

*Teledyne Oil & Gas*



# Subsea Pipeline Corrosion Monitoring – Generic Case Studies and Future Developments

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**TELEDYNE OIL & GAS**

# Content



Subsea Pipeline/Flowline Corrosion & Erosion Challenges

Monitoring Technologies: Selection & Differentiation

Case Studies

Future Sensor Technologies

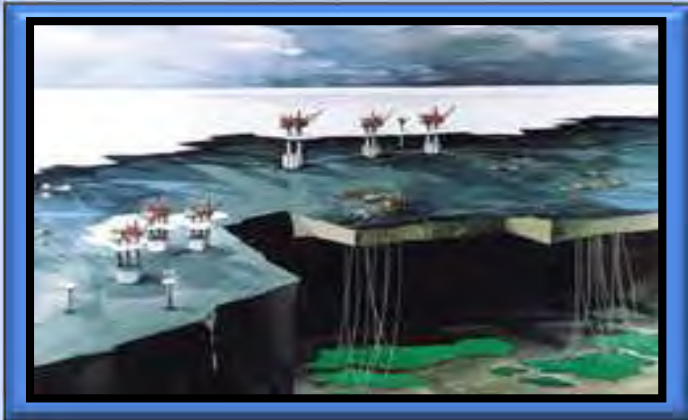


Affleck Corrosion Control System

	Tag	Corrosion (mpy)	Tag	Metal Loss (wt)	Tag	Temperature (°C)	Comments
Ring Pair 1 - Average	GL_121010E		GL_121014A		TL_12101		
Ring Pair 2 - Average	PL_121009P		GL_121024A		TL_12102		
Tipside Probe	GL_121098B		GL_121056A		TL_12105		
Master Control (M.C.)							
Monitor Control (M.C.)							



# Oil & Gas Industry Trends



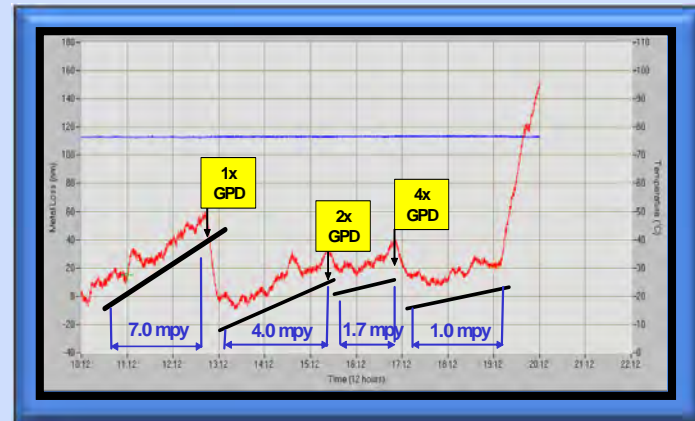
*Deep Water / Long Step Out*



*Natural Gas*



*Subsea Processing*



*Complex Data Management*

***Greater integrity monitoring challenges***

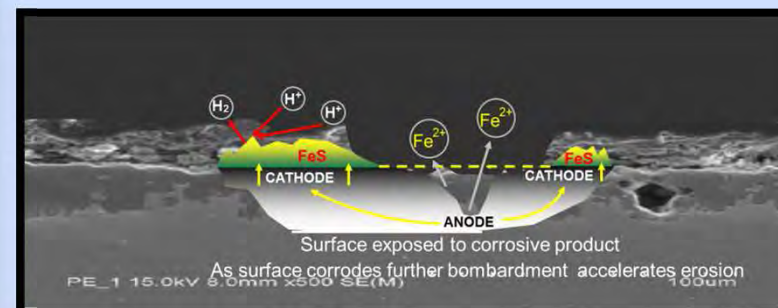
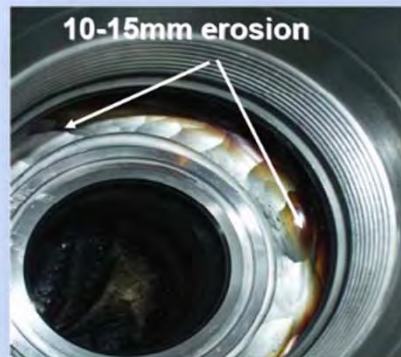
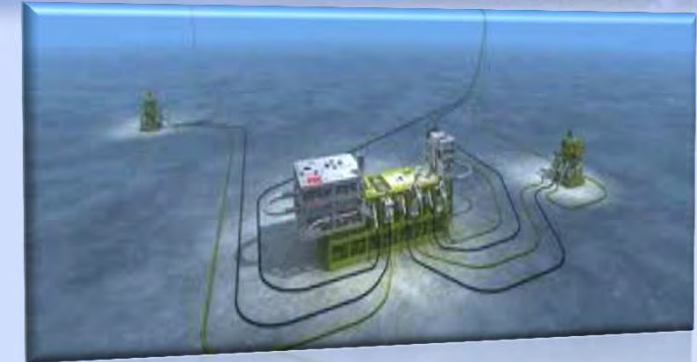
# Corrosion, Sand Production & Erosion: Major Industry Challenges

