Beneath the Terminal

How NIPA helps operators understand buried pipeline integrity without stopping operations

Lewis Barton | TSA Conference | Coventry | 17/09/2026

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Facility Pipelines
Main Challenges and Threats

Limited Access
Difficult to access due to elevated height or temperatures

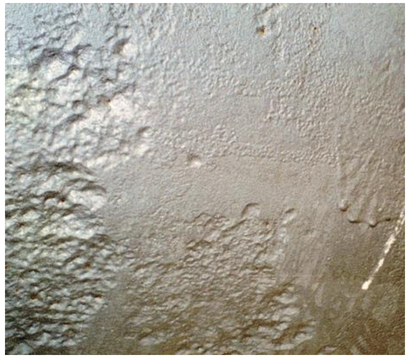
Complex Design
Limits inspection coverage

Line Under Pressure and in Operation
Personnel safety and inspection restrictions due to pumping vibrations.

Multiple Damage Mechanisms
Addressing dead legs, corrosion under pipe supports (CUPS), microbiologically influenced corrosion (MIC) and corrosion under insulation (CUI) require the integration of multiple technologies.

Hazardous or Reactive Media
Special measures required, e.g., ignition source analyses of equipment.

Internal corrosion occurs when contaminants like oxygen, CO_2, H_2S, chlorides, and water react with the pipeline and leads to threats such as erosion corrosion or microbiologically induced corrosion.



External corrosion is driven by environmental exposure – such as soil, moisture, and humidity – and includes threats like pitting, stress corrosion cracking, erosion, and corrosion under insulation.

Corrosion under insulation occurs when moisture penetrates insulation material, leading to hidden corrosion on the underlying metal surfaces. Common in insulated piping and equipment in humid or wet environments.

Corrosion under pipe supports develops at contact points between pipes and their supports, where water and debris can accumulate, creating crevice conditions that accelerate corrosion

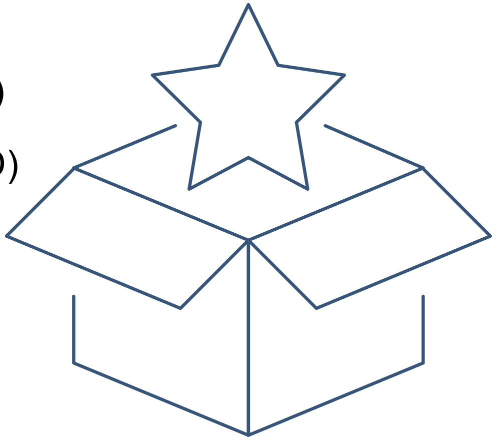
Solutions for Challenging and Unpiggable Pipelines
Toolbox Elements

In-line Inspection Methods

- Magnetic Flux Leakage (MFL)
- Ultrasonic Testing (UT)
- Internal Eddy Current (IEC)
- Electromagnetic Acoustic Transducer (EMAT)
- Inertial Measurement Unit (IMU)
- Time-of-Flight-Diffraction (TOFD)
- Caliper
- Camera

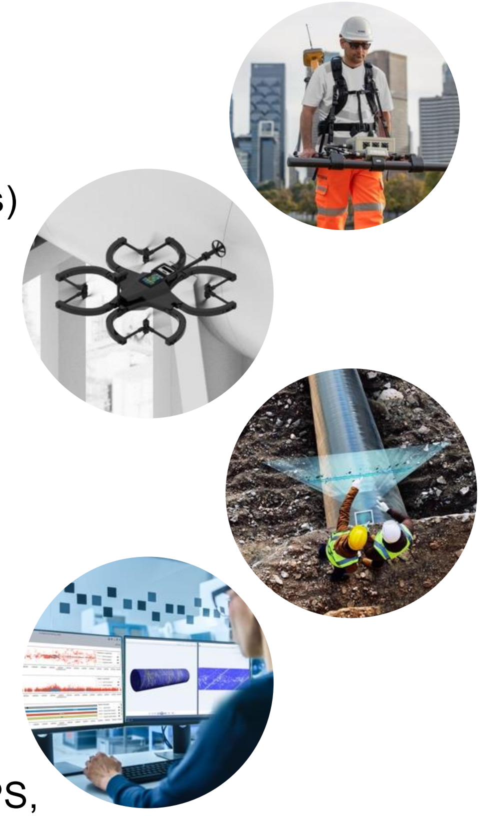
Propulsion Methods

- Free-swimming
- Robotic operator controlled (gas/liquid)
- Bi-directional



Non-Intrusive Inspection Methods

- Aerial Inspection (Drones)
- Guided Wave UT (SRUT, MRUT, LRUT)
- 3D Laser Scanning
- Flow Modelling
- **Non-Intrusive Pipeline Assessment (NIPA)**
  - Large Standoff Magnetometry (LSM)
  - CP and Coating Integrity Surveys (CIPS, DCVG/ACVG)
  - Virtual ILI (using Integrity Data Warehouse)



