SKIPPER NDT

PHMSA

AERIAL MAGNETOMETRY FOR THE PRECISE 3D-POSITIONING OF PIPELINES

Non-intrusive solution in geotechnical and hydrotechnical context

Identification of technical challenges and solutions to improve pipeline safety and protect the environment.

Pipeline Safety Research and Development Forum 2023

Summary

- **Context**
- **State of the art: Skipper NDT UAS magnetometry**
- **Enbridge (USA) / SSD : Geotechnical case study**
- **GRTgaz (FR): Hydrotechnical case study**
- **Discussions and conclusion**

Pipeline monitoring: geotechnical

Current risk assessment technologies are either manual or invasive

Inspection enforced by regulator

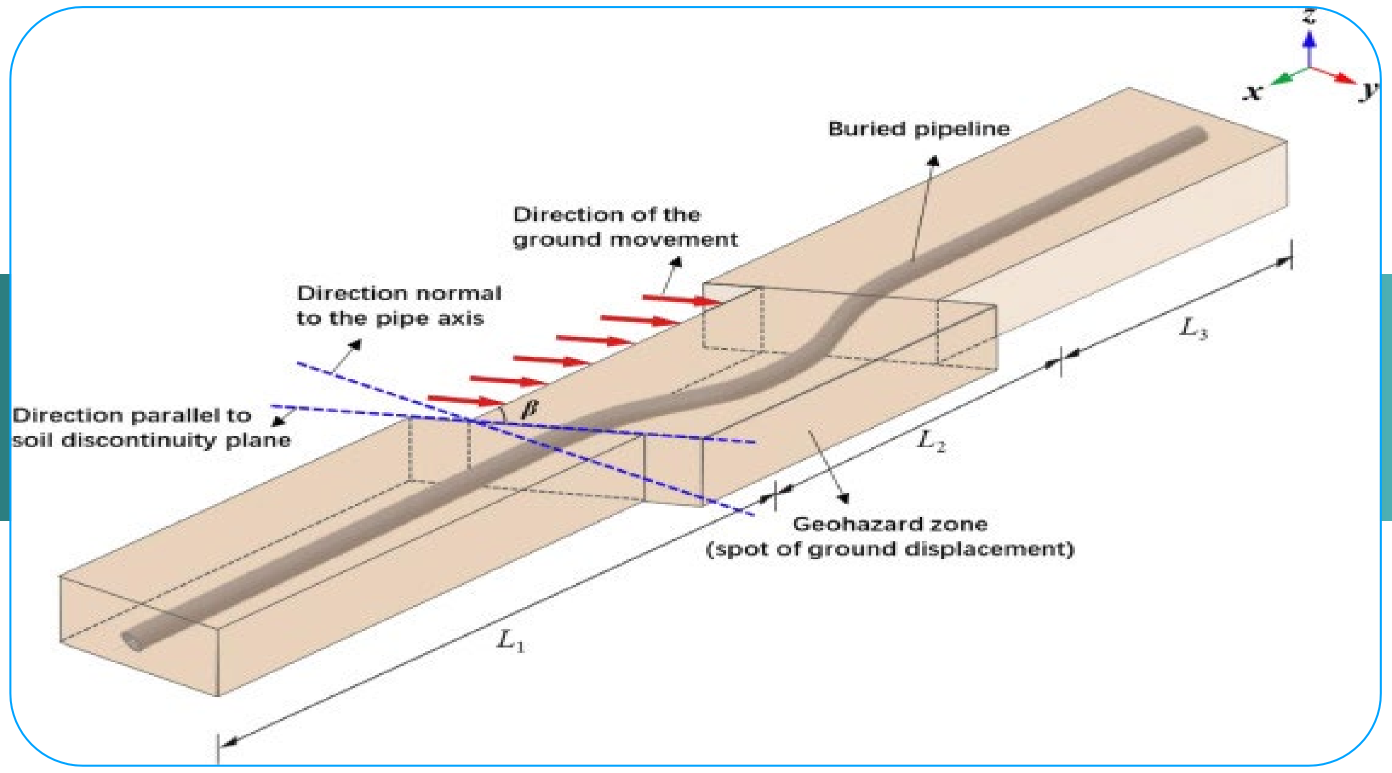
Risk assessment and Strain assessment and intervention are PHMSA requirements

Inspection frequency

Tend to have a proactive geohazard management through monitoring and intervention

