SONOMATIC

RISER INSPECTION

CAPABILITIES STATEMENT

ADVANCED INSPECTION SOLUTIONS

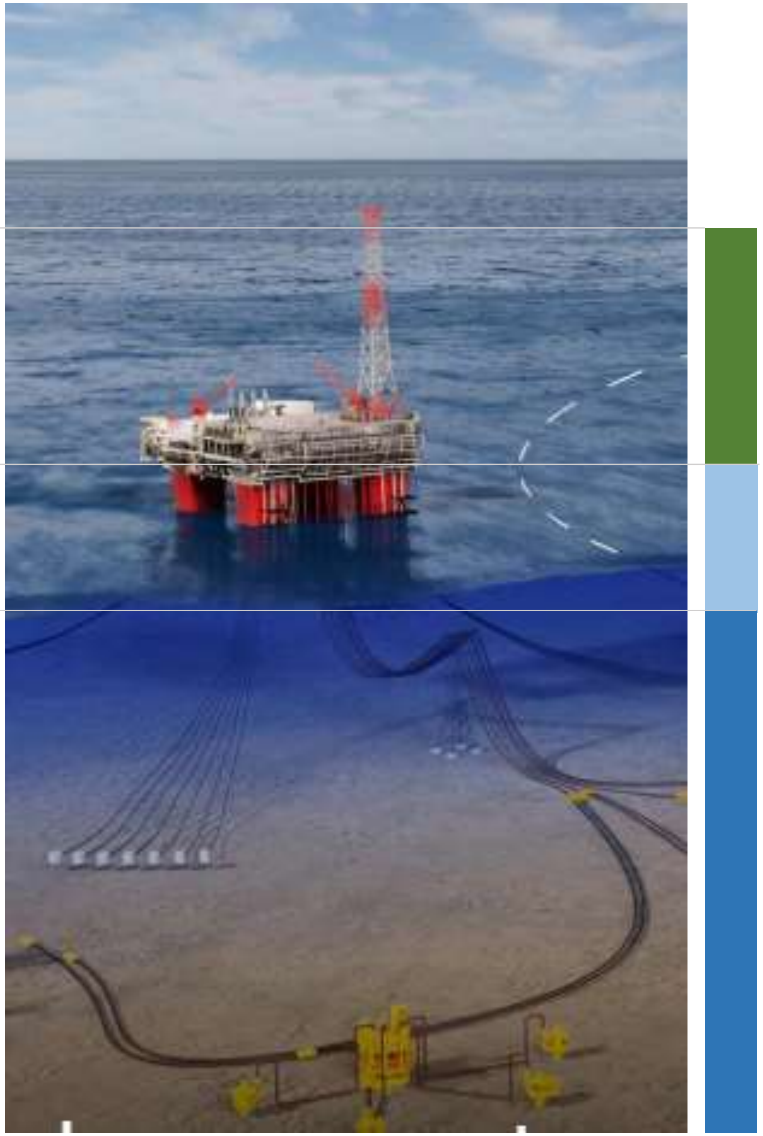
MEC & SUBSEA ROBOTICS

February 2023

In partnership with IEV

Focus

Understand the needs and work with the Clients on their specific tasks



Zone	TARGET	TASKS
TOPSIDE	• Pressure Vessels • Piping	✓ Corrosion mapping ✓ MIC – Microbiological Corrosion detection ✓ CUI – Corrosion Under Insulation detection ✓ Insulated and Coated lines Corrosion mapping ✓ Caviblaster and HPWJ Cleaning ✓ Visual inspection (GVI/CVI) ✓ NDT Inspection above/below water ✓ Screening and Quantitative Inspection ✓ Flexible Risers flooded annulus detection ✓ Flexible Riser armor defects mapping ✓ Automated Subsea Inspection ✓ Bends Inspection ✓ Photogrammetry ✓ Measurements ✓ 3D modeling ✓ Life Extension ✓ Weld Inspection ✓ Critical Girth Weld inspection ✓ Tension Leg Girth Weld inspection ✓ Flow Assurance ✓ Emission Monitoring ✓ Oil pollution and emission detection
SPLASH ZONE	• Risers • Caissons • Conductors • Structures • Flex Joint • Fairleads • Mooring Chains • Tension Legs • Hulls • Cargo and Ballast Tanks • Spider Buoys	
SUBSEA	• Pipelines • Flexible Risers • Steel Catenary Risers • Tendons • Mooring Lines • Umbilicals	

Value Proposition

Mission Oriented Integrated Robotic Solutions

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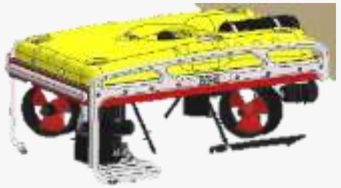
- Subsea Robots
- Crawlers
- ROV
- AUV
- USV


CARRIERS

ACFM – Alternate Currents Field Measurement
EMAT Electro Magnetic Acoustic Transducer
MEC – Magnetic Eddy Current
TOFD – Time of Flight Diffraction
PAUT – Phased Array Ultrasonic Testing
AUT – Automated Ultrasonic Testing
DRS - Dynamic Response Spectroscopy
CT – Computer Tomography
Multiskip Screening

HD Cameras
Photogrammetry Kit
3D Sonar

Caviblaster – Cavitation Blasting
HPWJ – High Pressure Water Jet

PAYLOADS

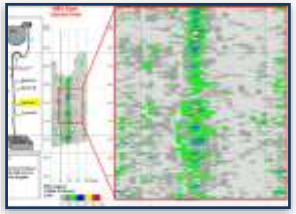
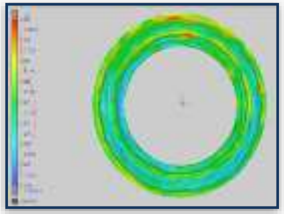
OPERATIONS

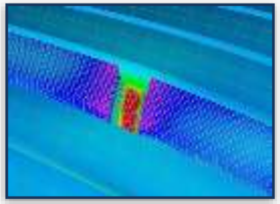
- Worldwide Footprint
- R&D
- Engineering
- Project management
- Operation management
- Remote Operations
- Training

DATA

From data to actionable information

- Real Time Info
- Custom software
- Communications
- Custom Reports



Value Proposition – Why Robotics

The SAFER OPERATIONS, OPERATIONAL COST REDUCTION and LOWER CARBON FOOTPRINT are the main drivers for implementing robotic intervention and inspection.

Intervention and inspection techniques are well known and mature, current efforts are focused on making them suitable to be carried by remotely operated vehicles.

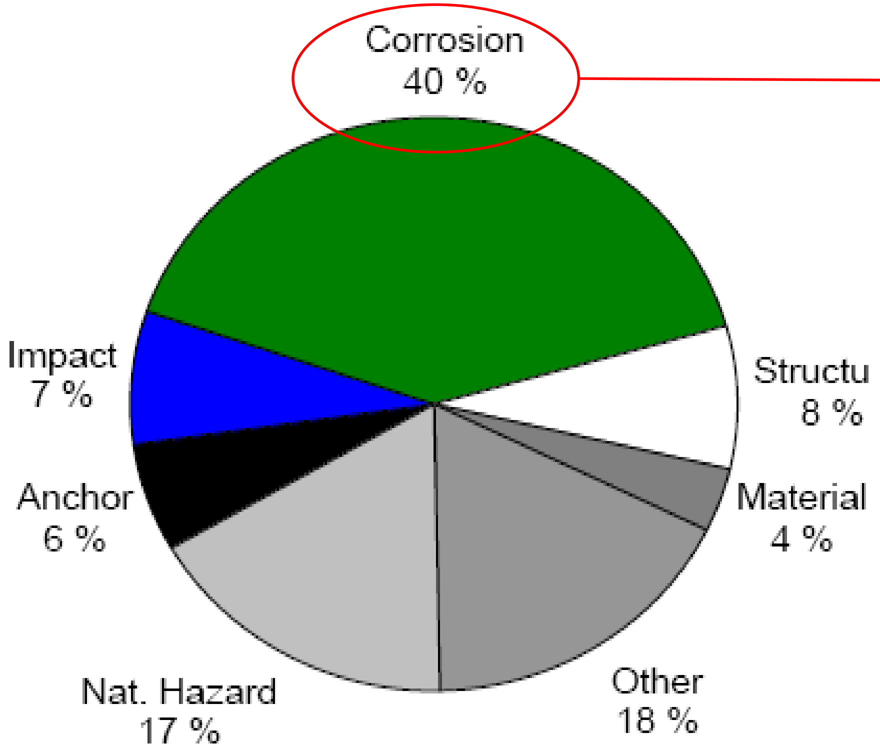
During the last five years robotic crawlers and subsea tooling have been developed and used to carry specific tasks on subsea pipelines, both rigid and flexible risers and structures.

PLATFORM BASED SOLUTIONS *RESIDENT VEHICLES* *RAPIDLY DEPLOYABLE ASSETS* *COMBINATION CRAWLER / ROV*

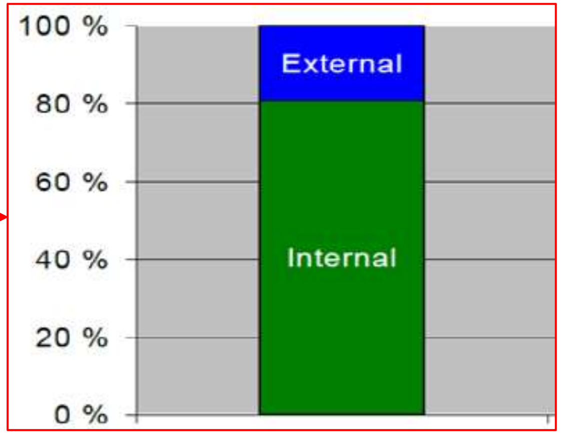
SPECIALIZED INSPECTION ROBOTS *SHARED TOOLBOX* *REMOTE OPERATIONS* *BESPOKE INSPECTION TECHNIQUES*

Problem Statement

WHY DO SUBSEA ASSETS FAILS?