NON-INTRUSIVE PIPELINE ASSESSMENT
An Introduction

Non-Intrusive Pipeline Assessment (NIPA) is a ROSEN service, consisting of a above ground inspections, NDT and integrity analysis for challenging and unpiggable pipelines

ROSEN incorporate a combination of above ground surveys with its vast engineering and ILI experience into a Direct Assessment (DA) methodology **guided by international standards:**

- ANSI/NACE SP0502-2015 – External Corrosion
- NACE SP204 – Stress Corrosion Cracking
- NACE SP206/08/10/16 – Internal Corrosion
- ISO 22974 – Pipeline Integrity Assessment Methods
- ASME B31 – Pipeline Fitness for Service and Defect Assessment

NIPA provides a **rigorous, structured and industry-recognized approach** to evaluate the integrity of a pipeline system. Where pigging isn't possible.

NON-INTRUSIVE PIPELINE ASSESSMENT
Enter NIPA

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In-Line Inspection (ILI) still sets the standard for quality inspection data

But it is the **combination** of above ground **inspections and ROSEN expertise**, which provides high confidence results - obtained without performing ILI

NIPA is a framework, we can attach various inspections to it. But… The key difference with ROSEN is the addition of Large Standoff Magnetometry (LSM) and Machine learning models (Virtual-ILI)

Some of the inspections that are used include

- **Cathodic protection Surveys** – CIPS, DCVG / ACVG, CAT, etc.
- **Geospatial / technical Surveys** – LiDAR, Photogrammetry, Ground resistance, Strata Analysis, etc.
- **Large Standoff Magnetometry –** identifies stress anomalies
- **AI Machine Learning and Data Analytics** – Virtual ILI – predictions driven by using ROSEN ILI Data (IDW)

This approach of overlaying data with NIPA, it is a cost-effective solution to:

- **Reduce** excavations, **monitor** existing defects – **lowering costs, increasing safety**
- Perform **monitoring** in between ILI – **increasing data availability and resolution**
- Increasing asset **utilization** **- Completely non-intrusive**
- **Screen** and **prioritize** pipelines for ILI or Estimated Remaining Life (ERL) – **Inspection when needed**

Data Analytics

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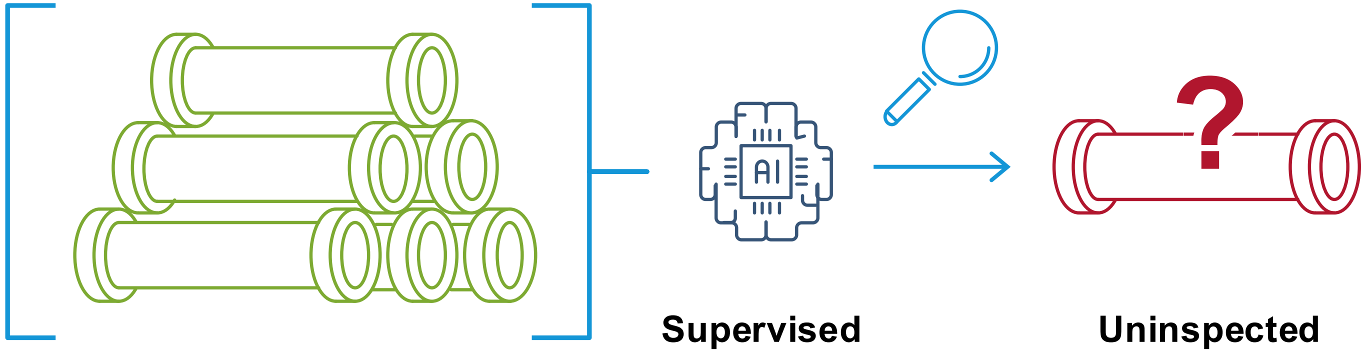
Inputs:

- Pipeline route
- Nominal wall thickness, nominal diameter, grade
- Coatings
- Construction year
- Age at inspection

Additional data is obtained through geoenrichment.



