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Development of the Public Safety System and a Safety-Guaranteed Society

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Abstract: Public safety is essential to a nation's development and is embedded in and linked to the goal of becoming a powerful nation. The study of the development of engineering science and technology long-term strategy in China has shown that public safety can be regarded as an interdisciplinary research field, as its core capabilities are protecting life and property for the public and maintaining economic development and social stability. To build a powerful and stable society with scientific and technological power, it is imperative that public safety at all levels is improved and that research on public-safety science and technology is carried out. This paper introduces the development strategy of public-safety science and technology along with its path design in China.
Keywords: public safety system; strategic research; safety and resilience; technology innovation

1 Introduction

The core objective of public safety is to ensure the safety of people, the protection of property, the stable development of society, and the continuous operation of economic and social systems [1]. Developing with safety in mind has been an important development concept in recent years. A safety-oriented society is a key objective of national development. Since 2003, public safety has been acknowledged in China as a key social and economic aspect of its national infrastructure development strategy and important to the development of science and technology. In recent years, public safety science and technology have advanced significantly, and public safety support has developed at a national level. A national emergency platform system has been developed and the preparedness of the emergency response and management system has been significantly improved [2]; the accuracy of natural disaster pre-warning and forecasting has been significantly increased, the on-site response capacity to emergencies has been enhanced [1], and China's safety products and equipment have been used in many overseas countries. For example, the ECU 911 system developed by a Chinese R&D group played a key role in rescue measures and post-earthquake reconstruction efforts in Ecuador [3]. The competitiveness of China's safety technologies and products has been significantly enhanced. Meanwhile, with rapid industrialization and urbanization, the number of crisis events and disasters remains at a high level and the complexity of response measures has increased, which presents a notable challenge to proponents of emergency management and public safety. Development of a public safety system that includes science, technology, management, and the establishment of a safety-assured society are major objectives of continuous national development [1].

2 Recent developments in public safety

Public safety provides a solid basis for national economic and social development and helps to maintain the smooth operation of government administration. Since the 9/11 attack in 2001, significant attention has been allocated to public safety worldwide, and many countries have included public safety in their national strategies. The United States, Britain, Japan, and Germany have established contingency management and response systems to

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ensure an efficient response to emergencies. The United States developed the "National Incident Management System (NIMS)" in 2004, issued *Presidential Policy Directive No. 8 on Homeland Security* in 2003 [4] and began the Strategic National Risk Assessment (SNRA) scheme in 2011 [5]. The British government passed the *Civil Contingencies Act* in 2004 and produced the Cabinet Office Strategy Report "Risk: Improving Government's Capability to Handle Risk and Uncertainty." A nation-wide risk analysis and evaluation was initiated in Britain in 2005 to prepare for major risks over the next five years [6]. Japan has established a disaster prevention and mitigation information system as well as an emergency response system; the system connects the central government to local offices. The German Ministry of the Interior has established a crisis management information system. In China, following the SARS event in 2003, the central government devoted significant attention to public safety issues and the national emergency response platform was developed. This platform effectively connects central government to local offices as well as different agencies at both provincial and municipal levels.

With the development of new technologies and the trend of globalization, the international community has reached a consensus around the issue of public safety. In 2015, the *Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework)* [7] was endorsed by the UN General Assembly. The *Sendai Framework* is a 15-year, voluntary, non-binding agreement, which recognizes the state as the primary actor in disaster risk reduction, but asserts that the responsibility should be shared with other stakeholders as well, such as local government and the private sector. The United States issued a progress report entitled "Crisis Response and Disaster Resilience 2030: Forging Strategic Action in an Age of Uncertainty [8]," which highlights the 2010–2011 insights of the strategic foresight initiative. The EU framework program for research and innovation, *Horizon 2020* [9], addresses the topic of "Secure societies—Protecting freedom and security of Europe and its citizens." The framework highlights the importance of undertaking the research and innovation activities necessary for the protection of citizens, society, and the economy, as well as the infrastructure, services, prosperity, political stability, and overall wellbeing. Among the primary aims of "Secure Societies" is the enhancement of our society's resilience to natural and man-made disasters. Japan has identified 13 priorities in scientific and technological innovation in its *Science and Technology Basic Plan (2016–2020)*, in which national security and three other priorities are directly related to public safety. China's *National Medium and Long-term Science and Technology Development Plan (2006–2020)* includes a systematic study of public safety science, technology, and its development and strategy.

