Sonardyne

SOUND IN DEPTH

Marine Monitoring for CCS using Cost Effective Autonomy

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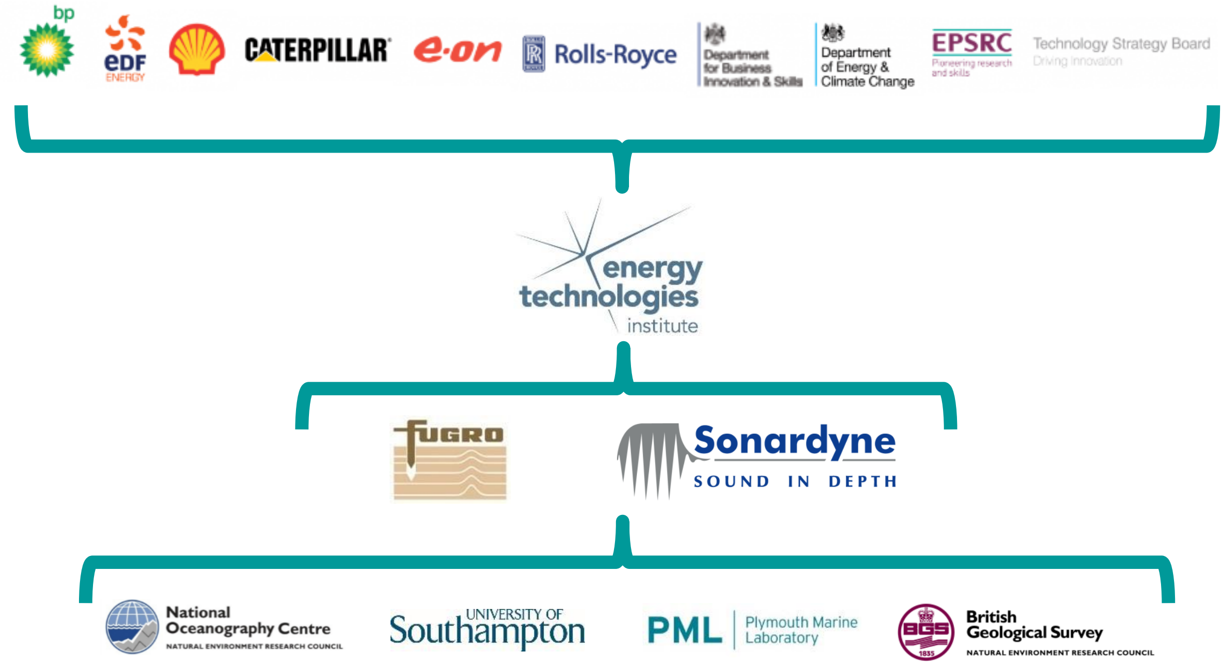
Agenda

(1) Marine CCS MMV progress in the UK

(2) ‘PMT the InSAR of the Seas’

The ETI is a public-private partnership between global energy and engineering companies and the UK Government.

Their role is to act as a conduit between academia, industry and the government to accelerate the development of low carbon technologies.



Enabling CCS Marine Monitoring, Measurement and Verification (MMV) in the UK

"The purpose of the Project is to develop and demonstrate a **cost-effective MMV system** for ongoing **environmental assessment of emissions** in the marine and shallow subsurface environment in order that operators involved in the injection of carbon dioxide into the subsurface can meet the **legislative requirements** for such activities."

Key Functional Requirements

- Detect and locate the source of leaks from a CO_2 storage site in the form they are expected to emanate from the sea bed;

- Provide a capability to detect CO_2 leaks which have the potential to damage the marine environment, jeopardise the financial success of the store, or represent no more than 0.01% loss store-wide per annum of the planned inventory at the end of the injection phase.

- Operate in marine environments of water depth of between 5 - 200m, CO_2 store depth between 800 - 4600m, over stores having an areal extent of 10 - 3000 km^2, at distances of 25 - 150 miles from land, and within sea temperatures between 5 - 17 °C

- Provide data analysis and interpretation capability to enable leaks from CO2 storage sites to be discriminated from other seabed emissions;

A reminder of the offshore CCS Environment in the North Sea

CO2 in the Marine System

Science and Sensors discussed at IEAGHG Meeting…

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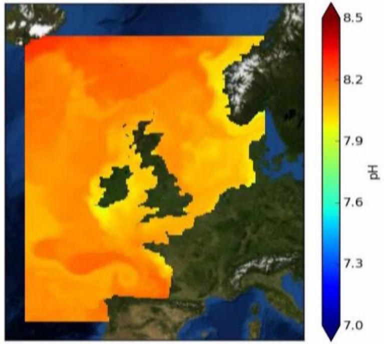
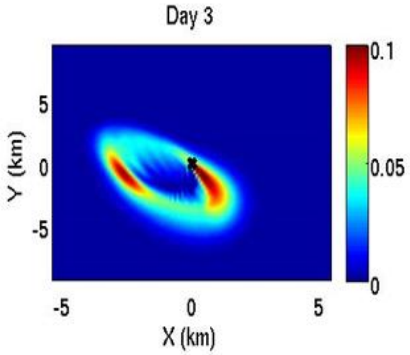
We have worked together to understand the problem:

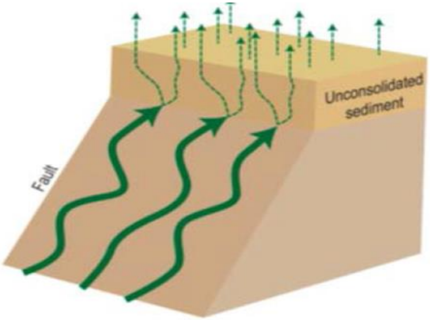
- pH and seawater chemistry variations on a sea scale across the seasons (& ocean interaction)
- How much might leak out of a reservoir
- How the leak may appear at the seabed
- Tidal mixing processes and how a leak signature would disperse
- How gas and chemical plumes would form and disperse
- What risks there are from different storage sites
- Mechanical vs geological risks (discuss later!)