Inspected Pipelines (ILI, Design and Construction, Environmental)

Supervised Machine Learning

Uninspected Pipeline

Outputs:

- Corrosion presence / count
- Max / percentile corrosion depth
- Probability of corrosion exceeding specified depth

Predictions provided at:

Joint level: Highest spatial resolution but can be limited data.

Virtual-joint (joint group) level: Groups of adjacent joints called virtual-joints provide more data for predictive models.

Pipeline level: High level risk metrics aggregated over joints for pipeline level predictions.

Independently for each of: BOL, TOL, near welds, pipeline body, POF classes.

Predictions implicitly assume routine pipeline maintenance. Sensitivities using pipeline construction year and age at inspection are performed.

Non-Intrusive Pipeline Assessment

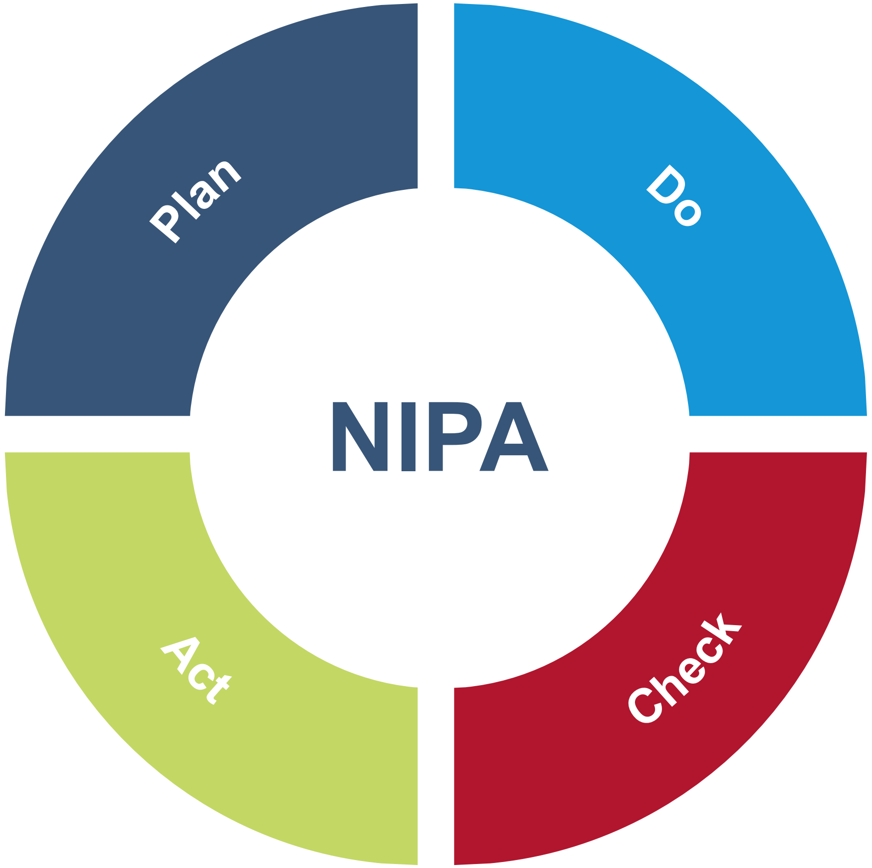
The stages

NIPA is a staged approach as per Code requirement – but is adaptable depending on the client requirements

Stage 1

Inspection Planning

We assess the pipeline for its suitability and work with the client to set expectations.



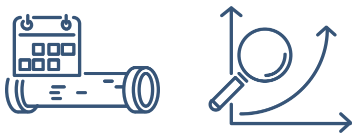
Stage 2

Above ground inspections and Virtual-ILI analysis

We survey the pipeline and identify areas of concern for further examination

Stage 3 - NDT

Physical defect verification following excavation using conventional or advanced NDT



Stage 4 - Final Assessment

We provide the client with an estimated remaining life, reinspection interval and any integrity recommendations

