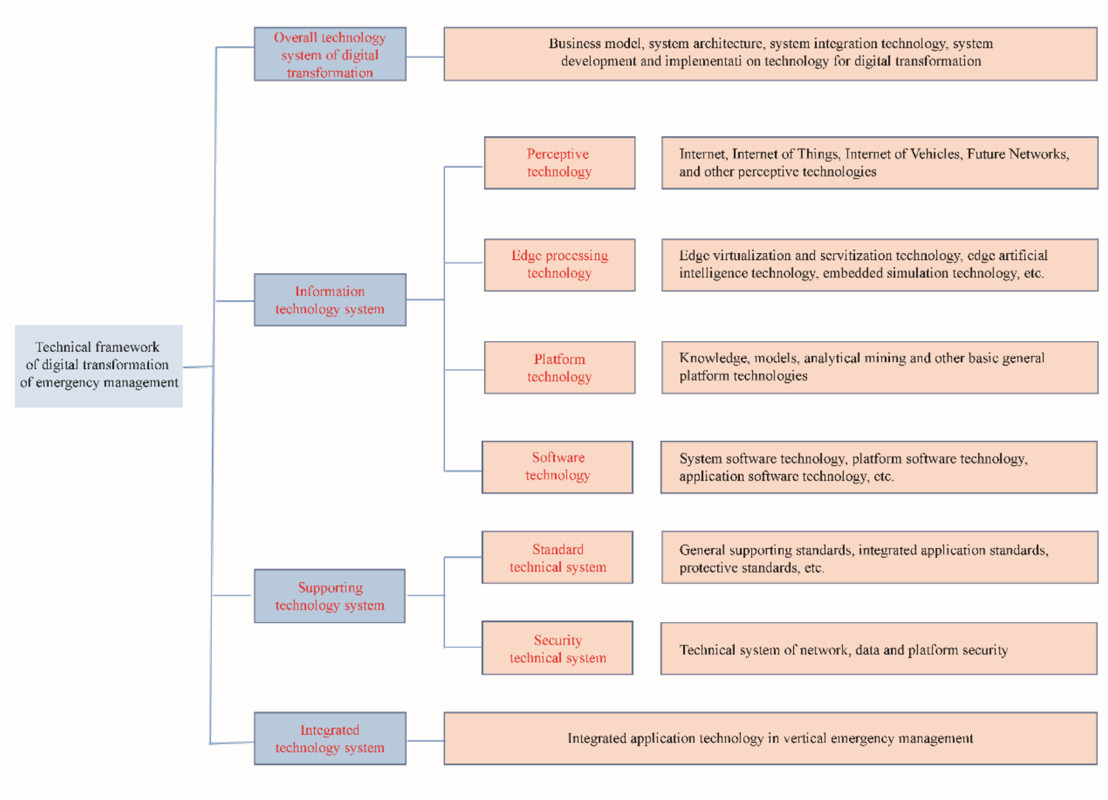

Fig. 2. Technical framework of digital transformation of emergency management.

4.3 Layered architecture of digital transformation of emergency management system

Currently, the digital transformation of emergency management can be divided into three main levels: edge, platform, and decision-making. The edge layer focuses on technical systems and product fields, such as perception, collection, and early warnings, closely related to the physical world and social systems, paying attention to the demands of underlying risk points for monitoring, identification, and alerts. It is the terminal level and portal of the digital emergency management system and the basic neuron to achieve "intelligence" in intelligent emergencies [8].

The platform layer consists of three main parts that constitute the support system for intelligent managerial decision-making; (1) infrastructure as a service (IaaS), which mainly cloudifies the collected data and establishes an operable, callable, and structured cloud system based on cloud computing to lay a solid foundation for the subsequent analysis step; (2) platform as a service (PaaS), which mainly structures cloud-based data to develop databases, model libraries, and knowledge bases for further analysis; (3) software as a service (SaaS), which mainly develops applications in general and vertical fields supported by the cloud and structured data, and constitutes callable, reusable, and shareable digital products and services of emergency management, finally supporting the emergency management system to make scientific decisions. The platform layer is the core of the entire digital emergency management system, in which data are key elements. Based on data access, storage, sharing, and analysis, the platform layer breaks data fragmentation, enables data sharing, and provides subsequent data analysis and mining. Based on embedded emergency databases, knowledge bases, and model libraries, it provides services, such as data management, early warning models, and regulation suggestions, for emergency decision-making.

