

RISK COMMUNICATION FOR OIL SPILL ACCIDENT USING GEO-INFORMATICS AND SNS

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Commission VIII, WG VIII/1

KEY WORDS: Risk communication, Oil spill accident, Disaster, Web-GIS, SNS, Decision support system

ABSTRACT:

The tanker *Nakhodka* oil spill in the Sea of Japan was happened on January 2 1997 and this accident caused serious environmental damages. After the accident, discussions and collaborations involving citizens and government have been started to make significant steps to protect natural environment of river banks, mountains and hills in the vicinity of human residents and these activities seem to require setting up new social schemes.

For this object, this study discussed the integrated geo-informatics technology combined as mash up service, such as Web-GIS, Remote Sensing imagery and SNS (Social Networking Service), for support of decision-makers and for providing the information to public community in cases of the near-shore oil spills following the lessons after the *Nakhodka* oil spill accident.

The Web-GIS in combination with the oil spill simulation model is used for the forecast of the spatio-temporal oil slick trajectory. The oil spill subsystem was used for the planning of the protection and oil removal operations using its result. At the initial stage of the oil spill accident the oil-drift simulation is started. Remote sensing data (RADARSAT SAR images, and X-band radar etc.) are used to estimate the position and state of the spilled oil. Forecasted spill information is assimilated in to the oil spill model.

The observational and simulation results are uploaded to the Web page and are available for public through the Web-GIS application. The case of the oil spill accident January 1997 in the Sea of Japan is demonstrated and discussed as the example.

Except for the emergency stage, for the application of this system in the ordinary stage, using GIS based ESI (Environmental Sensitivity Index) map can show the environmental sensitivity to the oil spill. For this object, fishery damage by contingent oil spill accident was estimated. And ESI map including the socio-economical information such as fishery catches and fishing ground was used for resolving confliction among stakeholders. For making the communities for the oil spill accidents, as the communication tool for the ordinary stage, SNS including GIS was proposed. SNS covers the unformatted information and buzz information, and GIS covered the location data. These output were used for contingent Sakhalin oil spill accident around the near shore area of the Sea of Okhotsk.

1. INTRODUCTION

As it was clarified from the evolution and consequences of the serious oil spill accident following the breakage of the Russian tanker *Nakhodka* in the Sea of Japan on January 2, 1997, the GIS-based information and decision-support system could significantly improve the organization and management of the spill protection and recovery operations (Goto et al., 1997). As a prototype application the Web GIS system was constructed for the coastal environment of the Ishikawa prefecture of Japan, seriously damaged after *Nakhodka* oil spill. This application linked the basic cartographic and geo-environmental information with a different kind of additional tabular and graphical information, necessary for the near-shore management in cases of similar environmental disasters. It is the Internet-based solution that could provide the access to the information for the wide public community. The feedback with the users, including the public, local authorities, special disaster committees etc. is organized through the BBS (Bulletin Board System). It gives the possibility to centralize the information gathering on the oil spill related environmental problems etc.

The system tends to unify the access to the different kinds of environmental information available from number of governmental agencies and international organizations. It includes the meteorological analysis and forecasts data, the oceanographic data like sea currents structure and intensity etc., the observations of the oil spill drift and coastal line pollution, transportation routes info etc. It is believed that serious contribution in to the oil spill detection and into the estimation

of the environmental conditions will belong to the satellite, airplane and land-based remote sensing technique. It is especially important if take in to account the usually complicated weather conditions during the accidental oil spills that prevent the direct marine observations. Such situation took place during the evolution of the *Nakhodka* oil spill January 1997. To resolve this problem it requires utilizing and establishing the observational systems that are not so strongly influenced by weather condition. As examples, the synthetic-aperture radar (SAR), HF radar and X band radar for monitoring of the sea surface state could be mentioned.

However the perfect informational coverage of the environmental state and the spill evolution in the nearest future seems to be not achieved by observational facilities. As a solution to close the lack of information and to provide the prediction for the expected oil spill evolution the oil spill simulations system would be linked with the informational Web-GIS and decision-making support system. As for the Sea of Japan, (Varlamov et al., 2000; Varlamov and Goto, 2002) oil spill simulation system was selected for the implementation in to the prototype application. This system have reproduced basic features of the *Nakhodka* oil spill accident in the Sea of Japan and is oriented on the operational prediction of the oil spill evolution. Some details of the system organization are discussed below.

