OIL SPILLS IN ICE
Remote Sensing

Technology Overview and Upcoming JIP Research

David Dickins – Chevron

IOSC2014 – Savannah

COLLABORATION AMONG TEN COMPANIES

- **International arctic research programme**
- **Builds upon decades of R&D**
- **Experts across industry, academia and independent research centres**
- **Research integrity** - technical review and publication

Six areas of research:

Remote Sensing

Dispersants

Environmental Effects

In Situ Burning (ISB)

Mechanical Recovery

Trajectory Modelling

bp

eni

ConocoPhillips

Chevron

ExxonMobil

Statoil

TOTAL

GAZPROM

NCOC
NORTH CASPIAN OPERATING COMPANY

ARCTIC RESPONSE TECHNOLOGY
OIL SPILL PREPAREDNESS

REMOTE SENSING PROJECTS WITHIN THE JIP

Aim: Advance oil spill remote sensing and mapping capabilities in darkness and low visibility; in broken ice; and under ice

- Phase 1 complete – technology review
- Phase 2 experiments launched May 1
- Phase 3 field work planned 2015

Phase 1

Technology Review

COMPLEX ICE ENVIRONMENTS

Photos: DF Dickins

Many Different Forms affecting oil in ice detection

Fast ice (attached to shore)

Grease/nilas at freeze-up

Open pack at break-up

Shore ice interaction

Multi-year/2nd year ice

Deformed ice

ARCTIC RESPONSE TECHNOLOGY
OIL SPILL PREPAREDNESS

MULTIPLE SENSORS AND PLATFORMS

Space (SAR)

Airborne (Radar, UV/IR, FLIR, SLAR, LFS, Visible, NMR)

Surface (GPR, FLIR, Dogs, High Speed Marine Radar)

GPS ice tracking buoys

Subsurface (Sonar, LFS, Fluorometer, High Dynamic Range Camera)

Fixed wing, helicopters, AUV, UAV, Satellites

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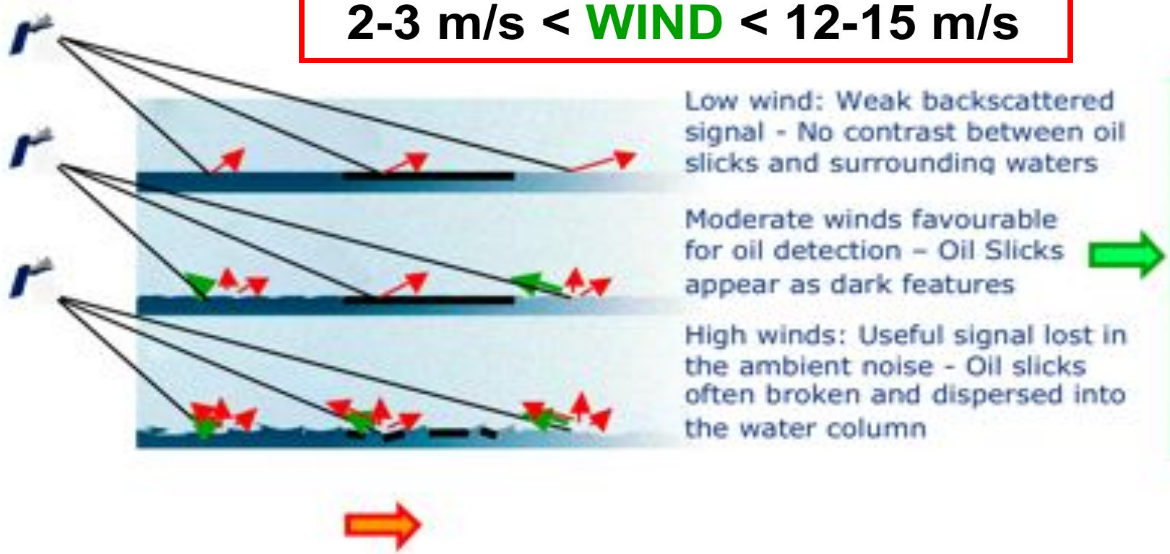
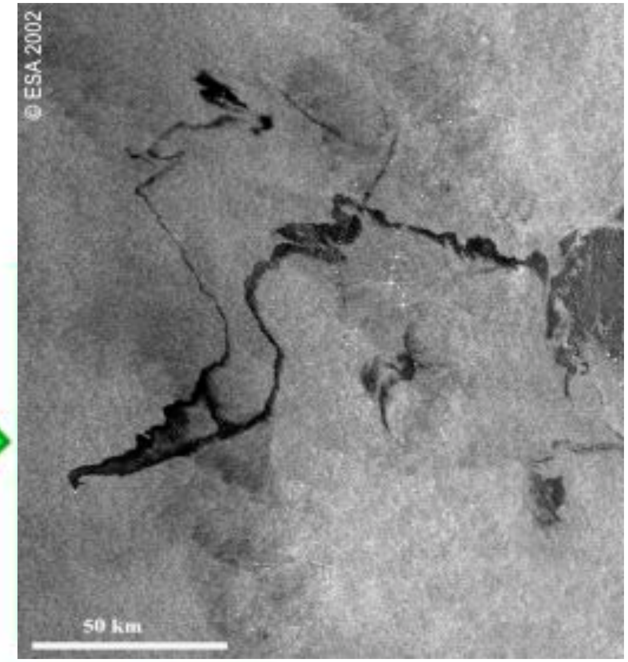
OIL SPILL PREPAREDNESS

Satellite remote sensing

2-3 m/s < WIND < 12-15 m/s





We can see large oil slicks at sea with SAR satellites. Is it possible to see oil among ice?

