



10-2015

2015 Oil Observing Tools: A Workshop Report

Coastal Response Research Center (CRRC)

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Coastal Response Research Center (CRRC), "2015 Oil Observing Tools: A Workshop Report" (2015). *Coastal Response Research Center*. 18.
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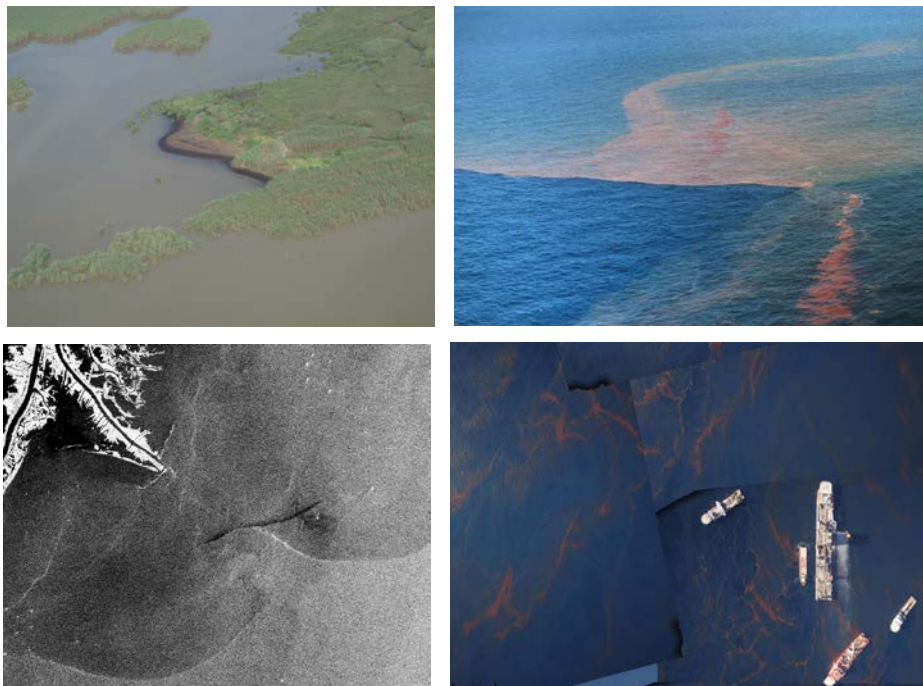


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OIL OBSERVING TOOLS WORKSHOP REPORT

OCTOBER 20 -22, 2015

COASTAL RESPONSE RESEARCH CENTER



The findings and conclusions in this report are those of the workshop participants and do not necessarily represent the view of NOAA.

Acronyms

ADIOS	Automated Data Inquiry for Oil Spills
AIS	Automatic Identification System
API	American Petroleum Institute
ARD	Assessment and Restoration Division
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVIRIS	Airborne Visible Infrared Imaging Spectrometer
AVIRIS NG	Airborne Visible Infrared Imaging Spectrometer Next Generation
BRI	Bubbleology Research International
BSEE	Bureau of Safety and Environmental Enforcement
CA DFW	California Department of Fish and Wildlife
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization
CGA	Clean Gulf Associates
COP	Common Operating Picture
COTP	Captain of the Port
CRRC	Coastal Response Research Center
DMSC	Digital Multi-Spectral Camera
DWH	Deepwater Horizon
ERD	Emergency Response Division
ERMA®	Environmental Response Management Application
FOSC	Federal On Scene Coordinator
FOSTERRS	Federal Oil Spill Team for Emergency Response Remote Sensing
FSU	Florida State University
GIS	Geographic Information System
GNOME	General NOAA Operational Modeling Environment
GPS	Global Positioning System
HD	High Definition
HICO	Hyperspectral Imager for the Coastal Ocean
HSRL	High Spectral Resolution Lidar
ICS	Incident Command System
IPIECA	International Petroleum Industry Environmental Conservation Association
IR	Infrared
ISODATA	Iterative Self-Organizing Data Analysis Technique Algorithm
KSAT	Kongsberg Satellite Services
LWIR	Long Wave Infrared
MARPLOT	Mapping Application for Response, Planning, and Local Operational Tasks
MDA	MacDonald Dettwiler & Associates Ltd
MODIS	Moderate Resolution Imaging Spectroradiometer
MPSR	Marine Pollution Surveillance Reports
MSRC	Marine Spill Response Corp
MWIR	Mid Wave Infrared
NASA	National Aeronautics and Space Administration
NCP	National Contingency Plan

NESDIS	National Environmental Satellite Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
NRDA	Natural Resource Damage Assessment
NRL	Naval Research Laboratory
NRMRL	National Risk Management Research Laboratory
OCAP	On-Call Acquisition Planner
OEDA	Oil Emulsion Detection Algorithm
OGP	Oil and Gas Producers Association
Ohmsett	Oil and Hazardous Materials Simulated Environmental Test Tank
ORR	Office of Response and Restoration
OSPO	Office of Satellite and Product Operations
OSRL	Oil Spill Response Limited
OSRO	Oil Spill Response Organization
SAR	Synthetic Aperture Radar
SMART	Special Monitoring of Applied Response Technologies
SOP	Standard Operating Procedure
SPSD	Satellite Products and Services Division
SWIR	Short Wave Infrared
TCNNA	Texture-Classifying Neural Network Algorithm
TIR	Thermal Infrared
TM	Thematic Mapper
TRACS	Tactical Rapid Airborne Classification System
UAF	University of Alaska Fairbanks
UAS	Unmanned Aircraft System
UAVSAR	Uninhabited Aerial Vehicle Synthetic Aperture Radar
UNH	University of New Hampshire
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
USF	University of South Florida

Acknowledgements

The content for this workshop was developed by the CRRC* in partnership with NOAA ORR and the following Organizing Committee members:

George Graettinger, NOAA ORR, ARD, Spatial Data Branch
 Charles Henry, NOAA ORR, Gulf of Mexico Disaster Response Center
 Nancy Kinner, CRRC, UNH
 Jeffrey Lankford, NOAA ORR, ERD, Technical Services Branch

ORR is NOAA's primary office charged with responding to oil spills, hazardous material releases, and marine debris. ORR is tasked with providing the science and information needed to support the USCG during spills and coordinating with federal, state, and tribal natural resource trustees to restore coastal resources damaged by those spills. ORR maintains an interdisciplinary team to forecast the movement and behavior of spilled oil and chemicals, evaluate the risk to resources, and recommend protective and cleanup actions. The office also provides training, prepares and tests spill response contingency plans, and conducts research to improve response capabilities.

The workshop was facilitated by Dr. Nancy Kinner, the UNH Co-Director of the CRRC (www.crrc.unh.edu). CRRC focuses on issues related to All Hazards, and has extensive experience with hydrocarbon spills. The Center is known for its independence and excellence in environmental engineering, marine science, and ocean engineering in regards to spills and other hazards. CRRC has conducted numerous workshops bringing together researchers, practitioners, and scientists of diverse backgrounds (government, academia, industry, and non-governmental organizations) to address issues in spill response, restoration and recovery.

We wish to thank all presenters for their participation in the workshop:

Robyn Conmy, USEPA, NRMRL	Cathleen Jones, NASA Jet Propulsion Laboratory
Carles Debart, KSAT	Jeffrey Lankford, NOAA ORR, ERD
Lisa Dipinto, NOAA ORR, ARD	Ira Leifer, BRI
Sonia Gallegos, NRL	James Litzinger, USCG, Gulf Strike Team
Oscar Garcia, Water Mapping, LLC	Scott Lundgren, NOAA ORR, ERD
George Graettinger, NOAA ORR, ARD	Judd Muskat, CA DFW Spill Prevention and Response
James Hanzalik, USCG FOSC (Ret.), CGA	Mark Roberts, U.S. Army Night Vision & Electronic
Mark Hess, Ocean Imaging	Sensors
Jamie Holmes, Stratus Consulting	Gordon Staples, MDA
Kevin Hoskins, MSRC	Davida Streett, NOAA NESDIS OSPO SPSPD
Chuanmin Hu, USF, College of Marine Science	Jean Teo, OSRL
Michele Jacobi, NOAA ORR, ARD	Mark Thomas, USEPA ASPECT

We would like to thank the following individuals who helped lead or record for the breakout groups:

Laura Belden, UNH	Tim Gallagher, NOAA	Peter Murphy, NOAA
Drew Casey, USCG	Jessica Garron, UAF	Judd Muskat, CA DFW
Robyn Conmy, USEPA	JB Huyett, NOAA	Lexter Tapawan, NOAA
Samira Daneshgar, FSU	Scott Lundgren, NOAA	Cory Rhoades, NOAA

*A list of Acronyms is provided on Page 1 of this report.

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1.0 Introduction

Since 2010, the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) have provided satellite-based pollution surveillance in United States waters to regulatory agencies such as the United States Coast Guard (USCG). These technologies provide agencies with useful information regarding possible oil discharges. Unfortunately, there has been confusion as to how to interpret the images collected by these satellites and other aerial platforms, which can generate misunderstandings during spill events. Remote sensor packages on aircraft and satellites have advantages and disadvantages vis-à-vis human observers, because they do not “see” features or surface oil the same way. In order to improve observation capabilities during oil spills, applicable technologies must be identified, and then evaluated with respect to their advantages and disadvantages for the incident. In addition, differences between sensors (e.g., visual, IR, multispectral sensors, radar) and platform packages (e.g., manned/unmanned aircraft, satellites) must be understood so that reasonable approaches can be made if applicable and then any data must be correctly interpreted for decision support.

NOAA convened an Oil Observing Tools Workshop to focus on the above actions and identify training gaps for oil spill observers and remote sensing interpretation to improve future oil surveillance, observation, and mapping during spills. The Coastal Response Research Center (CRRRC) assisted NOAA’s Office of Response and Restoration (ORR) with this effort. The workshop was held on October 20-22, 2015 at NOAA’s Gulf of Mexico Disaster Response Center in Mobile, AL. Attendance at the workshop was by invitation only. Invitees were determined by consensus of the workshop organizing committee based on the expertise each could bring to the workshop discussion. Participants at the workshop included representatives of industry, government, and academia on regional, national, and international levels who have a wide array of experience related to oil observation tools (Participant list in Appendix B).

The expected outcome of the workshop was an improved understanding, and greater use of technology to map and assess oil slicks during actual spill events. Specific workshop objectives included:

- Identify new developments in oil observing technologies useful for real-time (or near real-time) mapping of spilled oil during emergency events.
- Identify merits and limitations of current technologies and their usefulness to emergency response mapping of oil and reliable prediction of oil surface transport and trajectory forecasts. Current technologies include: the traditional human aerial observer, unmanned aircraft surveillance systems, aircraft with specialized sensor packages, and satellite earth observing systems.
- Assess training needs for visual observation (human observers with cameras) and sensor technologies (including satellites) to build skills and enhance proper interpretation for decision support during actual events.

The workshop consisted of plenary sessions, a series of hands-on training stations, and group breakout discussions (Agenda in Appendix A). It commenced with initial introductions and presentations on the need for oil observing in response, and current operational programs, oil observing tools, and data analysis. The participants were divided into groups for hands-on training on (1) traditional high resolution photography and video, (2) synthetic aperture radar (SAR), (3) Landsat/Tactical Rapid Airborne Classification System (TRACS), (4) balloons and vessels, and (5) night vision. Day 2 began with

plenary presentations on new technologies and applications. The participants returned to groups for breakout sessions, identifying needs and gaps in oil observing technology, and subsequently performing a gap analysis on selected topics. The discussions/answers from each breakout group were summarized and presented to all participants during the following plenary sessions. Day 3 began with each individual ranking priorities for future oil observing tools, developments, and next steps (the potential solutions identified in the gap analyses the previous day). Then, the breakout groups discussed recommendations for a job-aid that could be developed regarding oil observing. The workshop concluded with breakout groups reporting on their discussions and several individuals were asked to summarize the workshop.

2.0 Plenary Sessions

A summary of each presentation from the workshop is provided below. Slides for the presentations are available in Appendix D.

2.1 Need for Oil Observing in Response

2.1.1 Scott Lundgren, NOAA ORR, ERD

Scott Lundgren discussed the need for oil observing in response primarily from the perspective of NOAA's ERD. For example, he discussed ERD's role in scientific support coordination reporting directly to the Unified Command, and the Environmental Unit of the Planning Section. He noted the associated oil observation needs to perform those roles and identified five key questions that need to be answered during a response: (1) What happened? (2) Where could the oil go? (3) What could it affect? (4) What harm could it cause? and (5) What can be done to help minimize the damage? Oil observations during a response are critical to help inform and answer questions #2 and #5 in terms of developing oil spill trajectory projections and determining what can be done to address the situation and reduce impacts. In order to do that effectively, information regarding oil observations needs to be accurate and timely. The oil detection information can be used to create a Common Operating Picture (COP), perform trajectory modeling, identify resources at risk, and provide on-water response support. Lundgren briefly reviewed some of the existing resources, tools, and technologies available to responders, and reminded the group that the majority of spills are relatively small scale spills where more basic technology is used. However, technology is moving quickly and the Deepwater Horizon (DWH) spill allowed for technology to expand into new arenas and for new technologies to be tested, as most spills are orders of magnitude below the volume and flow of the DWH spill.

2.1.2 James Litzinger, Gulf Strike Team, USCG

The USCG can act as the Federal on Scene Coordinator (FOSC) and Captain of the Port (COTP) during a spill. Litzinger explained the applicable regulations and authorities that could apply in an oil spill response. The National Contingency Plan (NCP), which gives the FOSC certain authorities, has four general priorities: (1) give safety and human health top priority, (2) stabilize the situation in order to prevent the event from worsening, (3) use all necessary containment and removal tactics in a coordinated manner to ensure timely, effective response, and (4) take action to minimize further environmental impact from additional discharges. The goals of the emergency response are to minimize

the adverse impacts of the incident and to maximize public confidence and stakeholder satisfaction (by doing a good job and communicating well). USCG officials need oil observation information during a response to perform their duties as FOSC and COTP. They use a lot of information from aerial observations, NOAA's Environmental Response Management Application (ERMA®), and USEPA to make decisions during a spill. Remote sensing oil observations provide the COP, without which the odds of a successful response are lower. Oil observing is used to develop the best strategies and tactics to respond to the threat and minimize adverse impacts. For example, a plane cannot put dispersants on an area of oil, or a boat place boom to catch the leading edge of a spill, without knowing where the oil is going. The USCG also uses oil observations when choosing the best enforcement action(s).

2.1.3 Lisa DiPinto, NOAA ORR, ARD

Lisa DiPinto presented information on how oil observation data are important during response from the damage assessment and restoration perspective. Under the Oil Pollution Act (1990), Natural Resource Damage Assessment (NRDA) must: (1) determine the amount of injury to natural resources and lost services from the time of the incident through recovery of resources, (2) develop and oversee implementation of restoration plan(s) to compensate the public and natural resources for injuries and lost services, and to ensure the polluters pay for assessment and restoration. To perform injury assessments, oil observations are needed to assess: (1) surface oiling "footprints" of exposure, (2) percent cover of oil within the footprint, (3) persistence of surface oiling for exposure duration, and (4) surface oil thickness. Even sheens must be observed and documented because they may be toxic. In some cases, qualitative information is sufficient, but in many cases detailed information such as thickness and percent water in the slick are required. NOAA has used synthetic aperture radar (SAR) and aerial imagery together to document oiling for NRDA, which provided additional information regarding exposure in the nearshore environment that they would not have had otherwise. Ideally, future field sampling would collect many types of samples at once (e.g., satellite, overflight, surface water, subsurface water gradient, air gradient, slick thickness) so that as complete a picture as possible can be generated.

2.2 Current Operational Programs

2.2.1 NOAA ORR Oil Observing Program and Tools – Jeff Lankford, NOAA ORR, ERD

Jeff Lankford discussed NOAA ORR's current oil observing program. A large component of this involves human observers in airplanes or helicopters documenting their findings with notes and photographs. Overflights collect a variety of information related to the spill: location and size of the oil slick, oceanographic features (e.g., currents, convergence lines, rip tides), environmental conditions (e.g., winds, currents, visibility), and presence of wildlife in the vicinity. Human observations can also help identify false positives (e.g., kelp beds, sargassum, cloud shadows, natural slicks) and validate or recalibrate models. An overflight map is created using the observer's notes, photographs, and Global Positioning System (GPS) trackline. The map is available approximately one hour after the flight is completed. The advantages of human observation include: a fast turnaround for results, real-time decisions regarding where the aircraft should go, fairly accurate detection of the size of the spill by

trained observers, the ability to conduct multiple flights per day and deploy tracking devices, and flexibility for use in rivers and lakes. Factors that can limit or prevent flights or observations include: poor weather conditions, equipment failure, limited pool of trained observers (i.e., there are not many available), use only during daylight hours, limited distance and time from home base, or delays encountered in generating the post-flight map. Flights are limited to 2 to 3 hours due to time restrictions and fuel capacity, and observations are limited to where the plane traveled. Lankford provided a list of equipment needed for overflights, and noted that observers bring backup equipment (e.g., GPS, cameras). He expects that future needs will be constrained by time and funding, but suggests a hand-held data tracker (e.g., tablet) would be useful to speed availability of information to decision makers. In addition, there is a lot of bureaucracy to address prior to flying an aircraft and using human observers (e.g., contracts, agreements, approvals). If these were streamlined, it could occur more quickly, more often, and would facilitate training additional observers. It was noted during the Q&A period that NOAA does not have a formal protocol to standardize aerial observations and photography.

2.2.2 NOAA NESDIS-MPSR and Remote Sensing for Surface Oil Assessment – Davida Streett, NOAA NESDIS OSPO SPSP Satellite Analysis Branch

Davida Streett discussed the Marine Pollution Program operated within the NOAA NESDIS Satellite Analysis Branch. The NESDIS program operates continuously (24, 7, 365) and provides satellite imagery and analysis for a variety of hazard mitigation programs. Marine Pollution Surveillance Reports (MPSR) provide spill and dumping monitoring for huge areas, and can be the first warning of a spill. A variety of ancillary data are used to reduce false results. NESDIS data can be used to (1) provide input to oil spill trajectory models, (2) compare results from various models, (3) verify areas that do not need spill response (i.e., there is no oil), (4) reassure the public that areas are being monitored daily, (5) determine where overflights should be performed, (6) provide coverage when aircraft cannot fly due to weather, and (7) provide resources for use by the media during high profile spills. NESDIS data are often the primary means of developing a synoptic picture of very large spills.

The biggest limitation for routine monitoring (e.g., releases from ships) is lack of available imagery, which is especially limited at night and under cloud cover when most of these events occur. For moderate spills, there is a little more imagery available (with some delay). The possibility of having the National Geospatial-Intelligence Agency task commercial satellites to collect such data would be a big improvement. During large spills, an International Disaster Charter is activated, so member countries provide imagery for free. While the amount of imagery vastly increases, challenges still remain in how to integrate this information into the response, because it is unfamiliar and has format issues. Streett identified the need for (1) more imagery in a timely manner (2) a quick/approximate method of determining oil thickness (distinguish sheens from recoverable oil) (3) experience/algorithms/ collaborative framework/user interactions/education to eliminate false results, particularly in the Arctic where there is little experience.

Ongoing collaborations (e.g., Federal Oil Spill Team for Emergency Response Remote Sensing [FOSTERRS]) encourage interagency cooperation to ensure that during a spill oil observing techniques

and imagery can be quickly, effectively, and seamlessly used to support the response. FOSTERRS is interested in ensuring that new technologies are developed where existing ones do not meet responders' needs.

2.2.3 USEPA ASPECT – Mark Thomas, USEPA

Mark Thomas discussed the current capabilities and proposed enhancements to the USEPA's Airborne Spectral Photometric Environmental Collection Technology (ASPECT) remote oil detection system. It provides 24/7 emergency response capability and is activated with one phone call. An aircraft takes off within one hour of activation, and can collect chemical, radiological, and imagery data. Once data are collected, it takes approximately 5 minutes to process onboard and provide oil location and relative thickness to first responders. ASPECT products are provided in Google Earth/Maps and ESRI formats. ASPECT costs \$1,300 per flight hour. Due to difficulties with traditional aerial photography (e.g., low oil to water contrast, high glare/glint contamination, day light dependent, difficulty in interpretation), the open ocean detection system uses multispectral infrared imaging systems (which also allows for nighttime use). An Iterative Self-Organizing Data Analysis Technique Algorithm (ISODATA) method is useful and permits various levels of oil content/water content to be contoured. Shallow water oil detection is complicated by the thermal environment of near shore waters, and therefore requires the use of multispectral multivariate methods. The program has found that spectral pattern recognition is most effective in this case. More information on ASPECT sensors, systems, methods, coverage areas, resolution, and speed of coverage can be found in the presentation slides (Appendix D). Mr. Thomas also reviewed planned upgrades to ASPECT, including the imaging sensors (expected March 2016) and software (expected late 2016). The software should be able to support oil spill response efforts ranging from tropical waters to Arctic ice.

2.2.4 NASA Programs – Cathleen Jones, NASA Jet Propulsion Laboratory

Cathleen Jones gave an overview of current NASA programs on oil observation including a table showing existing spaceborne instruments and satellites (Moderate Resolution Imaging Spectroradiometer [MODIS], Advanced Spaceborne Thermal Emission and Reflection Radiometer [ASTER], Multi-Angle Imaging SpectroRadiometer [MISR], Hyperspectral Imager for the Coastal Ocean [HICO], Cloud-Aerosol Lidar with Orthogonal Polarization [CALIOP]) and details of each (e.g., bands, resolution, swath). MISR combines different viewing angles/directions and bands to help detect false positives (e.g., distinguish oil from clouds). Jones provided a similar table of airborne sensors (Airborne Visible Infrared Imaging Spectrometer [AVIRIS], Uninhabited Aerial Vehicle Synthetic Aperture Radar [UAVSAR], High Spectral Resolution Lidar [HSRL]) along with images from each technology. During the DWH spill, NASA analysts were able to quantitatively map thickness of oil using AVIRIS. UAVSAR is NASA's L-band synthetic aperture radar. UAVSAR is very good for monitoring oil spills because it has a very fine resolution, quad polarization, and a high signal to noise ratio. It "sees" through clouds, fog, and storms, and data collected during the DWH spill was used to develop a method to quantify the oil volumetric fraction. It can distinguish where oil has landed on beaches and along vegetated shorelines in wetlands, and can be used to identify newly oiled areas overnight.

Oil can be difficult to distinguish from new/thin sea ice using SAR, however, recently published work (Brekke, 2014) has yielded promising methods. NASA is interested in developing this capability further to study and respond to oil on ice spills. With respect to logistics, UAVSAR flight cost is \$3,000/hour for NASA-approved users. NASA is working with other agencies to facilitate rapid response using UAVSAR. If the UAVSAR aircraft is available, the instrument can be deployed within 24 hours. NASA recommends that NOAA communicate ahead of time if they may want to use UAVSAR. The instrument is designed for portability to different platforms, and products are usually available in 24 hours. NASA participated with UAVSAR in a Norwegian oil-on-water spill exercise in June 2015 that involved controlled releases of oil in the North Sea. Goals included: (1) studying slick development, transportation, and weathering; (2) characterizing volumetric oil fraction of slicks using polarized SAR; (3) differentiating mineral oil spills from biogenic slicks using SAR; and (4) evaluating onboard processing capability. This research will advance the use of SAR for spill response.

Q&A

Some of the discussion emphasized the need for oil remote sensing to identify “recoverable oil”. The term “recoverable oil” depends on what method of response is used (e.g., in situ burning, skimming, dispersant application) and the resources available (e.g., the grade of the skimming equipment). In some cases, knowing where the heaviest oil is located is sufficient (without detailed measurements). In other cases, knowing the oil volume per pixel (or another related measurement) would be ideal.

2.3 Current Oil Observing Tools and Data Analysis

2.3.1 SAR – Gordon Staples, MDA and Oscar Garcia, Water Mapping LLC

Gordon Staples discussed spaceborne radar capabilities, and data acquisition, processing, and delivery. Spaceborne radar is an established tool for emergency response that can provide situational overview, broad coverage area, relatively low cost, easy deployment, and all-weather day and night imaging. Oil slicks are detected from the images using a combination of analyst knowledge and algorithms. Data can be provided in many formats (e.g., Geo TIFF, PDF, SHP, KML) and provide information on surface area of the spill, wind speed and direction, and locations of vessels and infrastructure. Spaceborne radar analysis can be integrated into ERMA® and combined with other data to form a COP. The time from the initial request until delivery of the product varies, but can be obtained in four hours during an emergency.

Oscar Garcia presented his work using satellite remote sensing to study the 11 year old Taylor Energy oil leak in the Gulf of Mexico. He presented a table of current and future sources of SAR data, and images from four sensors for the same oil slick conditions. He stressed that an aerial observer should always confirm the SAR data. Garcia believes that SAR can detect the presence/absence of oil and emulsions, including relative thickness. He recommended using the Taylor Energy site to test/compare oil remote sensing technologies, as well as experiments at the Bureau of Safety and Environmental Enforcement’s (BSEE) Oil and Hazardous Materials Simulated Environmental Test Tank (Ohmsett) facility.

2.3.2 Landsat/TRACS – Mark Hess, Ocean Imaging and Kevin Hoskins, MSRC

Mark Hess and Kevin Hoskins stressed the importance of multi-level, tactical remote sensing to efficiently put response resources in the best location (day and night) to recover oil. In past spill experience, responders have been less interested in a numerical value of oil thickness vs. knowing the location of “recoverable” oil. In order to do this, real-time tactically-oriented information is needed quickly (e.g., identifying and tracking actionable oil). The Ocean Imaging-Marine Spill Response Corp (MSRC) “ABC” (Aircraft-Balloon-Close-in) remote sensing strategy was developed specifically for this purpose. Rapidly deployable portable tools, based on multiple sensors and platforms, provide an oil spill mapping system that combines thickness estimates from visual oil spill surveys with digital capabilities (e.g., thermal imaging) for real-time direction of recovery assets as well as near-real-time input into the COP. This combination provides greater spatial detail and uses wavelengths outside those in the human range. Combined visible multispectral and thermal-infrared (IR) imagery provided by Ocean Imaging’s TRACS system improves thickness measurements, oil characterization, and location capability. One challenge is getting information distributed to the on-water responders quickly and efficiently. Ocean Imaging and MSRC are researching technologies that can provide efficient, moderate-cost air-to-ground communication links to deal with this challenge. The “B” and “C” components of the ABC system allow the responding vessels to further hone in on the oil deemed most actionable oil.

2.3.3 AVIRIS Next Generation – Ira Leifer, BRI, presented by Chuanmin Hu (USF)

Chuanmin Hu presented Ira Leifer’s information on AVIRIS Next Generation (AVIRIS NG) and its use in the Refugio Incident Spill. AVIRIS NG has better geolocation, finer resolution, and an improved signal to noise ratio than AVIRIS. While AVIRIS NG was used during the Refugio spill, it was not until several days into the incident, when oil slicks were minimal. AVIRIS NG maps contaminated areas by matching target spectra (e.g., the spectral signature from a laboratory oil) to observed spectra (actual observed spectral signature of oil in environment). Other materials besides floating oil, such as sargassum or debris/trash, can also be identified by their spectra, helping to identify false positives. The primary application demonstrated for AVIRIS NG in the spill was beach tar mapping. AVIRIS NG had a spatial resolution of 30 cm at the altitude flown and can map 30 km of beach in 30 minutes, and provide real-time data telemetry to Incident Command.

2.3.4 Oil Spill Response Limited (OSRL) – Jean Teo, OSRL

Oil Spill Response Limited (OSRL) is an industry-funded international (outside the U.S.) organization that provides oil spill preparedness and response services. Jean Teo gave an overview of OSRL’s oil observing tools including satellite imagery, tracking buoys, trained observers, and aviation platforms. CarteNav AIMS is a software that overlays key information to assist with response tasking. It quantifies the extent of the oil slick and relays real-time information (e.g. images, slick perimeter) to ground stations. For satellite imagery, OSRL and MDA work together to provide radar imaging and optional visual capability. On average, there are two satellite overpasses globally per day. Buoys are used to track and monitor surface oil using a bi-directional iridium satellite system. Trained observers use a camera and GPS, and employ quantification tools such as the Bonn Agreement Oil Appearance Code. OSRL combines

different technologies (e.g., oil spill modeling, satellite imagery, digital mapping) to increase the usefulness of the visual observation reports. In 2014, OSRL participated in an exercise which released oil and diesel fuels into United Kingdom waters. Various vessels, equipment, technologies, and overflights monitored movement of the oil, its recovery, and dispersant effectiveness. Lessons learned included that surveillance and modeling are essential for effective containment and dispersant operations, and that integrating numerous data sources into useful intelligence is extremely valuable, but requires significant planning to ensure timely and comparable data.

2.3.5 Night Vision Applications – Mark Roberts, U.S. Army

Mark Roberts discussed available night vision (infrared) applications the U.S. Army and BSEE are developing that could allow oil spill response operations to be more effectively conducted in low light environments. Near infrared is what is most commonly referred to as “night vision”, with the signature green hue. Lower quality but very effective analog-based night vision goggles are even available at stores (e.g., Walmart). Digital technologies have advantages over analog, such as allowing for post processing, and information can be sent directly to a command post for evaluation. Currently for low light and degraded environments, sensor technology is available in near infrared, short wave infrared (SWIR), mid wave infrared (MWIR) and long wave infrared (LWIR). Using SWIR, water appears opaque so the viewer sees what is on top of it. SWIR is expensive and still a relatively new sensor but from an airborne platform it is very useful to distinguish false positives (e.g., vegetation). MWIR, used mostly in aircraft, offers higher resolution in degraded environments, but is expensive because the detectors require cooling. LWIR technology shows the most promise for oil detection, identification, and thickness estimates. LWIR can be used in less than ideal weather conditions, and uncooled sensors allow for smaller and lower cost sensors. Overall, a multispectral approach with real-time post processing is the most promising for oil observation during spill response. However, he did not feel a true hyperspectral sensor is needed due to cost and the few wavelengths that are actually needed to detect and quantify oil on water during a spill response.

2.4 New Technologies/New Applications

2.4.1 NASA Out-Year Planning & Expectations – Sonia Gallegos, NASA, presented by Cathleen Jones, NASA

Cathleen Jones presented information from Sonia Gallegos on NASA out-year planning and expectations. All information from NASA is summarized in Section 2.2.4.

2.4.2 NRDA/Assessment Use: DWH Multi-sensor Assessment - Jamie Holmes, Stratus Consulting

Jamie Holmes discussed how data integration from multiple sensors was used for the DWH damage assessment. SAR provides the greatest sensor coverage (i.e., northern Gulf of Mexico nearly every day). MODIS offers advantages such as high spatial and temporal coverage, and published methods for detecting oil. However, MODIS has coarse resolution and is subject to weather limitations. Landsat Thematic Mapper (TM) has a relatively high resolution, but has limited temporal coverage (i.e., one

image every 8 days during DWH) and also has weather limitations. AVIRIS has high resolution and is hyperspectral, though has narrow flight lines (i.e., limited spatial coverage), limited temporal coverage (i.e., only one day during DWH), and weather limitations. Ocean Imaging's Digital Multi-Spectral Camera (DMSC)/Thermal Infrared (TIR) imager has a high resolution and almost daily imagery, but does have weather limitations and narrow flight lines. Thick oil could be discerned using the high resolution sensors (AVIRIS and DMSC) and thick oil could be inferred in the more coarse satellite data using similar spectral relationships similar to those in the high resolution imagery. There is also a SAR analysis method for detecting emulsions. The Oil Emulsion Detection Algorithm (OEDA) was used during the DWH NRDA to delineate thick, heavy oil emulsions. A multi-sensor integrated model was developed for the DWH NRDA to create a single integrated product using the best available data and provide a rough thickness assessment, although the model was not completed before the DWH settlement occurred. For future incidents, more synoptic sampling and ground-truthing of remote sensing imagery should be collected. Overall, using remote sensing data to estimate adverse impacts on biota is a challenge (due to low resolution of the data) but has significant potential going forward.

2.4.3 NRDA/Assessment Use: DWH SAR Applications – George Graettinger, NOAA ORR, ARD

George Graettinger discussed the application of SAR for NRDA. A NRDA assessment requires demonstration of causality (i.e., the oil causing injury). A key component of this is determining exposure, and SAR can help with this assessment by documenting the extent of surface and potential shoreline oiling. SAR oiling features can also add value to traditional assessment techniques and modeling (e.g., SCAT, pre/post oiling screening). NOAA NESDIS created oil footprints for almost every day of the response, primarily using SAR data. During the DWH response SAR oiling extent assessment was performed manually by NESDIS analysts. However, during the DWH Damage Assessment a semi-automated approach was developed and deployed. This automated approach, known as the texture-classifying neural network algorithm (TCNNA) pre-processes images prior to final assessment by the analyst. This process produced more consistent delineations in a more timely fashion. NESDIS and a team from Florida State University (FSU) jointly developed TCNNA and first published the method in 2009. SAR TCNNA derived sensor products include daily composites, a cumulative composite, cumulative days of oiling, days of shoreline oiling, and time of oiling. Images of these products were shown during the presentation. Days of shoreline oiling defines initial near shore exposure dates, and characterizes the duration and persistence for potentially exposed shorelines. A time of oiling shoreline grid allows water and sediment samples (characterizing chemical concentrations) to be rapidly filtered for pre/post oiling conditions. The use of SAR data helps prioritize NRDA assessment efforts for habitats and species assemblages at the greatest risk of exposure. Current and emerging applications of SAR data will provide significant support to the NRDA process in future incidents. Because medium to large response and assessment efforts often rely on SAR data, it is important to coordinate between the Unified Command and Agency technical experts to ensure that the use of these data are understood and then to collect, analyze, and deliver the appropriate information efficiently.

2.4.4 UAS Potential Use & Limitations – Michele Jacobi, NOAA ORR, ARD

Michele Jacobi presented on Unmanned Aircraft Systems (UAS) potential uses and limitations. UAS can be helpful for response and assessment data by accessing areas that may be difficult to reach (e.g., issues of distance or safety). A UAS survey could collect a variety of information including: oil coverage/extent, convergence zones, sensitive habitats, targeted species, socio-economic impacts, marine debris, ephemeral data collection, and images for use in public outreach. A UAS has similar weather limitations to manned aircraft. NOAA has tested UAS deployments for oil observing and resources observations, as well as during the Refugio (CA) oil spill. The NOAA Puma UAS covered a large portion of the spill area during the Refugio incident in a single day, but the resolution was not adequate and outputs could not be spatially rectified. The Puma High Resolution Nadir camera also was tested and produced a high resolution geo-rectified image for Refugio. Ideally, Geo Tiffs would be available for input into the ERMA® COP within 30 minutes of the end of the flight and derived products within four to six hours. That delivery specification has proved difficult, (though industrial representatives said this was possible). Working through all the logistics of flying a UAS can be challenging, involves a high degree of coordination for approvals, and may not be practical if other manned air operations are occurring during an incident. A contracting vehicle is needed so that funding within the appropriate Incident Command System (ICS) structure can occur quickly. Further evaluation is needed regarding UAS collection platforms, mission needs, and improved information flow. Jacobi presented a table outlining mission requirements. Again, the improvement of information flow and pre-planning between ERD and ARD is essential.

2.4.5 KSAT – Multi-Mission Near Real-Time Satellite Imagery – Carles Debart, KSAT

Carles Debart presented about the Multi-mission and Near Real-Time satellite data delivery and services available through KSAT. KSAT has an extensive network of ground stations including one in Svalbard Island, a unique location near to the North Pole from which to access data from polar orbiting satellites. This provides the shortest possible acquisition-to-delivery time globally (≤ 2 hours), accessing 85 satellites and 20,000 passes per month. In North America, the expected delivery time from KSAT SAR satellite's portfolio is about one hour from acquisition. Debart showed a spreadsheet of the satellites that would be available for an example oil spill scenario off Mobile, AL, including when each satellite image would need to be ordered to ensure the satellite can be tasked before cut-off times, and when the images and oil spill detections would be distributed to the response teams.

3.0 Hands-On Training Stations

Five stations were available for attendees during the hands-on training session.

3.1 Traditional High Resolution Photography and Video – Jeff Lankford, NOAA ORR, ERD

Jeff Lankford, with the help of Lexter Tapawan (NOAA ORR ERD Geographic Information System [GIS] staff), gave an overview on making an overflight map. The trained aerial observer takes a camera, GPS, notebook, and perhaps a basemap on the flight and collects photographs, notes, and GPS coordinates. Upon return, the observer gives the GPS unit, camera, and field notes to an information manager.

Garmin MapSource software is used to extract waypoints and track logs from the GPS unit. Three files are exported: gpx file (the primary file used for map creation) and gdb and txt (backup files). Mapping Application for Response, Planning, and Local Operational Tasks (MARPLOT) is used as a platform for the gpx file, where some edits are made. Ideally, the information manager and overflight observer have a post-flight briefing. The information manager goes through each waypoint with the overflight observer to generate notes corresponding to a particular waypoint/observation. Electronic data capture could help address the difficulty of a face-to-face briefing during an actual spill. The shapefile is then brought into a template in ArcMap and notes are added as text boxes. Photo points can also be added. The map is reviewed by the overflight observer and then exported into various formats and distributed. Because the process is tied to ArcMap it is not possible to create this map without GIS staff. In the future, NOAA ARD and ERD need to coordinate, perhaps by having a Standard Operating Procedure (SOP), so that the data collected during overflights can be used for NRDA (e.g., noting the presence of sargassum).

3.2 SAR - Gordon Staples, MDA

An MDA On-Call Acquisition Planner (OCAP) (available 24/7) is given the location and approximate size of the spill, and availability of spaceborne radar services is accessed. A contract must be in place to request an order; the U.S. government and most large oil companies have these. MDA has three direct downlink locations in North America. The practical minimum time from the initial request to acquisition is 12 hours. Four hours is possible, but only for large-scale emergencies. Once the image is acquired, analysis time and data delivery typically take less than two hours. There can be conflicts if a satellite is already tasked for another acquisition. Sometimes conflicts can be resolved to obtain the image as quickly as possible, but not always. Staples presented an example oil spill scenario in the Gulf of Mexico, for which an oil spill outline and oil tracker report (via email) and processed SAR data (via ftp site) would be delivered within 18 hours after notification. False positives (if detected) are delineated and wind speed and direction. Confidence intervals are assigned based on the imagery along with knowledge of the area. MDA has worldwide coverage (accessing many satellites) except for a part of the Arctic and Antarctic and some countries (e.g., Iran). The larger the swath width, the lower the resolution (the most common is 50 m resolution for a 300 km swath which provides 90,000 sq km of coverage in a single image).

3.3 Landsat/TRACS – Mark Hess, Ocean Imaging

Mark Hess discussed TRACS, aerial mission planning, data acquisition for tactical use, oil classification, and data delivery strategies. There are many considerations to take into account:

- Aircraft (e.g., understand differences between mounting unit and flying in a non-pressurized vs. pressurized aircraft, FAA certification, portholes have to be right size, maximum allowed altitude).
- In order to quickly locate to site of the incident and utilize aircraft of opportunity, camera technology should be portable and be able to be checked onto commercial aircraft without being damaged.

- Visual observers are still very important. They are not eliminated by this technology (i.e., they determine what images to collect).
- Consider time of day of overflights - flights in morning and afternoon are best to avoid sun glint.
- The intended purpose of the acquired data must be known to optimize mapping, recovery, and monitoring.
- Consider flight altitude in order to maximize efficiency of overflights and data collection based on size of spill.
- Know your target area. Open ocean data acquisition is very different from coastal. For example, the rocky intertidal zone is one of the most difficult areas to monitor because biota growing on the rocks are black and absorb heat.
- TRACS system can be used in multiple ways. 1) direct tactical information communicated to responder vessels, 2) creation of 'quick view' image mosaics sent down to boats to provide them a picture of the situation and 3) further classification of the incident imagery to generate oil type and thickness classification maps for ingestion into the COP.
- A good internet connection is critical to upload/offload data (e.g., a poor internet connection required 2 hours to transfer data during the Refugio spill).
- A combination of multispectral and thermal data is best to identify what type of oil is present (i.e. thicker oil vs. sheen, fresher oil vs weathered and emulsified oil). Multispectral and thermal data can be co-located where one appears on top of the other in order to improve the efficacy of the classification process and the information products generated.

3.4 Night Vision Applications - Mark Roberts, U.S. Army

The night vision training was held in a dark area, so workshop participants could try the technology. The U.S. Army can loan these to other Federal agencies, but not private entities. However, they can offer support with collection assistance to any potential user. Raw video footage that was taken from a helicopter at pre-dawn demonstrated the user could see a lot of detail. With night vision technology, thicker areas of oil can also be determined because those areas appear cooler (depending on the settings of "black hot" or "white hot" these areas would appear brighter or darker than other areas). The best times to use night vision technology are pre-dawn (complete lack of solar energy) and mid-day (complete overwhelming solar energy), resulting images are reversed in these cases. The worst times of day are at thermal cross-over just after dawn and evening pre-sunset (in these cases there will be no thermal diversity). The cost of night vision technologies varies: devices cost \$60,000 to \$100 (i.e., excellent to adequate resolution). Cooled sensors are higher resolution but are some of the more expensive options. Some technologies integrate directly to an iPhone or Android. A multispectral approach helps to distinguish false positives.

3.5 Balloons and Vessels – Kevin Hoskins, MSRC

Kevin Hoskins discussed aerostat systems, which may be deployed from a vessel or the shoreline in support of day and/or night operations. Aerostats may be flown at altitudes up to 500', which provides a much broader view of the response area given the high height of eye, therefore enhancing the ability

to identify and stay in the most actionable oil. The sensing unit on the balloon contains gimbal mounted High Definition (HD) and TIR cameras, as well as an Automatic Identification System (AIS) repeater. The sensing unit equipment is powered by a 12 VDC battery, which is incorporated into the balloon's kite assembly. The balloon can be flown in winds up to 34 knots. The viewer terminal allows the operator to control the camera view and identify the coordinates of potential targets. This positioning information can be overlaid onto a sea chart for further clarity. The operator also has the ability to see images in 100% optical or 100% IR, or any combination thereof. This is a very useful feature in determining if targets are actionable or may be false positives. The IR camera can be switched from white hot to black hot modes depending on conditions. Finally, both cameras have record capability and the operator can also capture screen shots of the viewer terminal screen.

3.6 Lessons Learned from Hands-On Training – Plenary Panel

Following the hands-on training, a panel of responders discussed lessons learned and practical applications:

Judd Muskat - California Department of Fish and Wildlife

- Radar satellites are fantastic for providing synoptic coverage. They are a great tool for first alert, and can cover hundreds or thousands of miles instantaneously. However, false positives are a problem. The California Office of Spill Prevention and Response uses Ocean Imaging's TRACS system to provide a quick determination of whether oil is present, its condition (e.g., fresh or emulsified), and the thickness distribution within the slick.
- Aerial observers should employ the best achievable technologies such as thermal imaging night vision goggles, similar to those demonstrated during the hands-on session.

Lisa DiPinto – NOAA ORR, ARD

- Oil observing needs are different for small vs. large spills. For small spills, numerous types of sensors, images, and specialists would not be used.
- Because of the potential of litigation, data and analyses have to be of high quality and defensible when collected for NRDA. False positives are a problem. Each oil observation product or technology must be defensible and have stronger validation than is currently available.
- It would be good to standardize overflight maps and make them more "high tech". For the long term NRDA cases, it would make a significant difference if additional information is collected during overflights (e.g., distance to object, camera angle). This could probably be done for not much more cost and not slow up the response people.

Robyn Conmy - USEPA

- Conmy also noted oil observing needs are different for small vs. large spills.
- Needs are also different for short-term vs. long-term monitoring (e.g., immediate response vs. NRDA).

- More trained aerial observers are needed (i.e., NOAA has five observers). Observer techniques could be improved in various ways (e.g., additional handheld instruments, reduce the subjectivity of the process).
- False positives are problematic. In the long term, infrared, SAR, and multispectral technologies are needed to rule out false positives.
- Data transfer to the FOSC is critical (e.g., good connections and platforms to speed information transfer).
- Plumes within the water are important to damage assessment. Methodologies for plume detection need to be incorporated into guidance documents such as the Special Monitoring of Applied Response Technologies (SMART). There are ongoing efforts to do this.
- The detection of a heavier oil released from a pipeline needs to be expanded (e.g., test bed studies at Ohmsett on different types of submerged oils).
- EPA is also responsible for inland waters, so detection in big rivers and lakes must be possible.

James Hanzalik - USCG FOSC (Ret.), CGA

- He reiterated the different needs between incidents of short (hours-days) vs. long (weeks-months) duration.
- Oil observation technologies must help the FOSC determine what resources/response measures to deploy first (e.g., in situ burning, dispersant application, protective boom, skimmers).
- Response decisions are normally based on the oil's trajectory, especially for longer duration incidents. Having the best tools to inform the personnel providing the trajectory (e.g., infrared, visual, or other) is important. As experienced during DWH, often the majority of the oil in the trajectory was sheen that was not recoverable and resources may have been misdirected to respond to those areas.
- There appears to be no lack of oil observing technologies, only a need to integrate them into existing systems.
- While much information can come from these technologies, it is most important that the right information gets to the decision-makers in a timely manner.
- Some technologies that are promising include:
 - Balloon and UAS systems – to deploy cleanup vessels to where the most oil is located. During the DWH spill, vessels were not always in the best locations.
 - Night vision or thermal imaging – can facilitate nighttime operations and 24/7 oil tracking.
 - Geotagging information – is important to locate where the oil is observed.

4.0 Breakout Sessions

4.1 Breakout Session 1 – Needs and Gaps in Oil Observing Technology

During the first breakout session, each group was asked to brainstorm needs that exist in oil observing technology and justify their selections (e.g., quickly need to know where heavy oil is to effectively manage tactical response). Results of each group can be found in Appendix G.

4.2 Breakout Session 2 – Gap Analysis

For the second breakout session, 13 of the needs that were identified in the first session were selected by the organizing committee and considered “gaps” for further analysis by the breakout groups. Needs were selected as gaps if they were complex technical or policy/protocol needs that would benefit from further analysis. Needs that were straightforward action items were not selected for the gap analysis, but are available in Appendix G. Each group was assigned three of the selected gaps to analyze. There was some overlap in the gaps assigned to the groups to gauge the diversity of viewpoints. The groups provided the following information about each gap:

- Applicable location
- Technical limitations causing the gap
- Other issues or limitations causing the gap
- Potential technological solution
- Schedule to develop solution
- Cost to adapt technology to oil observing
- Logistics for deployment
- Other notes/considerations

Results from each group are provided in Appendix G.

4.3 Plenary/Breakout Session 3 – Prioritize Needs and Path Forward

At the beginning of Day 3, participants were asked to rank (high, medium, low) in order of priority, the potential solutions that had been identified to address the gaps discussed during Breakout Session 2. Participants did not rank solutions outside their area of expertise. Forty-nine of the participants submitted rankings. Table 1 shows the highest ranked priorities. The table includes whether the solutions are technical or policy/protocol related, short or long term, and relatively high or low cost. The ranking sheet, detailed results, and method of scoring are shown as Appendix H.

In addition, as part of the path forward, the general consensus was that a job aid should be developed on oil observation technology for oil spills. During the third breakout session, participants were asked to discuss who the audiences should be, what the most important sensors are to include, and other things they would like to see included. Results for each group are provided in Appendix G. As part of the session, the job aids developed or being developed by industry and BSEE were presented. American Petroleum Institute (API) published a Remote Sensing in Support of Oil Spill Response Planning Guidance (API, 2013), which includes the following: incorporating remote sensing into oil spill response and mission support planning, establishing a remote sensing team, determining the appropriate technology, deploying the technology, and analyzing and communicating data. An assessment of current research and emerging trends in surveillance technologies for oil spill response is also included. The Naval Research Laboratory (NRL) is currently finalizing a remote sensing selection guide for BSEE, which can be used for a variety of oil spill scenarios. The selection guide is an excel workbook that contains extensive information on sensor capabilities. Based on user input, and pre-loaded data/calculations for a wide

Table 1.

Solutions Prioritized per Workshop Participants*	Score**	Category	Timeframe	Cost
Georeferenced data with standard format (metadata) (Re: Integration of Synoptic Sampling into Mission Planning)	234	technical	short-term	low
Coordinating remote sensing acquisition with field data collection (Re: Integration of Synoptic Sampling into Mission Planning)	226	Policy/Protocol	short-term	med
Bandwidth - software compression, portable network stations, pre-planning of data demands, satellite communications/infrastructure (Re: Delivery Infrastructure)	223	technical	short-term	med
Accessibility/connectivity - remote site data integration away from ICP (Re: Delivery Infrastructure)	222	technical	short-term	med
On-site testing during exercises (Re: Data Delivery Time)	218	Policy/Protocol	short-term	low
A go kit multi sensor package (SAR, multispectral, infrared, high resolution imagery) (Re: Remote Sensing Operations - skimming, dispersants, burn, night operations)	218	technical	long-term	high
Advancements in/complete on-board processing (Re: Real Time Capture of Data)	218	technical	short-term	med
Standardize human observer methodology and output (Re: Oil Observation)	217	Policy/Protocol	short-term	low
Supplement human observers with digital tools (Re: Oil Observation)	216	Policy/Protocol	short-term	low
Multi sensor approach with repeated surveys over time including hyperspectral, SAR, and high resolution visual (Re: Shoreline Oil Data and Habitat)	214	Policy/Protocol	short-term	high
Digital georeferenced photo subjects (Re: Oil Observation)	214	technical	short-term	low
Technology scalability for volume calc that is defensible (Re: Technologies for Oil Thickness)	212	technical	long-term	high
Quad-pol SAR (Re: Technologies for Oil Thickness)	210	technical	short-term	med
Identify standard equipment and training (Re: Oil Observation)	209	Policy/Protocol	short-term	low
AVIRIS (Re: Technologies for Oil Thickness)	204	technical	long-term	high
Thickness: Creating operational systems and validating methods for application of those systems (Re: Flow Rate, Footprint, Thickness)	203	technical	long-term	high
Web-mapping service for data sharing (Re: Data Deliver Time)	200	technical	short-term	low
Microwave-based air-to-ground communications system (Re: Real Time Capture of Data)	200	technical	short-term	med
Calibration events minimum once per incident (Re: Integration of Synoptic Sampling into Mission Planning)	200	Policy/Protocol	short-term	med
Contemporaneous collection (Re: Integration of Synoptic Sampling into Mission Planning)	199	Policy/Protocol	short-term	low
Multiple sensors and platforms in order to fill out the gaps for the required schedule (Re: Shoreline Oil Data and Habitat)	198	technical	long-term	high
Quad-pol UAS SAR (Re: Technologies for Oil Thickness)	198	technical	short-term	med
Better data capture (Re: Other Data)	197	technical	short-term	med
Capture data from multiple observers (Re: Oil Observation)	197	Policy/Protocol	short-term	low
Aerial assets for schedules and resolution (Re: Shoreline Oil Data and Habitat)	196	Policy/Protocol	short-term	low

* There were 4 categories with no solutions ranked as high priority: detection of oil in ice, trajectory modeling, subsurface, and oil/chemical composition.

** The lowest and highest possible scores respectively were 49 (or zero if nobody voted) and 245.

range of parameters (e.g., availability, ownership, deployment time, tool strengths, limitations, data latency, cost), the workbook recommends an appropriate remote sensing tool(s). The workbook will be updated as remote sensing technology develops. Further information is provided in the presentation slides (Appendix D). A number of other existing resources were identified during the workshop that assess remote sensing capabilities (e.g., for airborne remote sensing, the International Petroleum Industry Environmental Conservation Association [IPIECA] and Oil and Gas Producers Association [OGP] have a report titled *An Assessment of Surface Surveillance Capabilities for Oil Spill Response using Airborne Remote Sensing* [Partington, 2014]). A list of these identified resources is compiled in Table 2.

5.0 Workshop Conclusions and Recommendations

5.1 Specific Workshop Objective Summary

Objective: Identify new developments in oil observing technologies useful for real-time (or near real-time) mapping of spilled oil during emergency events.

The 2010 Deepwater Horizon represented an unprecedented challenge to the oil spill response community. The scope and magnitude of the oil spill demanded creative use of existing technologies and the development of new options for capturing daily operational data to facilitate an effective response. The use of remote sensing was invaluable for understanding the characteristics and location of the surface oil and to predict where it was going. Additionally, many sensor technologies were employed coincidentally to capture multi-resolution data to better understand the scale and degree of surface oiling and its potential to cause harm to natural resources.

The use of the NOAA NESDIS daily SAR for oil footprint delineation facilitated daily operational decisions, representing a new reliance on remote sensing that had never before occurred. Additionally, NOAA SAR analysis was further enhanced during the NRDA as a twofold semi-automated process, TCNNA, for footprint creation and further delineation of heavy emulsions (actionable oil) using the OEDA. The TCNNA and OEDA processes for delineation of the oil footprint and heavy emulsified oil represented innovative uses of SAR data that will be evaluated for development and use as operational products for NOAA support at future spills.

The Ocean Imaging (BP contractor) high resolution aerial multispectral and thermal imagery was collected almost daily at the DWH rig site to capture thickness and volume estimations. This effective product was very useful for response source monitoring missions, but this use was limited by the small footprint that these missions could capture in one day, particularly for NRDA. This reality reduced the impact these tools had on the overall response, however, this daily experience allowed the application of methods to medium resolution Landsat data. In doing so, qualitative thickness estimates were generated to support the NRDA and look across a larger area than had been possible during the response itself. The private sector/Oil Spill Response Organization (OSRO) partnership that occurred was an example of a very effective pairing of technology for operational response or assessment. From this work, Ocean Imaging developed the TRACS portable sensor package that can be deployed on

platforms of opportunity, support oil observation imagery capture, and deliver data to a Unified Command COP in near real-time. These rapid response capabilities were demonstrated at the 2015 Refugio Pipeline spill response.

EPA ASPECT and NASA AVIRIS sensors were active during the DWH oil spill, however, their data products were not integrated into the COP to the fullest extent possible. The EPA ASPECT high resolution imagery data were underused. This fast response asset has significant application for air monitoring and spill assessment and is well integrated into Agency activities. Indeed, ASPECT data could provide significant support to multiple response and assessment activities, particularly in the identification of actionable oil. The EPA employs rapid capture, on-board processing and near-real time data delivery as the core of the service. ASPECT true color imagery was used as a ground truth source for oil on water characterization as well as for sargassum assessment in the DWH NRDA. The NASA AVIRIS hyperspectral sensor is an extremely high resolution technology that has a published record for surface oil characterization and quantification. Unfortunately, AVIRIS data collection suffers from difficulty of capture (environmental conditions), huge data volume (220 bands of data) and ineffectual data delivery (~1 day lag for DWH). Regardless, these data were very important in adjusting or “tuning” the surface oiling data from SAR and MODIS satellites.

The Workshop provided the opportunity to see the NASA UAVSAR and U.S. Army Night Vision technology and products. NASA is very interested in using the UAVSAR technology to provide more practical support for oil spill response and damage assessment. NASA is working with NOAA to expand the application of these technologies into direct response support. The UAVSAR technology is uniformly accepted by the remote sensing community as an extremely effective SAR sensor. Unfortunately, there are significant costs to deploy UAVSAR and it has long lag times for data delivery.

The U.S. Army Night Vision tools and technology are not widely used or routinely available to the oil spill community. There are some very high costs to the equipment, and there are limitations regarding how these tools can be used. Currently, the night vision tools do not include the laser range finders or measurement support that would make them more useful for feature identification. Regardless, there are real potentials in the technology demonstrated, because it could allow oil spill response work to continue after dark (e.g., 24 hours a day). The application of night vision tools to response should be considered.

There is still much more work to inventory and understand how best to apply all of the technologies to support oil spill response decision-making. It seems clear that there are many platforms and sensors currently in use that will be part of the multi-sensor toolkit identified by the Workshop participants. We need to better: (1) understand what the current strengths and weaknesses of each sensor are, (2) develop experiments to demonstrate how these technologies relate to each other, and (3) develop new and smaller deployment packages to put the most effective sensors in the sky.

Objective: Identify merits and limitations of current technologies and their usefulness to emergency response mapping of oil and reliable prediction of oil surface transport and trajectory forecasts. Current technologies include: the traditional human aerial observer, unmanned aircraft surveillance systems, aircraft with specialized sensor packages, and satellite earth observing systems.

Current remote sensing technologies provide significant support to traditional visual oil observing programs. These technologies provide supplemental evidence of oiling and provide additional “eyes” in the sky to move people and equipment to where “actionable” surface oil exists and can be addressed. However, there are still questions regarding the extent to which any remote sensing assessments can be relied upon exclusively. Human observation of surface oiling is still needed for characterization and validation.

As identified by a majority of the workshop participants, a combination of human and technological sensors are required to effectively target “actionable” oil. Furthermore, a combination of sensor technologies increases confidence in the findings via a weight-of-evidence approach. A combination of sensors was used during DWH assessment and provided a strong approach, however, it has still not achieved sufficient community support or necessary validation.

Academics, industry partners, and Agency representatives all identified the need for a robust series of synoptic sampling experiments including detailed requirements and procedures to better quantify the performance of individual sensors or any combination of sensors for realistic qualitative thickness characterization of surface oil. Then, quantitative thickness (or volume) calculation of surface oil may be evaluated. Experiments should be undertaken to capture a series of satellite, aerial, and on water remotely-sensed data, along with in situ surface water/oil sampling. This will allow examination of the relative performance of these sensors and build the understanding of the quality of the data they are providing to the response and damage assessment communities. As a result of the Oil Observing Tools Workshop, BSEE and NOAA are working toward a cooperative series of experiments to examine these questions in open water and controlled tank tests.

Objective: Assess training needs for visual observation (human observers with cameras) and sensor technologies (including satellites) to build skills and enhance proper interpretation for decision support during actual events.

Trained overflight oil observations still appear to be the “gold standard” in surface oil characterization. NOAA’s ORR provided overview training and is actively looking to expand its oil observing program with partner agencies. NOAA is actively developing tools to support the capture of oil observer observations and the delivery of these observations to a COP (e.g., ERMA®), providing decision-making capabilities. Regardless of the ongoing, rapid developments in the remote sensing of surface oil, it is extremely important that a robust Oil Observing Training program continues. It is difficult to maintain a broad base of trained observers. It has been difficult over the past decade to train new aerial observers with

the proper skill set that is needed for the long term. Cuts in program funding and the ability to add FTE's has left us with fewer persons available to train as aerial observers. Many potential observers from outside organizations have been trained in half to full day classes that typically cover the fundamental principles for conducting aerial observations. These classroom lectures while valuable are not able to provide the student with the complete skill set needed to go out into the field and capture the information that is needed. The key component that is missing from this training is the practical field experience that can only be gained by observing oil on open water. To observe oil on the water complicates the learning process as there are only a couple of locations where this can easily be done. To make the training truly valuable for those participating, the training sessions need to take place at or near these locations. Another option that has been employed over the years is to use actual spill events as a training opportunity. This option has its own drawbacks such as the aircraft type, available seats, and can usually only accommodate one student observer at a time.

5.2 Workshop Key Themes and Areas of Interest:

Throughout the workshop, the following key needs, themes, and points were repeatedly emphasized. An associated recommendation and action is provided for each one.

Small spills, which are the most common, are significantly different from large scale spills in terms of response time, technologies used, funding, and staffing. Many experiences and considerations related to oil observing are based on the highly atypical very large DWH spill.

Recommendation: Remote sensing may provide limited utility to small spills in selected settings. Remote sensing is effective in supporting evaluation of risk in many, but not all responses or assessments. Understanding when remote sensing should not be used is almost as important as knowing what sensors to choose and where they will help. As UAS and other compact remote sensing solutions become more common, the use of these technologies for small spills will become more and more practical.

ACTION: Develop a list of criteria/metrics where remote sensing tools are useful in oil spill response and assessment.

Oil observation consists of three steps characterized as data capture, processing, and delivery.

Recommendation: Data delivery must be stressed whenever data is to support response or assessment. Agencies will often only identify capture and processing requirements without addressing delivery. The process often fails because delivery of observational and analytical data, which is critical, is left unspecified. Delivery requirements must be included for any contracts being written for remote sensing work.

ACTION: Develop a short list of delivery requirements that could be included for remote sensing data collections to ensure complete and timely delivery of products.

Human observation is the cornerstone of all oil observation. NOAA needs more trained aerial overflight observers. In addition, observation methodology should be updated and standardized to provide consistency.

Recommendation: NOAA and other agencies should pro-actively train staff for aerial overflight oil identification.

ACTION: Continue development of NOAA's Oil Over-flight Observation training program.

The most useful technology to supplement the data obtained by trained aerial observers is a package of all sensors combined. It would be helpful to repackage existing technologies into a deployable "go kit" that is small enough to fit onto a UAS and able to deliver data quickly.

Recommendation: While a combination approach of different sensors cobbled together in some fashion has some use, there is little technology available that brings multiple sensors together in one physical package. This reality is likely to continue for some time. The current solution is to develop a post-processing mash-up of data or deploy a variety of sensors on platforms-of-opportunities including fixed wing, helicopters, and UAS to achieve this combination effect.

ACTION: Develop workable combination packages of existing technologies and develop multiple platforms and sensor packages based on the most common response or assessment needs.

Responders need to know where the thick/"actionable" oil is located in order to make the most effective response decisions.

Recommendation: This is the target for operational tools development now. Understanding where we have "no oil", "sheen or thin oil" or "thicker, actionable oil" is the level of characterization that we can and should target with existing/emerging remote sensing technologies while keeping the future goal of supporting more discrete quantification as a future goal.

ACTION: Conduct a NOAA/BSEE led diverse synoptic sampling experiment that will validate the qualitative characterization technologies for surface oil developed during DWH. This validated, operational methodology will then allow the use of these data and tools in support of day to day decision-making for response and assessment.

False positives are a significant concern that must be addressed.

Recommendation: During a response, false positives cost time and money. False positive tracking should continue to be a significant task for over-flight observers and analysts. The observer is in a unique position to identify and locate features that can cause responders to mistakenly act. False positive sources should be identified and then be mapped and loaded into

the COP to help prevent additional resource expenditures on a known feature.

ACTION: Develop better methods to identify false positives as part of overflight observation training. False positive sources must be identified and located so that they are “known” and can be used to inform subsequent over-water surveys.

Ground truthing of data is needed, especially a protocol for synoptic sampling.

Recommendation: Remote sensing data supplement what is captured in the field. It is critical to have in situ “truth” for the image analysis products generated to understand the data collected by remote sensing. Standardized synoptic sampling protocols will provide the data necessary to correlate the relative sensor response to specific features.

ACTION: Conduct data collections in situ as part of any remote sensing activity.

Responders need the data delivered quickly to the right people at the right time. Information from more sophisticated technologies often does not make it into the COP or command post before decisions about the response are made. Data delivery should be practiced in training and drills (i.e., conduct drills to simulate Days 4 and 5 of a spill response). Requirements for delivery of data and related time requirements must be included in contracts.

Recommendation: More drill/exercise focus must be placed on data delivery activities. Data delivery mechanisms are an afterthought in training scenarios, while at the same time being one of the most critical activities for success. Collected and even processed data are of little value if they are not delivered in a timely manner to decision makers. This could be the topic of a NOAA lead drill at the DRC in Mobile, AL.

ACTION: Conduct drills emphasizing Days 3 or 4 of a response so as to focus on data delivery.

API, BSEE, and others, have funded and developed guidance to determine appropriate remote sensing technology. The output from these efforts should be developed into an online tool that can become part of NOAA’s integrated modules (e.g., General NOAA Operational Modeling Environment [GNOME], Automated Data Inquiry for Oil Spills [ADIOS]) available in the responder’s toolbox.

Recommendation: Do not create more guidance documents as good resources are already available. Create an information portal/webpage that allows responders, damage assessors, and developers access to existing information. Additionally, the findings and priorities from this workshop should inform remote sensing controlled and open water/real world testing and experimentation.

ACTION: Build a portal/landing page for API and BSEE work with descriptions of what they have already done. Include other existing resources and reference documents. Keep the information at the site updated.

Data collected during the response needs to be useful to the NRDA process. NOAA ORR ERD and ARD must coordinate better to address the needs of response and assessment.

Recommendation: There is a continuum of data collected from response to assessment to restoration. Data should be managed and shared across this range of activities for an incident and common needs should be considered for data collection activities in situ and via remote sensing. OR&R's ARD and ERD have been working to ensure that data management and data sharing are key components of their cooperative response and assessment strategies. The OR&R "Data Management and Sharing Plan (incident template)" has been developed as part of the OR&R Data Management strategy and represents an effort currently underway.

ACTION: Use the OR&R Data Management and Sharing Plan incident template during events and training to further ensure cooperative data management for response and subsequent NRDA casework.

There must be continued integration between end users and data providers.

Recommendation: There needs to be ongoing coordination and communications between consumers and developers to ensure data needs are identified and appropriate products are generated.

ACTION: Continue recurring discussions between emergency responders, damage assessors, data managers and developers. More regular meetings would help solidify some of the ongoing needs that developers should target. This should be a regular track session at oil spill conferences (e.g., Clean Gulf, IOSC).

Some of the gaps identified, if addressed, could change the usefulness of oil observing significantly. This means that the path forward includes a mix of solutions including some less expensive actions that could advance the state of the art in oil observing, as well as some very high cost ones that may be delayed out of necessity.

Recommendation: With the current technological solutions that exist today, a combination of sensors and platforms will be required.

ACTION: Do not expect a "single solution" tool-box in the near term. Rely on a multi-platform, multi-sensor approach based on settings and conditions.

One major problem is the limited funding to address the gaps in oil observing tools identified. The oil response community must develop a plan to help fund the necessary actions.

Recommendation: Public agencies must work closely with industry to identify the needs and potential funding options to address them. This will be problematic with the current low price of oil. Public and private partnerships will continue to provide more cost-effective comprehensive solutions.

ACTION: Pursue joint agency and industry demonstrations of oil observing tools and focus on flexible funding mechanisms.

5.3 Workshop Portal Page

There is a portal/landing page for Oil Observing Tools at the CRRC website (http://crrc.unh.edu/oil_observing). The portal includes links to this report and other resources, such as the work done by API and BSEE, as well as other job-aids and references. A summary of the information in the portal (as of the final date of this report) is shown in Table 2, however the information on the portal will be updated as new information becomes available.

Table 2. Additional Resources		
Title	Author/Source	Year
Remote Sensing in Support of Oil Spill Response, Planning Guidance	API	2013
Standard Guide for Selection of Airborne Remote Sensing Systems for Detection and Monitoring of Oil on Water	ASTM	2015
Standard Guide for Visually Estimating Oil Spill Thickness on Water	ASTM	2006
Standard Practice for Reporting Visual Observations of Oil on Water	ASTM	2008
Remote Sensing Systems to Detect and Analyze Oil Spills on the U.S. Outer Continental Shelf – A State of the Art Assessment	Burrage et al, NRL, funded by BSEE	2016
Use of Remote Sensing Technology for Oil Spill Response: An Overview Report to the Administrator of the California Department of Fish and Wildlife (CDFW), Office of Spill	Muskat, Judd	2016 DRAFT Available*
ExxonMobil spill response book	ExxonMobil	2014
Detection, Tracking, and Remote Sensing; Part VII in the Handbook of Oil Spill Science and Technology	Wiley, edited by Merv Fingas	2015
Bonn Agreement	Various	Various
NOAA OR&R Spill Response Job-Aids/One-pagers:		
Open Water Oil Identification Job Aid for Aerial Observation	NOAA	2012
Guide to Delineation of Oil	NOAA NESDIS	2009
OR&R/ERD Job-Aids (e.g., Overflight, Oil Identification, Shoreline Assessment)	NOAA	Ongoing
Reference Documents:		
Discrimination of Oil Spills from Newly Formed Sea Ice by Synthetic Aperture Radar	Brekke et al	2014
State of the Art Satellite and Airborne Marine Oil Spill Remote Sensing: Application to the BP Deepwater Horizon Oil Spill	Leifer et al	2012
The Federal Oil Spill Team for Emergency Response Remote Sensing, FOSTERRS: Enabling Remote Sensing Technology for Marine Disaster Response	Leifer et al	2015
Natural and Unnatural Oil Slicks in the Gulf of Mexico	MacDonald et al	2015
An Assessment of Surface Surveillance Capabilities for Oil Spill Response using Airborne Remote Sensing, provided for International	Partington, Kim	2014

Petroleum Industry Environmental Conservation Association (IPIECA) and Oil and Gas Producers Association (OGP)		
Oil Spill Detection and Mapping in Low Visibility and Ice: Surface Remote Sensing, Final Report 5.1 for the Arctic Oil Spill Response Technology - Joint Industry Programme	Puestow et al	2013

*Draft posted with author's permission.

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7.0 Appendices

Appendix A: Agenda

Appendix B: Participants

Appendix C: Breakout Group Members

Appendix D: Presentation Slides

Appendix E: Plenary Session Notes

Appendix F: Hands-On Training

Appendix G: Breakout Group Results

Appendix H: Priorities Ranking

Appendix I: Technologies for Oil Thickness

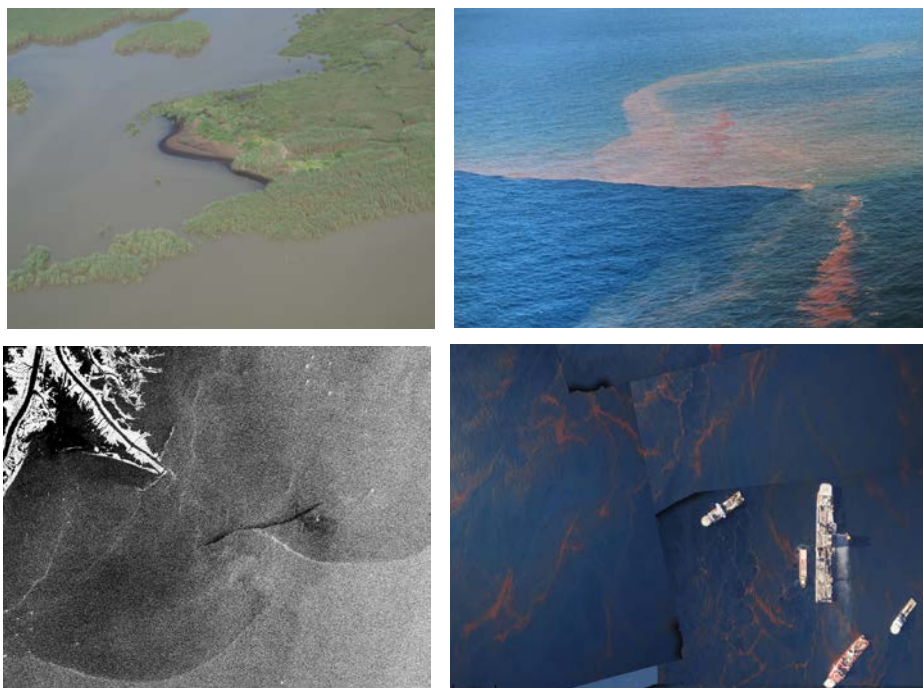


Photo Credit: Unified Command, U.S. Coast Guard

OIL OBSERVING TOOLS WORKSHOP REPORT APPENDIX

OCTOBER 20 -22, 2015

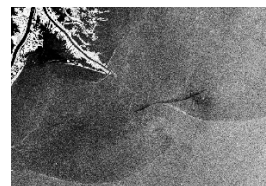
COASTAL RESPONSE RESEARCH CENTER



APPENDIX A

OIL OBSERVING TOOLS WORKSHOP

OCTOBER 20 – 22, 2015



AGENDA

Day 1: Tuesday 20 October

- 8:30 am Welcome and Introductions
Charlie Henry, NOAA ORR, Gulf of Mexico Disaster Response Center
- 8:45 am Background and Workshop Goals
George Graettinger, NOAA ORR ARD Spatial Data Branch
Nancy Kinner, Coastal Response Research Center, University of New Hampshire
- 9:00 am Participant Introductions
- 9:30 am Plenary Session: Need for Oil Observing in Response
NOAA ORR: Scott Lundgren, Chief Emergency Response Division
USCG: James Litzinger, Gulf Strike Team
NOAA ORR: Lisa DiPinto, Assessment and Restoration Division
- 10:00 am *Break*
- 10:15 am Plenary Session A: Current Operational Programs
NOAA ORR Oil Observing Program and Tools: Jeff Lankford, Emergency Response Division
NOAA NESDIS-MPSR and Remote Sensing for Surface Oil Assessment: Davida Streett
US EPA ASPECT: Mark Thomas
NASA Programs: Cathleen Jones
 - Q&A – Speakers Panel
- 11:15 am Plenary Session B: Current Oil Observing Tools and Data Analysis
SAR: Oscar Garcia, Water Mapping, LLC; Gordon Staples, MDA, Canada
Landsat/TRACS: Mark Hess, Ocean Imaging; Kevin Hoskins, MSRC
AVIRIS Next Generation: Ira Leifer, Bubbleology Research International (BRI)
- 12:15 pm *Lunch provided*
- 12:45 pm Plenary Session B continued
Oil Spill Response Limited (OSRL): Jean Teo
Night Vision Applications: Mark Roberts, U.S. Army Night Vision & Electronic Sensors
 - Q&A – Speakers Panel
- 1:45 pm Hands-On Training Stations with Real Field Data
Traditional high resolution photography and video
SAR
Landsat/TRACS
ASPECT
Night Vision Applications
- 3:00 pm *Break*
- 3:15 pm Plenary Panel: Lessons Learned from Hands-On Training
Lisa DiPinto, NOAA ARD; James Hanzalik, USCG FOSC, Robyn Conmy USEPA, and
Judd Muskat, CA DFW Spill Prevention and Response
 - Q&A – Speakers Panel
- 5:00 pm *Adjourn*

OIL OBSERVING TOOLS WORKSHOP

OCTOBER 20 – 22, 2015

AGENDA

Day 2: Wednesday 21 October

- 8:30 am Review/Charge for Day 2
 Nancy Kinner and George Graettinger
- 8:45 am Plenary Session: New Technologies/New Applications
 NASA Out-Year Planning & Expectations: Sonia Gallegos
 NRDA/Assessment Use:
 • DWH Multi-sensor Assessment: Jamie Holmes, Stratus Consulting
 • DWH SAR Applications: George Graettinger
 UAS Potential Use & Limitations: Michele Jacobi, NOAA ORR ARD
 KSAT – Multi-Mission Near Real-Time Satellite Imagery: Carles Debart
- 10:00 am Charge to Breakout Groups: Needs & Gaps in Oil Observing Technology
- 10:15 am Breakout Group Discussion: Identify Needs & Gaps in Oil Observing Technology
- 11:30 am Plenary Session – Breakout Group Reports on Gaps
- 12:30 pm *Lunch provided*
- 1:30 pm Breakout Group Discussion: Specific Gap Analysis
- 3:00 pm *Break*
- 3:30 pm Plenary Session: Breakout Group Reports on Gap Analysis
- 4:30 pm *Adjourn*

Day 3: Thursday 22 October

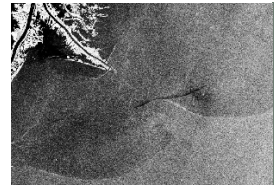
- 8:30 am Charge to Breakout Groups: Prioritize Needs & Path Forward
- 8:45 am Breakout Group Discussion: Prioritize Needs & Path Forward
- 10:30 am *Break*
- 10:45 am Plenary Session: Breakout Group Reports on Priorities & Path Forward
- 11:15 am Plenary Session: Workshop Summary
- 12:30 pm *Adjourn (no lunch provided)*



APPENDIX B

OIL OBSERVING TOOLS WORKSHOP

OCTOBER 20 – 22, 2015



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APPENDIX C

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Group Lead:	Robyn Conmy	Drew Casey	Tim Gallagher	Scott Lundgren	Peter Murphy	Judd Muskat
Group Recorder:	JB Huyett	Cory Rhoades	Jessica Garron	Lexter Tapawan	Samira Daneshgar	Laura Belden
Meeting Room:	<i>Boat Barn</i>	<i>Plenary (front)</i>	<i>Conference Rm</i>	<i>Conference Rm 2</i>	<i>Plenary (back)</i>	<i>Command</i>
	Brandon Aten	Mark Hess	Mike Aslaksen	Derek Burrage	Mike Caruso	Rebecca Brooks
	Chaz Comerford	Richard Knudsen	Carles Debart	Lisa DiPinto	Jay Cho	Oscar Garcia
	Adam Davis	Jeff Lankford	Merv Fingas	Dan Hahn	Christian Haselwimmer	Charlie Henry
	Kelly Denning	Jim Litzinger	George Graettinger	James Hanzalik	Cathleen Jones	Kevin Hoskins
	David Gionet	Ian MacDonald	Jamie Holmes	Robbie Hood	Steve Raber	Dylan Righi
	Charlie Huber	Henk Renken	Pierre le Roux	Chuanmin Hu	Aaron Racicot	Gordon Staples
	Michele Jacobi	Kate Rose	Mark Roberts	Amy MacFadyen	Tom Ryerson	Jordan Stout
	David Palandro	Gregg Swayze	Gerardo Toro-Farmer	Jacob Tustison	Lisa Symons	Jean Teo
	Davida Streett	Ian Zelo				

APPENDIX D

OIL OBSERVING TOOLS WORKSHOP

OCTOBER 20 – 22, 2015



Welcome to the Oil Observing Tools Workshop

October 20 – 22, 2015

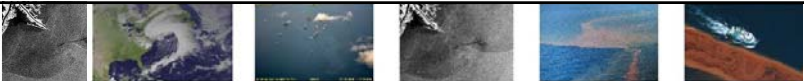
NOAA's GOM Disaster Response Center





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OIL OBSERVING TOOLS WORKSHOP

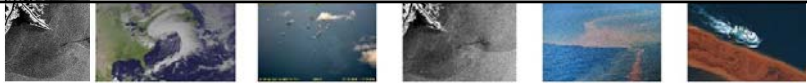
OCTOBER 20 – 22, 2015



Charlie Henry, Director NOAA GOM Disaster Response Center



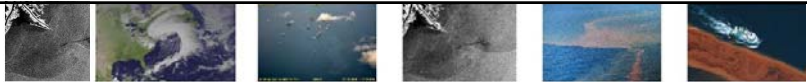
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Nancy Kinner, UNH Director Coastal Response Research Center (CRRC)



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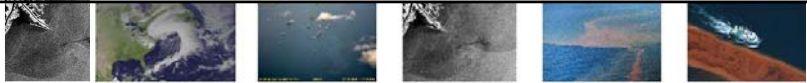


Logistics

- Access
- Fire exits
- Restrooms
- Safety
- Recycling
- Smoking area



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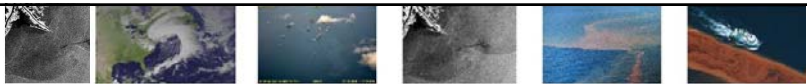


Logistics

- Cell phones/laptops
- Breaks (coffee, tea, snacks)
- Meals (lunch provided, dinners on your own)
- Logistical Questions – see Kathy Mandsager or me



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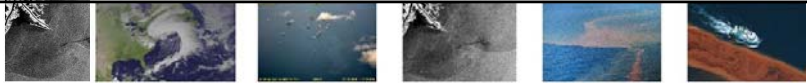


Coastal Response Research Center (CRRC)

- Partnership between NOAA's Office of Response and Restoration and the University of New Hampshire
 - Emergency Response Division (ERD)
 - Assessment and Restoration Division (ARD)
- Since 2004
 - UNH co-director – Nancy Kinner
 - NOAA co-director – Mark Miller



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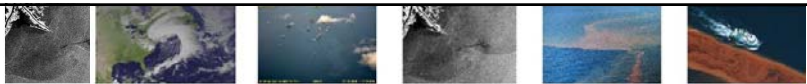


Overall CRRC Mission

- Conduct and oversee basic and applied research and outreach on spill & environmental hazard response and restoration
- Transform research results into practice
- Serve as hub for spill /environmental hazards R&D
- Facilitate workshops bringing together ALL STAKEHOLDERS to discuss spill/hazards issues and concerns



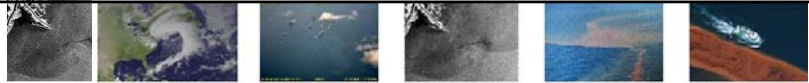
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George Graettinger
NOAA ORR
Assessment Restoration Division



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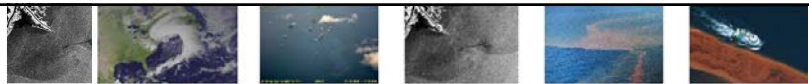


Meeting Overview

- DRC proposed Oil Observing Training to support ERD's Oil Observing program (deepening the bench)
- Proposal was expanded to include a Workshop focusing on OR&R needs including the use of remote sensing and lessons learned during Deepwater Horizon
- Workshop has evolved to assess the Office-wide needs for both Response and Assessment missions



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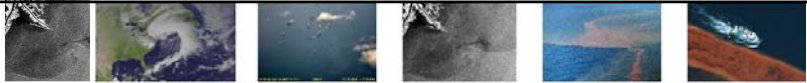


Meeting Goals & Objectives

- Identify any *new developments in oil observing technologies* useful for real-time (or near real-time) characterization of surface oil during response and assessment
- Identify *merits and limitations of current technologies and their usefulness* to emergency response mapping of oil and predicting oil surface transport and trajectory forecasts



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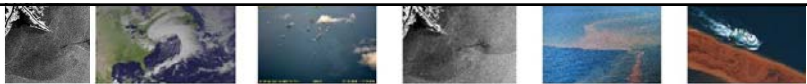


Meeting Goals & Objectives

- Focus on Applying Tools to Response and Assessment (Practical Applications, not Research)
- Identify specific needs and current limitations to supporting these missions (needs assessment)
- Each presentation will tee up topic to start the conversation on needs
- We will not cover all options, and we will not see all the potential tools that should be considered
- Please identify sensors and data that make sense for the break-out group discussions



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Meeting Goals & Objectives

- Current technologies to be considered
 - Traditional human aerial observer
 - Aircraft with specialized sensor packages
 - Satellite earth observing systems
 - UAS/unmanned aircraft surveillance systems
- Assess and document utility of both visual observation and sensor technologies to enable appropriate tool selection for decision support during actual events
- Produce practical guide or Job-Aid for remote sensing oil observation



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Meeting Strategy

- Identify functional needs and potential solutions (understanding benefits and limitations)
- Consider bringing pieces *together in new ways* (Multiple sensors, alternative sensors)
- Collect, Process, Deliver, if we cannot bring the information to the table in a timely fashion we may lose the value of the effort



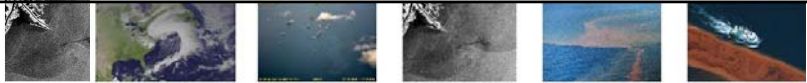
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Meeting Questions

- What tools are currently available or evolving?
- What is the potential to meet needs?
- What is needed/where is the gap?
- How can we ensure that data can be recorded and delivered for subsequent use?



