THE TOP-LEVEL DESIGN STUDY FOR THE INTEGRATED DISASTER REDUCTION INTELLIGENT SERVICE

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Abstract
Geo-spatial information technology can provide data resources, positioning benchmarks, basic framework and key technologies for disaster prevention and reduction. At present, there are some problems in China's disaster reduction services. Too much emphasis is placed on decision-making and not on early warning. In addition, the technology, system and application integration of disaster reduction services is not enough. There is still a lack of a unified understanding and a holistic top-level design guidance framework of disaster reduction services. In order to solve the technical problems of integrated perception, location, integration and comprehensive scene simulation of emergency information such as disaster events, various disaster-bearing bodies and the disaster-pregnant environment, and knowledgeable disaster reduction services, this paper returns to the nature of disaster reduction services, outlines the background of the concept of top integrated design of the integrated disaster reduction intelligent services, puts forward and explains the concept, connotation and characteristics of the integrated disaster reduction intelligent services from the perspective of surveying, mapping and geoinformation. Besides, an integrated disaster mitigation intelligence services architecture is designed with the consideration of the demand for disaster prevention and reduction services. This enterprise architecture is composed of the perception layer, the network layer, the technology layer, the system layer and the application layer. Finally, the paper mainly elaborates comprehensive disaster reduction technology system, including high-precision indoor and outdoor seamless positioning, accurate integration of spatial information, emergency scenarios integrated simulation and intelligent information services as the core technology in complex disaster environment, and formed the intelligence, totalization, integration and accurate thinking of disaster reduction services technology. The proposed top-level design for the integrated disaster reduction intelligent services can solve the integrated perception, positioning, integration and simulation of the scene, and intellectualized disaster reduction services and other technical problems.

Keywords: Disaster Reduction; Intelligent Services; Top-level Design; GIS.

INTRODUCTION:

China is one of the countries which seriously affected by natural disasters in the world. According to the statistics of the past 5-20 years, there are 3573.5 people died in the earthquake in China, and the average annual economic losses were 29.587 billion yuan in every year. The annual average number of deaths caused by geological disasters such as landslides, collapses, and mudslides were 1,090, so economic losses were between 12 and 15 billion yuan; The annual death toll from floods and disasters was 1647.8 people, and economic losses were 110.634 billion yuan[1-2]. Affected by the coupling of natural, economic and social factors such as global climate change, extreme weather events, and their secondary disasters will increase in the future. Destructive earthquakes are still frequent occurrences. The suddenness of natural disasters, abnormalities and complexity have increased. At the same time, there are some problems in Chinese disaster reduction services. Too much emphasis is placed on decision-making and not on early warning. The integrated disaster reduction services system is incomplete. Local governments at all levels have weakly integrated disaster prevention and reduction capabilities[3-5].

At present, comprehensive disaster-relief “intelligent” technology to solve the predictable, controllable and preventable issues of emergency disaster incidents has been the consensus view of experts in related research fields at home and abroad. In the past decade, “intelligent” system for comprehensive disaster reduction has been applied and validated in a few developed countries or regions. The National Emergency Management System (NIMS) was established in 2008. Implementing a cross-section using the life cycle model, multi-event emergency management guide all departments, governments at all levels, non-governmental organizations, and private organizations to collaborate[6-7]. The Copernican Emergency Management Services Center (EMS) is an emergency management services center in the European Union.
which provides timely and accurate geospatial information services for human-made emergency events and humanitarian crises\cite{8,9} services. The earthquake and tsunami warning system built-in Japan that covers the whole country, the disaster information system, emergency response support system, and early evaluation system were established\cite{10,11}. The Korean U-City plan is a redefinition of future high-tech cities. It integrates IT infrastructure, technologies, and services to provide intelligent city services for urban housing, urban economy, and urban transportation. Among them, U-Facility Management(FM) can not only provide services for the allocation and efficient use of urban facilities. And more importantly, it can provide very flexible resource scheduling services in the emergency handling process\cite{12,13}.

