A Pathway to Thickness Measurement Digitalisation

inductosense

Who We Are

UK-based technology developer, specialising in ultrasonic solutions for monitoring internal corrosion and erosion.

How We Work

We work directly with end users, or through partners who install our technology, and can also provide service offerings around it.

What We Do

We design, develop and manufacture WAND solutions, designed to make wall thickness monitoring simpler, safer, and more cost effective.

Our clients include:

Chevron, Shell, PETRONAS, PETROBRAS, Santos, Sinopec, bp

Our History

2015

Inductosense founded

2017

Investment secured

2018

Product Launch

2018

ISO9001:2015 Achieved

2022

Launch of our WAND-RDC

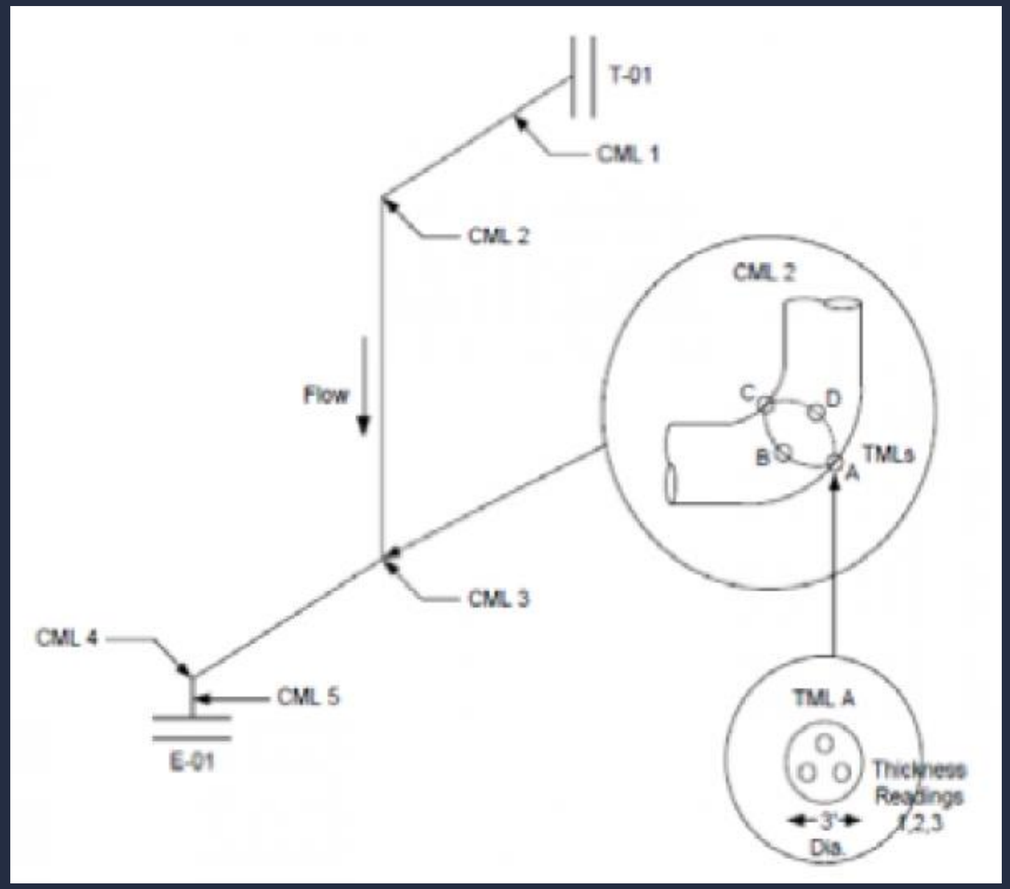
2023

Investment from Saudi Aramco

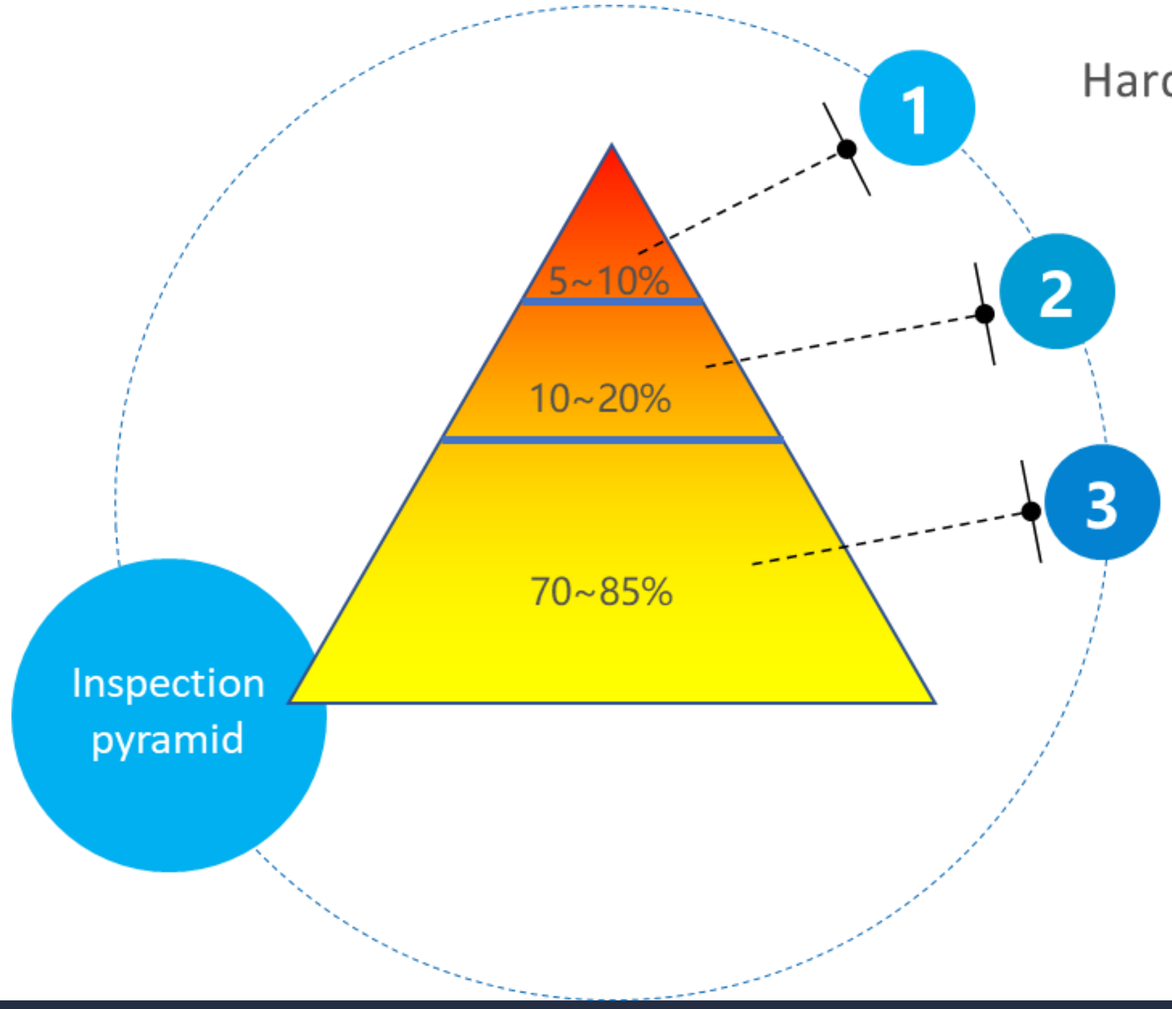
- Name: Erik Fabre
- Company: Inductosense
- Title: Head of R&D projects
- Experience: 8 Years in the Industry
- Specialty: Corrosion Monitoring, Ultrasonic testing, applications and product development

Thickness Measurement

- **CMLs:** corrosion monitoring locations
  - 100,000 CMLs at a typical refinery
  - 20,000 CMLs at a typical offshore platform
- **TMLs:** thickness measurement locations
  - Multiple TMLs within CMLs
  - Significant TMLs across the assets
- **Thickness readings**
  - A single ultrasonic testing (UT) measurement
- One of the biggest data sets to digitalise



