Extending communications and navigation to the most challenging environments using Seatooth

- ExtremeEdge IoT and Cloud Computing

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Military Diver Capabilities – UDT, Glasgow
27th June 2018

Abstract

Conventional diver communications and location systems are based on acoustic technology. The technology provides excellent medium range communications. Compact sonar systems provide effective location solutions. But acoustic technology is challenged by complex waters with high turbidity, thermoclines, biofouling and background noise. Acoustic systems can be readily detected.

Seatooth is radio based technology that provides secure, persistent communications in the most challenging environments. Developed with support from the UK MoD, Seatooth technology complements acoustic systems extending the operating envelope and offering new operating scenarios.

This paper provides an insight into Seatooth technology, its applications in the Ocean Industries and Defense and a summary of trials undertaken in November 17 at a SOCOM TE event in Key West.

Agenda

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- Technical challenges:
  - Extend Comms and Navigation to ExtremeEdge: underwater and underground
  - Persistent, covert, low cost
- Key advances
- ExtremeEdge IoT and Cloud Computing
- Underpinning Technologies
- Products and solutions
- Applications
- Summary and conclusions
- Backup

Seatooth wPAN – Wireless Jetboots Control

Seatooth Video – Total, Laggan Tormore, 800m

Technical Challenge

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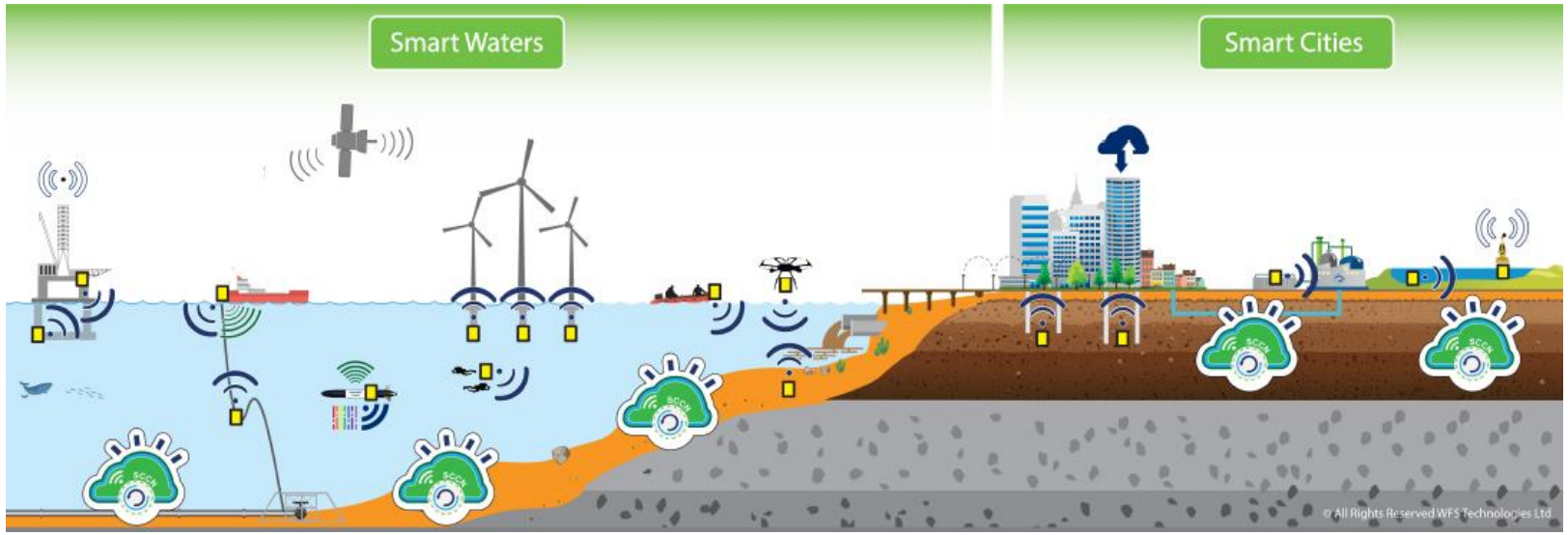
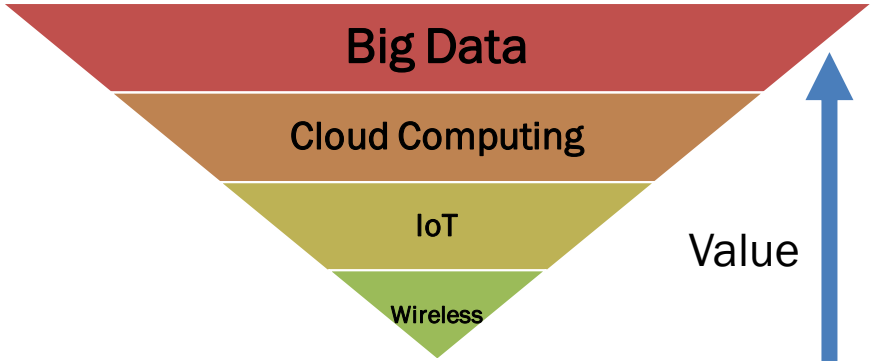
- **Big Data** and low cost location are disrupting society
  - Collapse in cost of processors has led to collapse in the cost of data and location information
  - Low cost wireless technology is the enabler of IoT and Cloud Computing: Bluetooth, Wi-Fi, 3/4/5G, GPS….

