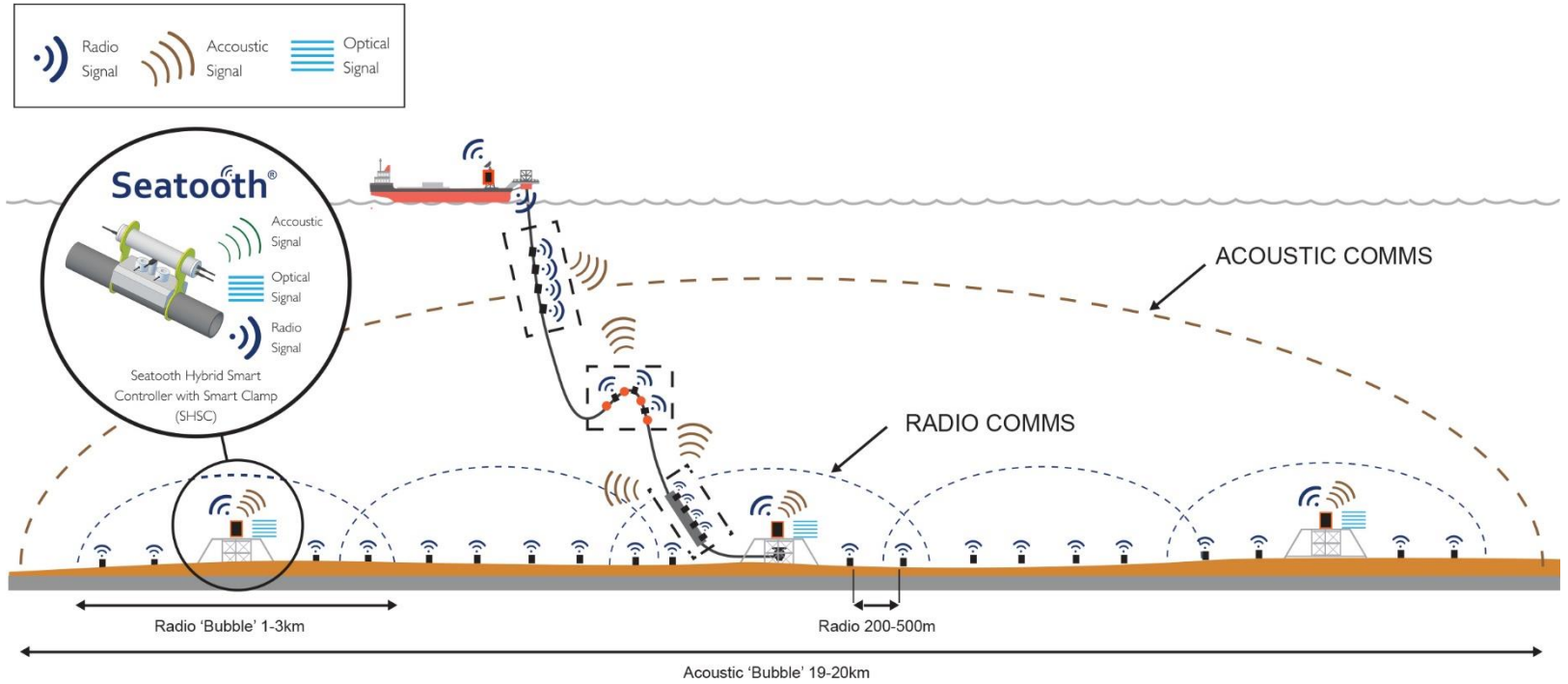
Reducing Costs Through Subsea Wireless Automation



Subsea Cloud Computing & Subsea Internet of Things®

WFS Technologies

June 2017

Agenda

- About WFS Technologies
- Why subsea automation matters
- Advances in subsea wireless technology
- Subsea internet of Things
- Subsea cloud computing
- Examples
  - Increasing production/reducing operating costs
  - Reducing inspection costs/extending asset life
- Summary

Abstract

This paper explores the latest subsea wireless products and automation technologies including hybrid wireless, Subsea Internet of Things and Subsea Cloud Computing and their use to increase production, reduce operating costs, reduce asset integrity management costs and extend asset life.

WFS Technologies

- *Background*

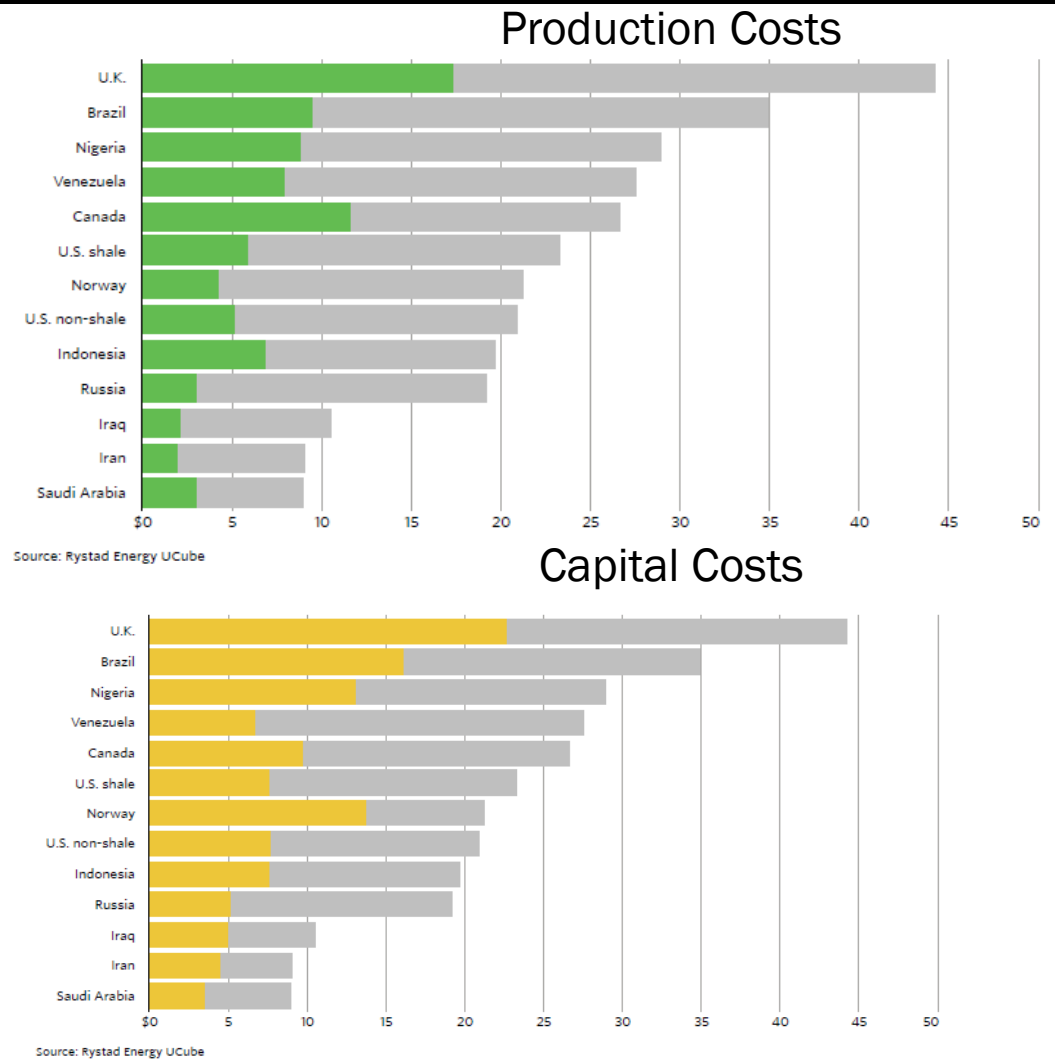
- Founded Edinburgh, Scotland in 2003
- Locations: Edinburgh, Houston, SE Asia
- World leader in subsea wireless automation
    - Seatooth radio
    - Seatooth Hybrid: radio, acoustic, optical
        - >200 man-years of research
        - >40 US patents granted
    - >7000 Seatooth products delivered
    - Subsea Internet of Things®
    - Subsea Cloud Computing
- WFS Oil & Gas
    - Production optimisation solutions
    - Asset integrity monitoring solutions
- WFS Defense
    - Subsea wireless C4ISR