Modern spatial information technology has become a universally adopted high-tech method for disaster prevention, disaster reduction, and disaster relief in various countries. It can provide data resources, positioning benchmarks, basic frameworks, and key technologies for disaster prevention, disaster reduction, and disaster relief. It plays an irreplaceable role in public safety management. With the increasing popularity of the Internet, artificial intelligence, Internet of things, and communication technologies, the location-related disaster-afflicting bodies, and typhoon-related environmental data have become increasingly abundant. Uncertainty, unpredictability, and complexity of emergencies require that comprehensive disaster reduction services technologies continue to be integrated, integrated, spatialized, refined, and intelligent\cite{14,15,16,17}. It is urgent to solve technical problems such as the integration of disaster events, various disaster-afflicting bodies, and typhoon-prevention environments, as well as the integration of sensing, positioning, integration and scenario simulation, and knowledge-based services. Spatial information technology provides an important role for emergency decision-making, disaster prevention, and reduction, and has an irreplaceable role in public safety management. The top-level design of the integrated disaster reduction intelligent services proposed in this paper is mainly from the perspective of information technology. Based on mapping geographic information technology and various information carriers such as Beidou networks, communications network, Internet and sensor networks, it builds a comprehensive disaster reduction technology system with high-precision indoor and outdoor seamless positioning, accurate spatial information integration, integrated simulation of emergency scenarios, and intelligent information services in complex disaster environments. Independently developed an integrated, full-flow integrated disaster reduction intelligent services system. A multi-level comprehensive disaster reduction application demonstration system was established for different disasters.

1. THE CONNOTATION AND CHARACTERISTICS OF THE INTEGRATED DISASTER REDUCTION INTELLIGENT SERVICES

The Integrated Disaster Reduction Intelligent Services, which integrates advanced technologies like public safety, artificial intelligence, big data, cloud computing, Internet of things, network communications, etc, is based on mapping and GIS technology. By fully perceiving the disaster site, the services can enhance the relationship of things-things and things-persons and comprehensively, accurately, grasp the dynamic trend of various risks in real-time, and predict and prevent and control possible dangerous accidents and emergencies. After a crisis event occurs, the services can do information sharing and coordination and cooperation, and the full integration of people and technology can be achieved, too, and all of these make the prevention, mitigation and relief management of disaster more intelligent, efficient, and secure. The Integrated Disaster Reduction Intelligent Services is a comprehensive systematic project, which can achieve information sharing and collaboration among different departments and systems when facing up complex disasters, and more intelligently perceive and analyze and handle disaster events and make full use of existing resource to make the best management decision so that incidents and disasters can be predicted in time. Utilizing Information and intelligent methods to help the reduction and relief of disaster, which can minimize the number of casualties and economic losses\cite{15}.

The disaster reduction services refer to the services that provide disaster reduction and mitigation and damage-loss protection in the entire process of disaster management, including prevention and preparation, monitoring and early warning, disposal, and rescue, recovery and reconstruction. Intelligence is the core of disaster reduction services. It requires the ability to automatically identify users' explicit and implicit needs, and actively, efficiently, and safely provide the services they demand. Comprehensiveness is the essence of disaster reduction services. It mainly deals with various natural disasters and their entire processes, and comprehensively studies and integrates them. Integration is the foundation of disaster reduction services. It is a service that integrates multiple independent resources and provides them with the same system to accommodate each other, cooperate with each other, and work together. Accuracy is the requirement of disaster reduction services. It is mainly aimed at different disaster environments and different disaster services targets. It provides precision in the concept of time, accurate spatial location, and refined services content.
The integrated disaster mitigation intelligence services have its own characteristics, which are mainly reflected in (1) Comprehensive and thorough sensing. Through sensing technology, various aspects of urban security management are monitored and sensed. Utilizing all types of intelligent sensing devices and systems to monitor all aspects of the city's environment, status, and location, monitor potential hazards, integrate, analyze, and process perceived data, and integrate it with intelligent emergency services to promote each key system of city operate safely and efficiently. (2) Broadband ubiquitous interconnection. In urban integrated intelligent disaster reduction, various types of broadband and wireless technologies provide the basic conditions for urban applications. Broad interconnection as the "neural network" of smart cities greatly enhances the ability of intelligent emergency response as an adaptive system for information acquisition, real-time feedback, and intelligent services at any time and place. (3) Ubiquitous positioning. Positioning terminals based on GNSS, Bluetooth, UWB, WIFI, etc. can achieve high-precision indoor and outdoor seamless positioning\(^\text{[18]}\), obtain real-time and accurate position information, and use the multi-positioning system coordination platform to collect, transmit and process information collected by various positioning system data collection terminals. So it can provide real-time and effective location services information for emergency decision-making and command systems. (4) Efficient and rapid processing. The integrated disaster reduction intelligent services system is a complex integrated system. The application of a new generation of comprehensive sensing technology has increased the city's massive data. Based on cloud computing, storage, calculation, and analysis of massive data is implement through the application of intelligent fusion technology, which greatly improves the ability of decision support. (5) Smart collaborative services. The integrated disaster reduction intelligence service is a comprehensive system engineering. In the face of complex disasters, different departments and systems in the city can achieve information sharing and collaborative operations, and more intelligently perform disaster awareness, analysis and disposal, make full use of resources, and make the best city development and management decisions, timely forecast and response to emergencies and disasters.