    ➔ Improved productivity, safety & flexibility, reduced costs, new business models, new CONOPs
- Conventional wireless stops at the water/air and ground/air boundaries
- **Technical Challenge**: Extend Big Data & Location to underwater and underground environments



Extending Big Data to the ExtremeEdge



Wireless: the Enabling Technology

Key Advances at WFS

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- 250 man-year R&D program into low frequency radio & associated technologies
  - Seatooth/Terratooth: Efficient, covert, persistent wireless comms through water, ground, solids, metal
  - Seatooth Hybrid: Integrated Seatooth radios, acoustic, FSO (optical)
  - Seatooth Endure: Ultra-low power, Seatooth radio technology – 30 year battery life
  - Seatooth Navigation: Ultra low power, low cost, covert, GPS independent location
  - Seatooth Connect: Wireless data+power for AUV docking
  - Subsea/Underground Internet of Things: Bandwidth & power constrained wireless networks, Edge analytics
  - Subsea/Underground Cloud Computing: Data permanently at the edge
    Distributed and hybrid Cloud computing
    AI/ML at the edge
    Wide area 'Subsea GPS' location networks
    Database synchronisation using AUVs
    Hot-swap, connector-less devices
    Digital Ledger (Blockchain) to manage asset data
- >300 patents filed

ExtremeEdge IoT and Cloud Computing

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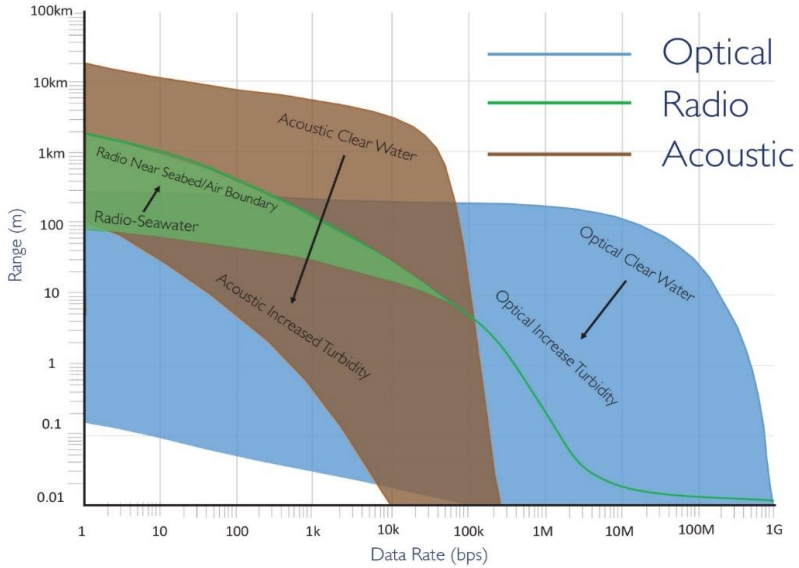
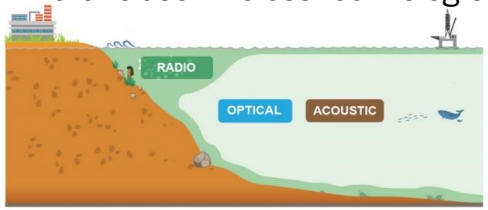
- Conventional wireless stops at air/water and air/ground boundaries
- Recent advances extend C4ISR & Location to ExtremeEdge
  - Subsea/Underground Internet of Things (SIoT/UIoT)
  - Subsea/Underground Cloud Computing
  - Subsea/Underground Navigation

