SMART: SCIENTIFIC MONITORING OF ADVANCED RESPONSE TECHNOLOGIES

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ABSTRACT: *SMART (Scientific Monitoring of Advanced Response Technologies) is a new monitoring program designed to provide the Unified Command with real-time field data when* in situ *burning and dispersants are used during oil spill response.*

For dispersant monitoring, SMART recommends a three-tiered approach. Tier I has visual observation by trained observers from vessels or from aerial platforms. Tier II combines visual observations with water-column sampling using a fluorometer at a single depth. Tier III expands the fluorometry monitoring to several water depths, and uses a water-quality lab. Water samples for later analysis and correlation of fluorometry readings are taken both in Tier II and Tier III.

For in situ *burning, SMART recommends deploying three or more monitoring teams, each equipped with a real-time particulate monitor with data-logging capability. The teams deploy downwind of the burn at sensitive locations, and report particulate concentration trends to the Unified Command.*

Background

Since the early 1980s the need for protocols to monitor oil spill response technologies has been recognized. Technological advances in dispersant use and *in situ* burning (referred to as “advanced response technologies”), their acceptance in several regions in the United States and, in some cases, a conditional approval of *in situ* burning only if monitoring is done, reaffirmed the need for protocols. Protocols would standardize monitoring of these methods when used at oil spill responses for which the federal government assumes full responsibilities under the National Oil and Hazardous Substances Pollution Contingency Plan. Protocols have also been needed to serve as guidelines for assisting or overseeing industry’s response to spills.

In November 1997, a workgroup consisting of federal oil spill scientists and responders from the U.S. Coast Guard, the National Oceanic and Atmospheric Administration, the U.S. Environmental Protection Agency, and the Centers for Disease Control and Prevention, convened in Mobile, Alabama, to create the guidelines needed for generating the protocol. The workgroup built upon existing programs and procedures, mainly the Special Response Operations Monitoring Program (NOAA, 1994), and lessons learned during spill responses and drills. The result of this collaboration is the Scientific Monitoring of Advanced Response Technologies (SMART) program.

SMART is not a regulatory requirement. Rather, it is an option available to the Unified Command when it needs real-time, yet scientifically based, information, to assist with decision making when *in situ* burning or dispersants are used. Furthermore, users may choose to tailor the SMART guidelines to specific regional needs. The SMART program is divided into two modules: one for *in situ* burning operations, the other for dispersant application.

Monitoring dispersant efficacy

Dispersant operations and the need to monitor them vary greatly. Therefore, SMART recommends three levels (or tiers) of monitoring.

Tier I: Visual observations. Tier I recommends visual observation by a trained observer who can use visual aids to provide a qualitative assessment of dispersant efficacy. Observations should be documented, photographed, and videotaped to help communicate them to the Unified Command.

When available, visual monitoring may be enhanced by advanced sensing instruments such as infrared thermal imaging. These and other devices may provide a higher degree of sensitivity in determining dispersant effectiveness.

Visual monitoring is relatively simple and readily done. However, visual observations do not provide ground truth that the oil is dispersed. Such validation is provided by Tier 2.

Tier II: Fluorometry for efficacy. To confirm the visual observations, teams deploy to the dispersant application area to conduct on-site real-time monitoring.

Water column monitoring uses a continuous flow fluorometer (Turner Design or equivalent) at 1-meter sampling depth and three primary target locations: (1) background water (no oil); (2) oiled surface slicks before dispersant application, and (3) post-application, after the oil has been treated with dispersants. Data are collected in a real-time mode by both a built-in data-logging device and by the technician who monitors the instrument's output and records the readings in a sampling log. The sampling log not only provides a backup to the data logger, but also communicates the results near real-time, to the Unified Command. The data from the instrument's data logger (Figure 1) are used for dispersant efficacy documentation and scientific evaluation.

The monitoring team records the time, instrument readings, and any relevant observations at selected time intervals of between 3 and 5 minutes. Exact position is tracked by a global positioning system (GPS) and recorded in the log.

Water samples are collected into bottles to quantify the fluorometry observations. Samples are collected at the outlet port of the flow-through water duct, past the fluorometer cell. Exact time and location are noted for each sample, for correlation with fluorometer readings. The number of water samples taken reflects the monitoring effort. Generally, five samples are collected for each fluorometer data run in addition to background samples. The water samples are stored in a cooler and later sent to a laboratory for analysis.