TMLs- Accessibility

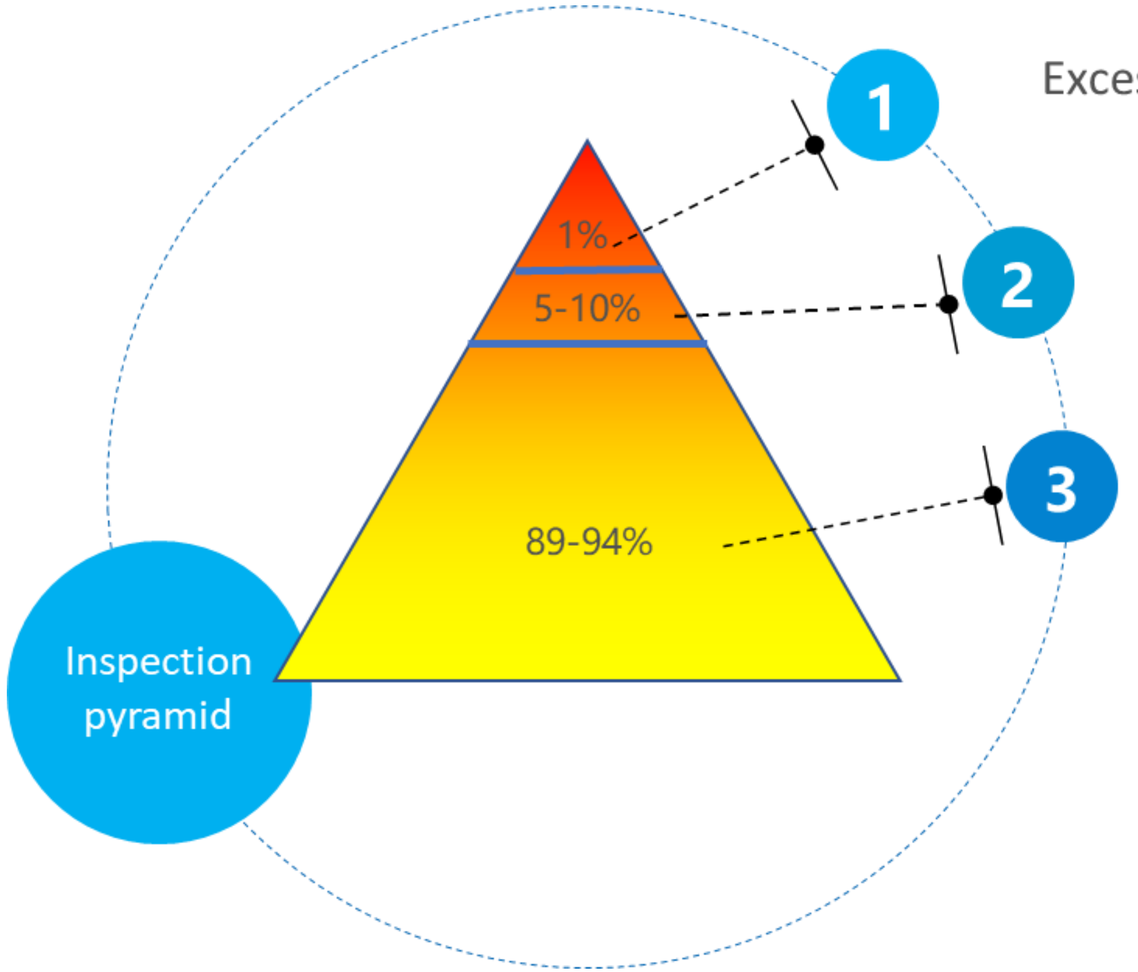


Hard access； current cost $3~5K/CML

Limited access； current cost $1000/CML

Easy access； current cost $500/CML

TMLs – Inspection frequency



Excessive corrosion; min 4 inspection/yr

Server corrosion; 1 inspection/yr

Mildly and low corrosion; Every 5 yrs

Current solutions

Manual UT (Majority)

Manual UT:

- Certified inspector
- Exposure to risk at hard access locations
- Less digitalized solution

Potential error:

- Transducer design, condition, calibration
- Measurement locations
- Couplant
- Data transfer

Current solutions

Robotics UT

Robotics UT:

- UT equipment as payload
- Reduce human exposure to risks
- Digitalized solution

Limitations:

- Same error as manual UT
- Most of platforms are limited to the uninsulated assets

It is estimated that uninsulated assets (e.g. piping, pressure vessels and tanks) comprises less than 10-20% of the entire fixed equipment population. Most fixed equipment in oil and gas is insulated.

Current solutions

Online monitoring solution

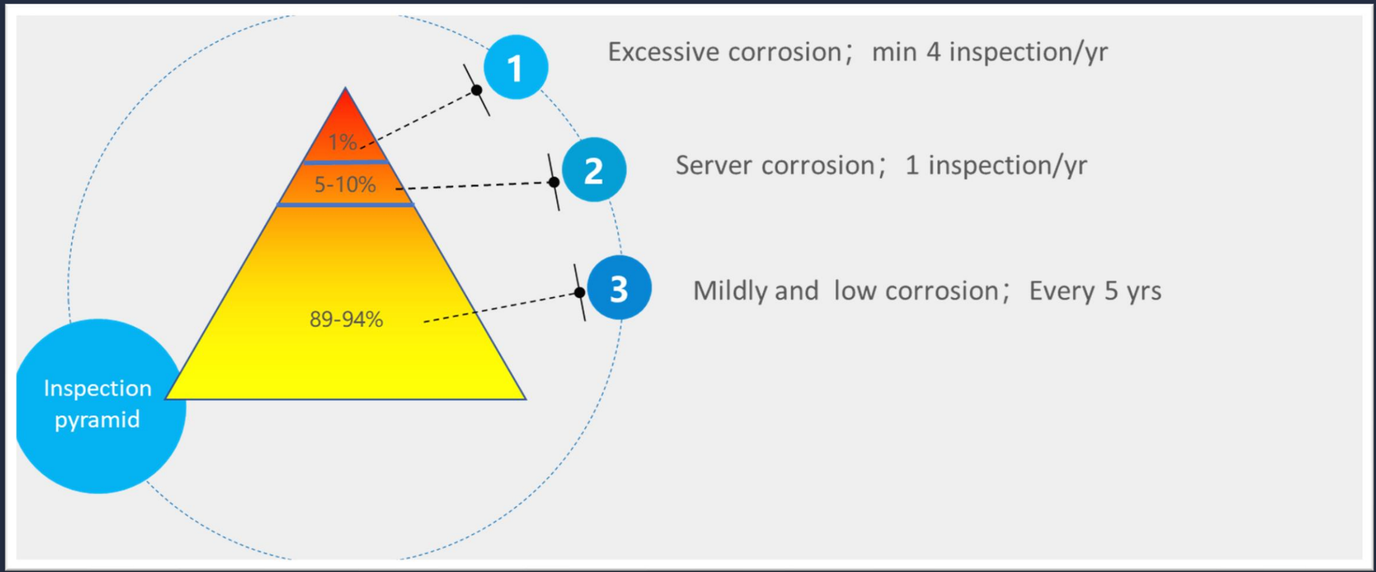
Online monitoring solution:

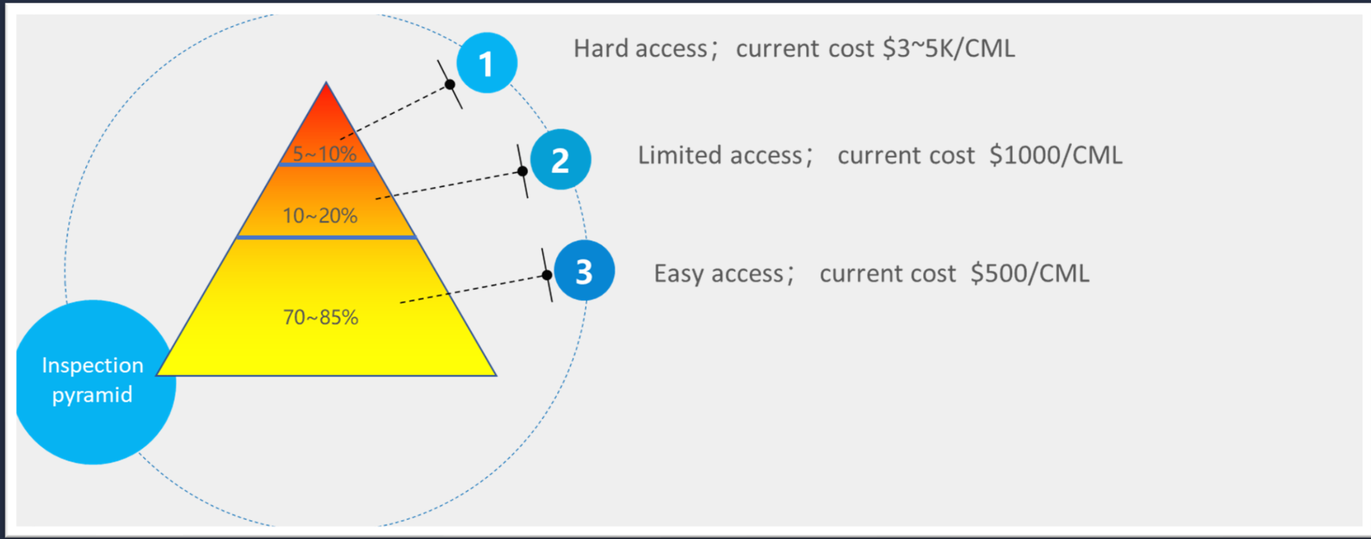
- UT equipment coupled with communication circuit
- Fixed location
- Fully digitalized solution

Limitations:

- Cost
- Network setup
- Large size with flame-proof enclosure

Current solutions





Application Tier:

- **Tier 1: Online monitoring devices**
- **Tier 2: Robotics UT**
- **Tier 3: Manual UT**

Current solutions

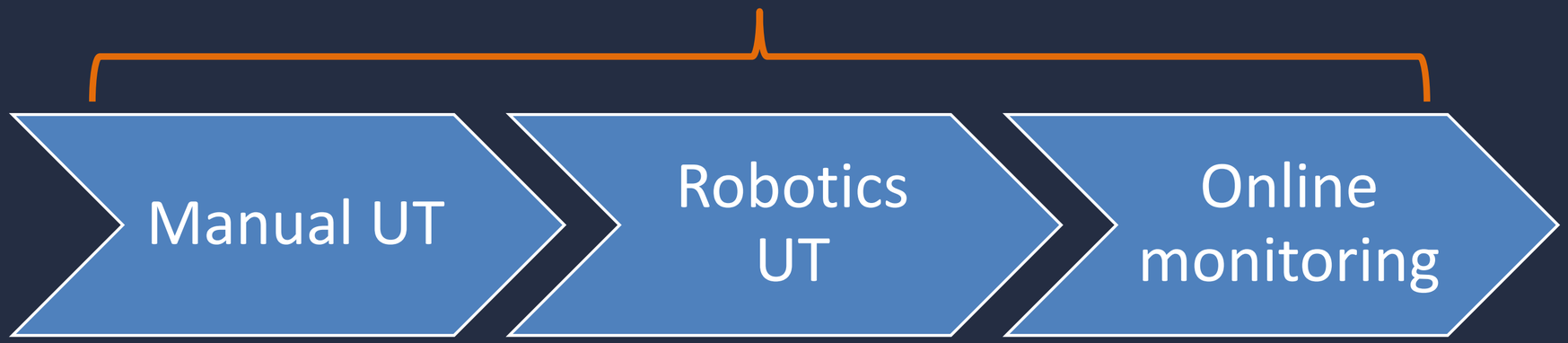
Challenges

Discrete process:

- Location continuity
- Data type/formatting
- Calibration
- Thickness calculation method
- etc

Wish list:

- Easy to upgrade/downgrade
- Consistent data
- Cost-effective
- Can be integrated with the asset management software



WAND Sensors

Key Features

WAND sensors are completely passive and generate repeatable wall thickness data free from human error

- Battery-free
- Thin & embeddable
- RFID tagged
- 65mm footprint
- -40°C up to 180°C, standard (-40°C up to 130°C)
- 10-year lifetime minimum*
- ATEX/IECEx approved (Zone 0)

*based on independent testing done by the UK National Physics Laboratory, performed under specific environmental conditions

Data Collectors

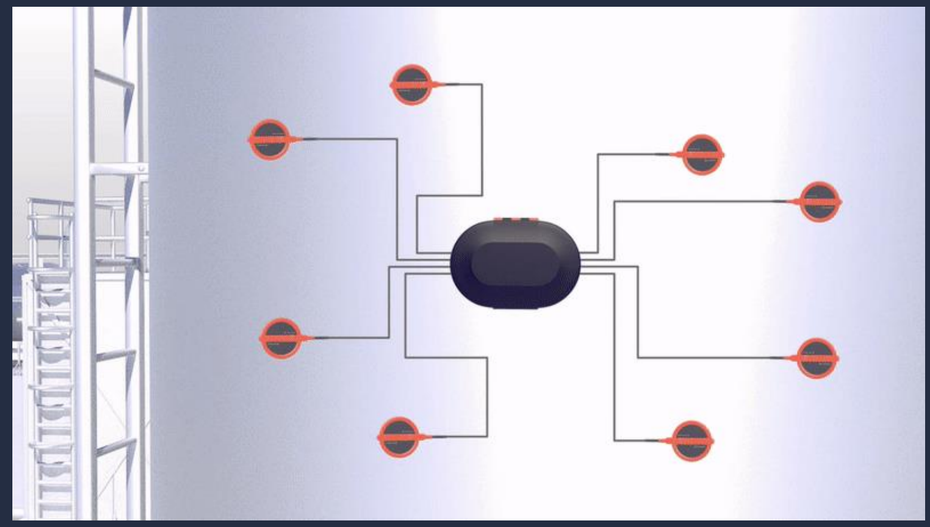
Handheld Data Collector

Handheld data collection probe designed to wirelessly activate and collect thickness readings from a single WAND sensor:

- Anyone can use the WAND – minimal training required
- Up to 4cm stand off

Data Collectors

Remote Data Collector



Protection:

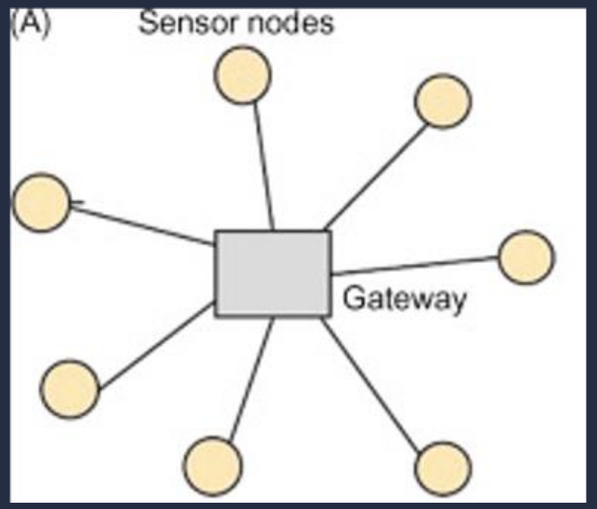
- The ATEX directives are two EU directives describing the minimum safety requirements for workplaces and equipment used in explosive atmospheres.

- Intrinsic Safety (IS) is an approach to the design of equipment going into hazardous areas. The idea is to reduce the available energy to a level where it is too low to cause ignition. Cheaper and light, difficult to design.
- Flameproof/Explosion proof: If heat or sparks from faulty equipment within the enclosure ignite flammable gas present with it the resulting explosion is contained within the enclosure. Expensive and heavy, easy to design.

- 1st 8 channel IS design
- IoT product of year, ELEKTRA 2022

Data Collectors

WAND-Gateway



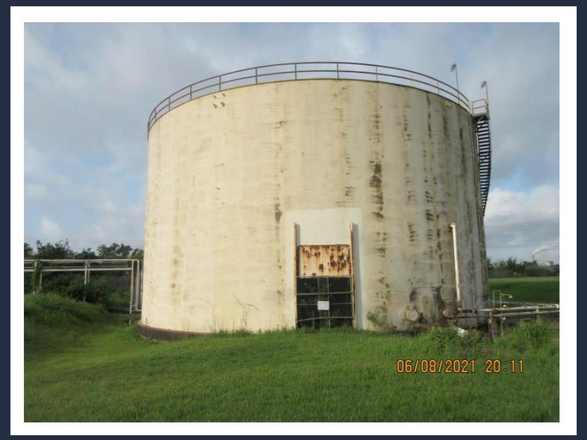
Point to Point Network:

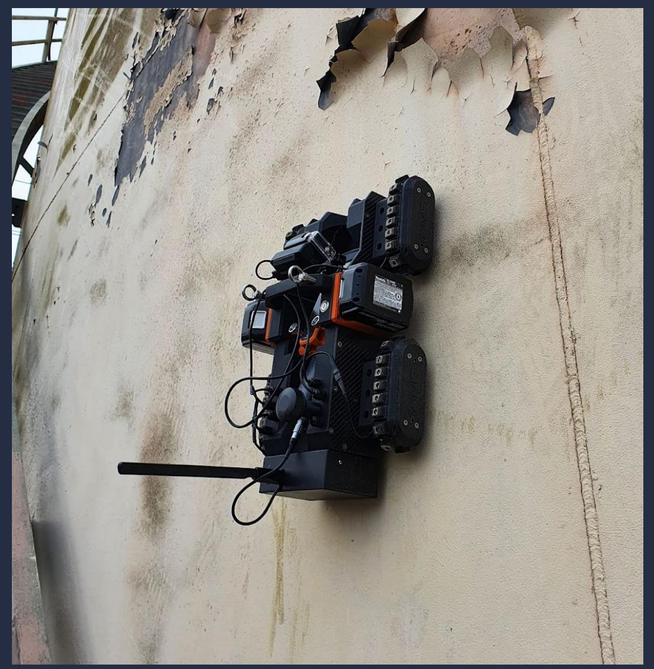
- BLE 5.0
- Flexible to upgrade

WAND Crawler

- Refinery in Houston area

- Storage tank:
  - Diameter: 93 ft
  - Height: 43ft
  - Shell type: butt welded
  - Fixed roof
  - Flaky coating





