한국지리정보학회지 6권 1호 : 48~58(2003)

Constructing the Forest Fire Extinguishment Helicopter Management System by Integrating GPS and GIS

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GPS와 GIS를 통합한 산불진화 헬기 관리시스템 구축

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ABSTRACT

Recently in order to extinguish the large scale of forest fire efficiently and rapidly the forest fire extinguishment equipment such as helicopters and vehicles has been mobilized. In this situation, the most consideration for the effective extinguishment is to understand the forest fire surrounding area and situation very well and arrange and manage the extinguishment equipment timely. In this paper, the client/serve-based forest fire extinguishment helicopter management system was constructed by integrating GPS(global positioning system) and GIS(geographic information system) technologies. This system manages and considers not only extinguishment equipment information such as helicopters and vehicles including manpower arrangement but also extinguishment environment information such as storing reservoir status and road situation and so on. For this, the real time tracking of helicopter location was first acquired through GPS technology then all the information about forest fire surrounding area was offered through the user-friendly interface of GIS concept. The result of constructing this system helps to extinguish a large scale of forest fire rapidly and effectively within shorter time then reduces physical damage and much manpower mobilization.

KEYWORDS: GPS(Global Positioning System), GIS(Geographic Information System), Forest Fire Extinguishment Helicopter Management System

요 약

최근 각광받고 있는 공간정보 기술인 GIS와 위치정보를 실시간으로 서비스하는 범세계 위치결정시스템인 GPS(global positioning system)를 활용함으로써 지표의 지형지물 및 정확한 현장 상황 파악뿐 만아니라 실시간 물체 이동상황과 이들의 위치정보 파악이 신속하게 이루어지고 있다. 본 연구에서는 이런 최신의 GIS와 GPS 기술을 바탕으로 신속하고 효과적으로 대형 산불을 진화

2003년 2월 11일 접수 Received on February 11, 2003 / 2003년 3월 16일 심사완료 Accepted on March 16, 2003
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할 수 있는 클라이언트/서버 중심의 산불진화 헬리콥터 관리시스템을 구축하였다. 특히 GIS를 이용하여 산불진화 환경을 손쉽게 파악할 수 있도록 123여 정도의 주제도를 공간 DB로 구축하고 여러가지 속성자료와 관련 데이터를 DB화하였다. 아울러 GPS와 기존의 무선통신시스템을 통합하여 원거리에 위치한 산불진화업무 관리자에게 진화헬기나 차량 및 인력의 이동상황이 실시간으로 파악 가능되도록 하여 효과적으로 산불진화장비를 배치하고 관리하도록 하였다. 본 시스템을 통하여 산불진화 환경정보를 신속하고 정확하게 획득하고 산불진화 장비를 과학적이고 효과적으로 전진배치 및 관리함으로써 향후 대형산불에 적극적으로 대처할 수 있을 뿐만 아니라 피해상황을 최소화하고 진화업무의 효율성을 극대화할 수 있으리라 사료된다.

주요어: 범세계 위치결정시스템, 지리정보시스템, 산불진화 헬리콥터 관리시스템

INTRODUCTION

Recently most domestic forest fires tend to be terribly big and the amount of its damage becomes huge so that the rapid extinguishment at its first stage is regarded importantly. In order to extinguish those large forest fires efficiently and rapidly, lots forest fire extinguishment equipment such as helicopters and vehicles has been mobilized (Jo et al., 2001b).

Therefore, the deep understanding of forest fire extinguishment environment and arranging and managing forest fire extinguishment equipment especially airplanes or vehicles are considered very significantly.

However, not only the forest fire extinguishment environment information such as storing reservoir or road status but also the forest fire extinguishment equipment information especially the exact location, the current movement status or the direction are still acquired by using wireless network such as cellular phone or radio. By the way, recently GPS and GIS technologies have been developed very remarkably and also supposed to be integrated with each other (Kim et al., 1999; Jo et al., 2001a).