Landslide at the pipeline ROW

Source: Mobiltex

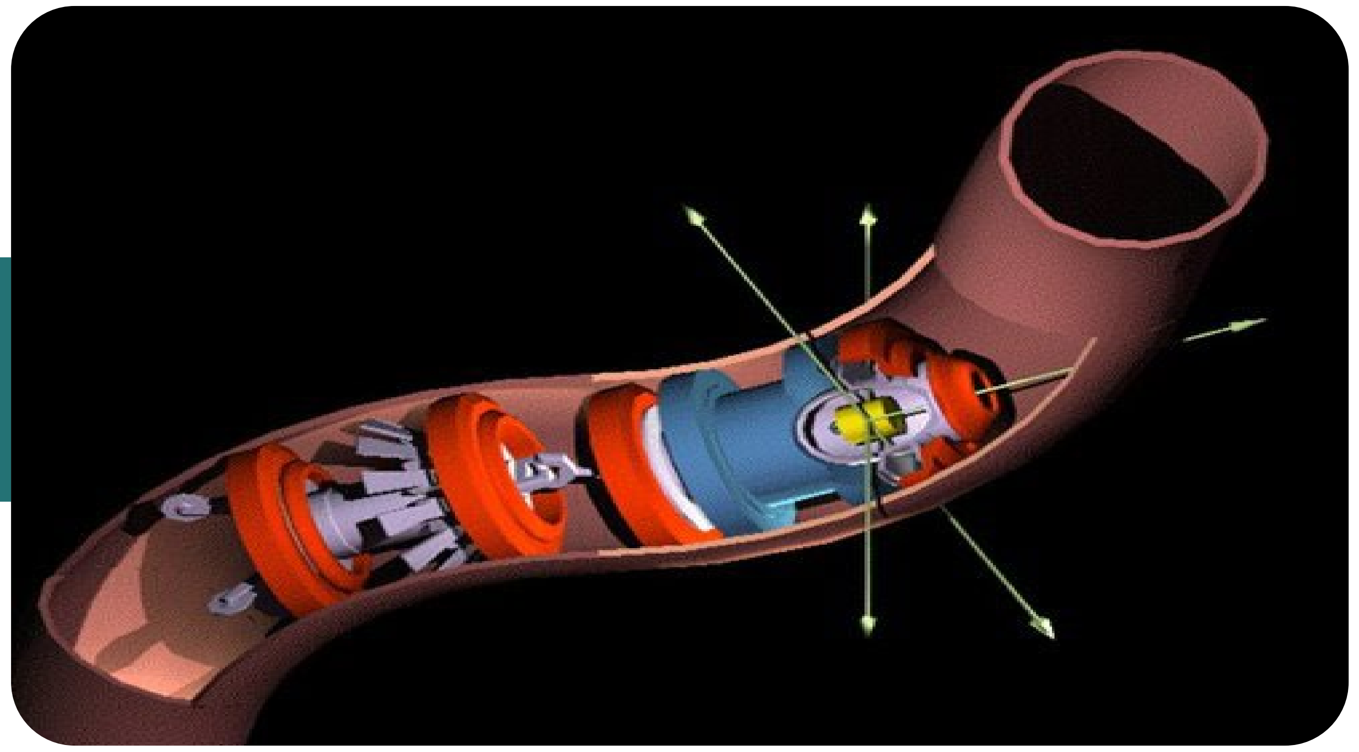


Ground displacement induced by geohazard

Source: Zheng 2021

ON-SITE INSPECTIONS

Position of the asset determined using handheld EM locators and soil sampling



ILI/IMU INSPECTIONS

In-line inspections to determine to estimate the bending strain levels

Safety concerns

Operator's safety is at risk in challenging terrains (On-site inspections)