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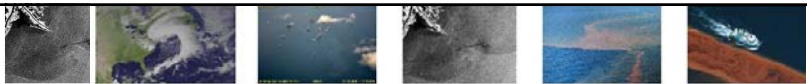


Participant Introductions

- **Name**
- **Affiliation**
- **What is your interest for this workshop?**



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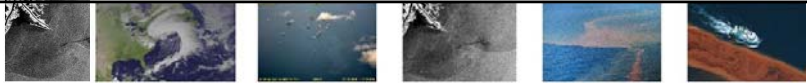


Agenda – Tuesday, October 20

- **0830** **Welcome**
- **0845** **Background and workshop goals**
- **0930** **Plenary Session : Need for Oil Observing in Response**
 - NOAA ORR: Scott Lundgren, Chief of Emergency Response Division
 - USCG: LT James Litzinger, Gulf Strike Team
 - NOAA ORR: Lisa DiPinto, Assessment and Restoration Division
- **1000** **Break**



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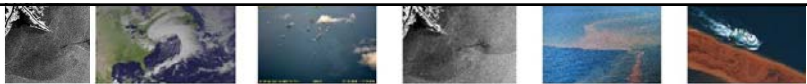


Agenda – Tuesday, October 20

- **1015** **Plenary Session: Current Operational Programs**
 - NOAA ORR Oil Observing Program & Tools: Jeff Lankford, ERD
 - NOAA NESDIS-MPSR & Remote Sensing for Surface Oil Assessment: Davida Streett
 - USEPA ASPECT: Mark Thomas
 - NASA Programs: Cathleen Jones
 - Q&A – Speakers Panel
- **1115** **Plenary Session: Current Oil Observing Tools & Data Analysis**
 - SAR: Oscar Garcia, Water Mapping, LLC & Gordon Staples, MDA Canada
 - Landsat/TRACS: Mark Hess, Ocean Imaging & Kevin Hoskins, MSRC
 - AVIRIS Next Generation: Ira Leifer, Bubbleology Research International
- **1215** **Lunch provided**



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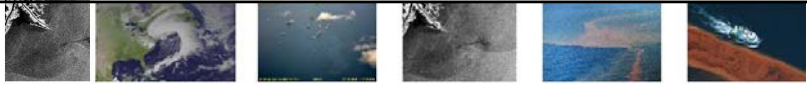


Agenda – Tuesday, October 20

- **1245** **Plenary Session Continued**
 - Oil Spill Response Limited (OSRL): Jean Teo
 - Night Vision Applications: Mark Roberts, US Army Night Vision & Electronic Sensors
 - Q&A – Speakers Panel
- **1345** **Hands-On Training Stations with Real Field Data**
 - Traditional high resolution photography and video
 - SAR
 - Landsat/TRACS
 - ASPECT
 - Night Vision Applications
- **1500** **Break**



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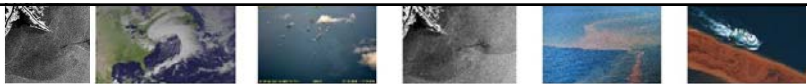


Agenda – Tuesday, October 20

- **1515** **Plenary Panel: Lessons Learned from Hands-on Training**
 - Lisa DiPinto, NOAA ARD
 - James Hanzalik, USCG FOSC
 - Robyn Conmy, USEPA
 - Judd Muskat, CA DFW Spill Prevention and Response
 - Q&A – Speakers Panel
- **1700** **Adjourn**



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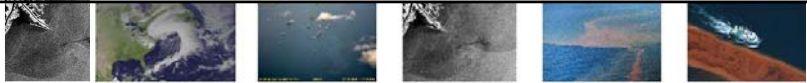


Agenda – Wednesday, October 21

- **0830** **Review/Charge**
- **0845** **Plenary Session: New Technologies/New Applications**
 - NASA Out-Year Planning & Expectation: Sonia Gallegos
 - NRDA/Assessment Use:
 - DWH Multi-sensor Assessment: Jamie Holmes, Stratus Consulting
 - DWH SAR Applications: George Graettinger
 - UAS Potential Use & Limitations: Michele Jacobi, NOAA ORR ARD
 - KSAT- Multi-Mission Near Real-Time Satellite Imagery: Carles Debart
- **1000** **Charge to Breakout Groups**
- **1015** **Breakout Groups: Identify Needs & Gaps in Observing Technology**



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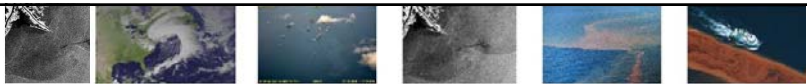


Agenda – Wednesday, October 21

- **1130** **Plenary Session – Breakout Groups Reports**
- **1230** **Lunch provided**
- **1330** **Breakout Groups: Specific Gap Analysis**
- **1500** **Break**
- **1530** **Plenary Session: Breakout Group Reports**
- **1630** **Adjourn**



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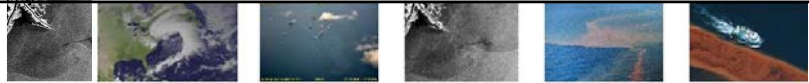


Agenda – Thursday, October 22

- **0830** **Charge to Breakout Groups**
- **0845** **Breakout Groups: Prioritize**
- **1030** **Break**
- **1045** **Plenary Session – Breakout Groups Reports**
- **1115** **Plenary Session: Workshop Summary**
- **1230** **Adjourn (no lunch provided)**



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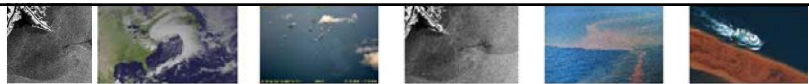


Facilitation Pledge

- I will recognize and encourage everyone to speak
- I will discourage side conversations
- I commit to:
 - Being engaged in meeting
 - Keeping us on task and time
- Stop me if I am not doing this!



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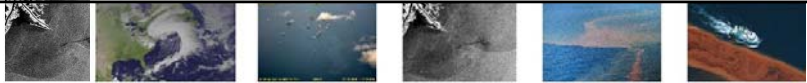


Participant Pledge

- Be Engaged
 - Turn off cell phones & laptops(except at breaks)
- Listen to Others
- Contribute
- Speak Clearly; Use Microphones in Plenary
- Learn from Others
- Avoid Side Conversations



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Agenda – Tuesday, October 20

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- **0930** **Plenary Session : Need for Oil Observing in Response**
 - NOAA ORR: Scott Lundgren, Chief of Emergency Response Division
 - USCG: LT James Litzinger, Gulf Strike Team
 - NOAA ORR: Lisa DiPinto, Assessment and Restoration Division
- **1000** **Break**



NOAA | Office of Response and Restoration | Emergency Response Division




NOAA Emergency Response Division: Requirements for Oil Observation

October 20, 2015
Scott Lundgren
Chief, Emergency Response Division

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Topics

- NOAA ERD Role in Response
 - Scientific Support Coordinator
 - Scientific Support Team
- Oil observation needs for NOAA roles and customers in response

5/19/15 at 1700 PDT from bluff overlooking Refugio (Stout)



NOAA | Office of Response and Restoration | Emergency Response Division

Department of Commerce / NOAA

National Ocean Service

Office of Response and Restoration

Emergency Response Division

Assessment and Restoration Division

Marine Debris Division

Marine debris threatens marine life and our oceans and coasts. It affects us too, whether we are boating, fishing, swimming, or simply enjoying a day at the beach. Trash can travel through rivers, oceans, streams, and storm and end up in your community, as well as in the ocean. Learn ways to stop this from happening.

www.marinedebris.noaa.gov

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Emergency Response Division

Assessment and Restoration Division

Marine Debris Division

1 What happened?

2 Where could it go?

3 What could it affect?

4 What harm could it cause?

5 What can be done to help?

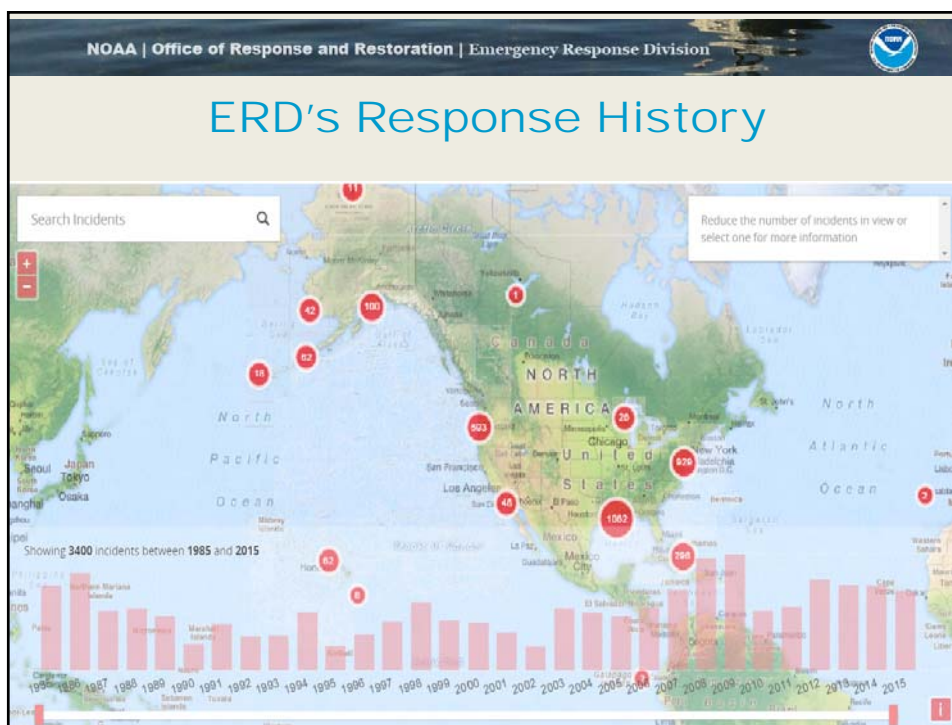
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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What we do....

- **Response 24/7:**
 - On-scene and remote support
 - Modeling, shoreline assessment, resource assessment, weather coordination, overflights, data management, communications, development of guidance (BMPs, endpoints, priorities), RRT/NRT
- **Preparedness:** National & Regional Response Teams, exercises, guidelines, maps, training, outreach
- **Development:** Tools, models, web access
- **Coordination:** States, academia, other NOAA offices
- **Restoration (Assessment & Restoration Division):**
 - Assess injury to coastal and marine resources
 - Restore affected natural resources

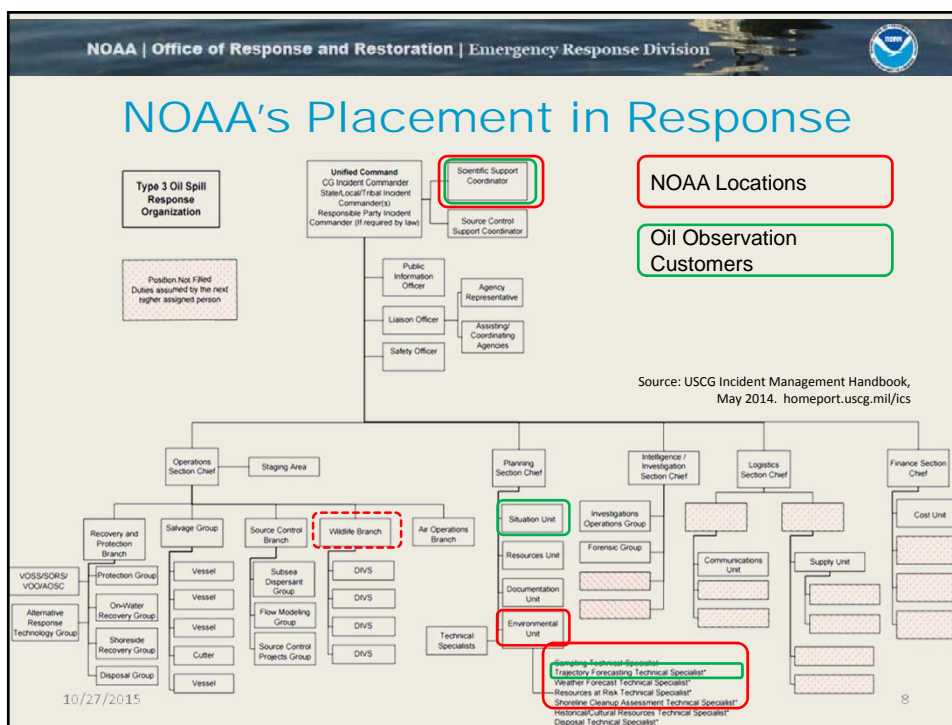



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ERD Oil Observation: Regulations

- **National Contingency Plan / 40 CFR 300.145**
 - Scientific Support Coordinators (SSCs) may be designated by the OSC... as the principal advisors for scientific issues...
 - NOAA SSCs are assigned to USCG Districts and are supported by a scientific support team that includes expertise in environmental chemistry, **oil slick tracking**, **pollutant transport modeling**, natural resources at risk, environmental tradeoffs of countermeasures and cleanup, and information management.
- **Industry Planholder Dispersants Caps / 33 CFR 154.1045**
 - The owner or operator must provide responders trained in aerial observation “and familiar with the use of other guides, such as NOAA’s ‘Open Water Oil Identification Job Aid for Aerial Observation’”

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Overflights

OPEN WATER OIL IDENTIFICATION JOB AID
for aerial observation
With Standardized Oil Slick Appearance and Structure Nomenclature and Codes
Version 1.0, January 2015

U.S. DEPARTMENT OF COMMERCE - National Oceanic and Atmospheric Administration
Office of Response and Restoration - Emergency Response Division
Seattle, Washington

10/27/2015

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Remote Sensing – UAS, Aircraft, Satellite

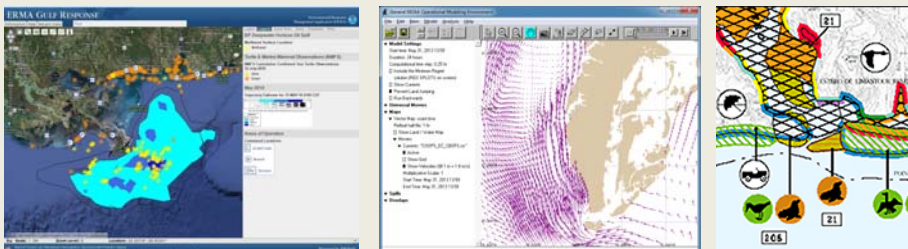
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Oil Detection: Information use

- Common Operating Picture / ERMA
- Trajectory Modeling / GNOME
- Resources at Risk
- On-water Response Support (generally RP)



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RESPONDER TOOLS

MAPLOTS (Mapping Applications for Response, Planning, and Local Operational Tasks) is a mapping program in CAMEO that allows users to add objects to maps, as well as view and edit data associated with those objects.

ERMA (Environmental Response Management Application) is an online mapping tool integrating static and real-time data in an easy-to-use format for environmental responders and decision makers.

ALOHA (Areal Locations of Hazardous Atmospheres) is an air hazard modeling program in CAMEO that estimates how a toxic cloud might disperse after a chemical release, including fire and explosion scenarios.

CAMEO (Computer Aided Management of Emergency Operations) is a software suite designed to help prepare for and respond to chemical emergencies.

ESI Maps (Environmental Sensitivity Index maps) Maps provide a concise summary of coastal resources at risk if an oil spill occurs nearby.

CRW (Chemical Reactivity Worksheet) predicts possible hazards from mixing chemicals and is used to help prevent dangerous chemical incidents.


ROC (Response Options Calculator) predicts how spilled oil will change and degrade over time and the volume of oil that can be recovered, burned, or treated using different response tactics.

TAP (Trajectory Analysis Planner) analyzes statistics from potential spill trajectories generated by the oil spill trajectory model.

GNOME (General NOAA Operational Modeling Environment) is a software modeling tool used to predict how oil and other pollutants might move and spread on the water.

CAFE (Chemical Aquatic Fate and Effects) Database is a software program that helps responders assess potential harm to aquatic life from chemical or oil spills.

ADIOS (Automated Data Inquiry for Oil Spills) models how different types of oil change and degrade in the marine environment.



NOAA | Office of Response and Restoration | Emergency Response Division

Questions?

Scott Lundgren
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NOAA Office of Response & Restoration
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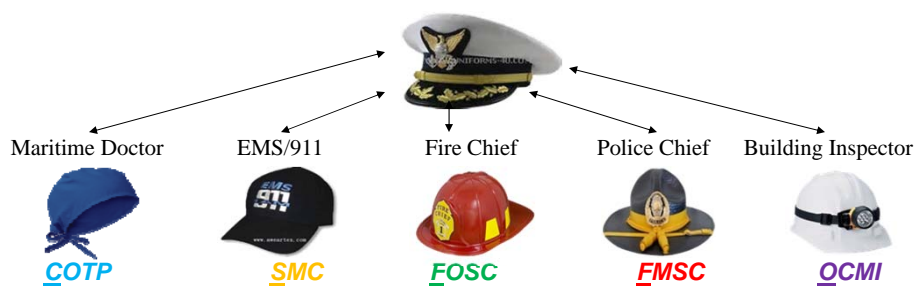
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USCG AUTHORITY REVIEW



Multiple Authorities



Guidance / Authorities

National Response System

Laws
Regs - NCP
Plans

People
Environment
Property
Economy



Authority

- **Identify the source of Federal On-Scene Coordinator Authority:**
 - Statutory Authority:
 - Federal Water Pollution Control Act as amended by
 - Clean Water Act
 - Oil Pollution Act
 - Comprehensive Environmental Response, Compensation, and Liabilities Act as amended by
 - Superfund Amendments and Reauthorization Act
 - Regulatory Authority
 - 40CFR300 The NCP
 - 33CFR
 - CG Policy Guidance
 - MSM Volume 9
 - M16465.29 (CERCLA authority)



Authority

- **Four general priorities of the National Contingency Plan (NCP)**
 - The purpose NCP is to provide the organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants.
 - To give safety and human health top priority during every response action.
 - To stabilize the situation in order to prevent the event from worsening.
 - To use all necessary containment and removal tactics in a coordinated manner to ensure timely, effective response.
 - To take action to minimize further environmental impact from additional discharges.



Authority

- **Authority the FOSC has under the NCP**
 - 40 CFR 300.2 The president delegated to the EPA the responsibility for the amendment of the NCP.
 - 33 CFR 1.01-70 CERCLA delegations to CG.
 - 33 CFR 1.01-80 FWPCA and OPA 90 delegations to CG.
 - 33 CFR 1.01-85 Re-delegation within CG.
 - 33 CFR 1.01-90 Delegation of authorities to commissioned, warrant, and petty officers.



Authority

- **On-Scene Coordinators primary responsibilities**
 - 40CFR300.120 The OSC directs response efforts and coordinates all other efforts at the scene of the discharge or release and oversees the development of the ACP.
 - Ensure that persons designated to act as their on-scene representatives are adequately trained and prepared to carry out actions under the NCP
 - OSC will coordinate, direct and review the work of other agencies, Area Committee members, and contractors to ensure compliance with NCP and other plans applicable to response



Best Response: The Goal

**Minimize ...the Adverse Impacts
and Consequences of the
Incident.**

- and -

**Maximize ...Public Confidence
& Stakeholder Satisfaction.**



Authority

- **The notification requirements outlined in the NCP**

- Notice of discharges and releases must be made telephonically through a toll free number or a special local number to the National Response Center (NRC).
- In accordance with 33CFR153.203 and 40CFR302, the notice of an oil discharge or release of hazardous substances in an amount equal to or greater than the reportable quantity must be made *immediately*.

	Inland (gal)	Coastal (gal)
Small	<1,000	< 10,000
Medium	1,00-10,000	10,000-100,000
Large	>10,000	>100,000



Authority

- **(continued)**

- 40CFR110.6: Notification of a discharge of oil in a harmful quantity must be made to NRC as soon as RP has knowledge.
 - If not practicable, notice may be made to the local OSC.
- 40CFR117.21: Notification of a discharge of a designated hazardous substance in a harmful quantity must be made to the appropriate agency as soon as RP has knowledge.
- 40CFR302.6: Notification of a release of a hazardous substance in an amount over the reportable quantity must be made to the NRC as soon as RP has knowledge. No exceptions.



Jurisdiction

- **Define the jurisdiction that the following agencies have:**
 - USCG
 - Discharges of oil; release of hazardous substances, pollutants and/or contaminants into the environment in the coastal zone
 - US EPA
 - Discharges of oil; release of hazardous substances, pollutants and/or contaminants into the environment in the inland zone
 - Department of Defense
 - Discharges of oil; release of hazardous substances, pollutants and/or contaminants into the environment from military operated facilities, installations, munitions and/or military vessels (COI must be in-place)
 - Department of Energy
 - Discharges of oil; release of hazardous substances, pollutants and/or contaminants into the environment from DOE facilities or non-DOD radiation sources



Authority

- **Identify the source of COTP authority**
 - 33 CFR 6.04-5 ("Super 6")
 - The COTP may prevent any person, article, or thing from boarding or being taken or placed on board any vessel or entering or being taken into or upon or placed in or upon any waterfront facility whenever it appears that such action is necessary in order to secure such vessel from damage or injury or to prevent damage or injury to any vessel, or waterfront facility or waters or the US, or to secure the observances of rights and obligations of the US.
 - The COTP regulates access of personnel, movement of vessels and operations of facilities in order prevent or minimize damage or injury.



Authority

- **Explain FOSC and COTP authority to prevent access of personnel to vessels or waterfront facilities**
 - COTP (with a COTP Order) can take possession of any vessel whenever it is necessary to secure the vessel to prevent damage or injury to the vessel, waterfront facilities, or waters itself of the US.
 - FOSC may enter private property
 - To minimize the possibility of a spill
 - To minimize the damaging effects of a spill
 - To determine the severity of a spill
 - To determine the source of a spill
 - To decide possible courses of action to mitigate spill damage
 - FOSC may obtain Administrative Order that requires certain action prior to resuming on-site activities or operating vessel



Authority

- **Explain FOSC and COTP authority to control vessel movement**
 - 33CFR6.04-8 and 33CFR160 subpart B
 - The COTP may supervise and control the movement of any vessel and shall take full or partial possessions or control of any vessel or any part thereof...
 - Control of Private Activities and Property
 - For all actual or potential releases the FOSC may:
 - o curtail or prohibit private activities, such as near-by plant operations or use of a railway line...
 - o control the movement, or use, of the source of a release, or potential release, and undertake any corrective measures...
 - If a release or threatened release poses an imminent threat of substantial harm, the FOSC may:
 - o Requisition private property...
 - o Destroy the facility or vessel which is the sources of the release...



Authority

- **Explain FOSC and COTP authority to enlist aid from other local and government agencies**
 - The COTP may enlist the aid and cooperation of federal, state, county, municipal, and private agencies to assist in the enforcement of regulations of 33 CFR 6.04-11.
 - 40CFR300.175 During preparedness planning or in an actual response, various federal agencies may be called upon to provide assistance in their respective areas of expertise...consistent with agency legal authorities and capabilities.
 - DOD, USACE, DOI/NPS/BLM/USFW, SUPSALV, FEMA, USDA, DOC/NOAA, HHS/CDC/ATSDR, DOJ, DOL/OSHA
 - Special Teams
 - Resource Trustees



Authority

- **Explain how a Safety Zone may be used to manage a pollution incident**
 - Guidance for drafting a Safety Zone or COTP Order can be found in Marine Safety Manual vol. VI and 33 CFR 165.5 (Establishment Procedures for Regulated Navigation Areas and Limited Access Areas).
 - Safety Zones protect the area outside the zone from danger within the zone.
 - Limiting access
 - Site control
 - Human Health/Welfare and environmental protection
 - Security Zone protects the area inside the zone from danger outside zone.



Need for Oil Observing in Response

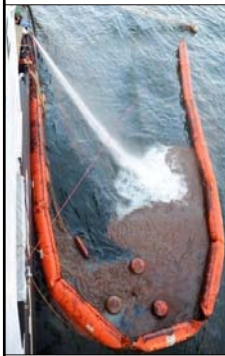
- So why does the USCG need Oil Observation in a Response?
 - ✓ As the Federal On-scene Coordinator (40CFR) and while exercising the authority given as Captain of the Port (33CFR) the USCG must:
 - Develop the best strategies and tactics based on observations and collected data to respond to a pollution threat, mitigate that threat and minimize the potential of adverse impacts on people, the environment and the economy.
 - Choose the best enforcement and response action based on information received



Alternative Response Technology



On Water Recovery



Shoreline Protection & Recovery



Questions?



NOAA | National Ocean Service

Office of **Response and Restoration**



Oil Observing Tools: An Assessment Perspective

NOAA Office of Response and Restoration
Assessment and Restoration Division
Lisa DiPinto, Ph.D.



1

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Natural Resource Damage Assessment (NRDA)

- Oil Pollution Act, 15 CFR 990
- Who: Trustees
- Responsibilities:
 - Determine amount of injury to natural resources and lost services from time of incident through recovery of resources
 - Develop and oversee implementation of restoration plan(s) to compensate the public for injuries and lost services
 - Ensure the polluters pay for assessment and restoration

2

Injury Assessment

- **Injury Determination**
 - **Pathway:** establish pathway from discharge to the exposed resource(s)
 - **Exposure:** confirming resources were exposed to oil/dispersants/other related materials
 - **Injury determination:** document adverse effects occurring resulting from exposure and response actions
- **Injury Quantification:** determine degree, geographical + temporal extent of injuries



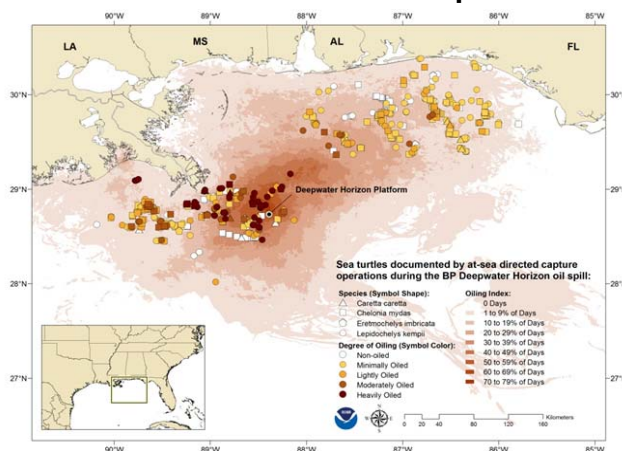
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Oil Observations Used in Assessments

- Surface oiling “footprints” of exposure
 - Cumulative, daily, weekly, or other timeframes relevant to resources of interest
 - Overlay resources (e.g., turtles, mammals, birds telemetry, boats and aerial surveys) with surface oil
- Percent cover of oil, or other information about surface oil ‘patchiness’
- Persistence of surface oiling for exposure duration
- Information about surface oiling “thickness”
 - Thin and ‘thicker than thick’
 - Estimates of oil thickness for determination of surface mixing zone concentrations, volumes of water exceeding toxic thresholds, etc.

4

Sea Turtle Example



Locations of turtles captured and assessed during rescue operations, shown by species and degree of oiling, overlaid upon cumulative oil-days within the overall oiling footprint.

5

Water Column Considerations

Surface oiling congregates in convergence zones and persists resulting in prolonged exposure to sensitive resources

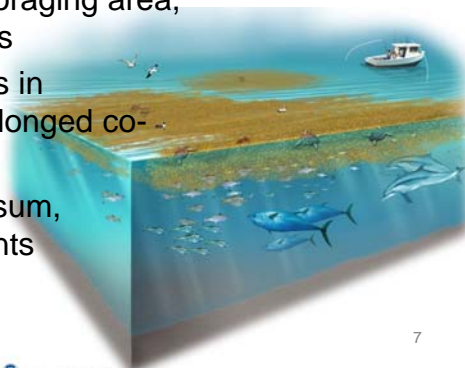
- High level of biological activity in ocean surface, sensitive early life stages concentrated at the surface
- UV enhanced toxicity – especially at/near surface
- Even thin sheens (~ 1 μ m) are toxic to fish and invertebrates
- Surface oil mixing into surface mixing layer results in toxic concentrations of oil in water



Sargassum Assessment Considerations

Sargassum: designated as Essential Fish Habitat (EFH)

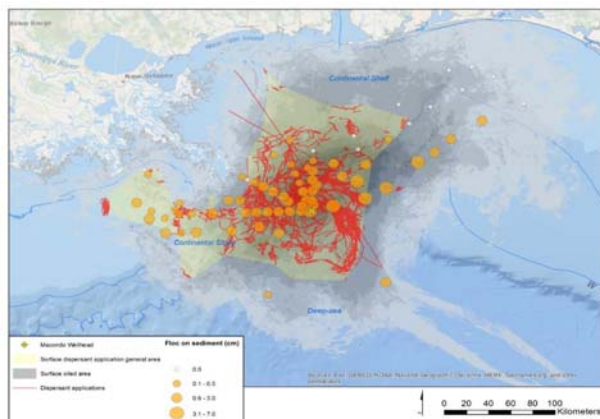
- Fish larvae and invertebrates, larger fish, sea turtles, sea birds rely on Sargassum as habitat, foraging area, protection from predators
- Sargassum concentrates in convergence zones, prolonged co-location with surface oil
- Direct toxicity to Sargassum, especially with dispersants



7

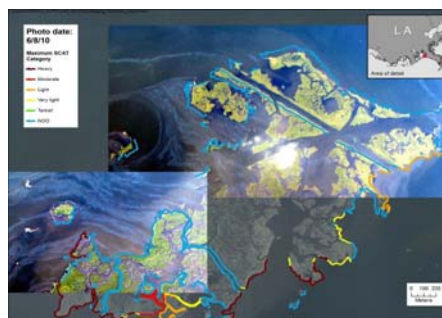
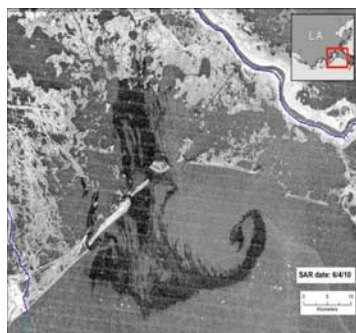
Surface Oil and Sea Floor Floc

- Larger quantities of floc were observed on the sea floor beneath areas experiencing persistent surface oil and application of dispersants.



8

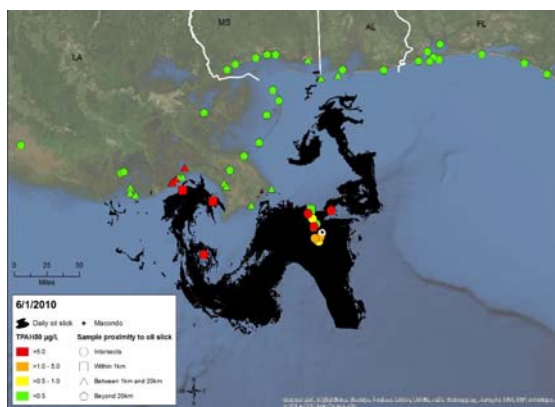
Use of SAR in Nearshore Environment




Use of SAR and aerial imagery to document oiling beyond SCAT for additional information on *exposure*

Surface Oiling Products to Guide Field Sampling?

- The synoptic sampling dream



Satellite
Overflight
Surface water
Subsurface water
gradient
Air gradient
Slick thickness



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NOAA ORR Oil Observing Program

Jeff Lankford
National Oceanic and Atmospheric Administration
Office of Response and Restoration
Emergency Response Division
Seattle, Washington

10/27/2015



NOAA | Office of Response and Restoration | Emergency Response Division

Why Conduct Overflights

- Surveillance of the Oil Slick
 - Location and Size of the Oil Slick
 - Scale the Problem
 - Oceanographic Features
 - Currents, Convergence Lines, Rip Tides
 - Environmental Conditions
 - Winds, Currents, Visibility

10/27/2015



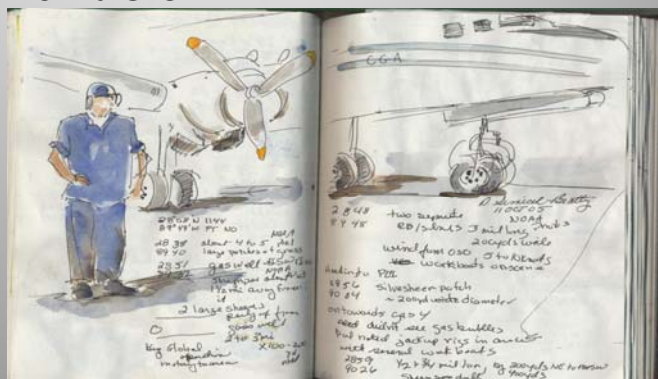
Why Conduct Overflights

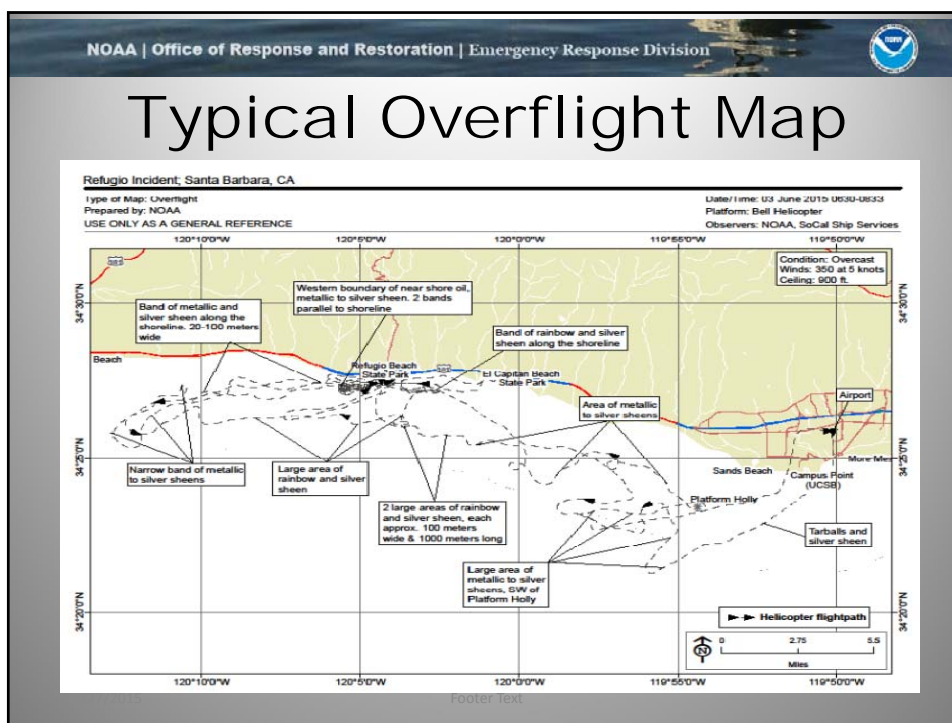
- False Positives
 - Kelp Beds, Cloud Shadows, Natural Slicks
- Validate and/or Recalibrate GNOME
- Wildlife in the Vicinity of the Spill



Overflight Map

- An overflight map is the combinations of:
 - Notes from the Observer
 - Trackline from a GPS
 - Photo's






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Overflights

- **Advantages**
 - Fast turnaround
 - Can Direct Flight Path
 - Able to Scale the Size of the Release
 - Can Conduct Multiple Flights Each Day
 - Deploy Tracking Devices
 - Trained Observer
 - Works Open Ocean, Rivers and Lakes


Footer Text

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Overflights

- **Disadvantage or Limitations**
 - Weather
 - Equipment Failure
 - No Trained Observer
 - Distance and Time
 - Daylight Hours
 - Delay Generating Final Map from Flight

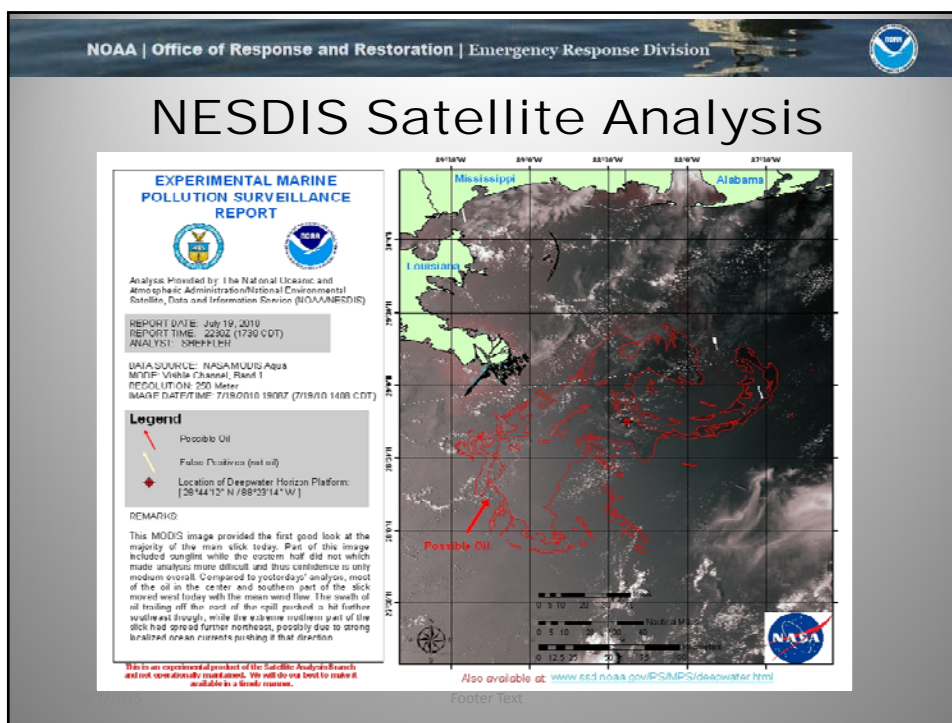
10/27/2015 Footer Text

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Equipment

- Aircraft/Pilot Fixed Wing/Rotary
- Trained Observer
- Safety Gear
- Note Pad
- GPS
- Camera
- Backup Gear

10/27/2015 Footer Text




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Future Needs

- Hand Held Data Tracker: Tablet
- Streamline Bureaucracy


Footer Text




NOAA/NESDIS Marine Pollution Program





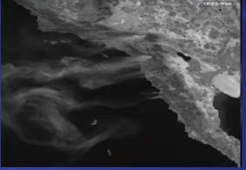

Davida Streett
NOAA/NESDIS



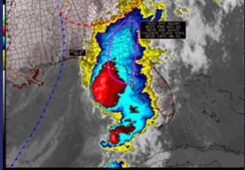
NESDIS Satellite Analysis Branch Hazard Mitigation Programs

Operational 24 x 7 x 365






Fire and Smoke




Precipitation

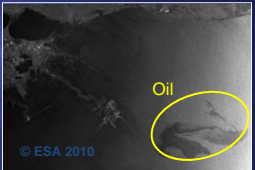


Tropical Storms/Hurricanes

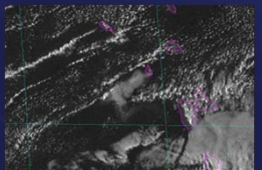
• Oil/Marine Pollution Phone: 301-683-1403
• Email: oceanmap@noaa.gov



Marine Debris
Lead focal point: Ellen Ramirez

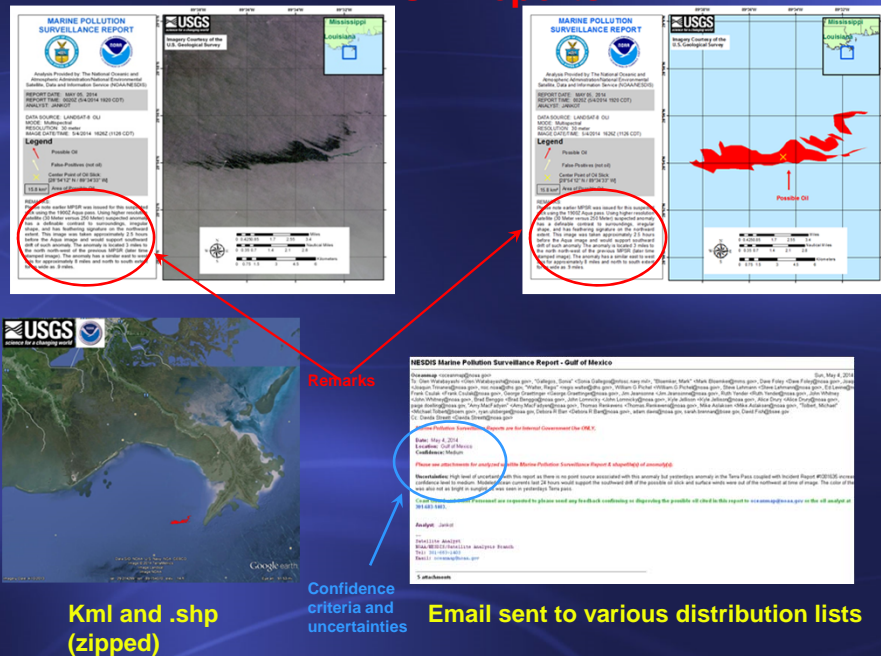


Marine Oil Spills
Team Lead: Mike Turk



Volcanic Ash

MPSR Reports



Confidence Criteria

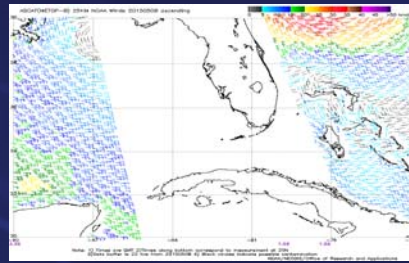
- Separate criteria for SAR & Optical (Multispectral) Imagery.
 - Criteria Levels:
 - Low
 - Medium
 - Medium-High
 - High
- Reports only issued on anomalies assigned Medium-High and higher criteria

Reports only issued for anomalies assigned Medium and higher criteria by analyst.

Ancillary Data (reduces false positives and negatives)

- Surface and Ship Winds
- Scatterometer Winds (ASCAT, WindSAT, RapidSCAT)
- Modeled Ocean Currents (HYCOM model)
- Chlorophyll Concentration and Anomaly Products (MODIS)
- GOES Sea Surface Temperature Ocean Frontal Product

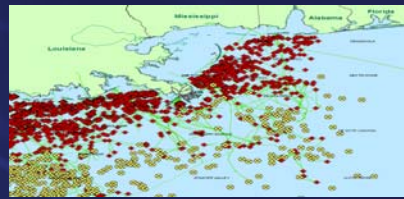
ASCAT winds
from METOP-B



Ancillary Data (reduces false positives and negatives)

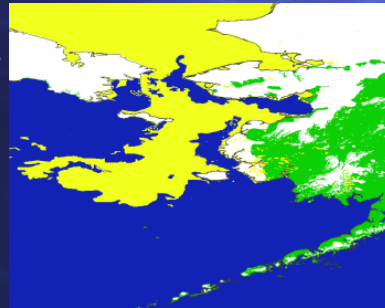
- Known Natural Seep Sites (GOM & CA)
- Oil Infrastructure: Platforms/Active Rigs/Pipelines/Oil Boreholes/Repeat Leak sources
- Known Shipwreck Sites and Shipping Lanes
- Lease Blocks/Lease Area Boundaries
- Bathymetry Data

Platforms – Red,
Pipelines – Green,
Seep Sites - Yellow



Ancillary Data (reduces false positives and negatives)

- National Ice Center (NIC) Daily Ice Analysis
- NRC (National Response Center) Alerts and Hotlines

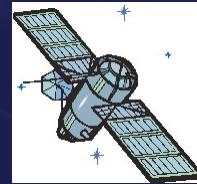


NIC Ice Analysis

Uses

- Provides input to oil spill trajectory models
- Helps determine which models are best “handling” an event
- Can be first warning of a spill.
- Provides illegal oil dumping notification to USCG in accord with MARPOL I
- Only efficient way to simultaneously monitor hundreds or thousands of Gulf platforms/rigs
- Has been effectively used to “rule out” areas that don't require oil response. Relieves unnecessary concerns of public
- Saves money and time by enabling reconnaissance aircraft to be more precisely targeted
- Provides coverage even when aircraft “grounded” by weather
- Primary means of developing a synoptic picture of very large spills
- Media resource during high profile spills
- Enables responders to better task resources (e.g., skimmers, boom) and planners to better prepare

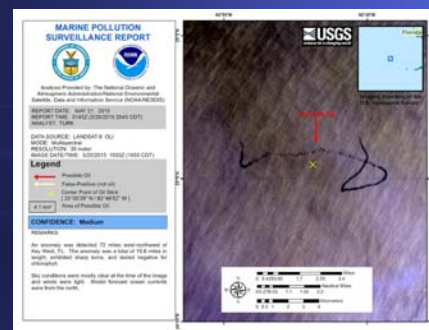
But here's the
problem...
(and it comes in three
flavors)



Routine monitoring (e.g., dumping from ships)

In support of MARPOL I
obligations, USCG, BSEE

Not much imagery...



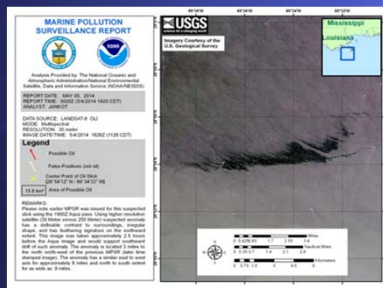
- Landsat 7, Landsat 8 and soon Sentinel 2 (Multispectral /moderate resolution)
- MODIS (TERRA and AQUA) (Multispectral /low resolution) ("sunglint season")
- Radarsat-2 (SAR)
- Sentinel 1a and soon 1b (SAR) (Not much Sentinel 1a in GOM, but 1b will have better coverage)

And after dark/under clouds, (when illegal dumping tends to occur), just a small amount of RADARSAT and SENTINEL

Moderate spills w a little persistence

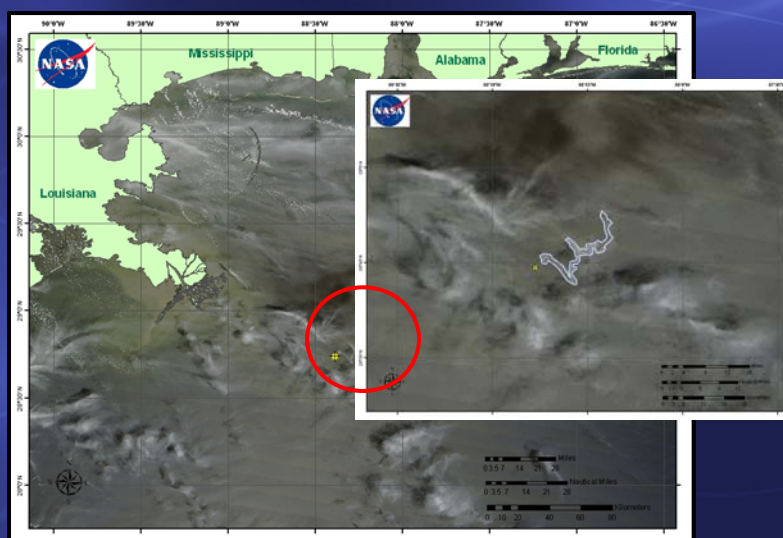
In support of USCG, NOAA, state and local responders, DHS, EPA, United Area Command Center

A little more imagery with some delay...



- All satellites on the previous slide
 - FORMOSAT (Multispectral)
 - EO-1 (Multispectral)
 - ASTER (Multispectral)
- A result of FOSTERRS discussions and courtesy of NASA
- And after dark or under clouds, just RADARSAT and SENTINEL and just over part of our area
 - NGA tasked commercial satellites ?!? Could be a big step forward for us.

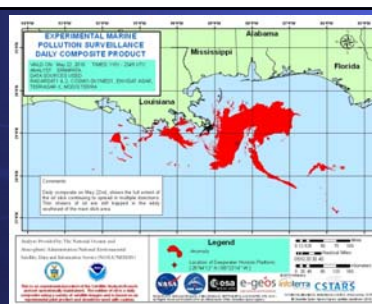
Another example of a “medium” spill



Big spills

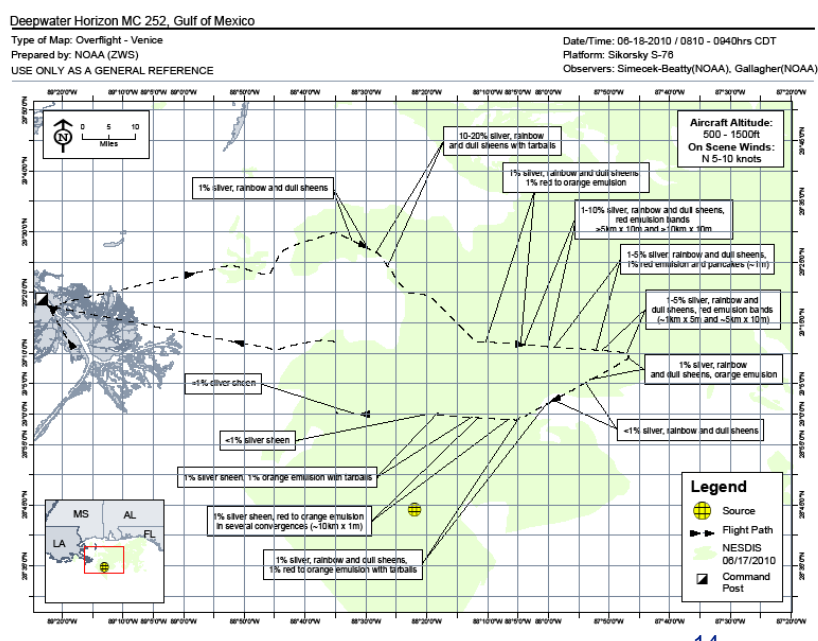
In support of NOAA, USCG, BOEMRE, state and local responders, USGS, DOI Hq, others in DOI, United Area Command Center, Pentagon, Navy, Air Force, Dept. of Homeland Security, NGA, White House, ESRI, Google, media

**International Disaster Charter
Activated and NGA did a massive
databuy!!!**



- Suddenly, no lack of imagery (the Charter is amazing). But how to best integrate into the response? How to analyze and disseminate quickly.
- Now question is what is best to use and when.
- Unfamiliar satellites and sometimes format issues
- And for an Arctic spill, little experience with satellite oil detection.
- And above all, how to differentiate sheens from recoverable oil

Use as Area in which to Search for Thick Oil



- [illegible]

- (1) suitable aircraft and satellite imagery is quickly made available in a manner that can be integrated into oil spill mitigation efforts,
- (2) existing imagery interrogation techniques are in the hands of those who will provide the 24 x 7 operational support and
- (3) efforts are made to develop new technology where the existing techniques do not provide oil spill responders with important information they need.

Other Collaborations?

- MOA between NGOs representing NESDIS and Taiwan's Center for Space and Remote Sensing Research providing, among other things, access to FORMOSAT.
- Pending Annex to the NOAA-Environment Canada MOA that would formalize collaboration between SAB and ISTOP (Integrated Satellite Tracking of Pollution) creating a North American collaboration.
- Planned discussions with Mexican counterparts about expanding collaboration to include Mexico.

Disaster Charter role

- An international agreement among Space Agencies designed to provide space-based data in the wake of a natural disaster
- Personnel at NOAA/NESDIS nominated as Project Manager of Disaster Charter
 - Responsible for soliciting imagery
 - Tried to ensure fast data & information delivery
- Charter provided 250 images during Deepwater Horizon event. NGA stepped in as Charter imagery waned.
- Restrictions on use of Charter imagery

Issues in the order in which they keep me up at night...












- Need more imagery and it needs to be timely
- Need a quick albeit approximate means of determining thickness (in multispectral and SAR)
- In Arctic: Need experience/algorithms/collaborative framework/user interactions and education/ways to eliminate false positives and false negatives

Questions?

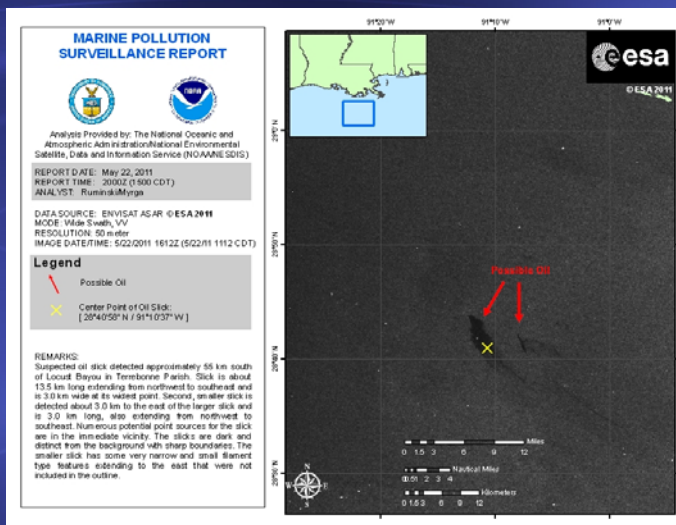
Thanks

Backup Slides

Potential Imagery Available During Major Event/Disaster

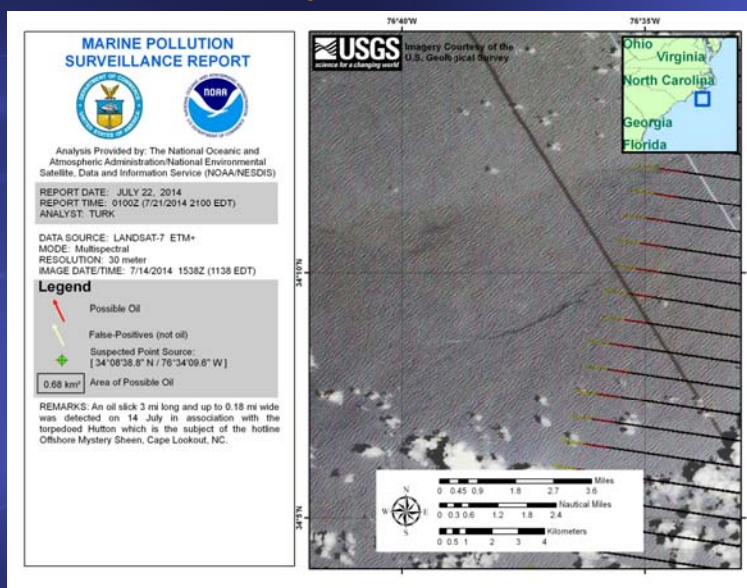
- Worldview 1,2,3 (Multispectral /1.8 meter) 
- Quickbird (Multispectral /2.4 meter) 
- Ikonos (Multispectral /3.2 meter) 
- GeoEye-1 (Multispectral /1.65 meter) 
- Aster (Multispectral /15 meter) 
- EO-1 (Multispectral /30 meter) 
- Formosat-2 (Multispectral /8 meter) 
- SPOT 5/6 (Multispectral /10 meter) 
- TerraSAR-x (SAR/1-18 meter) 
- COSMO-SkyMed(SAR/1-100 meter) 
- Radarsat-2 (Synthetic Aperture Radar-SAR/ 50 meter)  

May 22, 2011



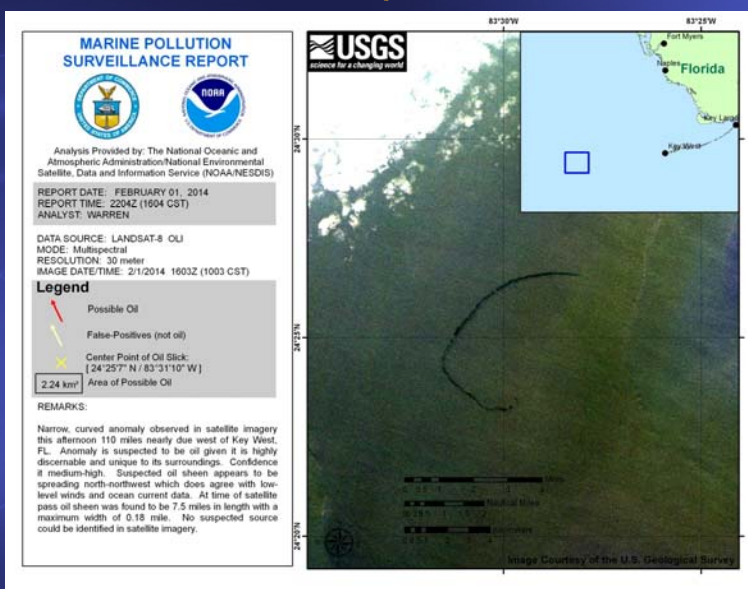
Email from USCG on 5/24 confirmed an oil sheen was reported to the National Response Center on the same day that the report was issued.

July 14, 2014



Mystery slick off North Carolina. Later identified as leak from WWII era (1942) shipwreck.

February 1, 2014



Unconfirmed anomaly west of the Florida Keys. Possible vessel link per USCG.



Current Capabilities and Proposed Enhancements to the Airborne Spectral Photometric Environmental Collection Technology -Remote Oil Detection System-

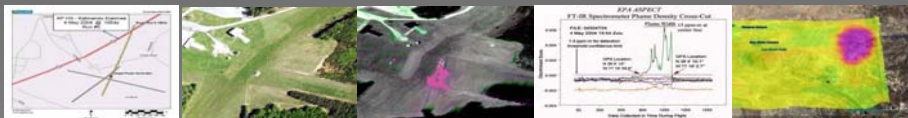
*Paul Kudarauskas, Branch Chief
Field Operations Branch, Consequence Management Advisory Division
Office of Emergency Management
United States Environmental Protection Agency*

Remote-Sensing & Imagery- Chemical, Radiological & Situational Awareness



- Provide a readiness level on a 24/7 basis
- Provide a simple, one phone call activation of the aircraft
- Wheels up in under 1 hour from the time of activation
- Once onsite and data is collected it takes about....

~ 5 minutes to process and turn around data to first responders



- Deployment Simplified:
 - Once on-scene collect chemical, radiological, or situational data (imagery) using established collection procedures
 - Process all data within the aircraft using tested automated algorithms
 - Extract the near real time data from the aircraft using a broadband satellite system and rapidly QA/QC the data by a dedicated scientific reach back team
 - Provide the qualified data to the first responder enabling them to make informed decisions in minimal time

Platform: N9738B



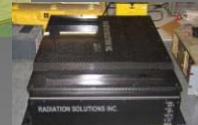
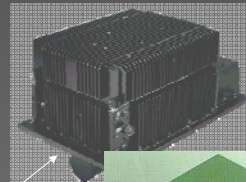
- N9738B: Full FAA DER/STC for all systems and components
- 1987 Cessna 208B Caravan
- TT6A Turbo Prop
- Useful Weight: 4180 lbs
- Typical Cruise Speed and Duration: 160 Kts at 6 Hours
- Full IRF Avionics with weather radar, live weather feeds and terrain/obstacle avoidance
- Broadband Satellite Communication/Data System
- Enhancements:
 - Exhaust modifications
 - Heavy lift modifications
 - Certified for ice landing and takeoff

3

CURRENT SYSTEMS

■ ASPECT Uses Six Primary Sensors/Systems:

- ✓ An **Infrared Line Scanner*** to image the plume
- ✓ A **High Speed Infrared Spectrometer*** to identify and quantify the composition of the plume
- ✓ **Gamma-Ray Spectrometer** Packs for Radiological Detection NaI and LaBr and **Neutron Detector**
- ✓ High Resolution **Digital Aerial Cameras*** with ability to rectify for inclusion into GIS
- ✓ Broadband Satellite Data System (**SatCom**)



*Scheduled for replacement in FY16

4

ASPECT Oil Detection Program



- Specificity – Detection is accomplished using a pattern recognition method to attenuate false alarms
- Due to the design of the imaging system, ASPECT can image a swath 1 mile wide with a pixel level spatial resolution of 3 feet. This permits the system to see both large oil masses and smaller isolated patches
- Each pixel of the image is geo-registered
- ASPECT can image about 2 square miles per minute or about 750 to 1000 square miles per patrol
- Oil location, relative thickness, and location can be relayed to the response team in about 5 minutes.

5

ASPECT Products

(Secured, Google Earth, Google Maps, ESRI)



**U.S. EPA ASPECT Program
Data Display Site**

BSA Jamboree July 2013

- Available Google Earth Data Products
[Google Earth Products](#)
- Available Flexviewer Data Products
[Flex Viewer Products](#)
- Available Google Maps Data Products
[Google Map Products](#)
- Available Google Earth API Data Products
[Google Earth API Products](#)
- Available Static Maps Products
[Static Maps Products](#)
- Available Mobile Data Products
[Mobile Maps Products](#)

Google Earth:
3D Infrared Line
Scanning Image

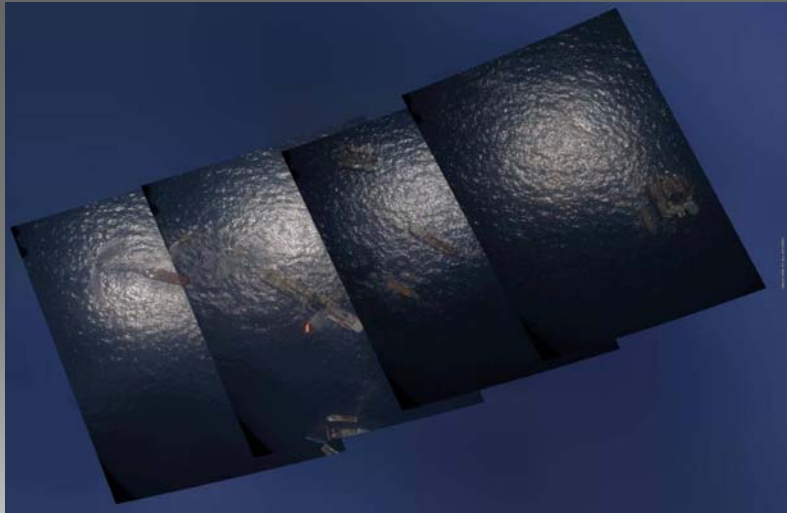


www.epaaspect3.net/googleearth/BSA_Jamboree_July2013/web/main/web_main_BSA_Jamboree_July2013_link.html

6

Deep Water Oil Detection

Aerial Photography



- Standard still frame photography is often used for Oil Detection
- While the method is simple to implement several complications exist:
 - Low target (oil) contrast to water
 - High glare and glint contamination
 - Day light dependent
 - Difficult to interpret

Open Ocean Oil Detection

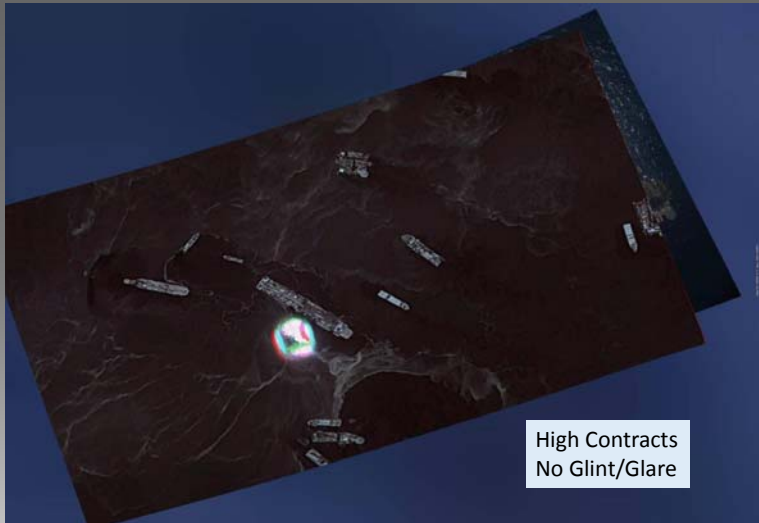


- Based on the difficulties of traditional aerial photography, the EPA ASPECT program has developed several methods to use data collected with the programs **RS800 multispectral infrared imaging systems** to quantify and locate surface oil in deep, open ocean waters
- A number of open ocean oil-on-water detection algorithms have been developed and successfully demonstrated including
 - ✓ Multi Spectral Infrared
 - ✓ ISO Data (Unsupervised Classification)
 - ✓ Spectral Pattern Recognition (Supervised Pattern Recognition)
- Trend analysis
 - ✓ Quantitative amounts (thickness of oils)
 - ✓ Dispersant effectiveness
 - ✓ Oil migration monitoring



Open Ocean Oil Detection

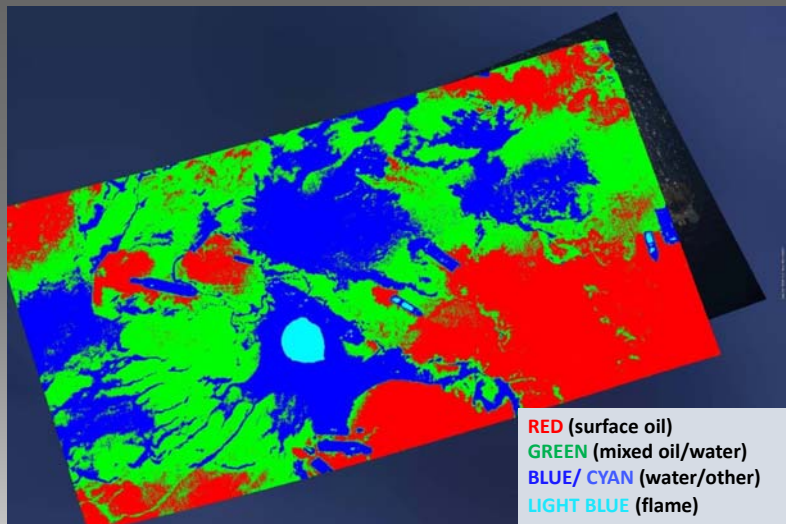
Multi Spectral Infrared Image – Deep Water Horizon Rig Location



- Multispectral infrared imagery permits physical properties of the water and oil (such as emissivity) to be exploited to show contrast.
- Since this method is driven by temperature and emissivity, day/night time operations are both possible.
- While contrast is outstanding, additional methods are needed to extract type and quantity of surface oils.

Open Ocean Oil Detection

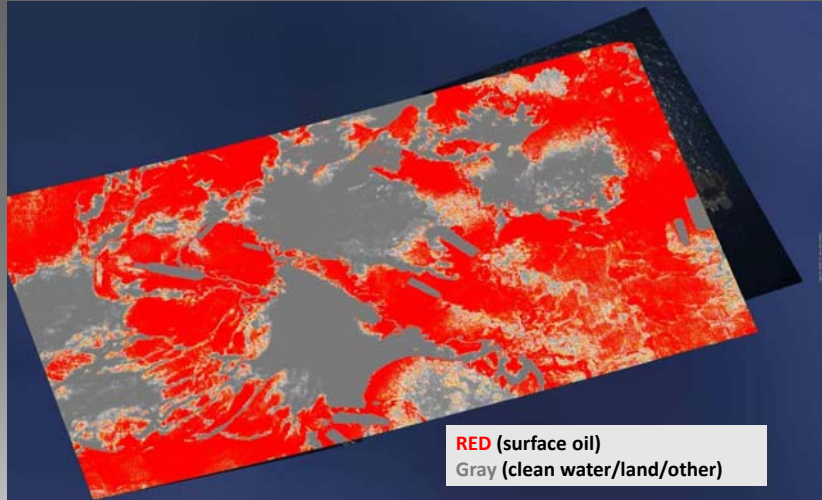
Unsupervised Classification Infrared Image



- Due to the fairly uniform surface temperature of the open ocean, simple classification methods can be employed
- An ISOData technique was found to be useful and permitted various levels of oil content/water content to be contoured.
- Since this method is unsupervised, caution must be used in interpretation since all data field are classified (Note the ships are classified as water)

Open Ocean Oil Detection

Supervised Pattern Recognition of IR Image

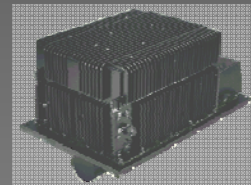


- By using several channels from the RS800 imager, a multi-variant pattern recognition method can be developed showing very strong oil to water discrimination
- By using several spectral channels, the software is trained to recognize oil and classify all other instances as non-oil

Shallow Water Oil Detection



- Shallow water oil detection is complicated by the thermal environment of near shore waters
 - Water can and does show high temperature gradients within the environment
 - These gradients complicate emissivity extraction giving rise to false oil detection and or detection clutter.
 - The shallow environment is often “contaminated” with natural substances which can be false identified as oil
- Shallow water detection requires the use multispectral multivariate methods. The program has found that spectral pattern recognition (Supervised Pattern Recognition) is most effective:
 - ✓ The thermal gradient environment is part of the training set and does not significantly drive false alarms
 - ✓ Vegetation and other natural features (land mass) are spectrally different than the oil and are placed correctly into the background training set.



Near Shore Oil Detection

Aerial Imagery – Barataria Bay



Aerial Images at 2880 feet

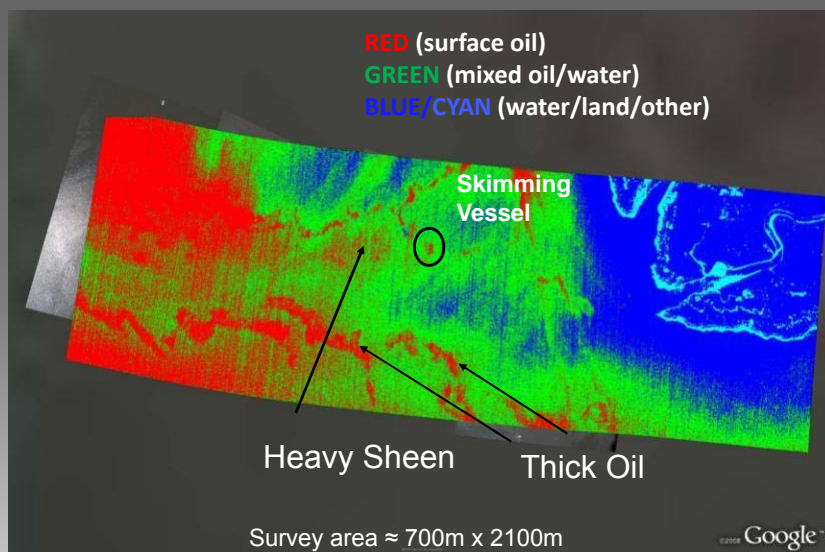


Low Contrast
High Glint Contamination
Difficult to Interpret

13

Near Shore Oil Detection

Unsupervised Classification Infrared Image

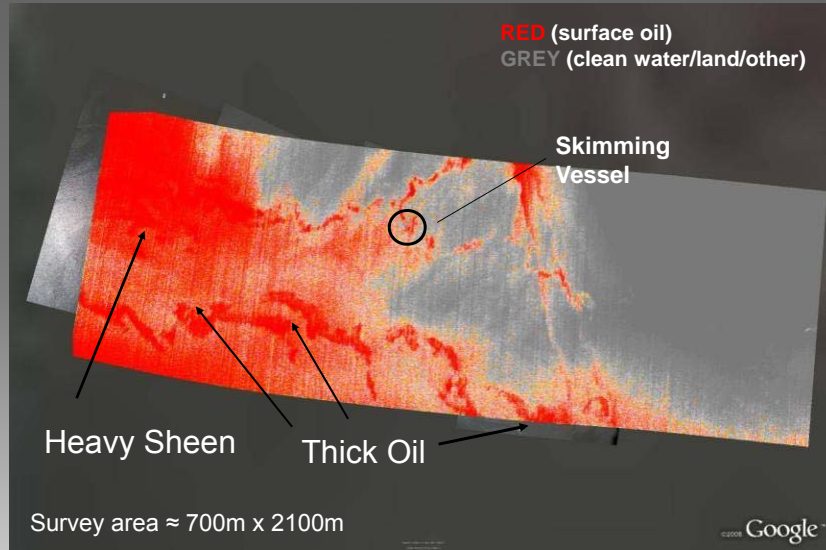


- The ISOData method becomes unstable when the surface temperature of the water begins to show a high gradient as present in show waters.
- Land masses also significantly impact the method and make interpretation difficult.

14

Near Shore Oil Detection

Supervised Pattern Recognition of IR Image



- The Supervised Pattern Recognition methods show strong performance in the high thermal gradient environments.
- The density of the detection effectively provides information on the amount of oil present on the surface.
- Land masses, structures, natural vegetation and other non oil targets are correctly identified as non oil and make interpretation much easier.