What is NIPA

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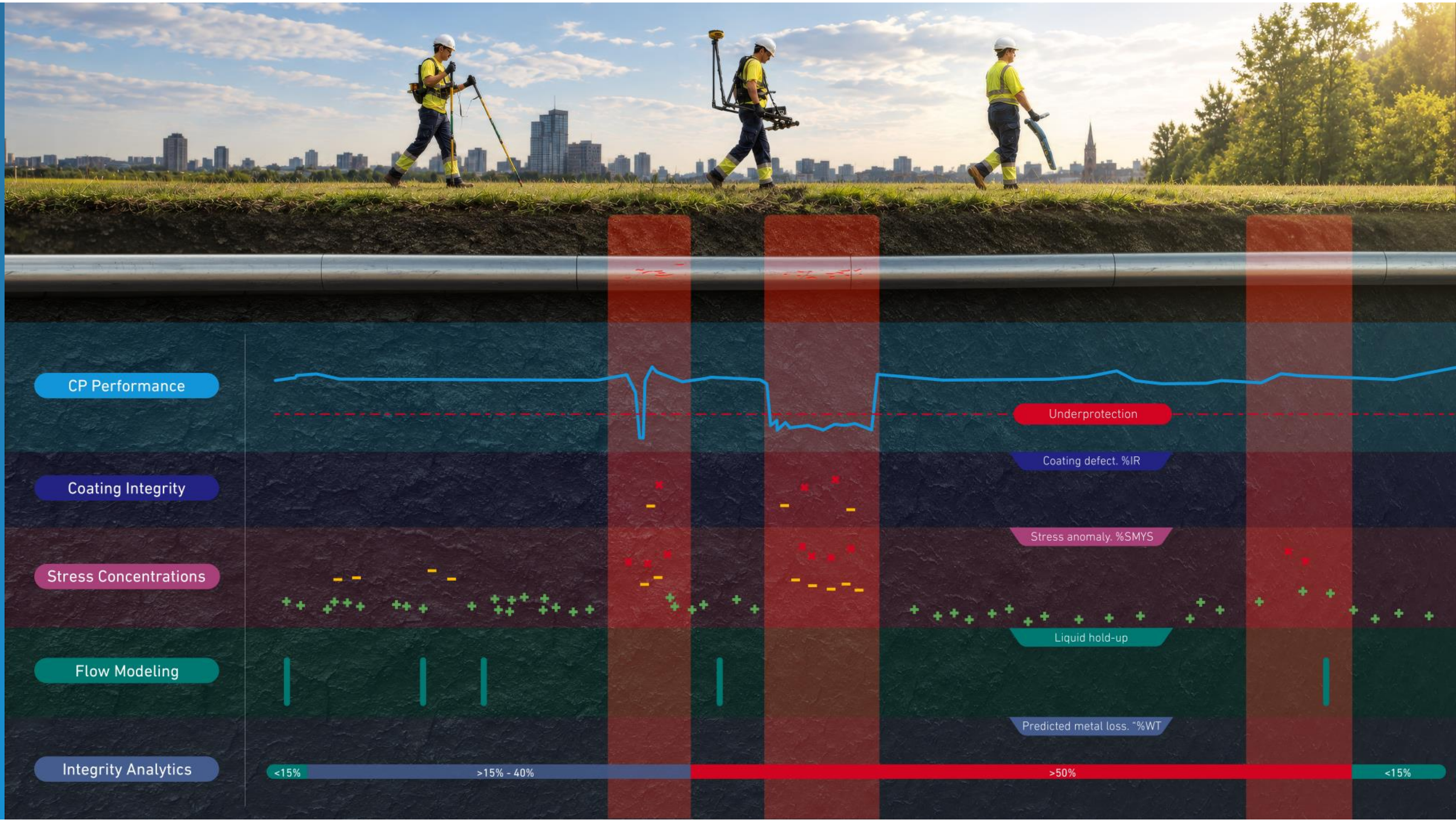
Non-intrusive.
No interference required to the pipeline operations.

Multi-layer.
A more complete and reliable understanding of asset condition by combining data sets.

Verifiable.
Produces an industry recognized FFP output for regulators.



