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OFFSHORE

Global Leaders in Through Water Communication and Positioning Technology for the Offshore Industry

Acoustic Positioning combined with Data Monitoring and Subsea Controls in a Future Field Concept

APSG Fall Meeting 2009
Bill Gilmour – VP Sales (Americas)

Structure of the presentation

- Nautronix ADS^2 Technology
- Ultra Deep Water Positioning
- Acoustic Controls, Data Communication and Monitoring
- Combined Positioning and Communication Systems
- Life of Field approach

Acoustic Digital Spread Spectrum (ADS^2)

Several years ago, Nautronix recognised the limitations of older (pulse) acoustic signalling techniques and invested heavily in the development of innovative technology to overcome the problems

The technology was originally developed in the mid 1990s for defence applications but is now in use in a range of commercial products

Underwater messages between submarines, over 20 km, at speed and depth (a world first). Now adopted by US Navy for fleet-wide fit

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ADS^2

Acoustic Digital Spread Spectrum

Subsea acoustics

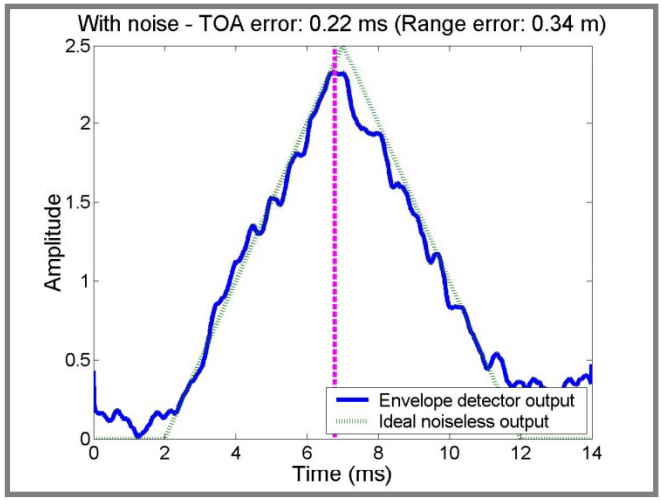
- **There are many challenges in designing subsea acoustic systems, including:**
  - **Multipath effects**
    - **There are reflections from hard surfaces and water layers**
  - **Signal to noise ratio**
    - **Systems are often used on dynamically positioned rigs where noise in the water under the rig is an issue**
  - **Range & Bandwidth**
    - **Long range requires low frequencies, which do not support high data rates**
  - **Interference**
    - **Acoustics are used for many other subsea applications, including vessel positioning and construction activities. The systems used to support all these activities must not interfere with each other**
  - **Latency**
    - **The rule-of-thumb for the speed of sound through water is 1,500 m/s**
  - **Refraction**
    - **Sound waves do not generally travel in straight lines through water**

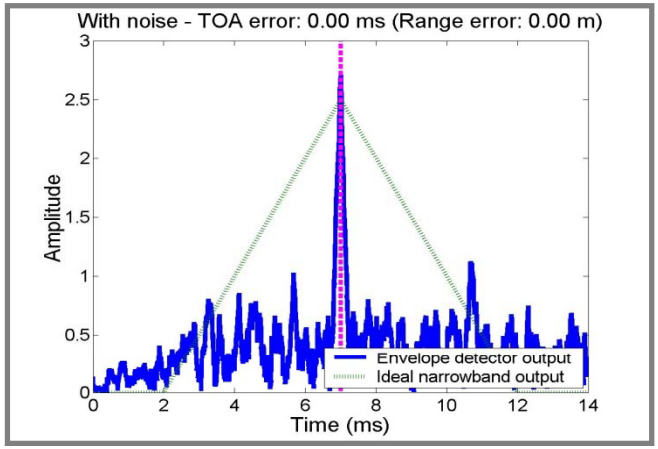
Conventional vs. ADS^2 signals

Acoustic Digital Spread Spectrum is the core to NASNet®

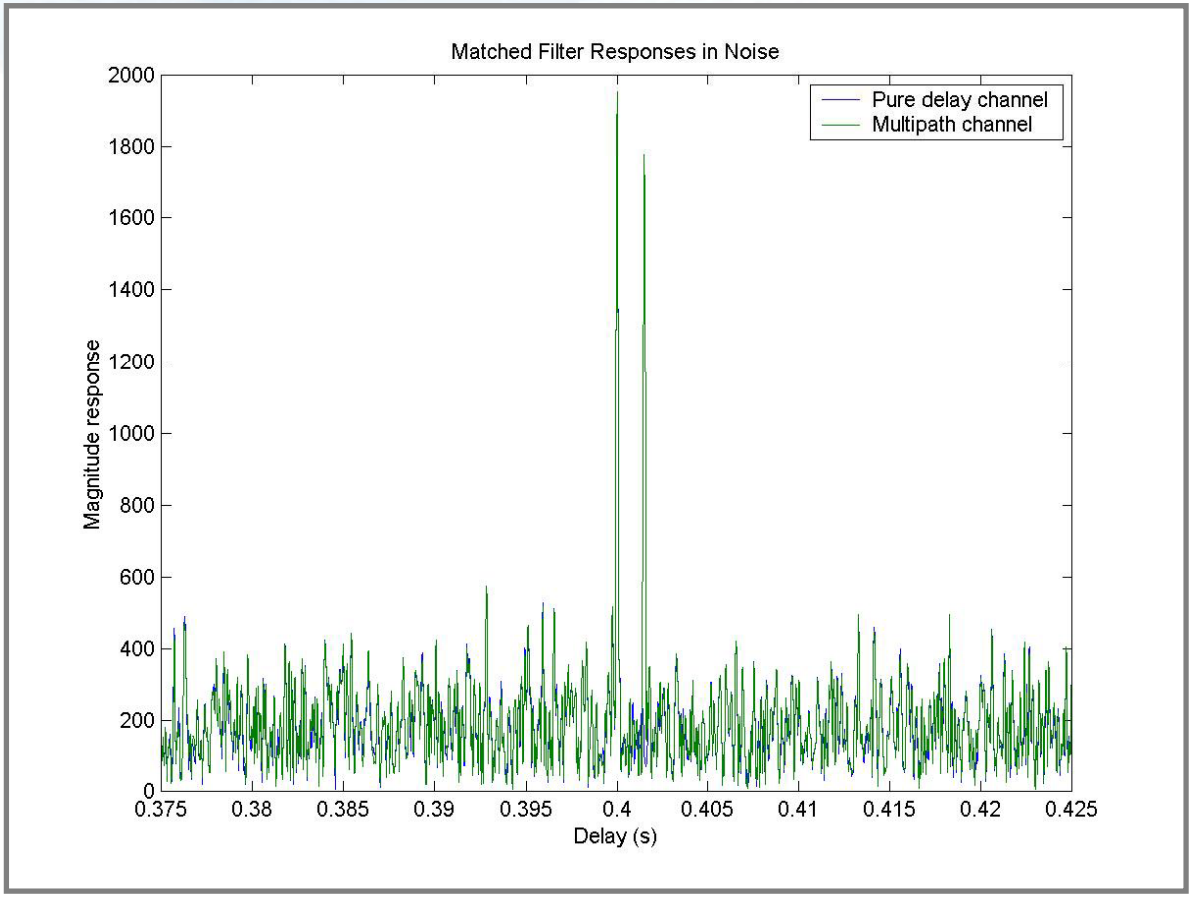
What is ADS^2?

- **ADS^2 is a broadband signalling technique**
- **Uses coded signals 'spread' over 3kHz**
- **Very high signal integrity**
- **Very accurate Time of Arrival (TOA) detection**
- **Higher accuracy**
- **Greatly improved SNR**
- **Combination of Low frequency and ADS^2 Increases range**
- **Improved noise immunity**
- **No interference with other system**





Signal detection + 20db noise + multipath



Robustness of acoustic digital signalling

- The use of Gold Codes and CDMA technique was developed significantly further by Nautronix to work within constraints of underwater acoustic propogation
- Several improvements have been made to the signalling technique which further reject unwanted signals
- Virtually impossible to occur randomly
- Protected from noises generated by biological or man made sources

A good analogy is to consider that each station is speaking a different language, and language selection is orthogonal –

i.e. Finish and Japanese selected not Spanish and French

For Example – NASBOP Emergency Disconnect Sequence:

Sequence of seven > 100chip CDMA Gold Codes which can be represented by 25 hexadecimal digits e.g. D74FC061F566719A4552EF0B4

- Telemetry Alert
- ID Code
- EDS command – four more 100bit codes
- Parity code – confirms no message corruption

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Ultra Deep Water Positioning

Ultra Deepwater Positioning

Obviously there is a need to move towards seabed based positioning:

- **USBL: Slow Update, repeatability degrades with water depth, low signal redundancy**
- **SBL: Medium update in pinger mode, accuracy degrades with water depth**
- **LBL: Very Slow update, Time consuming and expensive to set up, Frequency Spectrum Hungry (SIMOPS issues)**
- **NASNet ® : Fast 1 Hz Update rate, High Accuracy & repeatability, Long range hence high redundancy. Multi user - receive only architecture**
- **Inertial Navigation Systems: fast update – need additional references (sparse LBL or a series of reference markers)**

USBL – Ultra Short Baseline

Determines beacon position by measuring the relative phases of the acoustic signal received by closely spaced elements in a single hydrophone

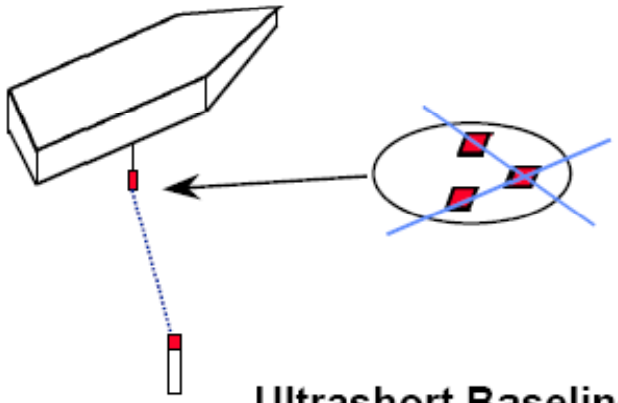
Accuracy in 2300m water depth = 11.5m

Advantages:

- **One time calibration - during installation**
- **Single Transducer**
- **Single Reference Transponder**

Disadvantages:

- **Accuracy varies with water depth (typically 0.5% of water depth)**
- **Accuracy depends on a good quality Motion Reference Unit**



Ultrashort Baseline

SBL – Short Base Line

Determines beacon position by measuring the relative arrival times at three or more vessel mounted hydrophones

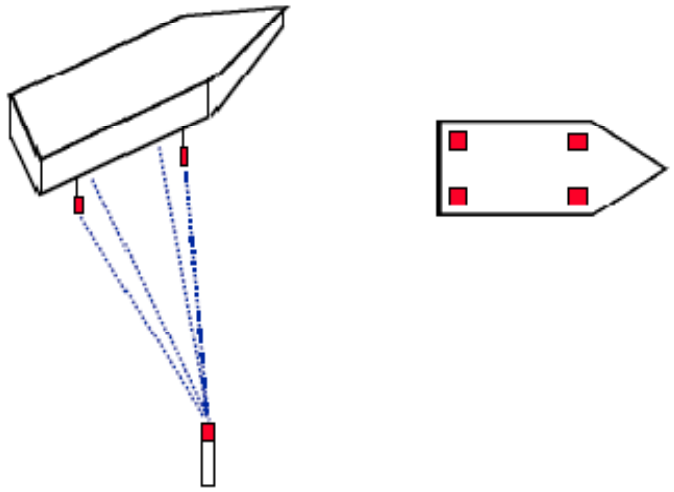
Accuracy in 2300m water depth = 6.25m

Advantages:

- **One time calibration - during installation**
- **Single Reference Transponder**
- **Multiple solutions leads to improved accuracy over USBL (Requires multiple hydrophones)**
- **Works with pingers and transponders**

Disadvantages:

- **Multiple transducers**
- **Accuracy varies with water depth (typically 0.25% of water depth)**
- **Accuracy depends on a good quality Motion Reference Unit**



Short Baseline

LBL – Long Baseline

Determines beacon position by measuring two way slant ranges from three or more widely spaced transponders

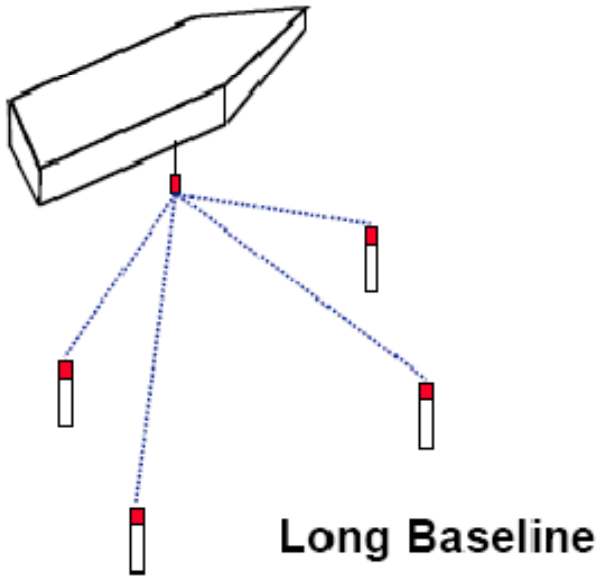
Accuracy in 2300m water depth = 2m

Advantages:

- **Independent of ship motion**
- **Highest accuracy of three methods**
  - **(Typically 2m independent of water depth)**
- **Single Hydrophone on ship**

Disadvantages:

- **Requires multiple beacons**
- **Requires calibration each time a reference beacon is deployed**



Long Baseline

NASNet® – a new concept

Determines beacon position by measuring one way slant ranges from three or more widely spaced transponders

Accuracy in 2300m water depth = 2m

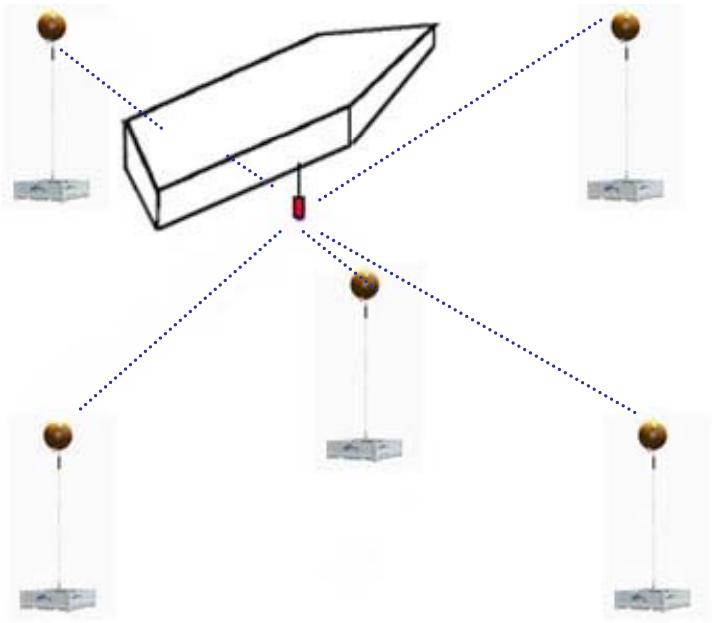
Advantages:

- **Independent of ship motion**

Similar accuracy as LBL

- **(Typically 2m independent of water depth)**

- **Single Hydrophone on ship**
- **Longer Range**
- **Multiuser system**
- **Fast update rate**



Disadvantages:

Requires multiple beacons

Requires calibration each time a reference beacon is deployed

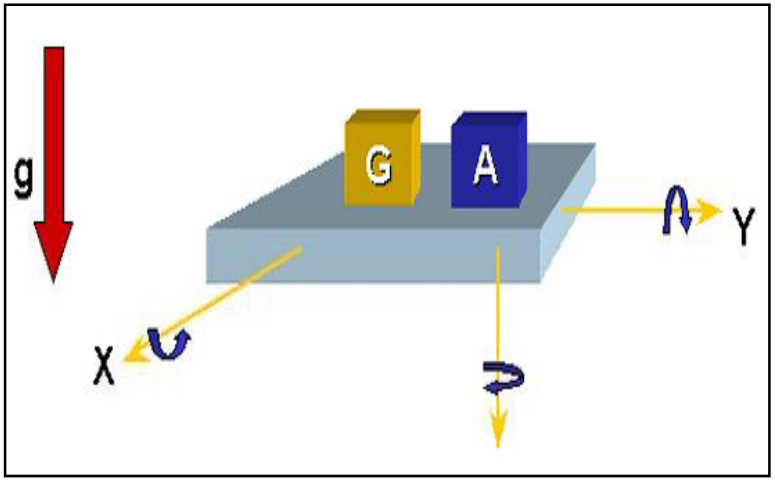
Inertial Navigation Systems?

ADVANTAGES

- Very fast update rates
- Accurate over short time periods

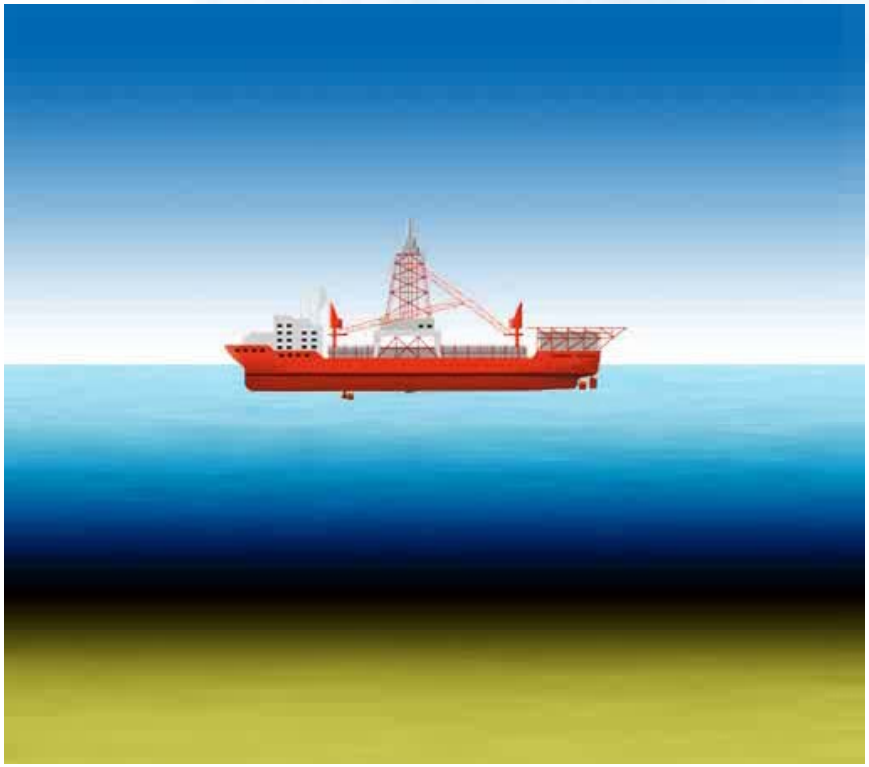
DISADVANTAGES

- Drift off exponentially over medium time periods
- Require reference position to update them
- Expensive (to date)



Courtesy of CDL

The NASNet® concept – *underwater GPS*



- **GPS revolutionised land positioning and navigation**
- **NASNet® offers this concept to the subsea market by providing field wide surface to seabed positioning and navigation**
- **Our vision is to provide NASNet® for life of field positioning and communication for the operator**
- **Also akin to mobile phone development**
  - **Mobiles: first talk then text**
  - **NASNet®: first positioning then communications**

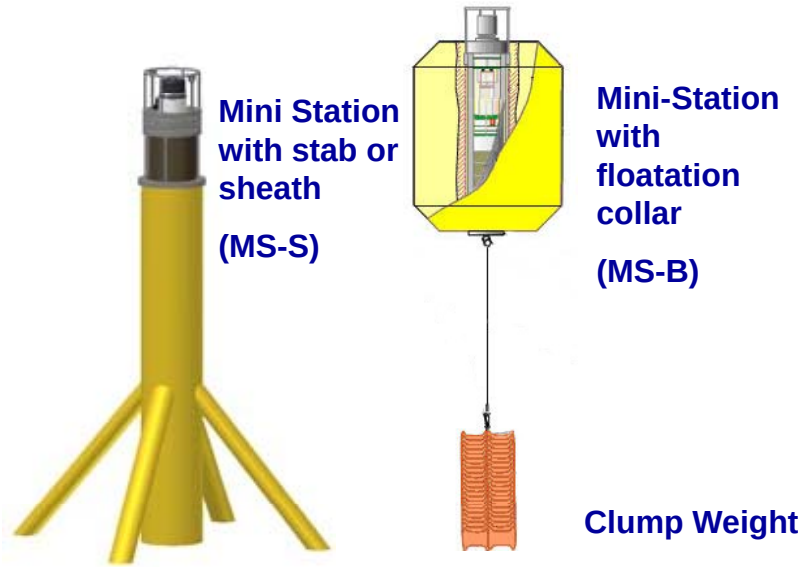
The only true multi-user system

NASNet® MS (Mini Stations)

NASNet® MS (Mini Station) is designed for use during ongoing field activities. NASNet® MS can be deployed as a stand alone unit, with a profile that allows compatibility with pre-existing transponder stands. Optional acoustic release.

Features:

- Fully compatible with traditional transponder buckets / stands
- Long Life Lithium Battery
- Full NASNet® architecture
- Wide area network – more coverage with fewer assets
- Fast update rate - typical position update 1Hz
- Suitable for short or long term deployment



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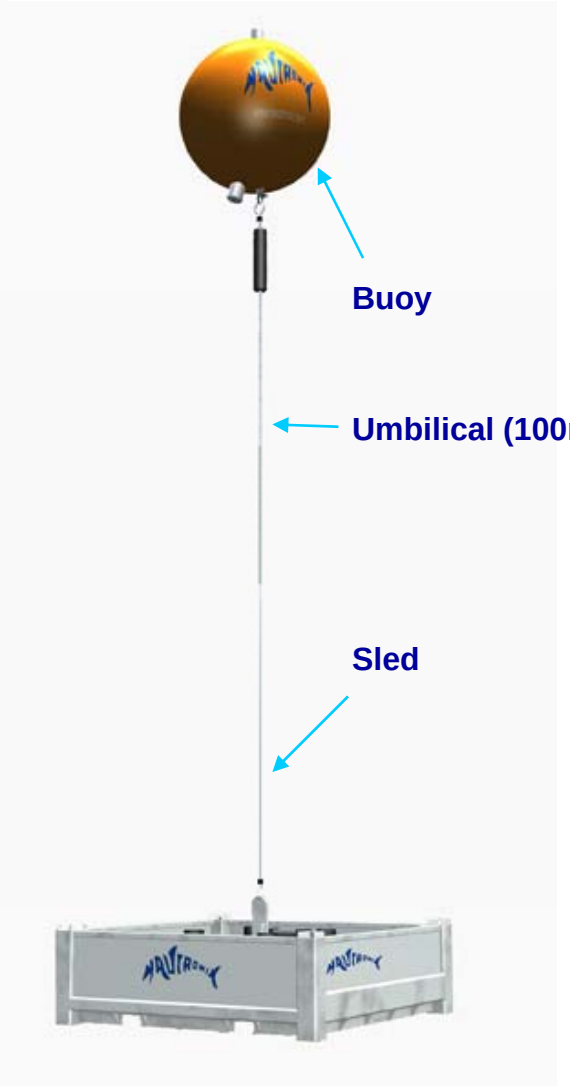
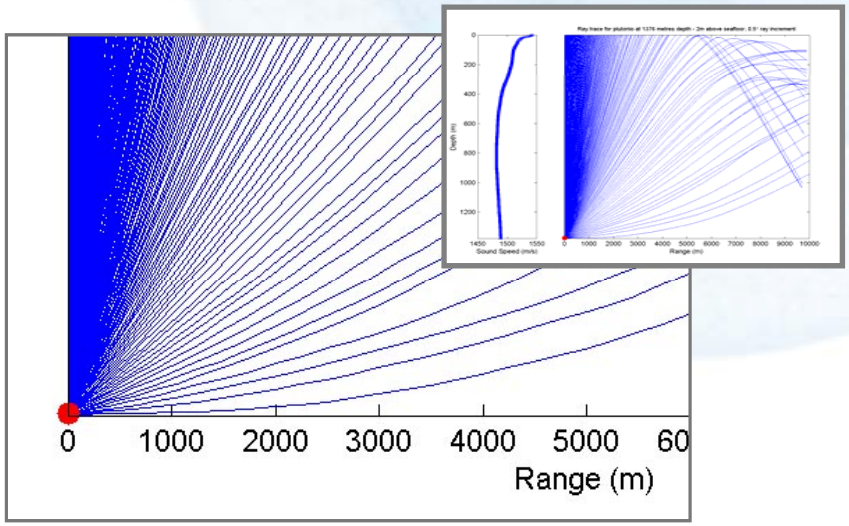
NASNet® Station

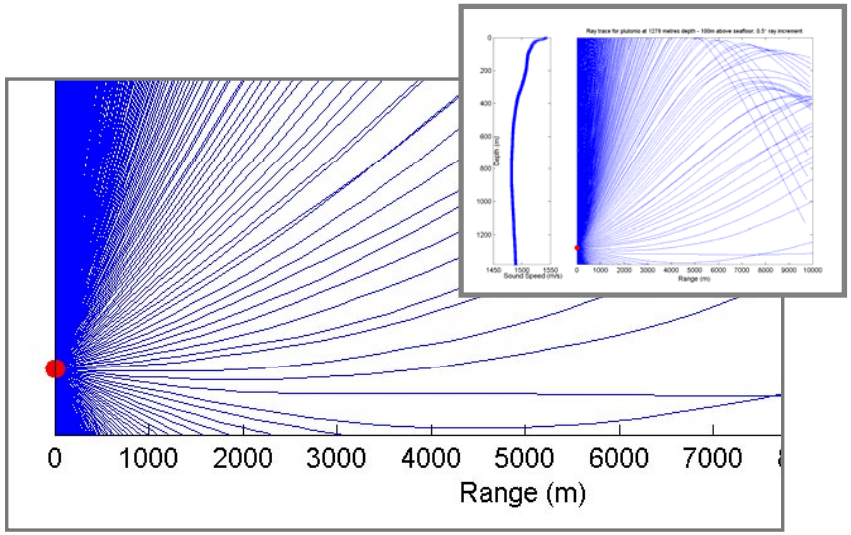
Features:

- Range and telemetry broadcast capability
- Buoy configuration enables long range capability
- Sophisticated signal processing electronics and software.
- Long life battery packs giving up to 4 years continuous transmission.
- High efficiency, low power technology for maximum battery life



NASNet® performance





NASNet® Mini Station

Signal transmitted from seabed stand / floatation collar

- **Distances of 2k + achievable**
- **Positioning available from the surface to the seabed**

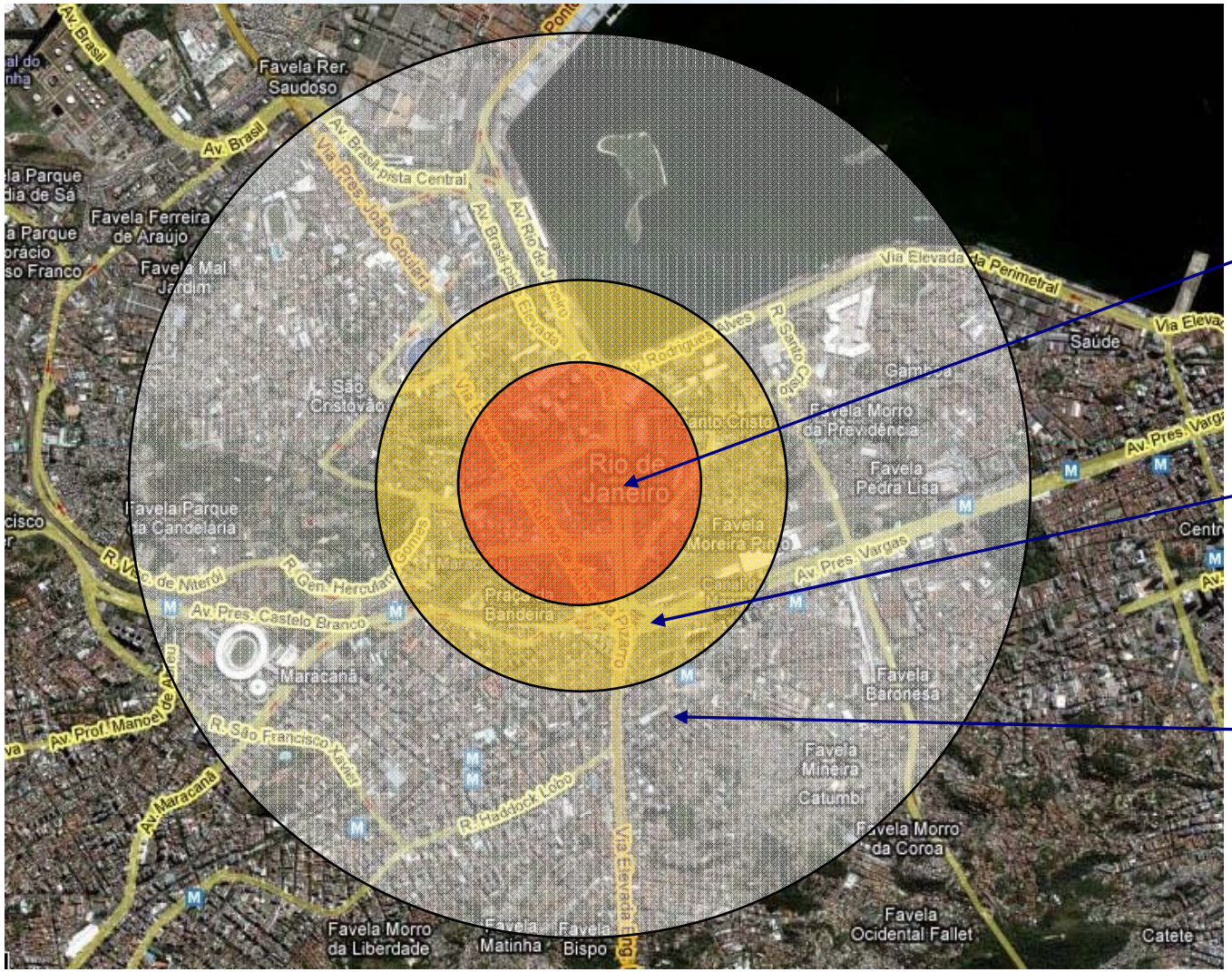
NASNet® Station

Signal transmitted from buoy (on 100m umbilical)

100m umbilical offers increased range along seabed

- **Increased distance between stations**
- **Positioning available from the surface to the seabed**
- **Distance approximately 3.5km**

Range coverage – Rio de Janeiro area



LBL = 3.14km²
- **Based on 1km range**

NASNet® MS's = 9km²
- **Based on 1.7km ranges**

NASNet® Sleds = 38.5km²
- **Based on 3.5km ranges**

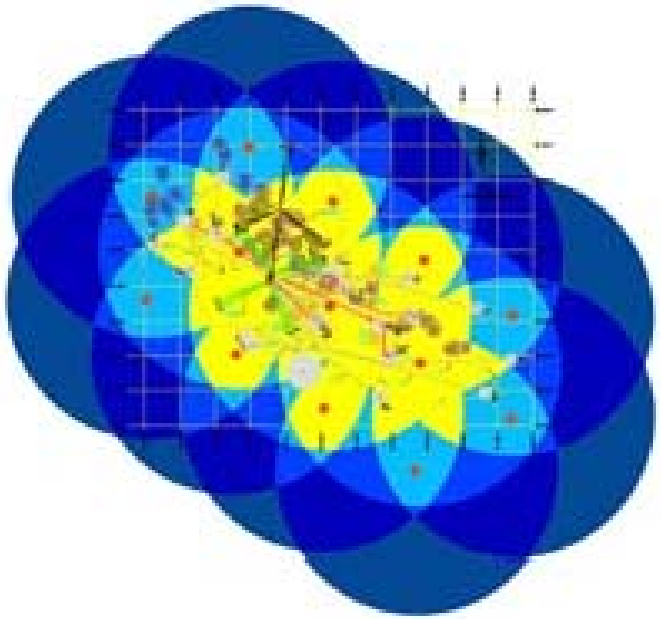
NASNet® Station Field Layout

AGBAMI

Offshore Nigeria, 350km SE Lagos
Water depths between 1,280 & 1,500 msw

14 x NASNet® sleds
22 x NASNet® Mtrx
2 x ROV systems

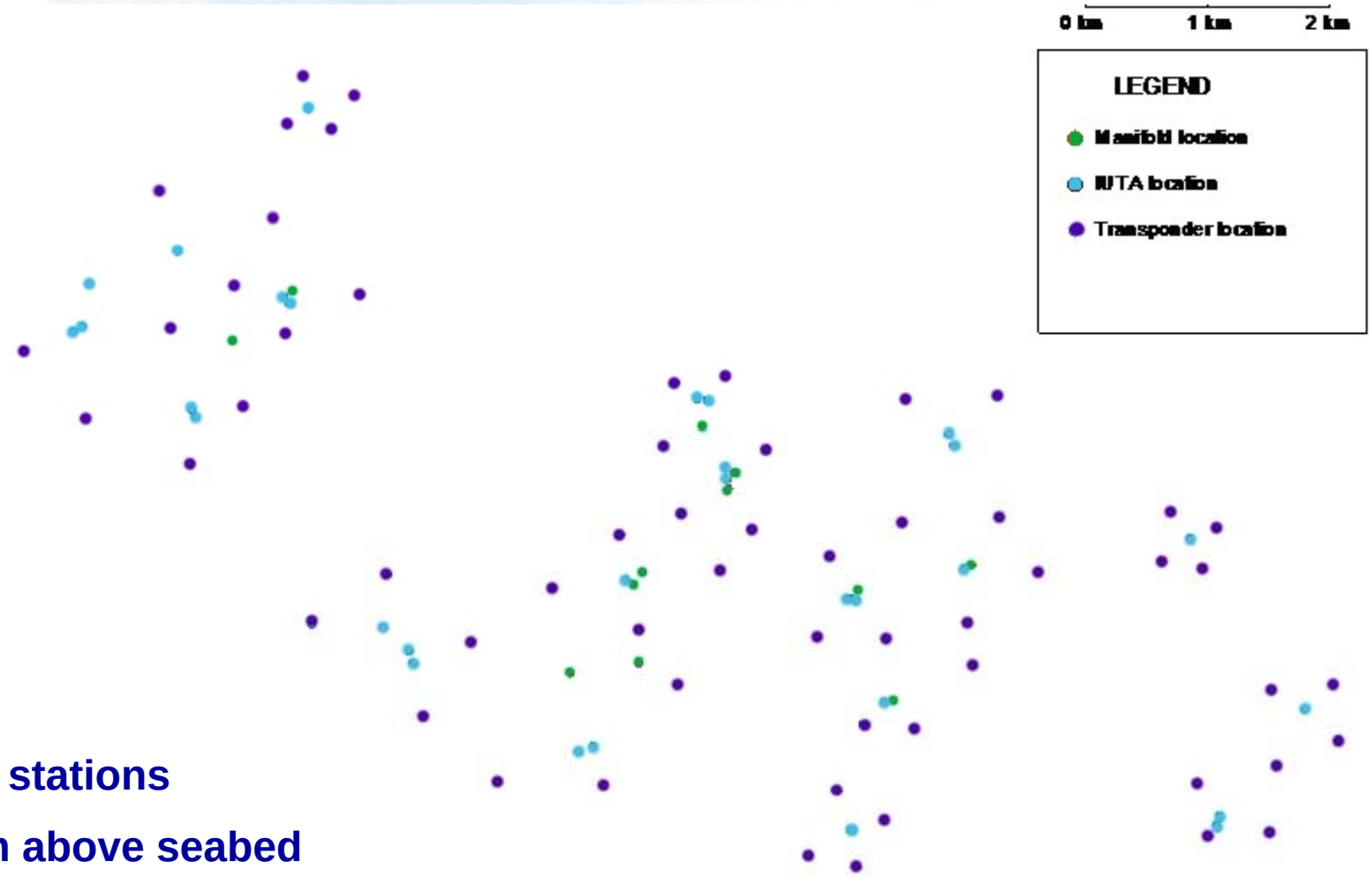
To be utilised for positioning laydown of:
12 suction piles
15 infield umbilical's
8 steel tube flying leads



