

A Personal Digital Assistant (PDA) System for Data Acquisition during Shoreline Assessment Field Surveys

Alain Lamarche
Environmental Performance
and Decision Support (EPDS)
Montreal, Quebec, Canada
alain.lamarche@epds-central.com

Doug Reimer
Environmental Mapping Ltd.
Victoria, British Columbia
Canada

Edward H. Owens
Polaris Applied Sciences, Inc
Bainbridge Island, WA, USA

Sonia Laforest
Environment Canada, Quebec Region
Montreal, Quebec, Canada

André Laflamme
Environment Canada, Atlantic Region
Halifax, Nova Scotia, Canada

Steve Clement
Environment Canada, Ontario Region
Toronto, Ontario, Canada

Abstract

Field collection of shoreline information using the Shoreline Cleanup Assessment Technique (SCAT) is now the recognised method to document shoreline oiling conditions in North America. The concept is also being adopted in other countries. SCAT field observations, however, generate a large volume of information. Analysing this information has been recognised as a potential bottleneck during spills impacting long stretches of shoreline. Computerised systems have been developed to alleviate this problem. Even though these systems have demonstrated their efficiency for data treatment and reporting, data entry of SCAT data within such systems still involves considerable effort and is the step that is the most subject to potential errors.

For this reason, a computerised field data collection system dedicated to the entry of SCAT shoreline observations was developed on a Windows CE based Personal Digital Assistant (PDA). The system was designed to be totally compatible with the SCAT methodology and take advantage of Global Positioning System (GPS) technology, available raster maps (such as digital orthophotos) and any available pre-spill information. Prototypes of that PDA field data collection system were tested during drills in Ontario (Canada) and Nova Scotia (Canada). Lessons learned during these tests were used to modify the system design, which was fully integrated within a GIS based computerised response data management system

1 Introduction

Field surveys to evaluate the extent and nature of oiling are essential for adequate planning of spill response operations. In North America, the Shoreline Cleanup Assessment Technique (SCAT)(Owens and Teal, 1990) is now the recognized method to report observations on the state of oiling. Within the SCAT method, oiling conditions are recorded on a set of standardized forms and sketches that contain all of the data necessary to evaluate the most appropriate treatment options, taking into account various environmental and operational constraints (Owens and Sergy, 2000). The benefits of the SCAT method come with a price: the

method typically generates a large volume of data, which needs to be rapidly processed in order to be useful. This potential pitfall is of concern during large spills and so led to the development of computerized tools that can rapidly provide reports and maps to support the decision process during response planning (Lamarche et al., 1996, 1998).

However, for these computerized tools to use the SCAT data, it must be manually transcribed from its original paper form. There are many issues related to this transcription process, which at the moment creates a bottleneck in the decision process. First, before the information can be entered in centralized databases, the SCAT data forms need to be brought back from the field. This would typically be done directly or by facsimile transfer. Also each paper form needs to be verified by the person responsible for SCAT data management in order to prevent interpretation mistakes. This will often require a brief interview with each SCAT team leader. Data entered manually also should be verified to ensure that there are no entry errors. There is always a possibility of missing important information when forms have been entered by less experienced surveyors, particularly at the beginning of a spill (which is also the time when data needs are the most crucial). Hand drawn sketches can often be difficult to understand, and location of oil on hand-drawn sketches can be difficult to interpret.

Early field trials have shown that it is possible to use an “all electronic” approach to the documentation of oiled shorelines (Rubec et al., 1998). At the time, however, the cost, weight and unreliability of field equipment made these tools difficult to implement. The situation is quite different now. The last few years have seen the development of inexpensive, small and powerful computers, also called “personal digital assistants” (PDA). These pocket size devices can be equipped with Global Positioning System (GPS) receivers. Some of the more expensive models are also weatherized, virtually unbreakable and can operate in extreme weather conditions. All of these characteristics make PDA ideal tools for data collection.

These reasons have motivated the development of a tool dedicated to the field capture of SCAT data. This paper describes how the field data collection system was designed, developed and tested. Some user interface details are also provided in order to illustrate how the large paper Shoreline Oiling Summary forms were made to fit on the small display screen that is typical of pocket-size devices.

2 Development

A preliminary analysis was performed to identify the key functions of the system. The nature of the data content and data structure partly came from that of the ShoreAssess® system, which is dedicated to the provision of decision and management support for the SCAT method. Some of the job aids incorporated in the system, such as the visual aid for estimating oil distribution percentiles, are derived from Environment Canada documents (Owens and Sergy, 2000).

The software development tools were selected, using the following general guidelines and principles: the tools needed to be flexible enough not to limit the selected system functionalities, and simple enough to be easily modified. An additional constraint was that the prototype could be distributed on an array of field computers with minimal costs.