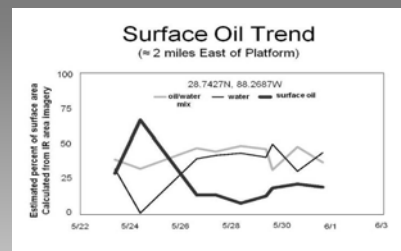
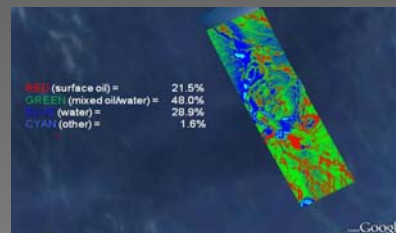
15

Spectral Analysis of Oil

Determining the Effectiveness of Dispersants



- During Deep Water Horizon ASPECT collected data approximately 2 miles east of the recovery site for a period of one month. Spectral analysis of the surface oil allowed a trend analysis to be conducted.
- Indicated that between 24 May and 26 May the surface characteristic of the oil changed.
- This observation is consistent with the application of dispersants to the area
- The features measured by ASPECT include the transition of oil from predominately surface oil to an oil/water mixture, consistent with dispersant physics.



Imaging Sensor Upgrade Status



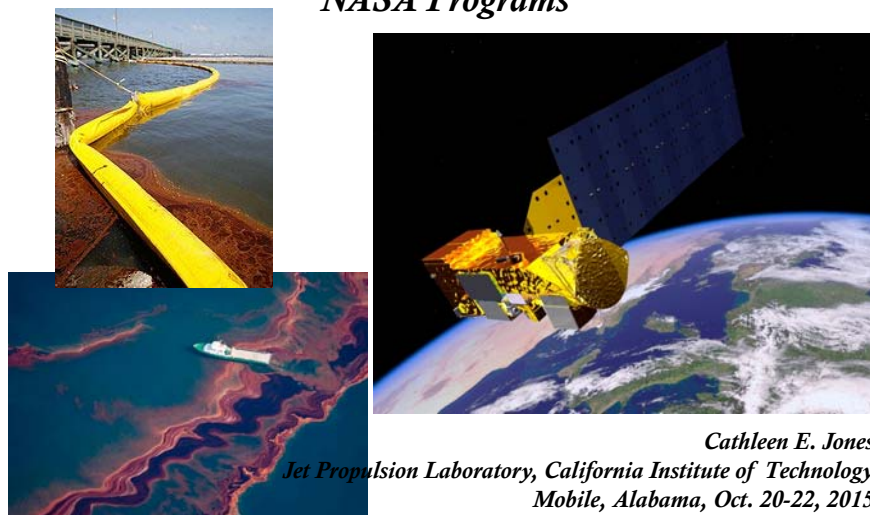
- The ASPECT program is replacing the current RS800 Infrared imaging systems with the LS1600 imager. This unit will have:
 - A 16 channel long wave detector providing higher resolution IR discrimination
 - Higher spectral throughput for the system to provide better noise equivalent temperature sensitivity
 - Enhanced data handling and onboard data processing to permit continuous data collection and continuous coverage selection areas of ocean
 - It is estimated that 2 square miles of ocean will be imaged and assessed per minute. A typical sortie will screen 750 to 1000 square miles of water.
- Anticipated delivery of the first modified unit – March 2016
- This up-grade/replacement includes the develop of additional software and training data to support the LS1600 sensor.

Planned Development Work Software



- Using experience developed by the ASPECT program and existing software tools to develop:
 - A fully automated detection algorithm using both unsupervised and supervised detection methods which will detection, locate and quantify oil on water and provide these results to response management in near real time.
 - Spatial resolution of the system will be approximately 1 square meter.
 - The software will support both day and night time operations
 - Through proper data training, the software will be trained to support oil responses ranging from tropical waters to arctic frozen ice.
- It is anticipated that the basic software package will be completed in 12 months.

Oil Observing Tools Workshop
Plenary Session A: Current Operational Programs
NASA Programs



Cathleen E. Jones
Jet Propulsion Laboratory, California Institute of Technology
Mobile, Alabama, Oct. 20-22, 2015

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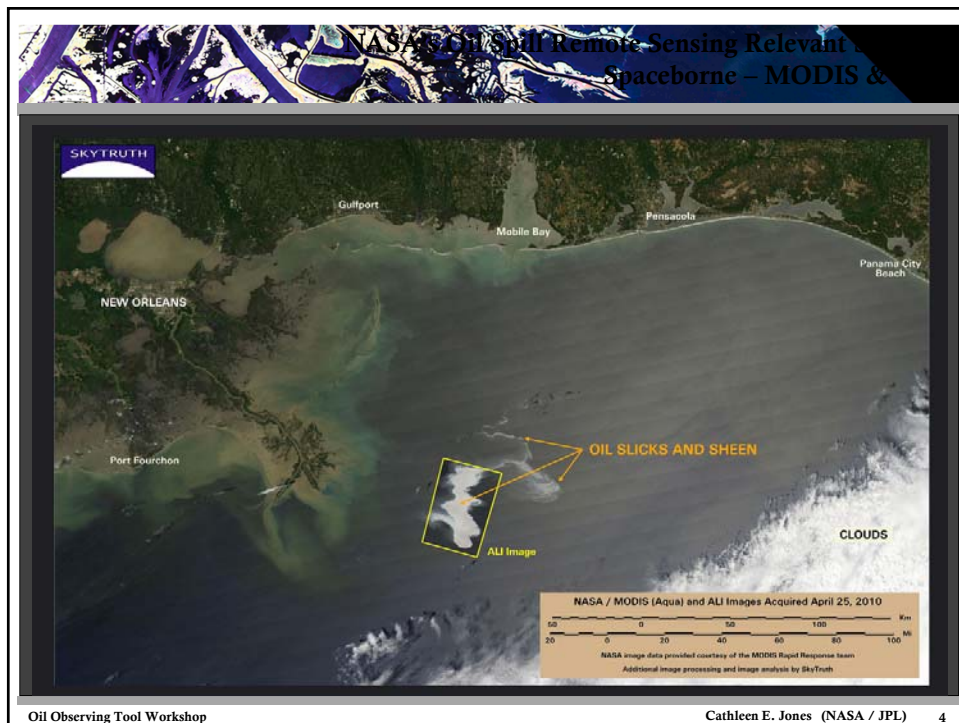
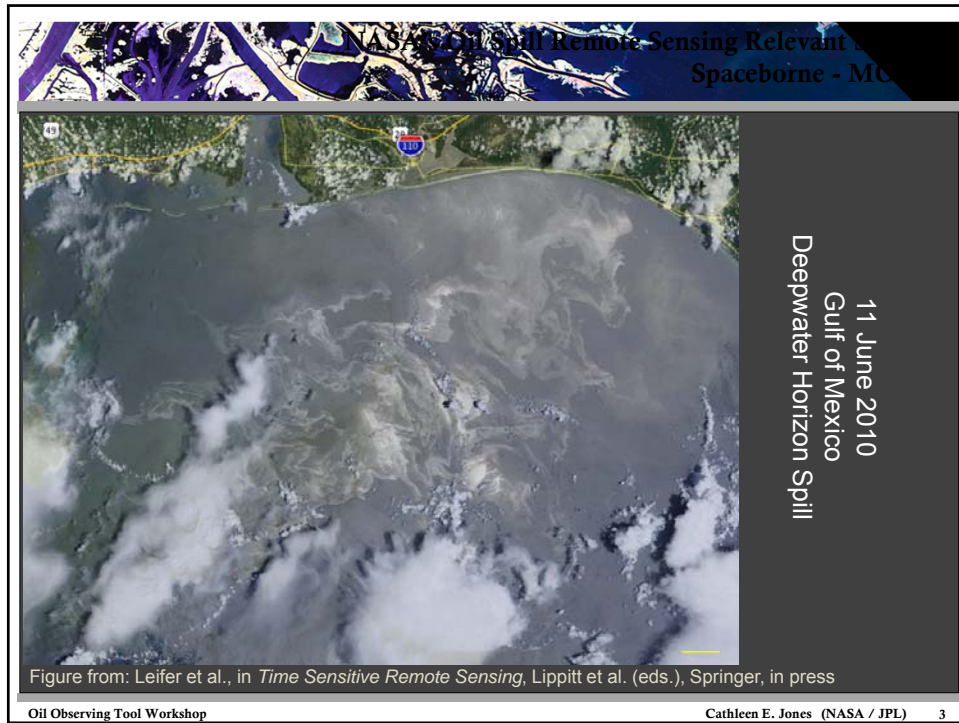
NASA Oil Spill Remote Sensing Relevant Spacecraft

Instrument (Satellite)	Bands (# bands)	Band Range (nm)	Resolution (km)	Swath (km)	Revisit (days)	Rapid Response
MODIS (Terra, Aqua)	Vis, MIR, TIR (36 bands)	405-14,385	0.25/0.5/1.0	2330	1-2	Yes
ASTER (Terra)	VNIR, NIR, TIR (14 bands)	520-11,650	0.015/0.03/0.09	60	4-16	No
MISR (Terra)	Vis, NIR (4 Bands)	446.4-866.4	0.275-1.1	360	2-9	No
HICO	Vis-NIR (90 bands)	400-1000	0.95	43	-	No
CALIOP (CALIPSO)	Vis, NIR (2 bands)	532, 1064	0.1	-	16	No


Add:

1. EO-1 satellite, ALI, Advanced Land Imager & Hyperion
2. AQUA – AIRS – Atmospheric Infrared Sounder

Table from: Leifer et al., in *Time Sensitive Remote Sensing*, Lippitt et al. (eds.), Springer, in press




NASA Oil Spill Remote Sensing Relevant Spaceborne - MISR



Multi-Angle Imaging SpectroRadiometer

Combine different viewing directions / angles & different bands

Differentiate oil from clouds



Chust, Guillem, and Yolanda Sagaminaga. "The multi-angle view of MISR detects oil slicks under sun glitter conditions." *Remote sensing of Environment* 107.1 (2007): 232-239.

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NASA Oil Spill Remote Sensing Relevant Spaceborne - Airborne

Instrument	Region (bands)	Range (nm)	Platform	Resolution (m)	Full Name	Agency
AVIRIS	UV-NIR (224)	380-2500	Twin Otter, ER-2	4.4 – 20	Airborne Visible Infrared Imaging Spectrometer	NASA / Jet Propulsion Laboratory
UAVSAR	L-band	1.2175 - 1.2975 GHz	Gulfstream 3	1.7-0.6 single look	Uninhabited Aerial Vehicle Synthetic Aperture Radar	NASA / Jet Propulsion Laboratory
HSRL	Vis, NIR (2)	532, 1064	B200 or Learjet	-	High Spectral Resolution Lidar	NASA / Langley

Add:


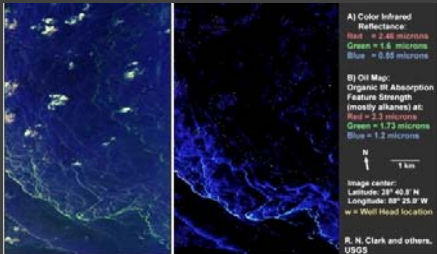
1. MASTER : UV-TIR : 400 – 13,000 n : 50 bands : 5-50 m : various platform : NASA/JPL
2. AVIRIS-NG

Table from: Leifer et al., in *Time Sensitive Remote Sensing*, Lippitt et al. (eds.), Springer, in press

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NASA's Oil Spill Remote Sensing Relevant Satellite and Airborne – AVIRIS & HSRL

AVIRIS / AVIRIS-NG

Clark, Roger N., et al. "A method for quantitative mapping of thick oil spills using imaging spectroscopy." *US Geological Survey Open-File Report 1167.2010* (2010): 1-51.

HSRL
High Spectral Resolution Lidar

Ottaviani, Matteo, et al. "Polarimetric retrievals of surface and cirrus clouds properties in the region affected by the Deepwater Horizon oil spill." *Remote Sensing of Environment* 121 (2012): 389-403.

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NASA's L-band Synthetic Aperture Radar



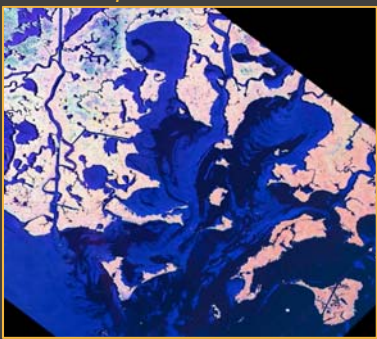
UAVSAR

Oil Observing Tool Workshop Cathleen E. Jones (NASA / JPL) 8

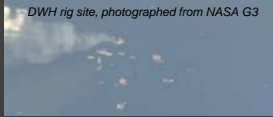

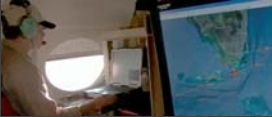
UAVSAR: NASA's L-band Synthetic Aperture Radar
Fine Resolution, Full Polarization, High Signal-to-Noise Ratio

Parameter	Value
Frequency	L-Band 1217.5 to 1297.5 MHz (23.8 cm wavelength)
Resolution	1.7 m Slant Range, 1.0 m Azimuth
Operational Altitude	12.5 km
Swath Width	22 km
Polarization	Quad-Polarization (HH, HV, VH, VV)
Repeat Track Accuracy	± 5 meters
Transmit Power	> 3.1 kW
Radiometric Calibration	1.2 dB absolute, 0.5 dB relative
Noise Floor	-47 dB average

*Barataria Bay, Louisiana
 23 June 2010
 Deepwater Horizon Oil*



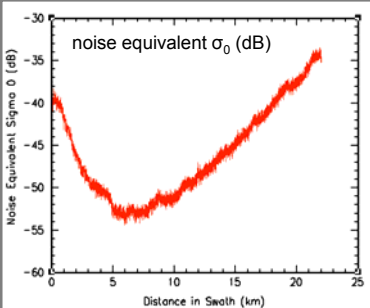
DWH rig site, photographed from NASA G3

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UAVSAR INSTRUMENT
NOISE FLOOR

UAVSAR NOISE FLOOR



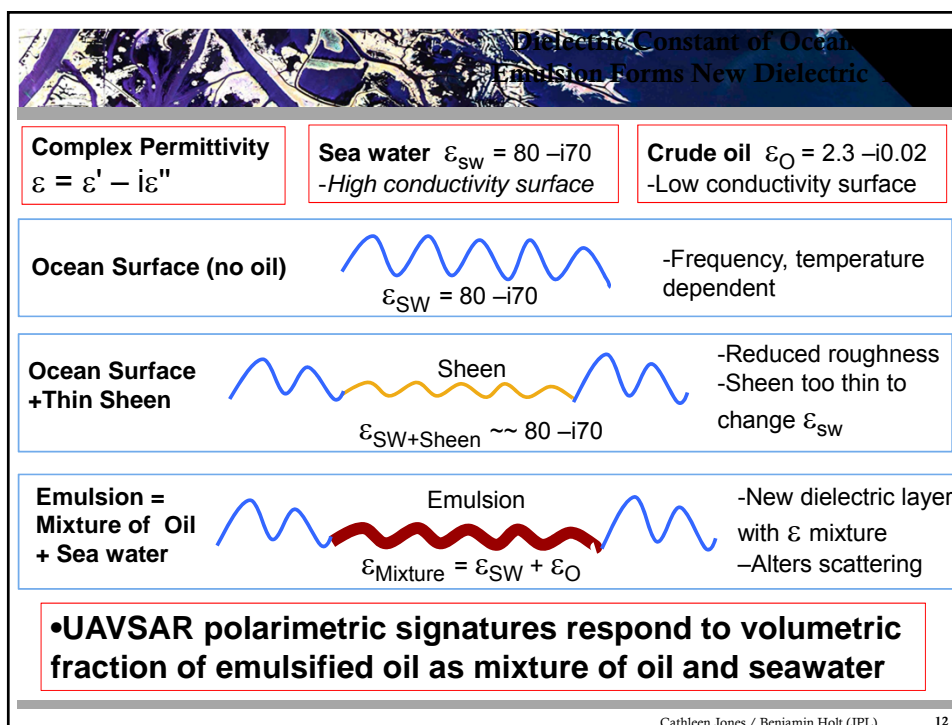
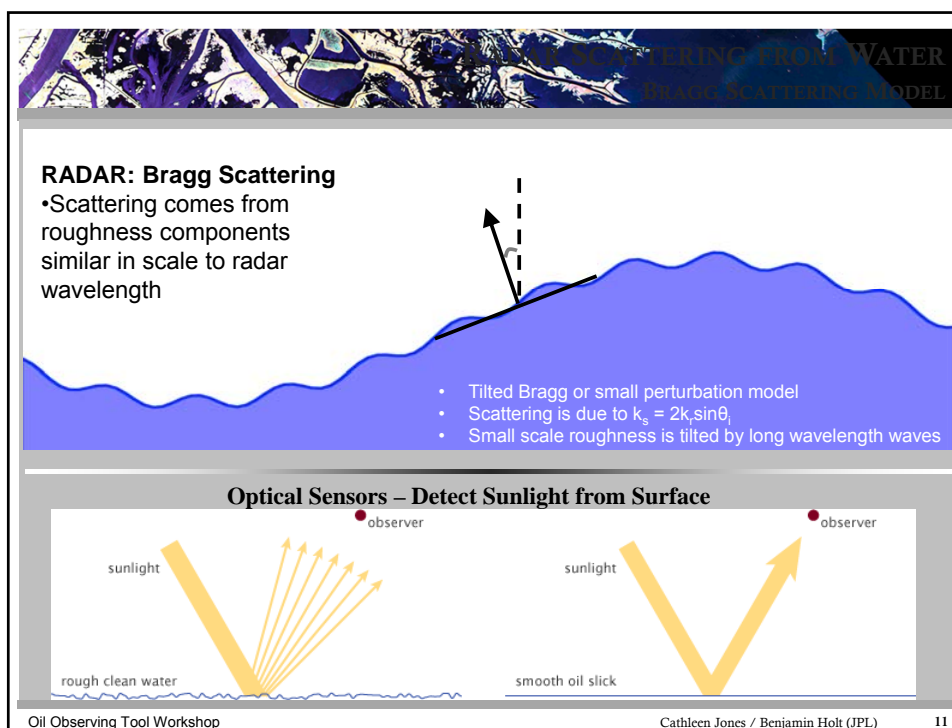
The low noise floor of the UAVSAR instrument makes it possible to measure the radar cross section from water with an L-band radar, even with oil damping the surface waves. We find that the instrument noise floor is reached only at the far edge of the swath for the HV returns from oil.

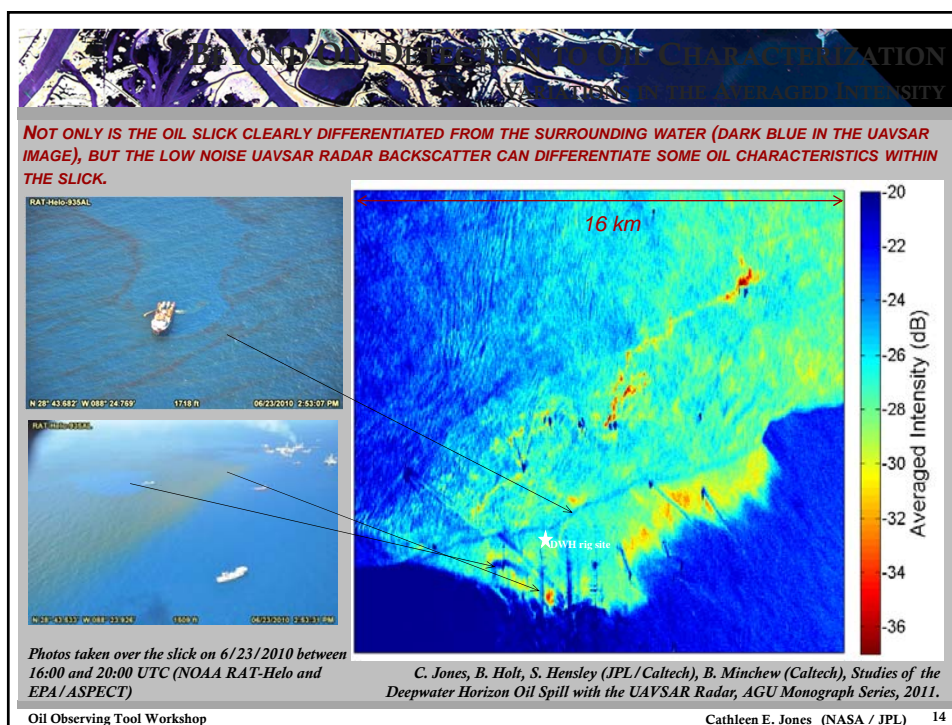
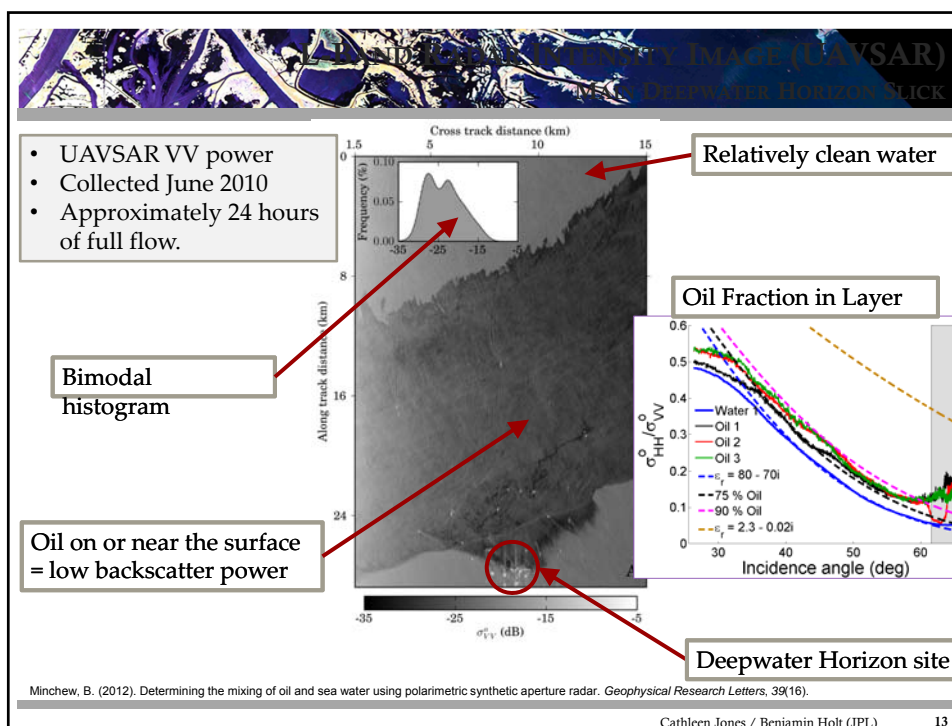
Comparison with other RADAR instruments

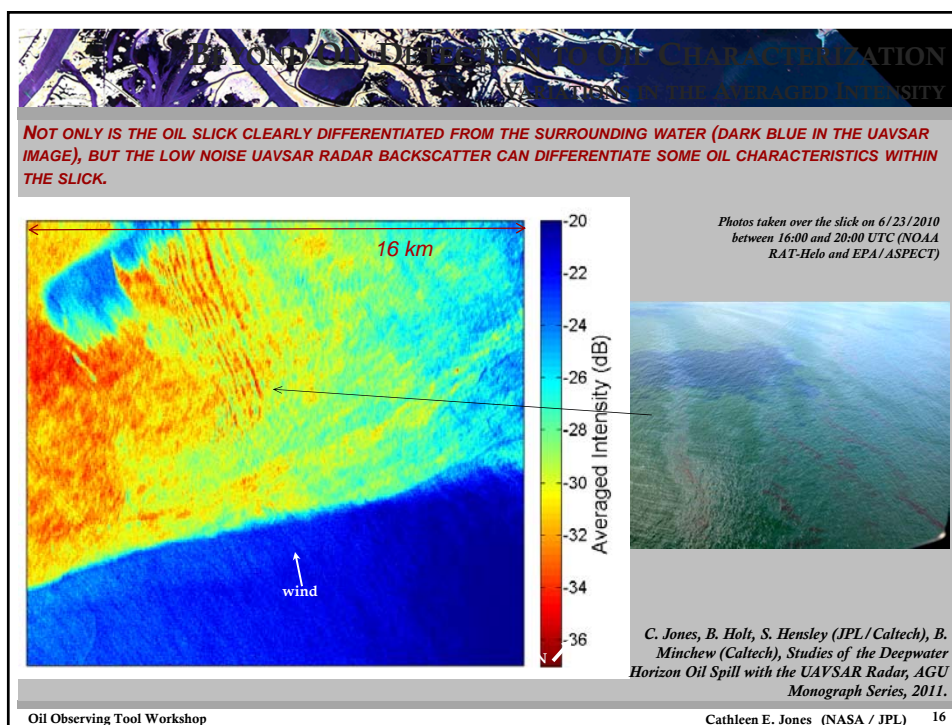
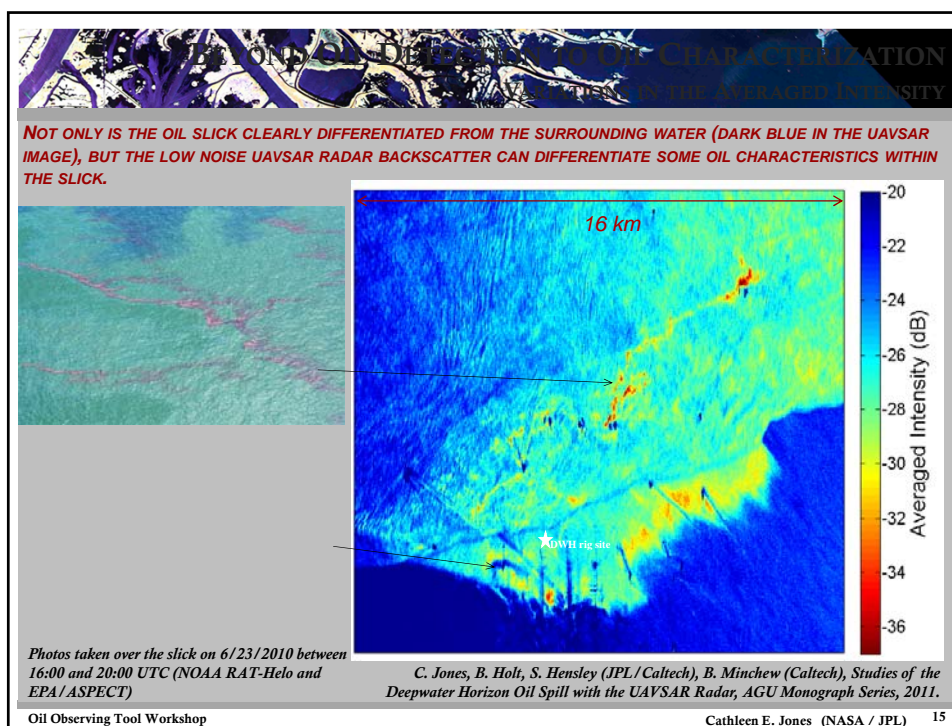
Sensor	Description (type, band, wavelength, polarization)	NESZ
UAVSAR	Airborne SAR; L-band (24 cm); quad polarization	-35 to -53 dB
ERS1/2	Satellite SAR; C-band; VV polarization	-20 to -29 dB ¹
Radarsat-2	Satellite SAR; C-band; single or dual polarization	-29 dB ²
ENVISAT ASAR	Satellite SAR; C-band; single or dual polarization	-20 to -29 dB ¹
ALOS PALSAR	Satellite SAR; L-band; single, dual, or quad polarization	avg -23 dB (HH or VV), -26 dB (HV) ³
TerraSAR-X	Satellite SAR; X-band;	avg -23 dB ⁴

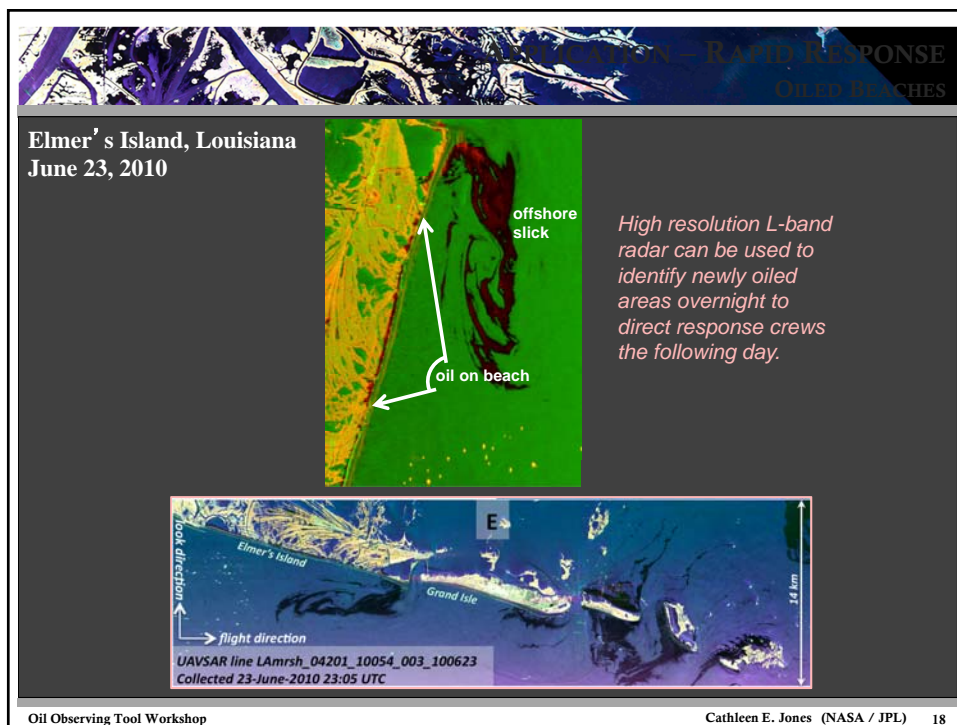
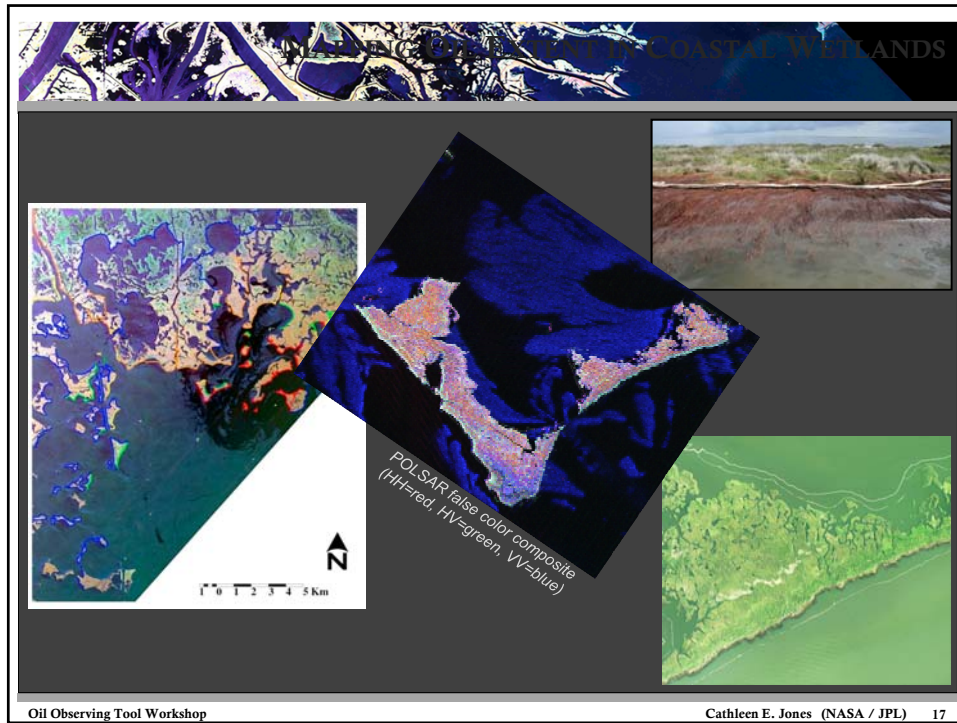
C. Jones, B. Holt, S. Hensley (JPL/Caltech), B. Minchew (Caltech), Studies of the Deepwater Horizon Oil Spill with the UAVSAR Radar, AGU Monograph Series, 2011.

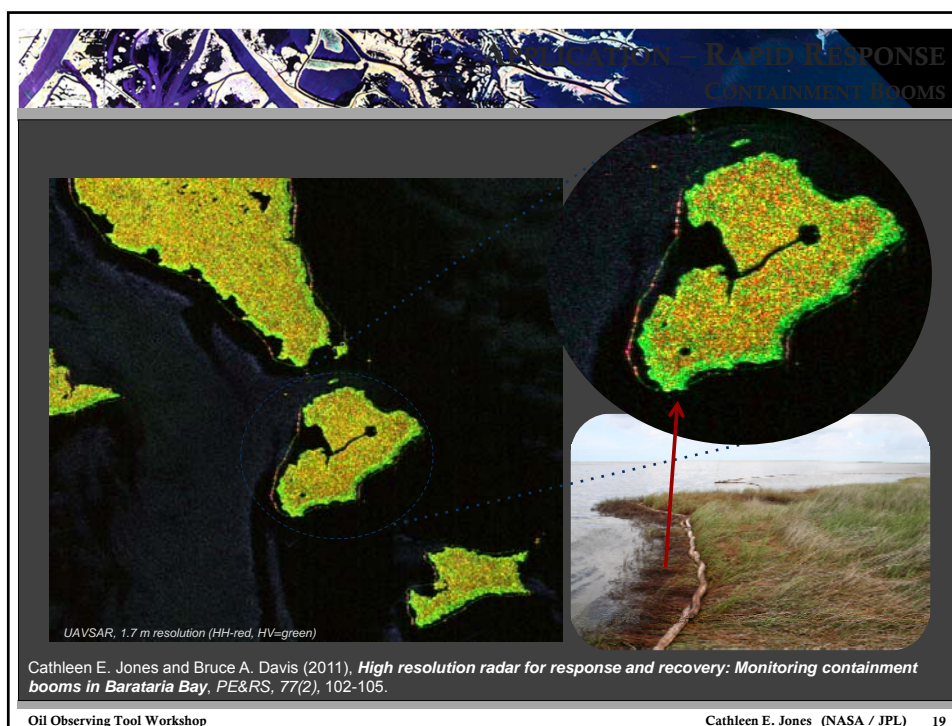
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Oil Observing Tools Workshop
Day 2 Plenary: New Technologies / New Applications
NASA



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UAVSAR: NASA's L-band Synthetic Aperture Radar

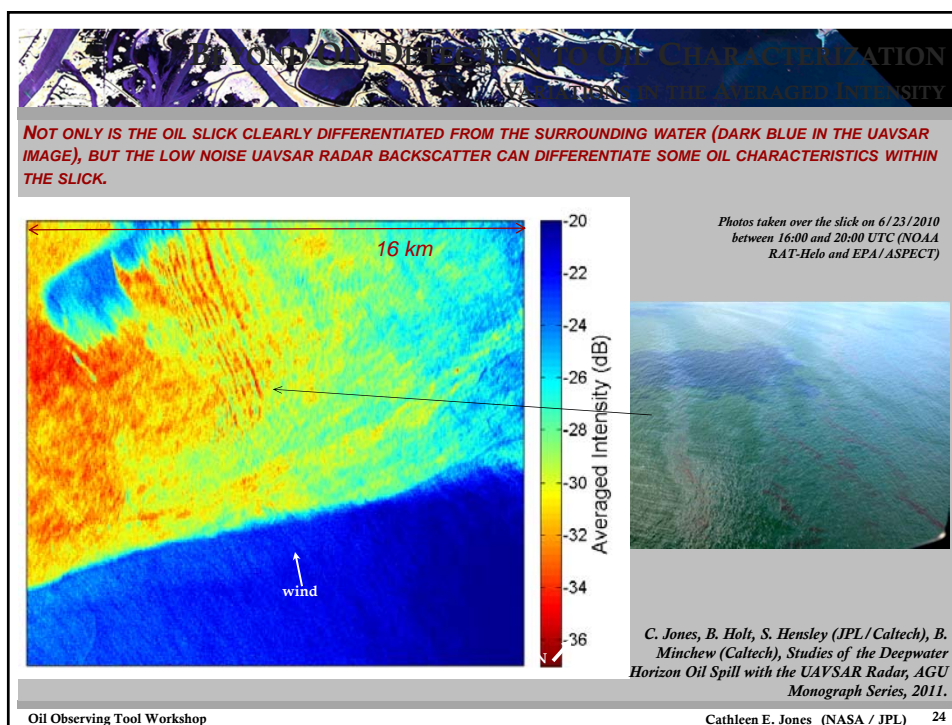
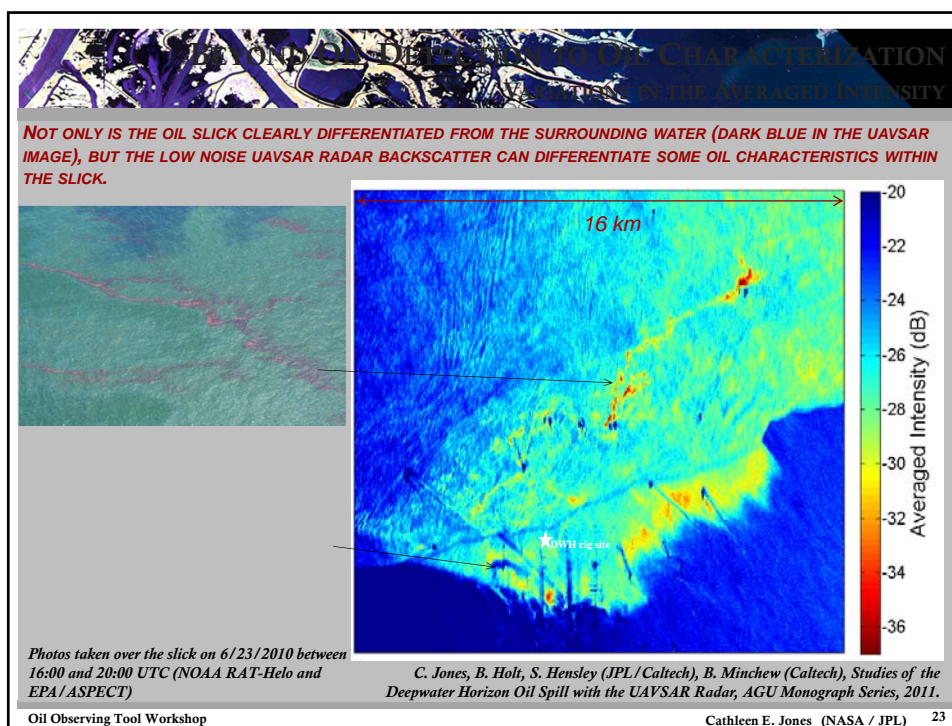
Fine Resolution, Full Polarization, High Signal-to-Noise Ratio

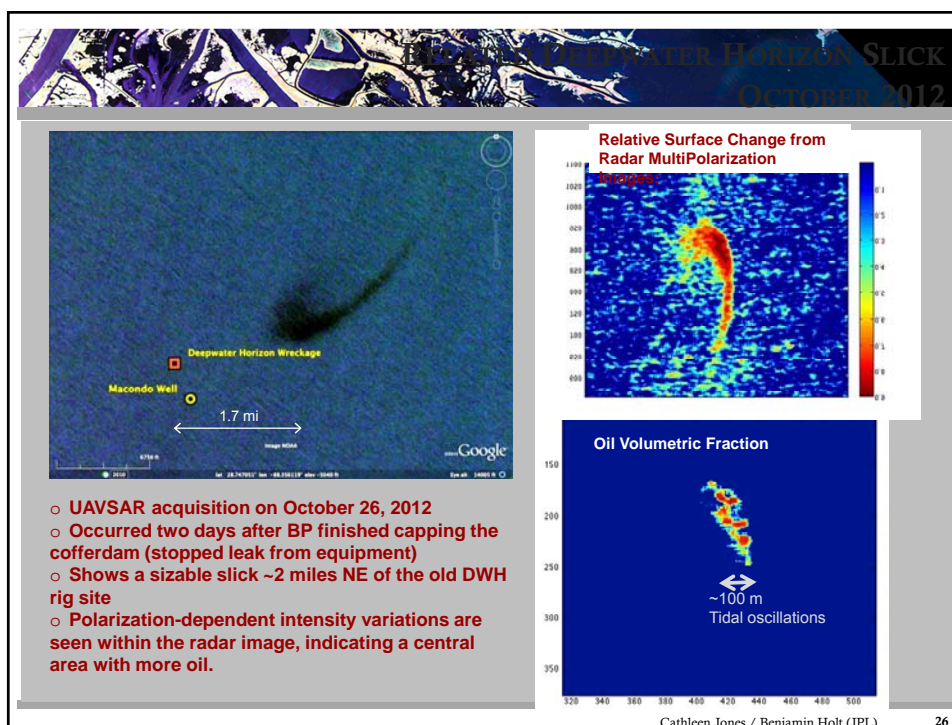
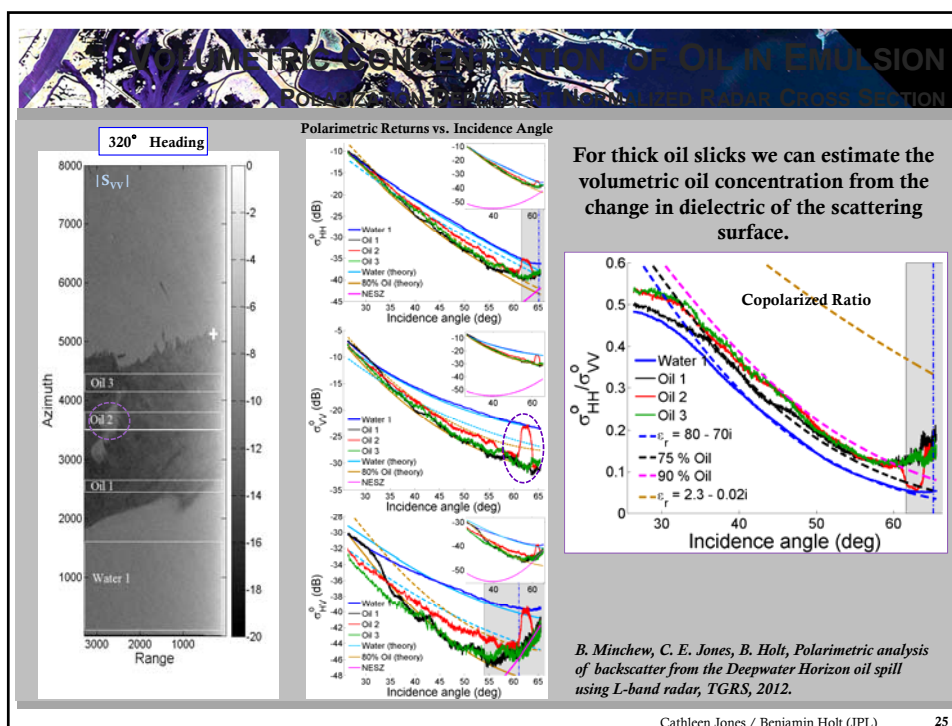
Parameter	Value
Frequency	L-Band 1217.5 to 1297.5 MHz (23.8 cm wavelength)
Resolution	1.7 m Slant Range, 1.0 m Azimuth
Operational Altitude	12.5 km
Swath Width	22 km
Polarization	Quad-Polarization (HH, HV, VH, VV)
Repeat Track Accuracy	± 5 meters
Transmit Power	> 3.1 kW
Radiometric Calibration	1.2 dB absolute, 0.5 dB relative
Noise Floor	-47 dB average

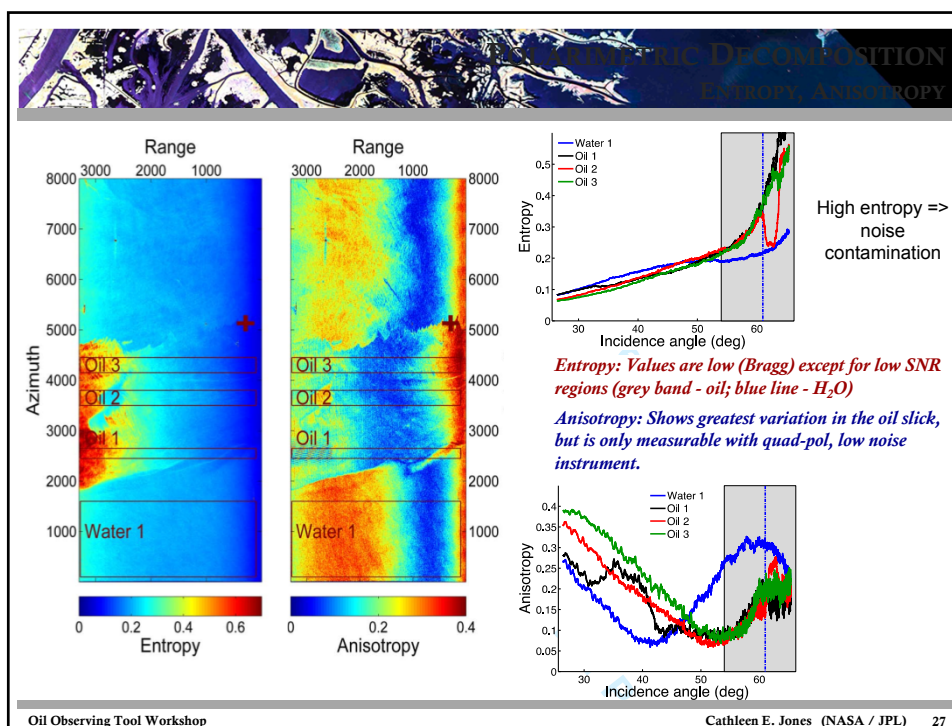
Barataria Bay, Louisiana
23 June 2010
Deepwater Horizon Oil

DWH rig site, photographed from NASA G3

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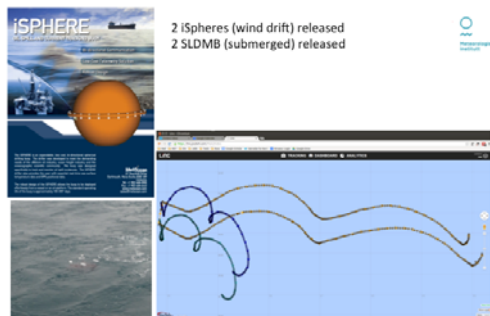





UAVSAR Norwegian oil-on-water exercise campaign June 2015 for advanced SAR-based oil characterization

Investigators: Cathleen Jones, Ben Holt (JPL), Camilla Brekke, Stine Skrunes (UiT, Norway)

- NASA/UAVSAR was invited to participate in the Norwegian oil spill exercises in June 2015.
- Exercise simulates a large spill (10s of kl) in North Sea
- UAVSAR participation requested to develop SAR-based oil characterization capability
- UAVSAR's exceptionally low noise make it a unique instrument for studying oil spills.
- Concurrent sea truth and optical, IR, and satellite SAR imagery all obtained at no cost to NASA.






Norwegian Oil-on-Water Spill Exercise


UAVSAR Campaign, June 2015

JPL, UIT-Arctic Univ. of Norway



NASA INVITED BY NORWEGIANS TO PARTICIPATE IN CONTROLLED RELEASES OF MINERAL & PLANT OIL IN COORDINATION WITH IN SITU MEASUREMENTS AND SAR ACQUISITIONS

Stril Mariner: vessel conducting the releases and met/ocean observations.



Controlled releases of emulsions with a range of oil fractions


Plant oil used as a biogenic slick simulator

All oils left untouched on sea surface

Multi-Polarization & Polarimetric SAR Data Acquired: UAVSAR, TerraSAR-X, Radarsat-2, RISAT-1, PALSAR2

UAVSAR imaging for 8 hours following release.

Buoys and optical/IR surface imaging provide ground-level validation








Exercise Site


Time 0 (T0)	T0+1h	T0+8h
Emulsion3	E3	E3
Emulsion2	E2	E2
Emulsion1	E1	E1
Plant oil	Plant	Plant

UAVSAR: VV-pol


Science & Applications Goals:

- Characterize volumetric oil fraction of slicks using polarized SAR
- Study slick development, transport, and weathering
- Differentiate mineral spills from look-alike biogenic slicks with SAR
- Determine radar frequency & polarization dependence of slick backscatter to optimize instrument design for slick response.

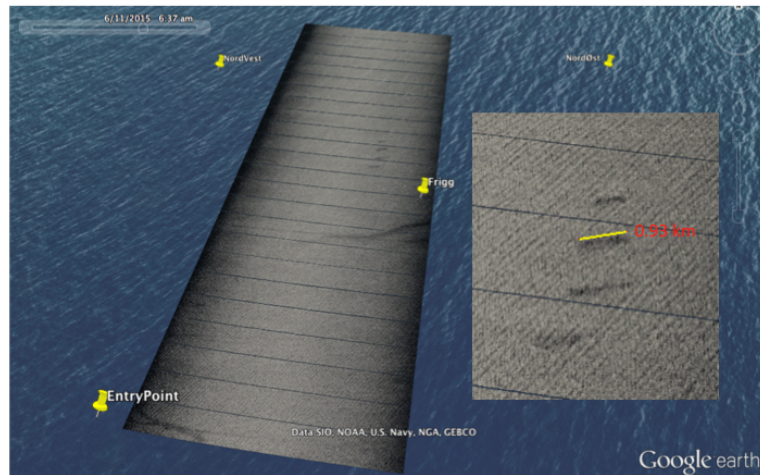


On-Board Processing Demonstration



UAVSAR VV-Polarization Image (from on-board processor)

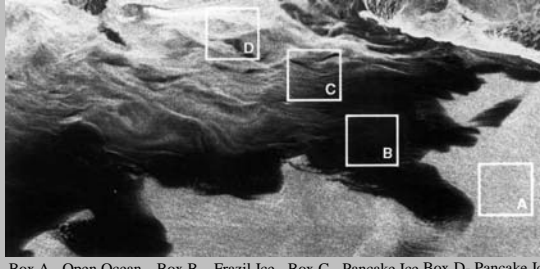
Line 4 VV (06:13 UTC, 38 min elapsed since final release)




UAVSAR data are courtesy NASA/JPL.

OIL-IN-ICE SPILLS


Seasat SAR – Chukchi Sea Marginal Ice Zone



Box A - Open Ocean Box B - Frazil Ice Box C - Pancake Ice Box D - Pancake Ice



Crude oil
Photo: Kuffelavikningen



Grease ice
Photo: Benjamin Holt (JPL)

Reference: Wadhams and Holt, 1991, *J. Geophys. Res.*

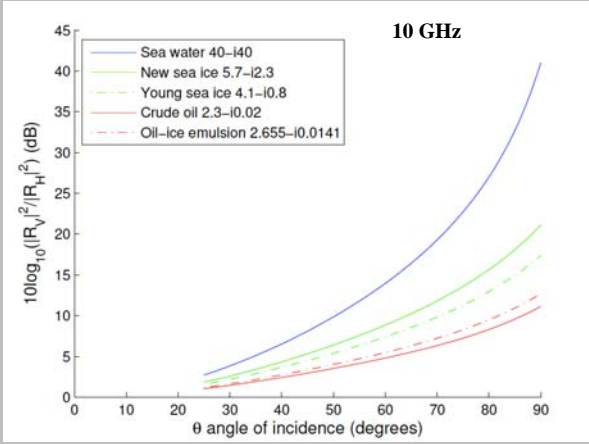
- Oil and new/thin sea ice have similar backscatter values on SAR
- Approach: Examine multifrequency, multipolarization SAR data to discriminate sheen and emulsified oil from grease/frazil, young, thin sea ice types for theoretical spill

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OIL-IN-ICE SPILLS THEORETICAL MODEL

Co-polarization Ratios for Varying Dielectric Media:

- The co-polarization ratio is investigated because the Bragg model predicts it to be independent of roughness and to depend only on the incidence angle and the complex relative permittivity of the medium.
- Results indicate appears to indicate that oil may be detected from young, thin sea ice.



10 GHz

10 $\log_{10}(|R_v|^2/|R_h|^2)$ (dB)


θ angle of incidence (degrees)

Legend:

- Sea water 40-i40
- New sea ice 5.7-i2.3
- Young sea ice 4.1-i0.8
- Crude oil 2.3-i0.02
- Oil-ice emulsion 2.655-i0.0141

Reference:
Brekke, C., Holt, B., Jones, C., & Skrunes, S. (2014). Discrimination of oil spills from newly formed sea ice by synthetic aperture radar. *Remote Sensing of Environment*, 145, 1-14.

Cathleen Jones / Benjamin Holt (JPL) 32

An aerial Synthetic Aperture Radar (SAR) image showing a large, dark, irregularly shaped oil spill on the surface of the ocean. The spill is surrounded by lighter-colored water. The word "SUMMARY" is written in a stylized, metallic font in the upper right corner of the image.

SUMMARY

Low-noise SAR:

- Characterize oil within a spill
- Relate to volumetric fraction of oil for a thick layer
- Infer thickness from oil fraction for emulsions
- On-board processing is an option
- Next Frontier: Oil-in-Ice Spill (theory & exercise)

Cathleen Jones / Benjamin Holt (JPL) 33



INFORMATION SYSTEMS

Oil Observing Tools: Spaceborne Radar

Gordon Staples
MDA Geospatial Services
Richmond, BC, CANADA

www.mdacorporation.com

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Outline

- Spaceborne radar capability
- Data
 - Acquisition
 - Processing
 - Delivery
- Information products

Spaceborne Radar Overview

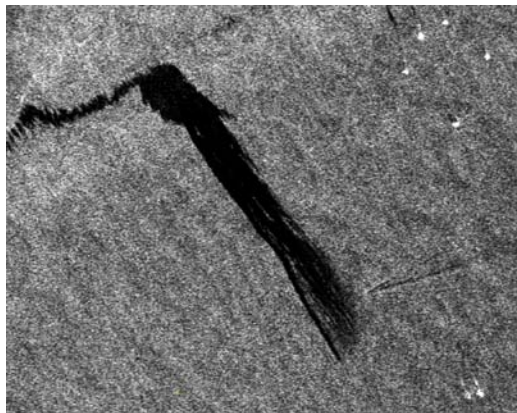
- Established tool for emergency response
- Globally accessible through multiple commercial missions
- Uniquely capable of providing the situational overview
 - Broad area coverage
 - Relatively low cost
 - Easy to deploy
 - Used for cueing other operational assets
 - All weather, day-night imaging

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3

Slick Detection

- Good understanding of slick detection which depends on:
 - Radar parameters
 - Environmental conditions
 - Oil characteristics
- Slick detection algorithms are used, but an analyst is usually required to:
 - Mitigate false positives
 - Apply contextual information (platforms, ships, etc.)
 - Assign confidence / classification levels

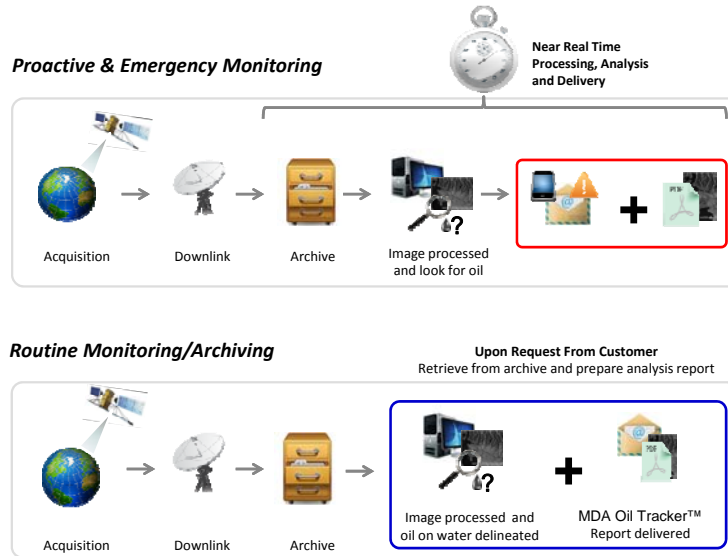


RADARSAT-2 image showing the Taylor energy slick. The oil appears as a dark tone and the offshore platforms appear as bright white targets.

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Data Delivery Workflow



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Data Acquisition

- Simulated incident in West Africa (December 5, 2014 at 08:24 UTC)
- Primary commercial sensors activated
- First available image from each sensor marked with ★
- The time is from the initial request for data to acquisition by the satellite
- On a different day or a different location, the results would vary



Satellite	Start
Cosmo-SkyMed-1	2014-Dec-05 17:16:14.115
Cosmo-SkyMed-3	2014-Dec-05 17:46:11.877
RADARSAT-2	2014-Dec-06 05:28:01.530 ★
RADARSAT-2	2014-Dec-06 18:06:21.620 ★
Cosmo-SkyMed-1	2014-Dec-07 05:46:15.332 ★
TerraSAR-X	2014-Dec-07 06:03:34.945
Cosmo-SkyMed-1	2014-Dec-07 17:52:11.103
TerraSAR-X	2014-Dec-07 17:58:04.483 ★

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Data Downlinking, Processing, and Delivery

Direct Downlink

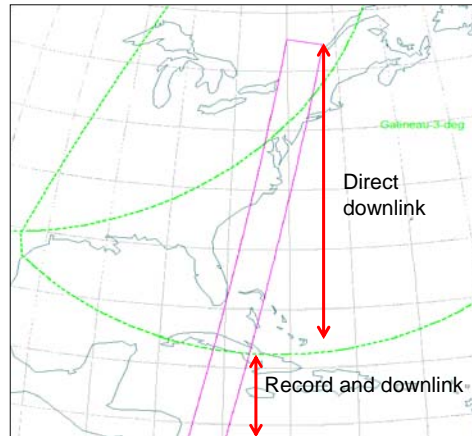
- satellite within ground station mask: acquire + downlink + processing < 2 hours

Record and Downlink

- satellite not within station mask: record + downlink + processing < 4 hours

Delivery

- < 15 minutes



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Data Formats and Information

- Data formats:
 - Radar imagery → GeoTIFF
 - Plus many other format: PDF, JPG, SHP, KML, NetCDF, ...
- Information
 - Size of the spill (surface area)
 - Wind speed and direction (directly derived from the satellite imagery)
 - Locations of vessels and other local/regional infrastructure to aid in response management
 - Oil slick characteristics: *Sheen vs. emulsion*

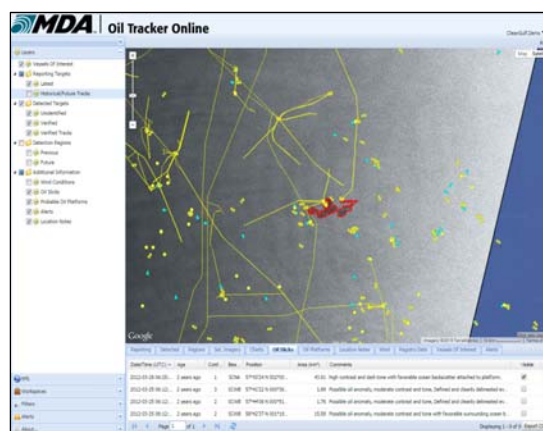
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8



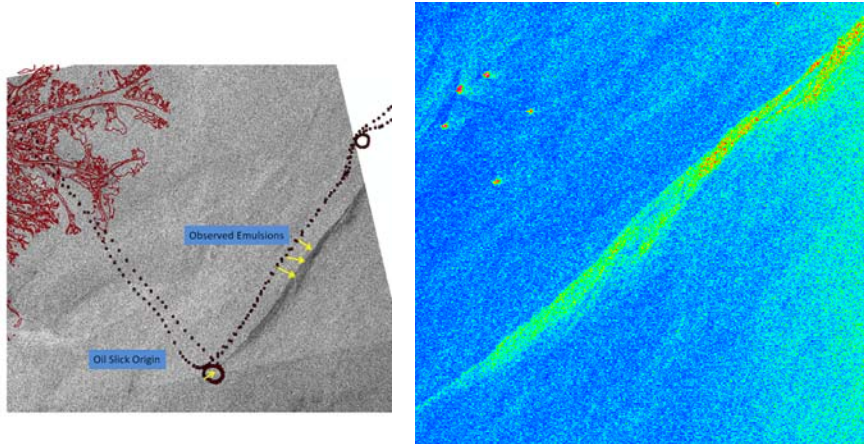
Data Integration and Common Operating Picture (COP)

- Oil spill information (e.g. GeoTIFF, shp, kml formats) can be integrated with other data sources into a COP.



Example of MDA OilTracker COP tool. Satellite products can be readily integrated into ERMA as well.

Oil Sheen - Emulsion Discrimination



- RADARSAT-2 image showing the location of emulsified oil from the Taylor Energy slick based on aerial observations (left) and the detection of emulsified oil (red area) using the polarimetric entropy (right).

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Summary

- There is a good understanding of the benefits and limitations of spaceborne radar for oil spill response
- Data acquisition (typical)
 - Initial request to acquisition: 12 – 24 hours
 - Acquisition to downlink: 0 – 4 hours
 - Processing to information products: < 2 hours
 - Information products to delivery: < 15 minutes
- Information products derived from radar can be readily integrated with other data sources into a COP

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Taylor Oil Spill

Case of study for Current Satellite Remote Sensing Platforms

Oscar Garcia-Pineda
Gordon Staples

The work presented here thanks to:
WaterMapping, NOAA, MDA-Cooperation, NASA, USGS, Stratus Consulting, FSU, USF.



Present and Future Sources of SAR data



Satellite	Launch (Lifetime)	Freq	Polarization	Resolution	Swath
TerraSAR-X	2007	X	Full-Pol	1 – 30 m	5 – 200 km
Radarsat-2	2007	C	Full-Pol	3-100 m	20 – 510 km
Cosmo-SkyMed (4)	2007(2)/2008/2010	X	HH, VV	1 -100 m	10 – 200 km
TanDEM-X	2010	X	Full-Pol	1 – 30 m	5 – 200 km
ALOS-2	2014	L	Full-Pol	1-100 m	25 – 350 km
Sentinel-1A	2014	C	HH, VV, VH, HV*	5-20 m	80 – 400 km
CSK- 2nd Gen (2)	2015	X	Full-Pol	0.8 – 20 m	10 – 200 km
PAZ	2015	X	Full-Pol	1-30 m	5 – 200 km
Sentinel-1B	2016	C	HH, VV, VH, HV*	5-20 m	80 – 400 km
RCM (3)	2018	C	Dual / Compact	5 – 50 m	20 – 350 km
NI-SAR	2020	L	Full-Pol / Compact	3 – 50 m	240 km



Taylor Oil Spill Experiment

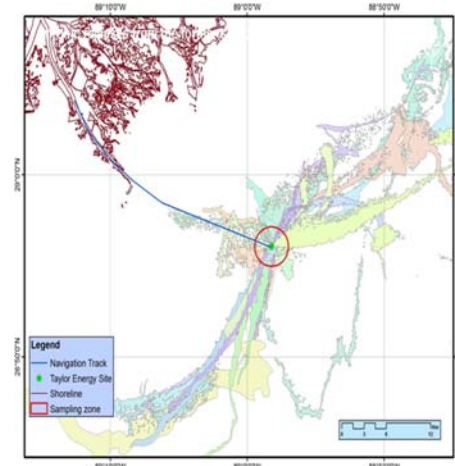


Figure 1: Composite of TCNNA extracted oil slicks associated with the Taylor site in BOEM lease block MC020.

Taylor Energy oil platform, destroyed in 2004 during Hurricane Ivan, is still leaking in Gulf

4



A 32-mile-long oil slick stretches east from the former site of Taylor Energy's Mississippi Canyon 25-A platform (X), which was knocked down and covered by a landslide during Hurricane Ivan in 2004. (NASA Aqua satellite)

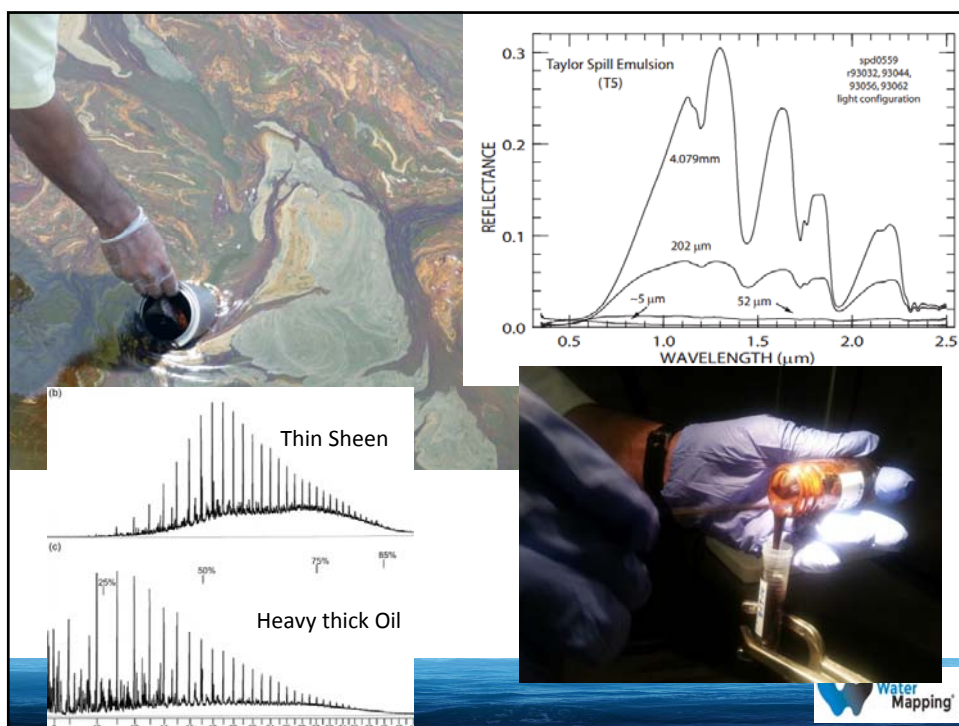


Oceanographic factors on Taylor

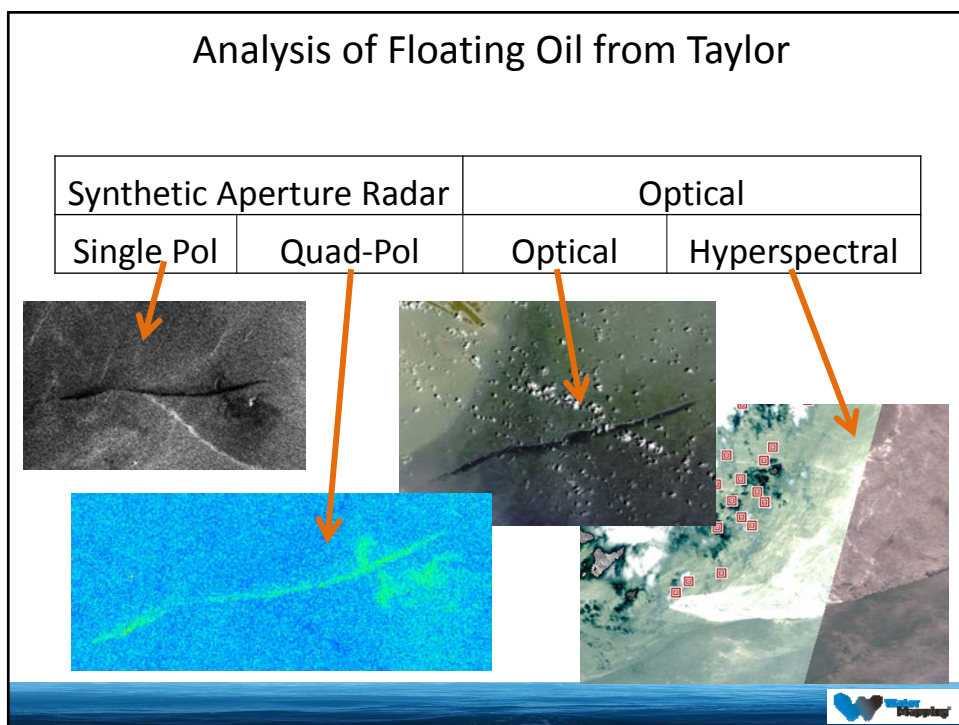


Play the Video Taylor Oil Spill

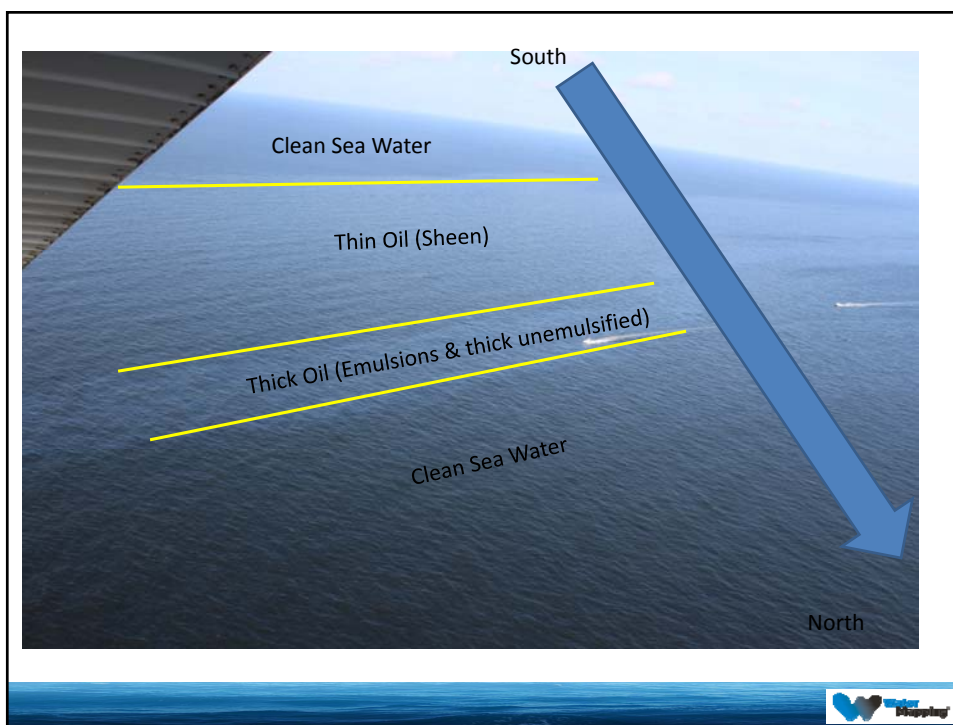
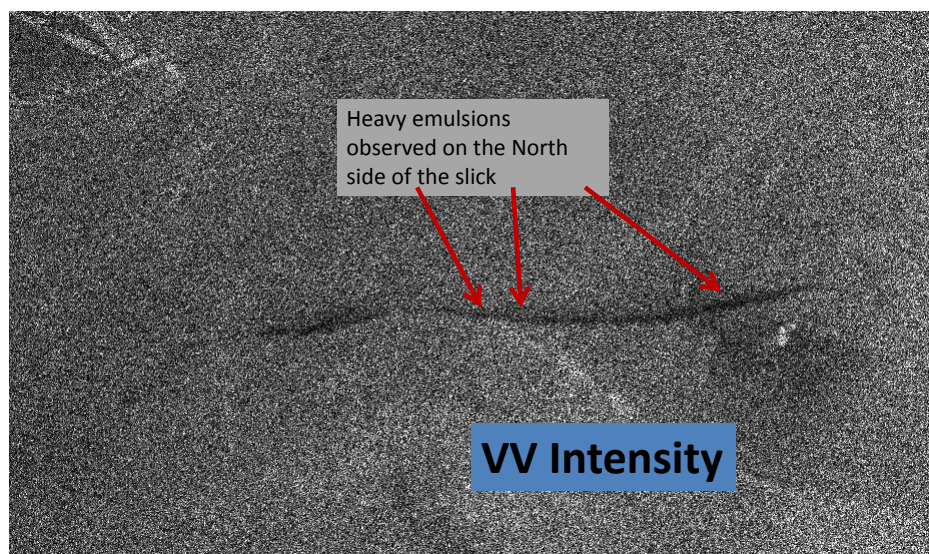




Analysis of Floating Oil from Taylor



Observations of Taylor May 6, 2015

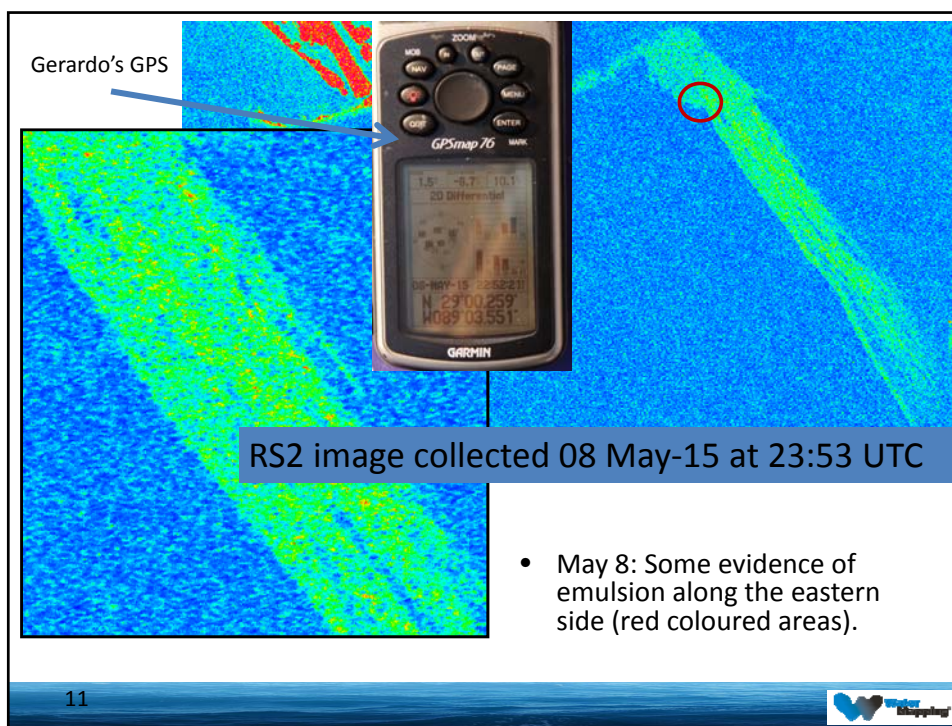


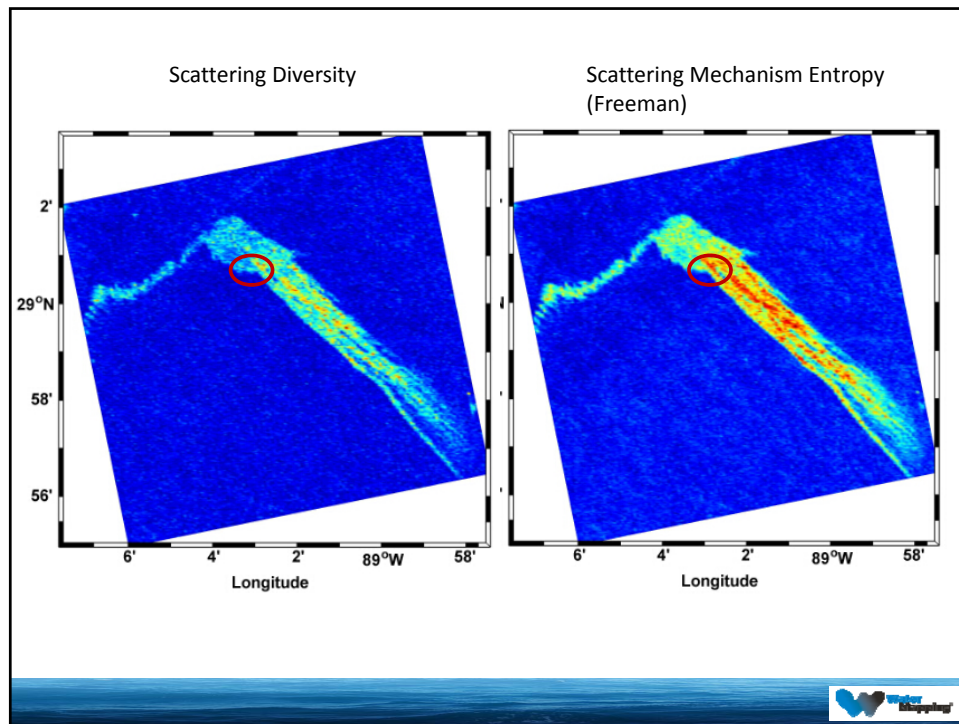
Same features observed on this next
day May 7 Landsat



Observations on May 8







Conclusion:

- The capability of SAR to detect oil emulsions sheds light on the monitoring and assessment of further oil spills. Not only to detect presence/absence of oil, but its relative thickness. This is of great importance on the planning and coordination of response operations.

