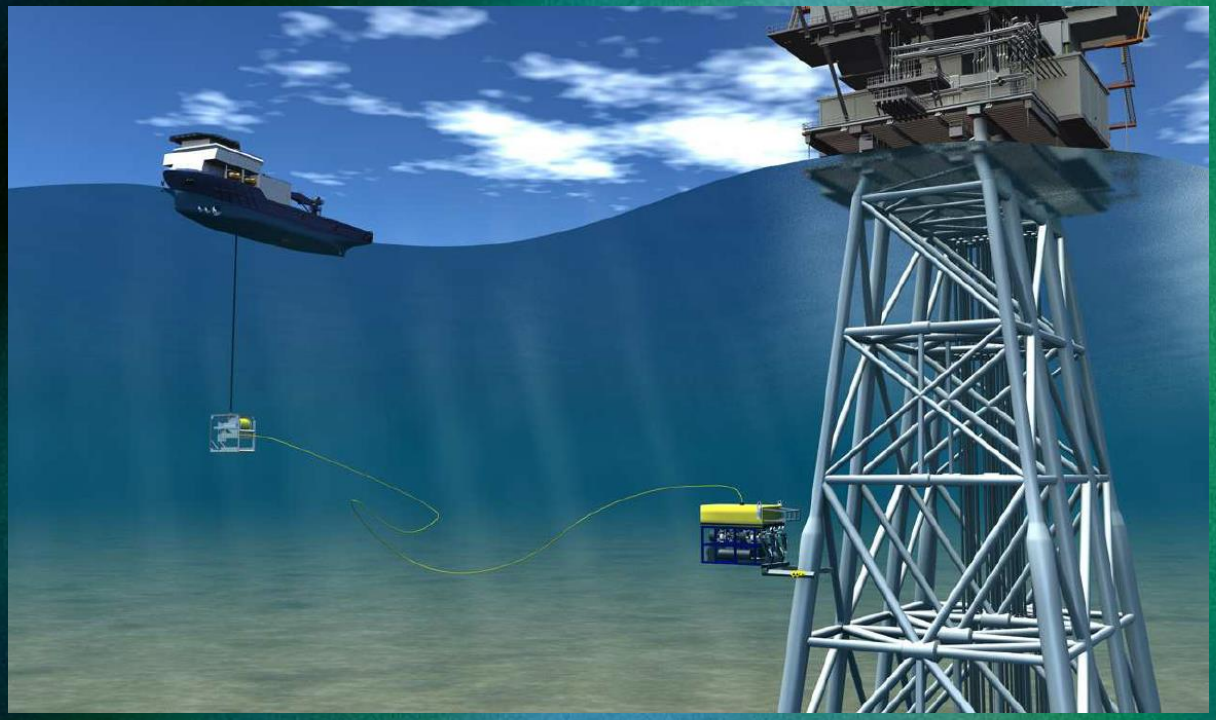
Wireless for Space and Extreme Environments Conference (WiSEE2018)

Oil and Gas Asset Integrity Management



John Nyholt

John Nyholt Consulting, LLC
BP NDE Inspection SME-Retired
API Subcommittee for Inspection and Mechanical Integrity
John.nyholt@SJCD.edu

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- Objectives:
  - **A brief review the Oil and Gas view of equipment integrity management and Non-Destructive Evaluation (NDE) technology**
  - **The types and roles of permanently installed NDE sensors**
  - **Existing and future wireless sensing technology applications**

Safety Moment: What Happened?

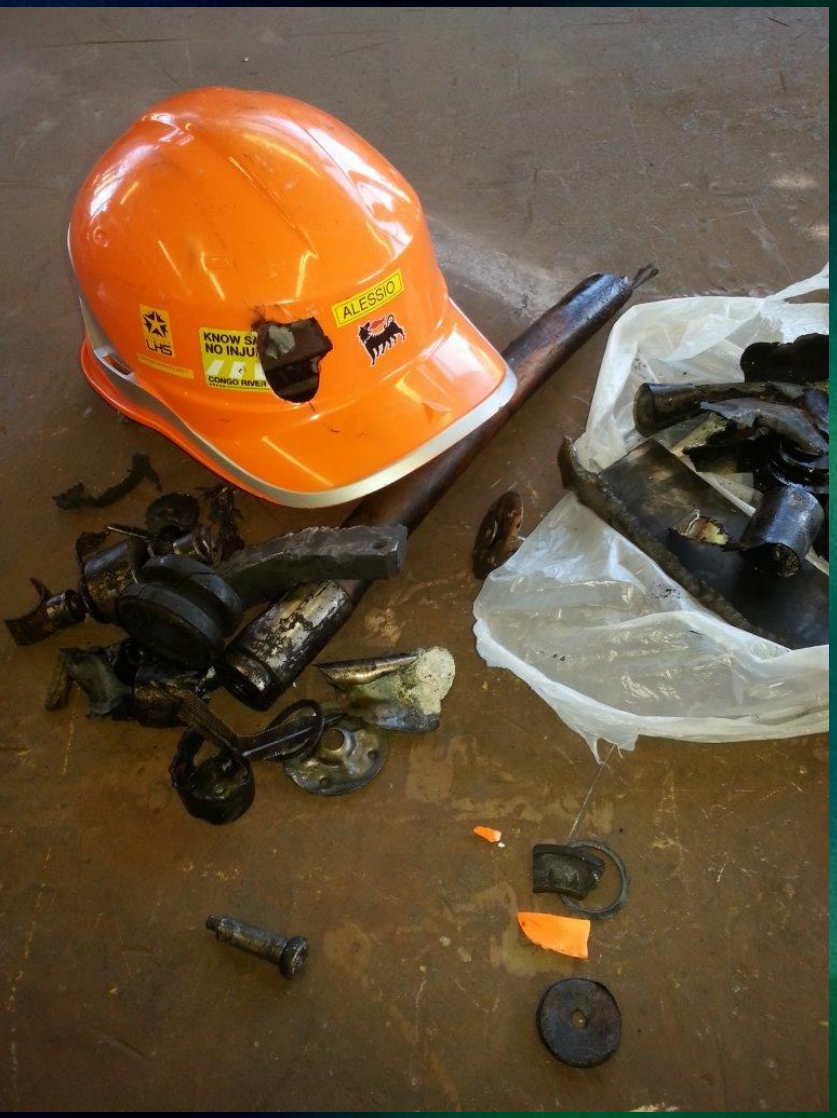
This is a picture shows an explosion of a wireless subsea permanently installed sensor system during its travel out for installation

A lithium battery pack supplying power to a Corrosion Erosion Monitor exploded on the ship deck

Significant damage to the surrounding steel work of the PLET (Pipe Line End Termination)

A number of individuals can be seen running from the scene

What Happened?



4 people required medical treatment with 1 IP requiring a number of stiches to the forehead as a result of flying debris.

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Emerging technology life cycle

- The end user decides what technologies are developed as well as their progress toward later life cycle stages
- The end user owns the risks and costs of operation
- End users come from a broad range of backgrounds; Inspection, Engineering, operations or management
- There are many new technology success stories, however the path to success can be difficult and the bar is higher than in the past (e.g. >$100 million)

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

O&G outlook on Emerging stage technologies:

- Un-proven technology for the field
- Boundary conditions for essential variables are not fully understood
- Test performance is frequently poor during the emerging stage
- Not yet adopted by codes, standards, or specifications
- Lack of qualified technicians to perform the application

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Emerging stage (cont.):

- High cost of service
  - R&D cost recovery
  - High equipment fees
  - Limited availability
  - High labor cost
  - Specialized technicians
  - T&E
  - HSE risks associated with non-routine personnel

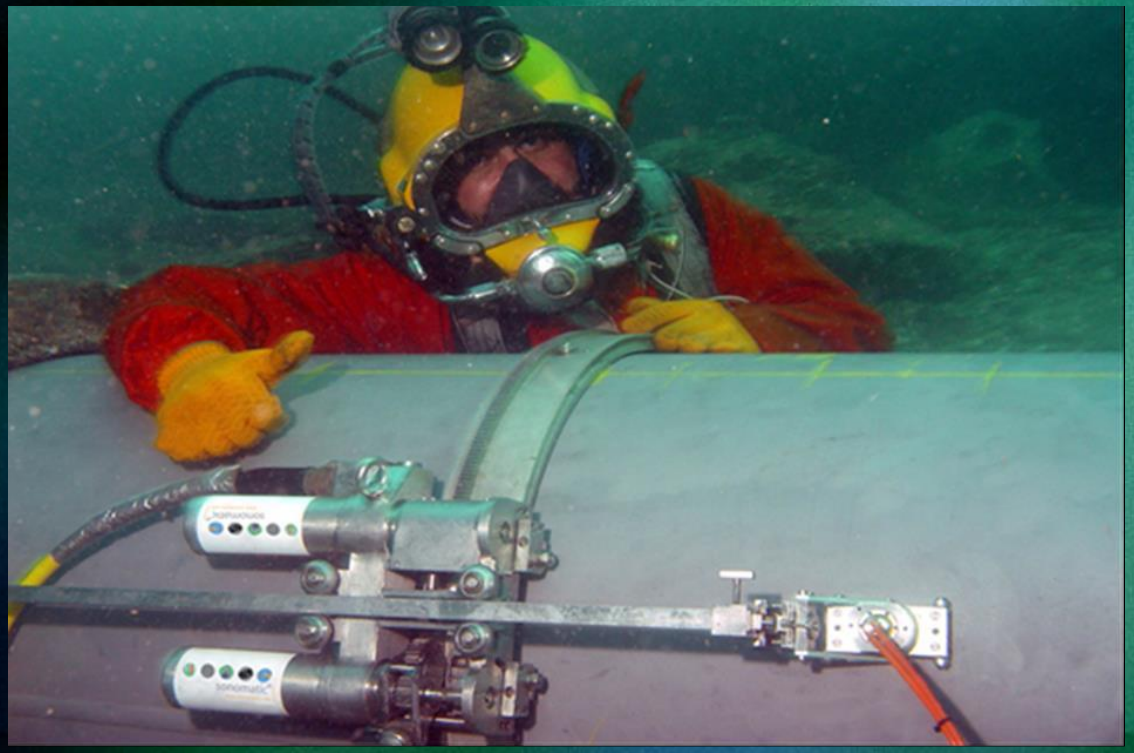
Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