The Gulf of Mexico



Ageing pipeline

- Coating breakdown
- CP system not functional
- Under deposit corrosion
- Corrosion Under Insulation (CUI)

Fluids

- HP/HT, Sour fluids
- Microbial Corrosion (MIC)
- Change from Design

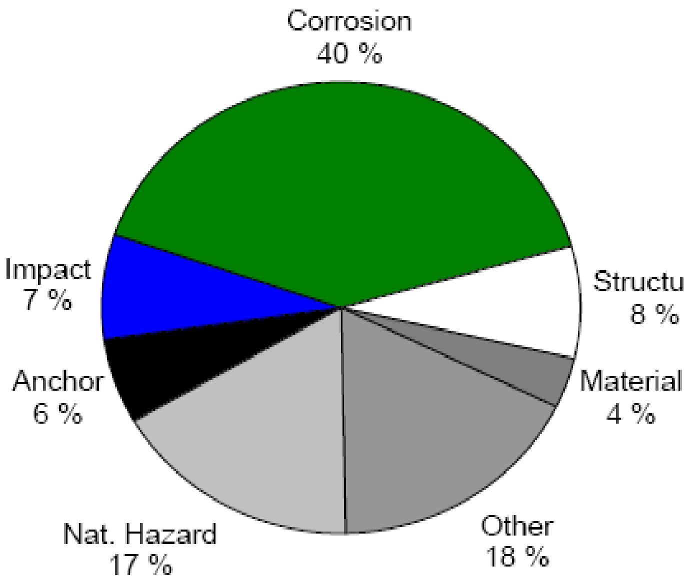
Increasing inspection capabilities to obtain reliable assessment data is critical

Sources: DNV GL and PARLOC 2001 HSE for PIPELINE failure

Problem Statement

WHERE DO SUBSEA ASSETS FAILS?

The **Splash zone** is probably the most critical area for Risers, Caissons, Conductors, Structures.



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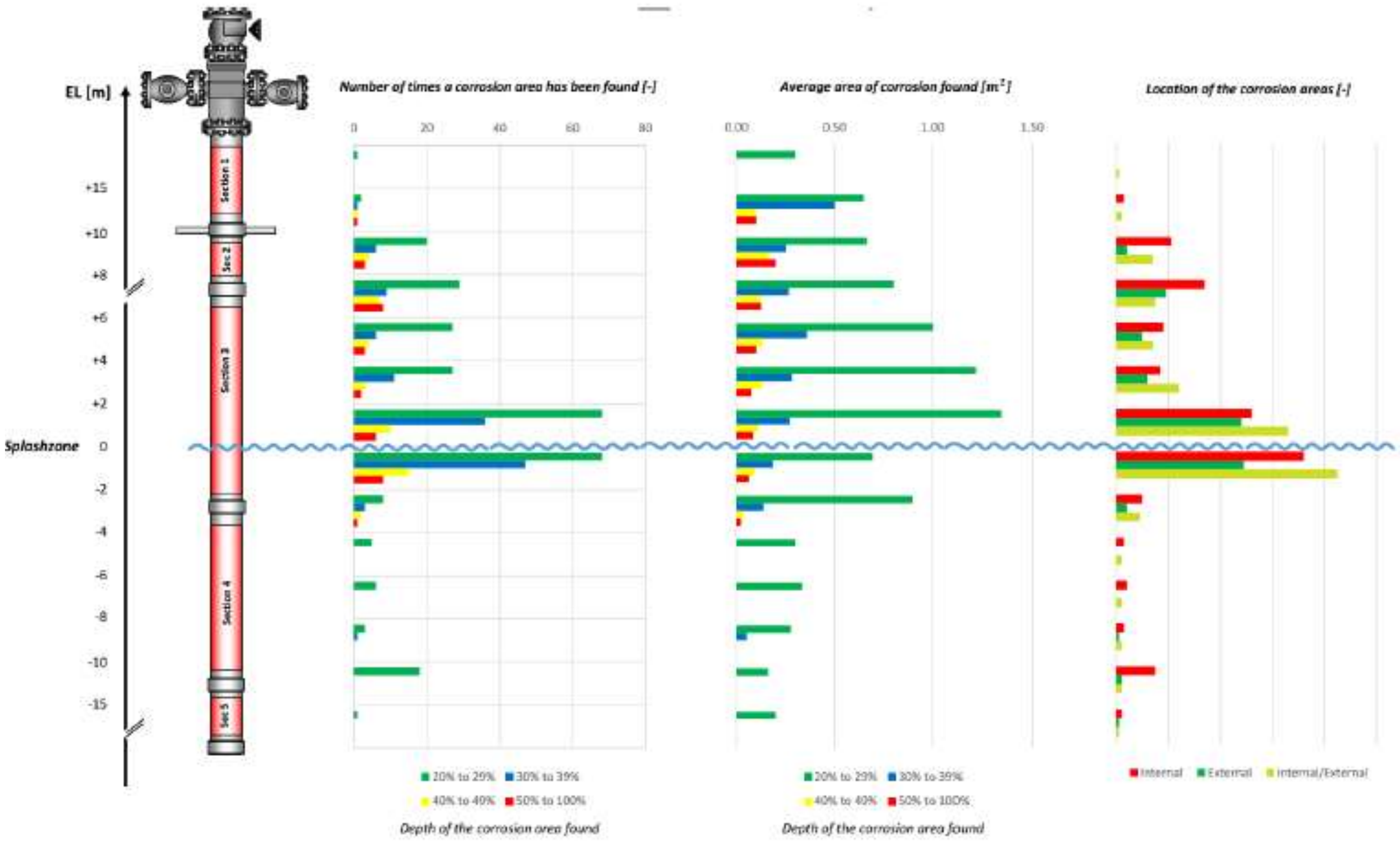


In partnership with IEV

Value Proposition

ELECTROMAGNETIC NDT TECHNIQUES

MEC – Magnetic Eddy Current

PECT – Pulsed Eddy Current Testing

MEC and PECT are **complementary** and **redundant** techniques to increase the accuracy of the detection and reduce false positive. The MEC technique with its accuracy and speed is more efficient and covers more area in a shorter time as compared with conventional radiography.

MEC is the tool of choice for straight pipe runs. However for complex geometries like pipe bends, PECT technology complements MEC and also provide redundancy.

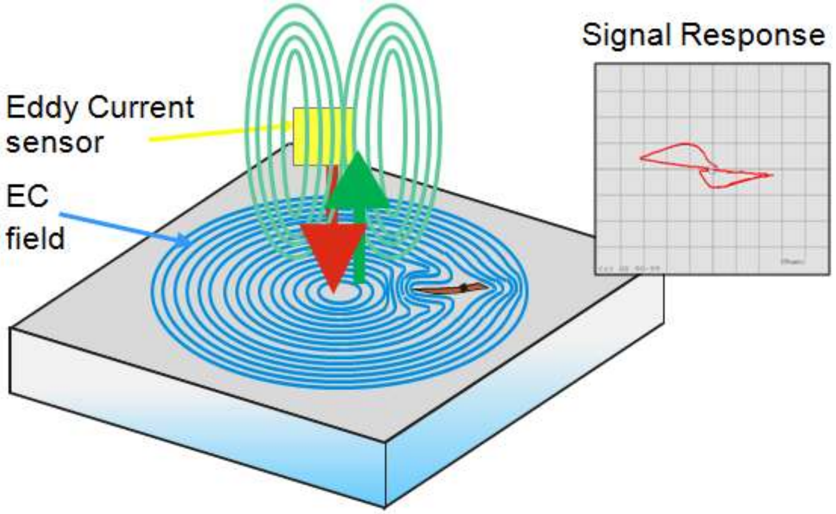
	MEC Technology	PECT Technology
Speed	High - as fast scanning (1ft/sec)	Low – as static measurement (2 sec each)
Resolution	Axial: ≥2mm (5/64’’), Circumference : ≥10mm (0.39’’)	General : ≥ 50mm x 50mm (2’’ x 2’’)
Accuracy	Range: +/- 10% (to potential +/- 5%)	Range ≥ +/- 10%
Geometry reach	Straight pipe areas	Straight and bend pipe areas

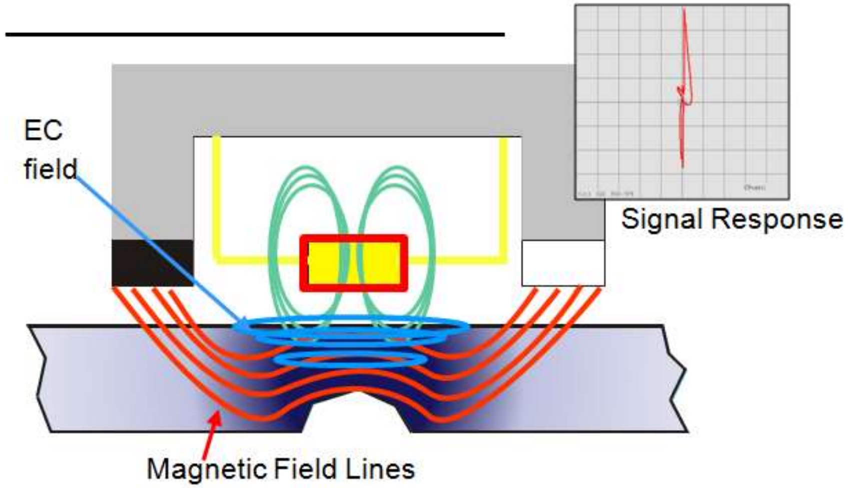
MEC – MAGNETIC EDDY CURRENT

The MEC technique combines DC (Direct Current) magnetic field lines with AC sensing field lines (Eddy Currents) – both induced in the material to be inspected. Measurement by Eddy Currents how the magnetic flux is distorted by a defect.

Defects either side of the wall – if isolated small pit or larger corrosion areas - provide a change of the induced magnetic field line in the wall which can be measured.

The signal information (amplitude, phase, shape) provides online analyzable details related to **WALL LOSS**, **SIZE OF THE DEFECT** and **POSITION**.





Technology

Why MEC?

The key advantage is the *capacity to rapidly screen large surfaces with or without coating and detect reliably very small and isolated corrosion*.