Answer depends on the conditions – ice concentration, size of slick, wind and waves – maybe a large slick in open drift ice cover?

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Airborne Remote Sensing

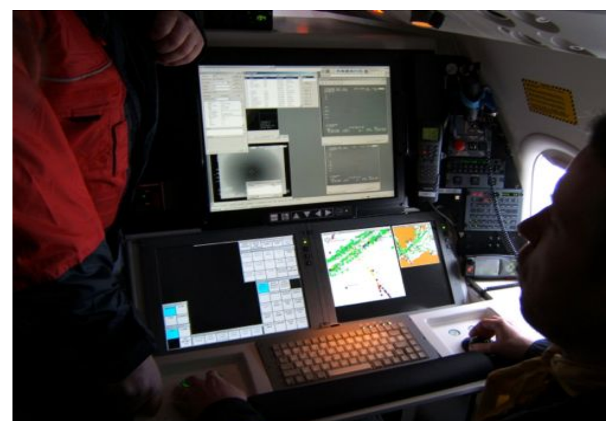
Swedish Coast Guard Dash 8 Q300

GPS and satcomm antennas

Radio antennas

Search radar
ELTA 2022 A

IR/UV Argon AA 3503



FLIR Wescam MX 15

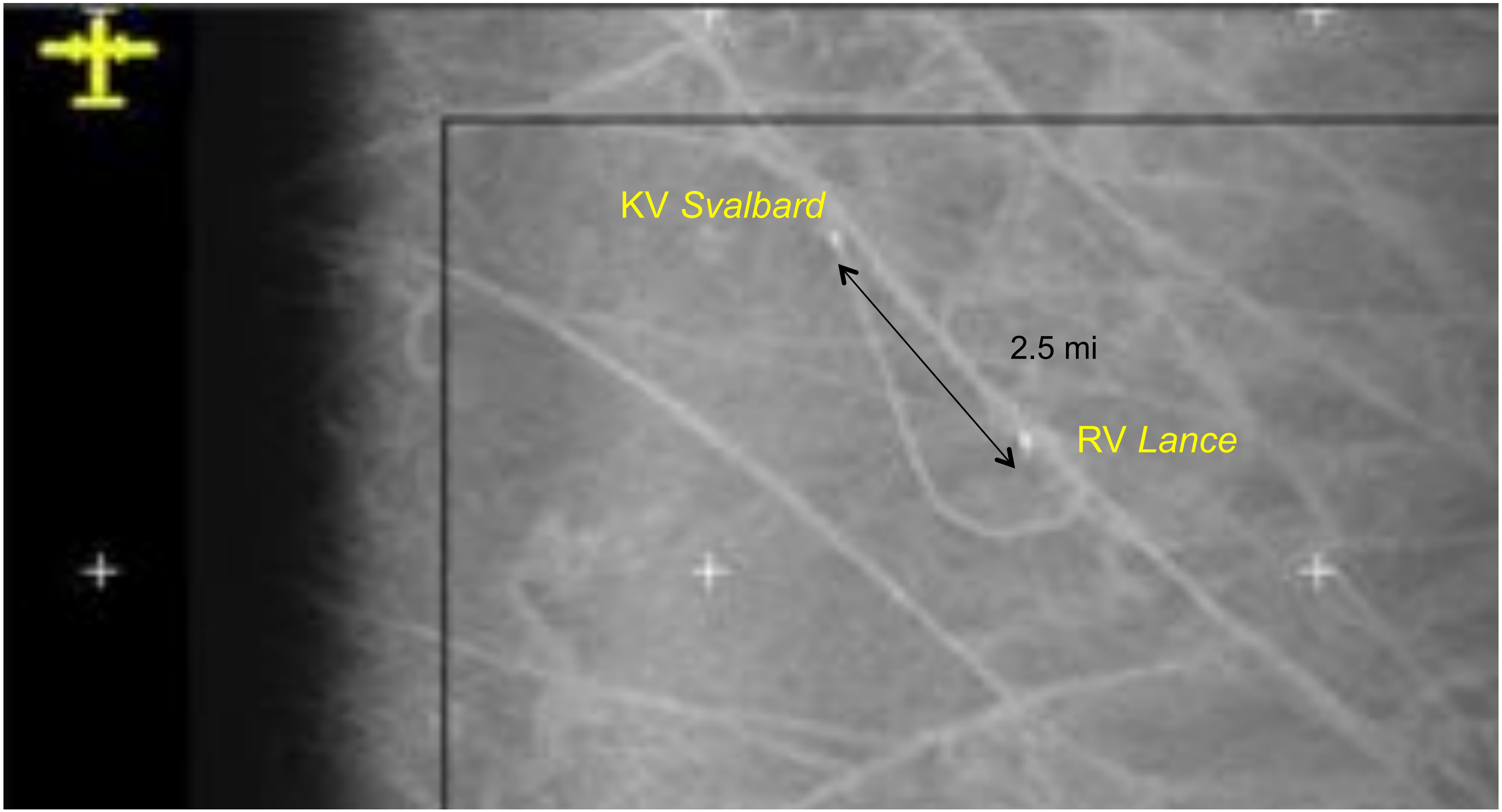
SLAR SSC/Ericsson

Weather radar Honeywell

SWEDISH COAST GUARD

TECHNOLOGY
OIL SPILL PREPAREDNESS

AIRBORNE SLAR IMAGE NORWEGIAN BARENTS SEA 2009
4 hours after end of discharge – 44 bbl spil in 8-9/10 pack



No oil visible – dimensions of the slick are much smaller than the SLAR resolution ~30-60 m

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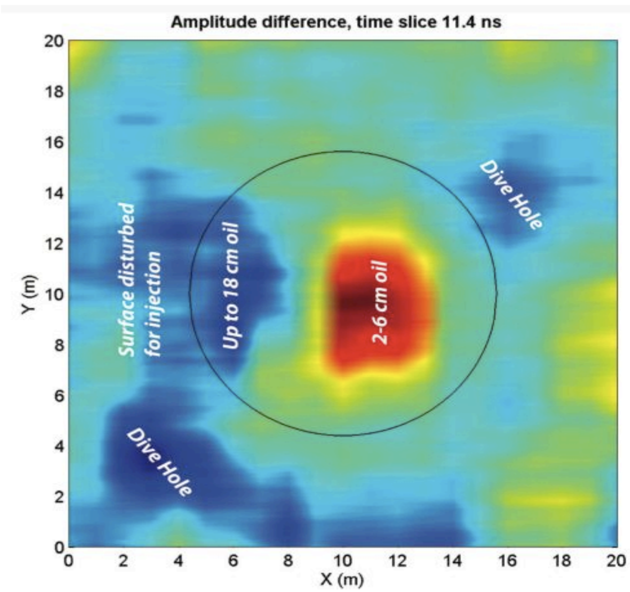
SURFACE & AIRBORNE RADAR

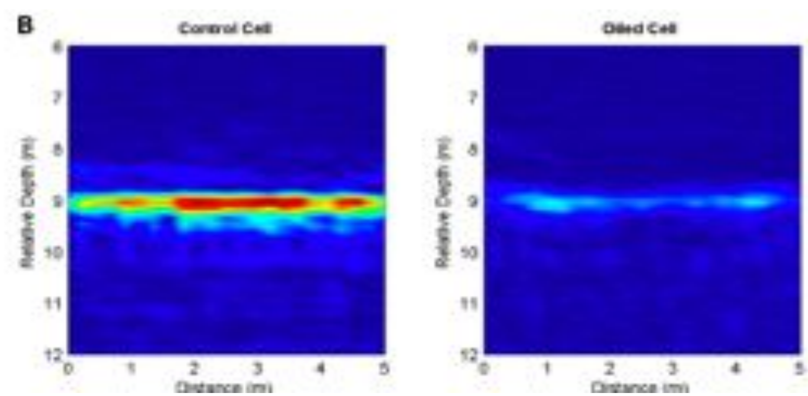
Boise State University and DF Dickins 2004 - 2012