### 2 OVERALL STRUCTURE OF COMPREHENSIVE DISASTER REDUCTION INTELLIGENCE SERVICES

The entire process of comprehensive disaster reduction, including advance prevention, disaster warning, disaster relief, and post-disaster recovery, will accomplish the integration of surveying and mapping geographic information technology, computer communication technology, and public safety management technology, establishes a new model for geospatial information technology to support public safety. The overall design with integration, comprehensiveness, intelligence, and precision as its core has initially achieved the integration of software systems, key technologies, and application services, and has established a system of technology, and apply a three-level index project management system. Using the model library-driven decision analysis and intelligent services technology, an integrated, full-flow integrated disaster reduction intelligent services system was developed. The overall architecture design of the project is
divided into five basic levels. As shown in the following figure, the design concept of an integrated disaster reduction intelligent services can be fully demonstrated through the division of effective hierarchical structure services.

![Figure2 Overall structure of the integrated disaster mitigation intelligence services](image)

(1) Perceptive layer

Perception layer is the data resource foundation of the integrated comprehensive disaster reduction intelligence services, and is a key part of comprehensive disaster reduction information collection, it consists of a basic sensing device (composed of basic identification and sensor components such as RFID tags and readers, various types of sensors, cameras, GPS, two-dimensional code labels, and readers), a network of sensors (RFID network, sensor network, etc.), and terminal devices such as mobile phones, tablet computers, and telephones.

The sensory layer is the data resource foundation of the integrated disaster reduction intelligent services and is a key part of comprehensive disaster reduction information collection. The network consists of basic sensing devices, which consist of basic identifications and sensor components such as RFID tags and readers, various types of sensors, cameras, GPS, two-dimensional code labels and readers, and sensors (RFID networks, sensor networks, etc.) and terminal equipments which consist of mobile phones, tablet computers, telephones, etc.

(2) Network layer

The network layer mainly implements the transmission of the integrated comprehensive disaster reduction intelligence services data, and is composed of Beidou network, communication network, Internet, and sensor network, and is seamlessly connected with the sensing layer, it is the basic security for integrated disaster reduction navigation positioning, disaster situation perception, disaster data transmission and emergency communication command.

(3) Technical layer

The technical layer is the technical support for the construction of project application systems, through the development of key technologies such as spatial orientation, fusion processing, scene modeling, rapid mapping, model analysis, and decision-making services for typical disasters, the integrated comprehensive disaster reduction intelligence services process model is established, to implement the integrated innovation of surveying and mapping geographic information technology, positioning and communication technology, geographic information services technology and public safety management technology.

(4) System layer

The system layer is the construction layer of the practical application system, through the establishment of the related integration mechanism at the technology layer, independently developed an integrated, full-flow comprehensive disaster
reduction intelligence services. The system layer has the functions of emergency rescue command, 3D scene of disaster scene, real-time acquisition of emergency personnel equipment position information, rapid emergency drawing and so on, and support emergency semantic model-driven scheduling aggregation and full-process emergency services, and provide software platform support for national, departmental and local application demonstration.