Fast Scanning – accurate ad highly reliable

Versatile – carriers for onshore, offshore, and robotic applications

Non-Conventional and Conventional Inspections – tailored or standard

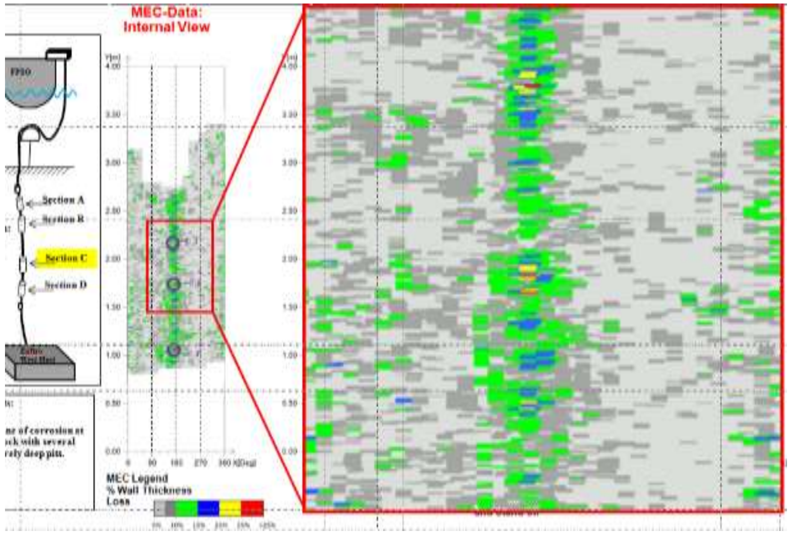
KEY FACTS

- IN-SERVICE INSPECTIONS
- FAST SCANNING
- INSPECT THROUGH VARIOUS TYPES OF COATINGS
- LOW INSPECTION PREPARATIONS
- HIGH POD - PROBABILITY OF DETECTION
- HIGH ACCURACY
- HIGH SENSITIVITY
- INTERNAL/EXTERNAL DEFECTS DIFFERENTIATION
- DETECTION OF ISOLATED PITS, CORROSION AREAS, CRACKS
- C-SCAN WITH MAPPING
- COST EFFECTIVE

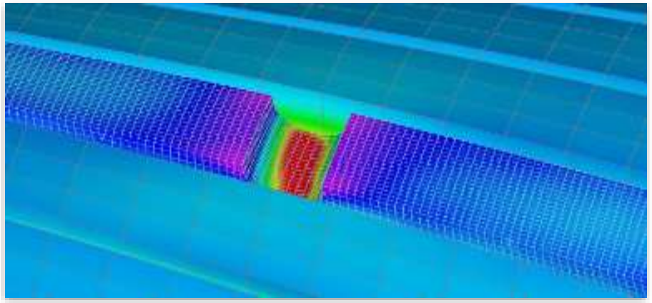
MEC – MAGNETIC EDDY CURRENT

The technique allows to **scan through coatings**.
Its high resolution identifies small volumetric isolated pitting up to general wall loss from inside or outside of the wall.

The technique **requires little to no preparation** scanning above and below water with high speed and high accuracy.
Well usable as fast scanning and mapping technique for **larger areas and distances in short time** above and below water.



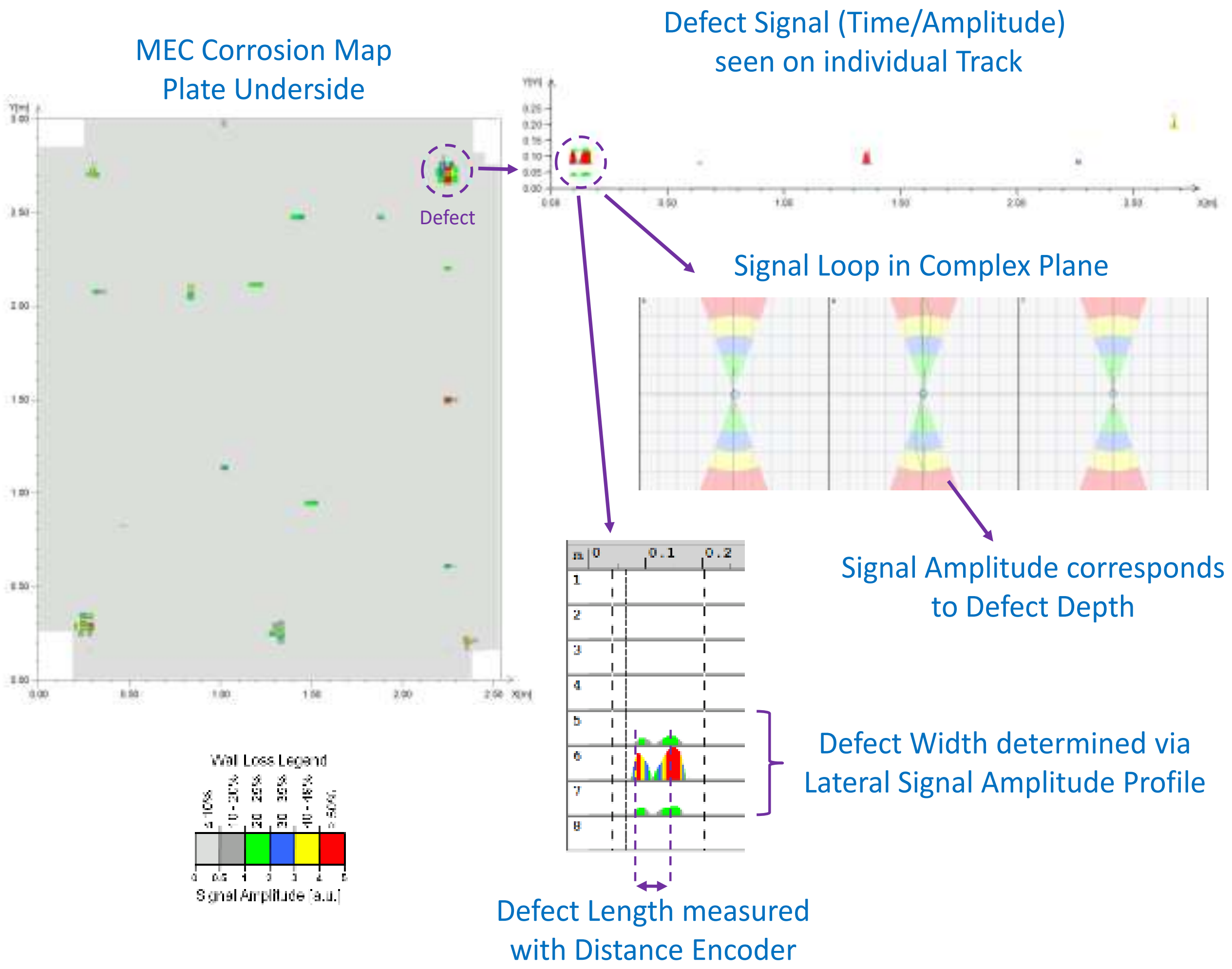
Indication	EL [m]	Orientation [deg]	Length [mm]	Width [mm]	Surface Location	Max. Wall Loss [%]	Description
1	0.80	105	200	60	external	25	
2	-3.20	230	20	20	internal	20	
6	-6.00	170	50	30	internal	40	
7	-6.45	220	30	40	internal	45	
8	-6.70	50	50	50	internal	45	
9	-6.85	220	30	30	internal	50	
10	-6.90	240	25	30	internal	[illegible]	



Displaying and c-scan mapping the internal and external wall condition separate as well as combined is possible as well as individual defect sizing.

MEC – MAGNETIC EDDY CURRENT

Analysis process for an individual underside defect



Typical Performances

POD
>95% of defects >30% wall loss

Defect Detection of Internal & External Wall Loss
- from 10% loss of nominal wall
- from ~ Ø 5mm

Sizing Accuracy
- fast analysis +/- 10% of given wall loss
- in depth analysis +/- 5% of given wall loss

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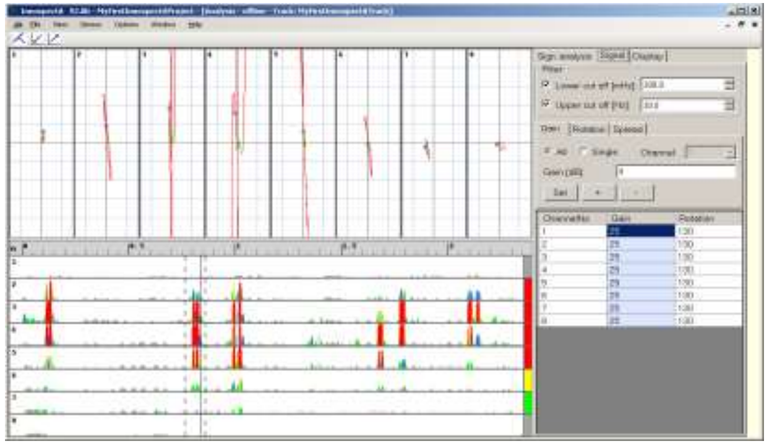
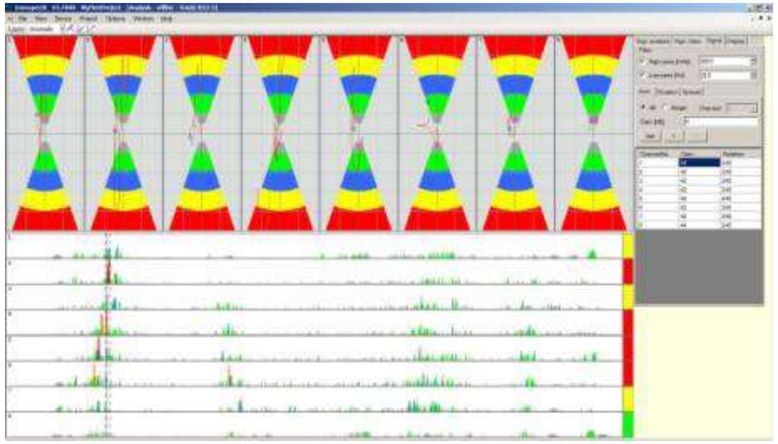
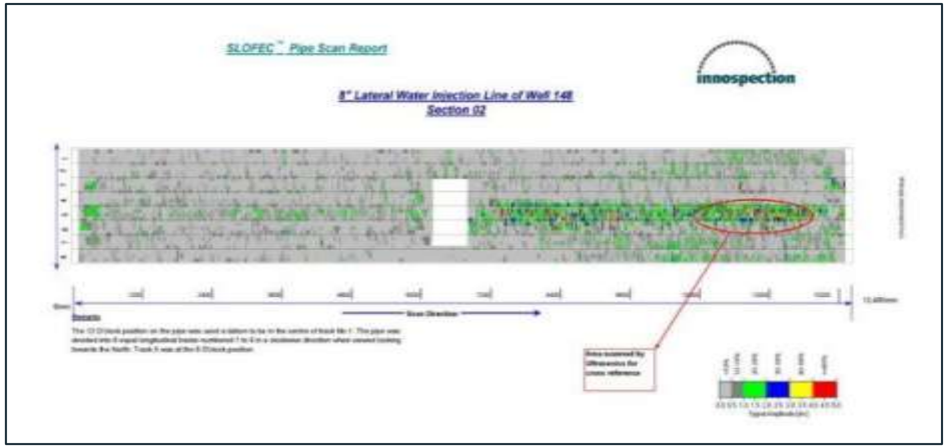
MEC – SOFTWARE