Time consuming

Several weeks are necessary for preparation and data acquisition

Resource intensive

Especially for ILI that are expensive and stop the flow of the line

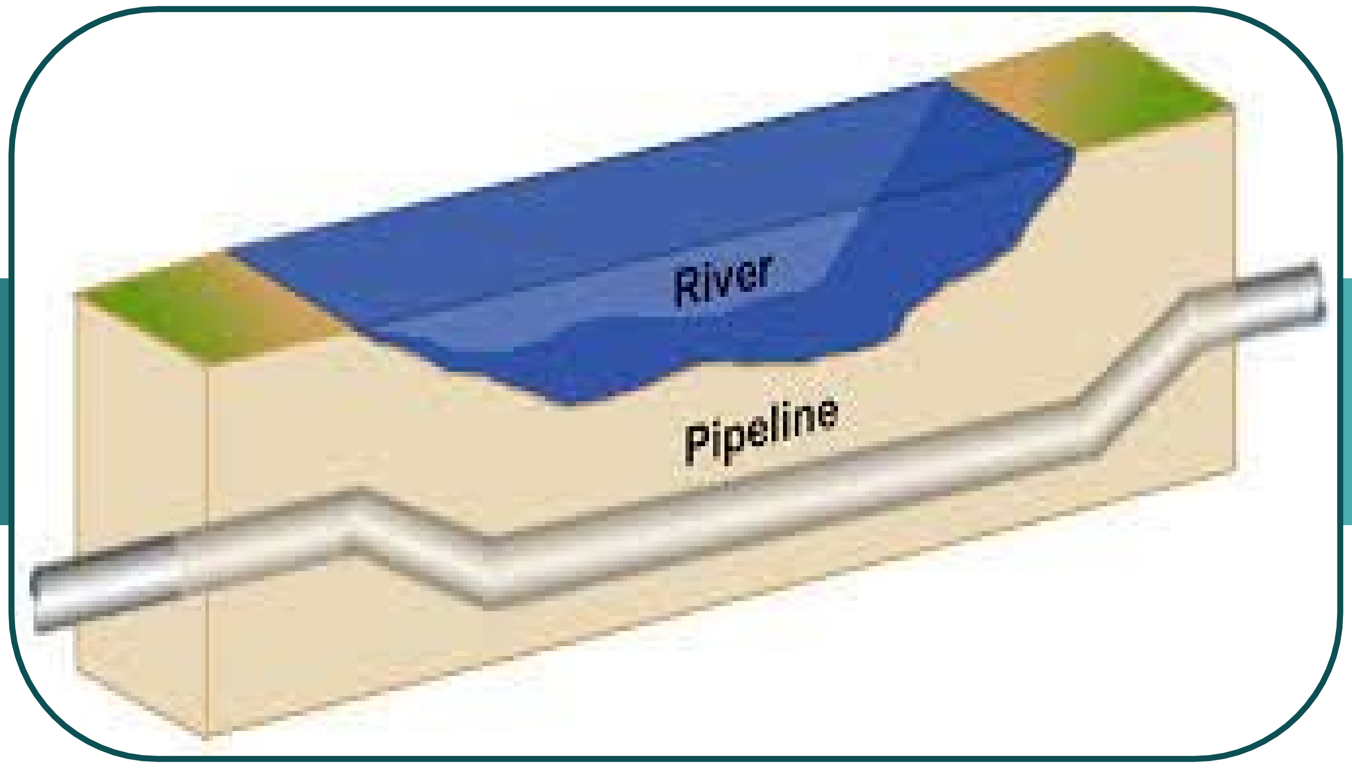
Pipeline monitoring: hydrotechnical

Available options are time & resource-intensive in addition to safety hazard potential for field crews.

Inspection enforced by regulator
Depth of cover assessment is required by both European and American regulators

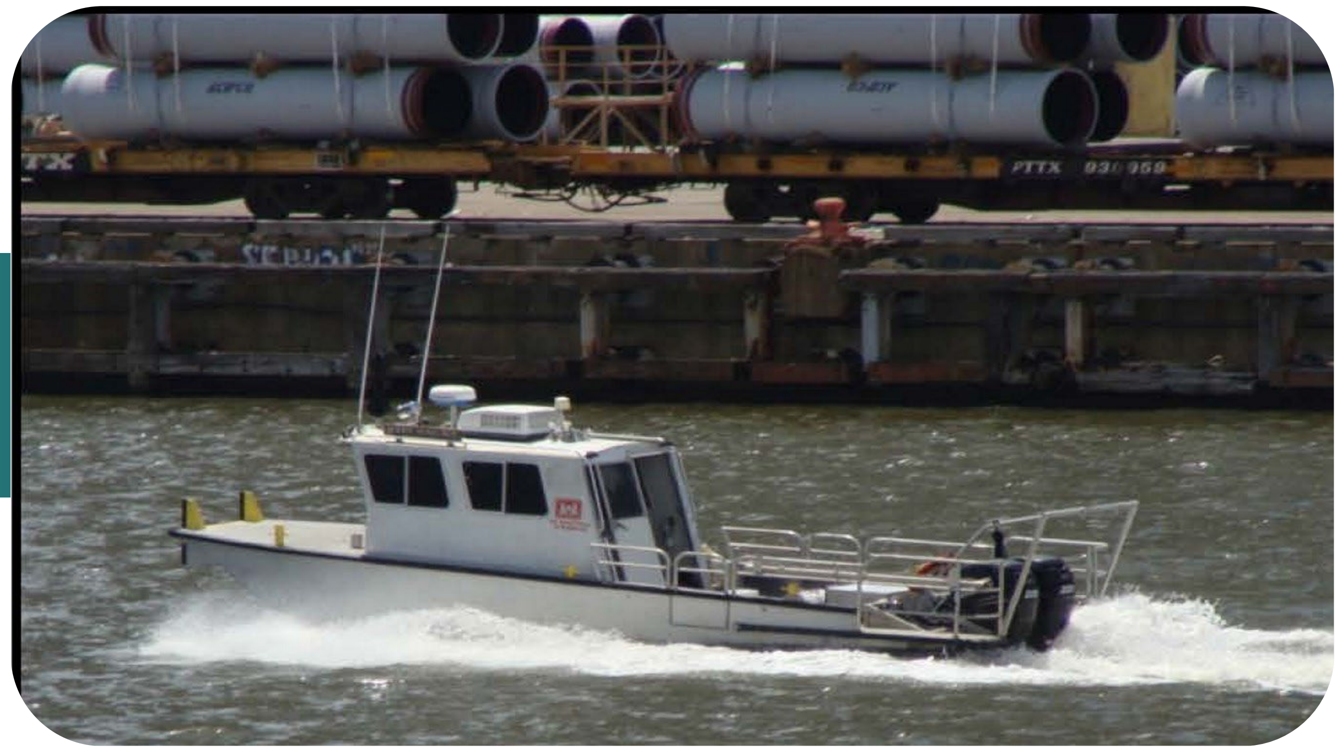
Inspection frequency of 5 to 10 years
Inspections are done on a regular basis to assure Pipeline safety and prevent scouring