(5) Application layer

The application layer mainly provides comprehensive disaster reduction intelligence services for three levels of users, which can implement new application methods, such as seamless connection of indoor and outdoor positioning, integration of scene expression, personalized presentation of information content, and active push of business functions for different disaster environments. Six types of disasters, including earthquakes, floods, geological disasters, urban fires, traffic accidents, and collapse of buildings, were used for demonstration applications at the emergency office of the State Council, five ministries, and five local governments.

3 TECHNOLOGY CONTENT OF COMPREHENSIVE DISASTER REDUCTION INTELLIGENT SERVICES

Comprehensive Disaster Reduction Intelligent Services, CDRIS, is researched among the soft hardware system of whole flow comprehensive disaster reduction intelligent services, which faces high-accuracy positioning, integration and analysis and knowledge services. The Comprehensive Disaster Reduction Intelligent Services implements the function including emergency rescue command, disaster on-site 3D scene, emergency personnel equipment location information real-time acquisition, etc. and forms a technological system based on Indoor and outdoor integration position and built a technology system on Indoor and outdoor multi-scale geospatial information fusion and visualization and finally accomplish multi-department and multi-level’s demonstration application. The technology content of the Comprehensive Disaster Reduction Intelligent Services mainly reflects intelligence, comprehension, integration and accuracy.

(1) Intelligence

Intelligence is the core of CDRIS, where intelligent positioning services, multi-source data fusion processing services, disaster on-site 3D scene visualization services, rapid mapping services, disaster modeling analysis services, emergency decision-making services, etc. contains. Spatial location in disaster environment, which can intelligently awareness and offers current user’s related location information and other useful information based on existed data mining, gradually develops towards the location-aware intelligent services that is under services-driven model. Multi-source data’s integration process utilizes characteristics like multi-source and multi-scale, and chooses three data processing methods including automatic semantic matching and conversion, self-heuristic fusion strategy and disaster reduction data activation to integrate data and ultimately implement the rapid integration of indoor and outdoor multi-source disaster information and multi-scale spatial information. The intelligence of disaster scene’s 3D modeling can implement disaster scene’s rapid awareness, self-adaptive automatic construction and disaster scene’s enhanced expression, and provide users with a displayed, analyzed and explored scenario. The intelligence of self-adaptive rapid mapping forms disaster mapping knowledge rule base to construct different types of mapping data and the collection of mapping relations about thematic symbols, and offers various map decoration templates and disaster map production services that adaptively provides different participation modes for user roles. By building up united model group management frame, disaster modeling analysis services actively integrates every single distributed heterogeneous model library and intelligently infer disaster’s whole process with combining disaster chain analysis, and implement intelligent call and uniform calculation of models in a model group when facing a complex disaster scenario, and use intelligent semantic analysis to implements human-computer interaction intelligent services with human-computer interaction interface. The intelligence of emergency decision-making services fully considers pre-disaster prevention, early warning and rescue during disasters, post-disaster reconstruction and assessment, with combining disaster spatial information integration, disaster scene fusion and enhanced visualization, self-adaptive dynamic mapping, and the technology of disaster model construction and management to build an united integrated disaster reduction intelligent services system. And then implements the intelligence in comprehensive disaster reduction decision services like situational awareness of location and visualization services, disaster reduction models intelligent services, online emergency plan matching and command decision-making, personalized knowledge recommendations, etc.

(2) Comprehensiveness

Comprehensiveness is the essence of Comprehensive Disaster Reduction Intelligence Services, which mainly reflected in the comprehensiveness of multi-source information resources, disaster modeling analysis, inter-departmental disaster reduction business, multi-level demonstration application, etc.
The comprehensiveness of multi-source information resources is an important breakthrough point to increase the breadth and depth of integrated data about the Comprehensive Disaster Reduction Intelligent Services, to process and comprehensively analyze some types of disaster information and can classify and archive data effectively and at the same time, according to the demonstration application scene field data, dynamic data access of multiple sensors, simulation analysis information data, and spatial data, basic disaster data can be provided. The comprehensiveness of disaster model analysis is of great significance for comprehensively analyzing various types of disasters by constructing model groups, for different types of disasters, models can be called on demand and aggregate dynamically with using specialization model based on different disaster scenario and building up typical disaster distribution and heterogeneous model library. With parsing the basic information of an incident and the need for emergency management users, task-oriented and emergent-semantic-driven disaster models analysis services can be achieved.