In this paper, client/serve-based forest fires extinguishment helicopter management system was constructed by integrating GPS and GIS technologies to use in case large sized forest fires are occupied. This considers not only the helicopters and vehicles information including

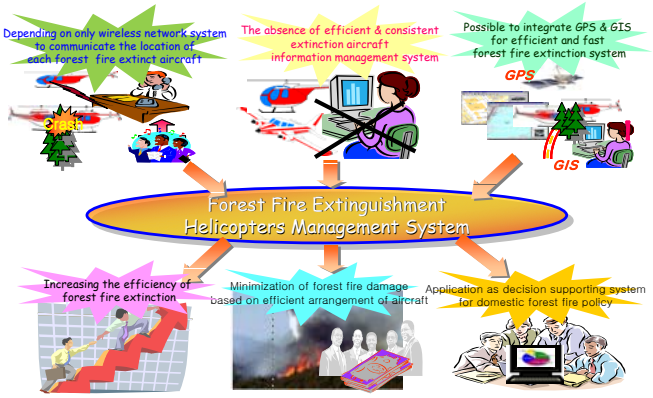


FIGURE 1. The background of constructing system

manpower arrangement but also the significant thematic maps such a storing reservoir, elevation, slope, aspect and road situation as the extinguishment environment information.

For this, the client/serve-based forest fire extinquishment helicopter management system design about 123 thematic maps and their attribute data in the local database by using GIS and presents the real time tracking of helicopter location by using GPS technology.

The result of constructing this system helps to extinguish large scaled forest fire rapidly and effectively within shorter time then reduces physical damage and much manpower mobilization. Finally, this system is expected to become the foundation of scientific and effective domestic forest fire extinguishment method. FIGURE 1 shows the background of constructing forest fire extinguishment helicopter management system.

CONSTRUCTING DATABASE FOR THE SYSTEM

In order to construct domestic physical environment database, national digital thematic maps were classified into 123 desired layers and stored in local spatial database. In addition, the whole information related to extinguishment airplanes and helicopters such as the name, accident history, each airplane shed situation, pilots and so on was also stored in DBMS(data base management system).

Then, GPS data acquired by tracking airplanes and helicopters was processed in real time to inform their locations on the thematic maps after converting to TM coordination. Also, all the tracking data of helicopters can be stored as TM coordination in database and is presented on the desired thematic maps in case it is needed to be verified.

FIGURE 2 presents the operating concept diagram for forest fire extinguishment helicopter management system.

1. Constructing GIS DB for the forest fire extinguishment environment information

In order to construct forest fire extinguishment environment database, the 123 various thematic maps such as rail road, stream, building, branch, facility, topography, boundary and labeling were classified from national digital map based on 1:25,000 scale in Korea by using