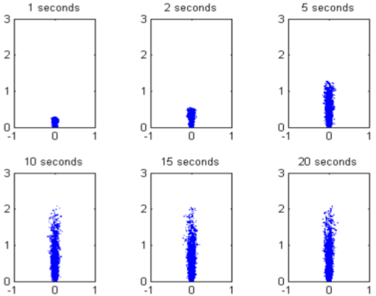
PML | Plymouth Marine Laboratory



National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

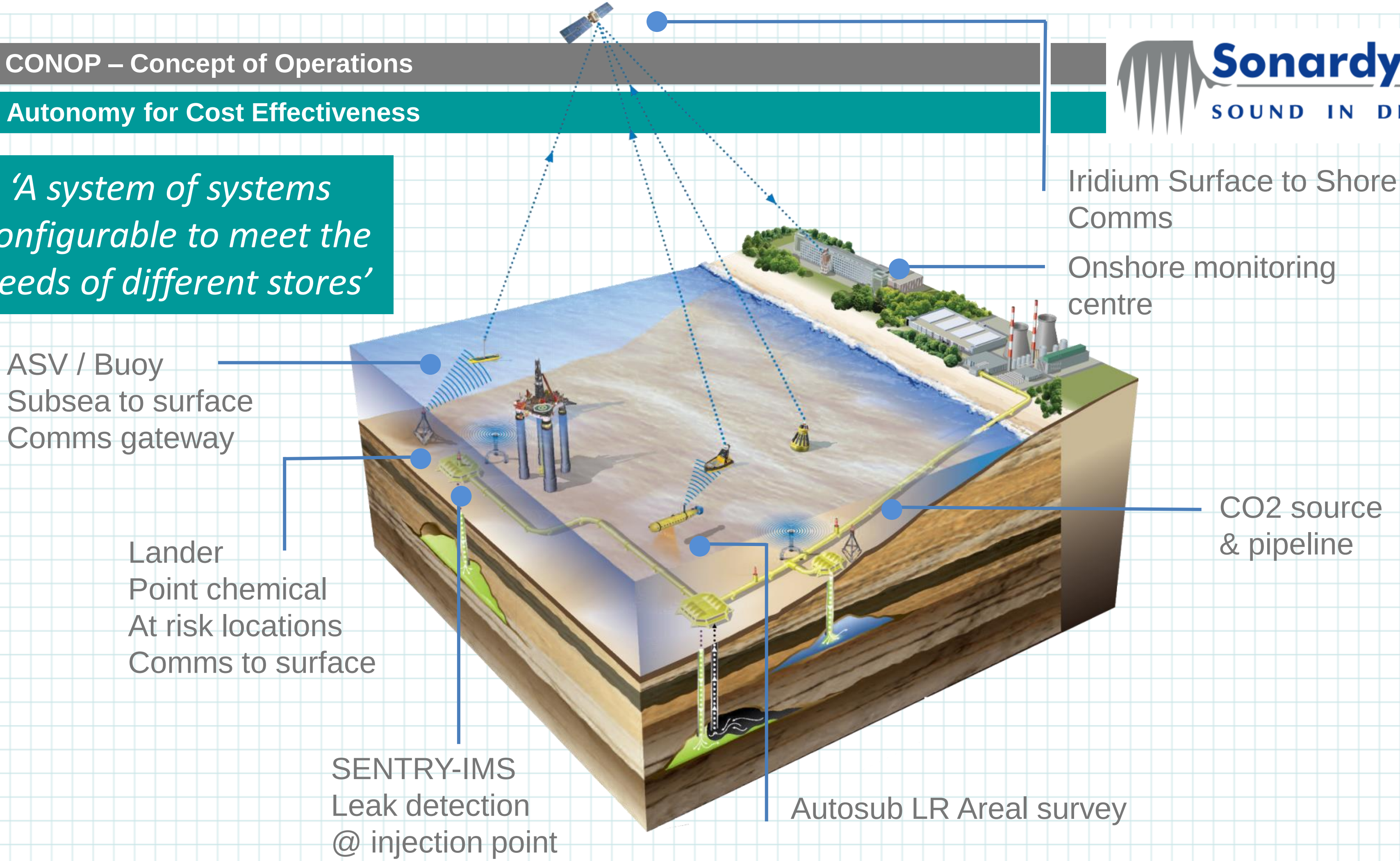


UNIVERSITY OF Southampton

CONOP – Concept of Operations

Autonomy for Cost Effectiveness

'A system of systems configurable to meet the needs of different stores'



Underwater Sensing Solutions
Processing
Decision Making
Static Landers & AUVs / ASVs

