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Remote Sensing

The Next Significant Enhancement in Spill Response

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Jan Svejkovsky, Ocean Imaging Corp.

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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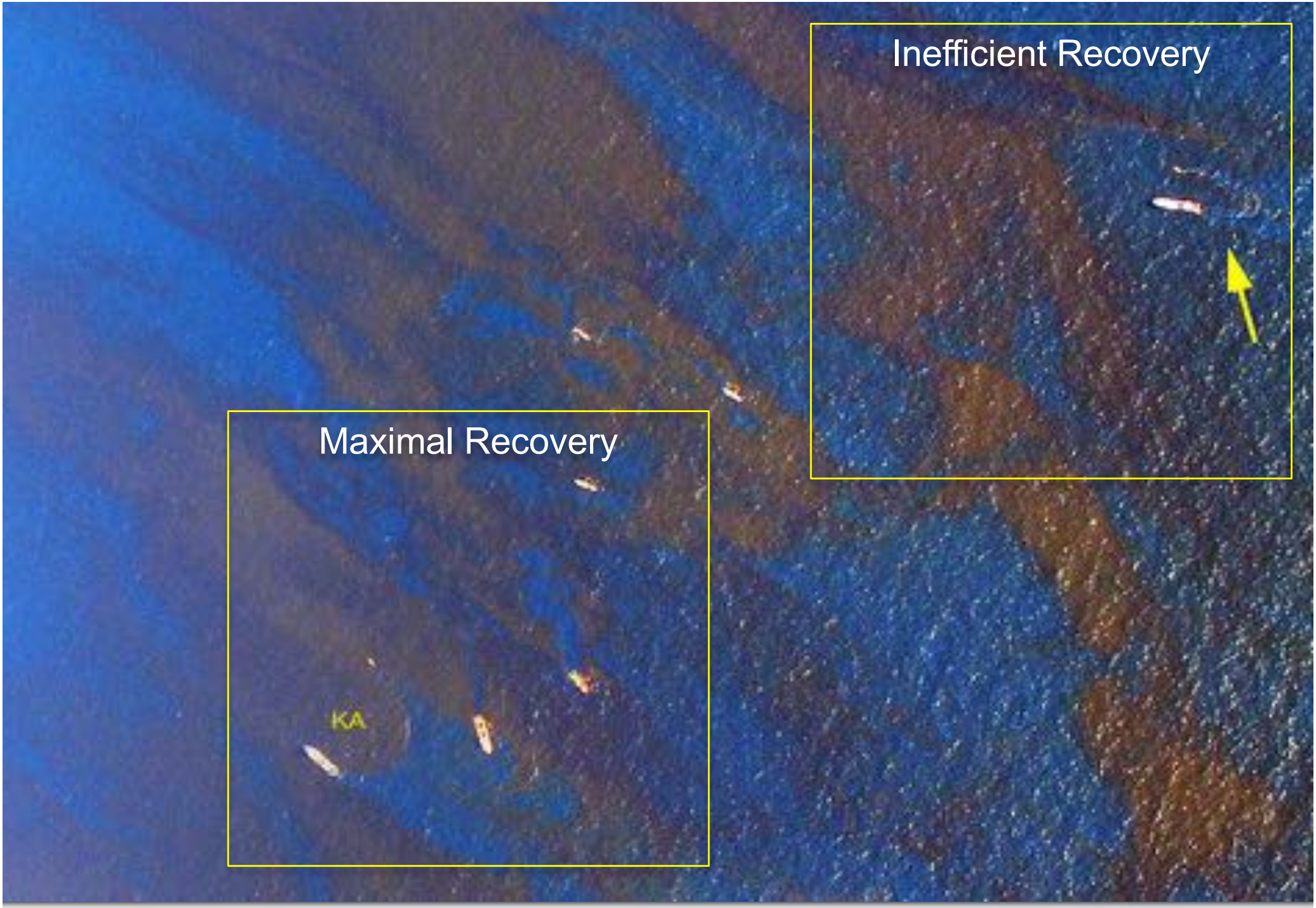

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MSRC Surveillance Objectives
Post DWH

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)

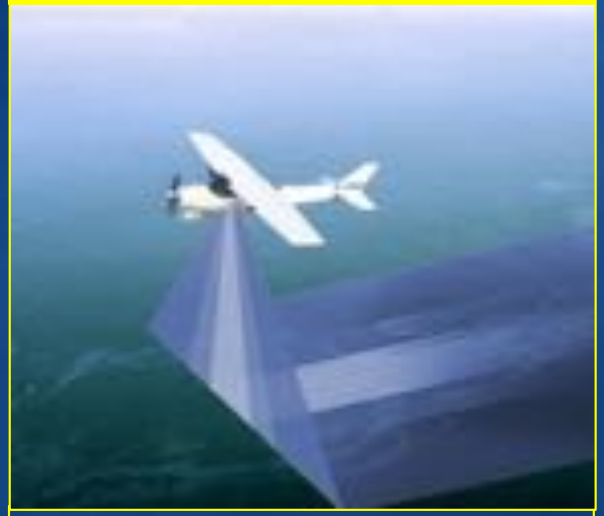
Key Criteria for MSRC's New Remote Sensing Tools

- 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)

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

MSRC **Level DV** Remote Sensing for Tactical Oil Spill Surveillance

D — Drone
Contracted Service

HD/TIR Cameras

Fixed and rotary wing aircraft

V — Visual
iPhone/iPad

Application utilizes internal GPS and camera

Visual Observation Report (VOR)

MSRC Level V

MSRC Level V

MSRC Level V

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Visual Observation Report

INCIDENT NAME | DATE

OBSERVER INFORMATION

Observer Name | Phone Number | Email

Company

FLIGHT INFORMATION

Air Service Provider | Departure Time | Departure Airfield

Pilot Name 1 | Pilot Name 2

Type of Aircraft | Tail Number | Radio Freq | Call Sign

Return Time | Return Airfield

WEATHER CONDITIONS

Conditions | Visibility | Wind Direction | Wind Speed | Heading

SEA CONDITIONS

Sea State | Wave Height | Current | Current Speed

Time of High Tide | Time of Low Tide

OBSERVATION

1 of 2


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OBSERVATION DETAILS

Length of Lead to Trail | Length of Left to Right | Orientation of Wind | Estimated Affected Area (m2)

Estimated Affected Area (m2) | Classification Method Used for Observations

Characteristic of Observations | Color of Observations | Percentage

1 | 2 | 3 | 4

Other Observations

Assets or Equipment Observed on Scene

Asset | Type | Quantity

2 of 2

MSRC Level A - Aircraft

- Three dedicated systems
  - Portable
  - Located in Edison, NJ; Lake Charles, LA; and Long Beach, CA
- Utilize pre-identified "Aircraft of Opportunity" (AOO)
  - Mounting brackets developed for various class aircraft
- High height of eye with 24-hr operations potential
  - ~500' to 12,500'
  - Fast speed of advance (120-200 mph)
- Sensors
  - Thermal Infrared (TIR)
  - Multi-spectral (color not seen with eye)

