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# PETROLEUM HAZARDS MANAGEMENT BY GEOMATIC SYSTEMS

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## ABSTRACT

One of the main advantages with a satellite-imaging sensor, such as RADARSAT SAR, is the ability to cover large areas of the Earth's surface in a short time. This has been verified it as powerful system for monitoring and management of environmental hazardous phenomena, especially when these data is combined with other geomatic systems such as GIS and GPS. Remote Sensing and GIS analysis in combination with Environmental Sensitive Index mapping have been used to create early warning system and automatic petroleum hazard management. Various data including SAR image, meteorological, environmental and historical data have been integrated with mathematical modeling in GIS system to construct contingency planning for petroleum hazardous in the Straits of Malacca situated in the south west of peninsula Malaysia.

## INTRODUCTION

An information revolution is in progress, fuelled by the availability of remotely sensed data from a growing number of commercial Earth observation satellites and Geographic Information Systems. Some of these systems have the capabilities required to contribute to a broad spectrum of disaster management applications on seawater environment, as demonstrated by recent experience with SAR data by Assilzadeh et al. (1999). Experience gained using RADARSAT image coupling with GIS system in Malaysia has highlighted a number of important petrochemical spills management issues, one of the most critical of which is the need for early warning system and prediction of potential risk area. This knowledge is especially important in view of forecasting of oil spill trajectory prediction, environmental sensitive index (ESI) map, and heightened resource management concerns. More recent studies such as Assilzadeh et al. (1999), (2000) and Ibrahim et al. (1999) have been cried out by Department of Civil Engineering and Department of Environmental Science for oil spill contingency planning and documentation of environmental sensitivity indexes under supervision of Dr. Shatri and Professor Ibrahim for Straits of Malacca. This paper describes ongoing multi-system efforts aimed at documenting and demonstrating oil spill and establishing oil spill contingency plan through of detection, classification, modeling, and programming oil spill and seawater environment by use of SAR image analysis and GIS.

The study area is located in region of the Straits of Malacca, situated in southern part of Peninsula Malaysia. This area was chosen as study area in order to constructing early warning system and oil spill contingency plan because this area were known as high traffic and high ship accident region according to the historical records carried out in department of environment.

## IMAGE ANALYSIS

The composite SAR image yielded from texture analysis of the image shows position and area of spillage in figure (1-a). Oil slicks that have resulted from discharges from ships, and other potential slick-like features such as natural film slicks caused by climatic and sea current effects, or algal blooms, can all resemble slicks produced by seepage, but will not keep their location and shape for long periods due to dispersion by sea surface conditions such as waves, winds and current.

At the sea surface slicks were seen to be formed by the slow collapse and spreading of bubbles of oil as they broached the surface. Coalescence of the thinnest, outer parts of these round iridescent blobs formed the thin, colorless slicks responsible for the wave-damping observed by SAR. The slicks, although small, could be seen on image. Contrast of the slicks against the sea surface varied with radar depression angle period of several days or longer under relatively calm sea conditions.

The speckle appearing on SAR images is a natural phenomenon, generated by the coherent processing of radar echoes. The presence of speckle not only reduces the interpreter's ability to resolve fine detail, but also makes automatic segmentation of such images difficult. To solve this problem several filtering methods such as Lee and Gamma filters can be helpful in cases such as oil spill detection and oil spill classification. Consequently, the SAR image histogram is a linear combination of several Gamma functions. Each mode in the histogram is a Gamma function and represents a class in this image. Filter size will greatly affect the quality of processed images. If the filter is too small, the noise-filtering algorithm is not effective. If the filter is too large, subtle details of the image will be lost in the filtering process. A 7x7 filter usually gives the best results (Figure 1-a).

For classification of oil spills the Gaussian probability density function is use to model the class-conditional probability densities. Only the features complexity mean local area contrast ratio, border gradient, smoothness contrast locally, homogeneity of surroundings, slick width and number of neighbouring objects are use to compute the probability density (Figure 1-b). Figure 2 shows the result of SAR image analysis based on enhancement and slicing of the image after Gamma distribution analysis and classification by PCI image processing software.