WFS Headquarters Edinburgh, Scotland

Seatooth Wireless Network

Why Subsea Automation Matters

- Onshore/dry tree efficiency typically 50% greater than offshore – why?
  - High cost of intervention ?
  - Low levels of automation
    - ➔ est >80% less investment; 90% fewer sensors
    - ➔ Less instrumentation = less data
  - Predictive models uncalibrated
    - Eg Flow, fatigue, corrosion, met-ocean etc
    - ➔Over-design
    - ➔ Excess conservatism
    - ➔ Low extraction efficiency
- How Subsea automation drives down Costs
  - Collapse cost of critical information
    - ➔ Increase production efficiency
    - ➔ Reduce inspection costs
    - ➔ Extend asset life
    - ➔ Lower field extension costs
    - ➔ Lower green field CAPEX/OPEX



Source: WSJ, Apr 16 http://graphics.wsj.com/oil-barrel-breakdown/

Evolution of Automation

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WIRELESS FOR SUBSEA

Subsea Automation

Manual Inspection

Diver Inspection

RO Inspection

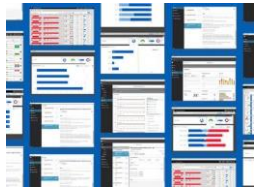
AUV Inspection

Process Automation

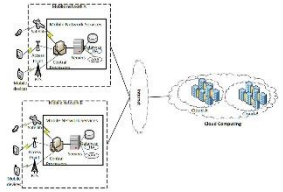
Manual Inspection

Local PID Control

Plant–wide
SCADA/DCS



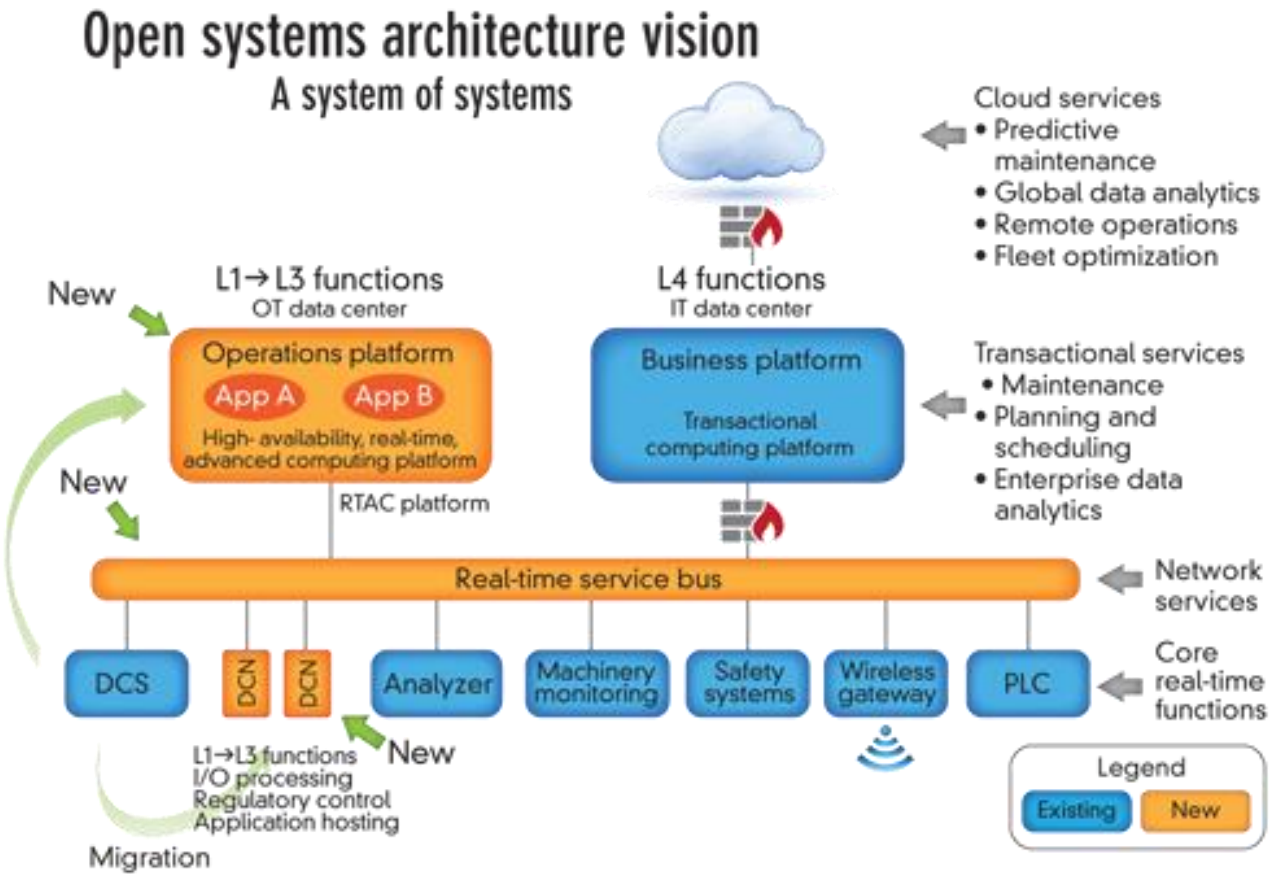
Industrial IoT
GE Predix



Mobile Cloud
Computiing

1970 1980 1990 2000 2010 2020

Process Industry Cloud Computing



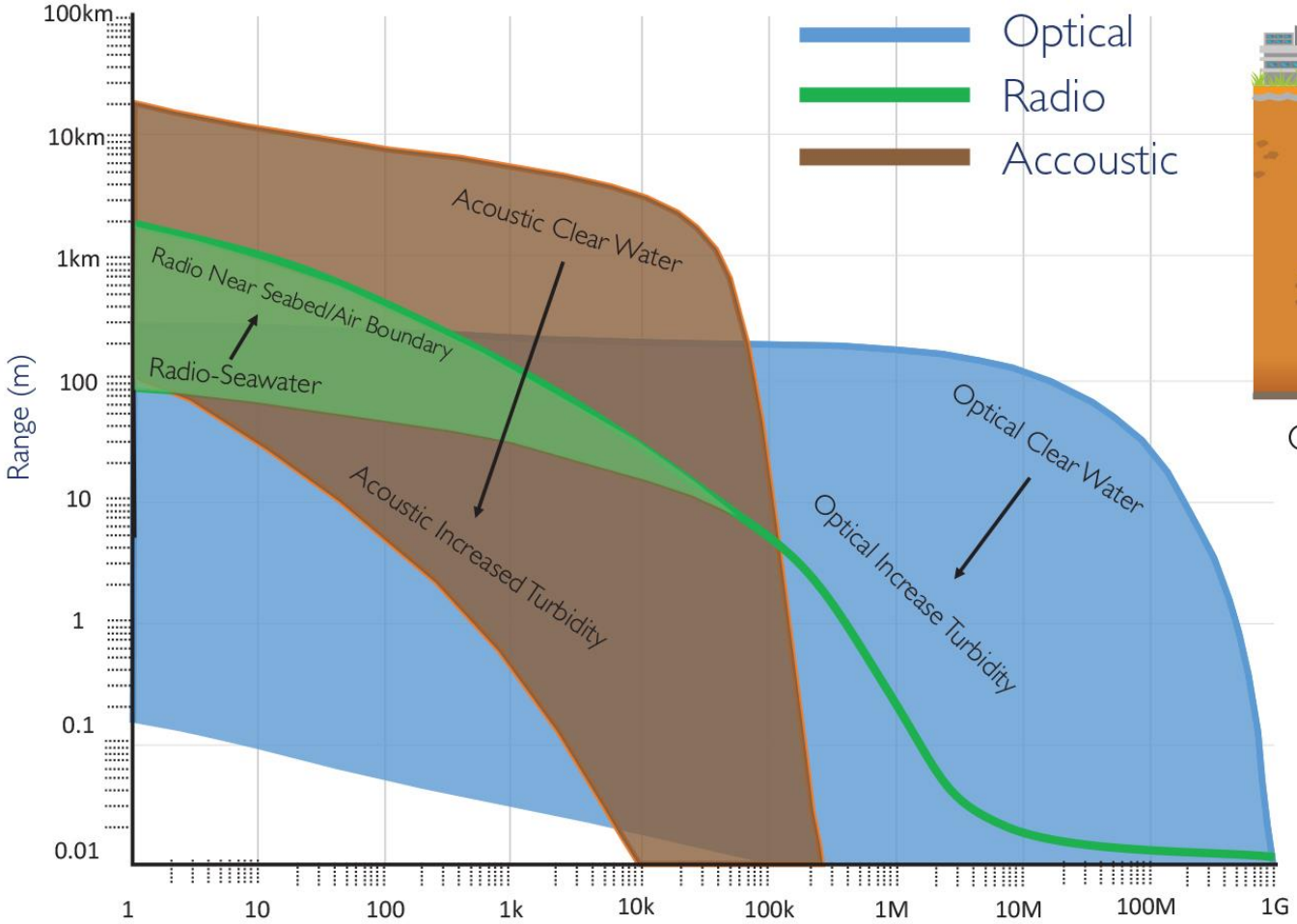