The comprehensiveness of inter-departmental disaster reduction business can be achieved by multi-sector disaster business coordination and multi-sector consultation and decision-making. With combining the existing work foundations of disaster departments, multi-level demonstration application, builds up intelligent services application demonstration system to implement integrated and the whole processing comprehensive disaster reduction services for disasters such as earthquake disasters, flood disasters, geological disasters, hazardous chemical disasters, urban fires, traffic accidents, forest fires, collapse of buildings, stability, etc.

(3) Integration

Integration is the foundation of comprehensive disaster reduction intelligent services, which is mainly reflected in the integration of indoor and outdoor positioning, disaster reduction services process, soft-hardware equipment and technology-system-application-standard. The integration of indoor and outdoor positioning utilizes the Beidou-based star-based multi-GNSS composite system, ground mobile communication positioning network and UWB, Wi-Fi, Bluetooth indoor base stations and sensors such as PDR and INS and choose. The data fusion algorithm is used to process the above-mentioned multi-source data to solve the problem of integrated positioning in strong signals, weak signals, and no-signal scenes. The integration of disaster reduction services processes is surrounded by advance prevention, early warning, disaster relief and disaster recovery to implement data acquisition and integration, data processing and analysis, comprehensive disaster reduction intelligence services and multi-level application demonstration, including functions like emergency rescue command, 3D scene at disaster site, and real-time acquisition of emergency personnel equipment location information, etc. An indoor and outdoor integrated positioning technology system need to formed and an indoor and outdoor multi-scale geospatial information fusion and visualization technology system will be established. The integration of software and hardware equipment through independently developing emergency positioning terminal, constructing emergency positioning network test field, researching The integrated disaster reduction services system, to achieve the integration of emergency positioning terminal hardware and software, scene modeling and visualization enhancement software and hardware, and perceived devices and services systems hardware and software.

Technology-system-application-standard integration focuses on key technologies such as indoor and outdoor location, fusion processing, disaster scene modeling, adaptive mapping, and intelligent services. Combining supporting technologies like the Internet of Things, cloud computing, and big data, the comprehensive disaster reduction intelligent services system was established and is applied to the demonstration of intelligent disaster mitigation services for typical disasters, condenses technologies, systems, and applications, and formulates standards and guidelines for disaster prevention and mitigation services.

(4) Accuracy

Accuracy is the requirement for disaster reduction services. Accuracy mainly includes disaster emergency positioning network, indoor and outdoor positioning of dedicated data collection terminals, indoor and outdoor data fusion of buildings, multi-granularity services, and precision matching of different user needs. The rapid networking of the emergency location base station, which is of great significance for achieving accurate rescue in the case of complex disasters, can provide initial value of base station location with rescue workers. Due to the suddenness and diversity of disaster events, the rapid and accurate positioning of the network has become a necessary method to save the lives and property of the people and achieve efficient and safe rescue. The indoor and outdoor positioning of dedicated data collection terminals integrates various information carriers such as Beidou network, communications network, Internet, and sensor network, in outdoor scenarios, the dynamic positioning precision of the high-precision dedicated data collection terminal is better than 1 meter, and the positioning precision of UWB and other indoor high-precision professional data acquisition terminals is better than 1 meters. The precision of indoor and outdoor data fusion of buildings is achieved by considering time, environment, structure, and spatial relationships of indoor and outdoor disaster information, then implement indoor and outdoor multi-source information fusion, and multi-scale integration of large-scale maps and indoor scenes. Finally, indoor and outdoor geography spatial information fusion accuracy is better.
than 0.5 meters. The precision of matching multi-granularity services and different user’ needs is to properly granulate the services according to different user requirements, and accurately match multi-granular emergency services with different user needs, thus making the rescue more efficient and efficient.