## UTILIZATION OF GEOGRAPHIC INFORMATION SYSTEM

Geographical information system (GIS) can be a powerful tool in visualizing the results of modeling, and in analyzing and visualizing potential impacts. Environmental information presented in map form is a necessary instrument for planning and management of hazards and natural resources, as well as for research on the distribution and allocation of resources and hazardous substance. Maps can be use as a tool for researchers, planners and decision-makers. The amount of information that can be presented in map form is tremendous. Both status, trends and projections can be presented in a conceptually simple way.

A geographical information system is a presenting spatial data. All kinds of data that are spatially determined can be stored, updated, analyzed in a multivariate fashion and presented, either in map form or as tabular data. Data at different scales can be linked to each other and that provides a base for generating spatially full-covering information from case studies over limited regions. Traditional computer assisted cartography and GIS was entirely vector based, i.e. the data was represented by x, y and z coordinates. The technical development of image processing has lead to an alternative to vector storage and analysis, the raster form, where every point on the map, in the form of a rectangular grid system, is stored. Following activities for mapping, modeling, trajectory simulation and assessment are carried on to manage oil spill in sea environment. Contingency planning for oil spill is the most developed application of remote sensing and GIS for hazardous substance in seawater.

### Mapping Oil spill

Mapping oil spill by classified raster image from radar satellite in GIS (Figure 3) can yield statistical information of oil spill such as volume, length, distribution, and thickness. These data then could be proceeded to model oil spill in any environment and extract more data from spill duration by time.

### Modeling oil spill

Oil spill modeling is the result of coupling the data acquired from oil spill analysis and environmental, historical or socio-economical data, such as meteorological data, wind and current data, ESI (Environmental Sensitive Index) map, spill history, and so on. These models can help for any decision making and oil spill combating.

### ESI map

ESI map (Figure 4) serves quick references for oil and chemical spill responders and coastal zone managers. ESI map contains three type of information. (i) Shorelines are color-coded to indicate their sensitivity to oiling; (ii) Sensitive biological resources, such as seabird colonies and marine mammal hauling grounds, are depicted by special symbols on the maps; (iii) ESI map also shows important human-use resources, such as water intakes, marinas, and swimming beaches.

### Oil Spill Trajectory Simulation

In any oil spill emergency response the short-range trajectory modeling studies are the most important; therefore it should be done on real time to give day- to -day support oil spill contingency plan at a specific spill. On entering water, oil undergoes a complicated multi-process phenomenon. The sum of all of this process is called weathering. Weathering includes, in the order of approximate occurrence, spreading, evaporation, dissolution and emulsification, auto-oxidation, microbiological degradation, sinking and resurfacing. While these processes are occurring, the oil slick continues to drift, under the influence of winds and ocean currents (Figure 5). The most important and well known among the weathering processes is the spreading and drifting, which occur simultaneously. Combining both current and wind effects, the relationship of the center mass of the slick movement.

### Spill Modeling and Programming in GIS System

Based on historical oil spill record, hypothetical spill trajectories could be simulated based on ground data and meteorological information for each of the potential launch areas in sea environment. The results then could be presented and assessed in each of the four seasons of the year from each launched area as simulation part in contingency plan. Figure 6 shows the potential risk of one hypothetical spill according to automatic simulations by programming in SPANS 7.1.

## CONTINGENCY PLANNING

A successful combating operation to a marine oil spill is dependent on a rapid response from the time the oil spill is reported until it has been fully combated. In order to optimize the decision support capability of the surveillance system, a GIS database should be integrated with the detection tool. Information on the exact position and size of the oil spill can be plotted or visualized in GIS environment and a priority of the combat efforts and means according to the identified coastal sensitive areas can be carried out. The system also can offer opportunities for integration of oil drift forecast models (prediction of wind and current influence on the oil spill) for risk assessment. An effective response to a marine oil spill requires knowledge of the sensibility of the coastal zones to enable to determine priorities of the combat activities to protect the most sensitive areas. The primary data should be available for the study area such as historical data of oil spills incidents. This includes information on the incident date, location, and sources of oil spill, types of spillage, width spill of oil and the effect of spillage to the coastal environment. Apart from the based map, other data includes shoreline natural resources, coastal land use, response team information, oil spill response capability and equipment, port location and meteorological data. Raster and vectorised spill data, environmental sensitive area and the above information will then be used for trajectory modeling and risk assessment and contingency planning (Figure 7).