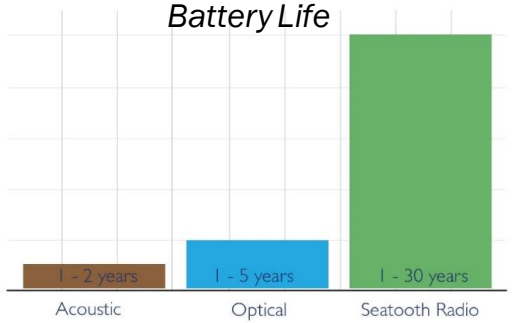
Range/Bandwidth in Seawater



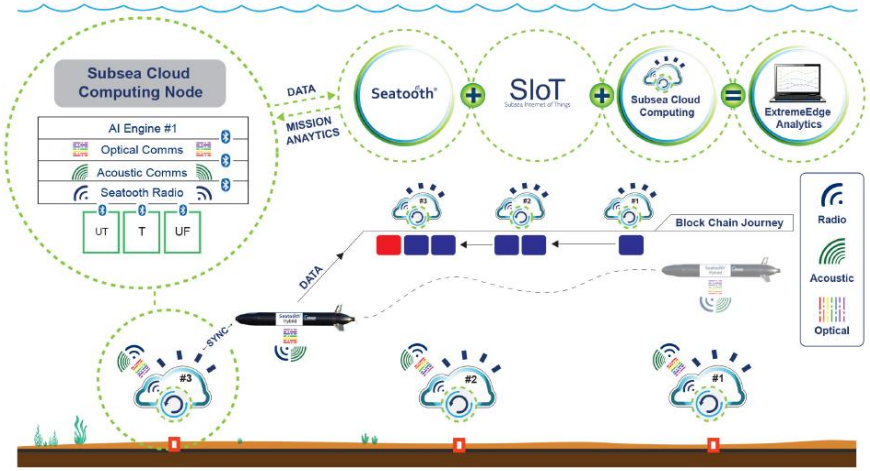
Where to use wireless technologies



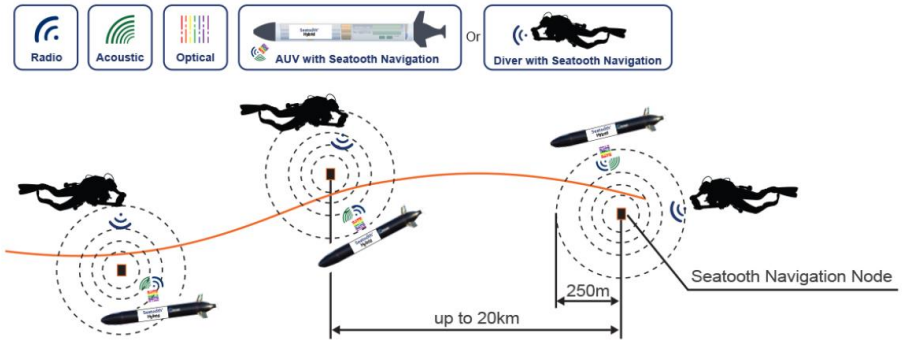
Battery Life



Subsea Wireless come of Age – the future is Hybrid



ExtremeEdge Cloud Computing - Underwater



Seatooth Navigation – Persistent, Covert, GPS-independent location

ExtremeEdge Applications

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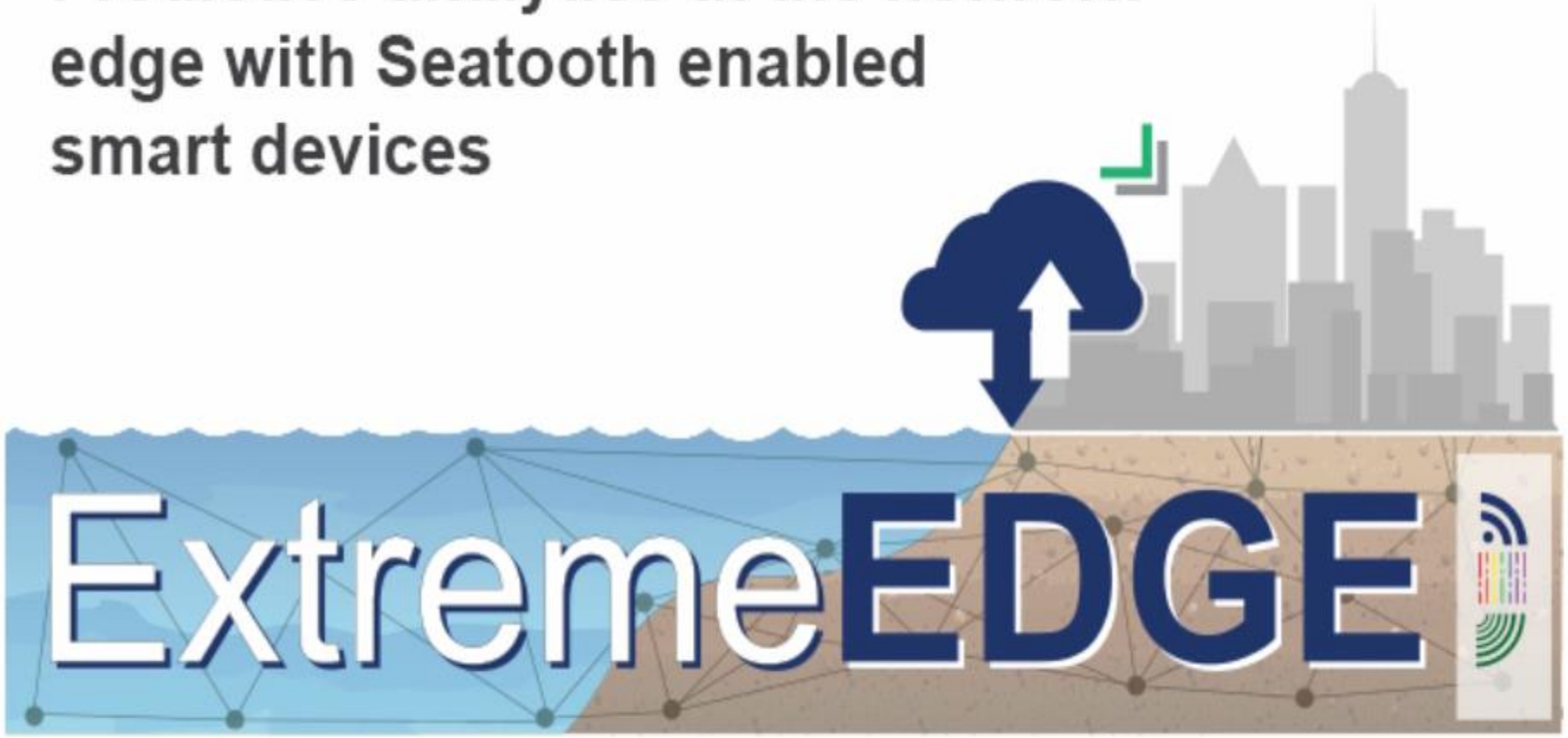
- Ocean Industries
  - Oil & Gas
  - Subsea mining
  - Alternative energy: wind/wave/tidal
  - Environmental monitoring
  - Submarine telecoms
  - Aquaculture
  - Fishing
- Applications
  - Production optimisation
  - Asset integrity automation
  - Infrastructure monitoring & protection
  - Environmental footprint monitoring
  - Construction, maintenance, repairs

- Defense
  - Covert, comms and location
  - Resilient to turbidity, buried, biofouling, bubbles
  - Wireless through-boundary comms
    - Water-air
    - Water-seabed
    - Air-ground
  - Up to 30 years between battery swaps
- Applications
  - Covert diver communications
  - Covert wireless Personal Area Networks (wPAN)
  - Diver health monitoring
  - Diver training solutions
  - Critical infrastructure protection
  - Asset integrity automation
  - Wide area sensor & navigation networks
  - AUV comms, navigation, docking