- Four sensors installed along the stairway

- Testing on shell:
  - Crawler performance
  - Data acquisition

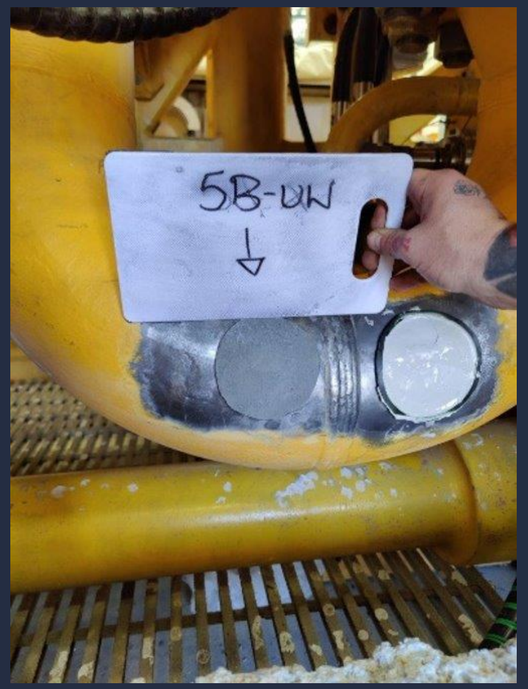
WAND Crawler

WAND-Subsea Phase I

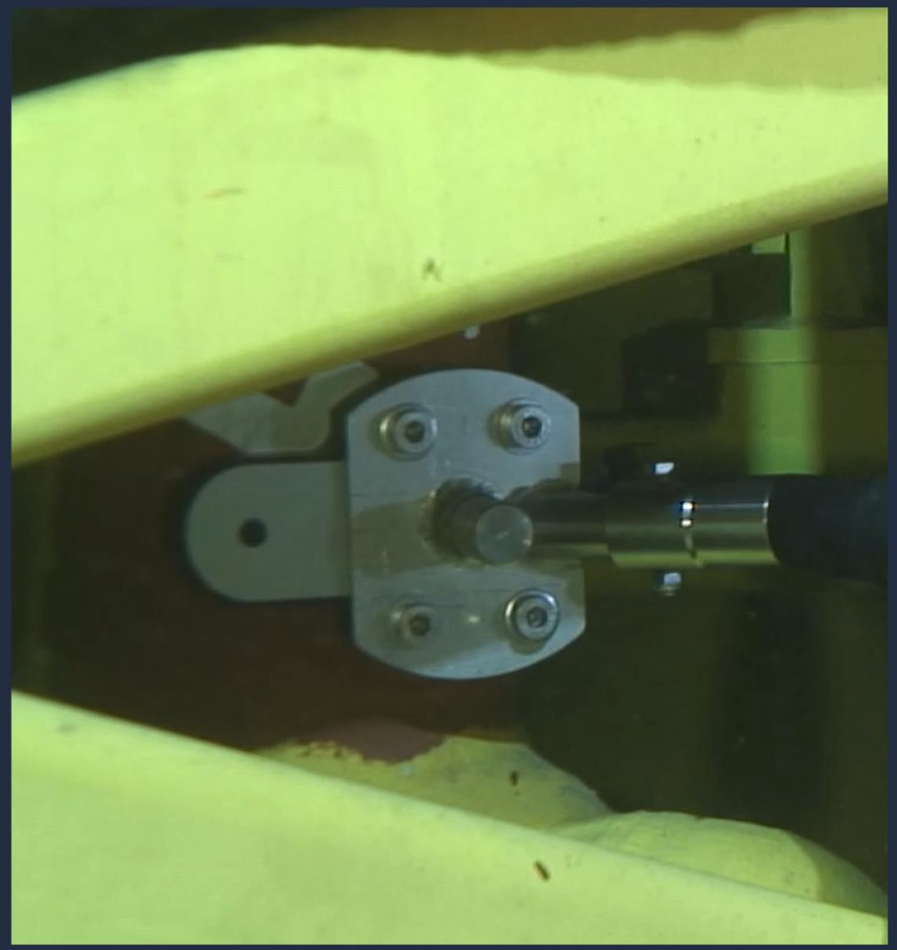
- ROV: Work class R0V

- Structure:
- ~200 meter depth
- Choke module
- 26 sensors installed on topside

- Testing:
- Stability
- Live signal feedback
- Practicality of taking readings



Prototype: Inductosense Subsea WAND system integrated with ROVs



WAND-Subsea

Phase 1: Proof of concept (TRL6 CRL4)

Phase 2: 18 months Deepstar JIP started with Petrobras and Chevron

WAND UAS Phase 1

- In door testing facility

- Structure:
  - Three sensors installed insulated piping,
  - Two on uninsulated piping,
  - Three on an insulated vessel
  - The sensors and extension cables were installed in various orientations; on vertical surfaces, and the top and bottom of horizontal ones.

- Testing:
  - Stability
  - Live signal feedbacks
  - Practicality of taking readings

Prototype: Inductosense WAND system integrated with UAVs

Chevron

inductosense

In collaboration with:

VOLIRO

FLYABILITY

QTF
Quasset Test Facility

WAND-UAS

Phase 1: Proof of concept (TRL6 CRL4)

Phase 2: Invite partners to JIP, aim to kick off Q4 2023

WAND-UAS InTank application

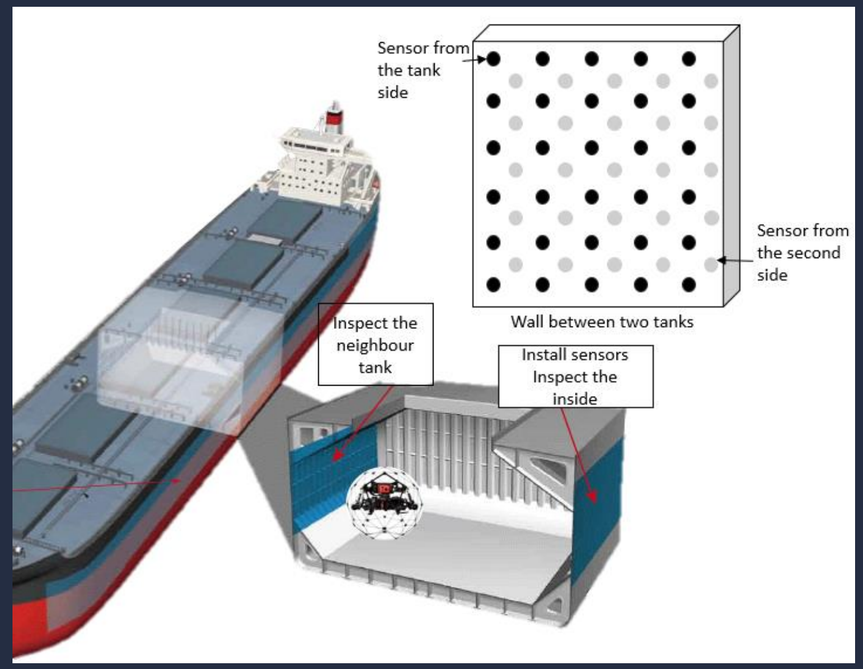
Monitoring: accurate results enable predictive maintenance and life extension

Faster inspection: no cleaning and quick contactless measurement reduce cost and exposure risks

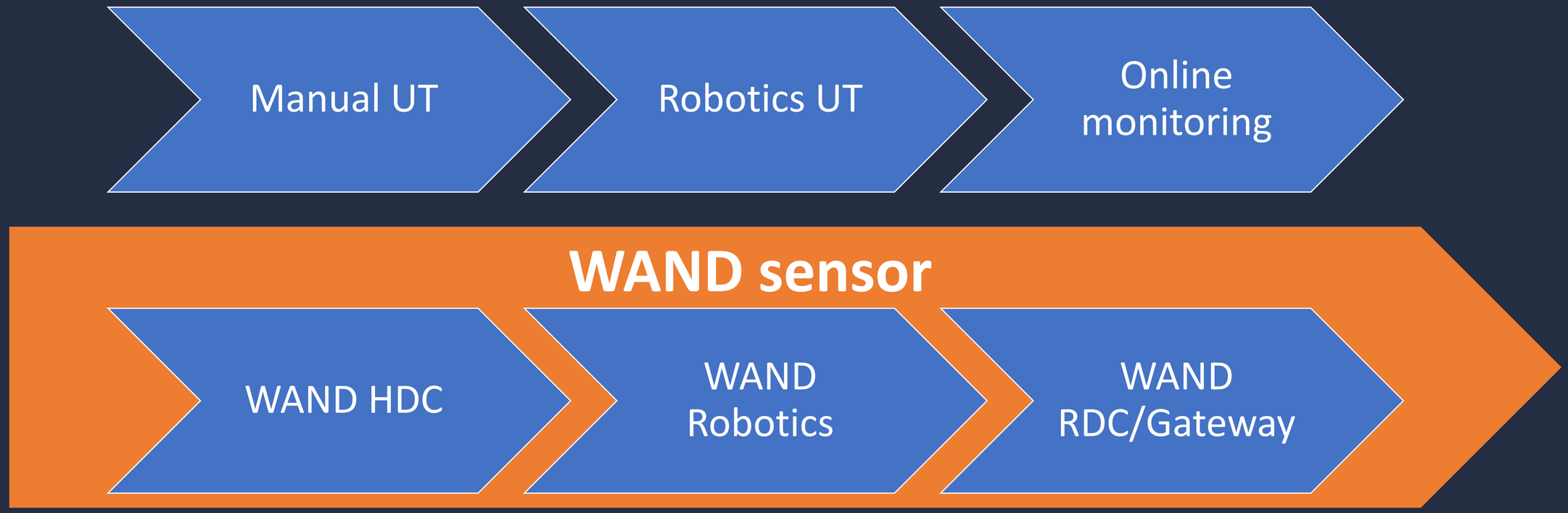
Hard-access: no blind spot approach enables full robotics solutions

Digitalisation approach: RFID enables automatic traceability and data integration