4 INTEGRATED DISASTER REDUCTION INTELLIGENT SERVICES SYSTEM CONSTRUCTION

Considering typical disaster scenarios and the comprehensive analysis of the whole process of disaster reduction, including the prevention, the warning, the rescue and the reconstruction, the integrated disaster reduction information intelligent service serving leadership decisions and rescue command is built up, and then we construct the Integrated Disaster Reduction Intelligent Service System. The system mainly consists of disaster information management and database construction, emergency events and perception, emergency information extraction and statistical analysis and deduction, comprehensive disaster reduction, emergency model smart services and integrated disaster reduction to demonstrate the application and so on six core modules, In addition, it also includes auxiliary function modules and components such as emergency duty, preplan drill, comprehensive experiment, real-time road condition, WeChat platform, common link, popular science publicity and system setting, etc. The main interface of the system is shown in figure 3.

![Figure 3 The integrated disaster reduction intelligent services system main interface.](image)

![Figure 4 Disaster information management and building module.](image)
The main content of the integrated disaster reduction intelligent services system is as follows (as shown in figure 4-figure 6). (1) The module of disaster information management and database construction contains basic information, emergency thematic information, emergency historic information and related disaster information. Specifically, the basic information contains population, economy, legal person, etc. The emergency historical information and relevant information of Internet mining. By integrating all kinds of emergency information, Multi-level feature extraction and multi-level correlation analysis are carried out. Finally, an emergency knowledge base is established. (2) The location and sensing module of emergency events include the location of disaster events, the integration of the indoor and outdoor areas of disaster, and the intervention of disaster site perception information, etc. The real-time positioning and visualization of a 3D scene of personnel, vehicles and relief materials are accomplished. (3) The emergency information extraction and statistics module mainly implements the extraction, integration, correlation and statistical analysis of all kinds of disaster information within the scope of the disaster. (4) The emergency model analysis and deduction module not only implement the general spatial analysis model, such as personnel evacuation, two-dimension path analysis, earthwork calculation, spatial overlay analysis, and buffer analysis, etc. It also includes the professional emergency disaster reduction model and two-dimensional analysis services of the typical disasters such as fire, earthquake, traffic accident and geological disaster. (5) The integrated disaster reduction intelligent services module implements the emergency rapid adaptive mapping services, the typical disaster knowledge mapping services, and the emergency services delivery services, etc. The integrated comprehensive disaster reduction intelligent emergency plan can be automatically generated. (6) The integrated disaster reduction demonstration application module mainly aims at the multi-level demonstration application of national, department and local level. In view of different disaster environments, new application forms such as the seamless connection of indoor and outdoor positioning, integration of
scene expression integration, personalized presentation of information content and active push of business functions are accomplished.

5 CONCLUSION

In order to solve the current problems in the information construction of disaster prevention and reduction in our country, such as individualized governance, low-level redundant construction, lack of sharing and integration of information resources, etc. and the improvement of integrated disaster prevention and mitigation capabilities, and to improve the comprehensive capability of disaster prevention and reduction. Through the breakthrough in high-precision seamless positioning, emergency and rapid adaptive networking, multi-granularity spatial information fusion, dynamic integration of disaster scenes and simulation integration expression, emergency rapid mapping, disaster model group management, disaster reduction intelligent services technology, the dynamic simulation and analysis problems of complex emergency scene and its evolution process are solved. This article gives an in-depth understanding of the top-level design of comprehensive disaster reduction intelligence services, based on the summary of studies on comprehensive intelligent disaster reduction services in recent years, the connotation and characteristics of comprehensive disaster reduction intelligence services are systematically described, and the overall architecture of comprehensive disaster reduction intelligence services is introduced, the technical content of comprehensive disaster reduction intelligence services was systematically analyzed from the four levels of intelligence, comprehensiveness, integration, and accuracy of disaster reduction services, at last, the construction of the integrated comprehensive disaster reduction intelligence services platform was introduced to promote the in-depth development and application of comprehensive disaster reduction intelligence services technology, and comprehensively improve the national emergency disaster prevention and reduction capabilities.

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REFERENCE