The decision-making layer establishes tools, systems, and solutions for direct decision-making based on the edge layer perception and platform layer data. Emergency managers can learn the processed data by accessing relevant application terminals, compare and analyze various emergency plans, and utilize visualization tools to observe and

DOI 10.15302/J-SSCAE-2021.04.013

guide front-line operations, thereby achieving cross-department coordination, dispatchment with a map, decision-making and command analysis, virtual reality simulation, and other business applications. Based on the efficient, intelligent perception of external risk points, the accurate transmission and rapid processing of on-site data, reliable responses, and accurate deployment commands are achieved. The decision-making layer can be regarded as the center of the emergency management system.

In addition to the above three layers, a security layer that runs through the entire emergency management digital system exists to ensure the safety and reliability of equipment, data, networks, platforms, and applications, thus supporting the safe operation of the emergency management system (Fig. 3).

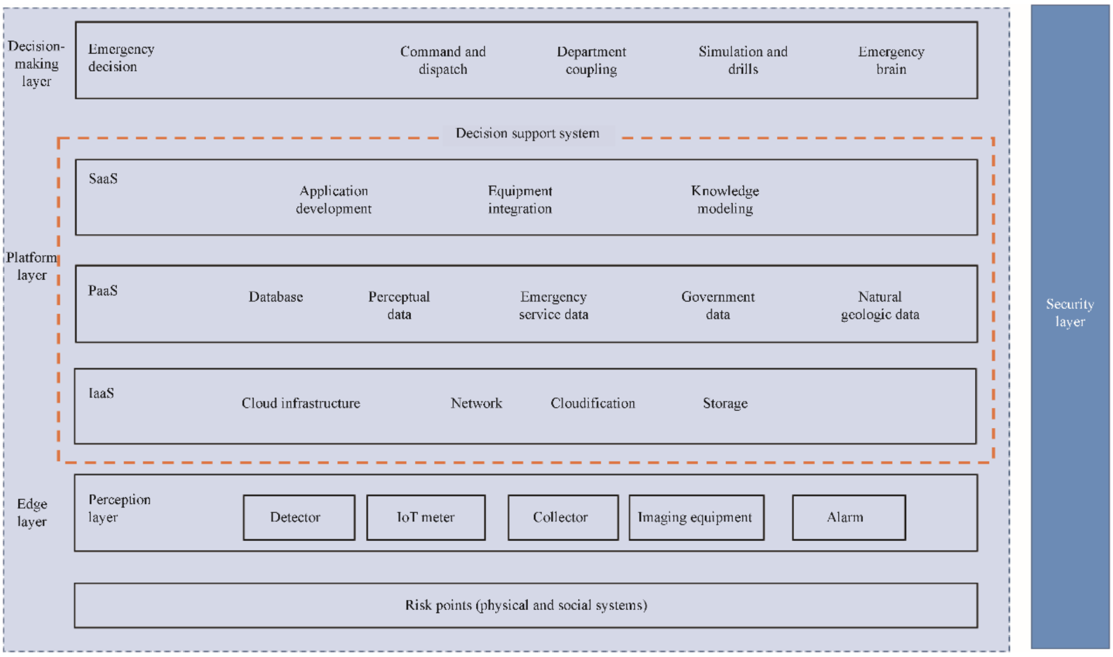

Fig. 3. Layered architecture of digital transformation of emergency management system.