Field layout diagram

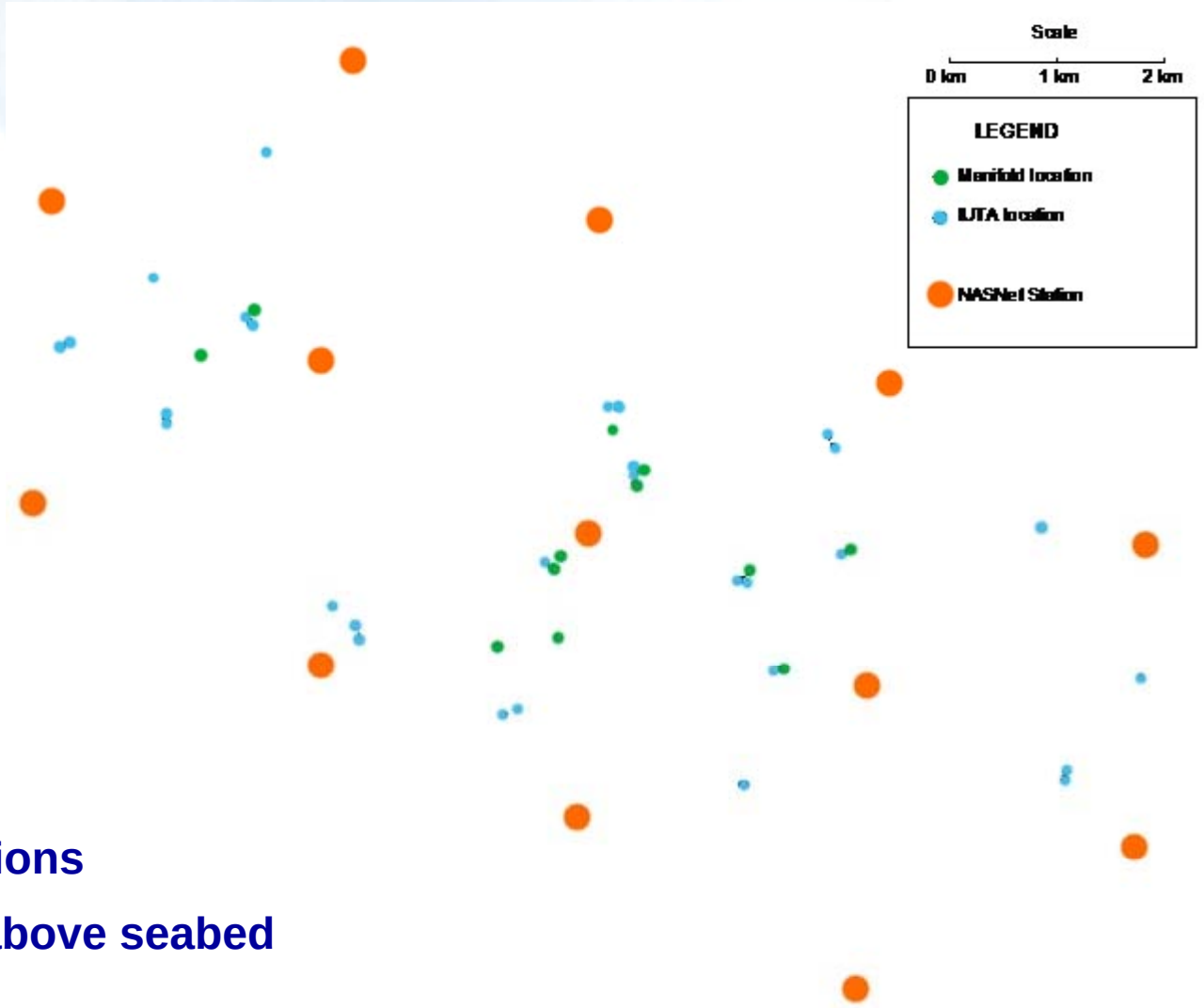
Field coverage - 12km x 5km

Traditional LBL Station Positions



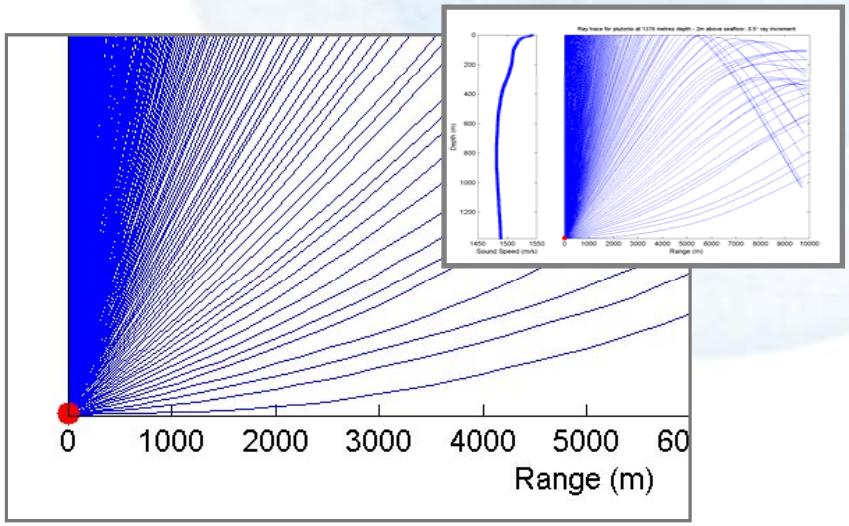
- 60 stations
- 5m above seabed

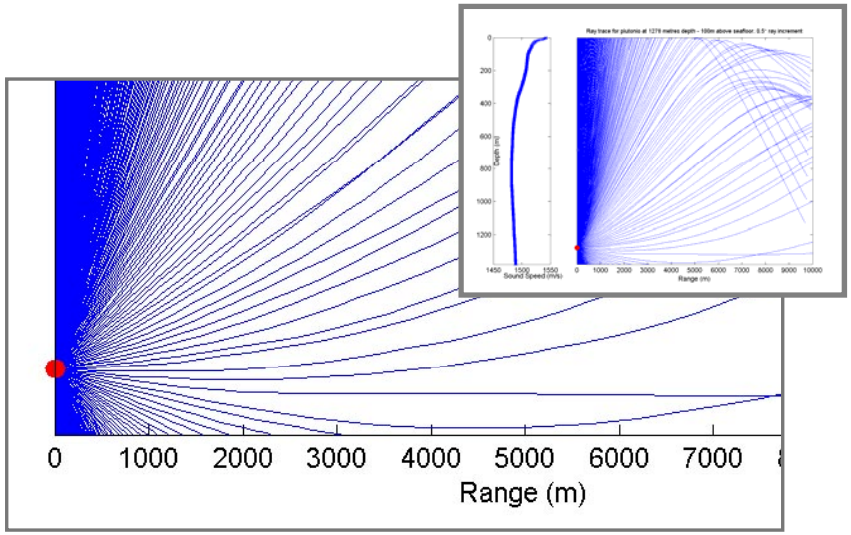
NASNet® Station positions



- 13 stations
- 100m above seabed

NASNet® performance





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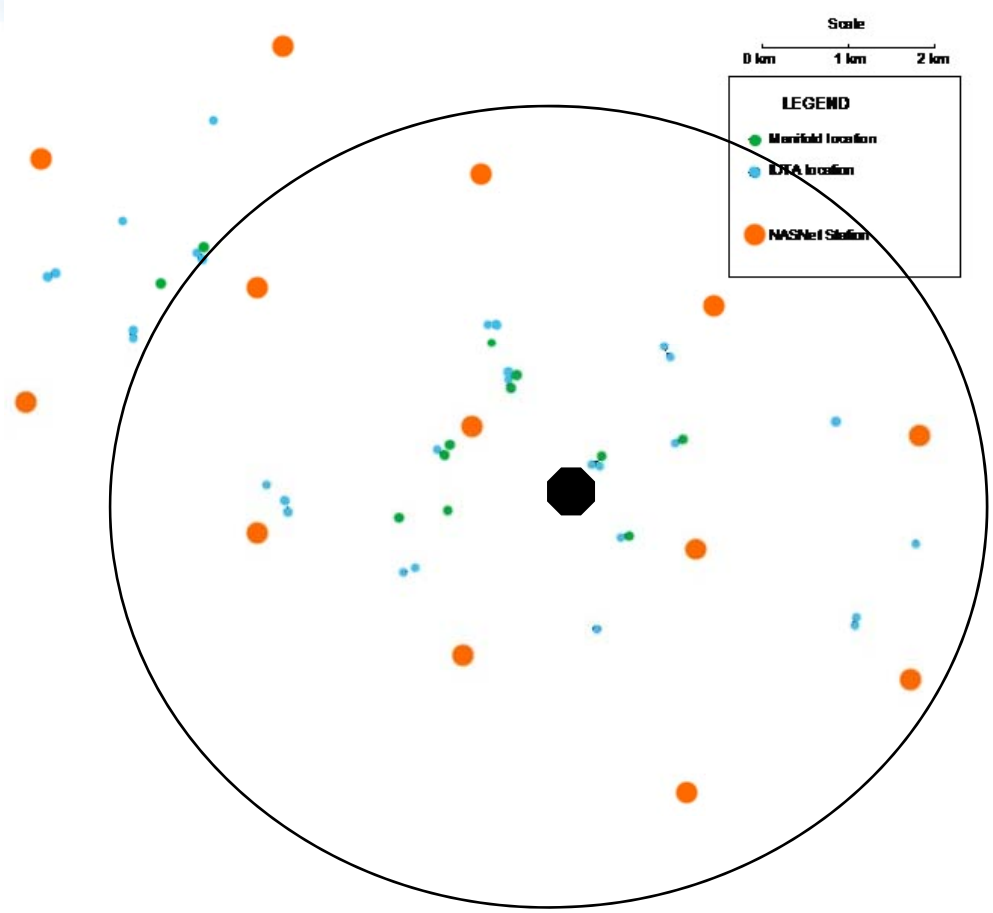
Drilling Vessel Visability

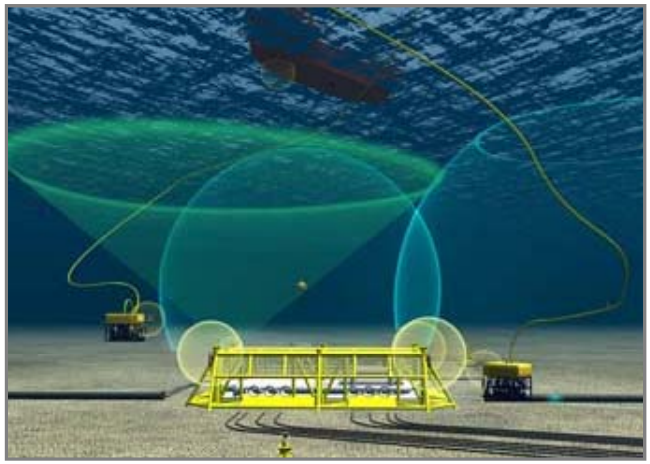


Average Surface to Seabed Range 7km dependant on environmental conditions

NASNet® summary

NASNet® System Architecture

- Receive only allows Multiple users
- System configuration provides fast updates circa 1Hz
- Equipment configured to overcome environmental constraints.
- No interference with other system
- Long Range
- Low Frequency combined with ADS^2 enables Low Power consumption for extended operational life



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Acoustic Controls, Data Communication and Monitoring

Acoustic Controls, Data Communication and Monitoring

Existing Monitoring Systems for :

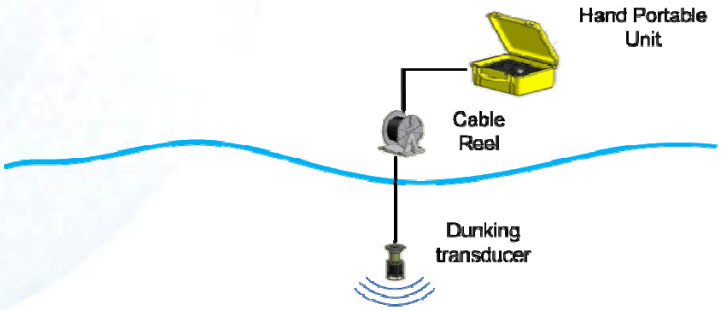
- Riser strain gauges and inclinometer
- Well pressure and temperature
- Flowline position
- CP or hydrate measurement

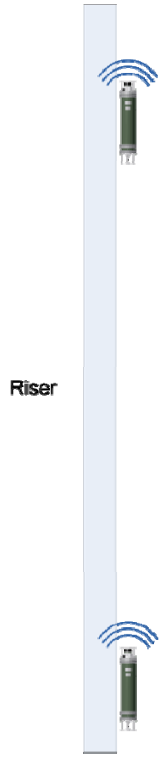
Existing Control Systems for :

- Emergency BOP shutdown (EBOP)
- Surface BOP monitoring and shutdown (NASBOP)
- Full BOP control (NASMUX) – in development

Riser Monitoring

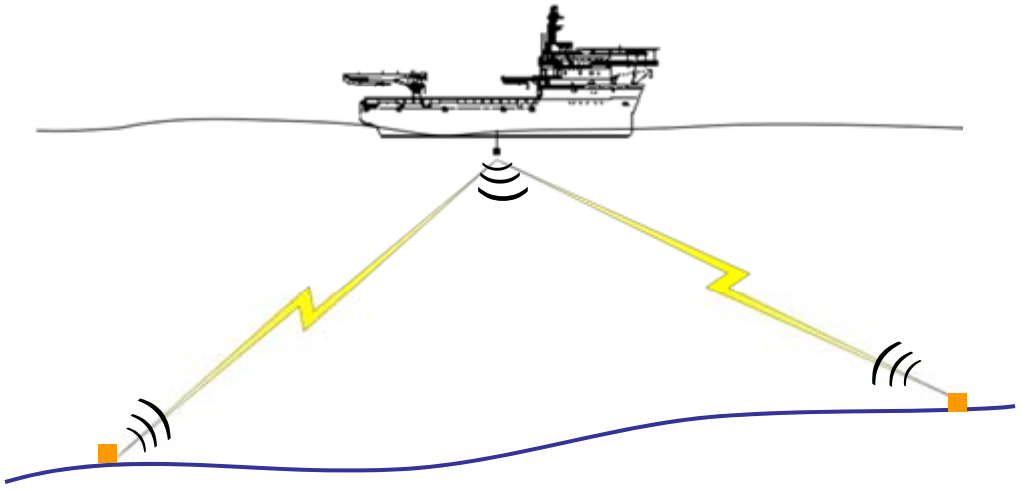
- **Use acoustics to**
  - **Monitor the X,Y position of the nodes on the riser**
    - (Will use either NASDrill RS925 or NASNet® technology)
  - **Telemeter the stress / strain data from the nodes to the surface**
  - **Supply inclinometer data in parallel**

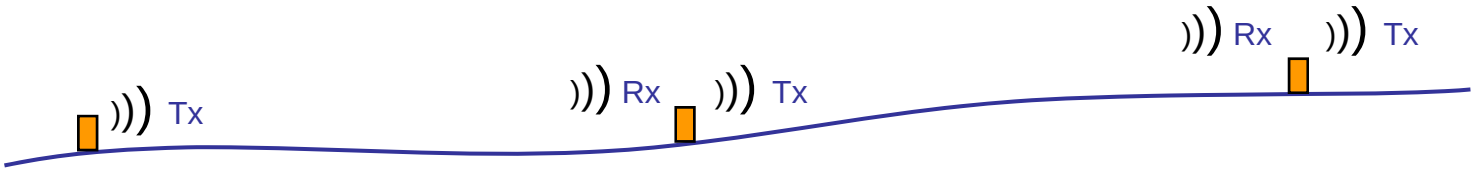




Pipeline Monitoring

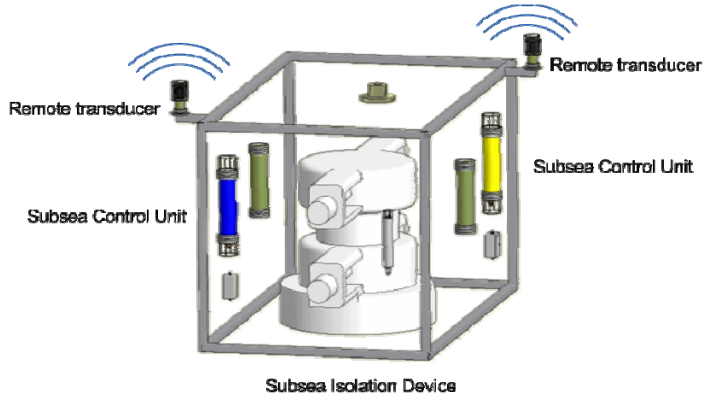
- **Approaches include**
  - **Data logging for later retrieval, e.g. fly-by using any size / cost of vessel**
  - **Data retrieval in pseudo real-time – either directly from source to end use, or via relay hubs**
  - **Corrosion**
  - **Flow**
  - **Temperature**
  - **Pressure**
  - **Hydrate build-up**
  - **Pig counting**