It is possible for O&G emerging technologies to languish or die on the vine due to:

- High risk or cost aversion
- Poor understanding of the technology
- No one wants to be the first to use it
- An over-reliance on poor internal or external technology performance demonstrations
  - too broad of a performance test
  - testing the technician rather than the technology
  - improper performance demonstration boundaries for a given essential test variable

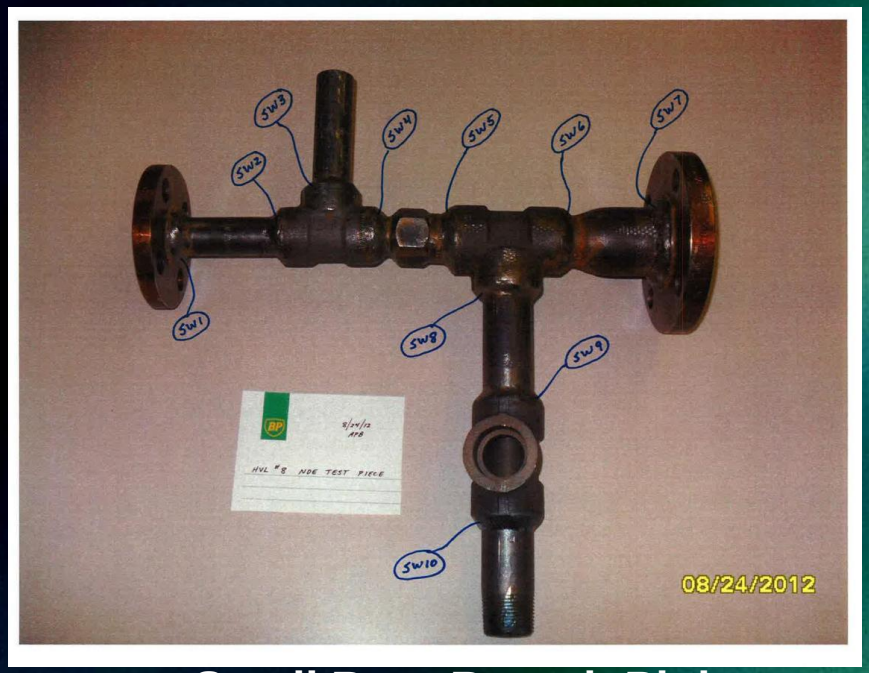
Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- **Difficult Access Inspection**



Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Wide Range of Topside and Subsea Piping Configurations



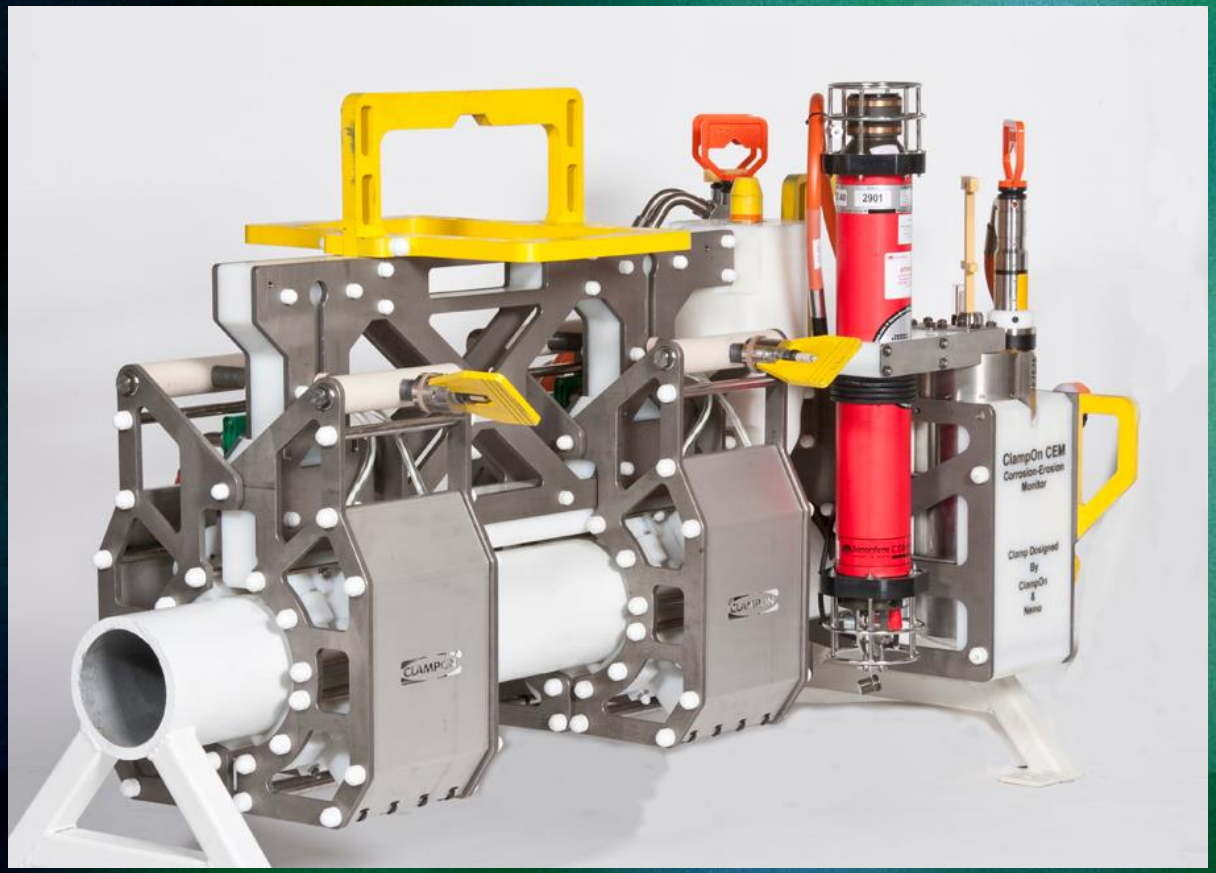
Small Bore Branch Piping

Subsea Wet Insulation

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- **SUBSEA Short Range Guided Wave Ultrasonics**

Water Depth: 6,900 feet



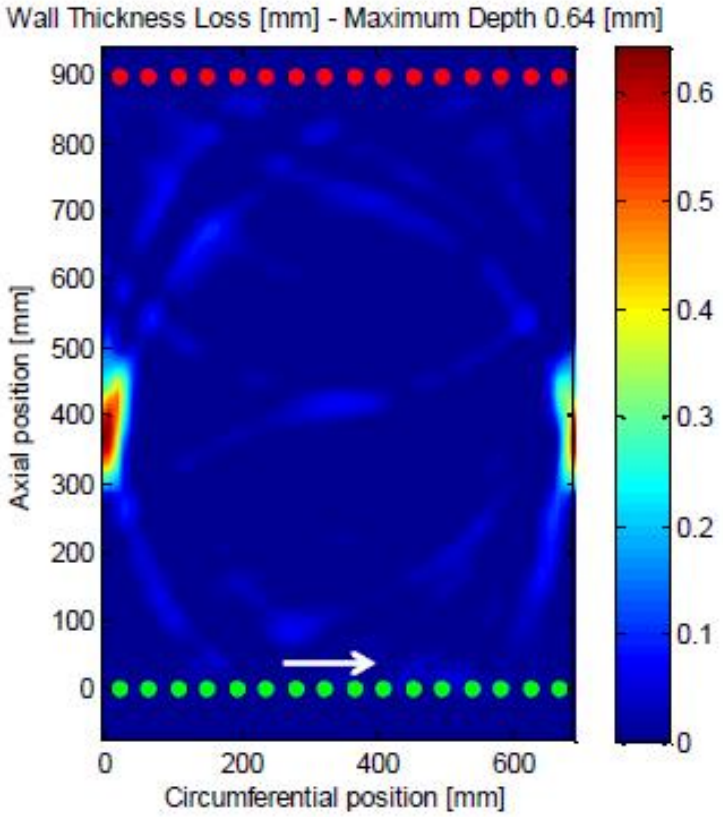
Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

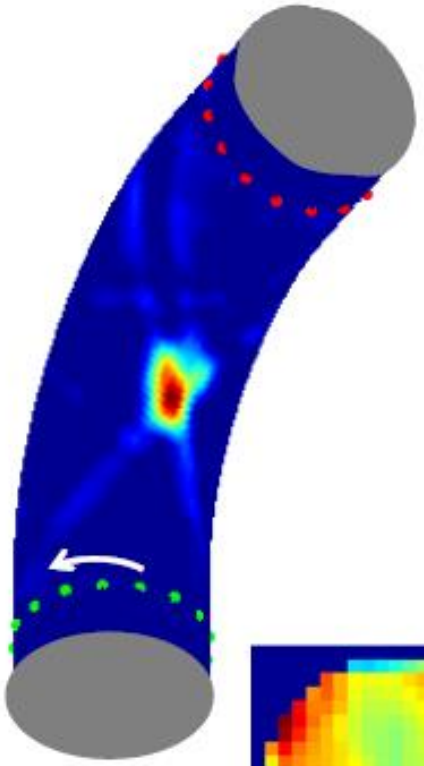
- **SONAR Wireless Communincation**

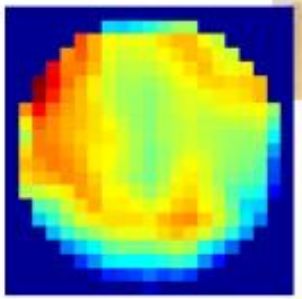
Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- **WAVEGLIDER Surface Sonar Transponder**