2. BASIC STRUCTURE AND OBJECTIVES OF WEB-GIS

As main goals, features, and objectives of the system that have to provide the informational support in cases of environmental disasters in coastal areas could be formulated in next form, as it followed from the respond and recovery activity after the *Nakhodka* oil spill accident (Goto et al., 1997).

- 1) System has to provide the wide range of environmental and oil spill-related information to the public community,
- 2) It must present the information in the geographical (mapped or map-linked) form,
- 3) It is advisable to unify the spill and environmental damage related information taken from different sources,
- 4) System must provide the links to the specialized environmental and socio-economical information from external databases.

If it is intended that the system will be accessed and operated by public, we cannot require from the users to purchase the specialized expensive GIS software and to be trained experts in the GIS system operating. System interface must be intuitive and mainly self-documented. As solution the Web-based GIS seems to be best one. For the end-user it operates like well-known Internet Home Page and the same time utilizes main functions of regular GIS.

The structural composition of the Web-GIS management support system for near-shore disasters is shown on Figure 1. The JASTEC's "Magellan" system was used as an engine of the Web-GIS. The Web-GIS operates with the basic geographic information and performs typical GIS operations like space data retrieval, geographical presentation and scaling of spatial information, attribution data retrieval, various measurements etc. Web-GIS runs on the WWW server and serves as a map server according to the client's demand. Requested results in form of vector maps, linked tables, images etc. return to the user for presentation by local WWW browser.

The feedback from the clients is realized in the form of BBS. Gathered information is immediately available to all users of system, is analyzed by responsible staff and forms the additional source of information for the decision-making authorities. Some governmental agencies and company databases could be linked to the system as well, if such permission will be granted.

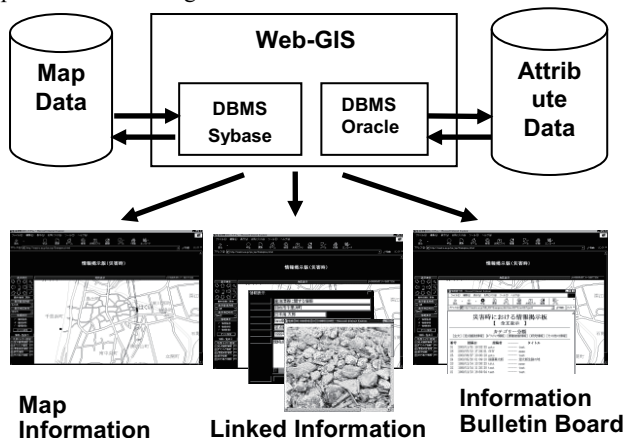


Figure 1 Schematic Structure of the Web-GIS Management Support System

3. NAKHODKA OIL SPILL SIMULATIONS: EXTENSION OF INFORMATION SYSTEM

The lack of in time observations on the oil spill evolution has objective reasons. It could be too wide area involved in to the accident, severe weather conditions that prevent the observations, the complicated spill dynamics, when oil is submerged due to the intensive turbulent mixing and drift subsurface etc. Development of the remote sensing methods, like synthetic-aperture radar, HF radar and X band radar for monitoring of the sea surface state could provide additional information, but currently do not solve the problem as a whole. To provide the required information on the expected oil spill evolution, the oil spill analysis and prediction models could be used. For the Sea of Japan the system developed in cooperation with Kyushu University by (Varlamov et al., 2000) was adopted and improved (Varlamov, 2001) for these purposes. Oil spill analysis and prediction system includes the meteorological data processing subsystem, ocean currents simulation models, oil spill simulation model, and the results presentation and analysis block. Spill model utilizes the particles tracking method and includes the simulation oil physical properties so that the model oil particle properties are modified during the spill evolution (density, size, viscosity and water content). System was tested with the sea current information provided by 3D modular ocean model (including the case with assimilation of satellite altimeter data) and more simplified 2.5D nonlinear drift current model. Last one was adopted for the operational system. Model provides the possibilities for the assimilation of any fragmental data on spill position. It could be the evidence of floating oil (traditional ship, airplane and helicopter visual observations or satellite remote sensing data could be utilized); coastal pollution or the HF radar based surface current estimations. Last data could be used by modification of the surface wind – surface sea current relation parameters.