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 Receiver

Small, compact easily transportable package

Proprietary viewing software and gimbal

WIFI transfer to host vessel

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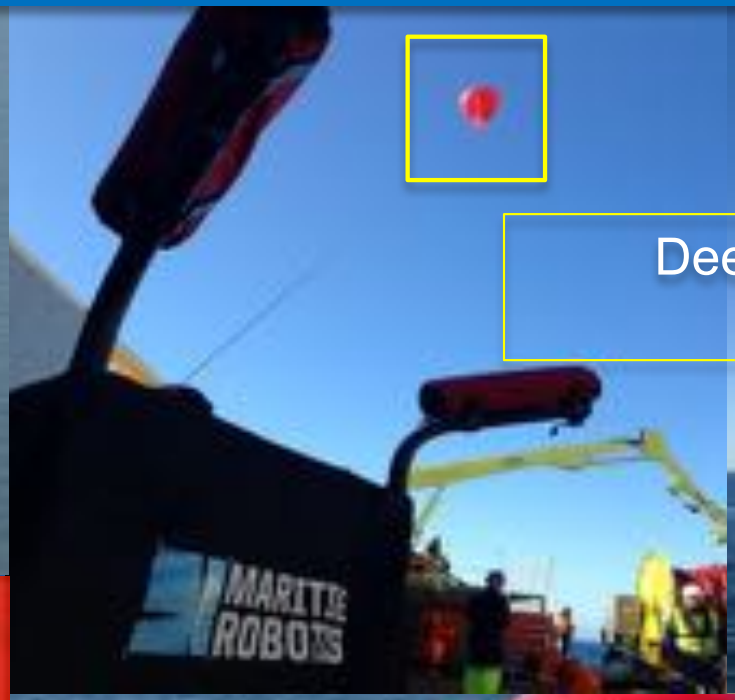
MSRC Level B – BALLOONS (Aerostats)



Deep Blue Responder
01/23/2014

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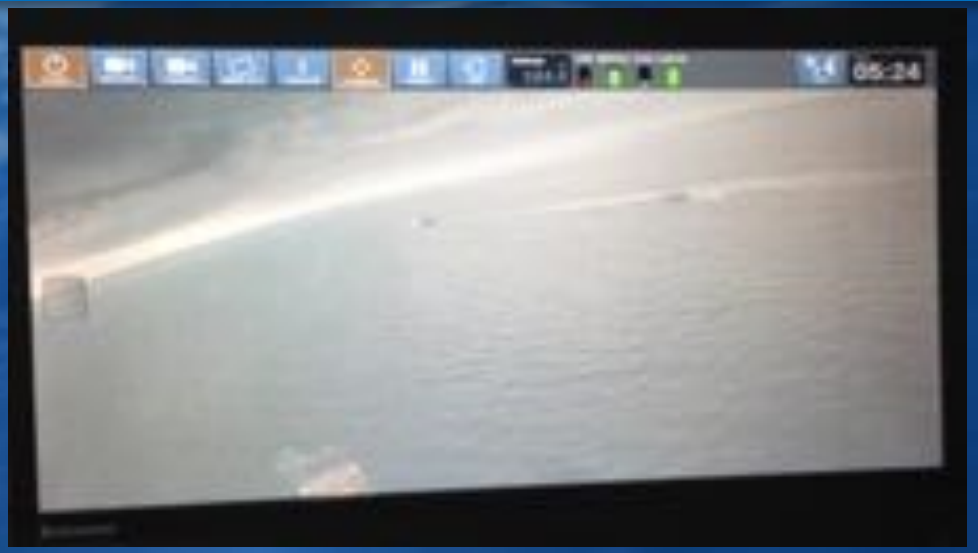
Maritime Robotics Aerostat – OOW 2013