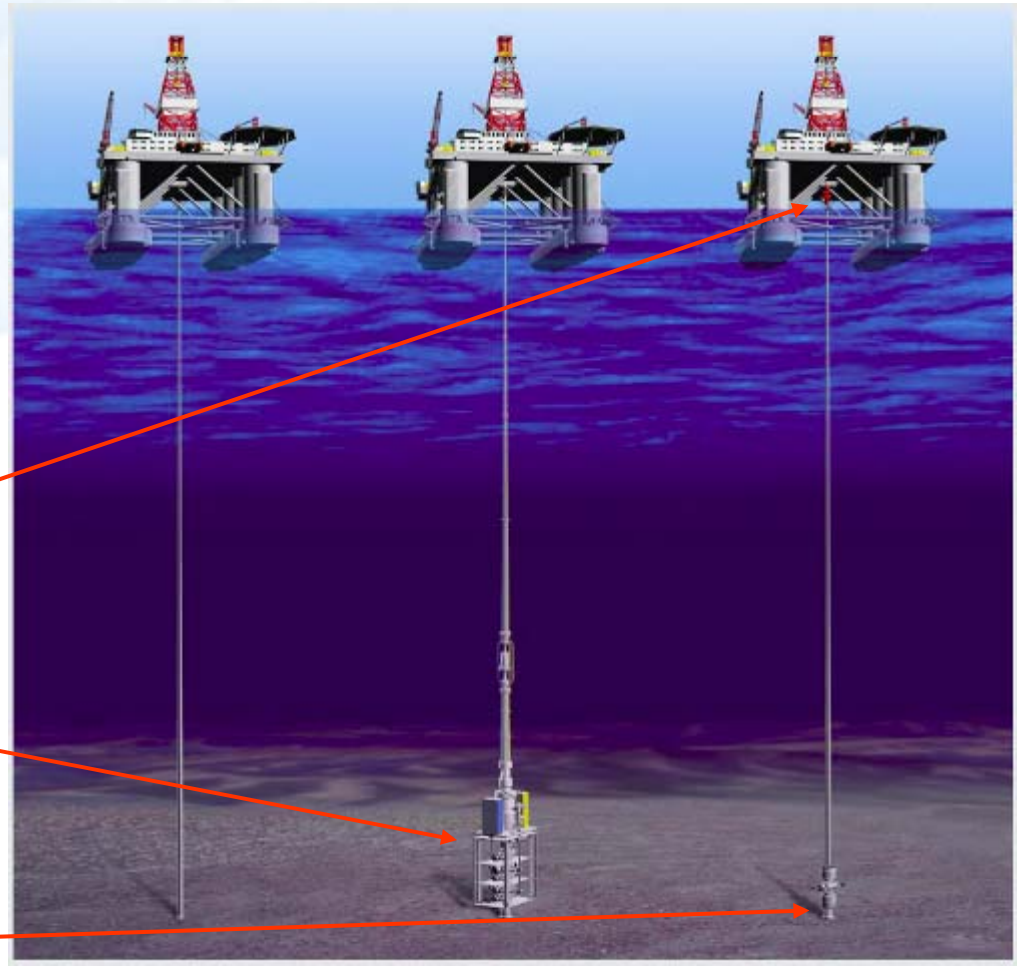
EBOP overview

- **Emergency BOP**
  - **Same subsea equipment as NASBOP**
  - **Portable topsides unit**
  - **Suited to use from deck or lifeboat**



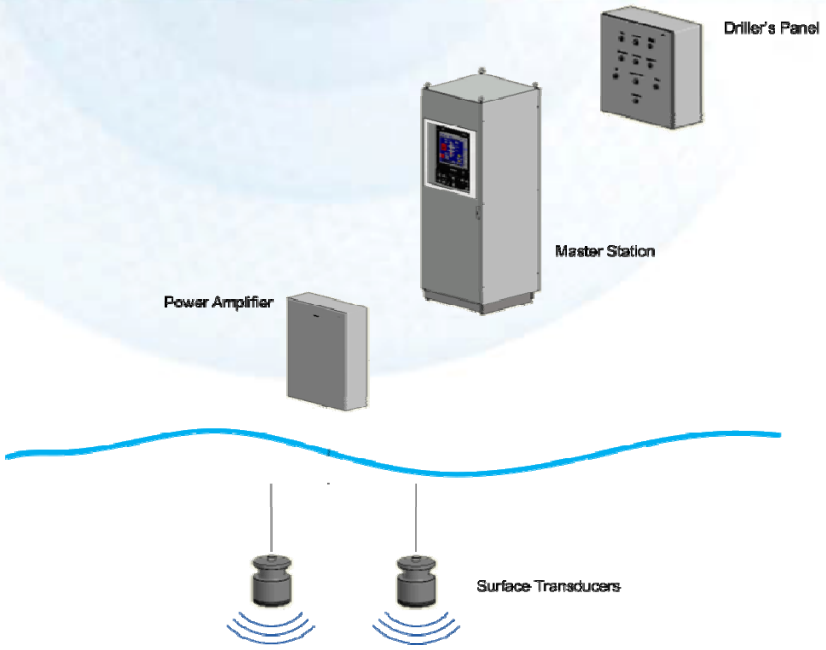
NASBOP

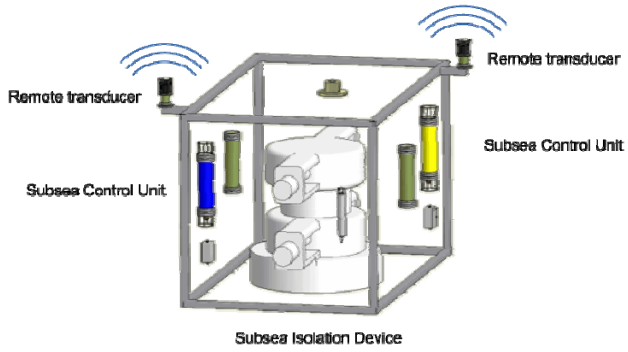
- **An enabling technology for Surface BOP drilling**



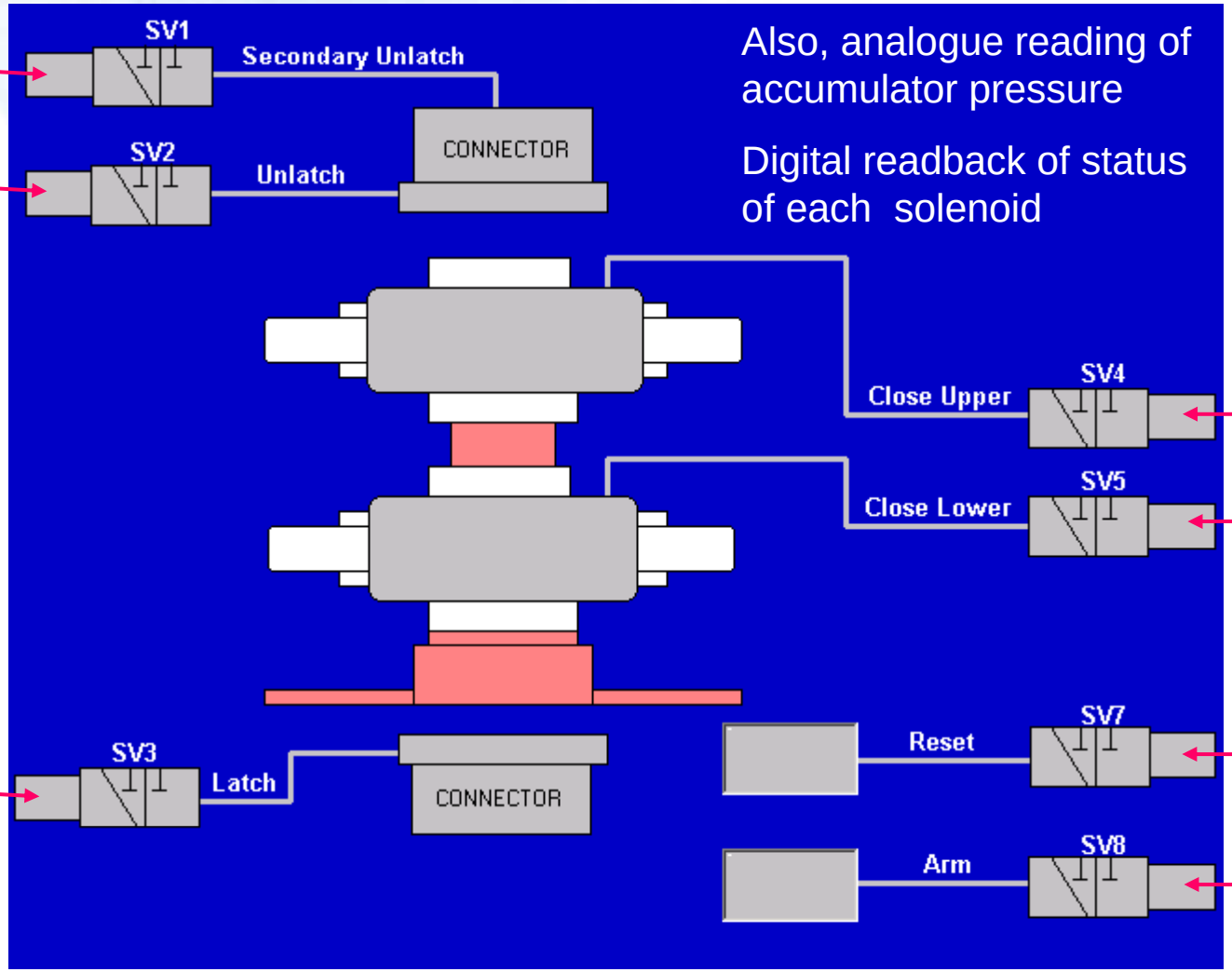
Cameron

NASBOP overview





Example Application (Cameron's ESG)



Function 1

Function 2

Function 3

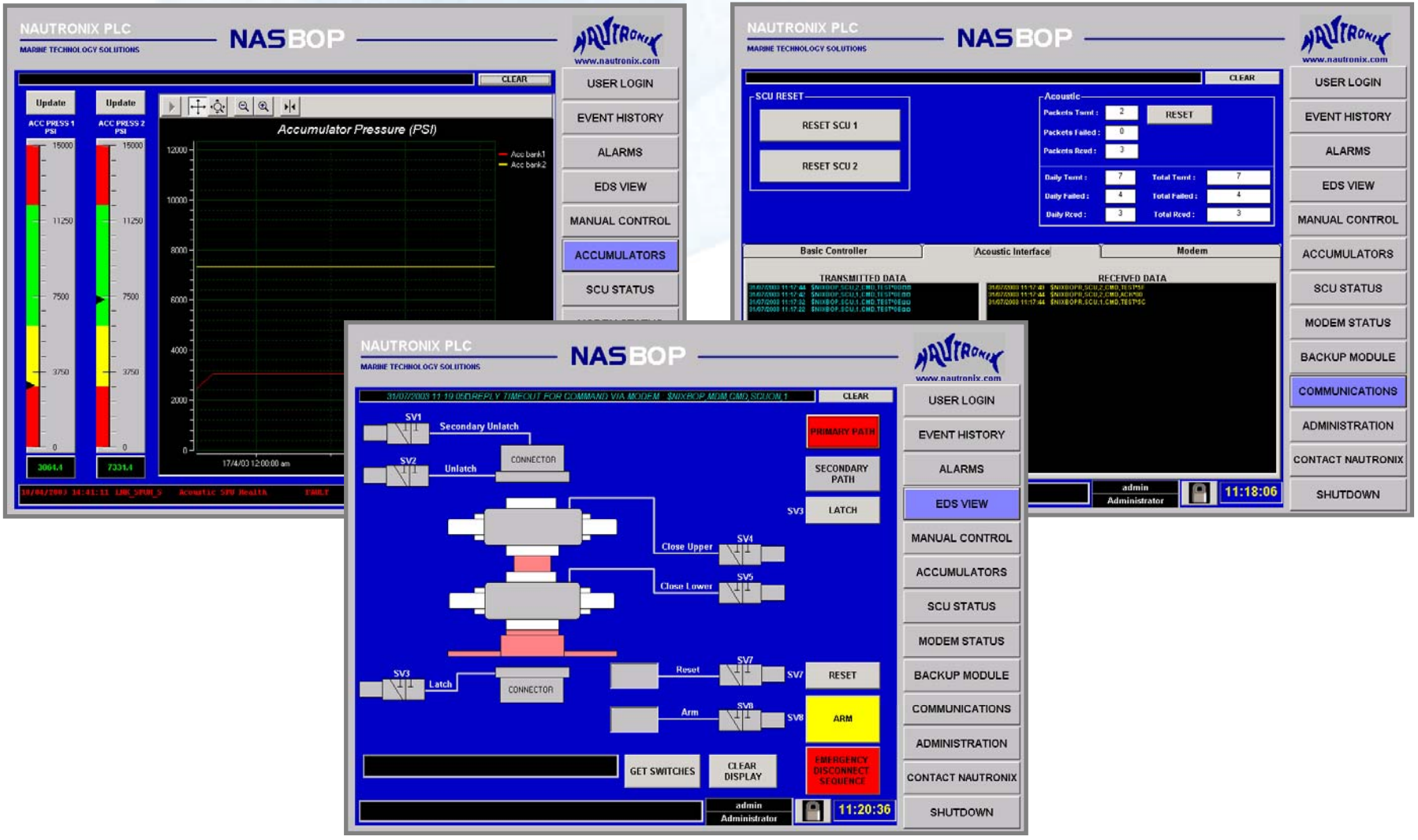
Function 4

Function 5

Function 6

Function 7

System information displays



NASMUX - Nautronix Acoustic Subsea Multiplex

- Cameron's Drilling Systems Division commissioned a Front End Engineering Design (FEED) study into full control of subsea BOP using acoustics as the communication link
- Joint effort by Cameron in Houston and Nautronix of Aberdeen from December 2008 to March 2009
- Examined the key areas for successful implementation