Tier III: Fate and transport. When information on the fate and transport of the dispersed oil is needed, the Unified Command may request expanded monitoring. In this case, Tier III replaces Tier II to include the following:

1. Simultaneous monitoring occurs at two different depths, 1 and 5 meters, by using two sampling lines and two different fluorometers.
2. Additional sampling station for static sampling. In addition to the primary transects (background, pre-application, and post-application), the sampling vessel moves to the center of the dispersed plume and monitors the duration and concentration of exposure. The same equipment used in the multiple-depth monitoring configuration is applicable.
3. A portable water laboratory is deployed in line with the fluorometer to collect ambient water data such as temperature, salinity, conductivity, and pH.
4. The plume profile is monitored and maximum dispersant oil depth at the plume centerline. A fluorometer sampling hose is lowered at 1-meter increments to at least 10-meters.
5. Water sampling for lab analysis is expanded in proportion to the expanded monitoring plan.

All aspects of Tier II monitoring documentation are valid for Tier III, including the use of a check standard to verify instrument response. It is important to keep in mind, however, that Tier II and Tier III are different plans. When deploying to the field, the sampling team should be prepared to conduct either Tier II or Tier III monitoring, because it would be difficult to shift from Tier II to Tier III in the middle of the operation.

Measure of efficacy. The goal of dispersant monitoring is to provide the Unified Command with objective information on dispersant efficacy. Visual observation by a trained observer may provide the evidence that dispersants are working, or may suggest that no dispersion has been observed. When using fluorometry, a clear indication of dispersant efficacy is increase in fluorometer readings over background. When visual observations and on-site monitoring confirm that dispersants are not effective, the Unified Command may consider evaluating further use. If, on the other hand, visual observations and/or fluorometry monitoring suggest that dispersants are effective, dispersant use may be continued.

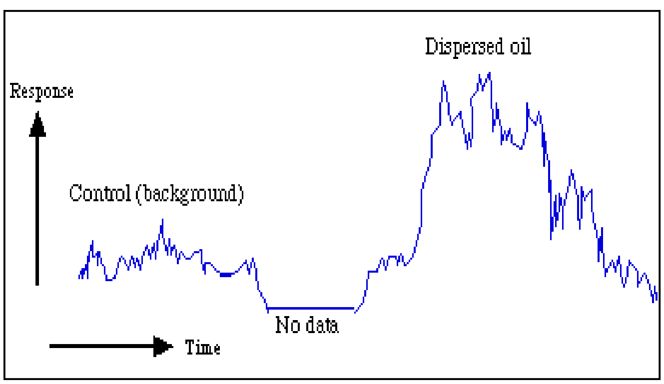

Figure 1. Graphical presentation of fluorometer data.

Monitoring *in situ* burning operations

During *in situ* burning operations, monitoring may be conducted when there is a concern that the general public may be exposed excessively to smoke from the burning oil. In this case, the Unified Command, for decision-making purposes, may need real-time data on the concentration trends of particulates, in addition to visual observation and modeling. Monitoring is not required, however, when public exposure to smoke is not predicted.

Sampling and reporting. SMART recommends that three or more monitoring teams be deployed. Each team uses a real-time particulate monitor (such as the DataRAM) capable of detecting the small particulates emitted by the burn (10 microns in diameter or smaller), a global positioning system, and other equipment needed for collecting and documenting the data. Each monitoring instrument provides an instantaneous particulate concentration as well as the time-weighted average (TWA) over the duration of the burn. The readings are displayed on the instruments' screen and stored in its data logger. In addition, particulate concentrations are logged manually every 5 minutes.

The monitoring teams are deployed at designated areas of concern to determine ambient concentrations of particulates before the burn starts. During the burn sampling, the recording continues. After the burn has ended and the smoke plume dissipated, the teams remain in place for some time (15–30 minutes) and again sample for and record ambient particulate concentrations.

During the course of the sampling, the instantaneous readings may vary widely. However, the calculated TWA readings are less variable (since they represent the average of the readings collected to this point) and hence are a better indicator of the concentration trends. When the time-weighted average readings approach or exceed the level of concern, the team leader conveys this information to the Burn Coordinator and the Scientific Support Team, who review and interpret the data and make recommendations to the Unified Command.

