THE STUDY ON 4S TECHNOLOGY IN THE COMMAND OF EARTHQUAKE DISASTER EMERGENCY[1]

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ABSTRACT :

With the rapid development of the 4S technology (RS, GPS, GIS, GPRS), the technology has widely been used in many fields (such as urban management, the management of mineral resources, land resource management, etc.). In seismic area, the technology has been successfully used in earthquake monitoring and forecasting and earthquake evaluating. However, in earthquake disaster emergency commanding area, considering the particularity of earthquake disaster emergency, the traditional commanding scheme of earthquake disaster emergency is difficult to adapt the increasingly complex social situation. In this case, the 4S technology can play an important role in solving the problems that exist in the command of earthquake disaster emergency command. The commanding system of earthquake disaster emergency based on the technology will be the trend of the earthquake disaster emergency command system.

In this paper, firstly, the problems in the command of earthquake emergency are analyzed, then the role and applied scheme of the technology in the command of earthquake disaster emergency are discussed too. Finally a framework of the commanding system of earthquake disaster emergency based on the technology is presented and some key technologies, such as the design of the earthquake disaster emergency database and application system, are also discussed.

KEYWORDS: Earthquake; Emergency; GIS; RS; GPS

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1. INTRODUCTION

As one of the largest natural disaster to human, earthquake is a serious threat to people's lives and property safety. A devastating earthquake often causes heavy casualties, or even destroys a city in a very short period of time. Since 1990s the number of earthquake accounted for 15 percent in influential disaster events, of which the number of death toll in earthquake accounting for 30 percent, economic losses accounting for 32 percent.

China as one of the countries having most serious earthquake, the number of death toll caused by earthquake accounted for more than 50 percent in the contemporaneous world's. The two imperial-scale earthquakes, causing more than 200,000 deaths, all occurred in china. In 5.12 Wenchuan massive earthquake in the May 12, 1998, the affected areas passed 100,000 square kilometers, and directly affected population passed 10 million with 30,000 people dead and 220,000 people injured and direct economic losses more than 500 billion.

Since the earthquake is an unavoidable natural phenomenon, it is difficult to forecast, therefore, effective earthquake disaster emergency action plays an utmost important role in reducing casualties, preventing the expansion of disasters and restoring social order, and of which key is to built the commanding system of earthquake disaster emergency, so that responding quickly and timely decision-making to actively and effectively organize and carry out disaster emergency relief in the time as shorter as possible, and minimize losses caused by earthquake.

In recent years, 4S technology, with GIS as its core, (Geographic Information System (GIS), Remote Sensing (RS), Global Positioning System (GPS) and General Packet Radio Service (GPRS) technology) has been developed by leaps and bounds. The technology in time and space-related areas, such as the environment, oceans, weather, the Board, geological and military aspects, has been widely applied in the protection of public safety, whether natural disasters or man-made industrial disaster, its monitoring, forecasting and assessment and disaster prevention, relief, rehabilitation, education and insurance, have also played an important role. Similarly, in the field of earthquake engineering, 4S technology has also been widely applied in seismic analysis, earthquake forecast, earthquake prediction, antiknock, disaster reduction, and other aspects of decision-making. In the earthquake disaster emergency commanding area, the application of the technology is also currently on a hot issue. This paper analyzed the application of 4S technology in the earthquake disaster emergency commanding area, on the basis of this, a framework of earthquake disaster emergency commanding platform based on 4S technology was presented.

2. THE APPLICATION ANALYSIS OF SPATIAL INFORMATION TECHNOLOGY IN THE EARTHQUAKE DISASTER EMERGENCY COMMAND

The command of earthquake disaster emergency involves a lot of process and links of post-earthquake, such as evaluation, disaster prevention, earthquake relief, rehabilitation, integrated management and etc. Which process and links all related closely to spatial and geographical elements, such as the temporal and spatial distribution, and intensity and frequency of earthquake disaster, the socio-economic disaster vulnerability and the ability of relief in disaster area, distribution of personnel, disaster emergency relief measures and contingency plans and so on. The advantages of spatial information technology can be played in the location and space-related content, with rational analysis and scientific decision-making, and making rapid responses to protect people's lives and property safety, and the public safety of community as much as possible.