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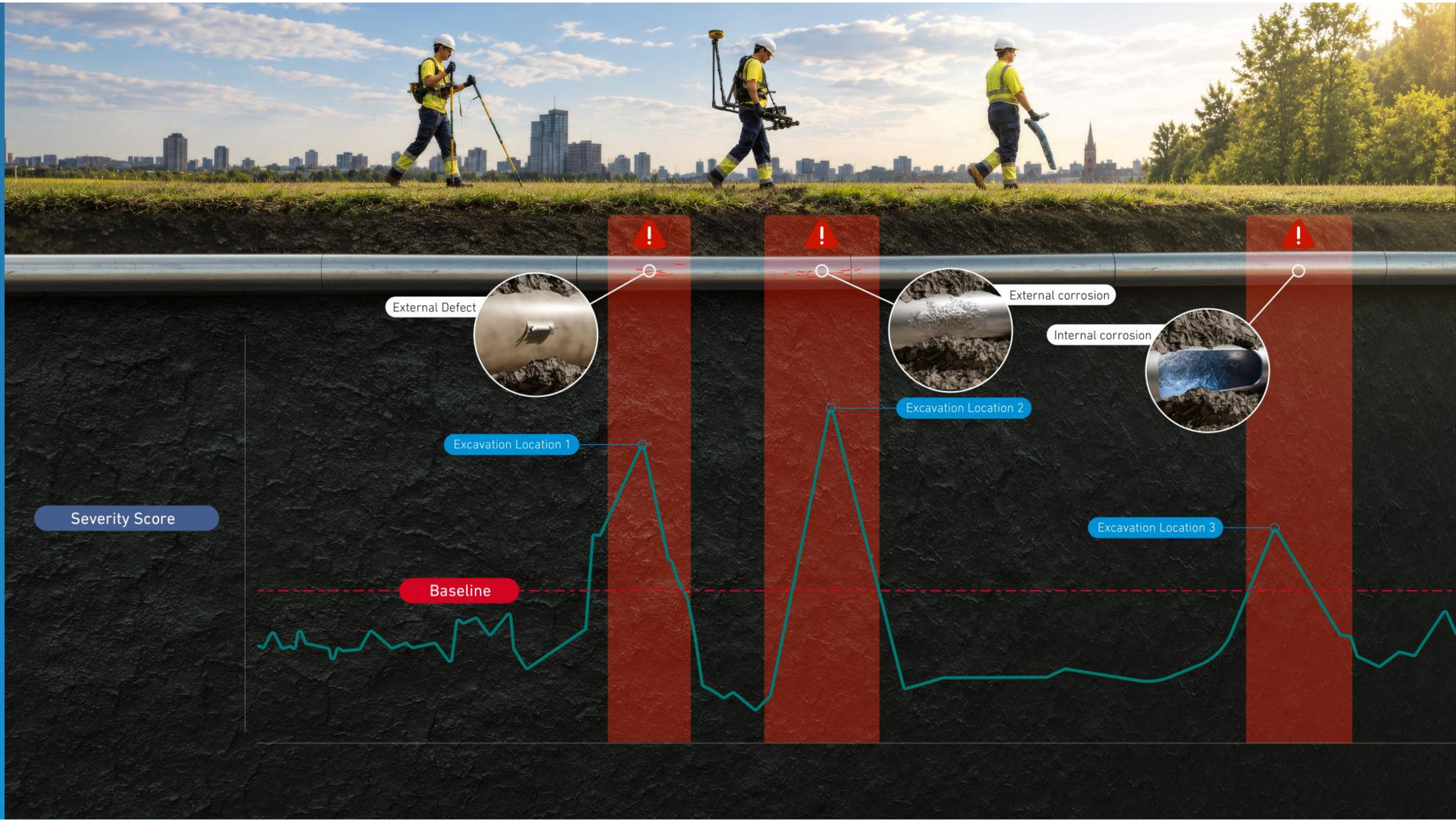

Case Study 1

Enter your Subheadline

CASE STUDY:
Synergy of NIPA

Pipeline Integrity Assessment Summary

- 26 critical facility pipelines which had previously only been monitored yearly by CIPS and DCVG methods.
- The client believed they were doing everything right and these pipelines were in good condition.
- ROSEN performed NIPA assessment of the pipelines in 2020, combining multiple inspection techniques and data analytics.
- Based on the integrated analysis of all available data, anomalous stress concentration zones were identified and using Integrity Analytics, defects were predicted to be within the 25–35%WT range in 2020 - with an expected exceedance of 50%WT in 2025.
- Calculations were performed to define recommended locations for excavation and direct assessment.

Example Pipe – 350 m Pipeline Segment:

- DCVG inspection identified **7 defects**, all with IR% values below the client-defined threshold of 20%. The most significant defect showed **10.4% IR**.
- LSM survey revealed **3 magnetic anomalies** meeting **Level 1 criteria**, flagged for further investigation due to potential severity.