Integrable: the sensors can be built in during the manufacture



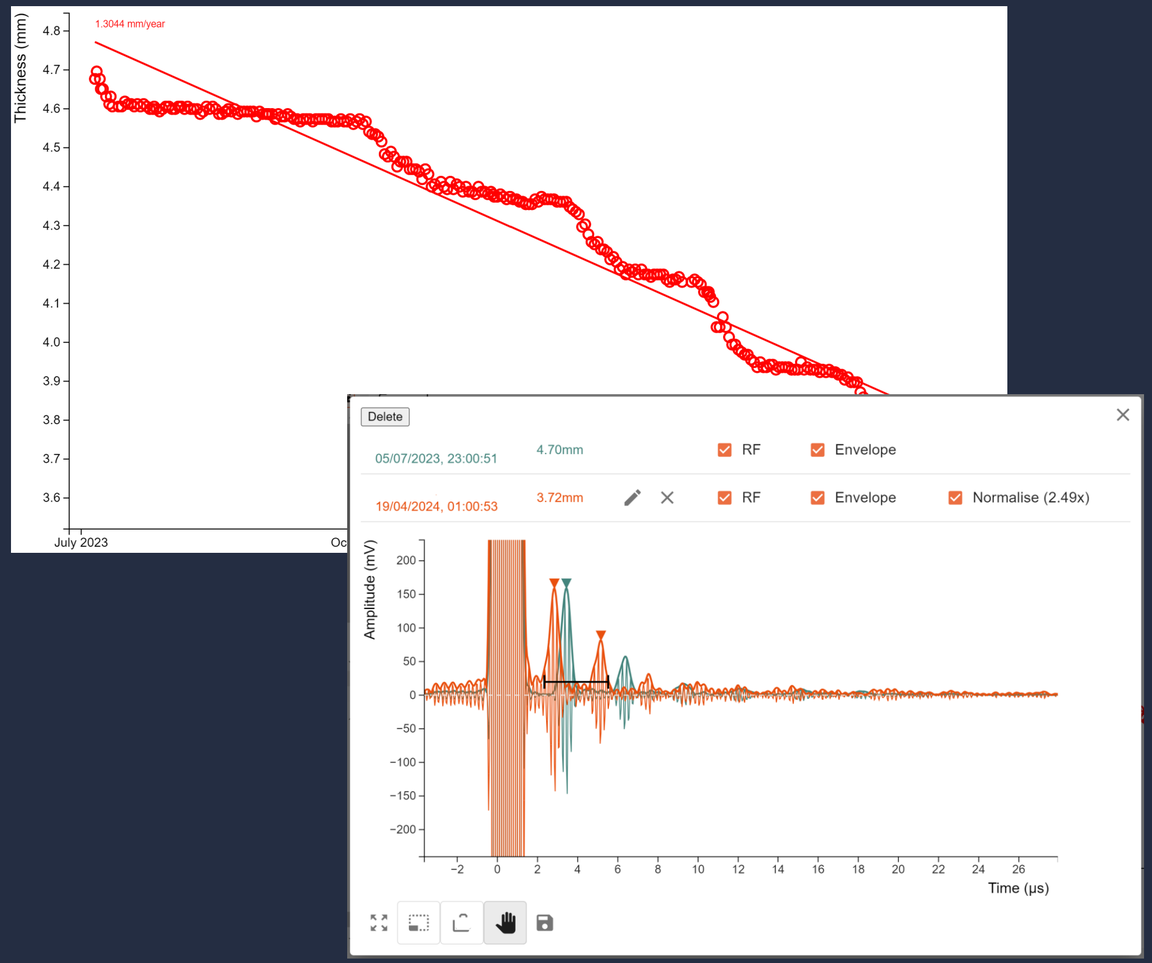
Pathway to digitalization



- Easy to upgrade/downgrade
- Consistent data
- Cost-effective
- Can be integrate to the asset management software

Pathway to digitalization – Cloud based software

- Provides enhanced data evaluation.
- Easy access to thickness data.
- Trending and analysis tools.
- Rate of wall loss
- Historical data analysis
- Configuration of WAND Devices.
- API for integration with business systems



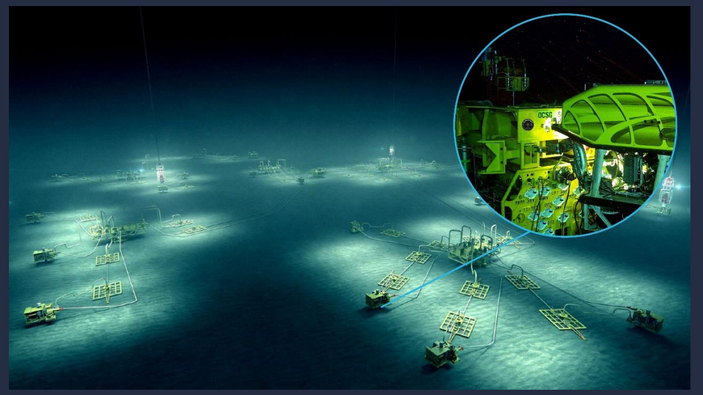
Pathway to digitalization

WAND-UAS, RDC

HDC

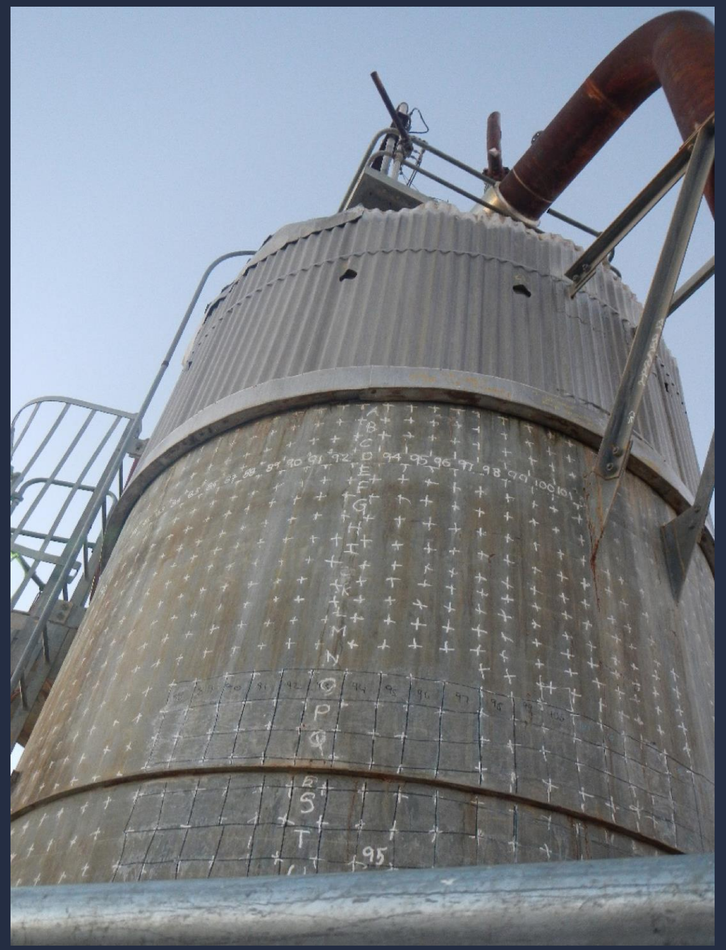
In-Tank solution

WAND-Subsea



CO2 absorber

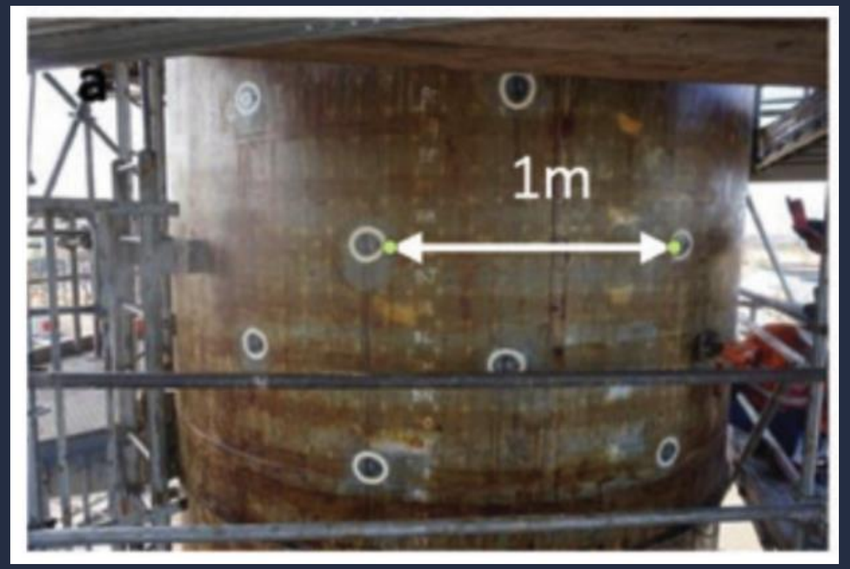
- CO2 Absorber
- Harsh environment, in the middle of a desert area
- 100 degrees C, UOP Benfield process
- Short period 3mm per month corrosion has been found on certain area due to the poor wall wetting



$$CO_2 + H_2O \leftrightarrow H_2CO_3$$

$$Fe + H_2CO_3 \rightarrow FeCO_3 + H_2$$

CO2 absorber



- 50 sensors installed with magnet and protected by coating
- Installation was carried out while the vessel was in service