Photos: D. Dickins



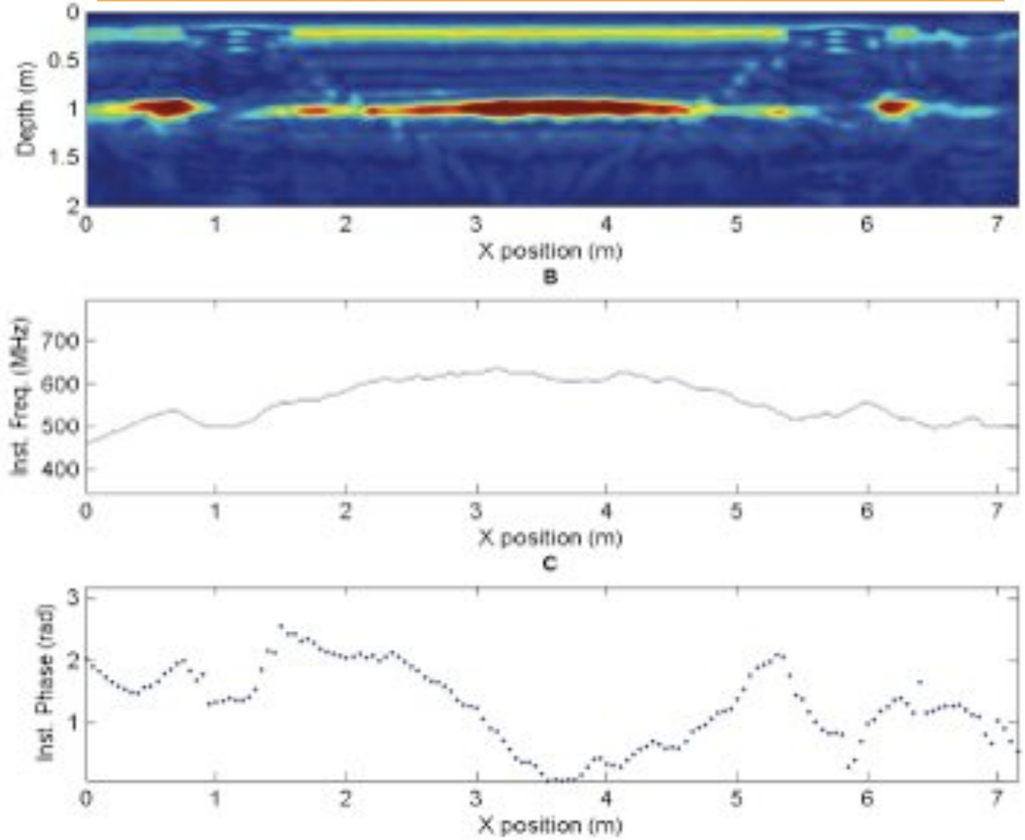
Testing 500 MHz impulse GPR over oil trapped under 65 cm ice at Svea – Svalbard 2006

Successful airborne detection oil on the ice under snow – Svalbard 2008



CRREL 2011 RADAR TESTING

Reflection attributes extracted from the cross tank profile over Hoop 2 clearly