- The FEED study concluded that the acoustic concept is both feasible and achievable

- Phase 1 of development will result in a full functional design specification

CAMERON

Spotlight on new TECHNOLOGY

NASMUX Objectives

- **What are the objectives?**
  - Acoustic primary control of subsea BOP
  - 128 functions, plus analogue readings and digital status signals
  - Replace the traditional control umbilical
  - Retain the existing, proven, Cameron surface and subsea control units
- **Qualification**
  - Development will follow DNV-RP-A203, Qualification of New Technology

CAMERON

NASMUX Animation

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Combined Positioning and Communication Systems

Combined Positioning and Communication Systems

We have existing examples on a local scale:

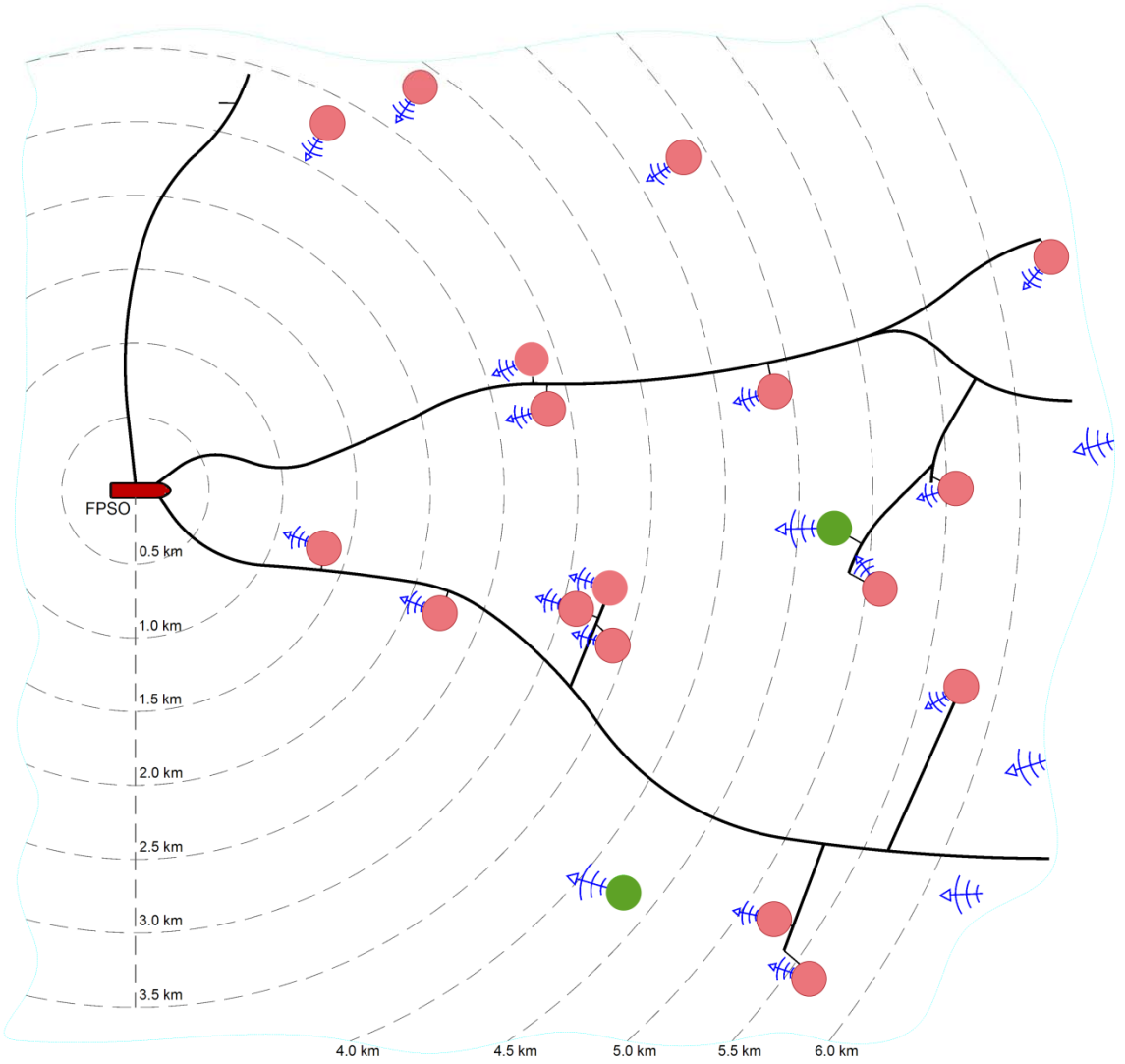
- Heading, pitch and roll data telemetered via LBL transponders
- Drilling stack inclinometer data via drilling vessel DP systems
- Riser position and strain gauge data direct to FPSO's etc

Nautronix is looking to combine these applications on a field wide scale and this is achievable because:

- Current architecture of NASNet® supports data relay
- LF frequency provides sufficient range for field coverage
- Additional data channels (128) will allow extension to field wide monitoring and control

Hypothetical Field

- Nodes
- Hubs
- Centred on FPSO
  - Data acquisition
  - Control
  - Sensors
  - Instrumentation
  - Connected to existing infrastructure
  - Independent of infrastructure



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Life of Field approach

Life of Field approach for positioning

Already some moves towards this:

- Use of transponder stands around well clusters and key field development areas allow for re-use of co-ordinates at different project phases

Applied to full field coverage there are greater advantages:

- No errors in positioning between project phases from seismic, drilling and construction
- Subsea infrastructure deployed with a homogenous seabed positioning system resulting in a field database with accurate position data.
- Leads to considerable efficiencies in later IRM activity
- Suitable for transition to AUV technology to perform inspection or light intervention tasks.
- Suitable for use “under the ice” applications

Through-Life Data Management

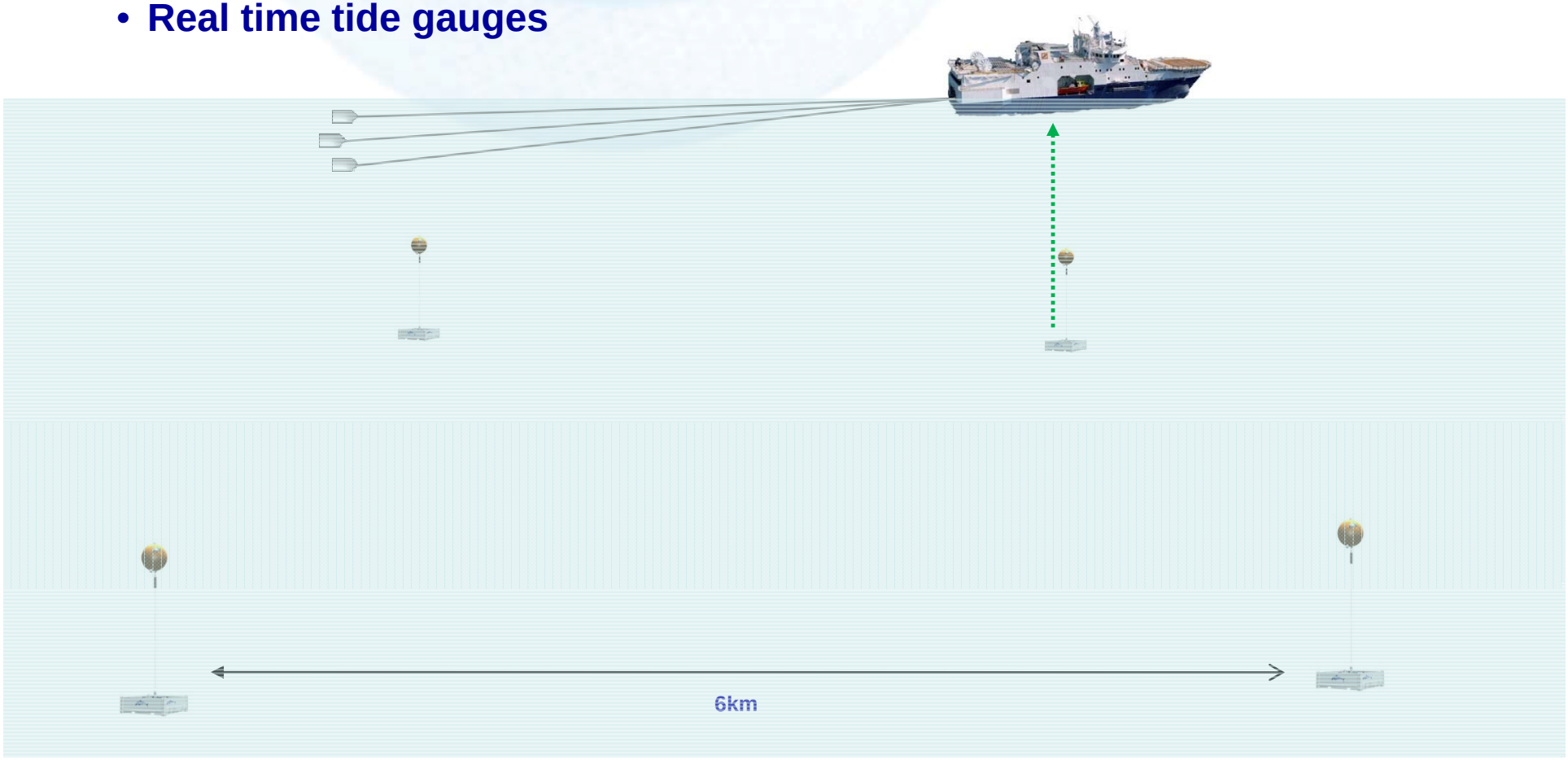
- Control systems
- Intervention systems
  - Communicate during and after deployment
  - Without umbilicals
- Subsea machines
- Subsea processing equipment
- Data logging
- Monitoring
  - Pipelines (corrosion, flow, temperature, pressure, hydrate build-up, movement/deviation…)
  - Wells (temperature, pressure, flow…)
  - Risers (movement, stress, strain for fatigue life…)
  - Valves (status…)
  - …

Intelligent Data Management

- Although acoustic data rates might be low, there is much that can be achieved through the application of intelligent data management
- Instead of sending all data, filter intelligently (report on exception)
  - On change
  - On rate of change
  - On scale of change
  - On direction of change
  - Using lower sampling rate
- In many situations strategies like these will provide all the information needed to make informed decisions, track trends, monitor equipment and manage operations

Seismic

- Vessel and Tail buoy positioning
- Environmental logging
- Real time tide gauges

