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Modernization of Special Monitoring of Applied Response Technologies (SMART) Technology and Methods – 2014

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Homeland Security

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16. Abstract (MAXIMUM 200 WORDS)
The Special Monitoring of Advanced Response Technologies (SMART) Protocol was developed to oversee oil dispersant application and in-situ burning during response incidents. The USCG Research and Development Center examined the use of the SMART Protocol at four major response incidents between 1999 and 2010 to identify future improvements in the areas of policy, training, and new technology. The review focused on four incidents:

- M/V *New Carissa* Grounding, 1999 (in-situ burning)
- Eugene Island Pipeline Spill, 2009 (dispersant)
- T/V *Krymsk* Oil Spill, 2009 (dispersant)
- Deep Water Horizon Blowout, 2010 (dispersant and in-situ burning)

We evaluated the effectiveness of the SMART Protocol through interviews with stakeholders and other subject matter experts. Where possible, we interviewed the Federal On-Scene Coordinators and NOAA Scientific Support Coordinators who led the responses, and other parties involved in the responses. We also reviewed agency reports, and discussed equipment use and performance with SMART team personnel and vendors. This review examines SMART team activities, incident commander assessments of the protocol's effectiveness, identifies SMART Protocol capability gaps, and identifies solutions for resolving those gaps. The report recommends modifications to USCG policies, training, and technology to improve the SMART Program's future performance.

17. Key Words
SMART, *New Carissa*, Eugene Island, *Krymsk*, Deep Water Horizon, dispersant, in-situ burning, ISB, air monitoring, NOAA, Tier I, II and III, National Strike Force (NSF), Fluorometry, water parameter sampling, water sonde, particulate, PM10

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EXECUTIVE SUMMARY

In 1997 a multi-agency working group, including the U.S. Coast Guard (USCG) and the National Oceanic and Atmospheric Administration (NOAA), was convened to establish guidelines for monitoring response technologies during oil spills, specifically, the use of dispersants and in-situ burning to reduce the spread of oil into the environment. The resulting guidance document is titled *Special Monitoring of Applied Response Technologies (SMART)*. The document also expresses the intent that SMART is not limited to oil spills, but can be adapted to other hazardous substance responses as well. The SMART methodologies and their continued refinement have undergone a number of reviews since around 2000, and the SMART Protocol has continued to evolve. The 2006 SMART Protocol remains in effect today, and has been employed in several major spill responses, most significantly the Deep Water Horizon blowout in 2010.

This project assesses current best practices, lessons learned from major incidents, and new technology since 2006, to develop recommendations for improving SMART program policies, guidance, technologies, and data products, in order to improve the program's effectiveness for the USCG. To conduct the research, the project team interviewed stakeholders and other subject matter experts (SMEs) (e.g., Strike Teams), reviewed agency reports, and conducted internet research. Some interviews were conducted at the International Oil Spill Conference 2014 in Savanna, GA, which also provided an opportunity to examine new technology with the vendors. The review focused on four incidents:

- M/V *New Carissa* Grounding, 1999.
- Eugene Island Pipeline Spill, 2009.
- T/V *Krymsk* Oil Spill, 2009.
- Deep Water Horizon Blowout, 2010.

The project concludes that the 2006 SMART Protocol meets its original purpose by providing general guidance. SMART lacks detailed guidance for operational data collection, processing, and data evaluation. This guidance should be developed and promulgated as job aids or appendices to the main body of the protocol. The SMART Protocol should be limited to "typical" responses that last a few days and cover a limited geographic area. Other more complex responses are better suited for events such as Deep Water Horizon, which is considered to be "atypical". The adequacy of training is another non-material gap. A routine curriculum of training on the equipment and procedures used by SMART that covers water sampling, water column profiling, and air monitoring is recommended for the Strike Teams. Also, the Strike Teams do not receive routine, comprehensive SMART Tier I training.

The procedures and division of responsibilities that were worked out between the USCG and NOAA during the Deep Water Horizon response effectively support the mission, and these developments should be incorporated into the Protocol. That methodology should be documented, along with more detailed guidance on executing the protocol. This additional guidance should be included in appendices to the basic protocol.

Inadequate communications was a common material gap for the four incidents we reviewed. Teams were unable to communicate with Incident Commanders, with other responders on the water, or with personnel in the air. This report recommends a combination of non-material measures: planning, preparation, and coordination, to partially address this problem; and recommends consideration of some interim solutions that may reduce the gap. The report also makes recommendations for material upgrades to the SMART Program's air monitoring instrument, multi-parameter water quality probes, and water sampling equipment.

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LIST OF ACRONYMS

API	American Petroleum Institute
BOEM	Bureau of Ocean Energy Management
BP	British Petroleum
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CDC	Centers for Disease Control and Prevention
CDOM	Colored Dissolved Organic Matter
CG	Coast Guard
CISB	Controlled In-Situ-Burn
COTS	Commercial Off the Shelf
DEQ	Department of Environmental Quality
DPnB	Dipropylene Glycol n Butyl Ether
DWH	Deepwater Horizon
EDD	Electronic Data Deliverable
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
EPAOSC	Environmental Protection Agency On-Scene Coordinator
ERMA	Environmental Response Management Application®
ERT	Environmental Response Team
FOSC	Federal On-Scene Coordinator
GIS	Geographic Information System
GPS	Global Positioning System
GST	Gulf Strike Team
GT	Gross Tons
HAZMAT	Hazardous Materials
IC	Incident Commander
ICP	Incident Command Post
ICS	Incident Command System
IOSC	International Oil Spill Conference
ISB	In-Situ Burn
ISPR	Incident Specific Preparedness Review
KML	Keyhole Markup Language
KMZ	KML Zip Archive
LED	Light Emitting Diode
LISST	Laser In-Situ Scattering and Transmissometry
LOC	Level of Concern
MC252	Mississippi Canyon 252
MDL	Minimum Detection limit
MSRC	Marine Spill Response Corporation
MSS	Mobile Satellite Service
MSU	Marine Safety Unit

LIST OF ACRONYMS (Continued)

NARAC	National Atmospheric Release Advisory Center
NM	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NRT	National Response Team
NSF	National Strike Force
ORR	Office of Response and Restoration
OSRL	Oil Spill Response Limited
OSRO	Oil Spill Response Organization
OSV	Off Shore Vessel
PAH	Polycyclic Aromatic Hydrocarbon
PM	Particulate Matter
PM10	Particulate Matter less than10 micrometers in diameter
PPM	Parts Per Million
RCP	Regional Contingency Plan
RDC	Research and Development Center
RRT	Regional Response Team
SCAP	Shared Corporate Allowance Plan
SCUFA	Self-Contained Underwater Fluorescence Apparatus
SMART	Special Monitoring of Applied Response Technologies
SME	Subject Matter Expert
SMU	Subsurface Monitoring Unit
SONS	Spill of National Significance
SOP	Standard Operating Procedure
SROMP	Special Response Operations Monitoring Program
SSC	Scientific Support Coordinator
START	Superfund Technical Assessment and Response Team
T/V	Tank Vessel
TAGA	Trace Atmospheric Gas Analyzer
TPAH	Total Polycyclic Aromatic Hydrocarbon
TPH	Total Petroleum Hydrocarbon
TS	Technical Specialist
TWA	Time Weighted Average
UC	Unified Command
U.S.	United States
USCG	United States Coast Guard
VOC	Volatile Organic Compound
$\mu g/m^3$	Micrograms Per Cubic Meter

1 INTRODUCTION

1.1 Background

The need for protocols to monitor response technologies during oil spills has been recognized since the early 1980s. In November 1997, a workgroup consisting of federal oil spill scientists and responders from the U.S. Coast Guard (USCG), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), and the Centers for Disease Control and Prevention (CDC), convened in Mobile, Alabama to draft guidelines for generating the SMART Protocol. The workgroup built upon currently available programs and procedures, mainly the Special Response Operations Monitoring Program (SROMP), developed in 1994, and lessons learned during spill responses and drills. The result of this collaboration is the Special Monitoring of Applied Response Technologies (SMART) program described in the guidance document (USCG, 2006, Special Monitoring of Applied Response Technologies Guidance Document).

The Coast Guard uses the SMART protocol to assess the use of dispersants, and in-situ burning (ISB) to mitigate the spread of oil into the environment. The SMART methodologies have undergone a number of reviews and refinements since around 2000, and the SMART Protocol has continued to evolve. SMART is not limited to oil spills, and can also be adapted to hazardous substance responses where particulate air emissions should be monitored, and to hydrocarbon-based chemical spills into fresh or marine water.

1.2 Summary of Existing Guidance

Existing USCG guidance for SMART consists of three elements:

SMART Protocol: The 2006 SMART Protocol remains the primary guidance document for SMART, and is described in more detail in Section 1.3 SMART Program Objectives. It is a consensus document developed by a host of federal agencies, including USCG and NOAA, the two primary agencies responsible for maritime spill response. It is prescriptive enough to indicate the situations in which it applies and which it does not, and provides a framework, in the form of a three-tiered monitoring regimen, for monitoring oil spill dispersant operations. The SMART Protocol is general enough to allow room for development of more detailed guidance without creating the need to update the protocol itself. It includes greater detail in a series of attachments that are designed to assist response personnel. The 2006 SMART Protocol lists the following attachments:

Monitoring Dispersant Operations:
- Roles and Responsibilities.
- Command, Control, and Data Flow.
- Dispersant Observation General Guidelines.
- Dispersant Observation Training Outline.
- Dispersant Observation Checklist.
- Dispersant Observation Pre-Flight List.
- Dispersant Observation Reporting Form.
- Fluorometry Monitoring Training Outline.
- Dispersant Monitoring Job Aid Checklist.
- Dispersant Monitoring Performance Guidelines.
- Dispersant Monitoring Field Guidelines.
- Dispersant Monitoring Water Sampling.
- Dispersant Monitoring Recorder Form.

Monitoring In-Situ Burning Operations:
- Roles and Responsibilities.
- Command, Control, and Data Flow.
- ISB Monitoring Training Outline.
- ISB Monitoring Job Aid Checklist.
- ISB Monitoring Equipment List.
- Particulate Monitor Performance Requirements.
- ISB Monitoring Possible Locations.
- ISB Monitoring Recorder Sheet.
- ISB Monitoring Data Sample: Graph.

COMMANDANT INSTRUCTION 16470.1: This guidance is titled "Use of Special Monitoring of Applied Response Technology (SMART) Protocols. The instruction: (1) mandates incorporation of the SMART Protocol into Regional Contingency Plans (RCPs), (2) directs the National Strike Force (NSF) to maintain the capability to deploy SMART monitoring groups, and (3) states that requirements in excess of those required by SMART are beyond the capability of the NSF.

SMART Training: In recent years, the NSF has obtained USCG specific SMART training through contractors. The training is designed to provide the USCG SMART field technician with the skills and operational overview necessary to perform SMART data collection. The NSF has also obtained equipment specific training from commercial vendors. In some cases, the equipment specific training is supplemented by additional information specific to SMART operations.

1.3 SMART Program Objectives

The SMART program objectives provide a context for reviewing SMART performance and identifying gaps, partly because they define what SMART is intended to do and not to do. These objectives can be found in the introductory material in the SMART Guidance Document. SMART is intended to change as experiences, improved operations, and implementation of new and upgraded technologies affect best practices. It establishes guidance to foster rapid collection and reporting of real-time, scientifically based information, to assist the Unified Command with decision-making during in-situ burning or dispersant operations. SMART recommends monitoring methods, equipment, personnel training, and command and control procedures that strike a balance between the operational demand for rapid response, and the Unified Command's need for feedback from the field to make informed decisions. The Guidance Document states the following about the content of the program:

- SMART is designed for use at oil spills both inland and in coastal zones, as described in the National Oil and Hazardous Substances Pollution Contingency Plan.
- SMART does not directly address the health and safety of spill responders or monitoring personnel, since this is covered by the general site safety plan for the incident (as required by 29 CFR 1910.120).
- SMART does not provide complete training on monitoring for a specific technology. Rather, the program assumes that monitoring personnel are fully trained and qualified to use the equipment and techniques mentioned and to follow the SMART guidelines.
- SMART guidelines are based on the roles and capabilities of available federal, state, and local teams, and NOAA's Scientific Support Coordinators (SSCs). The SSC most often fills the role of Technical Specialist (TS) for SMART. Users may adopt and modify the guides provided in the SMART Protocol to address specific needs.
- SMART attempts to balance feasible and operationally efficient monitoring with solid scientific principles.
- SMART uses the best available technology that is operationally practical. The SMART modules represent a living document and will be revised and improved based on lessons learned in the field, advances in technology, and developments in techniques.
- SMART should not be construed as a regulatory requirement. It is an option available for the Unified Command to assist in decision-making. While every effort should be made to implement SMART or parts of it in a timely manner, ISB or dispersant application should not be delayed to allow the deployment of the SMART teams.

- SMART is not intended to supplant private efforts in monitoring response technologies, but is written for adoption and adaptation by any private organization or public agency. While currently addressing monitoring for ISB and dispersant operations, SMART may be expanded to include monitoring guidelines for other response technologies.
- The dispersant monitoring component of the SMART Protocol recommends three levels (or tiers) of monitoring.
  - Tier I involves visual observation and reporting by a trained observer.
  - Tier II builds on Tier I and adds real-time oil detection instrumentation and water sampling deployed at a single water depth (typically one meter).
  - Tier III follows Tier II procedures, but collects information on the transport and dispersion of the oil in the water column. Tier III is an expanded monitoring procedure that is intended to meet the needs of the Unified Command and may include:
    - Multiple oil detection instrumentation deployed at different water depths.
    - Water sampling from multiple water depths.
    - The use of a portable instrument to measure water temperature, conductivity, dissolved oxygen content, pH, and turbidity.
- SMART does not monitor the fate, effects, or impacts of dispersed oil.
- SMART does provide:
  - A general outline for dispersant and ISB monitoring procedures.
  - Guidance on mobilizing SMART monitoring resources.
  - Guidance on using and interpreting monitoring results.
  - Recommendations on locations for ISB monitoring.
  - Recommendations on a Level of Concern for ISB monitoring.
  - Definition on the performance requirements for SMART instrumentation.
  - Definition on where SMART fits into the Incident Command System (ICS) organization.
  - Guidance on SMART information flow and data handling.
  - Recommendations on the roles and responsibilities for the Monitoring Group.
  - Recommendations for SMART command, control, and data flow.
  - Recommendations for SMART field equipment, job aids, and training requirements.

1.4 Objectives of this Study

The purpose of this study is to develop recommendations for improving SMART program policies, guidance, technologies, and data products, to improve the program's effectiveness. The recommendations are based on an analysis of interviews of stakeholders and other SMEs (e.g., USCG Strike Teams), agency reports, and internet research involving four significant oil response events.

- M/V *New Carissa*, 1999 (atmospheric monitoring).
- Eugene Island Pipeline Spill, 2009 (dispersant).
- T/V *Krymsk* Oil Spill, 2009 (dispersant).
- Deep Water Horizon, 2010 (dispersant and atmospheric monitoring).

2 METHODOLOGY

The project team followed three basic steps: (1) review the intent and scope of the SMART Protocol, (2) collect and review information on previous SMART deployments to identify capability and mission performance gaps, and (3) identify policy, personnel, and technological solutions to address those gaps.

The first step began with a thorough review of the SMART Protocol to familiarize the team with the intent and scope of the SMART program. The project team interviewed personnel from the various SMART stakeholder agencies (primarily USCG, NOAA, & EPA) to collect input on how well the 2006 SMART Protocol addresses the operational and informational needs of their respective agencies.

Following the interviews, the project team reviewed information on oil spill response operations where SMART was used, focusing on four relatively recent significant incidents. For each incident, the project team reviewed published literature, incident briefings, and After Action Reports from participating agencies. In addition, the project team interviewed personnel associated with SMART operations for each event. From this information the project team identified performance gaps and in the process, identified components of the SMART process that were not fully developed or well understood by stakeholder agencies.

After identifying the gaps, the project team reviewed published literature, interviewed SMART participants and stakeholders, and investigated technologies that might enhance the SMART process. The team then generated recommendations to assist the project sponsor in developing an improved data collection program to satisfy the requirements of the SMART Protocol.

3 HISTORY OF SMART USE

The project team evaluated the deployment of the SMART Protocol during the four incidents. For the M/V *New Carissa* grounding, SMART was used to monitor oil burn operations while for the Deepwater Horizon (DWH), T/V *Krymsk*, and Eugene Island Pipeline incidents, SMART was used to monitor oil dispersant operations. With the exception of the Deepwater Horizon incident, information specific to SMART operations was scarce, and the project team pieced together information from many different sources to create an overview of how SMART was utilized and how it satisfied the mission objectives.

3.1 M/V New Carissa Grounding, 1999

On 4 February 1999, the freighter *New Carissa* ran aground off the Oregon coast in gale force winds. Bad weather and logistics ruled out pumping the oil from the ship, and on 10 February, the Federal On Scene Coordinator (FOSC), the Responsible Party, and the Oregon State Incident Command documented their decision to attempt a controlled burn onboard the stricken vessel. The burn was aimed at removing as much of the 425,000 gallons of heavy fuel oil and diesel fuel as possible. Realizing a burn of this magnitude could generate a large volume of black smoke, and cause a public health concern, the FOSC requested SMART particulate air monitoring at nearby population centers. The USCG, EPA, and State of Oregon monitoring teams were notified when it became apparent that a burn would take place, and the first NSF SMART team arrived on-scene at 1400 on 10 February.

Working with the EPA and Oregon Department of Environmental Quality (DEQ), the NSF monitoring teams were deployed to five locations and were in place well before the sustained burn operation commenced on the evening of 11 February. The teams utilized a combination of DataRAM™, Personal DataRAM™, and Nephelometer instruments, calibrated and configured to monitor particulates smaller than 10 micrograms in size (PM10). The documentation is not clear on which of these specific air monitoring instruments was utilized by the NSF teams, but all the instruments work on the same principle of light scattering, with the readings converted to weight of particulates in micrograms per cubic meter of air ($\mu g/m^3$). The level of concern (LOC) adopted for this operation was 150 $\mu g/m^3$ of PM10 averaged over a one-hour period. This was based on the LOC value for ISB operations adopted by the Region 10 Regional

Response Team (RRT 10), of which Oregon is a member. The monitoring teams were instructed to notify the SSC if they observed time weighted average (TWA) PM10 readings above the LOC.
The monitoring teams remained on location for the approximately thirty hours of sustained burn operations. During this period, the teams observed TWA PM10 readings typically in the 0-50 μg/m³ range, with one team noting readings as high as 100 μg/m³ for a brief period. The highest readings came from a team located a few miles north of the burn area after the winds turned slightly onshore. Throughout the burn, the monitoring teams did not observe any TWA particulate levels above the LOC and the FOSC was satisfied that the smoke dissipated before reaching population centers. At midnight on 13 February, the monitoring teams were placed on standby, and later de-mobilized.

In the end, approximately 200,000 gallons of fuel oil, half of the oil on board, were burned in the operation without reported adverse health effects to the local population or responders. After action review by NOAA noted that "SMART was deployed successfully for the New Carissa incident. No significant smoke impacts were detected by the monitoring teams at population centers near the burn. Good cooperation among team members and federal, state, and local entities greatly contributed to the success of the monitoring operations." More information on the New Carissa grounding is provided in Appendix A.

3.2 Eugene Island Pipeline Spill, 2009

On 26 July 2009, USCG Marine Safety Unit (MSU) Morgan City notified the NOAA Hazardous Materials (HAZMAT) Duty Officer of an oil spill 65 miles south of Atchafalaya Bay, LA. An alarm indicated a pressure drop in a pipeline, but the location of a leak was unknown. Later that day, a slick was observed in the Gulf of Mexico, 20 to 25 miles south of Lake Pelto, LA. The Responsible Party, Shell Pipeline, estimated 63,000 gallons of crude oil had leaked from the pipeline. That same day (no time available) MSU Morgan City requested USCG Gulf Strike Team (GST) support for possible dispersant monitoring operations.

On the morning of 27 July, the Responsible Party requested authority to use oil dispersants on the surface oil. Under the RRT 6 preauthorization plan, authority was granted by the FOSC and a request was made for the USCG to provide dispersant monitoring services. The extended forecast suggested that on-shore transport conditions were predicted for the next few days, but predicted landfall for the oil was still days away.

On 27 July, GST personnel were mobilized to Gibson, LA to meet the morning overflight and provide SMART Tier I visual observation for the dispersant application. At that point it was practically impossible to get the SMART Tier II/III Team offshore and in position before the planned morning spray application sortie. Therefore, GST personnel provided SMART Tier I support for two dispersant application sorties that morning. The GST SMART Tier II/III teams were also on scene for the 27 July afternoon dispersant sortie, but a last minute change in the target location prevented them from arriving at the new location in time.

The GST continued to provide Tier I support for one dispersant application sortie on 28 July and two dispersant application sorties on 29 July, the third day of dispersant spray operations. All GST Tier I flights were made from the same aircraft as the dispersant spray spotting team. The spotter aircraft did not have the communications capability to relay a real-time verbal report from the SMART team to the NOAA SSC (located at the Shell Command Post in downtown New Orleans, LA), so reports and documentation were delivered to the SSC as soon as possible after each flight. The general assessment from the Tier I team indicated that the dispersant applications were effective. It is not clear, however, whether the spotter aircraft had the capability to communicate with the SMART Tier II/III team on the vessel. The project team was unable to locate information stating why SMART Tier II/III teams were not mobilized during the second and third days of spray operations.

The GST SMART teams were de-mobilized on 30 July when dispersant spray operations ended. The NOAA SSC involved with this incident later noted that he was satisfied with the SMART data for this incident, and felt the Tier I data were sufficient to support informed recommendations to the FOSC. The SSC also mentioned that if Tier II/III data been collected (as requested by the FOSC), it would probably not have changed his recommendation, as he considered the Tier I data very convincing. More information on the Eugene Island Pipeline spill is provided in Appendix A.

3.3 T/V Krymsk Oil Spill, 2009

On 20 October 2009, the Offshore Vessel AET Endeavor collided with the Tank Vessel (T/V) *Krymsk*, an 820 ft, 62,395 gross ton (GT) Liberian-flagged, double-hull crude oil carrier located approximately 40 NM off of Galveston, TX. The vessel reported a 1 m x 1 cm crack on the No. 2 port bunker (fuel) tank approximately 2-4 ft above the waterline. The crack did not impact the cargo area. The USCG estimated a loss of roughly 13,600 gallons of bunker oil to the sea. Internal fuel transfers on board the vessel prevented additional oil from being released. An oil dispersant plan was developed and a Regional Response Team 6 (RRT 6) conference call occurred the morning of 21 October. The RRT concurred with the FOSC to use dispersants if suitable oil was detected during an overflight.

On 21 October 2009, (0145 local time) Marine Safety Unit (MSU) Galveston requested dispersant monitoring assistance from the GST. By 0850, two GST SMART team members were airborne on a King Air twin engine aircraft providing Tier I SMART monitoring for the morning's dispersant spray sortie.

On 21 October 2009, an Airborne Support Inc. DC3 aircraft applied 1,000 gallons of COREXIT® 9500 dispersant, making several passes over the area of heaviest oiling off-shore, as well as over areas of fringe sheening. SMART Tier I observers reported that the dispersants appeared to have been somewhat effective (milky emulsion observed). Heavy weather prohibited a second dispersant sortie in the afternoon, and also prohibited the mobilization of SMART Tier II/III.

On 23 October 2009, a limited dispersant application was made to the residual slick to assess the potential for mitigation. The SMART team observed this application and deemed the application ineffective. As a result, a decision was made to discontinue dispersant applications.

Throughout the response, The SMART Tier I team members shared a King Air aircraft with the dispersant spotting personnel. The twin engine King Air was considered a safer air platform than the USCG HC144 for the SMART team, considering the long distance off-shore for the area of operation. The King Air aircraft did not have the communications capability to relay a real-time verbal report from the SMART team to the NOAA SSC during flight operations, so reports were filed after the aircraft landed.

The NOAA SSC later reported that he was satisfied with the SMART Tier I data for this incident, and considered it sufficient to make informed recommendations to the FOSC. More information on the T/V *Krymsk* spill is provided in Appendix A.

3.4 Deep Water Horizon Blowout, 2010

On 20 April 2010, the Macondo Prospect well, 45 miles off the coast of Louisiana, experienced a catastrophic blowout, causing a major explosion, fire, and subsequent sinking of the Mobile Offshore Drilling Unit Deepwater Horizon. The blowout resulted in a major oil spill one mile below the surface of the ocean, leading to the most challenging and complex oil spill response the United States has experienced.

3.4.1 DWH In-Situ Burn Operations

Due to the quantity of oil released, mechanical skimming assets were not sufficient to contain and collect all the surface oil that was released. On 26 April 2010, the use of ISB of the surface oil was proposed. Between 28 April and 19 July 2010, the Controlled In-Situ Burn (CISB) Group under the Offshore Operations Branch of Incident Command Post (ICP) Houma, LA conducted 411 burns, removing 5 percent of the 4.9 million barrels of discharged oil. Burn task forces conducted burns within the specified and approved CISB Burn Area, typically within 3 to 8 miles of the spill site.

In 1994, RRT 6 published an In-Situ Burn Operations Plan, which required monitoring for a potential threat to the general public by smoke generated from the burning of oil. To fulfill the criteria of the RRT 6 Pre-Authorization for ISB, the NOAA SSC helped implement the SMART ISB monitoring protocol designed to alert the FOSC of any potential impact of the smoke on a populated area for the first test burn on 28 April 2010.

USCG NSF personnel deployed SMART ISB monitoring equipment to an off-shore platform approximately 13 miles southwest of the planned test burn site. Two NSF SMART team members with two DataRAM 4™ particulate air monitoring instruments were deployed to the offshore platform and remained on scene throughout the burn operations. SMART air monitoring detected no particulates related to the test burn at this location. NOAA worked with the National Atmospheric Release Advisory Center (NARAC) to model potential plume releases from future ISBs. NOAA and NARAC determined that ISB would not pose a problem to the general population, given the off-shore location (a long distance from populated areas) and prevailing atmospheric conditions. Thus, SMART monitoring was not required for further burns, and the NSF burn monitoring effort was suspended.

The project team found very little documentation about the DWH SMART air monitoring effort. For example, no operations logs were located and interviews with both a USCG monitoring team member and a NOAA SSC involved in the monitoring operation did not lead to any data collected during the deployment. Despite the lack of documentation, a NOAA SSC involved with the 28 April 2010 test burn indicated he was satisfied with the deployment and performance of the NSF SMART air monitoring teams. More information on Deep Water Horizon ISB operations is provided in Appendix A.

3.4.2 DWH Dispersant Operations

During the Deepwater Horizon response, aerial dispersants were applied to minimize the potential for surface oil slicks to impact wildlife and environmentally sensitive shoreline ecosystems. The RRT Regional Contingency Plan requires that use of chemical dispersant in the region's waters be accompanied by the implementation of SMART Protocols. Accordingly, the protocols were implemented when aerial dispersant operations began on 22 April 2010, and continued through the final aerial dispersant application on 19 July.

SMART monitoring was initially conducted by the NSF, and later augmented by industry contractors and other USCG personnel. All SMART monitoring operations were coordinated through the USCG SMART Supervisor, with monitoring results reported to the FOSC through the NOAA FSC, who provided technical guidance. This was the first time SMART monitoring was implemented as part of a large-scale prolonged response effort during a Spill of National Significance (SONS).

Aerial dispersant operations were coordinated through the Aerial Dispersant Operations Group located at the ICP Houma and occurred over a period of 90 days, 61 of which involved active spraying. Twelve aircraft participated in the spray operations with a total spray capability of approximately 100,000 gallons per day. The spray aircraft applied approximately 973,000 gallons of dispersant during 412 sorties within an operating area of 18,000 square miles, dispersing an estimated 12 to 18 million gallons of oil.

The SMART teams adhered to the three tiers described in the SMART Protocol and on several occasions, the Tier III effort was enhanced with additional oil detection instrumentation and water sampling procedures (Tier III+). Out of 118 SMART missions conducted during the response, 77 were Tier I, 30 were Tier II/III, and 11 were Tier III+.

Equipment utilized in the SMART effort included three crew boats (>100 ft length), two small boats (<30 ft length), three helicopters, two forward staging areas, 50 USCG personnel, 30 contractor personnel, six C-3 Fluorometer kits, two Self-Contained Underwater Fluorescence Apparatus (SCUFA) Fluorometer kits, one Laser In-Situ Scattering and Transmissometry (LISST) instrument, and three HydroLabs DataSonde portable water labs. The largest SMART vessel (142 ft length overall) was also fitted with an onboard, portable dispersant spray system for SMART Tier III+ operations.

USCG SMART teams were on scene when aerial dispersant operations began on 22 April 2010 and performed all Tier I data collection duties for the duration of dispersant operations, and all Tier II/III data collection activities for the first few weeks of dispersant operations. In early May 2010, recognizing the need for extended dispersant operations, SMART teams from Oil Spill Response Limited (OSRL), a worldwide oil spill response organization, augmented USCG Tier II/III SMART data collection efforts. USCG/OSRL joint SMART data collection operations began in mid-May and continued into early June 2010, at which time the USCG was relieved of SMART Tier II/III data collection duties, and the OSRL SMART team began moving into enhanced SMART Tier III+ operations. The OSRL SMART Tier III+ team utilized standard Tier II/III techniques with the addition of more sophisticated instrumentation, expanded water sampling, and the use of an on-board dispersant spray system. OSRL SMART Tier III+ operations continued until dispersant spray operations were discontinued in late July 2010.

The SMART field data, consisting of annotated digital photographs, fluorometer and profiling instrument data, etc., in digital form, were delivered by hand to ICP Houma, where it was processed and evaluated by either NOAA personnel or NOAA contract personnel. Earlier in the response, basic data processing and evaluation techniques were suitable to address the informational needs of the SSC. As SMART data collection capability expanded, and the interest in dispersant efficacy data increased, more sophisticated data processing, evaluation, and presentation techniques were developed. More information on the Deep Water Horizon dispersant operations is provided in Appendix A.

4 PERFORMANCE GAPS AND SOLUTIONS

The project team grouped SMART performance gaps into three broad categories: policy, training, and technology. In each category, the team identified solutions to assist the USCG in developing a viable and sustainable SMART monitoring program that would satisfy the informational needs of SMART stakeholders. Additional details on the gaps and solutions are provided in Appendices B and C respectively. This section summarizes a gap and solution together for each subject indicated by the below subheadings.

4.1 SMART Protocol

The project team interviewed personnel from SMART stakeholder agencies to determine the level of satisfaction with the intent and scope of the protocol, as well as the level of guidance provided. Most SMART stakeholders indicated that the current SMART Protocol is adequate for a *typical* dispersant or ISB operation. They noted that the protocol was originally written to address the type of dispersant or ISB responses expected at the time - one lasting a few days, covering a limited geographic area. All stakeholders agreed that the 2010 Deepwater Horizon dispersant monitoring requirements far exceeded what was originally conceived in the SMART Protocol.

Many of the performance gaps identified from the DWH SMART operations resulted from the scale and duration of the DWH dispersant operations, while others were more fundamental and would likely occur regardless of the scale of the response. Some stakeholders emphasized that the DWH blowout was a highly unusual event and the associated response was an *atypical* response. These stakeholders suggested we focus on how SMART will be implemented during a typical response, and indicated that atypical dispersant and ISB monitoring may require guidance beyond the SMART Protocol. Most stakeholders preferred an additional guidance document that addresses atypical response operations, rather than an expanded version of the current SMART Protocol. This report notes all the performance gaps discovered in our review of past SMART deployments, but focuses on *solutions* that are appropriate for typical SMART response operations.