Some results for simulation of oil spill accident in the Sea of Japan January, 2, 1997 caused by breaking up of the Russian tanker *Nakhodka* are demonstrated on Figure 2 and 3. About 6500 kl (kiloliters) of medium fuel oil (Bunker C type oil from another sources) were realized into the sea. Spill simulation were run with the assumption that half of all spilled oil was realized in the initial incident point January 1, 18:00 UTC (January 2, 03:00 of local time), marked by cross at Figures 2-3. Additional 30% of oil were realized continuously along the observed drift trace of the tanker bow section, plotted by light gray line on Figures, until January 6, 03:00 UTC. Final 20% were spilled continuously during the last day before the grounding of bow section on rocks near the Japanese coast January 7, 04:00 UTC. Drift trace was estimated from the unpublished manuscript report on the *Nakhodka* oil spill prevention activity, kindly provided by Japanese Maritime Safety Agency (in Japanese). Thick arrows on Figures 2 and 3 present the wind field (advanced analysis data of ECMWF were used), the thin arrows demonstrate the model estimated subsurface (3 m) sea currents. Oil spill is presented as ensemble of particles of different size and simulated oil distribution in upper 2 m sea layer is shown.

Figure 2, a) demonstrates the simulated oil spill state for January 11, 06:00 UTC, when oil already widely spread along the Japanese coast and polluted it from the Kyoto up to the Ishikawa prefectures. The strong effect of the along-shore branch of permanent Tsushima current becomes evident from the spill shape formed. For that date the RADRSAT SAR data were available as plotted at Figure 2, b). Digitized slick position was used to re-allocate the part (15%) of randomly selected model particles. Modified by assimilation of this information oil

distribution is demonstrated on Figure 2, c) for January 11, 09:00 UTC. After the 10 day long simulation model did not reproduced so far north oil spreading as it were observed. Assimilation corrected this feature, keeping all other details of simulated oil spreading. Main reason for distinction between the simulated and observed spreading can be attributed mainly to the sea current presentation in the model. This conclusion is based partly on such result of the *Nakhodka* oil spill simulation that after about January 10 almost all permanently surface-floating modeled oil particles were removed from the sea. It was caused by simulated oil beaching at the coastline of the Hyogo, Kyoto, Fukui and Ishikawa prefectures under the strong NW wind effect. As result, all particles plotted at the Figure 3 belong to the medium and small sized fraction of spill that could disperse into the seawater. These model particles could reside both at the sea surface and submerge depending on relation between the buoyancy effect and dependant from the environmental condition random vertical diffusion.

Figure 3 demonstrates the comparison of observed spreading of oil compounds for January 14, 07:00 UTC (a) with the simulation result for January 14, 06:00 UTC (b). Simulation was continued after the RADARSAT SAR data assimilation. Both the model particles and the logarithm of the relative oil concentration in the upper 2 m sea layer are plotted. Simulation well reproduces the wide oil spreading along the Japanese coast, although some details differ.

The result is calibrated by comparison of the first beached dates as they were observed for the local sites located from the south to the north along the western coastline of Ishikawa prefecture (Report, 1998) was done with these two model cases.

4. RISK COMMUNICATION FOR OIL SPILL ACCIDENT

4.1 Why risk communication?

After the *Nakhodka* Oil Spill accident, discussions and collaborations involving citizens and government have been started to make significant steps to protect natural environment of river banks, mountains and hills in the vicinity of human residents and these activities seem to require setting up new social schemes. This part describes processes of preparing regional disaster prevention plan based on the actual collaboration of citizens and government in the Sea of Okhotsk, and also includes international comparative and case studies of such plans. It simply concludes that the risks associated with oil spill have to be discussed among various kinds of stakeholders in time of peace. These processes are indispensable for regional integrated risk management.

4.2 Why Geo-informatics and SNS ?

The daily communication exchanged in regional SNS fosters the fiduciary relation internal and external the region. The fiduciary relation is effective in the disaster.

In the Han-Shin Awaji Earthquake disaster and *Nakhodka* oil spill accident, many volunteers were collected from each place. The co-operation work was carried out in many fields tentatively by using mutual help networks such as the care of the disaster victims, the restoration of the beached oil, publicity support of the disaster information and the communication between volunteer and disaster countermeasure headquarters of the administration. etc.

