Construction of an Internet Geographical Information System for use in clearing offshore and onshore oil spills

Yojiro UTSUNOMIYA*, Muneo YOSHIE, Hideo MIURA*** Hiedeki SHIMAMURA*** Tomohito TSUCHIYA*****
Water and Soil Environment Div., National Institute for Environmental Studies, Japan.
utunomiy@nies.go.jp,
** Port and Harbour Research Institute, Japan
yoshie@cc.phri.go.jp
***Pasco com, Japan
HYPERLINKmiura@pascokankyo.co.jp
Hideki_Shimamura@sed.pasco.co.jp
HYPERLINKtsuchiya@pascokankyo.co.jp

Keywords: Internet GIS, oil spills, disaster countermeasure

ABSTRACT

Oil spilt from the Russian tanker Nakhodka, which sank in the Sea of Japan, contaminated the coast of central and northwestern Japan. Organizations and many volunteers worked to remove oil and grease that floated and adhered to sand grains, shingle/pebbles and rocks in the coastal zones. During the clean-up operation, it became apparent that in some places there was an overconcentration of volunteers, administrative delays in implementing the oil removal, misleading results of irrelevant simulation modeling, and insufficient communication of information about oil drifting. We therefore constructed a Geographical Information System (GIS) in order to improve the above-mentioned circumstances and the efficient clearing of oil from the coast.

1. INTRODUCTION

The oil spill from the Russian tanker *Nakhodka*, which sank in the Japan Sea, 106 km north-northeast of Tsushima Island on 2 January 1997, caused severe damage to the sea and coastline of the Japanese Islands. To counteract any repetition of such a man-made disaster, the National Land Agency promoted a special project entitled "Investigation for the construction of a database of environmental and disaster information for use in oil spill disasters" in fiscal year 1998-99. As part of this project, we constructed a Geographical Information System (GIS) for effective management of oil spills in the sea and along coastlines. Here we outline the system, which is now in test operation in our laboratory.

2. STRUCTURE OF GIS FOR MANAGEMENT OF OIL SPILLS

2.1 Subsystem of GIS

Our system for the efficient and effective cleaning of spilt oil from sea and coastal zones consists of several subsystems and functions. It has two components; one is accessible to the public, and the other is a closed system for specialists such as network/internet GIS administrators on the server side and in governmental offices. However, sharp discrimination between these components is not applied because our system is still at the prototype stage.

(1) Display of information about natural resources and industrial activity.
(2) System for prediction of spilt oil drifting ashore using satellite information and surveillance data.
(3) Support system for volunteer activity in cleaning the sea and coastal zones.
(4) System for retrieving information about equipment and materials for cleaning spilt oil.
(5) Internet GIS

2.2 Operational environment

The operational environment and application software of our Internet GIS are as follows.

a) **Hardware:** Gateway 2000 G7-450JP CPU: Pentium II 450MHz Memory: 128 MB
b) **OS:** Windows NT4.0 Workstation SP4 Peer Web Server 3.0
c) **Software:** Arc View 3.0a, Spatial Analyst 1.0a, Internet Map Server 1.0A, Image Analysis 1.0

As listed above, this system is constructed using software such as Windows edition ArcView3, Arc View Internet Map Server, Spatial Analyst (ESRI Co), and Image Analysis (ERDAS Co). The basic data formats in our

GIS are shapefile of Arc View GIS tools in vector-formatted data and GRID/ERDAS IMAGINE.ing files for raster format data.

3. OPERATION OF THE GIS FOR CLEARING OF OIL SPILLS

In our system, the GIS software is installed in the server system, and therefore the general public can access and operate the GIS through the Internet. The reason for installing the GIS software on the server side is to free the general public from the expense of software purchase. It was anticipated that economic considerations might prevent people from accessing this system, thus creating difficulty with information integration. In other words, we considered that financial pressure might prevent the production and storage of data and the creation of a self-proliferating database.