Technologies

Vehicle Load

Chemical Sensing – *'Smelling or tasting the leak' – Data flows*

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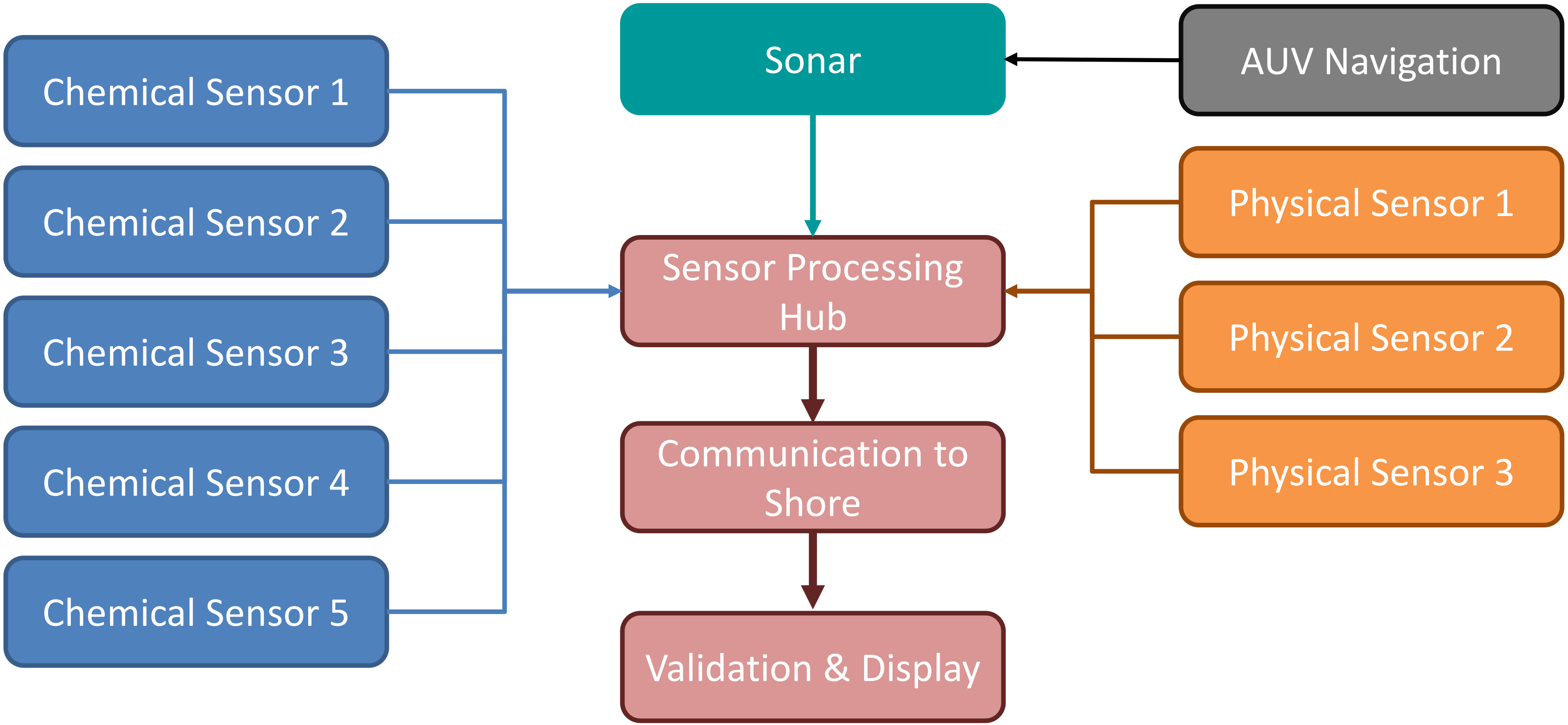
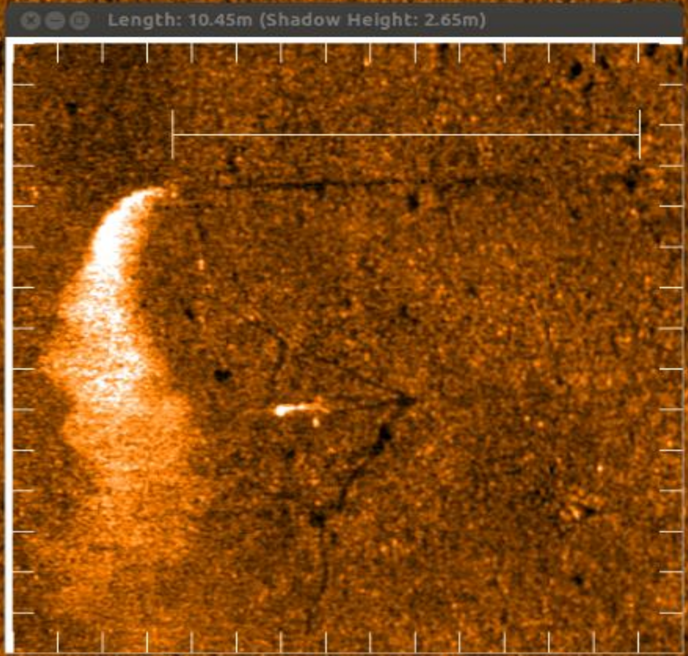


Solstice – AUV based low power wide area coverage leak detection with ATR

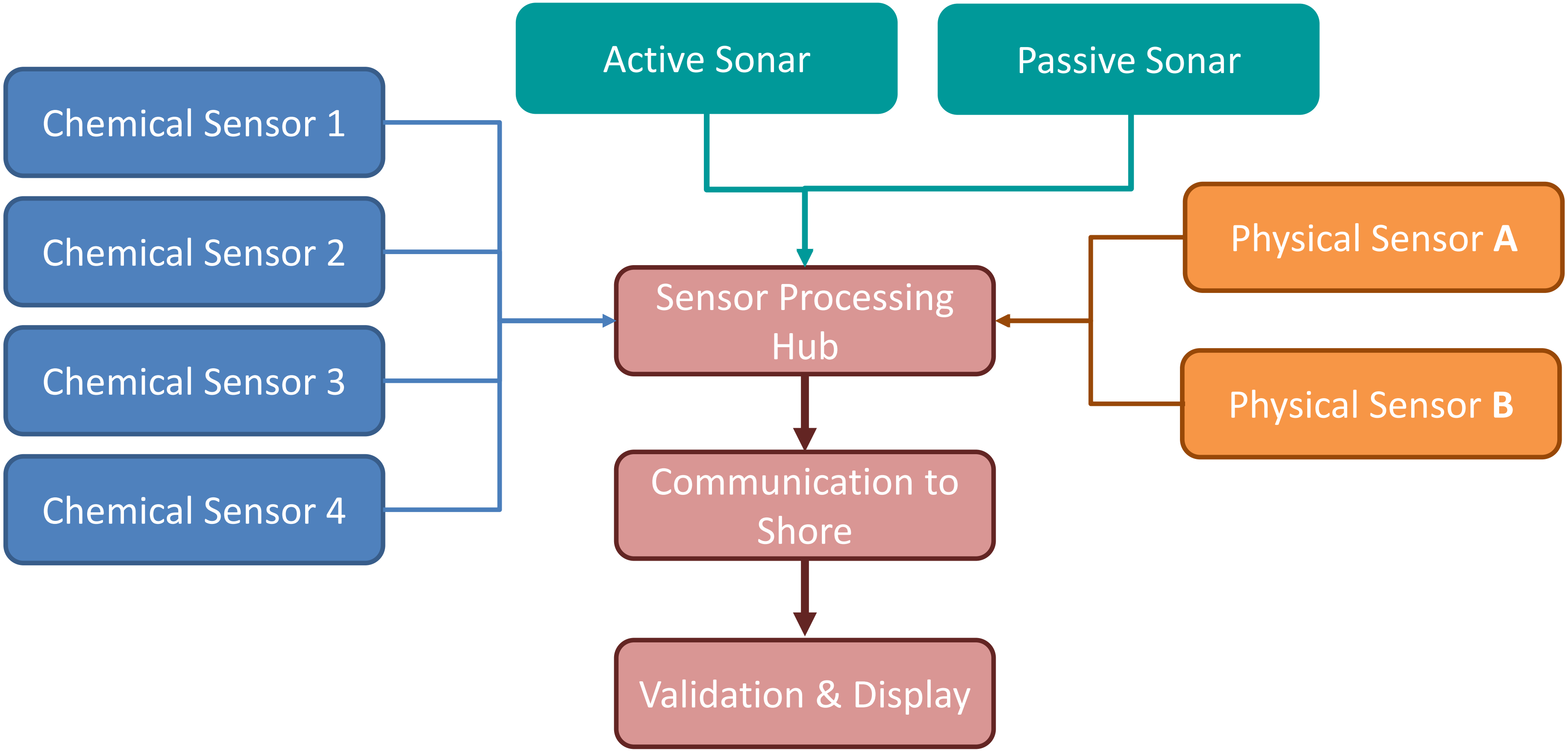
“10 l/min CO_2 gas leak, 2.65m tall plume from seabed”