This showed the importance of the fact the mutual help networks and preparation from the ordinary times were important. Afterwards, the social system which can maintain the human network in the disaster has been examined. Human network from the ordinary times is necessary in order to smoothly advance the co-operation work in the disaster. However, the life style in which life space and work space are not spatiotemporally same make it difficult to establish the human networks.

Noris (Noris,2003) shows that the internet has the function of 'bridging' and 'bonding' groups. Though in the disaster, functions of the mutual aid are necessary, but it is not realized only 'bonding' function for efficiently advancing supervision and control after the disaster.

4.3 Structure of the risk communication system for oil spill accident using geo-informatics and SNS

Combining the Web-GIS information system and the oil spill analysis and prediction system the decision-making support system was developed. The schematic structure of this system is demonstrated at Figure 4.

Part of system is operated routinely under the system manager. It includes the regular meteorological data requests from the Japan Meteorological Agency (JMA) FTP server. These data are used to re-start the ocean circulation model forecast up to 5 days based on available meteorological forecast data. Meteorological and sea current simulations data cover all the Sea of Japan and are saved in the system database, being available for the visualization and the spill simulation. Last will be started in case of oil spill accidents. Simulation results also become available to the Web-GIS through the Web Publisher in graphical form. Through the Web GIS as a main system core the oil spill prediction results could be linked with Environmental Sensitivity Index map and other attribute information. It serves as an informational basis for the decision making support system that could produce warning messages for the public and responsible authorities, estimate the probable and real environmental damage from the oil spill and support other requirements for the decision support in the oil spill disaster and informational management.

For making the communities for the oil spill accidents, as the communication tool from the ordinary times, SNS including Web-GIS was proposed. SNS covers the unformatted information and buzz information, and Web-GIS covered the location data. SNS is applicable for various cases, because information service, reading are possible in the schedule of each users. In this study, the function of SNS was added to the system shown in Figure 4.

It is difficult to sustain the enhancement sensation of the consciousness which lead to the mutual network must be fermented in the ordinary time. For this the visualization of preparatory processes of the event which frequently arises in the region simultaneously ferments the human linkage. It is shown that the risk communication is not independent on the linkage in ordinary time for this fact.

Until now, in the flood damage which arose in August, 2009, SNS makes the cooperation of region SNS which is scattered nationally from one writing, and it is mentioning the result of the possible of to collect relief goods in short time. Therefore, it seems to make the above-mentioned hypothesis must be correct.

5. CONCLUSION

Marine oil spills could cause the serious environmental, economical and social damages. Example of *Nakhodka* oil spill in the Sea of Japan when oil drifted in the Sea for a weeks and seriously damaged the effected coastal environment demonstrated the requirement for the in time information support for organization of necessary respond and recovery operations. Example of such system is developed by authors and shortly reported. It is oriented on wide provision of different types of spill related information in geographical environment and is realized as Web-GIS application. Necessity to integrate it with the oil spill simulation model is shown on the examples of information that could provide the coupled system for the case of *Nakhodka* oil spill. Other features of system, like the support for the information gathering from the public and the responsible agencies, possibility to implement any type of linked information etc. extend it applicability. The system interface relative simplicity also could be mentioned as its positive property because the end-users run the well-known WWW browsers to access the information. The further study on the installation of this system to the social systems will be discussed by the project for contingent Sakhalin oil spill accident around the near shore area of the Sea of Okhotuku.

ACKNOWLEDGMENTS

This research was supported by the "Regional Use of Geo-Informatics and its application to the environmental education" (FY2002-FY2009, Project leader: Prof. Shintaro Goto, Rissho University) of the "Open Research Center" Project of Ministry of Education, Culture, Sports, Science and Technology (MEXT), "Study on Crisis Management System for Oil Spill" (FY2003-FY2005, Project leader: Prof. Shintaro Goto) and "Construction of Oil Spill Response System by Collaborating Stakeholders Preparing Sakhalin Oil and Gas Development" (FY2008-FY2011, Project leader: Prof. Shintaro Goto) founded by Japan Science and Technology Agency.