The INSPECTION MODE is used for data acquisition. The signal is displayed in real time. Settings can be changed and optimized for the required inspection task. The signals for one inspection track are acquired and saved. A sequence of all tracks as defined in the layout mode can be run through.

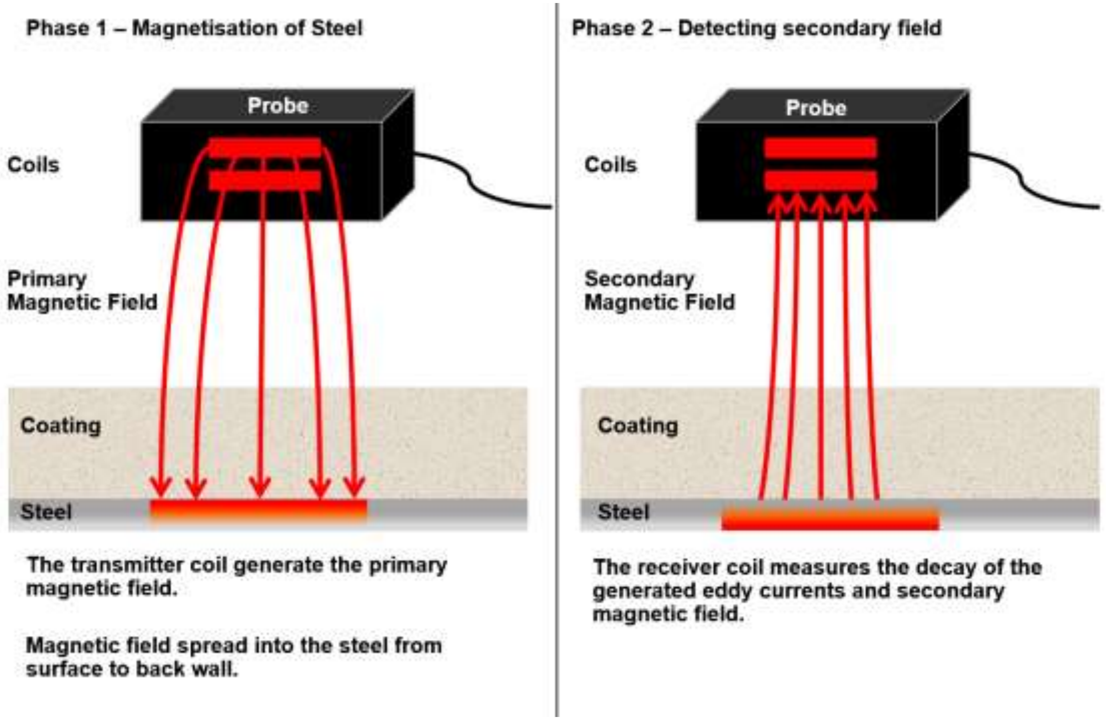
The ANALYSIS MODE is used to recall previously saved data and display it again on the screen. It can be replayed with different speeds. Settings can be changed and the changes can be saved. The data can be displayed in different configurations. Bitmaps or other formats can be exported to allow compiling a report.

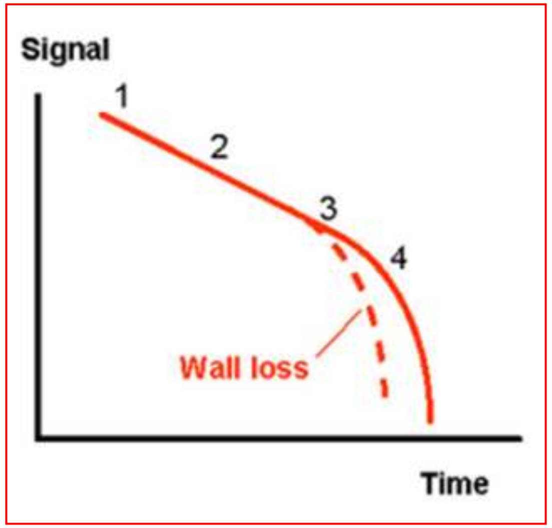
In the LAYOUT MODE the structure that is to be inspected can be defined. Signal data can be assigned to the geometric structure to georeference the defects. A report containing so called C-scans can be printed.

PECT – PULSED EDDY CURRENT TESTING

The Pulsed Eddy Current Technique is a static type electromagnetic measurement technique.

The sensor placed at the point to be inspected (footprint) generates electromagnetic pulses to the steel to be inspected. The pulsed primary field generates an eddy current field in the material which responses with a secondary field. In case of wall loss area larger than 10% than the footprint, the receiver coil measures the decay of the secondary field with a decreased response time which demonstrates wall loss.





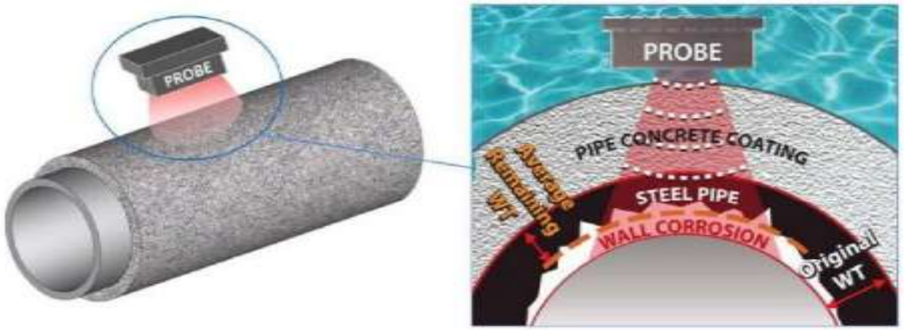
Technology

PECT – PULSED EDDY CURRENT TESTING

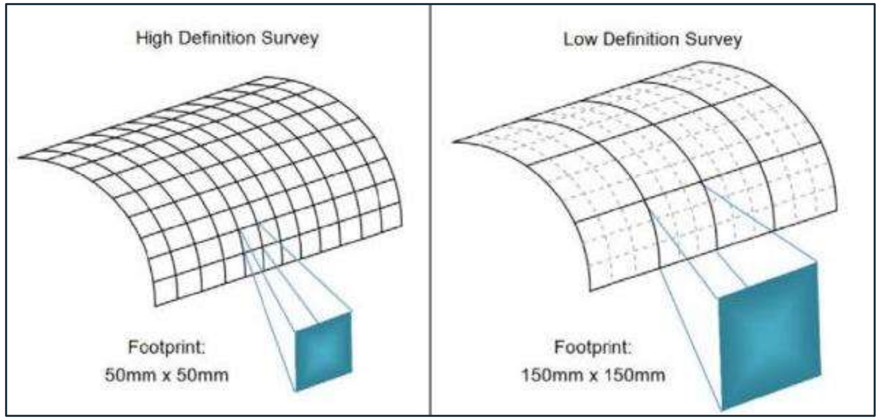
This PEC inspection is capable to be performed through thick coatings or insulations of up to 8”. As an electromagnetic technique it won’t require preparation or coating removal.

PECT is used on:

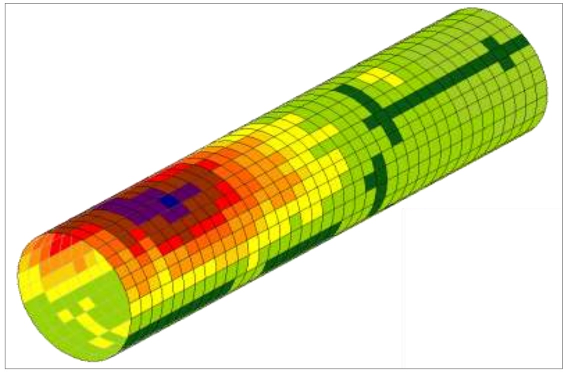
- Non-metallic pipe protection (concrete, composite wraps, coatings, and more)
- External corrosion product as blisters
- Corrosion under insulation (CUI)
- Marine growth
- Limited access areas as elbows, supports, valves



The measurement in the footprint area provides an average wall loss information.



Acquisition can be performed in high and low resolution for fast screening.



Color coded wall thickness readings are displayed on the laptop during data recording. An Excel file can be produced as well.