In recent years, the development of public safety science and technology in China has progressed significantly [10]. China's public safety technology is classified into three levels: a level that leads in developments internationally (leading), a level commensurate with international standards (juxtaposition), and a level that lags behind in developments internationally (backwardness). Most developments fall into the latter category (Fig. 1, Fig. 2). The development of public safety science and technology still needs additional support to arrive at the desired point of transformation. More attention must be given to building capacity of technical competence [1].

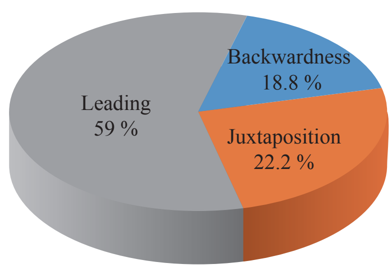

Fig. 1. The basic technology pattern in the field of public safety in China.

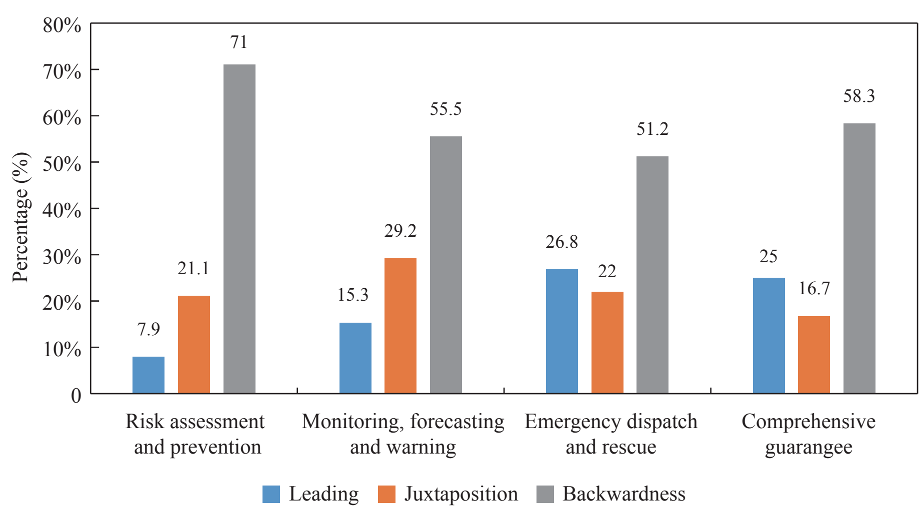

Fig. 2. The distribution of core public safety technologies in China.

3 The scientific system of public safety

The framework of the public safety technology system can be represented as a triangle, as shown in Fig. 3. The three sides of the triangle are emergency, affected individuals and objects, and emergency management. The hazard element links the three sides of the triangle. There are three types of hazard element: the matter, the energy, and the information [11]. Hazard elements cause emergency events when they reach a critical value or encounter one or more activators. The main task for the improvement of public safety technology is to guarantee public safety through research and the effective control of emergencies, affected individuals and objects, and emergency management. In the study of emergencies, research is needed about their evolution and mutation, as well as the risk types, intensity, temporal and spatial characteristics of the garnered substances, energy, and information. With regard to the affected individuals and objects, researchers examined their state and changes in emergencies and their process evolution, the possible destruction of the ontology and/or function, and the possible secondary and derivative events. For emergency management, researchers should study intervention best practices, which can be applied throughout the life-cycle of the emergency. These will prevent or reduce the occurrence of emergencies and minimize their impact; strengthen the disaster management capacity of the carriers, prevent an associated incident from occurring and reduce losses; and avoid the recurrence of emergencies, the destruction of disaster carriers, and excess costs of improper responses [12,13].

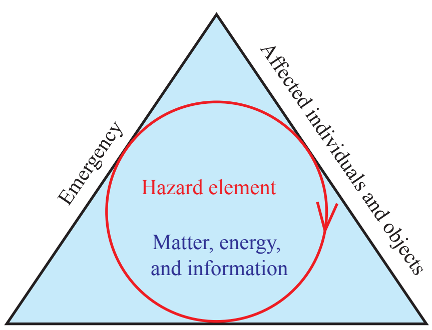

Fig. 3. Model of public safety framework.