Path Forward:

- Taylor Oil Spill Site
- OHMSETT

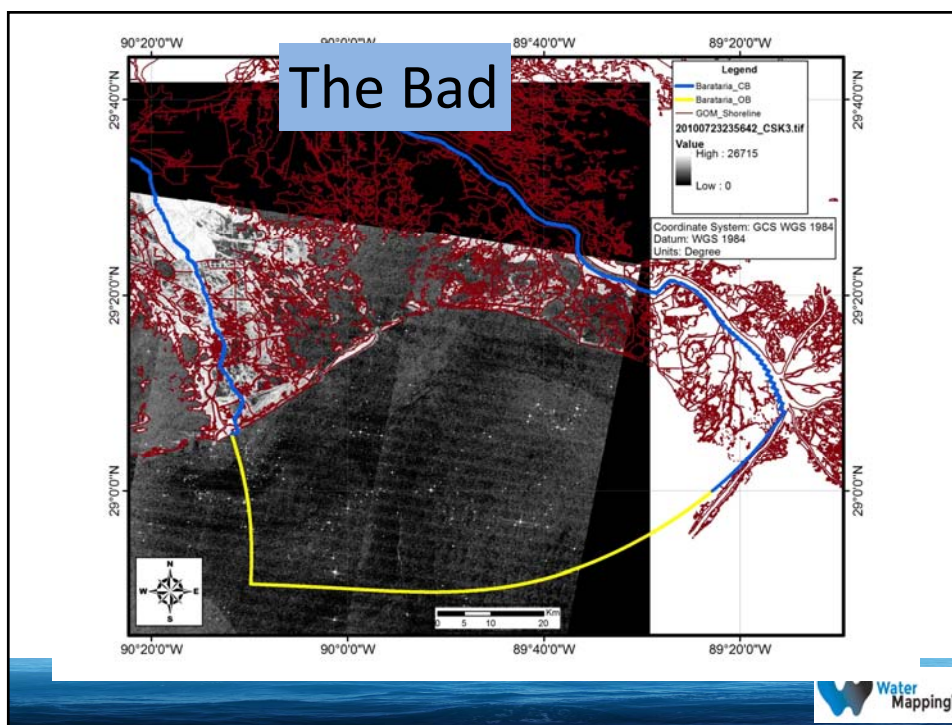
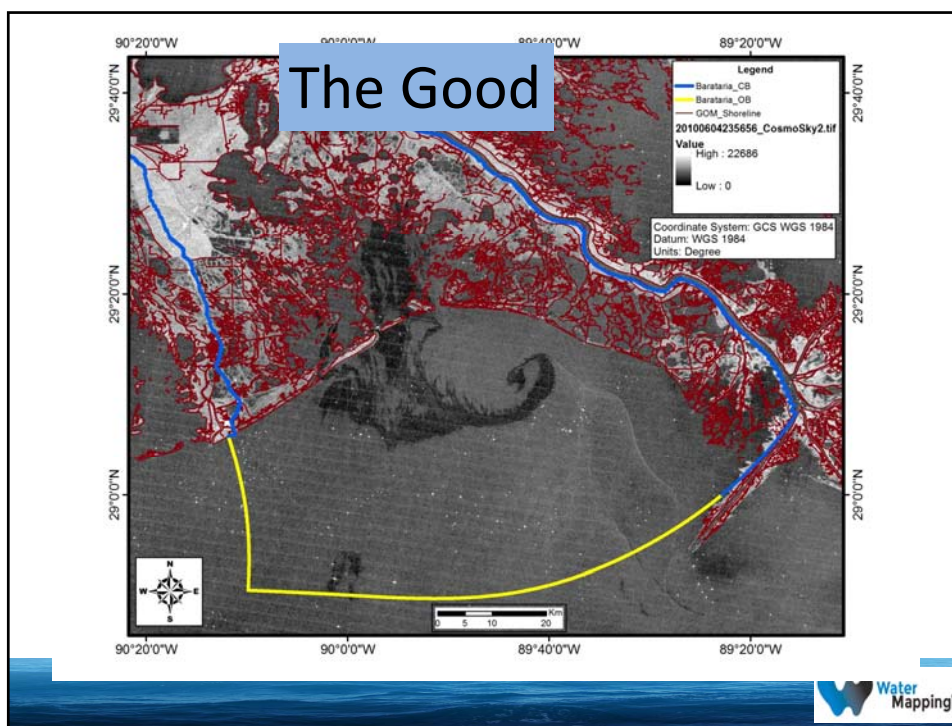


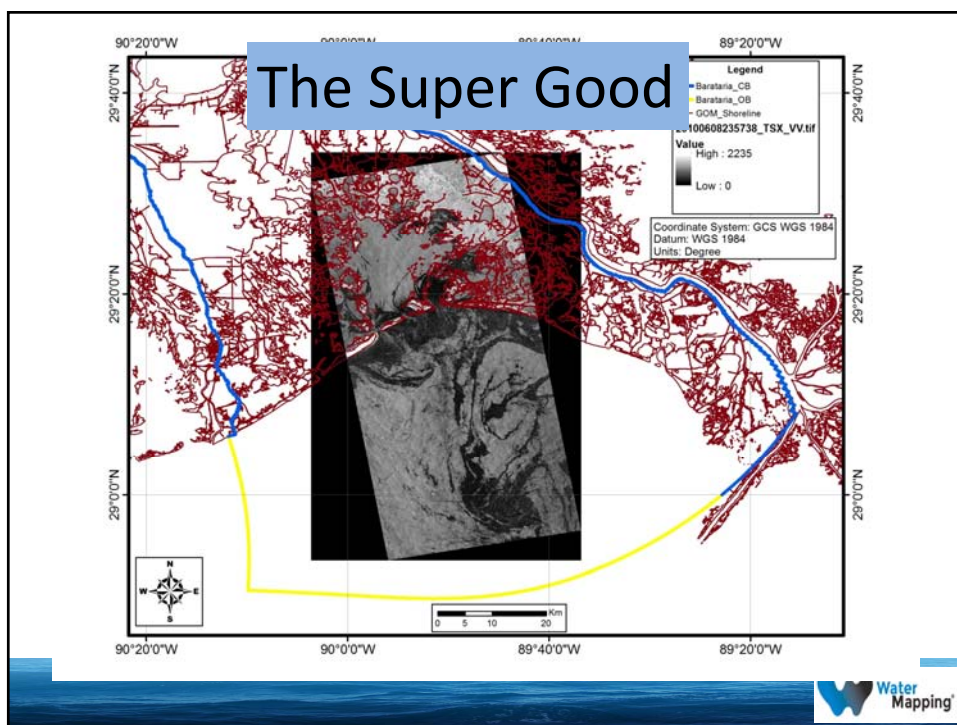
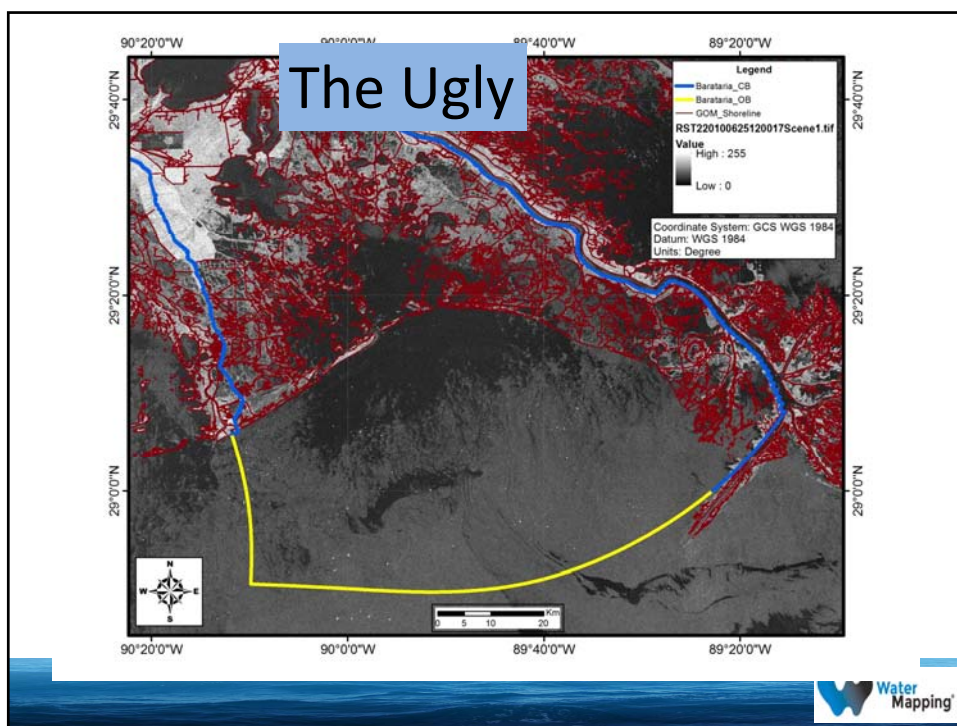
Round Table:



THE GOOD THE BAD AND THE UGLY







Thanks!



Aerial Remote Sensing Capability: Transitioning to Digital Real-Time Response

Mark Hess, Ocean Imaging Corp.

Kevin Hoskins, Marine Spill Response Corp.



All Materials ©2015 *Ocean Imaging*

MSRC DWH Observations

**Operations – post event interviews with all personnel
(over 11,000 man days offshore)**

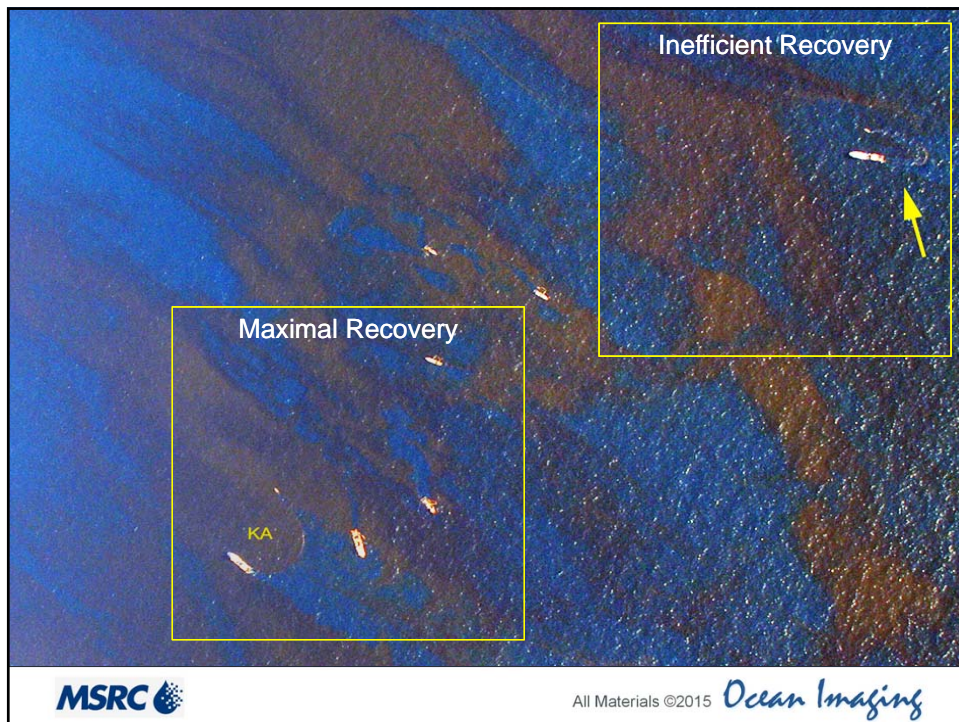
- Encounter rate tactics
- Debris handling
- Offloading of recovered product
- Sustainability and redundancy (human element)

**All of the above are downstream of the most critical
observation:**

- Efficiently putting resources in the right position
(day and night) to recover the oil



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MSRC Surveillance Objectives Post DWH

Real Time Tactical Information Besides Visual Spotting

- Classification of oil targets as actionable (skim, burn, disperse) or non-actionable (i.e. sheen)
- Tracking moving oil
- Staying in/with the actionable oil as it moves
- Expanding the operating window to low-light conditions (with safety always of highest priority)

Key Criteria for MSRC's New Remote Sensing Tools

- Multiple sensors/platforms since one does not do all
- Multiple platforms given importance of height of eye
- Portability given span of U.S. coastline and lack of dedicated surveillance planes
- Real time information for tactical use
- Provide "feed" to customer Common Operating Picture (COP)



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MSRC Level ABC Remote Sensing for Tactical Oil Spill Surveillance

A

AIRCRAFT
Ocean Imaging
Corporation

**Multispectral/TIR
Cameras (i.e. TRACS)**



Provides wide-area spill
detection, thickness
interpretation, and oil
distribution mapping

B

BALLOON
Maritime Robotics

**TIR & HD
Cameras**



Tethered up to 500 ft.
Medium range coverage
with long "hang" time

C

CLOSE-IN

**X Band Radar & TIR
Camera**



Optimizes close-in
recovery techniques



All Materials ©2015 *Ocean Imaging*

New Capabilities in Aerial Remote Sensing for Real-Time Tactical Use During Oil Spills

History, Technical Background &
Existing Capabilities



All Materials ©2015 *Ocean Imaging*

Ol's Aerial Oil Spill Mapping System

Our approach:

Develop an easily-deployable (portable) system that utilizes the same proven thickness estimation principles as visual oil spill surveys, with additional, digital capabilities e.g. thermal imaging, near-real-time input into COP/WMS.

Advantages over visual methods:

- 1) System is more objective – does not rely on opinion or educated guessing
- 2) Extends human eye visible wavelength limitations (e.g. adds thermal IR)
- 3) Survey map is in digital GIS format – allows accurate location determinations, direct computation of oil spill area and volume, etc.
- 4) Survey provides much greater spatial detail (1-3 meters)



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Based off of Multi-Agency Funded Research

California Dept. of Fish & Game (2004-2005)

Initial algorithm was developed for multispectral visible/near-IR system

MMS/BSEE (2006 – 2012) Thermal-IR imager was added, system geopositioning improved, algorithms extensively validated/improved, initial emulsion algorithm developed

BP (2013-2014) More compact/portable system integrated, field-of-view coverage vastly increased, near-real-time processing enabled, initial direct air-to-ground/boat data transfer options investigated

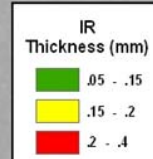
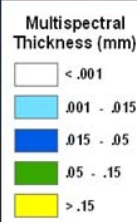
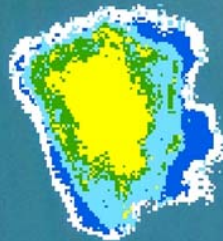


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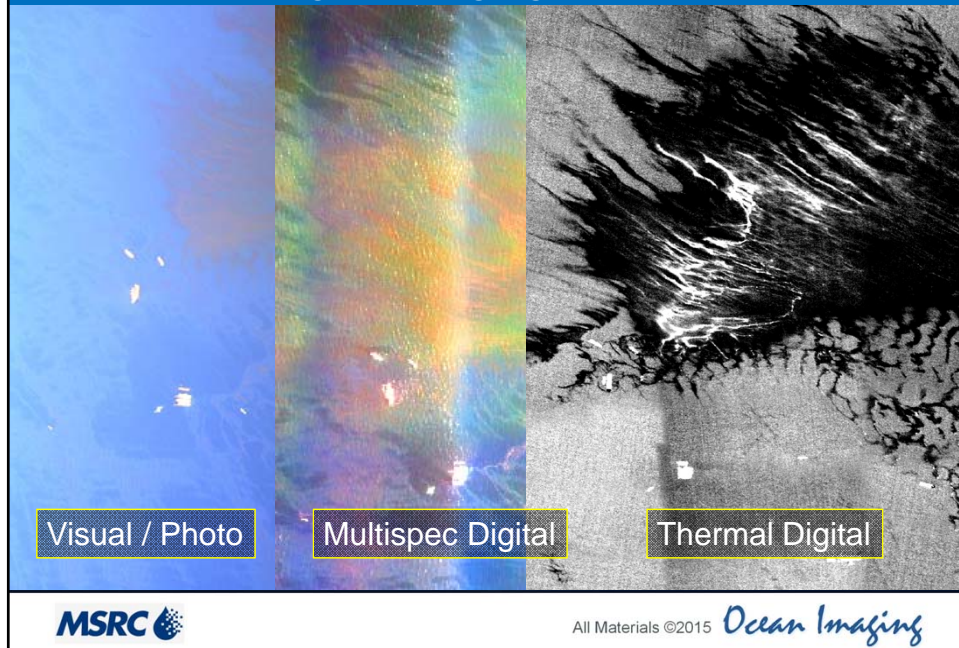
Combined Use of Visible Multispectral and Thermal-IR Imagery Extends Thickness Measurement Range

Visible wavelengths are most sensitive to thin oil films.

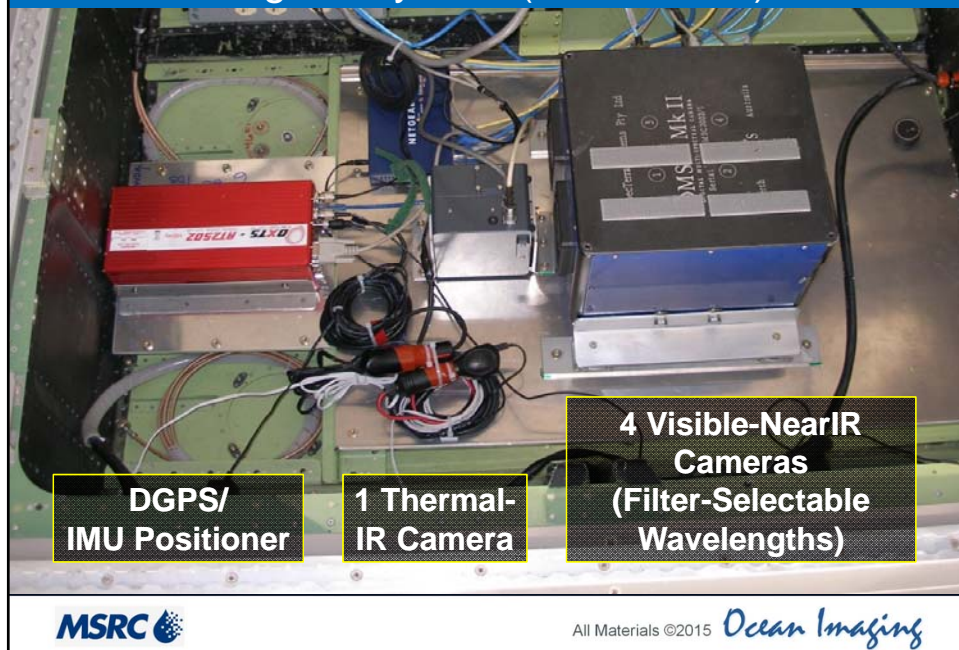
Thermal IR sees detail in thick oil films.

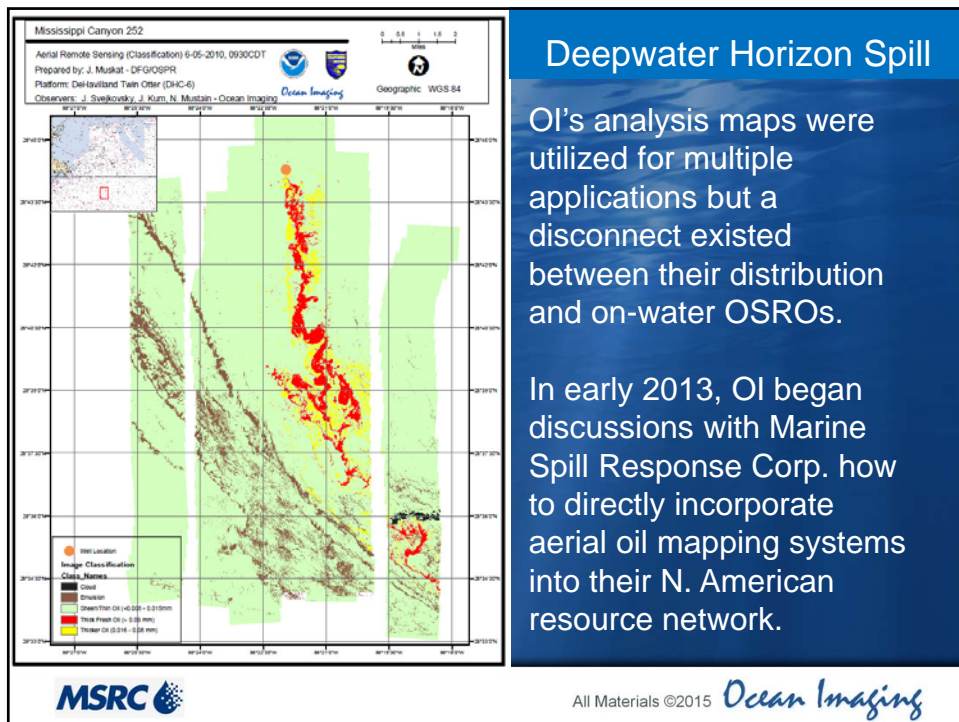


Visual & Digital Imaging Oil Comparisons



Original System (DMSC-MkII)





Design Enhancement Considerations for 2nd Gen Aerial Oil Spill Mapping System:

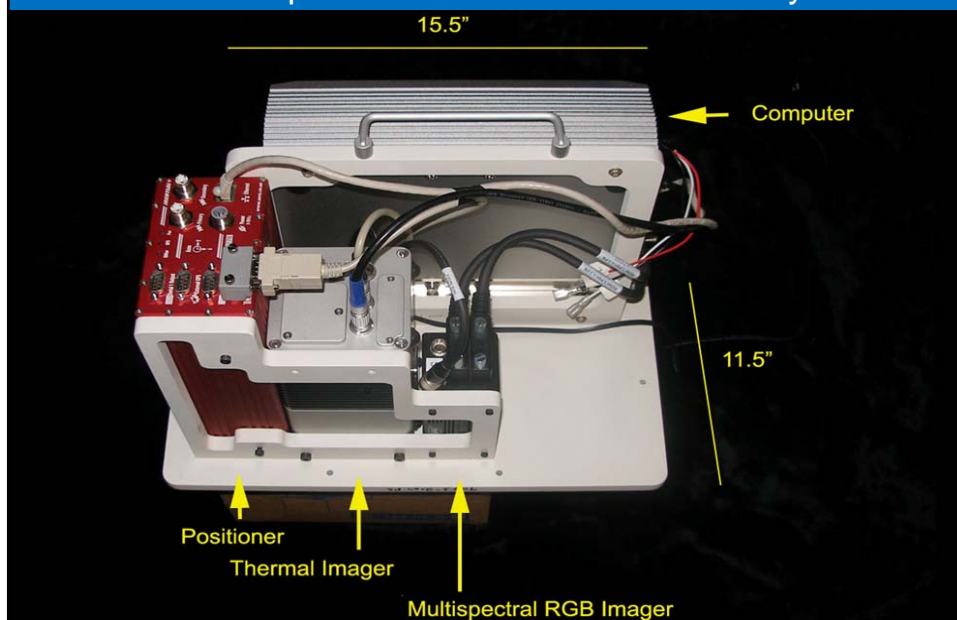
- 1) Must provide wider imaging swath
- 2) Must maintain sub-meter to <4m spatial resolution to adequately resolve existing oil targets
- 3) Hyperspectral not needed to separate main thicknesses for operations support
- 4) Single-unit portable integrated design
- 5) **Operable by trained non-specialist personnel**
- 6) Utilizable for both COP mapping and immediate tactical use (i.e. allow immediate on-board processing)



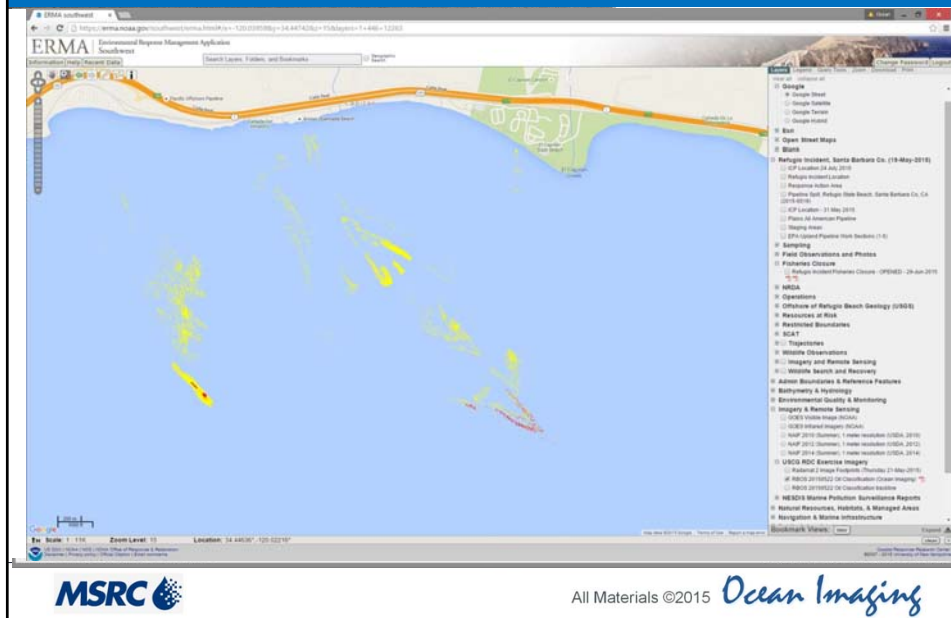
All Materials ©2015 *Ocean Imaging*

TRACS

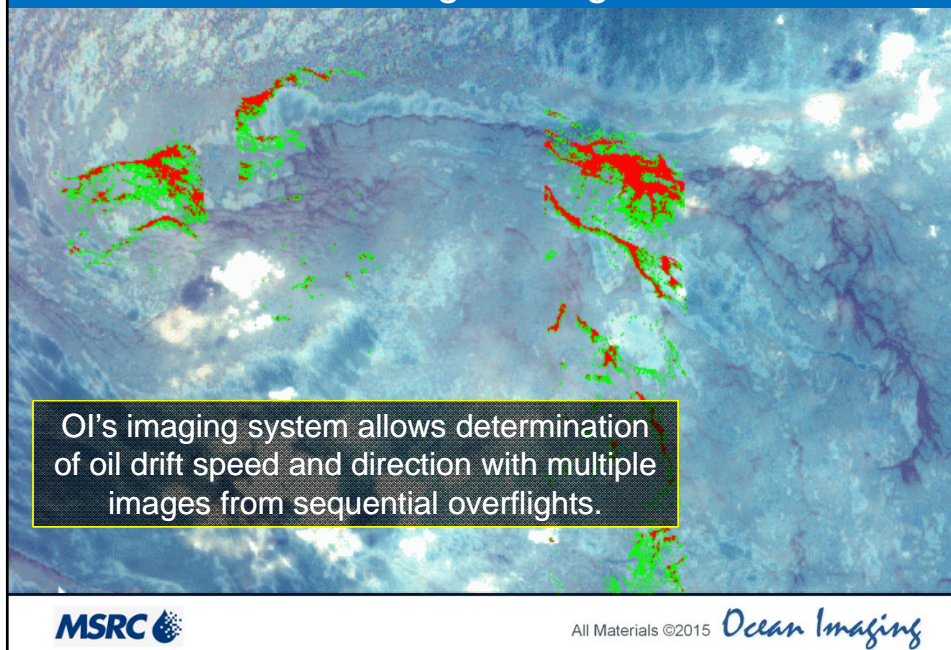
Tactical Response Airborne Classification System



TRACS Allows Real-Time Tactical Use as Well As Data Collection for COP Mapping



Tracking Moving Oil



Exclusive MRSC / OI Partnership

- ✓ OI presently maintains 3 TRACS at MSRC facilities in New Jersey, Texas and California.
- ✓ Systems are rapidly deployable on pre-identified aircraft of opportunity in each region.
- ✓ OI-trained MSRC remote sensing Strike Team members can independently use system(s) for tactical operations.
- ✓ MSRC can acquire imagery and forward to OI for full COP-oriented processing.
- ✓ OI is available for on and off-site expert support



All Materials ©2015

Ocean Imaging

MSRC Level B - BALLOON

Maritime Robotics Aerostat

Battery powered, non-wired tether

- Up to 12-hour "hang time"
- Rechargeable battery

Package includes:

- HD Camera
- TIR Camera
- AIS Repeater

Small, compact easily transportable package

Proprietary viewing software and gimbal

WIFI transfer to host vessel



NOFO: Oil On Water 2012



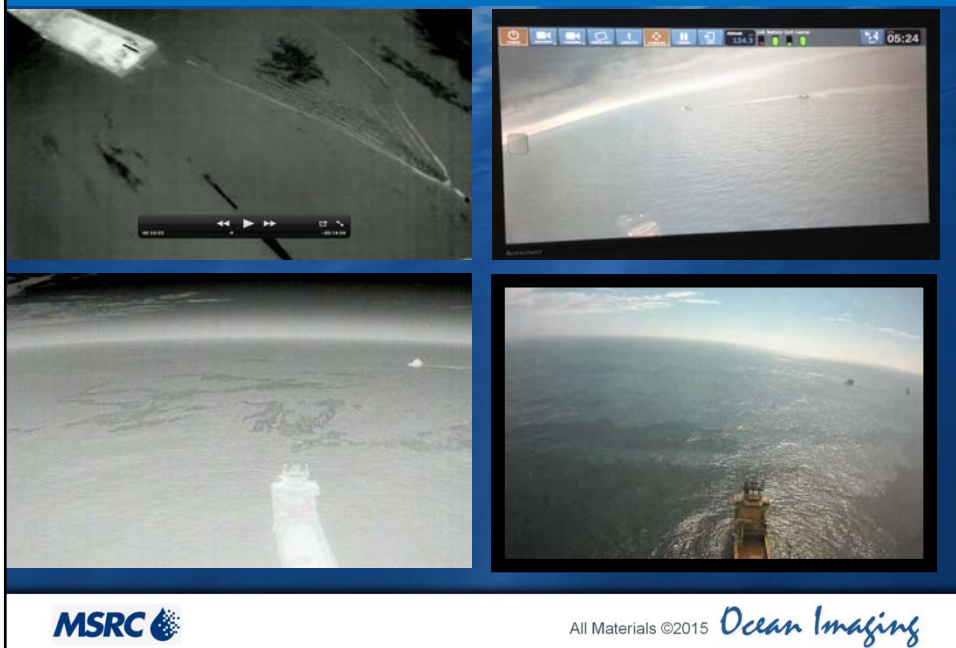
All Materials ©2015

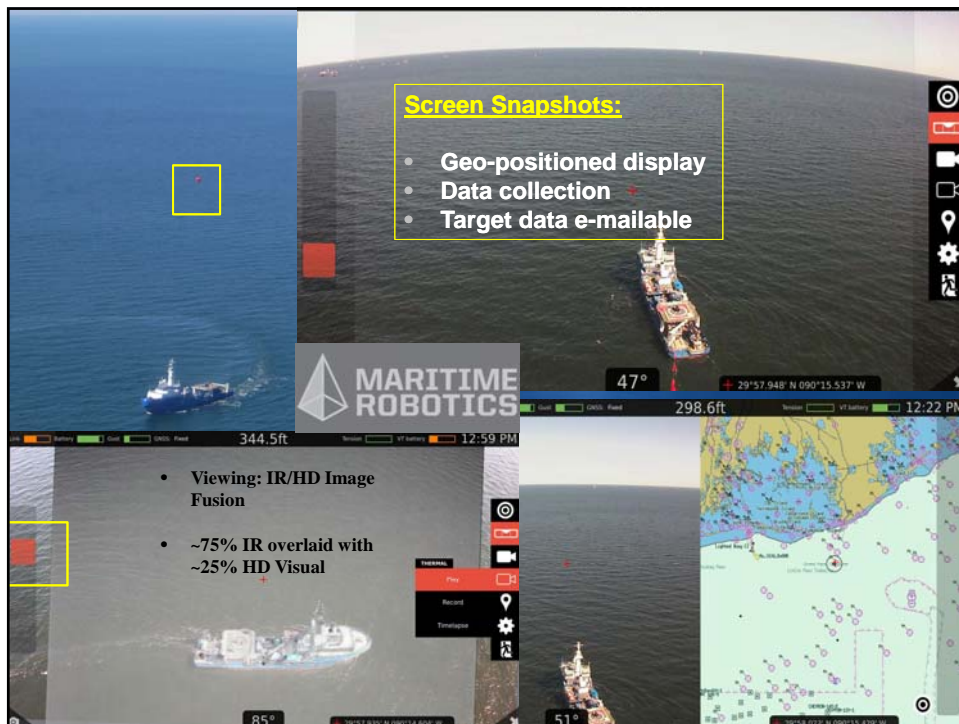
Ocean Imaging

MSRC Level B – BALLOONS (Aerostats)




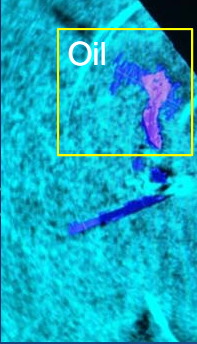

Maritime Robotics Aerostat – OOW 2013





MSRC Level C – CLOSE IN


OSRV-Mounted Systems for Tactical Optimization

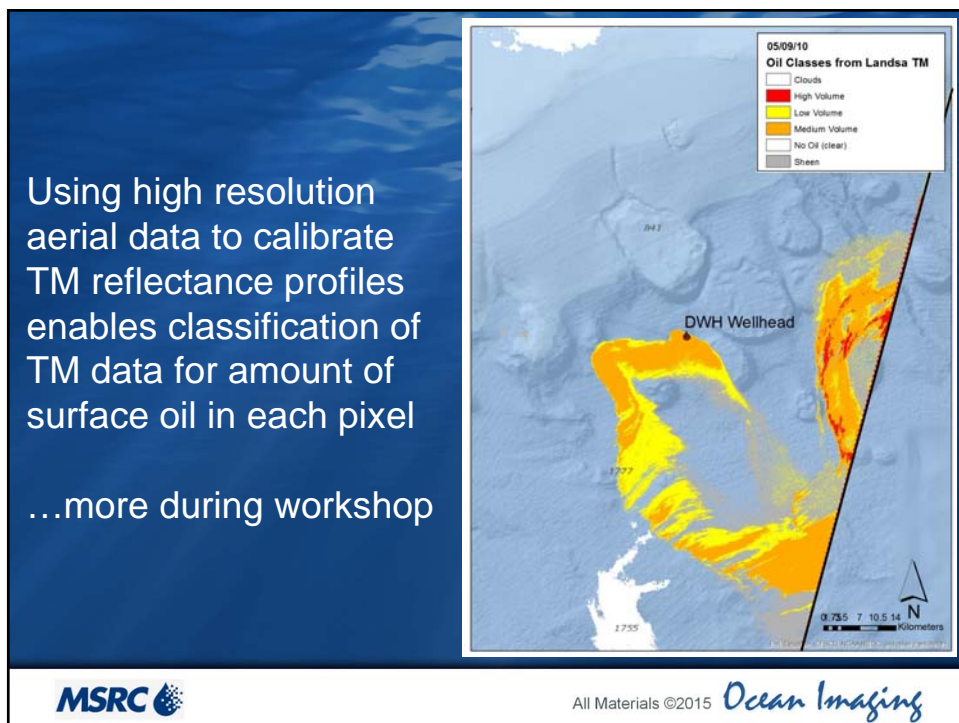
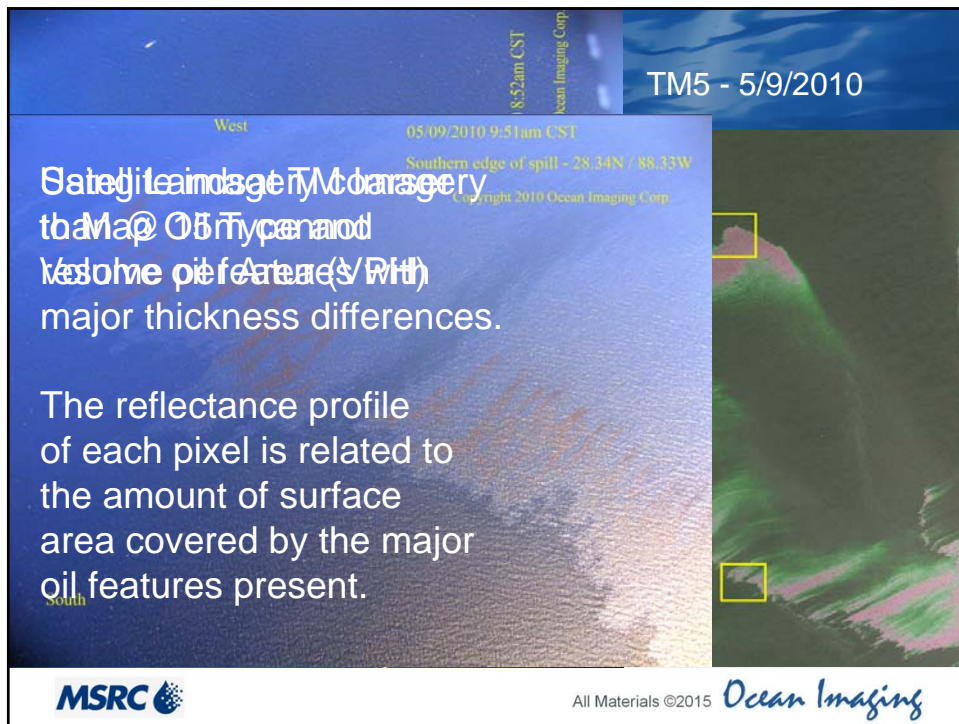
NOFO: Oil On Water 2013

X Band Radar and Thermal Infrared (TIR) on Responder Class Vessels

- Oil detection (X Band Radar)
- Better view of oil
- Stack oil vs. entrainment



All Materials ©2015 *Ocean Imaging*



THANK YOU!

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mhess@oceani.com

hoskins@msrc.org

Company Web Sites:

www.oceani.com

www.msrc.org



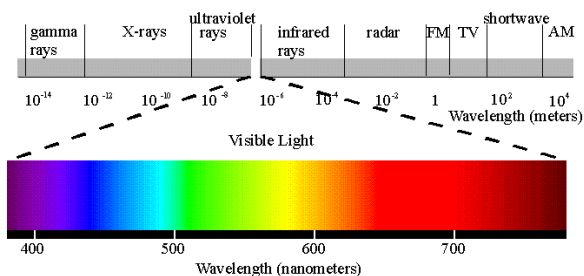
All Materials ©2015 *Ocean Imaging*

Hyperspectral Imaging Spectroscopy Oil Spill Response Sensing

Ira Leifer, Bubbleology Research International (BRI)

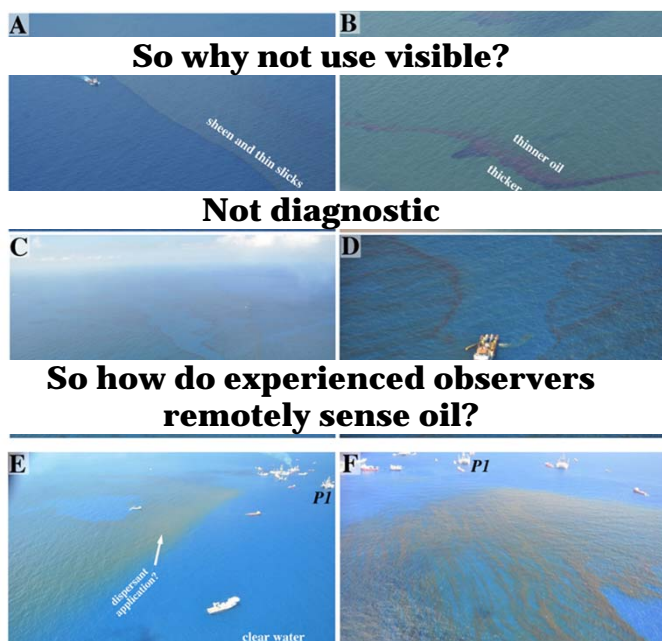
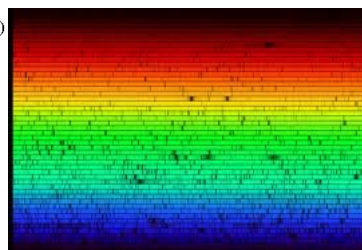
Presented by Chuanmin Hu (Univ S Florida)

Everything has color, lots of them,
more than the unaided human eye can see.

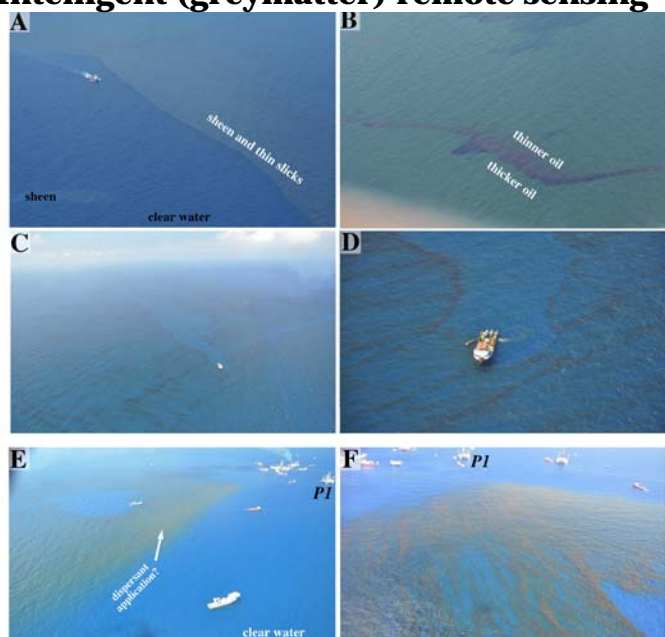


[Table of Contents](#)

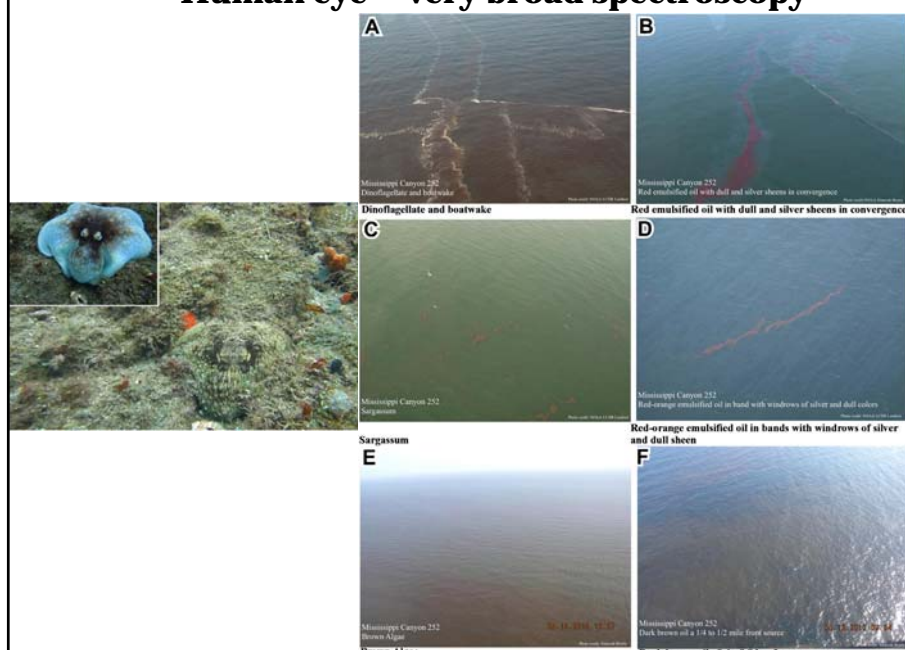
[Visual Stimulus](#)



Experienced Observers use Patterns and Colors Intelligent (greymatter) remote sensing



But Colors and Patterns can Deceive Human eye – very broad spectroscopy



So why Spectroscopy?

17 different oils a range of API – Nothing diagnostic in the V-NIR.

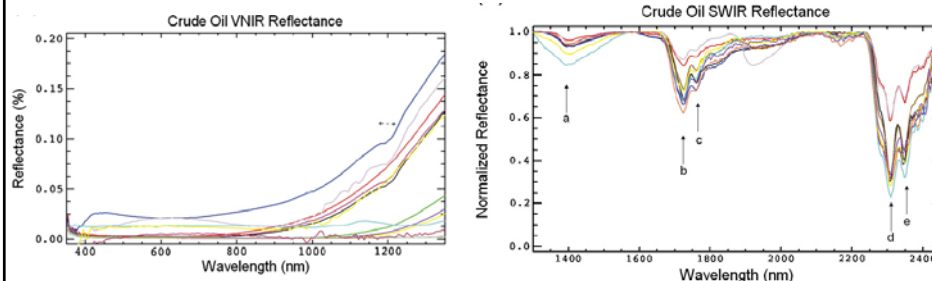


Fig. 2. (a) VNIR reflectance spectra of crude oil indicating range of C-H second overtone. (b) SWIR reflectance spectra of crude oil (continuum removed).

But the SWIR exhibits HC vibrational spectral features

From Lammoglia et al 2011

As volatiles are lost, spectral signatures weaken

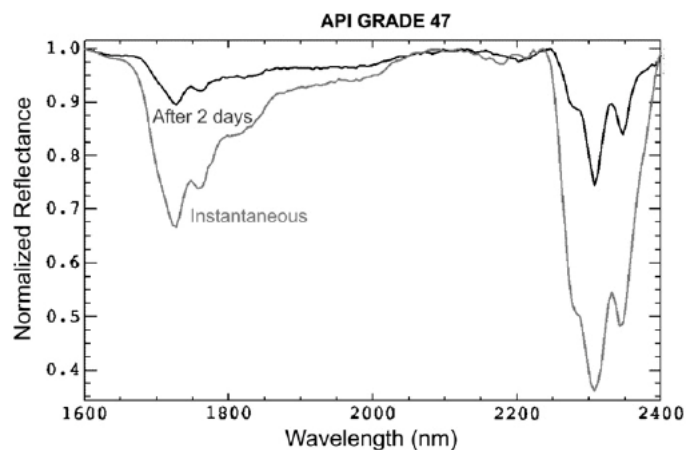
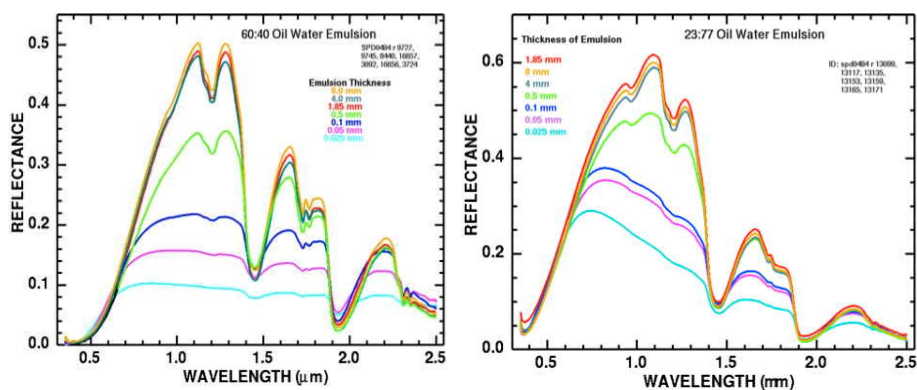


Fig. 4. Reflectance spectra measured between 1600 and 2400 nm for sample with API 47. Instantaneous measurements are represented in gray and measurements after two days are in black.

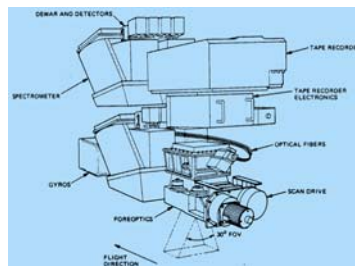
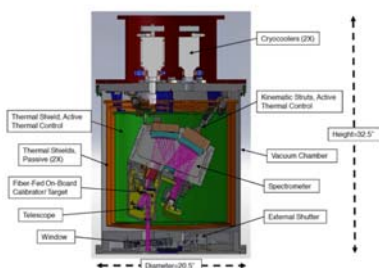
Spectral library for Macondo Oil Spill Emulsions



Laboratory spectra show spectral variability with thickness and oil to water emulsion ratio.

from Clark et al., 2010b.

AVIRIS Next Generation vs AVIRIS

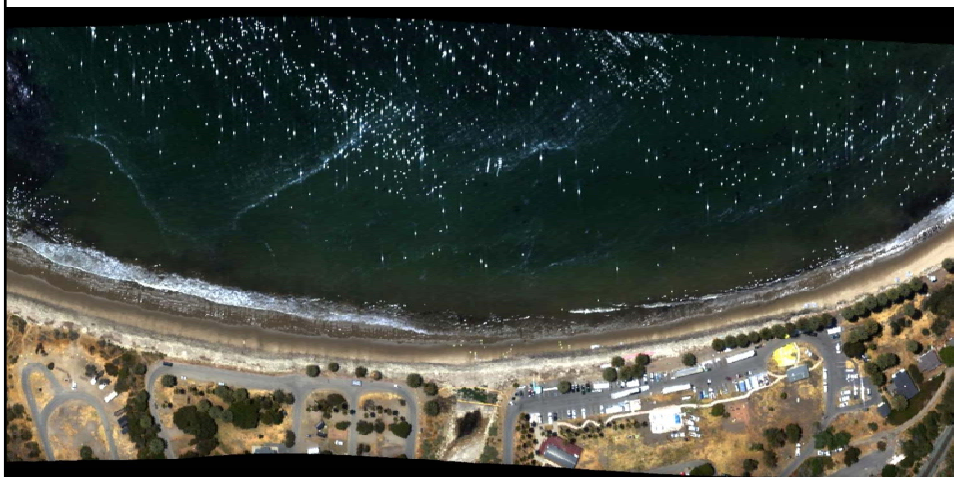


- 5 nm vs 10 nm
- Push broom vs Whisk broom
(better geolocation, finer resolution possible)
- Improved Signal to Noise
- 380-2510 nm vs 400 – 2500 nm

The Refugio Incident Response (May 19)
Minimal surface oil slicks by May 22 (AVIRIS NG mobilization)

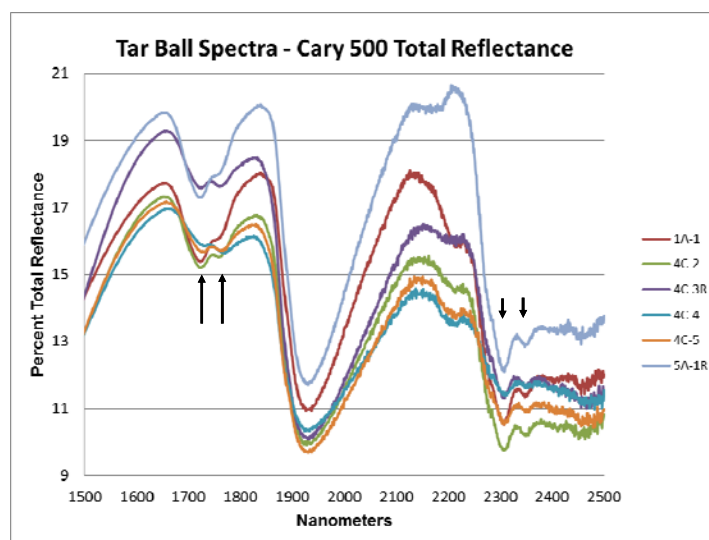


The Refugio Incident Response
- Some oil slicks near Refugio Beach



AVIRIS NG rgb imagery May 22

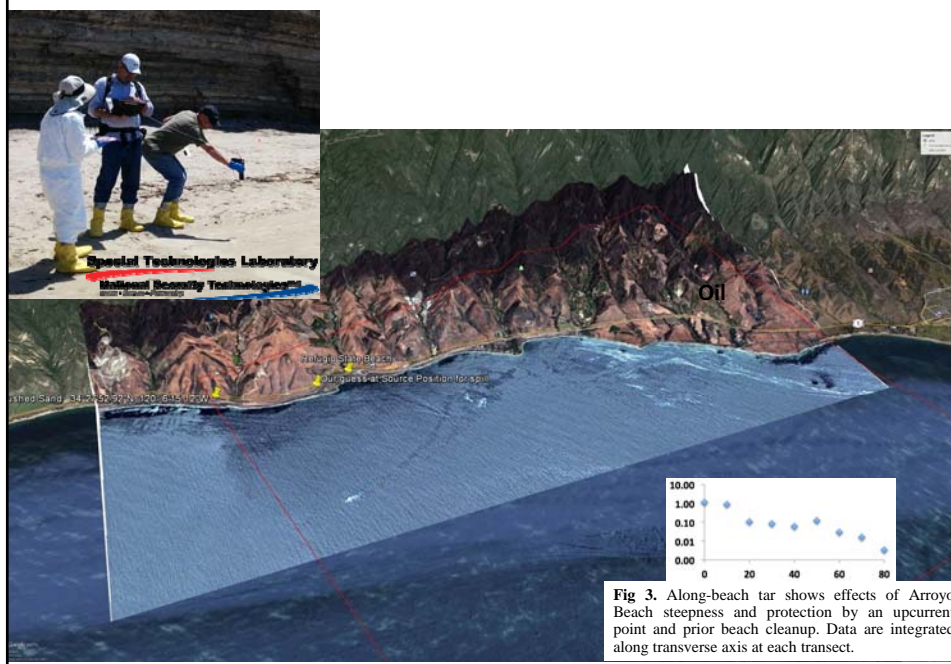
The Refugio Incident Response – Tar Has Spectral Features

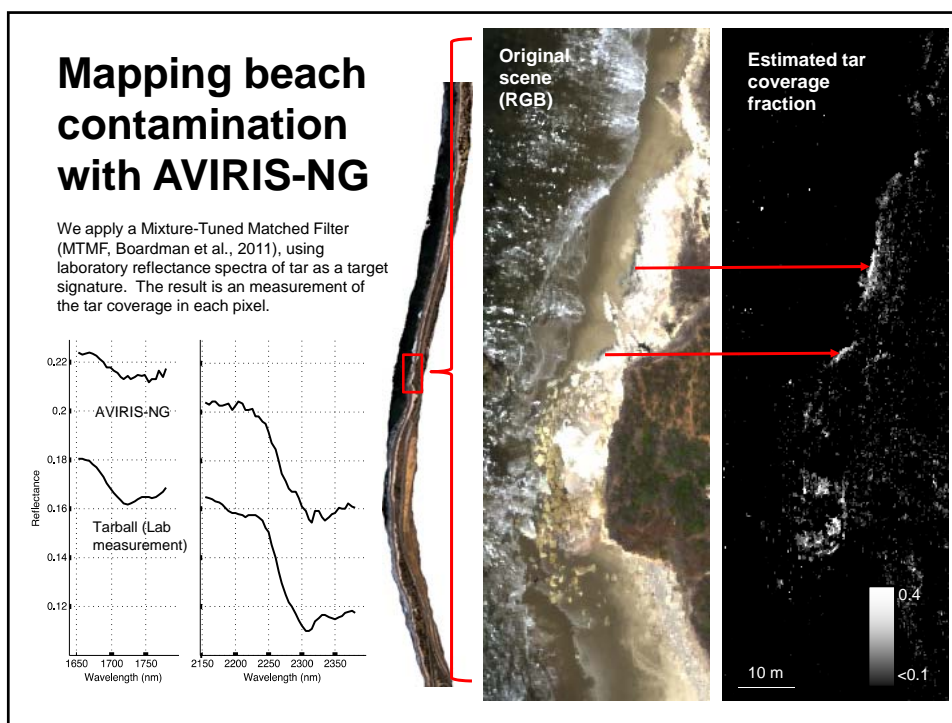


Special Technologies Laboratory
National Security Technologies
 Minor • Border • Partnership

Fig 1. Lab spectra of six Refugio Beach tarballs (collected 22 May). Note prominent petroleum hydrocarbon absorption features. (Cary500 Spectrometer, courtesy STL).

The Refugio Incident Response – Surface Validation Collected





Realtime Potential – CH₄ application: Operator Screen view

Thompson et al.: Real-time remote detection and measurement

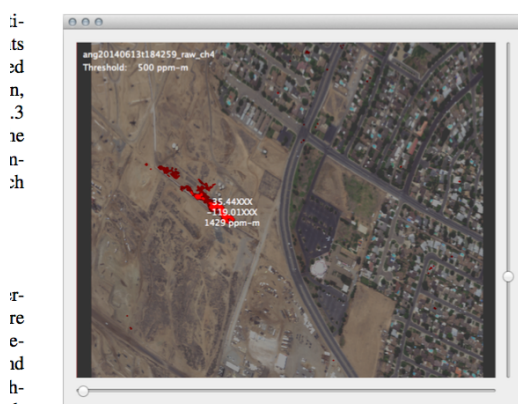


Figure 3. Screen shot of the graphical user interface, with an example of flight data from June 13 (ang20140613t184239). The red plume is displayed overprinted on RGB wavelengths. Real-time localization was implemented for use after the COMEX campaign, and we have redacted the precise coordinates in this image.

Matches target spectra with observed spectra

Thompson et al.: Real-time remote detection and measurement

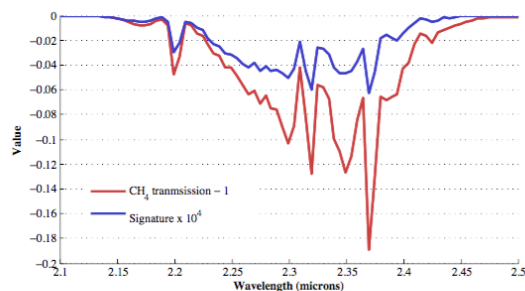


Figure 2. A comparison of spectral shapes between the CH₄ transmission spectrum, resampled to AVIRIS-NG wavelengths, and the target signature t used for detection. The vertical axis plots two different quantities as noted in the legend. Both signatures were calculated from a 20-layer atmosphere based on HITRAN 2012 absorption cross sections (Brown et al., 2013).

Realtime CH4 detection

Thompson et al.: Real-time remote detection and measurement

9

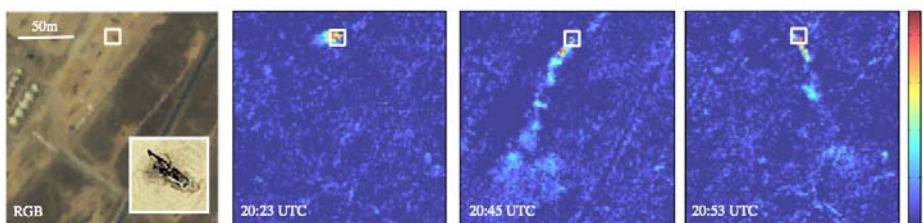
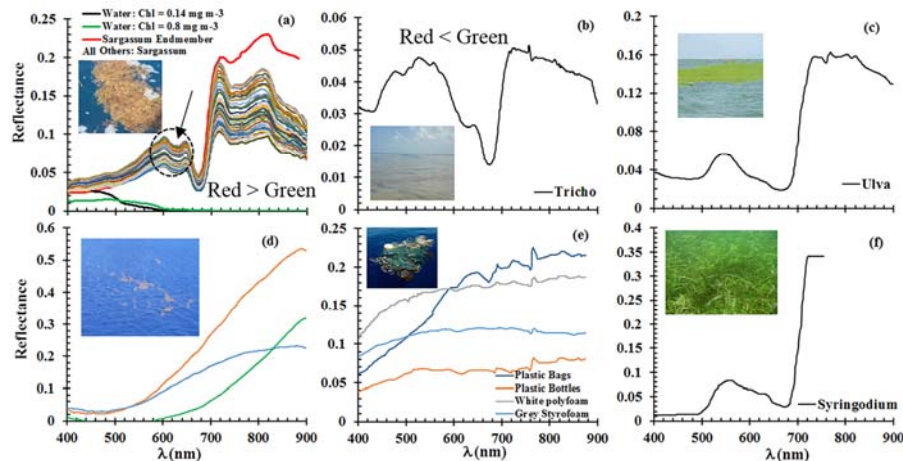


Figure 7. Left: subframe of ang20140904t205356. The insert (Google Earth, 2015) is a high-resolution visible image that reveals the source to be a pump jack. The proceeding panels, from left to right, show repeat overflights at 20:23h UTC, 20:45 UTC, and 20:53 UTC. Values show local CH₄ enhancement in ppm m.

During COMEX, realtime CH₄ detection was used to re-task a second airplane and surface vehicle.

Spectral shapes of various floating materials

Due to chl-c pigment and red-edge reflectance, Sargassum can be distinguished from others using the following 10-nm bands: 555, 605, 625, 645, 685, 755 nm.



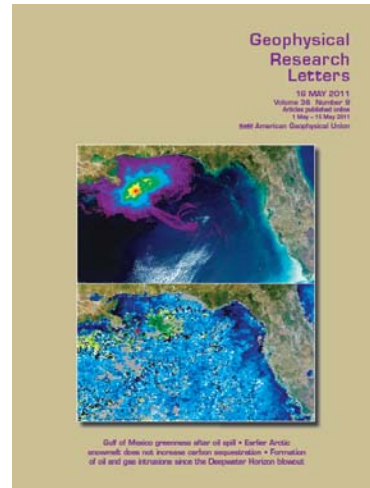
From Hu et al. (2015, RSE, Spectral and spatial requirements of remote measurements of pelagic *Sargassum* macroalgae)

17

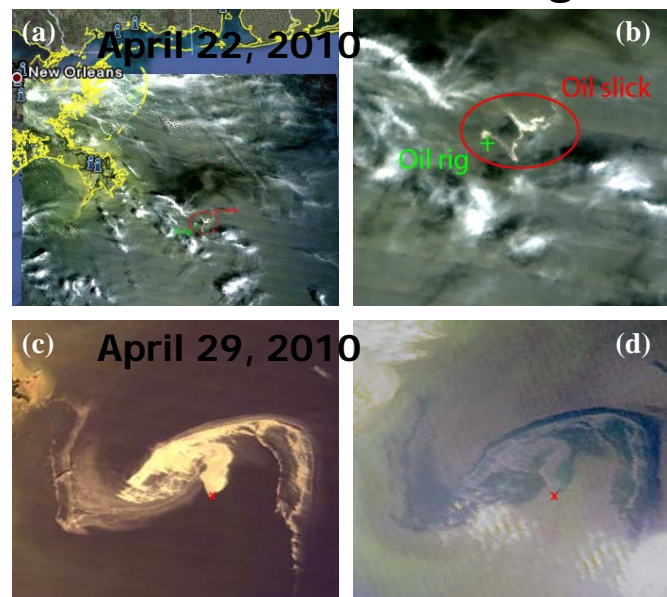
AVIRIS NG

- Spatial resolution – 30 cm
- Can map 30 km of beach in 30 minutes
- Ultimately should be able to discriminate to 5% pixel tar coverage (~4 cm)
- Realtime data telemetered to Mission Control
- Quantified, reproducible SCAT

VNIR oil observing

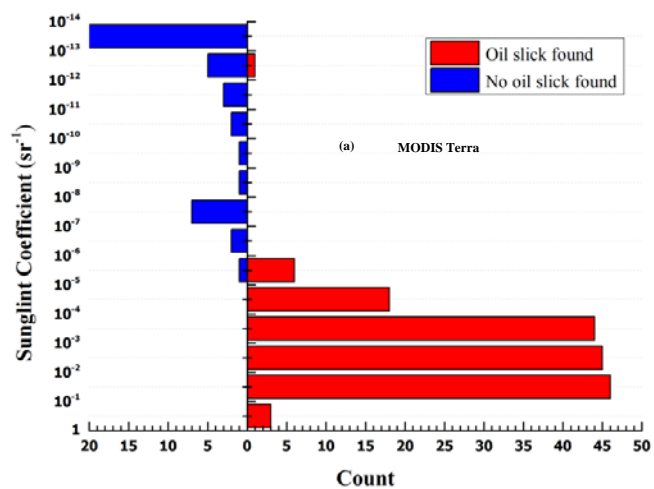


VNIR oil observing

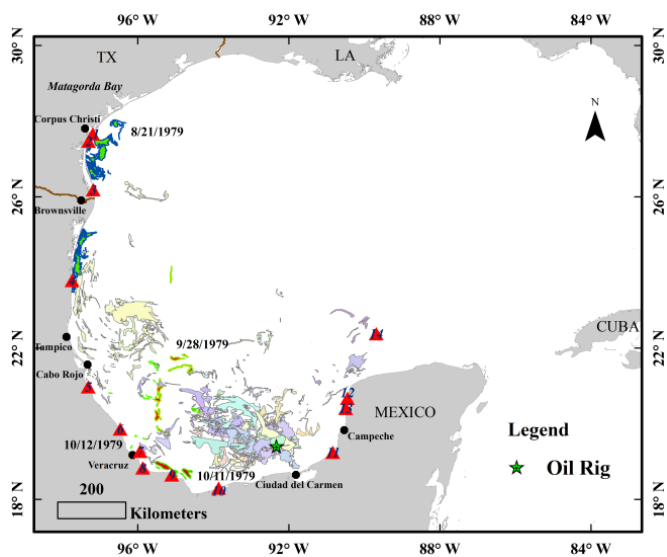


VNIR oil observing

Sun glint requirements to observe thin oil (Sun and Hu)



VNIR oil observing





OSRL Current Oil Observing Tools

► Aviation Platforms

- EO / IR / UV
- CarteNav

► Satellite Imagery

► Tracking Buoy

► Trained observers



Aviation Platforms

► West and Central Africa region (WACAF)

- Bandeirante in Accra, Ghana

► UK Continental Shelf

- 2 x Dornier Do228 in Bournemouth
- Island Defender in Aberdeen

► Equipment onboard:

- MX15 EO/IR Turret
- CarteNav



Dornier



Islander



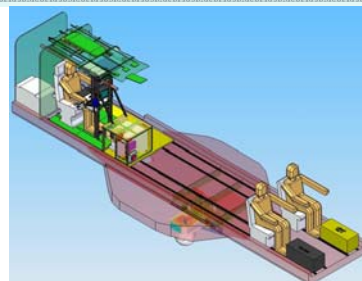
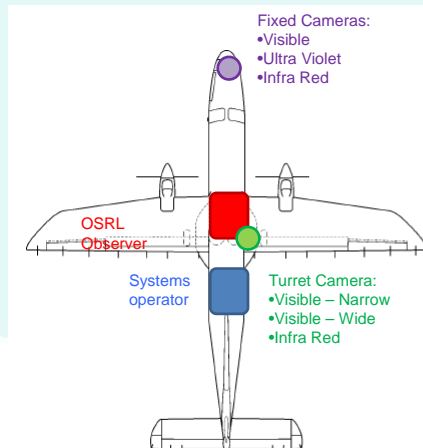
Bandeirante



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3

EO / IR / UV



MX15 EO/IR Turret



UV Camera



IR Camera



Color Camera

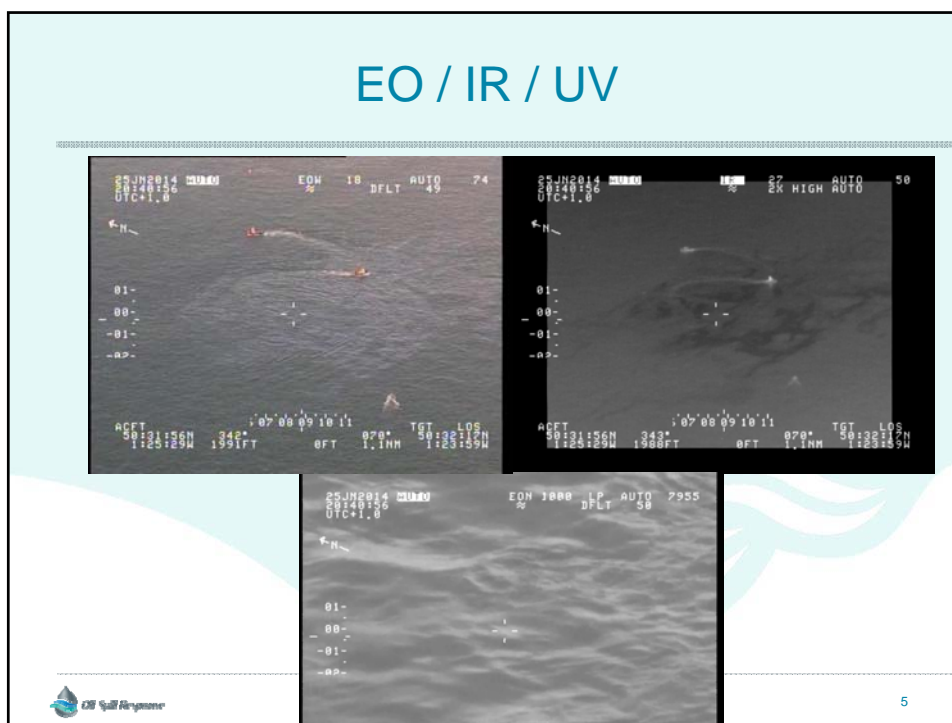
Nose Mounted Cameras



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4

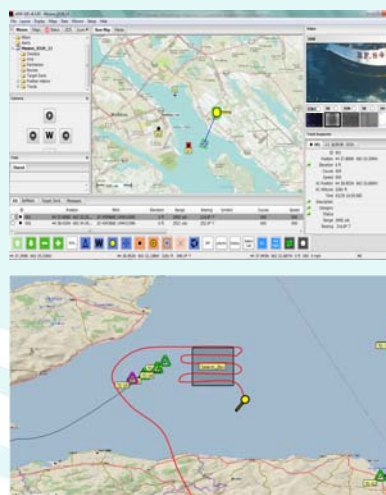
EO / IR / UV



5

CarteNav - AIMS

- Mission control software
 - Overlay key information to assist in tasking
- Perimeter mapping
 - Record and quantify extent of oil slick
- Real time information relayed to ground stations
- Replay mission data following overflight



CarteNav - AIMS

► Perimeter mapping



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7

CarteNav - AIMS

► Real time information relayed to ground stations

- Real time aircraft position
- Still images
- Reference marks
- Perimeter mapping
- Camera field of view
- Link to FTP site



► Replay mission data following overflight

- Capture additional video and still images as needed post mission
- Replay to client or regulator to show findings of mission



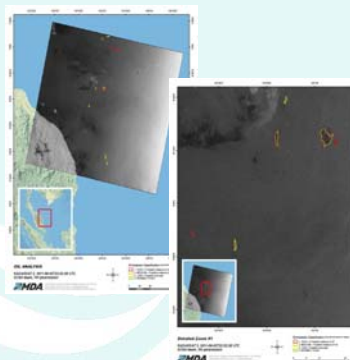
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8

Satellite Imagery

► Satellite Imagery Agreement between OSRL and MDA since 2012

- Radar imaging capability and optional visual capability
- On average 2 overpasses globally per day
- Surveillance data in various formats



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9

Tracking Buoys

► Track and monitor surface oil using the bi-directional iridium satellite system



iSphere



iSLDMB

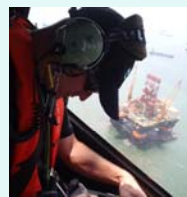


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10

Trained Observers

- Conventional and basic approach to surveillance
- Simple tools using camera and GPS
 - Geo-referencing software to link photos with location
- Quantification tools
 - Bonn Agreement Oil Appearance Code



OIL SPILL RESPONSE									
AERIAL SURVEILLANCE OBSERVATION LOG									
Observer	Date	Time	Area	Area	Area	Area	Area	Area	Area
Observer	DATE	TIME	Area	Area	Area	Area	Area	Area	Area
Observer	DATE	TIME	Area	Area	Area	Area	Area	Area	Area
Observer	DATE	TIME	Area	Area	Area	Area	Area	Area	Area

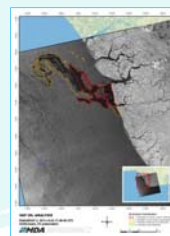


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11

Combined Outputs

- Combining different technologies to add credibility in the visual observation reports:
 - Oil Spill Modelling
 - Satellite Imagery
 - Remote Sensing Technology
 - Digital Mapping



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12

AirSAR Exercise 2014



G-MAFI GPS Track



Tracking the trajectory on CARTNAV



IR image of oil release



Colour image from turret



IR image of dispersant application

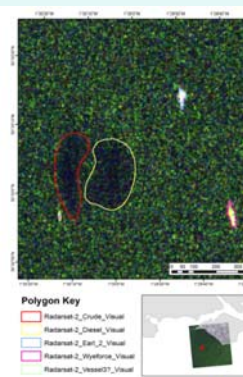


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13

Oil release after 10mins

Oceaneye – tethered aerostat (400ft)



MAFI dedicated surveillance aircraft



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14

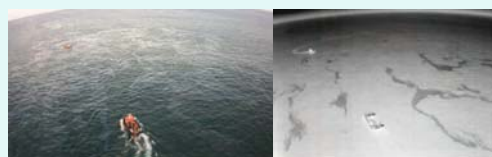
Oil Release after 1hr 30 mins



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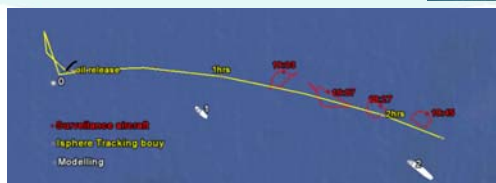
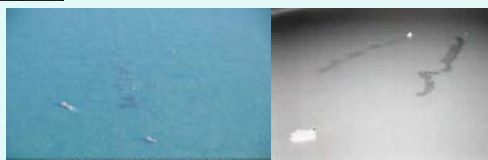
15

Surveillance Lessons



- Surveillance and modelling are essential for effective containment and dispersant operations

- Integrating numerous data sources into useful intelligence is extremely valuable but requires significant planning to ensure it is timely and that data is compatible.

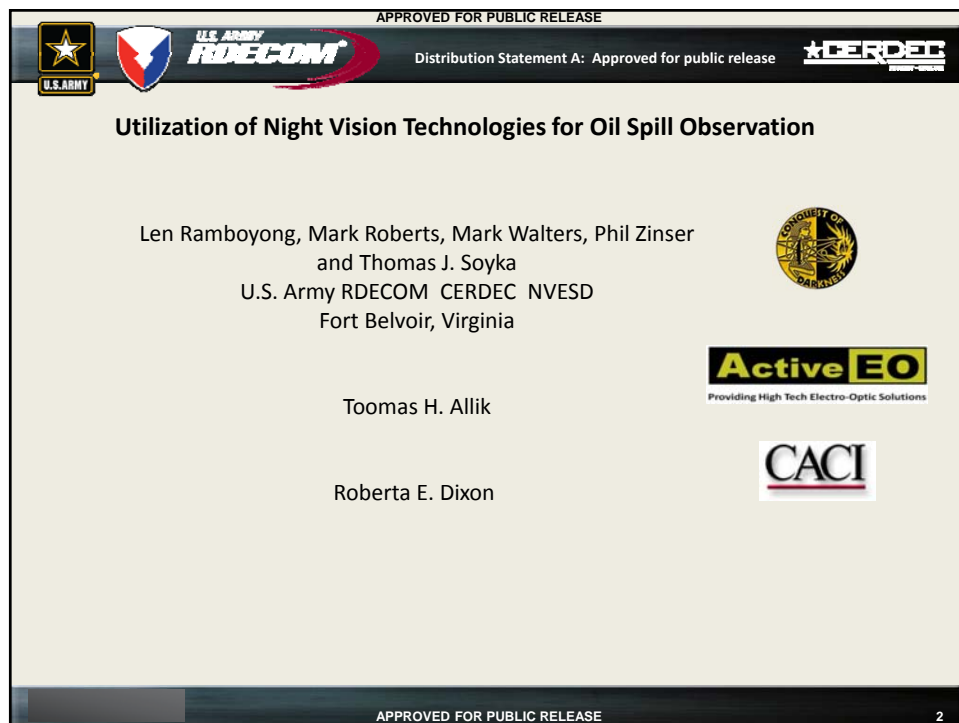
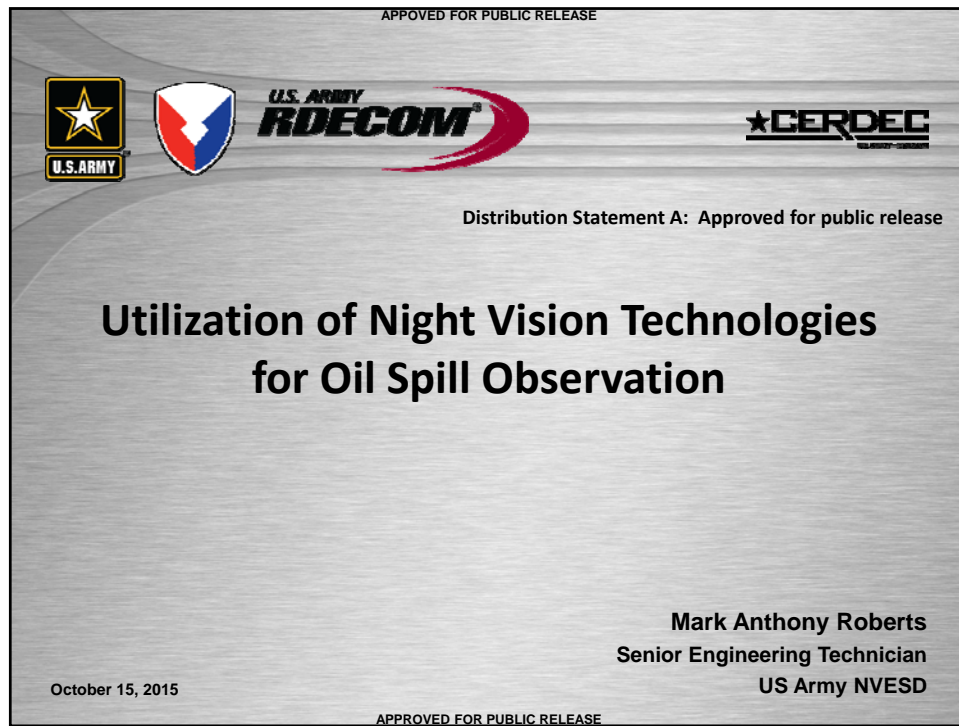


- The modelling, tracking and surveillance corresponded to the oil behaviour during the exercise.



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U.S. ARMY RDECOM Background HERDET

U.S. Army Night Vision and Electronic Sensors Directorate

NVESD

Fort Belvoir, VA

The Night Vision and Electronic Sensors Directorate (NVESD) dates back to 1954 with the founding of the Research and Photometric Section of the U.S. Army Corps of Engineers Engineering Research and Development Laboratories (ERDL). ERDL began with minimal funding and without laboratory facilities. The Research and Photometric section of ERDL began developing personalized night vision equipment intended for use by individual Soldiers in the field. This technology carved a unique niche for ERDL; many similar organizations focused on developing large weapons systems.

NVESD's initial mission was "the Conquest of Darkness so that the individual can observe, move, fight and work at night by using an image that he can interpret without specialized training and to which he can immediately respond." As NVESD expanded into new areas and across Army platforms, the mission also expanded to include new applications for sensor technologies.



The mission of the Night Vision and Electronic Sensors Directorate (NVESD) as "The Army's Sensor Developer" is to conduct research and development to provide US land forces with advanced sensor technology to dominate the 21st Century digital battlefield; land forces include ground and aviation troops. NVESD exploits sensor and sensor suite technologies to – see, acquire, and target opposing forces day or night under adverse battlefield environments; deny the enemy the same capabilities through electro-optic means and/or camouflage, concealment, and deception; provide for night driving and pilotage; detect, neutralize, clear and mark mines, minefields and unexploded ordnance; and, protect forward troops, fixed installations, and rear echelons from enemy intrusion.