Failure to control leads to major consequences

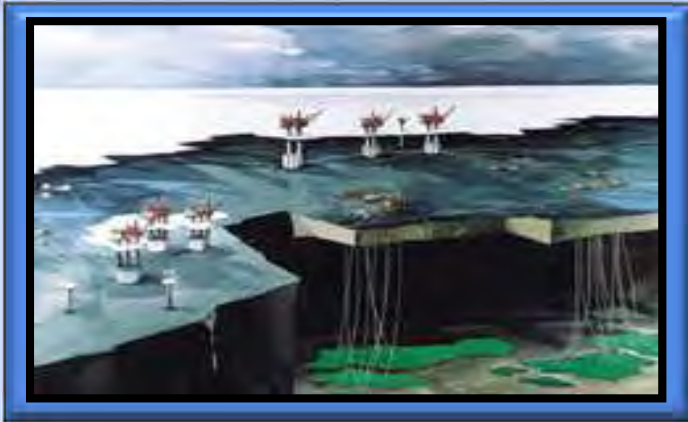
Cost of managing corrosion

Sand erosion

Sand accumulation – flow assurance



# Asset Integrity / Production Challenges



*HP/HT, Deep Water / Long Step-out*



*Maximise Wellhead Performance*

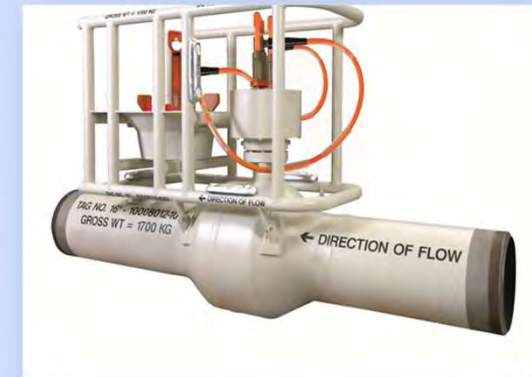
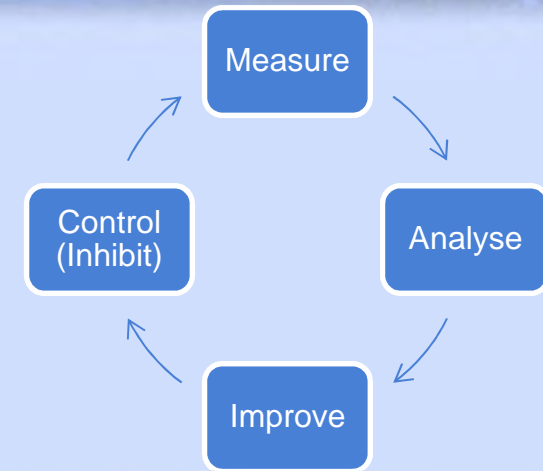
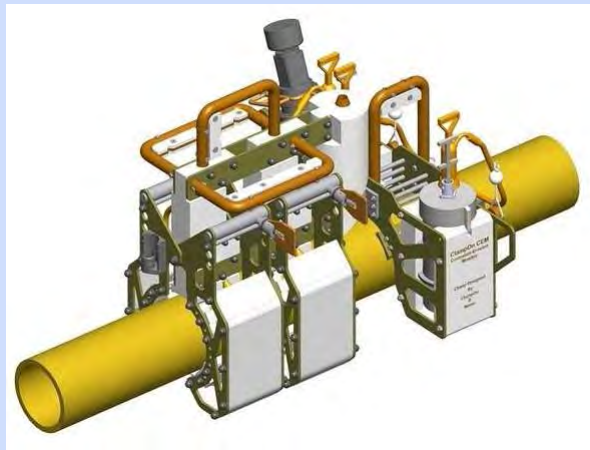


*Flow Assurance: Waxes/Hydrates*



*Subsea Leaks*

# Complementary Corrosion/Erosion Monitoring Technologies



***Inspection vs. real-time monitoring***

# Benefits of Monitoring Corrosion & Erosion

Reduce Operational Risk

Reduce CapEx

- Reduce requirement for CRA Cladding

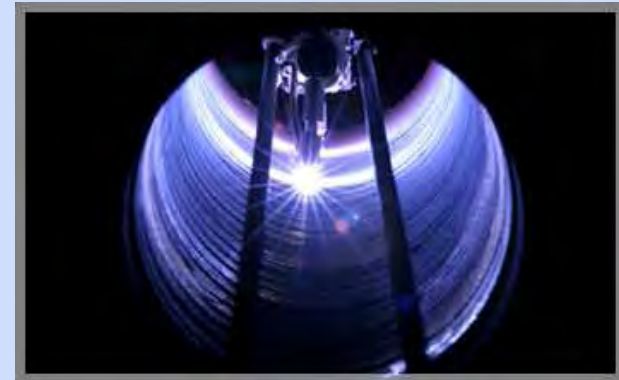
Reduce OpEx

- Inhibitor optimisation
- Reduce frequency of intelligent pigging
- Reduce intervention costs

