THE OIL SPILL SAMPLING ADVISOR (OSSA): EXPERT SYSTEM

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ABSTRACT

Expert systems are computer programs that emulate a human expert's decision-making process in a particular domain of knowledge. Over 15,000 expert systems have been developed around the world for assistance over a wide range of topics and subjects. Expert systems are seen as having a dual use as they assist in the training of individuals in a particular subject, and they also offer fast, effective on-the-spot advice in the form of easy to answer questions.

Oil spill response requires highly technical training and specialized knowledge. Several expert systems have been created to assist responders in the event of an oil spill and subjects have included beach cleanup, in situ burning of oil, protecting sensitive shorelines and the use of dispersants among others.

However, none of the published oil spill response expert systems to date have incorporated how to effectively sample an oil spill, and yet the sampling of an oil spill needs to adhere to strict legal, International Maritime Organization (IMO) and the American Society for Testing and Materials (ASTM) protocols in order to produce accurate and defensible data. The correct assimilation of data from oil spill response ensures that the responsible party/parties can be identified and are held accountable for any environmental damage that the spill has caused.

The authors have recognized the gap in sampling guidance within all the available Oil Spill Response expert systems worldwide and therefore have created the Oil Spill Sampling Advisor or (OSSA) expert system through Leeder Consulting in Australia. The OSSA expert system is the first of its kind; a unique system to train and assist responders and pollution investigators with how to successfully take samples that will produce legally defensible data before, during and after an oil spill.

For many small or developing countries (or ships at sea), it is not only highly impractical but also too costly to bring in sampling experts every time a spill occurs. As a result, if the responsible party has not been identified, the costs of cleanup and the environmental burden are frequently left for governments to bear. However, the new OSSA expert system provides a cost-effective means to help find oil spill polluters so that they can be responsible for paying the costs of cleanup. The OSSA expert system assists with training people to collect defensible forensic evidence, and it also provides on-the-spot information and advice to anyone having to collect an urgent spill sample. This includes all the necessary forms to be printed and filled out in order to ensure legal defensibility of the samples and resulting analytical data. Operating from a CD-ROM or an on-board ship laptop computer, OSSA is completely portable and accessible anywhere in the world at any time.

*This paper covers the advantages, disadvantages and common misconceptions of expert systems in the field of oil spill response. It also addresses how expert systems can be used as teaching tools and the unique framework utilized by Leeder Consulting in the creation of the **OSSA** expert system.*

INTRODUCTION

Data can be assembled into information. But information, used in the context of human experience and expertise, can become ***knowledge***. And, knowledge is what is taught by experts, and sought by non-experts, for application of cost-effective solutions to complex technical problems. Expert systems use human knowledge to solve problems that would normally require human intelligence. An expert system helps solve problems through a set of interactive rules in order to assist with decision making. Over 15,000 expert systems have been developed around the world for decision-making assistance over a wide range of topics and subjects (Graham 2003).

In basic terms, the concept of expert systems is a simple one but the translation and encoding of human knowledge into an interactive computer program is a complex undertaking. Basically, the knowledge of an expert in a particular field is transferred to a computer program and thus becomes readily accessible to whoever has the software, in any country, at any time. An expert system can be in many different places at once (i.e., it can exist as multiple copies), whereas the expert is limited in this ability; a human expert will not be available 24 hours a day at all times in many places. Simply put, an expert system is a decision-support computer program that aids people who have to make important decisions. Decisions can be based on a 'true/false' or 'if/then' hypothesis where the user is advised on a proper course of action based on 'expert' opinion from previous, similar conditions and circumstances.

ADVANTAGES/DISADVATAGES AND COMMON MISCONCEPTIONS

Many corporations and government organizations spend a great deal of money on increasing employees' knowledge through training programs, procedural manuals, guidelines, and on-line information systems (Barr & Tessler 1995). The purpose of all these expensive endeavors is to make information and knowledge available to those who need it. Expert systems, as the most popular applied Artificial Intelligence technology (Turban & Aronson 2001), does exactly that; it makes knowledge available to non-experts. However, the ***OSSA*** expert system goes one step farther—it makes both knowledge and related information available to non-experts in the critical field of oil spill sampling.

