299552

2014 INTERNATIONAL OIL SPILL CONFERENCE

# Recent Advances by the API Remote Sensing Technical Working Group for Oil Spill Preparedness and Response

David Sweeten
BP, Inc
201 Helios Way
Houston, Texas 77079

David Palandro
ExxonMobil Upstream Research Company
NW500, P.O. Box 2189
Houston TX 77252-2189

Lindsey Neuwirth
Cardno ENTRIX
5252 Westchester, Suite 250
Houston, Texas 77005



**ABSTRACT 299552:**

In 2010, the American Petroleum Institute coordinated the establishment of an Oil Spill Preparedness and Response Joint Industry Task Force (JITF) comprised of experts from industry and government. The JITF was established to examine the efforts implemented during recent oil spill events, assess the current state of the industry's ability to respond to significant spills, and identify potential learnings. A remote sensing technical working group (TWG) was formed under the Oil Sensing and Tracking program to document current remote sensing technology and future research and development needs related to tracking oil on the water's surface.

Since its inception, the Remote Sensing TWG has held face-to-face meetings, engaged with other joint industry groups, and completed a planning guide, "Remote Sensing in Support of Oil Spill Response," to assist in the identification of surveillance technologies, sensors, and platforms that could enhance response efforts. The document provides information related to both strategic and tactical response activities. The guide was designed as a practical "Users Guide" as well as a planning and preparedness tool for response personnel that may be required direct surveillance activities.

The group also identified key areas for industry and academia for future research and development, including:

- Quantifying the aerial extent and concentration of oil on the water's surface; and
- Enhancing ways to provide quality-assessed data in near real-time to both field resources and command centers.

In addition, the TWG is currently researching the development of a web-based tool that would aid in the selection of appropriate satellite sensors for a particular response scenario. The group is working with the National Aeronautics and Space Administration (NASA) to customize and expand an existing NASA satellite tool for use during oil spill response.

The TWG plans to continue collaboration and knowledge-sharing with other joint industry projects, and to continue to hold regular meetings to share recent experiences, collaborate on potential technology areas that need development, and disseminate scientific findings in the field of remote sensing that will enhance the capabilities and readiness for response.

## INTRODUCTION:

In response to the Deepwater Horizon (DWH) incident in 2010, a Joint Industry Oil Spill Preparedness and Response (OSPR) Task Force (JITF) was established by the American Petroleum Institute (API) to evaluate the incident response procedures and lessons learned. That same year, the JITF issued the draft report, "Joint Industry Oil Spill Preparedness and Response Task Force Draft Industry Recommendations to Improve Oil Spill Preparedness and Response." The draft report presented preliminary steps for conducting an assessment of the current oil spill program (JITF 2011).

In order to address the recommendations made by the JITF, the API Oil Spill Preparedness and Response Subcommittee (OSPRS) spent several months developing and prioritizing project plans for a multi-year work program funded by members of the oil and gas industry. The JITF subdivided their recommendations into seven work categories, including:

- Planning
- Dispersants
- Shoreline Protection and Cleanup
- Oil Sensing and Tracking
- In-Situ Burning
- Mechanical Recovery
- Alternative Technologies

Individual project teams are currently working on, or have completed, a number of projects within each category. Each project was developed to address a recommendation identified by the JITF and has been undertaken as a collaborative effort among industry, government, and academia (JITF 2011).

## OVERVIEW OF THE OIL SENSING AND TRACKING TECHNICAL WORK GROUP:

A technical working group (TWG), consisting of members from the oil and gas industry and federal and state governments, was formed under the Oil Sensing and Tracking category to assess the utility of remote sensing technology in oil spill response (API 2013). Active members of the Oil Sensing and Tracking TWG include representatives from Aramco Services Company, BP Inc., Cardno ENTRIX, Chevron Energy Technology Company, ExxonMobil Upstream Research Company, ExxonMobil Biomedical Sciences Inc., Marathon Oil, Shell Global Solutions US, Inc., and the U.S. Coast Guard Acquisition Directorate Research & Development Center.