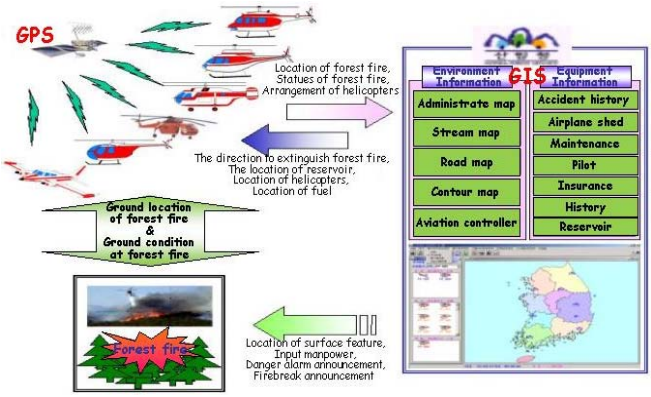


FIGURE 2. The operating concept diagram of the system

TABLE 1. GIS data for the forest fire extinguishment environment Information

Code	Item	Code	Item	Code	Item
Detail codes	Detail Items	Detail codes	Detail Items	Detail codes	Detail Items
1	**Railroad**	**4**	**Building**	**8**	**Boundary**
1111	Railroad	4218	Dong office	8116	Town
2	**Stream**	4219	Myon office	8117	Dong
2111	Waterways	4231	Fire station	8118	Myon
2112	Down wash, Rill, Rill flow	4243	Local forest office	8211	National industrial estate
2113	Bourn	4312	Power station	8212	Region industrial estate
2114	Lake · Reservoir	4217	Town office	8213	Agriculture and industry estate
2216	Dam	4218	Dong office	8214	Domestic animals estate
3	**Road**	4219	Myon office	8215	A program for land development
3111	National expressway	4231	Fire station	8221	Natural environment conservation
3112	Expressway	4243	Local forest office	8222	Natural ecosystem conservation
3113	Regional road	4423	Temple	8223	Water works conservation area
3114	Wide area road	4424	Other religion facility	8224	Greenbelt
3115	City road	4525	Airport	8231	Cultural properties protection area
3116	District road	**5**	**Branch**	8232	Tourist estate
3117	Rroad between myon & ri	5111	Branch stream	8233	Withering and falling estate
3118	Road inside a site	5211	Rice field	**9**	**Labeling**
3119	Narrow path	5212	Farm	9111	Road
3131	National expressway	5214	Grass land	9113	Road facility
3132	Expressway	5215	Waste land	9114	Bridge
3133	Regional road	5216	Afforested land	9115	Tunnel
3134	Wide area road	5231	Broadleaf tree	9116	Destination
3135	City road(plan)	5232	Needle tree	9121	Railroad
3136	District road(plan)	5233	Mixed forest	9122	Railroad facility
3137	Myon · ri road	5234	Bamboo forest	9123	Railroad bridge
3141	National expressway	5311	Cemetery land	9124	Railroad Tunnel
3142	Expressway	5312	Public cemetery	9131	Stream
3143	Regional road	5313	Royal mausoleum	9132	Down wash
3144	Wide area road	5315	Castle	9133	Stream facility
3145	City road	5316	Place of historic interest	9141	Region administrative organ
3146	District road	5335	Hot spring	9143	Administrative organ
3147	Myon · ri road	**6**	**Facility**	9151	Vegetation
4	**Building**	6354	Place of helicopter	9152	Open field · field
4111	Not residences from structures	**7**	**Topography**	9153	Mountain range
4112	Residence	7114	Valley line	9154	Transformation feature · rock
4113	Tenement house	7124	Valley line	9211	Special city name
4115	Apartment	7132	Elevation	9212	A wide area city name
4119	Group of house boundary	7213	Cliff rock	9213	Province name
4211	Special city hall	7214	Stony slopes rock	9214	City name
4212	Wide area city hall	7217	Elevation point	9215	Ward name
4213	Office of provincial	**8**	**Boundary**	9217	Administration name
4214	City hall	8112	Special, Wide area, Province	9221	Do name
4215	Country office	8113	City	9222	District name
4216	Ward office	8114	District	9223	Town name
4217	Town office	8115	Ward	9224	Myon name

ArcVeiw and ArcGIS(Kyungil University, 2002).