Therefore, clients can easily access the server on the Internet using the Internet Explorer or Netscape web browser. In addition, they can utilize the GIS using portable communication devices (PHS, portable telephone.)

As the information is constantly changing, it is important to renew the data on both the user and server sides after data processing. Therefore, Internet GIS/mobile GIS is an essential tool for input/output of the latest information in the area of the disaster. Of the above subsystems, nos. 1 and 3-4 work on the GIS through the Internet. Subsystem 2 is a stand-alone system, operating on the server side. In no. 2, an image analyzed by the network/Internet GIS administrator on the server side is put on the Web. Naturally the system can be made available and utilized at any time. The relationship between the general public's web browsers and the server side with the Internet GIS is shown in Figure 1. The private citizen sends a command to the GIS server at the National Institute for Environmental Studies to access the Internet GIS and obtain relevant geographical information on the Internet.

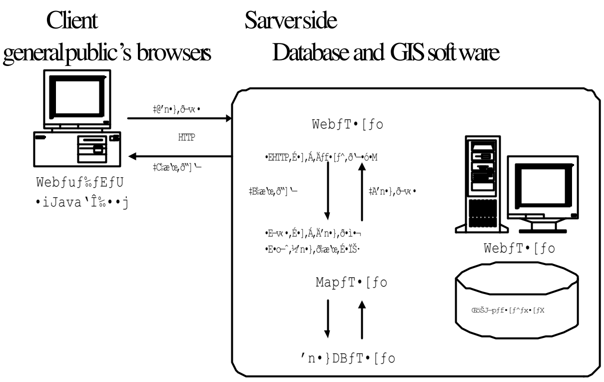


Fig. 1 Relationships between browser (client) and server site

Figure 2 shows the ideal hardware composition on the GIS server side. The input system components such as a digitizer, scanner and plotter are still lacking on the server side at this institute. However, we can use these devices if necessary, because we can input information through the LAN using these devices connected to the other system.

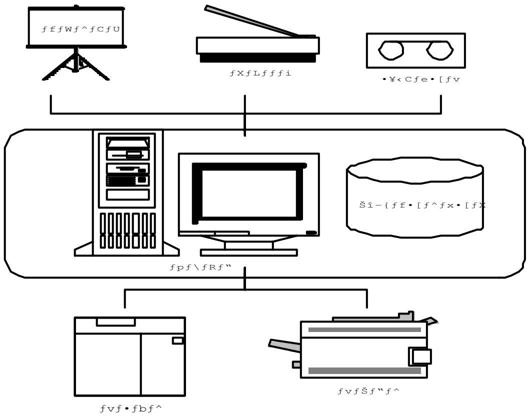


Fig. 2 Hardware composition on the GIS server side

Figure 3 shows the flow of information in the support system for volunteer activity. Since the input information is limited in this subsystem, a link to the headquarters from the server side has been established, making it possible for the general public obtain detailed information from the regional headquarters using their home pages.

On the server side, the administrator manages volunteer headquarters' registration, data processing of volunteer attributes, prediction of oil drift, and putting the results on

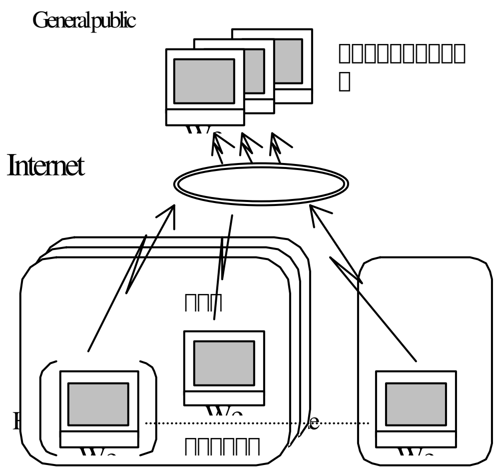


Fig. 3 Flow of information in volunteer support system

the Web for our Internet GIS. At the headquarters' registration, information input and renewal are carried out after the distribution of a name and password that is permitted only at each volunteer headquarters.