Predictive analytics at the network edge with Seatooth enabled smart devices



Subsea Cloud Computing Networks

TE 18-1, Key West, Nov 17

- Demo 1: Diver-Diver Comms

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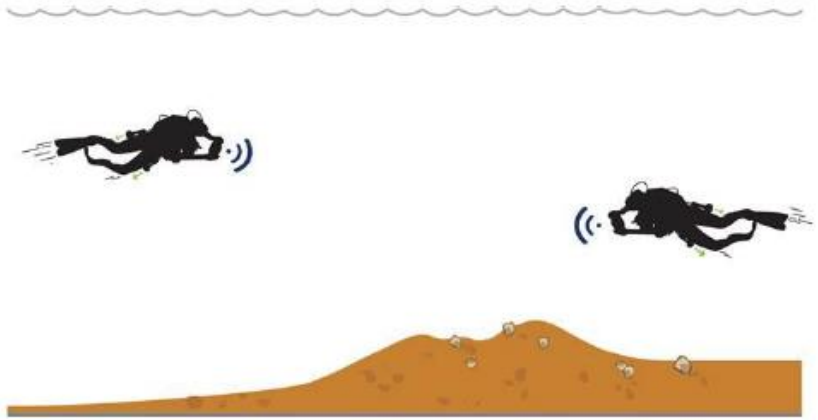
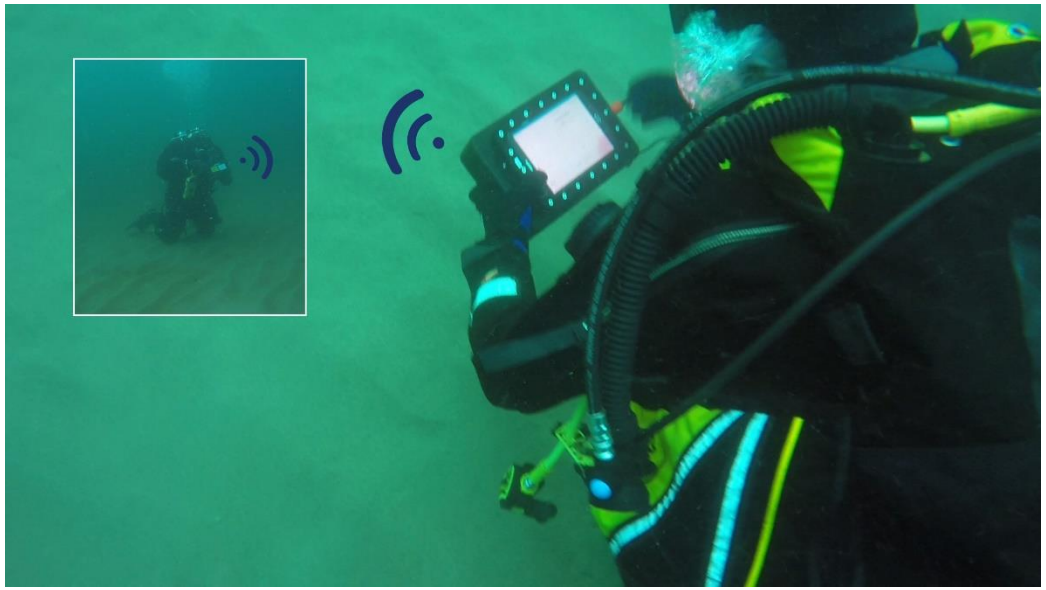
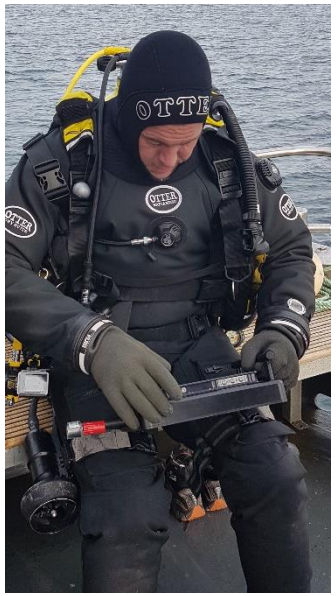
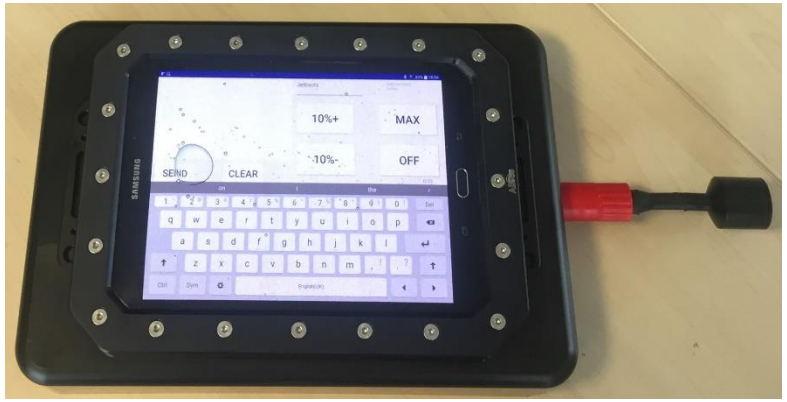
- Diver-diver text comms using Seatooth SWiCOM
- Range up to 10m
- Pre-configured messages and free text





Seatoot SWiCOM Diver-Diver Text Comms





TE 18-1, Key West, Nov 17
- Demo 2: Sensor Exfil

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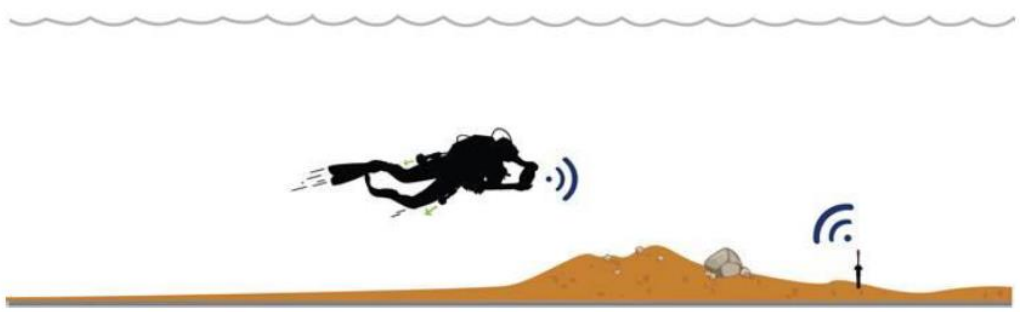
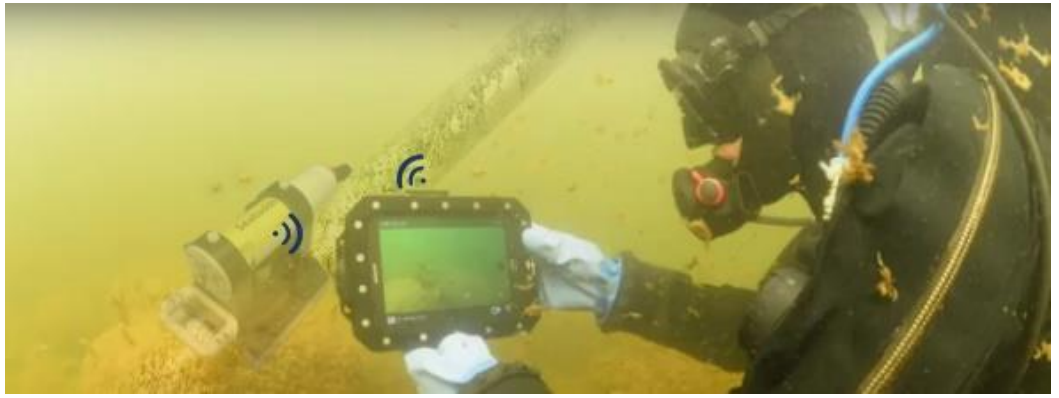
- Diver with Seatooth SWiCOM
- Remote sensor – Seatooth PipeLogger
- Data harvested when within 5m
- Notes
  - Remote sensor up to 30 year operating life
  - Immune to burial, biofouling