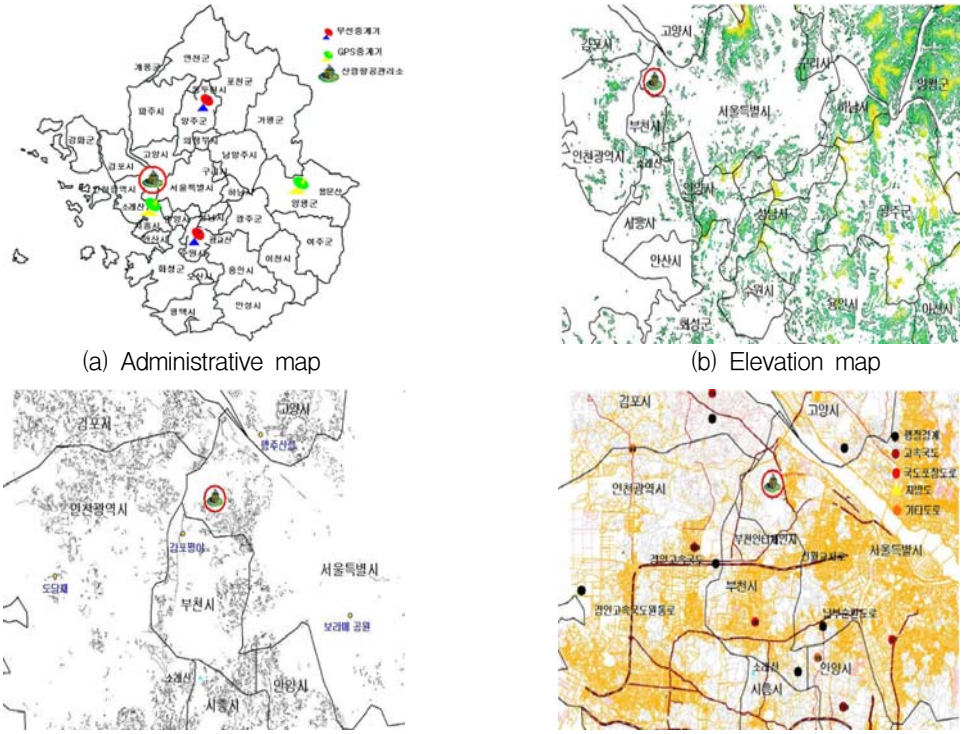
Especially, the important forest fire extinguishment environment information such as lakes, dams and reservoirs was classified from digital map and added more detail attribute datum such as the location, the exact coordination, the size, the depth, the amount, the maintenance data and so on through researching documents and statistical datum provided by Korea Forest Services(Kyungil University, 2002).

This forest fire extinguishment environment information helps officers to order the easy access of extinguishment helicopters toward the forest fire surrounding area and inform the detail surrounding information for a fire brigade. Especially, the periodical update of spatial data and its corresponding attribute data provide more exact and last datum to forest fire officers so that helps to extinguish at its first stage of forest fire.

TABLE 1 shows the 123 layers by defining nine categories and their detail categories classified from national digital map based on 1:25,000 scale while FIGURE 3 presents the example of it in Kim-po area.

2. Managing forest fire extinguishment helicopter information

In order to manage forest fire extinguishment equipment such as helicopters more effectively, the whole detailed information related to them such as its name, accident history, airplane shed situation, pilot's details and so on should be also



(a) Administrative map

(b) Elevation map

(c) Facility map

(d) Road map

FIGURE 3. The example of spatial data

stored in DBMS(Kyungil University, 2002).

Then the whole information can be monitored within real time by forest fire officials at Korea Forest Services by doing input, retrieval and update between Korea Forest Services and the eight local forest air traffic controllers through the internet networking.

TABLE 2 shows the data stored in the main DBMS to manage the whole domestic helicopter information.

INTEGRATING SYSTEM NETWORK ENVIRONMENT

The system network environment is composed of the wireless network to connect among the helicopters, relay stations, and the eight local forest air traffic controllers and use the internet networking to connect between the eight local forest air traffic controllers and Korea Forest Services.