During an initial workshop in early 2011, the Oil Sensing and Tracking TWG identified a need within the oil spill response community for guidance on implementation of remote sensing during an oil spill. Based on their discussions, the TWG initiated a project with the following key elements:

- Hold a series of workshops to identify and develop a deliverable that outlines current and emerging remote sensing technologies for oil spill response
- Research detection capabilities to determine reliability and performance expectations focusing on oil located at or near the water's surface (*assessment of the*

*vertical water column greater than a meter from the water's surface beyond the scope of this TWG*)

- Identify technologies most reliable for indicating the greatest concentrations of oil on the water's surface in order to direct response operations and maximize collection
- Develop a guidance document that evaluates sensing and tracking applications and technologies, and provides recommendations for their use in oil spill response (API 2013)

In order to meet the goals of their project, the TWG held regularly scheduled meetings throughout 2011, 2012, and 2013 to share recent experiences, collaborate on potential technology areas that need development, and to disseminate scientific findings in the field of remote sensing that will enhance the capabilities and readiness for response. The TWG also developed a planning guide, published in September 2013, to assist in the identification of surveillance technologies, sensors, and platforms capable of detecting surface oil slicks and enhance recovery efforts and assist in directing response resources to areas where they can provide the greatest value (JITF 2012). The guide is currently available online ((http://www.spillprevention.org/apijitfreports.html).

## REMOTE SENSING IN SUPPORT OF OIL SPILL RESPONSE – PLANNING GUIDANCE:

The TWG developed the document, "Remote Sensing in Support of Oil Spill Response – Planning Guidance" (API Technical Report 1144, September 2013) to introduce response personnel to oil spill remote sensing technology and to provide guidance on its effective incorporation into spill response operations. The guide is intended as a resource in response planning prior to a spill event, as a tool for planning readiness exercises and drills, and as a reference for responders during exercises and drills. The guide was supported by a snapshot assessment of the current research and emerging trends as of December 2012 that is enclosed as an attachment to the report. The guide provides an overview of how remote sensing should be incorporated into mission support planning for an incident. It also details the actions necessary to integrate remote sensing into an oil spill response. The guide presents five steps for implementing a remote sensing/surveillance program during an oil spill response, as follows:


The guide also includes the report, "Surveillance Technologies for Oil Spill Response: An Assessment of Current Research and Emerging Trends," which was developed to provide an overview of the global remote sensing "state of knowledge", remote sensing technology needs identified during recent spill events, and emerging trends in remote sensing research and development (JITF 2012).

**Understanding How Remote Sensing Supports a Response**

The guide explains the success of most spill response operations is directly linked to effective aerial surveillance and effective use of various remote sensing sensors. It identifies typical objectives for remote sensing systems during the early stages of a response as providing situational awareness at the source; assisting in determining the extent of the release; and providing information to direct the most effective combination of response and recovery methods.

As an incident progresses, the demands on a surveillance program increase, and the program often divides into a tactical and a strategic role. The tactical role includes support to response operations such as mechanical recovery, application of dispersants, controlled *in situ* burning, and shoreline assessments. The strategic role is focused on providing a synoptic overview of the overall extent of the release, identifying resources at risk, and gathering information to assist with prediction and trajectory modeling efforts.

Various remote sensors and technologies are deployed to detect and track oil. The sensors, which are often combinations of different types of sensors, support both tactical and strategic missions. Due to the dynamic nature of most incidents, the timeliness of delivering data from these sensors is critical. Slow delivery and complex processing of remote sensing data may lead to delays in tactical operations or misinterpretation of oil location when response assets are deployed. Therefore, rapid distribution of analyzed and interpreted images and associated data are critical for responders at both the tactical and strategic level to support operational decisions.

**Establish the Remote Sensing Team**

An essential function of a well-trained remote sensing team is supplying accurate and timely information to responders, as well as to the public and their political leadership. The guide explains that the value of remote sensing data is greatly diminished by delays between its acquisition and the production of actionable intelligence, and therefore the availability of well-trained staff able to quickly and accurately integrate multiple sources of information is critical to leveraging remote sensing tools during an oil spill response. The guide discusses the role of the remote sensing team within the Incident Command System (ICS) and the potential need for a Remote Sensing Subject Matter Expert(s) (SME). It also details the responsibilities of the Remote Sensing Team Manager, Remote Sensing Team Specialist, and Remote Sensing SME(s).

**Determine the Appropriate Technology**

According to the guide, although a range of airborne and spaceborne sensors are currently available from both the private and government sectors, each sensor and platform combination contains a balance between utility and availability. For example, synthetic aperture radar (SAR) can image through clouds and requires no solar illumination, but it cannot identify materials on the water’s surface based on their spectral characteristics and often does not provide a unique quantitative solution. As a result, most successful applications of remote sensing technology require the combination of several sensors and data sets to satisfactorily address the unique situation at hand. The guide discusses the process for determining the appropriate remote sensing technology for a specific response situation and describes the existing sensors and platforms available at the time of its publication.