According to Turban & Aronson (2001), *"Knowledge is a major resource, and it often lies with only a few experts. It is important to capture that knowledge so others can use it. Experts get sick or become unavailable, so knowledge is not always available when needed. Books and manuals can capture some knowledge, but they leave the problem of a particular application up to the reader. Expert systems can provide a direct means of applying expertise. The purpose of an expert system is not to replace the experts, but to make their knowledge and expertise more widely available. An expert system permits non-experts to increase their productivity, improve the quality of their decisions, and solve problems when an expert is not available."*

Expert systems are often used in emergency response decision-making (Slap *et al*). The advantages of expert systems or decision support tools in emergency situations, where concise, fast and accurate decisions need to be made are numerous. For example an expert system offers:

Consistent advice in a given situation (unlike advice provided by human experts)

- Reliable decision making
- Speed and time-saving decisions as the expert system can be on the scene immediately as opposed to a human expert. Furthermore, faster decision-making is of vital importance during an emergency response
- Knowledge base is not lost when there is staff turnover and can be transferred readily to remote locations
- An expert system offers a valuable second opinion and captures scarce expertise
- Significant cost reduction, as there is less need to pay travel and consulting costs for experts
- Increased employee productivity
- Improved employee satisfaction

Another advantage of expert systems is the uniformity and transparency of decisions that they create. For example, an emergency responder using a system can explain *"...the reasoning behind a decision, indicating that this was the best available course of action, as determined by experts who have been confronted with similar situations in the past"* (Graham 2003).

It is also of vital importance to understand the limitations of expert systems. There is a wide misconception that an expert system can replace the actual judgment of experts and this is not the case at all. On the contrary, there are some decisions or judgments that simply cannot be automated. An expert system will make an expert's knowledge and experience more widely available and allow non-experts to work better (Turban & Aronson 2001). An expert system can also help the actual expert by *"reminding an expert what he or she knows already, but has forgotten, perhaps in the 'heat of battle'"* (Graham 2003).

Some disadvantages of expert systems were listed by Turban & Aronson (2001):

- *"Knowledge is not always readily available*
- *Expertise can be hard to extract from humans*
- *Expert systems work well only in a narrow domain of knowledge*
- *There is often a lack of trust by the end-users*
- *Expert systems may not be able to arrive at valid conclusions*
- *Expert systems sometimes produce incorrect recommendations"*

EXPERT SYSTEMS IN OIL SPILL RESPONSE

Expert systems have been used in a plethora of fields including troubleshooting, help desk advice, auto mechanics and medicine to mention a few. They are, however, particularly useful and popular in the field of emergency response, such as oil spill response and firefighting.

Graham (2003) suggests seven aspects of oil spill response operations where an expert system can be applied to:

- Containing and recovering spilled oil at sea
- Protection of sensitive shorelines
- Beach cleanup
- *In situ* burning of oil
- Use of dispersants from the air or from a vessel
- Disposal of oil/oily waste
- Deciding on 'best response'

Furthermore, Graham (2003) suggests that an expert system can be used for planning and training purposes.

There are several oil spill response expert systems currently available. They range from *On Scene Command and Control* (***OSC***^{2}), *Automated Oil Spill Response Management* (***AIMS***), *Shoreline Oil Cleanup, Recovery and Treatment Evaluation System* (***SOCRATES***) to *Oil Spill Information System* (***OSIS***). Worldocean Consulting Ltd., in partnership with Acquired Intelligence, have designed *the On-Scene Coordinator's Advisor for Responding* to oil spills (***OSCAR***™) which is a prototype and helps the user determine the viability of mechanical recovery, dispersant use and *in situ* burning response options. The above are an incomplete, but representative, listing of expert systems in the field of oil spill response that are currently available.

But it is important to note that with the relatively large number of oil spill response expert systems currently available, none have incorporated oil spill sampling knowledge and advice. This is an extremely important gap because proper sampling is the first step in a series of technical procedures that lead to the forensic investigation and ultimate identification of the source of an oil spill. It is a fundamental principle that if samples from an oil spill are not correctly taken and preserved then all the rest of the expensive steps (including chemical analysis, QA/QC, data interpretation and reporting) are either for naught (giving erroneous conclusions) or, at the least, suspect and therefore not useable as legally defensible evidence.