4.2 Subsurface Monitoring

The stakeholders interviewed agreed that the subsurface dispersant injection monitoring performed during the DWH response is far beyond the scope of the SMART Protocol and the technical capability of the USCG SMART teams. The following overview of this monitoring effort illustrates the complexity of the effort.

During the DWH response, a separate Subsurface Monitoring Unit (SMU) was established at ICP Houma to address the uncertain applicability of existing plans and dispersant pre-authorizations, the lack of an existing monitoring protocol, and the absence of any single organization with the required monitoring capabilities. The SMU was a collaboration between NOAA, EPA, USCG, Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE, formerly Minerals Management Service), British Petroleum (BP), and various academic institutions. The subsurface monitoring effort utilized over 25 open water vessels, logging over 850 days at sea during more than 125 dedicated vessel sorties. These vessels deployed a variety of advanced instrumentation to depths up to 1500 meters to collect data on fluorescence, temperature, conductivity/salinity, dissolved oxygen, LISST particle sizing, and a suite of petroleum hydrocarbon measurements. The SMU also utilized advanced technologies such as subsurface ocean gliders, air-dropped water profilers, high frequency radar, drifting and moored buoys, and wave gliders. The combined effort collected over 31,000 physical samples in addition to data on chemistry, sediments, acoustics, and imagery from over 40,000 ocean observation sites (Walker, 2010).

When comparing the above effort with the surface dispersant monitoring program (SMART) that was in use at the same time, the differences are significant. The subsurface dispersant monitoring program required sophisticated equipment and expertise to collect data and samples from up to 1500 meters in the case of the DWH. SMART, on the other hand, was designed to monitor the effectiveness of dispersants applied on the water's surface, impacting perhaps the upper 10 meters of the water column. The procedures, equipment, and training of the SMART teams are aimed specifically at collecting data within that shallow surface water layer. Monitoring beyond that depth would require greatly expanded SMART capabilities. Some recent reports, such as the NRT Environmental Monitoring for Atypical Dispersant Operations, (National Response Team [NRT], 2013) and the API Industry Recommended Subsea Dispersant Monitoring Plan (American Petroleum Institute [API], 2013), have begun to lay the groundwork for developing a subsurface dispersant monitoring program. SMART stakeholders, however, cautioned that such a monitoring program was not a good fit for the current SMART Protocol. Most stakeholders recommended a separate guidance document for subsurface dispersant injection monitoring.

4.3 SMART Guidance

Stakeholders involved with past SMART deployments noted the absence of detailed operational instructions for executing the SMART mission. The SMART data collection teams (USCG) reported the lack of detailed guidance for SMART data collection, and the SMART data evaluation team (NOAA) reported the lack of guidance for SMART data processing and data evaluation. This lack of guidance was particularly evident during the DWH dispersant monitoring effort. Without such detailed guidance the USCG SMART field teams developed their own field data collection techniques. These techniques evolved with time and generally became very effective, but data collection efforts early in the response suffered from a lack of operational guidance. For example, the lack of operational guidance for water sampling early in the response led the USCG SMART teams to improvise a sampling pump that (as they discovered later) had the potential to contaminate subsequent samples due to adhesion of oil to the inner hose surfaces. The pump was later replaced with more rigorous sampling equipment and procedures. The same can be said for the SMART data processing and evaluation techniques used during the DWH response. Early during DWH SMART operations, there was no established process for quality control, data processing, and data evaluation. This resulted in a lack of uniformity in the data product, as different individuals processed and evaluated the SMART data. Ultimately, standardized practices were developed, but it was many days into the response before SMART data was processed and evaluated in a rigorous, consistent manner. Both examples illustrate the need for more detailed operational guidance at the onset of operations.

Some SMART stakeholders suggested bringing this detailed guidance into the protocol, while others cautioned that such detail would require more frequent updates and modifications to the document as procedures and technology evolves. An original contributor to the SMART Protocol noted that detailed operational guidance was intentionally left out of the document to keep the protocol at a manageable size to avoid providing techniques and instrumentation that might become outdated (C. Henry, interview, February 18, 2014). The project team's assessment however, is that detailed operational guidance is necessary and should be promulgated as separate job aids or appendices to the protocol that could be updated outside of the main body of the protocol.

4.4 SMART Roles and Responsibilities

A review of past SMART deployments found that roles, responsibilities, and expectations have not been adequately defined in the past. This gap was particularly evident during the DWH SMART operations. From the start, there was no question that the USCG Strike Teams would take the lead in the SMART data collection effort, but the type and form of data expected from the field teams by the SSC was not defined.

4.4.1 SMART Data Collection

SMART operations can be divided into two broad categories, data collection, and data processing/ evaluation. The NOAA and USCG personnel interviewed agreed that SMART field activities and data collection during a typical dispersant or ISB operation should be the responsibility of the NSF. NOAA will provide general SMART mission objectives, but the Strike Teams will be responsible for providing the personnel, equipment, and logistics necessary for SMART data collection. NOAA stakeholders indicated that they need a standardized SMART data package similar to what was developed during the Deepwater Horizon response. A detailed description of the recommended data packages for dispersant monitoring and ISB monitoring operations is provided in Appendix C.

4.4.2 SMART Data Processing and Evaluation

Both NOAA and USCG personnel agreed that NOAA should be responsible for SMART data processing and evaluation. NOAA indicated that they do not have a SMART data processing program in place, but are developing one.

4.5 SMART Response Timeline

4.5.1 Response Timeline for Typical Response Operations

Early in the study, the project team noted a lack of consensus by SMART stakeholders on a realistic response time for SMART operations. The project team felt it was important to weigh the response time expectation of the NOAA SSC, the primary SMART data user, against the realistic response capability of the USCG SMART teams. Experience indicates that USCG SMART response time relies on many factors outside the control of the Strike Teams. These factors include timely activation of SMART, the availability of transportation resources to travel to the incident location, and the availability of aircraft and vessels suitable for SMART operations.

With this in mind, the project team proposed a cascading approach to a SMART dispersant monitoring timeline. This timeline would provide SMART Tier I (aerial observation) coverage for the first day of dispersant spray operations, while building up to Tier II/III capability on the second day. A NOAA SSC agreed that Tier I coverage on Day 1 of dispersant operations should provide them with adequate monitoring information, with the assumption that SMART Tier II/III will be in place soon afterwards. For SMART ISB monitoring, the USCG data collection teams should be in place for the onset of burn operations.

4.5.2 Response Timeline for Atypical Response Operations

The project team asked the NOAA SSCs to consider the guidance of the NRT Environmental Monitoring for Atypical Dispersant Operations guide, a document that considers dispersant operations that continue for an extended period (beyond 96 hrs.) to be atypical, requiring resources and methods beyond the current capability of the NSF. After that time, the FOSC should consider replacing the NSF SMART teams with contracted personnel better equipped to satisfy the enhanced informational needs of an atypical response. The NOAA stakeholders interviewed felt this approach was reasonable, provided the NSF could remain engaged in SMART operations and provide federal oversight of SMART field activities. This most likely would involve placing NSF personnel as observers or advisors on board vessels engaged in SMART data collection activities.

The NSF stakeholders interviewed noted that although the Strike Teams will make every effort to provide full Tier I, II, and III SMART capability on day 1 of dispersant operations, they agreed that the cascading response timeline was more realistic. An NSF stakeholder also agreed with the NRT's recommendation that NSF personnel should be phased out of SMART data acquisition if dispersant operations were to continue for a prolonged period. The interviewee noted that the Strike Teams would be in high demand elsewhere in a prolonged response, but agreed that NSF oversight of SMART operations is important and should continue for as long as SMART is in operation.

4.6 SMART Monitoring Procedures

The project team identified a lack of detailed operational guidance for the SMART data collection process. The 2006 SMART Protocol provides general guidance, but very little detailed information on the deployment, operation, and maintenance of the equipment; and the data collection techniques necessary for successful SMART operations. In some cases, standard operating procedures (SOPs) do not exist, and in other cases they exist, but need to be updated with increased scope and/or detail as noted in the following subsections.

The USCG should consider engaging other SMART stakeholder agencies for assistance in developing these guidance documents. The EPA in particular has considerable experience with field data collection techniques and data quality management, and has offered assistance in developing SMART procedures and practices.

4.6.1 SMART Methodology SOPs

SMART is a compilation of several different components, each with a unique operational requirement. The project team concluded that each of the below components should have a detailed SOP that describes the mission goals for each component, guidance on how best to meet those goals, and the techniques and methodologies needed. The topics to include for each SOP are provided in Appendix C.

- Tier I Aerial Observation and Photo Documentation.
- SMART Aerial Spotting.
- Tier II/III Fluorometry Data Collection.
- Tier II/III Water Parameter Collection.
- Tier II/III Water Sampling.
- In-Situ Burn Air Monitoring.

In addition to the individual SOPs above, the project team recommends an overarching guidance document that describes how the components fit into the program. This document should be similar to the SMART Protocol but shortened to include only the information required for field operations.

4.6.2 SMART Equipment and Instrumentation SOPs

The project team also recognized the need for detailed guidance on the operation and maintenance of the SMART equipment and instrumentation. Though SOPs exist for some SMART equipment (e.g., fluorometry) SOPs for all SMART equipment should be developed. The SOPs should include step-by-step operational, calibration, and maintenance instructions. The topics to include for each SOP are provided in Appendix C. Below is a list of the SMART equipment that is not currently addressed by an SOP.

- Radios and Satellite Communications Equipment.
- Photography Equipment.
- Fluorometers.
- Multi-Parameter Water Sondes.
- Water Sampling Equipment.
- Particulate Air Monitors.

4.7 SMART Training

The project team interviewed USCG personnel and SMART stakeholders to identify USCG training procedures that may be developed or improved upon in order to maintain proficiency in all aspects of SMART operations. The current NSF SMART training curriculum addresses most of the SMART operational components, but some additional coverage and detail is needed. As an example, SMART fluorometry operations are covered in depth, while other components of SMART, such as water sampling, water parameters, and air monitoring are covered in theory only - there is currently no hands-on equipment training. Another example is the absence of a SMART Tier I training program. Past deployments have repeatedly demonstrated the value of SMART Tier I observations during dispersant spray operations, yet there is no routine, comprehensive SMART Tier I training within the USCG.

Below is a summary of the training modules recommended for a comprehensive SMART training program. The topics for each SOP are provided in Appendix C. In most cases, annual training with an SME is needed, along with semi-annual in-house refresher training. Experience demonstrates that a large-scale response (such as the DWH) may require the deployment of multiple SMART field teams, separately monitoring both dispersant and burn operations simultaneously. This may also involve Strike Team personnel from different regions joining forces to form a single SMART field team, and standardizing the training curriculum and requirements across units is an important aspect.

- Overall SMART Mission.
- Tier I Aerial Observation.
- SMART Aerial Spotting.
- Tier II/III Fluorometry Data Collection.
- Tier II/III Water Sampling.
- Tier III Water Parameter Collection.
- ISB Air Monitoring.

4.8 SMART Technology

During each of the four incidents reviewed for this project, USCG SMART teams provided some level of monitoring information to help the NOAA SSC make informed operational recommendations to the FOSC. In all cases however, the SMART field teams faced operational and technological challenges. Some challenges were common to all four incidents while others were the result of the unique circumstances of each specific incident.

4.8.1 Communications

Communications between the field teams and Command, and between the field teams and other response operations, is a key requirement, and the most significant technological challenge common to the four SMART deployments we reviewed. SMART establishes a monitoring system for the rapid collection and reporting of real-time, scientifically based information to assist the Unified Command with decision-making during ISB or dispersant operations. Communication of monitoring results should flow from the field to those persons in the Unified Command who can interpret the results and use the data.

M/V *New Carissa* Communication Gaps: During the *New Carissa* response, the available information suggests that the SMART field teams did an adequate job monitoring the in-situ burn operations, but had difficulty relaying this information to the Incident Commander (IC). An After Action Report (AAR) noted that radios did not always work due to distance and terrain, and though cellular phones worked well, not all teams had them.

T/V *Krymsk* and Eugene Island Communication Gaps: The USCG SMART Tier I teams deployed to the Eugene Island spill and the T/V *Krymsk* spill faced similar challenges. In both cases, the teams were operating in an aircraft of opportunity and did not have the capability to communicate directly with the ICP while in flight. The SSC associated with both incidents noted that the SMART Tier I data was valuable, but was not available until the end of the spray sortie. He noted that a real-time verbal report from the Tier I team would have increased the value of the data and facilitated more timely response decisions.

DWH Communication Gaps: Communications became a pressing issue from the first day of SMART operations. During the DWH response, SMART teams often operated many miles offshore and many miles from the ICP. The Tier I aerial teams lacked the capability to communicate with the NOAA SSC while in flight, so their reports and data were not available to the SSC until after the flight ended. Both the Tier I and Tier II/III SMART personnel on vessels were unable to communicate with SMART personnel in aircraft, because the radios on the SMART vessels were not compatible with the radios on the SMART aircraft. The Tier II/III teams on vessels also had difficulty communicating with aircraft involved in spray operations. This made coordination between spray and monitoring operations very difficult. It was several weeks into SMART operations before the SMART teams on vessels obtained the capability to transmit digital data to the ICP while at sea. Prior to that, the teams resorted to delivering the data to a Command Post on shore where the data could be emailed to ICP Houma. This meant that the day's data often was not available to the SSC until late in the evening or the next morning.

Aircraft: The project team was unable to identify an all-encompassing technological solution to the communication challenges faced by SMART teams operating in an aircraft of opportunity. However, good planning, preparation, and coordination can minimize the challenge. The Team Leader should assess the communications capability of the aircraft before departing on a mission. If the aircraft operator does not provide suitable communications equipment, the Team Leader should either arrange for suitable communications equipment or develop an alternate communications plan with the SMART Technical Specialist. At a minimum, the SMART team members should be supplied with headsets that permit two-way communication with the pilot, and preferably allow the team members to communicate directly over the aircraft's aviation radio. The use of cell phones can be an effective tool in fixed wing aircraft (with approval of the pilot) but can be difficult to use in a helicopter due to the high background noise. Another option is to provide the SMART Technical Specialist at the ICP with a handheld aviation radio so that two-way communication is possible when the aircraft is within radio range of the ICP.

Vessel: The SMART teams operating on vessels of opportunity have more options than those operating in aircraft, but the same philosophy of planning, preparation, and coordination applies. The Team Leader should assess the communication requirements of the mission against the communications capability of the vessel. If the vessel's communications capability does not meet the mission requirements, the Team Leader should either arrange for suitable communications equipment or develop an alternative communications plan with the SMART Technical Specialist. In the hectic environment of an oil spill response, the SMART team may find themselves on a vessel with less than ideal communications capability. The best way for a SMART team to assure reliable communication capability is to be as self-sufficient as possible. Over the course of the DWH response the SMART field teams adopted some technologies that greatly improved their communications capability. These technologies included handheld aviation VHF radios that facilitated the communication between the monitoring vessels and response aircraft as well as portable satellite communication terminals that provided voice and data communication between the vessels and the Command Post.

Vessel to Aircraft Solution: The simplest solution to addressing the challenges of SMART vessels communicating with aircraft is to provide SMART teams on vessels with hand-held aviation radios. These COTS radios are relatively inexpensive and widely available, a much better option than installing marine VHF radios in the aircraft. The hand-held aviation radios have shorter range than aircraft mounted radios, but they proved suitable for the mission.

Vessel to ICP Solution: During the latter portion of the DWH SMART operations the SMART Tier II/III team had very good success with a Broadband Global Area Network (BGAN) satellite communication system. This system provided good voice communication and adequate internet connectivity that allowed the team to relay verbal reports and digital data while at sea. The system performed well and eliminated many of the communication challenges associated with operating outside of cellular phone range. The project team identified only one COTS BGAN package that appears to meet the SMART mission requirements.

Ground Control MCD-800 Solution: The Ground Control MCD-800 is a self-contained portable BGAN package that utilizes auto-pointing antenna technology designed to maintain connectivity even on a moving vessel or vehicle. The unit is mounted in a weatherproof case, can be initiated in less than one minute and operate for up to 6 hours on an internal battery (or indefinitely with an external power supply). Based on our research and conversations with the manufacturer, the Ground Control MCD-800 should provide adequate voice and data communications capability to SMART teams operating outside cellular phone coverage. Details of the Ground Control MCD-800 can be found in Appendix C.

4.8.2 Air Monitoring

The SMART Protocol prescribes the deployment of air monitoring teams when there is a concern that the general public may be exposed to smoke from the burning of oil. Each team should utilize a real-time particulate monitor capable of detecting the small particulates (ten microns in diameter or smaller) generated by the burn. Each monitoring instrument should display and log the instantaneous particulate concentration, as well as a time weighted average (TWA) concentration. SMART recommends measuring TWA concentrations averaged over a one-hour period.

Of the four SMART deployments we reviewed, two involved SMART air monitoring of ISB operations. For both the *New Carissa* grounding and the Deepwater Horizon blowout, the SMART teams used the Thermoscientific DataRAM 4 air monitor to measure particulate material produced by the burning oil. Our research indicates that in both cases the DataRAM 4 performed well, satisfied the mission requirements, and continues to meet the minimum operating criteria for SMART. The DataRAM 4, however, is an older generation air monitoring instrument that has recently been discontinued by the manufacturer. Although the manufacturer plans to continue to provide technical support for the instrument through 2016, the project team took this opportunity to investigate newer COTS air monitoring instrumentation, in the event the USCG desires to update their SMART air monitoring capability. We identified two particulate air monitors that meet the minimum performance criteria required by the SMART Protocol. The major difference between the two units is how the monitoring information is displayed for the operator.

ThermoScientific ADR 1500: The ThermoScientific ADR 1500 is recommended by the manufacturer as a replacement for the discontinued DataRAM 4. The ADR 1500 is portable, self-powered (internal battery), and mounted in a weatherproof case. The unit can display real-time instantaneous and TWA concentration values on a small, built-in LED screen or in a text and graphical format to a connected laptop computer. The TWA display cannot, however, be configured to specifically display a one-hour TWA concentration. This is a potentially serious drawback because the SMART Protocol recommends a one-hour TWA. More details for the ThermoScientific ADR 1500 can be found in Appendix C.

TSI DustTrack DRX 8533: The TSI DustTrack DRX 8533 is portable, self-powered (internal battery), air monitoring instrument housed in a weatherproof case, and can be set up via the built in touchscreen or through a connected laptop computer. The touch screen display can show the instantaneous and time weighted average concentration values in either numerical or graphical form. Although the unit can display only a single, user-selected particle size concentration (PM1, PM2.5, or PM10), it simultaneously measures and logs the concentration for all three particle size categories. The project team had an opportunity to operate the TSI DustTrack DRX 8533 during an oil spill response training event, and found that the unit could not display real-time data through a connected laptop. The unit appears to have a high quality built-in display, which would compensate for the lack of laptop interface. More details for the TSI DustTrack DRX 8533 can be found in Appendix C.

Either the ThermoScientific ADR 1500 or the TSI DustTrack DRX 8533 would be a suitable upgrade when compared to the DataRAM 4 (which is currently in the USCG SMART inventory). A summary of the features for the DataRAM 4, ThermoScientific ADR 1500, and TSI DustTrack DRX 8533 can be found in Appendix C.

4.8.3 Spill - Tracking Drifters

As part of the SMART dispersant monitoring process, field teams attempt to sample the same portion of an oil slick at two different times. In between these two samples the field teams must move away from the area (sometimes up to two miles away) to remain safely clear of dispersant spray operations. Reestablishing the sampling locations for a subsequent sample following spray operations can be difficult. During the DWH response, USCG SMART teams improvised several different floating buoy systems that helped them mark and return to the sample location. These buoys were very simple (e.g., a weighted 5 gallon bucket), but they were effective as long as the field team could arrive within approximately 100 yards of the marker. Beyond 100 yards, the field teams had difficulty locating the marker. With a 2-mile safety standoff distance during spray operations, finding the marker proved quite challenging.

A better solution would be the use of a buoy system that would drift with the oil slick and transmit real time position information. The buoy can transmit position information either via a simple radio beacon (radio tracking system) or via a satellite communications network.

We identified two spill-tracking drifter packages that will satisfy the SMART operational requirements. The NovaTech RF-700C2 Buoy and DF-500N Direction Finder package utilizes radio beacon technology while the MetOcean iSphere is a GPS enabled package that transmits data via a satellite network. Both systems have been used successfully in the oil spill response industry. More details on spill tracking drifters can be found in Appendix C.

4.8.4 Water Parameter Measurement

In addition to fluorometry data, the SMART Protocol prescribes that water physical and chemical parameters be measured during Tier III operations. NOAA has requested that the Strike Teams develop the capability to measure and record sample depth, water temperature, conductivity, dissolved oxygen content, pH, and turbidity as part of their SMART Tier III capability. This use of a portable multi-parameter water quality sonde satisfies this capability.

The HydroLab DS 5 water quality sonde is currently in the USCG SMART inventory, but is an older instrument with a somewhat cumbersome user interface and difficult calibration and maintenance requirements. With the recent introduction of newer multi-parameter sondes with better performance and user interfaces, updating the NSF inventory to modernize the Strike Team SMART capability may be appropriate.

The SMART Protocol does not list specific performance criteria for multi-parameter water quality sondes, so the project team focused on instruments that are from well-established manufacturers and that are in common use by oceanographic and water quality professionals. All of the instruments evaluated are based on proven technologies, but two recently introduced instruments are notable in that they provide improved user interface and simplified calibration requirements.

Some researchers have suggested that a fluorometry based oil detection sensor would be a valuable addition to SMART water quality data. The project team considered this and identified only one instrument, the YSI Model 6600, which can be fitted with an optional crude oil fluorometry sensor.

<u>HydroLab HL4</u>: The HydroLab HL4 is the manufacturer's recommended upgrade to the HydroLab DS 5 that is currently in the USCG SMART inventory. The most notable improvement with the HL4 is in the user interface and calibration process. The HL4 utilizes a self-testing function that can alert the user when a sensor is out of calibrated range, and guide the user through the step-by-step re-calibration process. This allows the user to address only the sensors that are out of calibration and illuminates the steps associated with routinely calibrating all sensors, regardless of their condition. This self-testing function should streamline maintenance procedures and decrease the time required to prepare the instrument for deployment. More details for the HydroLab HL4 can be found in Appendix C.

<u>YSI EXO 2</u>: The YSI EXO 2 is another recently introduced water quality instrument that, like the HydroLab HL4, uses newer sampling technology such as a calibration self-testing feature with an assisted re-calibration guide. The YSI EXO 2 utilizes a handheld user interface that has a built-in GPS receiver that, according to the manufacturer, records the latitude and longitude of each sample location. The interface is tethered to the sonde so that GPS data can be received while the sonde is at depth. This feature could streamline the data collection process and improve the accuracy of the data. More details for the YSI EXO 2 can be found in Appendix C.

<u>YSI Model 6600V2</u>: The YSI Model 6600V2 multi-parameter sonde is an older instrument with one notable additional feature. The 6600V2 allows for the integration of a fluorometry-based oil detection sensor. The optional fluorometry-based oil detection sensor adds considerable cost ($7000) to the instrument package, but offers the advantage of providing a more accurate correlation between water parameter and fluorometric data. The project team noted, however, that the SMART data collection methodology for fluorometry data collection is different from the SMART data collection methodology for water parameters. SMART fluorometry data is collected at a constant depth across a lateral distance,

whereas SMART water parameter data is collected through a range of depths at a single location. Although the fluorometry data collected by the 6600V2 may add value to the water parameter data, SMART data end-users have not requested fluorometry as part of water parameter measurement. Additionally, from an operational perspective, the 6600V2 fluorometry data would not satisfy the total fluorometry data collection requirements of the SMART Protocol. The manufacturer plans to discontinue the 6600V2 in 2015. More details for the YSI Model 6600V2 can be found in Appendix C.

Water Parameter Summary: Any of the multi-parameter water quality sondes described above will satisfy the minimum performance criteria for SMART. A comparison table for all four water parameter instruments can be found in Appendix C.

4.8.5 Water Sampling

The SMART Protocol prescribes the collection of water samples during Tier II/III dispersant monitoring operations to validate the relationship between instrument readings in the field and actual dispersed oil concentrations in the water column. NOAA has requested the Strike Teams develop the capability to collect, store, and transport discrete water samples collected at depths ranging from 1 to 10 meters.

Of the four SMART deployments reviewed for this report, discrete water sample collection was performed only for the DWH response. During that response the USCG SMART teams did not have adequate equipment for collecting water samples. The FOSC requested water samples collected from 1 and 10 meters during SMART Tier II/III monitoring operations, but without the proper water sampling equipment, USCG SMART teams improvised various pump and hose configurations. These improvised systems worked fine for collecting the water sample, but it was impractical to decontaminate the pump and hoses after each sample. This may have cross-contaminated the samples and degraded the integrity of the sampling program.

Water Sample Solution: Water samples are difficult to collect where surface oil slicks are present. When sampling in areas covered by a surface slick, care is needed to "knock" the surface slick aside so that the sampling device can be lowered into the water without becoming contaminated. This can often be accomplished by utilizing the vessel’s prop wash to push away the surface oil. It is important that the sampling container be closed as it descends through the higher oil concentrations near the surface. When it reaches the desired depth, the container is opened, allowed to fill, and closed again before being brought to the surface. There are very few water sampling devices on the market that can meet these requirements. A thorough review of water sampling equipment and conversations with organizations involved in water sampling for oil spill response led the project team to two devices that should satisfy the SMART water sampling requirements.

CONBAR 7000 Sampler: For sampling from shallower depths (less than 5 m) a simple COTS “Pole Sampler” such as the CONBAR 7000 Series Telescopic Sampler should suffice. The CONBAR 7000 is a simple and reliable device for the retrieval of 1-liter water samples from a stationary vessel. With a telescopic handle capable of extending from 7 to 24 feet in length the device should be suitable for retrieving water samples from up to 5 meters below the surface. The CONBAR 7000 features a closed-open-closed sequence that minimizes the potential for contamination from near-surface water. The device also accepts standard sample size bottles (1000 ml wide mouth jar) so there is no need to transfer the water sample from the sampler to a separate storage container. More information on the CONBAR 7000 Series Telescopic Sampler can be found in Appendix C.

General Oceanics GO-FLO Sample Bottle: For deeper sample depths (up to 10 m) the project team located only one COTS device that satisfies the closed-open-closed requirement. That device, the GO-FLO Sample Bottle, has a proven history in the oil spill response and oceanographic research fields and should be adequate for the SMART water sampling requirements. The GO-FLO's unique closed-open-closed deployment sequence allows for the collection of sub-surface water samples without contaminating the collection bottle as it passes through the shallower water depths. This is a critical feature for a SMART water sampling device since there is a high likelihood that the near-surface water under an oil slick will contain more suspended oil than at deeper levels. The GO-FLO bottle is deployed in the closed position (to reduce potential contamination). A hydrostatic switch opens the bottle at both ends at approximately 10 m depth. The bottle is then brought to the desired sample depth and a weighted messenger is sent down the line to close and seal the bottle. Once back on deck, the contents can be transferred into the appropriate sample storage containers. More information on the Go-Flo Sample Bottle can be found in Appendix C.

5 RECOMMENDATIONS

As the project team considered how best to modernize the SMART dispersant and ISB monitoring program, some broad questions were posed:

- whether the 2006 SMART Protocol is still viable, given advances in technology and the lessons learned since the 2006 revision,
- whether the scope of protocol has changed as result of the unprecedented use of dispersants (surface and sub-surface applications) during the Deepwater Horizon blowout, and
- whether the informational needs and expectations of the SMART end user match up with the capacity of the USCG SMART data collection teams.

With a better understanding of these broad issues, the project team was able to review past SMART deployments to identify operational gaps and solutions that may guide future improvements to SMART responses.

5.1 SMART Protocol

As noted in Section 4, Performance Gaps and Solutions, most SMART stakeholders feel the 2006 SMART Protocol is adequate for "typical" dispersant or ISB operations. The stakeholders' comments do not suggest the need for a revision of the SMART Protocol. Most stakeholders also agreed there is a need to address the informational needs associated with an "atypical" response, but that guidance should be separate from SMART. For the purposes of this project, when we consider modernizing SMART we do so within the context of the current SMART Protocol and with typical response operations in mind.

5.2 Informational Needs

Early in this project the project team sought better definition of the expectations, roles, and responsibilities associated with the SMART process. The SMART Protocol provides basic guidance in this area but lacks the detailed information necessary for effective SMART operations. Interviews with the NOAA SSC (the SMART end-user), provided a detailed list of the data they need from the SMART field teams. The SSCs expect the SMART field teams to follow rigorous data collection techniques and deliver the data in a timely manner. Based on recent events, the conclusion is expectations of the end-users are consistent with the guidelines of the SMART Protocol and are within the capabilities of the USCG Strike Teams.

5.3 Response Timeline

The project team sought better definition on what the SMART stakeholders consider a reasonable response time for SMART. The tiered structure of the dispersant monitoring component of SMART lends itself to the concept of cascading SMART resources during an oil spill response. Both the NOAA SSCs and the USCG SMART data collection teams agreed that deploying SMART Tier I (visual observation) on Day 1 of dispersant operations while building up to Tier II/III capability by Day 2 is a reasonable response timeline. For the ISB monitoring component of SMART, both the NOAA SSCs and USCG data collection teams agreed that full monitoring capability should be in place for the onset of burn operations.

For both dispersant and ISB monitoring operations, the USCG data collection teams should prepare for a deployment of up to 96 hours. If the response continues beyond that timeframe, contracted SMART teams should relieve the USCG data collection effort, and the USCG will continue to provide oversight for SMART field activities. Considering historic response times for past SMART deployments and current Strike Team capabilities, these response timelines appear to be realistic.

5.4 Roles and Responsibilities

The NOAA SSCs expect the USCG SMART teams to be responsible for all SMART data collection activities for the first 96 hours of a response. This includes providing the personnel, equipment, and logistics necessary to support SMART data collection activities. The USCG SMART teams should provide the communications capability necessary to coordinate field operations, deliver near real-time verbal reports to the Unified Command, and deliver digital data to Unified Command on the day the data is collected. NOAA will take responsibility for processing and evaluating the SMART data once it is received at Unified Command. With a clear understanding that the USCG will be responsible for SMART data collection for the first 96 hours of a response operation, we can consider how best to satisfy the operational requirements.

5.5 SMART Monitoring Procedures

Modernization of the USCG SMART capability is focused on the three broad categories mentioned earlier - Policy, Training, and Technology.

5.5.1 USCG SMART Policies

The most pressing policy issue is the lack of SOPs for USCG SMART activities. These SOPs can be placed into two categories, Methodology SOPs and Equipment SOPs. Methodology SOPs should describe the objective for each SMART data collection activity, and provide detailed operational information that includes mission planning, data collection techniques, and field reporting expectations. USCG SMART response activity documentation guidance should specify how data is captured, formatted, and archived at the Strike Team level, in such a way that allows post-operation reconstruction of activities. In the case of the DWH response, the project team was unable to find comprehensive information to reconstruct SMART activities after 4 years, because no requirements existed to document them. For this study, the project team relied largely on the recollection of the stakeholders involved to characterize the response. Appendix C lists the activities would benefit from SOPs and the topics that should be included.