As shown in Fig. 4, the core technologies of public safety include risk assessment and prevention, monitoring and prediction or forecasting, emergency response, and rescue and safety protection. Risk assessment and prevention technologies are aimed at preventing or reducing the occurrence of emergencies, weakening their impact, enhancing the resilience of the carrier, and enhancing emergency response capability. They include technologies focused on risk identification, analysis, and evaluation, as well as risk prevention and control. The aims of monitoring and prediction are to achieve a comprehensive monitoring of emergencies, accurate positioning and forecasts, and full coverage of real-time warnings. This is achieved with technologies focused on monitoring public safety as well as emergency prediction, emergency warnings, and the release of information. Emergency response and rescue technology is aimed at achieving an efficient emergency response, and includes technologies focused on disaster assessment; emergency decision support; location and communication; and personnel search and rescue, evacuation, and on-site disposal and control technology. Safety protection technology is aimed at providing support for the consolidated emergency rescue process that includes emergency preparedness, monitoring, early warning systems, rescue operations, and restoration and reconstruction to provide basic and technical support. This technology includes emergency process and capacity assessment technology. Other safety protection technologies address aspects such as public safety data support, public safety standardization, certification and recognition, public safety experimental testing and simulation, emergency scenario construction and deduction, public safety training, and popular science education.

4 Goals and tasks for the development of public safety science and technology

4.1 Development ideas

Current development ideas adhere to the guiding principle of "independent innovation, key leapfrogging, supporting development and leading the future." We are standing in the present and looking to the future, with hopes of strengthening the application and comprehensive integration of new advanced technologies. Another key idea relates to the strengthening of the research and development of key technologies, such as real-time perception and prediction, big data analysis and decision-making, and multi-functional intelligent emergency equipment. Focus is placed on "safety" and "wisdom," and necessitates the adoption of scientific and technological innovations as the driving force, risk prevention as the foothold, and effective response and improved safety resilience as the goals. Other key objectives are the construction of an omni-directional stereoscopic public safety net, which will be systematically deployed to break through key barriers to realize the transformation of our public safety from a position of passive coping to proactive security.

4.2 Development goals

Current development goals include the improvement of the public safety system, construction of an omni-directional stereoscopic public safety net, and creation of a safeguarding society [1]. With regard to risk assessment and prevention, we aim to control the existing risk and identify future risks. With regard

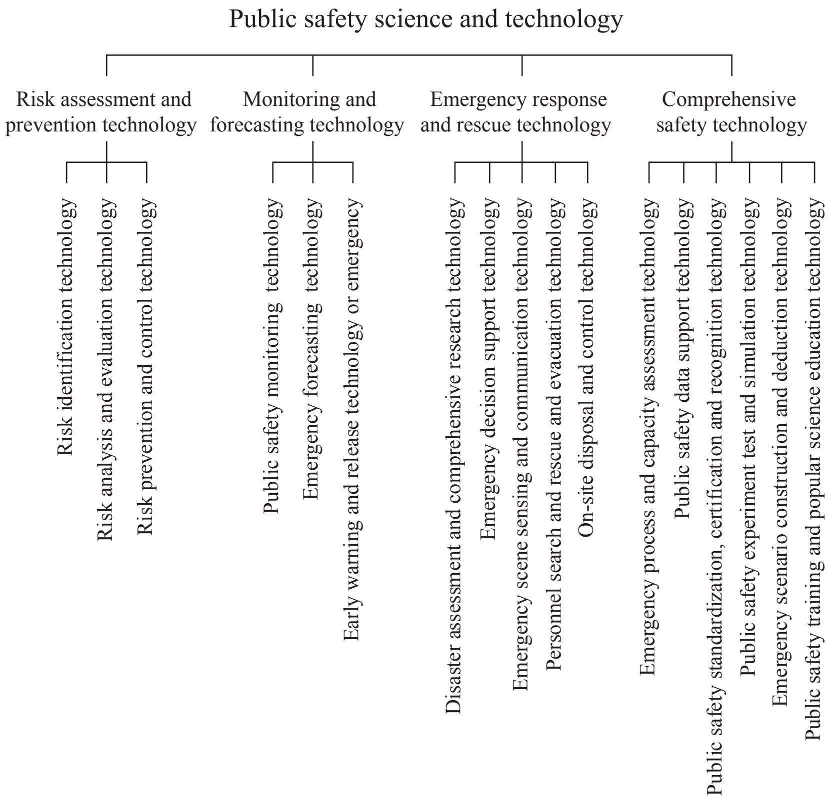

Fig. 4. Key technology systems of public safety

to monitoring, current focus areas are forecasting and warning, realization of comprehensive information perception, multi-source fusion of data, high intelligence prediction, and accurate release of early warnings. In terms of emergency disposal and rescue, our goal is to establish an effective emergency command, an orderly emergency coordination, and an efficient emergency dispatch. Lastly, with regard to public safety and security, we aim to sustainably strengthen the resilience of cities and communities through the in-depth sharing of emergency resources, and integration of emergency platforms and equipment.