Pipeline failure at river crossing
Yellowstone river



River crossing cut view
Threatened by scouring and geohazard

Divers inspection
Depth of cover assessment on the riverbed using handheld EM locators



Boat inspection
Bathymetric survey using boats and large river crossings

Safety concerns
Operator's safety is at risk

Time consuming
Several weeks are necessary for preparation and data acquisition

Resource intensive
diver or boat with a support team

UAS magnetometry achievements

UAS-based magnetic inspection tool.

2022

'3D-Localisation and magnetic mapping of buried pipelines using Unmanned Aerial System (UAS)',
Laichoubi et al., Pipeline Technology Conference 2022.

2023

'Novel Non-Contact Drone-based Tool for Pipeline Movement Assessment',
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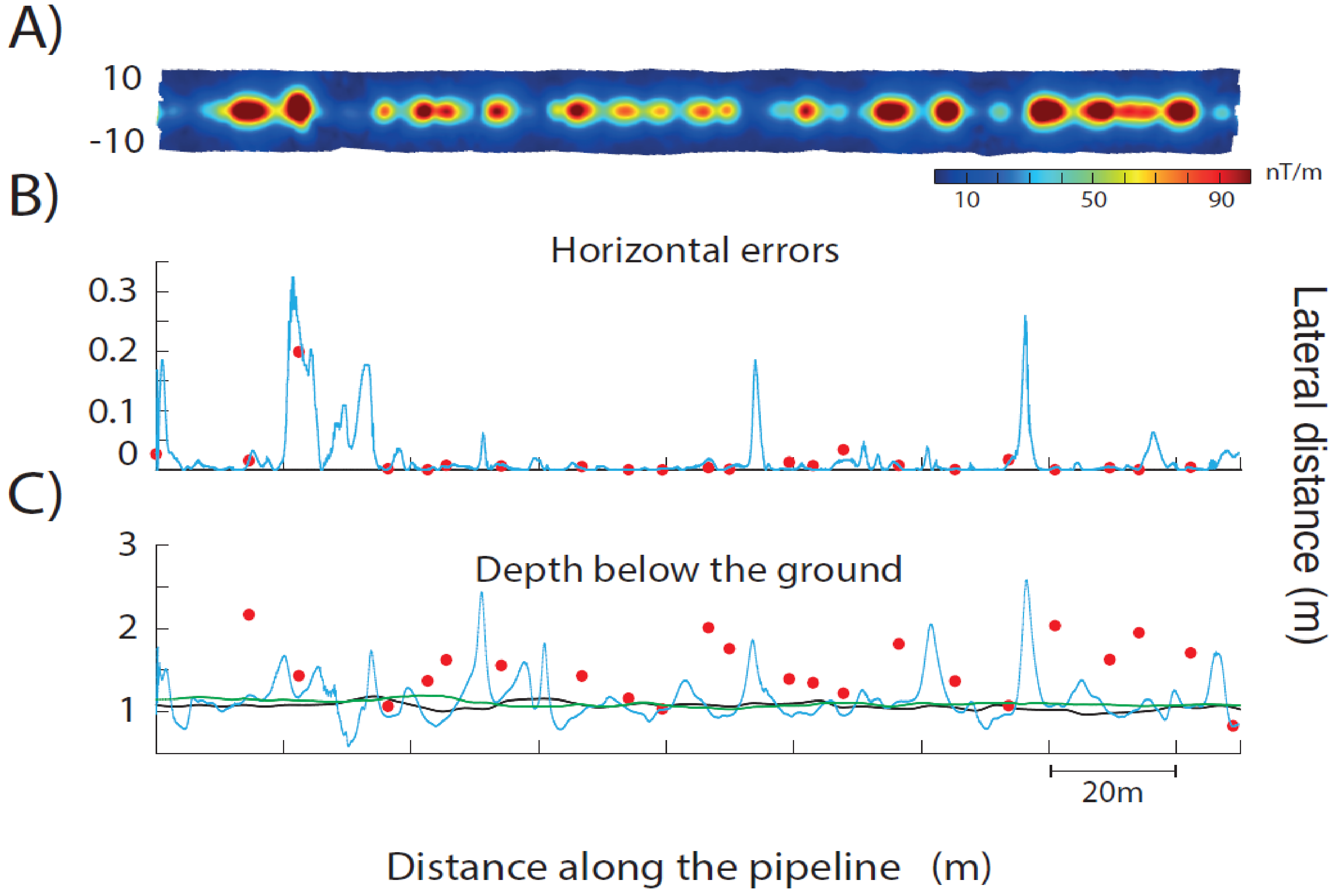