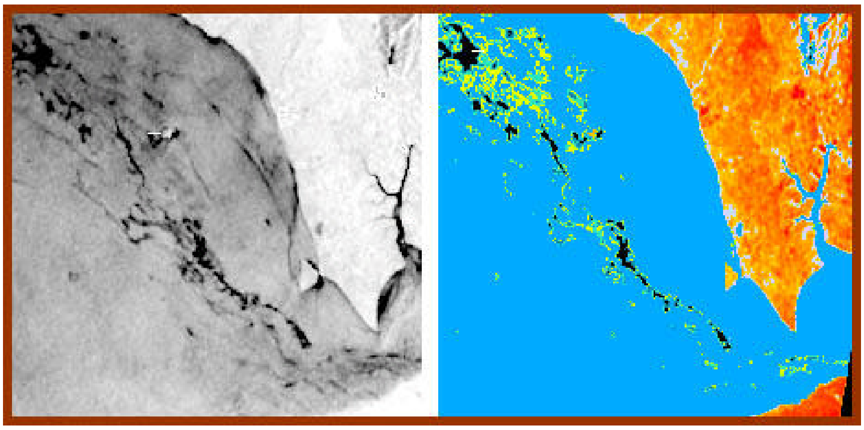
## REFERENCES:


H. Assilzadeh, S. B. Mansor, H.M. Ibrahim, Abdul Rashid Mohamed Shariff, Ahmad Rodzi Mahmud, 2000. Oil Spill in Geomatic Systems. 4th annual seminar of Geoinformation engineering GEOINFORMATION 2000 CONFERENCE & EXHIBITION University Putra Malaysia (UPM)

Hamid Assilzadeh & Maged, M. & S. B. Mansor & M. I. Mohamed, 1999. Application of Trajectory Model, Remote Sensing and Geographic Information System (GIS) for Oil Spill Emergency Response in Straits of Malacca. Proceeding of the Asian conference of Remote Sensing. Vol. (2). Hong Kong.

Mark e.Luther, Boris Galperin, and Edward S. Van Vleet. 1997 Development of an Integrated End-To End Marine Contaminant Management System. University of South Florida Department of Environmental Protection.

Moh. Ibrahim and Hamid Assilzadeh. 1999. RS and GIS solution to issues in the straits of Malacca. Malaysia. Paper Presented at the Malaysian Science and Technology Congress., Kuching.



a) b)

Figure 1:
SAR image processing for oil spill detection in the Straits of Malacca (a) processed data after Effect of gamma distribution analysis on the image (b) Classified image

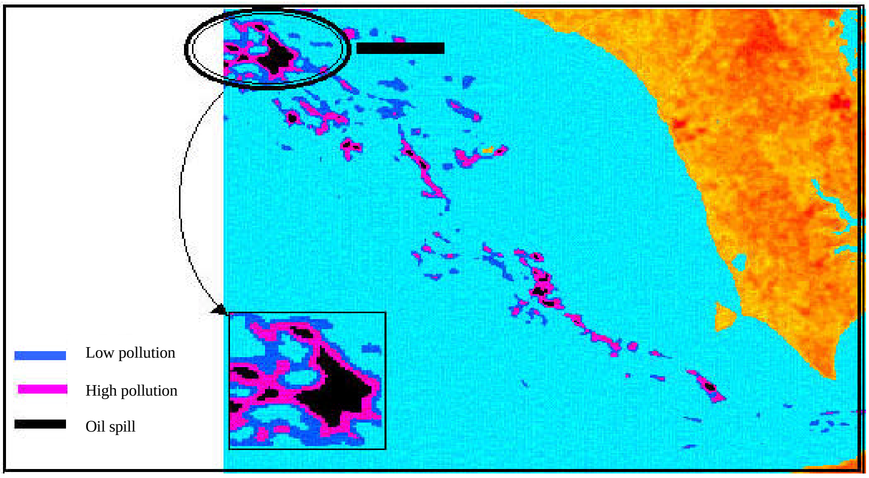



Figure 2.
Oil spill classification using PCI image analysis software; black color is spill area, red is high pollution area and blue is low pollution area.