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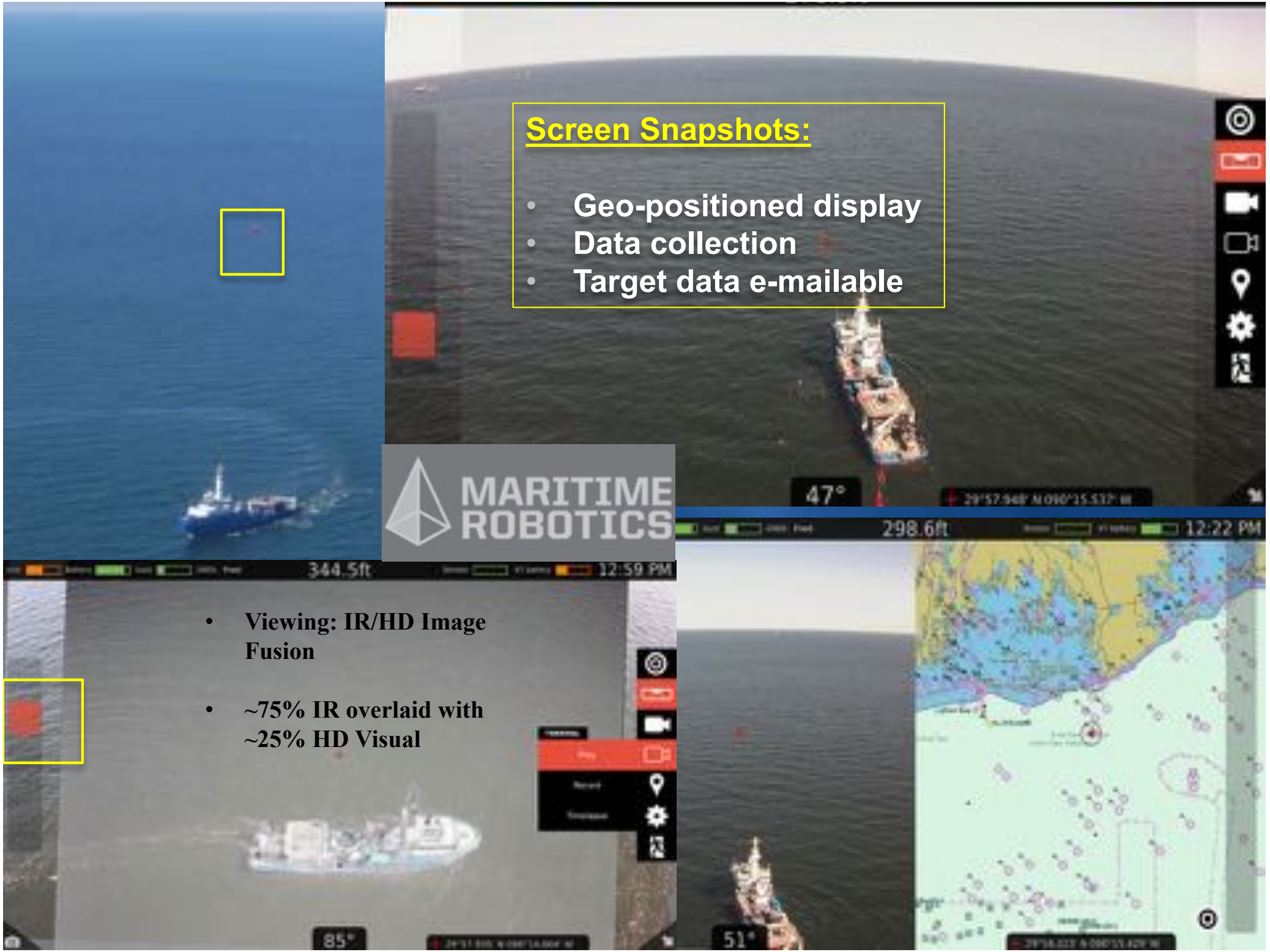
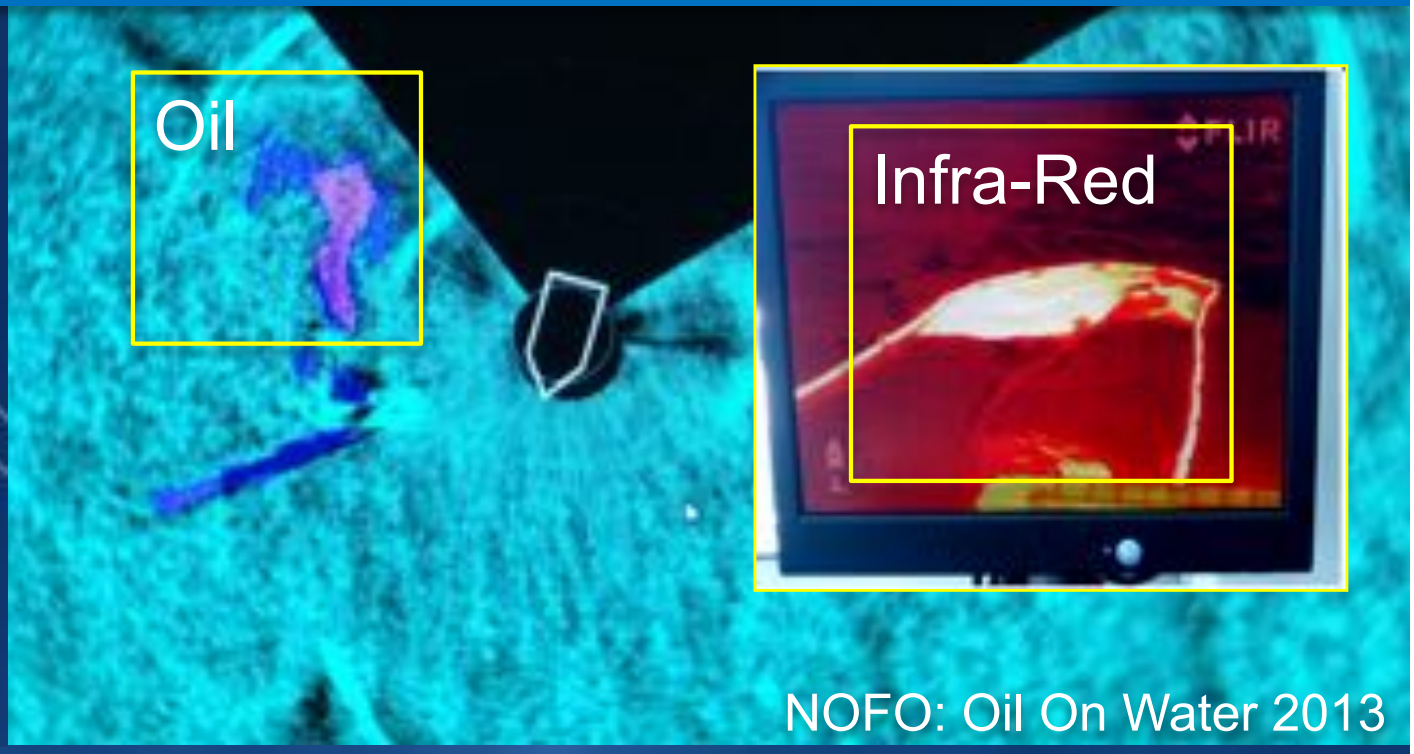

Screen Snapshots:
• Geo-positioned display
• Data collection
• Target data e-mailable
MARITIME ROBOTICS
• Viewing: IR/HD Image Fusion
• ~75% IR overlaid with ~25% HD Visual

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

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

History, Technical Background & Existing Capabilities

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OI'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)

Based off of Multi-Agency Funded Research

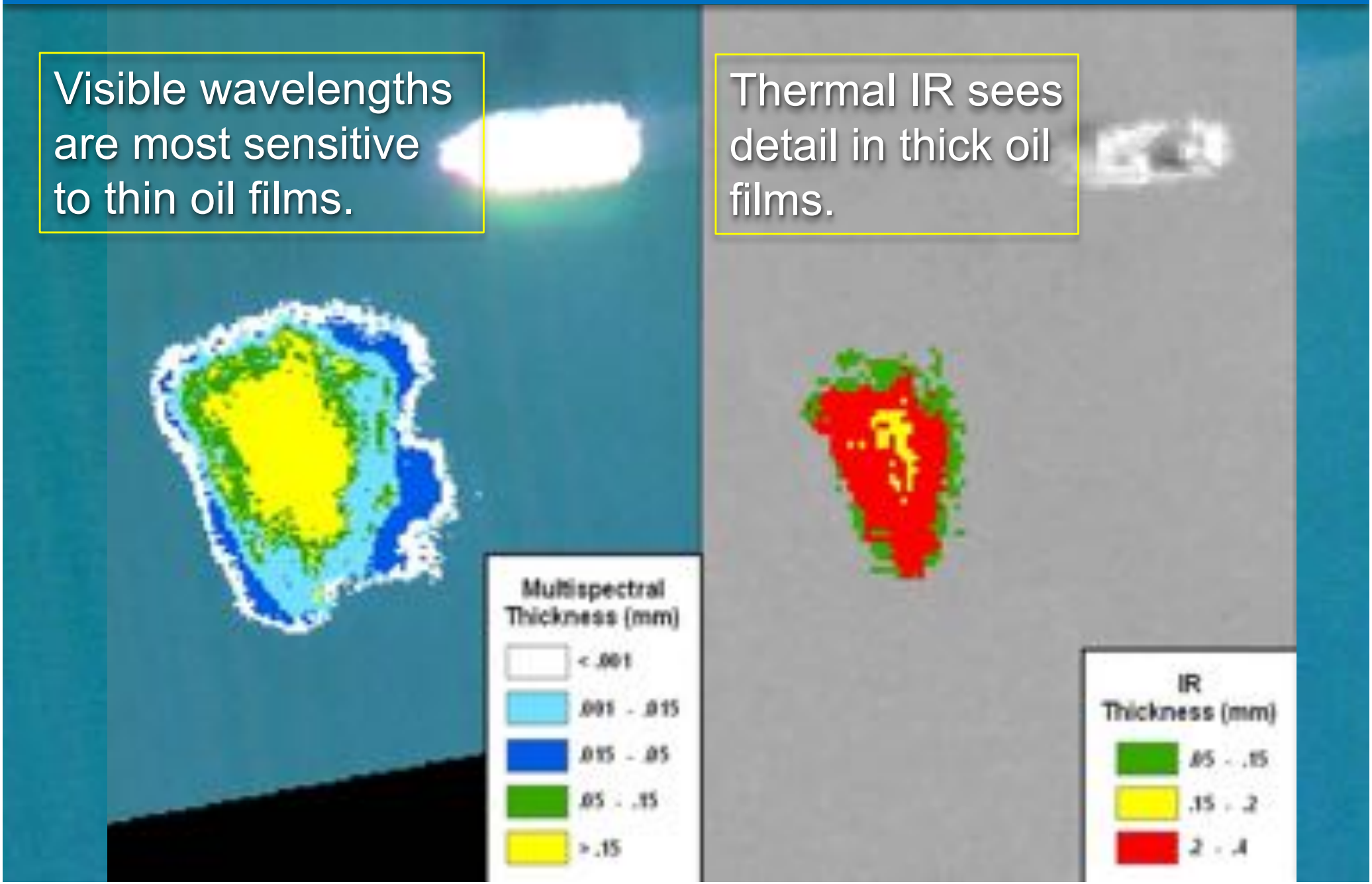
California Dept. of Fish & Game (2004-2005)