After initial testing and evaluation of a variety of approaches, the following software tools were selected: Microsoft embedded visual basic as the main programming language, and “gpsMapThingo” as the map display interface. GpsMapThingo (developed by Mobile Edge Software) is a direct link library (DLL) that provides the capability to read GPS signals from a device serial communication interface and to display captured positions as tracks and waypoints on top of raster images.

Rapid prototyping was used to develop the field acquisition system. This development method works in the following way: after an initial analysis and the development of specifications, a prototype is built, then evaluated. The evaluation leads to modifications, which in turn leads to the production of another prototype, which is then evaluated, and so on until no more modifications are judged necessary.

The first version of the field acquisition portion of the prototype was developed and tested locally during an Environment Canada SCAT field exercise in the Cornwall area. This first field experience was used to make modifications to the system, which was tested again during another Environment Canada field training course that took place near Halifax, Nova Scotia. During these tests, data from the Atlantic (Laflamme and Percy, 2003, Percy et al, 1997) and Ontario (Environment Canada, 1994) regions’ pre-spill databases was used to provide base maps, shoreline segment locations, and to populate part of the electronic SOS forms.

3 Results

The results of the development of the field data acquisition system are presented in four main sections. First, the main characteristics and capabilities of the system are described. Then, details are provided to describe the system data structure. The next section explains the necessary steps, processing and issues in the integration of field data into a “central database”. Then, examples are provided to show some elements of the user interface. Lastly, important lessons learned from the field evaluations are presented.

3.1 Field System Characteristics

The main characteristics of the field data acquisition system are summarized in Table 1.

First, the system operates on a Personal Digital Assistant hardware device, optionally connected to a Global Positioning System (GPS) receiver. A Windows CE - Pocket PC hardware device was selected primarily for the following reasons: 1) there is an array of these hardware devices available, from inexpensive to higher end weatherized units; 2) all of the response organizations involved in the study already possess these types of units; and 3) there is a good choice of development tools for the selected operating system.

Table 1 Main characteristics of the field data acquisition system.

- Pocket-PC (Windows CE) hardware platform
- Uses Global Positioning System (GPS) technology, if available
- Uses the SCAT method to the documentation of oiled shorelines
- Uses GPS captured point or pointing device to capture positional data Shoreline segment locations entered as lines Oiled zones location entered as lines Pit/trench location entered as points
- Coordinates are captured in digital degrees
- Provides electronic equivalent of Shoreline Oiling Summary (SOS) forms to enter data
- Captured data can be exported to standard GIS format (Shape, Tab, Mid/Mif)
- Captured data can be integrated within centralized management systems
- Database can be pre-loaded with information from shoreline segmentation systems.

The field data acquisition system takes advantage of Global Positioning Technology if it is available (i.e. if a GPS receiver is connected to the PDA). However, the system can also be used in the absence of a GPS receiver, since GPS positions may be unavailable or of poor quality. For practical purposes, the accuracy of a GPS signal should not be less than the size of the feature that is being mapped. In most cases, accuracy of 15 meters or less should be acceptable.

The field data acquisition system implements the SCAT method. This has become a standard in North America, and it is used by all of the response organizations involved in the study. The shoreline segment constitutes the basic unit and is defined as an alongshore section of coastline with relatively uniform shoreline character in terms of morphology and/or sediments. Oiling characteristics are all reported with reference to a shoreline segment.

GPS receivers provide positional data as points. A series of linked points, or “tracks”, are used to enter the location of shoreline segments as lines. Similarly, a series of points are used to represent oiled zones. A single point, or “waypoint”, is used to represent trenches or pits.

The system can use georeferenced raster images as base maps. In the absence of a valid GPS signal, the user can manually enter the positional data with a pointing device and using the raster image as the “backdrop” which provides the spatial reference.

Shoreline segment and oiling characteristics can be entered on electronic equivalents of Shoreline Oiling Summary (SOS) forms. Because of the very limited display dimensions of PDA’s, the electronic forms are separated into sections that correspond as closely as possible to those of their paper equivalents. Some visual job aids also have been integrated within the forms interface.

The captured field data can be extracted from the PDA and transferred to a desktop computer, where it can be merged or incorporated within a spill database. The extracted field data can be provided in the following formats: Shape Files, compatible with the ESRI Arcview GIS systems; Mid/Mif format; or Mapinfo TAB files. Finally, a merging function enables the transferred field data to be incorporated within a ShoreAssess® database. A mechanism has been designed in order to

simplify the transfer process as much as possible. This mechanism is further detailed in the following section.

Finally, existing shoreline segmentation data from pre-segmentation databases can be transferred to the field system for the benefit of the surveyor.

3.2 System Data Structure

The data structure was developed in order to accommodate and support the various functions provided by the field data acquisition system in the simplest way possible, with acceptable performance, as processing speed can be limited on PDA devices.