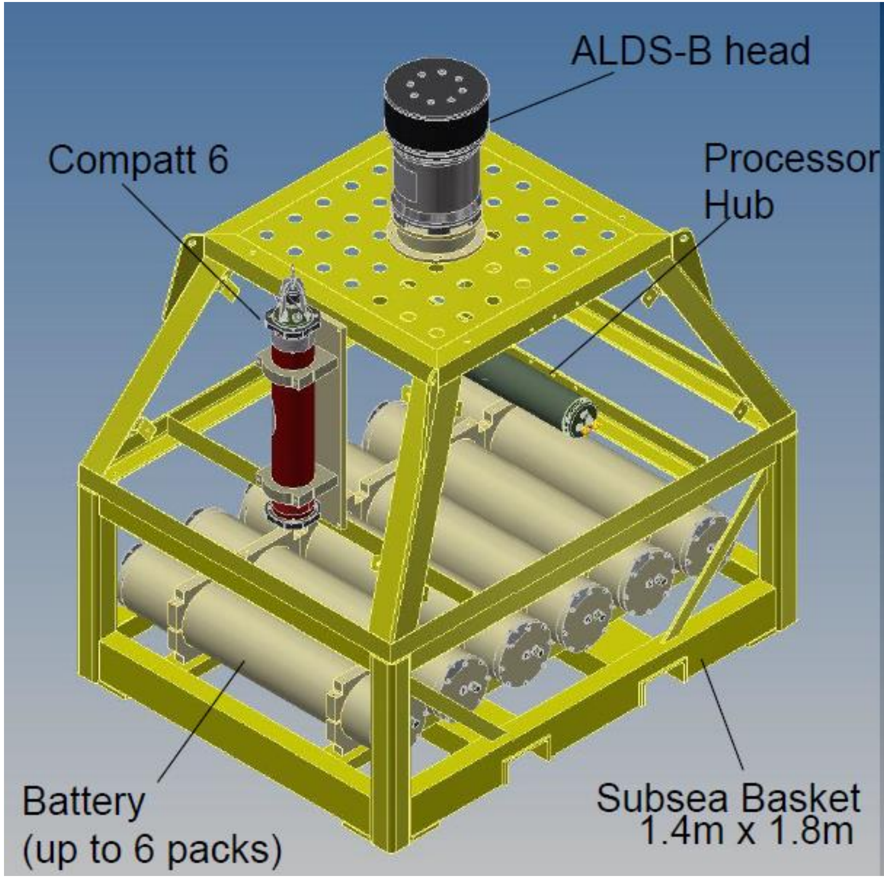
Seabed Lander Solutions

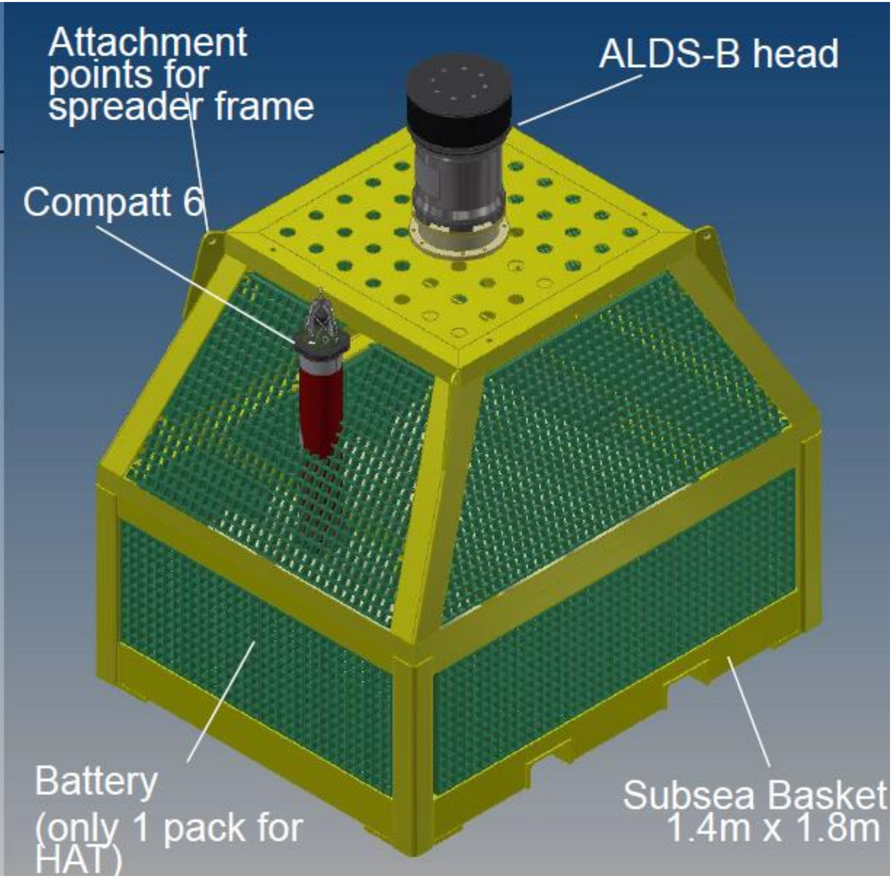
Autonomous Point Sensing

Lander Configuration



Active Lander

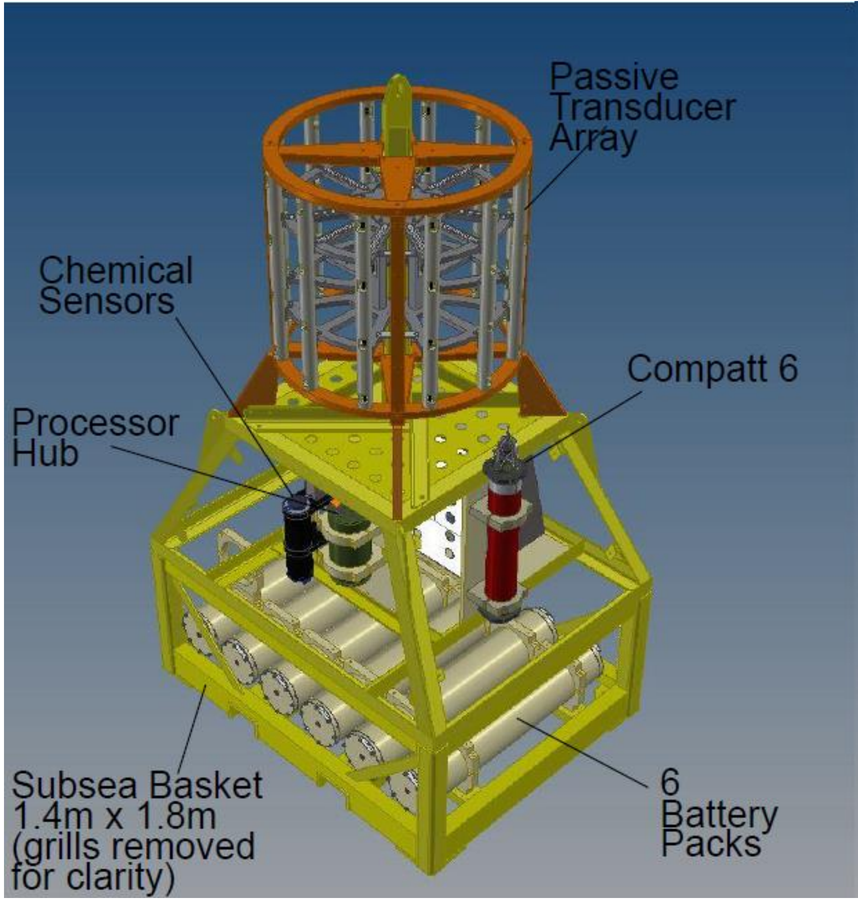


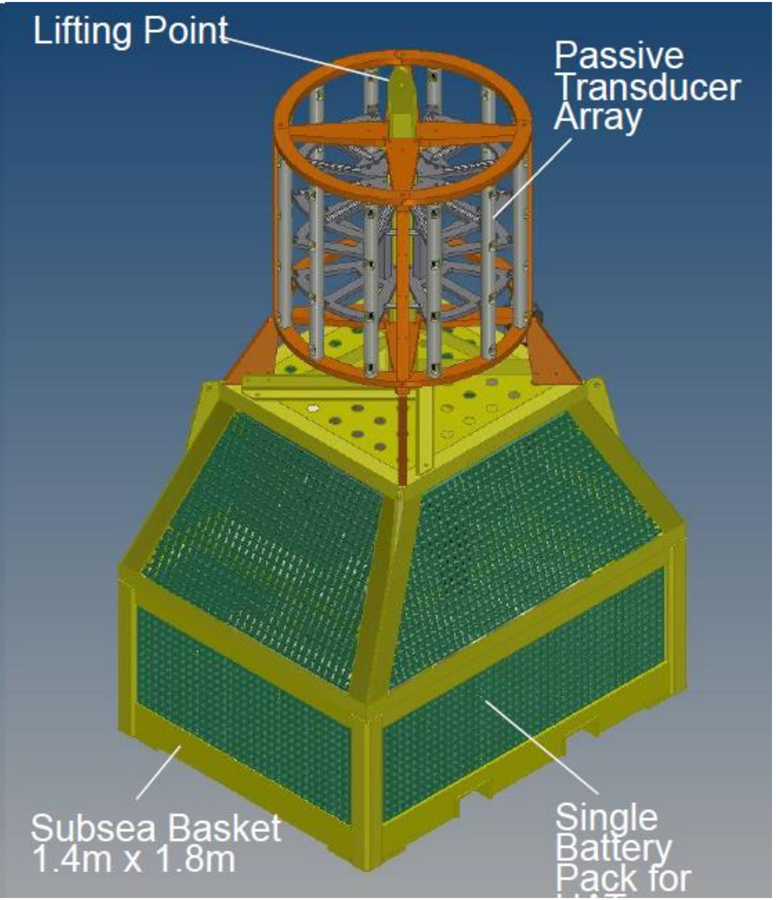


Active Lander

Technologies

Passive & Chemical Lander



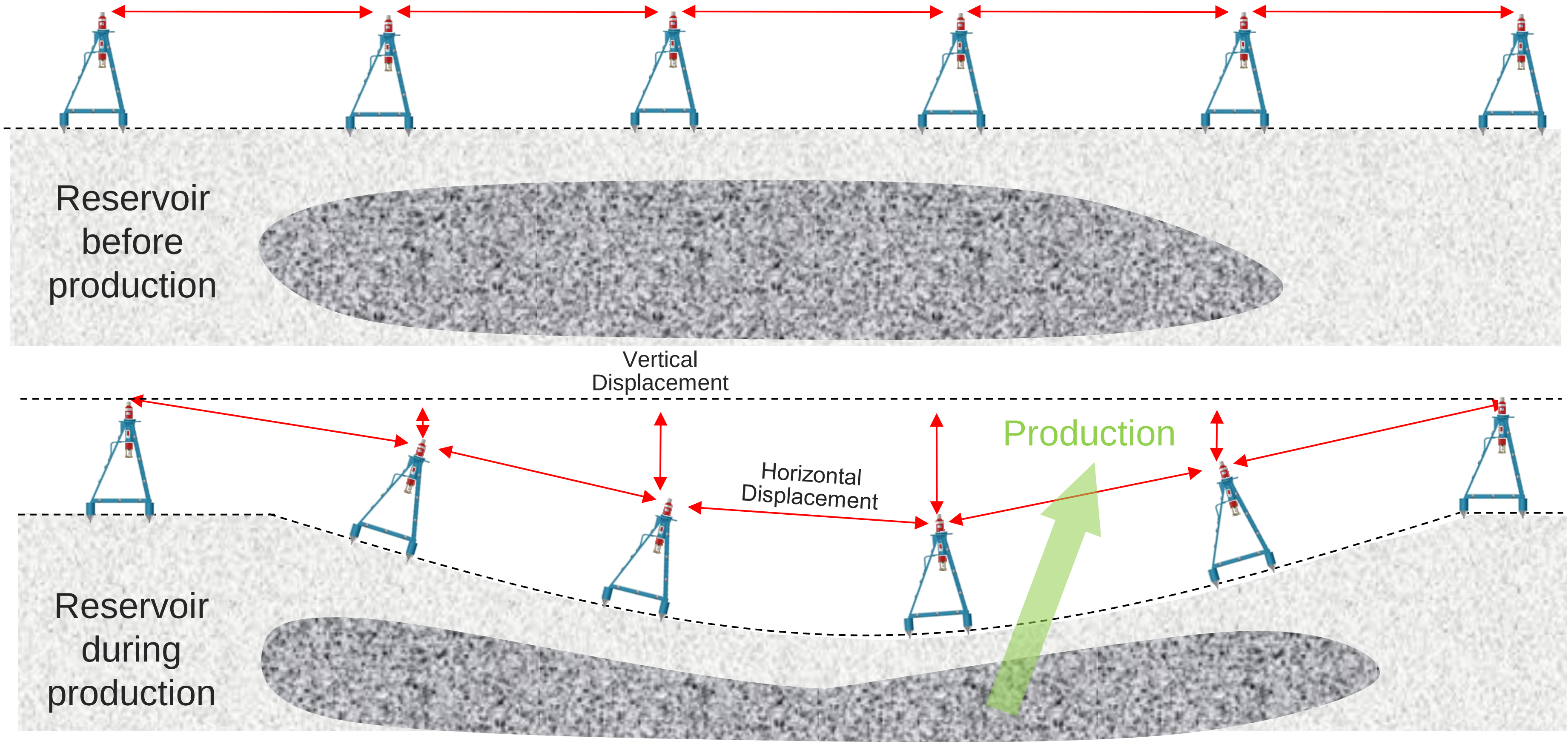


Passive Lander

Geodesy : Settlement : Heave

‘PMT the underwater InSAR’