CASE STUDY:
Synergy of Three into One

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Prioritization for Excavation – Based Aboveground Surveys Reports

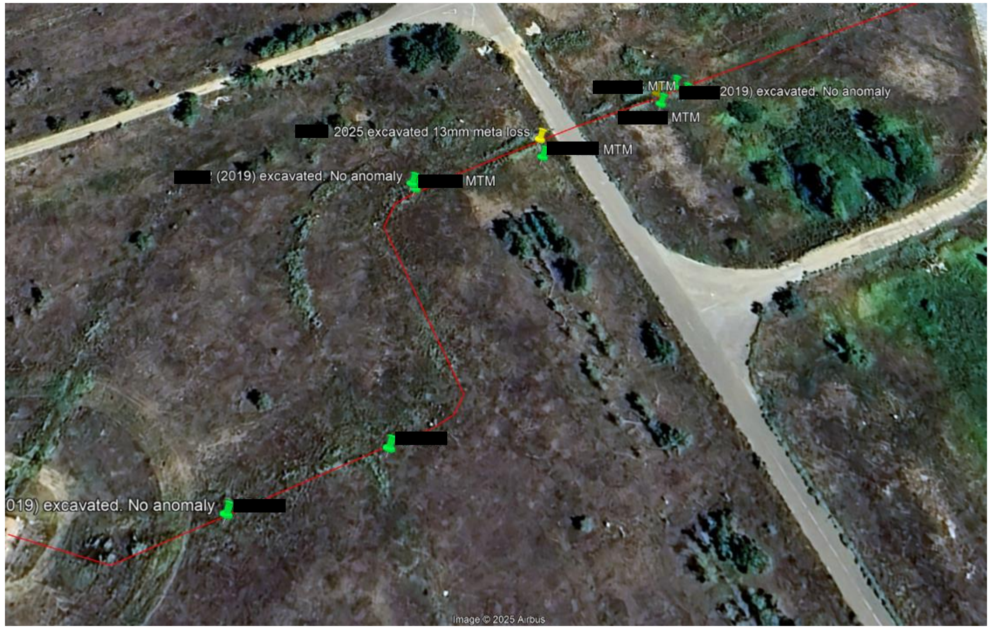
Based on the combined assessment of the magnetic survey LSM and DCVG / CP assessments, a list of priority sites was developed for excavation and direct examination. These sites were selected according to severity ratings and anomaly characteristics.

- One particular anomaly, which received a **Severity Rating of 21**, was excavated as part of a client planned excavation in 2025 (5 years after the initial assessment)

Rank	Defect Location (m)	Latitude	Longitude	Severity Rating
1	142.5	[redacted]	[redacted]	21
2	107.0	[redacted]	[redacted]	12
	71.5	[redacted]	[redacted]	
	180.7	[redacted]	[redacted]	
3	188.8	[redacted]	[redacted]	1
	339.7	[redacted]	[redacted]	
	0.0	[redacted]	[redacted]	

Note 1: Average severity rating was found to be 6.

Table 1: Excavation site selection for 06T01626.



CASE STUDY:
Synergy of Three into One

Direct examination in 2025 confirmed a **13 mm (~50% WT) metal loss defect**, matching the predictions of the integrity analytics and findings of the above ground surveys.

Had the client continued to perform their historic inspection campaign, this defect would have been ignored.

This outcome demonstrates the effectiveness of the multilayer defect selection approach.

Had this pipeline failed, it would have caused a significant outage in operations costing millions of $$$.

As noted by the client, combining methods provided a 70% increase in critical defect detection - and resulted in proactive repair with no production outages