The main features of the data structure (Figure 1) include: 1. shoreline and oiling characteristics data stored in an Access database; 2. positions and locations of shorelines, oiled zones and pits recorded in ASCII files; and 3. base maps stored in bitmap files.

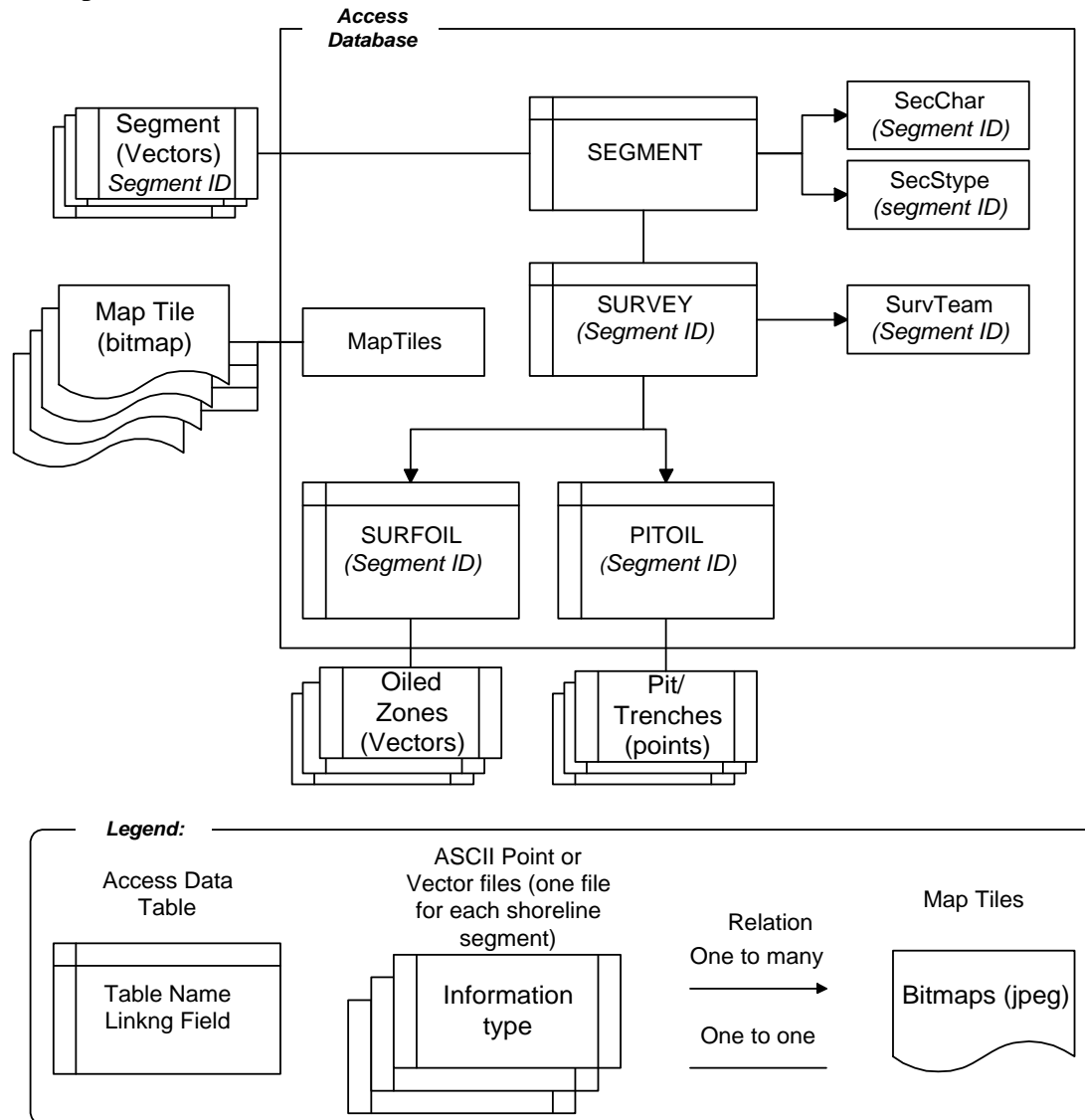


Figure 1 Data Structure for the PDA Field System

Shoreline segments constitute the “building block” of the field database. The characteristics of each of the segment are stored in a set of seven interrelated tables, regrouped within an Access database. Each segment is associated with a single survey, but can contain many oiled zones or pits and trenches. All of the data associated with a SOS form can be captured within the Access database.