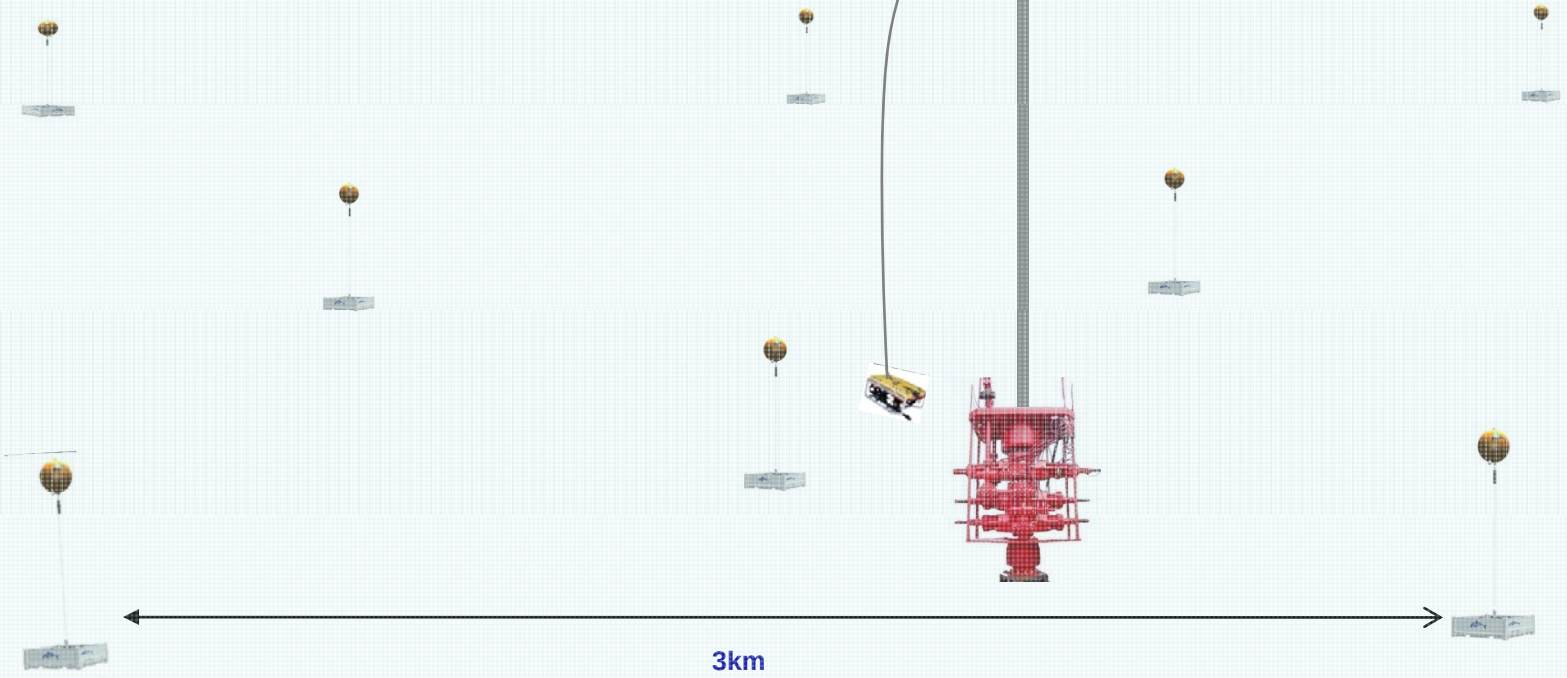


Exploration drilling

Surface DP reference (6+ ranges)

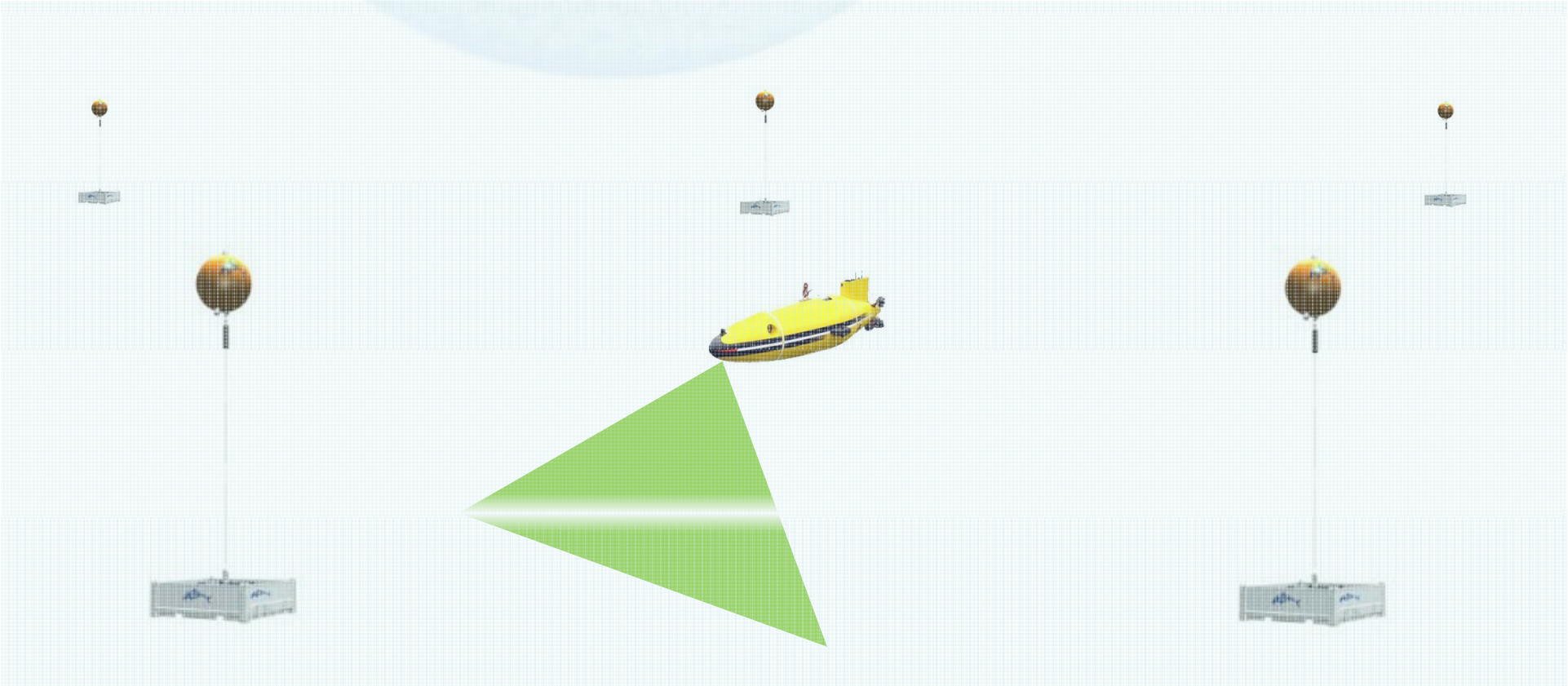
Subsea positioning (4+ ranges)