differentiate the oiled area with an increase in reflection amplitude, increase in instantaneous frequency, and decrease in instantaneous phase.



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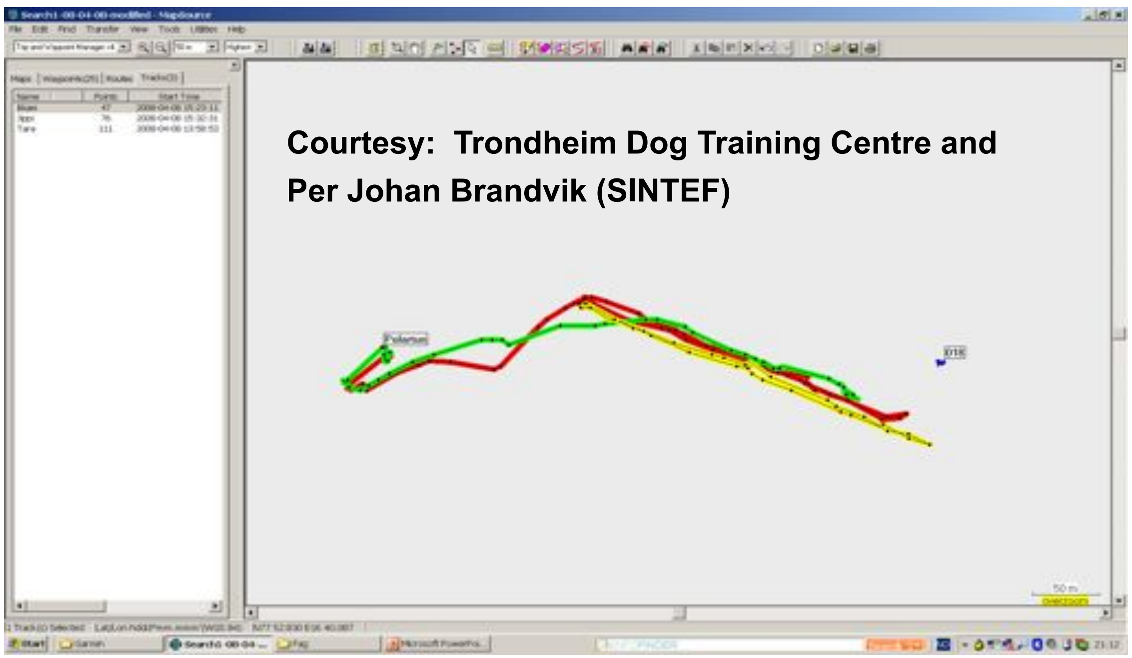
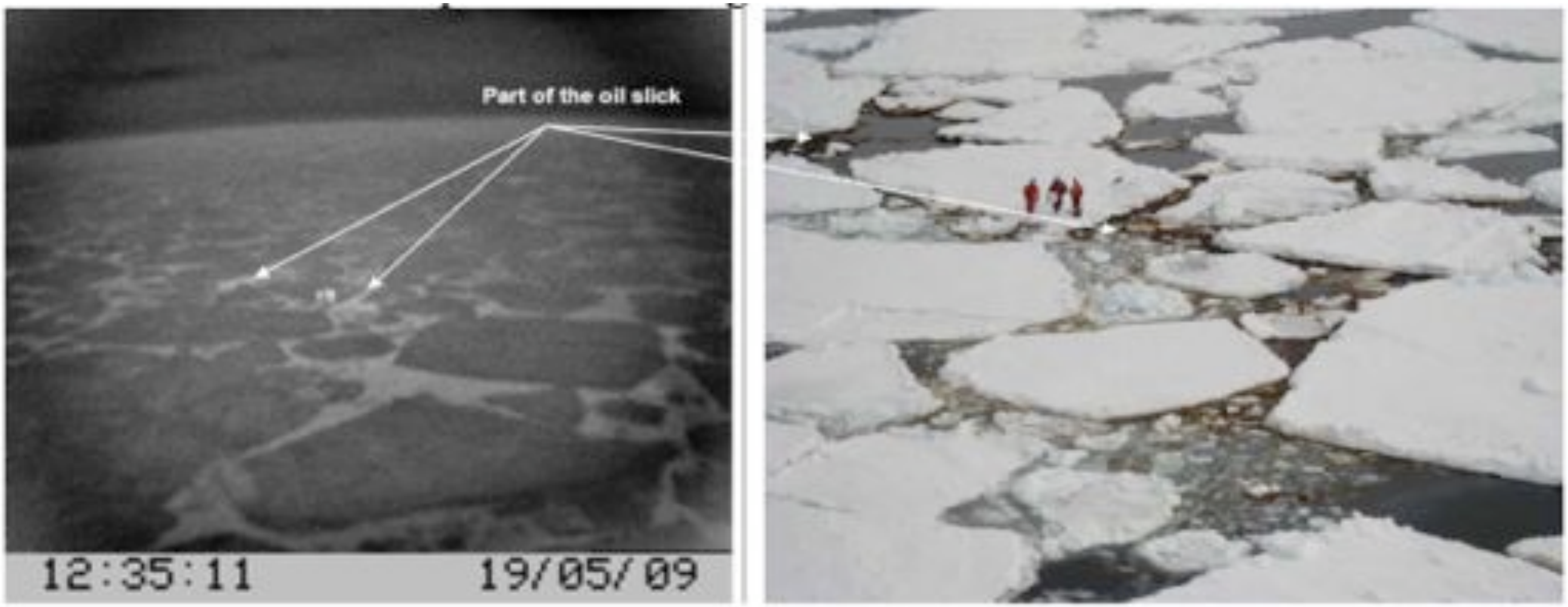
Trained dogs tested Trondheim and Svalbard