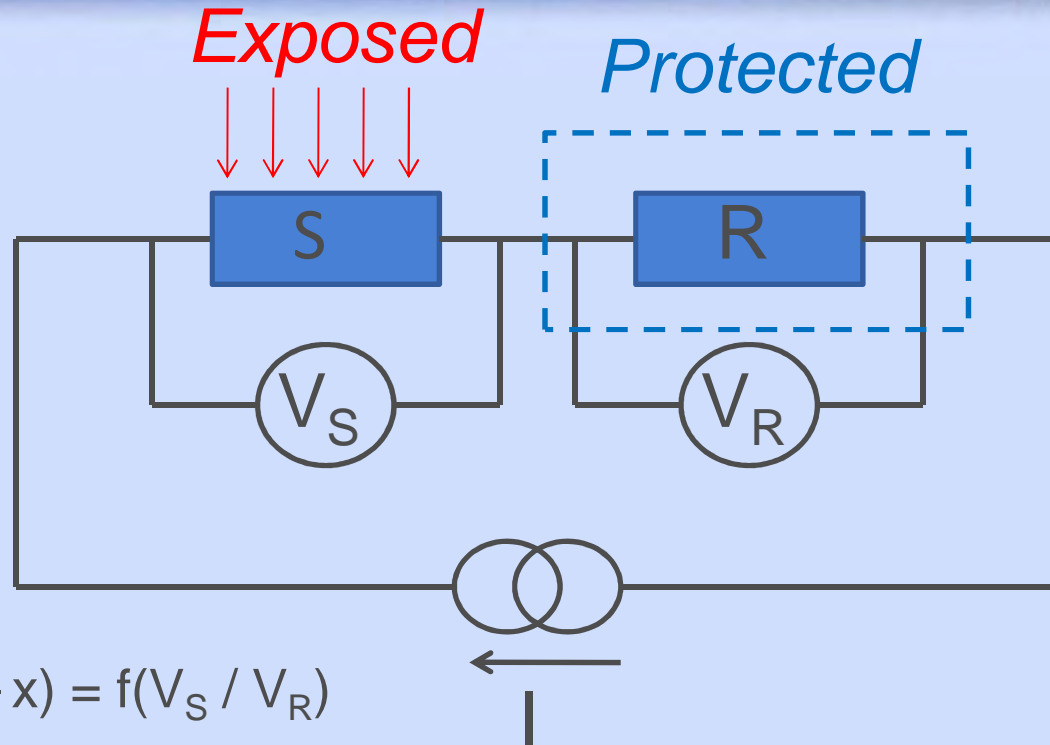
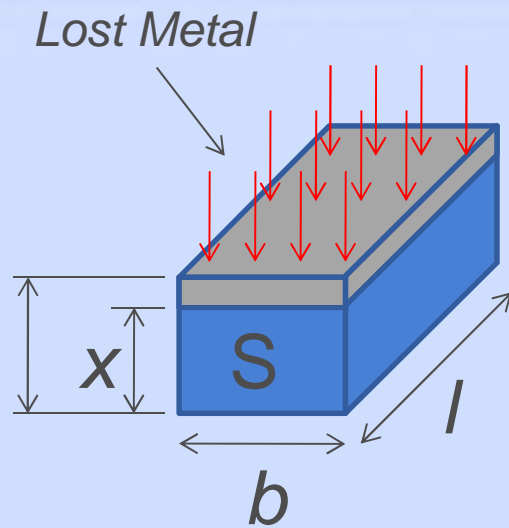
Extend Asset Life

- Ensure inhibitor is working correctly.
- Provide early feedback to enable timely corrective action