DCS dream taking flight

ExxonMobil envisions a new "system of systems" that will allow it to more easily adapt its operations environment to change needs and opportunities.

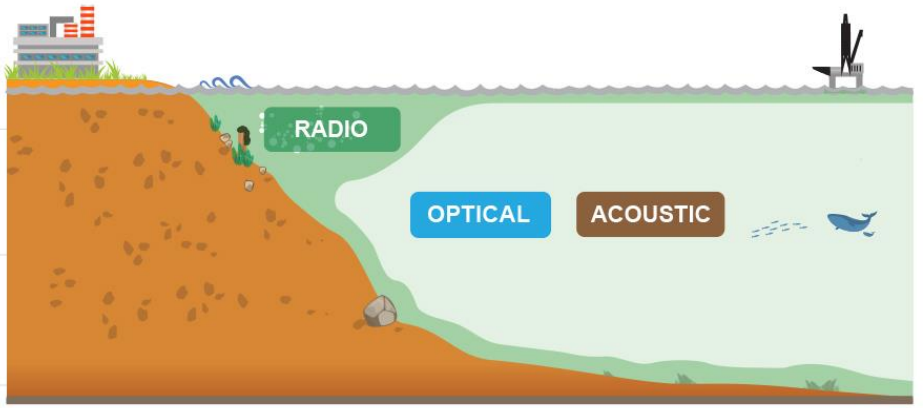
Graphic by ExxonMobil.

Source: http://www.controlglobal.com/industrynews/2016/exxonmobil-picks-lockheed-martin-to-develop-open-secure-dcs/

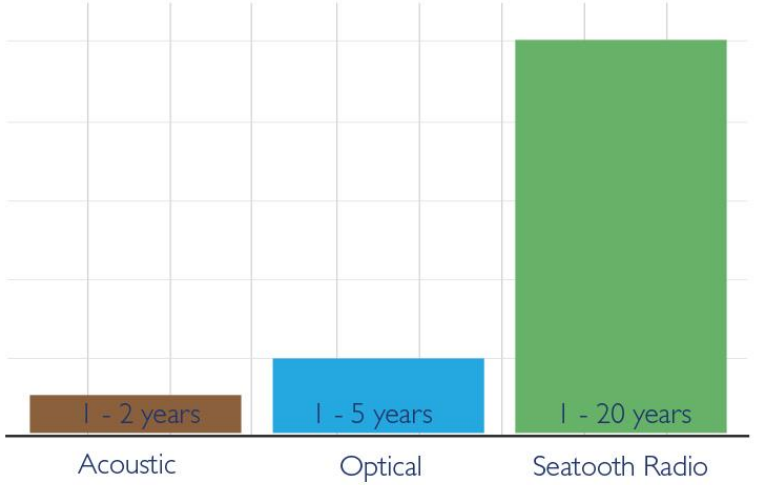
Advances in Wireless Technologies



Impact of water quality on wireless performance



Optimum operating environment of wireless technologies



Battery life of wireless technologies

Advances in Wireless Technology

- Collapsing the cost of critical information

Driving without a fuel gauge….

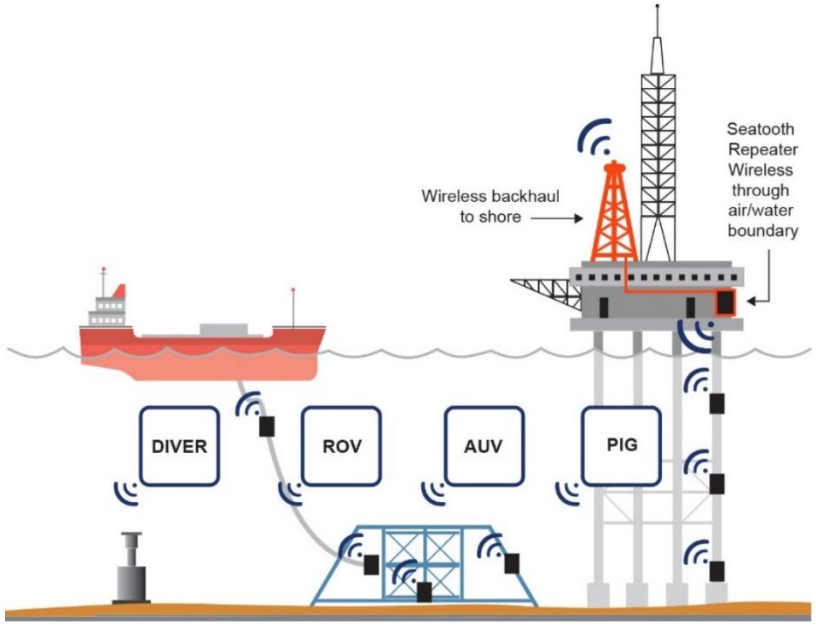
Access to information changes behaviours

Seatooth PipeLogger
– Retrofit Smart Temperature Controller

• **Battery life**	6 months	➔	5-20 yrs
• **Transit splash zone**	Cabled	➔	Wireless
• **Reliability**	Connectors	➔	Sealed for life
• **Installation**	Work class ROV/Vessel	➔	Light class ROV/Platform
• **Integration complexity**	High (wired)	➔	Low (wireless)
• **Information recovery**	Diver/WCROV	➔	Wireless network/LCROV/AUV/PIG

What is *Subsea Internet of Things*?

A network of smart wireless sensors and devices configured to provide actionable operational intelligence such as performance, condition and diagnostic information.



