SPILLVIEW: A SUPPORT TO DECISION-MAKING SOFTWARE IN EMERGENCY RESPONSE TO MARINE OIL SPILL

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ABSTRACT

In the event of a marine oil spill, it is necessary to quickly and clearly assess the situation and estimate the extent of the area potentially impacted by oil. This software combines the following features integrated in a Geographical Information System: Geo-referenced digital aerial survey; Access to trajectory forecast model results; charts with marine and terrestrial data. These features allows a better planning of the emergency response in terms of deployment of personnel and equipment, because it helps to document clearly the observed spill and to give rapidly the length of the coastline at risk and the forecasted time at which the oil spill will start reaching the coast.

Aerial surveys are one of the main tools used towards these ends. Aerial observations support the planning of oil cleanup and recovery work, and can also provide accurate data for oil spill fate and trajectory models.

Aerial surveyors traditionally use paper maps to record their observations. This way of doing things presents some limits. These include: 1) the difficulty to evaluate the exact location of observed features on the map; 2) the difficulty to record all the necessary information on a fixed-scale map and; 3) the issue of transferring the recorded observations to spill managers, which takes time, requires explanations from the observer and can be subject to interpretation mistakes.

These are the reasons why the Canadian Coast Guard, in partnership with Cogeni Technologie Inc., developed the SpillView software system. SpillView, which runs under the Windows XP operating sytem, is designed to operate on a pressure sensitive tablet PC equipped with a GPS and electronic maps. The system displays the real time location and trajectory of the aircraft. The observer can record different types of observations (such as oil location, environmental resources, and shorelines contamination) on georeferenced layers that can be individually exported to formats compatible with other Geographical Information Systems. The observer can also use the system to electronically transfer the observed oil location to a spill modeling center, and display the modeling results within minutes.

Spillview proved to be a good tool to support training and exercises, as it can be used to portray different spill scenarios on electronic maps. The software could also be used for other aerial survey needs, such as national security or forest fires. SpillView is presently being enhanced in order to provide operational support by enabling real time access to equipment inventory databases and fieldwork description forms.

INTRODUCTION

One of the roles of the Canadian Coast Guard (CCG), a branch of the Department of Fisheries and Oceans (DFO), is to act as the lead agency in the event of a marine spill occurring in Canadian waters. As defined in the "Marine Spills Contingency Plan National Contingency Chapter" (Government of Canada, 2004), the CCG also has a mandate to ensure response preparedness in the event of an environmental emergency. In addition to the provision of training, organization of spill simulation exercises, and development of partnerships with the private sector, the CCG contributes to the development of response methods and tools that will improve the efficiency of a response. One of these development efforts, financed within CCG's National Research and Development program, resulted in the creation of the SpillView software.

CONTEXT

One of the first steps following a marine oil spill is to clearly assess the situation and estimate the extent of the area potentially impacted by oil. The Quebec region includes more than 13 700 km of coastline, mostly located in remote and sparsely populated areas. In these conditions, aerial reconnaissance is the most efficient method to capture the data necessary to make early response decisions. Once captured, this data must be processed, analyzed and transmitted to the decision makers involved in the response.

Currently, aerial survey observations are recorded during the flight on paper maps or sketches. This way of doing things presents a number of limitations. These include: 1) the difficulty for the surveyor to evaluate the exact location of observed features on the map; 2) the difficulty to record all the necessary information on a fixed-scale map and; 3) the issue of transferring the recorded observations to spill managers, which takes time, requires explanations from the observer and can be subject to interpretation mistakes.

In order to solve these issues, it was decided to develop a computerized system that takes advantage of recent developments in data capture technologies. These include: the availability of small and powerful tablet computers; the development of wireless digital data transmission networks (cell phones, satellites, etc.); the Global Positioning System (GPS); and the availability of georeferenced electronic maps. The new was to support the capture of information used to plan oil recovery and shoreline treatment, and also to gather real time input data for an oil spill dispersion model. This would allow better predictions of the movement of oil slicks.