A centimetric 3D-positioning of buried pipelines is consistently achievable by UAS

UAS magnetometry achievements

UAS-based magnetic inspection tool.

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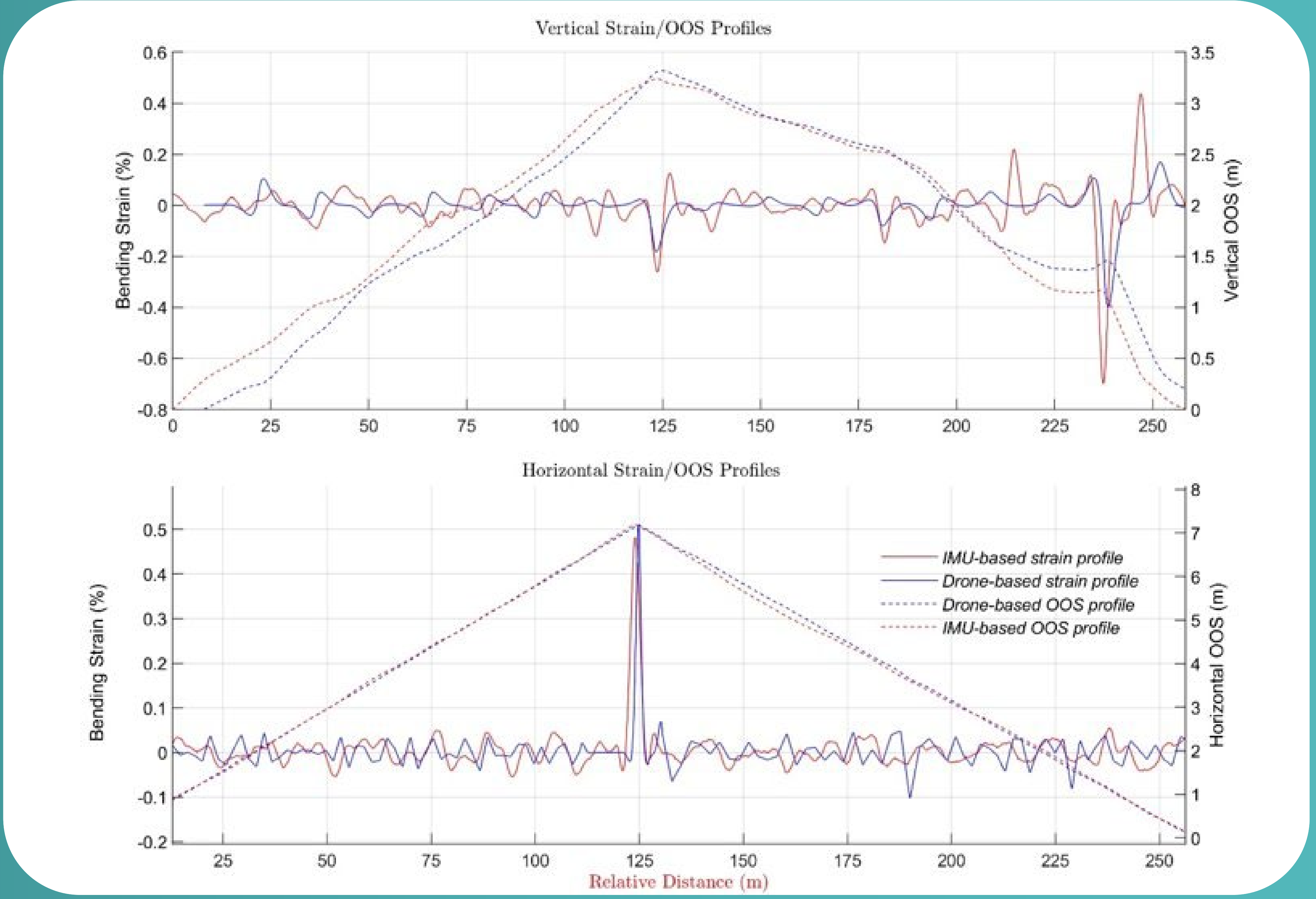