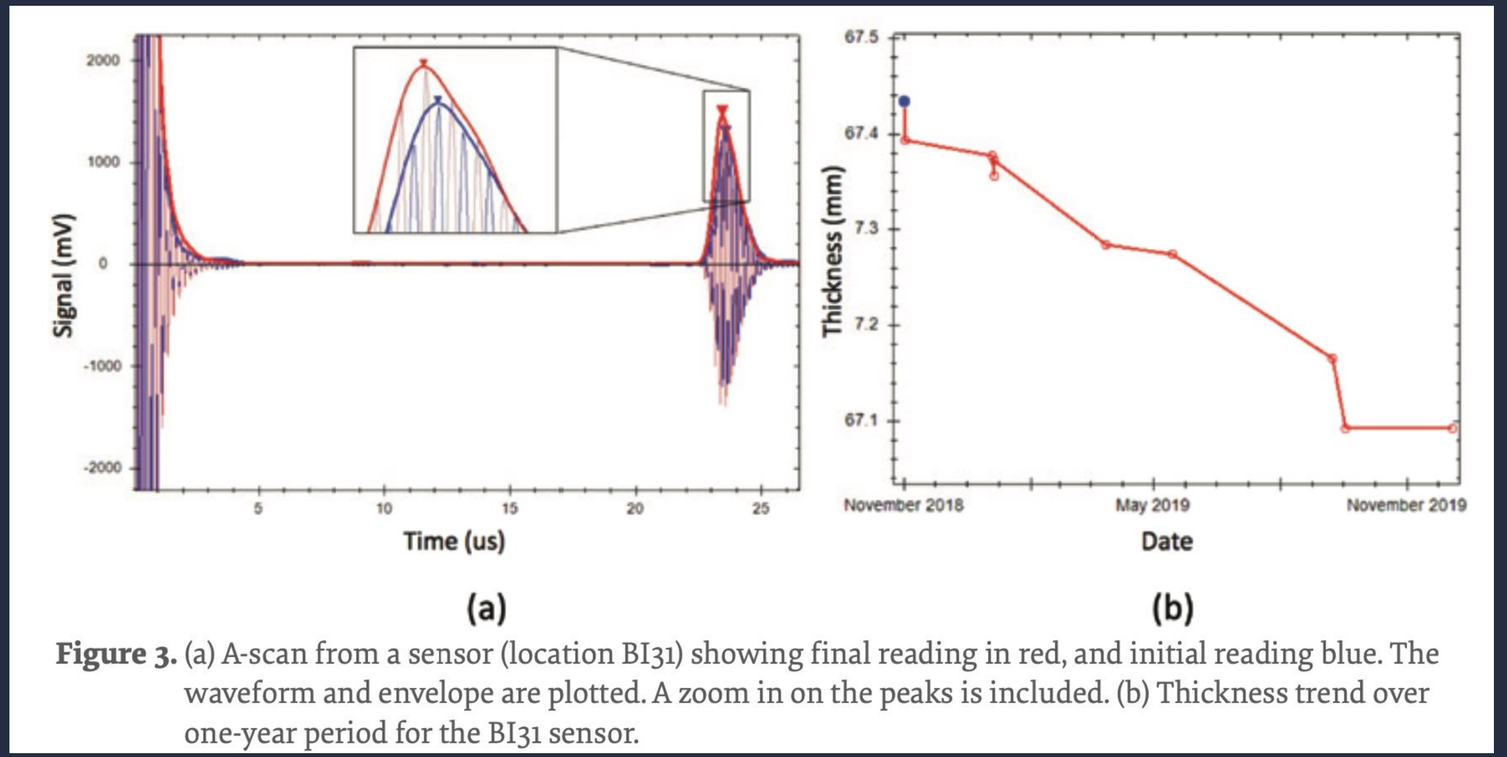
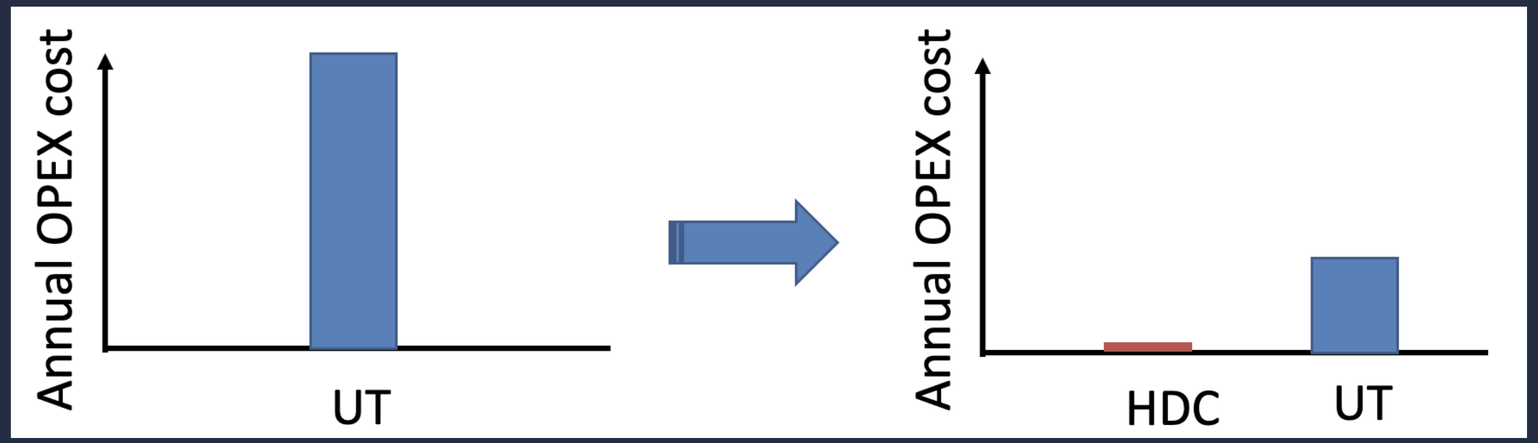


Figure 3. (a) A-scan from a sensor (location BI31) showing final reading in red, and initial reading blue. The waveform and envelope are plotted. A zoom in on the peaks is included. (b) Thickness trend over one-year period for the BI31 sensor.

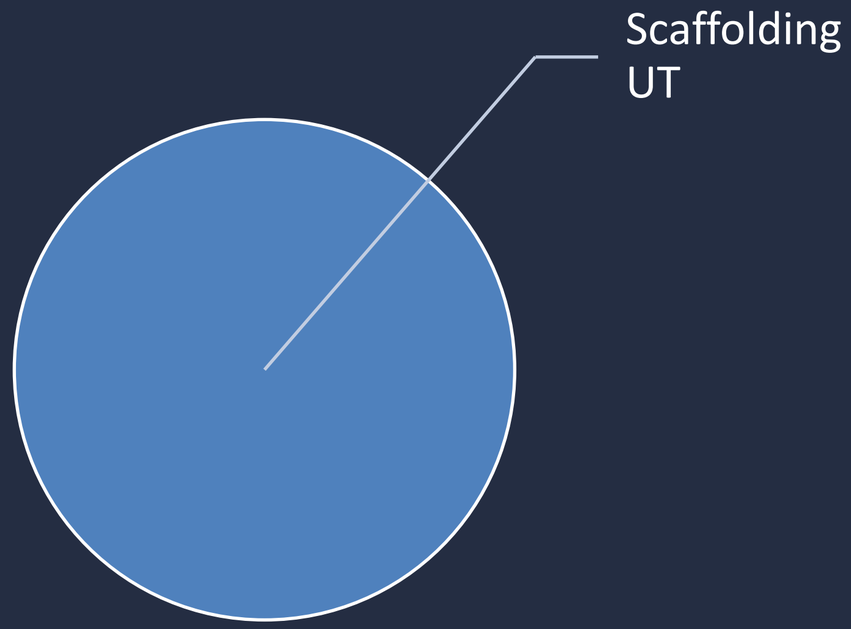
Corrosion rate mapping

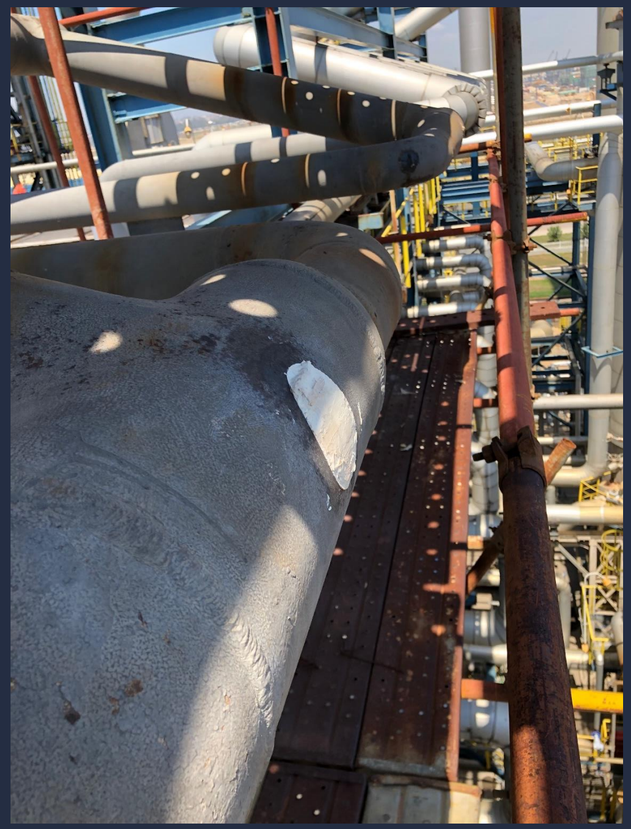
CO2 absorber



HDC have allowed the regular UT testing of the tower by rope access technicians to be extended or in some cases removed, significantly reducing OPEX costs

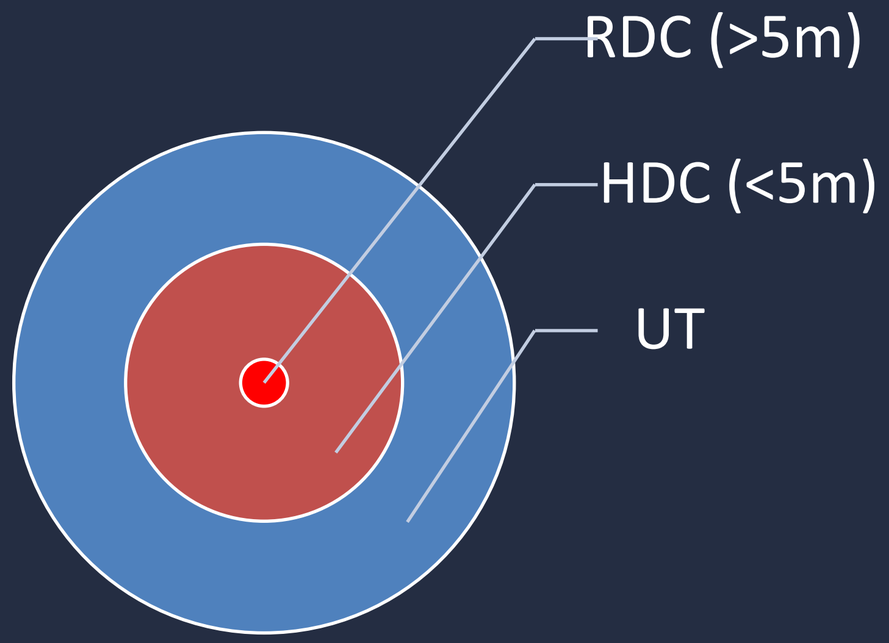
Refinery overhead pipeline

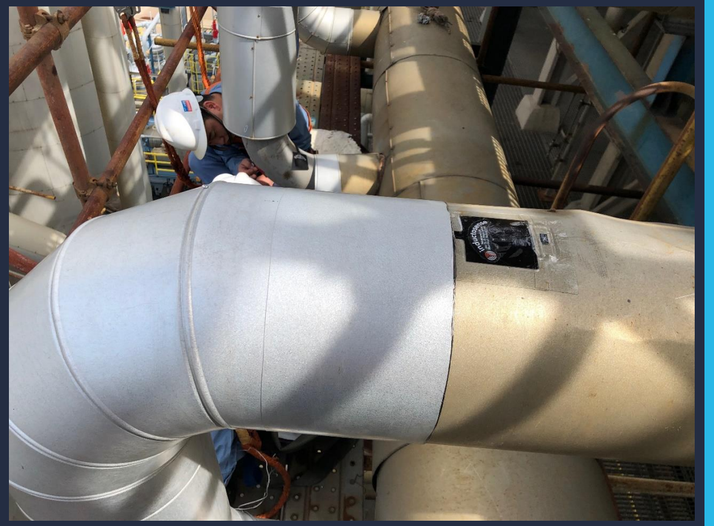




Scaffolding cost is 3X of inspection cost

Refinery overhead pipeline





752 locations with 20 RDCs, saving 1/3 access cost.