SYSTEM DESIGN, STRUCTURE AND FUNCTIONS

The data capture software, called SpillView, is a C/C++ application developed by Cogeni Technologie (Quebec, Canada). The system is designed to work on a tablet PC equipped with a pressure sensitive monitor (Figure 1). SpillView can also be operated on a standard Windows-based computer using any of the following operating systems: Windows 2000, NT and XP. The system can capture and display cartographic data in the Mapinfo format.

FIGURE 1: HARDWARE PLATFORM USED TO OPERATE THE SPILLVIEW SYSTEM DURING AERIAL RECONNAISSANCE.

The SpillView software can use topographic maps or nautical charts as base maps. It can read the signal from a GPS linked to the serial port of the computer, and use the information to display the position of the aircraft and capture data. SpillView supports two general types of tasks: data capture of oiling observations and spill modeling.

Capture of Aerial Observations

When interacting with the software, the user is presented with a topographic map or nautical chart centered on the position of the aircraft. As the aircraft moves, the cartographic display is automatically re-centered. The system automatically records a trace of the aircraft movement, showing the flight path. This trace can be saved and re-played at will. The observer can use the tactile monitor to record a number of features, such as the location of an oil slick, or the presence of oil along the shoreline. The data can be recorded by using pre-set standard categories in order to reduce the necessity to "key in" values, since the tablet computer does not have a keyboard. The main functions are available through buttons and menus. The system also includes tools typically found in Geographical Information Systems (GIS), enabling distance measurements, zooming, displaying pre-defined views, etc.

The main georeferenced data capture functions include:

- The description of oil slicks according to their tar code, following a method adapted from the oil slick characterization method developed by Allen and Dale (Allen and Dale, 1995). The function evaluates the oiled surface area and provides a rough approximation of the oil volume (Figure 2)
- A qualitative description of shoreline oiling, following four categories (none, light, medium and heavy oiling). Shoreline oiling observations are displayed following a simple color code. The function also provides an estimation of the length of oiled shoreline by oiling category.
- A description of sensitive environmental resources (birds, marine mammals, etc.). The system can capture the species name, number of individuals observed, and a description of the situation.

Once captured, the data can be directly transmitted to the decision makers at the command center through any network supporting the transfer of digital data, such as cellular or satellite networks. Only captured data layers are transmitted. This ensures that the size of the transferred files remains small.

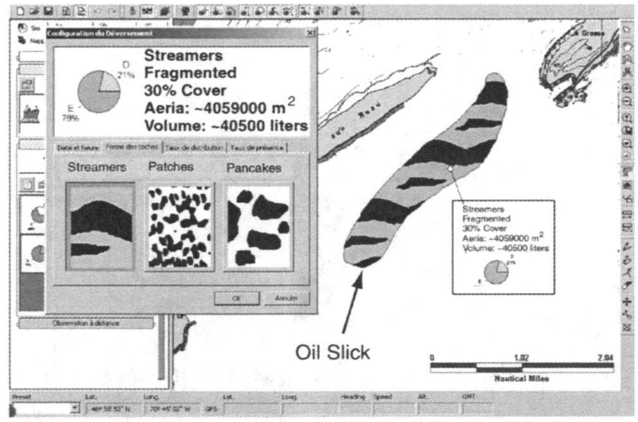

FIGURE 2: PORTION OF THE SPILLVIEW USER INTERFACE SHOWING AN OIL SLICK, CAPTURED BY THE OPERATOR, AND A DIALOG WINDOW USED TO DESCRIBE OILING CHARACTERISTICS.

Spill Trajectory Modeling Forecast

A special set of functions provide SpillView with the capacity to obtain a forecasted trajectory of the oil spill using the results of an ocean model. The model is operated daily by DFO Ocean Sciences Branch at the Maurice Lamontagne Institute.