Seatooth PipeLogger



Sensor Exfil

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- Demo 3:Wireless Jetboots Control

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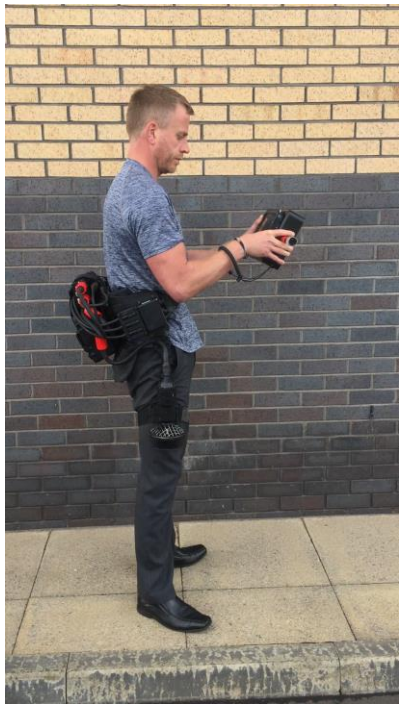
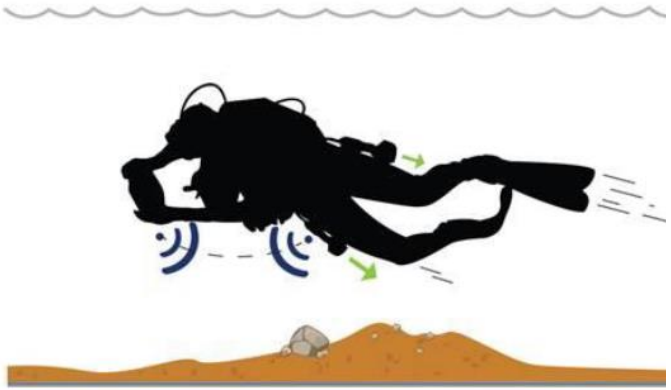
- Seatooth SWiCOm used as wPAN for propulsion control
- Joint demonstration with Patriot3

Seatooth Jetboots





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- Demo 4: Diver Core Body Temperature Monitoring

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- Seatooth Eers is industrial earpiece with integrated temp sensor and water pressure compensation
- Core body temperature monitored
- Local data storage, correction and analytics
- Seatooth SWiCOM provided User interface
- Data harvested when within 5m

Seatooth Eers

Seatooth wPAN

Other diver health monitoring issues

- Immersion pulmonary oedema (IPE)
- Arterial gas embolism (AGE)
- Gas toxicity/hypoxia

Seatooth SWiCOM

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- Demo 5: Mission Control and Reachback using UAV

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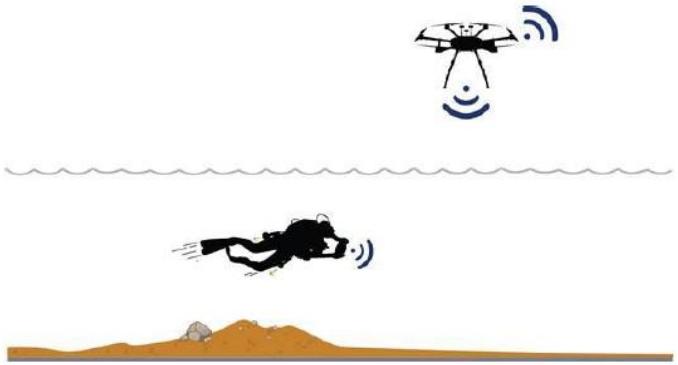
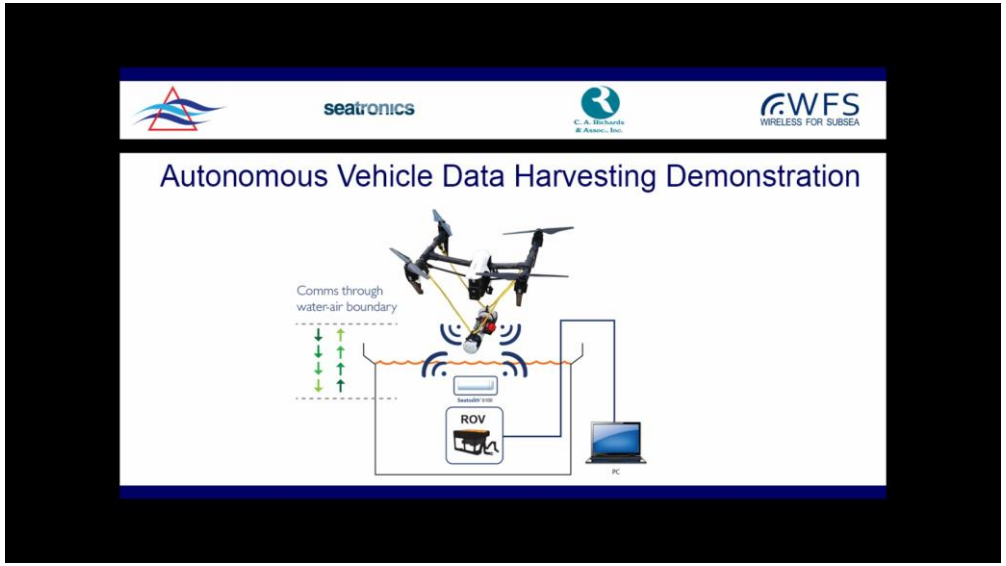
- UAV-to-diver/AUV/sensor comms
- Demo cancelled due to presence of helicopters
- Previous similar demos
  - HPT08, Kiel, Germany BAE Talisman AUV
  - Houston Feb 17, DJI drone/ROV