Included in the guide are discussions of how sensors are classified and a table detailing how a user might select a tool to fit their particular response missions (see Table 4-1 below). The remainder of the section is devoted to describing the major categories of sensors (e.g., radar), including what platforms they are compatible with (e.g., satellite), what they are, how they function, when they are and are not effective, "pros", "cons", and additional notes. Additional notes contain other helpful information regarding sensor swath, optimal polarization or other settings, or post-processing needs, etc.

**Table 4-1 Selection of the Appropriate Tool for Marine Spill Response Missions**

| Mission | Appropriate Sensor(s) | Derived Information |
|---|---|---|
| **Initial and Ongoing Synoptic and Tactical Situational Awareness, Spill Tracking, and Monitoring** | 1. Visual observation<br>2. Multispectral imaging<br>3. Thermal imaging<br>3. Synthetic aperture radar<br>4. Side-looking airborne radar | ▪ Extent of spill at time X<br>▪ Location and condition of personnel, resources, and assets at time X<br>▪ Indication of areas of information uncertainty (which areas were not covered by mission or sensor at time X)<br>▪ Indication of areas of information certainty (which areas were covered by mission or sensor at time X)<br>▪ Direction of slick movement<br>▪ Mission route |
| **Spill Trajectory Modeling** | 1. Synthetic aperture radar<br>2. Visual observations (with or without multispectral imaging support)<br>3. Side-looking airborne radar<br>4. Multispectral imaging<br>5. Thermal imaging | ▪ Extent of spill at time X<br>▪ Direction of slick movement<br>▪ Indication of areas of information uncertainty (which areas were not covered by mission or sensor at time X)<br>▪ Indication of areas of information certainty (which areas were covered by mission or sensor at time X)<br>▪ Observable meteorological conditions at time X<br>▪ Sea state at time X |
| **Reconnaissance and Tactical Planning** | 1. Visual observations (with or without multispectral imaging support)<br>2. Multispectral imaging<br>3. Thermal imaging | ▪ Condition of objects or areas of interest at time X<br>▪ Identification of hazards or other topics of interest per mission objectives<br>▪ Topographical and environmental context of objects or area of interest (AOI) at time X<br>▪ Target confirmation (eliminating false positives from other sensors)<br>▪ Mission route |
| **Command and Control** | 1. Visual observations (with or without multispectral imaging support) | ▪ Condition of objects or AOI at time X<br>▪ Identification of hazards or other topics of interest per mission objectives<br>▪ Topographical and environmental context of objects or AOI at time X<br>▪ Mission route |
| **Spill Volume Estimation** | 1. All available surveillance data are used, though primarily for determining the areal component | ▪ Visual appearance of slick at time X<br>▪ Weathered state assessment of slick at time X |

### Table 4-1 Selection of the Appropriate Tool for Marine Spill Response Missions

| Mission | Appropriate Sensor(s) | Derived Information |
|---|---|---|
| | of the volume estimate. Thickness is poorly quantified by remote sensing techniques. | ▪ Estimate of relative thickness<br>▪ Estimate of coverage (% distribution)<br>▪ Location of slick at time X<br>▪ Extent of slick at time X |
| **Determining "Best" Recovery Method** | 1. Visual observations (with or without multispectral imaging support)<br>2. Multispectral imaging<br>3. Thermal imaging | ▪ Visual appearance of slick at time X<br>▪ Weathered state assessment of slick at time X<br>▪ Location of slick at time X<br>▪ Extent of slick at time X<br>▪ Location and condition of personnel, resources, and assets at time X in relation to the slick<br>▪ Mission route |
| **Monitoring Dispersant Efficacy (Spotting)** | 1. Visual observations (with or without multispectral imaging support)<br>2. Multispectral imaging<br>3. Thermal imaging | ▪ Extent, location, and visual appearance of sprayed slick before application of dispersant at time X<br>▪ Extent, location, and visual appearance of slick after dispersant application at indicated time intervals<br>▪ Mission route |
| **Maximizing Volume of Recovered Oil (Skimming )** | 1. Visual observations (with or without multispectral imaging support) | ▪ Extent, location, and orientation (bearing or heading) of recoverable oil at time X<br>▪ Location and condition of personnel, resources, and assets at time X in relation to the recoverable oil<br>▪ Mission route |
| **Management and Monitoring of In-Situ Burning** | 1. Visual observations (with or without multispectral imaging support)<br>2. Multispectral imaging<br>3. Thermal imaging | ▪ Location of burn<br>▪ Footprint of burn at time X<br>▪ Location of staff, resources, and assets at time X<br>▪ Mission route |
| **Public Interest and Public Relations** | 1. All available surveillance data are used. | ▪ The essential information elements for the public interest and public relations use cases are similar to those for ongoing situational awareness, spill tracking and monitoring, and reconnaissance and planning.<br>▪ The information presented is succinct, clear, and self-interpreting to the extent that any media interpretation or commentary cannot misstate the actual facts that are presented in the distributed product.<br>▪ Surveillance and imagery intelligence data presented to the public or the media must be accompanied with factual and correct information about the product, as well as what is shown and what cannot be inferred from the data.<br>▪ Within the constraints of a safe and effective response, this information must be made available freely, rapidly, and as widely as possible.<br>▪ For significant spills, ensure that the responsible |