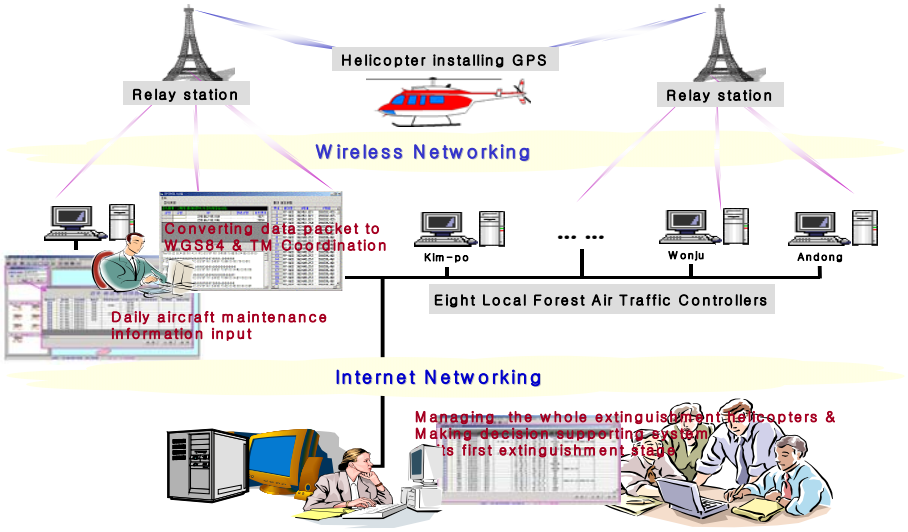


FIGURE 4. The system network environment of the system

TABLE 2. The data for the management of helicopter information

The information categories for helicopters	
Pilot status	Name, Telephone, Number, Phone, Department, The unit of an air-traffic controller
Airplane shed status	Size(Extra-large, Large, Medium, Small, Light), Light airplane
Insurance	No. of airplane, Purchase day, Purchase price, The fuselage, Crew, Passenger, Air freight
Maintenance	Stationing part, No. airplane, Navigation, Condition, Mooring area, Navigation time, Examination, Repairmen
Accident history	No. of airplane, Diary accident, Kinds, Accident place, Mission, Accident cause Section, Damage section, Personal damage, Physical damage, Persons concerned
Helicopters resource	Manufactory, Kind, Crew, Horse power, Navigation speed, Navigation time, Water lodge, Salvage ability, Water tank

TABLE 3. The data packet design

Name	No.	Value	Name	No.	Value	Name	No.	Value
Header	1	0x31	Time	11	G.Hour	Status of Hel	21	G.SatNo
	2	0x32		12	G.Min		22	G.Alt1
	3	0x33	Longitude	13	EW4		23	G.Alt0
	4	0x34		14	EW3		24	G.Spd1
	5	0x35		15	EW2		25	G.Spd0
Length	6	0x36		16	EW1		26	G.Bearing1
ID	7	0x37	Latitude	17	NS4		27	G.Bearing0
	8	0x38		18	NS3		28	HelState
	9	HellD.I		19	NS2	Data ID	29	CallID1
	10	reserved		20	NS1		30	CallID2

(provided by Tekmax Co., Ltd.)

1. Designing data packet and tracking the location of helicopters on the thematic maps

First of all, in order to acquire the location of helicopters in real time, GPS was installed on helicopters. TABLE 3. indicates the data packet, which is transmitted from one helicopter to one local forest air traffic controller through the wireless network. The 'Header' means general head data to verify whether data is correct and the length is the 'Length' of whole data. The 'ID' identifies each helicopter and the 'Time' tells the current time. The 'Longitude' and 'Latitude' mean the current helicopter's location while the 'Status of Hel' is the status of whether the helicopter is moving, standing, supplying water. Finally, the 'DataID' last for the extension of further data(Kyungil University, 2002; Yeungnam University, 2001).

In this paper the packet switching method is used to transmit data rapidly by establishing several logical circuits on one physical circuit. This data packets are converted into WGS84