Courtesy: Trondheim Dog Training Centre and Per Johan Brandvik (SINTEF)

ARCTIC RESPONSE TECHNOLOGY
OIL SPILL PREPAREDNESS

HAND-HELD IR IMAGES
SINTEF Oil in Ice JIP field experiment 2009

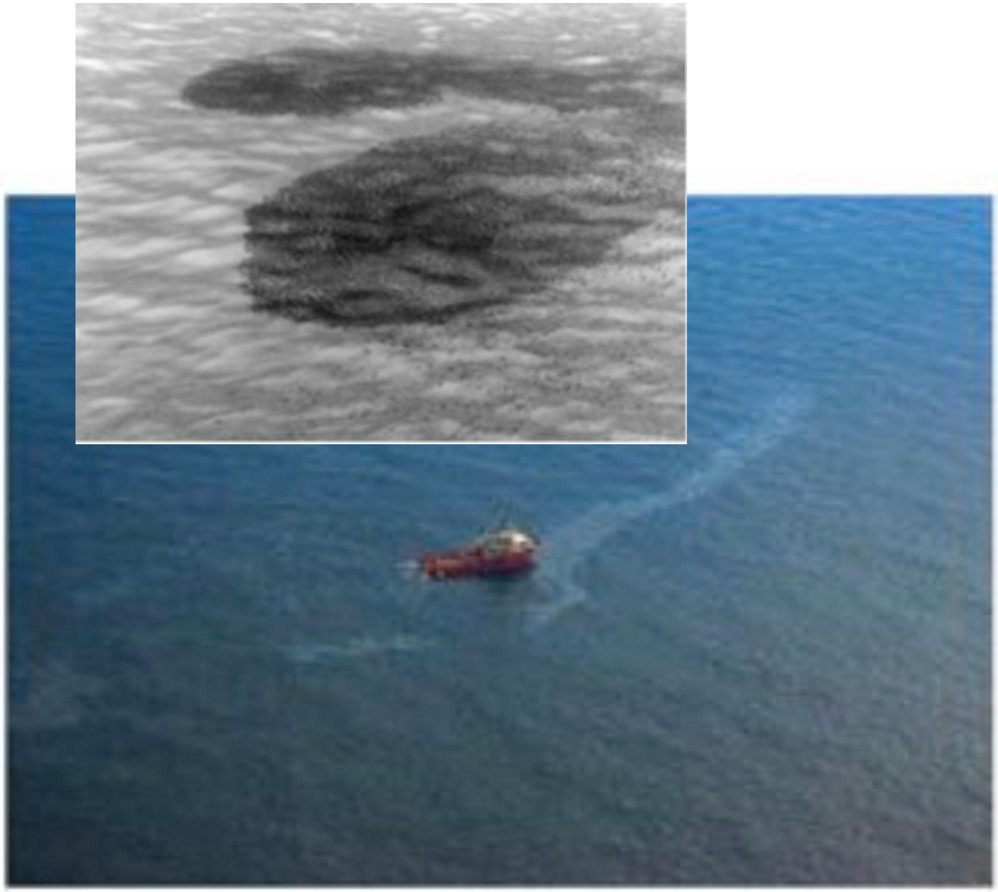


Source: Per Daling -Sintef

Greatest potential during daylight. More advanced cooled IR sensitive to very small temperature changes.

MARINE RADAR & FLIR

Examples from offshore trials off Norway (Courtesy: MIROS, Aptomar and NOFO)



Aptomar SECurus Integrates high resolution digital daylight and IR video – stabilized to accurately position each pixel on electronic chart display.

MIROS high speed radar separates thin and thick slick areas.

ARCTIC RESPONSE TECHNOLOGY
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KEY POINTS

Current capabilities

- Surface GPR can detect oil layers down to ~ 1 cm under smooth ice
- Subsurface sonar can detect a wide range of oil thickness from below but capabilities to detect encapsulated oil not fully understood
- No current surface system can find oil under rough ice