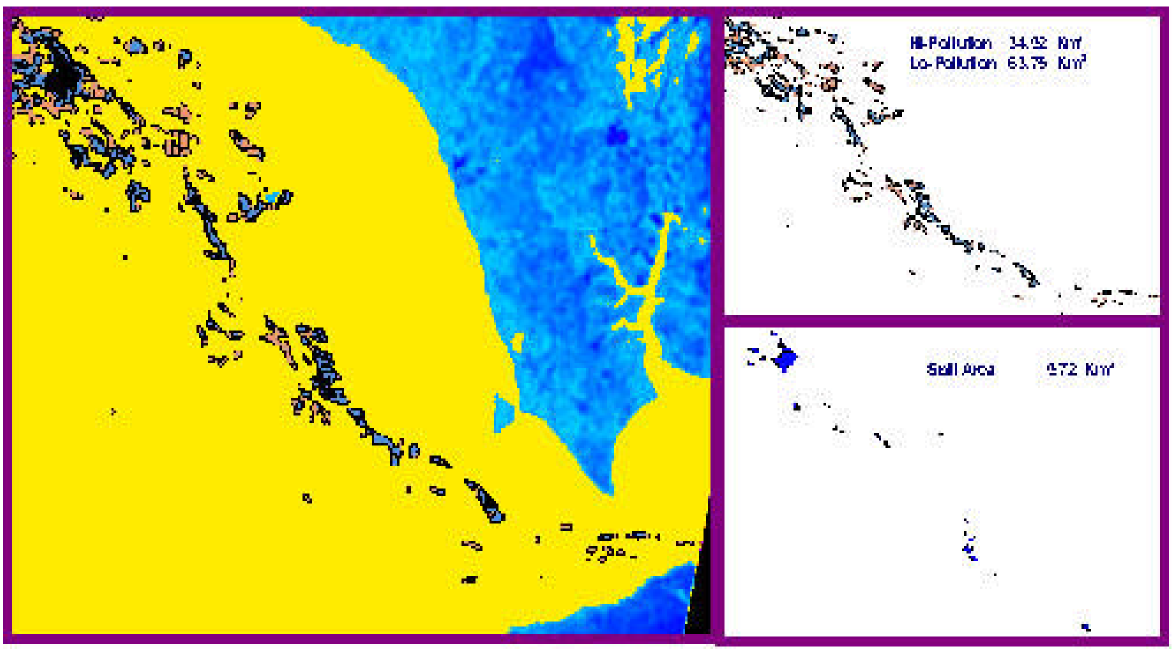



Figure 3. Mapping oil spill by GIS in SPANS 7.1 after detection and classification by PCI Image processing using SAR data

