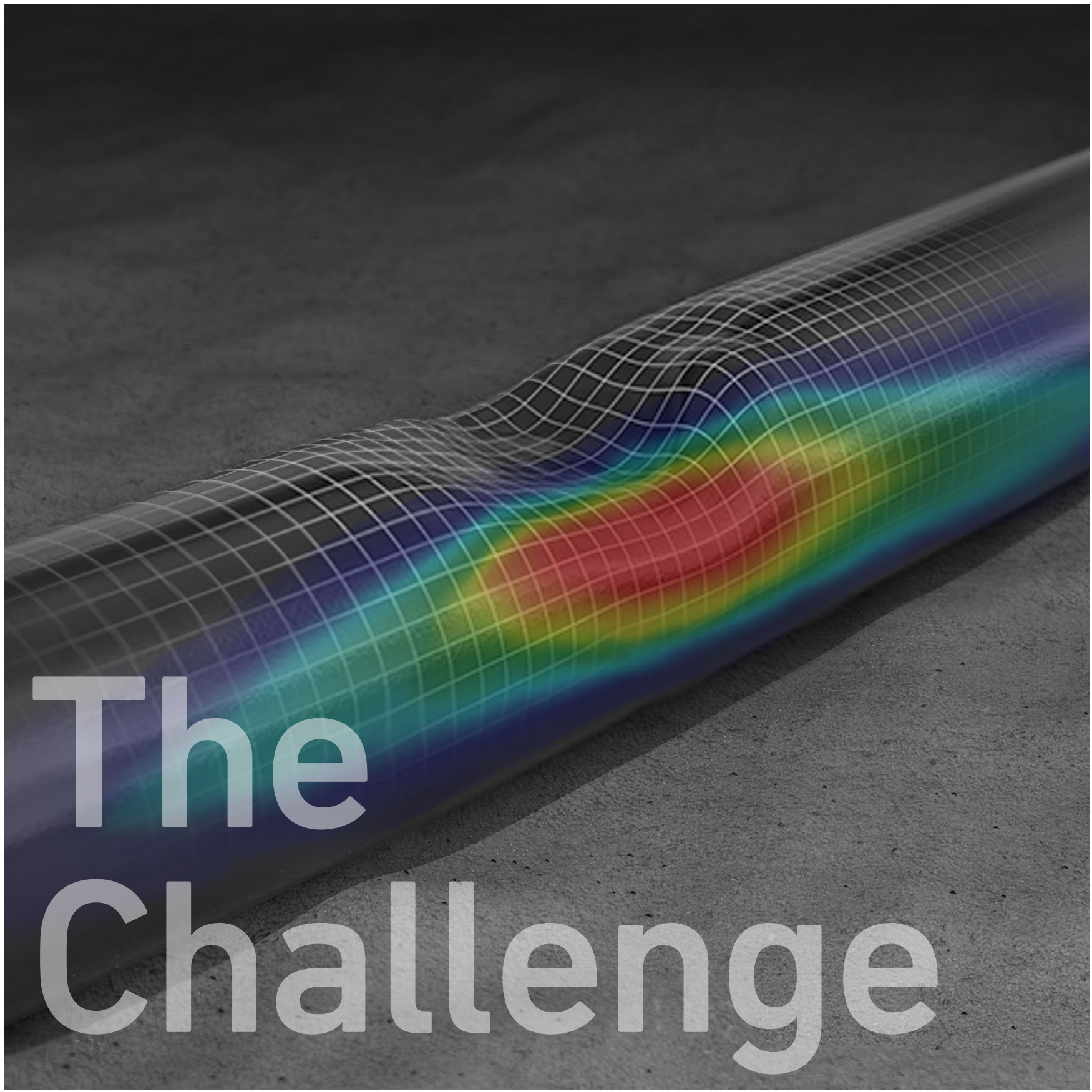


Geometry and Mapping

Shape up Your Pipe

ROSEN

empowered by technology



The Challenge



Preventing Deformation-Related Failure

Changes in the shape of a pipeline come in two basic forms. There are local features such as dents, ovalities and wrinkles, and there is bending. In most cases, deformation is caused by external influences: either natural phenomena, such as landslides, or accidental third-party actions, such as impact by excavation machinery. While pipelines are very tolerant of deformation damage due to the inherent ductility and toughness of steel, the high stresses and strains caused by these features can compromise integrity and result in failures, particularly when they are combined with other anomalies like gouges, corrosion or weld flaws. Severe deformation can also result in flow restrictions or prevent the passage of cleaning and inspection tools. Therefore, reliable means for identifying, locating, quantifying and assessing these changes in shape are critical for all pipeline operators.

In our networked and GPS-enabled world, we all take location information for granted. For many pipelines built before the days of satellites, construction survey records have been lost, and so the position is not known accurately. Rapid response to critical defects requires accurate information on the position to make sure that the right location is excavated. Cost-effective planned maintenance requires detailed data on the anomaly location. Understanding and managing geo-hazards requires a clear understanding of the transitions between stable and moving ground. Consequently, reliable information on the position of features in a pipeline, the position of the pipeline and changes in position is of great importance to all pipeline operators.