- Airborne or AUV surveys in moving ice require complex post-processing for positioning
- Generally need prior knowledge as to where the oil is most likely to be
- Traditional airborne or satellite remote sensing for large slicks in light ice cover (SAR imagery unaffected by cloud or darkness)

EVOLVING TECHNOLOGIES

- Frequency Modulated Continuous Wave Airborne Radar (FMCW)
- Nuclear Magnetic Resonance (NMR)
- AUV using single/multi-beam sonar and other sensors

FMCW RADAR

Three prototypes built 2011-12

Low altitude (10-20 m) and speeds over 40 knots

First validation over oil in ice expected 2014 at CRREL

Designed to fit Bell 206, AS 350 with FAA approved mount

Dickins 2006

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ONGOING NMR RESEARCH - EXXONMOBIL

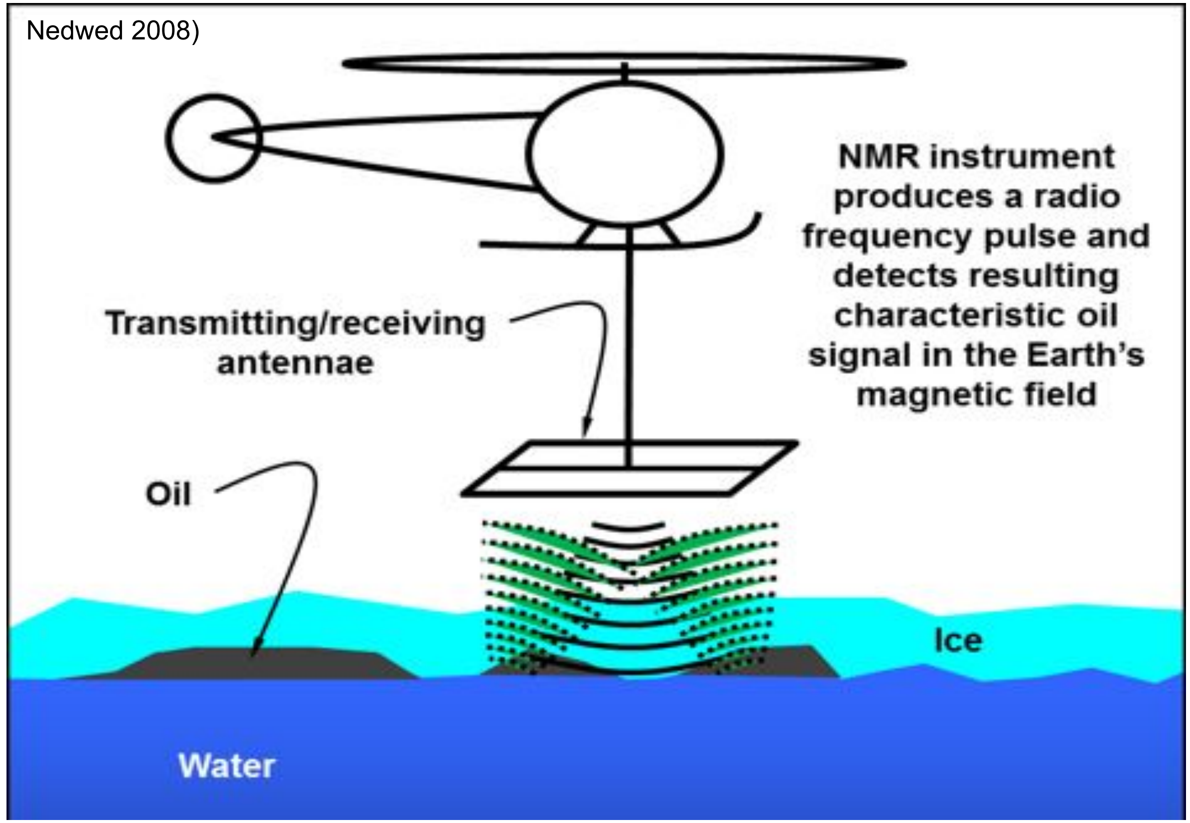
For detection of oil under ice, NMR antennae measures the time required (T_2) for hydrogen protons to return (precess) back to equilibrium after being perturbed (relaxation time)