This 3D position can be derived into Out-Of-Straightness calculations and Bending Strain estimations

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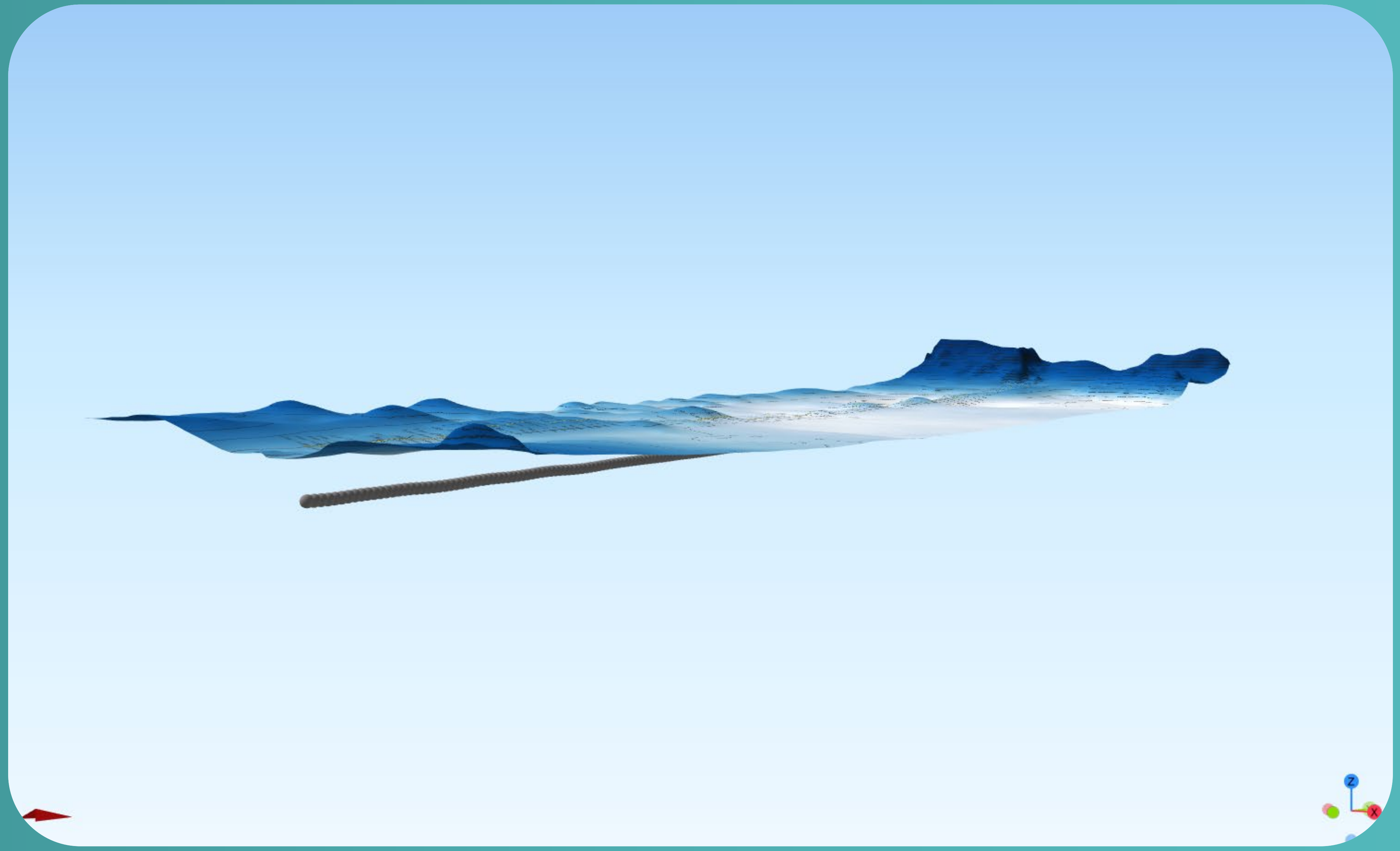


This methodology can be applied to river crossings with a 50 ft standoff

Skipper NDT Technology

4.4 lb carbon fiber payload

63'' wingspan enabling underwater mapping.