Positional data for shoreline segments, oiled zones or pits is captured as points or series of points. The data is stored within a set of files, each file corresponding to a single shoreline segments. Thus, there will be as many segment or oiled zones locations files as there are segments. Each file uses the segment code as part of its name. A prefix indicates if the file contains the position of oiled zones (OZ) or pits (PIT). For example, file CS-06.pps would contain a list of points corresponding to the location of the CD-06 shoreline segment. File OZ_CS-06.pps would contain the oiled zones locations recorded for shoreline segment CS-06. Within each file, the locations are simply stored as a list of coordinates. For oiled zones and pits, the file also contains the identification of each oiled zone (Figure 2).

```
A, 6
-63.43088 44.61399
-63.43041 44.61443
-63.42984 44.61473
-63.42860 44.61497
-63.42756 44.61497
-63.426428 44.61494
B, 3
-63.42642 44.61497
-63.42499 44.61392
-63.42442 44.61233
```

Figure 2 Example showing how positional data is stored within ASCII text files. In this example there are two (2) oiled zones, coded “A”, and “B”. This first oiled zone is defined as a line with 6 “nodes”, and the second with 3 “nodes”

This method of storing positional data, which is similar to the Mapinfo “Mid/Mif” format, was created to simplify data management. As will be seen, positional data is displayed as “tracks” (a series of linked points) of different colors, or “waypoints” (a single point) of different shapes over the raster base maps. This structure is reproduced in the storage design.

In order to simplify the entire positional data management, capture and editing mechanism, the system does not allow the editing of points within a track. In the event that it is necessary to modify the location of a segment or oiled zone, then the entire segment or oiled zone is erased and must be redrawn.

Base maps constitute the last data element of the field acquisition system, and are stored as georeferenced bitmap images. A table provides a list of all available maps within the Access database. This table includes: the name of the bitmap file, the identification of the map, the coordinates (latitudes and longitudes) of the area

covered by the map and the name of a scale bar file. Any bitmap, such as digital pictures or satellite imagery, can be used as a base map. The field system does not offer a “zooming” function. However, the system is designed to provide two selectable levels of scales for base maps: one smaller scale for “navigating” within an area, and the other larger scale for data entry.

3.3 Data Transfer Mechanism

One of the main purposes of the field acquisition system is to accelerate data analysis and processing. As previously discussed, the selected data structure is a somewhat irregular assemblage of many files, and does not correspond to any specific GIS standard. Thus a special mechanism to transfer data had to be devised (Figure 3).

First, in order to simplify the data transfer process, the various files and data tables that constitute the field database are all merged into one single ASCII transfer file with the use of a “coding” procedure. The procedure does not actually “encode” the data (although it could, if security is identified as an issue) but simply reads the information associated with the segment within each of the data tables and positional files, and then writes it to one single ASCII text file. Data attributes are simply delimited by commas. A linefeed separates each of the attributes categories.

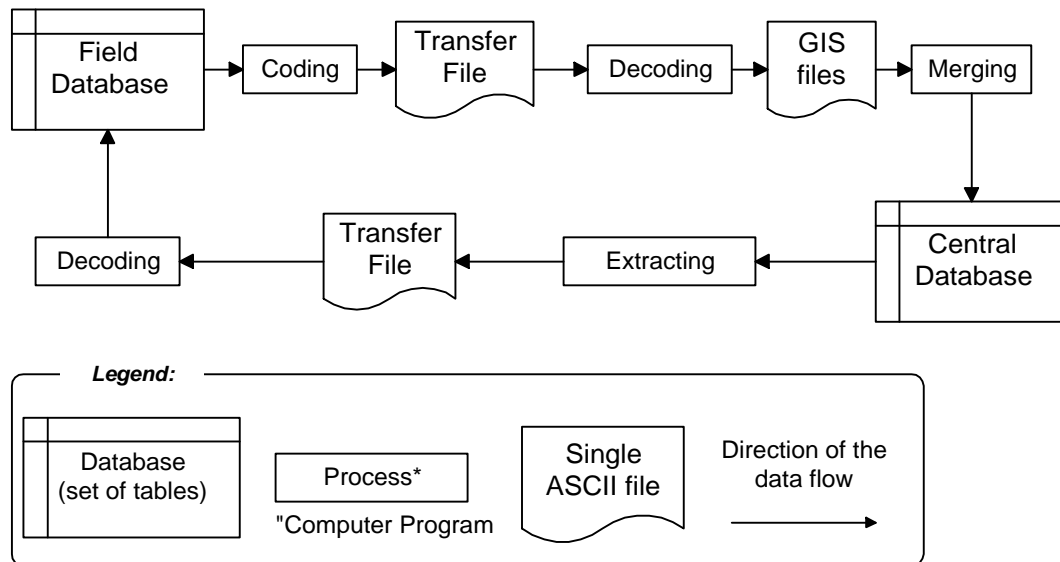


Figure 3 Dataflow Diagram Showing the Data Transfer Mechanism from the Field to the “Central” Database

This single ASCII file can be easily transferred back to a desktop or central computer, normally located in the command centre and operated by personnel responsible for spill data management.