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U.S. ARMY RDECOM Background HERDET

Enhanced Oil Spill Detection Sensors in Low-Light Environments

Operating Status

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About BSEE Newsroom Regulations & Guidance Inspections & Enforcement Exploration & Production Technology & Research International & Interagency Collaboration

Home Page > Research and Training

Oil Spill Response Research (OSRR) Program

Project Number	1013
Date of Summary	January 6, 2015
Subject	Enhanced Oil Spill Detection Sensors in Low-light Environments
Performing Activity	US Army Research Development and Engineering Command (RDECOM)
Principal Investigator	Lenard Ramboyoung
Contracting Agency	Bureau of Safety and Environmental Enforcement
Estimated Completion	June 30, 2016
Description	The goal of this collaborative effort is to enhance the methods currently in place to detect oil in a marine environment. The methods currently in place are not conducive to oil spill recovery operations during periods of low light and rely heavily on time-delayed aerial remote sensing technologies, or visual observation. This project will leverage the knowledge and expertise of RDECOM's Night Vision and Electronic Sensors Directorate (NVESD) personnel to assist BSEE in the identification and documentation of existing capability gaps, identification and assessment of technology gaps; test and evaluate potential new or alternative hardware; and if necessary, support the design, development and demonstration of new technologies to meet identified needs.
Progress	Imaging experiments were conducted at Otmsett during November 2014 using Hydrolac and Alaskan North Slope crude oil. Airborne data collection field work was conducted on the Santa Barbara seeps during December 2014.

Joint program between the U.S. Departments of the Interior and Defense to bring knowledge, expertise and military low-light level and hyperspectral imaging technologies to remote oil spill detection.

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U.S. ARMY **RDECOM** Night Vision ? **GERDEP**

What is Night Vision?

Sensor spectral sensitivities

Image Intensifier

Visible

Infrared

Wavelength(m)

Energy(J)

Frequency(Hz)

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U.S. ARMY **RDECOM** Night Vision ? **GERDEP**

What is Night Vision?

Near Infrared

Short Wave Infrared

Mid-wave

Long Wave Infrared

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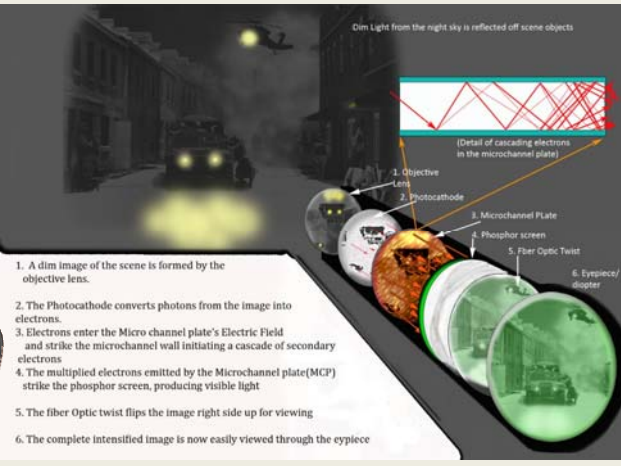
6

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U.S. ARMY RDECOM Near Infrared

Near Infrared or image intensified- Most Commonly referred to as "night vision"

Analog technology
Signature green hue
Now readily available
Goggle format

1. A dim image of the scene is formed by the objective lens.
2. The Photocathode converts photons from the image into electrons.
3. Electrons enter the Micro channel plate's Electric Field and strike the microchannel wall initiating a cascade of secondary electrons
4. The multiplied electrons emitted by the Microchannel plate(MCP) strike the phosphor screen, producing visible light
5. The fiber Optic twist flips the image right side up for viewing
6. The complete intensified image is now easily viewed through the eyepiece

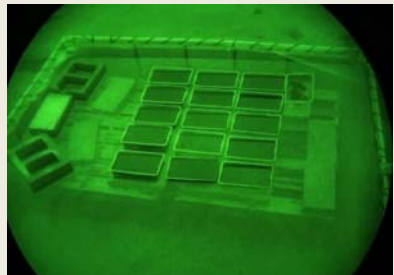
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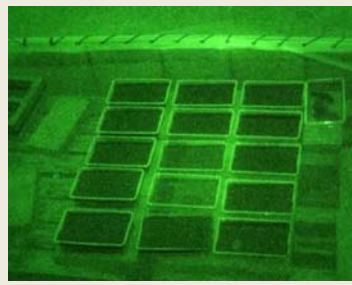
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U.S. ARMY RDECOM Near Infrared

Image intensified images



Night Vision Goggle w/ starlight



Night Vision Goggle w/ illumination

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Digital Sensing

- **Digital Sensing Devices**
- Digital sensors include wider bandwidth coverage than do analog sensors. They span from visible to long wave infrared. These technologies have long been used for their thermal sensing capabilities and have provided an excellent resource for detection on the battlefield up until recently, however, digital sensors could not meet analog performance for a near infrared solution and provide the benefits of a digital sensor.
- Digital sensor benefits will provide the ability to continue the advancement of sensors on the responder. These advances will enable advanced situational awareness through use of post processing algorithms, multiple wavelength fusion, and target detection and marking, among others,
- Currently, analog sensors cannot easily record and send video or snapshots over the net for improved situational awareness, and do not have an ability for post processing.

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Night Images

Image Intensified (I2)CCD and SWIR Cameras (No Moon - Starlight)

I2CCD Camera

SWIR Camera

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Short Wave Infrared Imaging



- Until recently, the SWIR waveband has been an untapped region of the electromagnetic spectrum for high resolution, passive imaging due to the lack of low light level imagers in this region.
- Over the past 15 years the US military has made an investment in the development of Indium Gallium Arsenide (InGaAs) array based sensors.







SWIR Monoculars with Various SWIR optimized lenses and telescopes.


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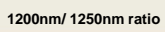

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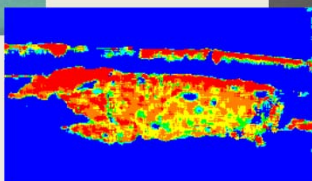
Short Wave Infrared Imaging



- **SWIR**
- Shows promise to distinguish between clutter and oil
- Slightly better atmospheric transmission in certain weather conditions,
- Increased solar irradiance in very low light level conditions,
- Increased contrast between oil reflectivity and water,
- Additional hydrocarbon spectral signatures and spectroscopic differences between crude oil and weathered emulsions

Visible



1200 nm SWIR

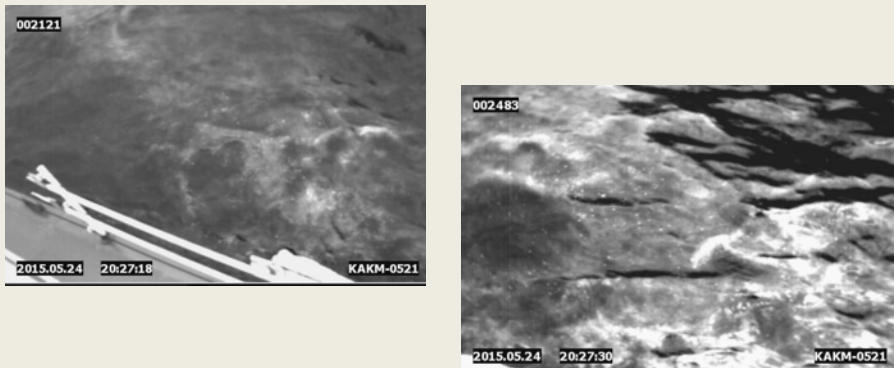
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U.S. ARMY **RDECOM** Short Wave Infrared Imaging **ALERT**

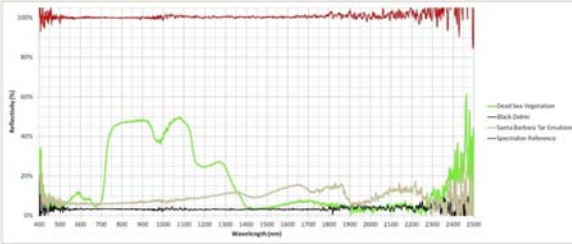
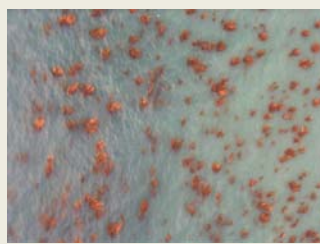
Images taken with hand held SWIR showing natural seep with Methane bubbles



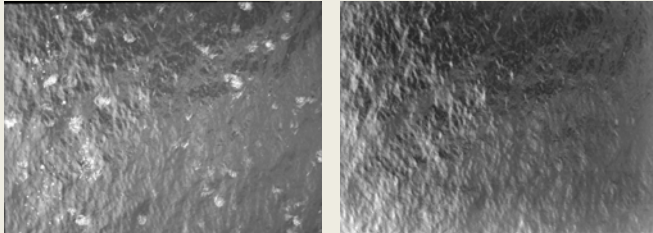
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U.S. ARMY **RDECOM** Vegetation Clutter **ALERT**

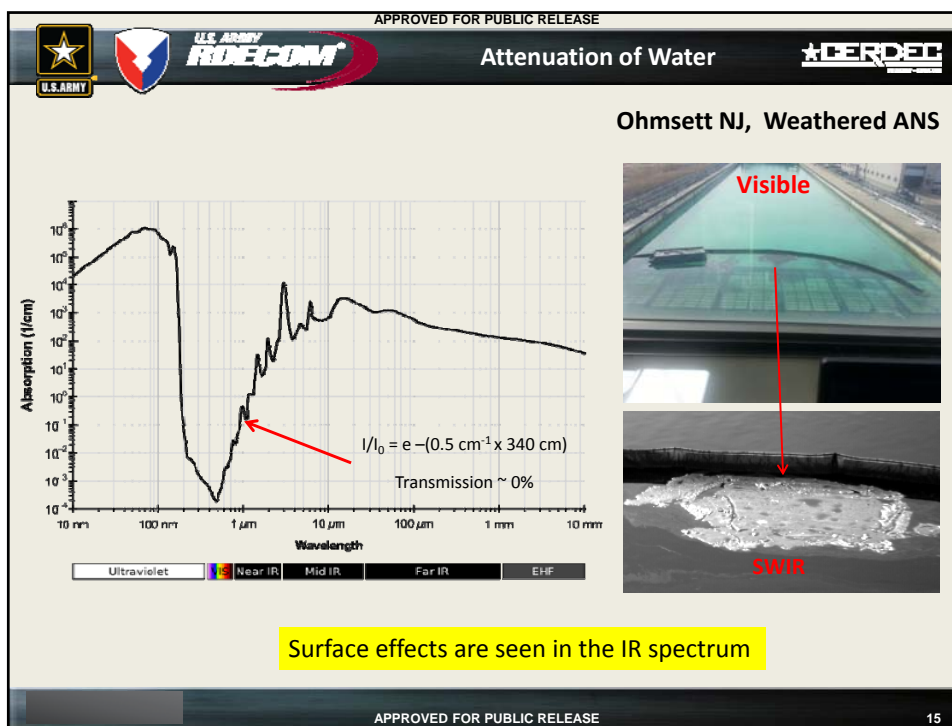



SWIR Images 975 nm (left) and 1600 nm (right).



Vegetation has comparable reflectivity to water at 1600 nm.

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U.S. ARMY RDECOM Mid Wave Infrared CERDET

- Mid Wave 3-5μm
 - Sensor commonly used in aerial applications
 - Cooled detectors allow for increased resolution and distance
 - Shorter Wavelength allows for smaller optics
 - However, detectors that require cooling significantly increase cost

FLIR

Dist = 1.0 Trefl = 20.0 ϵ = 0.95 15.3

MWIR of Osberg in saltwater

Right- Nader look at Osberg in water

IR

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U.S. ARMY RDECOM Mid Wave CERDET

- Mid Wave Infrared
 - 3-5 μ m – Still in “reflective region”
 - offers benefit in less than desirable conditions over Image intensified and SWIR
 - Not as good transmission in under-ideal conditions as Long wave

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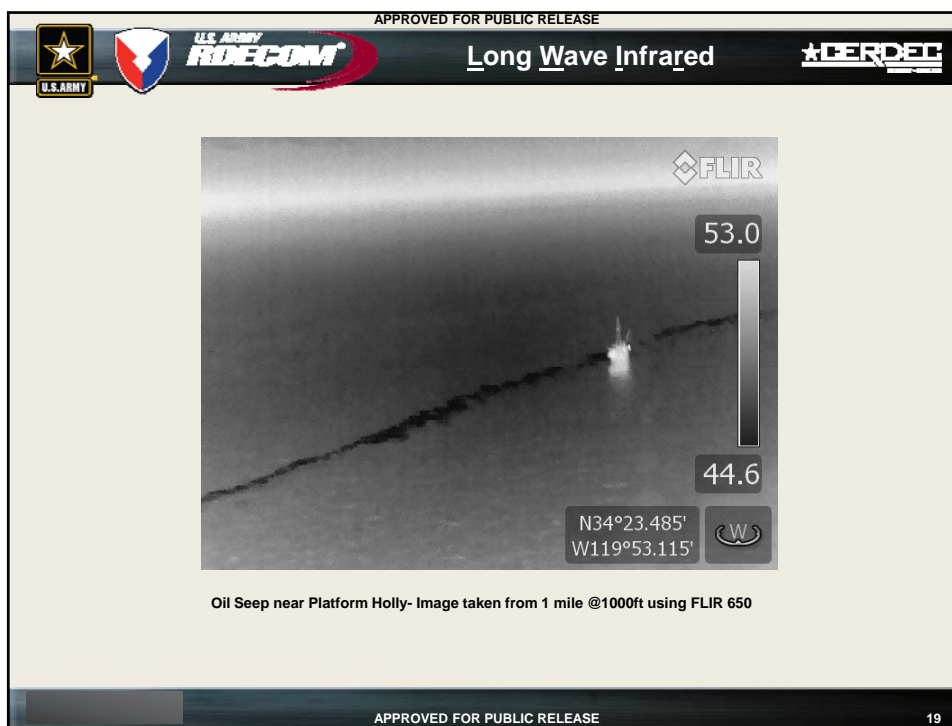
U.S. ARMY RDECOM MWIR vs LWIR CERDET

- Images of MWIR vs. LWIR

In handheld units, the differences are not obvious
Which is Which?

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U.S. ARMY **RDECOM** **Long Wave Infrared** **HERDET**

- Long wave Infrared has been shown to have the most promise currently in detection, and identification of oil on water.
- LWIR also has been shown to give the best indication of thickness of an oil slick on water.
- LWIR's transmission allows for utilization in less than ideal weather conditions (pictured below)
- Uncooled sensors allow for smaller and lower cost sensors than other bands



Transmission (%)

Wavelength (Microns)

— Tropical Radiation Fog (No Rain)
— Tropical Advection Fog (No Rain)
— Tropical Maritime Clouds
— Tropical Maritime Light Rain


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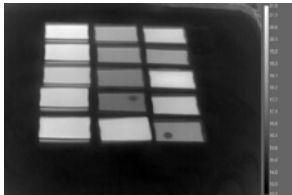



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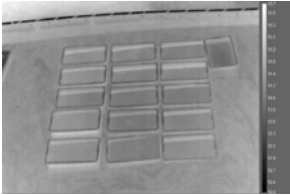
LWIR Thermal Imagery



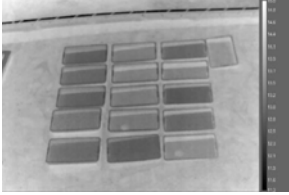
- **Thermal imagery proved to be the best sensor (provides identification).** Shown below are representative images taken in the afternoon, twilight and night.
- During the day, the thicker (≥ 10 mm) oil showed a higher apparent temperature than the thinner sample (2 mm). This was consistent for all crude oils.
- As seen in the center image below, there was a contrast reversal where the oil and water have the same apparent temperature before sunset. **Schedule Demo Mid Day or Evening**
- At low light levels, the thicker oil had a lower apparent temperature and appears darker.



14:58 hrs.



18:18 hrs.



19:12 hrs.

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Video over Platform Holly



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U.S. ARMY **RDECOM** LWIR **ICERDET**



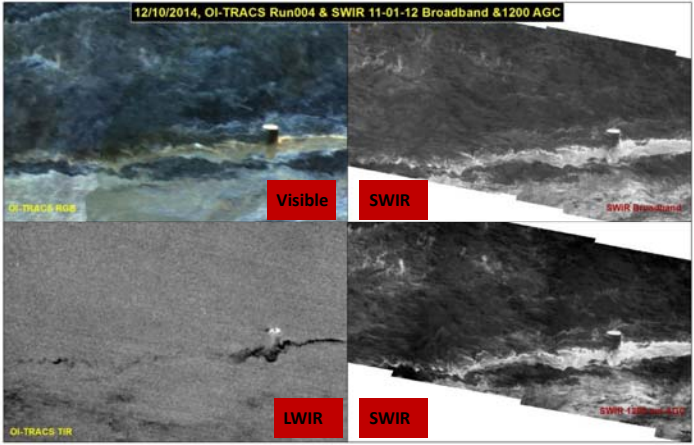
Images taken just before dawn @1000ft above platform. Notice oil not visible in visible sensor but wake is present(dark strip)
(Although Oil was visible to naked eye)

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U.S. ARMY **RDECOM** Multispectral Data **ICERDET**

12/10/2014, OI-TRACS Run004 & SWIR 11-01-12 Broadband & 1200 AGC



Data from SB Channel seeps

The optimal scenario would be a multispectral approach payload with real time post processing for command and control function

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U.S. ARMY RDECOM Night Vision ? CERDEC

Why Night Vision?

- Provide extended hours of observation/ cleanup
- Use of certain Wavelengths to aid in less desirable conditions
- Digital sensors will provide a means to collect data to send to command
- Hand held units can be a lower cost, in comparison to larger sensor platforms, and still provide superior capability improvements

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U.S. ARMY RDECOM Usage Examples CERDEC

Handheld units will provide observation capabilities for multiple platforms available during an emergency.

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U.S. ARMY RDECOM Night Vision ? CERDET

- Who could use It?
 - Image Intensifiers are available off the shelf and could be used as an aid in oil spotting in early morning or late night hours when broad spectrum lighting isn't available. We could see this possibly used on shoreline surveys or onboard watercraft and aircraft... (if mission would require)
 - SWIR, Due to the cost of SWIR at this time we are not sure the benefits outweigh the expense, however, SWIR from an airborne platform could be highly beneficial in clutter rejection
 - MWIR, Currently MWIR is onboard most USCG aircraft and vessels. In these applications it is nominal to have a standoff distance and optimal for their mission. Handheld MWIR is not cost effective when low cost LWIR sensors are available.
 - LWIR, This is the most effective sensor band currently in use for Oil detection and observation. The low cost of uncooled detectors makes LWIR the most useful for shoreline, water borne, and aerial applications

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U.S. ARMY RDECOM How Can we use it? CERDET




- The onset of more prevalent digital night vision technology will allow for more information to be sent directly back to a command post for evaluation.

Handheld sensors could be paired with a transmit capability and minimal processing to deliver a data product in accordance with whatever format may be requested
- An optimal approach would be development of a uniform data product that could be disseminated to all sensor types based on what the intent is: i.e., thickness measurement, vegetation impacts, etc...

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U.S. ARMY RDECOM Acknowledgements CERDEC

- The authors would like to thank the following:
 - Lori Medley and Jay Cho 
 - Jan Svejksky and Mark Hess 
 - Ohmsett Staff 

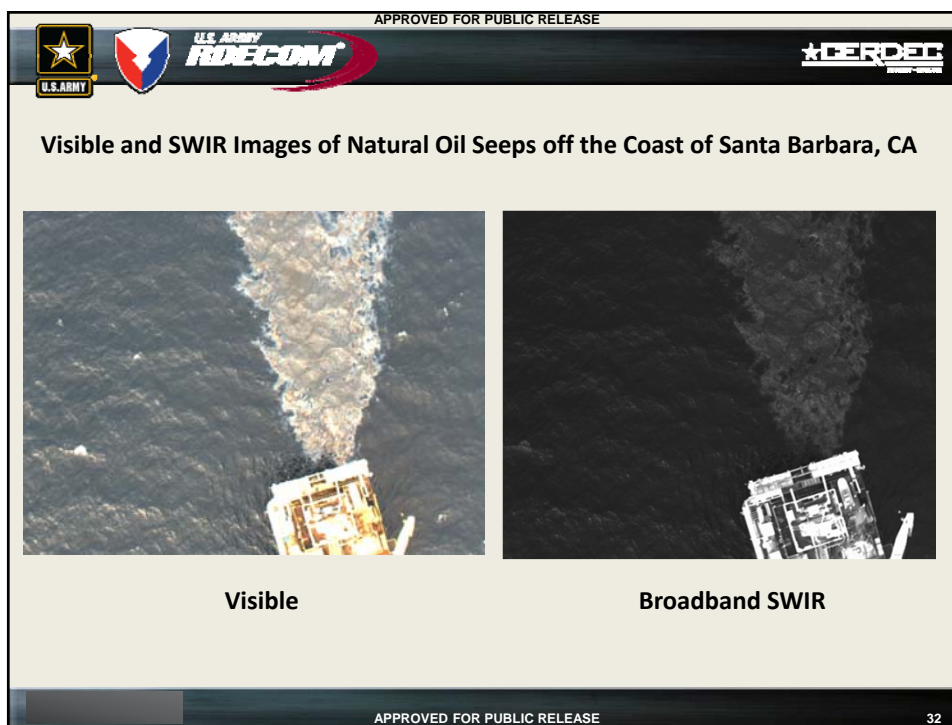
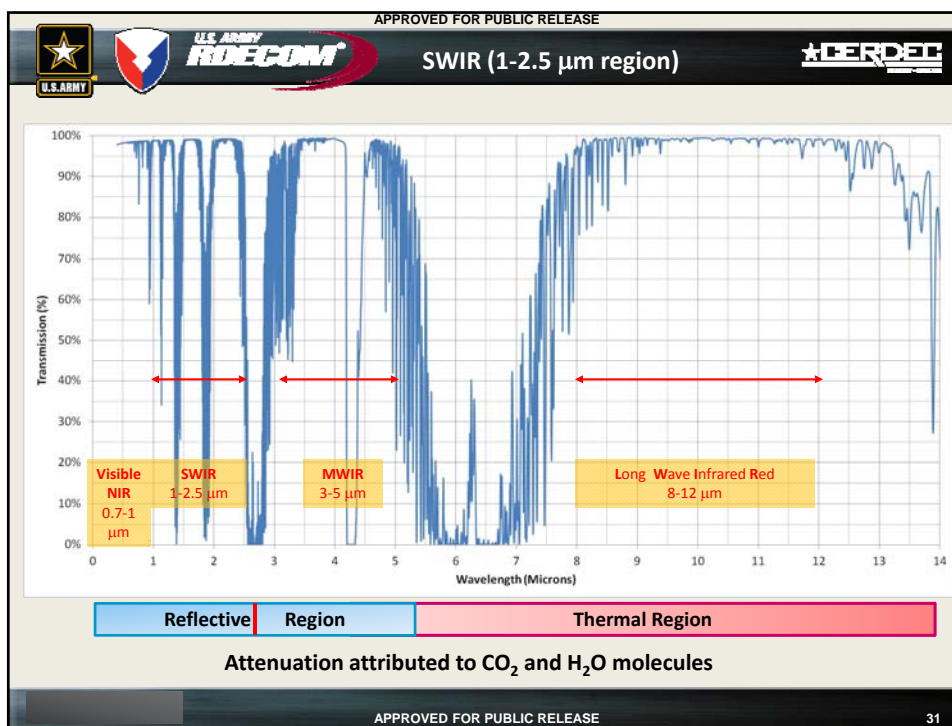
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U.S. ARMY RDECOM Backup CERDEC

- Backup slides

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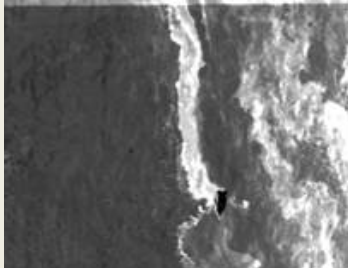

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Santa Barbara Test



Santa Barbara Oil Seep Testing - December 2014

We have identified two SWIR wavelengths that provide relative thickness measurements in the field. The images below show the processed SWIR image and visible photograph. The boat crew had determined that this area had a high thickness of weathered oil.



Processed SWIR Image (1600 nm – 975 nm)

Visible

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Conclusions



- **Improvements in Short Wave Infrared (SWIR) cameras have made them useful for military, pharmaceutical, and chemical detection.**
- **SWIR airborne hyperspectral cameras have shown their usefulness in oil spill detection.**
 - However, their high instrument and operational cost, coupled with the logistical issues in providing real-time spectral maps to Oil Spill Response Organizations (OSROs) are problematic.
- **Benefits of the SWIR spectral region over the Visible are:**
 - Slightly better atmospheric transmission in certain weather conditions,
 - Increased solar irradiance in very low light level conditions,
 - Increased contrast between oil reflectivity and water,
 - Additional hydrocarbon spectral signatures and spectroscopic differences between crude oil and weathered emulsions.
- **Hand-held SWIR imagers** use room temperature detectors with small pixels (15 microns), formats comparable to uncooled microbolometer LWIR cameras, and noise reduction allowing for passive low-light level imaging.
- **We discuss our man-portable SWIR camera, and spectral characterization that generate real-time imagery.** Demonstrate two SWIR wavelength approach for remote oil thickness measurements.

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Overflight Maps

Jeff Lankford
Lexter Tapawan

National Oceanic and Atmospheric Administration
Office of response and Restoration
Emergency Response Division
Seattle, Washington

This Power Point offers a quick overview on the process of making an overflight map during an oil spill response. This doesn't provide a detailed description on how to create an overflight map – it merely shows how an overflight goes from the actual observation to a presentable and deliverable map product.

10/27/2015

From Overflight Observers

- Information Manager needs the following from the overflight observer(s):
 - **GPS Unit**
 - **Camera** (We will not go over the processing of photos since it doesn't pertain to the creation of overflight maps)
 - **Field Notes**

10/27/2015

MapSource

- **Garmin MapSource:**
 - This software is used to extract waypoints and track logs from the GPS unit.
 - Three files are exported: gdb, gpx, and txt.
 - The gpx file is the primary file used for the map creation, the other two files are a security blanket in case something goes wrong with the gpx file.

10/27/2015

MARPLOT

- MARPLOT is used as a platform for the gpx file, where some edits are made.
- The primary use is to convert the gpx file to a shapefile for ingestion into ArcMap.

MARPLOT is available through:

<http://www2.epa.gov/comeo/marplot-software>

**There is also the option to convert the gpx file to other formats such as kmz and xlsx.

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MARPLOT Continued...

- Ideally, the information manager would sit down with the overflight observer in order to get a briefing of the field notes.
 - The information manager goes through each waypoint with the overflight observer to generate notes corresponding to a particular waypoint/observation.

MARPLOT is available through:

<http://www2.epa.gov/cameo/marplot-software>

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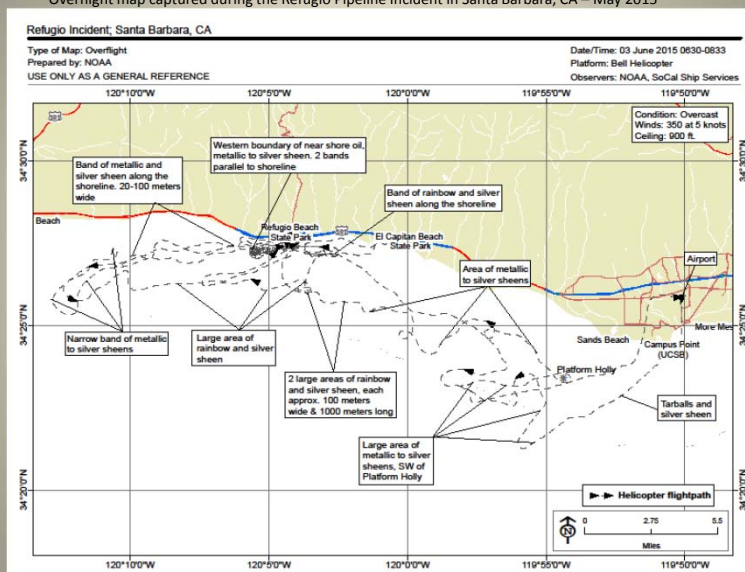
ArcMap

- Bring the shapefile into a template you have previously created.
- Notes are added as text boxes.
- Some tweaks are made such as date, time, weather observations and observers.
- The map is reviewed by the overflight observer.
- After the review, the map is exported into various formats and is then distributed.

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Visual example of a typical response overflight map

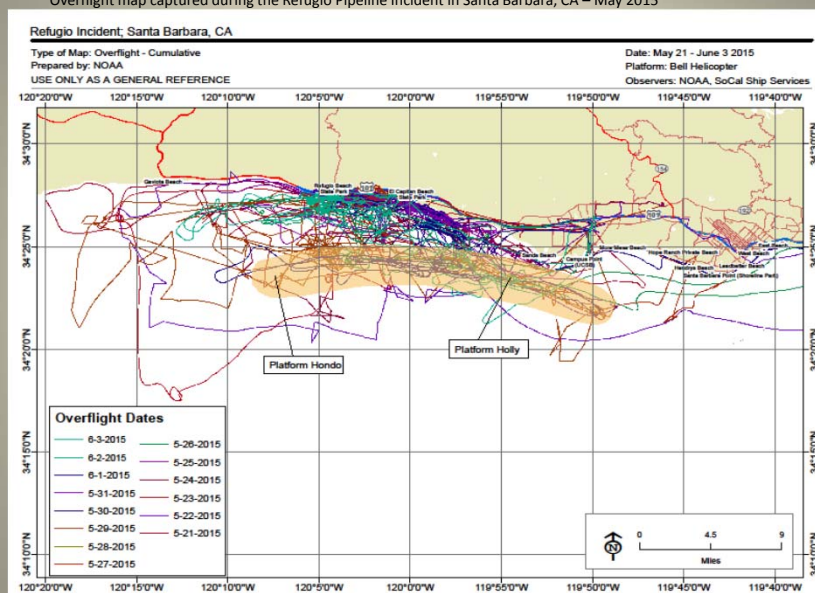
*Overflight map captured during the Refugio Pipeline Incident in Santa Barbara, CA – May 2015



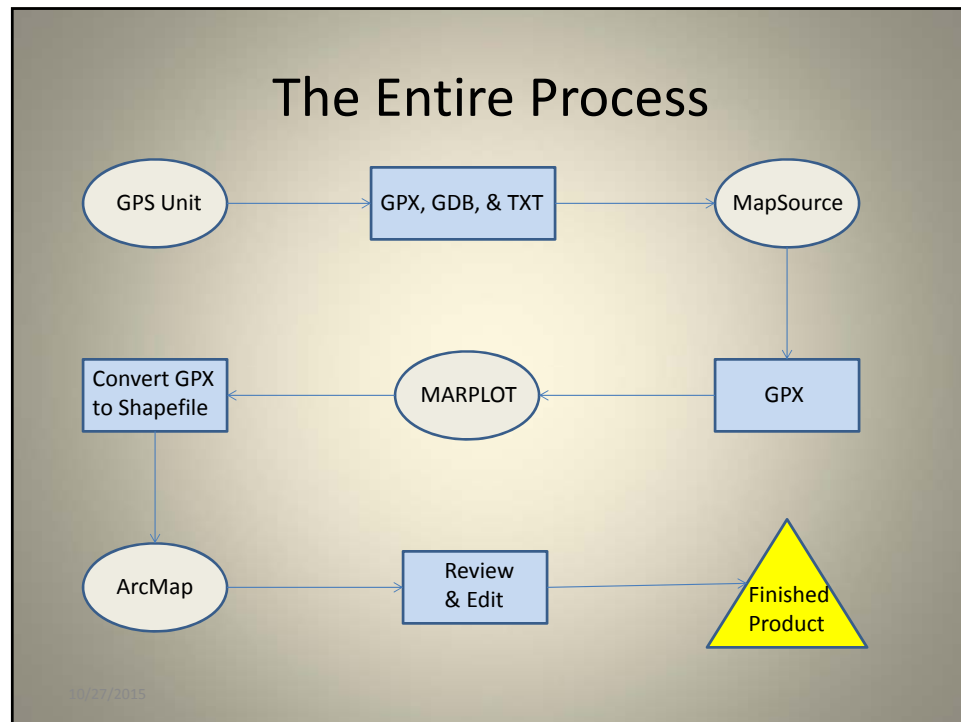
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Visual Example of a Compilation of Overflights

*Overflight map captured during the Refugio Pipeline Incident in Santa Barbara, CA – May 2015



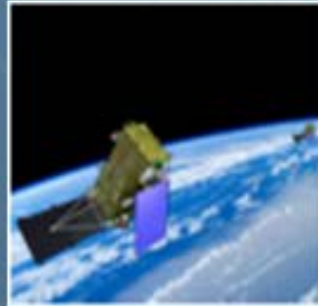
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COMET Overflight Class

- https://www.meted.ucar.edu/training_module.php?id=1044#.ViFgwf7ruUk

10/27/2015



INFORMATION SYSTEMS

Oil Observing Tools: Spaceborne Radar

David Gionet and Gordon Staples

www.mdacorporation.com

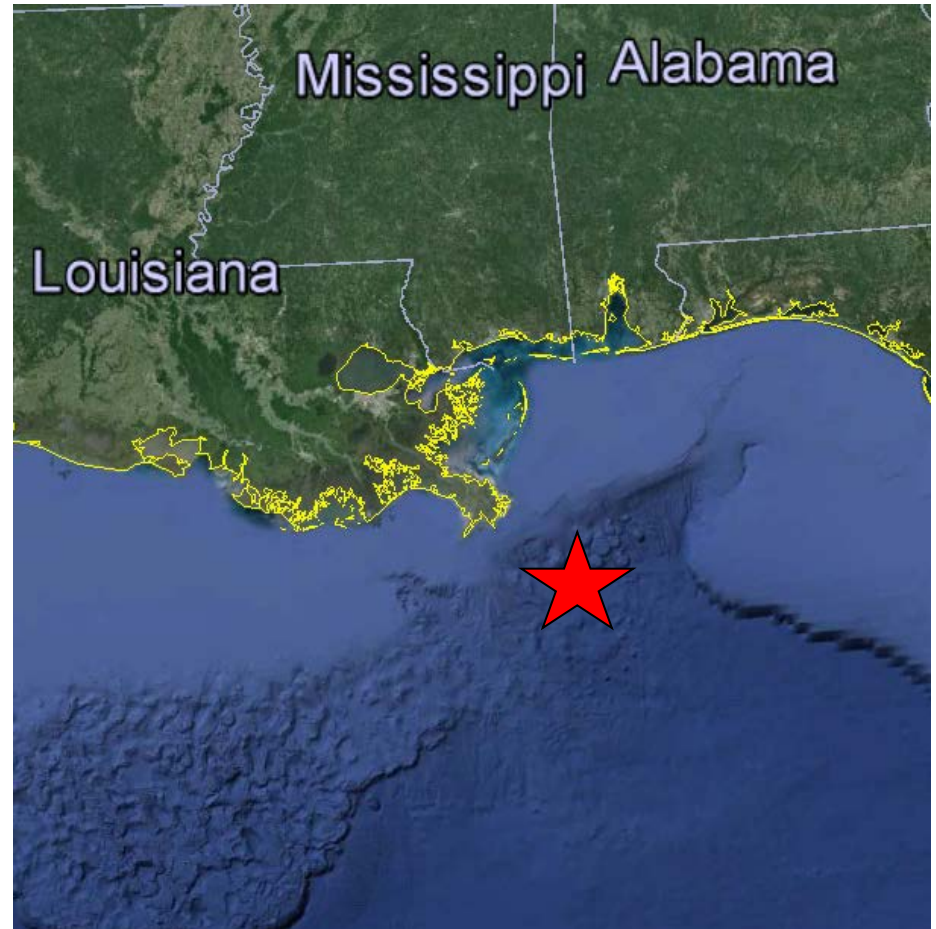
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Oil Spill Scenario

- An oil spill has been reported in the Gulf of Mexico on Tuesday Oct 20 at 2 PM local time.
- The spill was reported at $\sim 89^{\circ}$ W and 28° N



Spill Reported (Spill + 0 hours)

- You call the MDA On Call Acquisition Planner (OCAP) who is available 24/7.
- The OCAP needs to know:
 - Location
 - Approximate size
 - Preferred RADARSAT-2 imaging mode (optional)
- The OCAP starts the acquisition planning process

Acquisition Plan: Downlink Options



There are three options for direct downlink: Gatineau, Miami, Prince Albert

Acquisition Plan: Image Acquisition

- Due to the size of the spill, ScanSAR Narrow (50 m res and 300 km swath width) is selected)
- RADARSAT-2 modes are limited in the E-W direction by the swath width (300 km in this case), but not in the N-S → larger area to account for spill drift
- Acquisition date and times
 - Oct 21 12:00:22 UTC (~ 6 AM local time)
 - Oct 23 23:54:24 UTC (~ 6 PM local time)
- Note that there was an acquisition at ~ 6 PM local time on Oct 20:
 - On the cusp of the 12-hour cutoff
 - Acquisition possible if routine monitoring was in place.

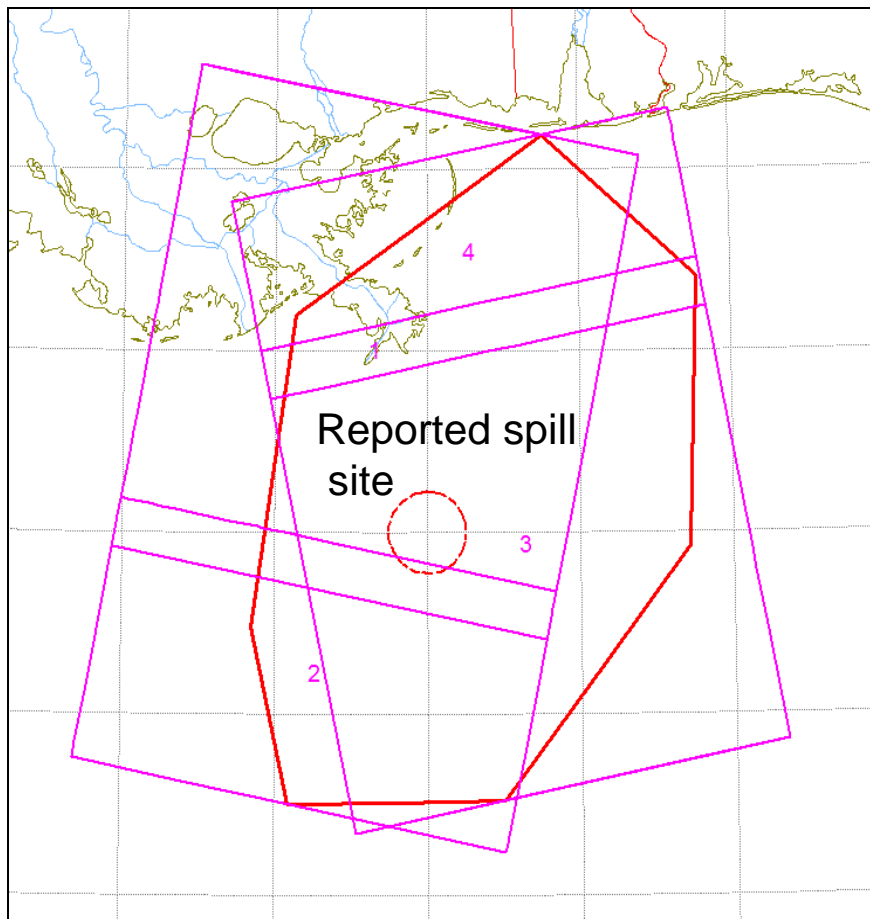


Image Acquisition (Spill + 16 hours)

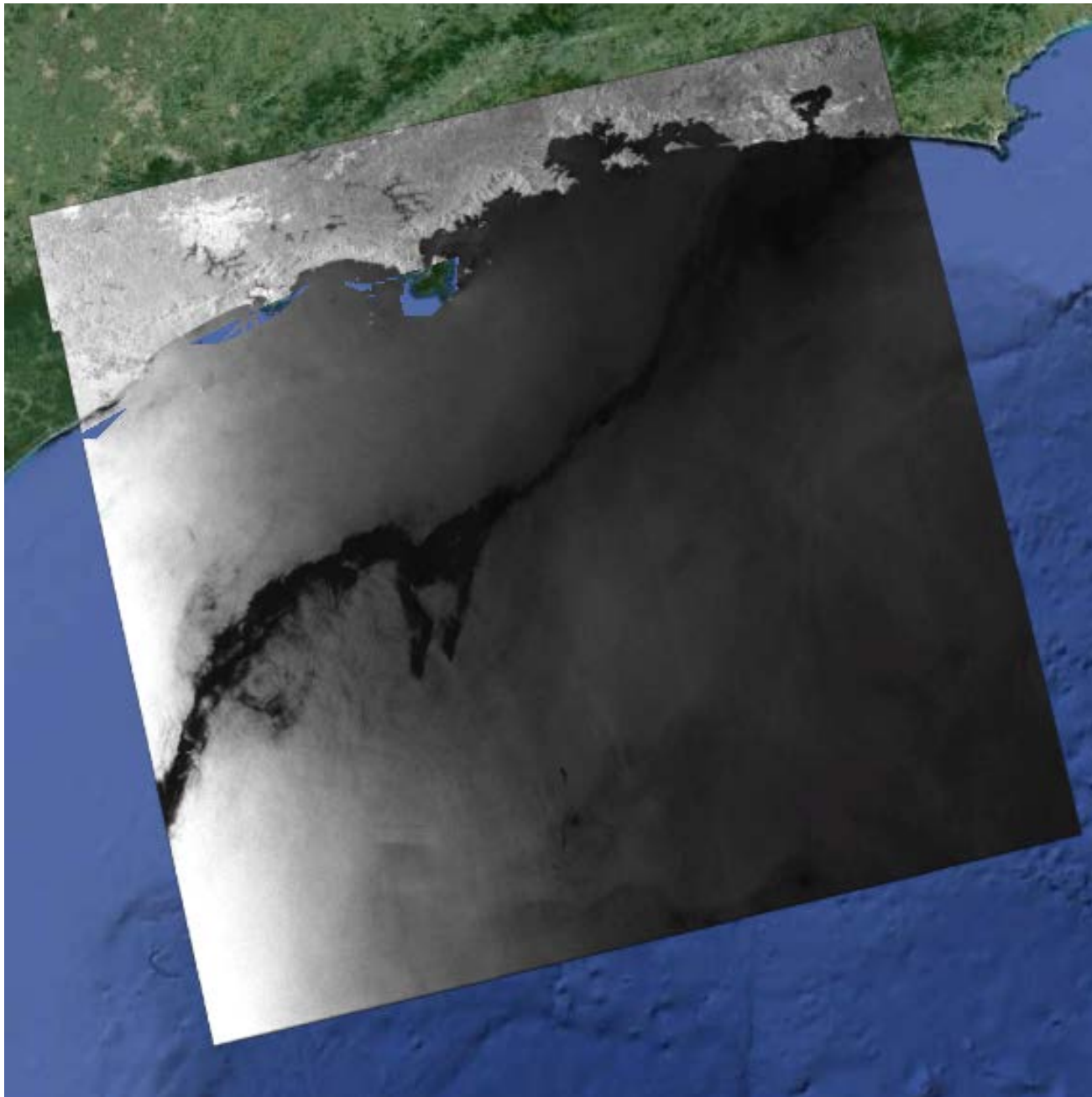
- The image acquisition is planned for Oct 21 at 12:00:24 UTC with downlink to Gatineau

- The following products and delivery options were requested:
 - Oil spill outline in kml → via email
 - OilTracker report in pdf → via email
 - Processed SAR data → via ftp

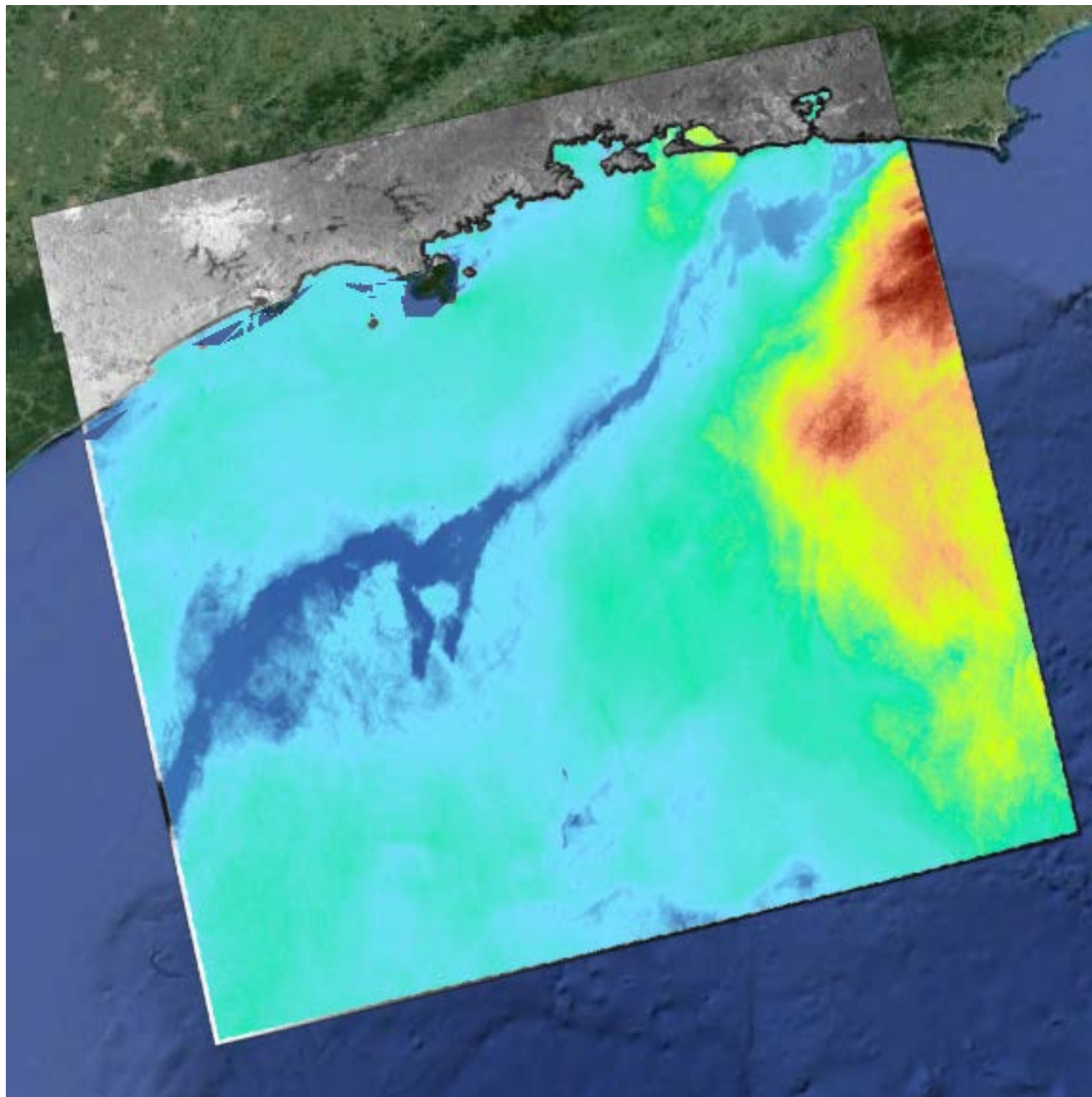
Delivery of Data and Oil Spill Report (Spill + 18 hours)

- The data are downlinked to Gatineau and processed.
- The image is analyzed:
 - Probable oil slick is delineated
 - False-positives (if detected) are delineated
 - Wind speed is extracted from the image to aid with the image analysis
- The oil spill report is sent via email and the processed data placed on a ftp site.

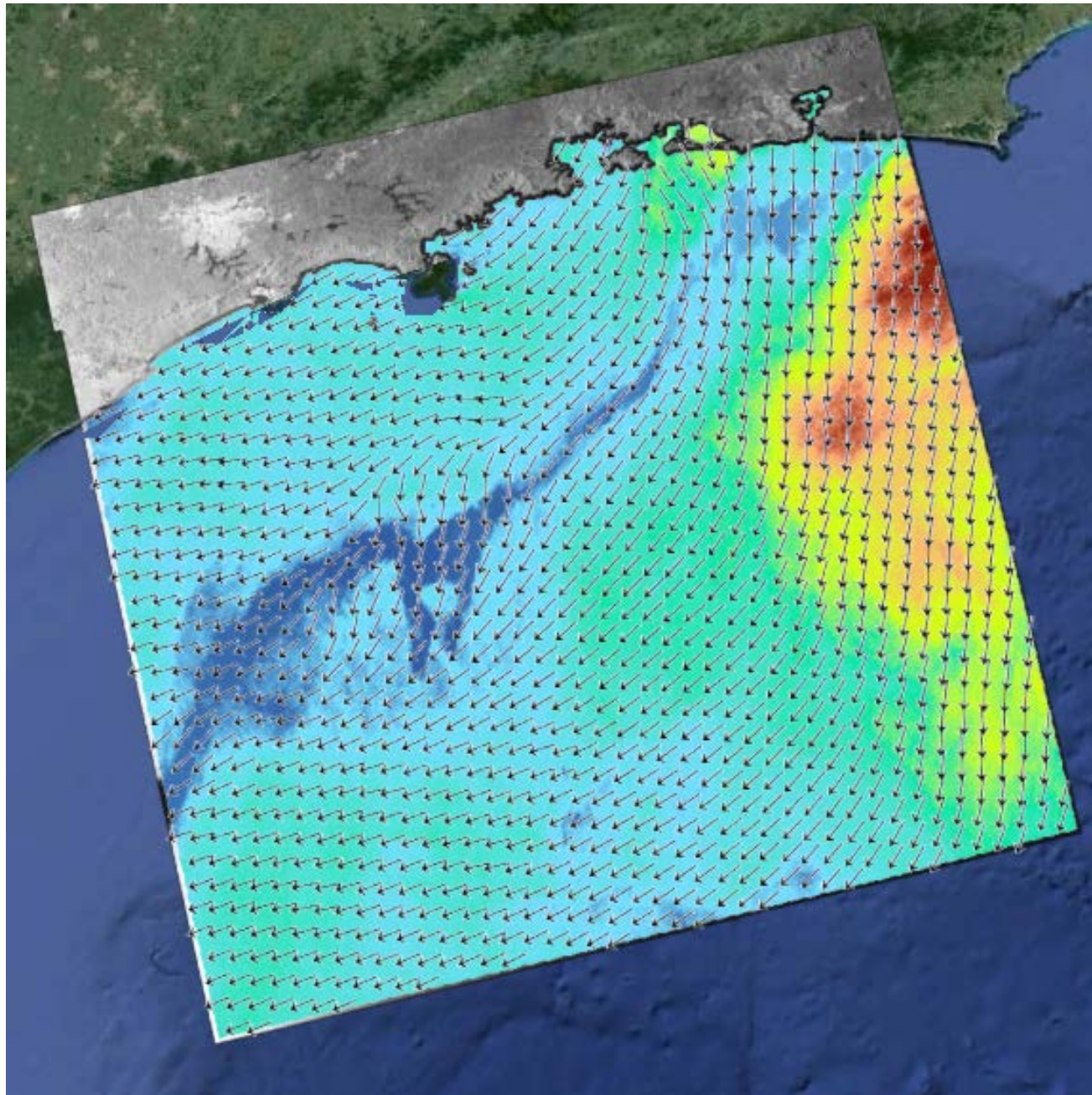
Example of Oil Spill Products



RADARSAT-2
ScanSAR image

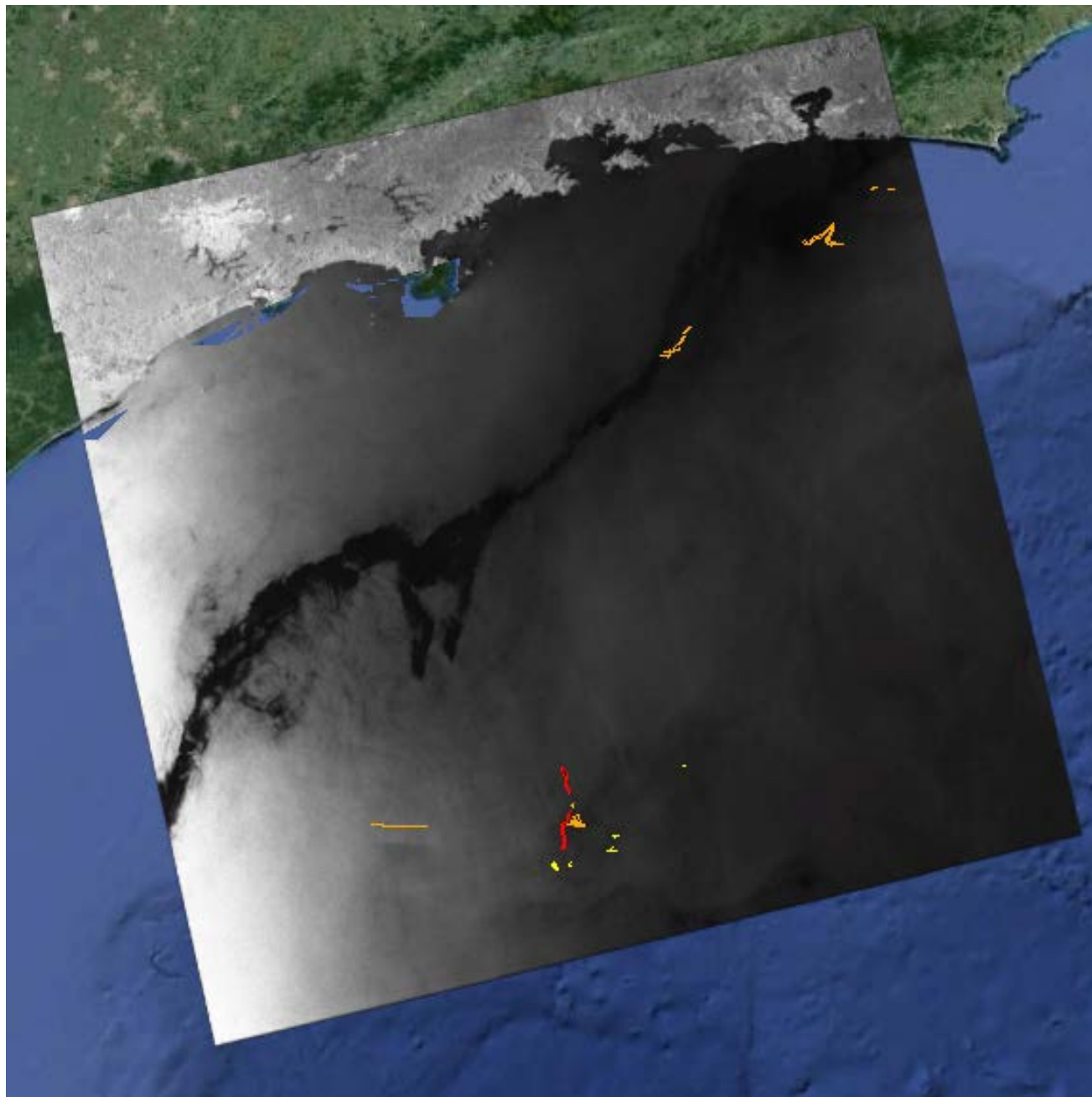


Wind Speed



Wind Speed

Wind Direction

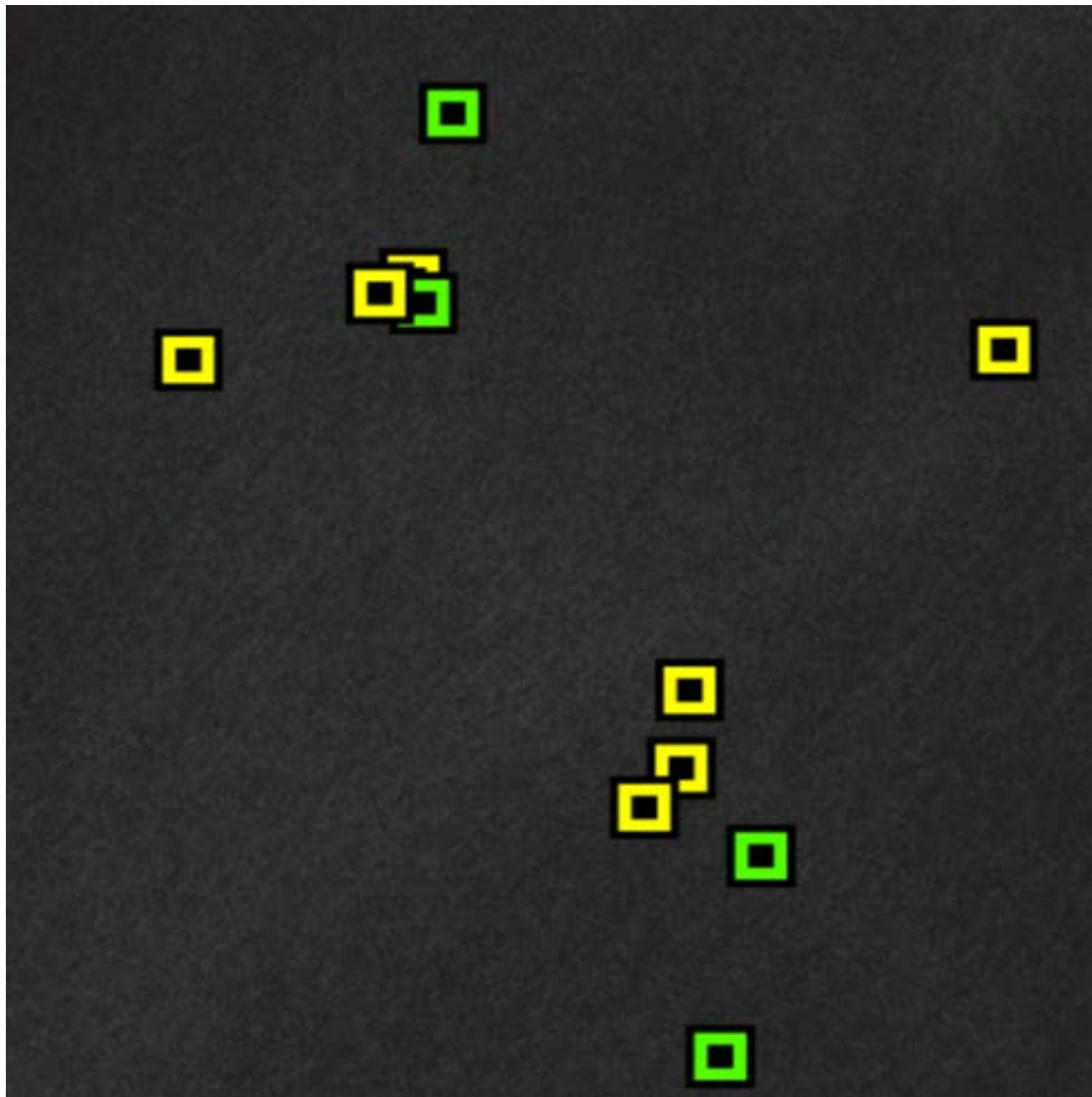


Slicks

- Seeps
- Pollution



Ships/Other



Ships/Other

- AIS correlated
- Non-AIS correlated

Summary and Comments

- The practical minimum time from the initial request to acquisition is 12 hours. Note that 4 hours is possible, but only for events defined by the Mission Planning Team (e.g. national security, humanitarian).
- The acquisition was planned using RADARSAT-2 data, but data from other SAR sensors, e.g. TerraSAR-X and COSMO SkyMed, can be acquired.
- The acquisition of the “next available” image was based on there not being a conflict with another planned acquisition. Conflicts can be mitigated by:
 - Asking for favours
 - Acquisitions that have been preplanned for areas of possible oil spills, e.g. shipping convergence zones, areas of intense oil&gas activities
- Once the spill site has been identified, the deterministic nature of satellite orbits means that acquisition date/time and the downlink date/time are known.
- The only variables are the image analysis time (depends on scene complexity) and data delivery (depend on internet bandwidth), but these are typically < 2 hours.

Image Credits and Disclaimer Language

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TRACS A-B-C Acquisition and Processing and LandSat TM Processing

Mark Hess, Ocean Imaging Corp.

Kevin Hoskins, Marine Spill Response Corp.



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TRACS: Level A



AIRCRAFT
Ocean Imaging
Corporation

**Multispectral/TIR
Cameras (i.e. TRACS)**



Provides wide-area spill
detection, thickness
interpretation, and oil
distribution mapping

Acquisition Considerations:

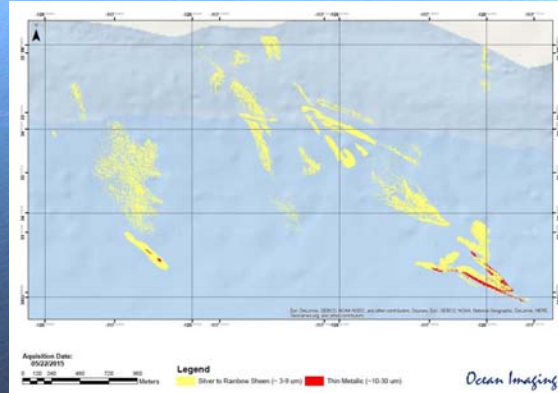
- Aircraft to be used, port hole, power requirements, etc.
- Preplanned flight path or 'scouting' mode?
- Frame overlap, flight line overlap
- Altitude = horizontal spatial resolution or ground sampling distance (GSD)
- Season and time of day – overflights around solar noon result in sun glint contamination (in RGB imagery only)
- Direction of flight lines (avoiding sun glint)
- Amount of data collected
 - What is intended purpose of acquired data?
 - Available 'pipe' size (Internet throughput capability) to offload/upload data for additional processing



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TRACS: Level A – Near Real-Time Oil Classification Maps

Acquire
RGB & TIR
imagery



Transfer raw data to OI office for additional processing and oil classification – make available for COP such as ERMA



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MSRC Level B & C Remote Sensing for Tactical Oil Spill Surveillance

B

BALLOON
Maritime Robotics

**TIR & HD
Cameras**



Tethered up to 500 ft.
Medium range coverage
with long "hang" time

C

CLOSE-IN

**X Band Radar & TIR
Camera**



Optimizes close-in
recovery techniques



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MSRC Level B - BALLOON

Maritime Robotics Aerostat

Battery powered, non-wired tether

- Up to 12-hour “hang time”
- Rechargeable battery

Package includes:

- HD Camera
- TIR Camera
- AIS Repeater

Small, compact easily transportable package

Proprietary viewing software and gimbal

WIFI transfer to host vessel



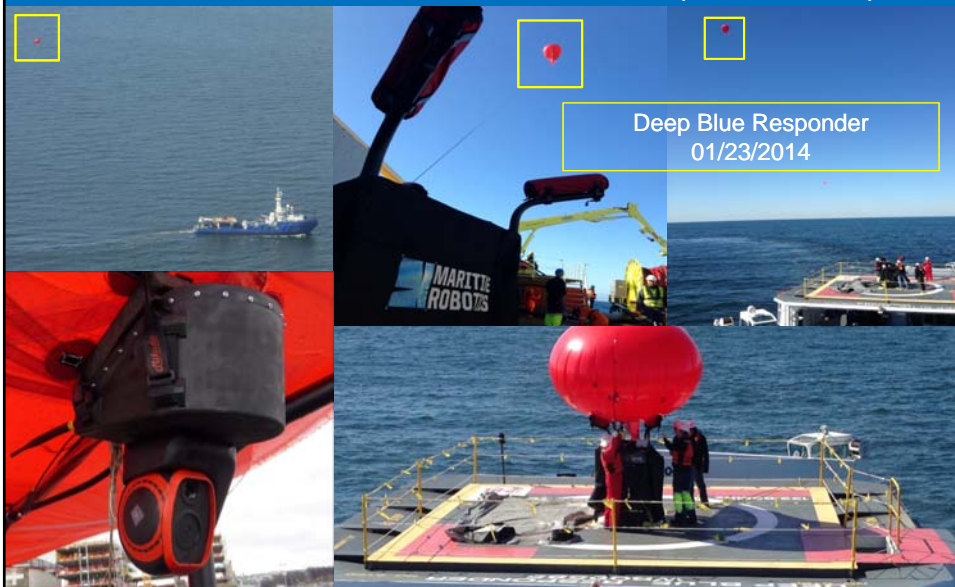
NOFO: Oil On Water 2012



All Materials ©2015

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MSRC Level B – BALLOONS (Aerostats)

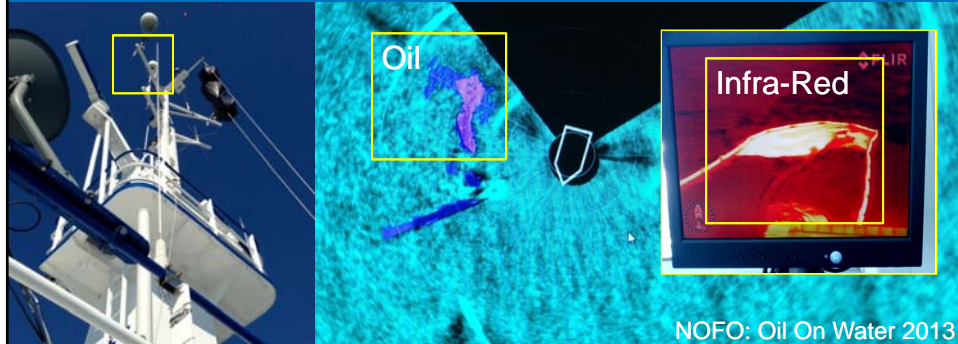


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MSRC Level C – CLOSE IN

OSRV-Mounted Systems for Tactical Optimization



X Band Radar and Thermal Infrared (TIR) on Responder Class Vessels

- Oil detection (X Band Radar)
- Better view of oil
- Stack oil vs. entrainment

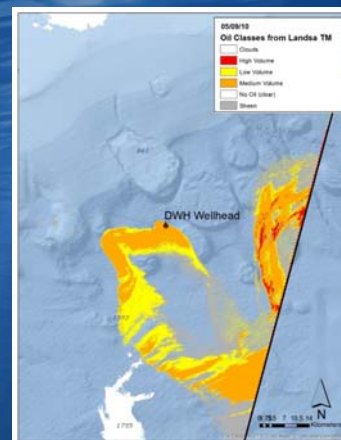


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Landsat TM – Classification Methodology Brief

As part of DWH NRDA work, eight TM scenes or two-scene mosaics acquired between 04/25/10 – 07/28/10 were classified into volume per surface area classes

Classifications were used to help determine the amount of oil on the ocean's surface during the DWH incident.

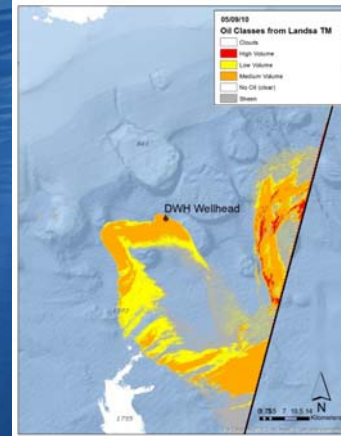


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Landsat TM – Classification Methodology Brief

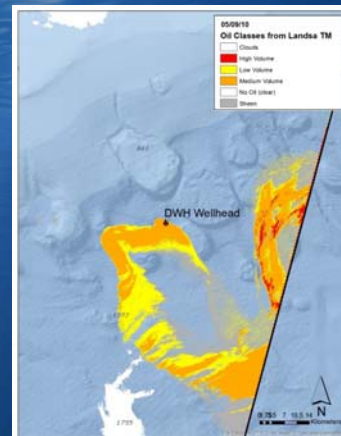
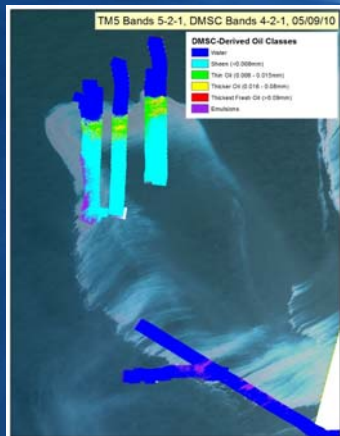
Found that in the DWH TM imagery there was a significant amount of oil thickness/type heterogeneity within each 27m pixel. Therefore, the reflectance profile of each pixel is related to the amount of surface area covered by the major oil features present.

Classification of TM imagery requires some type of higher resolution (preferably calibrated) data set to use for creation of training set used in a supervised classification such as 'maximum likelihood'.



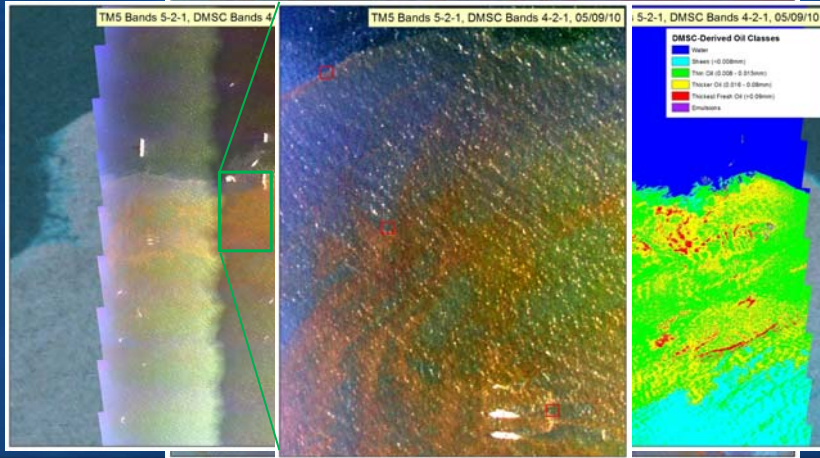
Landsat TM – Classification Methodology Brief

Used 4 meter multispectral imagery from DMSC sensor & aerial photographs to help train classification routines and guide relative calibration of TM data



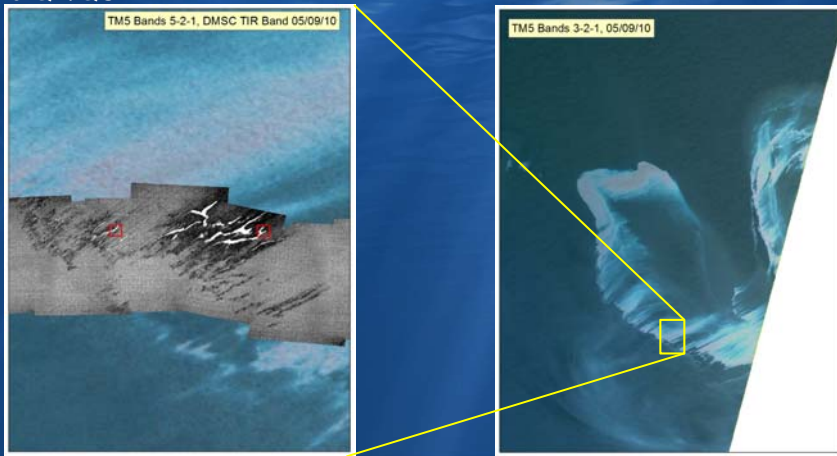
Landsat TM – Classification Methodology Brief

2.4 meter WorldView-2 satellite and 4 meter DMSC aerial imagery show the level of heterogeneity within the 23 meter TM pixel size



Landsat TM – Classification Methodology Brief

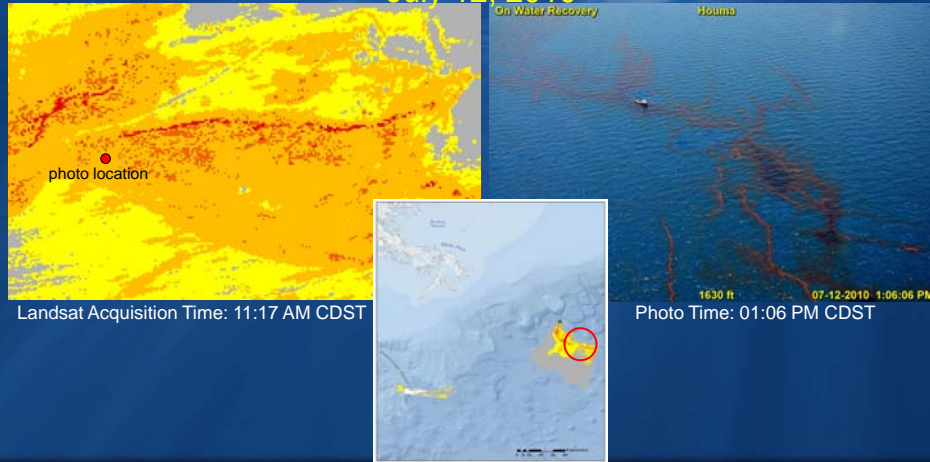
4 Meter TIR imagery & high resolution photographs also show the level of heterogeneity within the 23 m TM pixel size as well as used for training sets and QA/QC



Landsat TM – Classification Methodology Brief

4 Meter TIR imagery & high resolution photographs also show the level of heterogeneity within the 23 m TM pixel size as well as used for training sets and QA/QC

July 12, 2010



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Landsat TM – Classification Methodology Brief

Ocean Imaging Landsat TM Classification Processing Steps

- 1) Mosaic TM image path/row scenes if available
- 2) Use high resolution DMSC and TIR imagery along with high resolution photographs to create classification training sets
 - Use different thickness/type 'markers' seen in multispectral and TIR imagery (eg. thermal cooler than water cut-off and hotter than both water and oil transition, also bright orange reflectance of highly emulsified and weathered oil)
 - "Hot" to "cool" thermal cut-off corresponded well with thickest oil → higher volume per area
 - Subdivide the TM signal containing thick 'fresher' and emulsified oil patches into two classes based on multispectral reflectance intensity, with the higher reflecting class likely representing a greater portion of the sea surface covered by dense emulsion patches (versus thinner oil and sheen-covered water areas).



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Ocean Imaging

Landsat TM – Classification Methodology Brief

- **Sheen:** Invisible in thermal IR aerial, invisible or elevated reflectance in blue band of aerial and TM. IF included in TM classification, sheen derived from SAR-based total oiling footprint outlines derived by TCNNA analysis derived by Oscar Garcia
- **Low Volume:** Invisible in thermal aerial but detectable in aerial and TM multiple visible bands. Low reflectance in near-IR.
- **Mid-Volume:** Can contain both unemulsified and emulsified oil features covering an average of 10% surface area in each TM pixel. Visible in thermal IR aerial as negative contrast to surrounding water. Elevated reflectances in TM's longer visible and near-IR wavelengths.
- **High-Volume:** Can contain both unemulsified and emulsified oil features covering an average of 20% surface area in each TM pixel. Visible in thermal IR aerial as mostly negative and sometimes sparse positive contrast to surrounding water. Elevated reflectances in TM's longer visible and near-IR wavelengths are significantly higher than for the mid-volume class.
- **Super High Volume:** Elongated features showing very high values in TM Band7 – Band1 difference. Often emulsified and significantly weathered strands of oil showing a bright orange-red reflectance in visible bands



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Ocean Imaging

Landsat TM – Classification Methodology Brief

Ocean Imaging Landsat TM Classification Processing Steps

- 3) Run supervised classification (eg Maximum likelihood) routine to classify TM mosaic (all 7 TM bands used as input to the classification)
- 4) Edit classes using DMSC and TIR imagery along with high resolution photographs for QC/QA

.....3.5) In a few cases using an unsupervised classification method (i.e. ISOdata), starting with many classes and using the DMSC, TIR & photographic data to pare down the classes worked better than supervised method.



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Ocean Imaging

THANK YOU!

Corresponding Author e-mails:

mhess@oceani.com

hoskins@msrc.org

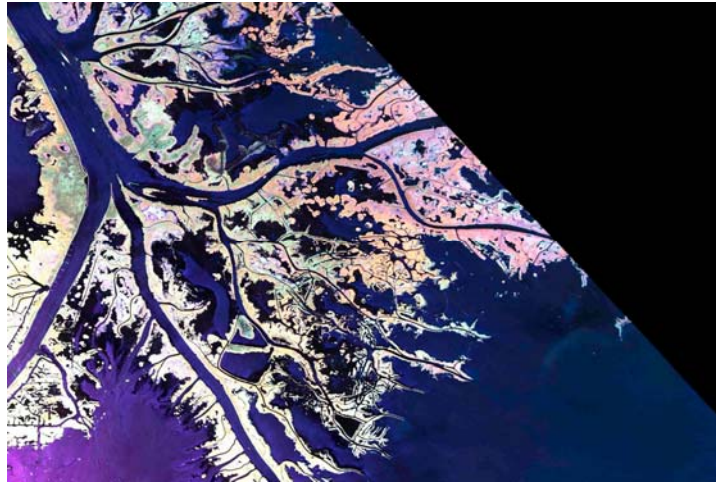
Company Web Sites:

www.oceani.com

www.msrc.org



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NASA Out-Year Planning

Oct. 20-22, 2015

Oil Observing Tool Workshop

1

UAVSAR

UAVSAR Platform, Gulfstream-III



Antenna can be changed to a different band and still use the common electronics back end:



- ❖ UAVSAR is an L-band Synthetic Aperture Radar (SAR) developed by NASA to support **repeat-pass radar interferometry** and to also serve as a **radar technology test bed** for future space-borne imaging radar missions.
- ❖ Instrument in the non-pressurized pod is compact, modular, and adaptable to support multiple airborne platforms and frequency upgrades.