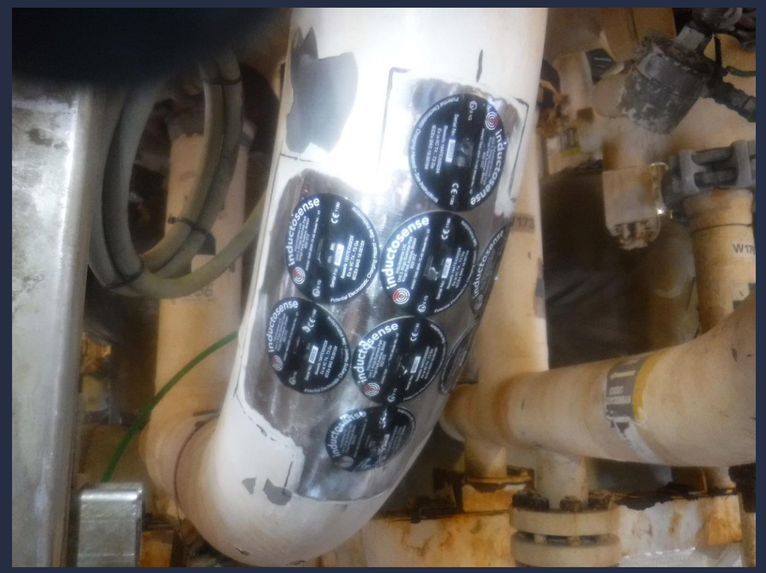
Buried pipeline

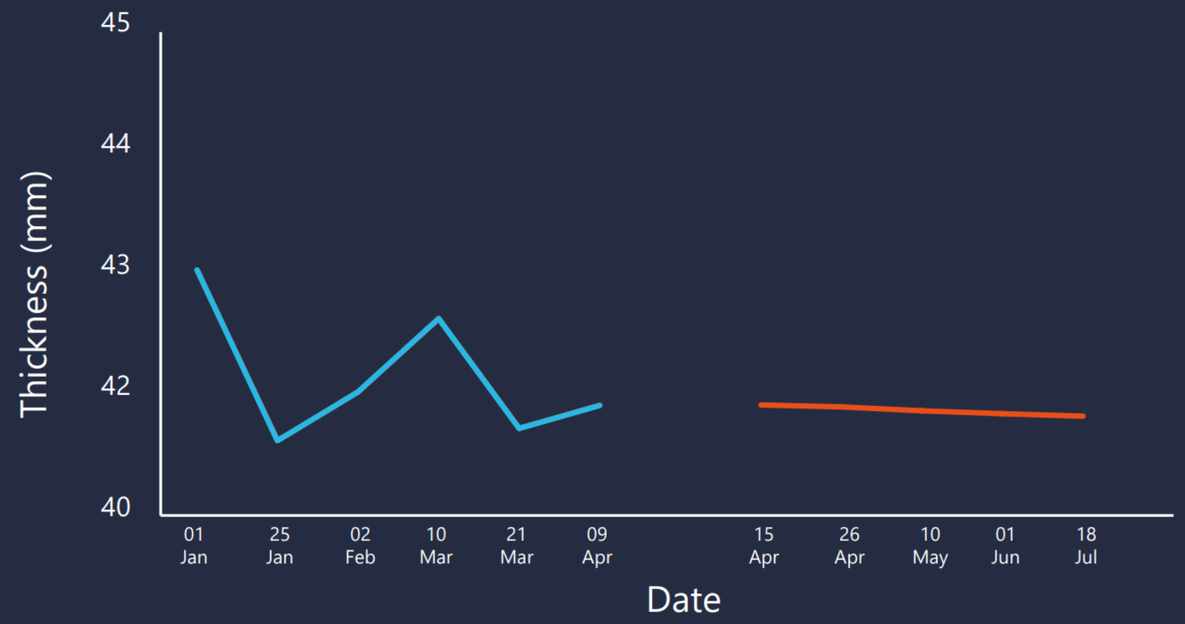
Digging cost is 10X + of inspection cost

Eliminate digging cost

Riser

- Offshore, flowline
- High erosion rate identifed at the elbows of flowline
- Sensors installed on elbows



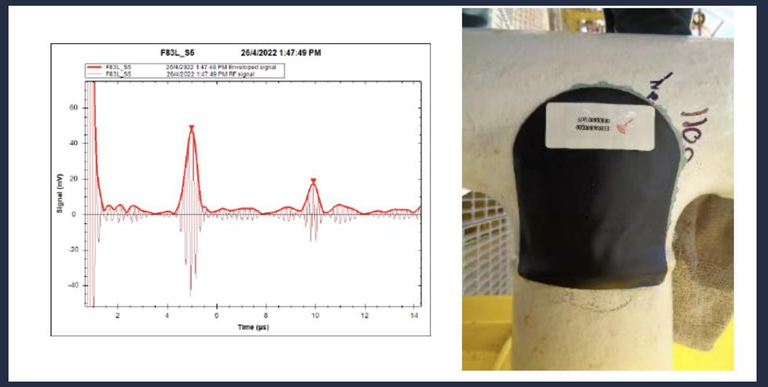


Representation of in-field data

WAND
Manual UT

Flowline

- 144 sensors were deployed in November 2021/April 2022 across a series of assets in the field.
- Application: Monitoring flow lines suffering from sand erosion.
- Three sets of data were collected from 2021-2023 where it showed stable thickness readings.
- 100% sensors performed as expected (repeatable data)
- Max erosion rate of 1.02 mm/yr have been detected and trended.

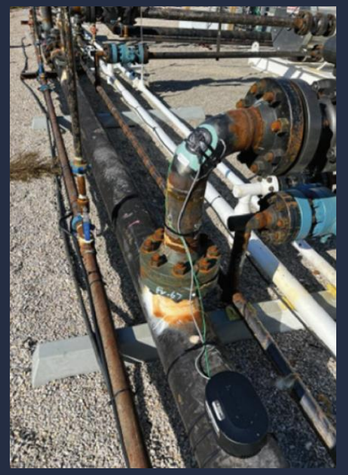


Flowline

					Nov-21	Apr-22	May/June-23			
N0	Platform	WELL	Component	Accesibility	WAND Reading, mm	WAND Reading, mm	WAND Reading, mm	RFID	Sensor	Remarks
1			Tee	Low level	10.81	10.8	10.82	1D70		
			Equal Tee	Low level	8.31	7.79	7.79	17A3		
			Tee	Low level	15.74	15.73	15.75	1D71		
			Equal Tee	High level (accessible using Reach tool)	8.5	7.95	n/a	17A5		High Level
			Tee	Low level	n/a	7.76	7.76	1A7A		
2			Center Tee	Low level	15.08	15.05	15.00	1D7A		
			Equal Tee	Low level	14.72	14.67	14.63	1D7C		
			Equal Tee	Low level	15.08	15.04	n/a	1D7E		Accessible using Reach Tool
			Equal Tee	Low level	15.24	15.21	15.16	1D7D		
			Equal Tee	High level (accessible using Reach tool)	16.44	14.91	n/a	1D7B		Accessible using Reach Tool
3			Elbow	Low level	8.69	8.1	8.1	177A		
			Elbow	Low level	6.09	5.55	4.53	176B		
			Tee	Low level	9.34	8.74	8.74	177D		
			Tee	Low level	11.23	10.65	10.68	176C		
4			Reducer	Low level	12.73	12.18	12.20	17B0		
			Center Tee	Low level	12.35	11.76	11.74	17AE		
			Straight pipe	Low level	8.68	8.28	8.22	1D6F		
			Center Tee	Low level	10.29	9.73	9.74	179E		
6			Equal Tee	High level (accessible using Reach tool)	9.03	8.46	n/a	17A2		High Level
			Elbow	High level (accessible using Reach tool)	7.71	7.14	n/a	179F		High Level
			Elbow	High level (accessible using Reach tool)	8.09	7.54	n/a	1785		High Level
			Elbow	High level (accessible using Reach tool)	8.13	7.62	n/a	17A1		High Level
			Elbow	High level (accessible using Reach tool)	7.77	7.25	n/a	1784		High Level
			Tee	Low level	n/a	7.48	7.33	1A7B		
7			Reducer	Low level	12.14	11.6	11.6	17B3		
			Tee	Low level	8.11	7.55	7.56	17A7		
			Equal Tee	Low level	7.73	7.17	7.16	17B2		
			Equal Tee	High level (accessible using Reach tool)	8.61	8.08	8.11	17B1		
8.			Straight pipe	Low level	9.07	9.07	9.07	176D		Different sensor name detected.