The SMART Equipment SOPs should be specific to each piece of SMART equipment or instrument; and should provide detailed instructions on the maintenance, calibration, and deployment of the equipment. The equipment SOPs should be written specifically for SMART operational requirements and not overwhelm the operator with details on features not utilized in SMART data collection. The SOP should also cover proper documentation and archiving of SMART data and field activities. Recommendations on which SMART equipment would benefit from SOPs and what topics those SOPs should cover are listed in Appendix C (SMART Monitoring Procedures - Equipment and Instrumentation).

5.5.2 USCG SMART Training

SMART data collection requires specialized training and employs techniques and equipment that are unlike any other USCG response activities. Because SMART is rarely deployed, maintaining a cadre of trained responders can be a challenge. Considering the regular rotation of personnel in and out of the Strike Teams, its recommended annual SMART training that covers the overall SMART mission as well as hands-on SMART equipment operation, maintenance, and calibration training. USCG SMART training has improved over the last few years, and those persons interviewed indicated that SMART training adequately covers many aspects of SMART, however; the training curriculum has gaps, most notably water sampling, water parameter measurement, and air monitoring. This project recommends that SMART training be expanded to include all activities that would be required for a SMART response.

5.5.3 Technology, Urgent Needs

As noted in the protocol, SMART attempts to balance feasible and operationally efficient monitoring with sound scientific principles, and uses the best technology that is operationally practical. The challenge for the SMART field teams is to identify technology that satisfies the informational needs of the end-user, but is portable and user friendly enough for a small team to deploy in a rapid response operation. The project team reviewed the current inventory of USCG SMART equipment, evaluated each piece of technology on its suitability for SMART operations, and investigated newer technologies that may improve SMART operational effectiveness. Though the team investigated a range of different technologies, the focus was on those that specifically address the informational needs expressed by the NOAA SSCs or enhance the operational capabilities of the field teams.

The current inventory of USCG SMART technology includes some state of the art instrumentation that is well suited to SMART field operations, some older instrumentation that still meets the minimum SMART operational performance criteria, and some equipment that does not meet the minimum SMART operational performance criteria.

5.5.3.1 Communications

As noted earlier, communication is the most pressing and persistent technology gap facing the USCG SMART field teams, and is considered an "urgent" need. Adequate communications were not available to the USCG SMART teams during the DWH response. The project team's investigation did not identify a one-size-fits-all technology that will solve all the SMART communications challenges. However, the combination of marine VHF radios, aviation VHF radios, and satellite communications packages described in Appendix C should address most SMART communications requirements.

5.5.3.2 Water Sampling

The water sampling equipment utilized by the Strike Teams during the DWH response did not meet the requirements of the FOSC and may have led to cross-contamination of samples. The water sampling equipment recommended in Appendix C is relatively inexpensive and has a proven history in the oil spill response industry. This should be a high priority for USCG SMART technology improvement.

5.5.4 Technology, Optional Needs

Some areas where the current USCG SMART inventory is outdated, but still meets minimum performance criteria, is particulate air monitoring and water parameter measurement.

5.5.4.1 Air Monitoring

The particulate air monitoring instrument currently in the USCG SMART inventory, the DataRAM 4, is an older generation instrument recently discontinued by the manufacturer. Although the DataRAM 4 has a proven history in the air monitoring field and will continue to be supported by the manufacturer until 2016, the technology is dated and does not provide the operator with the level of real-time information available with newer air monitoring instruments. If the USCG DataRAM 4 units are in good condition and are still within manufacturer recommended specifications, however, they should continue to satisfy the SMART mission requirements. As long as the DataRAM 4 units remain operational the project team does not consider upgrading an urgent need. Considering that the manufacturer will discontinue support for the instrument after 2016, an upgrade should be part of the USCG SMART planning process. The project team investigated newer particulate air monitoring instruments and identified two additional units that satisfy the SMART minimum performance criteria. Specifications for the ThermoScientific ADR 1500 and TSI DustTrak DRX 8533 can be found in Appendix C, along with a table comparing the attributes of all three instruments.

5.5.4.2 Water Parameter Monitoring

The HydroLab DS5 is the multi-parameter sonde currently in the USCG SMART inventory. It is an older generation with a proven history in the water resources field. The manufacturer that supports the DS5 gave no indication that support will end soon. As an older instrument, the user interface is not up to modern standards and the calibration procedures are somewhat complicated. Appendix C describes some multi-parameter instruments recently brought to market. These instruments promise to provide a better user interface with less complicated calibration and maintenance requirements. Either the HydroLab HL4 or the YSI EXO 2 described in Appendix C would be an improvement over the instruments currently in the USCG SMART inventory. As long as the DS5 units continue to perform up to manufacturer specifications, the project team does not consider upgrading to a newer generation instrument a high priority.

5.6 Summary

The overarching conclusion from this project is that the 2006 SMART Protocol still satisfies its original intent: providing guidance for monitoring typical dispersant and ISB oil spill response operations. The primary SMART end-user, NOAA, expects the USCG SMART teams to be self-sufficient in SMART data collection activities, utilize rigorous field techniques, and deliver to the Scientific Support Coordinator scientifically based monitoring data in a timely manner USCG SMART teams are well on the way to meeting those expectations. These enhancements to Coast Guard policies, training, and technologies will improve the effectiveness of the SMART Program.

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APPENDIX A. SMART, TECHNOLOGY, METHODS, AND OUTCOMES 2014 OPERATIONAL ISSUES

A.1 Deep Water Horizon, 2010 (Dispersant Operations)

A.1.1 Deep Water Horizon, 2010 (Dispersant Operations): Incident Overview

On 20 April 2010, the Macondo Prospect well, 45 miles off the coast of Louisiana, experienced a catastrophic blowout, causing a major explosion, fire, and subsequent sinking of the Mobile Offshore Drilling Unit Deepwater Horizon. The blowout resulted in a major oil spill 1 mile below the surface of the ocean, leading to an unprecedented oil spill response, the most challenging and complex our nation has experienced.

During the Deepwater Horizon (DWH) response, aerial dispersants were applied as part of the operational response to minimize the potential for surface oil slicks to impact wildlife and environmentally sensitive shoreline ecosystems. The RRT 6 Regional Contingency Plan (Regional Response Team 6 [RRT6], 2001) requires that any use of chemical dispersant in the region's waters be accompanied by the implementation of Special Monitoring of Applied Response Technologies (SMART) protocols. Accordingly, the protocols were initially implemented when aerial dispersant operations began on 22 April 2010 and continued through the final aerial dispersant application on 19 July 2010.

SMART monitoring was initially conducted by the United States Coast Guard (USCG) National Strike Force (NSF), and later augmented by industry contractors and other USCG personnel. All SMART monitoring operations were coordinated through the USCG SMART Supervisor with monitoring results reported to the Federal On-Scene Coordinator (FOSC), through the National Oceanic and Atmospheric Administration (NOAA) Scientific Support Coordinator (SSC), who provided technical guidance. This was the first time SMART monitoring was implemented as part of a large-scale prolonged response effort during a Spill of National Significance (SONS).

Aerial dispersant operations were coordinated through the Aerial Dispersant Operations Group located at the Incident Command Post, Houma, LA (ICP Houma) and occurred over a period of 90 days, 61 of which involved active spraying. Twelve aircraft participated in the spray operations with a total spray capability of approximately 100,000 gallons per day. The spray aircraft applied approximately 973,000 gallons of dispersant during 412 sorties within an operating area of 18,000 square miles. It is estimated that the aerial spray effort dispersed approximately 12 to 18 million gallons of oil.

The SMART teams adhered to the three levels (or Tiers) of effort described in the SMART Protocol. On several occasions, the Tier III effort was enhanced as described later and labeled Tier III+ in this report.

A.1.2 Deep Water Horizon, 2010 (Dispersant Operations): Level of Effort (Number of Personnel and Number and Timing of Sorties)

SMART teams employed in the DWH response included three crew boats (>100 ft length), two small boats (<30 ft length), three helicopters, two forward staging areas, 50 USCG personnel, 30 contractor personnel, six C-3 Fluorometer kits, two Self-Contained Underwater Fluorescence Apparatus (SCUFA) Fluorometer kits, one LISST (Laser In-Situ Scattering and Transmissometry), and 3 Hydro Labs DataSonde portable water labs. Out of 118 SMART missions conducted during the response, 77 were Tier I, 30 were Tier II/III, and 11 were Tier III+.

A.1.3 Deep Water Horizon, 2010 (Dispersant Operations): Measurement Techniques

To monitor the efficacy of dispersant applications, the SMART teams used the following measurement techniques.

- **Tier I:**
  - SMART Tier I observations were conducted by USCG personnel in helicopters in close coordination with spray aircraft. A trained Tier I observer flew over the oil slick and visually assessed and documented the efficacy of the dispersant application. This information was then reported back to the SSC at ICP Houma.
- **Tier II:**
  - Vessel-based field teams deployed a fluorometer at a water depth of 1 meter to measure and record the amount of oil present in the sample area before and after dispersant application. Discrete water samples were also collected within the sample area before and after dispersant application. The water samples were collected coincident with significant fluorometry readings. The Tier II fluorometry data, consisting of Global Positioning System (GPS) tracking information, photography, and all associated documentation, was physically delivered to the SMART forward staging area where it was digitally transmitted to ICP Houma. The water samples were physically delivered to ICP Houma by courier.
- **Tier III:**
  - Field teams expanded on the Tier II procedures to include fluorometry and water sampling at multiple depths (either 1 m and 5 m, or 1 m and 10 m). In most cases, this was accomplished by the use of two fluorometers operating simultaneously at different depths, although occasionally a single fluorometer was used to sample one depth, then return to the same area to sample the second depth. When circumstances permitted, Tier III teams deployed a portable water lab (Hydrolab DataSonde) along with the fluorometers. The portable water lab recorded data on water temperature, pH, conductivity, dissolved oxygen, and turbidity.
- **Tier III+:**
  - Although not prescribed in the SMART Protocol, several missions were conducted at what was referred to as Tier III+. These missions followed all the parameters of the normal Tier III protocol, but included more advanced instrumentation such as LISST, and increased water sampling for laboratory analysis.
  - The Tier III+ vessel was also fitted with an on-board dispersant spray system which allowed the team to perform self-contained, tightly controlled dispersant efficacy tests on small patches of oil. This provided valuable insight into how well the oil dispersed at various states of weathering and under various sea states.

A.1.4 Deep Water Horizon, 2010 (Dispersant Operations): Equipment and Technology Used

At the onset of the DWH response, the SMART teams deployed with the equipment and technology currently in their inventory. Some of that equipment was new (less than 1 year old) and of the latest technology, and some was more dated. As the response progressed, much of the older equipment was replaced with newer technology.

- **Tier I:**
  - Aerial Tier I SMART operations utilized high-resolution digital cameras, portable GPS units, NOAA Job Aids, and various documentation forms. High-resolution digital cameras with built-in GPS capability were added later in the response.

- **Tier II/III:**
    - The USCG NSF SMART Tier II/III teams utilized C3™ fluorometers manufactured by Turner Designs (Figure A-1) for all Tier II/III SMART missions. The C3™ fluorometer was mounted in a specially constructed housing which allowed the instrument to be towed horizontally through the water. The C3™ fed data through a hard-wired connection to a laptop on the deck of the vessel where the fluorometry data were combined with GPS data and logged for later transmission to data processing personnel at ICP Houma. To supplement fluorometry for Tier III monitoring, a Hydrolab DataSonde portable water lab manufactured by Hach Hydromet (Figure A-2) was utilized which recorded water temperature, dissolved oxygen, pH, and turbidity. Collection of the portable water lab data was considered a lower priority compared to the collection of fluorometry data, so the Hydrolab DataSonde was deployed only when its use did not interfere with SMART fluorometry and water sampling procedures. When deployed, the DataSonde was suspended in the water very near the fluorometer, while both instruments recorded data separately. Since the DataSonde was not set up for towing, the vessel had to be stationary for accurate positioning. The DataSonde data was logged separately from the fluorometry, and did not include GPS position information.

Figure A-1. Turner Designs C3™ fluorometer in specially constructed housing.

Figure A-2. Hydrolab DataSonde portable water lab.

- The contracted SMART teams from Oil Spill Response Limited (OSRL) utilized SCUFA fluorometers manufactured by Turner Designs for their Tier II/III SMART missions. The SCUFA fluorometer was mounted in a specially constructed weighted housing (Figure A-3) which allowed the instrument to remain in a vertical orientation while being towed through the water. The SCUFA is an earlier generation fluorometer that lacks the depth recording capability of the C3™ and is a bit more difficult to tow through the water.

Figure A-3. SCUFA fluorometer in weighted housing.

- For both the USCG NSF and OSRL teams, the fluorometers fed data through a cable to a Panasonic CF-30 laptop computer with an internal GPS receiver (Figure A-4). The fluorometry and GPS data were displayed and logged by a suite of software specifically configured for SMART operations.

Figure A-4. Panasonic CF-30 laptop computer with internal GPS receiver and SMART software.

- Water sampling at the 1 m and 5 m depth was conducted using either an off-the-shelf pole-mounted water sampler or an improvised submersible pump on a long pole (Figure A-5). Sampling at 10 m depth proved more difficult, but later in the response, the USCG NSF team fashioned a small pneumatic pump that could successfully pull a water sample from a 10 m depth. A general purpose submersible pump/hose setup was used that was not designed for water sampling, and may have introduced some shortcomings, such as potentially adsorbing oil into the pump/hose surfaces (the manufacturer lists the hose material as “pvc/nitrile”). These issues are discussed in Appendix B.
  - The OSRL team utilized a GO-FLO sampling bottle (Figure A-6) that effectively retrieved water samples from the 10 meter depth. The GO-FLO bottle is deployed in the closed position (to reduce potential contamination from the surface oil) on a metered cable. A hydrostatic switch opens the bottle at both ends at a depth of approximately 10 m. A messenger is then sent down the line to close and seal the bottle before retrieval.

Figure A-5. Improvised water sampling pump for 5 m samples.

Figure A-6. GO-FLO water sample bottle for 10 m samples.

- Of the five vessels used by the SMART teams during the DWH response, all were vessels of opportunity and four of the five vessels remained available for the duration of the SMART operations. Three vessels were used for the off-shore operations. These vessels ranged from 110 ft to 150 ft in length, and all had a cruising speed of greater than 20 kts. See Figure A-7 and Figure A-8. Two small boats of less than 30 ft in length were used primarily to shuttle personnel and supplies.

Figure A-7. SMART Tier II/III & III+ OSV *International Peace*.

Figure A-8. SMART Tier II/III OSV *Warrior*.

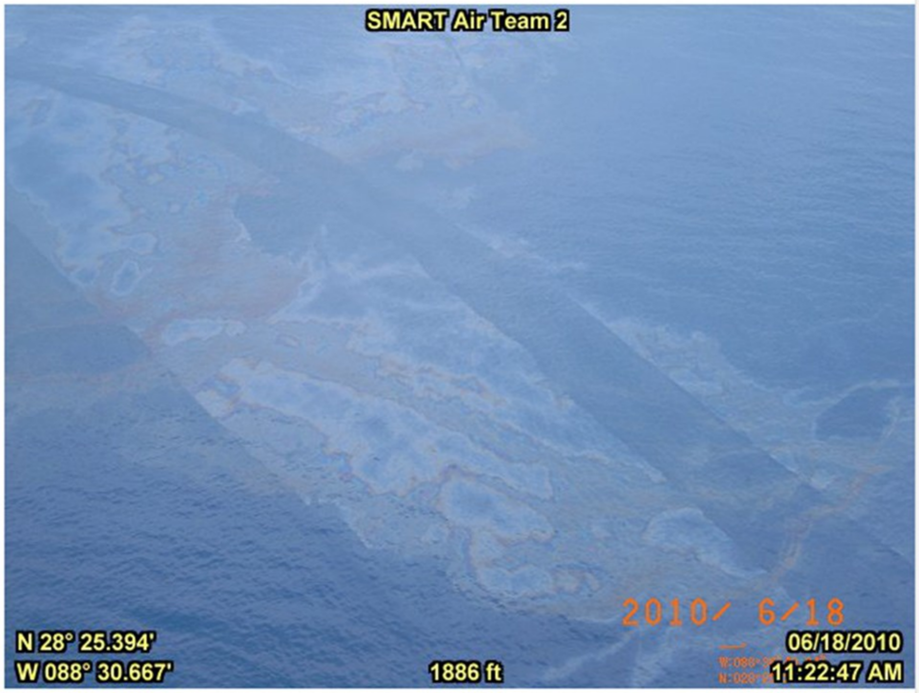
A.1.5 Deep Water Horizon, 2010 (Dispersant Operations): Data Products

Another challenge faced early in the DWH response was how best to present the results of the SMART monitoring effort, and again, the 2006 SMART Protocol provided little guidance. Over the course of the response the SMART data products evolved to meet the demands of the end-users and improved as the capabilities of the field teams improved.

- **Tier I:**
  - The final Tier I data product that evolved of the course of the response (Figure A-9) was in a Keyhole Markup Language (KML) or KML Zip archive (KMZ) file format and was

available on the web-based NOAA ERMA situation map. The individual photos were geo-referenced on the map and each photo was annotated with observer comments and other pertinent information.

Spray on . More steamers of dark heaviy oil wilth dull silver sheen.



Title	SMART Air Team 2
Sub Title	Tier I Documentation
Comment	Spray on . More steamers of dark heaviy oil wilth dull silver sheen.
Location	N 28° 25.394' W 088° 30.667'
Datum	Lat / Lon WGS 84
Elevation	1886 ft
Direction	0.0°
Time	06/18/2010 11:22:47 AM
Time Zone	(GMT-05:00) Central Daylight Time
Camera Make	RICOH
Camera Model	Caplio 500SE
Camera Software	2.78 Rev A
Original File	RIMG0002.JPG

Figure A-9. Example of the DWH SMART Tier I final data product.

- **Tier II/III:**
  - The SMART Tier II/III data product also evolved and improved over the course of the DWH response. After consulting with the NOAA SSCs and other end-users, the processing team developed a one-page poster format (Figure A-10) that summarized the SMART Tier II/III monitoring results. The poster was accompanied by a more detailed written evaluation of the Tier II/III data.
  - The Tier II/III water sample analyses were in the form of written lab reports that summarized the analytical results.

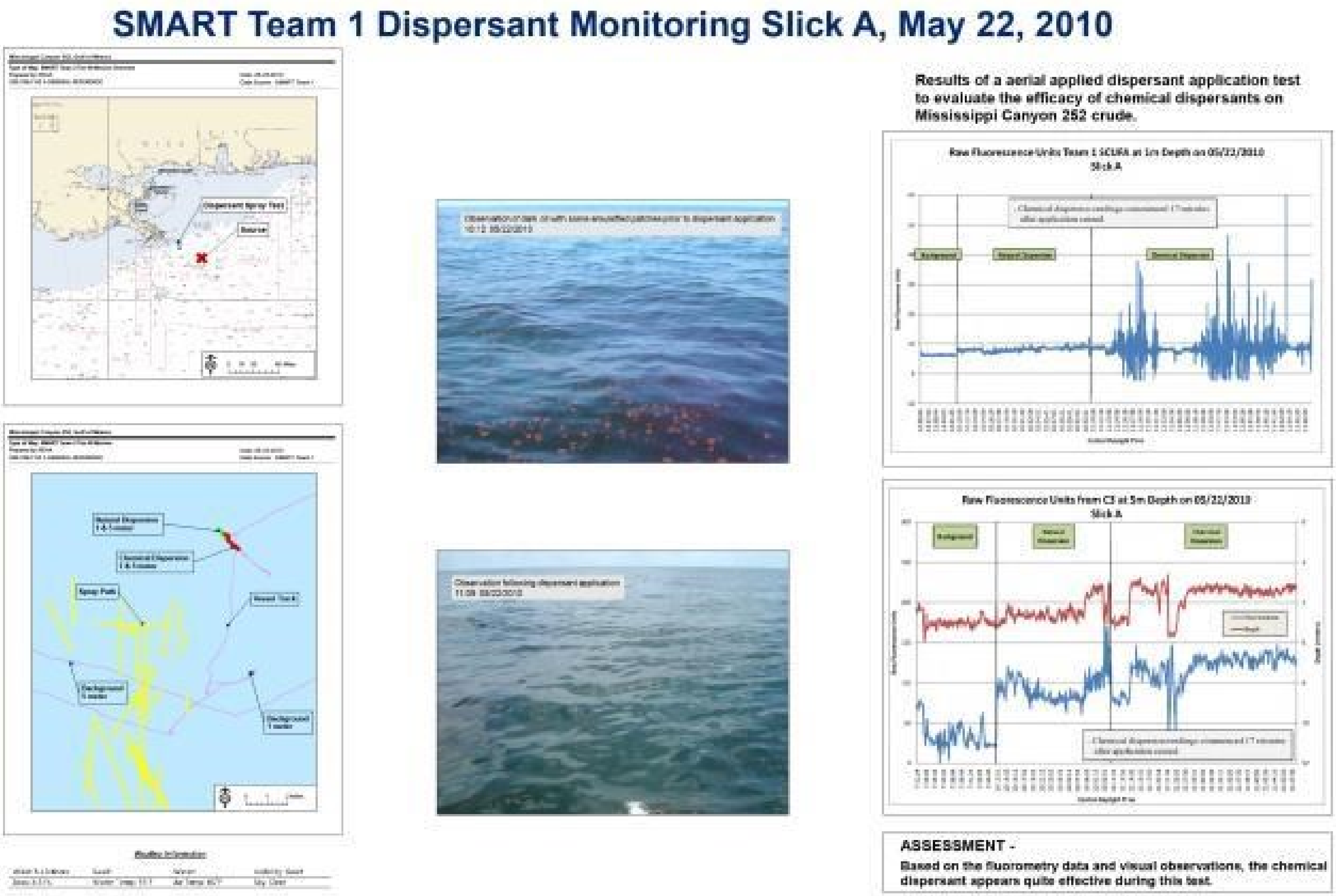


Figure A-10. Example of a SMART Tier II/III final poster.

A.1.6 Deep Water Horizon, 2010 (Dispersant Operations): Data Processing and Analysis Practices

Data processing and analysis was a formidable challenge for the DWH Dispersant Monitoring Group, as neither the 2006 SMART Protocol nor previous SMART deployments provided adequate instruction on how SMART data should be processed, analyzed, and presented for a response of this magnitude. It is important to note that the Deepwater Horizon dispersant operations were of an extraordinary scale and duration. As dispersant use became more visible (and controversial) during the course of the response, the FOSC requested SMART data products that could be distributed to a broader audience. Thus, the SMART data processing and data analysis team had to create a data product that provided the NOAA SSC with the technical information needed to make an informed recommendation to Command, as well as a more generalized data product suitable for a broader, less technical audience.

- **Tier I:**
    - The Tier I data consisted primarily of an Operations Log, Photo Log, and a set of photographs. Once the data arrived at ICP Houma, it was reviewed by the Environmental Unit for completeness and accuracy then converted to a KML or KMZ file format by the NOAA data team (Figure A-11). Initially, the KML and KMZ files were created by manually tagging the photographs with the GPS position documented by the observers. Later, the Tier I teams procured digital cameras that could communicate wirelessly (via Bluetooth) with handheld GPS units. This allowed GPS information (date, time, location, and elevation) to be digitally encoded with the photograph. The location associated with the photograph was the location of the photographer, not the location of the target. The KML and KMZ files were then uploaded to the Environmental Protection Agency On-Scene Commander (EPAOSC) web server, and the web-based NOAA Environmental Response Management Application® (ERMA) situation map, both of which are available to the NOAA SSC and FOSC.

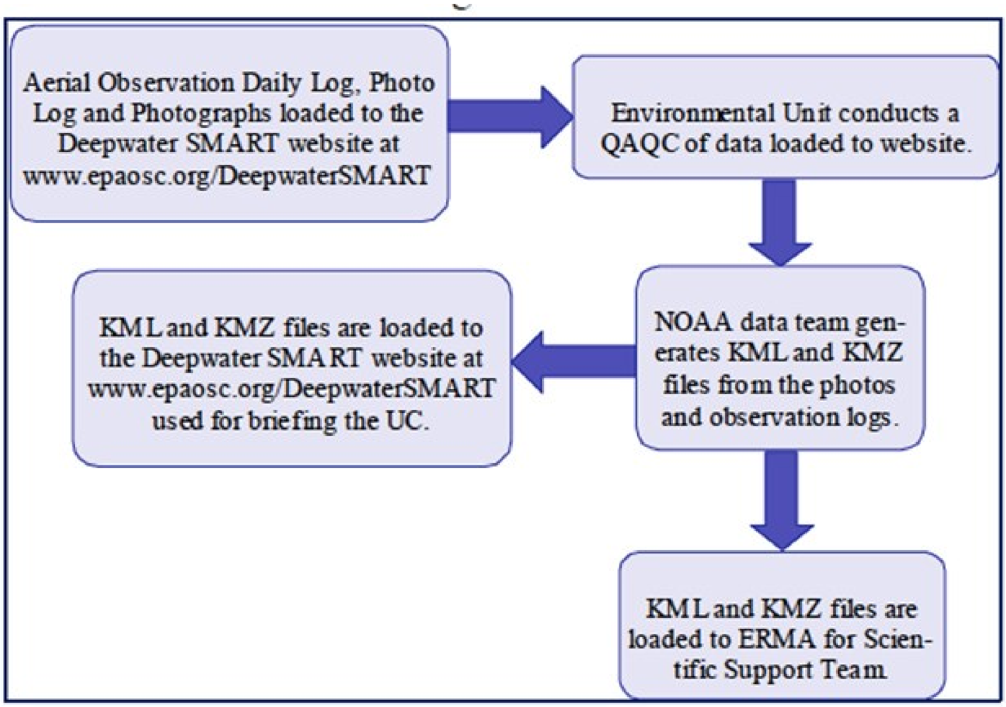


Figure A-11. DWH SMART Tier I data processing flow chart.

- **Tier II/III:**
  - SMART Tier II/III data processing (Figure A-12) and analysis practices evolved and improved dramatically during the course of DWH SMART operations. Early in the DWH response, the SMART Tier II/III field team members performed basic data processing in the field after each mission. The field processed data package included basic Excel charts of the fluorometry data, annotated photos in a PowerPoint format, and a written Operations Log. The data package was emailed to the Monitoring Group Leader who passed it on the NOAA SSC at ICP Houma. The SSC considered the fluorometry data, photo documentation, and Operator comments when evaluating the effectiveness of the dispersant application. One SSC involved in SMART operations at the time commented that, though not ideal, the field processed data package provided adequate information to form the basis of an evaluation. During this early phase of the response, there was a USCG NSF member on the field team with exceptional data processing skills. This individual was able to generate valuable dispersant monitoring data that was of use to the NOAA SSC without further processing at ICP Houma. The Monitoring Group quickly identified the need for a dedicated SMART processing team at ICP Houma however, to relieve the field teams of the data processing burden and provide a level of constancy to the process.

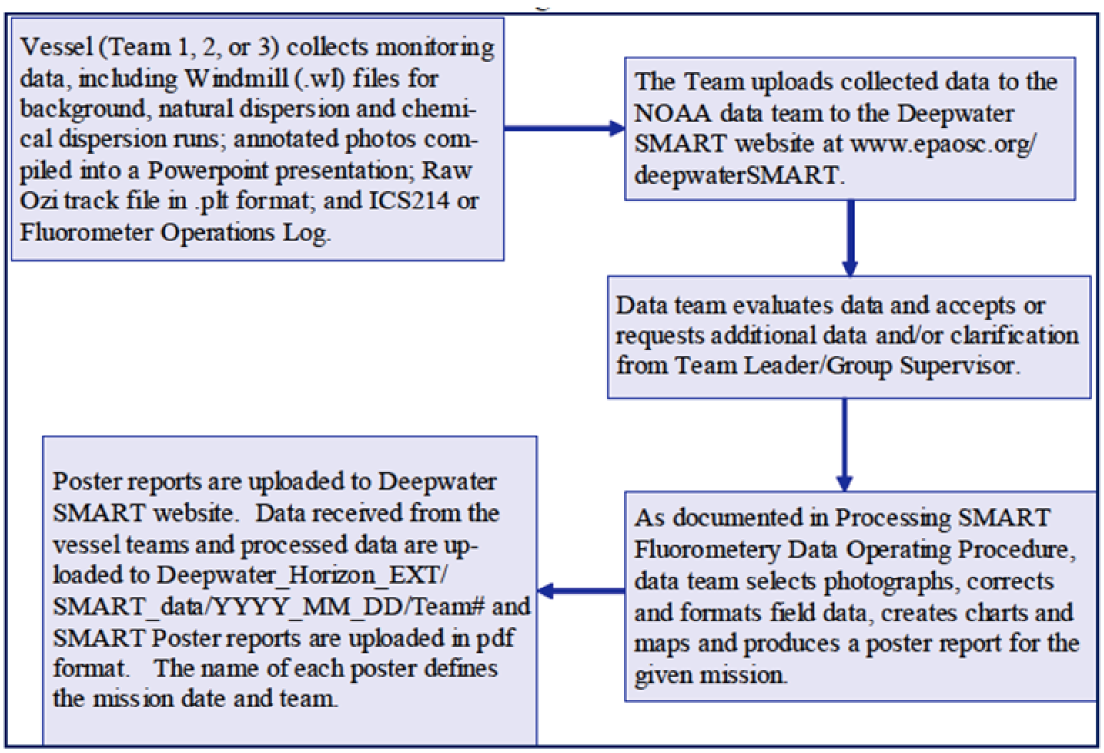


Figure A-12. Flow chart for the Tier II/III data processing procedure that evolved during the DWH response.