Usually earthquake disaster emergency command includes the following three stages: preparation phase, response phase and analysis phase, and 4S technology can run throughout its entire process.

(1) Preparation phase

After the earthquake, communication systems are often destroyed in disaster areas, resulting in that disaster information cannot be reported in time, thus delaying the relief work, in such circumstances, the use of remote sensing technology with the advantages of low cost, fast acquisition, easy to update, and macro-strong, mass information and so on, can timely acquire remote sensing image data, adopt the disaster information through

comparing with the image data before earthquake, which will provide the first-hand information for the relief work.
On this basis, use GIS analysis to analyze the distribution about the emergency rescue personnel and relief supplies (ambulances, fire engines, etc.) around the earthquake disaster, the best path for rescue personnel and relief supplies to disaster areas, the impact to disaster areas caused by secondary disasters triggered by the earthquake, its reasonable path for evacuation, in order to facilitate rapid evacuation (evacuation and transfer). And these information can be marked on the map, to map out relief materials distribution scheduling route map, to transfer route map of people and materials in disaster areas and other relief thematic map. All of these information is the important reference for decision-making of rescue plan.

(2) Response phase

The response phase is mainly to provide rescue services for victims, such as search and rescue, shelter, medical supply and food supply. This phase also includes stabilizing rapidly social situation and avoiding the second major losses, etc.
At this stage, 4S technology plays an important role in the process of the disaster emergency response command, according to the analysis results in the preparatory stage, contingency plans can be formed, organizing relevant personnel to carry out rescue operations.
In the rescue process, through GPS navigation, according to the optimal path, the rescue personnel can quickly reach the disaster scene to carry out relief activities. At the same time, under the circumstances of ensuring communication conditions, the use of GPRS technology can send the information of disaster scene to the command center, providing support for further decision-making.

(3) Analysis phase

In the analysis phase, we can analyze and sum up the earthquake disaster occurred, to improve the database of contingency plans, which will provide reference for future earthquake disaster contingency plans. In addition, the analysis also includes the restoration analysis of damaged facilities, such as, the rehabilitation and reconstruction of damaged building, bridges, roads, drainage systems and hospitals, schools and other public facilities. 4S technology can be used for tracking, monitoring and management in the process of restoration.

3. OVERALL FRAMEWORK OF SYSTEM DESIGN

3.1. Design goals

Making full use of modern spatial information technology, communication technology, network technology and database technology builds earthquake emergency disaster commanding system, to provide the necessary technical support for earthquake disaster relief command of government departments. When the earthquake occurred, on the basis of seismic scene data and basic data, with the support of quick judgments on the seismic scale, affected areas and extent of losses, the system can put forward a series of scientific and feasible disaster relief schemes and scheduling schemes, which will assist the command staffs to implement various acts of earthquake disaster relief, achieve the rapid transmission and efficient processing of earthquake disaster emergency information, and improve skill on disaster emergency relief commanding and decision-making, to minimize confusion, casualties and economic losses in the earthquake.

3.2. Overall structural design

The system framework consists of three parts: operating system, technology system, and information support, the framework of its architecture as shown in Figure 1.