The Solution

ROSEN Geometry and Mapping Services

A Flexible Approach to a Varying Challenge

Three Technologies. Three Purposes.

ROSEN geometry and mapping services allow you to choose between three high-quality technologies, based on your individual inspection needs.

○ **Commissioning and Proving**

Robust MD Technology mechanical dippers with high-resolution electronic angle sensors represent a cost-effective way to detect internal-diameter (ID) anomalies in any medium. The extremely lightweight tool causes only very low friction and provides reliable data even with low operating pressure.

○ **State-of-the-Art Strain and Stress Assessment**

The unique XT Technology combination of mechanical caliper measurements with eddy current proximity sensors provides unrivalled industry-renowned data sets of the highest quality for both liquid and gas pipelines. Detailed and accurate 3D representations of any geometric anomaly can be generated for visualization and modelling. Additional information includes the identification and characterization of bends and small changes in internal diameter, plus scale, debris and wax deposits profiling.

○ **Mapping, Bending and Movement**

Optimized XYZ Technology using integrated Fiber Optic Gyroscope (iFOG) and micro-electronic mechanical systems (MEMS) gives precise location and curvature data that can be used in geographic information systems, stress modelling and movement analyses.



RoGeo MD
Service

The
Solution

Robust and Reliable

Our Advanced Solution for Geometry Inspections

Our advanced geometry service is the perfect solution for many geometry inspection purposes. Fully compliant with codes and standards such as API 1163, the robust RoGeo MD Service can be used to inspect the as-built quality of a pipeline, identify third-party damage, or confirm passage for subsequent cleaning or in-line inspection tools. It is a cost-effective approach to surveying the geometric quality of pipelines ranging from 4" to 56" in ID.

The RoGeo MD Service tool is equipped with numerous calipers, ensuring outstanding detection capabilities and sizing performance. Furthermore, the optimized sensor design enables full circumferential and axial coverage. Thus, dents, buckles, bends and wrinkles, as well as other ID changes and installations, such as valves, tees, flanges and welds, can be reliably identified and sized. This helps ensure the success of subsequent inspections, as those features can cause significant changes in tool velocity, which may impact data quality negatively. An additional damping element significantly reduces lift-off behavior, and state-of-the-art passage capabilities enable the inspection of pipelines with up to 22 percent ID reduction.

- Reliable identification and sizing of pipeline ID anomalies
- Confirmation of pipeline pigability
- Optimization of data quality of subsequent inspections



RoGeo XT
Service

The
Solution

Sensitive and Strong

Our Premium Solution for Geometry Inspections

Our premium RoGeo XT service is a high-definition inspection service suitable for integrity management programs addressing dents, buckles, ovalities, stress-induced geometric features and pipeline bending. Even at comparatively low operating speeds of between 0.5 and 0.8 m/s, the RoGeo XT Service determines highly accurate feature profiles and contours that allow for precise stress- and strain-based assessments. It is the state-of-the-art inspection solution for addressing complex geometric anomalies and even combined threats such as corrosion in dents.

The RoGeo XT Service tool deploys contour-following dual-sensor technology. This allows for an exceptionally precise mapping and sizing of ID anomalies by providing full circumferential and axial coverage, even under tough operational conditions. The contactless sensors compensate typical dynamic lift-off effects at increased inspection tool speeds. In addition, the sensors differentiate between geometric features and debris, scale or wax deposits, significantly reducing false readings.

- Exact localization, profiling and contouring of geometrical features
- Detection of coincident features
- Quantitative determination of scale, debris and wax

An aerial photograph of a racetrack, overlaid with a semi-transparent grid. A blue circle in the upper right contains the text 'RoGeo XYZ Service'. The racetrack has several cars on it. The background is a dark, forested area.

RoGeo XYZ
Service

The
Solution

Precise and Proficient

Our High-Resolution Mapping Service

Our high-resolution mapping services provide precise information on the pipe route that can be integrated into the customer's GIS. The RoGeo XYZ service is a cost-effective way of producing pipeline drawings when original construction drawings may not be available. The tool can run through remote and inaccessible areas where conventional above-ground mapping surveys are impractical. In addition to providing information on the pipeline's position, RoGeo XYZ data serves as the basis for performing bending strain and pipeline movement assessments. These services are critical for addressing areas where the pipeline may have been influenced by ground movement such as landslides or settlement, or anchor strikes in offshore waters. When combined with other in-line inspection services, the RoGeo XYZ service provides critical data necessary to properly address pipeline buckles or depth of cover.

A gyro survey measures and maps the pipeline in three dimensions to give a precise depiction of its route and profile. A gyroscopic inertial measurement unit (IMU) on-board an inspection tool measures angular and linear velocity changes in the X, Y and Z axes as the tool moves through the pipeline. Gyro inspection enables the coordinates for girth welds and features to be calculated and recorded while also determining the radius of bends and identifying any departures from the as-built condition.