  - Later, a standardized SMART Tier II/III field-reporting guide was developed to facilitate the processing of the large amount of data arriving from the field teams. This guide provided the field teams with a standardized format for packaging the data and standardized process for transmitting their field data to ICP Houma. The C-3 SMART Data Formatting Guide specified which data files are included in the package, how the files are formatted and named, how the data is transmitted, and where the data package is delivered. (Figure A-13)

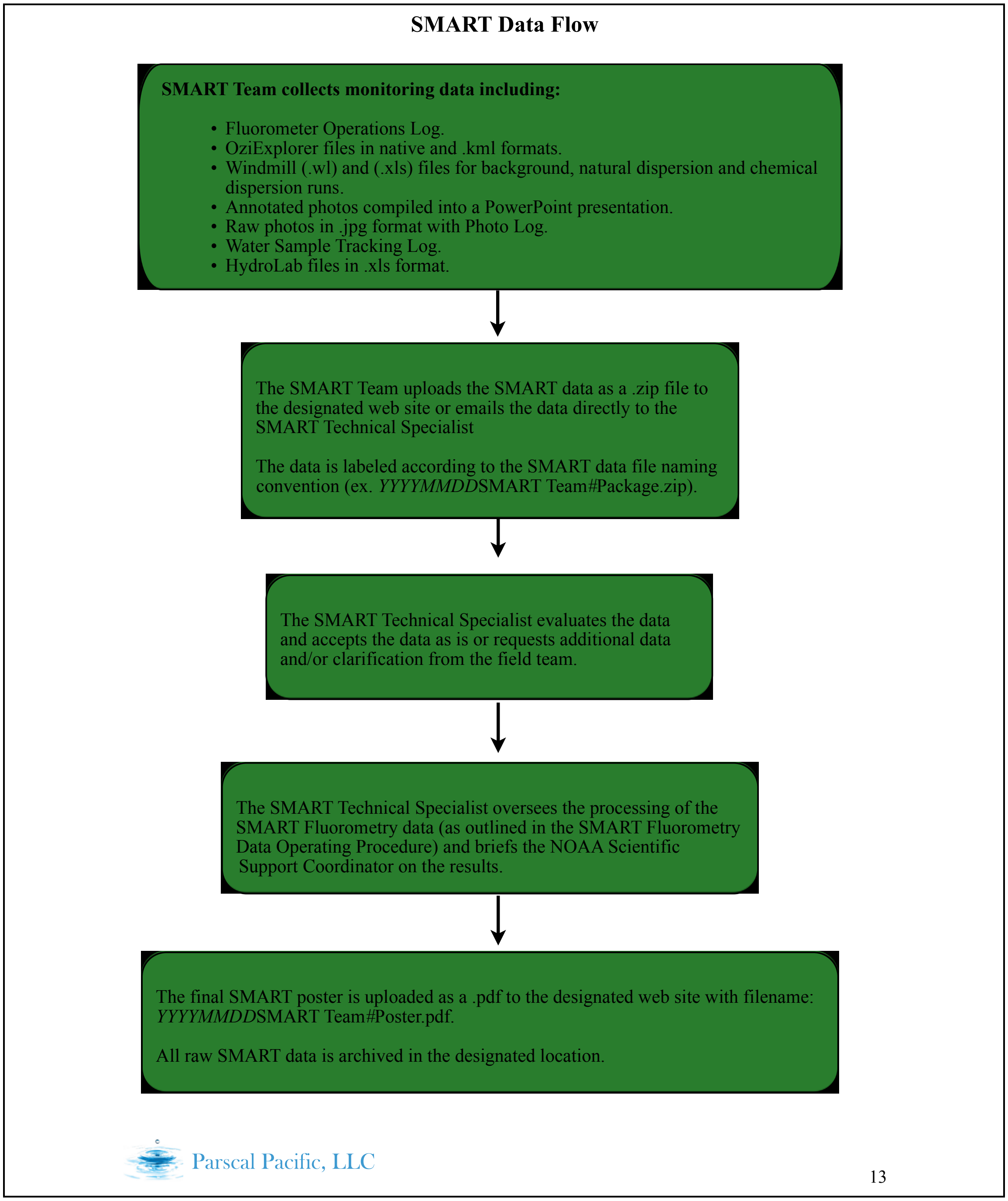


Figure A-13. Flowchart summarizing the SMART data formatting procedure.

- The SMART Tier II/III data processing team initially consisted of two NOAA contracted Geographic Information System (GIS) experts working closely with the SMART Technical Specialist (TS) and an OSRL SMART team member. Later, the NOAA GIS experts were replaced by two GIS experts from the Environmental Protection Agency (EPA) who were available to the SMART processing team full time. After SMART Tier II/III operations were scaled back to one field team, the SMART data processing team was reduced to one GIS expert and the SMART TS. The GIS expert provided geospatial support, while the SMART TS performed the fluorometry processing and overall data analysis.

- When evaluating the effectiveness of a dispersant application, the SMART TS considered all the data available. For DWH SMART operations, this data included fluorometry readings taken at 1 and 5 meters (or 1 and 10 meters, depending on the methodology of the field team), photographs taken by the field team, and the field team's Operations Log. If there were any ambiguities or inconsistencies in the SMART data, the TS contacted the SMART Field Team Leader for clarification.
- The SMART Protocol (2006) recommends the TS "look for trends and patterns providing good indications of increased hydrocarbon concentrations above background. As a general guideline only, a fluorometer signal increase in the dispersed oil plume of five times or greater, over the difference between the readings at the untreated oil slick and background (no oil), is a strong positive indication." Due to the enormous amount of oil in the water from prolonged natural dispersion and extensive chemical dispersant application during the DWH response, the background fluorometry readings became unreliable. The SMART field teams had little confidence that they were encountering any water that was unaffected by the spill. As a result, the TS placed less emphasis on the background fluorometry readings, and more emphasis on the difference between the Natural Dispersion and Chemical Dispersion readings.
- The fluorometry data from each SMART mission was examined for accuracy and reliability, and then combined with the SMART photographs, Operations Log, and Field Team Leader comments to arrive at a final evaluation.

- **Tier III+:**
  - Though the data from the LISST instrument was of interest to the research community, it was not included in the processing and evaluation of the SMART Tier II/III data.

A.1.7 Deep Water Horizon, 2010 (Dispersant Operations): Data Transmission

Due to the magnitude of the DWH event, data transfer was a formidable challenge throughout the duration of SMART operations. With multiple SMART Teams operating over a large geographic area far from ICP Houma, data flow was one of the first challenges faced by the Dispersant Monitoring Group during the DWH response. The 2006 SMART Protocol provides a general guideline for data flow, but does not address the specifics of efficiently moving data from the field to Incident Command in a timely manner.

- **Tier I:**
  - SMART Tier I operations were based out of ICP Houma, so the teams were able to hand deliver their photos and documentation to Command Staff immediately after each flight. Later in the response, the EPA offered their limited access On-Scene Coordinator website as a repository and clearinghouse for the DWH SMART data. This allowed the field teams to upload their data directly from the field.
- **Tier II/III:**
  - The first Tier II/III SMART teams on scene were made up of USCG NSF personnel who set up a SMART Forward Command Base in Venice, LA. The SMART vessels departed Venice each morning and returned late in the evening with the day's data. These data were then handed over to the USCG Field Response Coordinator in Venice who emailed the data up the USCG chain of command and ultimately to the NOAA SSC. Later in the response, the EPA offered their On-Scene Coordinator website as a limited access repository and clearinghouse for the DWH SMART data. This allowed the field teams to upload their formatted data (as described in Section A.1.5) directly from the Forward Command Post.

A.1.8 Deep Water Horizon, 2010 (Dispersant Operations): Data Product Turnaround Times

Delivering processed SMART data to Command in a timely manner was an immense challenge for the SMART teams early in the response. This was primarily due to the geographic scale of the response and the limited communications capability available to the field teams. Data turn-around times improved greatly over the course of the response as the SMART teams developed more efficient techniques.

- **Tier I:**
  - Verbal Tier I reports were phoned in to ICP Houma when circumstances allowed. This was generally done when the helicopter landed for re-fueling or at the end of the flight.
  - Digital Tier I data were delivered to the Monitoring Group (either in person or by webserver) shortly after the flight ended (usually by early evening), and the final data package was available to Command Staff later that evening or early the following morning.
- **Tier II/III:**
  - Immediate verbal reports from the Tier II/III field teams were delivered to ICP Houma when the technology on the vessel allowed and the information was requested by Command Staff.
  - Generally, the Tier II/III field data were available to the ICP Houma Processing Team late in the evening (initially via email, later via webserver) and the final data product was available to Command Staff mid to late the following day. The data processing team could usually turn around the Tier II/III data within 24 hours. The Tier II/III water sample analyses were generally available within 2-7 days, depending on the backlog. (M. BenKinney, February 3, 2014).

A.1.9 Deep Water Horizon, 2010 (Dispersant Operations): Level of Satisfaction with the Data Product

There appeared to be a high level of satisfaction with the SMART data products during the DWH response. The NOAA SSC, the primary user of SMART data, commented that even the earlier, less sophisticated SMART data products provided him with adequate information to make informed operational recommendations to the FOSC. (E. Levine, 2014)

- **Tier I:**
  - A NOAA SSC involved with the DWH dispersant operations indicated that the SMART Tier I data were useful and provided the information necessary to make informed operational recommendations to the FOSC (E. Levine, 2014).
- **Tier II/III:**
  - Though the data products from the earlier Tier II/III operations were not as sophisticated as the SMART posters developed later in the response, the SSC found the earlier products sufficient to make informed operational recommendations.
  - The SMART Tier II/III poster and associated written evaluation that was developed later in the DWH response was well received and seemed to satisfy the needs of the SSC and Command Staff.
  - A NOAA SSC involved with the DWH dispersant operations indicated that the results from the Tier II/III water sample analyses were not considered when making operational recommendations to the FOSC. The water sample analyses were generally not available until days or weeks after collection and were not considered pertinent to ongoing operations. (E. Levine, 2014)

A.1.10 Deep Water Horizon, 2010 (Dispersant Operations): Evolution of the SMART Protocol Following the Event

SMART dispersant monitoring procedures and methodologies evolved a great deal during the DWH response. Though much of this evolution was in response to the unanticipated challenges of a large and prolonged response, the Dispersant Monitoring Group also learned many lessons that are equally applicable to a smaller, more typical dispersant operation.

In an effort to improve SMART program effectiveness, many SMART stakeholders and participants have documented their experience with SMART during the DWH response and have offered comments and recommendations for future SMART operations. Below are some of the comments and recommendations that came out of the DWH experience.

- The USCG BP Deepwater Horizon Oil Spill Incident Specific Preparedness Review Final Report, January 2011 notes: (United States Coast Guard [USCG], 2011)
    - SMART monitoring is a suitable protocol to evaluate dispersant effectiveness. However, its application in an offshore environment, including coordination with spray aircraft, remains a challenge.
    - Rapid deployment of dispersant resources is critical to the successful use of dispersants. This implies that the rapid notification and deployment of the SMART teams is critical to a successful dispersant monitoring effort.
    - There needs to be a rigorous sampling and monitoring program if dispersants are applied in subsea environments.
    - The Coast Guard should engage EPA and the National Oceanic and Atmospheric Administration (NOAA) to continue to enhance SMART monitoring technologies and protocols in offshore environments.
    - Training, field exercises, and field experience are necessary to maintain proficiency of spotters, logistical and operational coordinators, pilots, and SMART teams.
    - The Coast Guard should ensure that training and exercise programs include key potential participants (e.g., Oil Spill Response Organizations [OSROs], industry, Coast Guard, EPA, and Department of Defense components) in dispersant operations including monitoring in the offshore environment to improve performance of spotters, pilots, aircraft spray systems, logistics, communication, and coordination.
- The United States Government Accountability Office notes (United States Government Accountability Office [USGAO] (2012):
    - One expert said that the SMART Protocols are simple, well defined, and standardized and are able to quickly provide information to decision makers during emergency response operations. However, other experts noted that the protocols do not provide an analysis of oil composition to determine whether and how long the dispersant remains present in the water and continues to break up the oil, making it difficult to assess the true effectiveness.
    - Additionally, the SMART Protocols were focused on providing operational guidance on dispersant effectiveness and were not designed to monitor the fate, effects, or impacts of chemically dispersed oil, but many experts said that research should be conducted to integrate monitoring of fate and effects into the protocols. Doing so would help inform research efforts to better address gaps and help spill responders make better decisions.
    - Some experts also noted that the fluorometry technology used in SMART is limited in that it only measures a portion of oil components and that the standardization and calibration of this equipment could be improved.

- Many experts also noted that SMART could be enhanced with different, newer equipment, such as particle size analyzers to measure oil droplet size, which could better monitor chemically dispersed oil.
- Moreover, a February 2012 NOAA review of SMART monitoring protocol implementation during the Deepwater Horizon incident found that the SMART Protocols were not sufficient to determine the effects of the dispersant and oil on marine life in the water column. In addition, the report found that for large spills with information needs beyond the question of whether the oil is dispersing, the protocols need to be revamped. This review concluded that the SMART monitoring methodologies used during the Deepwater Horizon incident lacked rigor and repeatability.
- The SMART Protocols are designed for use with surface application of dispersants and do not monitor dispersed oil resulting from deep water dispersant application. NOAA recognized such limitations in its recent review of the SMART data from dispersant monitoring during the Deepwater Horizon incident and has acknowledged improvements could be made.

- John Joeckel of SEA Consulting Group noted that SMART procedures, data deliverables and method of delivery, should be reviewed and revised in light of the actual operational and coordination requirements encountered during the DWH response. (Joeckle, Walker, Scholz, & Huber, 2011)
- The Coastal Response Research Center identified subsurface dispersant monitoring as a technology area with a large information gap and suggested the use of the SMART Protocol or some analogous methodology to fill that gap. (National Oceanic and Atmospheric Administration [NOAA], 2012)
- The SMART Technical Specialist for the DWH response recommended: (Parscal, 2011)
    - Identifying and training the personnel required to fill the various SMART operational roles including, SMART aerial spotting, SMART data acquisition and SMART data processing.
    - Developing standardized, equipment specific training for the SMART field teams.
    - Developing standard operating procedures (SOP) for the various SMART operational roles including, SMART aerial spotting, SMART data acquisition and SMART data processing.

As evident by some of the above comments and recommendations, there is a wide range of views on not only how to best implement SMART but at a more fundamental level, how to define the core mission of SMART. From a practical perspective, expanding the core mission of SMART to include measuring the fate and effects of the dispersed oil or determining the effects of the dispersed oil on marine life (as suggested by the GAO report) will add a level of complexity that is currently beyond the capabilities of the SMART teams. Although the additional information gained by an expanded SMART program would be of value to a broader response community, adding complexity to the program runs the risk of distracting the teams from the current SMART mission of providing decision makers with real time operational guidance on dispersant effectiveness. As noted in the SMART Protocol, SMART recommends monitoring methods, equipment, and personnel training that strike a balance between the operational demand for rapid response and the informational needs of Unified Command.

To date, only a few of the above recommendations have been implemented into the SMART program. Standard operating procedures (SOP) have been developed for SMART fluorometry and in 2012 and 2013 the USCG sponsored SMART training for the National Strike Force that included hands-on fluorometry experience. There is an overall awareness within the SMART community for the need to develop SOPs and training curriculum for other aspects of SMART (aerial spotting, water sampling, data processing, etc.) but thus far progress is slow. (Parscal, 2013)

A.2 Deep Water Horizon, 2010 (In-Situ Burning)

A.2.1 Deep Water Horizon, 2010 (In-Situ Burning): Incident Overview

Due to the enormity of the oil released, initial mechanical skimming assets were not sufficient to contain and collect all the surface oil that was released by the blowout. On 26 April 2010, the use of in-situ burning of the surface oil was proposed. Between 28 April and 19 July 2010, the Controlled In-Situ Burn (CISB) Group under the Offshore Operations Branch of ICP Houma conducted 411 burns, removing 5 percent of the 4.9 million barrels of discharged oil. Burn task forces conducted burns within the specified and approved CISB Burn Area, typically within 3 to 8 miles of the spill site.

In 1994, RRT 6 published an In-Situ Burn Operations Plan (RRT6, 1994), which required monitoring for any potential impact to the general public by the smoke generated from the burning of oil. In order to fulfill the criteria of the RRT 6 Pre-Authorization for in-situ burning, the NOAA SSC helped implement the SMART In-Situ Burn monitoring protocol for the first test burn on 28 April 2010 (Figure A-14). SMART In-Situ Burn monitoring protocols are designed to alert the FOSC of any potential impact of the smoke on a populated area.

Figure A-14. 28 April 2010 test burn monitored by NSF SMART team.

USCG NSF personnel deployed in-situ burn monitoring equipment to an off-shore platform approximately 13 miles southwest of the planned test burn site. This was the closest location where non-responding personnel were located. SMART sampling detected no oil burn related particulates at this location. NOAA worked with the National Atmospheric Release Advisory Center (NARAC) to model potential plume releases from in-situ burns. NOAA and NARAC determined that the off-shore location (a great distance from any populated areas) and atmospheric conditions would not pose a problem to the general population from particulates from the burns. Thus, SMART monitoring was not required for further burns, and the USCG NSF burn monitoring effort was suspended.

A.2.2 Deep Water Horizon, 2010 (In-Situ Burning): Level of Effort (Number of Personnel and Number and Timing of Sorties)

The NSF and the EPA both performed Particulate Matter (PM) air monitoring during the DWH response. The NSF effort was performed at the request of the FOSC specifically for a single test burn and was done in accordance with the SMART Protocol. The EPA, with its own extensive air monitoring network performed similar PM air monitoring as part of a much larger air monitoring effort. Since the EPA PM air monitoring effort continued long after the NSF SMART air monitoring was suspended, it is not known whether the EPA effort was driven by, or related to, the SMART Protocol.

- **National Strike Force (NSF):**
  - A NSF SMART burn monitoring team of 2 persons was deployed on 28 April 2010 for a single test burn conducted by the DWH CISB Group (C. Barnett, 2014). The SMART team was deployed to an offshore platform approximately 13 miles downwind from the burn site C. Barnett, 2014).
  - The NSF SMART team utilized two DataRAM 4™ particulate air monitors manufactured by Thermo Scientific.
  - The SMART team was on location for the duration of the test burn (no records were found to document the exact duration).
- **EPA:**
  - Throughout the DWH response, the EPA and its state and local agency partners implemented an air monitoring plan in response to the oil spill in the Gulf of Mexico that was not coincident with or associated with the monitoring conducted by the Strike Team. The plan was designed to look specifically for impacts of the spill on the coastal areas of Louisiana, Mississippi, Alabama and Florida. This included the monitoring of particulate matter (PM) that could come from the controlled burns of the oil (Environmental Protection Agency [EPA], 2010). However, it is unclear if this air monitoring was driven by the SMART Protocol, as the EPA followed its own prescribed procedures. The EPA established a monitoring station in Venice, LA that had PM10 capability and collected data on the same day. Figure A-17 is the PM10 data from that EPA station. In either case, this monitoring did provide additional air quality data. (USCG, 2011)
  - According to the QUALITY ASSURANCE SAMPLING PLAN AIR SAMPLING AND MONITORING FOR DEEPWATER HORIZON INCIDENT (5 May 5 2010), the EPA Superfund Technical Assessment and Response Team (START) was to "conduct particulate (dust) monitoring downwind of the in-situ burn using DataRAM instruments over a 24-hour period. The DataRAM collects air monitoring readings for PM10, and the instrument is capable of data logging, with results logged no less than every 5 minutes, and downloaded to a computer at the end of each operating period. The logged particulate data is then distributed through the Unified Command as directed by EPAOSC to support the NOAA SMART Air Monitoring Plan for In-Situ Burns." (EPA, 2010b)

A.2.3 Deep Water Horizon, 2010 (In-Situ Burning): Measurement Techniques

The NSF and EPA utilized air monitoring techniques specific to their respective organizations.

- **NSF:**
  - Monitoring techniques closely followed those prescribed by the SMART Protocol. The particulate monitoring equipment was set-up at the location nearest the burn site where a non-responding population was located. The instruments were monitored continuously during the burn period.

- **EPA:**
  - The EPA utilized its own monitoring protocol. The PM10 component of that protocol is similar to SMART but the EPA does not appear to require continuous monitoring of the sampling equipment.

A.2.4 Deep Water Horizon, 2010 (In-Situ Burning): Equipment and Technology Used

The NSF and EPA utilized similar PM10 air monitoring instruments during the DWH response. Whereas the NSF utilized a single type of instrument specifically for SMART oil burn air monitoring, the EPA deployed many PM10 instruments as part of a much more extensive air monitoring effort, which used other types of monitoring equipment as well.

- **NSF:**
  - The NSF SMART team utilized two DataRAM 4™ particulate air monitors manufactured by Thermo Scientific (C. Barnett, 2014) (Figure A-15).
- **EPA:**
  - The EPA used DataRAM 4™ instruments for PM10 air monitoring.

Figure A-15. Thermo Scientific DataRAM 4™ Particulate Monitor.

A.2.5 Deep Water Horizon, 2010 (In-Situ Burning): Data Products

The NSF did not generate a data product for the sole SMART air monitoring deployment during the DWH response. The EPA routinely generated Air Particle Matter Reports (Figure A-14) from PM10 monitoring sites. (Figure A-16)

- **NSF:**
  - The NOAA SSC did not request any data product other than the immediate notification of any PM10 readings above the LOC at the monitoring site. (E. Levine, 2014)
- **EPA:**
  - The EPA Air Particle Matter Reports were available to Command Staff in the NOAA ERMA Mapping web site.

U.S. ENVIRONMENTAL PROTECTION AGENCY

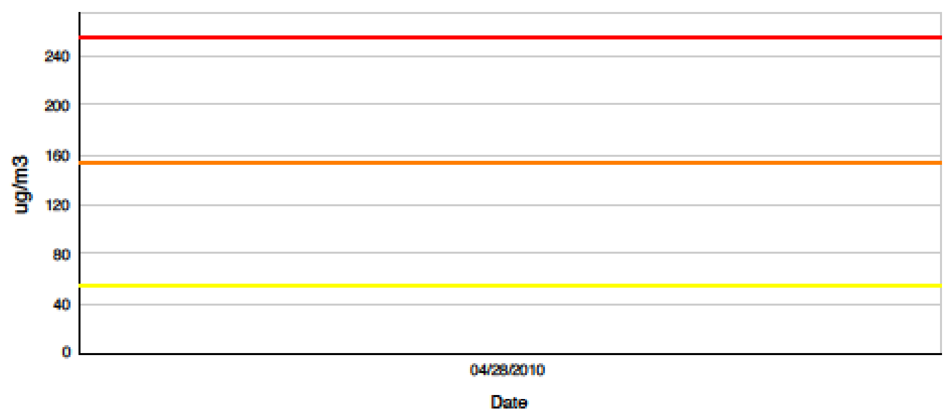
Air Particulate Matter Report

Location	V01
City, State	Venice, Louisiana
Latitude	29.27425
Longitude	-89.35406

Monitoring PM10 Daily Averages	Air Quality Index Value	Air Quality Index Levels of Health Concern	Cautionary Statements
0-54	0 to 50	Good	None
55-154	51 to 100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
155-254	101 to 150	Unhealthy for Sensitive Groups	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
255-354	151 to 200	Unhealthy	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
355-424	201 to 300	Very Unhealthy	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.
425-604	301 to 500	Hazardous	People with heart or lung disease, older adults, and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors

Particulate Matter 10 microns and smaller

Date	Number of Hours Averaged	Average for this day	Unit of Measure
04/28/2010	8*	0	mg/m3



* AQI daily averages are based on a minimum of 18 hours of data. On this date, at this monitoring location, there were less than 18 hours of data collected

Figure A-16. Example of an EPA Air Particulate Matter Report from Venice, LA for 28 April 2010.

A.2.6 Deep Water Horizon, 2010 (In-Situ Burning): Data Processing and Analysis Practices

The NSF SMART data processing and analysis was very simple: observe the air monitoring instruments during oil burn operations and immediately notify Command of any PM10 readings above the Level of Concern (LOC). The EPA utilized a much more sophisticated data processing and analysis program based on their own air monitoring protocols (Figure A-17).

- **NSF:**
    - The NOAA SSC was not aware of any processed air monitoring data provided by the SMART team. The SSC stated that immediate notification of elevated time-weighted average (TWA) readings was the goal. (NOAA, 2009a)
- **EPA:**
    - Field personnel retrieved the instrument log file, processed that data into a Scribe compliant Electronic Data Deliverable (EDD) format, and loaded it into a data reduction Scribe project. Scribe is a software tool developed by the EPA's Environmental Response Team (ERT) to assist in the process of managing environmental data. Scribe captures sampling, observational, and monitoring field data. Queries within the data reduction Scribe project create 8 hr and max result records for each parameter, by location and day. These reduced data are then loaded to the master project (Figure A-17). (EPA, 2010c)

2) Overall Workflow

2a) Data Flow Diagram:

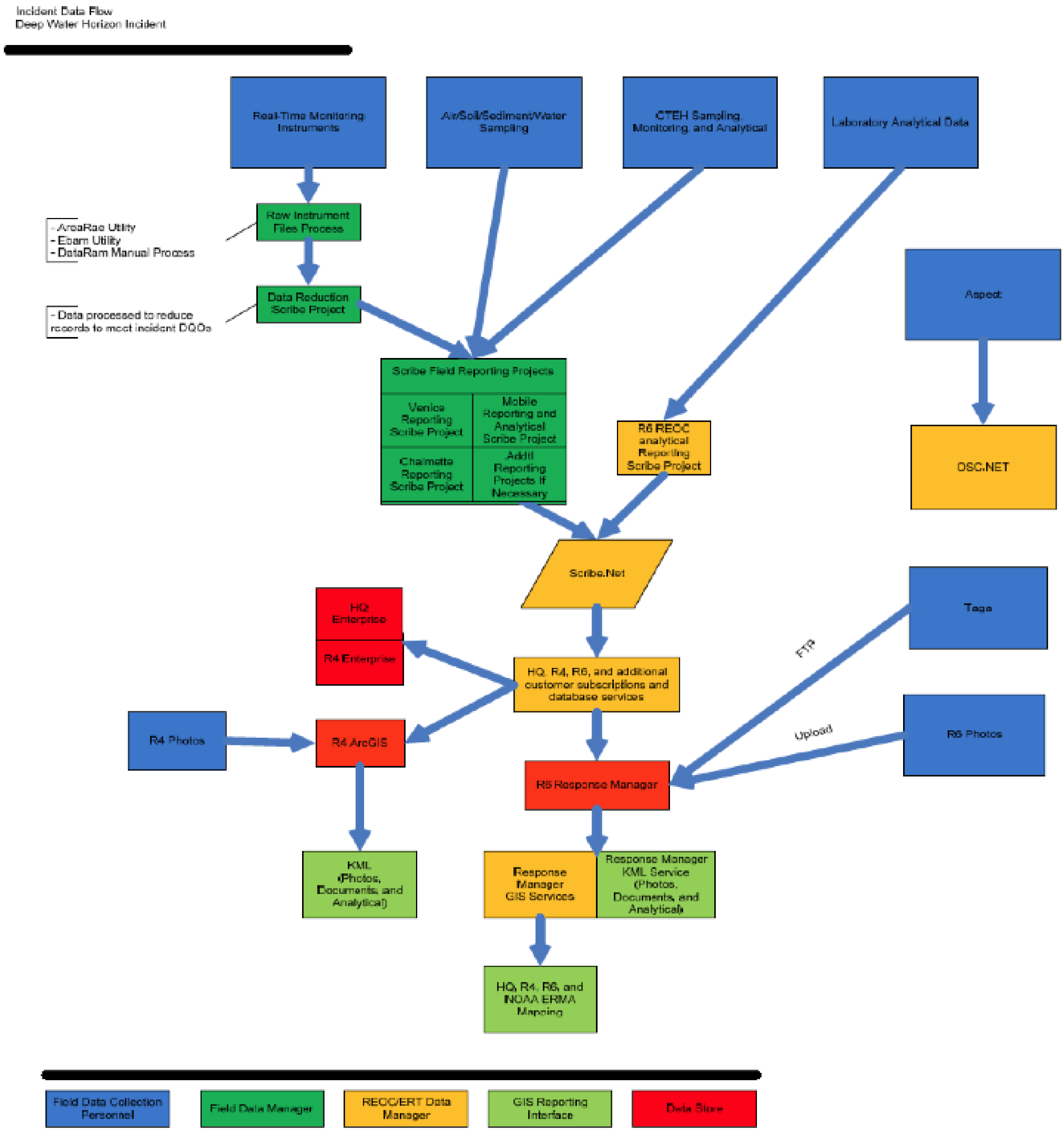


Figure A-17. EPA data flow diagram for the DWH response (EPA, 2010c).

A.2.7 Deep Water Horizon, 2010 (In-Situ Burning): Data Transmission

Unlike the EPA, the NSF SMART air monitoring team did not transmit data from the field to Command. The goal was to immediately notify Command in the event of elevated PM10 reads, but since no elevated readings were observed, no data were transmitted. Although NSF monitoring data may have been saved, no such data has been located.

- **NSF:**
  - The air monitoring data were observed by NSF personnel at the monitoring site and recorded by the monitoring equipment. Any indication of elevated readings would have prompted a telephone call to the NOAA SSC at ICP Houma, as the monitoring team was in telephone contact with ICP Houma. (C. Barnett, 2014)
- **EPA:**
  - Field personnel downloaded the monitoring files from the instruments at a frequency between once an hour and once in 24 hours, then stored the data in the appropriate directory specific for that day or delivered the data directly to the Data Manager. Generally, the filed data were uploaded to an EPA webserver from the field. (EPA, 2010c)

A.2.8 Deep Water Horizon, 2010 (In-Situ Burning): Data Product Turnaround Times

The NSF did not generate a SMART air monitoring data product, but the EPA Air Particle Matter Reports were generally available to Command within 1.5 – 2 days.

- **NSF:**
  - ICP Houma would have been immediately notified if the team observed any PM10 readings above the LOC. The NSF SMART team did not see any PM10 readings above the LOC at the monitoring site during the test burn so immediate notification was not implemented.
- **EPA:**
  - Turnaround time for the EPA PM10 data were approximately 1.5 - 2 days. This includes:
  - Approximately 24 hours for EPA regions to input data into the Scribe database, and for the database operators to collate these data and perform necessary data review (address any data input or other issues), and
  - Up to 24 hours for review by Emergency Operations Center (EOC) Environmental Unit and Air Desk. Some data, on occasion, required follow up by the Air Desk with regional and field personnel as part of data interpretation. The EOC prepared language for posting to the website during this time period as well.

A.2.9 Deep Water Horizon, 2010 (In-Situ Burning): Level of Satisfaction with the Data Product

Though no data product was delivered by the NSF SMART air monitoring team, the NOAA SSC was satisfied with the effort and felt no data product was necessary since no elevated PM10 readings were observed.

- **NSF**
  - The NOAA SSC involved in the DWH SMART in-situ burn monitoring operations was satisfied with the performance of the monitoring team and was confident that no detectable level of smoke particulates reached the monitoring location (E. Levine, 2014).

- **EPA:**
  - The NOAA SSC involved in the DWH SMART in-situ burn monitoring operations noted that he did not utilize the EPA air monitoring data (E. Levine, 2014).
  - During the oil spill, EPA monitored for PM at the shoreline and found the levels to be consistent with Gulf Coast summertime levels (Congressional Research Service [CRS], 2010).

A.2.10 Deep Water Horizon, 2010 (In-Situ Burning): Evolution of the SMART Protocol Following the Event

With only one SMART air monitoring deployment during DWH, no evolution of the SMART Protocol was achieved.

A.3 T/V *Krymsk* Oil Spill, 2009 (Dispersant)

A.3.1 T/V *Krymsk* Oil Spill, 2009: Incident Overview

On 20 October 2009, the OSV *AET Endeavor* collided with the T/V *Krymsk* (Figure A-18), an 820 ft, 62,395 gross tons (GT) Liberian-flagged double-hull crude oil carrier located approximately 40 NM off-shore of Galveston, TX. The vessel reported a 1 m x 1 cm crack on the No. 2 port bunker (fuel) tank approximately 2-4 ft above the waterline. The crack was in a fuel tank and did not impact the cargo area. USCG estimated a loss of roughly 13,600 gallons of bunker oil to the sea. Internal transfers prevented additional oil from being released. An oil dispersant plan was developed and an RRT conference call occurred. The RRT provided concurrence to the FOSC for the use of dispersants if suitable oil was discovered during an overflight.

Figure A-18. T/V *Krymsk* with damaged hull.

On 21 October 2009, an Airborne Support Inc. DC-3 aircraft (Figure A-19) applied 1,000 gallons of COREXIT® 9500 dispersant, making several passes over the area of heaviest oiling off-shore, as well as in areas of fringe sheening. SMART Tier I observers reported that the dispersants appeared to have been somewhat effective (milky emulsion observed). Heavy weather prohibited a second dispersant sortie in the afternoon.