Technology

2 complete L-band radars; electronically steered antennas compensate for winds ; G-III precision auto-pilot, 1 m x 1.7 m resolution

Science

L-band repeat-pass InSAR for surface deformation, vegetation structure, soil moisture mapping, land use classification, cryospheric studies, and archaeological research

2

EFFECT OF SURFACE LAYER OF OIL ON RADAR BACKSCATTER FROM WATER

Oil damps the small-scale capillary and gravity-capillary waves on the ocean surface mainly through a reduction in the surface tension at the gas-liquid interface.

Dispersion relationship for waves at the interface between air and a liquid of density ρ with surface tension σ :

$$\rho_{oil}/\rho_{water} \approx 0.8 - 0.9$$

$$\sigma_{oil}/\sigma_{water} \approx 0.25 - 0.5$$

$\omega^2 = gk + (\sigma/\rho)k^3$ gravity is the restoring force

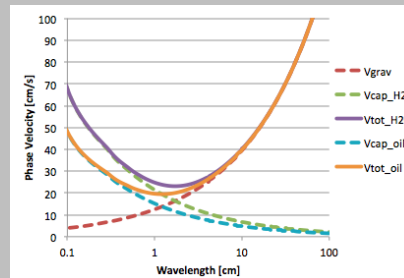
surface tension and inertia are the restoring forces

$$v_{phase} = \sqrt{\frac{g}{k} + \frac{\sigma}{\rho}k}$$

for a given velocity, k increases when the surface tension decreases

Ocean waves are excited by resonant forcing in a turbulent wind field. The wavelength of capillary waves resonantly excited in the presence of oil is smaller than for a clean water-air interface, hence the damping of the smaller wavelengths. This affects the roughness scale of the water surface. In a real slick, the surface characteristics will vary between pure H₂O and pure oil, depending upon layer thickness, oil type, and areal coverage.

Also, in viscoelastic fluids gravity waves with short wavelength are damped by restoring forces arising from gradients in the surface tension (Marangoni effect).



Oil Observing Tool Workshop

3

BRAGG SCATTERING THEORY

WAVE FACET MODEL

Radar backscatter from the ocean surface is dominated by scattering from small scale capillary and gravity-capillary waves that roughen the surface. In Bragg scattering theory, the dominant mechanism is resonant backscatter from surface waves of wave number k_{Bragg} where

$$k_{Bragg} = 2k \sin(\theta_{inc})$$

$$k = \frac{2\pi}{\lambda_{radar}}$$

As the incidence angle increases, the wavelength of the Bragg surface wave decreases to a minimum of $\lambda_{radar}/2$ at grazing angles.

L-band ($\lambda_{radar}=23.8$ cm) : $\lambda_{Bragg} = 23.8$ cm (30°), 13.7 cm (60°)

$$\sigma_{HH} = 4\pi k^4 \cos^4(\theta_i) W(2k \sin(\theta + \psi), 2k \cos(\theta + \psi) \sin \beta) \left[\left(\frac{\sin(\theta + \psi) \cos \beta}{\sin \theta_i} \right)^2 R_{HH} + \left(\frac{\sin \beta}{\sin \theta_i} \right)^2 R_{VV} \right]^2$$

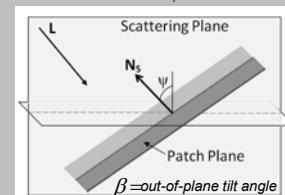
Ocean wave spectral density at Bragg wavelength

$$\sigma_{VV} = 4\pi k^4 \cos^4(\theta_i) W(2k \sin(\theta + \psi), 2k \cos(\theta + \psi) \sin \beta) \left[\left(\frac{\sin(\theta + \psi) \cos \beta}{\sin \theta_i} \right)^2 R_{VV} + \left(\frac{\sin \beta}{\sin \theta_i} \right)^2 R_{HH} \right]^2$$

$$\sigma_{HV} = 4\pi k^4 \cos^4(\theta_i) W(2k \sin(\theta + \psi), 2k \cos(\theta + \psi) \sin \beta) |R_{VV} - R_{HH}|^2$$

$$\theta_i = \cos^{-1}[\cos(\theta + \psi) \cos(\beta)]$$

$$R_{vv} = \frac{(\epsilon_r - 1)(\epsilon_r(1 + \sin^2(\theta)) - \sin^2(\theta_i))}{(\epsilon_r \cos(\theta_i) + \sqrt{\epsilon_r - \sin^2(\theta_i)})^2} \quad R_{uu} = \frac{\epsilon_r - 1}{(\cos(\theta_i) + \sqrt{\epsilon_r - \sin^2(\theta_i)})^2}$$



Oil Observing Tool Workshop

4

Cathleen Jones / Benjamin Holt (JPL)

POLARIMETRIC DECOMPOSITION

ENTROPY/ANISOTROPY/ALPHA

The Scattering Matrix relates the incident and scattered electric field vectors:

$$\begin{pmatrix} E_H \\ E_V \end{pmatrix}_{\text{scattered}} = \begin{pmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{pmatrix} \begin{pmatrix} E_H \\ E_V \end{pmatrix}_{\text{incident}}$$

The scattering matrix is expressed in the Pauli basis as

$$\begin{pmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{pmatrix} \xrightarrow{\text{Pauli}} k = \frac{1}{\sqrt{2}} \begin{bmatrix} S_{HH} + S_{VV} & S_{HH} - S_{VV} & 2S_{HV} \end{bmatrix}^T$$

Diagonalization of the coherency matrix $T = kk^*$ gives 3 eigenvalues, λ , and eigenvectors, u . Those define the scattering mechanisms and their backscattered power.

The Cloude-Pottier polarimetric decomposition yields 4 variables derived from the eigenvalues and eigenvectors:

$$\text{Entropy: } H = \sum_{i=1}^3 \left(\frac{\lambda_i}{\lambda_1 + \lambda_2 + \lambda_3} \right) \log_3 \left(\frac{\lambda_i}{\lambda_1 + \lambda_2 + \lambda_3} \right) \quad 0 \leq H \leq 1$$

$$\text{Anisotropy: } A = \frac{\lambda_2 - \lambda_3}{\lambda_2 + \lambda_3} \quad 0 \leq A \leq 1$$

$$\text{Mean angle: } \bar{\alpha}(u)$$

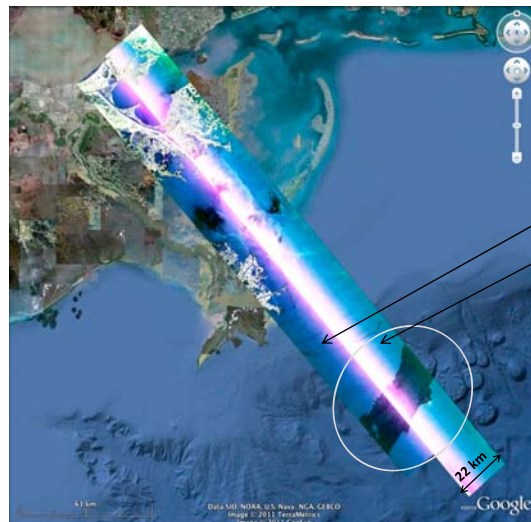
$$\text{Averaged intensity: } \Lambda = \sum_{i=1}^3 \left(\frac{\lambda_i^2}{\lambda_1 + \lambda_2 + \lambda_3} \right)$$

Oil Observing Tool Workshop

5

UAVSAR FLIGHT LINES

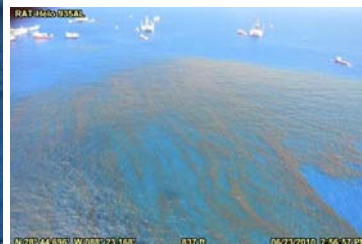
THE MAIN SLICK OF THE DEEPWATER HORIZON SPILL



Two UAVSAR lines viewing the main slick from opposite directions were used in our analysis of the polarimetric response of the oil from the DWH spill.

gulfco_32010_10054_101_100623
collected 23-June-2010 21:08 UTC

gulfco_14010_10054_100_100623
collected 23-June-2010 20:42 UTC



Sea state: 1.0-1.3 m SWH
Wind: 2.5-5 m/s from 115°-126°

6

Oil Observing Tool Workshop

NASA's Oil Spill Remote Sensing Relevant Sensors Spaceborne

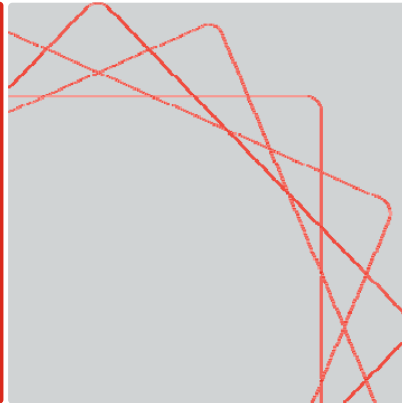
Instrument (Satellite)	Bands (# bands)	Band Range (nm)	Resolution (km)	Swath (km)	Revisit (days)	Rapid Response	Acronym
MODIS (Terra, Aqua)	Vis, MIR, TIR (36 bands)	405-14,385	0.25/0.5,1.0	2330	1-2	Yes	Moderate Resolution Imaging Spectroradiometer
ASTER (Terra)	VNIR, NIR, TIR (14 bands)	520-11,650	0.015/0.03/0.09	60	4-16	No	Advanced Spaceborne Thermal Emission and Reflection Radiometer
MISR (Terra)	Vis, NIR (4 Bands)	446.4-866.4	0.275-1.1	360	2-9	No	Multiangle Imaging SpectroRadiometer
HICO	Vis-NIR (90 bands)	400-1000	0.95	43	-	No	Hyperspectral Imager for the Coastal Ocean
CALIOP (CALIPSO)	Vis, NIR (2 bands)	532, 1064	0.1	-	16	No	Cloud Aerosol Lidar with Orthogonal Polarization (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation)

Table from: Leifer et al., in *Time Sensitive Remote Sensing*, Lippitt et al. (eds.), Springer, in press
Oil Observing Tool Workshop



Integrating Data from Multiple Sensors in the *Deepwater Horizon* Damage Assessment

Jamie Holmes
Abt Associates
October 21, 2015



NRDA Remote Sensing Group



- Convened after the spill
- Mission: use available data to quantify the extent of oil on water
 - Discern areas of thick oil vs. thin oil

Sensors



- Satellite
 - SAR
 - MODIS
 - Landsat Thematic Mapper (TM)
- Airborne
 - AVIRIS
 - Ocean Imaging DMSC

Abt Associates | pg 3

SAR



- Greatest sensor coverage
 - TerraSAR-X
 - Envisat
 - RADARSAT (-1 and -2)
 - COSMO-SkyMed (-1, -2, and -3)
 - ALOS (PALSAR)
 - ERS-2
- Coverage of northern GOM nearly every day



Abt Associates | pg 4

MODIS



- Advantages
 - High spatial and temporal coverage
 - Published methods for detecting oil
- Disadvantages
 - Clouds, sun glint, and wind limitations
 - Coarse resolution
 - Visible: 250 m
 - Thermal: 1,000 m

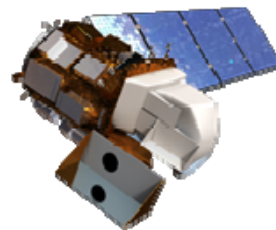


Abt Associates | pg 5

Landsat TM



- Advantages
 - Relatively high resolution (30 m)
- Disadvantages
 - Clouds, sun glint, and wind limitations
 - Temporal coverage
 - During DWH, one image every 8 days



Abt Associates | pg 6

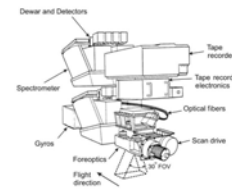
AVIRIS

Advantages

- High resolution (<10 m)
- Hyperspectral (>200 bands)

Disadvantages

- Clouds, sun glint, and wind limitations
- Spatial coverage
 - Relatively narrow flight lines
- Temporal coverage
 - USGS analyzed data from one day (May 17, 2010)



Abt Associates | pg 7

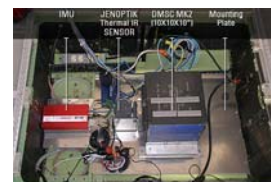
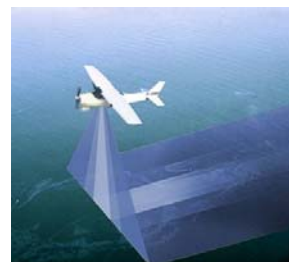
Ocean Imaging DMSC/TIR

Advantages

- High resolution (<10 m)
- Near-daily imagery
 - Part of response

Disadvantages

- Weather limitations
- Spatial coverage
 - Narrow targeted flight lines



Abt Associates | pg 8

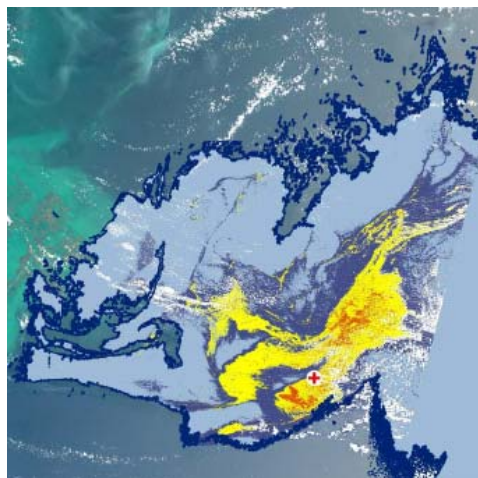
Data Analysis



- Inference from high resolution sensors
 - AVIRIS and DMSC could discern thick oil
 - Previously published methods
 - Use similar spectral relationships to infer presence of thick oil in coarse satellite data
- SAR analysis method for detecting emulsions

Abt Associates | pg 9

TM Output Based on DMSC

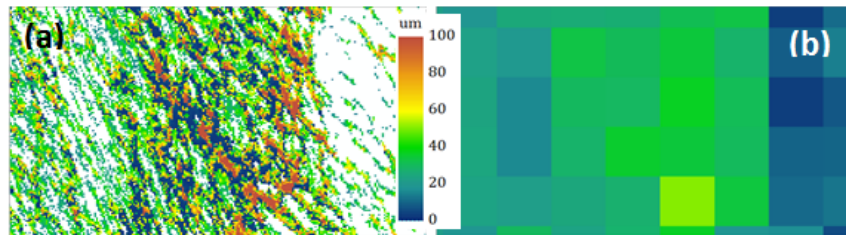


Abt Associates | pg 10

MODIS Visible from AVIRIS

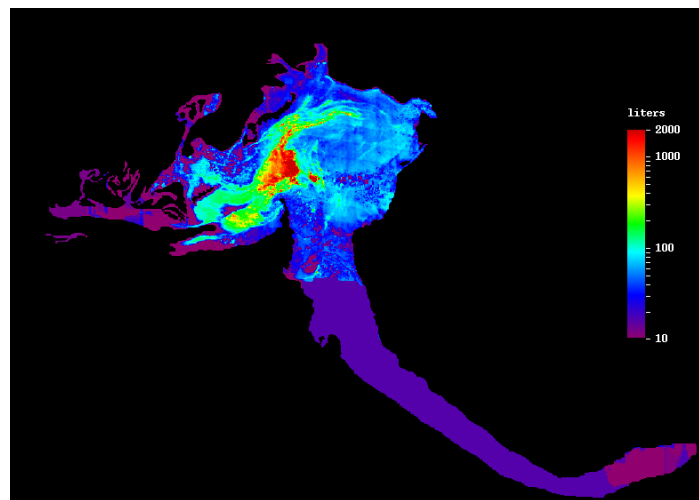


- MVIS: 250 m pixel
- AVIRIS: 7.6 m pixel
 - > 1,000 AVIRIS pixels in each MODIS pixel



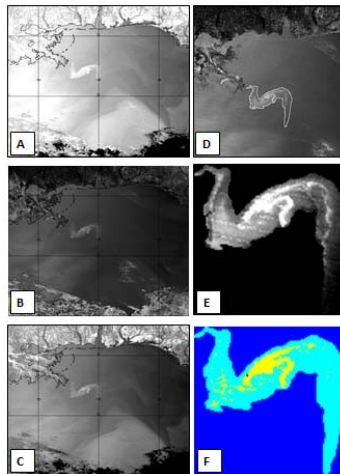
Abt Associates | pg 11

MVIS Output



Abt Associates | pg 12

MTIR Based on AVIRIS



Abt Associates | pg 13

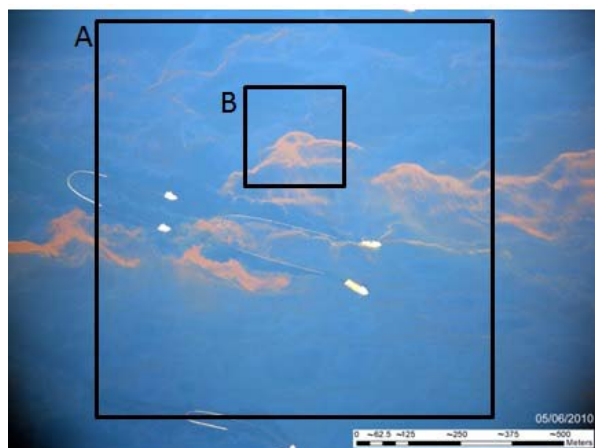
Multi-Sensor Integrated Model



- Integrates data from SAR, MVIS, MTIR, and TM
 - Single product using all available data
- Sensor data integrated into 5 km² equal area grid
- Rough thickness assessment
 - Identifies “thin” and “thicker than thin” oil
 - Very approximate quantitative (under)estimates

Abt Associates | pg 14

Subpixel Heterogeneity



Abt Associates | pg 15

May 17 Example



Abt Associates | pg 16

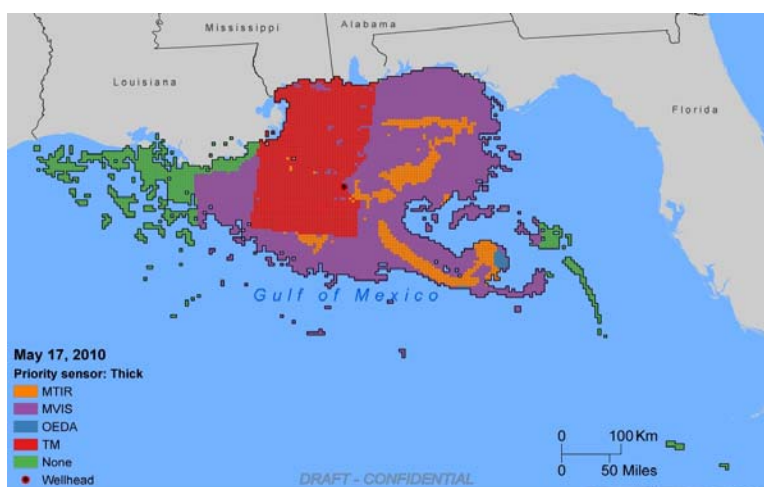
Area of Interest

- Cells where SAR saw oil at least once during spill



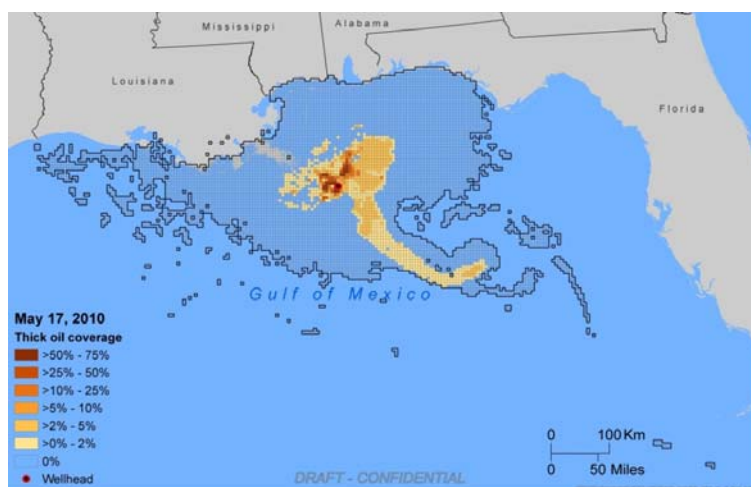
Abt Associates | pg 17

Sensor Coverage: Priority Thick



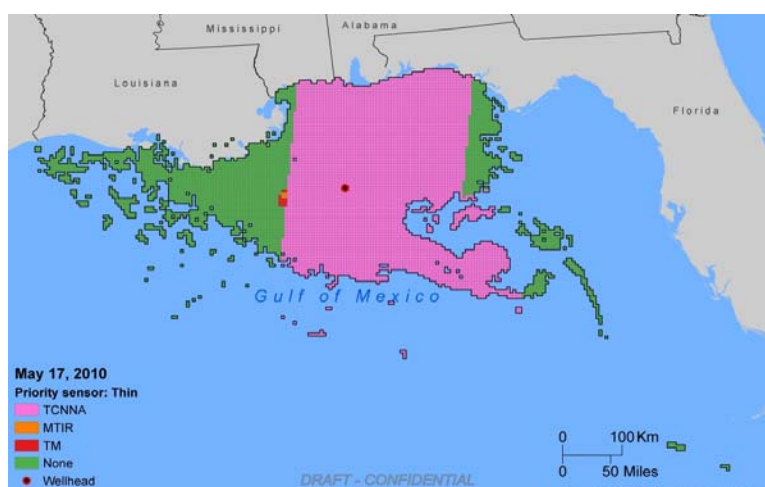
Abt Associates | pg 18

Model: Percent Thick Oil



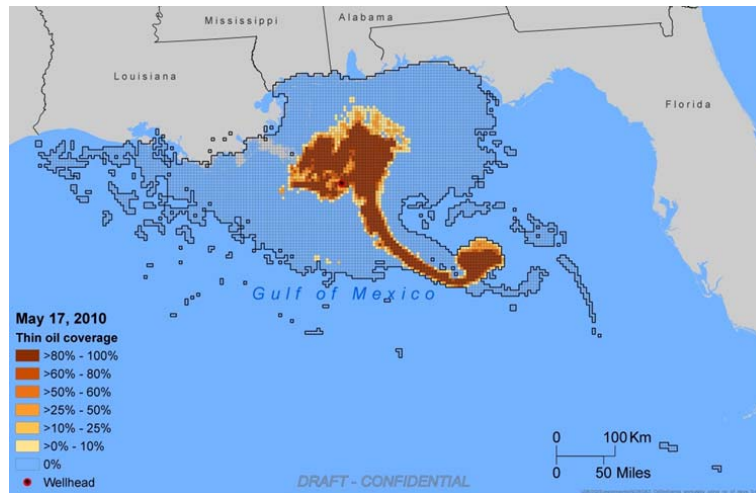
Abt Associates | pg 19

Sensor Coverage: Priority Thin



Abt Associates | pg 20

Model: Percent Thin Oil



Abt Associates | pg 21

Moving Forward

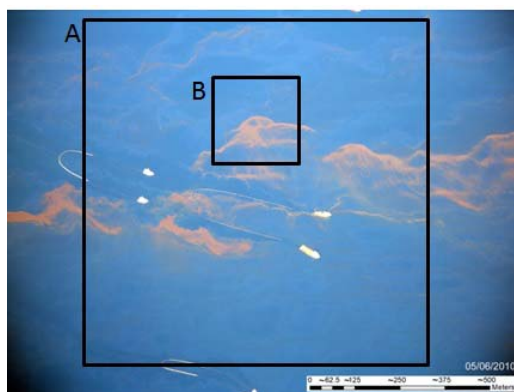
- Collect additional data during a spill
 - DWH NRDA remote sensing analyses started after the spill
 - Relied on weight-of-evidence
 - Little data for ground truthing
 - No planned synoptic sampling

Abt Associates | pg 22

Moving Forward



- Challenge of using remote sensing data to estimate adverse impacts on critters

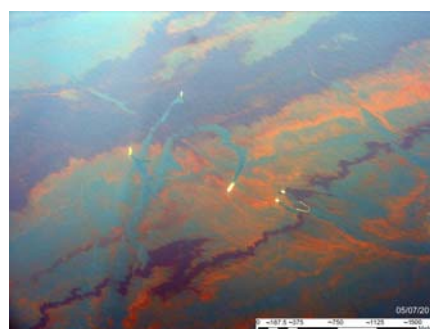
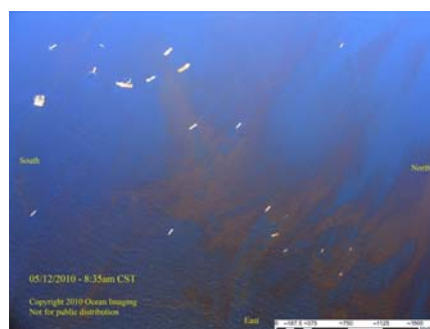


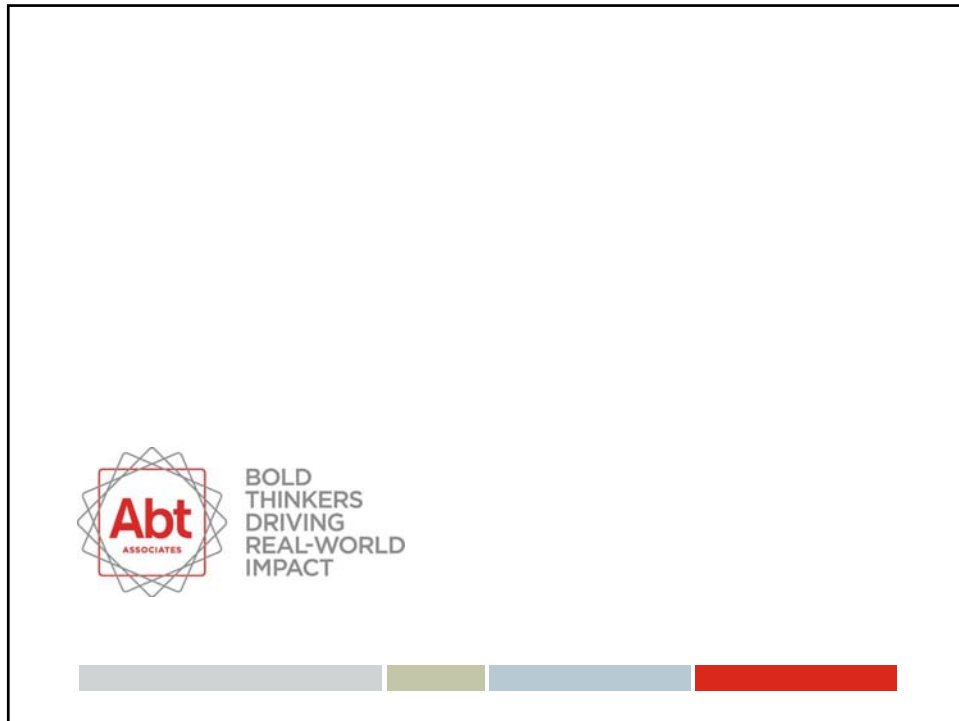
Abt Associates | pg 23



Questions?

Jamie Holmes
Abt Associates
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The Application of Synthetic Aperture Radar (SAR) to Natural Resource Damage Assessment



George Graettinger

NOAA's Ocean Service, Office of Response & Restoration

Oil Observing Tools Training & Workshop

Disaster Response Center, Mobile, AL

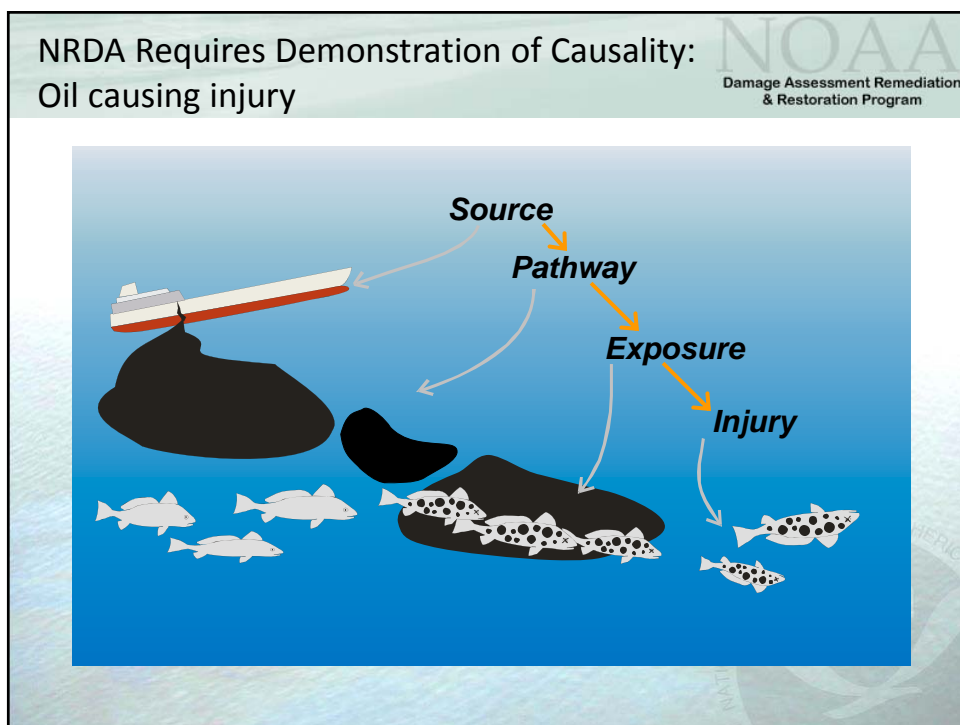
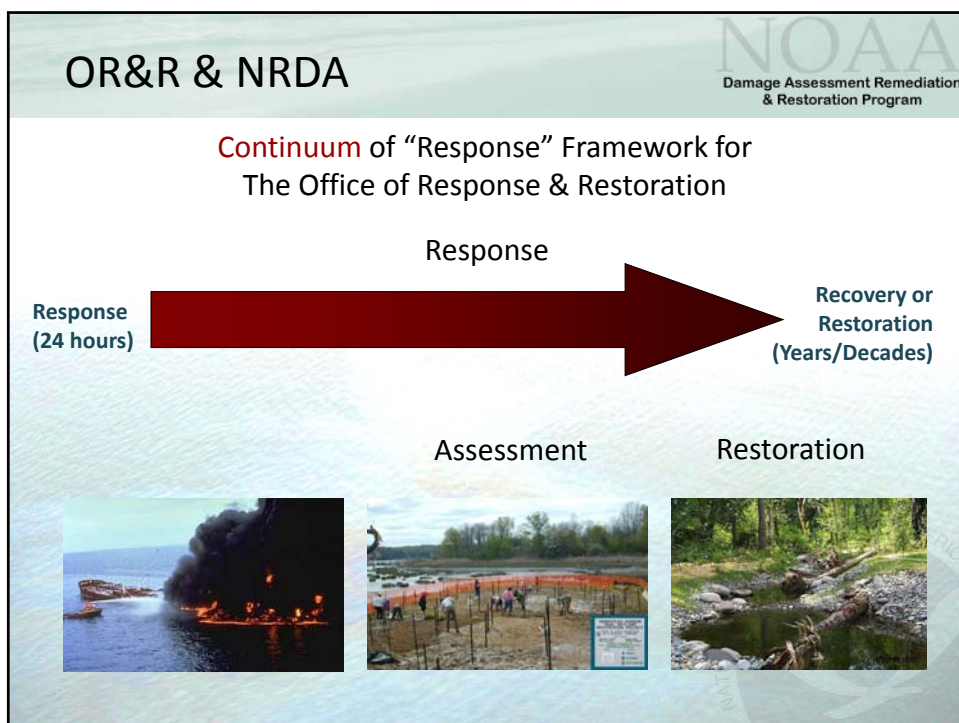
October 21st, 2015

Overview: NRDA and SAR

NOAA
Damage Assessment Remediation
& Restoration Program

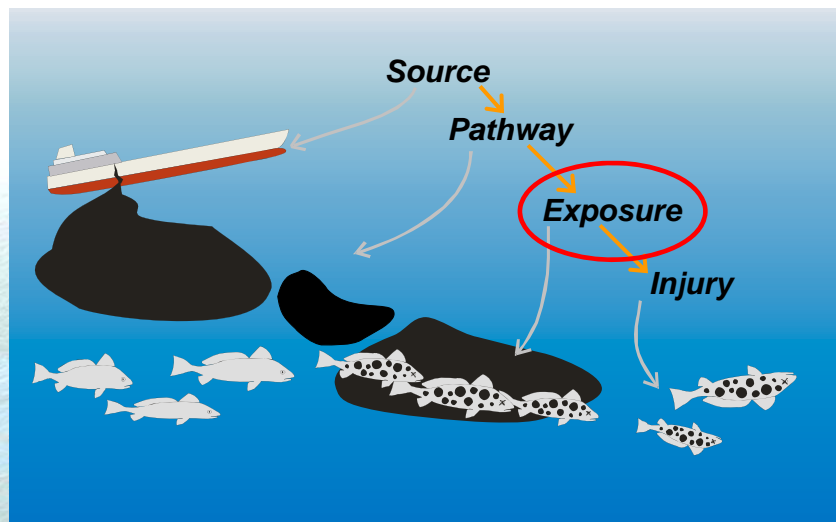
- OR&R and NRDA
- SAR and TCNNA Processing
- SAR Products
 - Cumulative Composite
 - Cumulative Days of Oiling
 - Shoreline Days of Oiling
 - Time of Oiling
- Summary/Conclusions





NRDA Requires Demonstration of Causality: Oil causing injury

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& Restoration Program



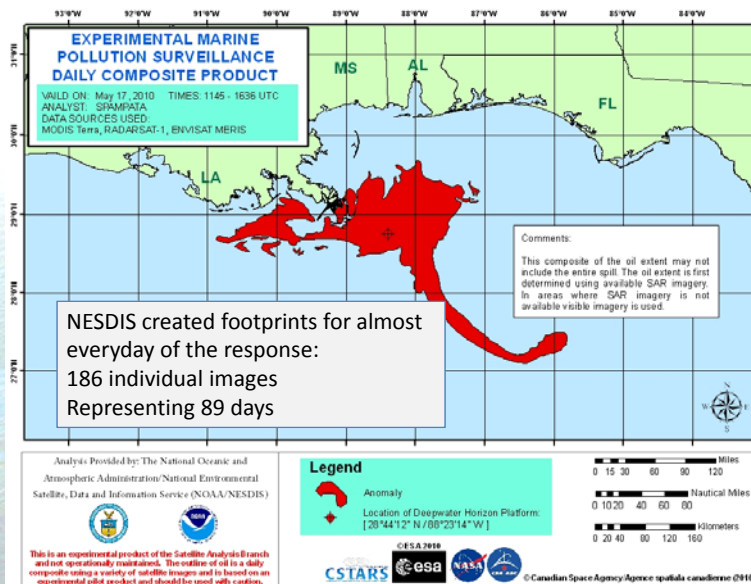
NRDA Exposure from SAR

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Damage Assessment Remediation
& Restoration Program

- Surface/Shoreline Oiling Extent
 - SAR data have been used for surface oil extent mapping for many years
 - Surface oiling extent supports injury determination for multiple natural resources (Larval life stages, mammals, sargassum, turtles, etc.)
 - SAR oiling features can add value to traditional assessment techniques and modeling (Operational search area, Trajectory model initialization, SCAT, pre/post oiling screening)

NOAA NESDIS Experimental MPSR – Anomaly Footprint

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& Restoration Program



SAR Oiling Extent Analysis

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& Restoration Program

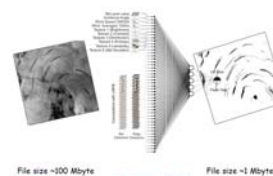
- SAR Anomaly Classification Methods
 - **NESDIS SAR analysis** (analyst specific, manual)
 - **TCNNA algorithm** (semi-automated)
- TCNNA (texture classifying neural network algorithm) developed jointly between NESDIS and FSU
- Methodology published in 2009

Can. J. Remote Sensing, Vol. 35, No. 5, pp. 411–421, 2009

Texture Classifying Neural Network Algorithm
Garcia et al. DSR-1 2010

Using SAR images to delineate ocean oil slicks with a texture-classifying neural network algorithm (TCNNA)

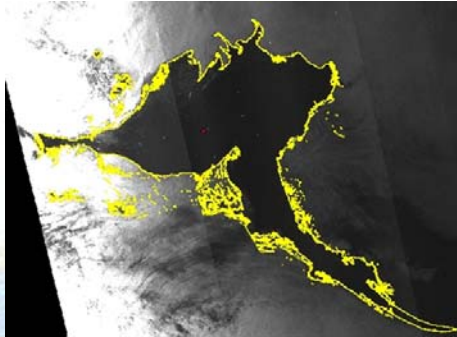
Oscar Garcia-Pineda, Beate Zimmer, Matt Howard, William Pichel, Xiaofeng Li, and Ian R. MacDonald



SAR TCNNA Oiling Footprint

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Damage Assessment Remediation
& Restoration Program

- Semi-automated process
- Detailed examination of environmental conditions
- Use data to map low wind features, false positives
- Help eliminate subjectivity of individual analyst
- Expedite delivery
- Oil not anomaly



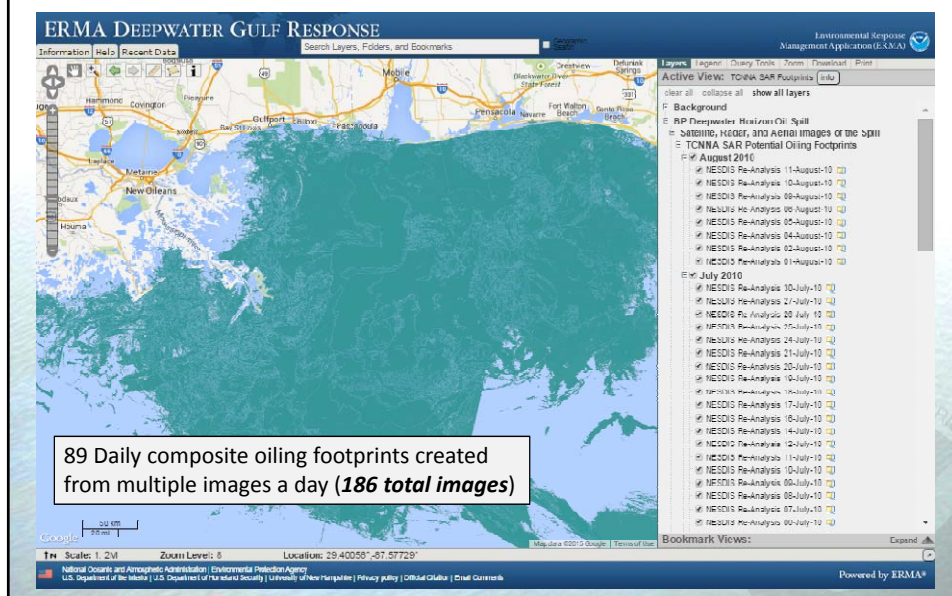
SAR TCNNA Products

NOAA
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& Restoration Program

- SAR TCNNA Sensor Products
 - Daily Composites
 - Cumulative Composite
 - Cumulative Days of Oiling
 - Shoreline Days of Oiling
 - Time of Oiling

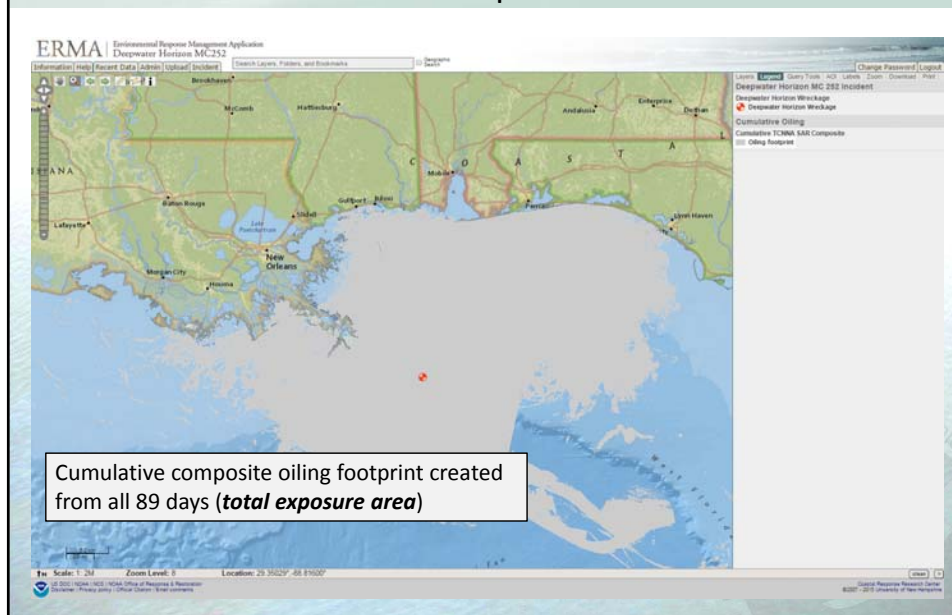
SAR TCNNA Products: Daily Composite/Cumulative Composite

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Damage Assessment Remediation
& Restoration Program



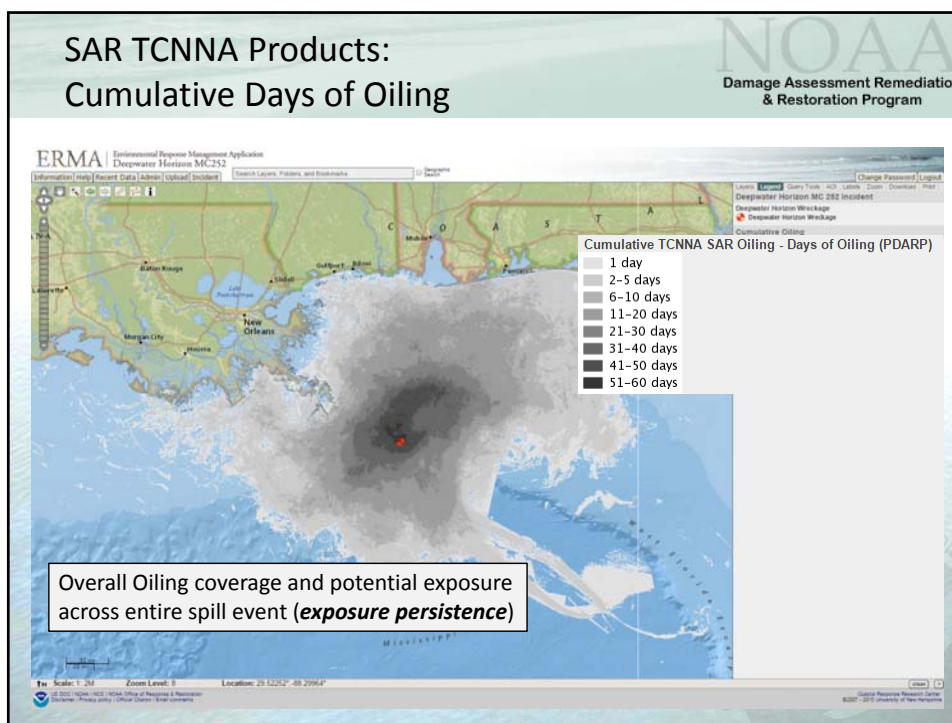
SAR TCNNA Products: Cumulative SAR TCNNA Footprint

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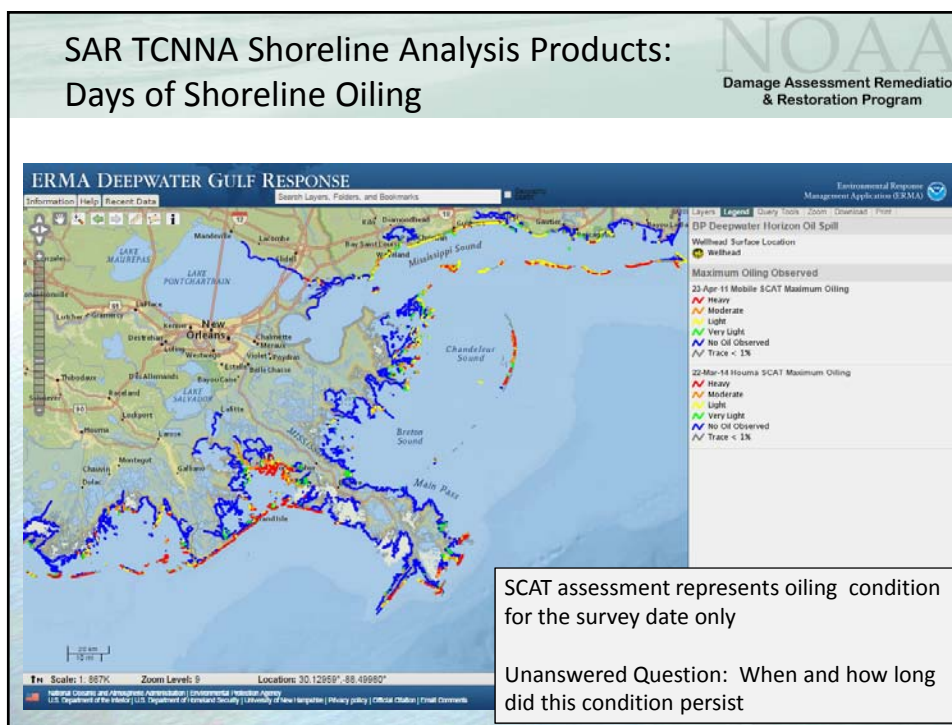
SAR TCNNA Products: Cumulative Days of Oiling

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Damage Assessment Remediation
& Restoration Program



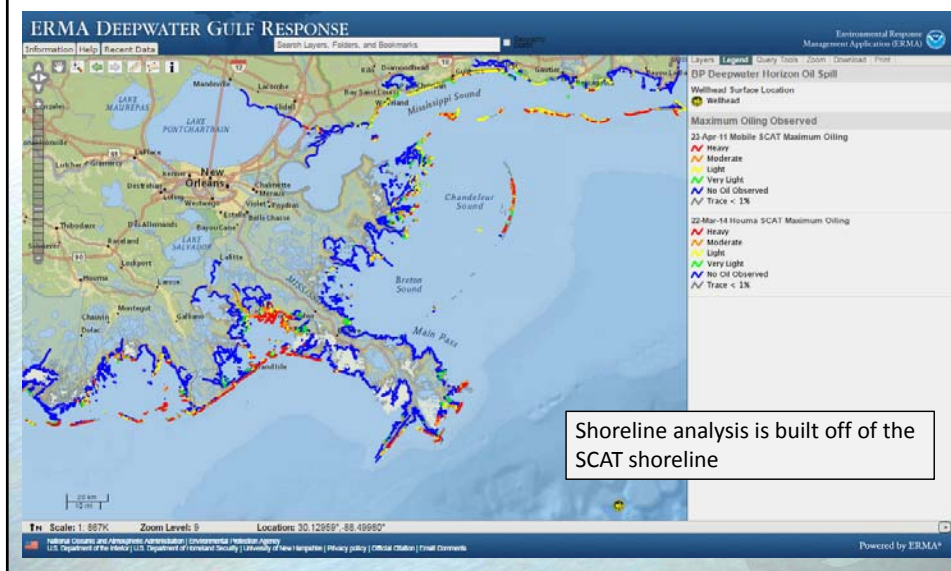
SAR TCNNA Shoreline Analysis Products: Days of Shoreline Oiling

NOAA
Damage Assessment Remediation
& Restoration Program



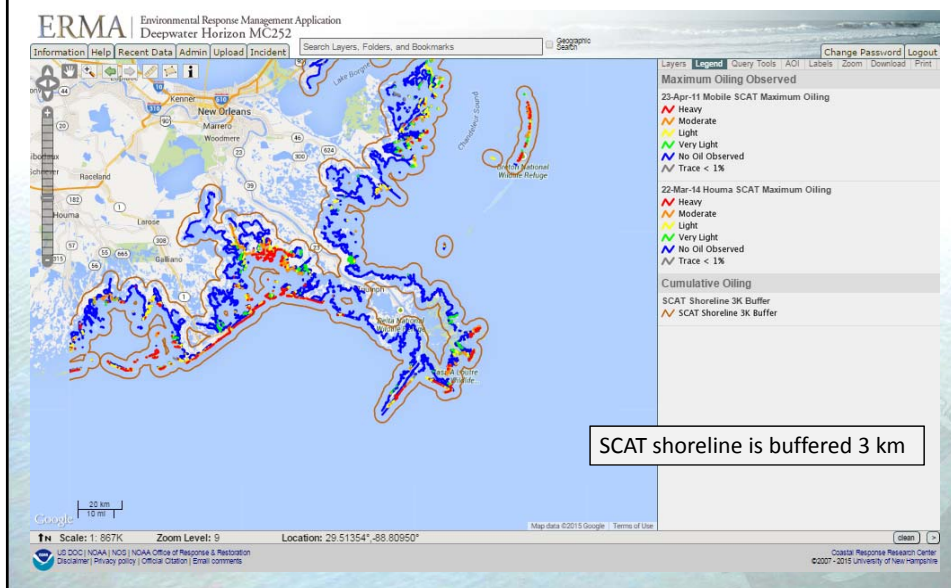
SAR TCNNA Shoreline Analysis Products: Days of Shoreline Oiling

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& Restoration Program



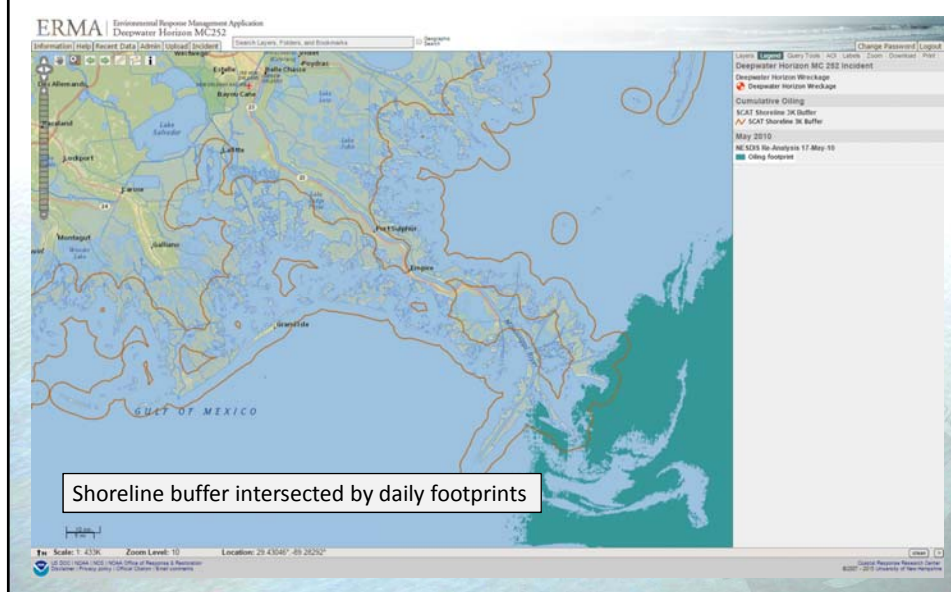
SAR TCNNA Shoreline Analysis Products: Days of Shoreline Oiling

NOAA
Damage Assessment Remediation
& Restoration Program



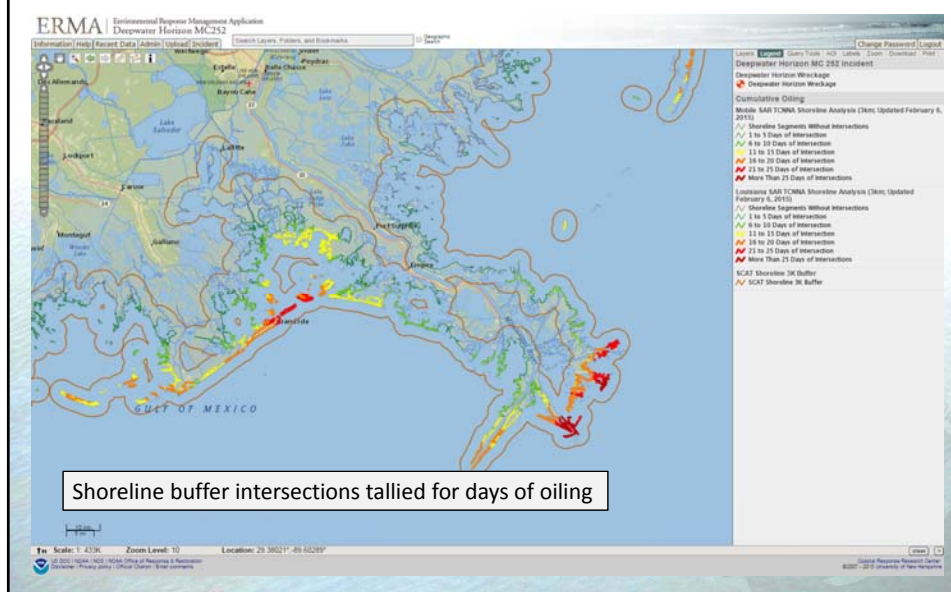
SAR TCNNA Shoreline Analysis Products: Days of Shoreline Oiling

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Damage Assessment Remediation
& Restoration Program



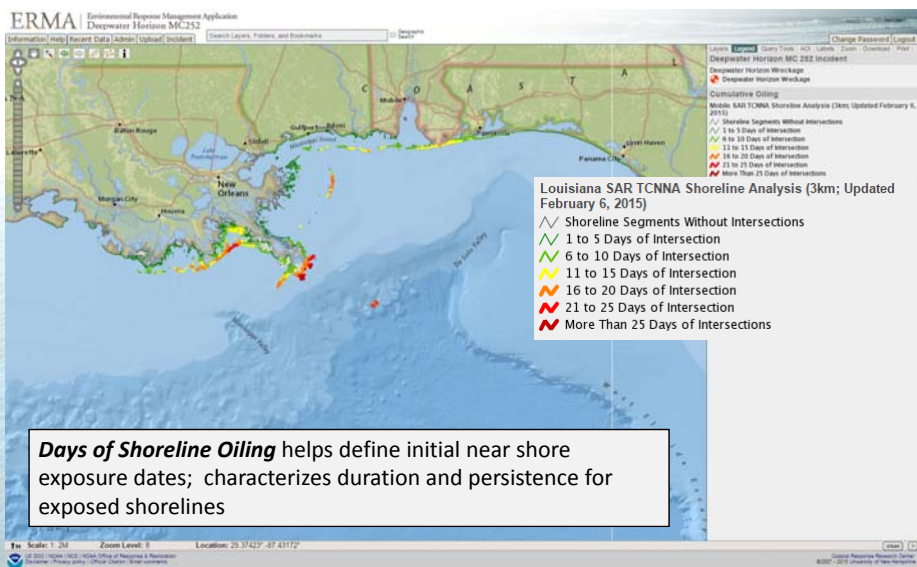
SAR TCNNA Shoreline Analysis Products: Days of Shoreline Oiling

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& Restoration Program



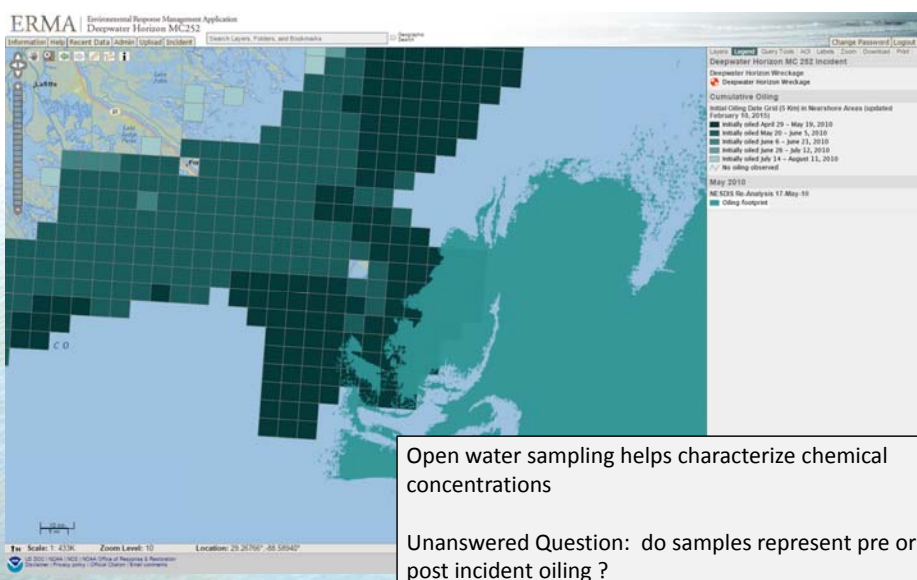
SAR TCNNA Shoreline Analysis Products: Days of Shoreline Oiling

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& Restoration Program



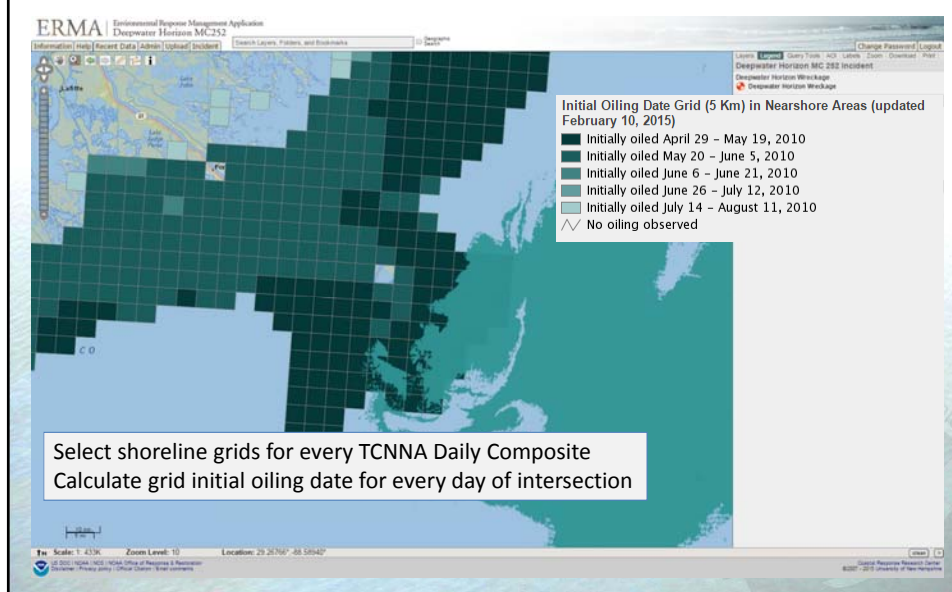
SAR TCNNA SAR Analysis Products: Time of Oiling

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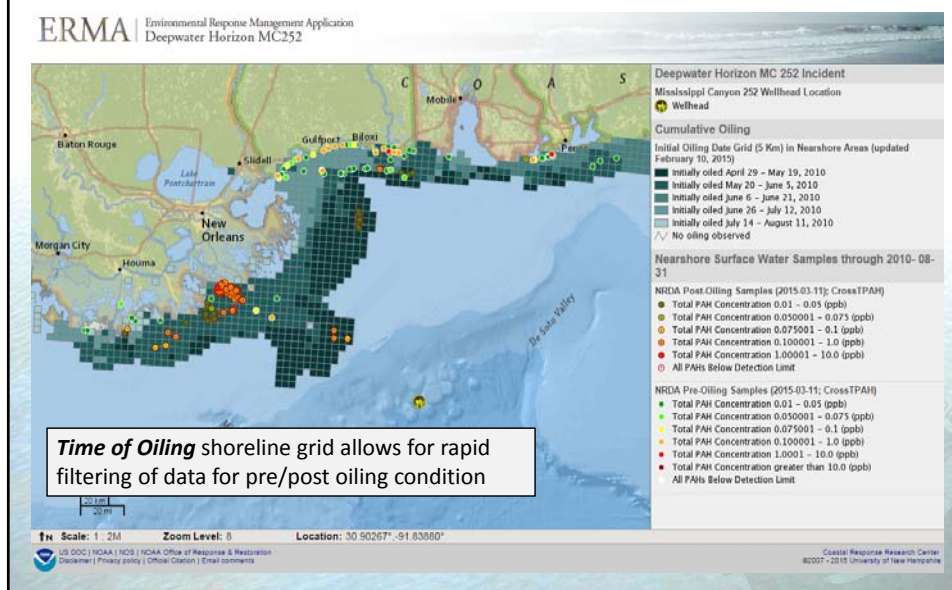
SAR TCNNA SAR Analysis Products: Time of Oiling

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SAR TCNNA SAR Analysis Products: Time of Oiling

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& Restoration Program



SAR use in NRDA

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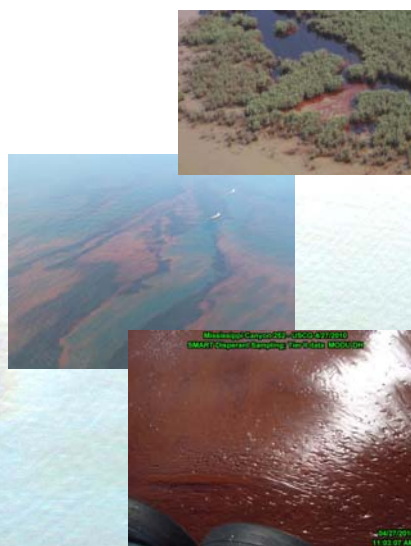
- SAR data add value as an effective screening tool
- Data provide tools for focusing and filtering on a particular resource
- Allows us to prioritize assessment efforts to habitats and species assemblages at the greatest risk of exposure



SAR and NRDA

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& Restoration Program

- Open water and shoreline conditions are informed by SAR analysis
- SAR data allow us to look at overall extent and duration of potential exposure
- Satellite analysis supplements in situ observations and sampling
- SAR data are a useful as an indication of exposure, but not injury



SAR and Damage Assessment



SAR Data Summary:

- SAR data provide a useful exposure surface area for a variety of Trust resources
- SAR data can provide temporal context to SCAT assessment and environmental sampling
- SAR data add value to traditional response and assessment investigations
- Current and emerging application of SAR data will provide significant support to the NRDA process in future incidents




Thank-you!

george.graettinger@noaa.gov

Questions?

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UAS Potential Uses and Limitations

October 21, 2015
Michele Jacobi
Office Response and Restoration


10/27/2015 1

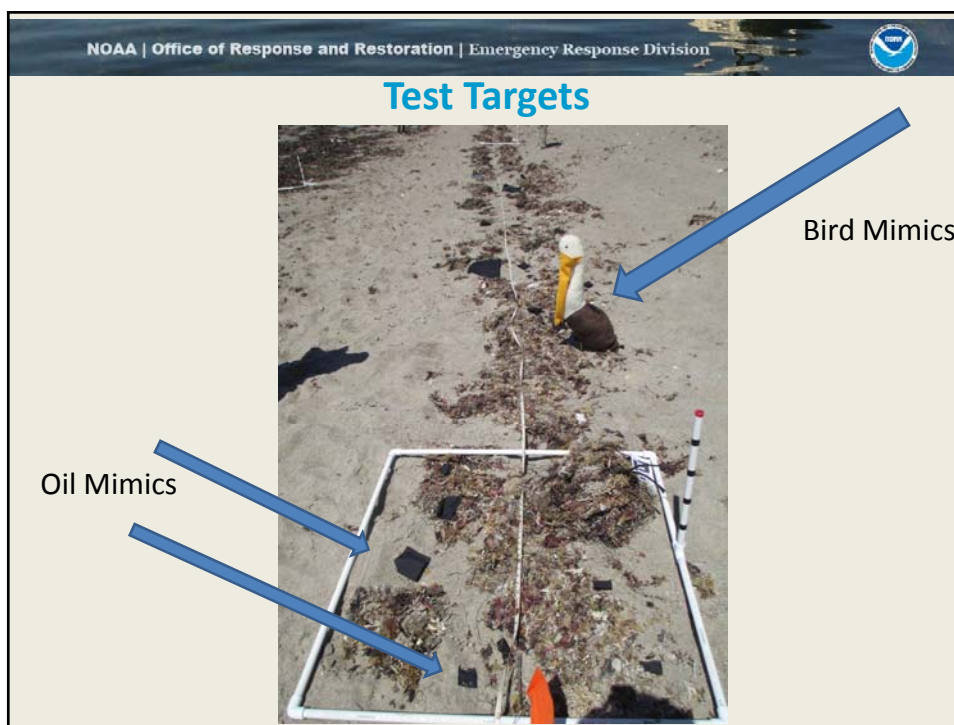
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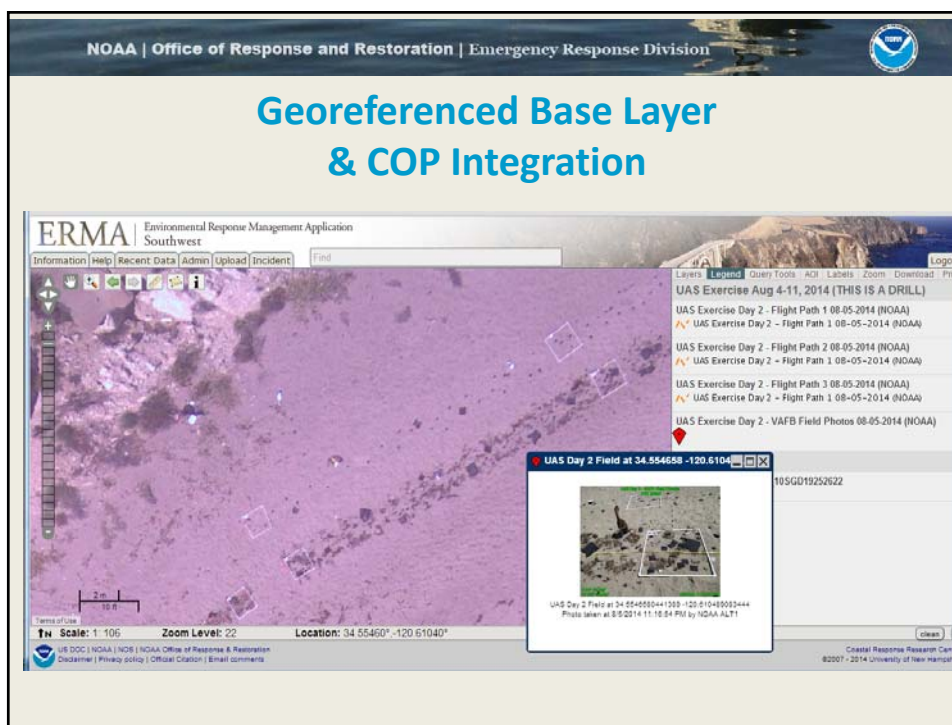


Needs for UAS in Response

- Limited access to areas of interest (distance, safety concerns, personnel bandwidth issues, etc.)
- Both response & natural resource damage assessment can be met with data acquisition
- Survey focus
 - Oil coverage/ extent
 - Convergence zones
 - Trust resource observations: sensitive habitats, targeted species, rookeries, etc.
 - Human Use/ Socio- economic impacts
 - Marine Debris characterization
 - Outreach and messaging






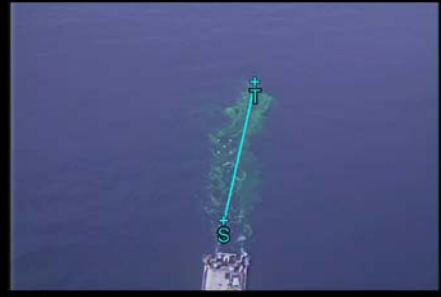


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Off Shore Deployments
Distance Calculations/ Annotations



Lat/Lon: N 34° 08' 59.17" W 119° 25' 30.19"
Alt: 334 ft MSL
Mag: 42°



Simbal
FOV Data:
Slant Rng: 171 m
CFOV Hdg: 313°
CFOV Lat/Lon: N 34° 09' 02.34" W 119° 25' 33.92"
Horiz. FOV: 29.6°

Targeting Data:
Target S Lat/Lon: N 34° 09' 01.63" W 119° 25' 33.34"
Target T Lat/Lon: N 34° 09' 02.97" W 119° 25' 34.76"
ADD 32 m LEFT 44 m
Ranger: 54 m Mag Bearing: 307°

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Practical Deployment & Reality





Process / Timeline

- Wanted to test deployment during real event due to prior UAS demos
- Trustees agreed due to hard to access areas of shoreline & potential wildlife impacts UAS images could be useful for damage assessment
- Response (SSC/ USCG) did not see an operational need
- OAR/ NMS supportive of deployment with vessel and staffing capacity
- NRDA had priority concerns relative to core ephemeral data collection and data in-take needs




Implementation

- Deliverables requested:
 - Geo Tiffs stills ready for input into ERMA within 30 minutes of a shore-based flight landing
 - Derived products (mosaics, stitching, etc.) available within 4-6 hours of a flight landing
 - Copies of data for potential litigation hold
- Logistics
 - OAR coordinated with Aerovironment for all asset field needs
 - NMS offered Vessel for off shore deployment
 - Response Operations approval and Air Boss coordination requirements
 - Effort Initially denied and only re-evaluated when former OR&R Staff rotated into the position
 - Manned air craft coordination was successful due to personal connections

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Standard NOAA Puma Flown



- Covered broad area in single day
- ~180 Images
- 5 videos
- No live wildlife observed
- Could not spatially rectify outputs
- Resolution not adequate for operational need

* Images not for public distribution due to on-going NRDA

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PUMA High Resolution Nadir Camera

ERMA | Environmental Response Management Application Southwest



Scale: 1:1
200 m
1000
10 ft
50 ft

US DOC | NOAA
Disclaimer | Privacy policy | Official Citation | Email comments

Coastal Response Research Center
©2007 - 2010 University of New Hampshire

* Images not for public distribution due to on-going NRDA



Lessons Learned

- Process involved a ***HIGH*** degree of coordination for approvals – FAA, FCC, NMFS Protected Resources, Managed Areas, Response ICS, and asset logistics
- UAS deployment while response air ops is occurring is likely **NOT** practical in the near term
- Delivery of high resolution geo-rectified images is the operational requirements for ARD
- Video is not a primary product need for ARD, but streaming video could help direct operations of other assets in future for the response



Lessons Learned

- Post processing time is ***MUCH*** slower than operational need at moment
- Creation of contracting vehicle would be needed for future use and funded within appropriate ICS funding structure
- Weather induced limitations on UAS flights (winds, ice, fog) very similar to manned
- Further evaluation is needed regarding collection platforms and mission needs (e.g. sensor type, fixed winged vs. copters, etc.) and improved information flow

NOAA Office of Response and Restoration Emergency Response Division			
Next Steps: Outline Mission Requirements			
Survey Need	Mission Type	Tool & Application	Output
<u>Overview Reconnaissance</u>	Pre-planned flight of a large area	-Longer range flight time/ capacity -Offshore capabilities -Planned Flight paths -Model input -Night time operations for resources planning	High resolution, geo-referenced photomosaic covering a defined area of interest in short processed time
<u>Remote Shorelines</u>	Pre-planned flight of a long stretch of shoreline with limited shore access. May include flight plan adjustments and/or additional, short ad-hoc flights for spot-checks.	Boat-based operation with teams using UAS w/live streaming video feed to vessels to guide SCAT/ NRDA teams to "hot spots" or areas of interest.	Live streaming video feed to vessel to guide field teams to areas of interest.
<u>Sensitive Habitats</u>	Pre-planned flight of a defined area (covering the entire marsh or GRP sensitive area)	High resolution visual image/video.	High resolution, geo-referenced photomosaic covering a defined area of interest
<u>Haul Outs/ Pocket Beaches</u>	Short duration, low altitude, as-needed flight(s) of small, discrete areas restricted / not safely accessible by other means	Daypack-sized UAS launched by field team (or accompanying Technical Specialist) on site for short spot checks.	Short video with associated trackline to accompany SCAT segment form & high resolutions still images for counts and species ID
10/27/2015		15	

NOAA Office of Response and Restoration Emergency Response Division		
Future Deployments		
		
Health Assessments	Image Recognition	Tag/ Recapture / Counts
		
Ephemeral Collections	Habitat Delineation	Arctic

KSAT – Kongsberg Satellite Services

Kongsberg 200

KSAT Svalbard ground station, Svalbard, 78° North

Multi-mission and Near Real Time satellite data delivery and services

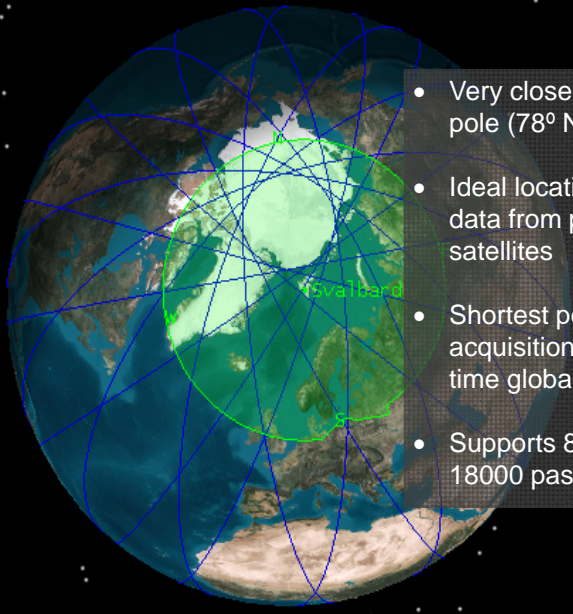
Carles Debart
Project Manager
Energy, Environment & Security (EES)

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11

KSAT Svalbard ground station location

Kongsberg 200



- Very close to the north pole (78° North)
- Ideal location to access data from polar orbiting satellites
- Shortest possible acquisition-to-delivery time globally
- Supports 85 satellites, 18000 passes per month

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12

KSAT Svalbard ground station Enabling NRT Earth Observation services

KONGSBERG 200

OIL SPILL & SEEP DETECTION

VESSEL DETECTION

MULTIRESOLUTION SAR DATA DELIVERY

**ICE EDGE MONITORING
ICEBERG TRACKING**

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KSAT Near Real Time concept Expected delivery times around the globe

KONGSBERG 200

- Green Area - direct downlink to Svalbard
• 30 minutes
- Brown Area – on board storage and downlink to Svalbard
• 1 hour
- Blue Area – extended board storage and downlink to Svalbard
• 1h 30 minutes

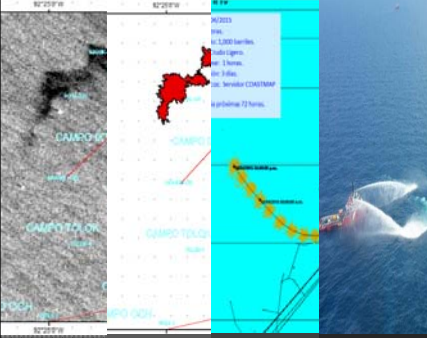
NRT Services can reach the final user in less than 2 hours from acquisition – worldwide and for all SAR satellites

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KSAT Near Real Time services

Things I am not going to talk about...