***An essential part of any Integrity Management Programme***



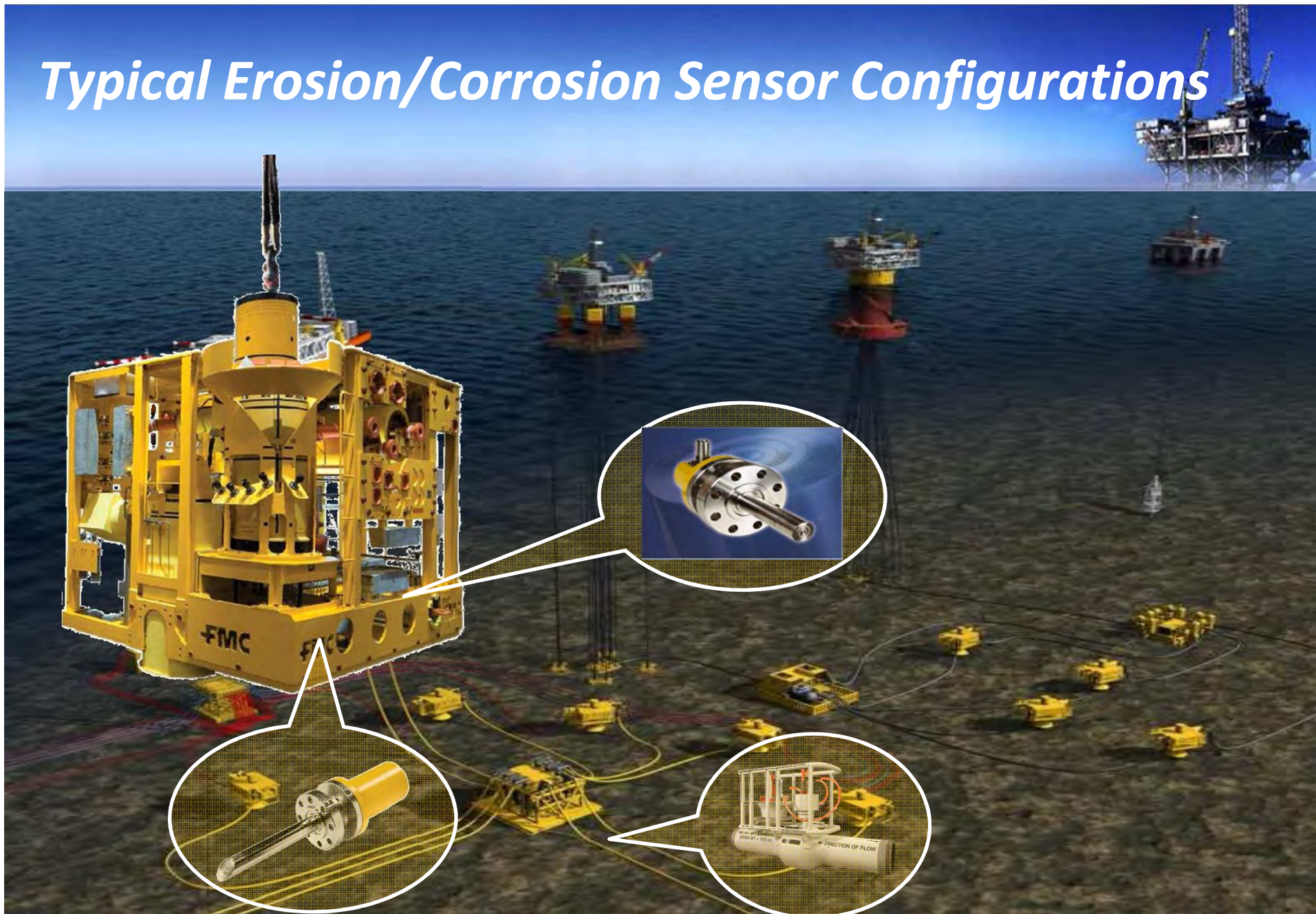
# ER Monitoring Technology



Cumulative Erosion  $(x_0 - x) = f(V_S / V_R)$   
Erosion rate =  $dx / dt$

- Resolution is critical
  - Rapid detection of corrosion events
  - Ability to select thicker element, thus longer sensor lifetime

# Typical Erosion/Corrosion Sensor Configurations

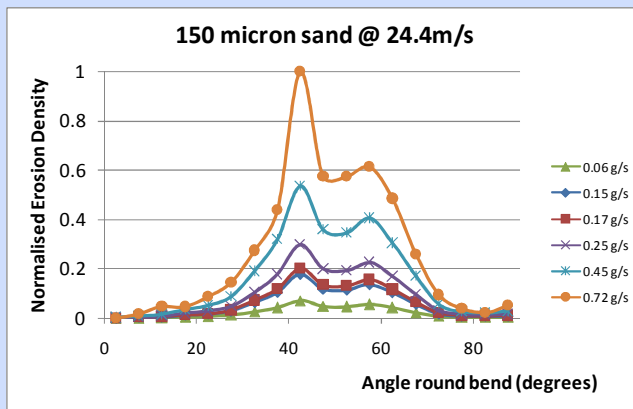
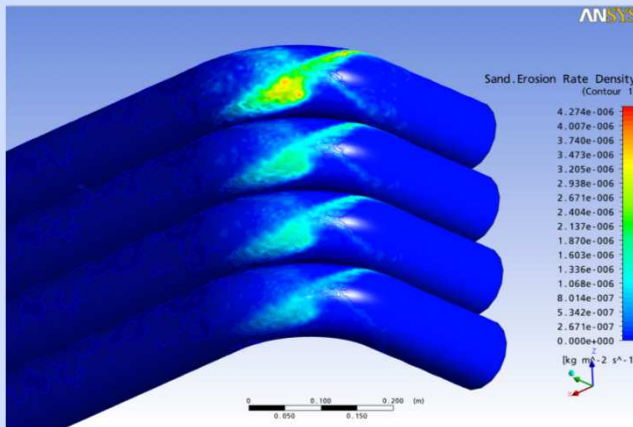


# Design Support/Engineering Services



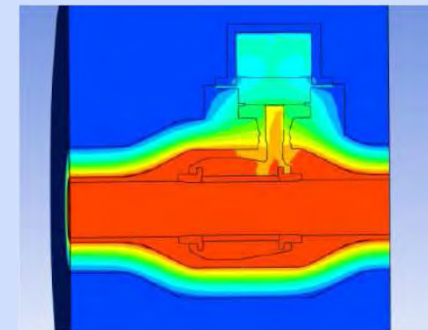
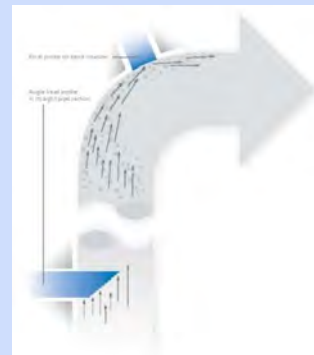
**Flow, Sand and Corrosion Modelling & Thermal Analysis Embedded Within Sensor Design.....For Performance Optimization.**

Increasing Sand Rate



## Multiphase CFD

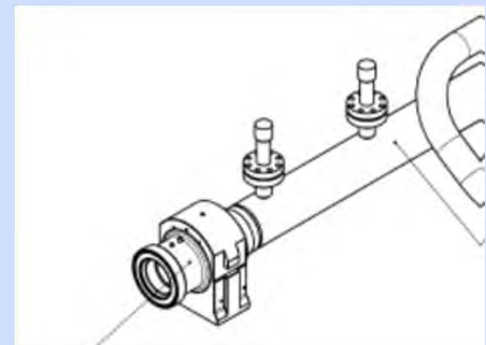
- Corrosion Optimisation
- Optimisation of sand detection systems
- Combined corrosion-erosion models
- Support during client FEED studies
- Thermal modelling