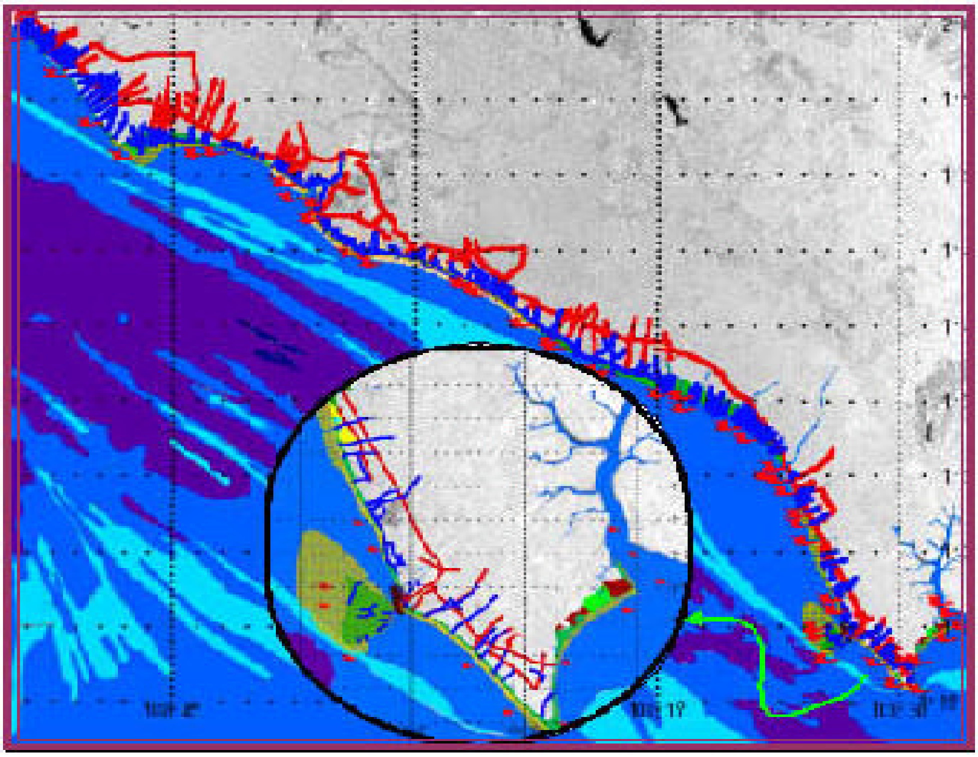


Figure 4. ESI map for entrance of the Straits of Malacca.

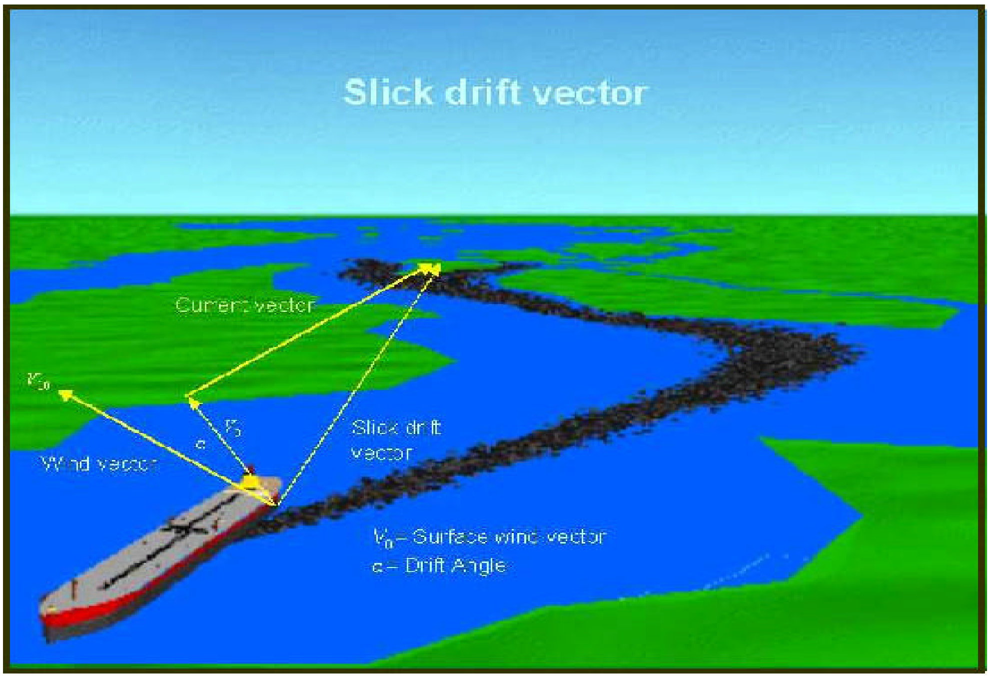



Figure 5. Schematic of oil spill trajectory modeling in sea environment based on wind induced current and net current.