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

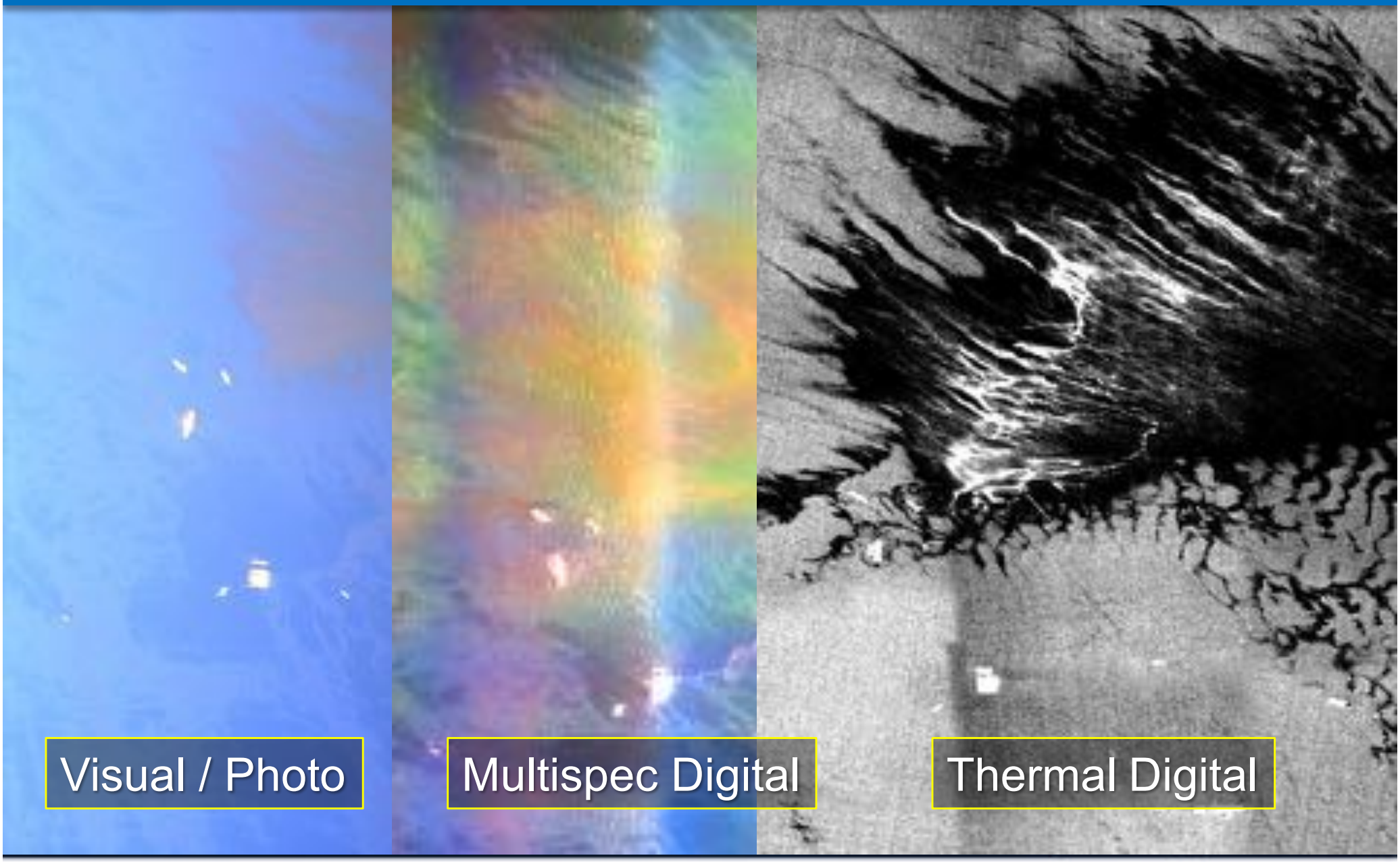
MMS/BSEE (2006 – 2012) Thermal-IR imager was added, system geopositioning improved, algorithms extensively validated/improved, initial emulsion algorithm developed