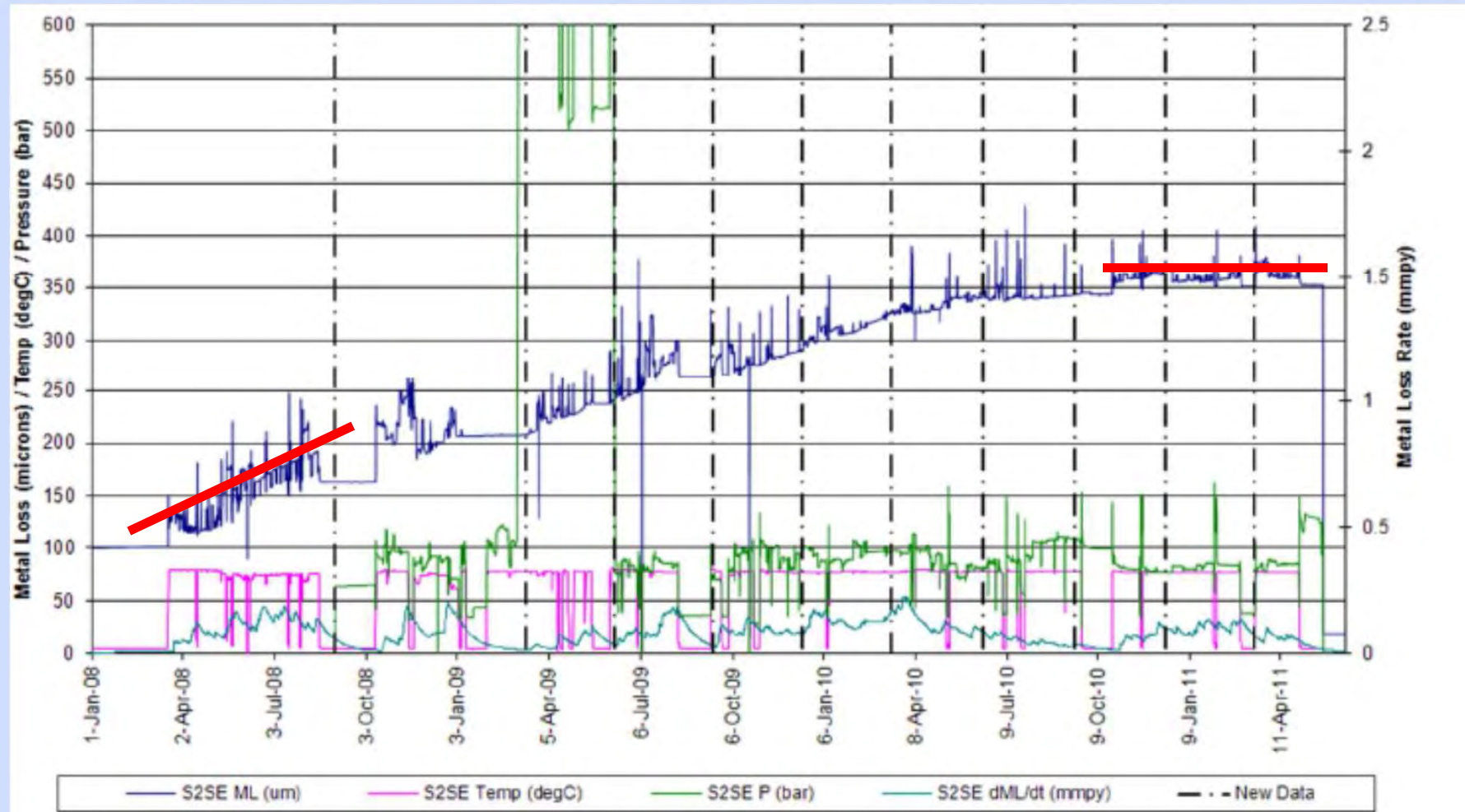
# Case Study: Corrosion Monitoring, Offshore West Africa



- ✦ Offshore oilfield, 1200m water depth, 9 manifolds
- ✦ One PTEC corrosion sensor installed on each manifold, downstream of inhibitor injection point
- ✦ Providing high-resolution, real-time metal loss & temperature data for the operator
  - Active inhibitor management
- ✦ Teledyne providing ongoing support for analysis – correlating with MPFM and injection data.
- ✦ Advising on effectiveness of Corrosion Program



# Typical Subsea Corrosion Probe Data



# Case Study: Top of Line Corrosion, Asia Pacific



Stratified flow / high temp

Dissolved CO<sub>2</sub> / H<sub>2</sub>S

Cold spots are **vulnerable**

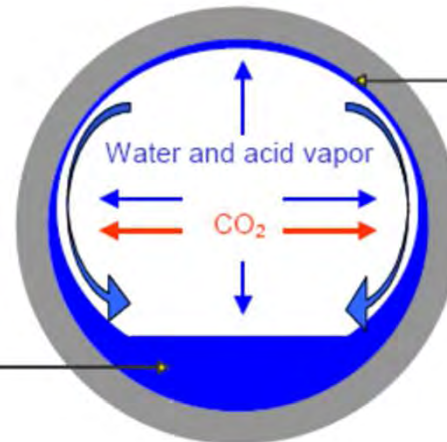
Organic **acids** (acetic, HCl)

BOL **protected** by inhibitor

Volatile **inhibitor**?!