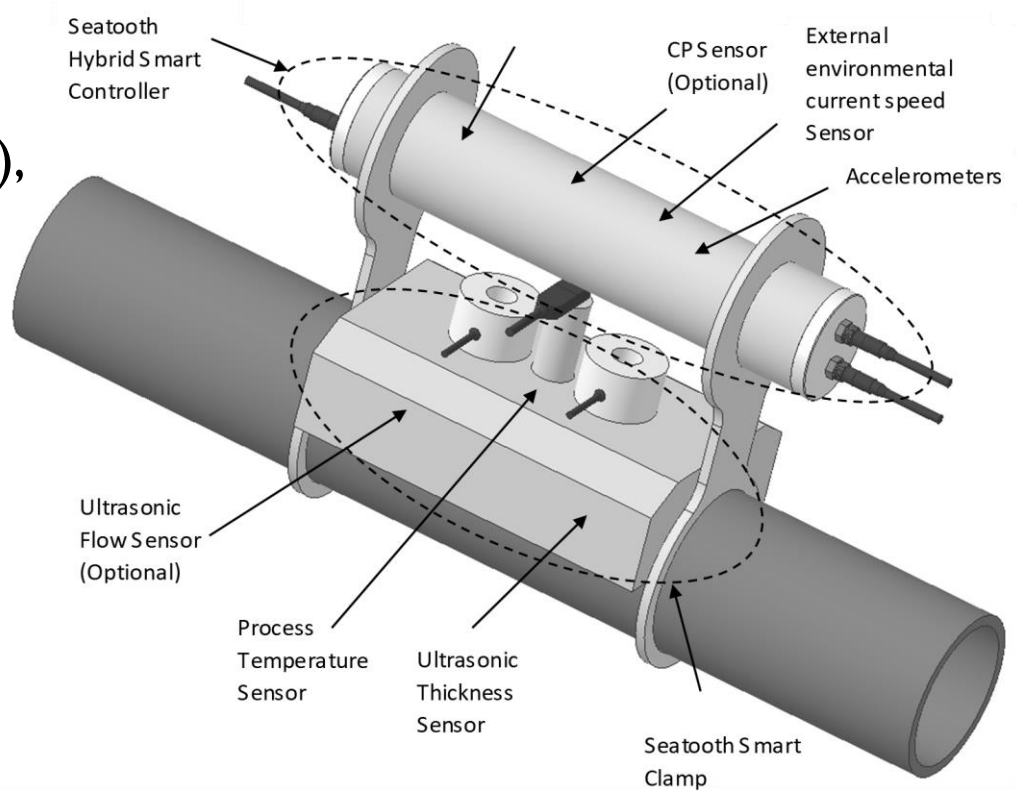
Subsea Internet of Things

Underpinning innovations

- Seatooth Radio - penetrates water, water/air, seabed, metal
- Seatooth Hybrid - integrated radio, acoustic, optical comms
- Seatooth Endure - extends battery life beyond 10 years

What is *Subsea Internet of Things*?
- *Smart Devices*

- Multi-parameter smart sensor
  - Flow Assurance: Temp, Flow, Vibration, Acoustic (slug)
  - Asset Integrity: Temp, UT, CP, Vibration, Crack, Video/Acoustic/sonar/hydrocarbon (leak),
- Hybrid communications
  - Wireless radio, acoustic, optical
- Intelligent bandwidth management
  - Local data processing ➔ low data density
  - Local process model correction ➔ 'fog' computing
- Intelligent power management
  - Intelligent bandwidth management ➔ 5-20 years
  - Local power generation using dT ➔ 20 years +



Subsea Internet of Things

- *Wireless automation solutions using standard sensors*

Seatooth PipeLogger
Non-penetrating temp controller
Process and seawater temp
Temp: 0-100DegC +/- 2DegC
Battery: up to 20 years

Seatooth PipeLogger-TI
Non-penetrating temp controller
Pipe-in-pipe or up to 4" foam
Temp: 0-100DegC +/- 5C
Repeatability: 1DegC
Battery: up to 20 years

Seatooth PipeLogger-UT
Retrofit corrosion monitor
Wall Thickness: <250mm
UT Accuracy: 0.1mm
Up to 8 UT sensors
Battery: up to 20 years

Seatooth WiPS
Wireless Pressure/Temp
Integrated display

Seatooth Video
Subsea wireless camera
Battery: up to 8 hrs use
Seawater Range: 3-5m

Seatooth SWiCOM
Subsea wireless diver automation
Seatooth wireless Android tablet
Battery: up to 8 hrs continuous
Seawater Range: 5-10m

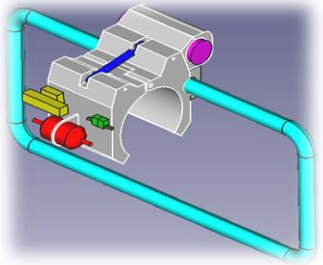
Seatooth PipeLogger-UF
EOR automation
Accuracy:+/- 2-5%
Repeatability: +/- 2%
Battery: up to 10 years

Seatooth CP
Corrosion automation solution
Stork Voltage/Current sensor
Battery: up to 20 years

Seatooth CTFM
Fatigue management
Real time & cumulative

Seatooth Vibration
Fatigue, VIV, FIV
monitoring
Up to 1kHz
Battery: up to 5 years

Seatooth LightRope
Subsea wireless RFID
For diver and ROV automation
Battery: 16 hrs use; 2 yr standby
Seawater Range: 5m

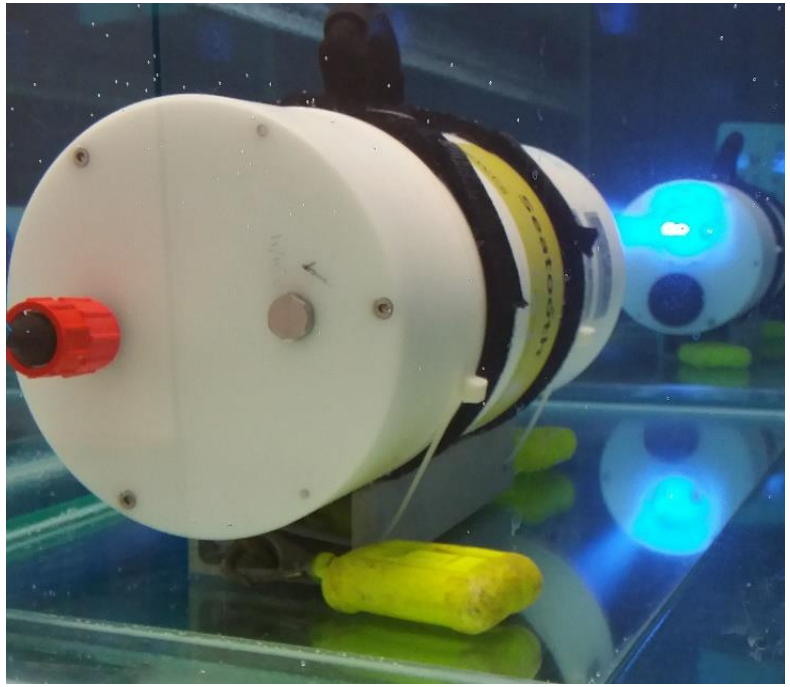


Seatooth Smart Clamp
For risers and flowlines
Suitable for splash zone
Deployable by light class ROV
Self-monitoring

Subsea Internet of Things
- *Smart Communications*

WFS
WIRELESS FOR SUBSEA

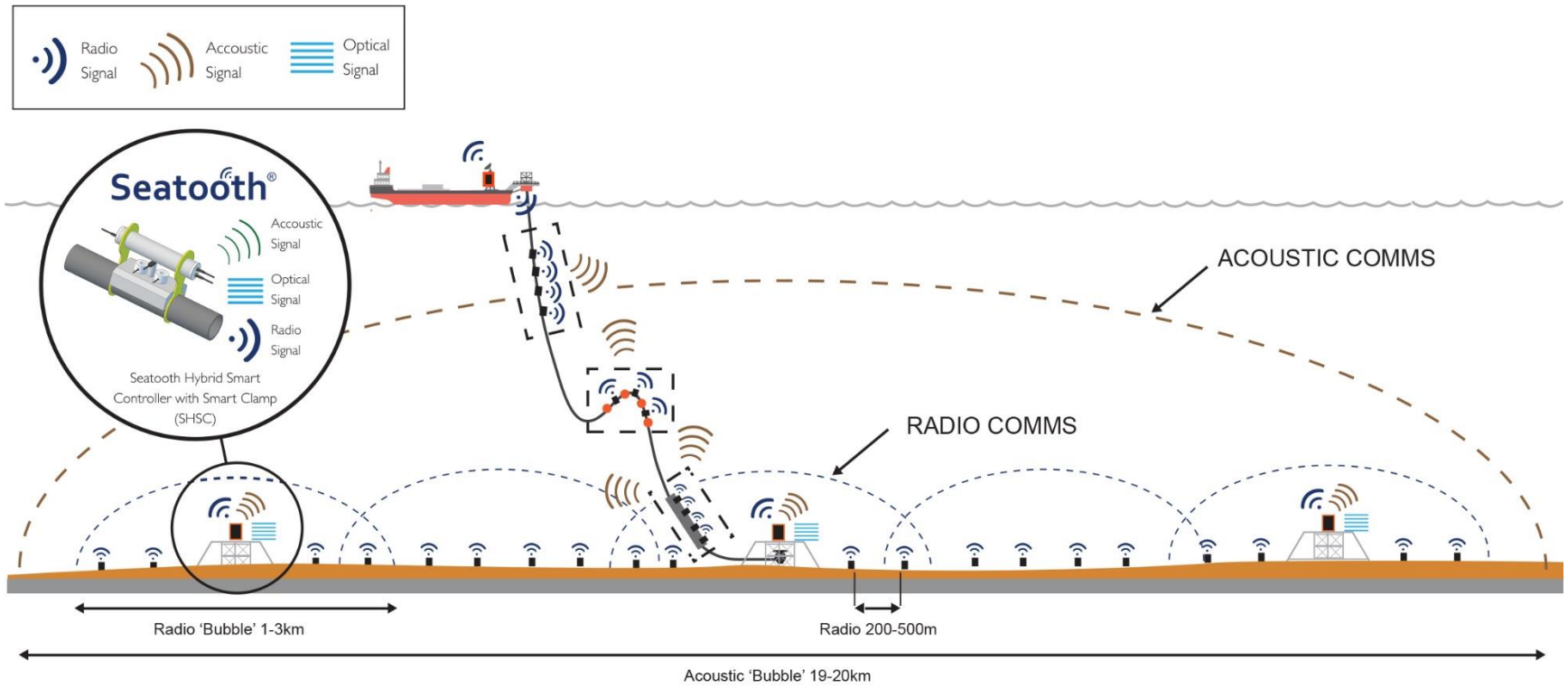
- Seatooth Hybrid:
  - Integrated radio, acoustic, optical
  - Auto channel selection
  - Battery life: up to 20 years
- Benefits
  - Single solution for all operating environments
- Applications
  - Asset integrity management
  - Production optimisation
  - Green field CAPEX/OPEX reduction