Once on a desktop computer, a second set of programs “decodes” the transfer file and returns the information into standard GIS format. During this transfer, the latitudes and longitudes coordinates are transformed into the coordinate system used on the central database. Once in that form, the information is merged and incorporated into a central database (in this case a ShoreAssess® database). The

merging process includes a mechanism to prevent accidental destruction or duplication of existing data.

A similar mechanism allows the transfer of selected information from the central database to the field system. In this case, however, there is no specific merging mechanism. Information for the shoreline segments selected from the central database simply replaces that of the field database.

3.4 Functions and User Interface

Three major elements constitute the user interface: menus, maps and data capture screens.

Menus are used to select major functions. The main menu (Figure 4), for example, is used to select between the map selection, shoreline selection or GPS settings.

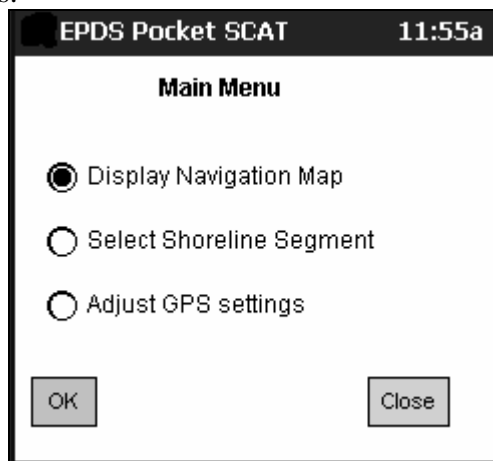


Figure 4 Field Data Capture Application's Main Menu

In the example, selecting the "Display Navigational Map" option opens the map selection menu (Figure 5). GPS data is used whenever possible for a variety of purposes, for example, to select the base map where the observer is located.

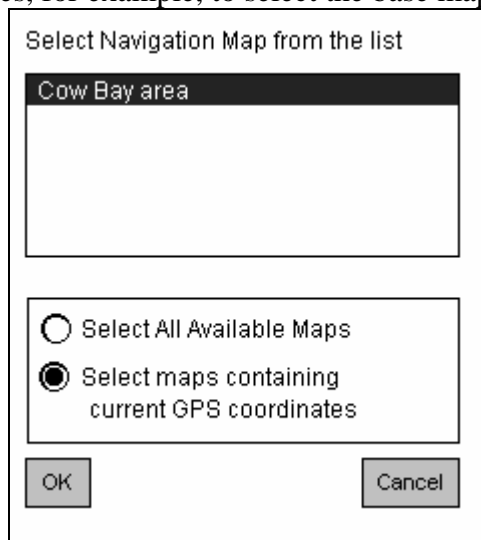


Figure 5 Field data capture application's map menu, showing only the base map corresponding to the observer's location

The map windows enable the user either to navigate within an area (Navigation map) or edit and enter data. Figure 6 shows a portion of a navigation map displayed on a PDA screen. The pointer can be used to “pan” the map. The map can also be centred on the observer’s GPS location. Navigation maps also contain “Area Markers”, which are used to select data capture base maps with the units pointing device. In the example (Figure 5), the observer selected Area D and a rectangle indicates the extent of the selected area

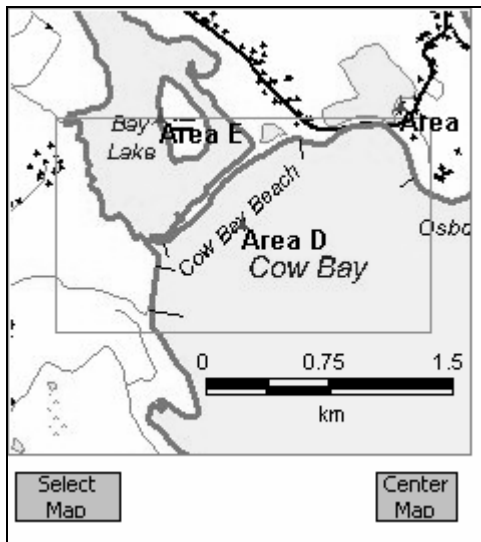


Figure 6 Example of a Navigation Map Screen

Data capture maps are used to enter, delete or modify the location of shoreline segments, oiled zones and pits. The operator points to the map symbol associated with their labels in order to select a segment, oiled zone or pit. Figure 7 shows a map data capture screen for segment CZ-06, within which two oiled zones, A and B, have been drawn.

The observer can use either a GPS position, if available, or the pointing device in order to draw a new element (segment, oil zone or pit). The two operations are quite similar: when using the GPS, the operator acts as the “Pointing Device” by moving to the desired location and a button is then displayed to allow entry of nodes. The GPS data entry option is automatically disabled if the GPS signal is not of sufficient quality.