Bend Tomography - Reconstruction



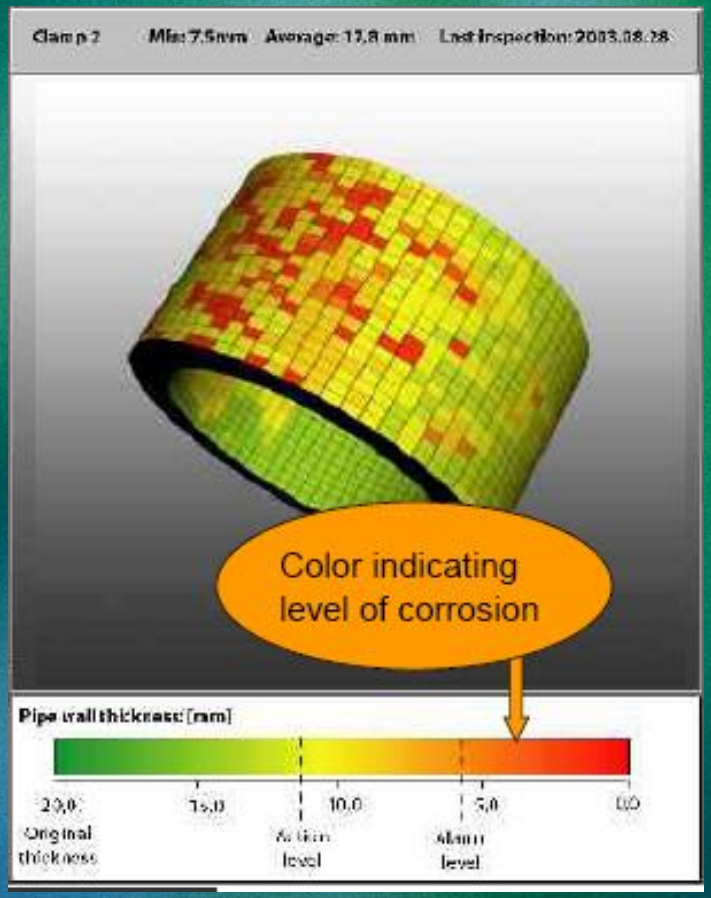


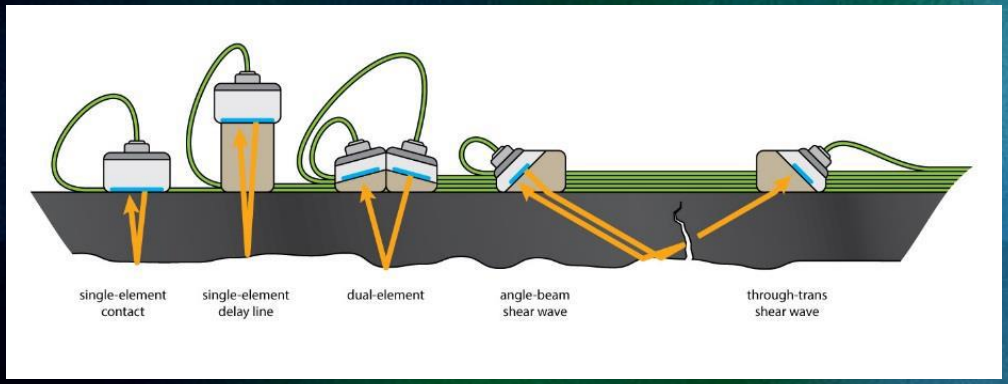


Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Permanently Installed Deep Water Sensors (PIMS)

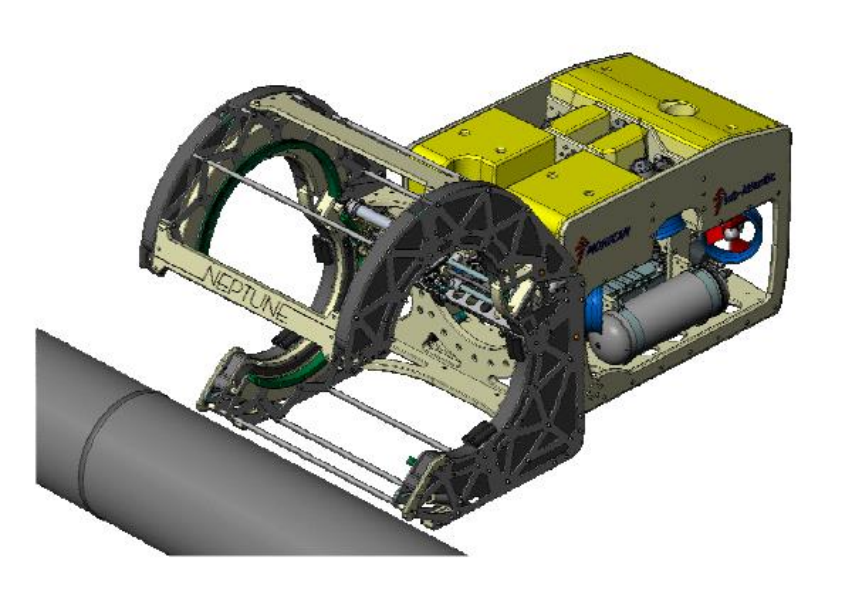
High density Ultrasonic Sensor Grid

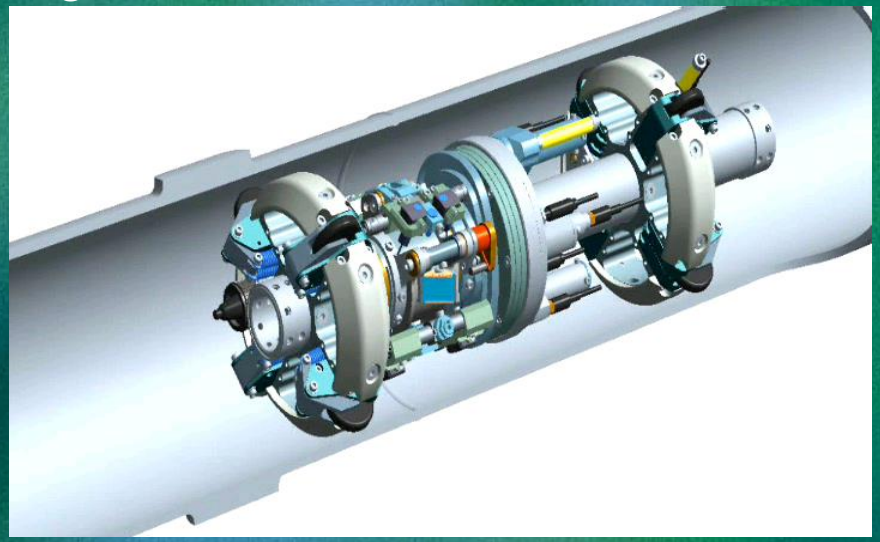




Robotic Subsea Pipe Inspection

External ROV Deployable Robots: Remote Video, Ultrasonics, Digital Radiography, Electromagnetics





Internal Inspection Robotics: In-Line Inspection Tools: Ultrasonics, Electromagnetics, Laser Profile, Tethered, Free Swimming

Wireless Inspection Challenges

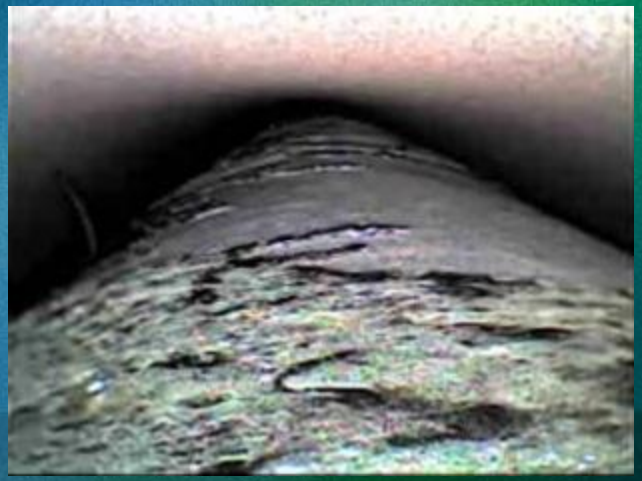
- Standardized design and manufacturing for a range of robotic inspection systems:
- Miniaturized
- Single NDT physics robots
- Multiple NDT physics robots
- Crawlers
- Track mounted
- Harsh environment
- Intrinsically safety
- Swimming
- AUV or ASV comminication

http://blogs.nvcc.edu/cbowman/files/2013/05/combined-testing-analysis.jpg

Wireless Inspection Challenges

Pipe in Pipe Inspection

- Pipe in pipe annulus inspection
- Subsea manifold dead leg inspection
- Through-wall wireless communication