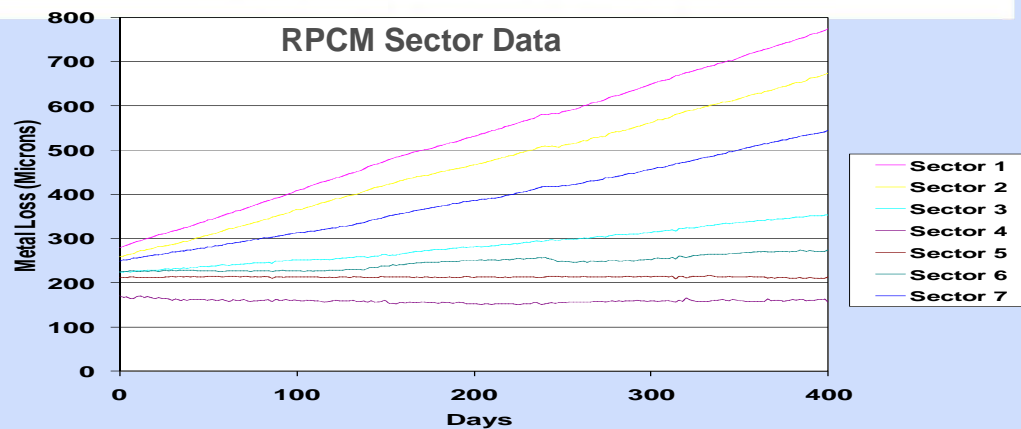
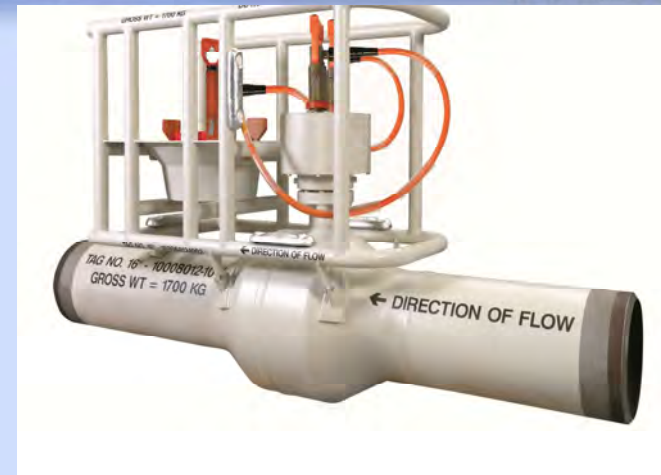
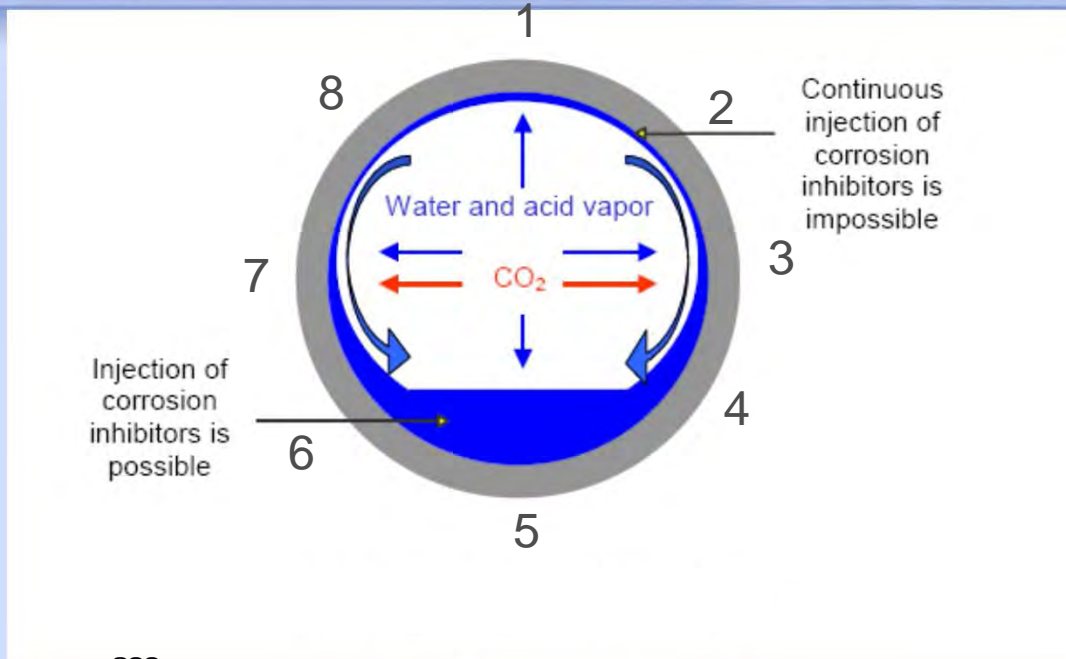
Dew-point and pressure