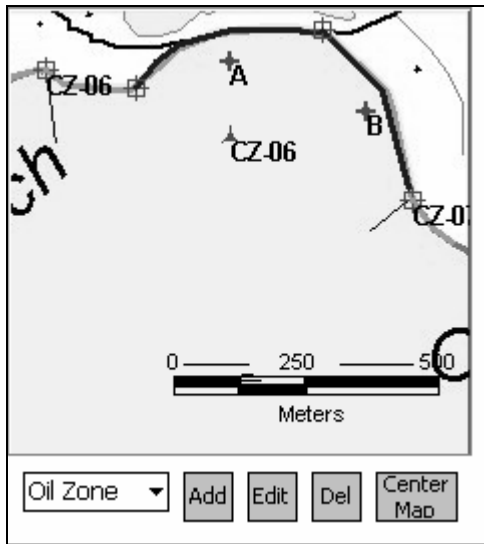


Figure 7 Example of a Data Capture Map Screen

The electronic SOS form can be accessed from either the data capture map interface or the shoreline segment selection menu. For example, selecting a shoreline segment and pressing the “edit” button located at the base of the screen opens an option window that enables selection between modifications of the segment location or of the segment data (Figure 8).

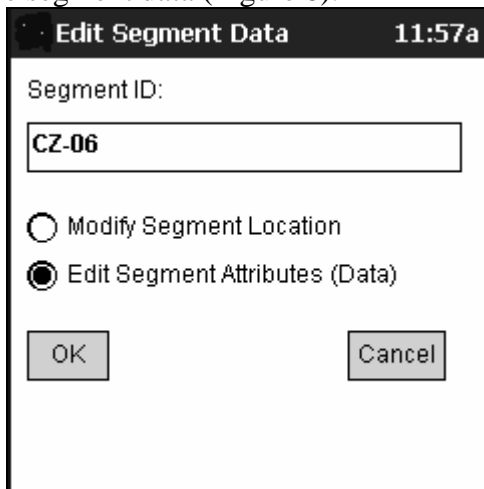


Figure 8 Segment Edition Selection Options

Segment attributes are modified within a set of numbered screens and each number corresponds to a section of a paper SOS form. Figure 9, for example, shows the first two screens of the series. Many of the fields within each form have special data entry support. For example, the date defaults to the PDA current date. Tapping once in the start time or end time boxes with the pointing device enters the current time. Team members can be selected from a list, which can be populated either beforehand, or on site

Figure 9 shows two sections of the SOS form interface. Section 1 (left) includes fields for Segment ID (CZ-06), Survey (1), Op. Division (C), Region (ATL-4), Date (3/24/04), Time (From 12:45 To 15:44), Tide Level (0.5m), and Tide Level type (Rising). Section 2 (right) includes Temperature (12 C), Wind Speed (5 km/h), Weather (Clouds), Surveyed By (Foot), and a list of Team Members (Lamarche, Alain (EPDS), Laflamme, André (EC), Owens, Ed (Polaris), Reimer, Doug (EML)).

Figure 9 SOS form interface, showing section 1(left) and section 2 (right) of the electronic SOS form

The segment length (Figure 10, left) is automatically calculated from the length of the drawn segment. The surveyed length defaults to the segment length. If the GPS unit is active and provides a valid signal, tapping once on the “GPS” button enters a GPS coordinate, with the appropriate number of significant digits (Figure 10 left). Drop-down lists of categories are provided whenever possible. As an example, Figure 10 (right) shows some of the shoreline types available in the list. The list of shoreline types varies according to the organization. The example shows the default list.

Figure 10 shows two sections of the SOS form interface. Section 3 (left) includes fields for Total Segment Length (940 m), Max. Width (2 m), Surveyed Length (940 m), Latitude (44.6143), Longitude (-63.4330), Start GPS, and End GPS (44.6121, -63.4242). Section 4A (right) shows a list of Shoreline Type(s) with a dropdown menu open, listing various types like Sediment Beach - Pebble Cobble, Sediment Beach - Mixed Sand, Sediment Beach - Boulder, Sediments Flats - Sand Flats, Sediments Flats - Pebble Cob, Sediments Flats - Mud, Sediments Flats - Sand Grave, and Sediments Flats - Boulder. It also includes a Moderate dropdown and an Open Coast dropdown.

Figure 10 SOS form interface, showing section 3(left) and section 4A (right) of the electronic SOS form

Similar aids are provided for the entry of oiling characteristics (Figure 11). In the left screen, selecting any of the oil character checkboxes provides the oil character description (in this case FR for Fresh). Pressing the “Eval” button opens an oiling distribution evaluation screen and tapping on one of the images automatically selects and enters the corresponding percentage of oil cover.