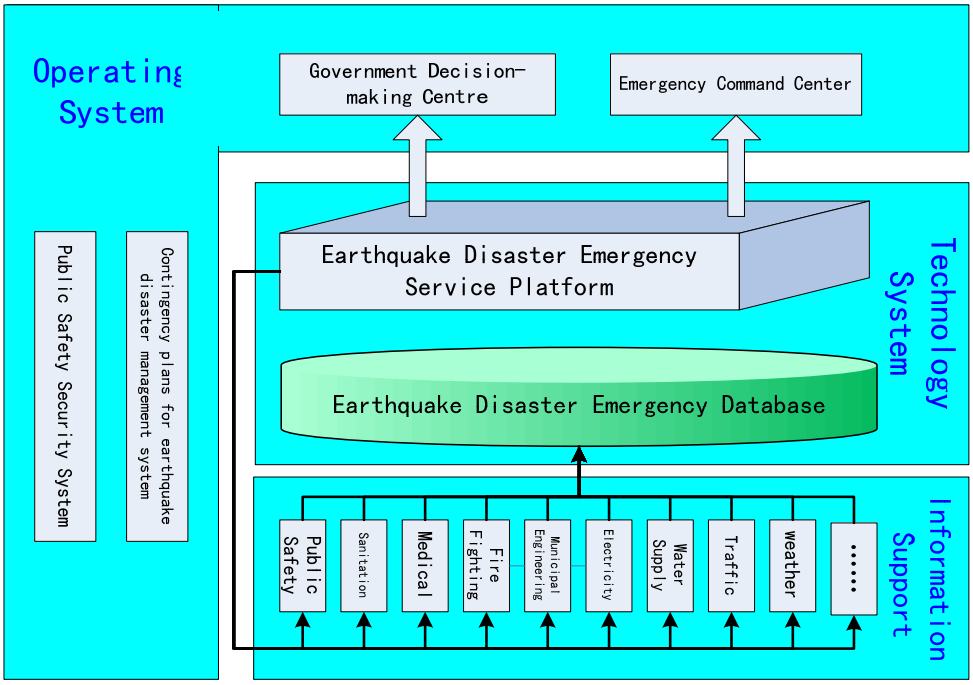

Figure 1. The architecture plans of Earthquake emergency command system

(1) Operating system

Operating system is the core and basis of the earthquake disaster emergency commanding system, including the relevant laws, regulations, various rules and the management system of earthquake contingency plans, and so on.

(2) Technology System

Technology system is a means and carrier to achieve operating systems. The earthquake disaster emergency database can be built, through collecting the information of city public security, sanitation, medical, fire, municipal, power, water supply, gas supply, traffic, weather and other department. Earthquake emergency disaster commanding service platform can provide decision-making support for the government by the analysis of the disaster.

(3) Information support

Information is the basis of city's earthquake disaster emergency service platform, the content of earthquake disaster emergency databases includes basic geographic data, the data of geological disasters, disaster assessment data, emergency resources data and the data of contingency plans, and other data.

3.3. Database design

Earthquake disaster emergency database includes basic geographic data, professional data, and support data three parts (as shown in Figure 2).