Increasing flow rates at shale gas well pad

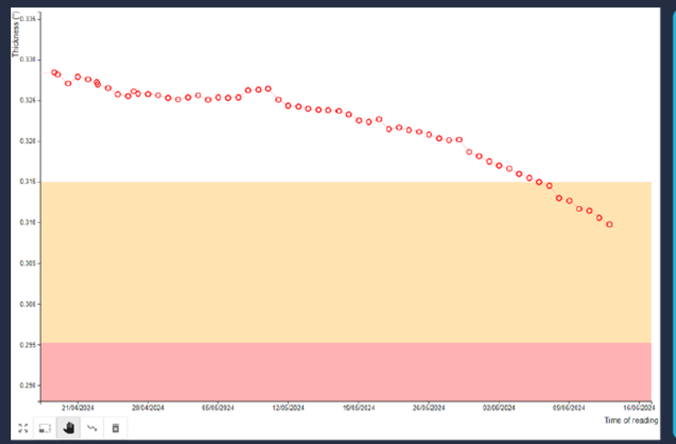
- Remote shale gas well pad in Ohio, USA
- 54 sensors, 9 RDCs and 1 WAND-Gateway (4G)
- On sand traps and Gas processing units (GPUs)
- Goal: Precisely and remotely measure the effect of increased flow rates on the rate of sand erosion.



Increasing flow rates at shale gas well pad

Results:

- Enabled the safe increase of production rates
- Yielded accurate, daily erosion rates



- Figure 1: Thickness loss trend line over 2-month period.
- Orange section represents warning thickness set by the user.
- Red section is the end-of-life thickness set by the user.

Impact

- Increased production rate by 50% -> **Additional $43,000/day**
- Savings of 840 hours of NDT personnel work per month -> ROI within 1 month
- Minimised well downtime and prevented potential unplanned shutdowns
- Minimised maintenance through optimisation

Corrosion system integration

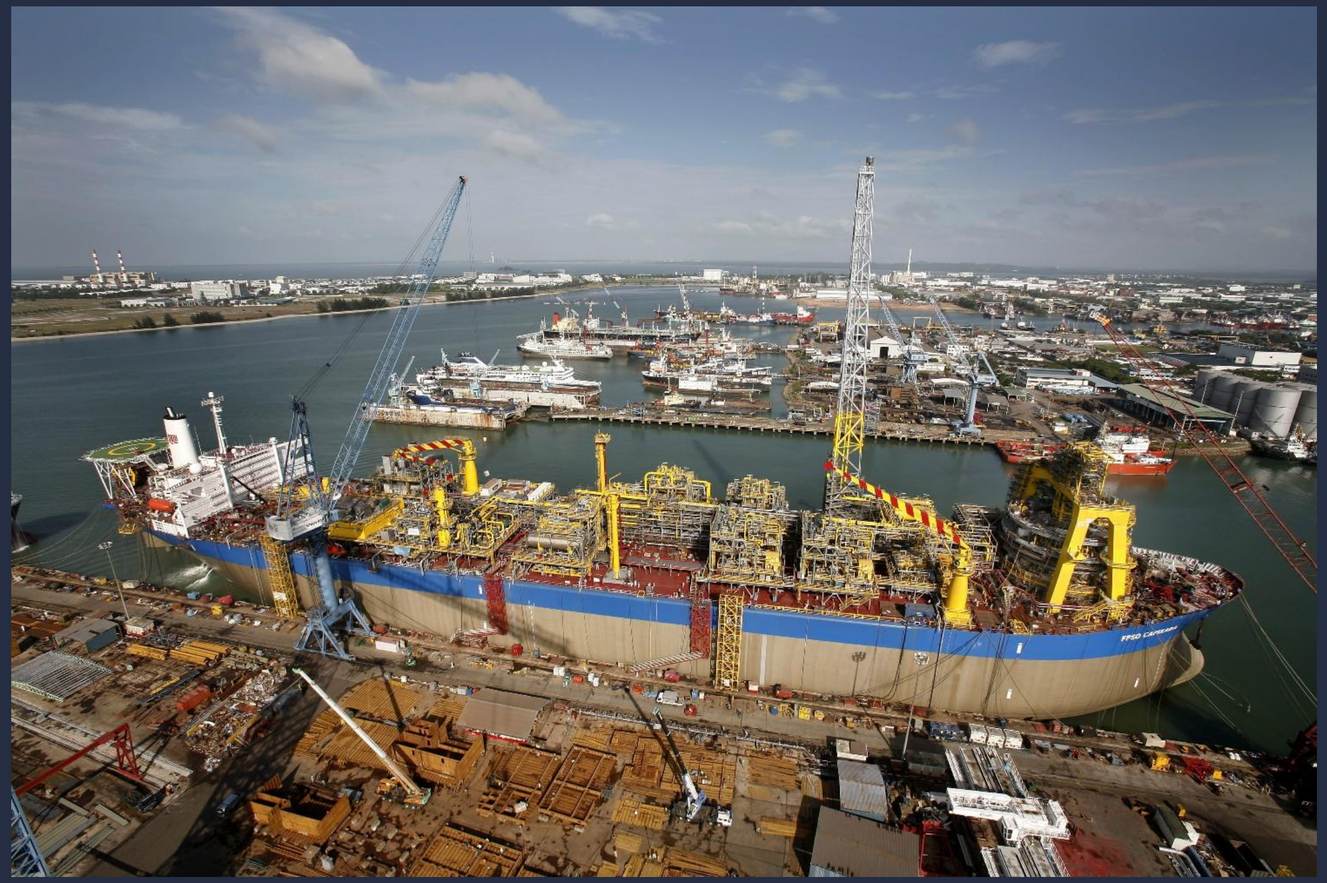
WAND TM Sensor installed on 6" pipe.

Composite repair applied over sensor.

Pipe samples following pressure testing.

← Can easily detect thickness of steel through coating

OEM integration



Digitalization to NDE 4.0

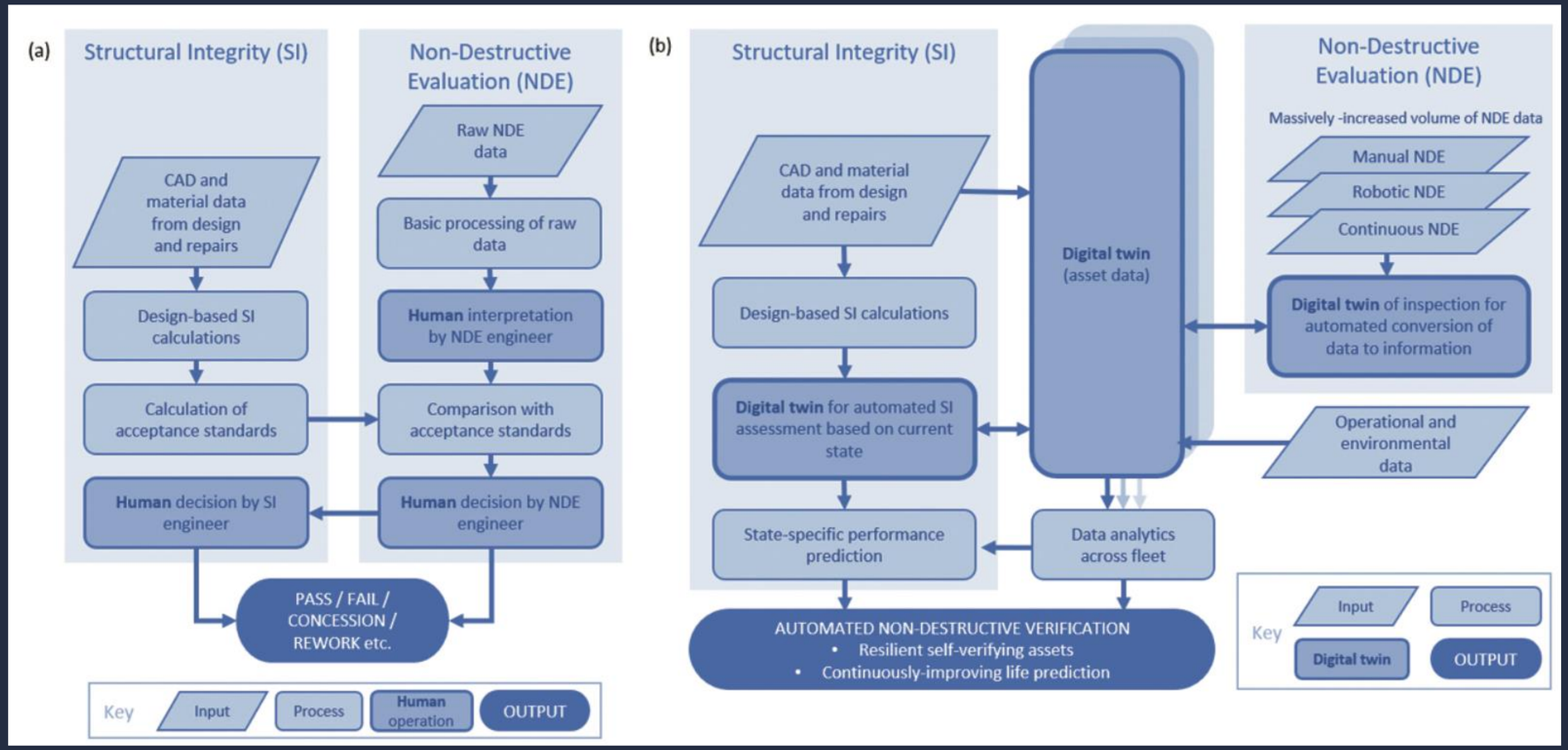


Figure 1. Schematic illustration of (a) the current standard NDE decision-making process about the fitness for purpose of an asset, compared with (b) the potential future state – Automated Nondestructive Integrity Verification (ANDIV) – where human inputs are moved to the process-design and verification stages. Ref: Advances in the UK Toward NDE 4.0

Get in Touch …

erik.fabre@inductosense.com
naceur.abdouni@inductosense.com
+44 117 403 4047