The relaxation time (T_2) for oil and water can be differentiated

Ice and snow are ‘virtually’ invisible

The NMR concept is a flat coil design to be placed on the ice for <3 minutes – not a moving survey tool

Current research is focusing on increasing the SNR ratio – full-sized prototype construction in 2014 with basin tests planned for 2015



Courtesy T. Nedwed

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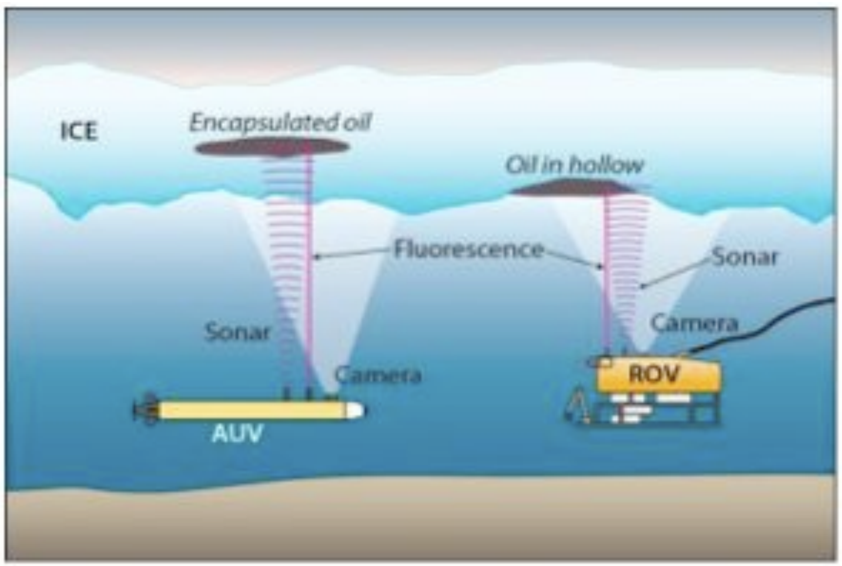
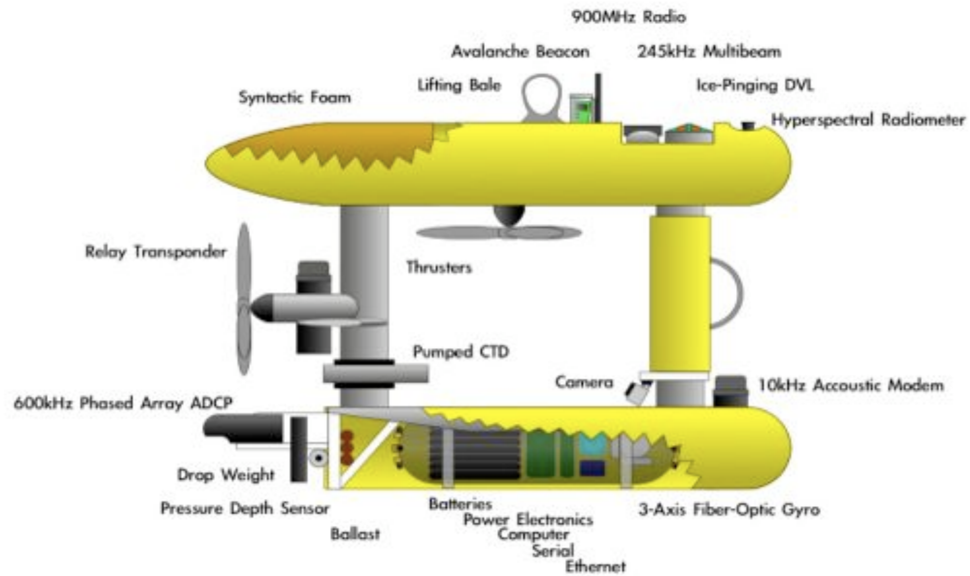
AUV WITH UPWARD LOOKING SONAR

Autosub
P. Wadhams

Successful Feb 2011 test with oil under ice at CRREL (Scottish Marine Institute and Woods Hole Oceanographic Institute supported by PWSSC) – Wilkinson et al. 2012