Injection of corrosion inhibitors is possible

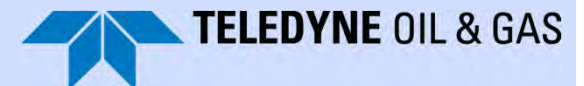


Continuous injection of corrosion inhibitors is impossible

# Case Study: Top of Line Corrosion, Asia Pacific



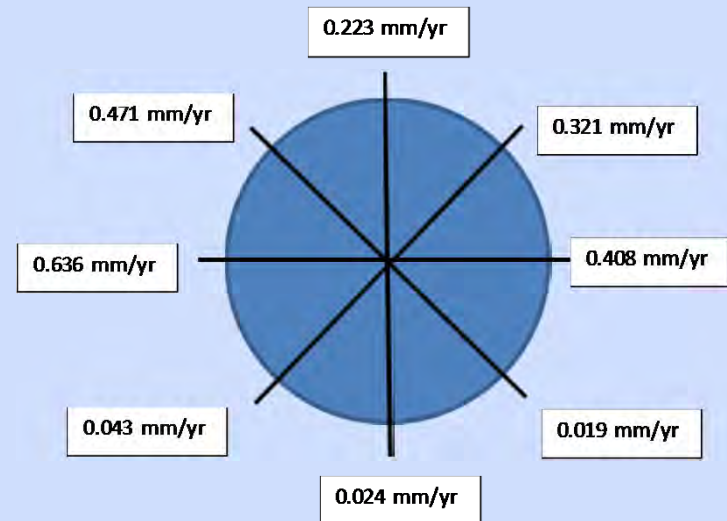
RPCM™ shows the type of corrosion occurring in real-time



# Case Study: Top of Line Corrosion, Asia Pacific



- ▶ RPCM installed subsea (100m water depth) in 2005
- ▶ RPCM revealed unexpected early life-of field pipeline corrosion
- ▶ Corrosion inhibitor regime changed – performance verified by RPCM
- ▶ Without RPCM it is possible that there could have been a loss of containment; certainly the lifetime of the asset has been extended as a result.
- ▶ RPCM gives operators the confidence to operate in highly corrosive fields



# Comments from the Field



**'the corrosion monitor paid for itself within days of operation when it detected increasing corrosion rates due to the inhibitor having been inadvertently switched off' – North Sea operator**



# Comments from the Field



**“to sanction the subsea carbon steel multiphase transportation pipeline the national petroleum directive required real-time subsea RPCM corrosion monitoring” Barents Sea operator**



# Comments from the Field



‘The advanced RPCM corrosion monitoring capability will enable 80km of 250mm diameter carbon steel pipe to be laid in water depths of around 2000m; if corrosion-resistant alloy steel were used, this would add some \$28M to the pipeline cost’ – BP Block 31 Offshore Angola



(April 2009 ‘Frontiers’)



# Case Study: Sand & Erosion Monitoring



- Passive Acoustic
  - Instantaneous response
  - No information about erosion
  - Sand rate?
- Electrical Resistance (PTEC™)
  - Invasive – flush or intrusive
  - Resolution is important!
  - Cumulative damage measurement
- Hybrid Sensor (SEPD™)