OIL SPILL SAMPLING ADVISOR (*OSSA*)

Sampling during an oil spill must adhere to strict legal, IMO (International Maritime Organization) (IMO 1998), and/or ASTM (American Society for Testing and Materials) (ASTM 2001) standards and protocols in order to be accurate and defensible. The correct gathering, handling and assimilation of samples and evidence ensure that the responsible party is held accountable for any environmental, physical and financial losses incurred as a result of the pollutant. Furthermore, sampling protocols vary significantly depending on the nature of an oil spill, which can range from a thin oil sheen to oil on beaches and/or animals (alive or dead) to oil in the hold of a ship. Thus, correctly obtaining samples related to an oil spill is a complex technical subject with many variables and decisions that involve multiple sampling tools, pro-

cedures, preservation protocols, documentation, and preparations for packaging and shipment to an analytical laboratory.

Samples collected in an inappropriate manner may not be admissible as evidence in a court of law. Ensuring that chain of custody is maintained with the samples is another critical step in the process if litigation is planned. The laboratory analysis is only as good as the samples. If the samples collected are not representative of the spill or are not representative of the oil collected from a suspect vessel then the data generated from the laboratory may not be conclusive.

OSSA is a unique expert system in many ways. Firstly, because it covers a topic within oil spill response that has not as yet been covered in any of the expert systems currently available, it is the first of its kind. And secondly, ***OSSA*** covers all aspects of sampling and evidence gathering required for oil spill responders and pollution investigators. ***OSSA*** also deals with taking samples from different environments, from different depths in the water column and on different types of vessels within different tanks. It also contains all of the relevant forms needed for correct documentation, packaging, and shipping. Thus, ***OSSA*** is a one-stop advice and information system for anyone who needs to gather evidence during and after an oil spill.

What makes ***OSSA*** truly unique are the "Three Planes of Information within ***OSSA***" and the "Dual-Screen Viewing" aspects of the system.

Three "Planes" of Information in *OSSA*

OSSA's unique 'planes of information' (Figure 1) offer the user an interactive, easy to use system by which they can get all their oil spill sampling and evidence gathering questions answered.

The top level or 'Executive Plane' gives the users advice and answers for their specific needs as quickly as possible. This is the level in which you obtain simple answers quickly. This is also where oil spill responders would find their necessary advice and information for making rapid decisions during a spill.

The second level or 'Educational Plane' provides explanations and ancillary information to help users to understand what is being asked of them, why it is being asked and what the consequences of their actions may be. This level is often consulted when the system is being used as a teaching and training tool.

The third level or 'Research Plane' is reached by internal and external hyperlinks from the second plane. This level contains extensive in-depth discussions and links to other relevant web sites such as those of US EPA, ASTM, IMO, AMSA, and many more.

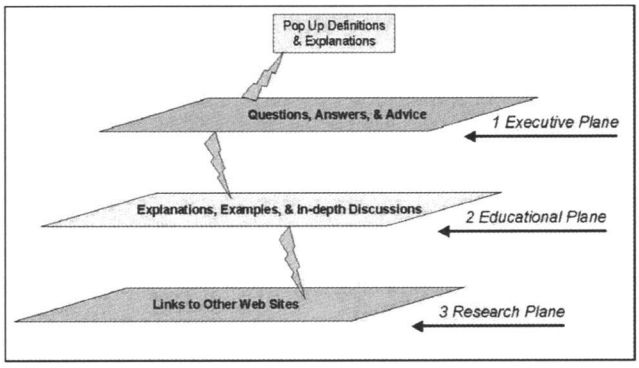

FIGURE 1: OSSA'S UNIQUE 'THREE PLANES OF INFORMATION" MAKES THE OSSA SYSTEM INTERACTIVE AND COMPREHENSIVE IN THE FIELD OF SAMPLING AND EVIDENCE GATHERING.

Dual-Screen Viewing

OSSA uses special programming to view two 'frames' at all times whilst using the system. This allows the user to see both the 'Executive Plane' and the 'Educational Plane' on one screen depending on his/her interests. The expert system question and answer software appears in the left screen frame, and the explanation box or additional information is presented in the right screen frame (Figure 2).