Seatooth Hybrid

What is *Subsea Cloud Computing*?

Is a secure and efficient computing architecture based on *Subsea Internet of Things* that provides shared computer resources and data to subsea devices on demand.



Subsea Cloud Computing

- Subsea automation data sets >>TB

  - Production, asset integrity, seismic, down-hole, met-ocean etc.

- Hardwiring every sensor impractical: cost, reliability, future proof
- Hybrid architecture

  - Cf telecoms fibre optic to 4G mast

- Move Intelligence to the edge
- Resilience:

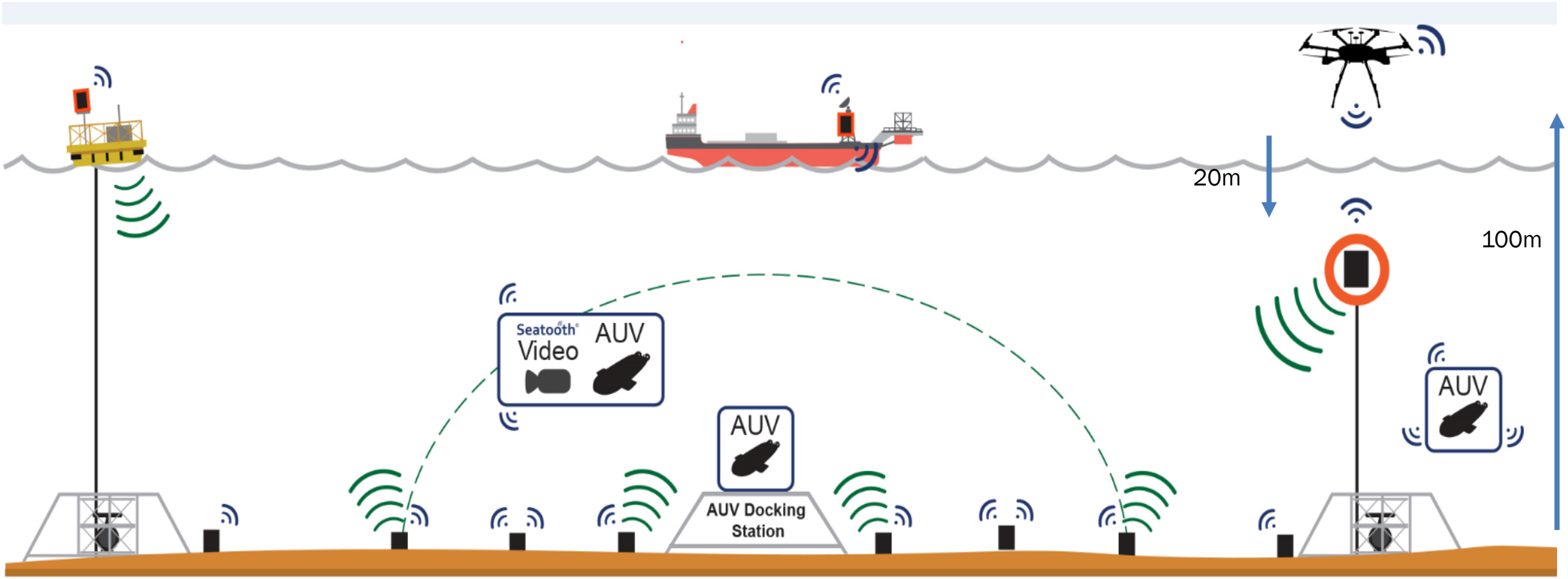
  - Overlapping radio, acoustic network;

  - AUVs 'fill gaps', 'cross-pollinate' critical information & synchronise large datasets

- Security: Blockchain manages access to subsea cloud 'servers'

Subsea Cloud Computing

- Extended capability with Autonomous Vehicles



Subsea Internet of Things

- *Wireless Automation Solutions – Key Application Areas*

- Process Optimization
  - Real time point & distributed temperature
  - EOR Water/Gas injection optimization
  - Slug management
  - Hydrate/Wax management
  - Chemical injection optimization

➔ *Increase production by up to 15%*

➔ *Decrease chemical costs by up to 50%*

- Asset Integrity Automation
  - Riser/completion fatigue monitoring
  - Mooring fatigue monitoring
  - Field-wide corrosion optimization (CP)
  - Point corrosion/Erosion automation (UT)
  - Crack inspection automation (ACFM)
  - Impressed Current optimization (ICCP)
  - Vibration Management (FLIP, VIV, Span)
  - Leak detection

➔ *Reduce costs by up to 90%*

Subsea Internet of Things – Process Optimization

- Increase production, Reduce Chemical Costs

- Modelling tools used for design, process & asset management often uncalibrated against field data
  - Flow
  - Temperature
  - Corrosion
  - Fatigue
- Lack of calibration leads to conservatism
  - Increased CAPEX
  - Sub-optimal production
  - Increased OPEX

- Improve system characterisation through model calibration
  - ➔ *Distributed temp, corrosion, fatigue sensors*
- Reduce latency of actionable information
  - ➔ *Wireless SCADA network*
- Improve control
  - ➔ *Dynamic models linked to real time data*
  - ➔ *Closed loop Chemical/EOR injection control*