4.3 Key direction

Current key directions are to meet the future development needs of close linkage, wisdom, and resilience management of the complex and public safety system "risk–forecast–disposal–security"; to construct an omni-directional stereoscopic public safety net; and to guarantee the interdisciplinary, cross-level, inter-temporal, and trans-regional public safety system. Key directions of development for public safety science and technology are as follows.

4.3.1 Whole-life and full-cycle risk assessment and prevention

Whole-life and full-cycle risk assessment and prevention is based on the development and the innovation of risk assessment and prevention technologies, such as multi-hazard, multi-scale, and multi-physical field synthesis, and systematic risk assessment technology; multi-hazard coupling disaster simulation processes and scenario construction technology; and technology used for assessment of potential and unknown risks. This supports optimal risk prediction and assessment in quantitative and systematic ways.

4.3.2 Deep coordination of multi-hazard and multi-domain processes in disaster monitoring, prediction, or forecasting

This aspect takes into consideration multiple factors and interactions in the development of public safety simulation using predictive or forecasting technology, multi-domain coordinated systematic monitoring, and early warning technology to help develop integrated systems for monitoring, prediction, and early warning. Some of these factors include the atmosphere, ocean, biological factors, solid earth interaction, and multi-hazard interaction.

4.3.3 Deep integration of interregional, cross-level, and interagency technologies for emergency response

Development of multi-functional and integrated emergency response technologies is key, to enable the support of a highly-organized and effective emergency rescue process through dynamic situational awareness and in-depth sharing of information. The technologies included relate to multi-functional and integrated emergency on-site response; rapid evacuation and refuge; multi-dimensional, real-time information transmission; public opinion analysis; virtual simulation; automatic search and rescue; human injury assessment; the integration of man-machine-object online emergency awareness; and emergency robot technology.

4.3.4 Standardized public safety and emergency response equipment and instrumentation

Objectives for this section are: to carry out basic scientific procedures, common key technologies, technical standardization, and industrialization research, and to develop a complete set of standardized, systematic, and intelligent emergency equipment, thus creating comprehensive enhancement for emergency support capabilities [1].

4.3.5 Integration platform for public safety protection

Bearing in mind the requirement of business continuity management and cross-industry integration for public safety, objectives for the integration platform are to develop and construct a comprehensive public safety platform to ensure risk assessment and prevention, monitoring, prediction, emergency response, and rescue. An additional objective is to achieve the integration of traffic safety, chemical control, public opinion supervision, anti-terrorism measures, electrical safety, water security, and improvement of public safety protection capabilities.

4.4 Major scientific and technological research and engineering construction tasks

4.4.1 A large public safety simulator with multilayer coupling and multi-domain fusion

Simulation technology considers the interactions between atmosphere, ocean, biology, and the complexity of solid earth, to simulate and express each layer of the earth's system, including physical and chemical processes and interaction mechanisms. Another task focuses on the study of risk assessment technology of the comprehensive index system, data statistics, and scenario evolution to realize the whole-chain risk assessment and the whole life-cycle management of dangerous chemicals and key facilities (dangerous chemical warehouses, city pipe networks, deep sea pipelines, transportation hubs, etc.) as well as significant energy infrastructure (electricity, oil, gas, hydrogen). Researchers should also aim to study technologies related to large-scale crowd risk warning and evacuation counseling, large-scale traffic evacuation simulation, emergency traffic assessment techniques, and construction of a regional evacuation shelter system. Other technologies that should be addressed are related to the perception, reproduction, simulation, and deduction of major disaster scenarios, realization of the effective superposition of digital and physical field information, and realization of the simulation and scenario deduction of complex disasters and its development and evolution processes. Studies should also address technologies concerning network public opinion propagation deduction, simulation and deduction of special individual identification, and tracking and tracing processes for counter-terrorism prevention, to realize the integration of event simulation and extrapolation from online to offline. Researchers should also focus on the simulation technology of the power system, water conservancy system, and other industries related to public safety, which will allow multi-event deduction and event chain deduction. Finally, researchers should construct simulations with multi-loop coupling, multi-domain fusion, and emergency evolution-integrated simulators.