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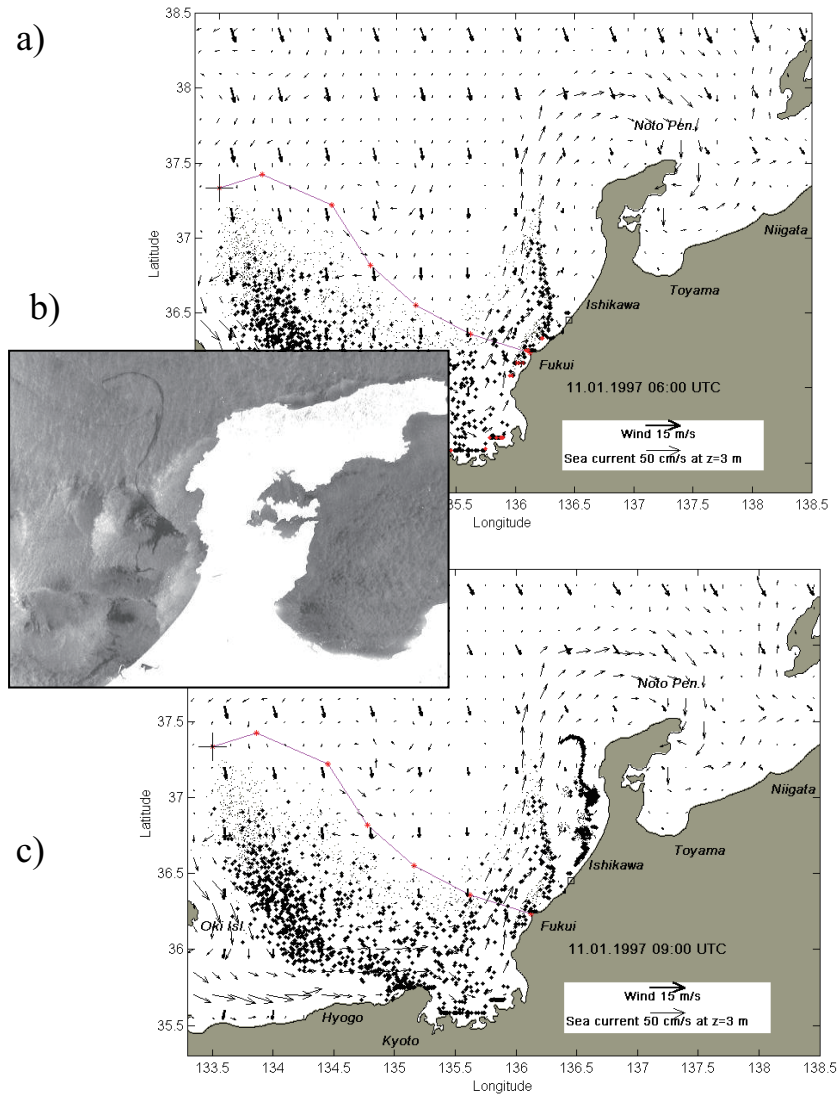


Figure 2 Assimilation of Remote Sensing Data in Oil Spill Simulation of the Nakhodka Oil Spill in the Sea of Japan, January 11, 1997

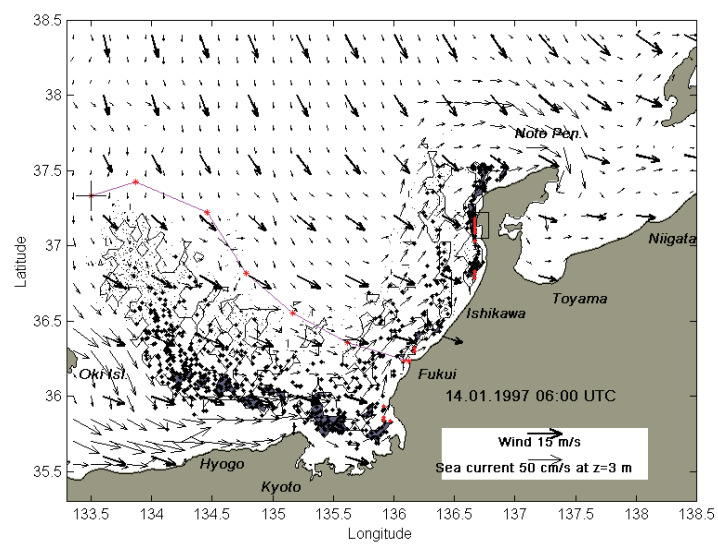


Figure 3 Simulation of the Nakhodka Oil Spill in the Sea of Japan, January 14, 1997