The model domain covers the Gulf of St. Lawrence. The ocean boundaries are Belle-Isles and Cabot straits. The upstream boundary is set on the St. Lawrence River at Trois-Rivières. Twice a day on the modelling server, the forecasted wind from the operational atmospheric model of the Meteorological Service of Canada is received. Using this forecast along with the tidal forcing and the freshwater runoff, an ocean model is run and issues a forecast of ocean currents for the next 48 hours. The hourly wind from the MSC observing stations is also received. The server is linked through DFO internal network between the CCG in Quebec City and the ocean model server in Mont-Joli. A process is running in the background to keep it on a waiting mode for a connection to the Spillview interface. Two ocean models are used: one for the whole Gulf of St. Lawrence on a 5 km grid and one for the upper St. Lawrence on a 400 meter one.

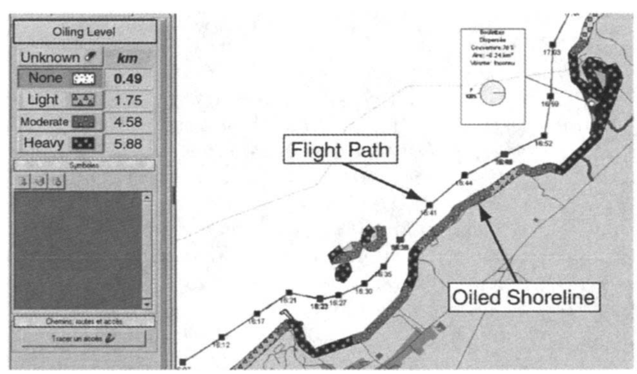

FIGURE 3: PORTION OF THE SPILLVIEW USER INTERFACE SHOWING OILED SHORELINES AND OILING CATEGORIES. TO RECORD AN OBSERVATION, THE OPERATOR FIRST SELECTS AN OILING LEVEL, AND THEN USES A POINTER TO FOLLOW THE CORRESPONDINGLY OILED SECTION OF THE SHORELINE ON THE PRESSURE SENSITIVE MONITOR.

When a trajectory simulation is initiated through the SpillView interface, the following fields are available: date and hour of the beginning of the trajectory, and in what time zone; forward or backtrack trajectory up to 36 hours; Position of the observed slick. This observation can be entered either in latitude and longitude, or by drawing its contours on the map from an aerial observation. The mean trajectory of the movement of the slick will be displayed as well as the contour of the patch at selected times.

The trajectory of the oil spill is calculated on the server in Mont-Joli by adding its displacement generated first by the surface currents of the ocean forecast model and second by the direct action of the wind using a factor of 3.3 % of the wind intensity in the downwind direction. Observed winds closest to the incident are used and merged into forecasted winds when needed. Prior to the calculation, the winds that will be used are shown for validation and edition. Common sense, other available data, consultation with a local forecaster, can all be put to contribution in this validation process.

The spreading of the oil spill is reproduced by using of the order of a hundred initial points with horizontal mixing randomly applied. The evolution of the mean trajectory and the evolution of the oil spill at specified times are returned to the interface to be displayed over the map of the area. The limitations of the modelled trajectory near the coastline are illustrated by displaying the coastline seen by the model which is quite irregular at a 5 km resolution.

The nature of the oil spilled is not taken in account in the modelling. Since the initial phase of spreading during which the nature of the product makes a difference is short, we neglect it. Rapidly, the spreading of the oil is governed by the movement of the surface waters which is independent of the nature of the spilled product. If the hydrocarbons are below the surface, such as Orimulsion, the movement is governed only by the currents in the water column and can be obtained by specifying so in the interface.