Figure A-19. SMART Tier I photo of a DC-3 aircraft applying dispersant to an oil sheen 40 miles off of Galveston, TX.

On Friday, 23 October 2009, a limited dispersant application was applied to the residual slick to assess the potential for mitigation. The dispersant was deemed ineffective, and a decision was made to not continue dispersant applications.

A.3.2 T/V *Krymsk* Oil Spill, 2009: Level of Effort (Number of Personnel and Number and Timing of Sorties)

Though operational details for this response are scarce, the USCG Gulf Strike Team Operations Log provides a general timeline for the dispersant operations.

- 21 October 2009, 0145: Marine Safety Unit (MSU) Galveston requested GST dispersant monitoring assistance.
- 21 October 2009, 0435: Two GST members departed Coast Guard Aviation Training Center Mobile via USCG HC-144 aircraft in route to Houma, LA.
- 21 October 2009, 0545: Two GST members prepared for SMART Tier I and Tier II/III operations arrived in Houma, LA.

- 21 October 2009, 0850: GST members provided Tier I support for a dispersant application sortie.
- 23 October 2009, (no time available): GST members provided Tier I support for a dispersant application sortie.
- 23 October 2009 (no time available): GST SMART team was demobilized.
- Tier II/III was not mobilized due to adverse weather conditions.

A.3.3 T/V *Krymsk* Oil Spill, 2009: Measurement Techniques

All indications are that the team utilized standard Tier I measurement techniques as prescribed by the SMART Protocol.

A.3.4 T/V *Krymsk* Oil Spill, 2009: Equipment and Technology Used

Tier I team members shared a King Air aircraft with the spray spotting personnel. The twin engine King Air was considered a safer air platform for the SMART team, considering the distance off-shore for the area of operation (C. Henry, 2014). Though not specifically identified in the reports, the Tier I photographs indicate the team utilized a digital camera. There is no mention in the reports of whether the team had a portable GPS unit. There is also no mention in the reports of what in-flight communications technology was available to the team, but the NOAA SSC recalled that the Tier I team was not able to communicate with Incident Command during flight operations. (C. Henry, 2014)

A.3.5 T/V *Krymsk* Oil Spill, 2009: Data Products

Tier I Data included digital photographs and a verbal report. The data may have included a written log, as is standard procedure, but no log was discovered.

A.3.6 T/V *Krymsk* Oil Spill, 2009: Data Processing and Analysis Practices

The NOAA SSC recalled receiving a set of photographs and a verbal report from the Tier I team shortly after the flight.

A.3.7 T/V *Krymsk* Oil Spill, 2009: Data Transmission

Tier I photos and verbal assessments were relayed to Unified Command. (C. Henry, 2014)

A.3.8 T/V *Krymsk* Oil Spill, 2009: Data Product Turnaround Times

The NOAA SSC recalled receiving a set of photographs and a verbal report from the Tier I team shortly after the flight (C. Henry, 2014). There was no communication between the Tier I team and the SSC during flight operations.

A.3.9 T/V *Krymsk* Oil Spill, 2009: Level of Satisfaction with the Data Product

The NOAA SSC was satisfied with the SMART data for this incident. He felt the Tier I data were sufficient for him to make informed recommendations to the FOSC (C. Henry, 2014).

A.4 Eugene Island Pipeline Spill, 2009 (Dispersant)

Very little information was discovered concerning SMART operations on this incident.

A.4.1 Eugene Island Pipeline Spill, 2009: Incident Overview

On 26 July 2009, USCG MSU Morgan City notified the NOAA HAZMAT Duty Officer of an oil spill 65 miles due south of Atchafalaya Bay. An alarm indicated a pressure drop in a pipeline, but the location of a leak was unknown. Later the same day, a slick was observed 20-25 miles south of Lake Pelto in the Gulf of Mexico. The Responsible Party, Shell Pipeline, estimated 600 bbls of 33.7 American Petroleum Institute (API) gravity crude oil had leaked from the pipeline. On the morning of 27 July 2009, the Responsible Party requested authority to use oil dispersants on the surface oil. Under the RRT 6 preauthorization plan, authority was granted by the FOSC. The extended forecast suggested that on-shore transport conditions were predicted for the next few days, but landfall was still days out.

USCG Strike Team personnel were mobilized to Gibson, LA to meet the morning overflight and provide SMART Tier I visual observation for the dispersant application. It was thought practically impossible to get the NSF SMART Tier II/III Team off-shore and in position before the planned morning sortie.

On 27 July 2009, two dispersant application sorties (Figure A-20, Figure A-21, and Figure A-22) were executed applying a total of 504 gallons of COREXIT® 9527 dispersant to the oil slick. Dispersant application was performed by Marine Spill Response Corp. (MSRC) using a King Air spray platform.

Figure A-20. SMART Tier I photo taken during dispersant application.

Figure A-21. SMART Tier I photo taken after dispersant application.

Figure A-22. 27 July 2009 SMART Tier I photo taken after dispersant application.

SMART Tier II/III equipment and personnel were deployed for the second 27 July 2009 sortie, and did arrive in the general area of dispersant operations. The team was unable to connect with the application aircraft, however, due to a last minute change in the dispersant target area.

On 28 July 2009, a 9 mile by 1 mile slick was observed further northeast of the 27 July position. The slick was composed of 6 streamers of heavier oil, rainbow sheen, and silver sheen that thinned into no observable sheen. This slick was believed to be the remnants of the original release. The leading edge was still within the pre-approval zone, and one dispersant application sortie was executed (NOAA, 2009b). On 29 July 2009, two dispersant application sorties (Figure A-23) were executed, applying something less than 600 gallons of dispersant. The Tier I report indicated there was some degree of effectiveness (NOAA, 2009a).

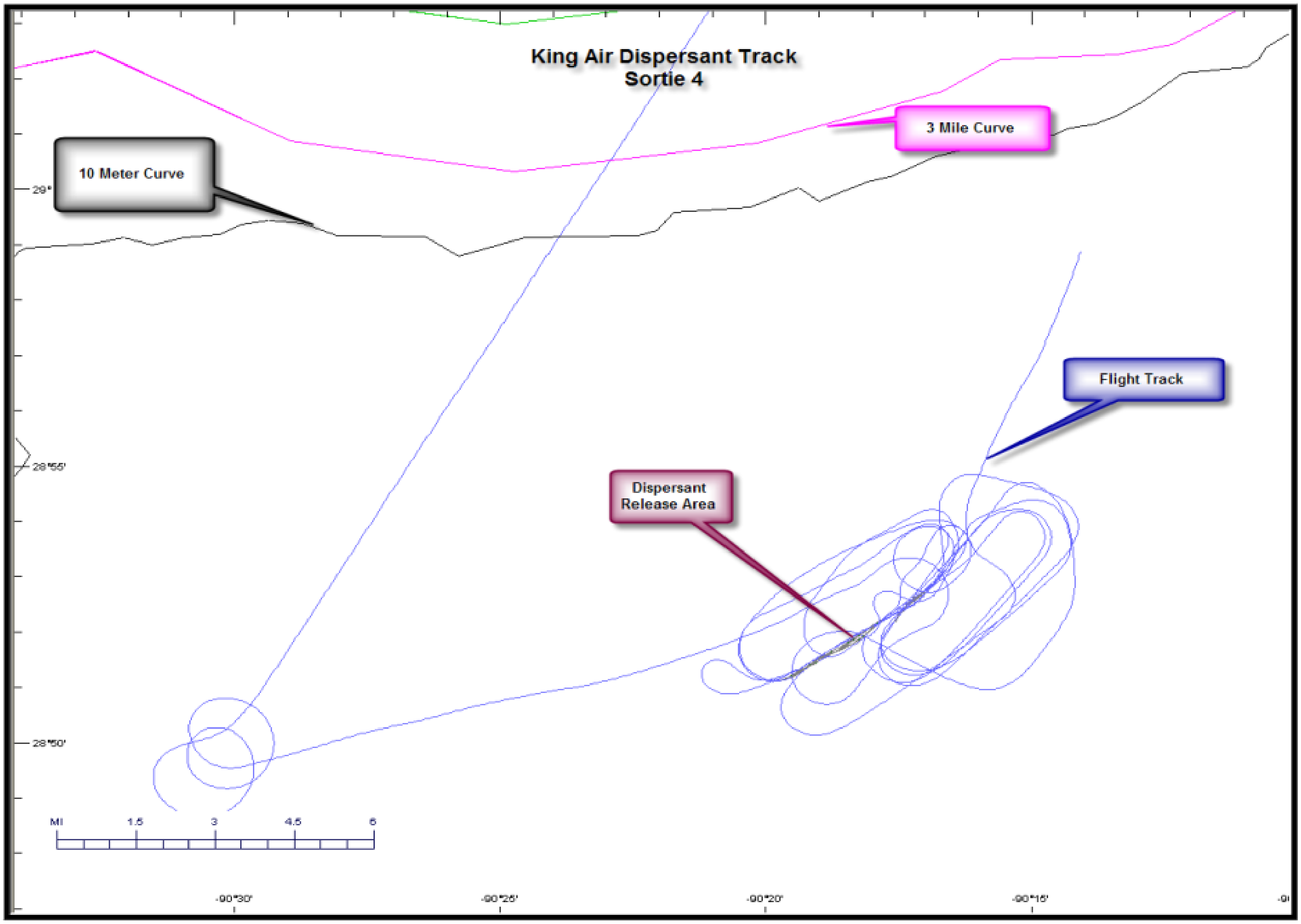


Figure A-23. Flight path for King Air dispersant spray aircraft sortie #4, 29 July 2009 (C. Henry, interview, 2014)

A.4.2 Eugene Island Pipeline Spill, 2009: Level of Effort (Number of Personnel and Number and Timing of Sorties)

Though operational details for this response are scarce, the USCG Gulf Strike Team Operations Log provides a general timeline for the dispersant operations.

- 26 July 2009 (no time available): MSU Morgan City requested GST support for possible dispersant monitoring operations.
- 27 July 2009 (no time available): GST provided Tier I support for two dispersant application sorties.
- 27 July 2009 (no time available): Tier II/III support was requested by Unified Command, but not executed due to Responsible Party logistical constraints.
- 28 July 2009 (no time available): GST provided Tier I support for one dispersant application sortie.
- 29 July 2009 (no time available): GST provided Tier I support for two dispersant application sorties.
- 30 July 2009 (no time available): MSU Morgan City released the GST.

A.4.3 Eugene Island Pipeline Spill, 2009: Measurement Techniques

All indications are that the team utilized standard Tier I measurement techniques as prescribed by the SMART Protocol.

A.4.4 Eugene Island Pipeline Spill, 2009: Equipment and Technology Used

The Tier I photographs indicate that the team utilized a digital camera. Beyond that, there is no information on other equipment or technology that may have been utilized for Tier I operations.

A.4.5 Eugene Island Pipeline Spill, 2009: Data Products

Tier I data included photographs and a verbal report. The data may have included a written log, as is standard procedure, but no log was discovered.

A.4.6 Eugene Island Pipeline Spill, 2009: Data Processing and Analysis Practices

The NOAA SSC recalled that receiving a set of photographs and a verbal report from the Tier I team shortly after the flight.

A.4.7 Eugene Island Pipeline Spill, 2009: Data Transmission

Tier I photos and verbal assessments were relayed to Unified Command after each flight. There was no communication between the Tier I team and the SSC during flight operations.

A.4.8 Eugene Island Pipeline Spill, 2009: Data Product Turnaround Times

The NOAA SSC recalled receiving a set of photographs and a verbal report from the Tier I team shortly after the flight. Again, no written log was discovered.

A.4.9 Eugene Island Pipeline Spill, 2009: Level of Satisfaction with the Data Product

The NOAA SSC was satisfied with the SMART data for this incident, and felt the Tier I data were sufficient to support informed recommendations to the FOSC. The SSC mentioned that if Tier II/III data been collected (as requested by the FOSC), he doubts the Tier II/III data would have changed his recommendation. He considered the Tier I data very convincing for this incident. (C. Henry, 2014)

A.5 M/V *New Carissa*, 1999 (Atmospheric Monitoring)

A.5.1 M/V *New Carissa*, 1999: Incident Overview

The freighter M/V *New Carissa* ran aground on the Oregon coast in a gale-force wind on 4 February 1999. Bad weather and logistics ruled out pumping the oil off the ship. After the ship was battered by high waves for a week, the engine room flooded and the ship began leaking oil. The Unified Command acted quickly to minimize the possibility that all 425,000 gallons of heavy fuel oil and diesel fuel aboard the vessel would spill into a pristine, protected environment. The FOSC decided to burn the oil aboard the ship to prevent a catastrophic spill. On 10 February 1999, the FOSC, Responsible Party, and the Oregon State Incident Command signed a memo documenting their decision to attempt a controlled burn aboard the stricken vessel (Figure A-24).

The FOSC requested SMART particulate monitoring at nearby population centers, considering the potential for a large amount of black smoke to be generated from a burn of this magnitude, and the corresponding public health concerns. An incident-specific monitoring program was prepared by NOAA, reviewed and signed by representative of the USCG, NOAA, EPA, and Department of Environmental Quality (DEQ), and adopted for use in this incident. The monitoring program was based on the SMART Protocol and called for several teams equipped with portable particulate air monitors to collect real-time data on particulate concentration trends at ground level.

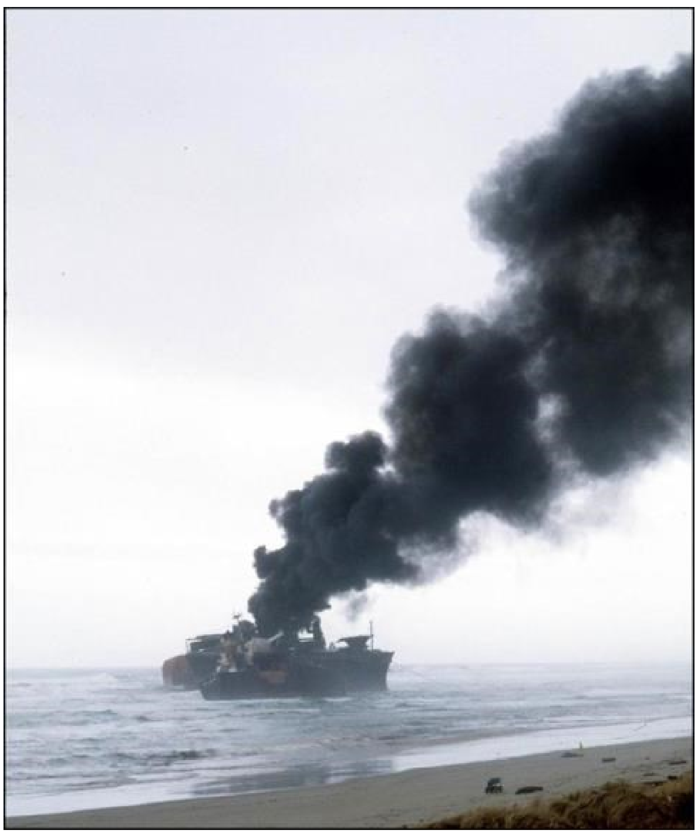


Figure A-24. Smoke plume from the burning of oil aboard the M/V *New Carissa*.

The first USCG NSF SMART monitoring team arrived on-scene at 1400 on 10 February 1999. Sustained burn operations commenced the evening of 11 February and by 0800 on 12 February 1999, most of the fires had burned out, with the exception of a fire on the stern section of the ship that burned for approximately 33 hours. At midnight on 13 February 1999, the monitoring teams were placed on standby, and later de-mobilized.

The highest reported measured concentration for particulate in air was 1.5 micrograms per cubic meter of air ($\mu g/m^3$). This is well below the most stringent standard, which is the Oregon State 8-hour time weighted average concentration of 10 $\mu g/m^3$. All measurements were either below the minimum detection limits of the instruments, or well below established threshold limits.
In the end approximately 200,000 gals of fuel oil, half of the oil on board, were burned in the operation and there were no reported adverse health effects from the smoke to the local population or the responders (USCG, 1999).

A.5.2 M/V *New Carissa*, 1999: Level of Effort (Number of Personnel and Number and Timing of Sorties)

USCG NSF, EPA, and State of Oregon monitoring teams were called on-scene as soon as it became apparent that a burn could take place. The Monitoring Group Supervisor coordinated the teams, a role shared by the USCG and NOAA.

Monitoring teams were deployed well before the burn at the following locations: The town of Empire, the airport at North Bend, near the Umpqua river outlet, and a roving monitor near Hauser and Shutter Creek (a correctional facility). In addition, a DEQ monitoring team collected air samples at Horsefall Beach, 2.5 miles north of the ship, and later at Lakeside. See Figure A-25. Particulate concentration levels exceeding the LOC would trigger calling in more monitoring teams, as well as notifying DEQ and public health officials. Monitoring teams remained on-scene for the duration of the burning operations, which lasted approximately 3 days (NOAA, 1999).

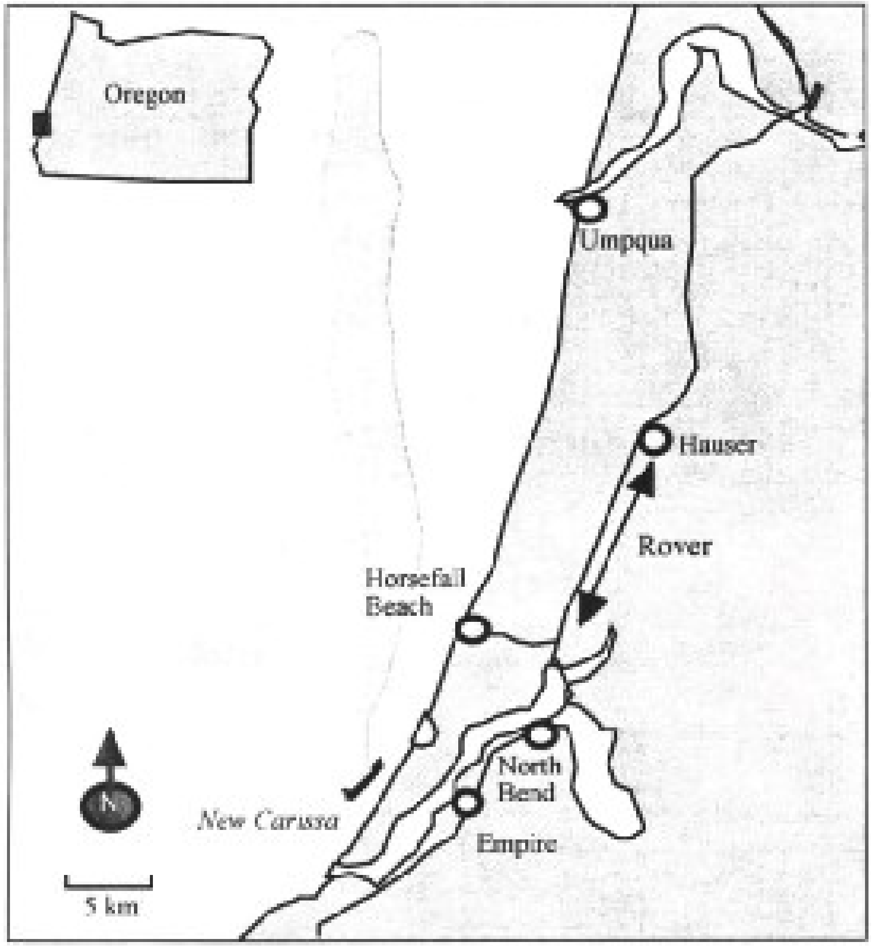


Figure A-25. Five SMART Tier I monitoring locations on 11 February 1999 (Barnea, Holloway, Kim, & Orme, 2001)

A.5.3 M/V *New Carissa*, 1999: Measurement Techniques

The LOC adopted for this operation was 150 µg/m3 of particulates smaller than 10 micrometers in diameter (PM-10) averaged over a 1-hour period. The Region 10 RRT (RRT 10), of which Oregon is a member, adopted this LOC value for in-situ burning operations.

A.5.4 M/V *New Carissa*, 1999: Equipment and Technology Used

The teams used DataRAM™, Personal DataRAM™, and Nephelometer instruments. These instruments work on the principle of light scattering, with the readings converted to weight of particulates in $\mu g/m^3$. The instruments were calibrated and/or zeroed before field use.

A.5.5 M/V *New Carissa*, 1999: Data Products

The SMART monitoring data were presented to the FOSC by the NOAA Scientific Support Coordinator during scheduled incident briefings. (NOAA, 1999)

A.5.6 M/V *New Carissa*, 1999: Data Processing and Analysis Practices

NOAA and the USCG reviewed the reported data and briefed representatives of the Unified Command and local health officials. The digital and manually recorded data were collected and archived by the Unified Command Documentation Unit. Monitoring operations were closely coordinated with the State of Oregon and local public health officials, who provided full support and assistance.

A.5.7 M/V *New Carissa*, 1999: Data Transmission

Monitoring teams were instructed to immediately notify the Group Supervisor at the Command Post when readings were above the level of concern and/or when three consecutive recorded readings were above background. Communication between the field teams and Command was conducted via radios and cell phones.

A.5.8 M/V *New Carissa*, 1999: Data Product Turnaround Times

Had there been any readings above the LOC, they would have been reported immediately to the SSC, however there were no such readings. The day's monitoring data were available for the evening FOSC briefing.

A.5.9 M/V *New Carissa*, 1999: Level of Satisfaction with the Data Product

The NOAA SSC commented that "The SMART real-time monitoring played an important role. In addition to providing the Unified Command with real-time input on particulate concentrations in the field, it provided public health officials with the data they needed to either advise the population of protective measures, or assure the public (and the media) that all was well, that exposure was monitored and did not occur, as was the case." (Barnea et al., 2001)

APPENDIX B. GAP ANALYSIS OF SMART, TECHNOLOGY, METHODS, AND OUTCOMES 2014

B.1 Deepwater Horizon, 2010 (Dispersant Operations) (Primary Attention)

B.1.1 Deepwater Horizon, 2010 (Dispersant Operations): Level of Effort (Number of Personnel and Number and Timing of Sorties)

Though few of the personnel participating in Deepwater Horizon (DWH) Special Monitoring of Applied Response Technologies (SMART) dispersant monitoring operations had previous SMART response experience, most had been trained in SMART procedures prior to the DWH response. The few team members without formal SMART training were quickly brought up to speed by those team members with more training and experience (Parscal, 2011). Of the 80 personnel associated with SMART operations, not all were participating simultaneously. Due to the protracted nature of the response, very few SMART team members served continuously for the duration of the response. The rotation of personnel in and out of SMART operations caused some discontinuity within the operation. (Parscal, 2011)

The coordination of SMART assets and dispersant aircraft proved to be an immense challenge during the early portion of the response. Since the oil was being released at a depth of 5,000 feet, shifts in ocean currents changed the location of its surface expression (i.e., where the oil broke the surface), sometimes by as much as two to three miles. This movement of the oil greatly increased the area in which dispersant aircraft, and consequently SMART teams, had to operate. The dynamics of this “moving target,” combined with the nearly four-hour boat transit time to get the SMART Tier II/III teams on scene, sometimes meant there would not be any oil in the area by the time the teams arrived. (Levine, Mearns, Shigenaka, Miles, Bejarano, Magdasy, & Bond, 2012)

- **Tier I:**
  - SMART Tier I observations were conducted by United States Coast Guard (USCG) National Strike Force (NSF) personnel from helicopters in close coordination with spray aircraft. Due to the demands of such a large-scale response, there was initially a shortage of trained SMART Tier I personnel available. This necessitated the development of on-the-job training for Tier I responders. The National Oceanic and Atmospheric Administration(NOAA) Dispersant Application Observer Job Aid was the starting point for on-the-job training and established a standardization of Tier I reports and documentation. Later in the response, this job aid was supplemented by a DWH response-specific Mississippi Canyon 252 (MC252) Job Aid, training meetings, and ongoing discussions among SMART observers, spotters, NOAA Scientific Site Coordinator (SSC), and experienced Tier I field personnel. (BenKinney, Parscal, Huber, Wood, Russel, Nevin, & Gass, 2011b)
  - Of the 74 aerial observation missions flown, 13 were made with no dispersant observations. There were several reasons for this - sometimes the observation aircraft were unable to locate the dispersant spray platforms, and other times, logistical and operational constraints led to mission reassignments. (Levine, Mearns, Shigenaka, Miles, Bejarano, Magdasy, & Bond, 2012)
  - Close coordination of SMART Tier I aircraft and aerial dispersant spray aircraft and spray spotters was complicated by the fuel limitations and slower flying speed of the SMART helicopters, compared to the fixed wing spray aircraft. Occasionally, the timing of spraying activities had to be delayed to enable the SMART aircraft to get into position and make observations prior to dispersant application. The coordination of SMART Tier I aircraft and aerial dispersant spray

aircraft was made more difficult by the fact they were operating from different airports. The DWH Aerial Dispersant Group Leader noted that the SMART Tier I teams would have benefited from attending the pre-flight briefings for the spray teams. (C. Huber, email) (Hunt, 2012)

- **Tier II/III:**
    - The SMART Tier II/III field teams were made up of personnel from USCG NSF and Oil Spill Response Limited (OSRL). For the most part, the field personnel worked well together, and the OSRL personnel adopted the USCG NSF operational procedures. However, at the supervisory level, there was occasionally some confusion as to who was directing the OSRL field activities. The OSRL field teams sometimes received conflicting instructions from the OSRL Supervisors and USCG NSF Monitoring Group Leaders.
    - Coordinating SMART Tier II/III on-water operations with aerial spray operations was quite challenging. The relative slow speed of the SMART vessels (cruising speed of approximately 20 knots) compared to the speed of the spray aircraft (120 knots +) meant that the Tier II/III teams sometimes could not reach the spray site before the end of spray operations. Since SMART relies on information collected before and after dispersant application, arriving on scene after spray operations ended diminished the value of the Tier II/III data. (Parscal, 2011; Gass, Albert, Huber, Landrum, & Rosenberg, 2011)
    - The lack of a dedicated SMART spotting aircraft added to the challenge of coordinating SMART Tier II/III on-water operations with spray operations. A SMART spotter aircraft can guide the Tier II/III teams to the area of interest before spray operations and help them return to the same sampling location after dispersant application. Without aerial spotter assistance, the Tier II/III teams found locating the sampling site after spray operations quite difficult. This was made more difficult after a two-mile safety stand-off was established. This meant the Tier II/III teams had to be at least two miles away from the sample location during spray operations. Without aerial guidance, the teams found it quite difficult to return to the sample site and locate the dispersant application area after the spray aircraft departed. (Parscal, 2011)

B.1.2 Deepwater Horizon, 2010 (Dispersant Operations): Measurement Techniques

- **Tier I:**
    - For Tier I operations, the teams closely followed the procedures outlined in the SMART Protocol. These procedures were augmented with the use of customized forms such as the Dispersant Application Observation Reporting Form, SMART Tier I Photograph Log, and SMART Incident Command System (ICS) 214 Form. The Dispersant Application Observation Reporting Form is notable in that it includes a standard dispersant effectiveness ranking system that provided standard reporting criteria for the Tier I personnel.

[redacted]

Figure B-1. Example of a dispersant application observation reporting form.

- **Tier II/III:**
  - The Tier II/III teams made every effort to follow procedures outlined in the SMART Protocol, but due to the extraordinary scale of the DWH event, several challenges became evident early on, including:
  - The lack of dedicated SMART spotting capability. A trained SMART aerial spotter can coordinate a SMART mission and guide the air and surface assets to the proper location in the proper sequence. The DWH SMART teams suffered from a lack of dedicated SMART spotting throughout the course of the SMART operations.
  - The enormity of the area of operations (over 12,000 sq. mi.).
  - The difficulty of coordinating SMART operations with multiple spray aircraft.
  - The lack of communication capability between the SMART vessels and aircraft, both spray and spray spotting.
  - The challenges of deploying instrumentation and retrieving water samples from a depth of 10 m.

B.1.3 Deepwater Horizon, 2010 (Dispersant Operations): Equipment and Technology Used

Complicating all SMART operations was the fact that the aircraft and marine vessels used completely different radio systems. To retrofit aircraft with marine band radios would have been a complex and expensive proposition due to Federal Aviation Administration (FAA) regulations, and hand held aircraft band radios for use on vessels have limited power and range. Communications between vessels and aircraft was a consistent problem throughout the event. (Hunt, 2012; Levine, Stout, Parscal, Walker, & Bond, 2011)

The two 100ft+ vessels (OSV *International Peace* and OSV *Warrior*) used for Tier II/III offshore operations were well suited for the large area of operation. They provided ample deck space for instrument deployment, comfortable accommodations for the crew during the long transit times, and the 20+ kt cruising speed was an asset, considering the large area of operation. These vessels were not well suited, however, for slow speed operations. Deployment of the SMART instrumentation at a depth 10 m requires a towing speed of less than 2 kts. Both the OSV *International Peace* and OSV *Warrior* struggled to maintain a speed of less than 2 kts, making it very difficult to deploy the fluorometers at a 10 m depth.

- **Tier I:**
  - For Tier I operations, close coordination between the SMART team members and aircraft pilots during flight operations are essential. Because some aircraft utilized by the Tier I teams did not have intercom headsets for the team members, and background noise in the helicopter made verbal communication difficult, coordination between the team members and pilots sometimes proved difficult. (Levine et al., 2012)
  - Air-to-surface and air-to-staging base communications are always necessary for SMART coordination. Although handheld marine Very High Frequency (VHF) radios were provided to the Tier I teams later in the response, they detract from overall flight effectiveness and safety. There is a need for a marine band radio to be built into spotter aircraft. (Gass, Albert, Huber, Landrum, & Rosenberg, 2011)
  - Because the Tier I helicopters had less speed and endurance than the spray aircraft, it was difficult for the Tier I teams to rendezvous with the spray aircraft in a timely manner, and stay on scene during and after spray operations (BenKinney et al., 2011b; Gass et al., 2011). This sometimes delayed spray operations, as the spray teams had to wait for the SMART team to arrive on scene.
  - The Tier I teams began the response with standard digital cameras and hand-held Global Positioning System (GPS) units, but later in the response they acquired high-resolution digital cameras with built in GPS capability. These cameras automatically added location information to each photo, which reduced the workload of the field teams and greatly enhanced the value of the photographs. (Levine et al., 2012)
  -
- **Tier II:**
  - For SMART Tier II operations (fluorometry and water sampling at 1 m) the USCG NSF teams utilized Turner Designs C3™ fluorometers fitted with crude oil optics. The instruments were mounted in towable bodies, which allowed the instrument to be towed through the water in a horizontal orientation. The fluorometers fed data through a hard-wired cable to a Panasonic CF-30 laptop computer with an internal GPS receiver. The fluorometry and GPS data were displayed and logged by a suite of software specifically configured for SMART operations.
  - The C3™ fluorometer held up well during the response. Of the six fluorometers deployed during the response, two were damaged during on-board operations but were quickly repaired by the manufacturer and put back in service. (Parscal, 2011). Overall, the C3™ fluorometer performed well. (USCG, 2011)
  - The towable body for the fluorometer was able to maintain the instrument at a consistent 1 m depth up to a towing speed of about 4 kts. At higher speeds, the water resistance increased drag to the point that maintaining a consistent instrument depth became difficult. Close coordination between the SMART team and the vessel Captain was required to maintain a slow towing speed and consistent 1 m instrument depth.