4.4 Horizontal architecture of digital transformation of emergency management system

The horizontal architecture of the digital transformation of an emergency management system refers to the construction of a closed-loop system of digital emergency management that focuses on risk sources, covers risk points, and integrates risk chains. From a horizontal perspective, an emergency management system comprises information and decision flows. Digital transformation first plays a critical role in information flow, connecting the entire procedure of information collection and processing, processing and organizing, analysis and service, and evaluation and feedback to ensure a precise and smooth flow, efficient and intelligent information utilization, and high-quality information transmission and execution. Big data technology is used to collect, clean, exchange, integrate, and structure- or program-process diverse and heterogeneous data. On the one hand, intelligent technology summarizes and organizes historical normal information and data, collects and matches previous emergency management knowledge, and builds case libraries, knowledge bases, strategy libraries, and model libraries, thus forming vertical application examples. On the other hand, it rapidly integrates emergency information and data and outputs real-time results through a platform analysis system, improving emergency analysis and service capabilities to support emergency management decision-making [9].

In the digitalization context, the core of emergency management decision-making is to digitize physical environment information, systemize decentralized data, and maximize data values. The information flow follows the collection–processing–analysis–monitoring–evaluation–prediction–judgment direction, and the intelligent system is upgraded in the data–information–knowledge–intelligent–smart direction to effectively prevent, warn, and deal with emergencies, transiting from traditional experience-based decision-making to intelligent decision-making. The decision flow aims to fully implement the decision-making arrangements, efficiently allocate emergency resources, effectively perform rescue and disposal operations, and comprehensively conduct recovery after decisions are adopted in emergency management (Fig. 4). The decision flow also seeks to eliminate and control risk points and sources and re-feedback related information and knowledge to the information collection and processing system to facilitate structuring and modeling, enhance the self-learning ability of the system, and facilitate the normalized operation of the emergency management system [10].

Specific technologies include data, platform, and decision-making technologies. Data technology includes information integration and exchange, message services, dynamic routing, streaming media, and databases. Platform technology includes decision supporting service, geographic information system (GIS) services, data mining services, information security services, and simulation services. Decision-making technology refers mainly to vertical technologies in different fields.

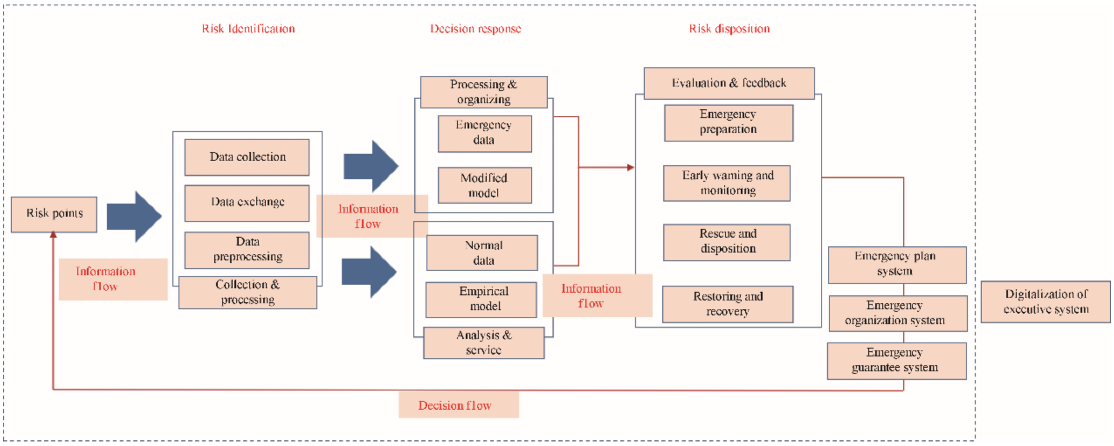

Fig. 4. Horizontal architecture of digital transformation of emergency management system.