Before the development of SpillView, an emergency officer needed to contact an expert from the DFO modeling group to obtain trajectory forecasts. This could introduce a delay of one hour and up to three hours when the incident was after working hours. The SpillView system uses its communication capabilities to automatically access the modeling server and obtain the forecasted trajectory in two to three minutes (Figure 4). Since the bulk of the calculation is done remotely, a limited quantity of data needs to be transmitted:

1) From the PC of the response officer, a series of latitude and longitude positions to define the contour of the spill.
2) From the server and back: A series of hourly wind intensity and direction.
3) From the server: A series of forecasted latitude and longitude positions to define the contour of the spill.

Other Functions

The software can import and display information layers provided in MapInfo .TAB format files. The system can also be used to create and attach mission related information files and describe the position of field response team. Research tools are also available, enabling the creation of search templates and exclusion zones. All the information is displayed as layers on top of the base-map, and each of these layers can be exported as an ASCII file following the MID/MIF format. SpillView stores all information in one single file called "Patrouille", in its own format. Information within this file can be extracted or exported, used to create thematic maps, or simply display all available information. Thematic maps can be saved as standard bitmaps in GIF, JPG, BMP or PNG format. The system can also produce a textual report (in .RTF format) providing a summary of each of the themes. Printing options include the possibility to select individual layers, add a title, explanatory comments, and a warning message. In addition, it is possible to zoom and pan maps in print-preview mode.

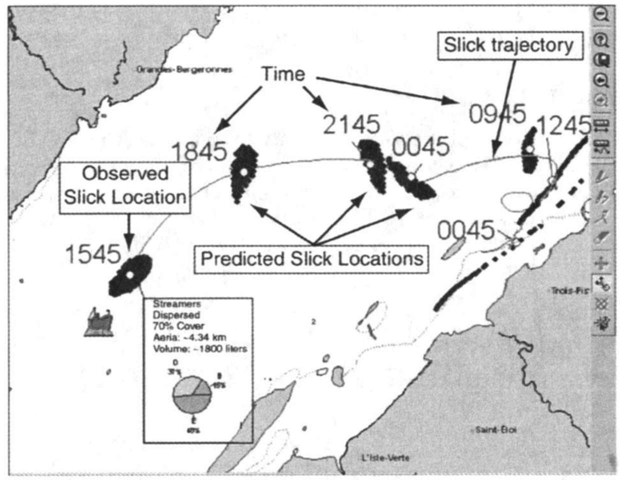

FIGURE 4: SPILLVIEW MAP WINDOW DISPLAYING THE FORECASTS OF THE SPILL MODEL. THE FORECAST USES THE LOCATION OF AN OIL SLICK ENTERED BY THE USER AS A STARTING POINT. THE MODEL PROVIDES THE SLICK TRAJECTORY (LINE), AS WELL AS THE SPREADING OF THE OIL (BLACK POINTS) AT DIFFERENT TIME INTERVALS.

DISCUSSION

SpillView is now fully functional. However, improvements are already planned. An interface that will receive and display real time data transmitted from a drifter buoy developed by the CCG is currently being developed. The buoy is designed to follow oil slicks and transmit its position as well as the air and water temperature through the Orbcomm satellite network. When available, this function will provide SpillView with the capacity to support the validation and enhancement of the spill modeling forecasts. In addition, real time data transmitted from the buoy will make it easier to localize the slick in the morning, always a difficult task after a night a-drift without positive observation.

Additional tools will also be developed to exchange information with our partners through Environment Canada's Internet-based GénieWeb system. This system was developed to integrate all of the data captured by government organizations involved in an incident. Providing direct access to databases of response equipment or bird inventories is considered.

SpillView proved to be an excellent tool when used for exercises and training. The system could also prove very useful to support aerial reconnaissance surveys in other domains than spill response, such as aerial surveillance of pollution, to validate the position of vessels or in forest fires delineation.

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BIOGRAPHY

Capt Martin Blouin graduated from the Canadian Coast Guard (CCG) College in 1985. After obtaining Merchant Marine Captain and CCG Command certificates, he participated in several Arctic missions on board CCG vessels. Capt. Blouin has been head of environmental response for the CCG in the Quebec region since 1997.

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