  - For SMART tier II Operations the OSRL teams utilized Turner Designs Self-Contained Underwater Fluorescence Apparatus (SCUFA) fluorometers fitted with crude oil optics. The SCUFA is an earlier generation fluorometer that proved reliable, but the lack of a towable housing or the ability to record instrument depth made the SCUFA a less effective instrument than the C3™ fluorometer. The OSRL teams utilized the same type of computers and data logging software as the USCG NSF teams.
  - The SMART data logging software proved adequate for the mission. Occasionally, the teams experienced a software issue during the start-up procedures but a restart of the computer usually solved the problem. The software did a fine job of combining the fluorometry, instrument depth, and GPS information into a single database.
  - The Panasonic CF-30 laptop computer proved to be a suitable computer for SMART field operations, and none of the teams experienced any hardware failures with their computers.
  - The 1 m water samples were collected in sample bottles by use of an off-the-shelf pole-mounted water sampler or equivalent. This method proved suitable for the 1 m water sampling.
- **Tier III:**
  - For SMART Tier III operations the teams used the same fluorometers as for Tier II operations but they were deployed at two different depths. If two instruments were available to the team, they were deployed at two different depths simultaneously. Otherwise, a single instrument was deployed at one depth for the first transect and at a second depth for a second transect. Because SMART attempts to compare the fluorometry readings from two separate depths, two fluorometers operating simultaneously at two different depths is the preferred method, thus, two complete fluorometer kits per team is preferable.
  - The Incident Command staff initially requested Tier III fluorometry and water sampling data from 1 m and 10 m depths. Early on, the USCG NSF team encountered difficulty deploying the fluorometer and collecting water samples at 10 m so they revised their procedures and collected Tier III fluorometry and water samples from 1 m and 5 m. Even at a sampling depth of 5 m the teams struggled to maintain a consistent instrument depth while towing the fluorometer. This was mainly the result of excessive vessel speed. The vessels used by the Tier II/III teams were designed for high speed operation and thus, not well suited for the 1 - 2 kt towing speed necessary to maintain consistent instrument depth.
  - Collecting water samples from 5 m water depth also proved challenging for the teams. The 5 m sample depth was beyond the reach of the off-the-shelf (or improvised) pole samplers, so the NSF teams devised a couple of different water samplers that utilized small pumps. For the most part these pumps worked well, but they had the disadvantage of moving different samples through the same hose, which could cause cross-contamination.
  - The OSRL team adhered to the 1 m and 10 m sampling depth that was requested by Command throughout the response. Because the SCUFA fluorometer used by the OSRL team did not record instrument depth, it is unknown if the team was able to consistently maintain a 10 m instrument depth.
  - The OSRL team utilized GO-FLO sample bottles to retrieve water samples from the 10 m water depth. These bottles are designed to retrieve samples from 10 m water depth and deeper, and all indications are the bottles performed well. The bottles were thoroughly cleaned between samples to avoid cross-contamination.
  - The different Tier III sampling depths (1 m & 5 m vs. 1 m & 10 m) between the teams caused some confusion in the final data product.

- **Tier III+:**
  - The Tier III+ team expanded the Tier III procedures by utilizing a Laser In-Situ Scattering and Transmissometry (LISST) instrument. The LISST instrument is a multi-parameter system for in-situ measurement of particle size, distribution, and volume concentration of particles suspended in the water column. For Tier III+ operations, the LISST was used to measure the size, distribution and amount of oil droplets in the water column before and after dispersant application. The LISST was not housed in a towable body, so all readings were taken with the vessel stationary. The ability to tow the LISST along with the fluorometer would have been an advantage.

B.1.4 Deepwater Horizon, 2010 (Dispersant Operations): Data Processing and Analysis Practices

Data processing was another formidable challenge for the Dispersant Monitoring Group. The 2006 SMART Protocol provides little information on how SMART data should be processed and presented. Data collection, handling, processing, and interpretation evolved through the course of the DWH response. After weeks of data flooded the command post, the SMART Data Processing Team was able to get the data into a more usable format. The methodology to archive and retrieve the data was also very cumbersome and evolved during the response. For future SMART operations, better data processing, analysis, and archival methodologies need to be implemented and institutionalized. (Levine et al., 2012)

It is important to note that the Deepwater Horizon dispersant operations were of an extraordinary scale and duration. As dispersant use became more visible (and controversial) during the course of the response, the Federal On-Scene Coordinator (FOSC) requested SMART data products that could be distributed to a broader audience. Thus, the SMART data processing and data analysis team had to create a data product that provided the NOAA SSC with the technical information needed to make an informed recommendation to Command, as well as a more generalized data product suitable for a broader, less technical audience. The SMART data poster (described in Section B.1.6) grew out of this need.

- **Tier I:**
  - The Tier I data consisted primarily of an Operations Log, Photo Log, and a set of photographs. Once the data arrived at Incident Command Post (ICP) Houma it was reviewed by the Environmental Unit for accuracy and completeness then converted to a Keyhole Markup Language (KML) or KML Zip archive (KMZ) format by the NOAA data team. The KML and KMZ files were then uploaded to the Environmental Protection Agency On-Scene Coordinator (EPAOSC) web server and web based NOAA Environmental Response Management Application® (ERMA) situation map, both of which were available to the NOAA SSC and FOSC.
- **Tier II/III:**
  - Early in the DWH response, the SMART Tier II/III field team members performed basic data processing in the field. During this early phase of the response there was an USCG NSF member on the field team with exceptional data processing skills. This individual was able to generate valuable dispersant monitoring data that was of use to the NOAA SSC without further processing at ICP Houma. Although this got the SMART teams off to a good start, it was not a sustainable situation. It is not reasonable to expect this level of data processing skill from the field teams, and without the data processing "ringer," field processing added several hours to the already overtaxed workday for the field teams. The Monitoring Group quickly identified the need for a dedicated SMART data processing team at ICP Houma to relieve the field teams of the data processing burden and provide a level of constancy to the process.

- Adding to the challenge of setting up a SMART processing team was the fact that the number of SMART field teams increased from one to three. This meant that data from three separate field teams needed to be processed simultaneously. In order to facilitate the processing of this large amount of data, a standardized SMART field-reporting guide was developed. This guide provided the field teams with a standardized format for packaging and transmitting their field data. Although writing the field reports and formatting the SMART data added to the field team's workload, it eliminated a tremendous amount of confusion on the processing end. The standardized data package, along with the use of the EPAOSC website, greatly improved the SMART data management.
- The SMART data processing team initially consisted of two NOAA contracted Geographic Information System (GIS) experts working closely with the SMART Technical Specialist (TS) and an OSRL SMART team member, but because the NOAA contractors were not available to work with the Monitoring Group full time, it was a struggle to keep pace with the processing demands of three SMART field teams. Later, the NOAA GIS experts were replaced by two GIS experts from the EPA who were available on a full time basis. This allowed the processing team to keep up with the incoming data. When SMART field operations were scaled back to one Tier II/III field team later in the response, the processing team was reduced to one GIS expert and the SMART Technical Specialist. This proved to be an ideal combination. The GIS expert provided geospatial support while the SMART TS performed the fluorometry data processing and overall data analysis.
- Following collection, the Tier II/III water samples were sent to a contracted lab where they were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX); saturated hydrocarbons; polycyclic aromatic hydrocarbons (PAHs); petroleum biomarkers (steranes, triterpanes), and the dispersant indicator dipropylene glycol n-butyl ether (DPnB). Toxicity studies were conducted on undiluted samples using the estuarine inland silversides fish (Menidia beryllina), planktonic mysid shrimp (Neomysis americana), and marine diatom (Skeletonema costatum) following standard test procedures. (BenKinney et al., 2011a)
- The methodology for collecting samples left unknown concentrations at intermediate depths between 1 and 10 meters. Since discrete water samples were only taken at 1 and 10 meters (or 1 and 5 meters, depending on the sampling team) below the surface there were no analytical results for the water column outside those sample depths. (Levine et al., 2012)
- Due to the enormous amount of oil in the water column and sea surface, the variability of "background" sample concentrations, both from fluorometry and chemical analysis, varied greatly. In addition, due to the frequency of applications and the wide spatial area they covered, it was difficult to know if locations for background samples were actually in areas where no dispersants had been applied, or if they had been applied the day before or the day before that, or where oil had naturally dispersed. Depending on where and when samples were taken, the background levels could be as high as areas where the dispersant were being applied (Levine et al., 2012). Due to these factors, the background fluorometry and water samples became less reliable as the DWH response continued.

- **Tier III+:**
  - Though the data from the LISST instrument was of interest to the research community, it was not included in the processing and evaluation of the SMART Tier II/III data, due to its infrequent use during SMART operations.

B.1.5 Deepwater Horizon, 2010 (Dispersant Operations): Data Transmission

Due to the magnitude of the DWH event, data transfer was a formidable challenge throughout the duration of SMART operations. With multiple SMART Teams operating over a large geographic area far from ICP Houma, data flow was one of the first challenges faced by the Dispersant Monitoring Group during the DWH response. The 2006 SMART Protocol provides a general guideline for data flow but does not address the specifics of efficiently moving data from the field to Incident Command in a timely manner. The SMART Protocol also suggests the field teams provide a near real-time report verbally to Command immediately after the data is collected. Due to the geographic scale of the DWH response, this proved quite challenging.

When technology was available, the Tier I teams phoned in a report when the helicopter landed on an offshore platform for refueling. Otherwise the teams delivered their report after the helicopter returned to base. The Tier II/III teams phoned in a report if the vessel's location and communications capability allowed. All SMART field teams would have benefited by having their own dedicated satellite telephone capability.

- **Tier I:**
  - Since SMART Tier I operations were based out of the same Command Center (ICP Houma) as the Dispersant Monitoring Group, the Tier I photos and reports could be hand delivered to the Group Leader after each mission. Later in the response, a limited access webserver was established where the teams could upload their data directly from the field after each mission. Although both methods worked well, the teams found that uploading data to the webserver was a quicker way to get information to the end users.
- **Tier II/III:**
  - Transmitting Tier II/III data from the field to the ICP Houma proved much more challenging (Hunt, 2012). The Tier II/III teams were based out of Venice, LA (a 2.5 hr. drive from ICP Houma), with the Tier II/III vessels operating as far as 80 miles from Venice (a 4 hr. one-way transit). The SMART vessels would depart Venice in the morning and return late in the evening with the day's data. These data were then handed over to the USCG Field Response Coordinator in Venice who emailed it up the USCG chain of Command and ultimately to the NOAA SSC. With the SMART data passing through several sets of hands between the field and ICP Houma, delays in the data flow developed as everyone's workload increased. After several unsuccessful attempts to streamline the SMART data email procedures, the EPA offered their EPAOSC website as a repository and clearinghouse for the DWH SMART data. With this, the SMART field teams could upload their data to the web site where it would be available to Incident Command immediately. This proved quite effective and was utilized for the remainder of the response.
  - A standardized Tier II/III data format was established during the DWH response. This standardized format streamlined the data transmission process and reduced the need for the data processing team to request clarifications from the field teams.

B.1.6 Deepwater Horizon, 2010 (Dispersant Operations): Data Products

- **Tier I:**
  - The final Tier I data were delivered in a KML or KMZ format and was available on the web based NOAA ERMA situation map. The individual photos were geo-reference on the map and each photo was annotated with Observer comments and other pertinent information. This made for an effective presentation of the Tier I, data, but it was not fully implemented until later in the response.

- **Tier II/III:**
    - How best to present the results of the SMART Tier II/III monitoring effort was another challenge faced early in the response and again, the 2006 SMART Protocol provided little guidance. After consulting with the NOAA SSCs and other end-users, the processing team developed a one-page poster format that summarized the SMART Tier II/III monitoring results. The poster was accompanied by a more detailed written evaluation of the Tier II/III data. The challenge was to present adequate dispersant monitoring information without overwhelming the decision makers who may have a limited knowledge of the SMART process. It is notable that the chemical and toxicity analysis of the water samples taken in conjunction with Tier II/III operations were not available in a timely manner and were not included in the Tier II/III poster.

B.1.7 Deepwater Horizon, 2010 (Dispersant Operations): Data Product Turnaround Times

- **Tier I:**
    - Tier I verbal reports were relayed to command when communications were available and Command requested a preliminary verbal report.
    - The final SMART Tier I data product was generally posted to the situation map (ERMA) and available to the SSC 24 hours after the field data arrived at ICP Houma.
- **Tier II/III:**
    - Preliminary Tier II/III verbal reports were delivered to Command when requested and the technology on the vessels allowed for telephone communication.
    - The SMART Tier II/III poster was generally delivered to the SSC within 24 hours of the field data arriving at ICP Houma.
    - The water chemistry analysis (Total Petroleum Hydrocarbon and Total Polycyclic Aromatic Hydrocarbon), and the toxicity analyses for water samples taken in conjunction with Tier II/III operations required post-action lead times and were not available to Command during dispersant operations. The Tier II/III water sample analyses were generally available within 2-7 days, depending on the backlog.

B.1.8 Deepwater Horizon, 2010 (Dispersant Operations): Level of Satisfaction with the Data Product

The SMART monitoring was able to determine the effectiveness of dispersant operations during the DWH response (Levine et al., 2012). SMART was able to provide monitoring data and oversight of the dispersant operations. Likening the Tier I and Tier II/III monitoring to the patrolman behind the billboard, the USCG SMART teams helped keep everyone honest and the application crafts (vessels and planes) within the boundaries agreed upon. SMART was not able to correlate between "effectiveness" and other factors such as oil weathering and field conditions during dispersal application. (Levine et al., 2012)

- **Tier I:**
    - The NOAA SSC involved in the DWH SMART dispersant monitoring operations was satisfied with the SMART Tier I data product and felt that it provided the necessary information to help make an informed recommendation to the FOSC (E. Levine, interview, 3 February 2014).
- **Tier II/III:**
    - The Tier II/III data product evolved during the course of the DWH response. The product for the initial Tier II/III efforts consisted of a Unit Log (ICS FORM 214-CG), Photo Log, photos, raw fluorometry/GPS data files and an Excel graph illustrating the fluorometry data. The early data

product initially satisfied the needs of Command, but as interest in the SMART data increased, a more sophisticated product with more information and analysis was requested. This led to a more comprehensive "poster" style presentation which was accompanied by a detailed written evaluation.
    - The SMART Tier II/III poster and associated written evaluation that evolved over the course of the DWH event was well received and seemed to satisfy the needs of the SSC and Command Staff (E. Levine, interview, 3 February 2014).
    - Due to the nature of the water sampling from a vessel, not all sites were sampled to the exact specifications of the protocols. This may explain why there is little or no correlation between the in-situ fluorometry and laboratory chemical testing data results. (Levine et al., 2012)
    - Due to the long lead times associated with the water sample analysis, the results were not incorporated into the Tier II/III data product. Thus, the water chemistry analysis was not considered by the SSC when evaluating the effectiveness of a dispersant application. (E. Levine, interview, 3 February 2014)

B.2 Deepwater Horizon, 2010 (In-Situ Burning) (Primary Attention)

B.2.1 Deepwater Horizon, 2010 (In-Situ Burning): Level of Effort (Number of Personnel and Number and Timing of Sorties)

Overall, there is little evidence of coordination between the NSF and EPA in-situ burn air monitoring efforts. This may be due to the fact that SMART air monitoring was suspended after a single test burn and no further air monitoring was requested of the NSF. Throughout the DWH response, the EPA continued to monitor for Particulate Matter (PM10) levels at various sites, and all indications are that any elevated PM10 readings would have been reported to the EPAOSC, who would in turn inform the FOSC. In the absence of any elevated PM10 readings, the EPA air monitoring data were posted to the NOAA ERMA situation map which was available to all Command personnel. A NOAA SSC involved in the in-situ burn operations noted that he did not routinely look at the EPA air monitoring data that was posted the ERMA situation map.

The BP Deepwater Horizon Oil Spill Incident Specific Preparedness Review (USCG, 2011) recommends: "the Coast Guard should engage EPA regarding the air-monitoring protocols for ISB. As necessary, these protocols should be re-evaluated based on the empirical evidence from the Deepwater Horizon incident and additional air quality studies conducted to ensure the level of monitoring is consistent with the risk posed by ISB, particularly in offshore areas." (USCG, 2011)

- **NSF:**
    - Both the NOAA SSC and NSF field personnel agreed that the air monitoring field team was adequately staffed and equipped for the scope of the mission.
- **EPA:**
    - According to the BP Deepwater Horizon Oil Spill Incident Specific Preparedness Review (USCG, 2011) the EPA ISB "Monitoring of air emissions exceeded what was necessary to establish safe air quality levels for exposed shoreline populations, which increased the complexity of the response by increasing the risks posed by additional response operations." (USCG, 2011)

B.2.2 Deepwater Horizon, 2010 (In-Situ Burning): Measurement Techniques

- **NSF:**
  - The NSF team closely followed the air monitoring procedures as prescribed by the SMART Protocol and the NOAA SSC felt the techniques were adequate for the mission.
- **EPA:**
  - Although the EPA air monitoring effort utilized many different instruments, techniques, and platforms, and targeted many different compounds, only a small part of that effort was consistent with the air monitoring prescribed by the SMART Protocol. This included the monitoring of particulate matter (PM10) that could come from the controlled burns of the oil. Though not specifically providing SMART air monitoring, the EPA provided air quality monitoring similar to SMART but in accordance with the EPA's own prescribed procedures.

B.2.3 Deepwater Horizon, 2010 (In-Situ Burning): Equipment and Technology Used

- **NSF:**
  - The NSF field teams reported no issues with the DataRAM air monitoring instruments and had no issues with the communication capabilities at the monitoring location.
- **EPA:**
  - The EPA utilized DataRAM Particulate Monitors for the PM10 component of their overall air monitoring effort.

B.2.4 Deepwater Horizon, 2010 (In-Situ Burning): Data Processing and Analysis Practices

The NSF air monitoring team was instructed to notify the SSC immediately upon observing PM10 readings over the Level of Concern (LOC). The SSC did not request any data processing or analysis beyond the verbal report. This may be due to the fact that no elevated readings were observed by the field team.

B.2.5 Deepwater Horizon, 2010 (In-Situ Burning): Data Transmission

The NSF field team had telephone communications with ICP Houma. The team did not attempt to transmit any data, but had no issues maintaining verbal communications with Command.

B.2.6 Deepwater Horizon, 2010 (In-Situ Burning): Data Products

The NOAA SSC did not request any data product other than the immediate notification of any PM10 readings above the LOC at the monitoring site. Again, this may be due to the fact that no elevated PM10 readings were observed.

B.2.7 Deepwater Horizon, 2010 (In-Situ Burning): Data Product Turnaround Times

The NSF air monitoring team was instructed to notify the SSC immediately upon observing PM10 reading over the LOC. This level was not reached.

B.2.8 Deepwater Horizon, 2010 (In-Situ Burning): Level of Satisfaction with the Data Product

- **NSF:**

  - The NOAA SSC involved in the DWH SMART in-situ burn monitoring operations was satisfied with the performance of the monitoring team and was confident that no detectable level of smoke particulates reached the monitoring location (E. Levine, interview, 3 February 2014). Since immediate notification was the mission objective, the SSC felt the objectives were met.
- **EPA**
  - Though the EPA air monitoring data were posted to the ERMA situation map (later in the response) and available to the NOAA SSC, the SSC noted that he did not utilize the data.

B.3 T/V Krymsk Oil Spill, 2009 (Dispersant)

B.3.1 T/V *Krymsk* Oil Spill, 2009: Level of Effort (Number of Personnel and Number and Timing of Sorties)

Early notification by MSU Galveston and the availability of Coast Guard Aviation Training Center Mobile aircraft enabled the GST team to meet the aggressive dispersant application timeline and be on scene for the first dispersant flight. Three GST members were mobilized in support of this response. This may not have been sufficient personnel had both Tier I and Tier II/III been deployed simultaneously.

B.3.2 T/V *Krymsk* Oil Spill, 2009: Measurement Techniques

All indications are that the Tier I teams adhered to the standard SMART Tier I procedures.

B.3.3 T/V *Krymsk* Oil Spill, 2009: Equipment and Technology Used

Tier I team members shared a King Air aircraft with the spray spotting personnel. The twin engine King Air was considered a safer air platform for the SMART team, considering the distance off shore for the area of operation. (C. Henry, interview, 18 February 2014)

The quality of the Tier I photos indicate that the digital camera used was sufficient for the mission.

The reports do not indicate what communication technology was available to the Tier I team, but one team member mentioned that the communication capability was insufficient. The NOAA SSC recalled that the Tier I team was not able to deliver a report until after the aircraft landed.

B.3.4 T/V *Krymsk* Oil Spill, 2009: Data Processing and Analysis Practices

The Tier I data most likely included an Operations Log and photos, neither of which would require post-acquisition processing.

B.3.5 T/V *Krymsk* Oil Spill, 2009: Data Transmission

Communication between the SMART field team and Unified Command proved challenging due to inadequate communications equipment.

B.3.6 T/V *Krymsk* Oil Spill, 2009: Data Products

The NOAA SSC commented that the Tier I photos were not labeled with date, time, and location information.

B.3.7 T/V *Krymsk* Oil Spill, 2009: Data Product Turnaround Times

The reports suggest the Tier I photos and logs were delivered to the UC shortly after each flight.

B.3.8 T/V *Krymsk* Oil Spill, 2009: Level of Satisfaction with the Data Product

The NOAA SSC was satisfied with the SMART data from this response and confirmed that the Tier I data were adequate to make an informed recommendation to the FOSC.

B.4 Eugene Island Pipeline Spill, 2009 (Dispersant)

Very little information exists concerning the SMART deployment for the Eugene Island Pipeline Spill. The NSF provided a Gulf Strike Team Incident Summary Message that gives a basic timeline for NSF participation but provides no specifics on the procedures and technologies utilized. The NOAA SSC was also unable to provide many operational details.

B.4.1 Eugene Island Pipeline Spill, 2009: Level of Effort (Number of Personnel and Number and Timing of Sorties)

NSF personnel provided Tier I support for all dispersant spray sorties.

NSF personnel were unable to perform Tier II/III despite being requested by the FOSC.

B.4.2 Eugene Island Pipeline Spill, 2009: Measurement Techniques

All indications are that the Tier I teams operated as prescribed by the SMART Protocol.

B.4.3 Eugene Island Pipeline Spill, 2009: Equipment and Technology Used

The NOAA SSC recalled that the Tier I team shared a King Air aircraft with the spray spotting team. This was done mainly for safety reasons, a twin engine fixed wing aircraft was deemed safer than a helicopter given the distance off shore. The SSC also mentioned that Command wanted to minimize the number of aircraft in the area of dispersant operations.

The King Air aircraft lacked the communications capability to allow the Tier I team to contact Command from the air. The Tier I reporting did not take place until after the flight returned. (C. Henry, interview, 18 February 2014)

B.4.4 Eugene Island Pipeline Spill, 2009: Data Processing and Analysis Practices

The NOAA SSC recalled that Tier I photos, documentation, and verbal reports required no data processing or additional analysis.

B.4.5 Eugene Island Pipeline Spill, 2009: Data Transmission

The Tier I team lacked the capability to transmit photos or verbal reports from the aircraft. Thus, all reporting was delayed until the end of the flight.

B.4.6 Eugene Island Pipeline Spill, 2009: Data Products

The NOAA SSC recalled that the Tier I photos and verbal reports provided adequate information to support an informed recommendation.

B.4.7 Eugene Island Pipeline Spill, 2009: Data Product Turnaround Times

The NOAA SSC noted that the FOSC would have benefited from real time verbal reports from the Tier I team, but the capability was not available. As it was, the data were available shortly after the flight ended, and the delay was not a serious issue.

B.4.8 Eugene Island Pipeline Spill, 2009: Level of Satisfaction with the Data Product

The NOAA SSC was satisfied with the SMART data from this response and confirmed that the Tier I data were adequate to make an informed recommendation to the FOSC. He also noted that the failure to mobilize Tier II/III monitoring was not a set-back. The Tier I data were adequate to support the operational decisions.

B.5 M/V *New Carissa*, 1999 (Atmospheric Monitoring)

Although there is a fair amount of published information concerning the M/V *New Carissa* response, information specific to SMART air monitoring for that incident is somewhat scarce. The bulk of the information we obtained for this analysis came from three sources: a NOAA Office of Response and Restoration (ORR) fact sheet (NOAA, 2006), a USCG FOSC's Report (USCG, 1999), and a published case study by Nir Barnea (Barnea et al., 2001). We were unable to locate any USCG After Action Reports or Operation Logs associated with the M/V *New Carissa* SMART air monitoring effort.

B.5.1 M/V *New Carissa*, 1999: Level of Effort (Number of Personnel and Number and Timing of Sorties)

Early notification is key to timely monitoring. The first monitoring team arrived on scene at 1400 on 10 February 1999, in time to deploy for the first burning attempt. Rapid notification for monitoring should be given in future burns.

B.5.2 M/V *New Carissa*, 1999: Measurement Techniques

All indications are that the measurement techniques as prescribed by the SMART Protocol worked well and contributed to a successful deployment.

B.5.3 M/V *New Carissa*, 1999: Equipment and Technology Used

All indications are that the air monitoring equipment (DataRAM, Personal DataRAM, and Nephelometer instruments) worked well and satisfied the mission requirements.

B.5.4 M/V *New Carissa*, 1999: Data Processing and Analysis Practices

No information on the SMART data processing and analysis was discovered for this response.

B.5.5 M/V *New Carissa*, 1999: Data Transmission

Communication was spotty at times. Radios did not always work due to distance and terrain. Cellular phones worked well, but not all teams had them.

B.5.6 M/V *New Carissa*, 1999: Data Products

We were unable to locate an example of the SMART data product produced by the *New Carissa* SMART teams nor did we find any mention of a SMART data product in the published reports. However, the FOSC's Report noted that the air monitoring data that was ultimately distributed to the local health agencies by Unified Command caused a certain amount of consternation and confusion in the local community (NOAA, 2006). Although disseminating air monitoring results to the local agencies is a Command level responsibility, all participants in SMART air monitoring operations should work towards clear and concise reporting.

B.5.7 M/V *New Carissa*, 1999: Data Product Turnaround Times

Despite the communications challenges, the NOAA SSC was briefed on the SMART air monitoring at the end of each operational period.

B.5.8 M/V *New Carissa*, 1999: Level of Satisfaction with the Data Product

Both the FOSC and NOAA SSCs appeared satisfied with the *New Carissa* monitoring effort and results. (Barnea et al., 2001)

While similar monitoring had been done before, this was the first monitoring under the SMART program. Both the concept and the execution worked well. (NOAA, 2006)

State and local public health officials were very interested in the monitoring results. Once informed of the monitoring plan, they cooperated closely and provided valuable assistance. Including them in the planning and providing them with timely results worked well. (NOAA, 2006)

The dissemination of conflicting information by State and local health agencies caused a certain amount of consternation and confusion in the local community. (USCG, 1999)

B.6 Performance Gaps Shared by Incidents or Circumstances

Communication is a persistent challenge faced by SMART field teams whether mobilized for dispersant monitoring or air monitoring activities.

- During the New Carissa response the air monitoring teams relied on VHF radios and cell phones for communication with Command. The radios had limited range, and were restricted by the local topography. Some of the team members did not have cell phones, and it is not known if there was adequate cellular coverage in the area. Team members are more likely to have cell phones today, but cellular coverage can still be spotty when working in remote locations.
- For the T/V Krymsk, Eugene Island, and DWH responses the Tier I teams did not have the ability to communicate with Command from the aircraft they were in. Many times the Tier I teams used aircraft of opportunity, with no assurance that these aircraft would have satellite phone or other long-

range communication capability. Some of the Tier I personnel involved in the DWH response noted that they were not provided with headsets and had difficulty communicating with their own pilot.
- The Tier II/III teams faced similar challenges when working from vessels of opportunity. Satellite phones are becoming more common on larger vessels, but can be expected to be rare on smaller vessels of opportunity. The Tier II/III team also needs to communicate with spotter and spray aircraft. Very few vessels of opportunity have Aviation VHF capability, and very few aircraft have Marine VHF capability. Communication between SMART vessels and aircraft is an ongoing challenge
- Transmitting digital data (photos, fluorometry, and documentation) is even more challenging than voice communication for all SMART operations. Internet connectivity in remote locations can be hard to find and satellite phone systems have limited bandwidth.
- SMART is designed to provide the FOSC with near real-time, scientifically based information. In order to meet this goal, SMART field teams in remote areas must be able to rapidly and reliably convey observations to the decision-makers in command centers. This remains a significant challenge today.

B.7 Performance Gap Trends

SMART has been deployed relatively few times since its inception so it is difficult to identify performance gap trends with so few examples. However, communication does stand out as a performance gap for every deployment. From the *New Carissa* response in 1999 to the DWH response of 2010, communication between the field teams and Command has been the most significant challenge, and SMART communication capability has improved little in those intervening years. The DWH SMART teams faced many of the same communication challenges as the SMART teams from the *New Carissa* response eleven years earlier.

B.8 Performance Gaps Associated with Atypical Oil Spill Events

As an original contributor to the SMART Protocol noted, SMART was designed to address what was considered to be a typical oil spill dispersant operation: small scale (thousands of gallons of oil), short duration (several days), and near-shore (within 10 miles). The August 2006 version of SMART (US Coast Guard, 2006) provides sufficient guidance to address dispersant efficacy and to answer the needs of the Unified Command for operational decision-making. The DWH incident however, stretched those capabilities beyond the bounds of imagination. It is doubtful that anyone involved with SMART prior to DWH imagined a dispersant operation involving 20 aircraft, lasting 90 days and covering an area of over 18,000 square miles.

The core mission of SMART, providing real-time, scientifically based information to Unified Command, remains the same regardless of the scale of the response. However, the 2010 DWH oil spill illuminated some of the challenges of deploying SMART in an atypical oil spill response environment. For the purpose of this report atypical response operations may include surface dispersant operations far offshore, surface dispersant operations of a long duration, and deep sub-sea dispersant injection.

Below are some performance gaps identified by organizations that either participated in the Deepwater Horizon SMART operations or utilized the data from those operations. Though these comments are specific to the DWH response, they suggest gaps in the current SMART program that may apply to other atypical oil spill events.