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

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



Visual & Digital Imaging Oil Comparisons



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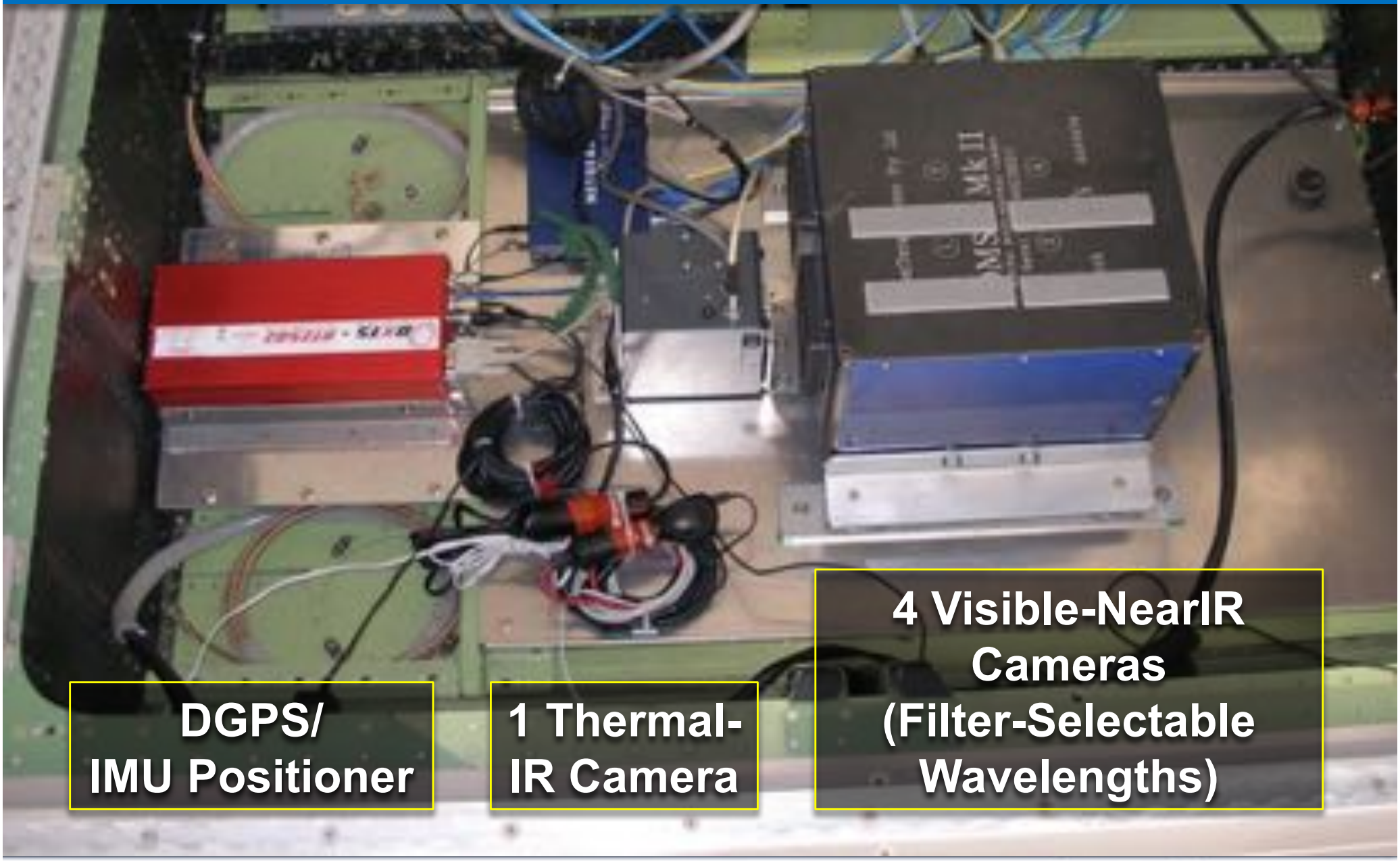
Original System (DMSC-MkII)



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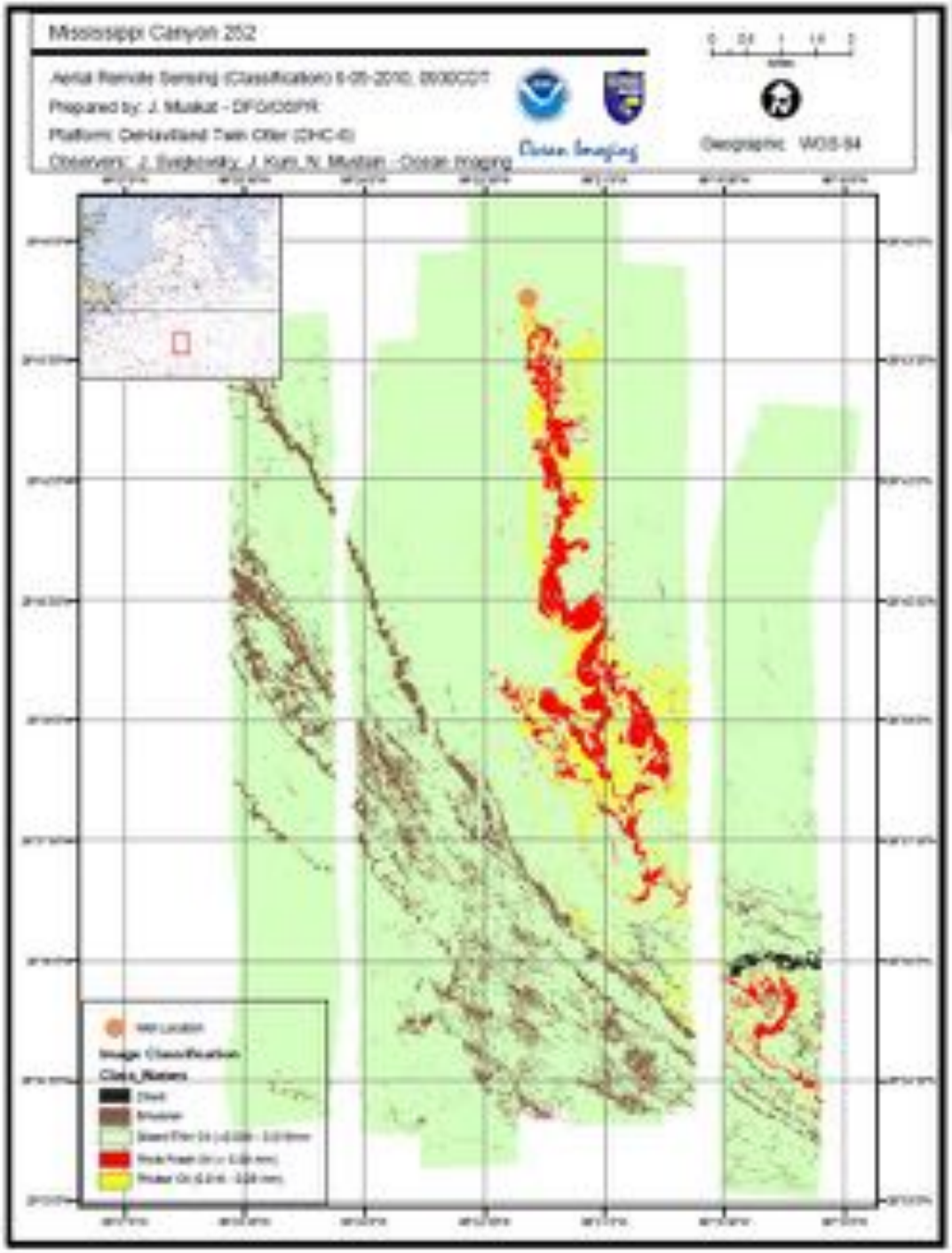

Deepwater Horizon Spill

OI's analysis maps were utilized for multiple applications but a disconnect existed between their distribution and on-water OSROs.

In early 2013, OI began discussions with Marine Spill Response Corp. how to directly incorporate aerial oil mapping systems into their N. American resource network.