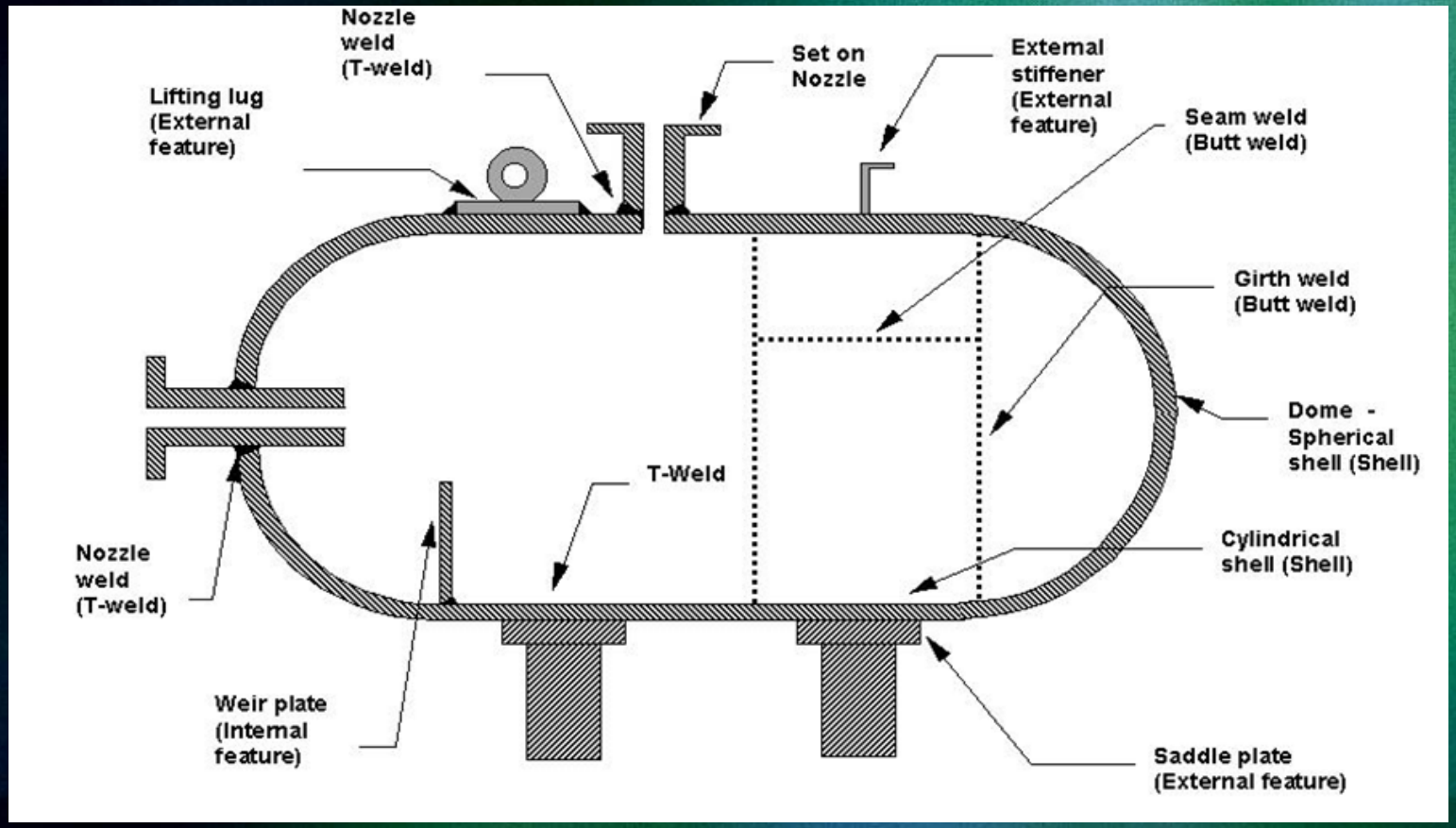


Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- **Underground Piping**

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Pressure Vessel Design Components

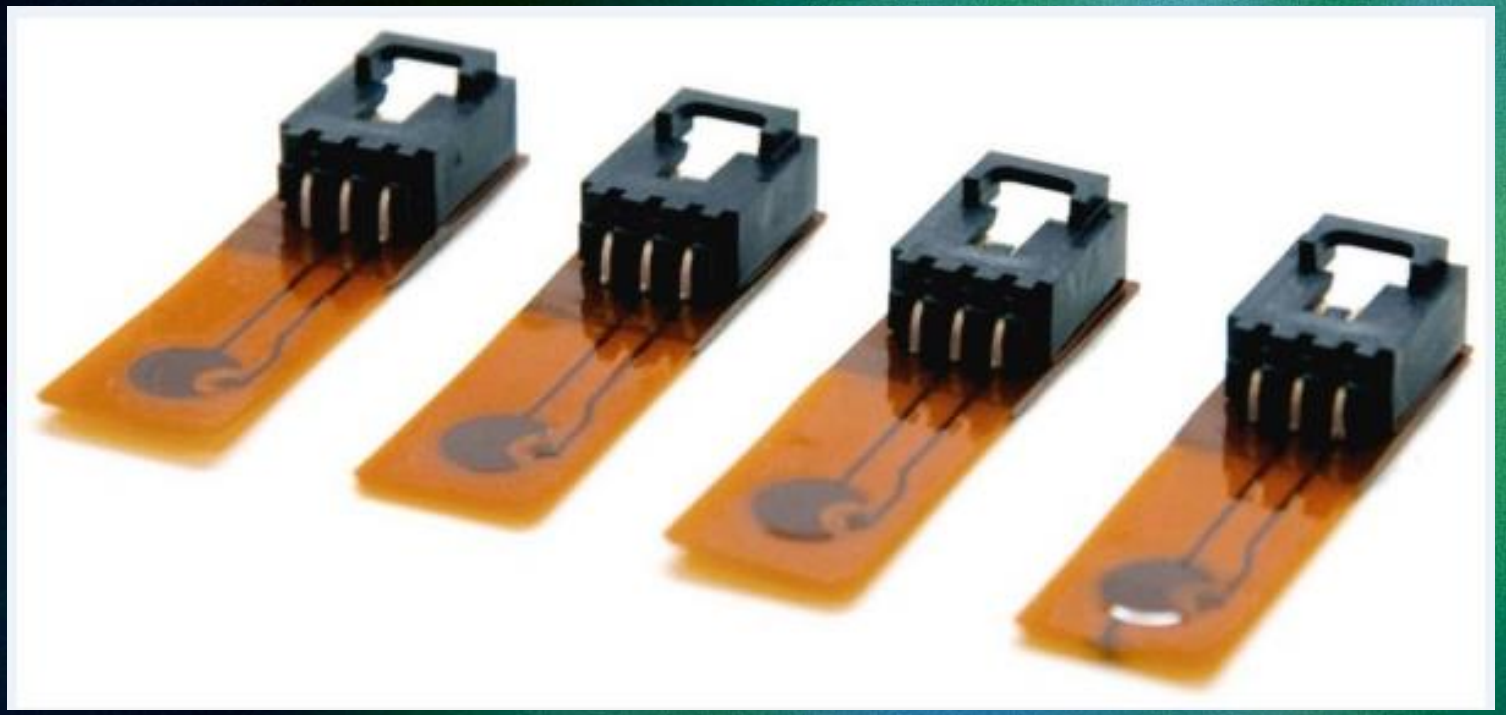


Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- **Permanently Installed Ultrasonic Sensors**

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- **Permanently Installed Ultrasonic Sensors**



Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

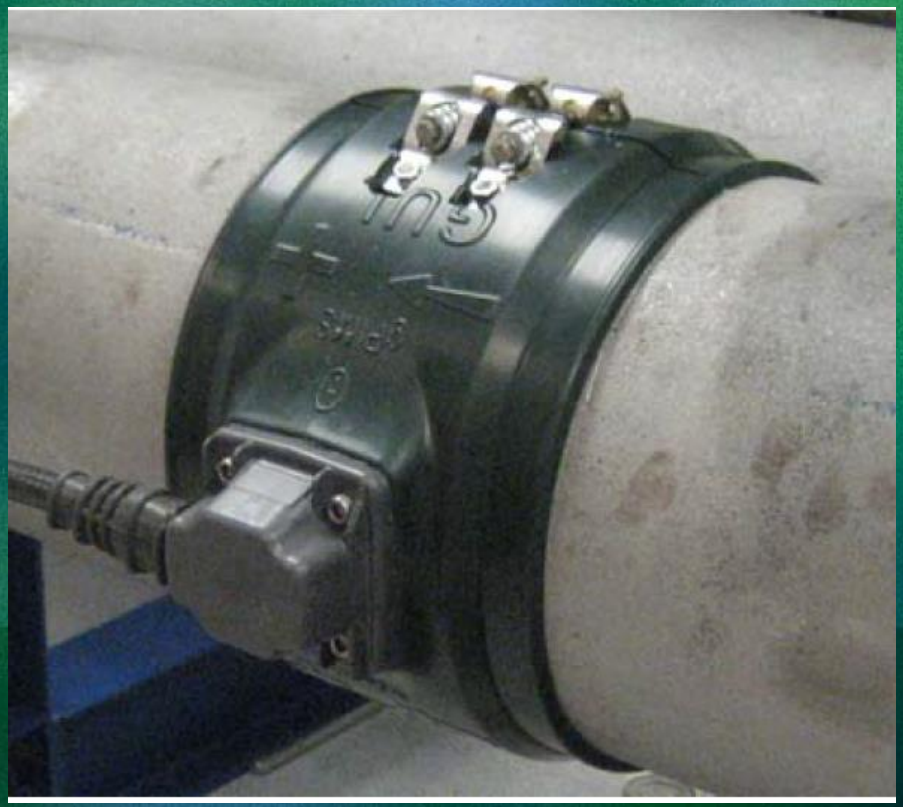
- **Currently >20 Commercially Available UT-PIMS**

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

UT-PIMS Plug and Play (no integrated electronics)

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

UT-PIMS Plug and Play (no integrated electronics)