Monitoring locations should be flexible and determined on a case-by-case basis. In general, one team is deployed at the upwind edge of a sensitive location (e.g., a town). A second team is deployed at the downwind end of this location. Both teams remain at their designated locations, moving only to improve sampling capabilities. A third, more mobile team is deployed at the discretion of the Burn Coordinator.

Level of concern. The level of concern for *in situ* burn monitoring operations follows the National Response Team (NRT) guidelines (NRT, 1995). NRT recommends a conservative upper limit of 150 micrograms of PM-10 per cubic meter of air, averaged over 1 hour, a level that should be used as a general guideline. If it is exceeded substantially, human exposure to particulates may be elevated to a degree that justifies terminating the burn. However, if particulate levels remain generally below the recommended limit with few or no transitory excursions above it, there is no reason to believe that the population is being exposed to particulate concentrations above EPA's National Ambient Air Quality Standard.

When addressing particulate monitoring for *in situ* burning, NRT emphasizes that concentration trends rather than individual readings should be used to determine whether to continue or terminate the burn. For SMART operations, the TWA generated by the particulate monitors should be used to ascertain the trend.

SMART in the ICS organization

SMART activities are directed by the Operations Section in the Incident Command System (ICS), of which the *in situ* burning and dispersant monitoring teams form a Group (Figure 2). At a minimum, each monitoring team in the group consists of two members: monitor and assistant monitor. The monitor serves as the team leader. The teams report to a Monitoring Group Supervisor who directs and coordinates team operations, and reports to the Operation Section.

The Operations Section maintains operational control of the unit. Information from the field to the Unified Command flows to the SSC in the Planning Section. The SSC and his/her team review and assess the data in the context of other available information, and, most importantly, formulate recommendations on whether to continue or discontinue the burning or dispersant operations. The SSC forwards these recommendations to the FOSC. Quality assurance and control are applied to the data both in the field and at the ICS.

Conclusions

SMART provides the Unified Command with an option to carry out a simple, field-oriented monitoring plan for dispersant and *in situ* burning operations. To monitor dispersant efficacy, SMART recommends three tiers of monitoring, ranging from observation to fluorometry measurements at several water depths. For *in situ* burning SMART recommends monitoring downwind of the burn at sensitive locations using field-portable particulate monitors. Monitoring for *in situ* burning and dispersants were recently tested in training and real spills, and proved operational. SMART is designed to be flexible and adaptable, changing as more experience and expertise are gained over time.

Biography

Nir Barnea is an industrial hygienist, who has worked with NOAA's Office of Response and Restoration since 1992. He provides technical support during spill response, supports the program's *in situ* burning applied research, and co-chairs the SMART workgroup.

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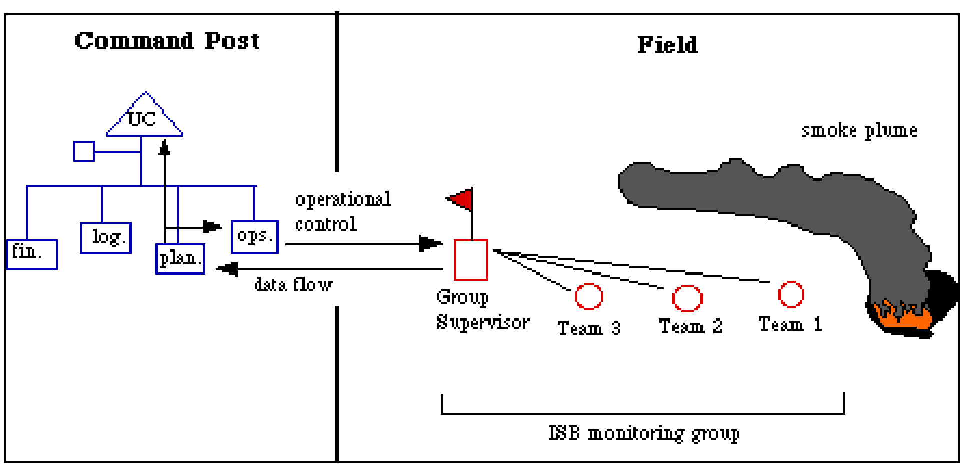

Figure 2. Command control and data flow during SMART *in situ* burning monitoring.