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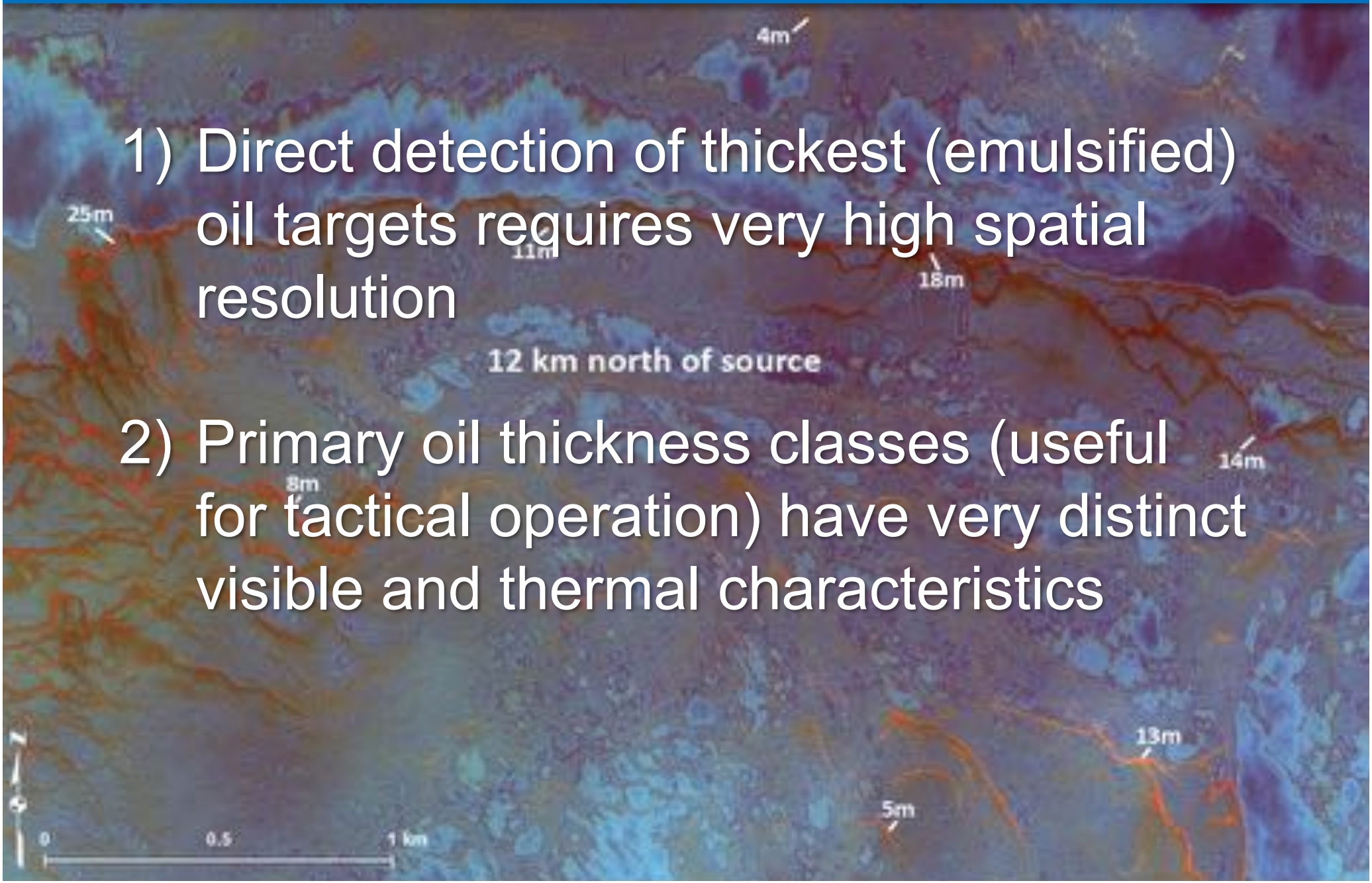
Designing a New System for Direct OSRO Use:
Deepwater Horizon Example



1) Direct detection of thickest (emulsified) oil targets requires very high spatial resolution

2) Primary oil thickness classes (useful for tactical operation) have very distinct visible and thermal characteristics

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)