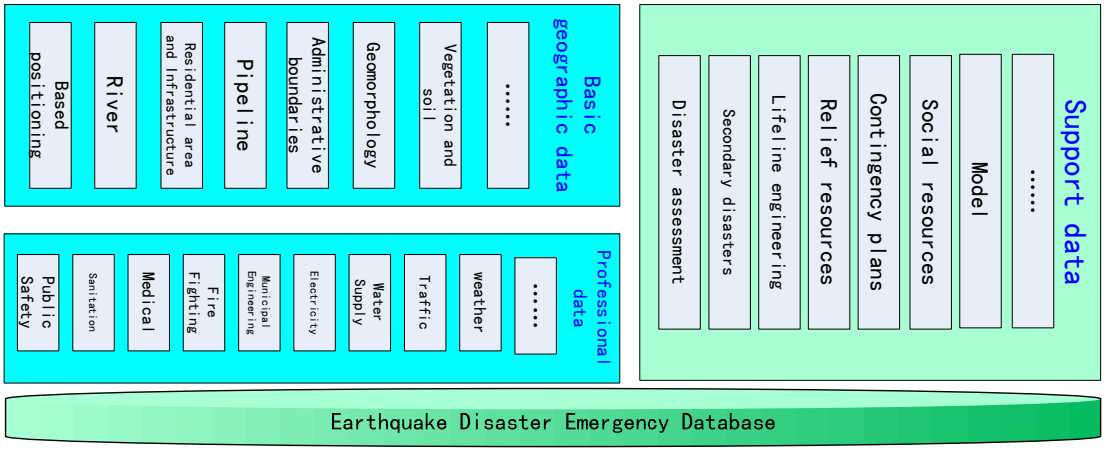

Figure 2. Data architecture of earthquake disaster support system

(1) Basic data

1) Basic geographic data

The data of this part includes: based positioning, river, residential area and infrastructure, pipelines, administrative boundary, geomorphology, vegetation and soil and so on.

2) Professional data

The data of this part includes the data of weather, traffic, water supply, electricity, municipal engineering, fire fighting, medical, sanitation, public safety, and other aspects.

(2) Support data

This data mainly includes disaster assessment data, secondary disasters data (landslides, mud-rock flows, Yan Sehu, fire), relief resources data (such as police cars, ambulances, fire engines, road road-block removed vehicles, rescue helicopters and emergency evacuation site), the lifeline engineering data (such as water pipelines, drainage lines, gas pipelines, telecommunications cables, power lines, substations, refueling stations, water sources and a major source of risk), contingency plans data, community resource data and model data, etc.

3.4. Functional model design

The function model of earthquake disaster emergency commanding system as shown in Figure 3:

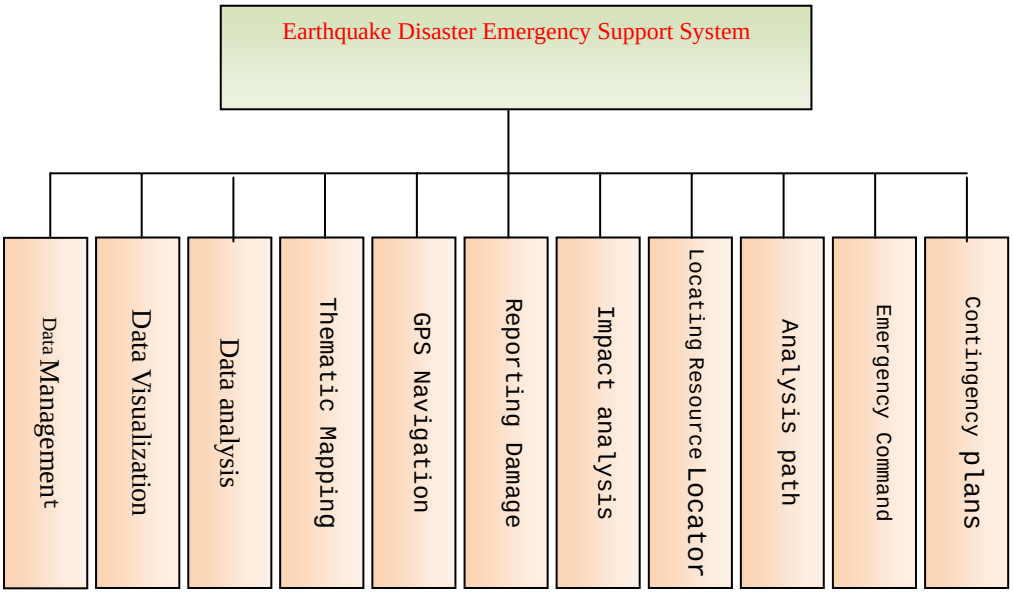

Figure 3. System model of earthquake disaster support system

(1) Data management

Data management is mainly used for management and maintenance of the earthquake disaster emergency database, specifically including the establishment of geospatial databases, the establishment and maintenance of layers, topology building and maintaining, the collection and validation of spatial data.

(2) Data visualization

It mainly includes the operation of zooming and panning of map, the setting of map shows, the control of map coordinates, the scale effect, legends, Hawkeye, and other contents related to map.