- Provision of precise centerline data
- Identification of areas of high bending strain and movement
- More efficient planning of field activities like maintenance work and field verifications

Get an early warning confirmation

Through repetitive runs, our pipeline movement screening service PipeDrift monitors the pipeline system for any positional changes and compares each new data set with the data from an initial baseline inspection. It can also indicate whether a second, more detailed run and analysis are required.

The Solution

Data Management, Evaluation and Reporting

Solid solutions for dynamic data

Good decisions require reliable information, which in turn relies on high-quality data. Data is generated constantly by monitoring and inspection, but important historical data is also available in multiple legacy formats. ROSEN has a history of generating vast quantities of data and working with assets that may be over 100 years old. Building on this experience of digitizing, storing, aligning and manipulating data, we have developed a range of digital solutions for easy and effective asset integrity management.

NIMA Report is our reporting software that allows operators to retrace our evaluation of the inspection results presented in the final report. It provides 3D visualizations of every single anomaly reported, and, since ROSEN delivers inspection data for the entire pipeline, an overview of the overall integrity status. In addition, it offers an executive summary for operational goalsetting and action.

NIMA integrity management solution that guides the user through robust and quality-assured bespoke processes, working on available data to perform appropriate and reliable integrity assessments and maintenance planning. The unique Process Engine supports workflow and process automation and unifies data and integrity management activities.

Engineering Assessment and Consultancy

Expertise built on experience

We know that inspection and engineering assessment must go hand in hand. Therefore, our high-end inspection technologies are complemented by a broad range of assessment services. Combining inspection and assessment reduces uncertainty, thereby increasing safety and minimizing cost.

Our assessment services, such as fatigue assessment, finite element analysis, soil loading models and many others, support the decision-making process with the aim of ensuring safety, while avoiding unnecessary and costly excavations.

In addition to assessing the possible consequences of geotechnical hazards such as landslides, seismic events and erosion resulting in pipeline movement and high associated strains, ROSEN can complete geographical investigations such as depth-of-cover mapping and geo-hazard mapping.

Assessments are always performed in accordance with industry standards (e. g. ASME B31.8), recommended practices (e. g. API 579, DNV-RP-F101, AS 2885.1-2012), guidelines (e. g. EPRG, PRCI, PDAM) and federal regulations (PHMSA).

- **Fitness-for-Purpose Assessment:** Assessment of the current and future integrity of a pipeline following an in-line inspection, assessing the significance of all geometry features and other pipeline anomalies or damage reported.
- **Strain Assessment:** The strain associated with deformation can be high and may result in cracks in the steel as it starts to fail. The detailed accurate profile data given by our tools is used to calculate and assess surface strains in accordance with ASME B31.8 Appendix R.
- **Stress Assessment:** Dents cause local stress concentrations that accelerate fatigue cracking. The advanced finite element analysis package ABAQUS is used to model reported dents to give accurate specific stress concentration factors for the best possible dent-specific fatigue assessment.
- **Bending Strain and Pipeline Movement:** External loads such as landslides, ground settlement and ship anchor snagging can result in significant displacement and high pipeline bending strains. Locations of high strains are reported, and the potential causes can be identified. Areas of movement can be highlighted, even if the strains have not reached critical levels, to provide an early warning.
- **Depth-of-Cover Mapping:** Calculation of pipeline depth of cover by combining ground elevation data with high-resolution RoGeo XYZ mapping.

Your Benefit



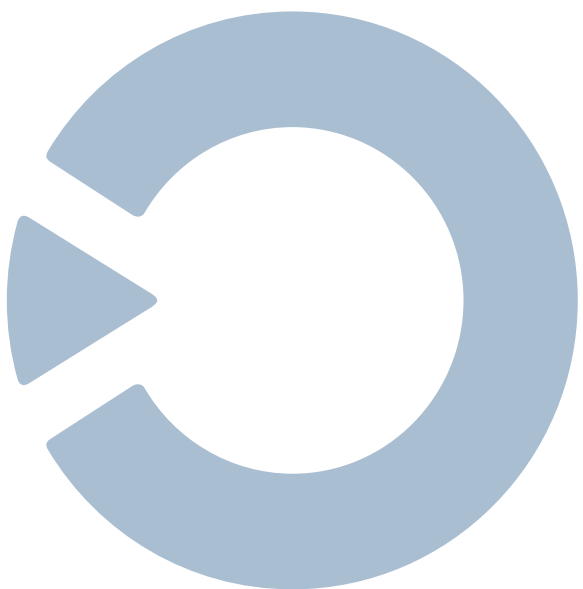
Don't bend your standards

ROSEN's excellent geometry and mapping services deliver clear and actionable reporting. Complemented by a variety of corresponding defect assessment services and digital solutions that perfectly fit your data management needs, our RoGeo Services play a crucial part in developing an efficient and effective integrity management strategy.

Rely on our geometry and mapping services to:

- Ensure the success of future in-line inspections
- Identify safety-critical damage
- Identify and monitor geo-hazards
- Facilitate better planning of field activities
- Comply with regulations

All RoGeo Services can be combined with all other ROSEN ILI services. In this way, we ensure optimal inspection results while keeping operational costs to a minimum.



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