The Process…


Reservoir before production
Vertical Displacement
Production
Horizontal Displacement
Reservoir during production

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Height
(or seabed depth)

Gravity
(≈ 9.8m/s² …..but not constant on earth surface)

Absolute Pressure
(measured by sensors which drift)

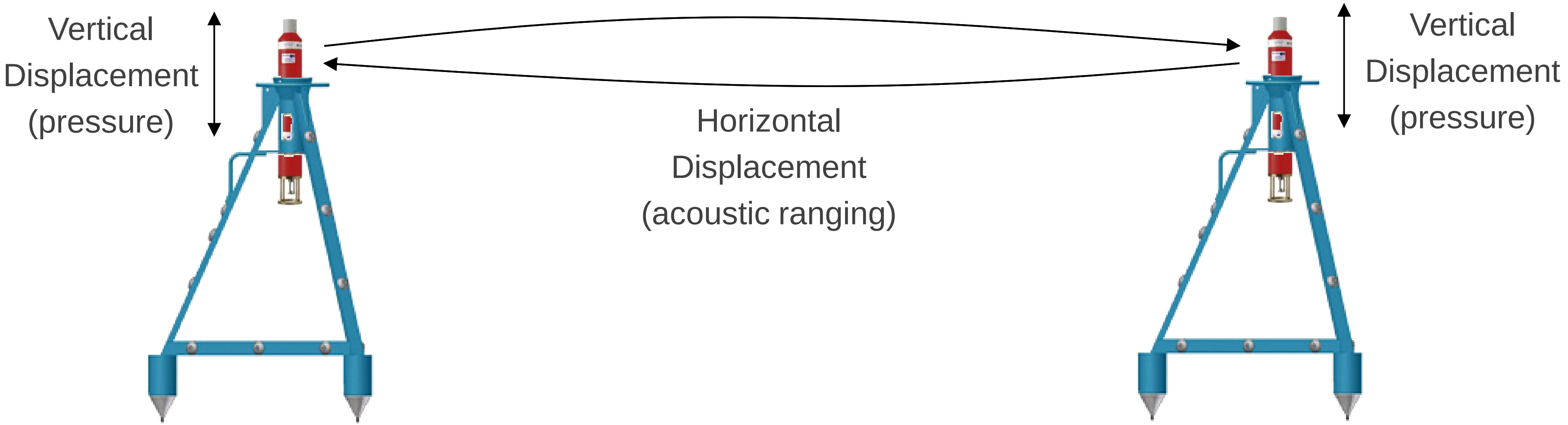
$$p_{abs} = h\rho g + patm$$

Density