(3) Data analysis

Data analysis mainly contains the following areas: investigating attributes through graphic, investigating graphics through attributes, graphics positioning, buffer investigation, buffer analysis, statistical analysis, path analysis, graphics measurement.

(4) Thematic mapping

Provide various forms of thematic map information, such as road traffic map, distribution map of medical establishments, distribution map of fire fighting facilities, etc. in order to facilitate management, it provides the production function of different thematic maps, facilitating to get thematic maps when necessary. It can both output common thematic maps, and conduct statistical analysis based on thematic maps.

(5) GPS Navigation

In the process of scheduling vehicles, if vehicles equip with GPS, through GPS navigation, the vehicles will quickly and accurately reach the disaster scene.

(6) Reporting Damage

After the earthquake, providing a sound and multi-channel method of reporting damage can facilitate the collection of disaster information, in order to organize rapidly rescue forces. On the scene, PDA end-users having a handheld GPS device can report directly damage information, through combining PDA and GPS to acquire coordinates.

(7) Impact analysis

After the earthquake, GIS spatial analysis functions can provide impact analysis for disaster environment and public facilities (such as schools, hospitals, power plants, and substations), so as to offer reference for the mobilization of relief resources and evacuation of staff.

(8) Locating Resource Locator

Emergency resources have two parts: the first part is fixed resources, such as hospitals, fire hydrants, emergency shelters and other places. The second part is mobile resources, such as ambulances, fire engines and so on in order to locate fixed targets, just use GIS spatial analysis functions. Locate moving targets, needing to use GPRS and GPS technology, the command center sent signals to moving targets, moving targets send the information to the command center after receiving signals, achieving target positioning.

(9) Analysis path

Analysis path includes rescue path analysis and evacuation path analysis two parts. The rescue path analysis is used for analyzing the shortest distance of time for relief resources reaching to disaster areas, so as to guide rescue personnel quickly arriving at the disaster scene. And the evacuation path analysis is used for analyzing the most appropriate transfer path for planning officers, to guide the person’s quickly evacuation in dangerous areas.

(10) Emergency Command

Emergency command is the core of emergency command process. When the earthquake occurred, getting the disaster information by the function of analysis damage and remote sensing satellite images, on the basis of this using GIS assisted decision-maker with analysis, judgment, decision-making and forming disaster emergency command schemes, then the implementation schemes will be noticed to the relevant personnel via radio, telephone, phone, pager, computer, networking and other communication tools, to mobilize the corresponding social emergency rescue resources (government, police, fire, medical, sanitation, etc.) quickly reaching the disaster scene to rescue.

(11) Contingency plans

Contingency plan is the core of Earthquake Disaster Emergency Support System. Establishing a scientific and rational contingency plans will offer better support for emergency rescue. This function mainly includes

customizing templates of contingency plans and generating contingency plans.

3. CONCLUTION

4S technology, which GIS as its core, is a great potential emerging information technology, and this technology has been applied in many areas. Because 4S technology has great advantage whether in spatial data acquisition or in spatial data management, it will undoubtedly enhance spatial data-processing capacity of the system to use 4S technology in earthquake disaster emergency commanding system, providing timely accurate and effective decision-making support for rescue work of disaster areas.

REFERENCES

Wu Huanjuan, GuoMingzhu, Zhang Jiao, Application of remote sensing technology in the field of earthquake prevention and disaster reduction, *Earthquake Engineering and Engineer Vibration*, **2006, 26(2):**267-269

Mao Zheng-li, ZHU Bao-xun，Study on The Frame of Decision Support System for Emergency Plan of City, *Geomatics & Spatial Information Technology*,**2007,30(2)**,8-11

Jiang Lixin,Shuai Xianghua. Study of earthquake emerency command system[J]. *Earthquake*,**2003,2(23):**115-120

Zhou Bin,Liu Tao,Wen Junwu. The current application of GIS in earthquake studies[J].*Progress in Geophysics*,**2005,1(20):**160-164