Technology

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GW – MAGNETOSTRICTIVE SENSOR-BASED GUIDED WAVES

GW is used on:

- Inspection of pipes under **Clamps** and **Supports**

- Computer-controlled through USB
- Small and lightweight
- Multi-frequency (20 to 128 kHz)

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SUBSEA / SPLASH ZONE – MEC COMBI FAMILY

MEC Combi Crawler

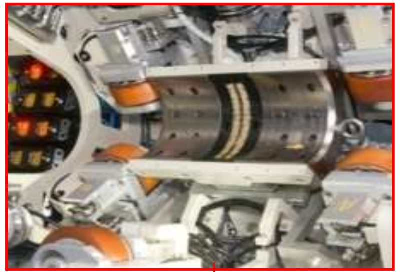
MEC MPS200+

MEC-Combi Pipe Crawler V1

MEC-Combi Pipe Crawler V2

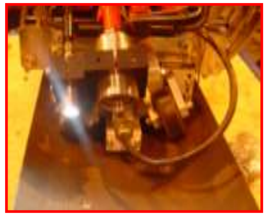
MEC – Hug Crawler

Core: **MEC** Pole Shoe & Sensor Array
Focus: external/internal corrosion Mapping



ADD-ON Techniques for MEC-Combi concept

UT Array
Absolute WT Mapping



PEC
Average WT Mapping

Eddy Current Array
Crack Detection

Subsea Laser
Geometry Scan

HD Camera
Visual Inspection

Applications

- Pipe OD : 2" to flat
- Wall Thickness Range : Up to 1 ½ "
- Coating: Up to ½ "
- Length Range : Not limited;
- Temperature Range : 200°F / 90°C
- Inspection Coverage : 360° with multiple pass

Typical Performances

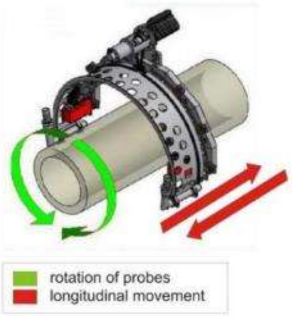
- POD >>95%
- Ability to distinguish internal/external defects
- Fast scanning, max speed 90ft/min (30m/min)
- Accuracy typical +/- 10%, (fine tune +/- 5%)
- Smallest Defect Size: Ø 3mm
- Resolution: 2mm axial 10mm circumferential
- Sizing Depth +/- 5% to 10% of nominal Wall Thickness
- Wet/Dry inspection technique; no couplant and no coating removal required
- Capable of online pre-analysis of data with offline final data analysis

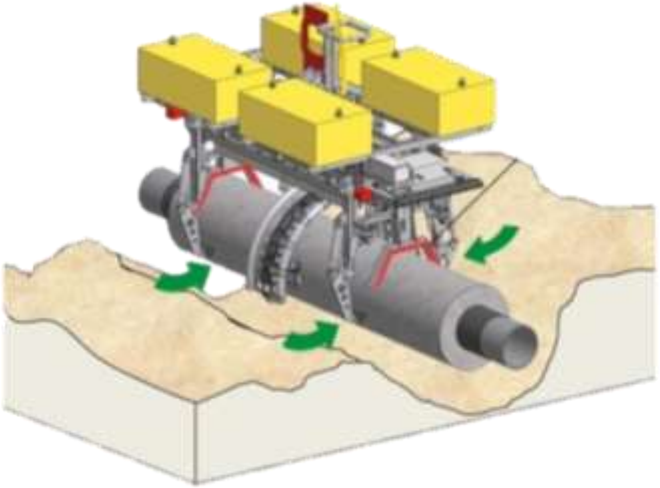
Equipment

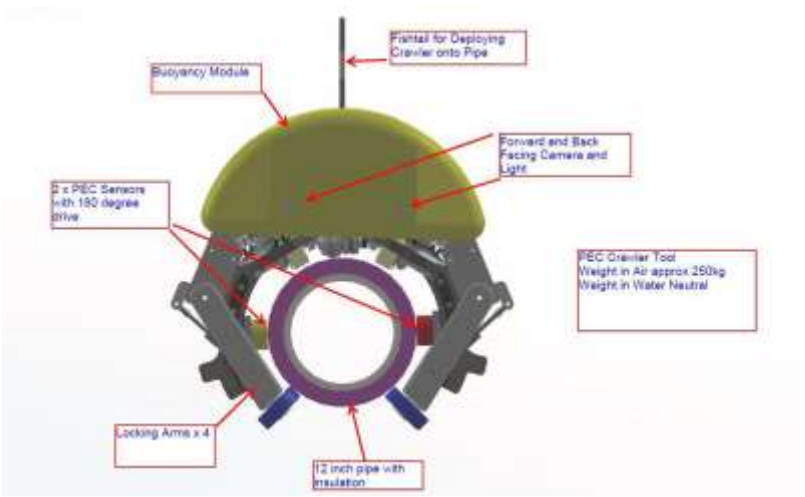
SUBSEA / SPLASH ZONE – PEC CRAWLER

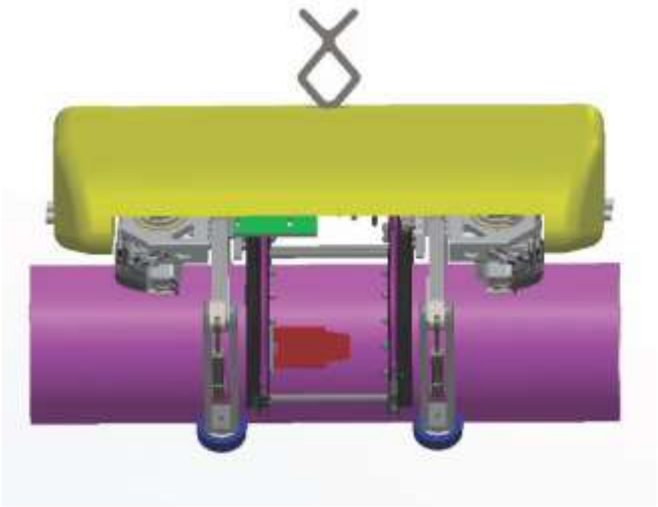
PEC - Pulsed Eddy Current

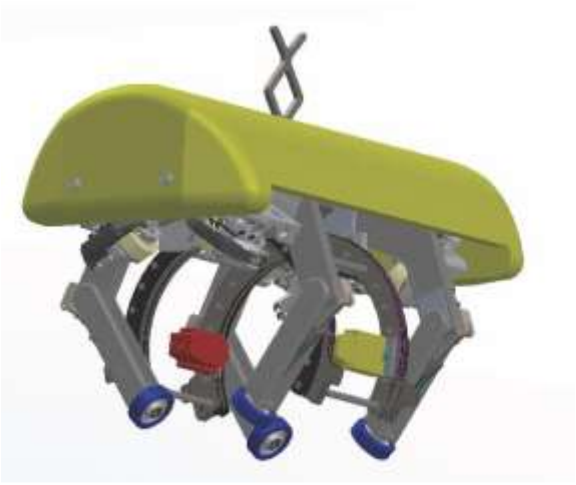
Multiple PEC probes on a ROV or Diver operated deployment frame.











Equipment

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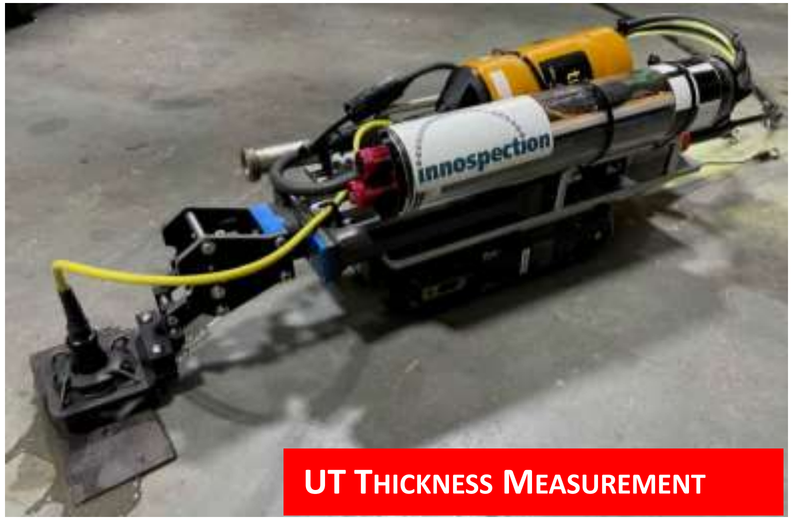
SUBSEA / SPLASH ZONE ROBOTIC CRAWLERS