4.4.2 Omni-directional stereoscopic public safety net

Objectives related to this project involve the establishment of a comprehensive three-dimensional public safety net to conduct horizontal and longitudinal node research. The horizontal node research should focus on risk assessment and prevention; monitoring, forecasting and early warning; emergency treatment and rescue; and public security-integrated support. Longitudinal node research should focus on traffic safety, dangerous chemicals, public opinion, anti-terror, electricity security, and water security. In addition, researchers should strive to achieve interconnection among network nodes, to break through the bottleneck of key technology innovation and key equipment research in the field of public safety, to solve the core scientific and technical problems of public safety, and to realize in-depth integration of the industries in the creation of an omni-directional stereoscopic public safety net.

4.4.3 Urban public safety and resilience project

With the acceleration of urbanization, the number of large cities, mega-cities, and urban agglomerations is growing. The urban public security situation is grim, and the vulnerability of densely inhabited districts, road traffic, and the pipe network is increasing. To decrease the public risk of densely-inhabited districts that transformed cities (towns) into emergency risks, we must establish a behavior database that aligns with the characteristics of all people in China, as well as a platform that monitors, identifies and evaluates urban dynamic risk based on multi-source data. We must use GIS, mobile interconnection, the Internet of Things, and other new technologies comprehensively to build rapid evacuation and refuge systems, resulting in an intelligent and connected city. The life-cycle management of factors such as urban planning, important facilities, and key places should be implemented to ensure the efficient and smooth functioning of these factors. In short, we must build a unified national platform for urban safety management and resilience.

4.4.4 Construction of public safety research bases

Based on our research, we recommend the construction of a number of internationally advanced public safety research bases, such as national laboratories, engineering centers, and innovation centers, including those that carry out experimental research on the reappearance and coupling mechanism of emergencies.

Another important objective relates to the construction of a large experimental research base for the development and evolution of responses to primary emergencies, secondary events, and event chains. In addition to the research base, we recommend construction of public safety testing centers and certification bases for product testing and equipment testing. Finally, research guides us towards the construction of experimental verification bases, databases and computing platforms, advanced visualization systems and platforms for the core technologies of the whole process simulation, scenario deduction, comprehensive research, decision-making, and emergency command.

5 Prospects and challenges

In the future, quantum technology, artificial intelligence, additive manufacturing, micro nanomanufacturing, biomanufacturing, new forms of energy, new modes of transportation, marine economy, space exploration, the Internet of Things, and other emerging technologies will provide significant conveniences and benefits for human life. Meanwhile, new risks to public safety will also be created by evolving situations such as global economic integration, the aging of society, the intensity and frequency of natural disasters, and terrorism.

5.1 Assessment of unknown risks

New technologies create new risks. The ability to maintain an awareness of unacceptable or unrecognized potential risks posed by new technologies, new materials, new industries, or new policies is extremely important for the future of public safety. The application of the Internet of Things, big data, cloud computing, artificial intelligence, simulations, scenario deduction, and other technologies may help in the assessment of unknown risks.

5.2 Future prediction and deduction methods through the integration of "data-computing-reasoning"

Based on the future development of a deduction "data-computing-reasoning" integrated method, it will be possible to achieve life cycle monitoring; forecasting; and early warning about key sites and facilities, important energy reserves, and major projects. In addition, it will be possible to predict the influence of the future technology revolution and shifting global trends on the public safety situation from the perspective of network coverage. This will result in a future-oriented public safety response system.

5.3 Public safety with ubiquitous information and the Internet of Things

Unlimited data and storage space as well as unlimited bandwidth will become available with technological developments in the field of computing and communication. A number of elements will bring about great challenges to the development of safety science and technology, as well as the enhancement of public safety governance and services. This includes the Internet of Things, consisting of human-computer interaction, and highly integrated and personalized data acquisition, processing, and analysis. It also includes interaction and collaboration between government, institutes, and individuals and the leveling of the decision-making hierarchy and process.

In facing future challenges, it is necessary to advance public safety science and technology to develop a safety-oriented society. Public safety science and technology will protect and support the creation of a harmonious society.

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