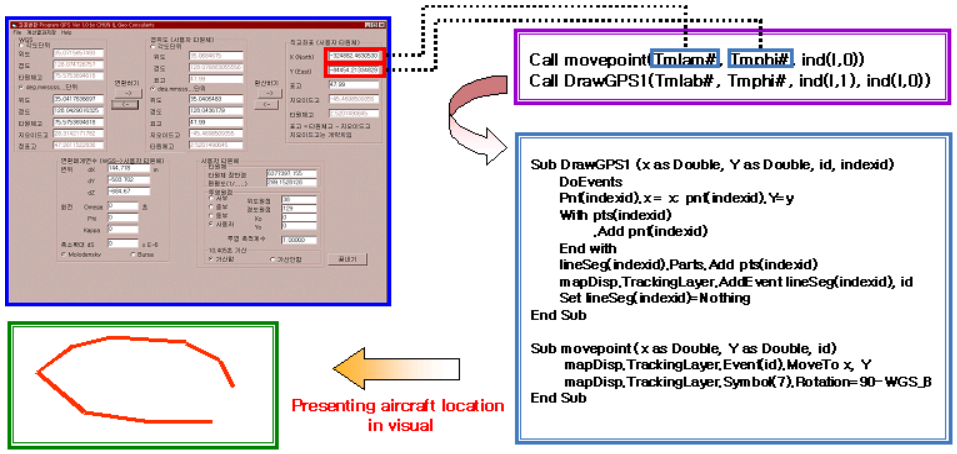


FIGURE 5. The code for tracking of helicopter location

coordination and TM coordination at each local forest air traffic controller then transmitted toward Korea Forest Services. The main system of Korea Forest Services integrates the status and related data and presents the movement of helicopters on various thematic maps by using AddEvent and Move of TrakingLayer in MapObjects 2.1, GIS component. Through this, the central officers of Korea Forest Services can understand in detail the real situation of forest fire surrounding area and then can reach rapidly the final goal for the scientific forest fire extinguishment ordering system(Yun et al., 2001; Kim et al., 2002).

2. Managing database for the system

As shown in FIGURE 6, the whole information of helicopter such as the name, accident history, shed situation, and consolidation is easily input at each local forest air traffic controller through user friendly interface then goes to the central center at Korean Forest Service in real time. Especially, daily aircraft maintenance data should be input at each local forest air traffic controller every day and can be retrieved, updated, deleted at central center. The officials at central center, Korea Forest Services, can monitor all the situation at the eight local forest air traffic controllers and control the domestic forest fire extinguishment resources.

For this, the central center officials grant and manage all the user authority information for the access to main database. Also they access to database, input, retrieval and output the whole data in database. Moreover, in case the mode of user authorities is need to change or limited, it is easily modified.

For the effective management of GIS data, all GIS data is stored as the format of stand alone. As you see, most GIS data(vector data) tend to be large sized so that it is hard to transmit that through network in the view of cost and time. In this system, every installed system has its own local GIS data and update it periodically by the distribution of the central center, Korea Forest Services .