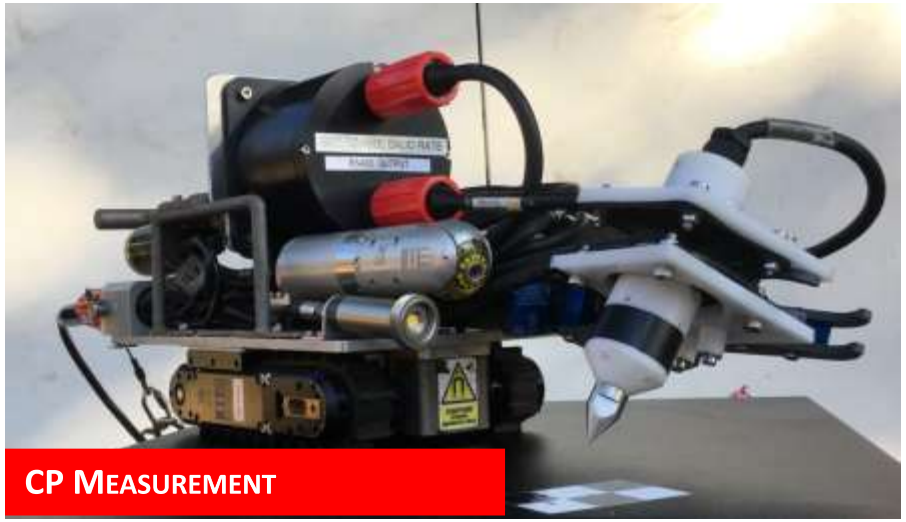
GVI / CVI CONFIGURATION

CAVIBLASTER CLEANING

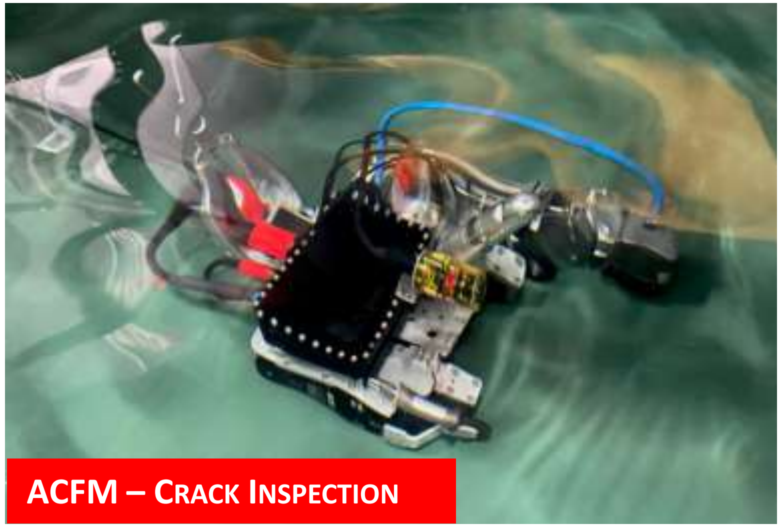
SPECIAL MISSIONS CONFIGURATION



UT THICKNESS MEASUREMENT



CP MEASUREMENT



ACFM – CRACK INSPECTION

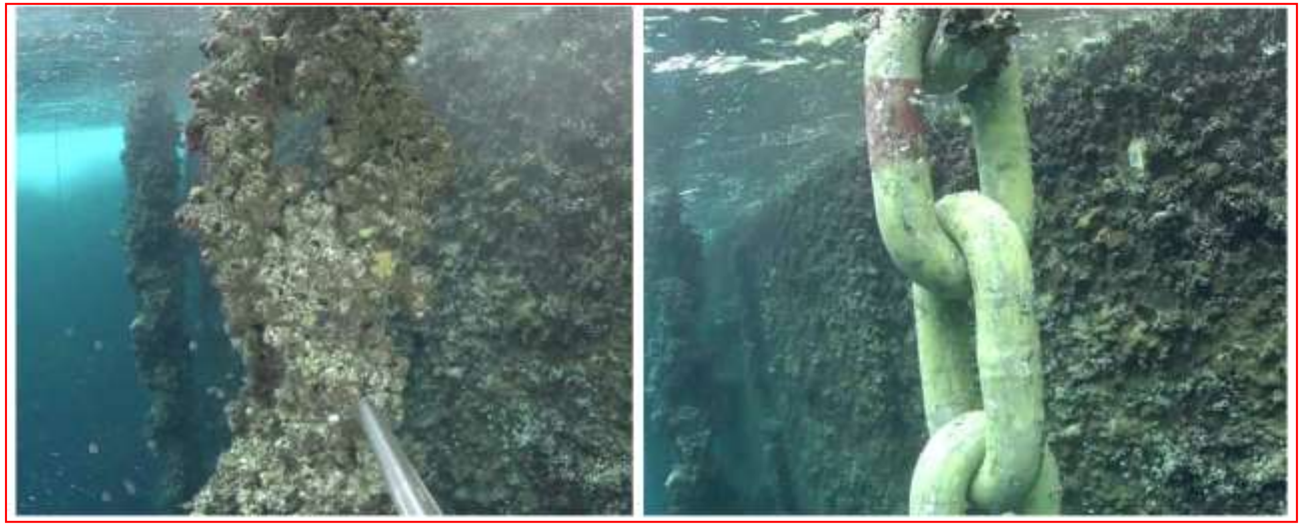
Equipment

SUBSEA / SPLASH ZONE CRAWLERS

3D PHOTOGRAMMETRY

SUBSEA / SPLASH ZONE CRAWLERS

CAVIBLASTER CLEANING



Case Studies

SPLASH ZONE

- Corrosion under Splashtron/Blisters
- Combined NDT solutions for Risers Inspection
- Caisson Conductors Inspection
- Monel Clad Riser
- Splashtron Coated Riser
- E-SUMP Inspection

SUBSEA

- Rigid Risers
- Rigid Risers / Tendons

Case Study – CUI Corrosion Under Insulation

PEC can read thorugh aluminium or stainless steel cladding, and any non conductive material as foam, resin, neoprene or techno repairing epoxy materials.

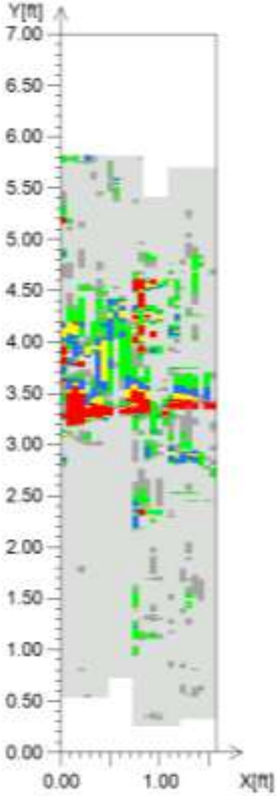
Insulated / repair coated pipe inspections

Coating Thickness: up to 10‘‘
Wall Thickness: up to 4‘‘

Case Study – Corrosion under Splashtron/Blisters

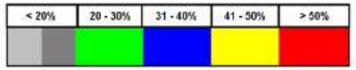
Magnetic Eddy Current (MEC) and Pulsed Eddy Current Testing (PECT) are used on risers that showed corrosion blisters.

Data were compared with Radiographic Images. The MEC inspection of the riser including the setup off the Rope Access Team was performed in about one hour. Results were available in real time.



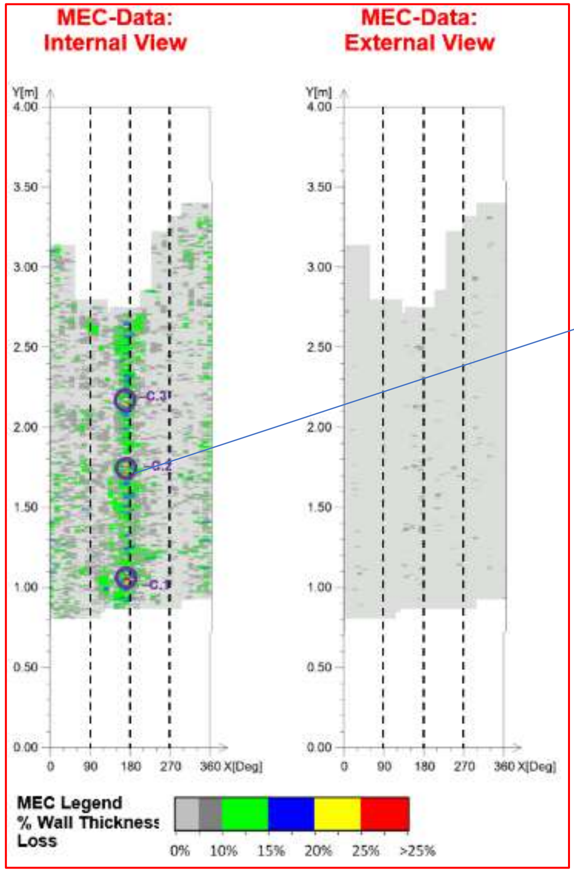
Riser on XX-yyy	
Wall Thickness:	Nominal 0.5’’
Diameter :	6 Inch
Inspection Time	1 hour *including RAT setup*

The riser had various blisters across the circumference. Defects have been found under the blisters in the internal and external surface of the pipe. Measurements confirmed radiographic images (when available).



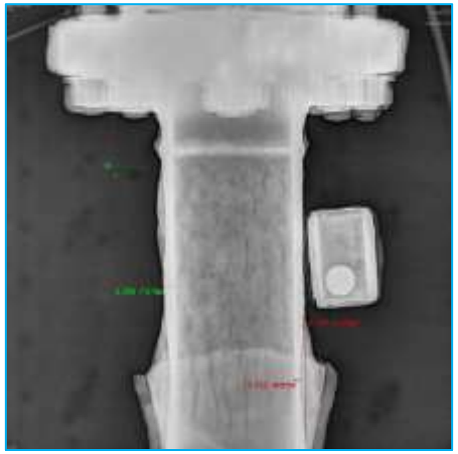
Case Study – Combined NDT solutions for Risers Inspection

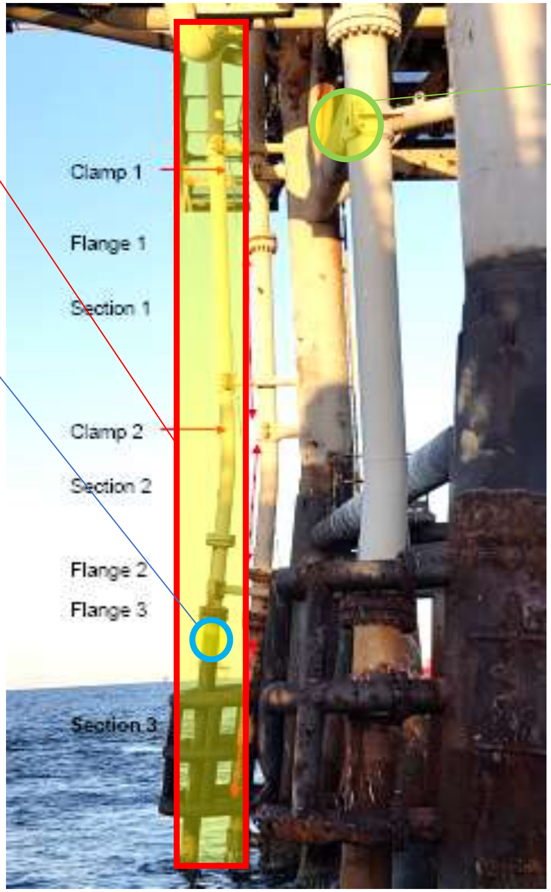
Risers splash zone is challenging to inspect, leaving an inspection gap in a highly critical section of the pipeline system where coating degradation can lead to accelerated corrosion and loss of containment. Most risers inspection practices are based on visual and spot NDT checks, Innospection solution is a multi-techniques approach that aim to cover the entire internal and external surface of the riser including the splashtron zone in a effective and cost efficient way. The Innospection RAT crew is cross-trained on all the techniques. Inspection results are immediately available.