Real Time current meter data



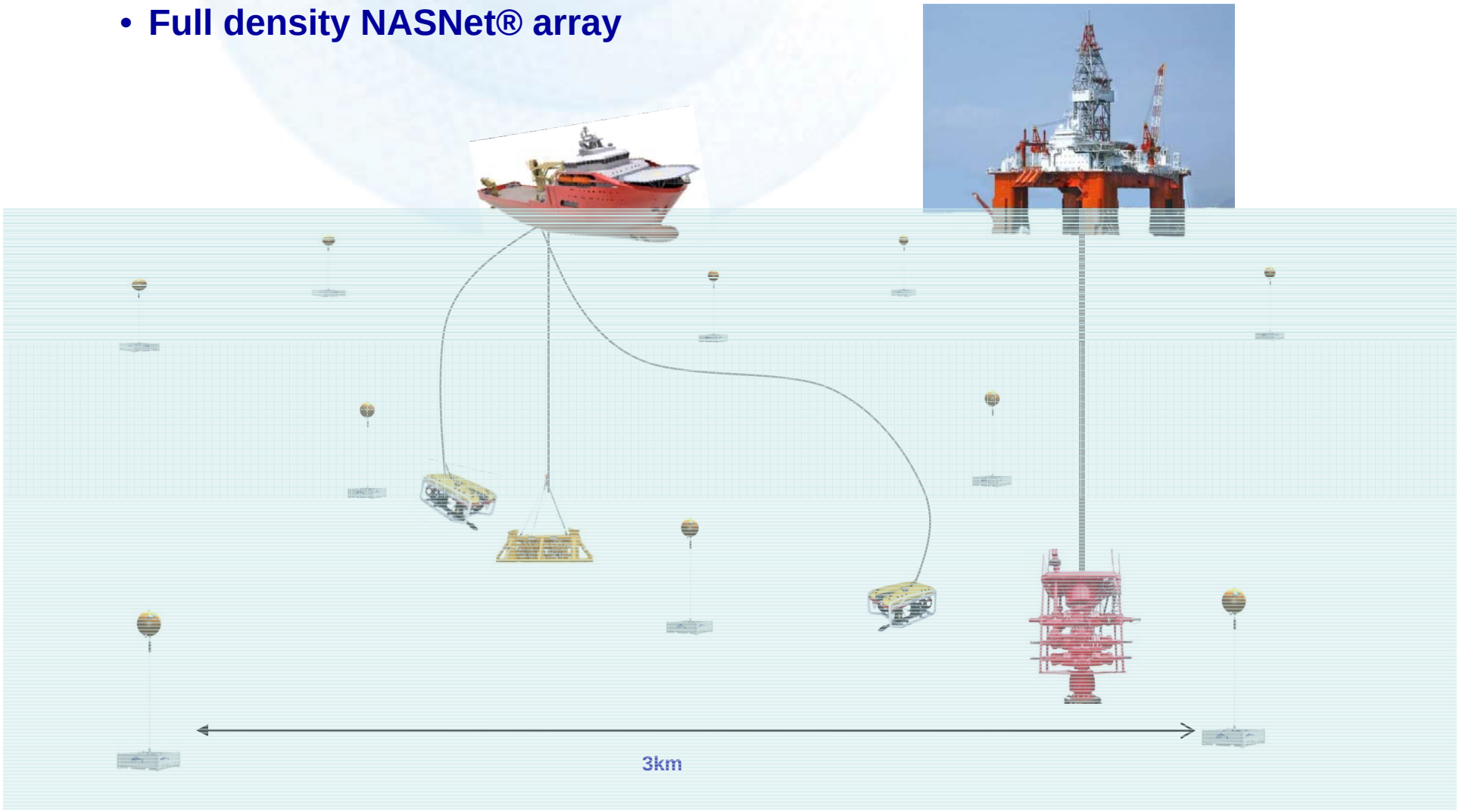
Site survey

Bathymetric and geophysical AUV survey



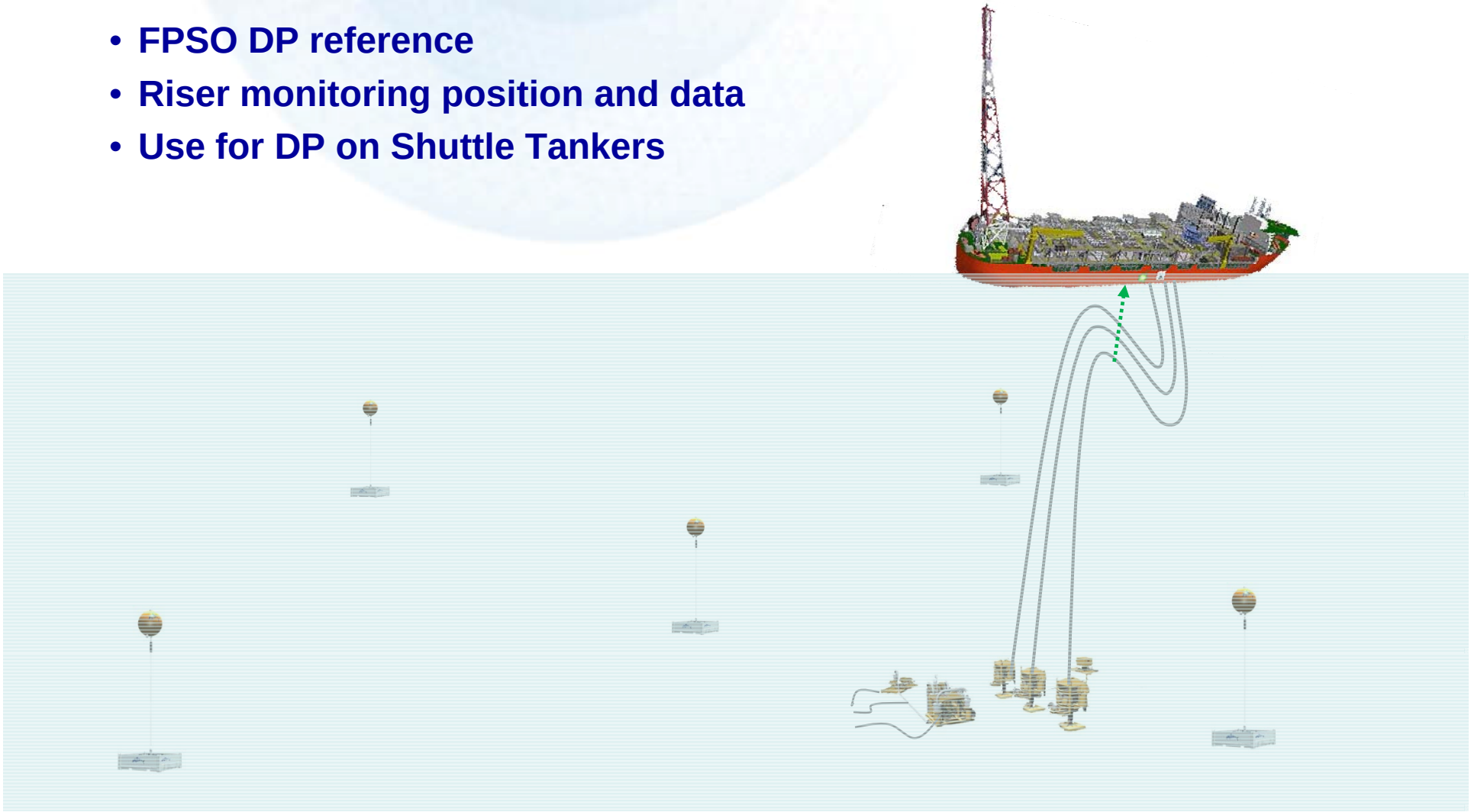
Construction – simultaneous operations

- **Full density NASNet® array**



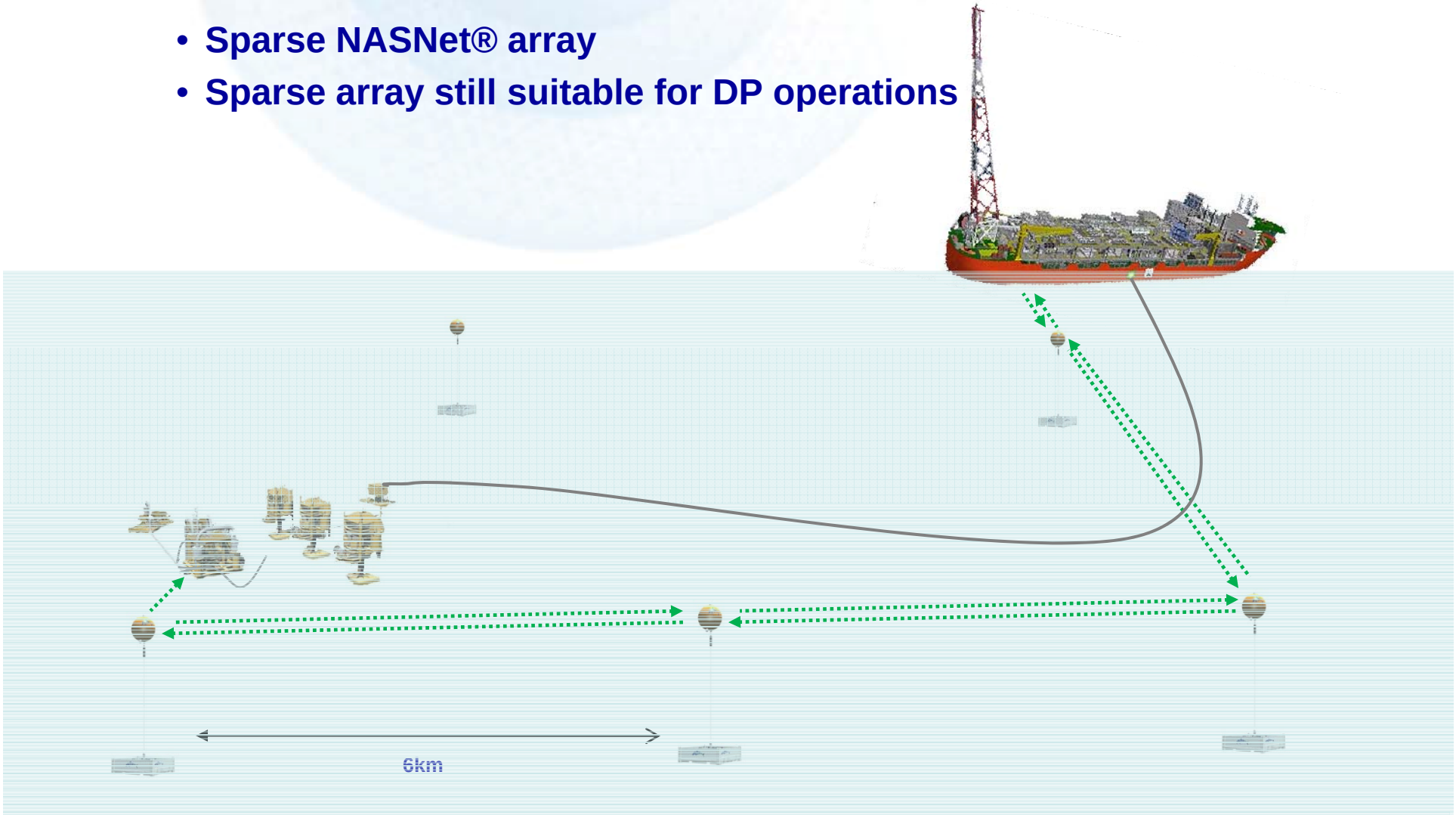
FPSO DP Riser Monitoring

- FPSO DP reference
- Riser monitoring position and data
- Use for DP on Shuttle Tankers



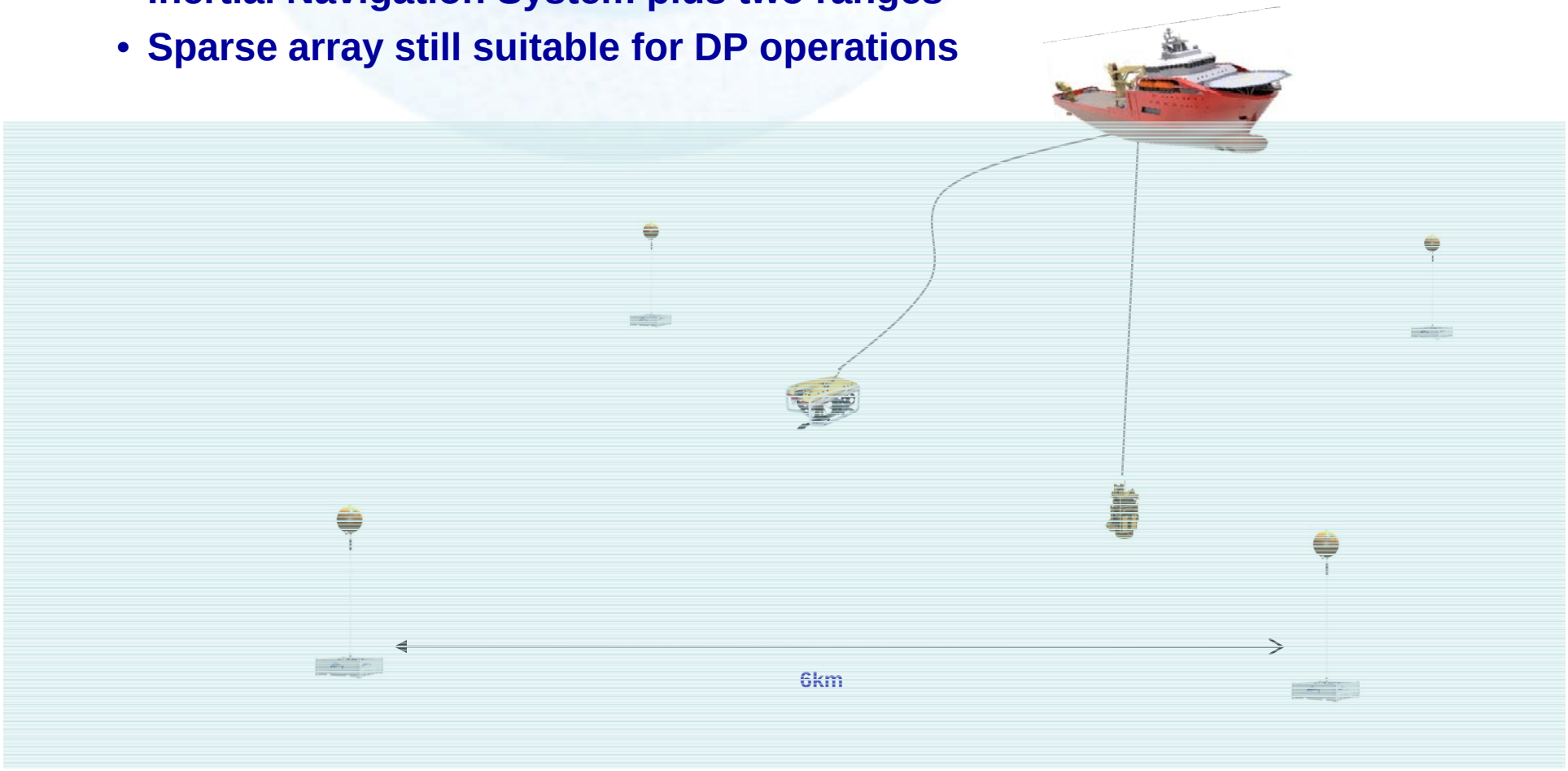
Monitoring and control - Relay

- Sparse NASNet® array
- Sparse array still suitable for DP operations



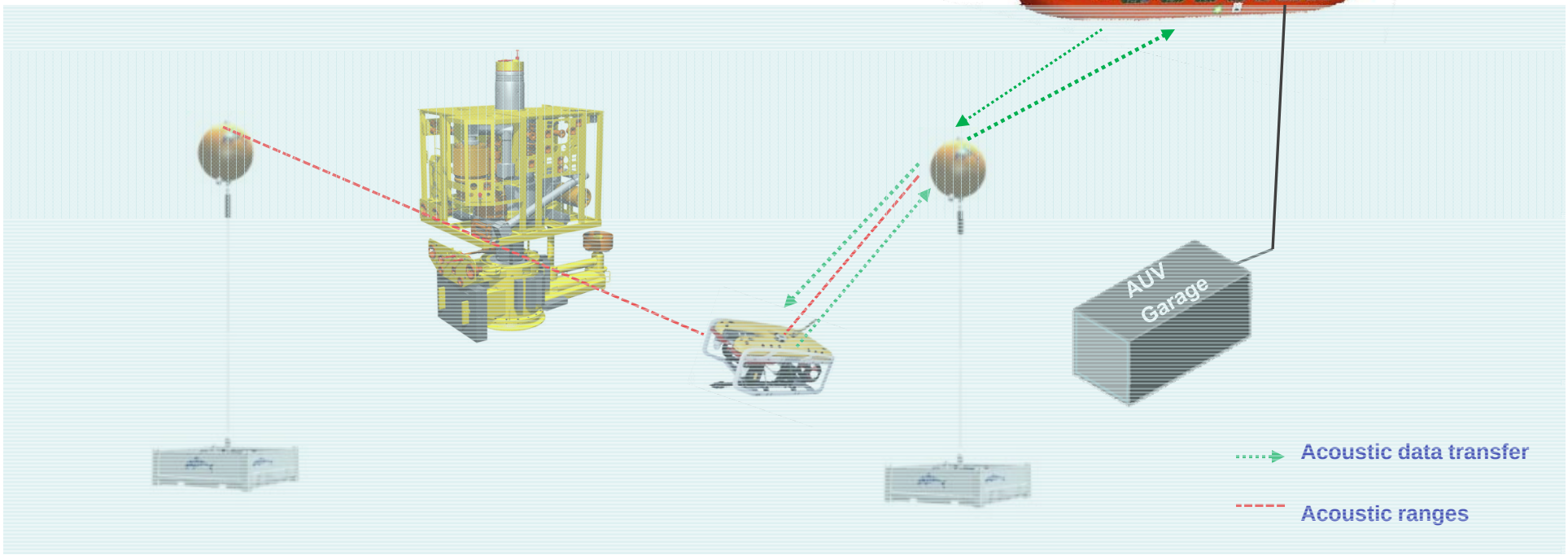
Intervention ranges

- Sparse NASNet® array
- Inertial Navigation System plus two ranges
- Sparse array still suitable for DP operations



Hybrid AUVs, communication & navigation

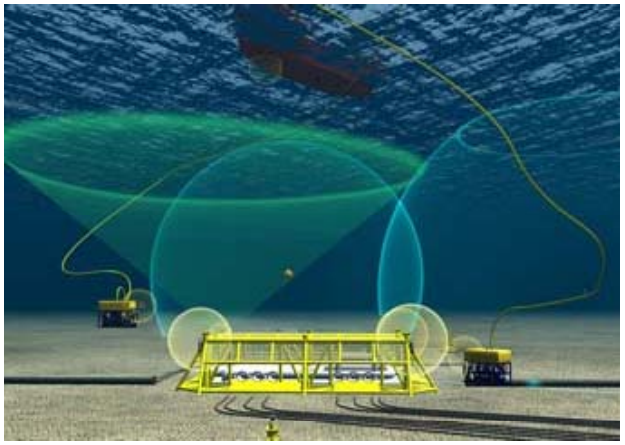
- Sparse NASNet® array
- Positioning from inertial navigation system plus two ranges
- Acoustic commands relayed to AUV
- Data QC transfer relayed from AUV

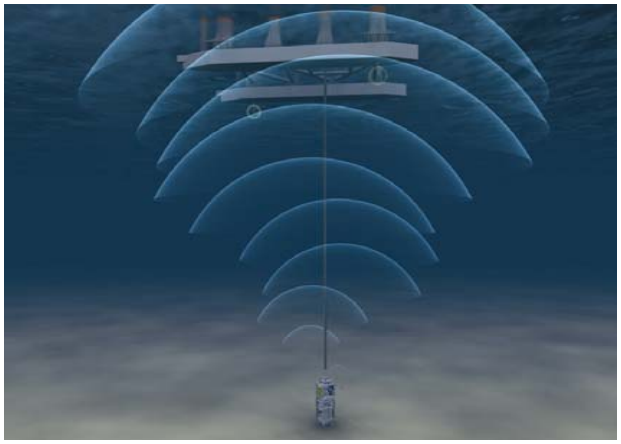


AUV animation

Summary

- Field wide positioning is already active via NASNet®
- Extension to Life of Field is only a matter of time (and understanding)
- Riser monitoring is commonplace using acoustic communications
- Digital acoustics applied to controls is in its infancy but gaining wider acceptance
- Digital acoustic solutions will be more readily accepted as developments go deeper due to reliability and economics
- Our vision is to provide NASNet® for life of field positioning and communication for the operator





'Global Leaders in Through Water Communication and Positioning Technology for the Offshore Industry'

QUESTIONS?