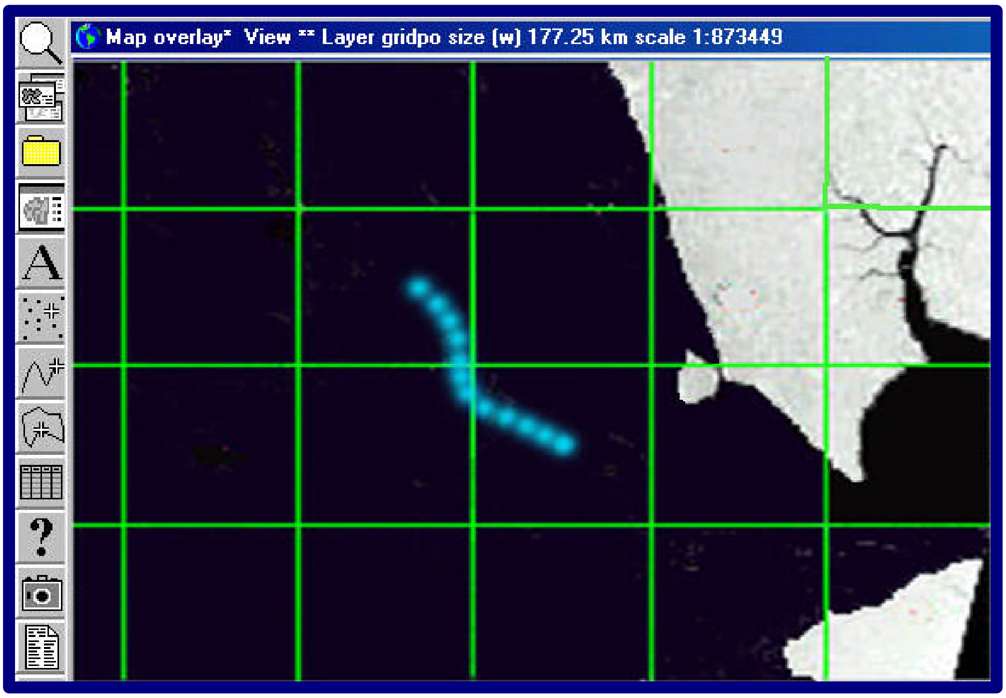



Figure 6. Hypothetical oil spill, trajectory modeling and programming by EASI in SPANS 7.1.

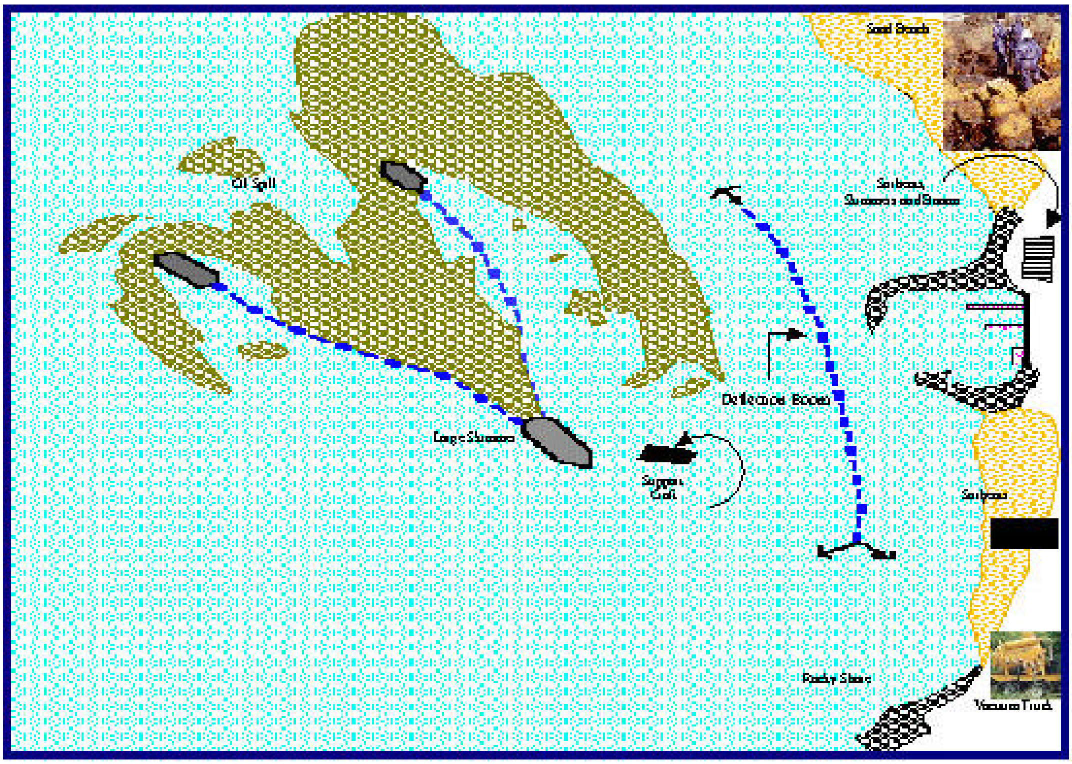



Figure 7. Schematic contingency planning in a cargo area in the Straits of Malacca.