5 A typical case: Construction of emergency management system from perspective of digital twins

5.1 Construction of emergency management digital-twin system

A digital twin is a technical process with digital technology as the foundation, integrated with multidisciplinary methods to achieve comprehensive, highly synchronous, and deep reflection of the physical world. In a digital twin, the connection between the physical and digital worlds is first established to form an integrated model of cyberspace and reality, and holographic simulation mapping is conducted using intelligent approaches, such as data analysis, interactive feedback, and decision-making optimization. The technologies and concepts of digital twins enable people to simulate the virtual digital world before recognizing and transforming the physical world to control, intervene, and create the physical world more precisely and effectively. Digital-twin technology was first applied to industry and manufacturing, where the design, manufacturing, and maintenance of engines are typical application scenarios. The developmental cycle and production costs are significantly shortened and reduced, respectively, through digital simulations and real-time tracking of products, production lines, and processes. Currently, digital twins have penetrated the fields of architecture, medical care, and urban management. For instance, structural framework establishment, civil engineering construction, and assembly maintenance are based on building information modeling to optimize building resource allocation. Digital twins are evolving toward digital twin villages, the digital-twin natural environment, and other global directions.

Constructing a digital twin system of physical and social systems is critical for supporting the digital transformation of emergency management in the future. The performance of the emergency management system depends on the comprehensive and accurate cognition of the physical and social systems, particularly the recognition and identification of emergencies and unique situations during physical and social system operations. Therefore, a comprehensive understanding of the risk points in physical and social systems is the key project that the emergency management system needs to complete. With the application of digital twin technology, the digital space mapping to the physical world is gradually constructed, the physical world operation is increasingly presented visually, and anomalies in the real world become prominent for accurate identification. In the future, it will be possible to build a digital twin system for emergency management based on a digital twin system rooted in the entire physical world. The digital twin of physical and social systems not only generates and accumulates a vast amount of data, such as documents, pictures, audio, video, geographical location, and social networks, to provide meaningful information on population, transportation, weather, housing, fire protection, and environmental protection for emergency

DOI 10.15302/J-SSCAE-2021.04.013

management; it also provides a reference model for emergency prevention and control by constructing virtual space scenarios, thus becoming a major carrier for emergency plans, emergency drills, and intervention effect evaluation.

Recently, digital twin technology has been extensively applied to smart cities. The construction of digital twin cities promoted by local governments has supported the digitalization of urban emergency management. Digital twin technology leverages sensors, such as smartphones and smart terminals in people's hands, to generate user portraits of urban residents, fill trajectory loopholes in the social system, and promptly present individual social activities and behaviors, creating conditions for innovation in emergency management systems based on digital twins [11]. Digital twin technology can precisely portray emergency management application scenarios. By accessing various sensor data, real-time dynamic monitoring of emergency application scenarios can be achieved through sorting, analysis, mining, and presenting massive public safety data. It ultimately works in the physical world, promoting comprehensive perception, overall control, and rapid and accurate response in urban emergency management such that emergency management bodies can share information, interconnect, and establish an integrated early-warning prevention and control system.

5.2 Emergency simulation management based on digital twin platform

The digital twin platform is essentially a simulation system. The digital twin system of emergency management does restore not only the environments of accident sites, such as geological disasters, droughts, floods, and fires but also construct a corresponding virtual emergency management model for each potential risk point. With the support of emergency knowledge bases, we can simulate multiple possibilities of emergency events, deduce the path of emergency risk evolution, evaluate different emergency event trends under different conditions, and predict the emergency decision-making effect to select the optimal emergency management plan. Furthermore, we can perform emergency plan drills based on the digital twin platform, conduct training, and rehearse emergency management work targeted at different trends observed in emergency simulations to evaluate and optimize the plan and train relevant personnel.

5.3 Emergency plan management based on digital twin platform

The digital twin platform is a knowledge system. In vertical industries, digital twin platforms are built on different knowledge graphs, presenting various knowledge projects. The construction of the digital twin system for emergency management is also a reconstruction of emergency incidents and emergency management knowledge. This system helps clarify the nature of emergency management activities in different fields and guides emergency management practices. The digital twin platform of emergency management not only reconstructs the emergency management knowledge system but also provides functional scenarios for the emergency management knowledge system, models emergency events based on different application scenarios, and precisely and intuitively reflects the ontological characteristics of emergency events. While modeling the event, various responses can be modeled. After entering different data and variables, an emergency plan database is generated, an essential part of preparing for emergency events. As a feedback system, the digital twin platform can scientifically evaluate the implementation of emergency plans based on prior management.