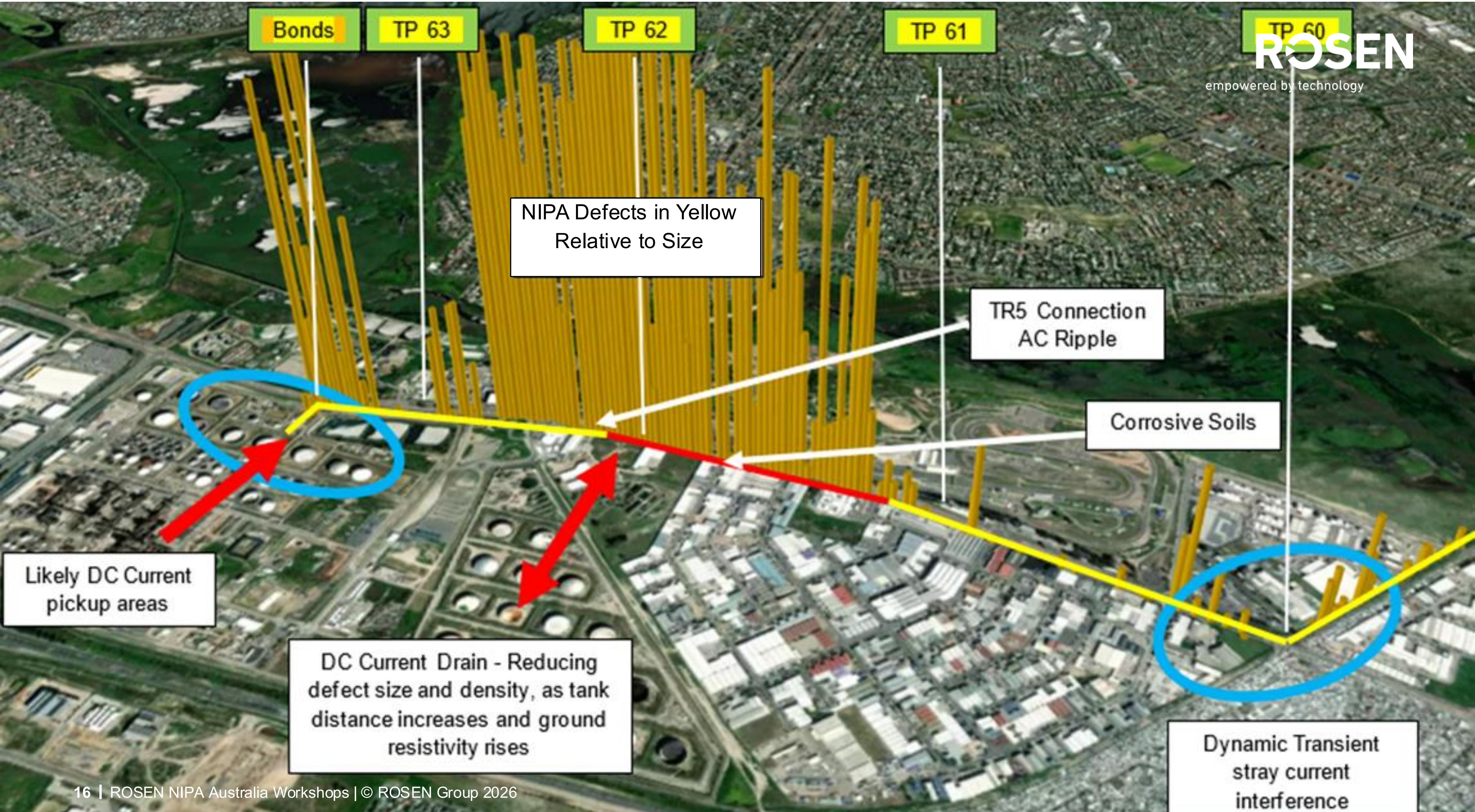
Case Study 2

When the Moon and Stars Alighn

Introduction
Project Background

Why a combined approach is best

- NIPA was performed on the export Crude oil pipeline transporting Oil to a major storage facility with over 60 storage tanks and refinery.
- The pipeline was piggable, but operational issues (major repairs at the refinery) meant that no flow in the pipeline was possible - hence no pigging
- Due to the major refinery repairs, the pipeline hadn't operated for 2 years; but 2 leaks had appeared on the pipeline.
- Although the initial leaks were repaired the Operator and Regulator wanted assurance that when the line was pressurised for operation no more leaks would occur.
- ROSEN Performed a full NIPA assessment of the final section of pipe where the leaks had been identified, in summary it identified:
  - Ineffective cathodic protection
  - Stray Current Int. (AC/DC) – (growth of >6mm/yr)
  - Significant number of defects on the final section next to the storage facility and refinery