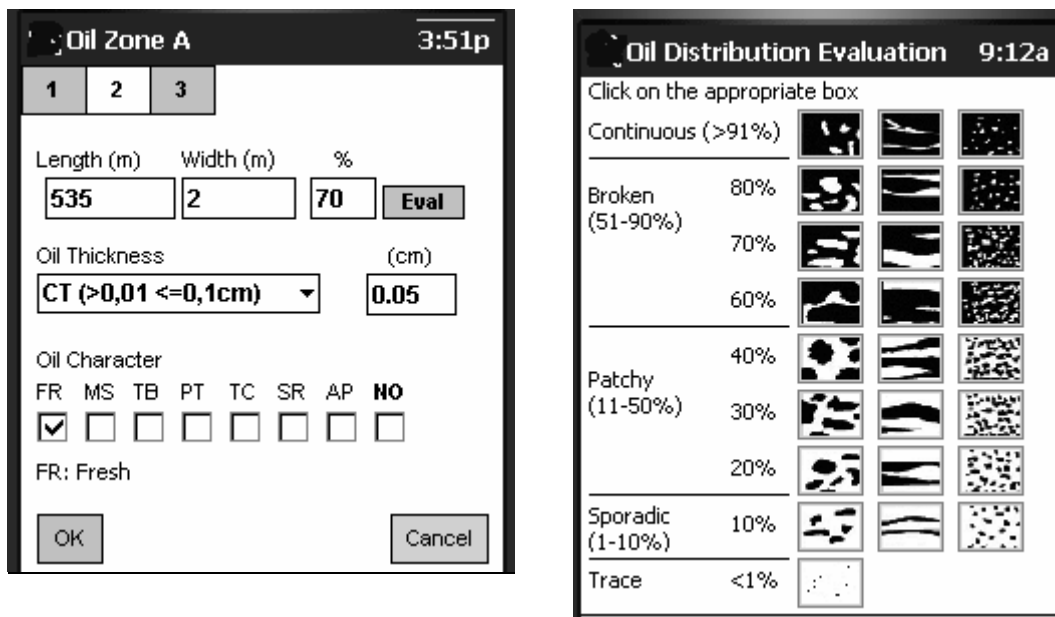


Figure 11 Examples of the SOS form interface, showing section 2 (left) of the oiling characteristics data entry screen, and an oil evaluation aid (right)

Limiting the necessity to use the virtual keyboard, simplifying user interaction and accelerating data entry were the main purposes behind all these mechanisms.

3.5 Field Tests: Lessons Learned and Design Modifications

The development process involved three prototypes. The first prototype was developed and tested during an Environment Canada – Ontario region SCAT course and exercise near Cornwall, Ontario. Data from the Ontario region pre-spill database was used to populate the field database. The information transferred from the pre-spill database included: raster base maps showing the location of shoreline segments and topographical information, along with the location of shoreline segments and shoreline types. In this first prototype, data capture maps only allowed the documentation of one single shoreline segment at a time, including that of oiling data (oiled zones and pits). The system did not allow the modification of shoreline locations, as it was thought that sub-segmentation might not be necessary if an organization uses a pre-spill segmentation database.

The field test showed that, in the event of a spill, there would most likely be a need to create new segments or modify the location of existing ones. This capability was added to the next prototype. Modifying the shoreline segment location was done by erasing it and re-capturing it using the GPS signal or the pointing device.

The second field test took place during an Environment Canada SCAT course and exercise held in the CowBay area, near Halifax, Nova Scotia. The prototype was further modified before the test in the following way: the list of shoreline types was changed to that used for SCAT surveys in the Atlantic region as the earlier exercise used a slightly different set of Great Lakes shore types. A new screen was added (Figure 12) to display and enter resource information recorded in the Atlantic Region sensitivity mapping system.

1	2	3	4A	4B	5A	5B	6-7	8
---	---	---	----	----	----	----	-----	---

Primary Resource

BIO/ECO: lobster fishing area

Wildlife Observations

Birds Mammals
 Shellfish Vegetation
 Reptiles/Amphibians

Other:

OK Cancel

Figure 12 Section 5B of the electronic SOS form. The form allows the display and editing of resource information

The prototype generally worked well in both field tests, showing that the technology is reliable. However, some issues were raised from these practical experiences.

First, preparing base maps from raster images was a long process, even with some software support tools. Preparing and distributing base maps to field acquisition units could become an issue during a large spill so that the field data acquisition system also should be designed for use without predefined base maps.

Field surveyors considered that having access to existing pre-segmentation data during field acquisition was a real advantage.

Although the field PDA devices could easily be operated, some training is still needed, particularly to understand how to capture or modify special data, as this part of the user interface does not follow a known standard. The nature of the difficulty is that, although the interface might look like one of a geographic information system, it is in fact very different and is closer to the interface found on certain GPS units. These interfaces generally offer limited capacity in terms of zooming and editing spatial features.