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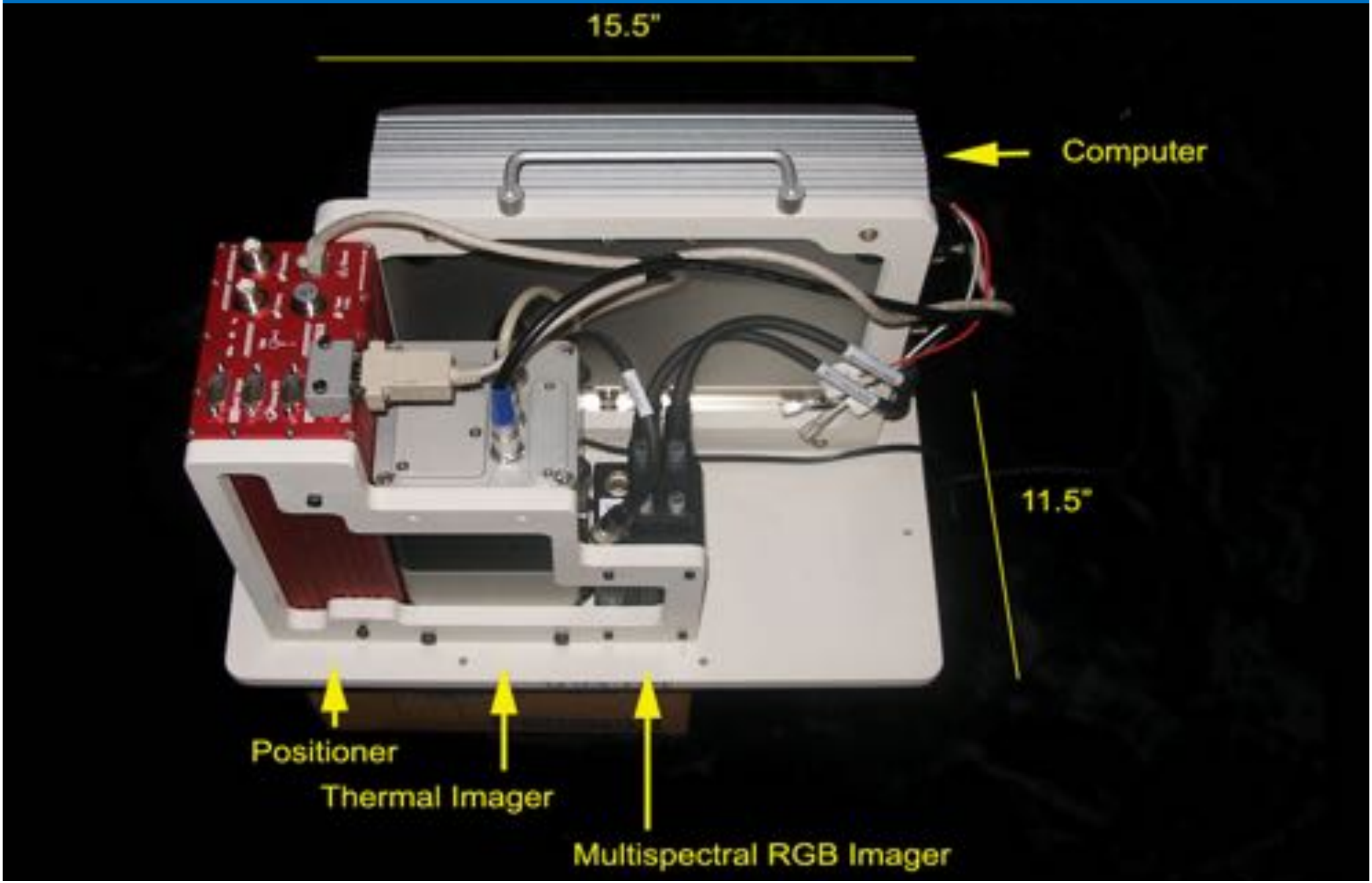
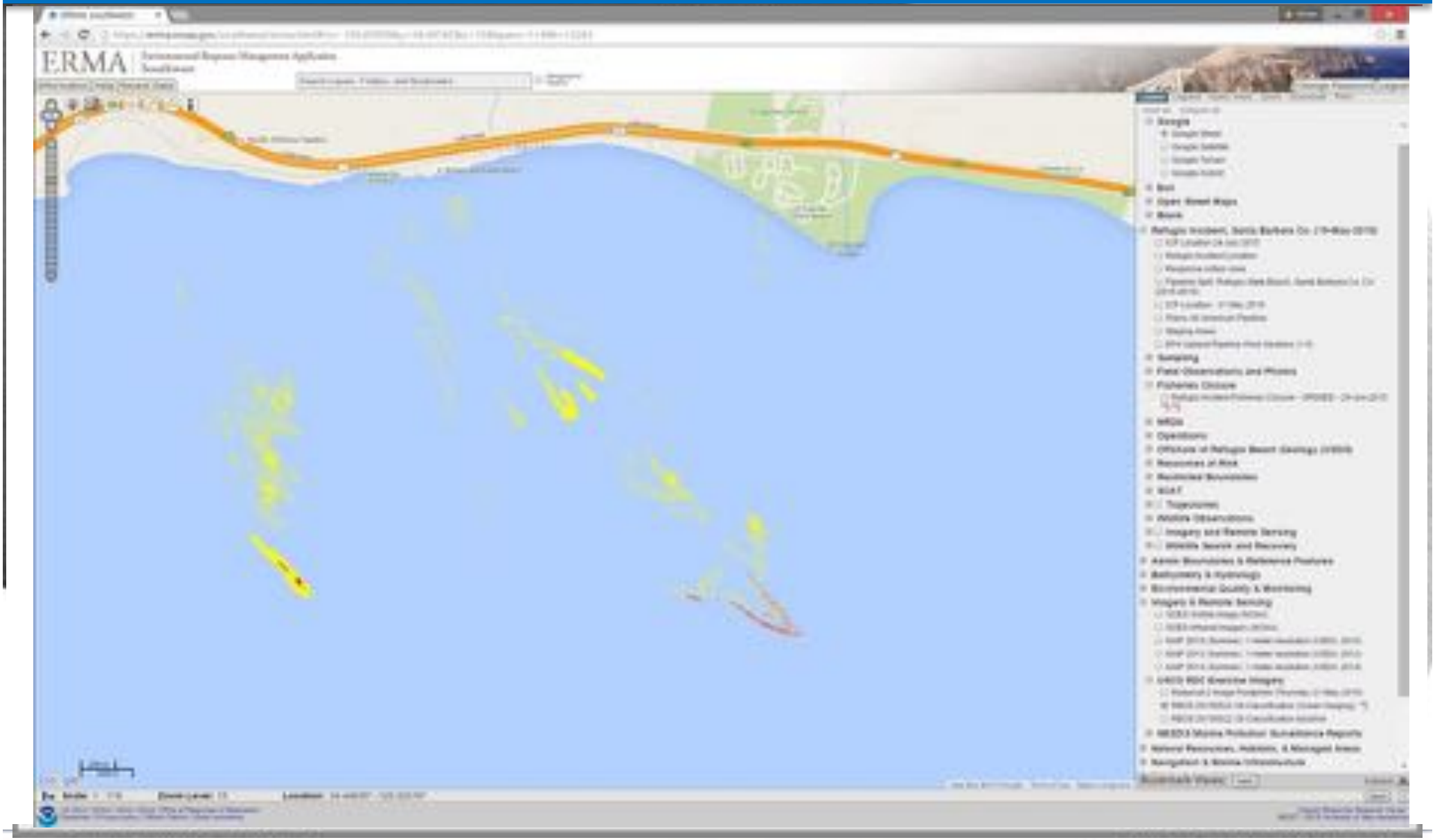
TRACS