**Table 4-1 Selection of the Appropriate Tool for Marine Spill Response Missions**

| Mission | Appropriate Sensor(s) | Derived Information |
|---|---|---|
| | | party has information dominance in the social media domain. |
| **Detection and Monitoring of Submerged Oil Mats In Very Shallow Water** | 1. Visual observations (with or without multispectral imaging support)<br>2. Multispectral imaging | ▪ Visual appearance on shoreline or very shallow water (less than 1 meter of water) at location Y at time X<br>▪ Size and appearance of foreign objects, damage and oil substance, and hazards at location Y at time X<br>▪ Location and condition of personnel, resources, and assets at time X in relation to the area imaged<br>▪ Mission route |
| **Shoreline Categorization and Assessment** | 1. Visual observations with multispectral imaging support | ▪ Visual appearance of shoreline or AOI at location Y at time X<br>▪ Size and appearance of foreign objects, impact assessment and oil substance, and hazards at location Y at time X<br>▪ Location and condition of personnel, resources, and assets at time X in relation to the area imaged<br>▪ Mission route |

(Source: API 2013)

## Deploy the Technology

The guide explains that one reason remote sensing is such a useful tool for oil spill response is that its technology can be deployed on a variety of platforms. Depending on the size, timing, and location of an incident, different types of data can be gathered from different platforms. The guide identifies the major types of platforms currently utilized for remote sensing as satellite systems, aircraft systems, unmanned aerial vehicles, tethered balloon systems, and surface vessels. The guide includes a description of each platform, how they work, their "pros" and "cons", and any additional relevant information users should be aware of. Additional notes may contain examples of situations each platform may be most useful for or added capabilities some specific models or systems may include.

## Analyze and Communicate the Data

Once the remote sensing technology has been selected and deployed, it will acquire data in the chosen manner and transmit it to the remote sensing team. The guide explains that the remote sensing team is then responsible for processing and interpreting the acquired data, integrating it with other data sources, and producing a usable product that can effectively communicate the information to the appropriate parties. Often the collected data and images are integrated into a Geographic Information System (GIS) for analysis and displayed in the incident command center on a Common Operating Picture (COP) system. The guide discusses, in detail, the steps necessary to ensure the remote sensing data are communicated accurately. Those steps include image acquisition, analysis, and interpretation; data integration and exploitation; and internal and external data communication.

## ONGOING PROJECTS:

### Collaboration with Other TWGs

In response to the DWH incident, the International Association of Oil and Gas Producers (OGP) and the International Petroleum Industry Environmental Conservation Association (IPIECA) formed a group (similar to the API JITF) that was tasked with identifying potential learnings and recommendations. This group developed a number of Joint Industry Projects (JIPs) that were implemented under a "Surveillance, Modeling & Tracking" work category. Project teams for the JIPs were formed with goals similar to the Oil Sensing and Tracking TWG (OGP IPIECA 2013).

The TWG and OGP-IPIECA project team convene periodically to identify potential areas of collaboration. Collaboration between the two groups is essential to ensuring they provide a consistent body of oil spill remote sensing knowledge to the public, government, and industry. Furthermore, by sharing and reviewing publications the two groups are not only able to provide consistency, but are also able to enhance each other's work with insight and expertise.