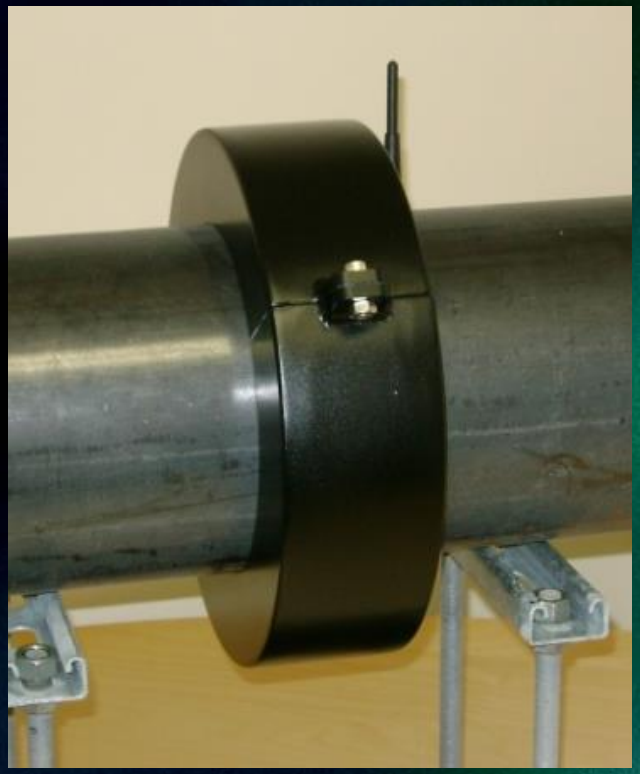


Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

UT-PIMS with on Board Electronics

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

UT-PIMS on Board Electronics and Wireless Communications



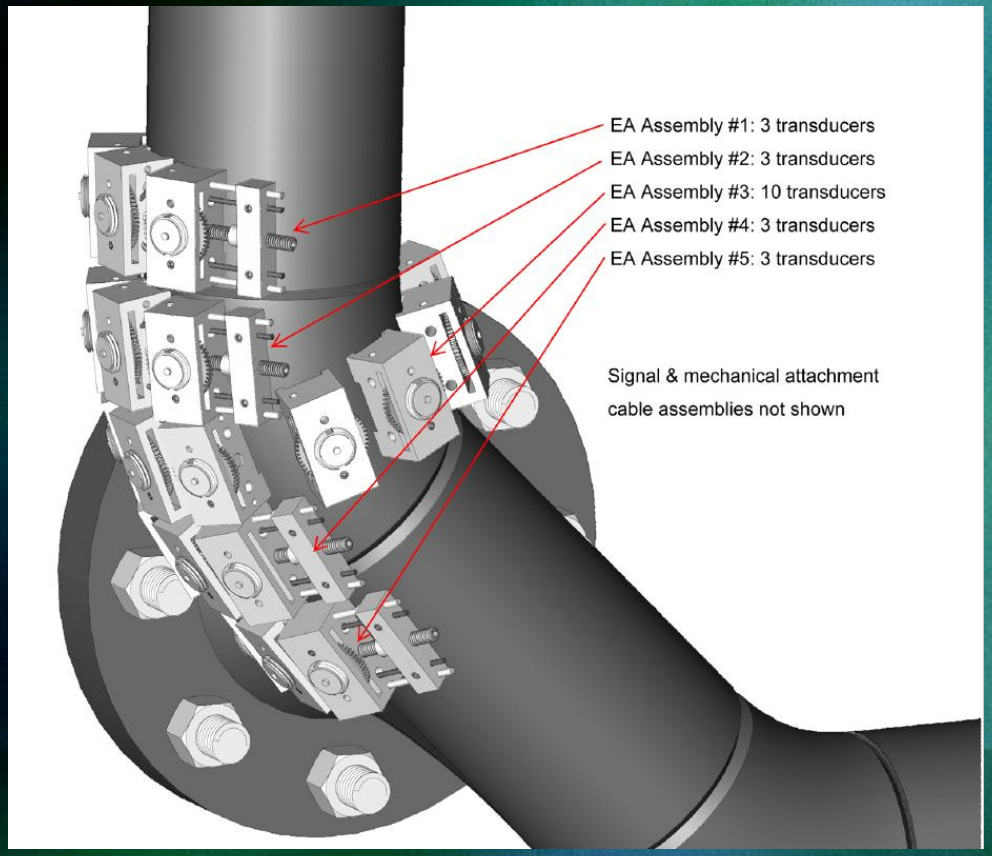
Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Wireless with solar power

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

UT-PIMS are seen as complicated and expensive

Costs range from $2,500-$180,000

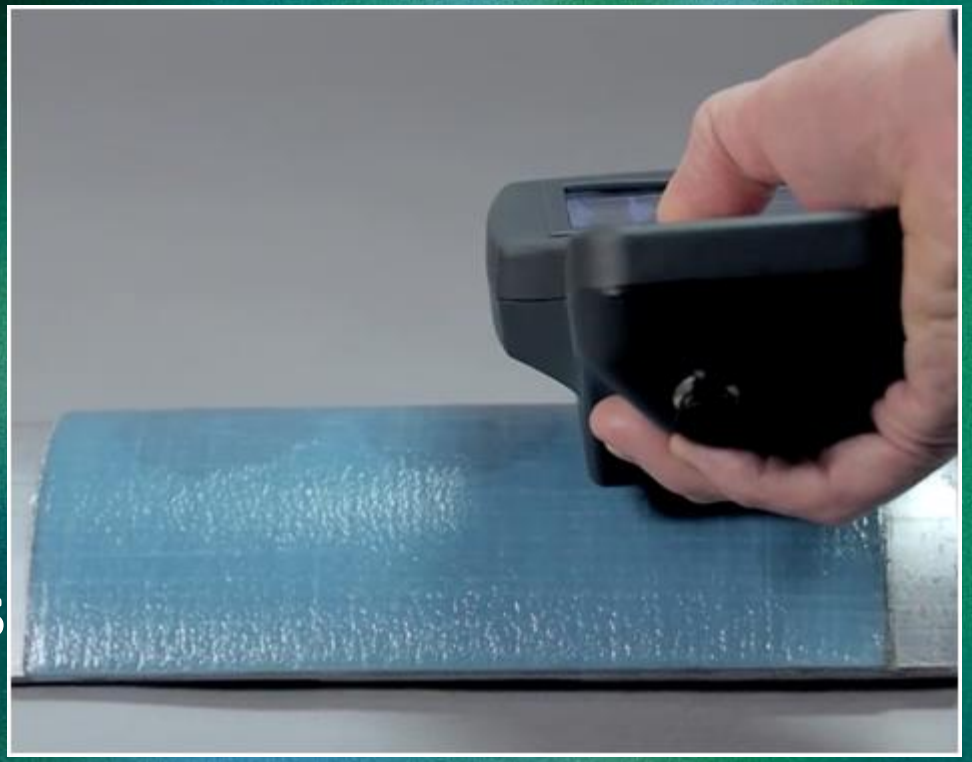


Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Inexpensive, Inductive, Wireless, Battery-Free UT sensors

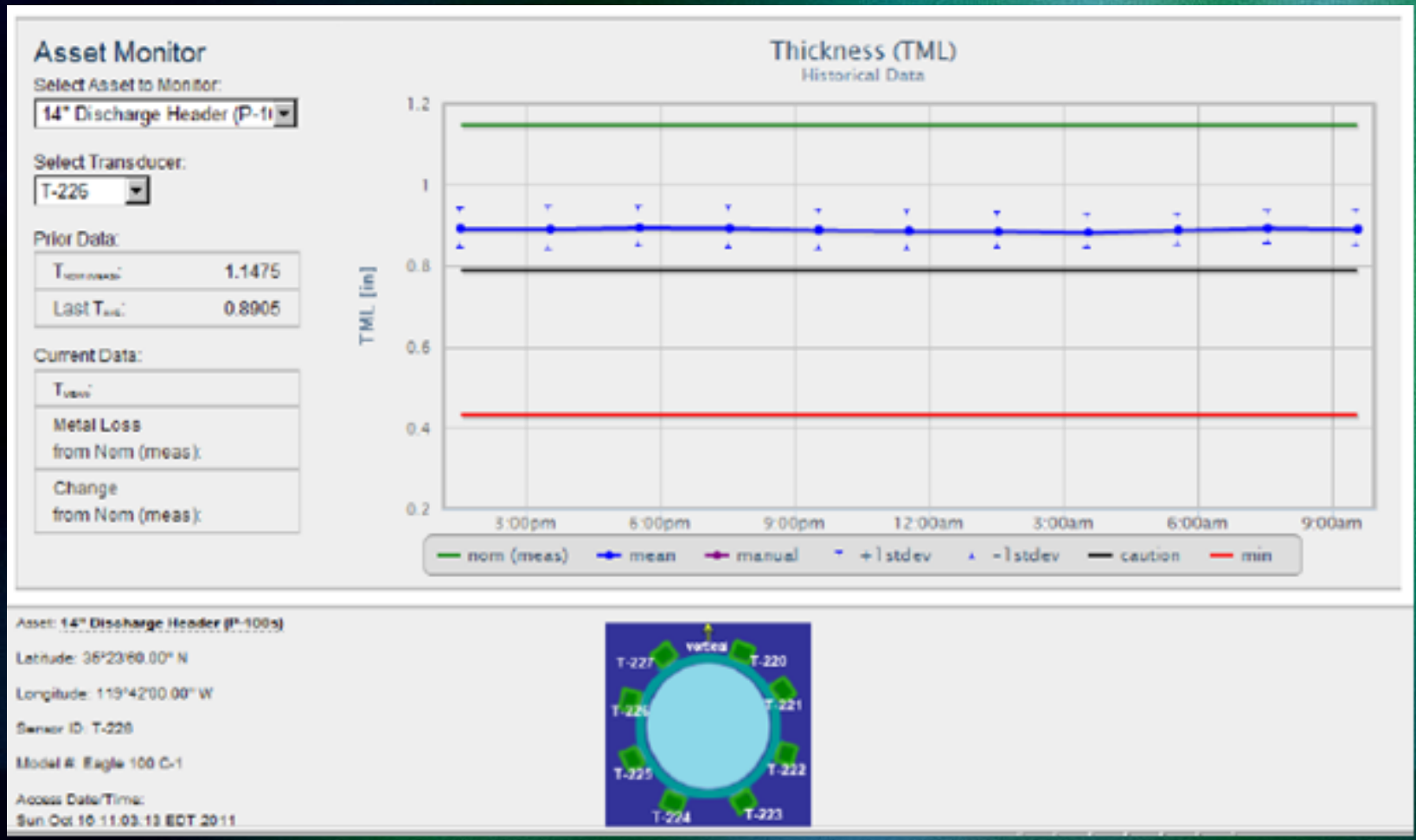
Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- Potentially <$100/sensor
- Very similar to current UT-TM processes
- Compensates for most UT error sources
- Can be installed beneath coatings and insulations



Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

On-line sensor activation and analysis



Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

- Real time digital radiographic (DR) imaging:

Manual DR scanner

On above ground

Insulated pipe

100 14X17” DR

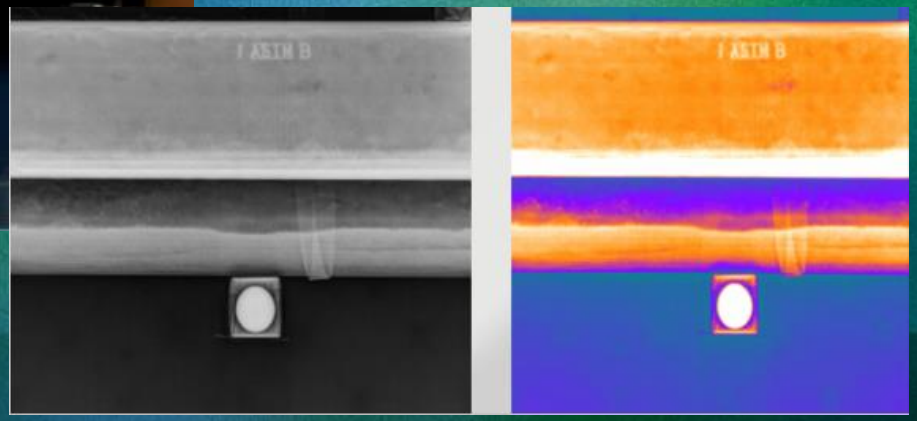
Shots per hour

Now wireless!

Passive Wireless Sensor Needs in Oil and Gas Asset Integrity Management

Remote real time digital radiographic imaging work station

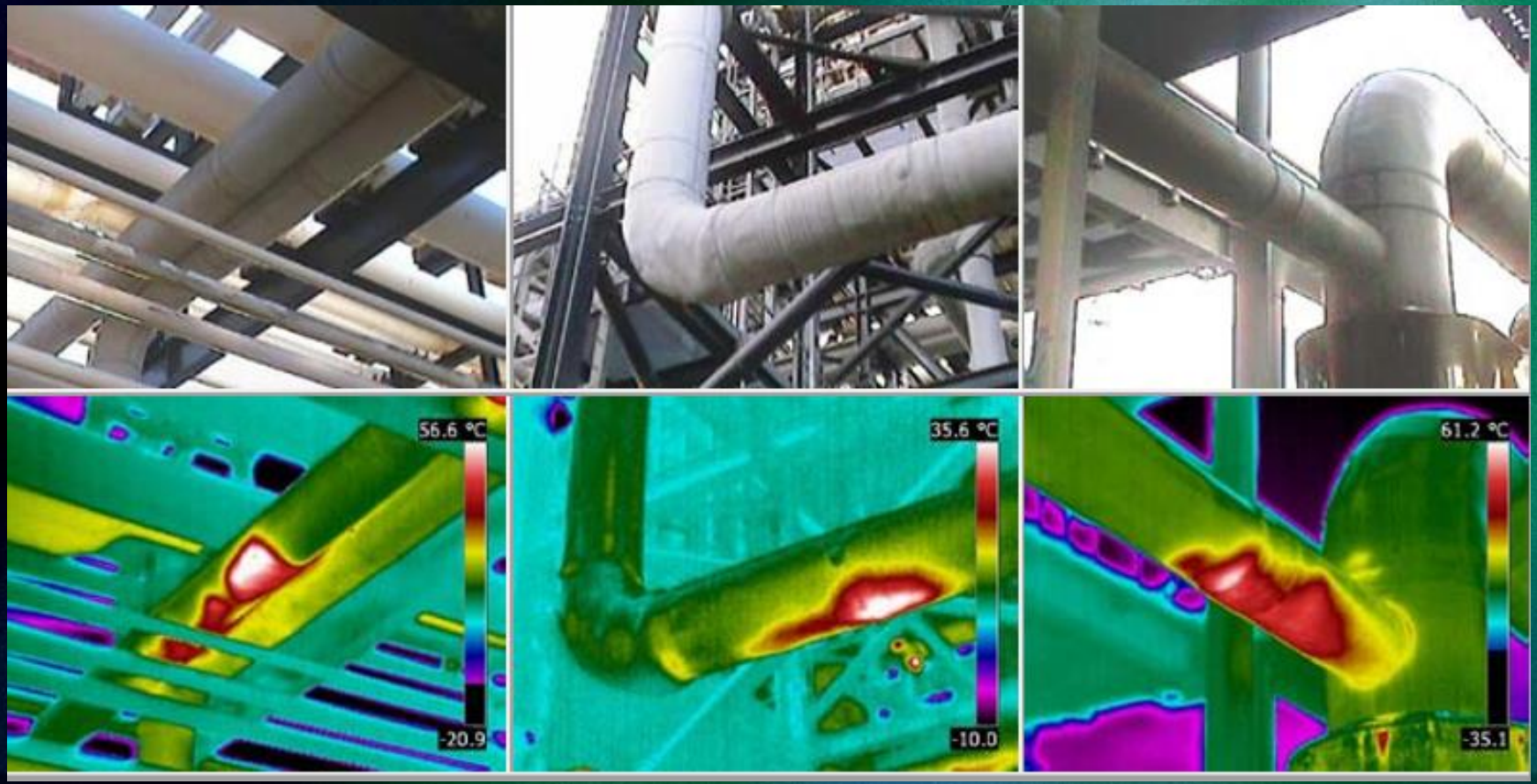
Real time DR image



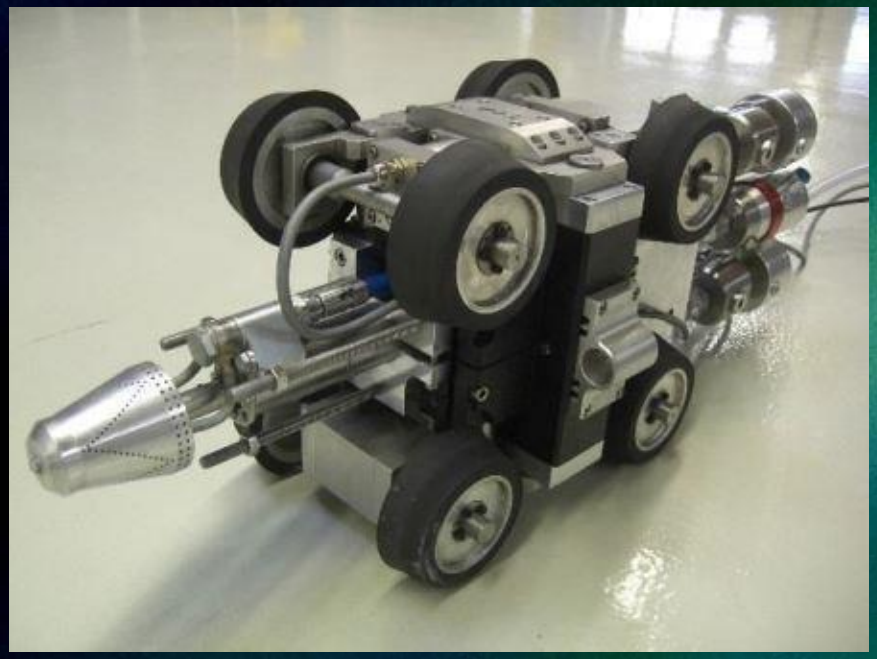
Drone RVI and IR CUI/CUF Inspections

Aqueous Water Detection

Thermal/Infrared Examination Method



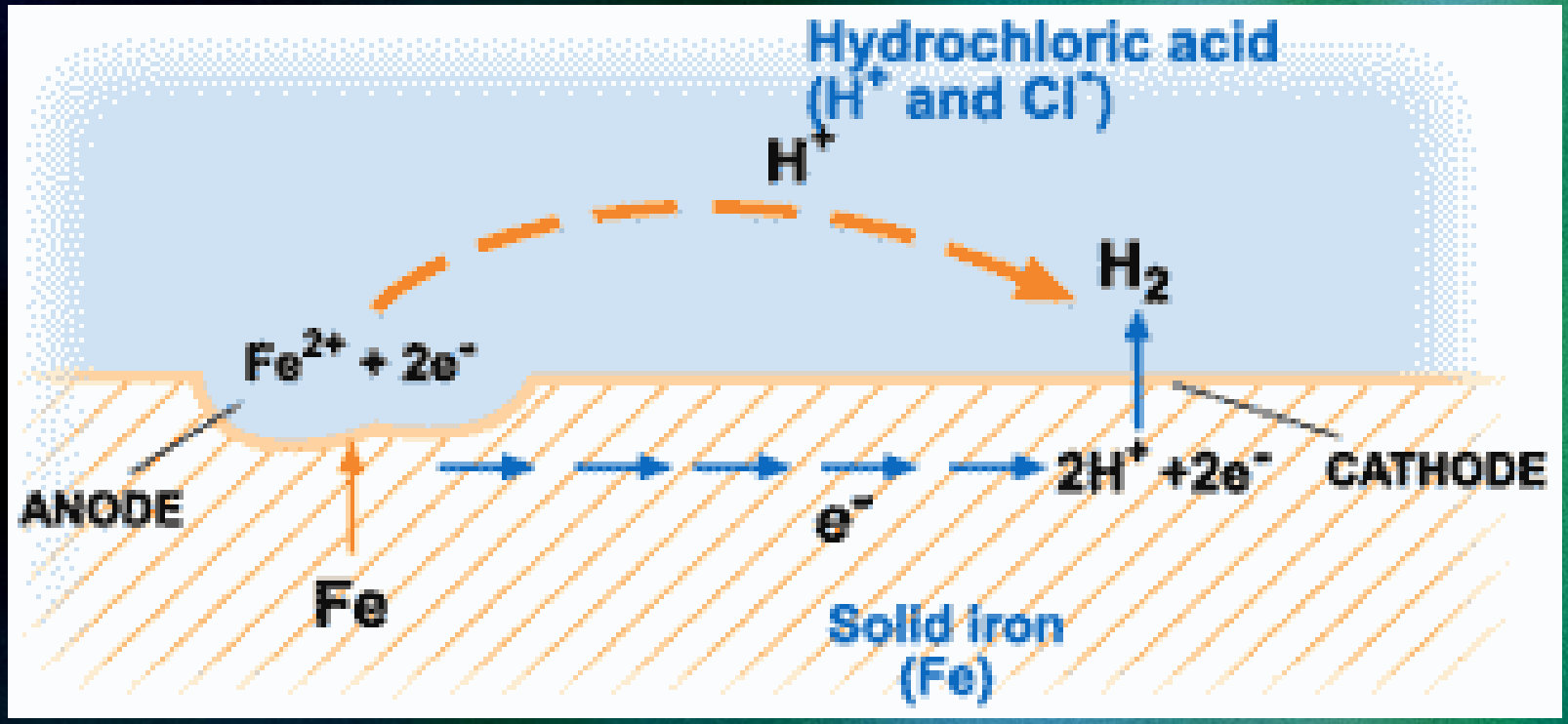
Robotic Crawlers Install Internal Corrosion Resistant "SMART" Coatings