Subsea Internet of Things

- Process Optimization ➔ Real time point & distributed temperature

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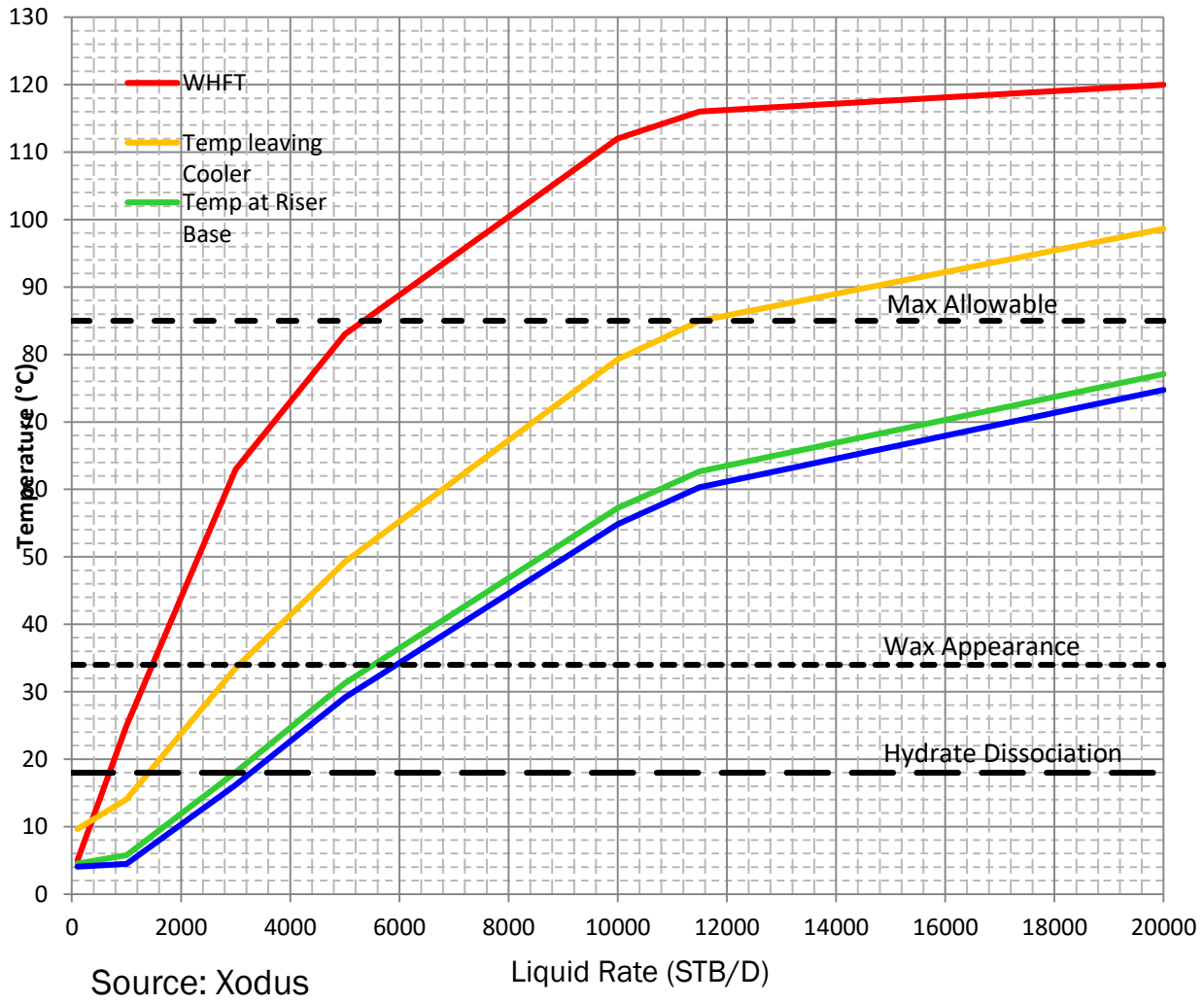
WIRELESS FOR SUBSEA

- Point Temperature Monitoring
  - Broken well-head sensor replacement
  - Riser base
  - Flexible inlet
  - Hot/cold spots
  - Seawater temperature
- Distributed Temperature monitoring
  - dT across pipe-in-pipe
  - dT across buried pipe
  - dT across cooling spool
  - Seawater temperature through water column
- 5DegC reduction in margin
  - ➔ **Production +800 bpd /+15%**
  - ➔ **$15m pa @ $50/bbl**



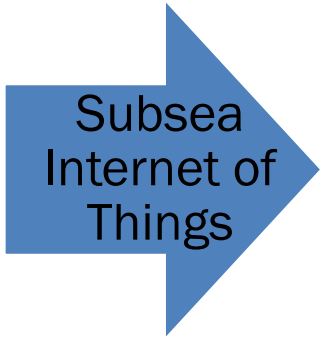
Source: Xodus

Subsea Internet of Things

- Reduce Inspection costs and detecting failures

WFS
WIRELESS FOR SUBSEA

- Inspecting what?
  - Leaks, Corrosion, Cracks, Fatigue, Movement
- Why so few asset integrity sensors?
  - High cable installation costs
  - Poor reliability of connectors & jumpers
  - Battery swap costs
  - High cost of repair
- Inspection cost drivers:
  - Diver ➔ DSV costs, safety, complexity
  - ROV ➔ ROV spread costs, complexity
- Regulatory driven
- Low data density ➔ limited root cause analysis

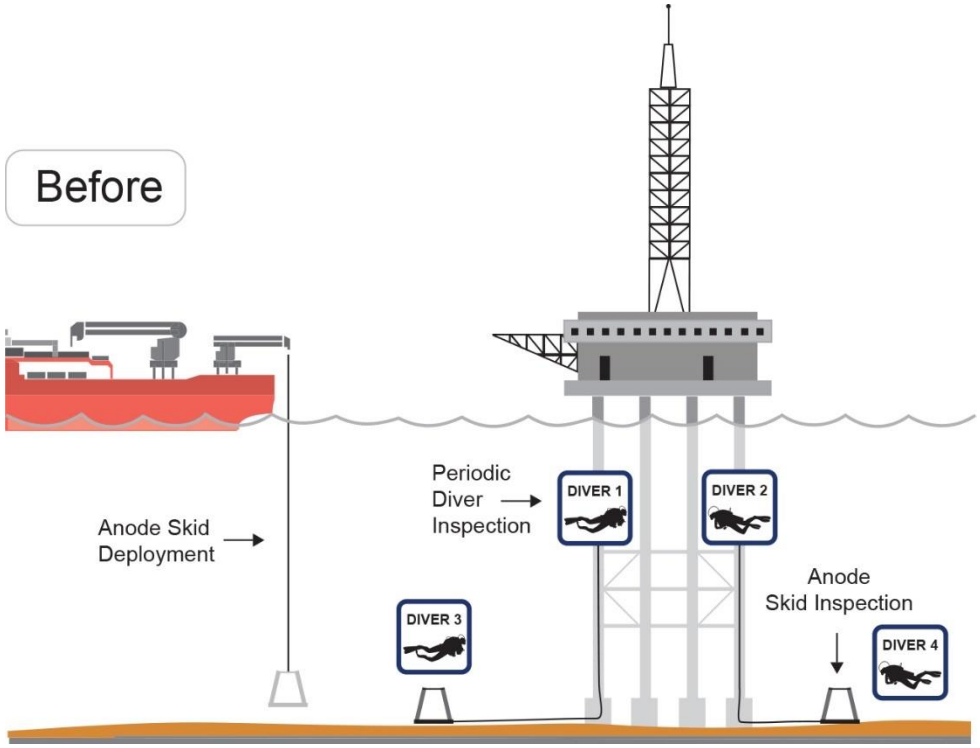


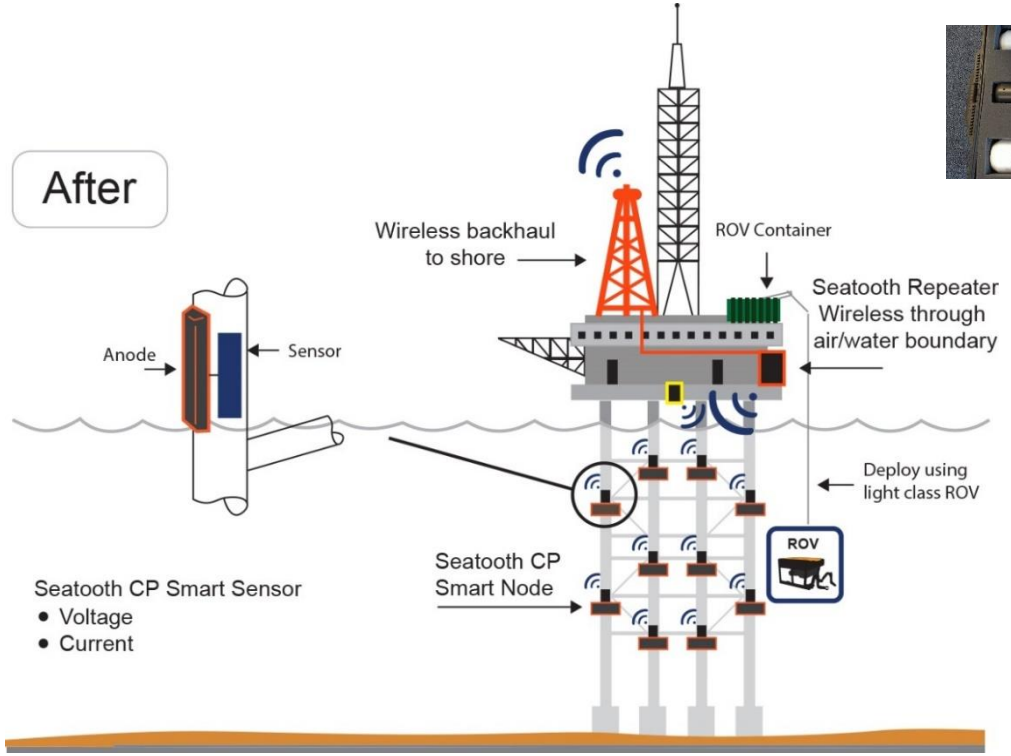
Benefits of Subsea Internet of Things

- Reduce inspection costs by >50%
- Reduce installed sensor cost by >80%
- Reduce information latency
- Increase data density by $>10^2$
- Increase repeatability, accuracy, resolution
- Reduce AIM maintenance/repair costs
- Extend asset life