UAV-AUV 2-way Comms, HPT 08



UAV-AUV 2-way Comms, Houtson Feb 17

TE 18-1, Key West, Nov 17

- Demo 6: Remote Sensor Data Exfil using AUV

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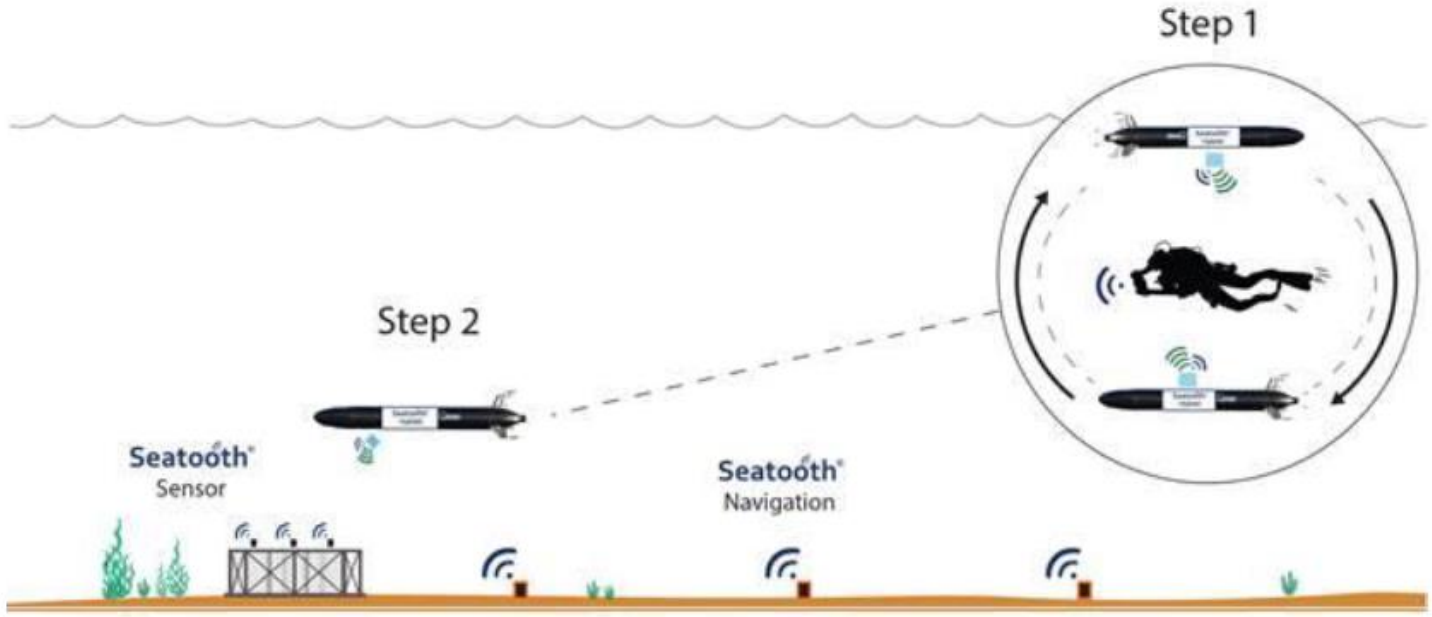
- Seatooth integrated with Riptide AUV
- AUV sent on mission to recover data from remote sensor
- Data provided to diver using Seatooth SWiCOM



Seatooth enabled AUV

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- Feedback and Next Steps

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- Feedback
  - Seatooth system provides reliable comms in water and through water-air
  - Seatooth SWiCOM
    - Good text range
    - System too large
    - Touch-screen problematic
  - Seatooth Jetboots
    - Full system too bulky
    - Interference from motors limits performance
  - Seatooth AUV
    - Interference from motors limits performance

- Next steps
  - Seatooth SWiCOM
    - Investigating marinized smart phones with external buttons to improve User Interface
  - Seatooth AUV/Jetboots
    - Developing ultra-low EMI motor drive for integration with motorised systems to optimise comms/navigation range and performance

Summary and conclusions

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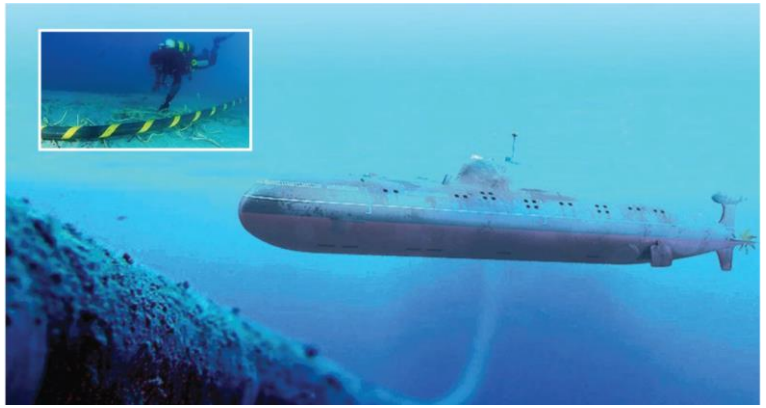
- Conventional wireless comms/location stops at water/air and air/ground boundaries
- Conventional subsea acoustic comms/location systems challenged by environmental conditions and battery life and not covert
- Innovations at WFS extend comms/location seamlessly through the water/air and air/ground boundaries
- Seatooth SIoT & SCCN systems are covert, persistent, resilient
- Oil & Gas is early adopter of SIoT to increase production, reduce costs and increase safety
- SIoT & SCCN are game-changer for Defense & security
  - Diver comms, location, health monitoring
  - AUV comms, location, monitoring
  - Critical infrastructure monitoring & protection