Jaguar AUV courtesy Pete Kimball - WHOI

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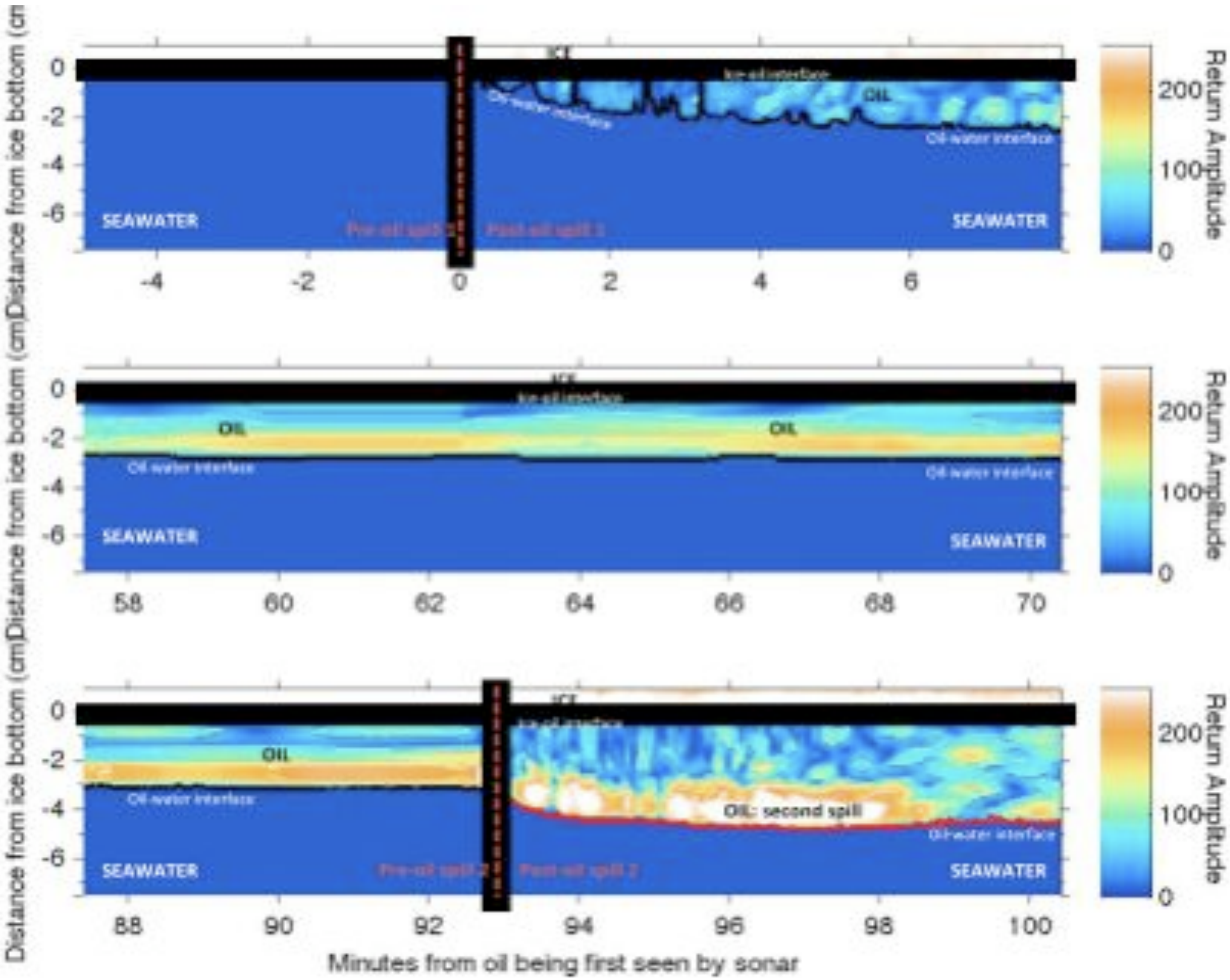
SUCCESSFUL SONAR DETECTION 2011
(WILKINSON ET AL., 2012)



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PHASE 1 CONTRACTOR RECOMMENDATIONS

C-CORE - Detection from Above

Work Scope covered surface, airborne and satellite systems

- Continue research on GPR and NMR
- Compare sensors in different ice conditions (basin and field)
- Validate existing technologies focusing on:
  - Hyperspectral sensors (including IR)
  - Laser based systems
  - Radar based systems
  - NMR

PHASE 1 CONTRACTOR RECOMMENDATIONS

Polar Ocean Services & Woods Hole Oceanographic Inst.

Work Scope focused on under ice remote sensing (AUVs)

- Develop operational AUV platform
- Develop sensor package including:
  - Cameras
  - Sonar
  - Laser Fluorometer
  - Radiometer
- Conduct controlled repeatable sensor testing with oil within, under and on ice
- Field testing should focus on:
  - AUV deployment
  - AUV navigation and survey control
  - Challenges of data telemetry from under ice

Phase 2

Tank testing at US Army CRREL starting July 2014

Prime Contractor

Prince William Sound Oil Spill Recovery Institute (OSRI)

CRREL TEST BASIN IN PREP FOR 2014 TEST PROGRAM

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Photo: D. Dickins

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Questions?