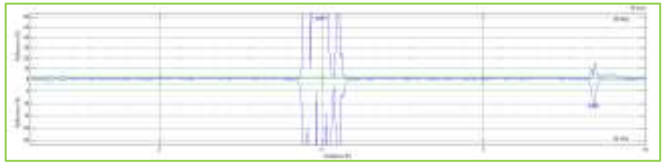
MEC – 100% Internal and External surface mapping including Splashtron coated zone

Digital X-Ray – Localized widespread blistered areas identified with MEC





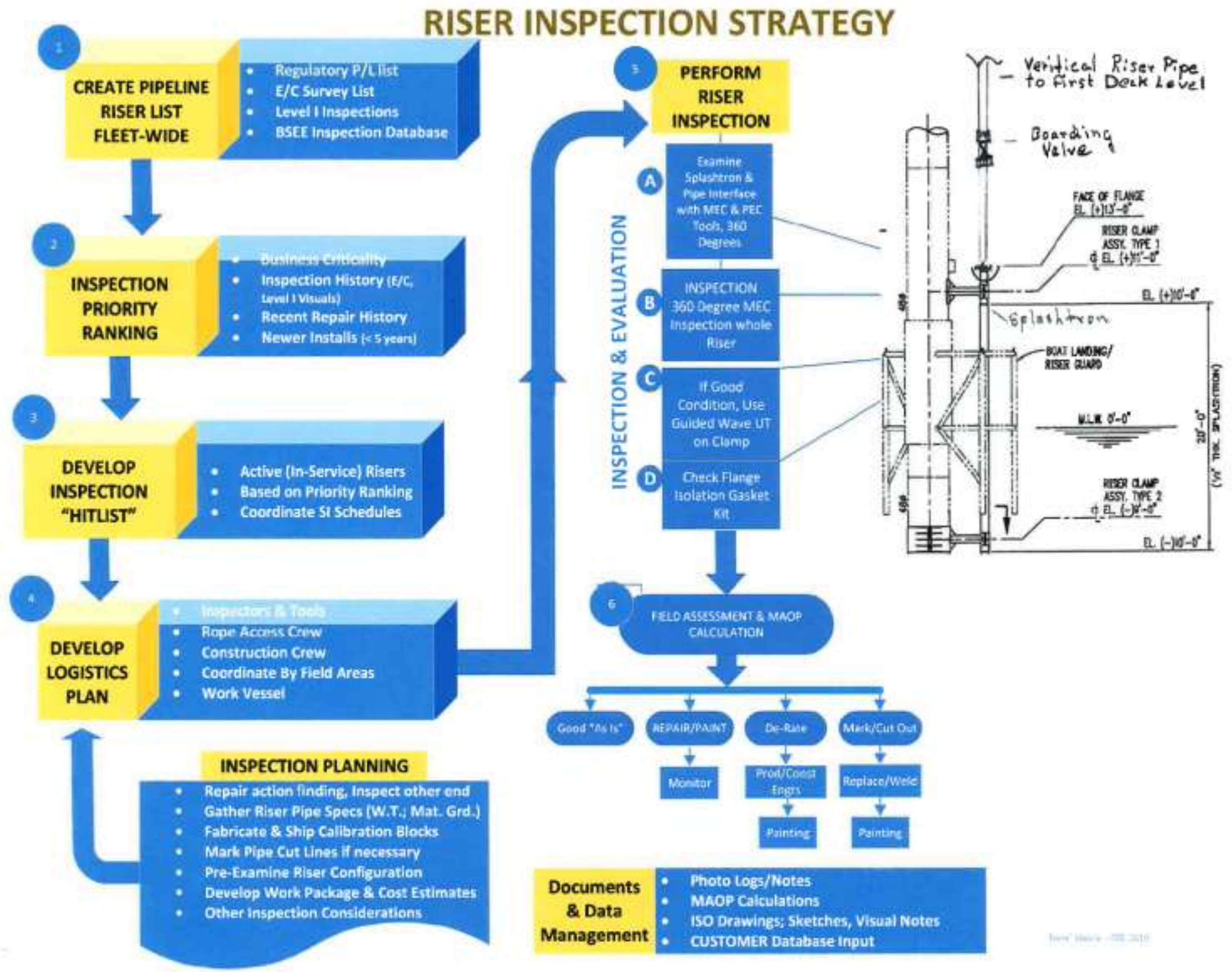
GW – Corrosion detection under Clamps and Supports without need of removal.



Additional Activities – Visual Inspection, Continuity Testing, Yield Strength Assessment, Residual Strength assessment based on ASME B31.G, complete near real time reports.

SPLASH ZONE

Case Study – Risers Inspection



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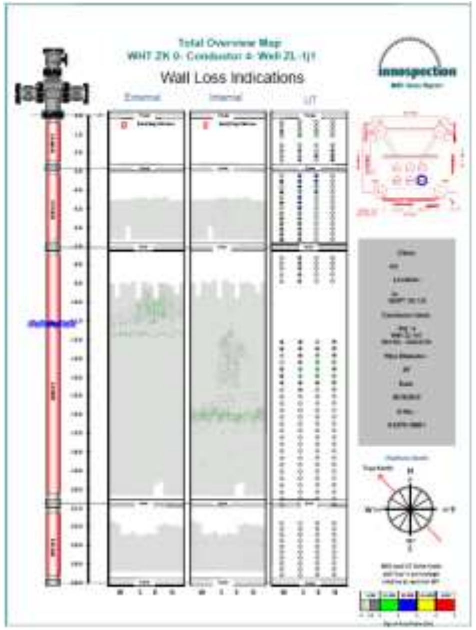
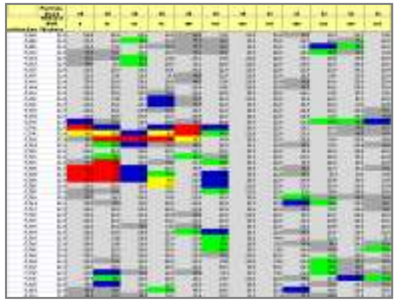
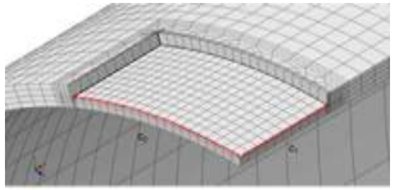
Case Study – Caisson Conductors Inspection

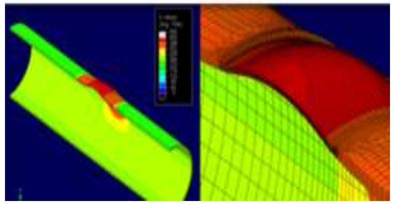
Scanning for external/internal corrosion & general wall loss assessment.

- Wall Thickness of up to 1 ½“
- Coating up to ½’’
- External & internal localised wall loss detection
- No preparation / Cleaning









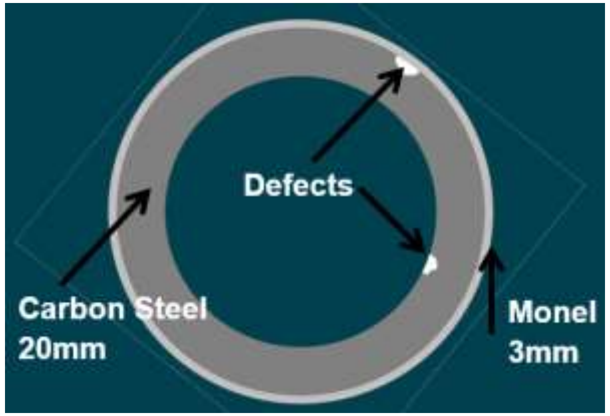
SPLASH ZONE

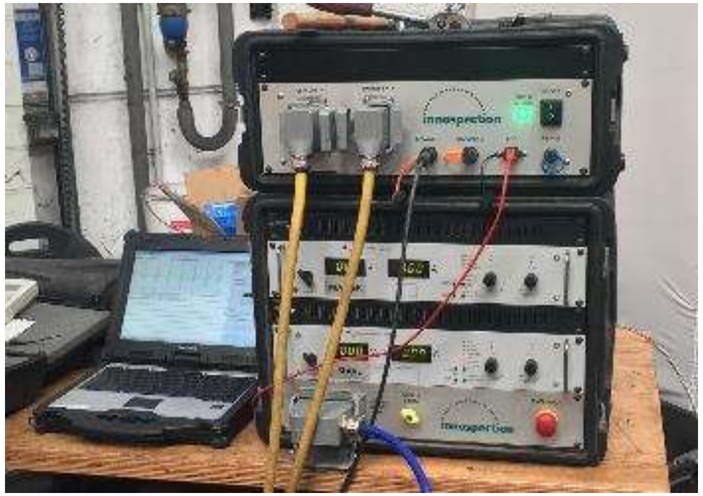
Case Study – Monel Clad Riser

Monel clad Riser scanning
External & internal corrosion mapping.

Penetrating field through Monel.

- Wall Thickness 20mm
- Monel 3mm





SPLASH ZONE

Case Study – Splashtron Coated Riser

Riser inspection
OD: 6’’, 8’’, 20’’
External & internal corrosion mapping.