- How slicks
- How posit auxilli
- How detec trajec
- How 1
- How to run an operational broad scale proactive monitoring



PIONEERED BY KSAT IN NORWAY IN 1995

NORWEGIAN COASTAL ADMINISTRATION IN 1996

ESTABLISHED EMSA CLEAN SEA NET - MONITORING 26 COUNTRIES - COORDINATED BY KSAT

PEMEX MONITORING 2014 - DAILY COVERAGE

KONGSBERG 200


1995 - 2015
20 years
Oil Spill Detection

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KSAT Multimission concept

Why matters

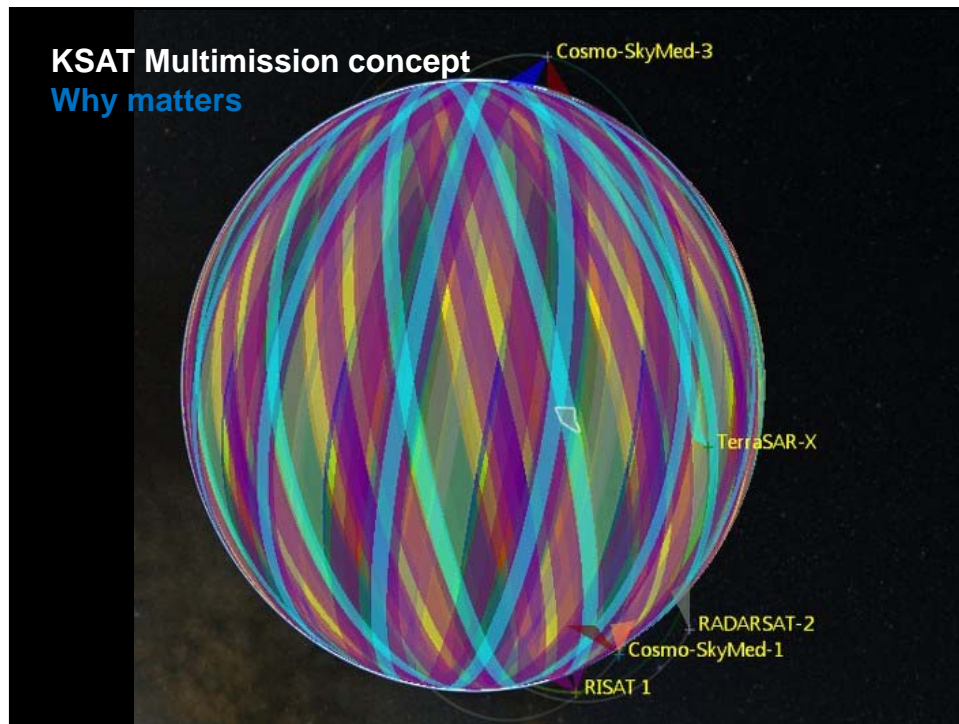


KONGSBERG 200

RADARSAT-2

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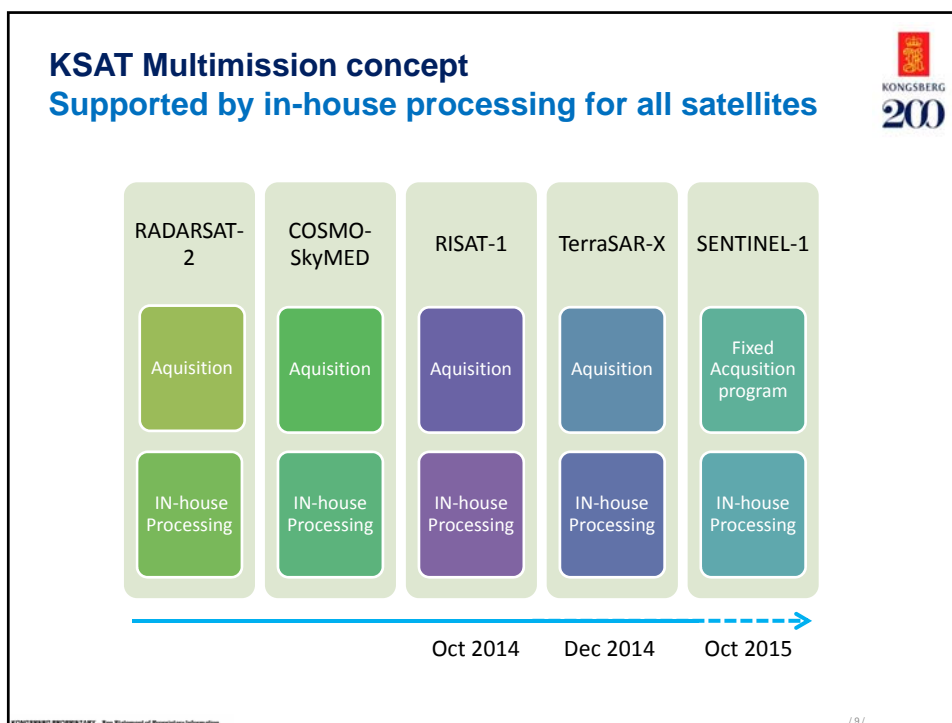
KSAT Multimission concept
SAR Satellites we are able to offer in NRT

RADARSAT-2 4 COSMO-SkyMed TerraSAR-X

SENTINEL-1A* TANDEM-X RISAT-1**

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KONGSBERG 200



KSAT Multimission concept In support of an emergency scenario



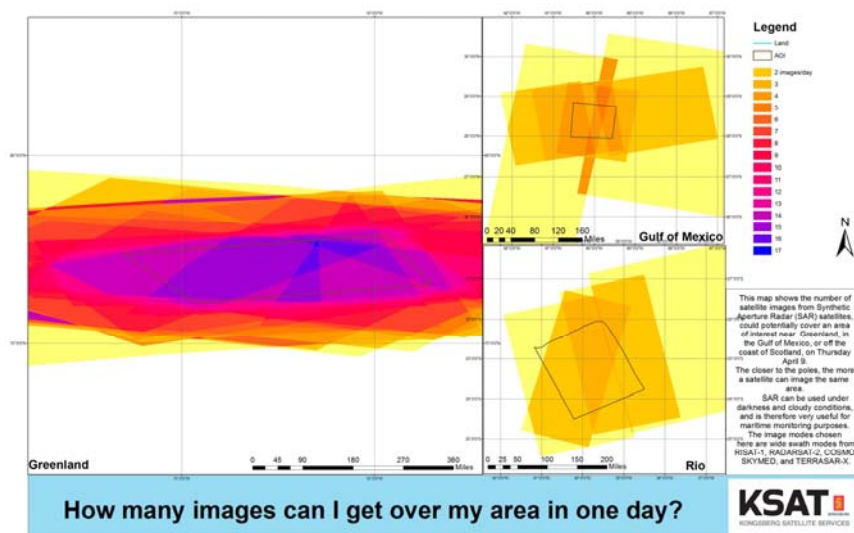
Comments I heard yesterday during the workshop...

- "We need tactical information right on time"
- "We need synoptic information"
- "We need oil thickness to respond where is most needed"
- "We do not respond to most of the small oil spill events"
- "We didn't have SAR satellite data available on a given days"

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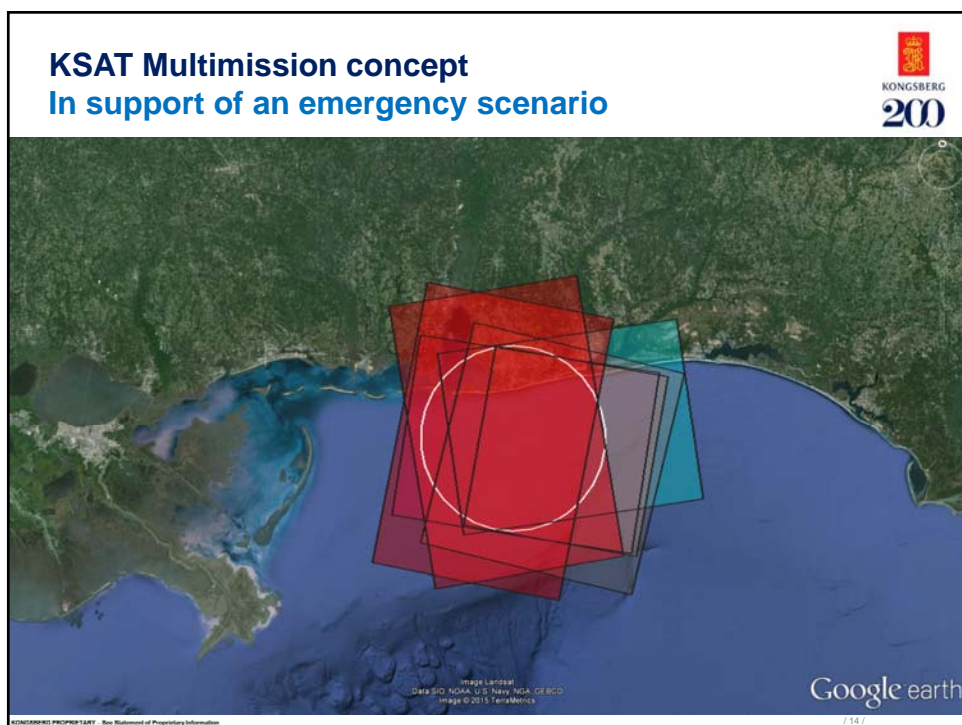
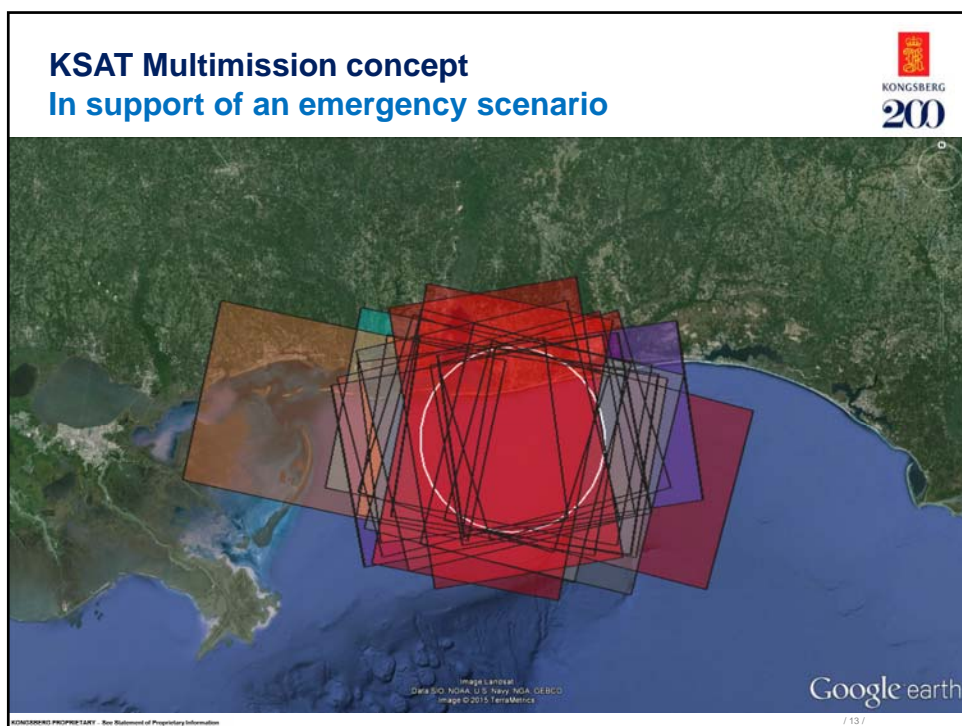
/ 11 /

KSAT Multimission concept In support of an emergency scenario



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/ 12 /



Thanks for you attention!
Any questions?

Carles Debart - carlesd@ksat.no

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KONGSBERG
200



Remote Sensing Systems to Detect and Analyze Oil Spills on the US Outer Continental Shelf – A State of the Art Assessment

Derek Burrage (P.I. & Technical lead/POC),
Sonia Gallegos, Joel Wesson, Richard Gould, and Sean McCarthy
**Oceanography Division, Ocean Sciences Branch,
Naval Research Lab., Stennis Space Center, MS, USA**

Email: derek.burrage@nrlssc.navy.mil Phone: 228 688 5241

Acknowledgement

This work is supported by The Bureau of Safety and Environmental Enforcement (BSEE) under an interagency agreement between BSEE and NRL.

Disclaimer

The ideas and views expressed in this presentation are those of the authors, and do not necessarily represent the views of BSEE, NRL or the U.S. Government.



Goals

Analyze and report on State-of-the-Art technologies for the detection and analysis of oil spills on the US outer continental shelf.

Sub-Goals

- Develop a set of evaluation criteria for the technology.
- Construct scenarios describing a variety of possible continental shelf oil spill sizes and types.
- Survey and assess the technology.
- Evaluate it against the selection criteria.

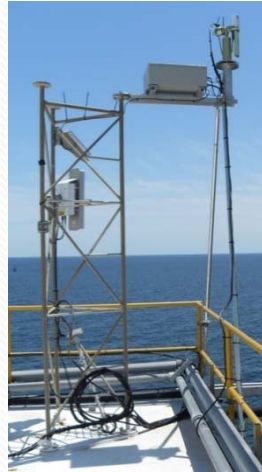


Principal Information Sources

- Reviews (e.g. API 2013; Puestow et al., 2013; several others).
- Scientific papers (e.g. Leifer et al., 2012 on BP DH oil spill).
- Manufacturer specifications (web sites and phone contact).
- Site visits to selected sensor operators or developers.
- Interviews with Oil Spill/Response professionals and experienced instrument users.

Instrument Platforms

ABOVE SURFACE-FIXED

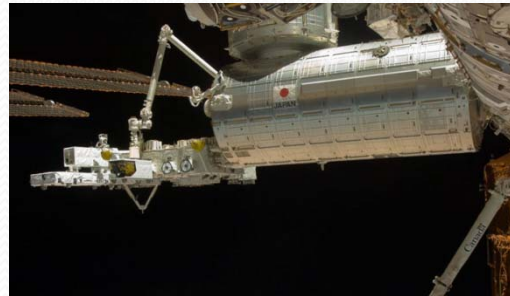


Chevron Rig – WaveCIS SeaPRISM



SPACECRAFT

A-Train AQUA - MODIS



ISS - HICO

AIRCRAFT



R.A. Navajo - STARRS

ON OR BELOW SURFACE

Buoyed
Radiometer



Slocum Glider
– Wet Labs
(FL, Chl-a)



WATERCRAFT



Barge - Surface Lidar



Skye Eye 350
– Optimare MEDUSA 4



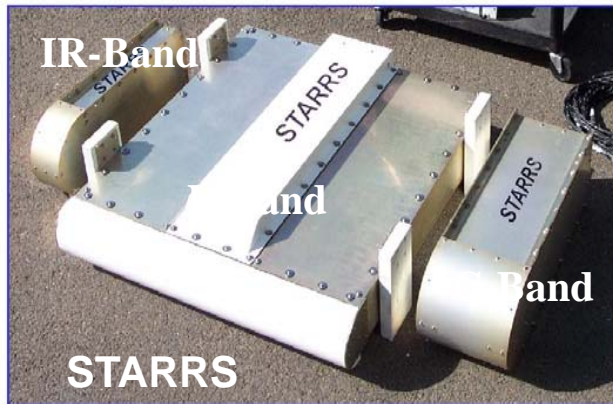
Major Instrument Categories

- Optical (UV, Vis, IR) cameras, multi- and hyper-radiometers, lidars and fluoro-sensors, FLIRS.
- Microwave Radiometers and Radars (SLAR, SAR and Marine Radar).
- Other experimental sensors (e.g. Acoustic and NMR).

Sub-Categories

- Active (e.g. Lidar, Radar) vs. Passive (scanning imaging or spectral radiometers).
- Platform type: Surface (rig or ship) Aerial (aircraft, aerostat, UAV) Space (space station or satellite).
- Other sub-categories.

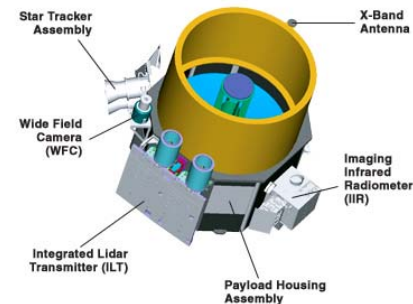
Instrument Classes



**Passive Microwave and Thermal IR
Airborne Radiometer System**



**Active Optical
Lidar Systems**

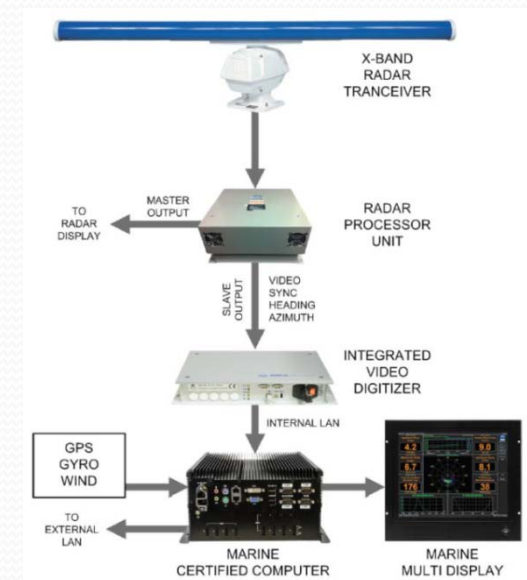


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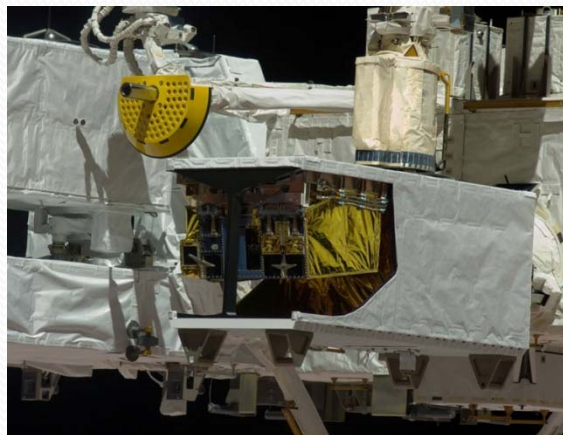
Active Microwave Radar



GS-III - UAVSAR



**Marine Radar
(Miros OSD)**



**Passive Optical Hyper-
Spectral Radiometer
(ISS HICO)**

Remote Sensing Bands for Oil Spill Detection

Table 2. Remote sensing bands and related instruments used for oil spill detection
(Adapted from Goodman, 1994).

Band	Wavelength	Type of Instruments
Radar	1-30 cm	SLAR/SAR
Passive microwave	2-8 mm	Radiometers
Thermal infrared (TIR)	8-14 μm	Video cameras and line scanners
Mid-band infrared (MIR)	3-5 μm	Video cameras and line scanners
Near infrared	1-3 μm	Film and video cameras
Visual spectrometers	350-750 nm	Film, video cameras and
Ultraviolet	250-350 nm	Film, Videocams and line scanners

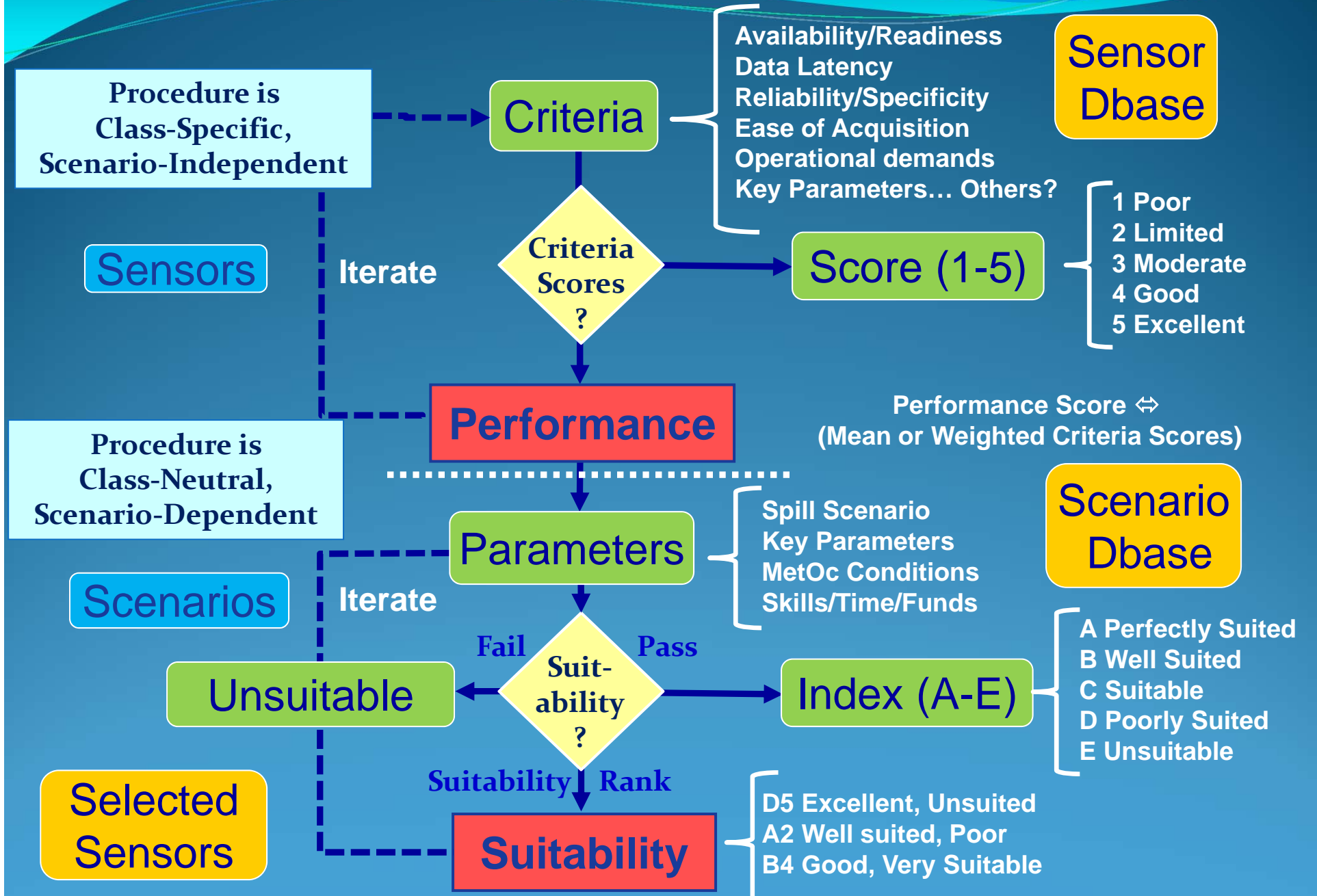
Source: Jha, M. N., J. Levy and Y. Gao (2008)



Assessment Criteria

- Availability (operational, prototype, and one-off systems).
- Ownership (e.g. gov. agency or private contractor)
- Deployment readiness (time to deploy).
- Practical utility under different spill scenarios.
- Suitability for intended use (key spill measurement).
- Strengths and limitations (specificity, false positives/negatives).
- Spill notification potential (timeliness, reliability).
- Hardware mounting and maintenance requirements.
- Operational and processing requirements (skills needed).
- Data latency (near-real time or delayed mode).
- Acquisition costs and delivery options.

Sensor Assessment Procedure



Spill Scenarios – Some

Defining Parameters

Qtr 2

- Scenario ID
- Discharge Location
- Date/Time
- Duration
- Spill Rate
- Volume
- Incident Type (A-I)
- Oil Type
- Oil Condition

Spill
Time/
Space

Spill
Size

Spill
Type

Incident Type

- A Blowout
- B Well leak
- C Pipeline leak
- D Riser leak
- E Process leak
- F Storage tank spill
- G (Un-) Loading spill
- H Vessel collision
- I Shipping leak

Oil Type

- A Light Crude
- B Heavy Crude
- C Fuel Oil

Oil Condition

- A Subsea/Floating
- B Slick/Emulsion
- C Mousse/Tar

Adapted from: Norwegian Ministry of the Environment (2011)

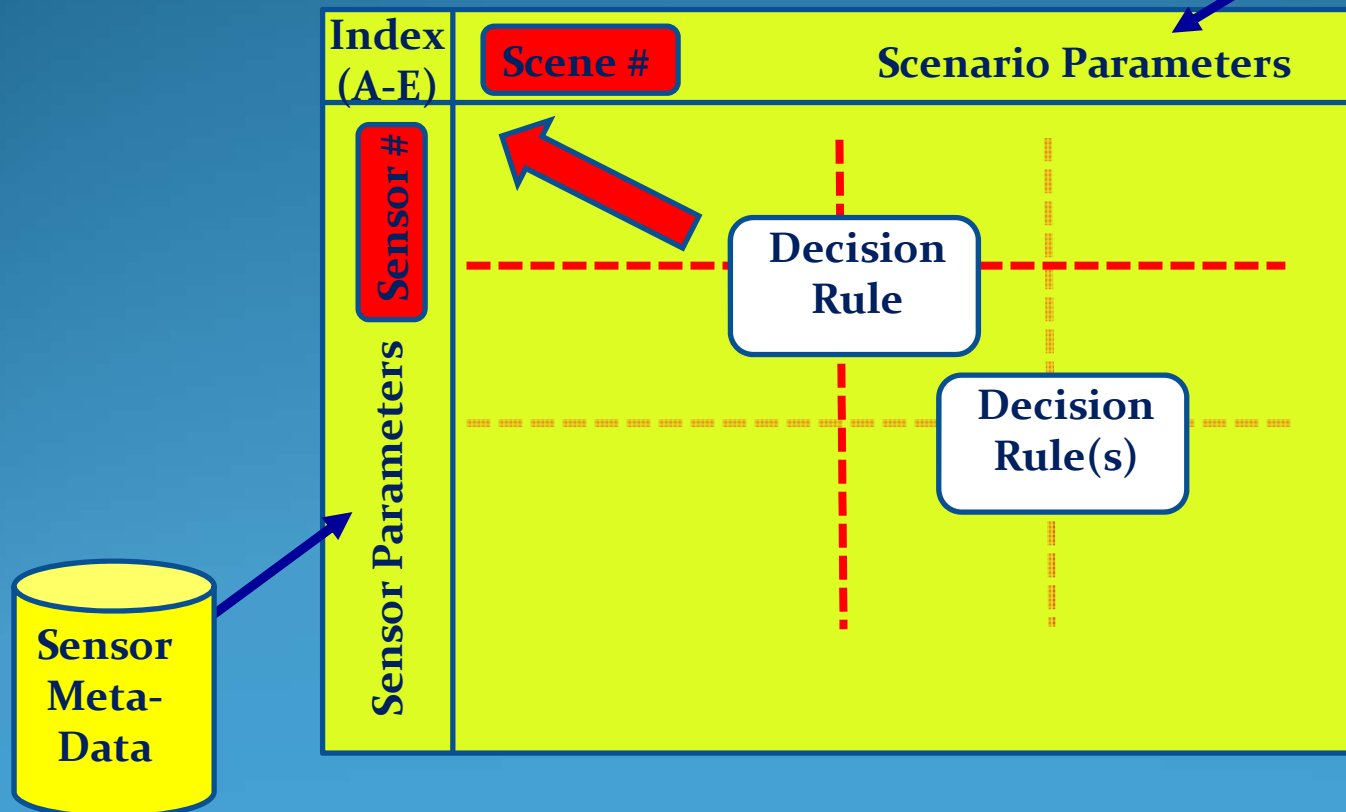
Determining Sensor Suitability Index

Spreadsheet

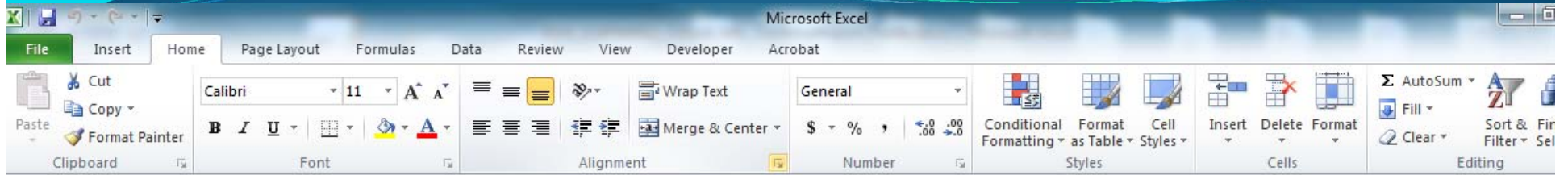
Functional
Prototype

Sensor/Scenario Matrix

Scenario
Meta-
Data



IDAOS Sensor Data Base



IDAOS_ME_V15k.xlsm

Instruments to Detect and Analyze Oil Spills (IDAOS)											
Instrument Table						Instrument Table					
Decision Rule Parameter:						.					
Sensor ID			Sensor Identity			Technology Class					
Sequence Number (Not for Sorting)	Original Sort Index To Sort or Re-Sort: Press [v]	Data Entry Analyst Initials	Sensor Mean Score	Short Name/Range(s)		Category Primary	Category Secondary	Technology Class	Sensor Brand-Model or Type	Hardware Type	Platform Type
		Validity [Units]				"V" Menu	"V" Menu	"V" Menu	"V" Menu	"V" Menu	"V" Menu
Scoring Row: 20											
SeqNum	SenNum	Analyst	MeanScore	SenShrtNam		PrimCat	SecCat	TechClass	Model	HardwareTyp	PlatformTyp
1	1	DB	3.95	SAMPLE		Microwave	Passive	Radiometer	Optimare-MWR	Real Aperture	Aircraft
2	2	DB	3.30	STARRS		Microwave	Passive	Radiometer	STARRS	Interferometer	Aircraft
3	3	DB	3.75	SMOS		Microwave	Passive	Radiometer	MIRAS	Interferometer	Satellite
4	4	JW	3.20	Selux ST OSD		Microwave	Active	Marine Radar	ST 340 OSD	Real Aperture	Ship or Rig
5	5	RG&DB	3.85	HICO		Optical-UV,Vis,Nir	Passive	Hyperspectral Radiomet	HICO	Real Aperture	Space Station
6	6	SG	4.05	MODIS		Optical-UV,Vis,Nir	Passive	Multispectral Radiomet	NASA MODIS	Real Aperture	Satellite
7	7	DB	3.30	MEDUSA-SLAR		Microwave	Active	SLAR	Optimare-SLAR	Real Aperture	Aircraft
8	8	DB	3.40	MEDUSA-IR/UV		Optical-UV,Vis,Nir	Passive	Radiometer	Optimare-IRUV	Real Aperture	Aircraft
9	9	DB	3.65	MEDUSA-LFS		Optical-UV,Vis,Nir	Active	Fluorosensor	Optimare-LALFS	Real Aperture	Aircraft
10	10	DB	3.65	MEDUSA-MWR		Microwave	Passive	Radiometer	Optimare-MWR	Real Aperture	Aircraft
11	11	JW	3.55	UAVSAR		Microwave	Active	SAR	UAV-SAR	PoISAR	Aircraft
12	12	SG	3.85	OLI		Optical-UV,Vis,Nir	Passive	Multispectral Radiomet	Landsat OLI	Real Aperture	Satellite
13	13	SG	4.15	TIRS		InfraRed-SW,MW,LW	Passive	Multispectral Radiomet	Landsat TIRS	Real Aperture	Satellite
14	14	DB, SG	3.75	AVIRIS		Optical-UV,Vis,Nir	Passive	Imaging Spectrometer	NASA AVIRIS	Real Aperture	Aircraft
15	15	RG	4.00	Hyperion		Optical-UV,Vis,Nir	Passive	Hyperspectral Radiomet	E01-Hyperion	Real Aperture	Satellite
16	16	SG	4.15	WV-3		Optical-UV,Vis,Nir	Passive	Multispectral Radiomet	DG WorldView-3	Real Aperture	Satellite
17	17	JW	4.30	Radarsat2		Microwave	Active	SAR	Radarsat-2	Synthetic Aperture	Satellite
18	18	JW	4.30	CSK		Microwave	Active	SAR	Cosmo-SkyMed	Synthetic Aperture	Satellite
19	19	DC	4.25	TerraSAR-X		Microwave	Active	SAR	TerraSAR-X	Interferometer	Satellite
20	20	DC	4.20	MSI		Optical-UV,Vis,Nir	Passive	Multispectral Radiomet	MSI	Real Aperture	Satellite
21	21	DC	4.20	CSAR		Microwave	Active	SAR	CSAR	Synthetic Aperture	Satellite
22	22	DC	3.95	OLCI		Optical-UV,Vis,Nir	Passive	Imaging Spectrometer	OLCI	Real Aperture	Satellite
23	23	JW	3.70	MIROS OSD		Microwave	Active	Marine Radar	Furuno	Real Aperture	Ship or Rig
24	24	JW	3.70	Rutter OSD		Microwave	Active	Marine Radar	Furuno	Real Aperture	Ship or Rig

IDAOS Scenario Data Base

Microsoft Excel

FileInsertHomePage LayoutFormulasDataReviewViewDeveloperAcrobatDesign

NormalPage LayoutPage Break PreviewCustom ViewsFull Screen

Workbook Views

☒ Ruler☒ Formula Bar

☒ Gridlines☒ Headings

Show

Zoom100%Zoom to Selection

Zoom

New WindowArrange AllFreeze Panes

SplitHideUnhide

View Side by SideSynchronous ScrollingReset Window PositionWindow

Save WorkspaceSwitch WindowsMacros

G11SE of Mississippi R. Delta, LA

IDAOS_ME_V15k.xlsm

Instruments to Detect and Analyze Oil Spills (IDAOS)						Instruments to Detect and Analyze Oil Spills (IDAOS)					
Scenario Table						Scenario Table					
Decision Rule Parameter:											
Scenario ID		Scenario Identification				Estimated Spill Size					
Sequence Number (Not for Sorting)	Original Sort Index. To Sort or Re-Sort:	Short Name	Scenario Name	Oil Spill Geographic Region	Estimate Date & Time	Spill Duration [day]	Estimated Spill Volume [bbl]	Estimated Spill Volume [m^3]	Estimated Spill Length [m]	Estimated Spill Width [m]	
SeqNum	ScnNum	ScnShrtNam	Scenario Name	SpillGeoRgn	EstimDatetime	SpillDurn	SpillVolBl	SpillVolm3	SpillLen	SpillWid	
1	1	Dummy	Deep Water Horizon-Macondo Well	Gulf of Mexico	20-Apr-2010 00:00	0.00	0	0.00	#N/A	#N/A	
2	2	DWH-Initial	Deep Water Horizon-Macondo Well	Gulf of Mexico	20-Apr-2010 00:00	0.00	0	0.00	#N/A	#N/A	
3	3	DWH-1	Deep Water Horizon-Macondo Well	Gulf of Mexico	25-Apr-2010 00:00	5.00	308,736	49085.93	#N/A	#N/A	
4	4	DWH-2	Deep Water Horizon-Macondo Well	Gulf of Mexico	30-Apr-2010 00:00	10.00	614,944	97769.92	#N/A	#N/A	
5	5	DWH-Final	Deep Water Horizon-Macondo Well	Gulf of Mexico	15-Jul-2010 00:00	86.00	4,900,000	788279.57	#N/A	#N/A	
6	6	Ixtoc	Pemex Exploratory Oil Well, Bay of Campeche	Gulf of Mexico	23-Mar-1980 00:00	294.00	3,483,175	553779.54	#N/A	#N/A	
7	7	Kirby Barge	Summer Wind and Kirby Oil Tank-Barge Collision	Gulf of Mexico	22-Mar-2014 00:00	0.00	4,000	636.36	#N/A	#N/A	
8	8	Exxon Valdez	Exxon Valdez Oil Spill, Prince William Sound	NE Pacific	24-Mar-1989 03:30	0.14	215,000	21955.38	#N/A	#N/A	
9	9	Exxon Valdez	Exxon Valdez Oil Spill, Prince William Sound	NE Pacific	24-Mar-1989 06:00	0.25	215,000	34068.69	#N/A	#N/A	
10	10	Exxon Valdez	Exxon Valdez Oil Spill, Prince William Sound	NE Pacific	27-Mar-1989 00:00	3.00	260,000	42000.00	#N/A	#N/A	
11	11	Long Island	Central Long Island Sound GNOME1/ADIOS-2	NW Atlantic	02-Dec-1999 05:30	1.00	830	131.96	#N/A	#N/A	
12	12	Santa Barbara	Santa Barbara Oil Spill of 1969	NE Pacific	29-Jan-1969 08:00	0.89	4,427	703.85	#N/A	#N/A	
13	13	Santa Barbara	Santa Barbara Oil Spill of 1969	NE Pacific	08-May-1969 10:45	100.00	#N/A	#N/A	#N/A	#N/A	
14	14	Santa Barbara	Santa Barbara Oil Spill of 1969	NE Pacific	08-May-1969 10:45	100.00	77,000	12242.00	#N/A	#N/A	
15	15	Argo Merchant	Argo Merchant 1976	NW Atlantic	21-Dec-1976 18:00	0.00	183,333	29147.62	#N/A	#N/A	
16	16	Argo Merchant	Argo Merchant 1976	NW Atlantic	21-Dec-1976 18:00	0.00	183,333	29147.62	#N/A	#N/A	
17	17	Mega Borg	Mega Borg Tanker Oil Spill, Galveston, Texas	Gulf of Mexico	08-Jun-1990 12:00	0.00	238	37.85	#N/A	#N/A	
18	18	Mega Borg	Mega Borg Tanker Oil Spill, Galveston, Texas	Gulf of Mexico	13-Jun-1990 12:00	5.00	71,667	11394.07	#N/A	#N/A	
19	19	Mega Borg	Mega Borg Tanker Oil Spill, Galveston, Texas	Gulf of Mexico	15-Jun-1990 12:00	7.00	100,238	15936.55	#N/A	#N/A	
20	20	Mega Borg	Mega Borg Tanker Oil Spill, Galveston, Texas	Gulf of Mexico	18-Jun-1990 12:00	10.00	92,857	14763.08	55,590	18,530	
21	21	Mega Borg	Mega Borg Tanker Oil Spill, Galveston, Texas	Gulf of Mexico	28-Jun-1990 12:00	20.00	92,857	14763.08	24,089	9,265	
22	22	Eagle Otome	Eagle Otome Oil Tankship Oil Spill, Port Arthur, Texas	Gulf of Mexico	23-Jan-2010 12:00	0.10	11,000	1748.86	3,706.0	121.9	
23	23	Selendang Ayu	Selendang Ayu Alaska Oil Spill	Bering Sea	08-Dec-2004 17:05	0.00	8,000	1271.90	#N/A	#N/A	
24	24	Refugio	Refugio Oil Spill	NE Pacific	19-May-2015 11:30	0.00	480	76.31	11,000	#N/A	
25	25	OilRig2	Hypothetical Oil Rig Spill of 2 bbl in 1 m/s winds	Gulf of Mexico	13-Nov-2015 16:00	0.50	1	0.22	#N/A	#N/A	

IDAOS Sensor/Scenario Matrix

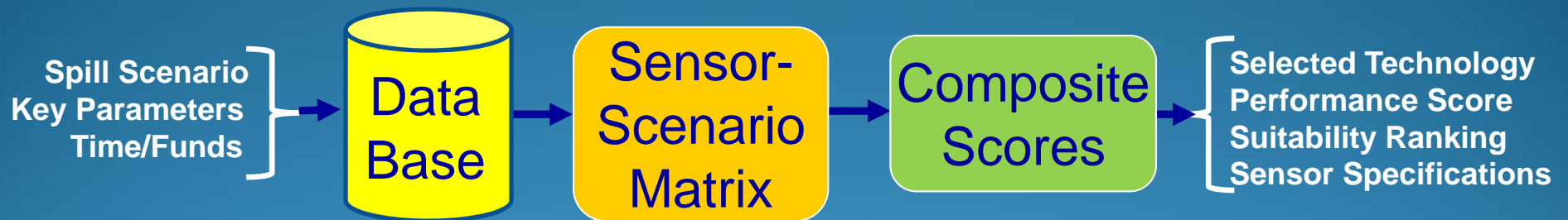


IDAOS_ME_V15k.xlsm										
A	B	C	D	E	G	I	J	L	P	
Instruments to Detect and Analyze Oil Spills (IDAOS)										Instru
Sensor-Scenario Matrix										
Click Red Buttons to	Sensor #:	Selected Instrument:		Selected Scenario Sequence #:	Scene #/ Scene Count	Table: ScenarioTable				
Select Sensors and Scenes	29	Sequence #:		12	12					
User: To Advance	Sensor Count	29		Santa Barbara	25					
Press Red Buttons	46	WV-1		Scene #	.					
Performance Score (1.00-5.00):	4.05	Sensor #		Scenario Identification			Scenario Analysis			
Suitability Index:	4.45	A		Scenario	Oil Spill		Analysis	Analysis	Estimated Spill	
Counter Cell:	SCS6	[1.0-E-1.8-D-2.6-C-3.4-B-4.2-A-5.0]		Parameter:>	Country	Short	Event	Event	Length	
Table:	Instrument Table	Decision Rule:		Sensor :v	Location	Name	Date	Time	[m]	
Total No. Rules Applied:	Sum Mean Row Scores	Sum Raw Scores:		WV-1	Contig. US	Santa Barbara	29-Jan-1968	8:00	#N/A	
11	40.50	49.00		Sensor Identity						
No. Rules Applied to Row:	Mean of Row Scores:	Sum of Row Scores:			Contig. US					
1	5.00	5.00		Sensor Country Location	Global					
	A			Global	Covered					
					5					
					A					
				Technology Class				0.33		
						29-Jan-1968	8:00			
				Category Primary		Optical-UV,Vis,Nir	Optical-UV,Vis,Nir			
				Optical-UV,Vis,Nir		Winter	Day			
						2	5			
						D	A			
									#N/A	
				Primary Mean Space Resolution					1	
				0.500					#N/A	

Sensor Selection Tools

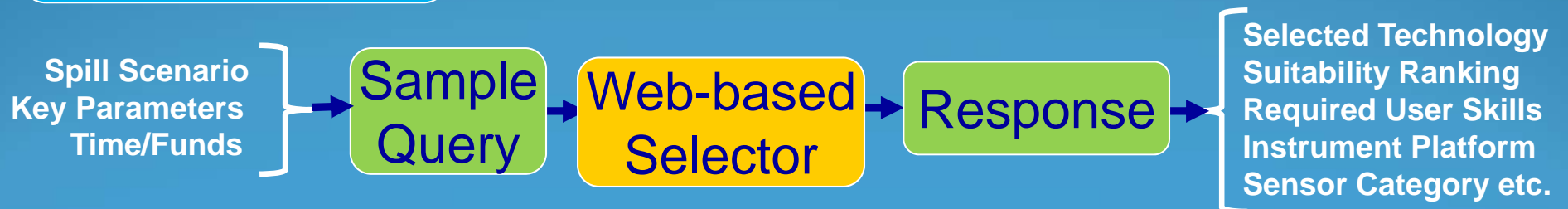
Spreadsheet System

Functional
Prototype
- Release Pending



Web-based Sensor Selector

Prototype
Under
Construction





Sensor Deployment Modes

- **Monitoring from Oil Platforms on the OCS.**
Rig2 – Hypothetical Spill Modelled using ADIOS, GNOME
- **Satellite Tracking & Mapping in Open Seas.**
1989 Exxon Valdez, Prince William Snd, 260,000 bbl after 3 days
- **Tactical Response Using Aircraft.**
1969 Santa Barbara, Channel, 4,427 bbl, after 21.25 hrs
- **Deploying All Available Sensors for a Major Spill.**
2010 DWH-2, GoM, 614,944 bbl after 10 days
- **Ship and Aircraft Sensors to Guide Oil Recovery.**
1990 Mega Borg, GoM, 92,857 bbl after 20 days

(See Technical Report Part IV for Corresponding Sensor Selections)



Monitoring from Oil Platforms

- Semi-Enclosed Sea Monitored with Above Surface Sensors.
- Short (Temporary) and Medium-Long term Sampling.
- Provide Early Detection from Sources on or near a Rig.
- Deploying All Available Sensors for a Major Spill.
- Ship and Aircraft Sensors to Guide Oil Recovery.
- Detect Smaller, Less Obvious Spills.
- A hypothetical 2 bbl Spill Selects for These Sensors:
 - A/c EPA ASPECT IRLS (4.15,4.40-B)- Cost prohibitive if small spill?
 - Rig or Ship - Marine Radar Rutter OSD (3.70,3.25-C) – Wind effect?
 - Sats -World View-1 WV-1 (4.05,4.09-B),GeoEye-1, WV-2 (4.00B)
 - These cannot see through Cloud!
- => Need for Integrated on-Platform Instrument Suite



Desirable Sensor Characteristics for Monitoring on Oil Platforms

- Automatic Operation and Data Transfer.
- Self Diagnostics and Built-in Fault Reporting.
- Routine Maintenance Schedule.
- Provide Spill Detection Alerts.
- Local and/or Remote Display and Control.
- Report Spills Within Sensor Range plus Detection Confidence Level and Criteria.
- Give Estimates of Spill Location and Size.
- Ideally Thickness and Oil Type to Mitigate False Alarms.



The End

Questions?

APPENDIX E

Appendix E – Plenary Session Notes

Day 1

Background and Goals – George Graettinger

Goal started as: Deepen the bench – more people who understand and do oil observing.

Assess ORR office wide needs for both response and assessment.

Need for Oil Observing in Response - Scott Lundgren

Map: spills asked to respond to from 1985 to 2015. Reminder that many are small and not like DWH or Valdez – more basic technology used.

NOAA role – scientific support direct to unified command, also major role in Environmental Unit in Planning Section. Also green. Dashed red – also presence there. (referencing color on slides)

Open Water Oil Identification Job Aid – exists. Put out by NOAA. (USCG uses too)

Technology is moving very fast. DWH allowed to expand into new arenas and test out technologies.

Needed for response – early, timely, and accurate.

Need for Oil Observing in Response - James Litzinger

OSC – on scene coordinator

Public confidence – do it by actually doing their job (explanation of point on slide)

Whether or not it is the USCG depends on where the spill is.

COTP – Captain of the Port

FOSC – Federal on Scene Coordinator

They use a lot of info from aerial observations, ERMA, and EPA etc. to make decisions during spill.

Good slide on Need for Oil Observing

Cannot direct a plane to put out dispersants without knowing where product going, what does it look like, potential impacts etc.

Boom – to catch leading edge of sheen need to know where oil is going so can direct boat to correct place.

Enforcement – certain elements are needed to prosecute a case and take enforcement action – another “need”.

One regulation was not on slide – role of RP to report spill.

They also do chemical response – not just oil.

The remote sensing oil observation information is their common operating picture – without it they cannot do their job and is what makes or breaks their success.

Need for Oil Observing in Response - Lisa Dipinto

OPA – Oil Pollution Act

Percent cover – within footprint

Sometimes more qualitative info is ok and sufficient, others do need very detailed info about thickness and percent water etc.

Even very thin sheens can be very toxic to the early life stages.

UV can increase toxicity approximately 100 fold.

Toxicity to sargassum itself and all the organisms that live there, toxic to organisms and then organisms also depend on sargassum as critical habitat for protection and food.

Even deep see benthos benefits from evaluation of surface oil.

Use of SAR in Nearshore Environment – they had done what describe on this slide prior in NRDA case. Worked well and provided additional info they didn't have/know about otherwise.

Would be great for field sampling to have all those samples at once so can compare and check things. (Surface Oiling Products to Guide Field Sampling slide) Air gradient - is important to have air at oil/water interface with air that marine mammals are breathing. (for discussion later at workshop – dream big)

Jeff Lankford

Santa Barbara – lots of kelp beds – dark, kelp also puts off a natural sheen.

Sargassum also looks like oil. They end up chasing down lots of false positives.

Overflights also pick up wildlife in vicinity of spill – that's not why they are flying but they do note them.

Everyone develops their own note shorthand style when doing overflight observations. The people the observers work with learn to interpret their shorthand.

Flights are limited by time and fuel capacity – 2 or 3 hours. Don't know if there's oil where they didn't go.

Overflight advantages - Get overflight map out about an hour after land. Good can go where you want – plane flies wherever.

Drifters – plane goes low and slow, door open, throw something down there (can deploy devices).

Limitations – equipment failure (like helicopter).

Backup gear – camera, GPS, etc. in case equipment breaks.

Future needs – mostly constrained by time and money.

Davida Streett

24 7 group

Uses – can be used to rule out areas that don't require a response (one of the more surprising ones) – saves resources and can ensure public that areas are being monitored every day and not seeing oil.

Biggest limitation for routine monitoring is the amount of imagery.

Midsized spills – they get a little more imagery. Through agreement they have and can tap into. Still have limitations – still less imagery than would like.

Big spill – imagery vastly improves. USGS invokes international disaster charter and everything gets better. Countries provide all imagery for free at this point – Charter makes a huge difference and saves lots of lives in disasters.

Good last slide of Needs

Mark Thomas, EPA ASPECT

ASPECT is a program operated by EPA, Provides 24 7 emergency response capability.

Government world is ESRI centric, rest of world is google centric – so they produce both products (ASPECT Products slide).

DWH had so much oil it was hard to see contrast of when there wasn't oil. Waves, sunlight, etc. all make a simple photo problematic.

ISO classification of oil (Open ocean oil detection slide)

Cathleen Jones

Good table of different satellite instruments.

MISER uses different viewing direction and bands and angles to differentiate false positives.

Slide 6 – NASA 3 instruments – AVIRIS UAVSAR HSRL

Were able to quantitatively map thickness of oil in DWH. (AVARIS)

UAVSAR – very good for seeing through clouds/storms, not always on a UAC, designed to be portable to different platforms (like a UAV). Very good for looking at oil spills – 4 reasons 1) very fine resolution, 2) quad polarization 4?) high signal to noise ratio (“noise floor”). Used in DWH – not only to detect but could determine oil volumetric fraction in layer. High spatial resolution – advantage can actually tell where oil has landed on shore/wetlands

Q&A Panel – Mark Thomas, Cathleen, Davida, Jeff

Lisa Dipinto – they are interested in this technology UAVSAR – how does NOAA access aircraft and sensors to use? What is cost? What is post processing time? \$3,000/hour. It is pretty fast. NASA is trying to facilitate rapid response, and working with other agencies for this. If the aircraft is available, can be flown within 24 hours. Communicate with NASA ahead of time if are going to want to use and set up those channels and communication. Post flight processing – typically products are returned to lab within one day, then have products out in about 24 hours. Have demonstrated an onboard processing capability. Same questions for ASPECT – one hour wheels up operation, \$1300/flight hour, fairly weak detection for chemicals, much higher for oil, they do data processing on aircraft, 5 or 10 minute delay. Post post processing 2 – 6 hours depending on how much data load they have.

Greg Swazey – mapping amount of oil in water Cathleen mentioned? – it is the oil to water ratio. More accurate at high end than it is at low end (depends on 40% oil or 95% oil – higher).

Greg Swazey – what do response people need to have provided by remote sensing data? (such as thickness)

- Mark Thomas – attention wasn’t getting drawn to recoverable oil, due to politics, etc. Cut through all the nonsense and tell the people where to go to get the oil.
- “Nice for you to tell us the entire area of oil, but tell us where the recoverable oil is” is what Davida heard a lot. Recoverable oil.
- “Recoverable oil”, need to look at what can do to oil – 1) burn 2) skim 3) dispersant 4) let it be. Depends on what resources you have available – highest grade skimming equipment vs. less capable equipment.
- Charlie – where is the heaviest oil, not necessary need to get down to mm.
- Volume per pixel would be super or some other related measurement
- Proximity to shoreline (want to keep it offshore).
- Critical thing for response is post processing time, for NRDA might be resolution.
- What other types of sensors are out there that can help us identify resources at risk, in addition to where oil is. Chlorophyll sensor could help identify upwelling region. Most chlorophyll sensors are very low resolution.
- Beyond post processing. Latency time. Not just raw imagery but consumable info by operators to make decisions quickly, so get there while oil is still there.
- Are we getting toward a protocol for standardizing aerial photography? Polarizing filters, lens types, etc.? To help address some of these questions. NOAA doesn’t use

anything to polarize as it brings up a lot of false positives. NOAA doesn't have any formal protocols on this.

- Civil Air Patrol – can't fly offshore. Would be given 3 – 4 hours of continuous video which is hard to get through all that. Lower resolution. Limited by man power – no one available to devote the time to going through video.

Gordon Staples

Spaceborne radar - sees through clouds/weather.

Routine monitoring – do for offshore platforms

Response – task the satellite

Acquire data and then downlink it if within green link (ground station mask) – typically within 3 – 4 hours if can't downlink right away.

GeoTIFF is useful to SAR people, but they put it into other useable formats (pdf, kml, etc.).

Can detect wind speed etc. from satellite info.

12 – 24 hours (summary slide) – can get in 4 hours if officially deemed emergency.

Oscar Garcia

Table of satellites that can use today (blue) satellites that will be available in future (bottom part).

Taylor started 11 years ago after hurricane disrupted oil platform, has been leaking since. Unfortunate occurrence, though taking advantage of it to develop/test technology.

Showed video taken last year – showed surface and aerial cameras together.

Collect surface oil and take to labs to analyze.

Good slide showing 4 views of same shot of Taylor using different sensors.

Need to be there (visually/aerial) when satellite is so can confirm what seeing.

Path forward – take advantage of Taylor, OHMSETT – coordinate and experiment with this.

Mark Hess and Kevin Hoskins

Kevin Hoskins:

MSRC interviewed every MSRC employee that worked on DWH and got lessons learned – efficiently putting resources in the right position day and night to recover oil. Data doesn't do any good if too late. False positives.

Real time tactical information is their goal.

Portability – so can ship and install in whatever aircraft may be available.

ABC slide: Long hang time – up to 12 hours

Mark Hess:

OI – Ocean Imaging

They want to provide information, not necessarily data. (useful information to make decisions, such as actionable oil)

Visual & Digital Imaging Oil Comparisons - Multispec helps digitally isolate different types of oil. Thermal Infrared –

People didn't seem to care what numerical value of thickness is, just "where is thick recoverable oil?".

Swath – cover larger area at once, critical for DWH but for smaller spills even too.

Trained, but not specialist (can have more people able to use system).

Will cover specifics of Level B and C and LandSat in hands on training portion.

Ira Lifer – Chuanmin Hu gave his presentation

There is AVARIS and AVARIS NG. "NG" is Next Generation (this one has just started).

AVIRIS NG has fast turnaround time - 30 km beach in 30 min.

Can tell what is sargassum and what is not by looking at spectral signature (spectral shapes of various floating materials slide)

What is most useful? All sensors combined.

Jean Teo, OSRL

Gave overview of what OSRL is using in other countries.

AirSAR Exercise – released 500m oil and diesel into UK waters. Vessels, equipment, aerial overflights, etc. to look at movement of oil, recovery, dispersant, etc. Lessons learned on "Surveillance Lessons" slide.

Mark Roberts

Able to do some of this work at night.

Things in their "arsenal" right now can help oil spill response community.

"Image intensified" is the typical historical night vision – the green look.

Green with boxes is calibration grid, each box is filled with different thicknesses of oil.

Even night vision goggles at Walmart now could take to beach at night and see if oil is there.

Image intensified I2 “I squared”

SWIR – Short Wave Infrared Imaging. Water is opaque in SWIR, so you just see whatever is on top of it.

Long wave – can tell thickness of oil.

LWIR slide – pre dawn, could barely see oil with eye, shows clearly with LWIR.

Multi spectral approach is best approach. (slide 24)

Plenary Panel after Hands On

Panel to provide reality check.

Judd represents state.

Lisa represents NRDA hat, damage assessment.

Robyn EPA.

Jim Hanzalik – USCG and Oil Spill Response Organization hats

Judd

- RadarSat – radar satellites fantastic for synoptic view. Great tool for first alert. Hundreds or thousands of miles in an instant. False positives are a concern. Led to Ocean Imaging TRAC system to have quick yes or no “that is oil”.
- Always have had aerial observers. Would push to have night vision cameras.

Lisa

- Always have to think about possibility of litigation. Have it “perfect”.
- Small vs. large spills – on small spill can’t pull in 15 imagers etc. - has to balance that.
- One of her needs is to validate any of the products we have. False positive problem etc. Needs to use these products confidently with enough validation from previous experience etc. Needs to know when they say “it’s oil” that it’s oil. Validation is super important to her. Needs to be defensible and stronger validation, for each technology heard about.
- Overflight maps. A lot of people are looking for ways to standardize and make more high tech. Would be great to update and get more info on how far away they are, camera angle, etc. so can use better for long-term NRDA case. There were 5,000 images from DWH. Probably could collect additional info for not much more money and not slow up response people and make big difference.

Robyn

- Big spills vs small spills. What can do for one vs. the other.
- Chuanmin Hu – 6 images all look like oil but only one was.
- Observer techniques – need to spend some time on doing this better. Can't believe less than 5 trained observers right now. More qualitative and less subjective. Handheld instruments.
- Long term – infrared, SAR, multispectral – need to use all of these things to rule out false positives.
- Now is the time to be thinking about having right connections and right platforms so don't slow down data/info – how data gets transferred to an FOSC.
- Short game (aerial observer?) vs long game (includes NRDA)
- What happens when it is not a slick and it is no longer at surface? Not a slick. It is a plume in water. No one talked about detecting a plume, just slicks. Plumes important to damage assessment. What are technologies there for plumes and what need to get us there?
- Great test beds – different types of oils. What happens when a heavier one from pipeline leaks? Looks different from Louisiana crude.
- What about big rivers and big lakes we also need to be aware of? EPA is responsible inland

Hanzalik

- Short vs. long incidents. Days vs. months.
- What is most effective way to get to oil in quickest way possible and best way to do it? Burning, dispersant, boom, etc.
- FOSC gets call. What resources put on scene first?
- At night, used to have to go at first light. Now could use night vision or thermal imager etc.
- Having best tools helps with the trajectory, which is what all decisions based on – important. Infrared good tool.
- Problem saw: trajectory info looks like a cartoon. Giant blob. When actual picture see 90% sheen. Find where most of it is and where actually need to go.
- Macondo event looked like major spill occurring every other day.
- Was using snorkel scat to try to detect tar balls.
- Thermal imaging – lots of ways can use this information, to track oil at night.
- Balloon systems – keeping vessels in sweet spot – use that resource most effectively. In DWH didn't always have vessel in best spot – not always directed.
- Lots of good tech available, just need to integrate it.
- And get info to right people at right time to make right decisions.
- Lots on info can come from these technologies – but who does it need to go to and how does it get there?
- Geotagging info is good for use down the road.

Day 2

NASA – Kathleen Jones

UAVSAR – L band synthetic aperture radar. Designed with ambient air cooling. Refreshing memories from yesterday. Can discern from radiometric backscatter intensity where...is (characteristics of oil?)

- For thick oil slicks we can estimate the volumetric oil concentration from....(see slide)
- Can tell from tidal oscillations how long slick has been on surface (can see when convert to volumetric fraction).
- Can do polarimetric decomposition of data where relate it to entropy and anisotropy.
- Participated in Norwegian oil on water experiment with UAVSAR June 2015. They set up experiment which allowed them to do a validated test of volumetric fraction of oil. Mixed up different emulsions of oil. Flew UAVSAR and had buoys in water. Between 40% 60% and 80% oil in mixture. Also used plant oil as biogenic slick simulator. Did onboard processing. Data georeferenced. 80% stuck around longer than 40%. Plant oil slick became circle and stuck around longer than other oils.
- Low signal to noise ratio is incredibly important.
- Have done oil on ice theoretical models. That where she wants to go next is to use this instrument to study oil on ice and develop this capability to respond to oil on ice.

Jamie Holmes – DWH multi sensor assessment

Presentation Overview: What did during DWH, what wish we had done, what did for Taylor, what do for next big spill?

P.2 – group became Oil on Water Group. Formed AFTER spill

p.3 – these are the sensors they looked at

p.4 – had lots of SAR coverage because everyone pointed at Gulf once spill started.

p.6 if weather is not good, image is useless

p.7 only had one day. If had AVIRIS coverage from whole spill would have just used that, but didn't.

Presentation is great overview of pros/cons of sensors.

p.10 Landsat TM image

p.11 MODIS is based on AVIRIS

p.12 is outcome of p.11

p.14 model put together to use in NRDA assessment but settlement occurred before actually got to use it.

p. 15. A is a 1 km pixel. B is size of MODIS visible pixel.

p. 16. MODIS image. When good weather conditions get nice image.

18 and 19. Priority of thick areas based on different sensors.

P 22. Relied on weight of evidence looking at bunch of different sensors.

p. 23 Usually use toxicity testing to do this for NRDA – want total PAH concentration, which they don't have. Learned oil on surface is highly heterogeneous – even in beaker thickness varied by more than order of magnitude.

The settlement stopped some interesting work.

Questions: During spill Navy had some classified info that was taken. Answer: Didn't see but was assured it didn't show anything additional that they weren't already seeing.

George Graettinger – DWH SAR Applications

Following up on Jamie's presentation.

Focus NRDA on EXPOSURE piece (see graphic).

Even think sheen can have big impact.

SAR data added significant value to traditional methods they employ.

NOAA NESDIS created guide to delineation of oil – quick for response.

A methodology published in 2009

Exposure persistence – over time how often was that area oiled?

If within 3 km of shoreline, assume it will hit shoreline.

SAR use in NRDA (slide title) – using existing data to help us.

Satellite analysis is supplementing data collected.

Used available data to add value to his program.

Questions:

Jessica Garron – had not seen SAR data used in data fusion like this before. Loves it.

Total area of oil increased by 40%, volume decreased by 21% - paper in final review, that's what see once they started application of subsea dispersants.

Dave Pallandro 2 questions:

What have we learned? Multi sensor approach is way to go.

Satellite data have two masters – one is Response and one is Assessment. What can we do so have to stop analyzing it 40 times – do it once and get it right. Answer: absolutely, pushing for data agreements, and get further coordination with ARD and ERD. That is why doing this workshop with both Response and Assessment.

Michelle Jacobi – UAS

There is a definitely gap and niche in response that could be filled by UAS - have just touched ice berg of possibilities and need to strive for this going forward.

UAS fill need to assess areas with limited access (burning, sensitive habitats, not able to access etc.)

If you collect well and right, should be able to use these data sets for both response and assessment – just need preplanning. Collect once, use many times – should be motto – saves money and resources.

Use to inform trajectory models, skimmers, etc.

Human/socio – will always be a security concern with UAS with taking pictures of people.

They have done some trials. Working with industry, sanctuaries, CA, etc.

Flew at 300'.

Did tests offshore on water using dye.

Refugio (“Process/Timeline” slide) – there was security concern to fly with other manned aircraft in air. Probably only reason finally approved was change of staff and person flying drone knew helicopter captains.

PUMA High Resolution Nadir camera – was nicer image – this sensor is of interest going forward.

Lessons slides – their office has interest in improving information flow – who is it going to in response, who in assessment. How quickly will have info?

Future deployments for UAS

- Image recognition – make going through photos more automatic (faster, less staff requirements)
- Ephemeral collections – sample breath of whale for chemicals

Questions: Turnaround time for data was long (part was equipment and assets using). Sometimes these problems are alleviated by using a different system. ASPRS (Pierre) doing some work relative to this and would love to have people join this – active program with training and calibration sites throughout U.S.

Dave Pallandro:

They are getting data 30 minutes after flight. Need to find another contractor.

Stop thinking of UAVs as unique. They are just another remote sensing platform.

Carles Debart, KSAT

Ground station is unique. Polar orbiting satellites always pass over their ground stations – makes it ideal location to access all this data. Today will focus on small subset of satellites – radar satellites.

Radar satellites combined with near real time delivery – allow for oil spill detection and other. (slide 3)

2 hours (slide 4) is unique taking into account the amount of satellites they manage etc.

Not only is it near real time, they can get a lot of data (slide 6) by using all possible satellites.

They don't own or operate any satellites but they own ground station and processing. (slide 9)

Radar satellites and ground station work well together – deliver super-fast and all these platforms (addresses need for quick data)

Had spreadsheet of satellites if spill today off of mobile – when need to be ordered by, when will be tasked, etc.

Right data and right time from multiple satellites allows for better coverage.

Question: what is our access for this type of info through NESDIS? Davida: Access is limited if it is routine. If disaster can get pretty much all of this. Can get direct from vendors, but not KSAT.

Pierre

- Multi modal response is very important. Doesn't mean just SAR.
- Have a plan B – sometimes don't get satellite tasked, maybe some other need overrides, maybe broken, etc.

Breakout Group Report out - 1st Session, Day 2

Group B report out – chemical samples (means of floating oil itself)

Group C

- NRT is “near real time”
- r/s is “remote sensing”
- res is “resolution”
- “see above” means the line directly above regarding human resources

Group F

- Talked a lot about guides – one for non-technical people
- Maybe matrix that matches tools to need (could be in a guide)
- Logistics – channels in ICS, get info can use and avoid post processing

- Capitalize on spills of opportunity
- Ice
- others

Breakout Group Report Out – Session 2, Day 2

Subsurface need - Other group concluded optical probably isn't useful either because need to sample below surface to validate, so might as well just measure it directly. Maybe by UAV? Europe(?) has UAVs ready to deploy if needed.

HALO should be HALOE (group B)

Group B other items other than oil

- Better data capture = PDAs etc

Group B Oil Observing

- Improving old school methods might be good place to start

Breakout Group Report Out – Session 3, Day 3

Group C Report out:

Group spent most of time talking about job aid for remote sensing

r-s = remote sensing

mutual aid agreements – between agencies and also with organizations/companies that provide technical services

Group D:

Found it hard to fit remote sensing into small laminated job aid, might be useful to have instead (manual? Handbook? What was word?)

Work Derek is doing drove much of their conversation. Has sensor assessment procedure flow chart.

- Determining Sensor Suitability Index slide – a decision matrix
- They have an interactive spreadsheet system and an online system they are working on. Spreadsheet will be a product of their one year effort. One year is up now – currently in extension. End of Dec 2015 is end.
- Dave Pallandro and EPA both really likes his work.
- The idea is to maintain the database in the future and continually update it as sensors develop.
- Lundgren – human observer is included in their group's worksheet, but not included in Derek's work. We will always have human observers, so need to keep this in mind.

Group B:

Job aids are used for variety of purposes – not just sensor selection. (to collect specific kind of data, talking points to make a case for something, etc).

They also talked about a synoptic sampling job aid:

- Communication tool
- Decision making tool
- Data collection guide

Full spectrum of remote sensing tools should be in job aid.

Have job aids provide references – links to further resources/document, and contacts who are experts can contact further.

Group F:

Judd points out that standards we listed are very important.

Group A:

JIC/PIO might just be 2 page document instead of job aid.

Clearly state who job aid is for, and clearly state what it does, and what it doesn't do.

Don't limit sensors – all ones that have been used and will continue to be used. Be very clear what each can and can't do, pros and cons.

Separate sensors from platforms.

Should be a living document.

Don't start from beginning – Pallandro has 6 job aids sitting on his desk.

An iPad app would be great.

Short vs. long response – break recommendations down this way.

Group by "should work" "might work" "won't work".

Have points of contact, but then needs to be living document.

Group E:

3 copies of document - #1 in file name is the one to use

They focused on one job aid – for planning stage for responders. How does person in planning stage know what to order up front and how to order it in way of remote sensing technology?

Planners would still use remote sensing experts to help them determine what to use.

Path Forward

Job Aid, and collect all good related resources in one place. Won't start from scratch.

Action items that were not taken forward to subsequent breakout sessions will be posted on website and used going forward.

APPENDIX F

Appendix F - Hands on Training Notes

Overflights

Camera, gps, notebook, maybe a basemap – have on plane

Return from flight and someone puts into MapSource

MARPLOT – was taking 2-3 hours to convert map, advertise 1 hour so that took too long, decided to try using MARPLOT instead and it worked. MARPLOT is a viewer – they don't do analysis there – can create a map without having to go to a GIS person. There are people interested in using MARPLOT that aren't currently.

Showed what do with data once done with flight. Make map showing overflight, enter notes which show on map. Can also add photo points to map. They did this at Refugio and it went well – whether people want photos depends on audience.

Challenge is when Jeff walks into room he is pulled in 4 different directions, when needs to get with Dexter (GIS staff), and Dexter is also getting pulled in 4 directions. Electronic data capture would help with this.

Would be nice if people can create map without GIS person if one is not available. Since it is still tied to ARC, that's not possible currently.

ARD needs to coordinate with ERD so that ERD collected data which eventually gets pulled into ARD is helpful to them. Ian for example had suggestions of what would have been useful – official protocol, do always note sargassum etc.

SAR

OCAP – On Call Acquisition Planner (available during non-business hours). You give them info, then they go about acquiring satellite data. They can make recommendations for what might be helpful (e.g., polarized vs. not). Contract has to be in place to make order. Feds have that, and most large oil companies.

Swath width vs. resolution is a tradeoff – larger swath gets less resolution.

Their most common is 50 m resolution, 300 km swath.

Routine is 12 hour acquisition window, 4 hour if deemed emergency but difficult to get this.

Assigns confidence intervals to what they see – based on knowledge of area and what see etc.

Can add wind direction.

Worldwide coverage except for a part of Arctic and Antarctic and some countries (Iran etc.)

When you call MDA they also call/access other satellite companies, so accessing them all.

Landsat, TRACS

Gave group choice of two topics: 1) more on processing of data, 2) processing of LandSat data which is not rapid response (every 16 days unless get lucky) but it is valuable in NRDA. Decided on #1.

Processing of airborne data for tactical use.

- What kind of plane can it fly on? Can't fly on pressurized plane, portholes not right size, etc. All things need to consider.
- Can check it on commercial aircraft without it being damaged.
- Visual observers still very important – first step is them looking out window to determine what to image.
- Rocky intertidal zone is one of most difficult areas – lots things growing on rocks that are black and absorb heat.
- Flights in morning/afternoon to avoid sun glint.
- Need to know intended purpose of acquired data.
- If going to upload/offload data be sure have good internet connection – important for getting info needed in time to make decisions.
- They are working on developing something that sends it 4 megabits/second.
- COP – common operating picture
- 2 – 4 hours. Internet connection in Refugio lost them 2 hours trying to transfer data. Want to get it down to 1 to 2 hours. Can go back later and make a different version for NRDA etc. that would take more time.
- 3 – 5 pixels right now as far as geo referencing
- Need combo of multispectral data and thermal data to really identify what have – coregister so one of top of other

Night Vision

Incorporated I2 with thermal channel – get advantages of both, one passed around

Can give these to other federal agencies, but not private entities.

When they stopped production during Refugio the seeps started producing like crazy.

Great video at pre-dawn, when could barely see with eye. Just leaning out of helicopter with it. Not processed, straight raw video.

In the Army they do everything at night that they do during the day, because of night vision etc. Advantage of this to spill response.

Thicker stuff appears darker.

Pre-dawn (total lack of solar energy) and mid-day (complete overwhelming solar energy) they have found are best times to image. Images get flipped/reversed.

Cooled sensor – do not recommend \$60,000(?)

\$30,000 camera

Varying degrees of these down to \$100.

Goes from very very good resolution to not good resolution but still adequate.

Some integrate directly to iPhone or Android.

Need multispectral approach. Helps differentiate false positives.

Windtack – something he mentioned for future?

The stuff showed today is available “today”, not just for future.

Balloons and Vessels

Level B or “balloon”

Battery powered (bring down every 12 hours or so) or run power through tether

Includes HD camera, TIR camera, AIS repeater

They can direct the camera with pan and tilt control.

Limited to 500 feet

Very hard to fly close to airport (5 miles?) – almost impossible to get approvals.

There is a cut down system in case it comes off tether. But never had to activate it.

Maximum winds 34 knots. Image is pretty stable even when windy.

Have flags on tether so can see. Have tether lit if flying at night. Both every 50' for over 150'.

Examples of what it will produce.

Can look at 100% optical or 100% IR or anywhere in-between with slide bar. Helps to vet false positives.

If see it in optical but not in IR it is probably not worth going after because it is likely sheen.

Balloon linked via Wi-Fi connection.

Put crosshairs on something you see and get lat long. Can go look at it with boat etc.

Can take screen shots of what seeing.

Can switch from white hot to black hot with IR.

Can overlay it onto chart/map.

Have deployed at day, at night, from pickup truck (shoreline applications perhaps). Have their own way to send info from balloon if need/vessel doesn't have it. Approximately 70ft might be minimum vessel size. Need deck space to lay it out.

Can use to direct skimmers.

Have to maintain below 34 knots – what is wind and what direction heading to determine how fast can go from one spot to another, or reel it in in 10 minutes.

Can do this 24 hours/day.

4 nautical miles is range of ability to detect.

Radius, 3,000 ft, ability to quantify relative thickness (aerostat from MSRC)

3 locations – Long Beach CA, Houston TX, New Jersey

Level C – close in

- Close proximity to vessel. Real time.

APPENDIX G

First Breakout Session **Response, Damage Assessment and Restoration Needs and Gaps**

Group: A	Group Lead: Robyn Conmy	Group Recorder: JB Huyett
What do you need?		Why do you need that?
Remote Sensing Quick Reference Guide		To give operational advice to response. Need catalog for a variety of scenarios and platforms based on where they are most useful (nearshore, inshore, offshore systems, operational, monitoring, wildlife, etc.). Small reference guide, one page (Example: API quick reference guide). Points of contact.
Photo documentation of exposure (time series)		To evaluate exposure and damage to resources. Need for both Response and Damage Assessment.
Near real-time standardized remote sensing observations (human)		To increase the utility of flexible human based overflight observations. Using best available equipment.
Validation for false positives		A quick validation for false positives either from a handheld system or coordinated multi-sensor system.
Formal remote sensing roles in ICS		Standardized role within ICS for remote sensing; either the SITL, Tech Spec, or a full unit. Scaled based on incident to provide technical advice to the Situation Unit, Planning Section, Operations on available tech. Also the conduit for data ingest and management.
Infrastructure for data transfer based on need		Both short term and long term data needs (response vs. NRDA). Example: transferring operational data processed on the platform to Operations or ICP. To make the usable remote sensing information available to the needed audience at different time scales.
Augmenting SMART protocols to include remote sensing		Limited observers and need to validate the data. Example is flourometry. Need to validate whatever dispersant operation is being used with spotter craft or remote sensing.

First Breakout Session

Response, Damage Assessment and Restoration Needs and Gaps

Oil on water radiometry for calibration validation	Need calibration validation exercises to give us a baseline for actual response validation.
Night observations	There are approx. 12 hours unobserved during an Op period. Need this for operational response, wildlife ops, ephemeral data collection. Multi-sensor approach (i.e. satellite based, aerial, vessel, hand-held).
Remote sensing Oil observations: footprint, source, fate	Need to direct operational assets and reduce impact. The foot
Regional remote sensing workgroups	Need regional specific groups identifying technologies and protocols for remote sensing. RRTs? API
Oil specific remote sensing package on satellites	There are sensor packages for other emergency applications. The oil response community could use a dedicated sensor package.
Real time remote sensing chemical/dispersant monitoring	To validate and use monitoring data to alleviate public perception of dispersant application and the extent of use. Public information
Persistent monitoring of spill location	For continuous monitoring. Could be geo-stationery, airborne, UAS, etc.
Dedicated platform with all sensors for oil identification	For quick deployment to oil spills. Flexible sensor payload to use best available or best for the incident. Could be used for other disasters or emergencies.

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Group: B	Group Lead: Drew Casey	Group Recorder: Cory Rhodes
What do you need?		Why do you need that?
I need to know quickly where heavy oil is.		So I can manage tactical responses.
What is the scale of the oil spill?		Helps select appropriate assets/approach needs to be scalable
What is the rate of discharge?		Helps select appropriate assets
Field data collected using established protocols		Validate remote sensing to make sure it is useful/to inform response decisions in the field
Trained field observers and a standardized procedure		Consistency in data collection/identify recoverable/actionable pockets of oil/better use of data for alternate analysis
Manage samples/quality data		Realization that your sample might be the only one collected (need good documentation)
Chemical samples		Evaluate burnability of oil, emulsion state,

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Better understanding of oil below water, sargassum, etc.	Additional questions to answer/helps guide the response
Integrate sampling efforts into response	Information can be used later on/prediction can get better/prevent duplication/validate remote sensing methods
Include academia as technical specialists	Contribute out of the box ideas/enhance subject matter
Unification coordination	Visibility of “side projects”/optimize overlap of data collection
Technology (remote sensing, airborne, surface, and subsurface drones, etc.)	To reduce hazards to people, assess impact to marine mammals, etc.
Mechanism to identify remote sensing assets	Coordinate collection of field data with remote sensing

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Group: C	Group Lead: Gallagher	Group Recorder: Garron
What do you need?		Why do you need that?
Focused coordination effort in response/NRDA community with r-s community (at large)		Many resources out there that aren't being integrated into oil spill response/NRDA
NRT data/imagery to decision-makers in format that is consumable; Data Services into COP		Meet needs of next operational period; leveraging r-s data for quality decisions
Systematically go through r-s tools to determine utility in oil spill id/response/NRDA		So we know what products to utilize in an emergency/NRDA and HOW to use
Imagery + interpretation = Information product		Accelerate ability to consume r-s data in response/NRDA
Collect once		Analyze twice (both in response and NRDA)
Spatial extent of oil of all thicknesses		NRDA
Water content of emulsion		Impact on wildlife

First Breakout Session

Response, Damage Assessment and Restoration Needs and Gaps

Spatial expansion of oil in a daily basis (obs)	Fate and transport, sans modelling; what got exposed to it
Set of criteria for COP	Sensor developers can support COP and response
Data on an operational period basis in ICS	Making tactical decisions to deploy resources in ICS
Solid infrastructure for data collection and delivery	Consistent infrastructure that is reliable
Appropriate res for appropriate use without delay	Delivery of operational data to remote areas without quality communication infrastructure
Drill more on complex data integration	Be able to fully utilize data in response
Drill on data use/integration	More people able to use information for decision-making and ops
When did oil reach my resource/how long did that condition persist?	Exposure of that resource and potential injury assessment
Where is the oil and where is it going	Resource deployment in front of oil leading edge

First Breakout Session **Response, Damage Assessment and Restoration Needs and Gaps**

Tactical support with r-s data	Directing dispersant use, ISB, (see above)
Military UASs in response setting	Greater payloads
Response community to track other things, not just oil (e.g. animals, sea weed, etc.)	First opp to id exposure, ability to id false positives to improve response and NRDA
Use spotter aircraft for actual collections	Save time and resources
Use UASs for more than observations	e.g. Dispersant delivery
Track oil other than actionable oil	Still important for NRDA
Sensor calibration for emulsified oil	Understand sensor representation of different emulsification levels below surface (greater than 6 inches below surface)
Synoptic sampling of a sat image/plane/boat,	NRDA validation; scalable ground truthing
FAST Synoptic sampling of a sat image/plane/boat	For response

First Breakout Session **Response, Damage Assessment and Restoration Needs and Gaps**

NRT air chemistry data stream integration	Data fusion, validation of r-s obs and ground truth info
Near water air chemistry sampling	To understand exposure of nat. res. At air:water interface
Partnerships with countries that can spill oil in water	Field testing of tech
All samples and photos with spatial-temporal info of sampled area (not where observer is taking photo from)	We know what we are looking at and where and when
Standardized methodology for capturing obs data	Quality data to meet need of response and NRDA

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Group: D	Group Lead: Scott Lundgren	Group Recorder: Lexter Tapawan
What do you need?		Why do you need that?
Offshore, nearshore – know where the thickest part of the oil is located. Frequently or real-time.		To direct tactical resources (mechanical recovery, dispersants, in-situ burn)
The footprint and variation of thickness, where the oil is located on a daily basis.		To initialize oil trajectory model.
Measuring many points per pixel in a short time-frame. Standard sampling measurement in-situ to validate. Classification of images. Measuring thickness.		To validate for remote sensing applications.
Giving out real-time data. Ground-truthing of observations.		To validate where ops would go (SCAT Teams, etc).
An expert in the preparedness phase and command post for remote sensing capability management.		To identify the most appropriate remote sensing methods and applications.
Quantitative of analysis of oil on the surface within a given grid.		For injury quantifications.
To inform on development and products of the latest sensors and the kind of spills they're going to be used in.		Tasked by BSEE to develop a framework and decision tools for sensor selection

First Breakout Session

Response, Damage Assessment and Restoration Needs and Gaps

Persistence and movement, subsurface, co-location of the surface with the underlying of water	For exposure of planktonic animals within
Chemical composition of oil on the surface, above the surface, and below the surface.	To help determine exposure and injury to the resources
Subsurface and surface plume tracking sensors.	To determine sub-sea dispersants efficacy.
Repeated observations of the same patches of oil – continuously	For trajectory model validation.
Better inversion models to better discriminate look-alikes. Ways to better quantify.	To classify type by volume. To identify and quantify.
More trained oil observers and analysts.	For rapid response and to decrease error rates.
Modernizing some response equipment (camera, GPS, etc)	Aerial observations and to support multiple use
Knowing where the oil is in relation to ocean feature extraction – convergence areas, eddys	Co-occurrence of organisms and oil.
Where shoreline oiling has occurred, when, and how much (quantitative determination). Integration with SCAT.	To target resources for cleanup.