5.4 Overcoming professional emergency barriers based on digital twin platform

The digital twin platform is a converged system. Because of the deep barriers of vertical industry solutions in emergency management, significant differences in technology and knowledge, and restrictions in the overall effectiveness of the emergency management system, the integrated applications of general technical methods and professional technical tools have become critical for facilitating high-quality development of emergency management. Digital twin technology and systems have strong capabilities in decoupling, refining, and packaging professional emergency knowledge and skills. Building a general industry application model can support general emergency management, such as professional emergency rescue simulation, professional analysis, plan optimization, emergency simulation, precise planning, and program optimization, in various industries [12].

The new emergency management model based on digital twin technology can considerably improve the ability to adapt to the complexity, fluidity, and continuity of emergencies, significantly optimize the openness and dynamics of the management system, and enhance the diversified and complex integration of technical tools and comprehensive presentation of emergency events.

6 Recommendations

With the rapid development of digital technology and the constantly growing requirements for emergency management in recent years, it is necessary to fully utilize digital technology to accelerate the digital transformation of the national emergency management system. In this context, it is crucial to establish a policy framework to promote the digital transformation of an emergency management system covering infrastructure, platform systems, and integrated applications (Fig. 5).

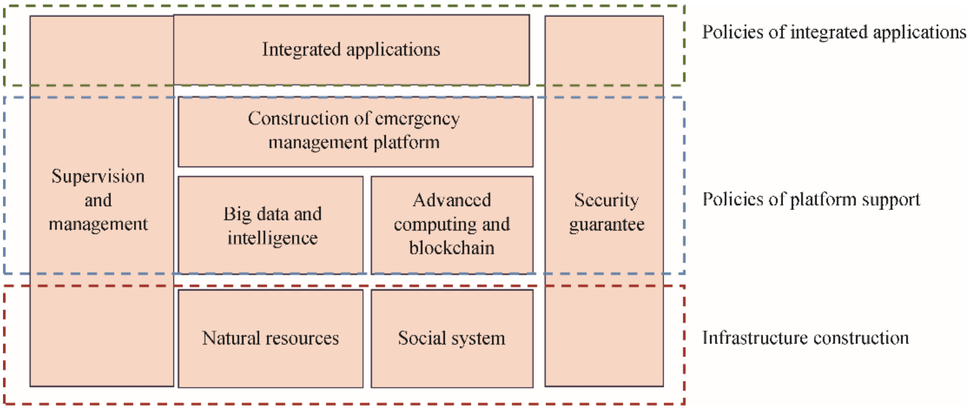

Fig. 5. Policy framework to promote digital transformation of emergency management system.

6.1 Accelerating digital transformation of emergency infrastructure

The 2018 Central Economic Working Conference proposed accelerating the commercialization of 5G and strengthening the construction of new infrastructures, such as AI, industrial Internet, and IoT. Accelerating the construction of new infrastructure has become an effective national strategy. Promoting the large-scale development of "new infrastructure" with high quality will lay a solid foundation for digitalizing and modernizing emergency management systems. Accelerating the digital transformation of the emergency infrastructure is the basis for promoting the transformation of the entire emergency management system. While implementing the 14th Five-Year Plan formulation regarding emergency management, we must consider infrastructure policies. Digital technologies such as big data, AI, and cloud computing should be used at a higher level to achieve more precise and effective prevention, monitoring, and guarantee. In addition, we need to focus on application directions, such as safe production, natural disasters, urban safety, and on-site rescue, to build smart emergency infrastructure that can perform deep perception, edge computing, and intelligent assistance to achieve a whole-field, whole-round, and whole-process perception and comprehensively improve the emergency management capability [13].