Diver comms, location, health



Critical Infrastructure Protection

Thank You

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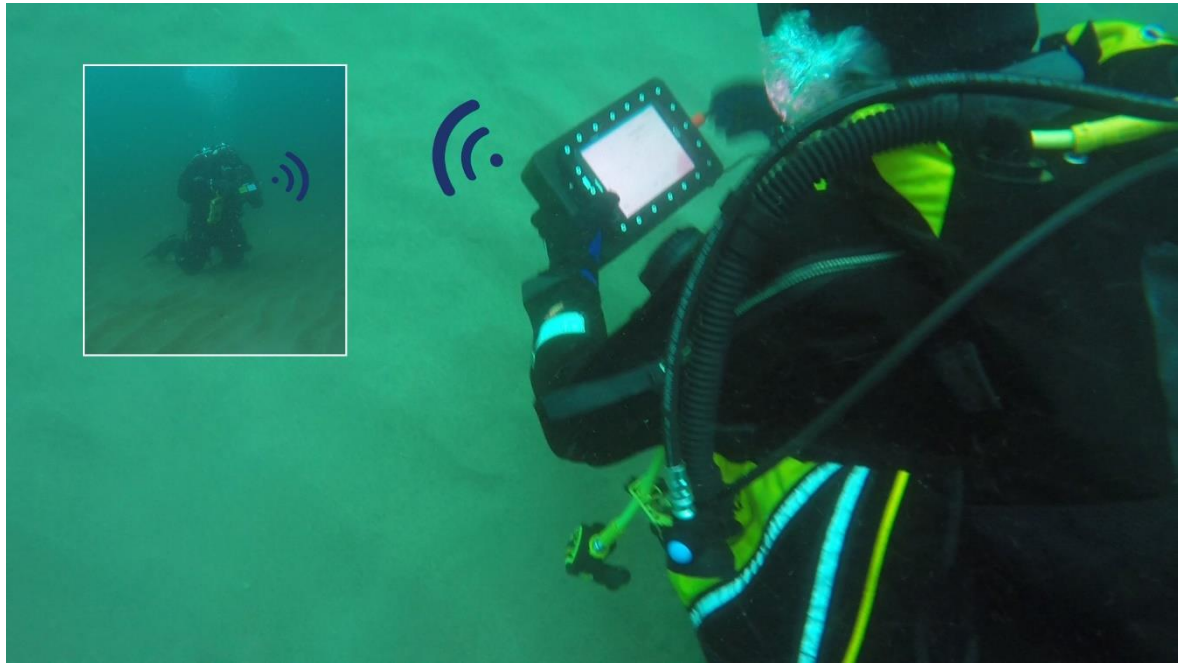

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Backup

ExtremeEdge Products and solutions

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Seatooth PipeLogger Mk2
Non-penetrating temp controller
Process and seawater temp
Temp: 0-100DegC +/- 2DegC
Battery: up to 30 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 30 years

Seatooth PipeLogger-UT
Retrofit FMD/
corrosion monitor
Wall Thickness: <250mm
UT Accuracy: 0.1mm
Up to 8 UT sensors
Battery: up to 30 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 30 years

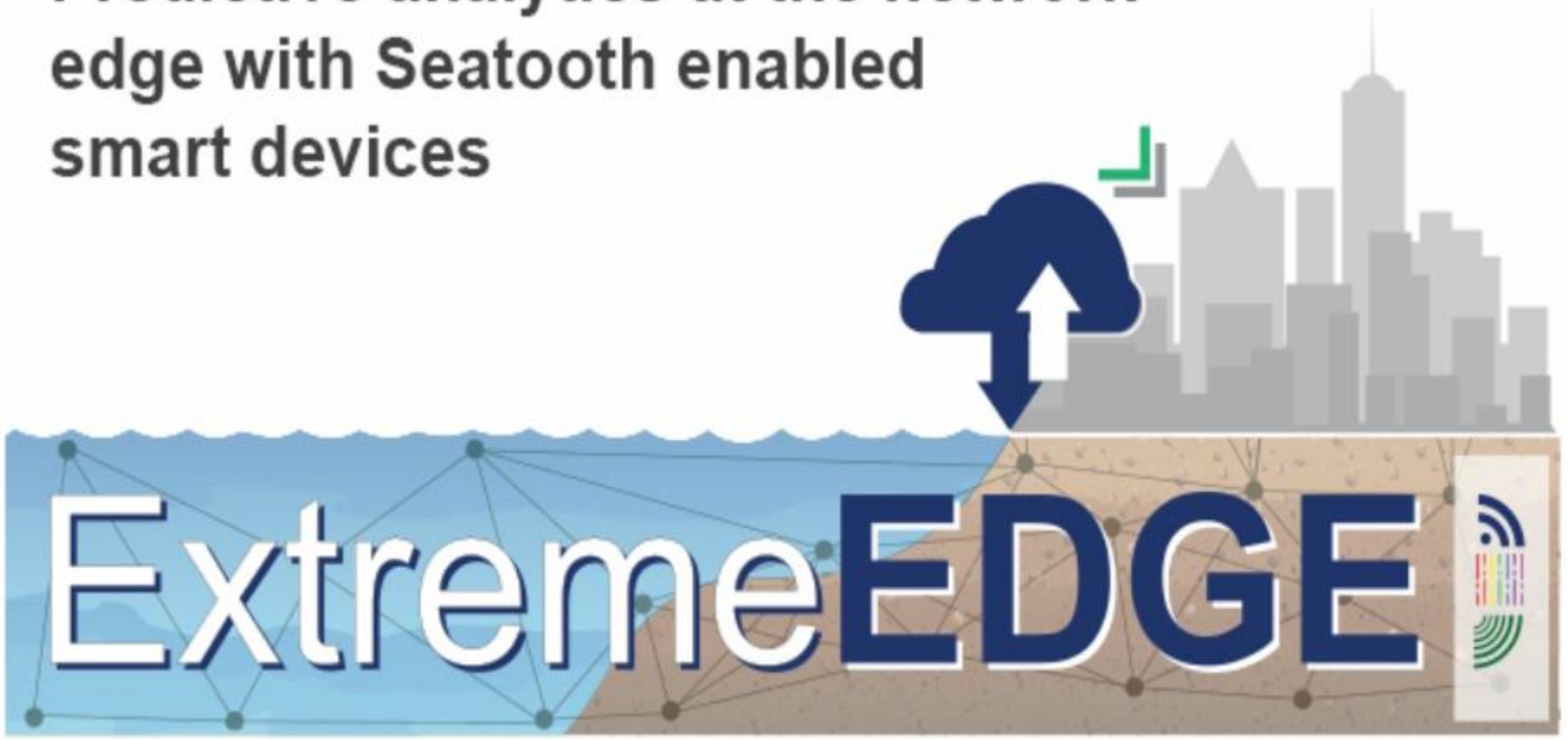
Seatooth CTFM
Fatigue management
Real time & cumulative

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; 2 yr standby
Seawater Range: 5m

Seatooth Eers (Prototype)
Diver core body temperature
monitoring
Seawater range: 3-5m
Battery: 16 hrs;

Predictive analytics at the network edge with Seatooth enabled smart devices



Platform Online Monitoring

Leadership Team

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- Brendan Hyland, Founder, Chairman
  - Sectors: O&G, Defence, Consumer, Environmental
  - Location: Edinburgh

- Paul Tooms, Advisory Board, London
  - Former Chief Engineer, BP
  - Location: London