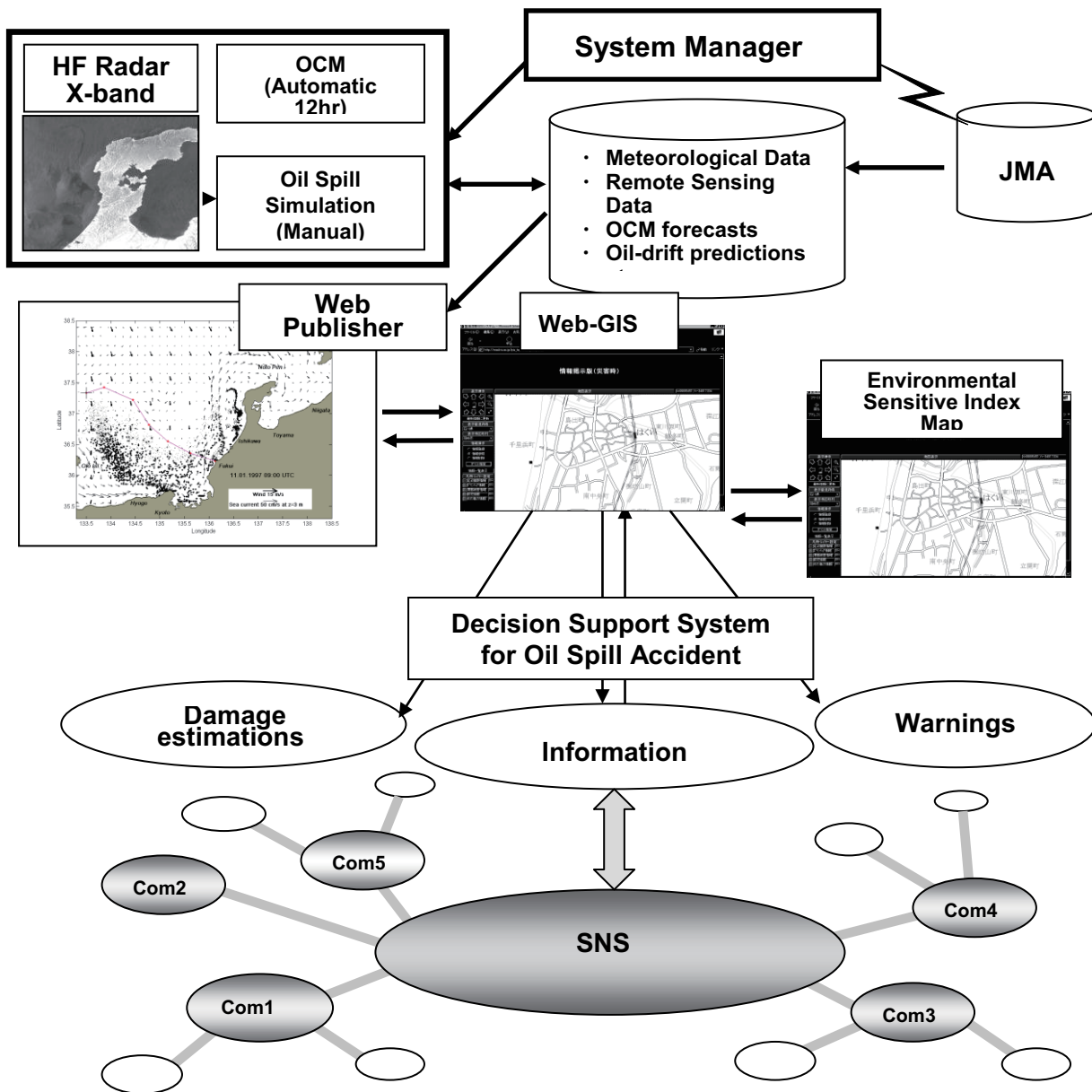


Figure 4 Schematic Structure of the Decision-Making Support System for the Oil Spill Accident