Skipper NDT's embedded system mounted under an off-the-shelf UAS

Magnetometers

- Fluxgate 3-axis magnetometers
- Light, robust with high acquisition frequency
- Allows calibration/compensation process

GNSS

- Real time Precise Point Positioning (PPP) correction services
- Accuracy ± 1.5'' cm at 95% rms worldwide
- Facilitates operations and logistics

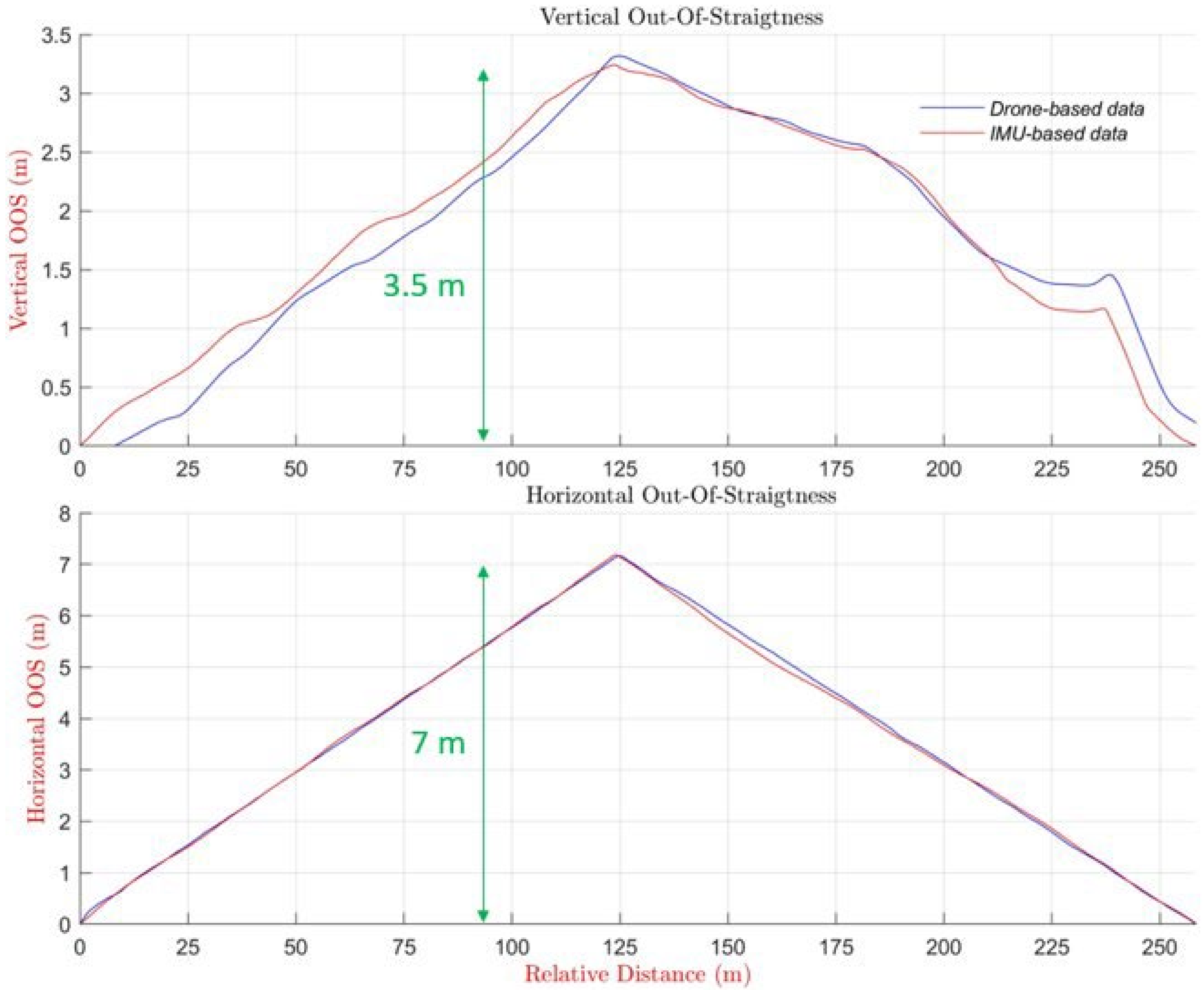
Navigation sensors

- Inertial Measurement Unit (IMU) for level-control
- Telemetric sensors for topography
- Allow post-processing corrections