- Wall Thickness 20.6 mm
- Splashtron ½ ‘’

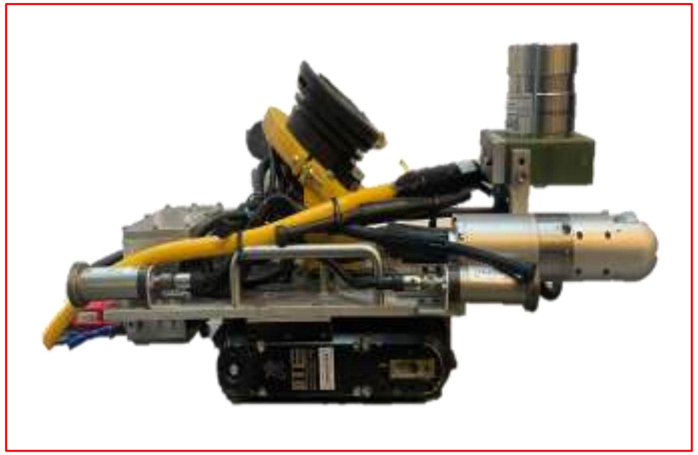
SPLASH ZONE

Case Study – Mooring Chain Inspection inside a Fairlead

Robotic Crawler - Cleaning Configuration

Fairlead internal BEFORE Caviblaster cleaning

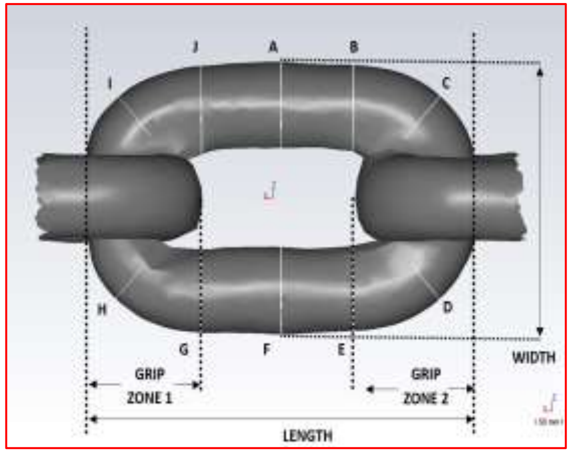
Fairlead internal AFTER Caviblaster cleaning



Robotic Crawler - Photogrammetry Configuration

Mooring Chain Image

Mooring Chain Measurable 3D Model



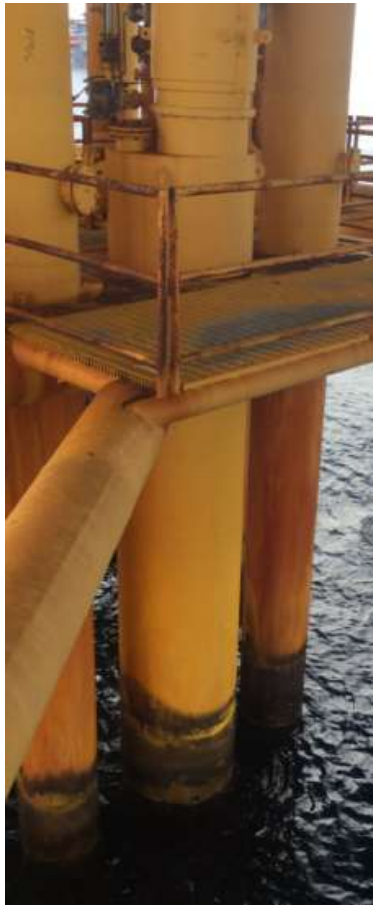
Case Study – E-SUMP Inspection

Internal E-SUMP Inspection with robotic crawler.

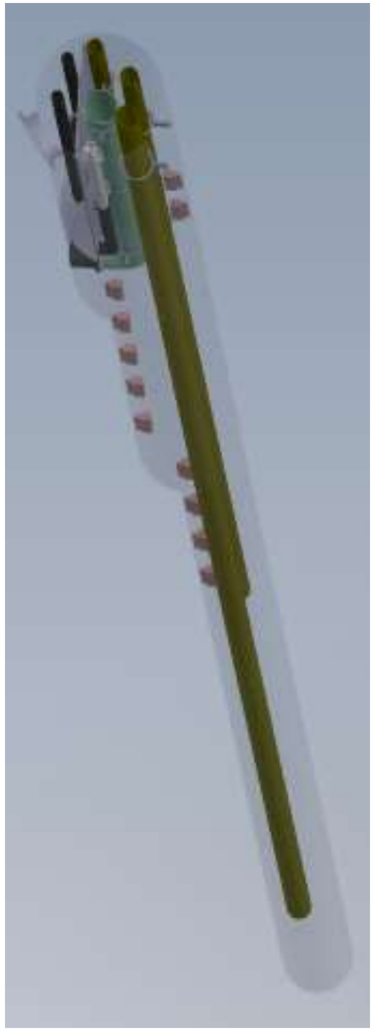
- 300ft total length
- 250ft underwater
- OD 48’’ – 36’’ – 28’’

GVI/CVI (internal surfaces)
NDT (internal piping, shell)

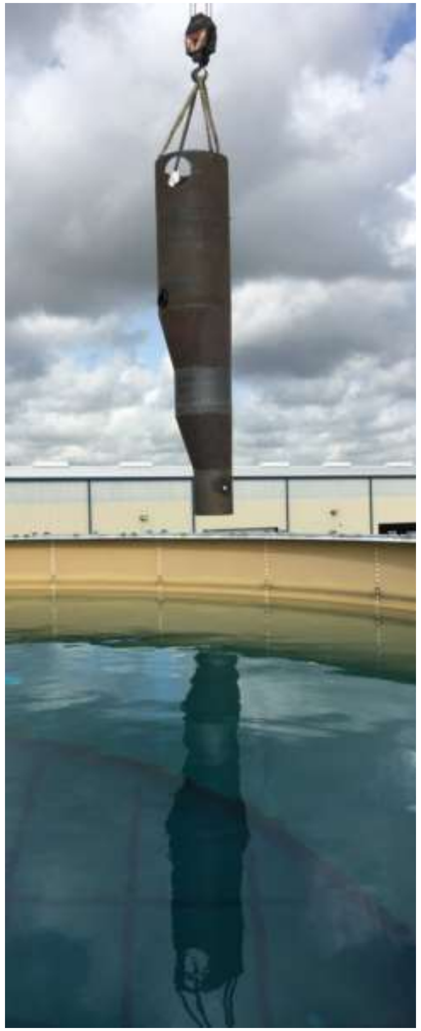
Robotic Crawler - UT Configuration



E-SUMP#1



E-SUMP#1 – 3D Model



E-SUMP#1 – Scaled Mock-up

E-SUMP#1 – Scaled Mock-up internal piping

E-SUMP#1 – UT Probing

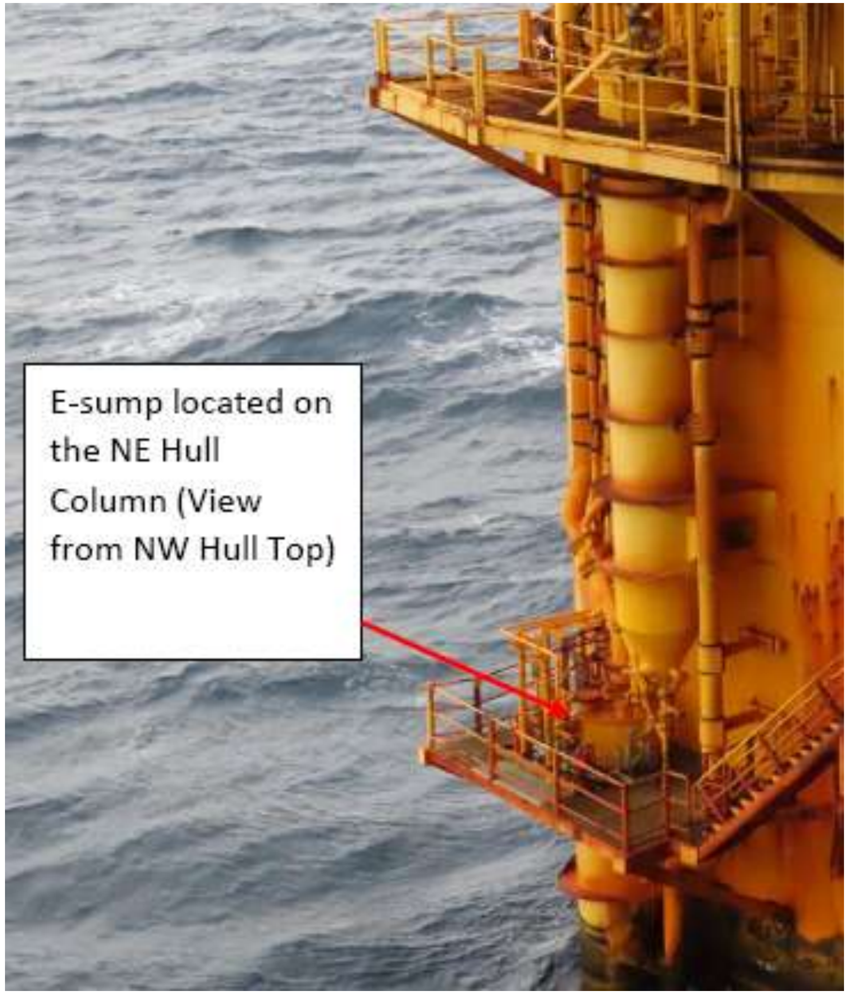
SPLASH ZONE

Case Study – E-SUMP Inspection

Internal E-SUMP Inspection with robotic crawler. ROV assisted.

- 50ft total length
- 50ft underwater
- OD 18’’ – 60’’

GVI/CVI (internal surfaces)
NDT (internal piping, shell)

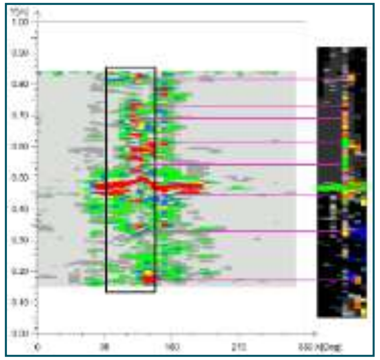


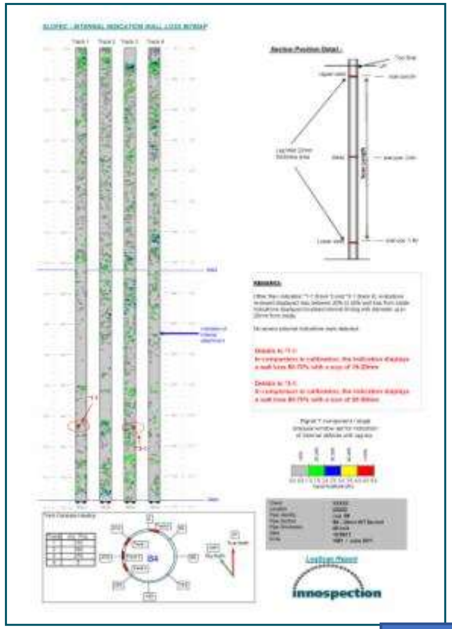
E-SUMP#2

SUBSEA

Case Study – Rigid Risers

MEC – Combi crawler ROV deployed with MEC & Ultrasonic Sensor arrays





Case Study – Rigid Risers / Tendons

Clients

Thank You

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