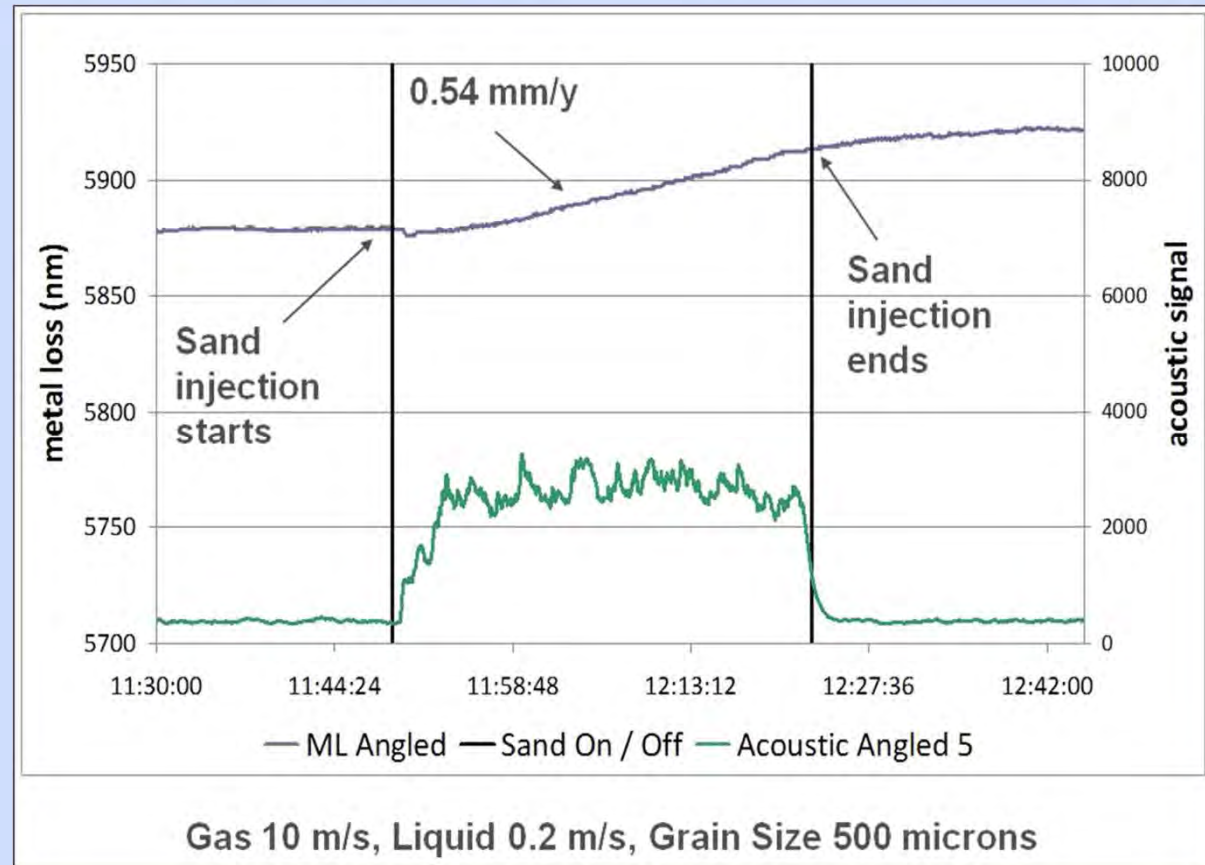


# Case Study: Sand & Erosion Monitoring

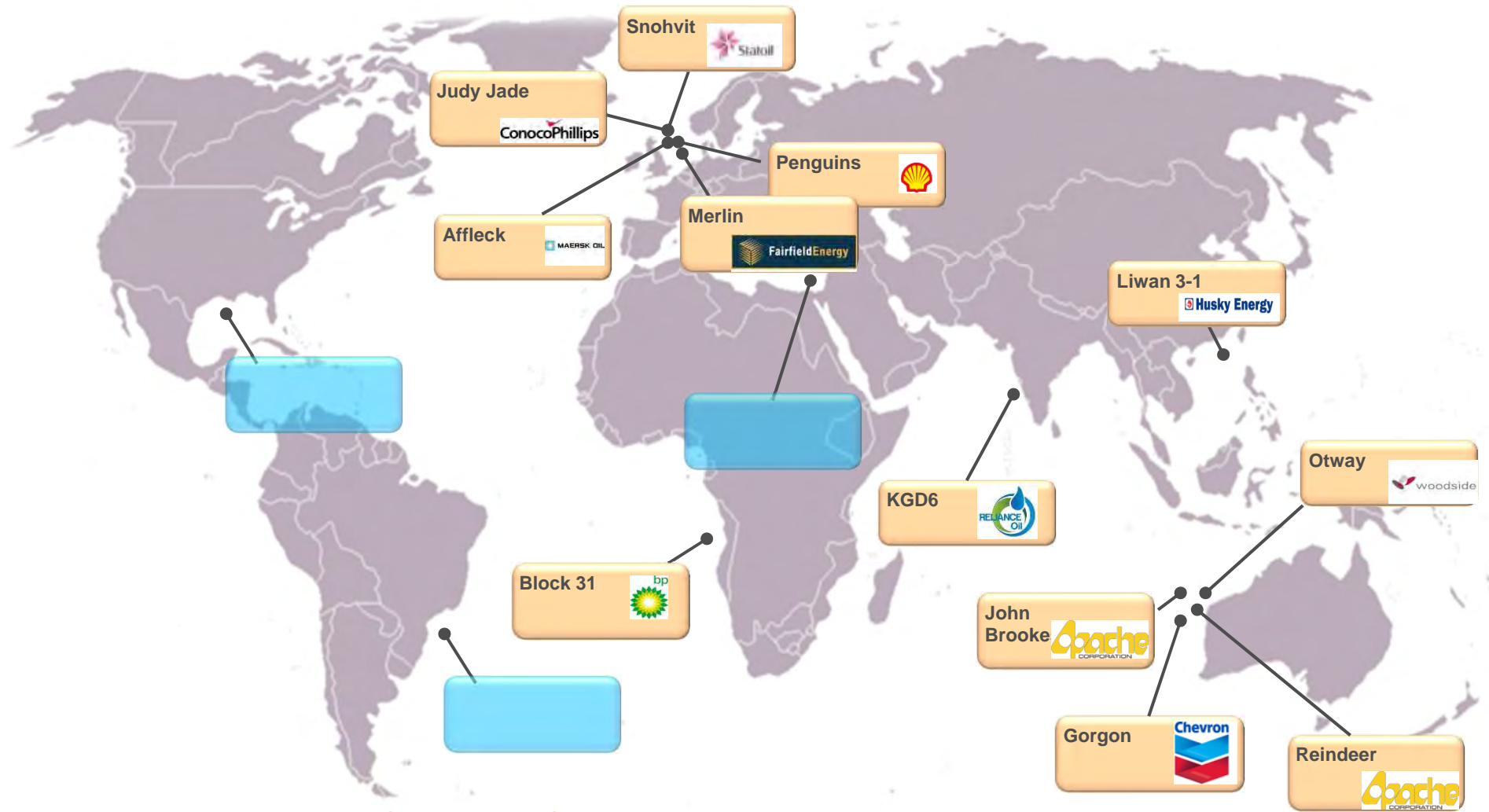
## Unrivalled Sensitivity and Speed of Response



- Dual independent technologies in one package
- Most rapid sand response
- Quantifies metal loss



# Some Existing RPCM Users



***Increasing trend towards continuous monitoring***

# *Future Sensor Technologies*



 **RPCM – platform for other flow assurance measurements**

 **‘Smart’ subsea facilities & trees**

 **Subsea Condition Monitoring & Data Management**




 **Broader pipeline/flowline integrity monitoring**

- Distributed & retrofit sensors
- Subsea leak detection

 **Alternative Sensor Technologies**

# *Summary*



-  **Minimise operational risk,**
-  **Maximise pipeline/asset lifetime,**
-  **Optimise production**