- The SMART teams initially fell short in providing the number of trained Tier I monitors required for the large scale spray operations. This situation improved as additional personnel were trained and put into service.
- Coordination between the SMART teams and the spray aircraft remained difficult throughout the response. This was partly due to the large number of vessels and aircraft involved in the response and the fact that few of the aircraft and vessels had compatible radio systems. (Parscal, 2011; Hunt, 2012)
- SMART was slow to expand into more scientifically sophisticated data collection methodologies as dispersant operations expanded. As dispersants became more visible (and controversial) during the DWH response the SMART teams struggled to provide the amount and type of monitoring information requested by Command. The SMART teams entered into the DWH response with the basic skills and equipment prescribed by the SMART Protocol (photography, fluorometry, water sampling etc.) but had to expand their operations to include the use of more advanced instrumentation (e.g., LISST) and more rigorous water sampling techniques. (Levine et al., 2012)
- The SMART teams were initially poorly equipped for the expanded water sampling methodologies requested by the FOSC. The teams were provided with suitable water sampling equipment later in the response but early on, the team's improvised equipment and methods did not meet the needs of the FOSC. (Parscal, 2011; Levine et al., 2012)
- The SMART teams did not initially have the data processing techniques and personnel in place to handle the amount of field data arriving at Incident Command. Later, as the informational needs of the FOSC expanded, the SMART teams struggled to develop a data product that satisfied those needs. (Parscal, 2011; Levine et al., 2012)
- Due to the large area of operation and the distance off shore communications between the SMART field teams and Incident Command proved quite challenging. The Tier I teams did not have the capability to communicate directly with IC Houma from the aircraft and the Tier II/III teams often times relied on the communications capabilities of the vessels they were operating from.
- The SMART teams had difficulty transmitting their field data to Incident Command in a timely manner. The lack of internet connectivity on the SMART aircraft and vessels prohibited the field teams from sending data directly from the field. Instead, the data was hand delivered to a Command Post or staging area where it could be emailed to the NOAA SSC. With the SMART data passing through several sets of hands between the field and IC, delays in the data flow developed as everyone's workload increased. (Levine et al., 2011; Hunt, 2012)
- The enormous operating area of the DWH dispersant operations continuously challenged the SMART teams. It was extremely difficult for the SMART vessels traveling at 20 kts to cover the distances required to successfully meet up with the spray aircraft traveling at 120+ kts. (Parscal, 2011; Gass et al., 2011)
- The SMART resources were insufficient to provide monitoring for the twelve dispersant application aircraft participating in spray operations. The SMART teams utilized three helicopters and two vessels to conduct 118 Tier I and/or Tier II/II sorties compared to the 412 spray application sorties. The teams quickly learned that they could not monitor every spray sortie and focused on the sorties that provided the highest likelihood of success. (Levin et al., 2012; Houma ICP Aerial Dispersant Group, 2010)
- The SMART teams were not equipped or trained for the task of monitoring the effectiveness of deep-sea dispersant injection.
- SMART procedures and methodologies were not sufficient to determine the effects of the dispersant and oil on marine life in the water column. (Levin et al., 2012)

- SMART was not able to correlate between “effectiveness” and other factors such as oil weathering and field conditions during dispersal application. (Levin et al., 2012)

Although the SMART Protocol does not discuss dispersant monitoring in ice conditions nor has SMART been mobilized to perform dispersant monitoring in ice conditions, the possibility of such a response exists. Some research has been done that can serve as a starting point as we consider how (and if) SMART methodologies can be modified to address this challenging environment. (Daling, Holumsnes, Rasmussen, Brandvik, & Leirvik, 2010; Sørstrøm, 2009)

The SMART Protocol notes that SMART is not limited to oil spills and that the protocol can be adapted to other hazardous substance responses. This implies that the equipment, methodologies, and expertise of the SMART teams may be of value in responses other than oil spills. One recent example is the USCG Pacific Strike Team’s involvement in the Sept. 2013 molasses spill in Honolulu, HI. In coordination with a NOAA SSC, the team deployed a Hydrolab DataSonde portable water lab equipped with a dissolved oxygen sensor. The premise was to identify any depletion of dissolved oxygen in Honolulu Harbor that could harm marine life. The operation lasted for “a day or so” and the NOAA SSC later reported that the data from the effort was of little value. (R. Yender, 9 April 2014)

APPENDIX C. SURVEY OF TECHNOLOGY AND METHODS TO ADDRESS SMART PERFORMANCE GAPS

C.1 Introduction

This Appendix proposes solutions that address the SMART performance gaps identified in Appendix B. To identify these solutions, the project team relied primarily on interviews with SMART stakeholders and web-based research. In addition, the project team attended the International Oil Spill Conference (IOSC) 2014 to meet with multiple vendors and discuss their offerings. The team also operated some equipment at field demonstrations. The result of these activities is the set of proposed solutions described here under four major categories: monitoring protocol, Coast Guard (CG) policies, personnel training, and technology.

C.2 Monitoring Protocol

The project team asked SMART stakeholders how well the 2006 SMART Protocol provides guidance for dispersant and in-situ burn (ISB) monitoring operations. The team discussed response operations currently considered by the SMART Protocol, as well as newer response operations that are not covered in the document. Monitoring topics discussed included:

- Tier I: Visual Observations.
- Tier II: On-Water Monitoring for Efficacy.
- Tier III: Additional Monitoring.
- Water parameter measurement.
- Water sampling.
- Deep Ocean Dispersant Injection Monitoring (not currently addressed by SMART).
- In-Situ-Burn Air Monitoring.
- Mobilizing Monitoring Resources.
- Using and Interpreting Monitoring Results.
- Information Flow and Data Handling.

Most SMART stakeholders agreed the current SMART Protocol is adequate in providing general guidance for monitoring a typical dispersant or ISB operation. They noted that the existing protocol was written to address the type of dispersant or ISB responses that were anticipated at that time - a response lasting on the order of a few days, covering a limited geographic area. All interviewees agreed that the 2010 Deepwater Horizon (DWH) dispersant monitoring requirements far exceeded the requirements that were provided in the SMART Protocol, and that such “atypical” response operations require more detailed guidance. Most stakeholders prefer an additional guidance document that addresses atypical response operations rather than expanding the scope of the current SMART Protocol. In addition, the National Response Team (NRT) finalized a document addressing atypical response prior to the beginning of this study. In that document, dispersant or ISB operations greater than 96 hours are considered atypical responses. When asked specifically about whether SMART should include guidance for monitoring sub-sea dispersant injection, most stakeholders agreed that such monitoring is beyond the technical capabilities of the existing SMART teams and beyond the scope of the SMART Protocol. Again, most stakeholders recommended a separate guidance document for this type of monitoring.

There is however, one element of SMART that might be applied to an atypical response. The Tier I (visual monitoring) techniques described by the SMART Protocol (Section C.3.3) may also be of value for monitoring the surface expression of oil during a sub-sea dispersant injection program. This is an area where the USCG SMART teams may be able to contribute to a sub-sea dispersant injection monitoring effort.

Most stakeholders indicated that beyond general guidance, the current SMART Protocol lacks the detailed operational instructions required by the participating agencies. The USCG SMART field teams noted a lack of direction for their specific SMART data collection procedures, and equipment, and NOAA data evaluation teams noted a lack of operational instructions for data processing and data evaluation techniques. Some stakeholders suggested bringing this type of detailed operational instruction into the protocol, while others cautioned that such detail requires unnecessarily frequent updates and modifications to the document as technology evolves. More detailed procedural instructions, such as stand-alone job aids or additional attachments to the protocol might address both points of view. Section C.3.3 includes a list of recommended instructions.

C.3 Coast Guard Policies

The project team interviewed United States Coast Guard (USCG) and National Oceanic and Atmospheric Administration (NOAA) personnel to identify changes or additions to existing policies that would minimize the SMART performance gaps. The team discovered policy gaps in three broad categories: SMART roles and responsibilities, SMART response timelines, and SMART monitoring procedures. Recommendations based on that information are presented below.

C.3.1 SMART Roles And Responsibilities

Conversations with both the SMART data collection group (USCG) and the SMART data end-user (NOAA) helped the project team establish some basic roles and responsibilities for the SMART process.

C.3.1.1 SMART Data Collection

The NOAA and USCG personnel concurred with their respective roles and the data collection requirements described below. NOAA will provide general SMART mission objectives. The Strike Teams will conduct the SMART field activities, and provide the personnel, equipment, and logistics necessary for SMART data collection during a typical dispersant or burn operation. If dispersant or ISB operations extend beyond 96 hours, the Strike Teams will turn over SMART data collection activities to contracted SMART Teams, and provide oversight for SMART field activities. Both USCG and contracted SMART teams will provide a standardized SMART data package, similar to the package developed during the 2010 DWH response. The SMART data package may be modified per the needs of the NOAA SSC, but in general the SMART teams should be prepared to provide the following data for dispersant monitoring operations:

- Descriptive photographs (from both aerial and on-water platforms).
- Photo Log.
- Fluorometry data (from both 1 meter and 5 meter depths).
- Fluorometer Operator's Log.
- Water parameter data (water temperature, conductivity, dissolved oxygen content, pH, and turbidity) versus depth, down to 10 meters.
- Water Parameter Sampling Log.
- Discrete water samples at depths down to 10 meters (collected and preserved in a manner appropriate for the level of analysis).
- Discrete Water Sampling Log and Chain of Custody (if required)

For ISB monitoring operations, NOAA requested immediate notification of particulate readings above the Level of Concern (LOC) followed up by a data package containing:

- Descriptive photographs.
- Photo Log.
- Air Monitor Operator's Log.
- Digital Air Monitoring data.

For both dispersant and in-situ burn monitoring operations the SMART data packages must be standardized and include all the information needed by the stakeholders. This will require the development of detailed operational guides.

C.3.1.2 SMART Data Processing and Evaluation

Discussions with NOAA personnel indicate that NOAA will take on the responsibility for SMART data processing and evaluation, and that NOAA has begun the process to put a SMART data processing program in place.

C.3.2 SMART Response Timelines

NOAA and USCG stakeholders agreed on the below as an acceptable SMART response timeline;

- ISB air monitoring is operational on Day 1 of burn operations.
- Tier I dispersant monitoring is operational on Day 1 of dispersant spray operations.
- Tier II/III dispersant monitoring builds in on Day 2 of dispersant spray operations.
- Contractors replace USCG monitoring teams after 96 hours of monitoring effort for both ISB and dispersant monitoring operations.
- USCG personnel continue to oversee contracted SMART data collection teams for as long as dispersant application operations occur.

C.3.3 SMART Monitoring Procedures

Stakeholders identified a lack of detailed operational guidance for the SMART data collection process. The 2006 SMART Protocol provides high level guidance on the overall SMART process along with some detailed operational instructions. However, USCG SMART teams indicated the need for more detailed information on the deployment, operation, and maintenance of the equipment and data collection techniques specific to USCG SMART operations. As an example, the Dispersant Water Sampling section of the SMART Protocol (Section 3.12) describes a sampling procedure based on a flow-through fluorometer, an instrument the USCG no longer uses.

The USCG should consider engaging other SMART stakeholder agencies for assistance in developing these guidance documents. The EPA in particular has a great deal of experience with field data collection techniques and data quality management issues, and has offered their assistance in developing SMART procedures and practices. Below are some general categories of information useful in developing guidance documents more specific to USCG operations.

Tier I Aerial Observation and Photo Documentation
- Coordination with dispersant spray platforms
- Photography techniques
- Documentation
- Air to air communication
- Air to surface communication
- Data transmission
- Reporting to Command

SMART Aerial Spotting
- Mission planning
- Oil slick identification and characterization
- Coordination of dispersant spray platforms and SMART vessels
- Air to air communication
- Air to surface communication
- Reporting to Command

Tier II/III Water Sampling
- Site selection
- Sample collection protocols
- Documentation
- Sample storage
- Sample delivery
- Chain of Custody requirements

Tier II/III Fluorometry Data Collection
- Site selection
- Tracking buoy deployment
- Instrument deployment & calibration
- Data logging
- Data formatting
- Documentation
- Data transmission
- Reporting to Command

Tier II/III Water Parameter Collection
- Site selection
- Instrument deployment & calibration
- Data logging
- Data formatting
- Documentation
- Data transmission
- Reporting to Command

ISB Air Monitoring
- Mission planning
- Site selection
- Instrument deployment & calibration
- Data logging
- Data formatting
- Documentation
- Data transmission
- Reporting to Command

Tracking buoy deployment
- Data Processing and Evaluation
- Overall data quality control and quality assurance
- Evaluating data collection procedures
- Interpreting Tier I photos and Observer Log
- Processing and interpreting fluorometry data
- Processing and interpreting water quality data
- Overseeing water sample analysis
- Presenting the SMART data

C.3.3.1 Equipment and Instrumentation

The project team recognized the need for detailed guidance specific to the operation and maintenance of the USCG SMART equipment and instrumentation. This additional guidance need not be included in the SMART Protocol but should be available to the Strike Teams. For example, USCG standard operating procedures (SOPs) should specify the instrument or piece of equipment, and include detailed operational, calibration, and maintenance instructions. Below is a list of the SMART equipment and suggested topics for USCG specific SOPs.

Radios and Satellite Communications Equipment

- Operating instructions
- Inspection checklist
- Maintenance procedures
- Inspection and maintenance schedule

Fluorometer

- Operating instructions
- Calibration check
- Inspection checklist
- Maintenance procedures
- Inspection and maintenance schedule

Water Sampling Equipment

- Operating instructions
- Inspection checklist
- Maintenance procedures
- Inspection and maintenance schedule

Photography Equipment

- Operating instructions
- Inspection checklist
- Maintenance procedures
- Inspection and maintenance schedule

Multi-Parameter Water Sonde

- Operating instructions
- Calibration check
- Inspection checklist
- Maintenance procedures
- Inspection and maintenance schedule

Particulate Air Monitors

- Operating instructions
- Calibration check
- Inspection checklist
- Maintenance procedures
- Inspection and maintenance schedule

C.4 Personnel Training

The current NSF SMART training curriculum addresses most of the topics below, but in some cases not to the level of detail needed to maintain proficiency in all aspects of SMART operations. As an example, SMART fluorometry operations are covered in great detail, while other components of SMART, such as water sampling, water parameters, and air monitoring are covered in theory only, and currently no hands-on equipment training exists. Below is a summary of the training modules that should be included in a comprehensive SMART training program.

Overall SMART Mission

- Purpose/Role
- Dispersant monitoring
- ISB monitoring

Tier I Aerial Observation

- Aircraft suitability
- Coordination with dispersant spray platforms
- Photography requirements & techniques
- Documentation
- Air to air communication
- Air to surface communication
- Data transmission
- Reporting to Command

SMART Aerial Spotting

- Mission planning
- Oil slick identification and characterization
- Coordination of dispersant spray platforms and SMART vessels
- Air to air communication
- Air to surface communication
- Reporting to Command

Tier II/III Fluorometry Data Collection

- Site selection
- Instrument deployment
- Data logging
- Data formatting
- Documentation
- Data transmission
- Reporting to Command

Tier II/III Water Sampling

- Site selection
- Sample collection protocols
- Documentation
- Sample storage
- Sample delivery
- Chain of Custody requirements

Tier III Water Parameter Collection

- Site selection
- Instrument deployment
- Data logging
- Data formatting
- Documentation
- Data transmission

ISB Air Monitoring

- Mission planning
- Site selection
- Instrument deployment
- Data logging
- Data formatting
- Documentation
- Data transmission
- Reporting to Command

C.5 Technology

Of the SMART technology gaps identified in Appendix B, communications is the most persistent and pressing challenge facing the SMART field teams. The project team also noted several areas where the SMART technology is dated or does not meet the required functional capabilities. In some cases, mission capability will be enhanced with better deployment strategies and maintenance programs, while in other cases, newer, more effective equipment is needed.

C.5.1 In-Situ Air Monitoring Instrumentation Technology

The SMART Protocol prescribes the deployment of air monitoring teams when a concern about public exposure to smoke from the burning of oil exists. To perform this function effectively, each team requires a real-time particulate monitor capable of detecting the small particulates emitted by the burn (ten microns in diameter or smaller). Each monitoring instrument should display and log the instantaneous particulate concentration as well as a time weighted average (TWA) concentration. SMART recommends averaging concentrations over one-hour periods. The SMART Protocol does not require nor endorse a specific brand of particulate monitoring instrument. Rather, SMART specifies performance criteria, and instruments meeting those criteria useful for ISB monitoring Table C-1.

Table C-1. SMART ISB air monitoring performance criteria.

Criteria	Description
Rugged and portable	The monitor should be suitable for field work, withstand shock, and easily transportable in a vehicle, small boat or helicopter. Maximum size of the packaged instrument should not exceed that of a carry-on piece of luggage.
Operating temperature	15-120 ºF
Suitability	The instrument should be suitable for the media measured, i.e., smoke particulates.
Operating duration	Eight hours or more.
Readout	The instrument should provide real-time, continuous readings, as well as time weighted average (TWA) readings in µg/m³.
Data logging	The instrument should provide data logging for 8 hours or more.
Reliability	The instrument should be based on tried-and-true technology and operate as specified.
Sensitivity	A minimum sensitivity of 1 µg/m³.
Concentration range	At least 1-40000 µg/m³.
Data download	The instrument should be compatible with readily available computer technology, and provide software for downloading data.

Market research by the project team identified three particulate air monitoring instruments meeting the minimum performance criteria set by the 2006 SMART Protocol (sec. 3.6). Beyond these minimum performance criteria, the team also considered other features offering faster response times, lower maintenance requirements, or a better user interface. Details for each instrument are provided below and a cost summary to equip one Strike Team is provided in Table C-6.

C.5.1.1 ThermoScientific DataRAM 4 (Discontinued By Manufacturer)

Production of the DataRAM 4 (Figure C-1) is discontinued. However, because it remains the NSF's current air monitoring device, and because the manufacturer indicates it will continue to provide support for the unit through 2016, the product is included as a technology solution. The DataRAM 4 meets the minimum SMART performance criteria, but lacks some features that would assist the field operator – features that are included in newer generation instruments. In particular, the DataRAM 4 does not provide a real-time graphical display of the instantaneous and TWA concentrations. Since SMART is concerned with the overall trend of these values, a historical presentation of the data is valuable. In addition, the set-up software is not compatible with Windows operating systems beyond Windows XP. This will become more problematic as Windows 7 increasingly becomes the standard operating system for most USCG computers. A summary of the ThermoScientific DataRAM 4's characteristics against the SMART requirements is shown in Table C-2.

Table C-2. ThermoScientific DataRAM 4.

Pros	Cons
Currently in the NSF SMART inventory	Discontinued by Manufacturer (Replaced by ADR 1500)
	Product support will end 2016
	Interface software is not compatible with Windows 7

Figure C-1. ThermoScientific DataRAM 4.

C.5.1.2 ThermoScientific ADR 1500

The ThermoScientific ADR 1500 (Figure C-2) is the next generation air monitoring instrument recommended by the manufacturer to replace the discontinued DataRAM 4. The ADR 1500 is portable, self-powered (internal battery), and mounted in a weather proof case. The unit displays real time instantaneous and TWA concentration values in a text and graphical format to a connected laptop computer. The TWA display however is not configured to specifically display a one-hour TWA concentration. The project team considers this a serious drawback considering that the one-hour TWA is the most important piece of information monitored by the operator during SMART operations. A summary of pros and cons for the ThermoScientific ADR 1500's is shown in Table C-3; the field deployment configuration is shown in Figure C-3.

Table C-3. ThermoScientific ADR 1500.

Pros	Cons
Weatherproof enclosure	Poor instrument display
Real time laptop computer display	Configured more for unattended use
Battery powered	Cannot display one-hour TWA values

Figure C-2. ThermoScientific ADR 1500 Area Dust Monitor.

Figure C-3. ThermoScientific ADR 1500 Area Dust Monitor field deployment.

C.5.1.3 The TSI DustTrak DRX 8533 W/ Weather Proof Case

The TSI DustTrak DRX 8533 is portable, self-powered (internal battery), housed in a weather proof case (Figure C-4 and Figure C-5), and set up via the built in touchscreen or through a connected laptop computer. The built-in touchscreen display is capable of displaying instantaneous and TWA concentration values in either numerical or graphical form (Figure C-6). Though the unit can display only a single, user-selected particle size concentration (PM1, PM2.5, or PM10), the instrument simultaneously measures and logs the concentration of all three particle size categories, which might be valuable after the fact, if more detailed particle size analysis is requested.

Of the three instruments the project team considered, only the TSI DustTrak DRX 8533 has the capability to measure and log three particle size categories simultaneously. The project team had an opportunity to operate this instrument during an oil spill response training event, and the only disadvantage noted is that the unit cannot display real time data through a connected laptop. This instrument has a high quality built-in display screen that might make-up for the lack of a connected laptop (Figure C-6). Pros and cons of the TSI DustTrak DRX 8533 are shown in Table C-4.

Table C-4. The TSI DustTrak DRX 8533.

Pros	Cons
Unit is operated with case open or closed	No real-time computer display
Weather proof case (Pelican Case)	
Good computer interface for instrument set-up	
Battery powered (25-30 hr with aux battery mounted in case)	
Simultaneously logs PM1, PM2.5, and PM10	
Real time instrument display of instantaneous and one hour TWA particle concentrations (for a single particle size only)	
Very simple pre-deployment calibration	
Annual maintenance and calibration from manufacturer is available	

Figure C-4. TSI DustTrak DRX 8533 air monitor with weather proof enclosure.

Figure C-5. TSI DustTrak DRX 8533 air monitor field deployment.

Figure C-6. TSI DustTrak DRX 8533 air monitor touch screen showing a graphical view of instantaneous and TWA particle concentration values.

C.5.1.4 Air Monitoring Instrument Summary

A summary of in-situ air monitoring instrumentation meeting SMART criteria is provided in Table C-5. Additional attributes are also displayed. The instruments described in Table C-5 satisfy the requirements of the SMART Protocol.

Table C-5. Air monitoring sensor table.

Performance Criteria Air Monitoring Sensors	DataRAM 4*	ADR 1500	DustTrak DRX
SMART Performance Criteria			
Rugged and portable	✓	✓	✓
Operating temperature	✓	✓	✓
Suitability	✓	✓	✓
Operating duration	✓	✓	✓
Readout	✓	✓	✓
Data logging	✓	✓	✓
Reliability	✓	✓	✓
Sensitivity	✓	✓	✓
Concentration range	✓	✓	✓
Data download	✓	✓	✓
Other Attributes			
Currently within NSF SMART inventory	✓		
Simultaneously logs different particle size categories			✓
Real time graphical display of TWA on instrument			✓
Real time computer display		✓	
Weatherproof Case		✓	✓
Technological Maturity		✓	✓
Windows 7 Compatibility		✓	✓
Intrinsically Safe			
Hot-swappable battery			✓
PM2.5 and PM10 Concentration Capability	✓	✓	✓
Typical Battery Run Time (hrs.)	20	24	32
Package Weight (lb.)	12	29	38†
* The ThermoScientific DataRAM 4 has been discontinued by the manufacturer †Package Weight includes a second, auxiliary battery.			

Table C-6. Air monitoring instrumentation cost.

Acquisition Cost			
	ThermoScientific DataRAM 4	ThermoScientific ADR 1500	TSI DustTrak DRX 8533 W/ Weather Proof Case
Instrument cost	Currently within the USCG Strike Team inventory	$21,000 (3 units @ $9,000 each)	$39,000 (3 units @ $13,000 each)
Ruggedized laptop computer with weather proof case	$18,600 (3 units @ $6,200 each)	$18,600 (3 units @ $6,200 each)	$18,600 (3 units @ $6,200 each)
Software	not required	No cost	No cost
Total acquisition cost	**$18,600**	**$39,600**	**$57,600**
Annual Cost			
Manufacturer's maintenance and service plan.	$2,100 (3 plans @ $700/yr each)	$2,100 (3 plans @ $700/yr each)	$1,875 (3 plans @ $625/yr each)
In-house training*	$700	$700	$700
Total annual cost	**$2,800**	**$2,800**	**$2,575**

*Annual training cost represents the additional cost required to add the device specific training to the existing annual SMART training curriculum.

C.5.2 Spill - Tracking Drifters

As part of the SMART dispersant monitoring process, field teams attempt to sample the same portion of an oil slick at two different times. In between these two samples the field teams must move away from the area (sometimes up to two miles away) to remain safely clear of dispersant spray operations. Reestablishing the sampling locations for a subsequent sample following spray operations can be difficult. During the DWH response, USCG SMART teams improvised several different floating buoy systems that helped them mark and return to the sample location. These buoys were very simple (e.g., a weighted 5 gallon bucket), but they were effective as long as the field team could arrive within approximately 100 yards of the marker. Beyond 100 yards, the field teams had difficulty locating the marker. With a 2-mile safety standoff distance during spray operations, finding the marker proved quite challenging.

A better solution would be the use of a buoy system that would drift with the oil slick and transmit real time position information. The position information can be transmitted from the buoy either via a simple radio beacon (radio tracking system) or via a satellite communications network. Details for two tracking drifters are provided below and a cost summary to equip one Strike Team is provided in Table C-9.

C.5.2.1 NovaTech RF-700C2 Buoy and DF-500N Direction Finder

The NovaTech RF-700C2 radio tracking buoy (Figure C-7) transmits a repeating tone over a radio frequency that can be received by the DF-500N Direction Finder (Figure C-8). Past deployments have demonstrated that this portable radio tracking systems has an operational range of around two miles. The system provides the operator only with the direction to the buoy and a rough estimation of the distance (based on signal strength). The primary advantage of a radio beacon buoy is that it is a self-contained system - no outside communications network is required. The pros and cons of the NovaTech RF-700C2 buoy and DF-500N Direction Finder are listed in Table C-7.

Table C-7. NovaTech RF-700C2 buoy and DF-500N Direction Finder.

Pros	Cons
Portable and self-powered: - buoys using standard D-cell batteries - DF-500 uses internal multi-year rechargeable battery*	Limited range
Does not require additional communications capability or network services	Directional information only
"Sticks" to the oil and tracks well with the slick	
Operating life of up to 8 days on a single charge (per manufacturer)	
Proven history in oil spill response	
A single DF-500N Direction Finder can operate with multiple buoys	

*Use of 7-8 years without issues reported by Parscal Pacific

Figure C-7. NovaTech RF-700C2 buoy.

Figure C-8. NovaTech DF-500N Hand Held Direction Finder.

C.5.2.2 MetOcean iSphere Tracking Buoy

The MetOcean iSphere is a satellite tracking buoy with a history of use in the oil spill response industry. A satellite-based tracking buoy utilizes a built-in GPS receiver and has the capability to transmit an accurate position periodically over a satellite communications network. Retrieving the buoy position requires an internet connection, which may be problematic for the SMART field teams. However, if internet connectivity is available, a satellite tracking buoy system would be a valuable tool. The iSphere buoy is relatively small (about 16" in diameter) and designed to adhere to and drift with a surface oil slick (Figure C-9. and Figure C-10.). Once activated (via a magnetic switch) the unit automatically transmits position data every 10 minutes. The data are transmitted through the Iridium satellite network to an internet website where it can be accessed by registered users (Figure C-11). A third party vendor provides access to the Iridium satellite network and hosts the website where the data are displayed. The vendor, JouBeh, offers a service plan specifically designed for the emergency response industry that costs $175 per buoy annually for satellite access, plus a fee of $1.40 per kilobyte of data used. One kilobyte of data represents approximately 10 hours of buoy operation. The pros and cons of the MetOcean iSphere Tracking Buoy are listed in Table C-8.

Table C-8. MetOcean iSphere Tracking Buoy.

Pros	Cons
Built-in GPS receiver	Requires Iridium satellite communications data plan (Approx. $175/yr.)
Tracks well with the slick	Requires internet connectivity to access real-time data in the field
Data available to any operator with an internet connection	Internal batteries must be replaced by the manufacturer after 2-year shelf life (this cost is covered in the maintenance plan)
Provides accurate position information	
Long battery life (180-365 days of operation)	
Simple deployment	
Manufacturer offers a battery replacement and maintenance plan	

Figure C-9. MetOcean iSphere Tracking Buoy.

Figure C-10. MetOcean iSphere Tracking Buoy deployed.

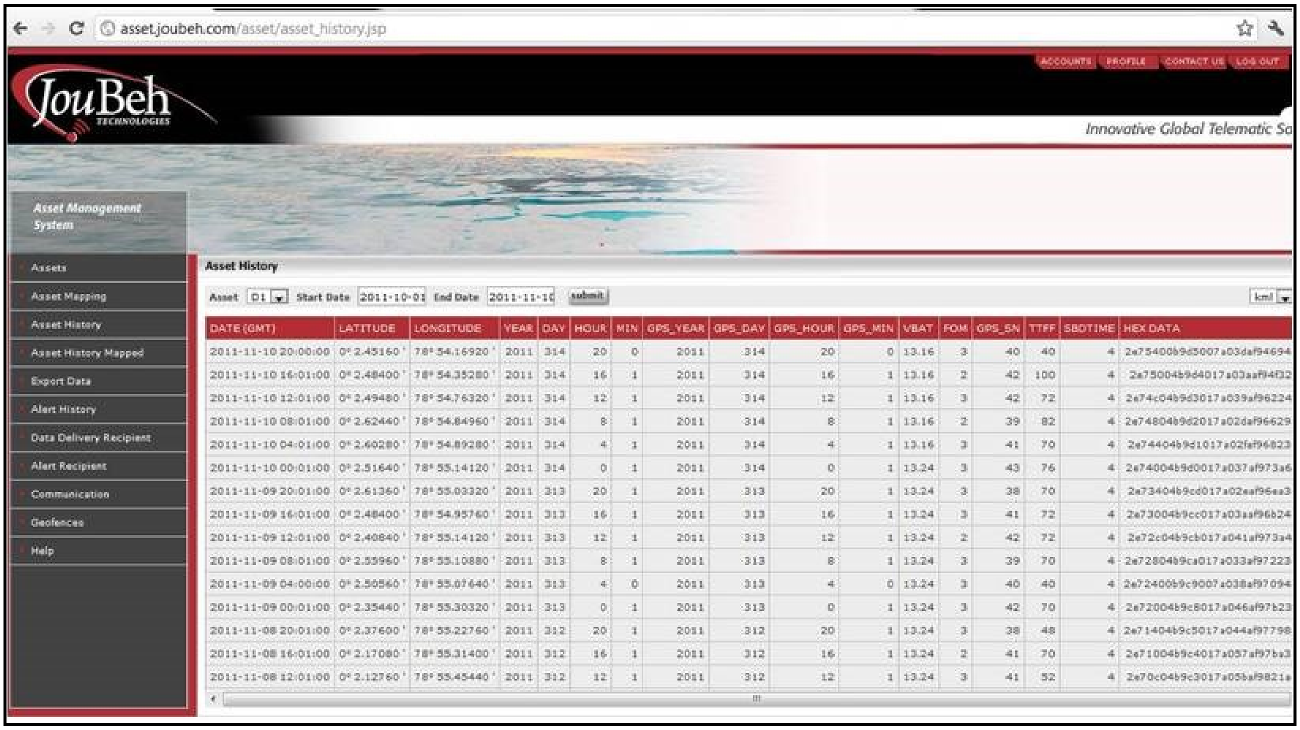


Figure C-11. Example of the iSphere data webpage.

Table C-9. Tracking buoy cost.

Acquisition Cost		
	NovaTech RF-700C2 buoys	iSphere tracking buoys
Buoy cost	$3,800 (2 buoys @ $1,900 each)	$5,600 (2 buoys @ $2,800 each)
DF-500N Direction Finder*	$2,200 (1 @ $2,200 each)*	Not applicable
Software	not required	not required
Weather Proof travel case	$250 (1 @ $250)	$400 (1 @ $200)
Total acquisition cost	**$6,250**	**$6,000**
Annual Cost		
Maintenance**	negligible**	Not applicable
JouBeh data plan	Not applicable	$350 (2 plans @ $175/yr each)***
Battery replacement and service plan	Not applicable	$750 (2 plans @ $375/yr. each)
In-house training****	$350	$350***
Total annual cost	**$350**	**$1,450**

* A single DF-500N Direction Finder can operate with multiple buoys.
** The DF-500N Direction Finder requires no periodic maintenance and the NovaTech RF-700C2 batteries are user replaceable (standard "D" cell batteries).
*** Plus $1.40 per kilobyte of data used. (One kilobyte of data represents approximately 10 hours of buoy operation.)
**** Annual training cost represents the additional cost required to add the device specific training to the existing annual SMART training curriculum.

C.5.3 Water Parameter Measurement

In addition to fluorometry data, the SMART Protocol prescribes that water physical and chemical parameters be measured during Tier III operations. NOAA has requested that the Strike Teams develop the capability to measure and record sample depth, water temperature, conductivity, dissolved oxygen content, pH, and turbidity as part of their SMART Tier III capability. This capability is satisfied by use of a portable multi-parameter water quality sonde.