6.2 Accelerating construction of digital platform for emergency management

Digital transformation features platformization, an objective requirement for establishing a closed-loop of full-link connections, gross-data aggregation, and fully intelligent decision-making. The digital platform of emergency management can store geographical data, biomedical data, epidemic monitoring data, and public opinion and perform management activities, such as full lifecycle assessment, supervision, and guidance starting from planning, collection, processing, and intelligent use to achieve data value conversion. The key to building a digital platform lies in policies that promote data to play a critical role in the emergency management system to achieve the open sharing of various data categories. These encourage technological innovation and stimulate the initiative to conduct prospective experience verification of the emergency management platform, laying a solid foundation for the integrated application of emergency management.

6.3 Strengthening integrated application of digital technology and vertical emergency management

The digital transformation value lies in its integrated applications. Stakeholders should guide integrated applications through policies and pilot demonstrations, launch a batch of demonstration projects of emergency management, and promote integrated applications, such as GIS, network communication technology, cloud computing, big data, IoT, and AI. Accelerating the comprehensive transformation of technological integration achievement, strengthening the technical support for emergency management equipment, enhancing research and

DOI 10.15302/J-SSCAE-2021.04.013

development of critical technologies, introducing more abundant technical products, and improving the scientific, intelligent, and refined levels of emergency management should be conducted. The market-oriented service of the digital transformation of the emergency management system should be improved, and a group of comprehensive solution providers should be trained. Integrated applications should be encouraged through statistical monitoring and a standard implementation. Furthermore, reward localities and departments with best practices in digital transformation, and motivate various entities to actively apply digital technology products to emergency management.

References

[1] Xue L. The evolution of China's emergency management system [J]. Administrative Management Reform, 2010 (8): 22–24. Chinese.

[2] Gao X P. Achievements and development of the construction of emergency management system with Chinese characteristics [J]. Chinese Administration, 2008 (11): 18–24. Chinese.

[3] Zhu Q W. From new public management to holistic governance [J]. Chinese Public Administration, 2008 (10): 52–58. Chinese.

[4] Zhao F Z, Zhao G H. Research on the integrated governance of public health emergencies under the big data environment [J]. E-Government, 2020 (5):34–44. Chinese.

[5] Xiao Z L, Chi Y Q, Liu F. The application of blockchain technology in the national emergency management system under COVID-19 [J/OL]. Social Science Research Network Electronic Journal, (2020-03-23)[2021-03-05]. https://www.researchgate.net/publication/340159680_xinguanyiqingxiaqukuailianjishuzaiguojiayingjiguanlitixizhongdeyingyong_The_Application_of_Blockchain_Technology_in_the_National_Emergency_Management_System_under_COVID-19. DOI: 10.2139/ssrn.3559361. Chinese.

[6] Huang Z W. Resilience governance: Promoting the new direction of emergency management modernization [N]. Study Times, 2020- 04-20 (A5). Chinese.

[7] Dong B Y, Zhang Z Q, Xu L J, et al. Research status and development trend of intelligent emergency rescue equipment [J]. Journal of Mechanical Engineering, 2020 (11): 13–37. Chinese.

[8] Yu X H, Liu M, Jiang X H, et al. Industrial Internet architecture 2.0 [J]. Computer Integrated Manufacturing System, 2019, 25(12): 2983–2996. Chinese.

[9] He W, Zhang W D, Wang C X. Strategic updating of Internet Plus considering digital transformation [J]. Strategic Study of CAE, 2020, 22(4): 11–17. Chinese.

[10] Lei T, Sun Q, Wang M X. The 5G-based smart emergency command platform [J]. Journal of Command and Control, 2020 (4): 319–323. Chinese.

[11] China Academy of Information and Communications Technology. White paper on digital twin cities [R]. Beijing: China Academy of Information and Communications Technology, 2019. Chinese.

[12] Tang Z H, Peng S R, Zhou X Y. Research on the construction of smart city emergency management system under digital twin technology: Taking the practice of new coronary pneumonia joint prevention and control as an example [J]. Social Sciences, Education and Humanities Research, 2020, 446: 146–151.

[13] Peng L, Xu W H, Su Y C, et al. "New infrastructure" and smart emergency [J]. China Emergency Management Science, 2020 (9): 40–48. Chinese.