(affected by temp/salinity etc., Major source of variability!!)

Atmospheric Pressure
(weather variation)

The Process #2

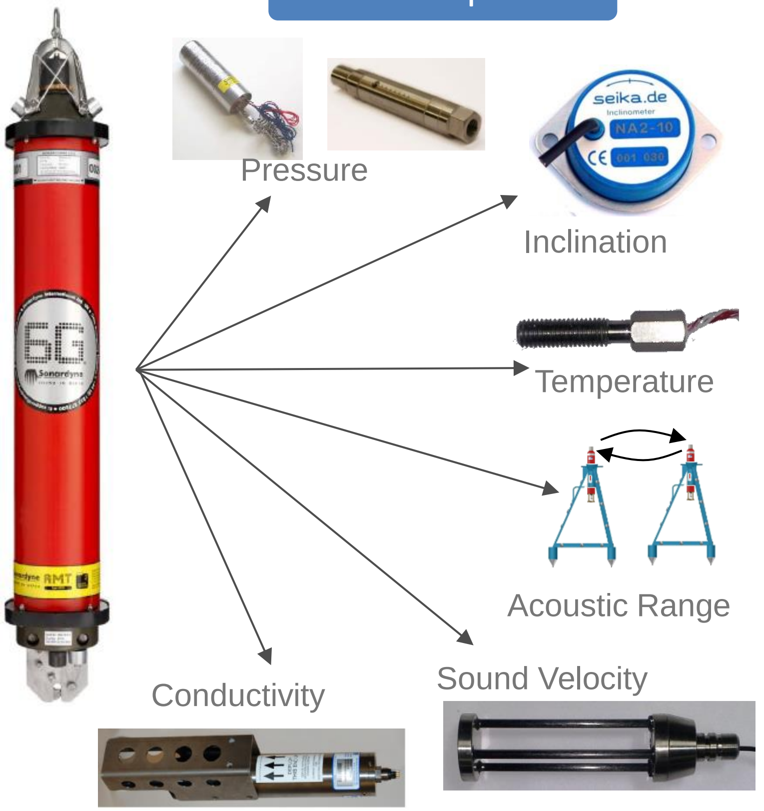
- Instruments continually measure:
  - Horizontal Displacement using two way acoustic ranging – accuracy (1cm/km)
  - Vertical Displacement using highly accurate pressure sensors
  - Extremely high precision and long term monitoring is required to detect/monitor minute settlement velocities.