Each organization involved in SCAT surveys had its own region-specific requirements. In particular, the shoreline types and backshore categories differed greatly between the Ontario and Atlantic Regions. The nature of the resources data and the method of recording access restrictions also varies slightly between these two organizations.

These observations led to some modifications in the design of the field acquisition system. More precisely, the system was modified to accommodate small variations in the content of electronic forms. In addition, the capability to capture and display the limits of shoreline segments, oiled zones and pits over an “empty” base map was also added. In order to do this, the system displays over an empty map the location of shoreline segments, oil zones or pits over an empty screen, in a way similar to what is done with certain types of GPS units.

4 Discussion

The fact that the field data collection prototypes worked quite well was certainly to be expected. The tool does not require particularly exotic or advanced hardware components, or software tools. However, the development of the tool did show that the work was not as simple as it looked.

One of the main difficulties resided in the large amount of information generated by SCAT observations, and the very small size of the PDA device. The other difficulty came from the lack of keyboard. These problems led to the extensive use of various methods to limit the user interaction, and also to the break down of SOS forms into very small units. The drawback, of course, is that it is rather difficult, from just looking at one of the many screens that make up the equivalent of a single SOS form, to have a quick overview of oiling conditions for a single segment, which is why the centralized management systems, such as ShoreAssess®, will allow the paper SCAT forms to be printed.

The second difficulty came from the decision to use an array of tables and files to store positional and attributes data. Although this decision simplified the programming of the field tool, it led to the necessity of developing a “decoding and encoding” mechanism to simplify data transfer.

Similarly, the small screen size led to the decision to use two base map scales, one for navigating and the other for data entry. The scale of the data entry map was selected so that the longest shoreline segments would fit in the drawing area.

Field capture tools, whether paper or electronic, are elements of a long chain of processes whose ultimate goal is to apply the most appropriate and efficient method to document the character of oiled shorelines. SCAT surveys and data are well defined and standardized and this makes computerization possible. The use of efficient electronic field tools should greatly enhance the concerted effort of the many teams involved, not only in surveying shorelines but also in providing treatment recommendations, planning, and effecting the treatment. Additional types of survey could certainly also benefit from the use of field captures systems. These include wildlife surveys, inspections, and the creation of pre-spill segmentation databases. Before some of these types of surveys can benefit from field capture tools, however, it would be necessary to further define the exact nature of the data to be captured.

The use of electronic tools will probably not replace the need to fill-in paper forms. Also, however much we try, it will always be very difficult, if not next to impossible, to reproduce the flexibility of pen and paper for the production of sketches, especially when the drawing area that can be used for a PDA is so small. We do believe, however, that this diminished flexibility on the one hand is largely offset by the potential to easily and quickly obtain accurate GPS positions, length measurements, and to quickly integrate field data within a centralized treatment system, where maps, reports, and readable forms can be displayed or printed.

5 References

Environment Canada, *Environmental Sensitivity Atlas for the St. Clair River, Lake St. Clair and Detroit River Shorelines*, Environmental Emergencies Section, Ontario Region, Downsview, ON, 79 p., 1994.

Lamarche A., P. Rubec and A.P. Varanda, "Geographical Information System (GIS) Support for Shoreline Cleanup Operations", in *Proceedings of the 19th Arctic and Marine Oils Spill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 1131-1143, 1996.

Lamarche A., D. Morris, E.H. Owens, S. Poole and J. Tarpley, "The Benefits of Computerized SCAT Data Management within an Incident Command System", in *Proceedings of the 21th Arctic and Marine Oils Spill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 157-166, 1998

Laflamme, A. and R. Percy, "Sensitivity Mapping - with Flare! An Internet Approach to Environmental Mapping", in *Proceedings International Oil Spill Conference*, American Petroleum Institute Publication No. 14730B, Washington, DC, pp. 95-102, 2003.

Owens, E.H. and G.A. Sergy, *The SCAT Manual: A Field Guide to the Documentation and Description of Oiled Shorelines*, Second Edition, Environment Canada, Edmonton, AB, 108 p., 2000.

Owens, E.H. and A.R. Teal, "Shoreline Cleanup Following the *EXXON VALDEZ* Oil Spill: Field Data Collection within the SCAT program", in *Proceedings of the 13th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa ON, pp. 411-421, 1990.

Percy, R.J., S.R. LeBlanc and E.H. Owens, "An Integrated Approach to Shoreline Mapping for Spill Response Planning in Canada", in *Proceedings International Oil Spill Conference*, American Petroleum Institute, Washington DC, Pub. 4651, pp. 277-288, 1997.

Rubec P.J., A. Lamarche, A.A. Lavoie and J.K. Winner, "Wireless Electronic Support to the SCAT Process", in *Proceedings of the 21th Arctic and Marine Oils Spill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 147-155, 1998.