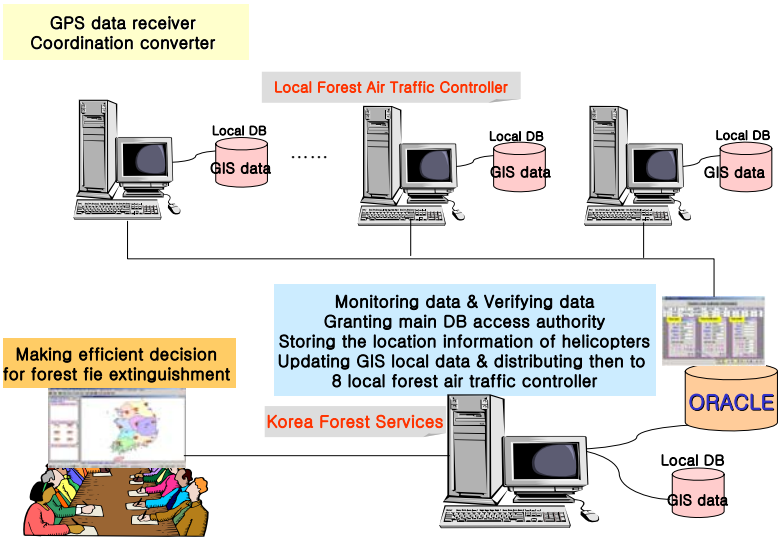


FIGURE 6. The management of database for the system

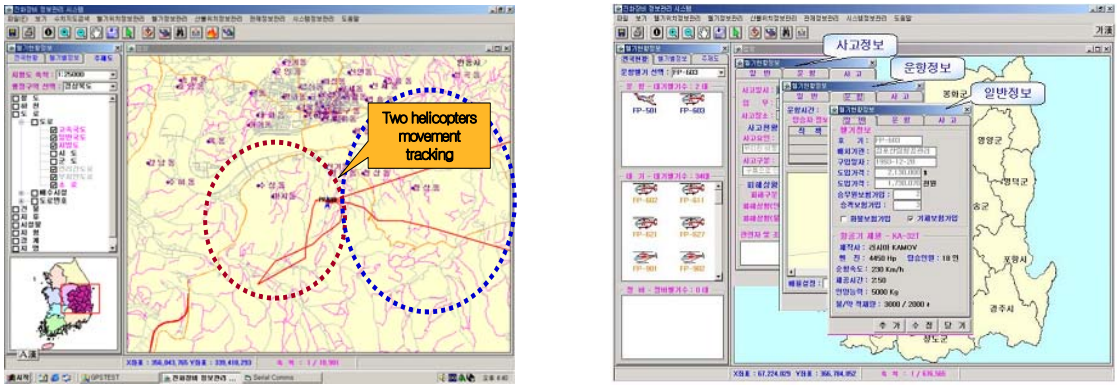


FIGURE 7. The location tracking of helicopters and its attribute data

IMPLEMENTING FOREST FIRE EXTINGUISHMENT HELICOPTER MANAGEMENT SYSTEM

This system was developed based on Windows 2000 and implemented by using Visual Basic 6.0 as development programming language, Map Objects 2.1 of ESRI as GIS component and Oracle8i as DBMS, respectively.

As shown in FIGURE 7, the movement information of helicopters is presented on various thematic maps so that the forest air traffic controllers can easily notify the current location of helicopters and order the exact direction of it.

Also, the information of helicopters such as the equipment name, accident history, each airplane shed situation, pilots information and fuel information and so on is presented with its current tracking.

The forest fire extinguishment environment information especially the detail attribute data helps to inform the easy access of helicopters toward forest fire area by using various GIS DB such as stream layer, road layer, building layer, facility layer, topography layer, labeling layer, and administration layer.

FIGURE 8 shows the overlay of desired

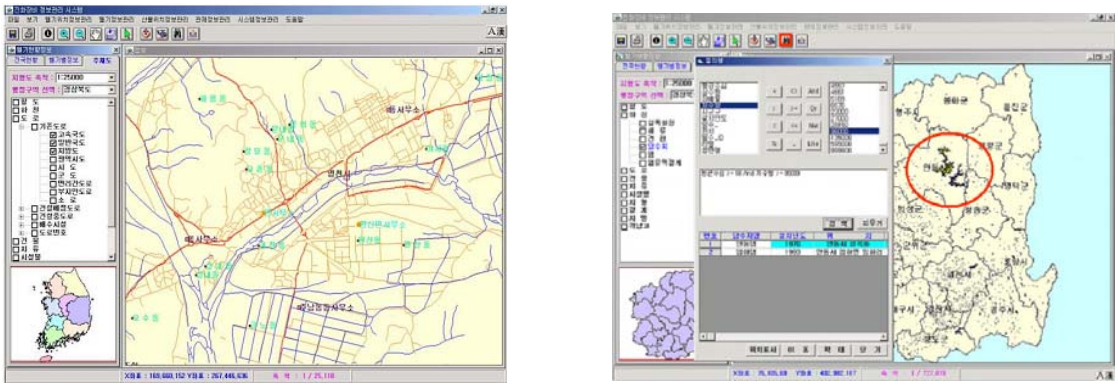


FIGURE 8. The retrieval of desired map and query of spatial data(reservoir)

layers on map window also the location of a certain reservoir and its detail attribute data by retrieving.

CONCLUSION

Recently most large sized domestic forest fire extinguishment depends on airplanes or helicopters. However, those forest fire extinguishment equipment still focuses on using wireless network technologies such as cellular phone or radio to inform their location and directions. By the way, nowadays GPS technology has developed very rapidly also integrates with other spatial information technologies such as GIS.

In this paper, the client/serve-based forest fire extinguishment helicopters management system using GPS and GIS was constructed to use in case a large scaled forest fire is occupied. This system helps not only to arrange and inform the location of airplanes and helicopters but also present the forest fire extinguish environment for forest air traffic controllers, central foreset fire officials and pilots to manage and extinguish forest fire areas efficiently. Following descriptions have indicated the effect of our study.