Internal Coating Robot

Installed Corrosion Resistant Coating

Corrosion Resistant Coatings Arrest Electrochemical Corrosion Activity



Bare metal surface in electrolyte

Localized Damage to Corrosion Resistant Coatings Create an Accelerated Anodic Corrosion Cell (Leaks)

Failures due to Internal coating damage

Corrosion Resistant Coatings Arrest Electrochemical Corrosion Activity

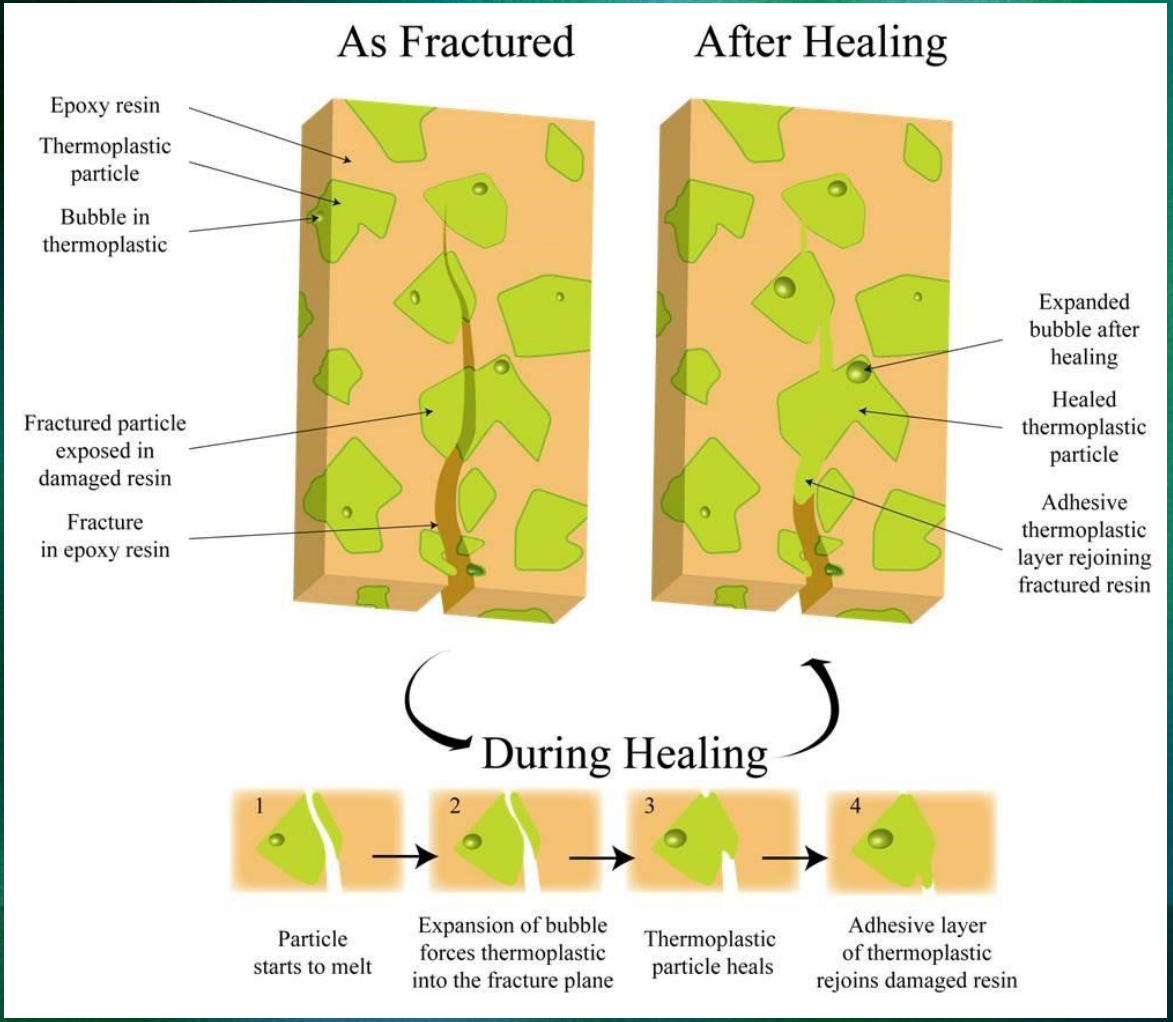
Current Oil and Gas research: Self-Healing Internal Coatings

Micro thermoplastic particles

Reacts with iron oxide

Enters and expands inside of localized coating failures

Self-healing



Corrosion Resistant Coatings Arrest Electrochemical Corrosion Activity

Wireless sensor technology challenges:

1. **How to determine if the coating system is working in miles of piping?**
2. **How to detect areas of coating failures**
3. **How to grade the severity of coating failure?**
4. **How to accurately identigy repair areas without large scale inspection proceses (e.g. In-Line Inspection Tools, external radiography, ultrasonic imaging)**

Medical Case for Nanorobots

- Nanorobotic devices will be used to protect the human body against pathogens
- Nanocomposites: Carbon will be a primary material of construction due to its strength and chemical inertness.
- Nanorobots will contain electric circuitry and sensors as well as mechanized control surfaces such as propellers, fins and functional appendages

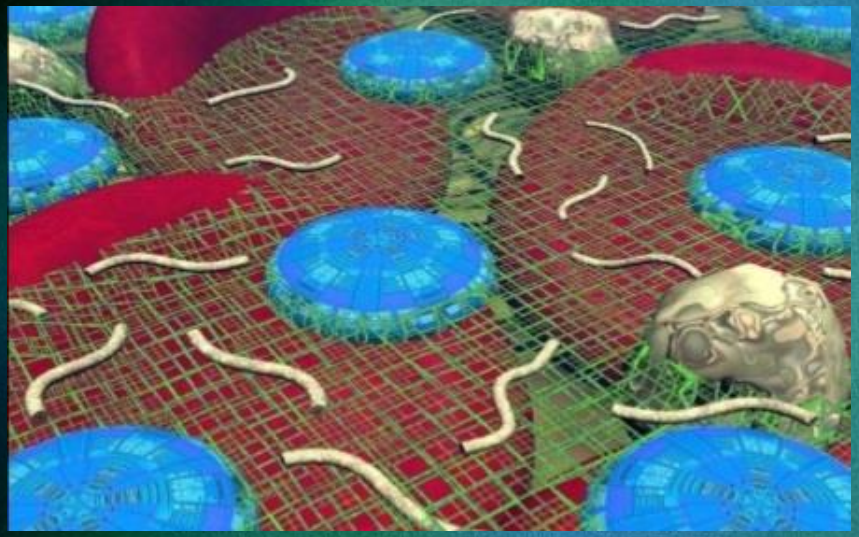
Robot size = 0.1-10 micrometers

Future Wireless NDT Sensors

- **Nanorobots** (nanobots or nanoids) are typically devices ranging in size from 0.1-10 micrometers and constructed of nanoscale or molecular components.
- Electrical circuits (on/off switch, etc.)
- Commercial viability estimated within 15 years

Nanorobots

- Self-Replication: Nanorobots might be able to re-produce themselves in order to remain operational for years