Tactical Response Airborne Classification System



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



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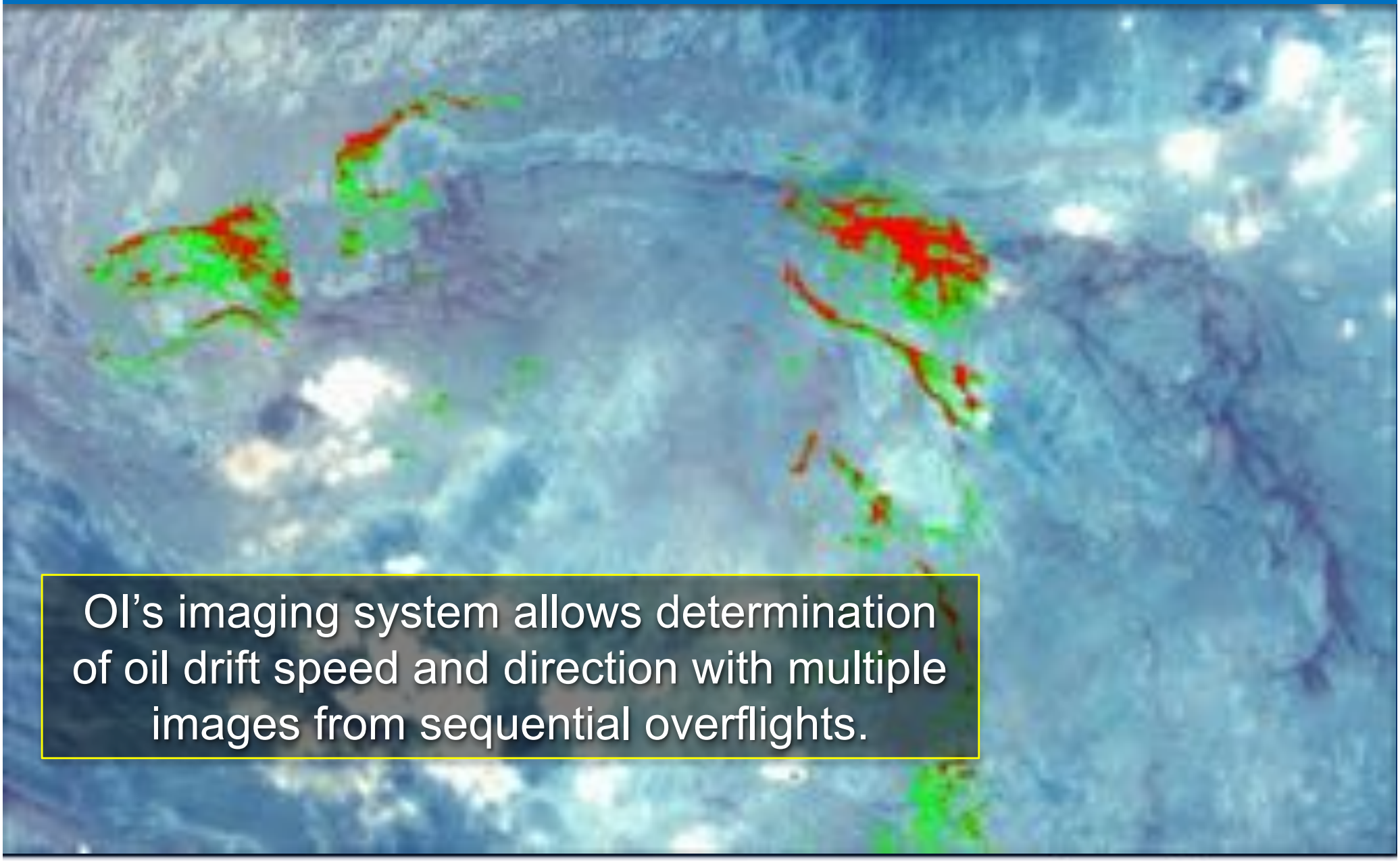
Tracking Moving Oil



OI's imaging system allows determination of oil drift speed and direction with multiple images from sequential overflights.

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Exclusive **MRSC / OI** Partnership

✓ OI presently maintains 3 TRACS at MSRC facilities in New Jersey, Louisiana, 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

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On-going R&D:

Algorithm development:

1) Emulsified oil quantification
2) Real-time image mosaic product enhancements

New sensor evaluation:

1) UV imager
2) Polarimetric Thermal Imaging
3) “Mini-SAR”

Principles guiding R&D

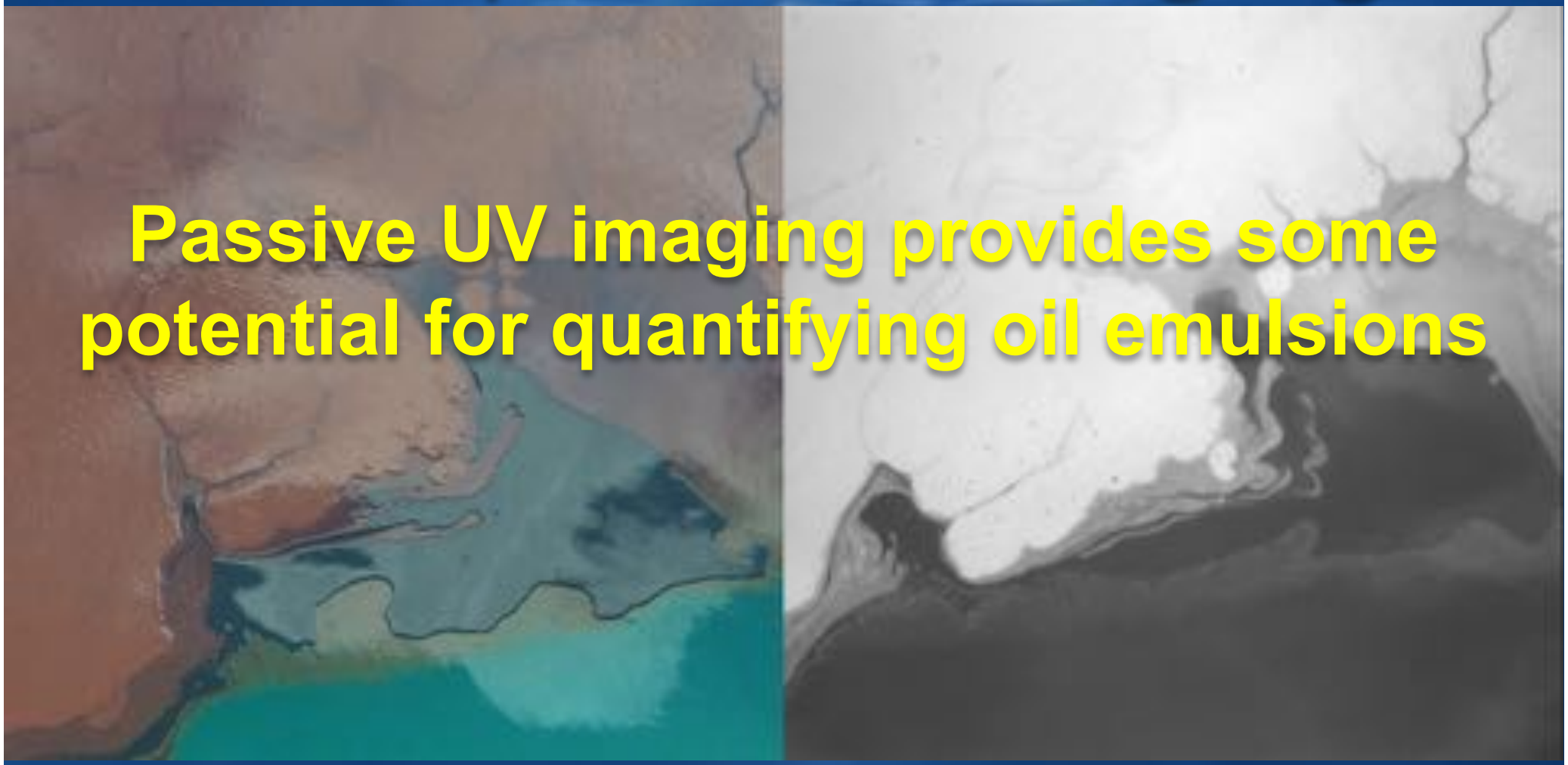
Will additional sensor/algorithm increase TRACS' operational efficiency?

1) Improve quantitative characterization of oil targets

2) Improve identification of false targets

Will new sensor benefits outweigh increased complexity and cost?

Example: UV imaging



Passive UV imaging provides some potential for quantifying oil emulsions

THANK YOU!

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