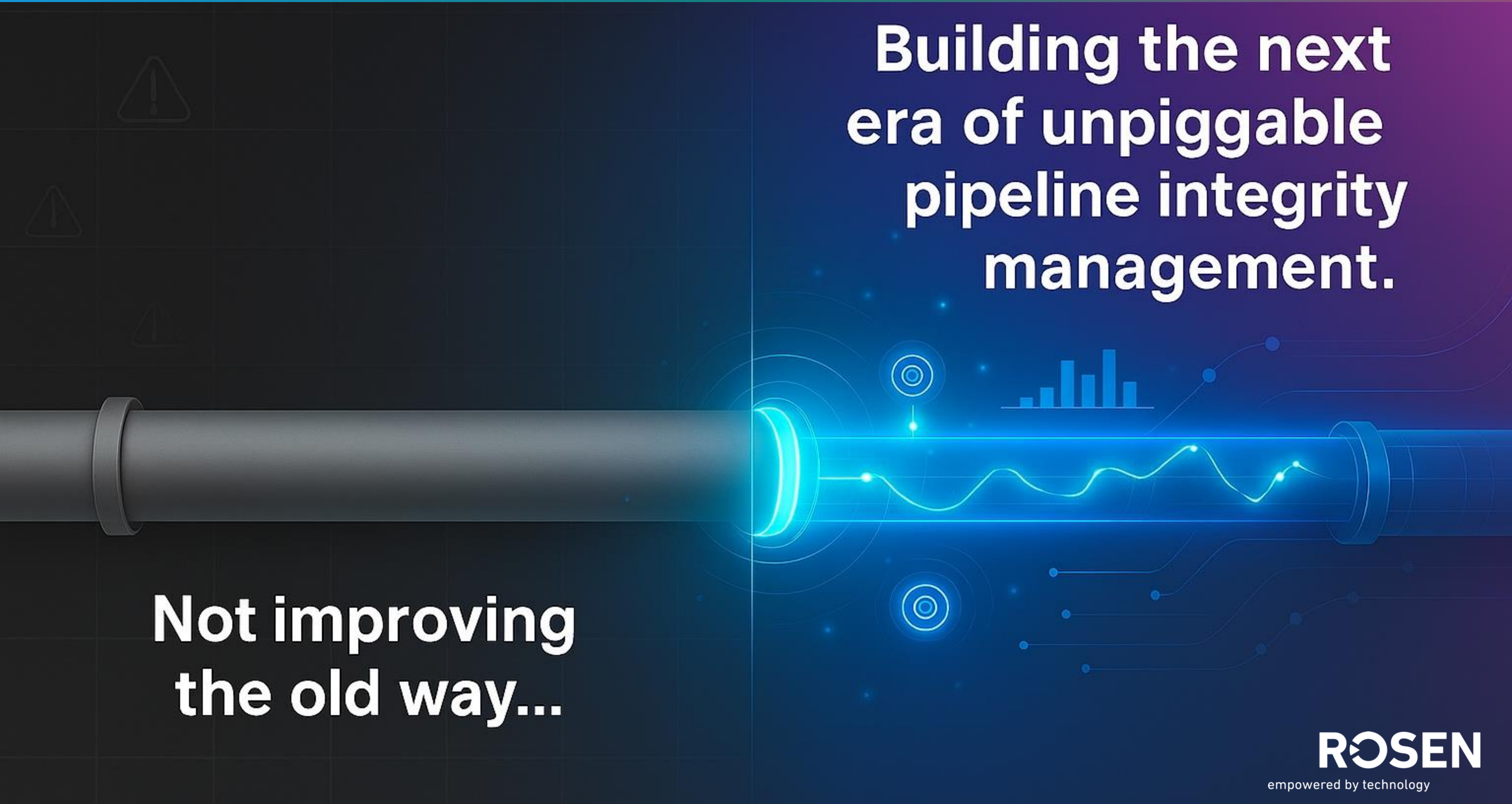

Bonds
TP 63
TP 62
TP 61
TP 60
NIPA Defects in Yellow Relative to Size
TR5 Connection AC Ripple
Corrosive Soils
Likely DC Current pickup areas
DC Current Drain - Reducing defect size and density, as tank distance increases and ground resistivity rises
Dynamic Transient stray current interference

Outcomes
What did we and the client do

- The client found over 800m of repairs that were required and had to undertake a major excavation and repair campaign – all because of one “minor” oversight.
- The NIPA assessment enabled the client to priortise excavation and repair along the pipeline and in addition:
  - ROSEN designed and commissioned a new cathodic protection system and stray current mitigation system
  - We assisted in the assessment defects identify which ones required repair and created a repair schedule
  - We will be undertaking a resurvey of the pipeline to monitor and check mitigation measures in 2027

As noted by the client:

With ROSEN help, we were able to not only identify the problems, but they also supported us with developing a holisitic solution to ensure this problem does not happen again


Building the next era of unpiggable pipeline integrity management.
Not improving the old way...
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