### NASA COVE Tool

The TWG coordinated with members of the National Aeronautics and Space Administration (NASA) Langley Research Center to produce a web-based Oil Spill Response Satellite Data Planning Tool. The tool is intended to provide a user-friendly pathway for data discovery and acquisition. The final product will be a variation of NASA's existing CEOS Visualization Environment (COVE) tool, customized specifically to aid during oil spill response efforts. COVE forecasts 72-hour orbital and ground cover information, which allows users to identify which satellite data are available for their region of interest. It will also provide a listing of each satellite's sensors, their capabilities, and the scenarios in which they are most effective. The COVE tool is currently available for use online (www.ceos-cove.org), but not yet optimized for oil spill response use.

## RESPONSE TECHNOLOGY AND ORGANIZATIONAL GAPS:

During the regular meetings held throughout 2011, 2012, and 2013, the Oil Sensing and Tracking TWG identified potential remote sensing "gaps", not only within current response technology capabilities, but also within the ICS. To address these potential technological and organizational gaps, the TWG suggests the following efforts for collaboration among industry, government, and academia be further evaluated:

- During response operations, sensors should be used to quantify the aerial extent and concentration (e.g., thick vs. thin) of surface oil to maximize encounter rate and response performance
- Research and development should be conducted to enhance ways to provide processed data in near real-time for the COP
- Continue to encourage efforts to develop integrated sensor systems that can be adapted for multiple platforms.
- A Remote Sensing role should be incorporated into the Planning Section of the Incident Command System. The individual selected for the Remote Sensing role should possess a thorough understanding of:

- The capabilities and availability of providers
- The strengths and limitations of the sensors
- The fundamentals of data analysis and interpretation

**SUMMARY:**

Since its inception in September 2010, the Oil Sensing and Tracking TWG has held routine meetings to share recent experiences with remote sensing surveillance issues, collaborate on potential technology areas that need research and development, and disseminate new scientific findings. They have also held various meetings and workshops to drive the production of deliverables to meet the goals set forth by the OSPRS. The TWG's key deliverable, "Remote Sensing in Support of Oil Spill Response – Planning Guidance" (API Technical Report 1144) has been completed and was made available to the public in September 2013. In addition, the TWG is collaborating on a project currently underway with NASA to create a user-friendly oil spill response satellite selection tool to assist with selecting the most appropriate satellite platform and associated sensor for various tasks. Furthermore, the TWG continues to work together with other international oil and gas industry groups, commercial vendors, and various governmental agencies to enhance the field of remote sensing specifically in support of oil spill prevention, preparedness and response.

**ACKNOWLEDGEMENTS:**

The authors would like to acknowledge and give recognition to the remaining members of the TWG that participated in the API OSPR JITF on Oil Sensing and Tracking: Dirk Greene, Marathon Oil; Kurt Hansen, U.S. Coast Guard Acquisition Directorate Research & Development Center; Wolfgang Konkel, ExxonMobil Biomedical Sciences, Inc.; Robert LeFevers, Aramco Services Company; Buzz Martin, Shell Global Solutions US, Inc.; and Andrea Steffke, Chevron Energy Technology Company. Their insight, persistence, talent, and dedication drove the development and finalization of the Remote Sensing in Support of Oil Spill Response – Planning Guidance (API Technical Report 1144) on which a majority of this paper was based. The advancement of the report was a true team effort, with collaboration coming from not only the members of the TWG but also our colleagues in various industry and governmental groups. The authors would also like to recognize Joan Lynn (Egret, Inc.) for her herculean efforts to edit, format, and finalize the report.

**REFERENCES:**

American Petroleum Institute (API). 2013. Remote Sensing in Support of Oil Spill Response – Planning Guidance. API Technical Report 1144.

International Association of Oil and Gas Producers, International Petroleum Industry Environmental Conservation Association (OGP IPIECA). 2013. Oil Spill Response Joint Industry Project (OSR-JIP). Retrieved from: http://oilspillresponseproject.org/

Joint Industry Oil Spill Preparedness and Response Task Force (JITF). 2012. Second Progress Report on Industry Recommendations to Improve Oil Spill Preparedness and Response. Retrieved at: http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Exploration/Offshore/OSPR-JITF-Project-Progress-Report.pdf

Joint Industry Oil Spill Preparedness and Response Task Force (JITF). 2011. Progress Report on Industry Recommendations to Improve Oil Spill Preparedness and Response. Retrieved at: http://www.api.org/~/media/Files/Oil-and-Natural-Gas/Exploration/Offshore/OSPR-JITF-Project-Progress-Report-Final-113011.pdf