Seafloor Settlement Monitoring

Equipment…

Sensor Options

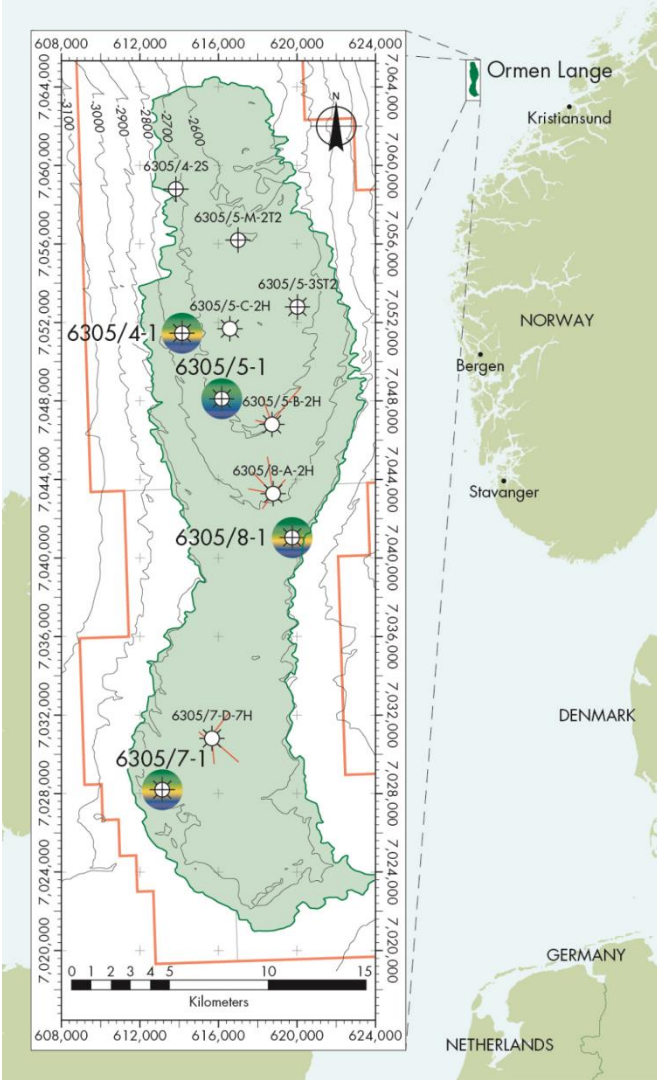


Instrument Types

Seafloor Settlement Monitoring

Example Project: Ormen Lange

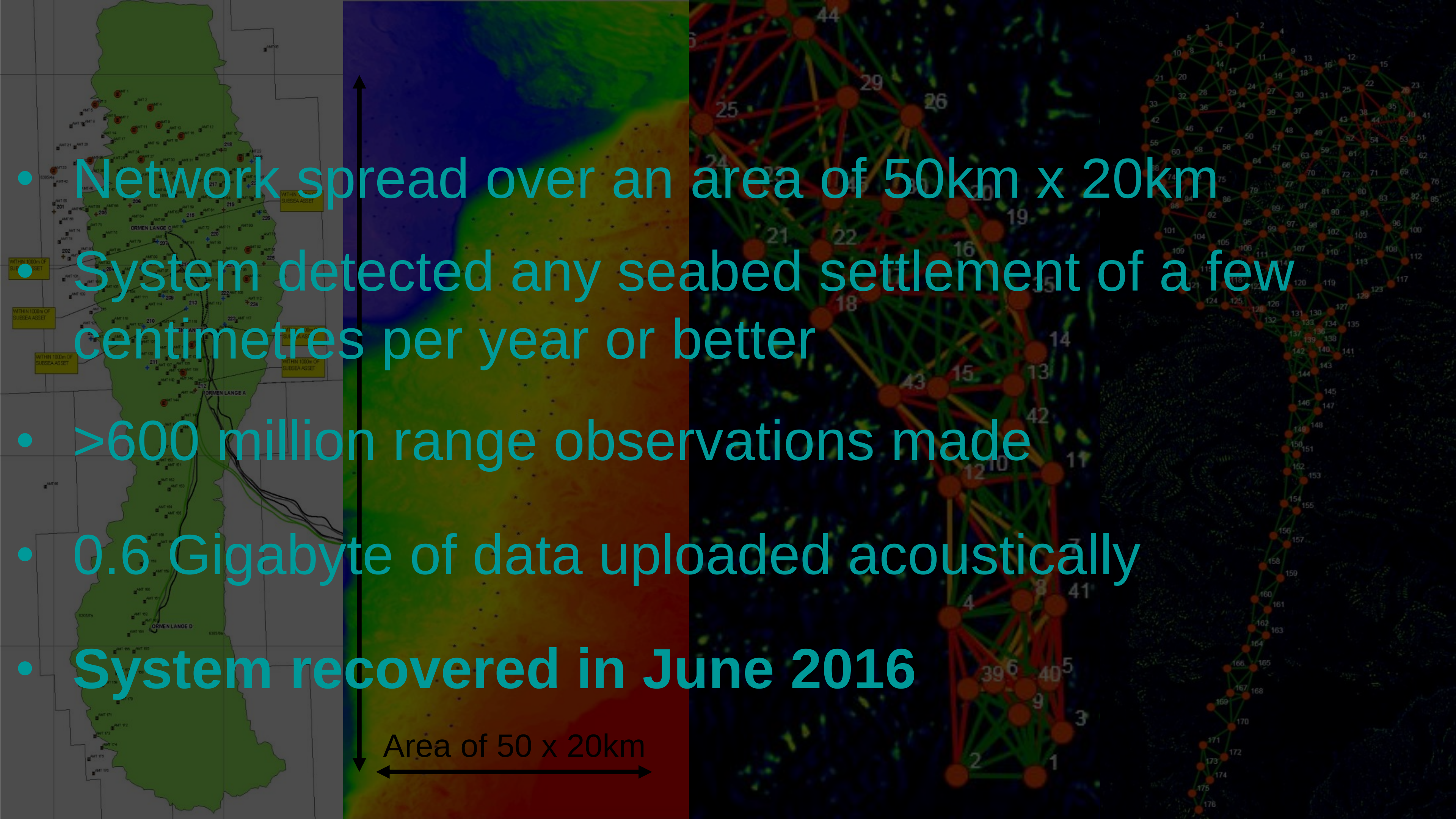
- Located in Norwegian Sea at site of Storegga landslides, circa 6000BC
- Seabed depth 850-1100m
- Reservoir depth 3000m below seabed
- Production induced uncertainties:
  - Aquifer influx (water replacing gas)
  - Compartmentalisation (regions of reservoir cut off from production)
- Reservoir uncertainties have large impact on recovery estimates and drilling decisions
- Long term geodesy monitoring campaign was focused on reducing these uncertainties