Asset Integrity Solutions

- Subsea Field-Wide Cathodic Protection (CP)





Seatooth CP System

- Reduce inspection costs → payback typically < 1 year
- Improve quality of information → location, timeliness, reliability, frequency
- Flexibility to extend sensor network → subsea wireless SCADA

Subsea Internet of Things

- *Real Time Wireless Riser Monitoring Solution*

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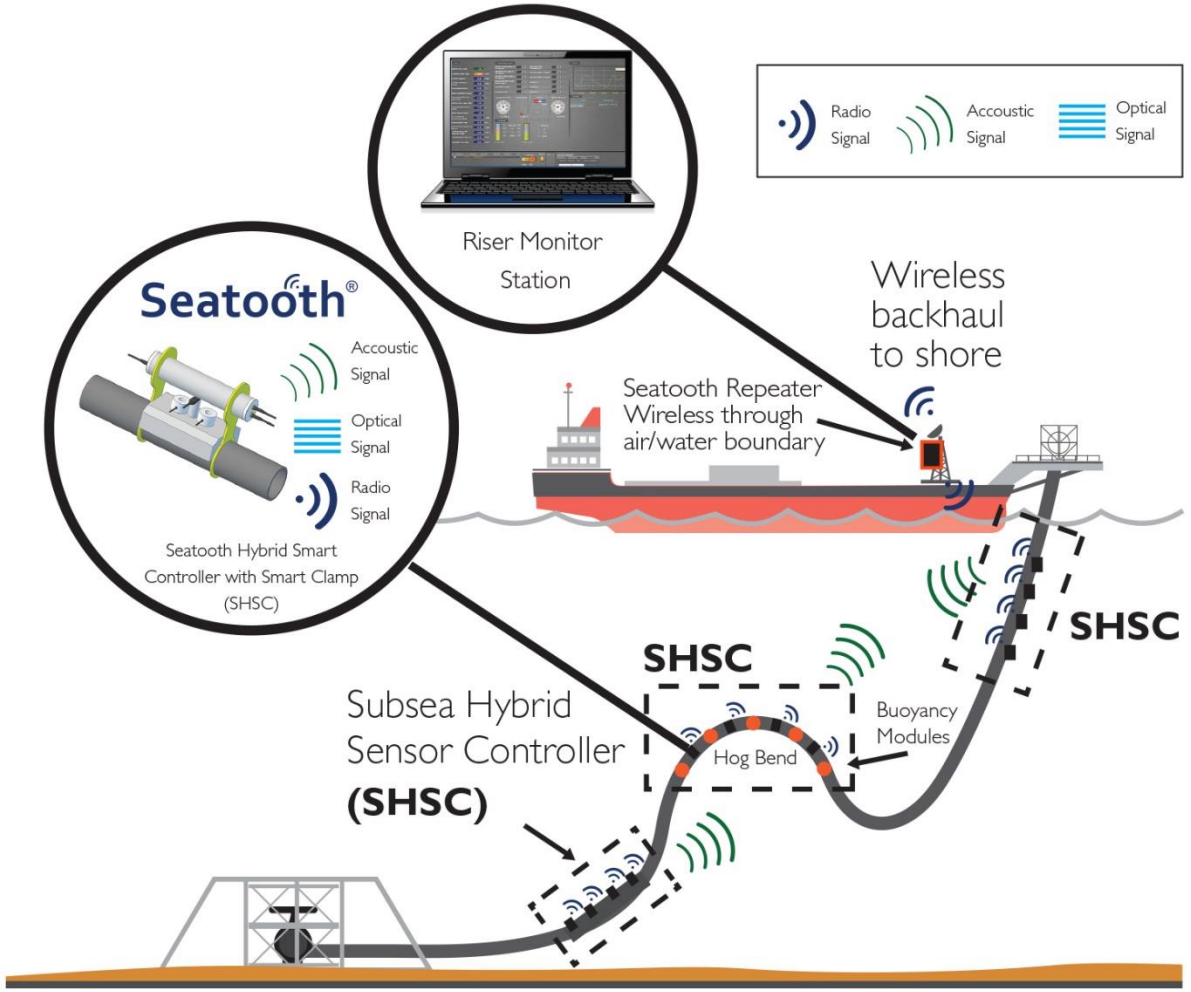
WIRELESS FOR SUBSEA

Functions

- User interface: Real time & cumulative fatigue, corrosion wax/hydrate, temperature, water currents
- Fatigue: Riser shape & motion; VIV
- Corrosion: Corrosion rate by region
- Flow assurance: Wax/hydrate management
- Environment: Water currents, temp, salinity

Features

- Sensor nodes: Up to 100
- Comms: Hybrid (radio, acoustic, optical)
- Battery life: 5 – 20 years
- Deployment: Using light or work class ROV
- Clamps: Self-monitoring (Smart)
- Interfaces: Real time meteorological data FPSO DCS/SCADA



Subsea Internet of Things

- *Real Time Mooring Monitoring Solution*

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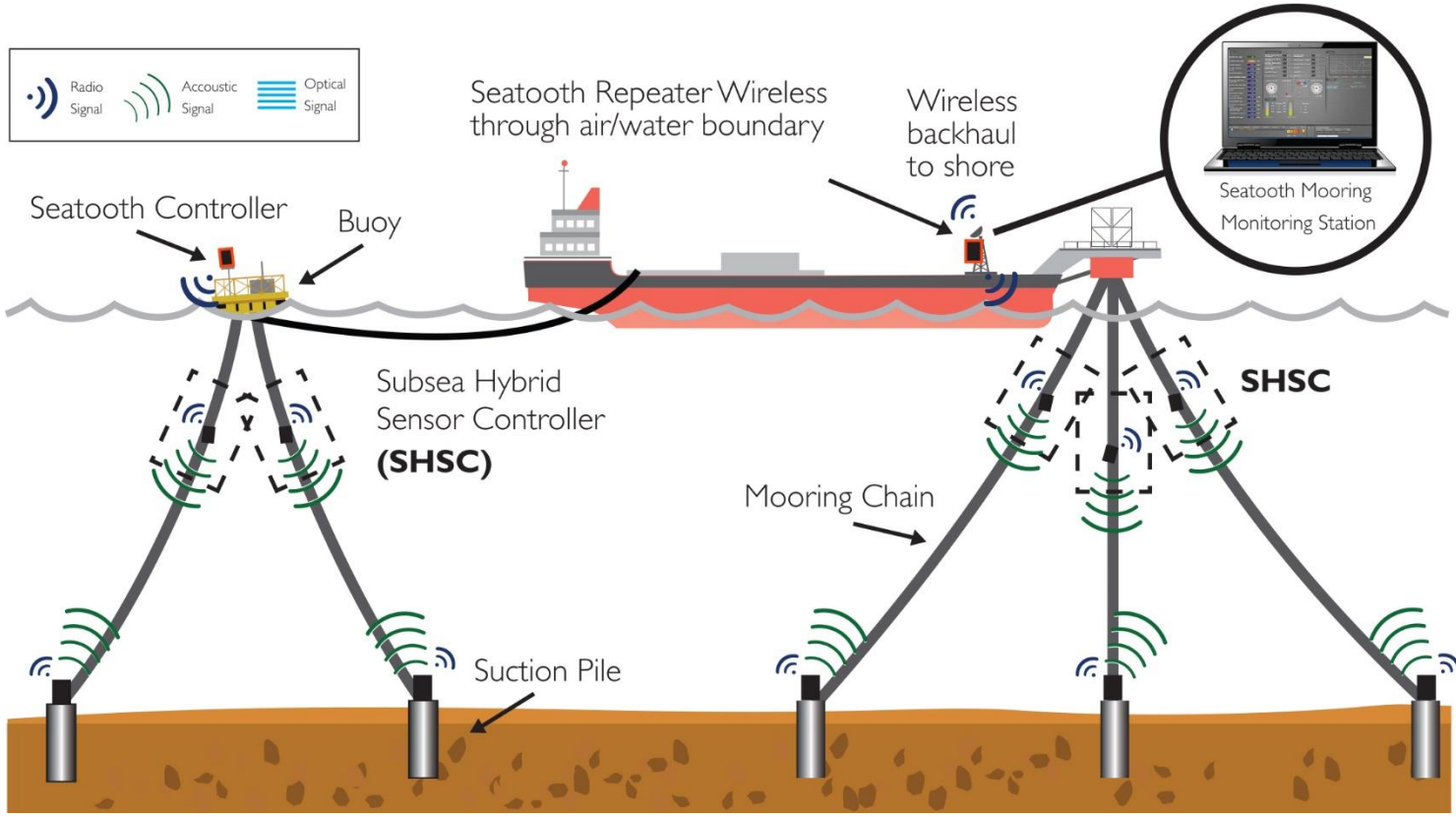
WIRELESS FOR SUBSEA