1. The entire database related to extinguishment environment and equipment is first constructed in forest fire extinguish helicopters management system then should be update periodically to maintain the last data.
2. The management and arrangement of extinguishment helicopters can be controlled in real time using GPS, GIS, and wireless technology. So, it is possible to acquire the environment information of forest fire surrounding area, present the exact location of current aircraft and navigation status in real time and help the scientific and systemic helicopters arrangement during the forest fire.
3. Finally, the forest officials can approach more scientifically and efficiently to extinguish forest fire so that they have been granted for their safety in case of a large scaled of forest fire. Moreover, the foundation of advanced Korean style forest fire extinguishment technology can be established. Also, the infrastructure of scientific forest fire extinguishment can be constructed. In addition, even large sized forest fire can be extinguished at its initial stage.

For the future works, the extension of system based on the user requirements should be considered and implemented in the view of efficient user interface and the tracking of helicopters navigation should be presented on the thematic map maintaining higher accuracy of GPS data.KAGIS

REFERENCES

Bu, K.D. and Y.J. Lee. 2002. Application of XML to develop GUI with satellite imageries search system. Journal of the Korea Association of Geographic Information Studies 5(4): 65-74.

Choi, H.S., K.E. Kim, S.J. Kim, Y.S. Kim, K.S. Lee and M.H. Jo. 2002. Environment Remote Sensing. Sigma Press, Seoul, Korea.

Kim, K.S., M.S. Kim, H. Choi and J.H. Lee. 1999. Real-time spatial analysis for

GIS/GPS-based AVL system. The 8th Annual Workshop of EMSEA. Seoul, Nov. 3-5, 1999. Vol. 1, pp.43-46.

Kim, S.B., J.H. Park, J.H. Choi and K.H. Choi. 2001. The design of GPS and INS for the MMSS(mobile multi sensor system). The 10th Annual Workshop of EMSEA. Cheju, Korea. Oct. 31-Nov.1, 2001. Vol. 1, pp.333-336.

Kim, J.S., S.J. Lee and Y.H. Woo. 2002. A study on the accuracy of GPS received data in travel vehicle. Journal of the Korea Association of Geographic Information Studies 5(4): 75-85.

Kyungil University. 2002. Constructing GPS system for the effective management of forest fire. Korea Forest Services Research Report. Gyeongsan, Korea. pp98.

Jo, M.H., K.D. Bu, K.J. Kim and J.S. Suh. 1998. Construction and evaluation of bank marketing database using geographic information systems. Journal of the Korean Association of Geographic Information Studies 1(1): 52-69.

Jo, M.H., M.B. Lee, S.Y. Lee, Y.W. Jo and S.R. Baek. 2000. The development of forest fire forecasting system using internet GIS and satellite remote sensing. Proceedings of the 21st Asian Conference on Remote Sensing. Taiwan, Nov. 5-9, 2000. Vol. 1, pp.1161-1166.

Jo, M.H., K.J. Lee, J.B. Kim and J.S. Oh. 2001a. Validation method of damaged area by pine wilt disease (*bursaphelenhus xylophilus*) using high resolution images and GPS. The 11th Annual Workshop of EMSEA. Seoul, Oct. 31-Nov.1, 2001.Vol.1, pp.43-46.

Jo, M.H., Y.W. Jo, J.S. Oh and S.Y. Lee. 2001b. Analysis and design of forest fire management system through CDBP (component based development process). The 11th Annual Workshop of EMSEA. Seoul, Oct. 31-Nov.1, 2001. Vol. 1, pp.43-46.

Jo, M.H., Y.W. Jo and S.S. Ahn. 2002. Case study of UML(unified modeling language) design for web-based forest fire hazard index presentation system. Journal of the Korea Association of Geographic Information Studies 5(1): 58-68.

Yeungnam University. 1997. The method to improve forest wireless network. Annual Report. Gyeongsan, Korea. 134pp.

Yun, S.M., I.S. Jo, S.Y. Yoo, S.H. Jo, C.G. Kim and J.H. Lim. 2001. The design and implementation of RTK-GPS error correction data transmission system using TCP/IP. Korean Association of Geographic Information Studies 2001 Spring Workshop. Taegu, Korea, May. 13. 2001. Vol. 1, pp.238-243. KAGIS