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Group: E	Group Lead: Peter Murphy	Group Recorder: Samira Daneshgar
What do you need?	Why do you need that?	
I need to know quickly where heavy oil is.	So I can manage tactical responses.	
Trajectory predictions	For planning acquisition & response	
Flow rate of surface and subsurface spills	To figure out the amount of dispersant needed to be applied + general equipments that we need to use + scope of the problem+ Assessment of the damages after the disaster	
Acoustic noise levels of the response operations	Develop standards for potential harm to marine mammals and other sensitive species	
Information about the impact on the animals	Document these information in order to respond	
Di electric of different mixtures of the oil with water, at different temperatures	To better understand the detection of the oil and do the calibration to aid in	
How effective the dispersants are with aerial equipment	Sensor confirmation, calibration of what was monitored by coast guard through smart monitoring	

First Breakout Session

Response, Damage Assessment and Restoration Needs and Gaps

Adding atmospheric hydrocarbon sensing from aircraft	How much oil remained on the surface before applying dispersant for addressing volumetric measurements and effectiveness
Understanding the effectiveness of the subsurface dispersants	In order to tune the dispersant application and better understand its transport and distribution in the marine environment
Having a common awareness of the sensing, capacities that exist and how to access them	Institutional knowledge or relationship based so having a common understanding and capture of the process is important
The formal structure and mechanisms to access the expertise (MOU, contracts etc)	In order to be able to access assets and expertise quickly
Technology transfer from public private and science/operational etc	Unawareness of different technologies being developed and how they are used. Issue of funding
What level of detail is expected from the product that we need? (Requirements) Aerial needs and satellite needs development of the job aid for developing request	To guide the response person in selecting sensors and mission profiles
Georeferenced aerial observations	In order to deploy assets operationally and to aid in later assessments
Increase connectivity and rapid downlinking of the data from the field (Latency)	In order to have rapid response
Integrating more advanced technologies into drills and exercises	To make sure that it will work when we need them

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Standardize and practical data access and management	There are access problems in terms of who can have access to data. There are issues with formatting and ownership.
Model measurements to quantify the effectiveness of the in situ burning	There is no standard to quantify the effectiveness of the in situ burning building on the atmospheric modeling and surface residuals

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Group: F	Group Lead: Judd Muskat	Group Recorder: Laura Belden
What do you need?		Why do you need that?
Run an experiment at OHMSETT for quantitative assessment of oil thickness for a whole range of oil sensing platforms.		Knowledge of oil thickness if of great importance for response operations and oil spill assessment.
Develop a full polarimetric SAR drone		That will be most efficient tool to detect location and quantities of oil.
Oil locations and thicknesses in timely fashion. Where is oil at that moment in time.		To initialize models and validate them. So can predict trajectory.
Trajectory based on oil location and thickness and modeling.		As responder to plan response.
Better identify oil thicknesses and ice densities/ice conditions in timely fashion		To respond to possible spills in Arctic
A general footprint of possible oil that an aerial observer can then ground truth		To plan more detailed observations and assessments. So trajectory modelers can not only see footprint of oil but understand heavier oil.

First Breakout Session

Response, Damage Assessment and Restoration Needs and Gaps

Guidelines or job aid or manual for what works for what. (e.g., to determine optimal mix of sensor packages)	To be able to ask for the right tools to get the info you need. To get at false positive question.
A realtime delivery of useful information in a digestible format, including interpretation notes	Eliminate post processing. Deliver as cleanly as possible for insertion into GIS. Because there is so much confusion/activity.
Multiple sensors on single aircraft	Multiple sensors is more information, better data.
Facilitate cooperation from all available assets across competitive entities.	More info quicker
Have a defined path to follow to ensure get these tools where need them in timely manner (including logistical hoops to jump through).	Get needed information more quickly
Manual or educational tool for incident commanders so they understand these tools are out there and how they can help them.	
Dummies guide (quick reference guide) to sensor packages with capabilities and limitations. For non technical audience.	To help explain to incident command, and help the people trying to explain it to them.
Validated proven technology during a response	We have to trust the information. Response is not the time to be experimenting in general.
A mechanism to evaluate tools during a response.	Continued learning and experimentation under real world spill conditions because we cant spill oil in environment for research (spill of opportunity).

First Breakout Session
Response, Damage Assessment and Restoration Needs and Gaps

Guide to include appropriate tool for size of spill.	So we employ appropriate tools.
Know more about oil characterization – water content, potential toxicity	To assess response technologies and potential threats.
True Oil thickness (not assumption of oil thickness)	To estimate oil volume
Know what else is out there that is of importance in addition to oil (oceanographic features, resources at risk)	Oil is not the only thing we need to know to make prioritized response decisions.

Second Breakout Session

Group: A	Group Lead: Robyn Conmy	Group Recorder: JB Huyett
Response, Damage Assessment & Restoration Need/Gap	Remote Sensing Operations (skimming, dispersants, burn, night operations)	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	All water bodies and shorelines	
Technical Limitations causing the gap	None identifiable. The systems available today and the data collected can be effectively used to direct operations and evaluate their effectiveness (not taking into account logistics, cost, or delivery). There are no technical limitations but there are operational implementations that can compound actual use.	
Other Issues or Limitations causing the gap	<ul style="list-style-type: none"> -Best practices. Calibration and validation of effectiveness. -Weather conditions either for flying airborne systems or satellite. -Time to deployment of remote systems. -Time to delivery from certain systems. Not near-real-time enough. -Cost -Finding equipped platforms or systems - Weather limitation and sensor effectiveness under specific conditions 	
Potential Technological Solution (i.e., an old technology that could	<ul style="list-style-type: none"> - Optimize your sensor to meet your environmental conditions. - Have multiple sensor plans established in advance- in a perfect world. 	

Second Breakout Session

be applied or a new technology that could be applied/developed)	-Combination of technologies to be used synergistically- spotter planes with combo of sensors used co-incidentally. - high definition images and video
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	<ul style="list-style-type: none"> - Technology is ready but optimization and combo of sensors into package of opportunity is lacking at the moment; - 3-5 years
Cost to adapt technology to oil observing (>\$100,000; 100,000 – 500,000; <500,000)	< 500,000 k to do optimization, training, testing, deployment and access. Regional specifics needs???
Logistics for deployment (e.g., need airplane to fly it in)	Need airborne or subsea platform. Go kit sensor box would be needed to be created and staged for access.
Other Notes	If aircraft grounded then you are into Satellites and limitation is the existing sensors.

Second Breakout Session

Group: A	Group Lead: Robyn Conmy	Group Recorder: JB Huyett
Response, Damage Assessment & Restoration Need/Gap	Ice	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Anywhere there is ice. Oceans, lakes, etc.	
Technical Limitations causing the gap	<p>Significant technical limitations in identifying oil under ice:</p> <ul style="list-style-type: none"> -Difficult to differentiate oil from ice on remote sensing systems, most sensors could not determine if returns are ice or oil. -Instruments are not necessarily designed for extreme environments. Not sure how typical in-water equipment would operate in harsh conditions. 	
Other Issues or Limitations causing the gap	<p>Weather/Conditions: cloud cover and weather conditions make remote sensing limited. Time of the year is</p> <p>Logistical challenges: transporting equipment and assets to remote locations. This would limit systems to satellite based or delayed airborne / UAS systems. Relying on minimal infrastructure in remote locations, either due to location or conditions. No contractual</p>	

Second Breakout Session

	<p>agreements for equipment or data collection for remote or oil in ice scenarios.</p> <p>Secondary releases: if oil is spilled during the growth period or is encased in ice once it melts could release oil in other locations based on ice flow and currents.</p>
<p>Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)</p>	<p>Oil in ice:</p> <ul style="list-style-type: none"> -There are two components to oil in ice. First finding oil in ice, then tracking the ice flows to monitor transport of encased oil, and finally identifying oil releasing from the thaw process. -Current operational practice is manual augering to identify oil / no oil. This is not viable since it requires someone on the ice. This is a logistical as well as safety issue. -Ground penetrating radar (GPR) is the only operational option for identifying oil in ice or snow. Nuclear Magnetic Resonance is another option and has been tested and is viable but the challenge is differentiating hydrogen protons between water and oil. Helicopter is the most plausible platform for these two systems. -Underwater vehicles and sensors are potentially useful for the first 72hours of a spill, if the ice is in a growth stage, after that the oil is encased in ice. -One option is using light contrast; shining a light up through the ice and the oil makes a contrast on the surface. -Acoustics could be an option but testing was not promising. -Dogs used for oil identification in ice or snow is a possibility. See Dog SCAT, also avalanche rescue dogs would be a starting point. <p>Current Projects working on oil and ice: See IOGP Arctic remote sensing. NASA Arctic</p>

Second Breakout Session

	Colors project.
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	3 – 5 years
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	Millions
Logistics for deployment (e.g., need airplane to fly it in)	See other issues/limitations.
Other Notes	An A, B, C multi plan approach is needed for equipment including identifying contracts and ownership. Includes maintenance.

Second Breakout Session

Group: B	Group Lead: Drew Casey	Group Recorder: Cory Rhodes
Response, Damage Assessment & Restoration Need/Gap	Other Data (sargassum, kelp, sea grass, convergence zones, sediment plumes, algae blooms, ships, oil rigs, sun glint, wood, floating debris, bottom reflectance, various substrates, physical oceanography and meteorological data, megafauna, surfactants, boat wakes, false positives, water turbidity, plankton blooms, etc.)	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Some or all of these data attributes will exist in all environmental locations.	
Technical Limitations causing the gap	Geolocating other data, multispectral vs. hyperspectral data, people who are trained to work with hyperspectral data	
Other Issues or Limitations causing the gap	Observer's eye, number of trained observers, multitasking to capture data, crowdsourcing: legal constraints	
Potential Technological Solution (i.e., an old technology that could be applied or a new technology)	Feature/pattern recognition (1-2 years; > \$500,000) , crowdsourcing (currently available; \$100,000), better data capture (1-2 years; \$200,000) voice recognition, custom software for analyzing hyperspectral data (3-5 years, \$5 million), neural networks and shape fitting)	

Second Breakout Session

that could be applied/developed)	algorithms (3-5 years; \$5 million
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	
Logistics for deployment (e.g., need airplane to fly it in)	
Other Notes	

Second Breakout Session

Group: B	Group Lead: Drew Casey	Group Recorder: Cory Rhodes
Response, Damage Assessment & Restoration Need/Gap	Real time (capture) of data (ops/planning section, wildlife teams, NRDA ephemeral data collection)	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	All environments	
Technical Limitations causing the gap	Communications, location, capacity to process the data, availability of remote sensing assets,	
Other Issues or Limitations causing the gap	data management, number of available trained personnel, accessibility (Arctic)	
Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)	Microwave-based air-to-ground communications system (currently available; \$60,000-70,000), advancements in/complete on-board processing (currently available; \$2 million), sea-level drone (currently available, \$250,000), AUV sensors (currently available, \$100,000 per sensor), more remote sensing airborne or orbital assets (currently available; \$1 million - 100 million), HALO platform for oil spill response (under development)	

Second Breakout Session

Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	
Logistics for deployment (e.g., need airplane to fly it in)	
Other Notes	

Second Breakout Session

Group: B	Group Lead: Drew Casey	Group Recorder: Cory Rhodes
Response, Damage Assessment & Restoration Need/Gap	Oil Observation	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	All environments	
Technical Limitations causing the gap	Available accessory equipment (e.g., cameras, night-vision capability),	
Other Issues or Limitations causing the gap	Trained personnel, angle of observation, distortion of image (aircraft), sea state, weather, limited utility of equipment during night flights	
Potential Technological Solution (i.e., an old technology that could be applied or a new technology)	Better IR/thermal equipment for use during day and night (currently available; \$25,000-100,000 per system), more camera pods (currently available; \$25,000)/portholes/open window viewing, digital georeferenced photo subjects (currently available; \$50,000-100,000)	

Second Breakout Session

that could be applied/developed)	
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	
Logistics for deployment (e.g., need airplane to fly it in)	
Other Notes	

Second Breakout Session

Group: C	Group Lead: Gallagher	Group Recorder: Garron
Response, Damage Assessment & Restoration Need/Gap	Subsurface	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Range of Water column, Arctic, river, open ocean	
Technical Limitations causing the gap	Penetration depth from surface remote sensors Communications from under ice sensors Data delivery infrastructure from subsurface Power limitations for lighting area for optical observations	
Other Issues or Limitations causing the gap	Ice when trying to image from air Mass spec needs refinement Mobilization logistics	
Potential Technological Solution (i.e., an old technology that could be applied or a new technology)	Sonar Floats/AUV/glider profiles with acoustics and optical Refinement Fluorescence from bottom up/ top down On-board sampling Pre-deployment of sensors and platforms	

Second Breakout Session

that could be applied/developed)	
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	Current-5 yrs RFI for sensors and platforms
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	\$1-5 mil.
Logistics for deployment (e.g., need airplane to fly it in)	
Other Notes	Mass spec that works at depth

Second Breakout Session – Note Taking Template

Group: C	Group Lead: Gallagher	Group Recorder: Garron
Response, Damage Assessment & Restoration Need/Gap	Oil Thickness (volume, footprint, flow rate) -is it skimmable, burnable -technology scalability for volume calc that is defensible	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Arctic, warm oceans, lakes, river, test basin Small-scale spill vs. Large-scale (tech may not work for both)	
Technical Limitations causing the gap	Qualitative (response) vs. quantitative (NRDA), and which has been calibrated? Imaging microwave radiometer sensitivity (beyond 0.1 mm – 5 mm) Verbiage - make sure we are all talking about the same thing vol per area to ascertain order of magnitude radar limitations in general (footprint, polarity, etc) EO can only generalize (not how thin or how thick, just thick or thin) SAR not usable outside of 1m/s-15 m/s	
Other Issues or Limitations causing the gap	Oil spill heterogeneity Private holdings (tech may already exist but is not accessible) SAR Quad-pol calculations require experts SAR Quad-pol interpretation requires experts Subvert the dominant paradigm (thick vs. thin is NOT only concern, true quantification)	
Potential Technological Solution	UAVSAR (quad-pol, not really taskable; not as effective on fresh due to dielectric	

Second Breakout Session – Note Taking Template

(i.e., an old technology that could be applied or a new technology that could be applied/developed)	constant) 1-2 yrs Private holdings (tech may already exist but is not accessible) 5 yrs AVIRIS quad-pol SAR (beyond UAVSAR) multispectral imaging (EG TRACS) quad-pol UAS SAR RISAT (circular polarity; alternative perspective on oil) LIDAR Thermal wavelength imagery Hyperspectral Human observations
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	RFI for airborne and satellite-based thickness indicators
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	\$1-5 mil.
Logistics for deployment (e.g., need airplane to fly it in)	Satellite, airborne, UAS, AUVs, boat
Other Notes	Adapting DoD developed tech for this environment

Second Breakout Session

Group: C	Group Lead: Gallagher	Group Recorder: Garron
Response, Damage Assessment & Restoration Need/Gap	Trajectory Modelling	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Arctic ocean, rivers, lakes, open ocean	
Technical Limitations causing the gap	Expertise for execution and interpretation Input data (r-s data NEAR REAL TIME, SAR, SLAR, slick location, meteorological and oceanographic data, thermal)	
Other Issues or Limitations causing the gap	Not able to add oil to ocean to test	
Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)	buoys geostationary satellites (GeoCAPE; hyperspectral, thermal; by 2025) refine algorithms	

Second Breakout Session

Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	Currently available (except new satellites)
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	<\$100,000
Logistics for deployment (e.g., need airplane to fly it in)	r-s data input availability
Other Notes	Need deep sea model for fate and transport (DEEP subsurface currents)

Second Breakout Session

Group: D	Group Lead: Scott Lundgren	Group Recorder: Lexter Tapawan
<p>Response, Damage Assessment & Restoration</p> <p>Need/Gap</p>	<p>Data Delivery (end user) -- response vs. assessment</p> <ul style="list-style-type: none"> -Getting the type of data in a resolution, format, and timeframe delivered to the enduser -Both response and NRDA have time critical data needs -Longer term NRDA data needs (study, evaluation) 	
<p>Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)</p>	<ul style="list-style-type: none"> • Command Post • Land-based group/division • Water-based single resources • Aircraft • Off-site (agency reps, public, etc) • Off-site (science support) 	
<p>Technical Limitations causing the gap</p>	<ul style="list-style-type: none"> • Bandwidth • Lack of standard deliverables (format, etc) • Lack of data protocols • Software compatibility 	
<p>Other Issues or Limitations causing the gap</p>	<ul style="list-style-type: none"> • Cost • Unknown data customers • Personnel/management of data (analysis and interpretation) • Security, confidentiality, proprietary 	

Second Breakout Session

Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)	<ul style="list-style-type: none"> • Web-mapping service for data sharing • Mobile-app developers • On-site testing during exercises
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	<ul style="list-style-type: none"> • 1-2yrs
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	<ul style="list-style-type: none"> • 100,000 – 500,000
Logistics for deployment (e.g., need airplane to fly it in)	<ul style="list-style-type: none"> • Contract employees • Contract for web-based system
Other Notes	

Second Breakout Session

Group: D	Group Lead: Scott Lundgren	Group Recorder: Lexter Tapawan
Response, Damage Assessment & Restoration Need/Gap	Oil/Chemical comp <ul style="list-style-type: none"> • Air • Surface • Water column 	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	<ul style="list-style-type: none"> • Applicable everywhere -- but complicated in the Arctic due to ice, climate, and conditions. Might be difficult in marsh areas. 	
Technical Limitations causing the gap	<ul style="list-style-type: none"> • Software (retrieval algorithms) • Hardware (spectral, spatial, temporal, radiometric resolutions) • Can't determine the type of oil from remote sensing. • Limited ability to penetrate the water column through remote sensing. • Platform (satellite, UAV, balloon, human) -- availability and capability to carry sensors. 	
Other Issues or Limitations causing the gap	<ul style="list-style-type: none"> • Weather • Time/satellite availability • Cost • Expertise/experience • Pre-planning for integration into an incident • Inability to carry out the mission (safety limitations) 	

Second Breakout Session

<p>Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)</p>	<ul style="list-style-type: none"> • Dedicated aircraft deployable <ul style="list-style-type: none"> -Microwave sensor technology -LIDAR -SAR -Hyperspectral (AVIRIS) -Infrared -Night vision • Geo-stationary platform
<p>Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)</p>	<ul style="list-style-type: none"> • > 5yrs for chemistry in the water • 3-5yrs for air remote sensing – currently available (research) • 1-2yrs for volume and water content in surface
<p>Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)</p>	<ul style="list-style-type: none"> • Chemistry in the water >500,000 • Air remote sensing >500,000 • Volume and water content in surface >500,000
<p>Logistics for deployment (e.g., need airplane to fly it in)</p>	<ul style="list-style-type: none"> • Aircraft and satellites
<p>Other Notes</p>	

Second Breakout Session

Group: D	Group Lead: Scott Lundgren	Group Recorder: Lexter Tapawan
Response, Damage Assessment & Restoration Need/Gap	Delivery Infrastructure	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Everywhere. More challenging in remote command post locations and during disasters.	
Technical Limitations causing the gap	<ul style="list-style-type: none"> • Bandwidth • Accessibility/connectivity • Power • Out-dated equipment • Incompatibility of equipment/software 	
Other Issues or Limitations causing the gap	<ul style="list-style-type: none"> • Data standards (naming conventions, how data is distributed, data format) • Volume of data generated • Time constraints • Unestablished work networks • Security requirements • Lack of routine demand for this service 	

Second Breakout Session

Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)	<ul style="list-style-type: none"> • Bandwidth – software compression, portable network stations, pre-planning of data demands, satellite communications/infrastructure • Accessibility/connectivity – remote site data integration away from ICP • Power – portable power • Cutting edge equipment, investments, incentives, or mandates • Incompatibility of equipment/software
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	<ul style="list-style-type: none"> • 1-2yrs
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	<ul style="list-style-type: none"> • > 500,000
Logistics for deployment (e.g., need airplane to fly it in)	<ul style="list-style-type: none"> • Space • Trailer • Software updates (can be done remotely) • Remote areas – need upgrades?
Other Notes	

Second Breakout Session

Group: E	Group Lead: Peter Murphy	Group Recorder: Samira Daneshgar
Response, Damage Assessment & Restoration Need/Gap	flow rate: Airborne chemical measurements size (footprint): SAR (airborne & spaceborne) Thickness: SAR & Hyperspectral and acoustic in water	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	<u>Indeterminate flow rate:</u> Everywhere except for 100% ice-coverage <u>Thickness:</u> Everywhere except on land or under ice	
Technical Limitations causing the gap	<u>Indeterminate flow rate:</u> Dedicated sensor payload <u>Thickness:</u> Additional development and calibration	
Other Issues or Limitations causing the gap	<u>Indeterminate flow rate:</u> Upfront government funding for building up the package (NOAA & BSEE/BOEM) Awareness (conferences & publications) Cannot fly at night <u>Thickness:</u> Cost of making operational systems	
Potential Technological Solution (i.e., an old technology that could	<u>Indeterminate flow rate:</u> Airborne chemical measurements	

Second Breakout Session

be applied or a new technology that could be applied/developed)	<u>Thickness:</u> Creating operational systems and validating methods for application of those systems
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	<u>Indeterminate flow rate:</u> 1.5 years <u>Thickness:</u> 1-2 years for validation 1 more year to make it operational
Cost to adapt technology to oil observing (>\$100,000; 100,000 – 500,000; <500,000)	<u>Indeterminate flow rate:</u> 5,000,000 <u>Thickness:</u> Acoustic: <500,000 SAR: 5,000,000 Hyperspectral: 2,000,000-3,000,000
Logistics for deployment (e.g., need airplane to fly it in)	<u>Indeterminate flow rate:</u> Multi engine turboprop <u>Thickness:</u> Aircraft For acoustic we need AUV
Other Notes	<u>Indeterminate flow rate:</u> Technology already exists within NOAA

Second Breakout Session

Group: E	Group Lead: Peter Murphy	Group Recorder: Samira Daneshgar
Response, Damage Assessment & Restoration Need/Gap	Shoreline oil (data) and habitat <ul style="list-style-type: none"> • Timing and the duration and persistence • Thickness • Avoiding false positives • Multi sensor • High spatial resolution (UAV, georectifying) Hyperspectral (chemical fingerprinting), probably SAR, visible (high resolution), and IR	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Shorelines, convergence zones, ice, and ice-water interface	
Technical Limitations causing the gap	Data latency issue (we need real-time data), quality of the data, access to the assets, sensor capability	
Other Issues or Limitations causing the gap	air-space deconfliction, cost, scalability in terms of efforts, time, and cost as it relates to the size of the incident	
Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)	Multi sensor approach with repeated surveys over time including hyperspectral, SAR, and high resolution visual We need to look at multiple sensors and platforms in order to fill out the gaps for the required schedule Most likely focus on aerial assets for schedules and resolution	

Second Breakout Session

Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	Some sensors are currently available (visible, IR and hyperspectral) SW SARs are also available Unknown for the rest
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	Unknown Robbie Hood & Greg Swayze
Logistics for deployment (e.g., need airplane to fly it in)	Manned and unmanned Aircraft and overall approach for data integration
Other Notes	Follow rapid commercial development of these technologies (UAS) Need to build in the existing workflows

Second Breakout Session

Group: E	Group Lead: Peter Murphy	Group Recorder: Samira Daneshgar
Response, Damage Assessment & Restoration Need/Gap	Validation/ synoptic sampling <ul style="list-style-type: none"> • Calibration and integrating that to the workflow • Coordinating remote sensing acquisition with field data collection • Georeferenced data with standard format (metadata) • Contemporaneous collection • Complimentary sensors based on conditions and target <ul style="list-style-type: none"> ○ Oil types and elements • Calibration events minimum once per incident • After specific types of treatment 	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Everywhere	
Technical Limitations causing the gap	Data integration	
Other Issues or Limitations causing the gap	Cost and logistics-coordination	
Potential Technological Solution	Integration of the mission planning into COPs (scheduling the operations in order to be able to stack them)	

Second Breakout Session

(i.e., an old technology that could be applied or a new technology that could be applied/developed)	Integration into the job aid (standard way of using remote sensing) Looking for opportunities of task automation Sensing technology is mostly available it is more about coordination
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	Sensing tech is currently available The integration is a iterative process
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	Small cost Primarily personnel
Logistics for deployment (e.g., need airplane to fly it in)	Need relevant sensors for the stack
Other Notes	Focus on obvious conflicts first We require precoordination

Second Breakout Session

Group: F	Group Lead: Judd Muskat	Group Recorder: Laura Belden
<p>Response, Damage Assessment & Restoration</p> <p>Need/Gap</p>	<p>Other Data (sargassum, convergence zones, false positives, etc) (could also include upwelling, flocks of birds)</p> <ul style="list-style-type: none"> • Satellites can identify oceanographic features. They can identify oil false positives with validation. Essentially cannot identify biologic resources at risk. • Only some aircraft mounted systems can identify resources as risk, and oil false positives with validation. Aircraft mounted systems are not useful for oceanographic features. • UAS can identify resources as risk but has challenges. UAS not likely be tool to identify oceanographic features. UAS can help identify false positives (though would still want to validate with sample or trained observer). 	
<p>Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)</p>	<ul style="list-style-type: none"> • All suitable for all locations, but have different strenths. • UAS will have smaller focuses and shorter time in air. Suitable for inland response, tight spaces, narrow canyons. 	
<p>Technical Limitations causing the gap</p>	<ul style="list-style-type: none"> • Validation 	
<p>Other Issues or Limitations causing the gap</p>	<p>Sensor type – active/passive</p> <ul style="list-style-type: none"> • Weather • Daylight • Clear skies <p>Target Type</p> <ul style="list-style-type: none"> • Spatial resolution (size of pixel coverage) • Radiometric resolution (active sensors; polarization, passive; frequencies) 	

Second Breakout Session

Potential Technological Solution (i.e., an old technology that could be applied or a new technology that could be applied/developed)	<ul style="list-style-type: none"> • UAS can capture data to help validate satellite data • Ground truthing for validation or alternate or complementary sensor package
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	Currently available
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	>500,000
Logistics for deployment (e.g., need airplane to fly it in)	How do you integrate data from multiple sensor packages
Other Notes	

Second Breakout Session

Group: F	Group Lead: Judd Muskat	Group Recorder: Laura Belden
<p>Response, Damage Assessment & Restoration</p> <p>Need/Gap</p>	<p>Sub Surface (submerged oil, droplet size, defining the plume, water chemistry,</p> <ul style="list-style-type: none"> • Radar will not detect subsurface oil • Optic systems have potential but no calibration etc • Thermal will not detect subsurface oil <p>Rest of sheet focuses on optical since that is only known technology with potential.</p>	
<p>Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)</p>	<p>Clear water, shallow low turbidity water.</p>	
<p>Technical Limitations causing the gap</p>	<p>Water clarity.</p>	
<p>Other Issues or Limitations causing the gap</p>	<p>Availability of background data Optical technology needs further validation for this application</p>	
<p>Potential Technological Solution (i.e., an old technology that could</p>	<p>Use some of these optical tools over seep or spill of opportunity to validate and take water column samples.</p>	

Second Breakout Session

be applied or a new technology that could be applied/developed)	
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	3 – 5 years
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; > 500,000)	>500,000
Logistics for deployment (e.g., need airplane to fly it in)	Need optical sensor package and vessel for sampling and various oceanographic conditions.
Other Notes	

Second Breakout Session

Group: F	Group Lead: Judd Muskat	Group Recorder: Laura Belden
Response, Damage Assessment & Restoration Need/Gap	Oil Observation (for response) <ul style="list-style-type: none"> • Supplement human observers with digital tools • Standardize human observer methodology and output • Capture data from multiple observers 	
Applicable Location (e.g., Arctic, shorelines, oil on water, river, open ocean)	Everywhere, all of the above. Would like tool to work in all locations.	
Technical Limitations causing the gap	<ul style="list-style-type: none"> • Georeference target – generalized location ok for response, more specific needed for assessment 	
Other Issues or Limitations causing the gap	<ul style="list-style-type: none"> • Different observers are going to have different equipment and different missions. • Weather, fog, clouds, storm • 	
Potential Technological Solution (i.e., an old technology that could	<ul style="list-style-type: none"> • Issue standard equipment and training 	

Second Breakout Session

be applied or a new technology that could be applied/developed)	<ul style="list-style-type: none"> • For low visibility conditions, use a different tool • Combine all parameters (e.g. georeferencing, low visibility) into a single intuitive tool
Schedule (currently available; ready 1–2 yrs; 3–5 yrs; >than 5)	3-5 years (for supplemented observer with standardized procedures)
Cost to adapt technology to oil observing (<\$100,000; 100,000 – 500,000; >500,000)	>500,000
Logistics for deployment (e.g., need airplane to fly it in)	Need airplane, trained equipped observer
Other Notes	This process could also help address capturing other data (see need #2).

Day 3 Breakout Session

What should be included in a Job Aid(s)?

Group: A	Group Lead: Robyn Conmy	Group Recorder: Michele Jacobi
<p>Who are the audiences for the job aid(s) to meet the needs we have discussed?</p>	<ul style="list-style-type: none"> • Responders- A generalist in the command post- section chiefs, SSCs <ul style="list-style-type: none"> ○ Remote sensing specialist (ICS position) should know the material but would need messaging out. Could have multiple hats (GIS, etc.) • Anyone who might have a need for remote sensing products to help do their role within the ICS or NRDA command. Would need NRDA Liaison on this • Anyone within the command should be first priority • Could do aids for specific regions like Arctic, subsea responders. • Clearly state who this is for and what it is NOT for 	
<p>What are the top sensors that should be described in the job aid(s)?</p>	<ul style="list-style-type: none"> • Platforms AND sensors should be included • Any and all that have been used in past responses should be considered • Capabilities centric vs platform / sensor focus; need to make that connection between products and mission need • Include specifics of the sensor, the costs of the data, time of delivery of the data product (list of products), latency • TOP sensor/ platforms <ul style="list-style-type: none"> ○ Radar ○ Multi spectral ○ IR ○ TIR ○ Hyperspectral ○ Acoustic ○ Hi Def cameras 	

Day 3 Breakout Session

What should be included in a Job Aid(s)?

	<ul style="list-style-type: none"> ○ Air Monitoring may be considered separately or included depending [on water vs air]??? What is collection mission for-exposure for workers vs evaporation rate to help with volume calc. etc.
<p>What are other things would you like to see included in the job aid(s)?</p>	<ul style="list-style-type: none"> ● LIVING Document ● In preparation of making the job aid reference and go through existing documentation- API, NRL, Judd's DWH help list, Pierre LeRoux doc, Exxon Mobile, ITOP, and others? ● Have reference list of existing useful documents ● Include timeframes to structure that will inform what is feasible to be used. If it is small folks won't be tasking Satellites ● Orient document towards- <ul style="list-style-type: none"> ○ Coastal/ Inland; ○ Size of incident: Small, Medium, Large (USCG class), ○ Anticipated length of response (short, near, longterm) ● "Nutshell" page that directs you to the asset that may be beneficial to your immediate decisions. Generic to specific in document framing. ● If digital would be good to have basic scenario descriptors that gives your decision tree. Simple options that gives options of "<i>should work, might work, won't work</i>" ● Spreadsheet of sensors and platforms: what they are for- pros/ cons and how applied ● Best practices: for example of manned aerial observe to include quantitative measure of oil – hand held radioometer for the observer; helps with calibration of satellite acquisitions ● POC for that particular sensor and the expert contact- Centers of excellence type access? ● How one gets the data- where to get the data itself (see API Doc/ NRL documents)

Day 3 Breakout Session
What should be included in a Job Aid(s)?

	<ul style="list-style-type: none">• Information flow for ingest COP• Arctic/ Ice prone suite of options may be specific; same for subsea acquisition• Capability suite may be dependent on Geographic constraints
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What format do want this in? Both hard copy and electronic;

Day 3 Breakout Session
What should be included in a Job Aid(s)?

Group: B	Group Lead: Drew Casey	Group Recorder: Cory Rhodes
<p>Who are the audiences for the job aid(s) to meet the needs we have discussed?</p>	<ul style="list-style-type: none"> • Operators in the field • Planning and Operations • Environmental Unit Leader • Remote Sensing Coordinator • NRDA • Unified Command • Communications personnel 	
<p>What are the top sensors that should be described in the job aid(s)?</p>	<ul style="list-style-type: none"> • Orbiting platforms (Optical sensors, Thermal sensors, Radar sensors) • Aerial platforms (Optical sensors, Thermal sensors, Radar sensors) • Observer tools (handheld and pod-mounted devices) • Sea level drone • Additional platforms on and under the surface 	

Day 3 Breakout Session
What should be included in a Job Aid(s)?

<p>What are other things would you like to see included in the job aid(s)?</p>	<ul style="list-style-type: none">• Chapters for different personnel in the field• Visual observations (reference pictures)• Sampling procedures• Remote sensing tool overview (product description, expertise recommendation for additional information)• Chapter on need and planning for synoptic validation sampling for remote sensing data• Links to more reference documents• Heavyweight detailed document and job aid well-coordinated (e.g., Shoreline Assessment manual) – same terminology, methodology, etc.• Feedback/help/comments - email address listed• When discussing individual sensors, talk about things you can identify with each
<p>Format (hard copy, electronic)</p>	<ul style="list-style-type: none">• Both

Day 3 Breakout Session
What should be included in a Job Aid(s)?

Group: C	Group Lead: Gallagher	Group Recorder: Garron
<p>Who are the audiences for the job aid(s) to meet the needs we have discussed?</p> <p>Job Aid for Identifying Oil Aspects Using R-S</p>	<ul style="list-style-type: none"> • ICS personnel - r-s primer • GeoINT coordinator/ r-s coordinator 	
<p>What are the top sensors that should be described in the job aid(s)?</p>	<ul style="list-style-type: none"> • Use case drives the representative tech in the document 	
<p>What are other things would you like to see included in the job aid(s)?</p>	<ul style="list-style-type: none"> • Use case scenarios to guide sensor choice • Where to access data and additional information • Data delivery time • Basic decision tree • Mutual aid agreements 	

Day 3 Breakout Session
What should be included in a Job Aid(s)?

Group: D	Group Lead: Scott Lundgren	Group Recorder: Lexter Tapawan
Who are the audiences for the job aid(s) to meet the needs we have discussed?	Response: <ul style="list-style-type: none"> • Industry • OSRO • Spill Management <ul style="list-style-type: none"> -Operations Section (On-water recovery group, Wildlife group) -Environmental Unit -Situation Unit -Scientific Support Team • Agency Reps (Chain of command) 	
	Damage Assessment: <ul style="list-style-type: none"> • Resource Specialist • Injury assessment 	
	Public (Fact sheets)	
What are the top sensors that should be described in the job aid(s)?	The guide should direct the user to the best sensor(s) and platform(s) for the question at hand and the environmental and incident conditions. <ul style="list-style-type: none"> • Optical <ul style="list-style-type: none"> -LIDAR -Human -etc • Microwave <ul style="list-style-type: none"> -SAR -GPR 	

Day 3 Breakout Session

What should be included in a Job Aid(s)?

	<ul style="list-style-type: none"> -etc • Thermal -IR -etc • Acoustic -Sonar -etc
What are other things would you like to see included in the job aid(s)?	<ul style="list-style-type: none"> • Product example • Example of applications (previous spills/response) • Description of multiple applications of data • Processing time/delivery time • Operator/interpreter skill level • Availability/maturity • Technology readiness level • Relative cost (rental, ownership, etc)
What Format? Hard-copy? Electronic? Both?	<ul style="list-style-type: none"> • Online application with input screen to target certain sensors for particular applications -Ability to research particular sensor and its capabilities • Offline version • Text version (pdf, printable) • Laminated field not preferred or needed • Fact sheets on specific sensors

Day 3 Breakout Session

What should be included in a Job Aid(s)?

Group: E	Group Lead: Peter Murphy	Group Recorder: Aaron Racicot
Who are the audiences for the job aid(s) to meet the needs we have discussed?	<ul style="list-style-type: none"> • Acquisition planning for remote sensing <ul style="list-style-type: none"> ○ (primary) Responders – Planning – (secondary) Media, Public 	
What are the top sensors that should be described in the job aid(s)? Platform, sensor, settings/mode, data product	<ul style="list-style-type: none"> • Satellite <ul style="list-style-type: none"> ○ Optical, Multi/Hyper spectral, etc • Manned Aircraft Assets <ul style="list-style-type: none"> ○ Visual, IR, SAR, Hyper spectral, radiometry, chemical, etc • Unmanned Aircraft (highlight limitations and benefits) <ul style="list-style-type: none"> ○ Same as above ○ Operational is really visible and IR 	
What are other things would you like to see included in the job aid(s)?	<ul style="list-style-type: none"> • Menu of options (small and big spills) • Reference for scale and what each option solves • Problems each option solves • Benefits of each • Cost (time and money) • Deployment time • What products will be delivered with each option • Defined process for how to make the decision • Points of contact (agency/person/phone number) • SAR primer • Synoptic sampling... think about overlap with other data sets • Mission planning • Realistic list of available products... operational • Make sure data products are compatible and useable 	

Day 3 Breakout Session
What should be included in a Job Aid(s)?

	<p>Output of job aid</p> <ul style="list-style-type: none">• Articulate requirements (end product)• Focus on translating actionable outcomes to technology
<p>What format do you want the job aid in? Hard copy or electronic?</p>	<p>Both paper and electronic</p> <p>Themes of the job aid:</p> <ul style="list-style-type: none">• Graphical• Decision trees• Examples, examples, examples• Applications and use cases• Examples of scale• Examples of habitat use cases <p>Level of detail</p> <ul style="list-style-type: none">• Raw vs Derived• Formats (raster vector)• Resolution/Scale/Detail

Day 3 Breakout Session
What should be included in a Job Aid(s)?

Group: E	Group Lead: Peter Murphy	Group Recorder: Aaron Racicot
Who are the audiences for the job aid(s) to meet the needs we have discussed?	<ul style="list-style-type: none"> • Interpretation remote sensing <ul style="list-style-type: none"> ○ (primary) Responders – Planning – (secondary) Remote Sensing / GIS 	
What are the top sensors that should be described in the job aid(s)? Platform, sensor, settings/mode, data product		
What are other things would you like to see included in the job aid(s)?		
What format do you want the job aid in? Hard copy or electronic?		

Day 3 Breakout Session
What should be included in a Job Aid(s)?

Group: F	Group Lead: Judd Muskat	Group Recorder: Laura Belden
<p>Who are the audiences for the job aid(s) to meet the needs we have discussed?</p>	<p>1) Technical Audience</p> <ul style="list-style-type: none"> • Data processing audience • Remote Sensing Technical specialist or person filling role • Academic/nontechnical responder <p>2) Unified Command</p> <ul style="list-style-type: none"> • Interpretation Guide for technical person to explain to Unified Command <p>3) PIO (Public Info Officer)/JIC (Joint Information Center)</p>	
<p>What are the top sensors that should be described in the job aid(s)?</p>	<p>Key Sensors</p> <ul style="list-style-type: none"> • SAR • Thermal infrared • Multispectral • Standard photography <p>Other Potentially Useful Sensors</p> <ul style="list-style-type: none"> • Hyperspectral 	

Day 3 Breakout Session

What should be included in a Job Aid(s)?

<p>What are other things would you like to see included in the job aid(s)?</p>	<ol style="list-style-type: none"> 1) Technical Guide Sensor and platform selection guide Flow charts based on spill size (scalability) Standards: Data Processing, Delivery (timeline and product/interpretation), terminology, and File Format List of capabilities, availability, and limitations of each sensor Examples of good and bad data Examples and levels of confidence of false positives 2) Unified Command Highlights version of what is in technical guide Matrix capturing capabilities and limitations Representative photos of product and platform 3) PIO/JIC General description of different levels of tools and what they are used for (satellite, aircraft mounted UAS) UAS – aviation safety concerns related to hobbyists Online references to useful documents
<p>What format would you like the job aid in? (electronic or hard copy)</p>	<ol style="list-style-type: none"> 1) Hardcopy, but potential for a knowledge based interactive selection guide 2) Hardcopy 3) Hardcopy

APPENDIX H

Priorities Ranking Sheet

Name (optional): _____			
Circle all that apply to your role:	emergency response	damage assessment	researcher
			decision maker
Prioritize the importance of doing each of the following (circle your answer):			
Remote sensing operations (skimming, dispersants, burn, night operations)			
<ul style="list-style-type: none"> A go kit multi sensor package (SAR, multispectral, infrared, high resolution imagery) 	low	medium	high
Detection of oil in ice			
<ul style="list-style-type: none"> Evaluating ground penetrating radar (GPR) to identify oil in ice or snow 	low	medium	high
<ul style="list-style-type: none"> Evaluating Nuclear Magnetic Resonance (NMR) to identify oil in ice or snow 	low	medium	high
<ul style="list-style-type: none"> Use of underwater vehicles and sensors to detect oil encased in ice 	low	medium	high
Real Time capture of data			
<ul style="list-style-type: none"> microwave-based air-to-ground communications system 	low	medium	high
<ul style="list-style-type: none"> Advancements in/complete on-board processing 	low	medium	high
<ul style="list-style-type: none"> AUV sensors 	low	medium	high
<ul style="list-style-type: none"> More remote sensing airborne or orbital assets 	low	medium	high
<ul style="list-style-type: none"> HALOE platform for oil spill response 	low	medium	high
Oil Observation			
<ul style="list-style-type: none"> Better IR/thermal equipment for use during day and night 	low	medium	high
<ul style="list-style-type: none"> More camera pods 	low	medium	high
<ul style="list-style-type: none"> Portholes/open window viewing 			
<ul style="list-style-type: none"> Digital georeferenced photo subjects 	low	medium	high
<ul style="list-style-type: none"> Supplement human observers with digital tools 	low	medium	high
<ul style="list-style-type: none"> Standardize human observer methodology and output 	low	medium	high
<ul style="list-style-type: none"> Capture data from multiple observers 	low	medium	high
<ul style="list-style-type: none"> Identify standard equipment and training 	low	medium	high
<ul style="list-style-type: none"> Identify and evaluate tools for low visibility conditions 	low	medium	high
<ul style="list-style-type: none"> Combine all parameters (e.g., georeferencing, low visibility) into a single intuitive tool 	low	medium	high
Other Data (sargassum, kelp, sea grass, convergence zones, sediment plumes, algae blooms, ships, oil rigs, sun glint, wood, floating debris, bottom reflectance, various substrates, physical oceanography and meteorological data, megafauna, surfactants, boat wakes, false positives, water turbidity, plankton blooms, upwelling, flocks of birds)			
<ul style="list-style-type: none"> Feature/pattern recognition 	low	medium	high

Priorities Ranking Sheet

• Crowdsourcing	low	medium	high
• Better data capture	low	medium	high
• Voice recognition	low	medium	high
• Custom software for analyzing hyperspectral data	low	medium	high
• Neural networks and shape fitting algorithms			
• Use satellites to identify oceanographic features	low	medium	high
• Some aircraft mounted systems can identify resources at risk, and oil false positives with validation	low	medium	high
• UAS to identify resources at risk	low	medium	high
• UAS to help identify false positives	low	medium	high
Trajectory Modeling			
• Develop new or refine existing algorithms to improve trajectory modeling	low	medium	high
Oil Thickness			
• Which of these technologies do you believe has the greatest potential for addressing oil thickness (volume, flowrate, footprint).			
○ Technology scalability for volume calc that is defensible			
○ UAVSAR	low	medium	high
○ AVIRIS	low	medium	high
○ Quad-pol SAR	low	medium	high
○ Multispectral Imaging	low	medium	high
○ Quad-pol UAS SAR	low	medium	high
○ RISAT	low	medium	high
○ LIDAR	low	medium	high
○ Thermal wavelength imagery	low	medium	high
○ Hyperspectral	low	medium	high
○ Human observations	low	medium	high
Subsurface			
• Sonar	low	medium	high
• Floats/AUV/gliders with acoustics and optical	low	medium	high
• Refinement Fluorescence from bottom up/top down	low	medium	high
• On-board sampling	low	medium	high
• Pre-deployment of sensors and platforms	low	medium	high
• Evaluate the ability of optical tools to detect oil in the subsurface	low	medium	high

Priorities Ranking Sheet

Delivery Infrastructure			
<ul style="list-style-type: none"> Bandwidth - software compression, portable network stations, pre-planning of data demands, satellite communications/infrastructure 	low	medium	high
<ul style="list-style-type: none"> Accessibility/connectivity - remote site data integration away from ICP 	low	medium	high
<ul style="list-style-type: none"> Power - portable power 	low	medium	high
<ul style="list-style-type: none"> Cutting edge equipment, investments, incentives, or mandates 	low	medium	high
<ul style="list-style-type: none"> Incompatibility of equipment/software 	low	medium	high
Oil/chemical Composition			
<ul style="list-style-type: none"> Remote sensing to do chemistry in water 	low	medium	high
<ul style="list-style-type: none"> Air remote sensing 	low	medium	high
<ul style="list-style-type: none"> Volume and water content in surface 	low	medium	high
Data Delivery (end user) time - response vs. assessment - Getting the type of data in a resolution, format, and timeframe delivered to the end-user -Both response and NRDA have time critical data needs -Longer term NRDA data needs (study, evaluation)			
<ul style="list-style-type: none"> Web-mapping service for data sharing 	low	medium	high
<ul style="list-style-type: none"> Mobile-app developers 	low	medium	high
<ul style="list-style-type: none"> On-site testing during exercises 	low	medium	high
Flow Rate: Airborne chemical measurements Size (footprint): SAR (airborne & spaceborne) Thickness: SAR & hyperspectral and acoustic in water			
<ul style="list-style-type: none"> Indeterminate flow rate: Airborne chemical measurements 	low	medium	high
<ul style="list-style-type: none"> Thickness: Creating operational systems and validating methods for application of those systems 	low	medium	high
Shoreline oil (data) and habitat			
<ul style="list-style-type: none"> Multi sensor approach with repeated surveys over time including hyperspectral, SAR, and high resolution visual 	low	medium	high
<ul style="list-style-type: none"> Multiple sensors and platforms in order to fill out the gaps for the required schedule 	low	medium	high
<ul style="list-style-type: none"> Aerial assets for schedules and resolution 	low	medium	high
Integration of synoptic sampling (validation) into mission planning			
<ul style="list-style-type: none"> Calibration and integration into the workflow 	low	medium	high
<ul style="list-style-type: none"> Coordinating remote sensing acquisition with field data collection 	low	medium	high
<ul style="list-style-type: none"> Georeferenced data with standard format (metadata) 	low	medium	high

Priorities Ranking Sheet

• Contemporaneous collection	low	medium	high
• Complimentary sensors based on conditions and target -Oil types and elements	low	medium	high
• Calibration events minimum once per incident	low	medium	high
• After application of counter measures	low	medium	high

Priorities Ranking - Raw Results

Name (optional): _____			
Circle all that apply to your role:	emergency response	damage assessment	researcher
			decision maker
Prioritize the importance of doing each of the following (circle your answer):	Low	Medium	High
Remote sensing operations (skimming, dispersants, burn, night operations)			
• A go kit multi sensor package (SAR, multispectral, infrared, high resolution imagery)	1	11	35
Detection of oil in ice			
• Evaluating ground penetrating radar (GPR) to identify oil in ice or snow	20	11	13
• Evaluating Nuclear Magnetic Resonance (NMR) to identify oil in ice or snow	14	11	10
• Use of underwater vehicles and sensors to detect oil encased in ice	14	14	10
Real Time capture of data			
• microwave-based air-to-ground communications system	3	12	24
• Advancements in/complete on-board processing	1	10	32
• AUV sensors	4	21	16
• More remote sensing airborne or orbital assets	7	13	23
• HALOE platform for oil spill response	7	14	8
Oil Observation			
• Better IR/thermal equipment for use during day and night	3	18	21
• More camera pods	16	16	10
• Portholes/open window viewing			
• Digital georeferenced photo subjects	1	12	31
• Supplement human observers with digital tools	1	12	34
• Standardize human observer methodology and output	0	14	35
• Capture data from multiple observers	1	21	25
• Identify standard equipment and training	2	13	31
• Identify and evaluate tools for low visibility conditions	2	24	19
• Combine all parameters (e.g., georeferencing, low visibility) into a single intuitive tool	2	21	21
Other Data (sargassum, kelp, sea grass, convergence zones, sediment plumes, algae blooms, ships, oil rigs, sun glint, wood, floating debris, bottom reflectance, various substrates, physical oceanography and meteorological data, megafauna, surfactants, boat wakes, false positives, water turbidity, plankton blooms, upwelling, flocks of birds)			
• Feature/pattern recognition	5	20	22

Priorities Ranking - Raw Results

• Crowdsourcing	27	18	2
• Better data capture	1	19	23
• Voice recognition	30	9	3
• Custom software for analyzing hyperspectral data	12	13	13
• Neural networks and shape fitting algorithms	6	9	6
• Use satellites to identify oceanographic features	6	21	16
• Some aircraft mounted systems can identify resources at risk, and oil false positives with validation	4	17	20
• UAS to identify resources at risk	8	20	16
• UAS to help identify false positives	6	22	17
Trajectory Modeling			
• Develop new or refine existing algorithms to improve trajectory modeling	6	17	21
Oil Thickness			
• Which of these technologies do you believe has the greatest potential for addressing oil thickness (volume, flowrate, footprint).			
○ Technology scalability for volume calc that is defensible	1	0	5
○ UAVSAR	2	11	14
○ AVIRIS	2	8	19
○ Quad-pol SAR	2	6	20
○ Multispectral Imaging	4	11	17
○ Quad-pol UAS SAR	2	9	16
○ RISAT	7	14	5
○ LIDAR	9	10	7
○ Thermal wavelength imagery	2	19	10
○ Hyperspectral	4	10	18
○ Human observations	10	22	10
Subsurface			
• Sonar	6	15	10
• Floats/AUV/gliders profiles with acoustics and optical	2	16	17
• Refinement Fluorescence from bottom up/top down	5	18	10
• On-board sampling	7	9	15
• Pre-deployment of sensors and platforms	11	11	13
• Evaluate the ability of optical tools to detect oil in the subsurface	11	10	13

Priorities Ranking - Raw Results

Delivery Infrastructure			
• Bandwidth - software compression, portable network stations, pre-planning of data demands, satellite communications/infrastructure	0	11	37
• Accessibility/connectivity - remote site data integration away from ICP	0	11	35
• Power - portable power	8	16	17
• Cutting edge equipment, investments, incentives, or mandates	10	20	8
• Incompatibility of equipment/software	5	19	16
Oil/chemical Composition			
• Remote sensing to do chemistry in water	14	18	7
• Air remote sensing	7	21	11
• Volume and water content in surface	4	18	18
Data Delivery (end user) time - response vs. assessment - Getting the type of data in a resolution, format, and timeframe delivered to the end-user -Both response and NRDA have time critical data needs -Longer term NRDA data needs (study, evaluation)			
• Web-mapping service for data sharing	5	12	31
• Mobile-app developers	7	20	20
• On-site testing during exercises	2	9	37
Flow Rate: Airborne chemical measurements Size (footprint): SAR (airborne & spaceborne) Thickness: SAR & hyperspectral and acoustic in water			
• Indeterminate flow rate: Airborne chemical measurements	10	16	10
• Thickness: Creating operational systems and validating methods for application of those systems	2	15	27
Shoreline oil (data) and habitat			
• Multi sensor approach with repeated surveys over time including hyperspectral, SAR, and high resolution visual	1	13	34
• Multiple sensors and platforms in order to fill out the gaps for the required schedule	1	19	24
• Aerial assets for schedules and resolution	3	14	23
Integration of synoptic sampling (validation) into mission planning			
• Calibration and integration into the workflow	4	13	23
• Coordinating remote sensing acquisition with field data collection	1	7	39
• Georeferenced data with standard format (metadata)	1	3	40

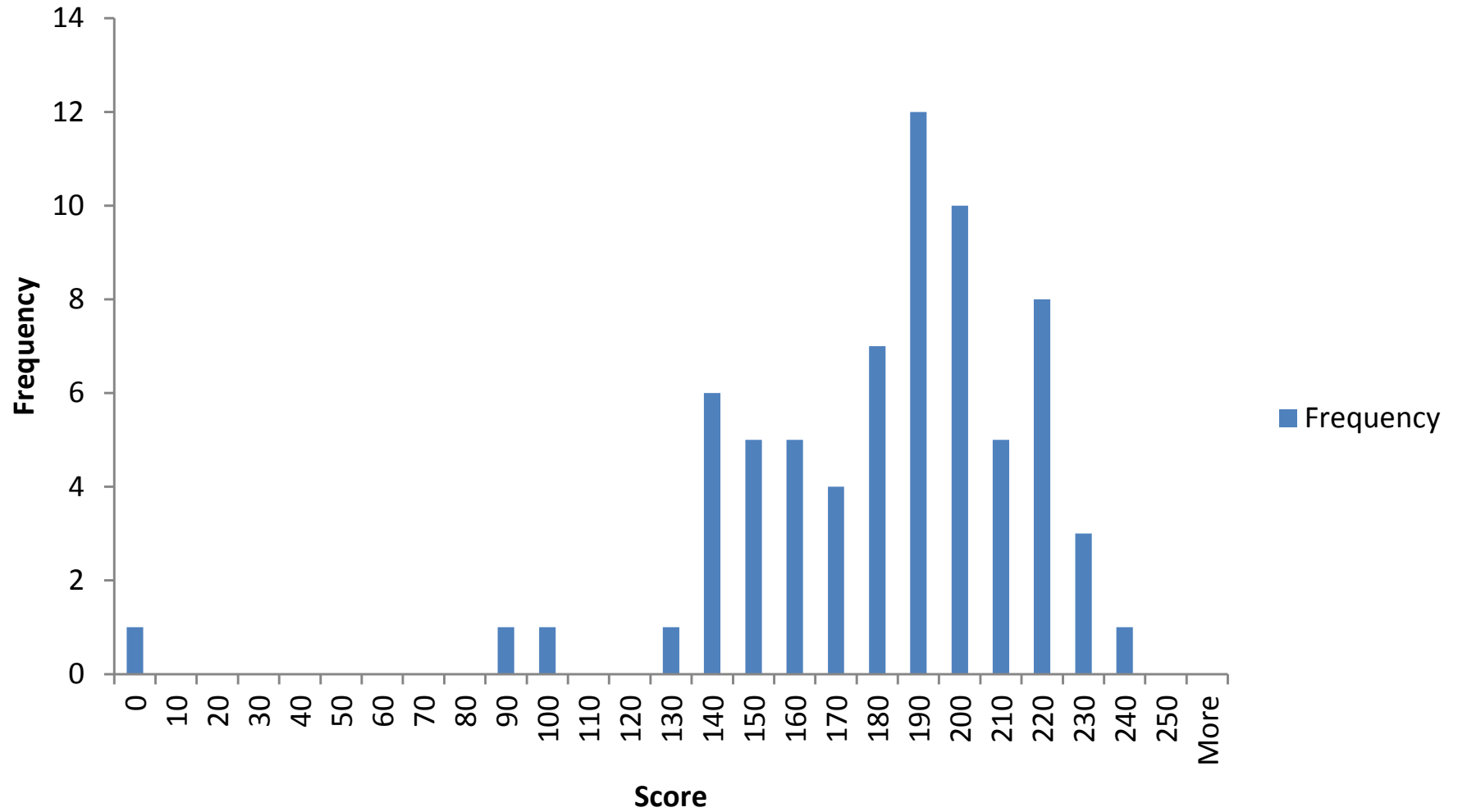
Priorities Ranking - Raw Results

• Contemporaneous collection	2	13	21
• Complimentary sensors based on conditions and target -Oil types and elements	2	17	15
• Calibration events minimum once per incident	1	17	23
• After application of counter measures	5	15	16

Priorities Ranking – Method of Scoring

The items were scored by assigning 1 point if it was ranked low, 3 points if it was ranked medium, and 5 points if it was ranked high. All the points were combined for each item, then adjusted to account for how many people voted on that particular action item. The maximum total possible score was 245 (if all 49 participants had voted it high, $49 \times 5 \text{ points} = 245$). Final scores ranged from 84 (lowest priority) to 234 (highest priority). A histogram was created to view the distribution of scores. Each score was also converted to a percentage of the total possible maximum score (245). Items scoring an 80% or higher, are highlighted as high priority in Table 1 of the report.

Priorities Ranking - Histogram



Priorities Ranking Scores - Sorted by Topic

Prioritized (per Workshop Participants) by Topic	# responding (out of 49 surveys)	Score	Percentage
Remote sensing operations (skimming, dispersants, burn, night operations)			
<ul style="list-style-type: none"> A go kit multi sensor package (SAR, multispectral, infrared, high resolution imagery) 	47	218	89
Detection of oil in ice			
<ul style="list-style-type: none"> Use of underwater vehicles and sensors to detect oil encased in ice 	38	137	56
<ul style="list-style-type: none"> Evaluating Nuclear Magnetic Resonance (NMR) to identify oil in ice or snow 	35	136	55
<ul style="list-style-type: none"> Evaluating ground penetrating radar (GPR) to identify oil in ice or snow 	44	131	54
Real Time capture of data			
<ul style="list-style-type: none"> Advancements in/complete on-board processing 	43	218	89
<ul style="list-style-type: none"> microwave-based air-to-ground communications system 	39	200	82
<ul style="list-style-type: none"> More remote sensing airborne or orbital assets 	43	183	75
<ul style="list-style-type: none"> AUV sensors 	41	176	72
<ul style="list-style-type: none"> HALOE platform for oil spill response 	29	150	61
Oil Observation			
<ul style="list-style-type: none"> Standardize human observer methodology and output 	49	217	89
<ul style="list-style-type: none"> Supplement human observers with digital tools 	47	216	88
<ul style="list-style-type: none"> Digital georeferenced photo subjects 	44	214	87
<ul style="list-style-type: none"> Identify standard equipment and training 	46	209	85
<ul style="list-style-type: none"> Capture data from multiple observers 	47	197	80
<ul style="list-style-type: none"> Combine all parameters (e.g., georeferencing, low visibility) into a single intuitive tool 	44	189	77
<ul style="list-style-type: none"> Better IR/thermal equipment for use during day and night 	42	189	77
<ul style="list-style-type: none"> Identify and evaluate tools for low visibility conditions 	45	184	75
<ul style="list-style-type: none"> More camera pods 	42	133	54
<ul style="list-style-type: none"> Portholes/open window viewing * 	0	0	0
Other Data (sargassum, kelp, sea grass, convergence zones, sediment plumes, algae blooms, ships, oil rigs, sun glint, wood, floating debris, bottom reflectance, various substrates, physical oceanography and meteorological data, megafauna, surfactants, boat wakes, false positives, water turbidity, plankton blooms, upwelling, flocks of birds)			
<ul style="list-style-type: none"> Better data capture 	43	197	80

Priorities Ranking Scores - Sorted by Topic

• Some aircraft mounted systems can identify resources at risk, and oil false positives with validation	41	185	76
• Feature/pattern recognition	47	182	74
• UAS to help identify false positives	45	171	70
• Use satellites to identify oceanographic features	43	170	69
• UAS to identify resources at risk	44	165	67
• Custom software for analyzing hyperspectral data	38	150	61
• Neural networks and shape fitting algorithms *	21	147	60
• Crowdsourcing	47	95	39
• Voice recognition	42	84	34
Trajectory Modeling			
• Develop new or refine existing algorithms to improve trajectory modeling	44	180	74
Oil Thickness			
• Which of these technologies do you believe has the greatest potential for addressing oil thickness (volume, flowrate, footprint).			
○ Technology scalability for volume calc that is defensible *	6	212	87
○ Quad-pol SAR	28	210	86
○ AVIRIS	29	204	83
○ Quad-pol UAS SAR	27	198	81
○ UAVSAR	27	191	78
○ Hyperspectral	32	190	78
○ Multispectral Imaging	32	187	76
○ Thermal wavelength imagery	31	172	70
○ Human observations	42	147	60
○ RISAT	26	139	57
○ LIDAR	26	139	57
Subsurface			
• Floats/AUV/gliders with acoustics and optical	35	189	77
• On-board sampling	31	172	70
• Refinement Fluorescence from bottom up/top down	33	162	66
• Sonar	31	160	65
• Evaluate the ability of optical tools to detect oil in the subsurface	34	153	62
• Pre-deployment of sensors and platforms	35	153	62

Priorities Ranking Scores - Sorted by Topic

Delivery Infrastructure			
• Bandwidth - software compression, portable network stations, pre-planning of data demands, satellite communications/infrastructure	48	223	91
• Accessibility/connectivity - remote site data integration away from ICP	46	222	90
• Incompatibility of equipment/software	40	174	71
• Power - portable power	41	169	69
• Cutting edge equipment, investments, incentives, or mandates	38	142	58
Oil/chemical Composition			
• Volume and water content in surface	40	181	74
• Air remote sensing	39	157	64
• Remote sensing to do chemistry in water	39	129	53
Data Delivery (end user) time - response vs. assessment - Getting the type of data in a resolution, format, and timeframe delivered to the end-user -Both response and NRDA have time critical data needs -Longer term NRDA data needs (study, evaluation)			
• On-site testing during exercises	48	218	89
• Web-mapping service for data sharing	48	200	82
• Mobile-app developers	47	174	71
Flow Rate: Airborne chemical measurements Size (footprint): SAR (airborne & spaceborne) Thickness: SAR & hyperspectral and acoustic in water			
• Thickness: Creating operational systems and validating methods for application of those systems	44	203	83
• Indeterminate flow rate: Airborne chemical measurements	36	147	60
Shoreline oil (data) and habitat			
• Multi sensor approach with repeated surveys over time including hyperspectral, SAR, and high resolution visual	48	214	88
• Multiple sensors and platforms in order to fill out the gaps for the required schedule	44	198	81
• Aerial assets for schedules and resolution	40	196	80
Integration of synoptic sampling (validation) into mission planning			
• Georeferenced data with standard format (metadata)	44	234	95
• Coordinating remote sensing acquisition with field data collection	47	226	92
• Calibration events minimum once per incident	41	200	81

Priorities Ranking Scores - Sorted by Topic

• Contemporaneous collection	36	199	81
• Calibration and integration into the workflow	40	194	79
• Complimentary sensors based on conditions and target -Oil types and elements	34	184	75
• After application of counter measures	36	177	72

* Note, for these items, the "Low, Medium, High" was inadvertently omitted from the spreadsheet so fewer people voted

Priorities Ranking Scores - Sorted by Score, with Additional Information

Prioritized (per Workshop Participants)	# responding (out of 49 surveys)	Score	Percentage	Category	Purpose	Solution	Timeframe	Cost
• Georeferenced data with standard format (metadata) (Integration of Synoptic Sampling into Mission Planning)	44	234	95	technical requirement	limitation	contract requirements	short-term	low
• Coordinating remote sensing acquisition with field data collection (Integration of Synoptic Sampling into Mission Planning)	47	226	92	Policy/Protocol	validation	training/drill	short-term	med
• Bandwidth - software compression, portable network stations, pre-planning of data demands, satellite communications/infrastructure (Delivery Infrastructure)	48	223	91	technical requirement	limitation	training/drill	short-term	med
• Accessibility/connectivity - remote site data integration away from ICP (Delivery Infrastructure)	46	222	90	technical requirement	limitation	training/drill	short-term	med
• On-site testing during exercises (Data Delivery Time)	48	218	89	Policy/Protocol	limitation	training/drill	short-term	low
• A go kit multi sensor package (SAR, multispectral, infrared, high resolution imagery)(Remote Sensing Operations - skimming, dispersants, burn, night operations)	47	218	89	technical requirement			long-term	high
• Advancements in/complete on-board processing (Real Time Capture of Data)	43	218	89	technical requirement	limitation	contract requirements	short-term	med
• Standardize human observer methodology and output (Oil Observation)	49	217	89	Policy/Protocol	Standards	training/drill	short-term	low
• Supplement human observers with digital tools (Oil Observation)	47	216	88	Policy/Protocol	Standards	training/drill	short-term	low
• Multi sensor approach with repeated surveys over time including hyperspectral, SAR, and high resolution visual (Shoreline Oil Data and Habitat)	48	214	88	Policy/Protocol	validation		short-term	high
• Digital georeferenced photo subjects (Oil Observation)	44	214	87	technical requirement	Standards	training/drill	short-term	low
• Technology scalability for volume calc that is defensible (Technologies for Oil Thickness) *	6	212	87	technical requirement			long-term	high
• Quad-pol SAR (Technologies for Oil Thickness)	28	210	86	technical requirement	limitation		short-term	med
• Identify standard equipment and training (Oil Observation)	46	209	85	Policy/Protocol	Standards	training/drill	short-term	low
• AVIRIS (Technologies for Oil Thickness)	29	204	83	technical requirement	validation		long-term	high
• Thickness: Creating operational systems and validating methods for application of those systems (Flow Rate, Footprint, Thickness)	44	203	83	technical requirement			long-term	high
• Web-mapping service for data sharing (Data Delivery Time)	48	200	82	technical requirement	limitation	training/drill	short-term	low
• microwave-based air-to-ground communications system (Real Time Capture of Data)	39	200	82	technical requirement	limitation	training/drill	short-term	med
• Calibration events minimum once per incident (Integration of Synoptic Sampling into Mission Planning)	41	200	81	Policy/Protocol	Standards		short-term	med
• Contemporaneous collection (Integration of Synoptic Sampling into Mission Planning)	36	199	81	Policy/Protocol	Standards		short-term	low
• Multiple sensors and platforms in order to fill out the gaps for the required schedule (Shoreline Oil Data and Habitat)	44	198	81	technical requirement	limitation		long-term	high
• Quad-pol UAS SAR (Technologies for Oil Thickness)	27	198	81	technical requirement			short-term	med
• Better data capture (Other Data)	43	197	80	technical requirement			short-term	med
• Capture data from multiple observers (Oil Observation)	47	197	80	Policy/Protocol	Standards	training/drill	short-term	low
• Aerial assets for schedules and resolution (Shoreline Oil Data and Habitat)	40	196	80	Policy/Protocol	Standards	training/drill	short-term	low
• Calibration and integration into the workflow (Integration of Synoptic Sampling into Mission Planning)	40	194	79	Policy/Protocol	Standards	training/drill	long-term	med
• UAVSAR (Technologies for Oil Thickness)	27	191	78	technical requirement	limitation		short-term	med
• Hyperspectral (Technologies for Oil Thickness)	32	190	78	technical requirement	limitation		short-term	high
• Combine all parameters (e.g., georeferencing, low visibility) into a single intuitive tool (Oil Observation)	44	189	77	technical requirement	limitation		long-term	high
• Better IR/thermal equipment for use during day and night (Oil Observation)	42	189	77	technical requirement	limitation		short-term	med
• Floats/AUV/gliders with acoustics and optical (Subsurface)	35	189	77	technical requirement	limitation		short-term	med
• Multispectral Imaging (Technologies for Oil Thickness)	32	187	76	technical requirement	limitation		short-term	med

• Some aircraft mounted systems can identify resources at risk, and oil false positives with validation (Other Data)	41	185	76	technical requirement	Standards		short-term	med
• Complimentary sensors based on conditions and target -Oil types and elements (Integration of Synoptic Sampling into Mission Planning)	34	184	75	Policy/Protocol	Standards		short-term	high
• Identify and evaluate tools for low visibility conditions (Oil Observation)	45	184	75	technical requirement	limitation		short-term	low
• More remote sensing airborne or orbital assets (Real Time Capture of Data)	43	183	75	technical requirement	limitation		short-term	med
• Feature/pattern recognition (Other Data)	47	182	74	technical requirement	limitation		long-term	med
• Volume and water content in surface (Oil/Chemical Composition)	40	181	74	technical requirement	limitation		long-term	high
• Develop new or refine existing algorithms to improve trajectory modeling (Trajectory Modeling)	44	180	74	technical requirement	validation		short-term	med
• After application of counter measures (Integration of Synoptic Sampling into Mission Planning)	36	177	72	Policy/Protocol	validation		short-term	med
• AUV sensors (Real Time Capture of Data)	41	176	72	technical requirement	limitation		short-term	med
• Mobile-app developers (Data Delivery Time)	47	174	71	technical requirement	limitation	training/drill	short-term	med
• Incompatibility of equipment/software (Delivery Infrastructure)	40	174	71	technical requirement	limitation	training/drill	short-term	low
• Thermal wavelength imagery (Technologies for Oil Thickness)	31	172	70	technical requirement	limitation		short-term	med
• On-board sampling (Subsurface)	31	172	70	technical requirement	limitation		short-term	med
• UAS to help identify false positives (Other Data)	45	171	70	technical requirement	Standards		long-term	med
• Use satellites to identify oceanographic features (Other Data)	43	170	69	Policy/Protocol	validation		short-term	low
• Power - portable power (Delivery Infrastructure)	41	169	69	technical requirement	limitation	training/drill	short-term	med
• UAS to identify resources at risk (Other Data)	44	165	67	Policy/Protocol	Standards		short-term	med
• Refinement Fluorescence from bottom up/top down (Subsurface)	33	162	66	technical requirement	limitation		long-term	med
• Sonar (Subsurface)	31	160	65	technical requirement	limitation		long-term	med
• Air remote sensing (Oil/Chemical Composition)	39	157	64	technical requirement	limitation		short-term	med
• Evaluate the ability of optical tools to detect oil in the subsurface (Subsurface)	34	153	62	technical requirement	limitation		long-term	high
• Pre-deployment of sensors and platforms (Subsurface)	35	153	62	Policy/Protocol	Standards		long-term	med
• HALOE platform for oil spill response (Real Time Capture of Data)	29	150	61	technical requirement				
• Custom software for analyzing hyperspectral data (Other Data)	38	150	61	technical requirement	limitation		long-term	high
• Human observations (Technologies for Oil Thickness)	42	147	60	Policy/Protocol	Standards	training/drill	short-term	low
• Indeterminate flow rate: Airborne chemical measurements (Flow Rate, Footprint, Thickness)	36	147	60	technical requirement	limitation		long-term	high
• Neural networks and shape fitting algorithms (Other Data) *	21	147	60	technical requirement	Standards		short-term	low
• Cutting edge equipment, investments, incentives, or mandates (Delivery Infrastructure)	38	142	58	Policy/Protocol	Standards		long-term	med
• RISAT (Technologies for Oil Thickness)	26	139	57	technical requirement	limitation			
• LIDAR (Technologies for Oil Thickness)	26	139	57	technical requirement	limitation		short-term	med
• Use of underwater vehicles and sensors to detect oil encased in ice (Detection of Oil in Ice)	38	137	56	Policy/Protocol	limitation		long-term	med
• Evaluating Nuclear Magnetic Resonance (NMR) to identify oil in ice or snow (Detection of Oil in Ice)	35	136	55	technical requirement	limitation		long-term	med
• More camera pods (Oil Observation)	42	133	54	technical requirement	limitation		short-term	med
• Evaluating ground penetrating radar (GPR) to identify oil in ice or snow (Detection of Oil in Ice)	44	131	54	technical requirement	limitation		long-term	med
• Remote sensing to do chemistry in water (Oil/Chemical Composition)	39	129	53	technical requirement	limitation		long-term	high
• Crowdsourcing (Other Data)	47	95	39	Policy/Protocol	validation		long-term	med
• Voice recognition (Other Data)	42	84	34	technical requirement			long-term	med
• Portholes/open window viewing (Oil Observation) *	0	0	0	technical requirement	limitation		short-term	med

* Note, for these items, the "Low, Medium, High" was inadvertently omitted from the spreadsheet so fewer people voted

Priorities Ranking - Highest Ranked, By Topic

Table 2.	
Solutions Prioritized per Workshop Participants, by Topic	Score
Remote sensing operations (skimming, dispersants, burn, night operations)	
<ul style="list-style-type: none"> A go kit multi sensor package (SAR, multispectral, infrared, high resolution imagery) 	218
Detection of oil in ice	
→ None of the solutions identified for this category ranked as high priority.	
Real Time capture of data	
<ul style="list-style-type: none"> Advancements in/complete on-board processing 	218
<ul style="list-style-type: none"> Microwave-based air-to-ground communications system 	200
Oil Observation	
<ul style="list-style-type: none"> Standardize human observer methodology and output 	217
<ul style="list-style-type: none"> Supplement human observers with digital tools 	216
<ul style="list-style-type: none"> Digital georeferenced photo subjects 	214
<ul style="list-style-type: none"> Identify standard equipment and training 	209
<ul style="list-style-type: none"> Capture data from multiple observers 	197
Other Data (sargassum, kelp, sea grass, convergence zones, sediment plumes, algae blooms, ships, oil rigs, sun glint, wood, floating debris, bottom reflectance, various substrates, physical oceanography and meteorological data, megafauna, surfactants, boat wakes, false positives, water turbidity, plankton blooms, upwelling, flocks of birds)	
<ul style="list-style-type: none"> Better data capture 	197
Trajectory Modeling	
→ None of the solutions identified for this category ranked as high priority.	
Oil Thickness	
<ul style="list-style-type: none"> Which of these technologies do you believe has the greatest potential for addressing oil thickness (volume, flowrate, footprint). <ul style="list-style-type: none"> Technology scalability for volume calc that is defensible Quad-pol SAR AVIRIS Quad-pol UAS SAR 	212
	210
	204
	198
Subsurface	
→ None of the solutions identified for this category ranked as high priority.	
Delivery Infrastructure	
<ul style="list-style-type: none"> Bandwidth - software compression, portable network stations, pre-planning of data demands, satellite communications/infrastructure 	223
<ul style="list-style-type: none"> Accessibility/connectivity - remote site data integration away from ICP 	222
Oil/chemical Composition	

→ None of the solutions identified for this category ranked as high priority.	
Data Delivery (end user) time - response vs. assessment - Getting the type of data in a resolution, format, and timeframe delivered to the end-user -Both response and NRDA have time critical data needs -Longer term NRDA data needs (study, evaluation)	
• On-site testing during exercises	218
• Web-mapping service for data sharing	200
Flow Rate: Airborne chemical measurements Size (footprint): SAR (airborne & spaceborne) Thickness: SAR & hyperspectral and acoustic in water	
• Thickness: Creating operational systems and validating methods for application of those systems	203
Shoreline oil (data) and habitat	
• Multi sensor approach with repeated surveys over time including hyperspectral, SAR, and high resolution visual	214
• Multiple sensors and platforms in order to fill out the gaps for the required schedule	198
• Aerial assets for schedules and resolution	196
Integration of synoptic sampling (validation) into mission planning	
• Georeferenced data with standard format (metadata)	234
• Coordinating remote sensing acquisition with field data collection	226
• Calibration events minimum once per incident	200
• Contemporaneous collection	199

* The lowest and highest possible scores respectively were 49 (or zero if no one voted) and 245.

APPENDIX I

Technologies for Oil Thickness (per Oil Observing Tools Workshop and Report)

Technology	Workshop Contact, Organization	Capability, Details, Notes from Report
ASPECT	Mark Thomas, USEPA	An Iterative Self-Organizing Data Analysis Technique Algorithm (ISODATA) method is useful and permits various levels of oil content/water content to be contoured. ASPECT data could provide significant support to response and assessment, particularly in the identification of actionable oil.
AVIRIS	Greg Swayze, USGS Cathleen Jones, NASA	While not used significantly during the DWH spill, NASA analysts have been able to quantitatively map thickness of oil using AVIRIS.
UAVSAR	Cathleen Jones, NASA	While not used operationally during the DWH spill, data collected during DWH was used to develop a method to quantify the oil volumetric fraction.
SAR	Oscar Garcia, Water Mapping LLC Ian McDonald, FSU	SAR can detect the presence/absence of oil and emulsions, including "relative thickness". These data were used significantly for the DWH NRDA.
OEDA, SAR Analysis	George Graettinger, NOAA Oscar Garcia, Water Mapping LLC Jamie Holmes, Abt Consulting	There is a SAR analysis method for detecting emulsions. The Oil Emulsion Detection Algorithm (OEDA) was used during the DWH NRDA to delineate thick, heavy oil emulsions.
ABC System, TRACS, Multispec. and Thermal, DMSC	Mark Hess, Ocean Imaging Kevin Hoskins, MSRC	The Ocean Imaging-MSRC "ABC" system was developed to identify actionable/recoverable oil. Rapidly deployable tools provide an oil spill mapping system that combines thickness estimates from visual oil spill surveys with digital capabilities (e.g., thermal imaging). Combined visible multispectral and thermal-infrared (IR) imagery from TRACS improves thickness measurements. TRACS can provide thickness classification maps. California OSPR uses TRACS for slick thickness distribution. High resolution aerial multispectral and thermal imagery was collected almost daily at the DWH rig site to capture thickness and volume estimations. Thick oil can also be discerned using Digital Multi-Spectral Camera (DMSC).
LandSat	George Graettinger, NOAA Mark Hess, Ocean Imaging Jamie Holmes, Abt Consulting	Thick oil can be inferred from the more coarse satellite data. Qualitative thickness estimates were generated using medium resolution Landsat data to support the NRDA.
Oil Observing Program	Jeff Lankford, NOAA	Trained observers employ quantification tools such as the Bonn Agreement Oil Appearance Code (observed oil color for each code is tied to an estimated thickness range).
Night Vision LWIR	Mark Roberts, Army Night Vision Lab	With night vision technology, thicker areas of oil can also be determined because those areas appear cooler (depending on the settings of "black hot" or "white hot" these areas would appear brighter or darker than other areas). Of the night vision technologies, long wave infrared (LWIR) technology shows the most promise for thickness estimates.
Multi-sensor Model	George Graettinger, NOAA Jamie Holmes, Abt Consulting	A multi-sensor integrated model was developed for DWH NRDA to create a single integrated product to provide a rough thickness assessment. The model was not completed prior to the DWH settlement.