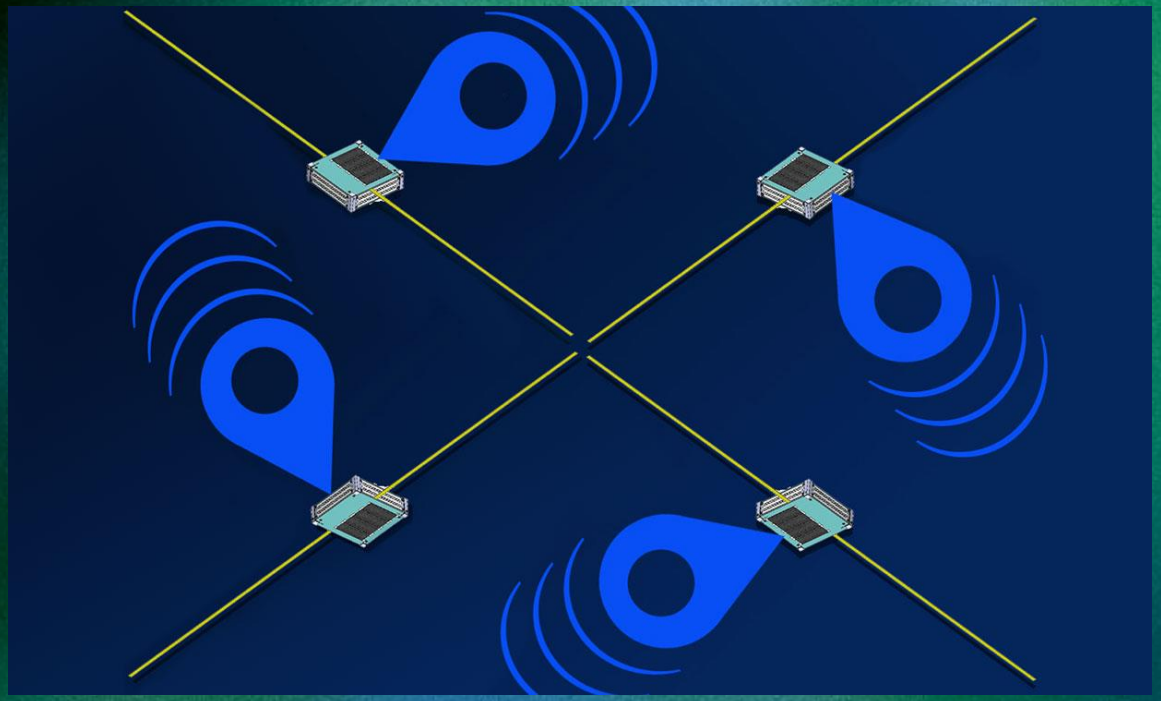


Nanorobot Colony

Nanorobots

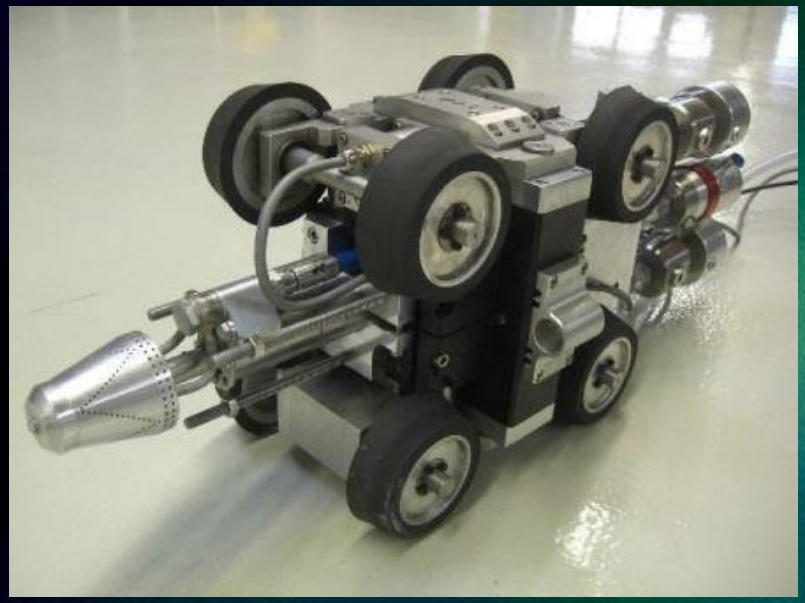
Swarm nano-circuits

- Transmit individual wireless codes when entering an energy field
- Manufactured in swarm batches for purpose
- Reclaimable
- Reusable



Swarm satellite example

Robotic Crawlers for Installed Corrosion Resistant Coatings

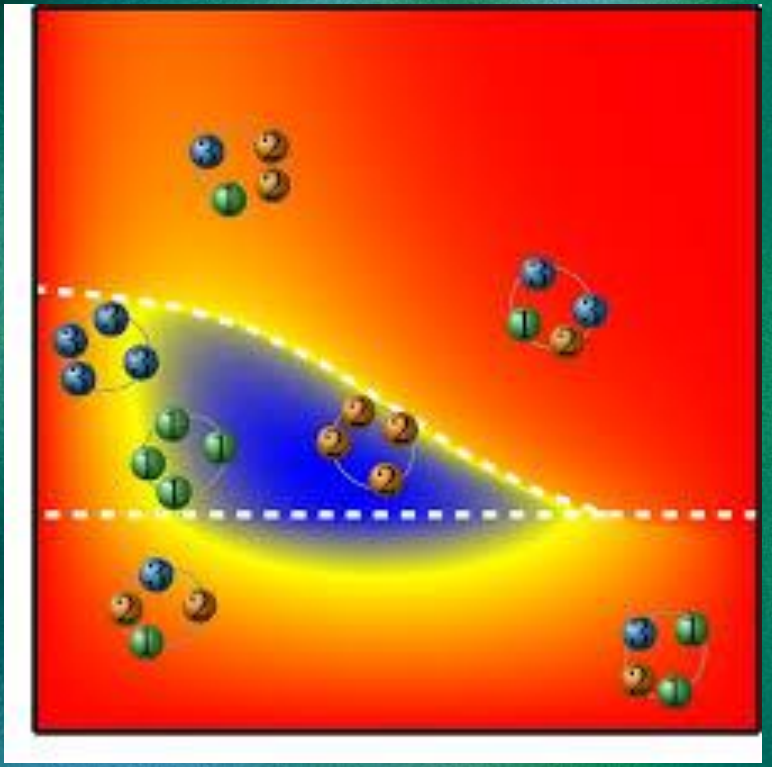


Internal Coating Robot with nano-circuit axial, circumferential and layer positional encoding

Installed Corrosion Resistant Coating

Nanorobots

- Wireless coded nanocircuits are introduced directly into the process stream when coating layers fail
- A wireless exciter is located at the inlet pipe of oil and gas separator pressure vessel
- The axial, circumferential and layer information of entrained nano-circuits are recorded and referenced against coating installation positions



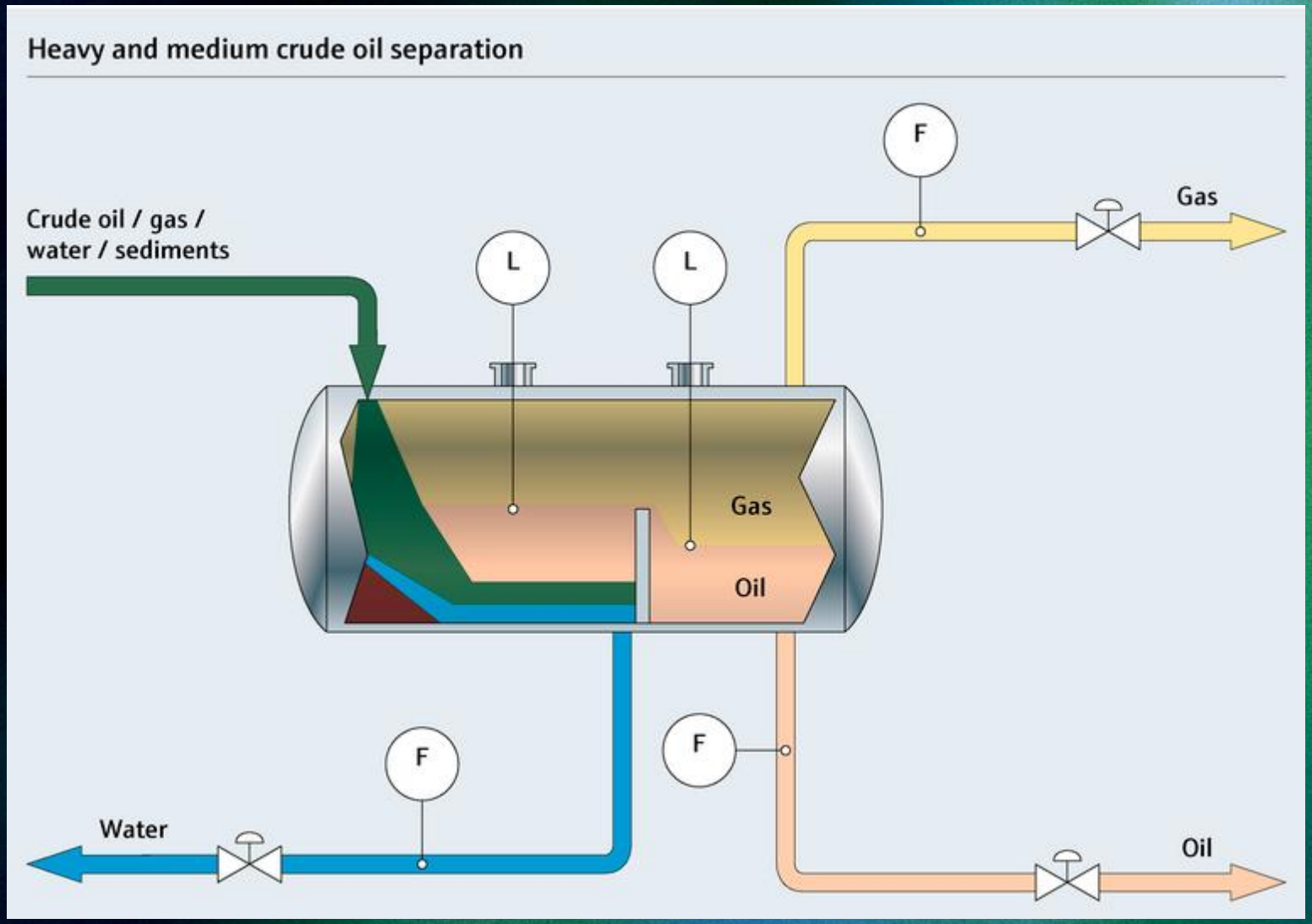
Robot size = 0.1-10 micrometers

Robotic Crawlers for Installed Corrosion Resistant Coatings

Production Well Head

Wireless Encoded Installed Corrosion Resistant Coating

Robotic Crawlers for Installed Corrosion Resistant Coatings



Seperator Pressure Vessel

Questions and Discussion

Thank You!