(1) Display of geographical information

Here, geographical information such as vegetation, water use (seaweed sites, boundaries of fishing rights, fishermen's cooperatives) and land use, accessibility to the shoreline, topography and geology, and digital elevation models etc. are displayed. This is a retrieval function for processing and displaying geographical information recorded in the database, and this basic function is equivalent to that installed in a wide spread application of GIS in the world. Here, it becomes important how much information is accumulated in the database.

(2) Oil drift prediction

Prediction of onshore drifting of oil spills using satellite images is done by a stand-alone working system on the server side. In this system, geographical correction is first carried out, then oil-spill areas are identified and extracted from the satellite/ airborne remote sensing images using the Isodata method and parameters such as NDVI. Though the algorithm of Isodata method is not explained, it seems to be a kind of cluster analysis. The oil spills and shoreline of land are geographically correlated on a same layer using the polygon-shapefile converted from oil spills area (raster data). The algorithm in this estimation model is developed on the basis of vector analysis using only four parameters: wind direction and
speed, and tidal current direction and speed. A few parameters such as the rate of expansion of the oil area, and modulation between these different parameters of wind and tide are also applied. Figure 4 shows an example of the analyzed result.

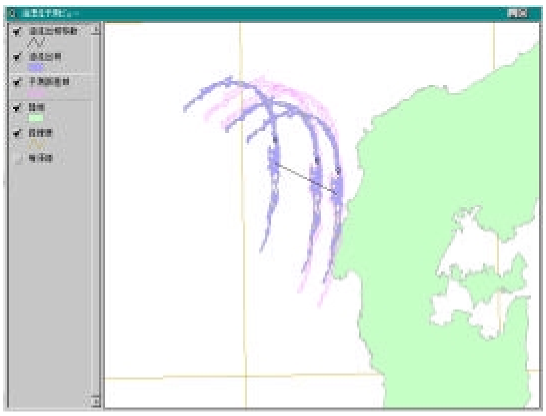


Fig. 4 Prediction results for oil drifting ashore

(3) Volunteer activity support system

In the volunteer activity support system, there are three functions: (a) Registration of the name and location of headquarters and broadcasting of their opening and operation on the Internet GIS. (b) Registration of the name and attributes of the volunteers at the headquarters. (c) The local system on the server side provides a function for analyzing the volunteers' attributes, and these analyzed results are placed on the Web. Detailed information can be obtained by additional functions such as links to home pages set up by the volunteer headquarters.

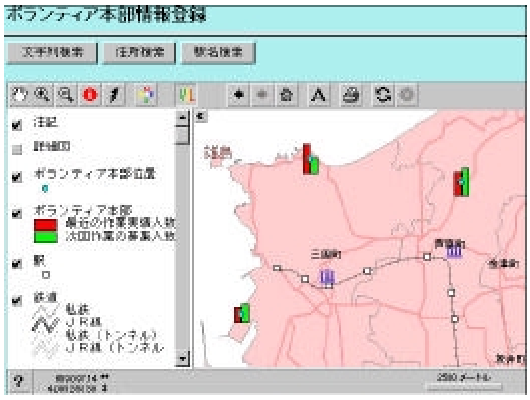


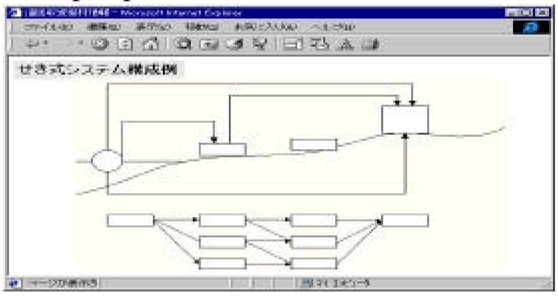
Fig. 5 Location of volunteer headquarters and display of bar-graph for the volunteer activity support system

Figure 5 shows an example of the above-mentioned function (a) in the volunteer activity support system. The number active personnel and the necessary personnel at each volunteer headquarters are displayed in these bar graphs at the locations of the headquarters mapped on the computer display. In addition, information such as position, attributes of the headquarters and volunteer's equipments is input and can be displayed in the other windows. Staff at the headquarters can easily and freely modify this information using their browser in the office or using a portable computer in the field.