The SMART Protocol does not list specific performance criteria for multi-parameter water quality sondes, so the project team focused on instruments that are from well-established manufacturers, and that are in common use by the Oceanographic and Water Quality professions. Of those instruments, the project team identified four instruments from two different manufacturers with a good user interface, and with well documented calibration and maintenance procedures. Two of the instruments (HydroLab DS5 [Figure C-12.] and YSI Model 6600 [Figure C-13]) are based on established technology, but with less user-friendly (older) interfaces. Two instruments (HydroLab HL4 (Figure C-14.) and YSI EXO 2 (Figure C-15.). use newer technology with more features and better user interfaces. The instruments are all available with Luminescent Dissolved Oxygen sensors. The purpose of this sensor is to eliminate the need for a membrane, and after a short warm-up period, provide nearly instantaneous readings. All four instruments can continuously log data and display data real time on a handheld interface. All can dump data to a computer after the fact. All but the DS5 can display and log data real-time to a connected computer.

Some stakeholders suggested a fluorometry-based oil detection sensor as a valuable addition to SMART water quality data. The project team identified only one instrument, the YSI Model 6600 which is configurable with an optional crude oil fluorometry sensor. However, configuring the YSI to perform both water parameter and fluorometry SMART data collection would require the development of a towing body for the instrument along with reconfiguring the current SMART data logging software. It may also require a change to the YSI 6600 Model firmware. Overall, this may not be a worthwhile effort, considering the unit is scheduled to be taken out of production within the next few years. The project team did not identify any fluorometer that could be easily modified to measure water parameters.

The HydroLab DS5 is currently in the USCG SMART inventory but is an older generation instrument with a cumbersome user interface and difficult calibration and maintenance requirements. The recent introduction of multi-parameter sondes with better performance and user interface characteristics makes these new devices candidates for modernizing the Strike Team SMART capability. The project team was unable to test either the HydroLab HL4 or YSI EXO 2 because they are so new to the market, however based on the published specifications and discussions with the manufacturers, they appear promising. The pros and cons of all four instruments are listed below (Table C-10, Table C-11, **Error! Reference source not found.**, and Table C-13**Error! Reference source not found.**), and Table C-14 **Error! Reference source not found.**summarizes the attributes of the four multi-parameter water quality sondes. Details for each instrument are provided below and a cost summary to equip one Strike Team is provided in Table C-15.

HydroLab DS5

Table C-10. HydroLab DS5.

Pros	Cons
Configurable to sample all the water quality parameters requested by the SMART Protocol	Older generation technology
Currently in the USCG inventory	Somewhat difficult user interface
Real time computer interface with data display	No built in GPS receiver
	Internal battery is optional
	No crude oil fluorometer integration
	Poor instrument user interface

Figure C-12. HydroLab DS5 multi-parameter sonde.

YSI Model 6600

Table C-11. YSI Model 6600.

Pros	Cons
Configurable to sample all the water quality parameters requested by the SMART Protocol	Older generation technology
Optional Crude oil fluorometer integration (additional $7K)	The manufacturer is discontinuing this model mid-2015. Support is scheduled to continue for approx. 5 years after discontinuance.
Real time computer interface with data display	Built-in GPS receiver is an added cost option
Self-powered (internal battery)	

Figure C-13. YSI 6600 multi-parameter sonde.

Table C-12. HydroLab HL4.

Pros	Cons
Can be configured to sample all the water quality parameters requested by the SMART Protocol	No standard built in GPS receiver (optional GPS receiver will be available soon)
Real time computer interface with data display	No crude oil fluorometer integration
Self-testing function	Internal battery is an added cost option
Calibration self-check and warning	
Software based calibration wizard	
Automatic calibration and usage log	
Manual GPS and user notes input capability	
Good handheld user interface	
Good real time data display with internal logging	

Figure C-14. HydroLab HL4 multi-parameter sonde.

YSI EXO 2

Table C-13. YSI EXO 2 (approx. $16k).

Pros	Cons
Configurable to sample all the water quality parameters requested by the SMART Protocol	No crude oil fluorometer integration
Real time computer interface with data display	
Built in GPS receiver	
Self-powered (internal battery)	
Smart QC assisted calibration - Assisted calibration process with automatic checks for faults and errors.	
SMART sensor technology - sensors are interchangeable between instruments while maintaining calibration.	
Universal sensor ports - all sensors are interchangeable within the instrument. Allowing for multiple sensor configurations.	

Figure C-15. YSI EXO 2 Multi-parameter sonde (shown without sensor cover).

Water Parameter Sensor Summary

Table C-14. Water parameter sonde table.

Performance Criteria Water Parameter Sensors	HydroLab DS5	YSI Model 6600	HydroLab HL4	YSI EXO 2
SMART Performance Criteria				
Instrument Depth	✓	✓	✓	✓
Water Temperature	✓	✓	✓	✓
Conductivity	✓	✓	✓	✓
Dissolved Oxygen Content	✓	✓	✓	✓
pH	✓	✓	✓	✓
Turbidity	✓	✓	✓	✓
Other Attributes				
Currently within NSF SMART inventory	✓			
Built-in GPS Receiver		†	**	✓
Crude Oil Fluorometer Available		✓		
Instrument Weight (lb.)	8	7	5	8
Built-in Calibration Guide			✓	✓
Data download	✓	✓	✓	✓
Real Time instrument Display	✓	✓	✓	✓
Real time computer display		✓	✓	✓
Weatherproof	✓	✓	✓	✓
Portability	✓	✓	✓	✓
Internal Battery Pack	†	✓	†	✓
Computer interface	✓	✓	✓	✓
Technological Maturity			✓	✓
Windows 7 Compatibility	✓	✓	✓	✓

† Optional at added cost
** Optional GPS receiver will be available in the near future

Table C-15. Water parameter sonde cost.

Acquisition Cost				
	HydroLab DS5*	YSI Model 6600	HydroLab HL4	YSI EXO 2
Instrument cost	$10,000	$15,500	$10,700	$16,000
Software	No cost	No cost	No cost	No cost
Weather proof travel case	$300	$300	$300	$300
Total acquisition cost	**$10,300**	**$15,800**	**$11,000**	**$16,300**
Annual Cost				
Manufacturer's maintenance and service plan.	$495	$375	$495	$1,800
Calibration supplies	$500	$500	$500	$500
In-house training**	$700	$700	$700	$700
Total annual cost	**$1,695**	**$1,575**	**$1,695**	**$3,000**
* Currently within the USCG Strike Team inventory **Annual training cost represents the additional cost required to add the device specific training to the existing annual SMART training curriculum.				

C.5.4 Water Sampling

The SMART Protocol prescribes the collection of water samples during Tier II/III dispersant monitoring operations to assist in correlating instrument readings in the field to actual dispersed oil concentrations in the water column. NOAA requested the Strike Teams develop the capability to collect, store, and transport discrete water samples collected at depths ranging from 1 to 10 meters.

Water samples are very difficult to collect where surface oil slicks are present. Water samples are ideally collected through deployment of water samplers to the desired depth of sampling, rather than the use of pumps and tubing to pull water samples from depth. With pumps and tubing, there is a risk that oil droplets will adhere to the inside wall of the tubing and be released randomly, potentially contaminating future samples. When sampling in areas covered by a surface slick, extreme care is needed to "knock" the surface slick aside so that the sampling device does not become contaminated as it is lowered into the water. The sampling container should be closed as it descends through the higher oil concentrations near the surface. Then the container opens at the desired depth, fills with sample water, and closes again at the sample depth before being brought to the surface.

For sampling from shallower depths (less than 5m) a simple commercial off the shelf (COTS) "Pole Sampler" such as the CONBAR 7000 Series Telescopic Sampler should suffice. For deeper sample depths (up to 10m) the project team located only one COTS device that satisfies the closed-open-closed requirement described above. Details for the two instruments are provided below (Table C-16) and a cost summary to equip one Strike Team is provided in Table C-18.

C.5.4.1 CONBAR 7000 Series Telescopic Sampler

The CONBAR 7000 Series Telescopic Sampler (Figure C-16) is a simple and reliable device for the retrieval of 1 liter water samples from a stationary vessel. With a telescopic handle capable of extending from 7 to 24 feet in length the device is suitable for retrieving water samples from up to 5 meters below the surface. The CONBAR 7000 features a closed-open-closed sequence that minimizes the potential for contamination from near surface water. The device also accepts standard sample size bottles (1000 ml wide mouth jar) with no need to transfer the water sample from the sampler to a separate storage container. This device satisfies the shallower water sampling requirements of the SMART Protocol. Pros and cons are listed in Table C-16.

Table C-16. CONBAR 7000 Series Telescopic Sampler.

Pros	Cons
Widely used in the water resources field and proven reliable.	At slightly over 7 ft long transport is cumbersome.
Simple deployment	Vessel must be stationary for deployment
7 ft retracted - 24 ft extended length	Sample collection depth is limited to 5 meters
No need to transfer the sample to another container for storage.	
The sampling head is designed to accept a standard 1000 ml wide mouth jar with 70-400 threads.	
Sampler head is made of chemically resistant polypropylene.	
An optional displacement plunger is available for use when sampling requirements specify a 1 inch air space between the sample and the cap.	

Figure C-16. CONBAR 7000 Series Telescopic Sampler.

C.5.4.2 General Oceanics GO-FLO Bottle

The General Oceanics GO-FLO sampling bottle (Figure C-17 and Figure C-18) is the only water sampling device the project team identified capable of satisfy the 5 to 10 meter water sampling requirements prescribed by the SMART Protocol. The device has a proven history in the oil spill response and oceanographic research fields and is adequate for the SMART water sampling requirements. The GO-FLO's closed-open-closed deployment sequence permits the collection of sub-surface water samples without the risk of contaminating the collection bottle as it passes to the sample depth. This is a critical feature for a SMART water sampling device since the near-surface water under an oil slick will contain more suspended oil than at deeper levels. The GO-FLO bottle is deployed in the closed position (to reduce potential contamination). A hydrostatic switch opens the bottle at both ends at approximately 10m depth. The bottle is then brought to the desired sample depth and a weighted messenger is sent down the line to close and seal the bottle. Once back on deck, the bottles are transferred into the appropriate sample storage containers. Pros and cons of the device are listed in **Error! Reference source not found.**.

Table C-17. General Oceanics GO-FLO bottle model 108001.7T.

Pros	Cons
Sample bottle is specifically designed to avoid contamination by near surface water.	The water sample must be transferred from the GO-FLO bottle into a suitable container for storage.
Widely used in the oceanography field and proven reliable.	Deployment requires the use of additional weight or a weighted line.
Available with Teflon Lining	Vessel must be stationary for deployment
A single unit was purchased and successfully tested for SMART operations by the USCG Gulf Strike Team.	

Figure C-17. GO-FLO sample bottle (USCG Gulf Strike Team package).

Figure C-18. Larger size GO-FLO sample bottle rigged for deployment.

Table C-18. Water sampling cost.

Acquisition Cost		
	CONBAR 7000	General Oceanics GO-FLO Sample Bottle
Instrument cost	$900 (2 units @ $450 each	$1,600 (one unit)
1 liter sample jars	$300 (48 @ $6.25 each)	$300 (48 @ $6.25 each)
Miscellaneous line and rigging		$300
Weather proof travel case	$300 (1@ $300)	$300 (1@ $300)
Total acquisition cost	**$1,500**	**$2,500**
Annual Cost		
Maintenance and service.	Negligible	$45 plus cost of any necessary repairs
In-house training*	$350	$700
Total annual cost	**$350**	**$745**

*Annual training cost represents the additional cost required to add the device specific training to the existing annual SMART training curriculum.

C.5.5 Communications Technology

SMART establishes a monitoring system for the rapid collection and reporting of real-time, scientifically based information to assist the Unified Command with decision-making during ISB or dispersant operations. Communication of monitoring results needs to flow from the field to those persons in the Unified Command who will use the data to interpret the results. Communications between the field teams and the command, and communications between the field teams and other response operations are key components of the SMART process.

Experience indicates that communications is one of the most challenging components of the SMART process. SMART field teams operate in vehicles, vessels, and aircraft of opportunity far from the command. As a result, field teams often find themselves in areas not covered by cellular telephone service and too far from the command for radio communication. Experience also suggests that field teams cannot rely on vessels and aircraft of opportunity to provide the communications capability necessary for SMART operations. Below, SMART communications are divided into two broad categories, communications between the field teams and the Unified Command (SMART reporting), and communications between field teams and other response operators (SMART operational communications).

C.5.5.1 SMART Reporting

C.5.5.1.1 Real-time Verbal Reports

Ideally, an initial verbal report is transmitted to the SMART Technical Specialist (TS) quickly. This should happen after the completion of monitoring activities, or as soon as the field team recognizes the need to make adjustments in the response operations, ideally in less than 1 hour. This initial report is a two-way conversation between the Field Team Leader and the TS at the Unified Command. The Field Team Leader should assess the communications capability of the vessel or aircraft before departing on the mission. If suitable communications equipment is not provided, the Field Team Leader should either make arrangements to obtain it, or develop an alternative communications plan with the SMART TS.

C.5.5.1.2 Supporting Data, Photos, and Written Reports

Digital data, photographs, and documentation collected during SMART field activities are transmitted to the SMART TS as soon as possible after a monitoring mission. Because this information requires some editing and formatting in the field, this data will not be available to the TS until sometime after data collection efforts end. However, this information is quite valuable to the TS, and every effort should be made to transmit the data as soon as possible. The capability to transmit this data directly from the field is an enormous advantage.

Considering that SMART field teams will likely be operating far from the Unified Command and possibly in areas not covered by cellular phone service, the project team investigated portable satellite communications systems with both voice and digital communication capabilities. These systems should provide the two-way voice communication capability necessary for initial verbal reports as well as the digital data capability to transmit the supporting data, photos, and written reports from the field.

SMART teams need a simple, ready-to-deploy, reliable standardized equipment package that quickly establishes communications. A satellite communication system will provide increased range and immediate availability that meets CG needs. COTS systems, known as Mobile Satellite Service (MSS) terminals, work with a laptop computer to establish data and voice communications. Key features to consider when selecting an MSS are listed in listed in Table C-19. .

Table C-19. Desirable attributes for Mobile Satellite Service (MSS) terminals.

Criteria	Description
Basic Features	• Telephone • Email • Internet connectivity • 2-way radio communications • Wi-Fi Hotspot • Worldwide range • GPS
Cost Effective	• Pay for only what is used • Pre-paid and post-paid plans • Service and support provided
Durability	• Ruggedized • Freezing and hot temperatures • Water resistant
Deployable	• Operable despite long shelf life • Operable on any moving vehicle, boat or other platform.
Usability	• Easy to operate
Mobility/Transportability	• One-person carry portability • Operable while mobile • Shippable • Carry on air craft and in vehicles
Power	• DC Power Port operable • Battery life • Rechargeable • Hot swappable battery • Field rechargeable • Battery expandable • Vehicle 12V power adaptable

C.5.5.2 Ground Control MCD-800

The team located one device with many of these key features, called the Ground Control MCD-800 (Figure C-19 and Figure C-20). The MCD-800 is an easy to carry and use system, connects with the satellite in one minute, and establishes a wireless hotspot for any in-range device. The following features apply to the MCD-800:

- One person portability (Figure C-20A).
- Operates for 6 hours on a single charge or continuously while plugged into a vehicle.
- DC power port or any 110 or 220 VAC wall outlet.
- Standard package comes with analog satellite phone capability.
- All-weather sealed enclosed case that remains closed during operations.
- Optional foldable solar panel ($1,100) for battery supplementation or recharging in no-power locations (Figure C-20B).
- External rechargeable and single use batteries available (Figure C-20C).

Ground Control offers an MCD-800 Demonstration System Rental program for organizations interested in evaluating the system. A one week rental currently costs $299 and a service charge of $6.99 per Megabyte, with $0.99 cents a minute calls to any phone with no minimum usage requirements. A cost summary to equip one Strike Team with the MCD-800 is provided in Table C-20.

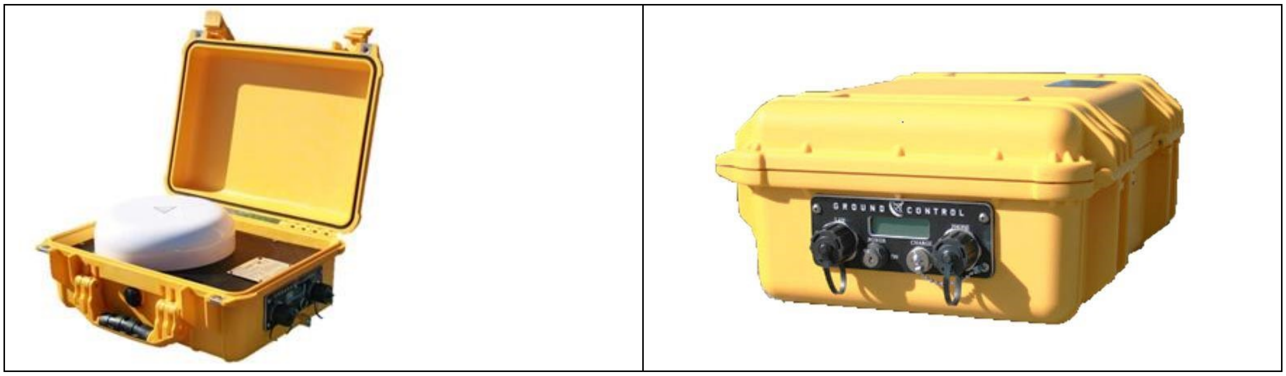


Figure C-19. Ground Control MCD-800.

A B C

Figure C-20. Features of the MCD-800.

MCD-800 Costs Factors

Table C-20. Ground Control MCD-800 cost information.

Acquisition Cost	
MCD-800	$13,000 (one unit)
Software	No cost
Total acquisition cost	**$13,000**
Annual Cost	
Satellite network access and data plan	$828*
Manufacturer's maintenance and service plan.	$175
In-house training**	$700
Total annual cost	**$1,703***

* Does not include data usage fee. Satellite network access and data plan includes an annual allowance of 30 megabytes (Mb) of data usage. After that, data usage is billed at $6.99/Mb. (A typical SMART Tier II/III data package is approximately 5Mb in size). Outgoing voice calls are billed at $0.99/minute. No charge for incoming calls. Outgoing text messaging is billed at $0.50 per text. No charge for incoming texts.
**Annual training cost represents the additional cost required to add the device specific training to the existing annual SMART training curriculum.

C.5.5.3 SMART Operational Communications

In addition to reporting to the Unified Command, the SMART field teams require the capability to communicate and coordinate with other response assets in the area of operation. This will almost certainly involve communications between aircraft and vessels. Communications capability gaps present challenging solutions because vessels and aircraft use different frequencies – aviation radios operate in the 108-137 MHz AM band while marine radios operate in the 156-162 MHz FM band. USCG experience indicates that vessels of opportunity are rarely equipped with air band radio frequency capability, and aircraft are rarely equipped with marine band radio frequency capability.

Past SMART deployments were successful using of handheld marine VHF radios and handheld aviation VHF radios for short-range communications between vessels and aircraft. These handheld radios are limited in range but considering the cost and logistics of installing permanent radios in vessels and aircraft, portable radios provide a workable solution. The project team investigated marine and aviation handheld radios suitable for SMART field operations, and found many candidates ranging from approximately $150-$500. The team did not however, find handhelds capable of communicating on both aircraft and marine VHF frequency bands. Based on this research, the project team recommends that a portable aviation VHF be provided on every vessel and a portable marine VHF radio be provided on every aircraft participating in SMART operations at the onset of a SMART mission.

C.5.6 Alternative Emerging Technology

The emerging technology described below is not associated with current gaps in the SMART program. The project team assessed it, however, as it may provide additional future capabilities for SMART operations.

C.5.6.1 Particle Size Analyzer

Some stakeholders mention particle size analyzers as complementary to the SMART capability. Although particle size measurement is not currently prescribed by the SMART Protocol, and NOAA has not requested such information, it could potentially be a future enhancement to the SMART data collection effort. The project team identified only one particle size analyzer that was portable, and therefore could potentially satisfy requirements of SMART operations.

C.5.6.1.1 Particle Size Analyzer (LISST-100X) (approx. $44k w/ laptop computer)

The Laser In-Situ Scattering and Transmissometry-100X (LISST-100X) instrument (manufactured by Sequoia Scientific) is a multi-parameter system for in-situ observations of particle size distribution and volume concentration (Figure C-21). The product name LISST is derived from the term that describes its operation.

In both laboratory and field deployments the LISST has proved to be effective in measuring the concentration of oil in sea water. The LISST, however, cannot discriminate between oil and any other particles present in the water column. To address this issue some researchers suggested that combining the particle size measurement capability of the LISST with the oil identification capability of a fluorometer would allow for the simultaneous detection and quantification of oil in the water column. The test team did not identify a COTS device combining these two capabilities. In addition, the LISST may get saturated when too much oil is present, adversely affecting sensitivity. LISST instruments are limited to diluted mixtures, below ~500 ppm, because the LISST signal saturates for more concentrated mixtures. Pros and cons are listed in Table C-21, and a cost summary to equip one Strike Team with the LISST-100X is provided in Table C-22.

Table C-21. Sequoia Scientific LISST-100X.

Pros	Cons
Measures particle size (Volume Mean Diameter) and particle concentration.	Cannot discriminate between oil and any other particles present in the water column.
	False positives in turbid water.
	Not currently configured for towing.
	No existing SMART data logging interface.
	Not currently prescribed by the SMART Protocol or requested by the NOAA SSCs
	Unreliable in oil concentrations above ~500 ppm

Table C-22. Sequoia Scientific LISST-100X cost.

Acquisition Cost	
LISST-100X	$36,250 (one unit)
Ruggedized laptop computer	$6,000
Software	No cost
Total acquisition cost	**$42,250**
Annual Cost	
Manufacturer's maintenance and service plan	$1,700
In-house training*	$1,400
Total annual cost	**$3,100**

*Annual training cost represents the additional cost required to add the device specific training to the existing annual SMART training curriculum.

Figure C-21. Sequoia Scientific LISST-100X.

C.5.7 New Technologies Recently Added to SMART

The technology described below is not related to a current gap identified in this report, but is an example of new technology successfully used in the NSF SMART program. Recognizing the challenges associated with the SMART fluorometry data collection process, the USCG and oil spill response industry initiated an effort beginning in 2007, to update and streamline that component of the SMART program. In 2009 this resulted in a newer, more efficient fluorometer, and the development of an associated SMART fluorometry

SOP and SMART fluorometry training module. The resulting fluorometry package was used extensively during the DWH response and proved very effective.

C.5.7.1 Fluorometry

The SMART Protocol recognizes fluorometry as the most technologically advantageous oil detection method for dispersant efficacy monitoring in an oil spill response environment. SMART does not require nor endorse a specific instrument or brand for dispersant monitoring, rather, SMART specifies performance criteria (Table C-23) and instruments meeting them as useful for monitoring.

Table C-23. SMART Fluorometer performance criteria.

Criteria	Description
Field rugged and portable	Instrument package must be able to operate from a vessel or small boat under a variety of field conditions, including air temperatures between 5 and 35°C, water temperatures between 5 and 30°C, seas to 5 feet, humidity up to 100%, drenching rain, and even drenching sea spray. The criteria for field deployment should be limited by the safety of the field monitoring team and not instrument package limitations.
Continuous operation	Instrument package must be able to operate continuously in real-time or near-real time mode by analyzing seawater either in-situ (instrument package is actually deployed in the sea) or ex-situ (seawater is continuously pumped from a desired depth).
Controllable depth	Monitoring depth must be controllable between 1 meter and 3 meters.
Oil detection	Instrument must be able to detect dispersed crude oil in seawater. No specific detection method is specified in order to allow a wide range of instruments for consideration. If fluorometry is used, the excitation and emission wavelengths monitored should be selected to enhance detection of crude oil rather than simply hydrocarbons, in order to reduce matrix effects.
Digital readout	Instrument must be able to provide a digital readout of measured values. Given that different oils that have undergone partial degradation due to oil weathering will not provide consistent or accurate concentration data, measured values reported as "raw" units are preferred for field or accurate concentration data, measured values reported as "raw" units are preferred for field operations over concentration estimations that might be misleading as to the true dispersed oil and water concentrations.
Data logging	In additional to a digital readout (as defined above), the instrument must be able to digitally log field data for post-incident analysis. Data logging must be in real-time, but downloading of achieved data are not required until after the monitoring activity, i.e., downloading the raw data to a computer once the boat returns from field operations is acceptable.
Minimum detection limit (MDL)	The instrument must have a MDL of 1 ppm of dispersed fresh crude oil in artificial seawater and provide a linear detection to at least 100 parts per million (ppm) with an error of less than 30% compared to a known standard.

C.5.7.2 Turner Designs C3 Fluorometer

The NSF Strike Teams currently utilize six Turner Designs C3 fluorometers (Figure C-22, Figure C-23). The C3 is an in-situ fluorometer with light emitting diode (LED) optics specifically tuned to detect a wide variety of crude oils in seawater. The C3 is configured specifically (the towed body and some instrument firmware optimized for SMART data logging requirements) to meet the operational needs of the SMART data collection teams. The Turner Designs C3 fluorometer SMART kit satisfies the Performance Criteria of the SMART Protocol, as well as the informational needs of the NOAA Scientific Support Coordinator (the SMART data end user) and has proven reliable and mission capable during past SMART deployments (Figure C-22, Figure C-23, Figure C-24, Figure C-25). The pros and cons of the C3 fluorometer are listed in Table C-24, and a summary of the cost to equip one Strike Team with the Turner Designs C3 is provided in Table C-25.

Table C-24. Turner Designs C3 Fluorometer.

Pros	Cons
Fluorometry is identified in the SMART Protocol as a suitable oil detection technology.	Fluorometry identifies oil but cannot measure total oil concentration
The C3 fluorometer satisfies the NOAA oil detection requirements.	Fluorometry can produce false positives in a high CDOM (colored dissolved organic matter) environment
USCG has six C3 fluorometer kits in use with proven reliability and mission capable.	
USCG training and maintenance procedures for the C3 are substantially in place.	

Figure C-22. Turner Designs C3 Fluorometer SMART response kit (USCG Gulf Strike Team).

Table C-25. Turner Designs C3 cost.

Turner Designs C3 Fluorometer	
Acquisition Cost	
Turner Designs C3 fluorometer	$18,000 (2@ $9,000 each)
Ruggedized laptop computer	$12,500 (2@ $6,250 each)

Table C-25. Turner Designs C3 cost.

Turner Designs C3 Fluorometer	
Software	$1,100 (2@ $550 each)
SMART software configuration	$7,200 (2@ $3,600 each)
Weather proof travel case	$1,600 (2@ $800 each)
Miscellaneous line and rigging	$600 (2@ $300 each)
Total acquisition cost	**$41,000**
Annual Cost	
Manufacturer's maintenance and service plan.	Not available**
In-house training***	$1400
Total annual cost	**$1400**

Currently within the USCG Strike Team inventory
** The manufacturer considers an annual in-house inspection by the user to be sufficient.
*** C3 fluorometer operations are already fully addressed in the existing annual SMART training curriculum.

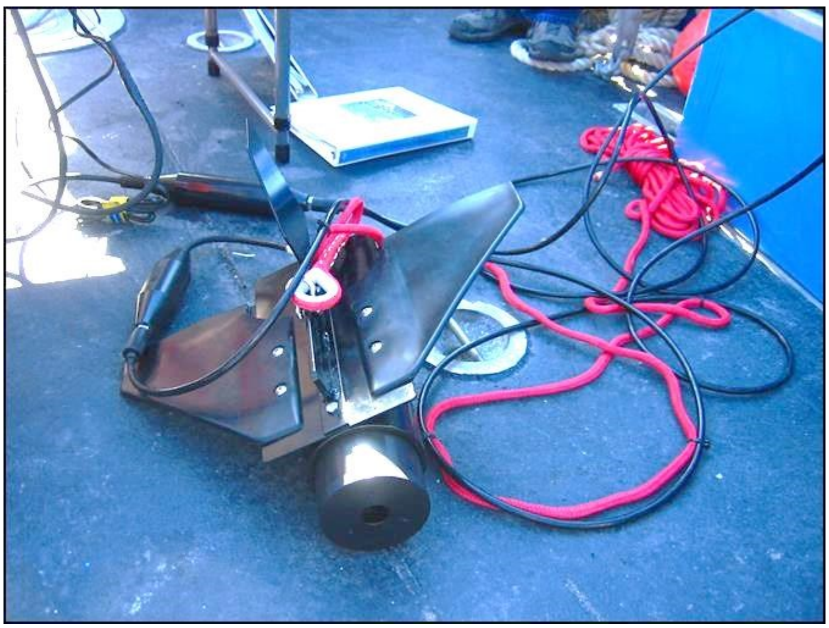


Figure C-23. Turner Designs C3 Fluorometer with tow package ready for deployment.

Figure C-24. USCG Atlantic Strike Team setting up the SMART software during the DWH response. The C3 SMART Operator's Guide is shown in the lower right corner.

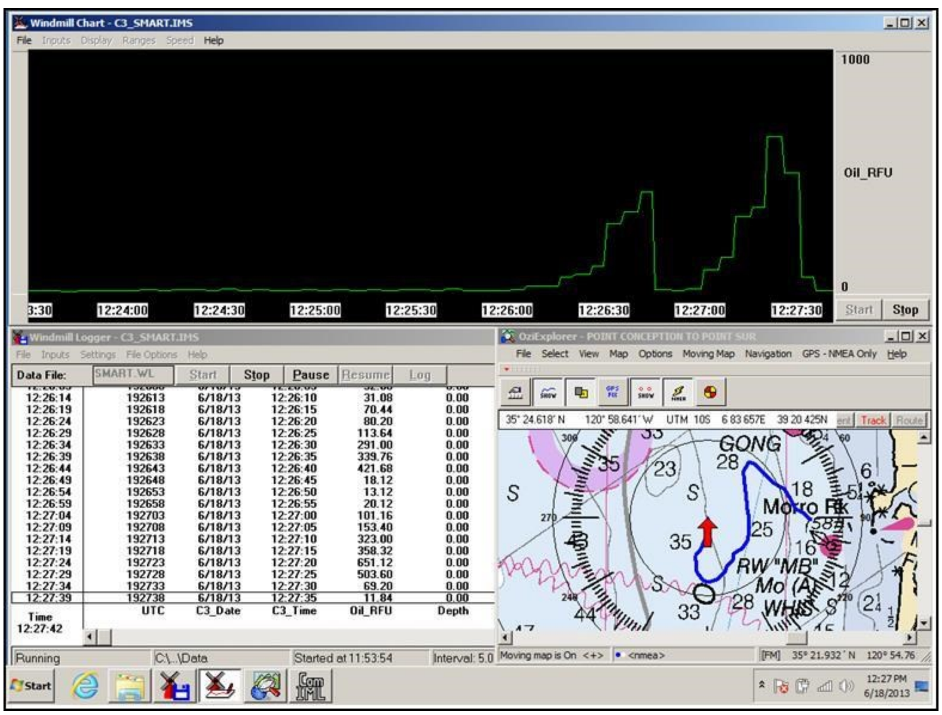


Figure C-25. SMART fluorometry user interface showing graphical and text displays along with live mapping application.

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