Functions

- User interface: Mooring & anchor status
  Real & cumulative time fatigue
  Water currents, temperature & salinity
- Failure: Mooring line failure
  Suction anchor failure
- Fatigue: Mooring system fatigue monitoring
- Corrosion: Corrosion rate by region
- Environment: Water currents, temp, salinity

Features

- Comms: Hybrid (radio, acoustic, optical)
- Battery life: Minm 5 years
- Deployment: Using light or work class ROV
- Clamps: Self-monitoring
- External links: Real time meteorological data
  FPSO DCS/SCADA

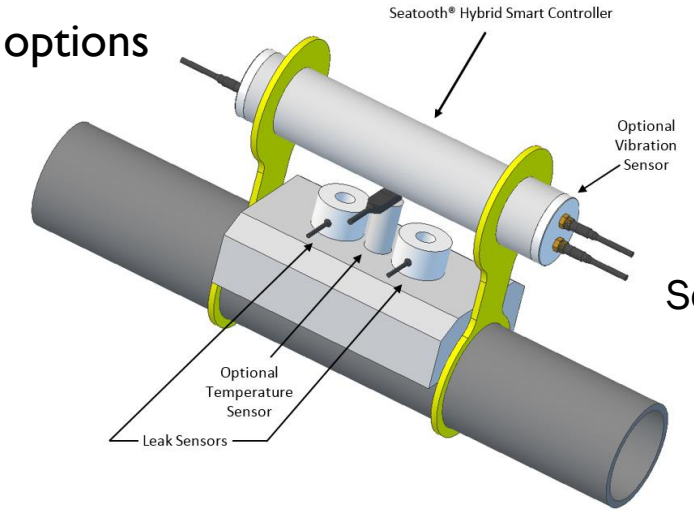


Facilities **FPSO, TLP, SPAR, Semi-sub**

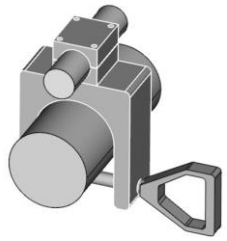
Subsea Internet of Things

- Subsea Field Leak Monitoring Solution

- Retrofit Wireless SCADA network
- Seatooth Hybrid Smart Controller sensor options
  - Leak
    - Acoustic (leak detection)
    - Photo/Video
    - Capacitive (leak capture)
    - Sonar
  - Asset integrity
    - Accelerometer (movement)
    - Corrosion (CP, UT)
  - Flow Assurance
    - Temperature (process and sea)
    - Flow (process)
- Seatooth Hybrid communications
  - Radio
  - Acoustic
- Local data processing
- Integration with SCADA/DCS
- Light-class ROV deployable
- Battery life: typically 5 years



Seatooth Hybrid Smart Controller



Seatooth Smart Clamp

Sonar

Capacitive Sensor

Camera & Light

Acoustic Sensor

Selected WFS Customers and Deployments

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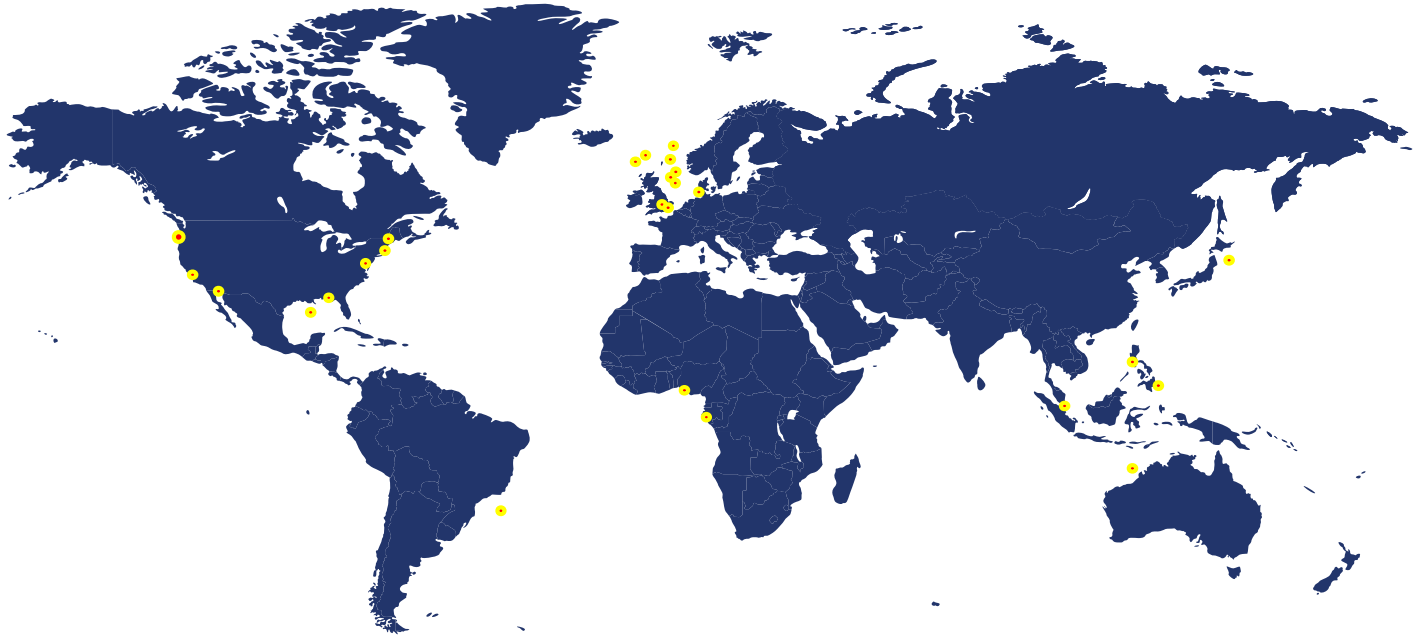

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SAAB
ISE International Submarine Engineering Ltd. Group of Companies
LOCKHEED MARTIN
subsea 7
TechnipFMC
i-Tech7
FUGRO
OCEANEERING
imagination at work
ECOSSE Subsea Systems
Environment Agency
AkerSolutions
Chevron
PETROBRAS
woodside
TOTAL
REPSOL YPF
TALISMAN ENERGY
Quadrant Energy
JAMSTEC
Shell
Apache
bp
EQ EnQuest
wavejet PROPULSION

Summary and Conclusions

- Low levels of subsea automation have led to inefficiency
  - Predictive models largely uncalibrated
  - Excess flow, fatigue, corrosion safety margins
  - ➔ Increased cost, reduced reliability
- Automation key to driving down subsea costs
- Advances in wireless & battery technology enables step reduction in subsea automation costs
- *Subsea Internet of Things* moves analytics to the edge
- *Subsea Cloud Computing* leaves data at the seabed
- The prize: step reduction in CAPEX and OPEX

Wireless SCADA Network

Thank you

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