(4) System for retrieving information about equipment and methods for oil cleaning

In this information retrieval system, some recommendations for the most suitable equipment and methods for oil removal from the sea and coastline and environmental recovery are made available upon input of geographic conditions in the field. This retrieval system is fundamentally similar to the function of subsystem (1) in our GIS. Figure 6 shows examples of the input and output of the retrieval system. . Many parameters are fed into the small rectangular frames on the display (left). Then the recommendations are listed on the screen. Figure 6 (right) shows the components of equipment for cleaning oil from the sea and coastal area.

(input: parameters)



(output: schematic component of equipment)

Fig. 6 Input and output examples of the retrieval system

4. SUMMARY

1) For disaster countermeasures, management staff and operation systems are always indispensable, and the procurement of information derived from multiple sources and rapid processing are required for this GIS.
2) In the mobile GIS, extension of the communications network and faster telecommunications will be important.
3) This system is effective for database recording/renewal with the support of the general public.
4) This Internet GIS will be developed further in future. In an EVOS system, the individual must purchase the GIS software for reading and processing the information. The general public can access our Internet GIS, and images can be input and analyzed conveniently on the server side.
5) As this system seems to be effective for analysis of land information, similar types of GIS are expected in future.

EMBEDEMBED

5. REFERENCES

Exxon Valdez Oil Spill Trustee Council (1997): EVOS Georaphic Information System Database and Data dictionary in Exxon Valdez Oil Spill Trustee Council Research & Restoration CD-ROM.

NASDA (1998): Observation of drifting heavy oil using airborne and space borne remote sensor. Tokyo, NASDA, 108 P. . (in Japanese)

Odamaki, M. (1999): Drift route predictions for recent huge oil spills. Bull. On coastal Oceanography, 37(1), 11-22. . (in Japanese)

Utsunomiya, Y., Yoshie, M. and R. Aoki (1998): Construction of GIS for the effective clearing of offshore and onshore oil. Procs.. General Meeting of the Association of Japanese Geographers, 54, 108-109. (in Japanese)

Utsunomiya, Y., Kosugi, S. and T. Suzuki (1999): Construction of GIS for the effective clearing of offshore and onshore oil (2). Construction of prototype of Internet GIS. Procs. Meeting of JSPRS, 24, 131-132. (in Japanese)

Utsunomiya, Y., Aoki, R. and K. Tsuchiya (1999): Construction of GIS for the effective clearing of offshore and onshore oil (3). Data acquisition and retrieval system for volunteer activity. Procs. Meeting of JSPRS, 24, 527-528. (in Japanese)

Utsunomiya, Y., Kosugi, S. and T. Suzuki (1999): Construction of GIS for the effective clearing of offshore and onshore oil (4). Estimation of the drifting of oil slick by satellite images and GIS.. Procs Meeting of JSPRS, 24, 647-648. (in Japanese)

Soil and Water Environment Section (1999): Mobile Geographical Information System as a support system for effective clearing of oil spills. A Prospect of Environmental Studies in the 21st Century. Public Symposium '99 sponsored by National Institute for Environmental Studies.

Utsunomiya, Y (1999): Construction of Internet GIS for the effective clearing of offshore and onshore oil. Procs. General Meeting of the Association of Japanese Geographers, 56, 76-77. (in Japanese)

Utsunomiya, Y. (1999): On the construction of Internet GIS as a support system for effective clearing of oil spills. Kankyo, 1999.12, 38-39. .(in Japanese)