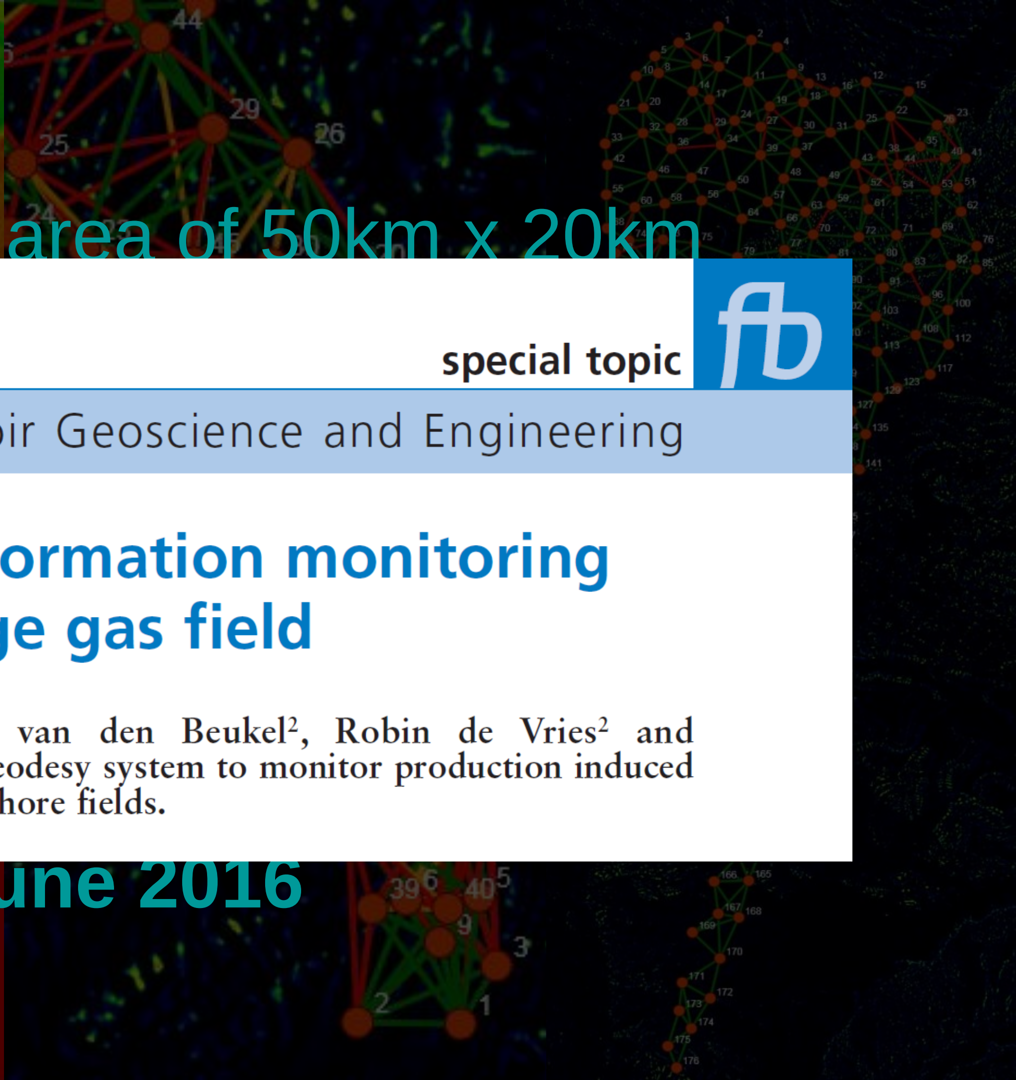


Ormen Lange

- 10 Settlement Monitoring Transponders deployed at Ormen Lange in 2007.
- 220 Autonomous Monitoring Transponders deployed 2010 onwards.
- Each AMT woke up every hour and measured the distances to all its neighbours and stored range and sensor data.

- Network spread over an area of 50km x 20km
- System detected any seabed settlement of a few centimetres per year or better
- >600 million range observations made
- 0.6 Gigabyte of data uploaded acoustically
- **System recovered in June 2016**





- Network spread over an area of 50km x 20km
- Sy… ce…
- >6…
- 0.…
- System recovered in June 2016

first break volume 34, October 2016 special topic

Reservoir Geoscience and Engineering

A long-term seafloor deformation monitoring campaign at Ormen Lange gas field

Shaun Dunn[1*], Paul Hatchell[2], Annemieke van den Beukel[2], Robin de Vries[2] and Tomas Frafjord[3] discuss the use of a seafloor geodesy system to monitor production induced changes to the reservoir and overburden at offshore fields.

Stakeholder Engagement Sea Trials 17th July 2017

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