- Jarett Carson, Advisory Board, Boston
  - Venture Capital/Private Equity
  - Chemical Engineer
  - Location: Boston

- Dr Terry Mah, Advisory Board, Boston
  - Former CEO Veolia N Ameria
  - Environmental Engineer
  - Location: Chicago

- Dr Grant Maclean, CTO
  - Former HP, Raytheon, Netthings,
  - Location: Edinburgh

- Chris Curran, Project Director Americas
  - Former BP Subsea Controls,
  - Chair API 17F (Subsea Controls)
  - Location: Houston

- Peter Sharpe, Defence Consultant, London
  - Former AWE, General Dynamics, MoD Chief of Staff
  - Location: London

- Rob Soni, Advisory Board, Boston
  - Former Partner, Matrix Partners, Bessemer Partners
  - Location: Boston

Selected WFS Customers and Deployments

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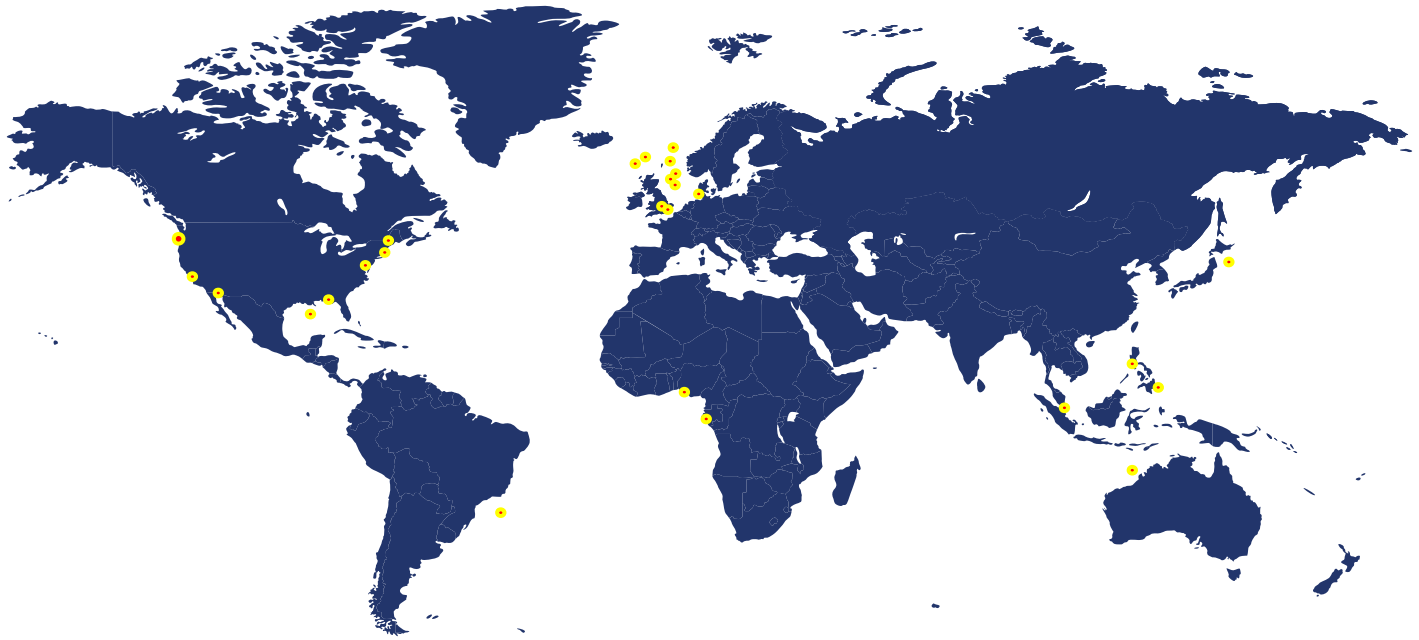

DRDC RDDC · DSO · SAIC · [dstl] · THALES · GD · BAE SYSTEMS INSPIRED WORK · BAAINBw · SAAB · ISE International Submarine Engineering Ltd. Group of Companies · LOCKHEED MARTIN · subsea 7 · TechnipFMC · i-Tech7 · FUGRO · OCEANEERING · imagination at work · ECOSSE Subsea Systems · Environment Agency · AkerSolutions · Chevron · PETROBRAS · woodside · TOTAL · REPSOL YPF · TALISMAN ENERGY · Quadrant Energy · Shell · Apache · bp · EnQuest · wavejet PROPULSION

Selected References

- *Oil & Gas/Asset Integrity*

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Date Installed	Operator/Field	Country	Solution	Sensor Make	Measured Parameter	Operational History
2013	Woodside, N Shelf	Australia	Packing valve video monitoring	Bowtech	Video	Used during IRM campaign
2014	EnQuest, Don Southwest	UK	Export line temperatue monitoring	RTD	Temperature	Deployed under concrete blanket
2014	Talisman/Repsol	UK	Flowline upheaval buckling monitoring	RTD	Temperature	20 systems supplied for deployment across UK assets
2015	Apache, John Brooks	Australia	Export line temperatue monitoring	RTD	Temperature	System installed Oct 15
2015	Petrobras, Santos Basin	Brazil	Coiled Tubing fatigue monitoring	Strainstall, Invensense	Strain, acceleration	10 x system deployments Aug - Dec 15
2015	Total, Laggan Tormore	UK	Video monitoring of construction	Bowtech	Video	Deployed 3 times furing 2015
2015	Taqa, N Cormorant	UK	Corrosion monitoring network		Voltage	Network of 14 nodes; commissioned 2H15
2015	JAMSTEC	Japan	Flow monitoring		Flow	Qualification trials completed 4Q16
2015	Shell, Malampaya	Philippines	Rock dumping monitoring	GE	Pressure	Deployed 2Q15
2016	DRDC	Canada	Submarine corrosion monitoring	Stork	Voltage, Current	Deployed Oct 16
2017	Quadrant Energy, John Brooks	Australia	Export line temperatue monitoring	RTD	Temperature	Deployed 1Q17
2017	BP/SD2,	Azerbijan	Pipeline Pre-commissioning automation	Yokogawa	Pressure, Temperature	Deployed 2H17
2017	YFP	Nigeria	Export line temperatue monitoring	RTD	Temperature	Deployed 1H17