The advantage of such a dual-screen viewing is that it drives a particular sampling, planning, or training session through its questions and "decision trees" that provide advice and answers. Furthermore, associated with each question is information on what, why, when, where, how, etc. about the question in the right screen frame.

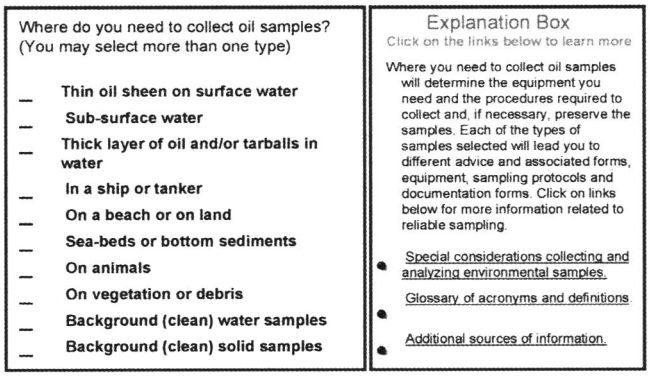

FIGURE 2: OSSA'S UNIQUE "DUAL-SCREEN VIEWING" MAKES IT EASY TO GET QUICK ANSWERS FROM THE OSSA SYSTEM AND ALSO MAKES IT AN IDEAL TEACHING TOOL WITH THE RIGHT SCREEN FRAME INCORPORATING BOTH THE 'EDUCATIONAL' AND 'RESEARCH' PLANES.

Examples of the type of information in the right screen frame include but are not limited to:

- The importance of sampling
- When to take a sample
- Site selection
- Objectives of sampling
- Difference between Type I and Type II sampling
- What is chain of custody
- Pro-forma 'chain of custody' forms available for printing
- How to label samples and labels for printing
- What are controls, background samples, and reference samples
- Health & Safety issues
- How to avoid cross contamination
- How to sample oiled wildlife
- How to handle wildlife
- Handling and transportation issues
- List of flashpoint ranges for petroleum products
- Other evidence that should be collected
- Material Safety Data Sheets
- Photographs, videos, and slide shows

It is this type of information in the 'Educational' Plane or 'right screen frame' that makes ***OSSA***, and other expert systems, ideal for teaching and training aids. A wealth of information used for teaching can be incorporated into the right hand frame through text, figures, and hyperlinks to other pages of information. Even test questions and other programs (e.g., metric conversion pro-

grams, statistical sampling programs, etc.) can be launched and used from links in the educational material in the right hand frame.

The ***OSSA*** system framework was developed under a United States National Science Foundation grant (Keith 2003) and it is flexible because of its dual use (training and immediate advice), ease of distribution and access, and intuitive ease of use. Expert systems, such as ***OSSA***, offer immediate answers and advice which sometimes in oil spill response can take too long (see Micronesia Case Study in Graham & Morrison 2004). By not getting immediate advice and answers, the oil spill response (including obtaining legally defensible samples and data) is put at risk and the environment is put at grave risk.

CONCLUSION

In some countries, regional offices, and on board ships at sea there can, at times, be no local expertise available. As oil spills are not a regular occurrence, many organizations and governments do not have the resources to assign full-time personnel to oil spill response. Often the task is assigned to someone who may have never witnessed an oil spill and thus has no or limited expertise in the area. In this case, when there are no experts available at short notice, the expert systems acts as a tool in order to guide the non-experienced in the right direction based on world-wide expertise and experts.

Much time and money has been invested in the field of oil spill response. However, little of this time and money has been dedicated to the processes of improving decision making, or as Graham & Morrison (2004) refer to it; *"the Achilles heel of spill response"*.

The *Oil Spill Sampling Advisor* is a new, innovative expert system, which addresses a new and critically important topic within oil spill response technology. Sampling has not been incorporated into any of the other oil spill response expert systems and yet the importance of correct sampling and evidence gathering is of the utmost importance for the identification of 'mystery' spills, for prosecution purposes and for insurance claims. Accessed from a CD-ROM or a laptop computer the information, advice, knowledge, and proper forms for documenting oil spill samples are portable for on-board access on a ship or anywhere in the world at any time, all the time.

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