Out-of-straightness and Bending Strain Assessment

ILI / IMU comparison on a 2.5° intentional cold bend

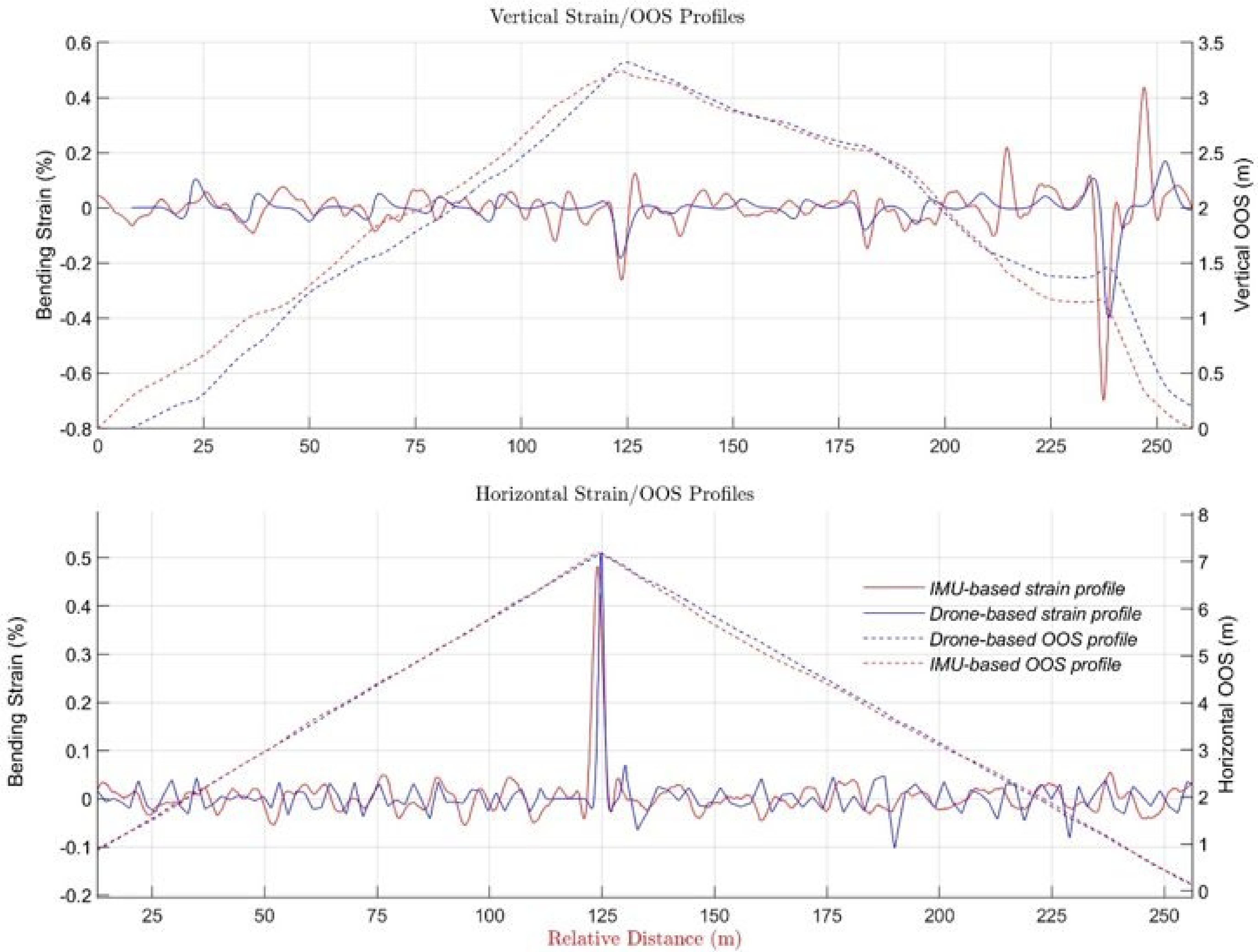
- The horizontal cold bend well captured,
- The horizontal position matches perfectly the one obtained with an ILI tool,
- The overbend-sagbend sequence has been successfully detected
- A reasonably good agreement between the two datasets



Out-of-straightness and Bending Strain Assessment

Strong correlation between ILI / IMU data

- The cold bend located at 410 ft is distinctly identified and captured (sharp and rapid strain)
- Vertical profile: there is a sudden curvature
- Change near the end of the surveyed section of the pipeline which corresponds to a strain peak that is well-identified using both technologies



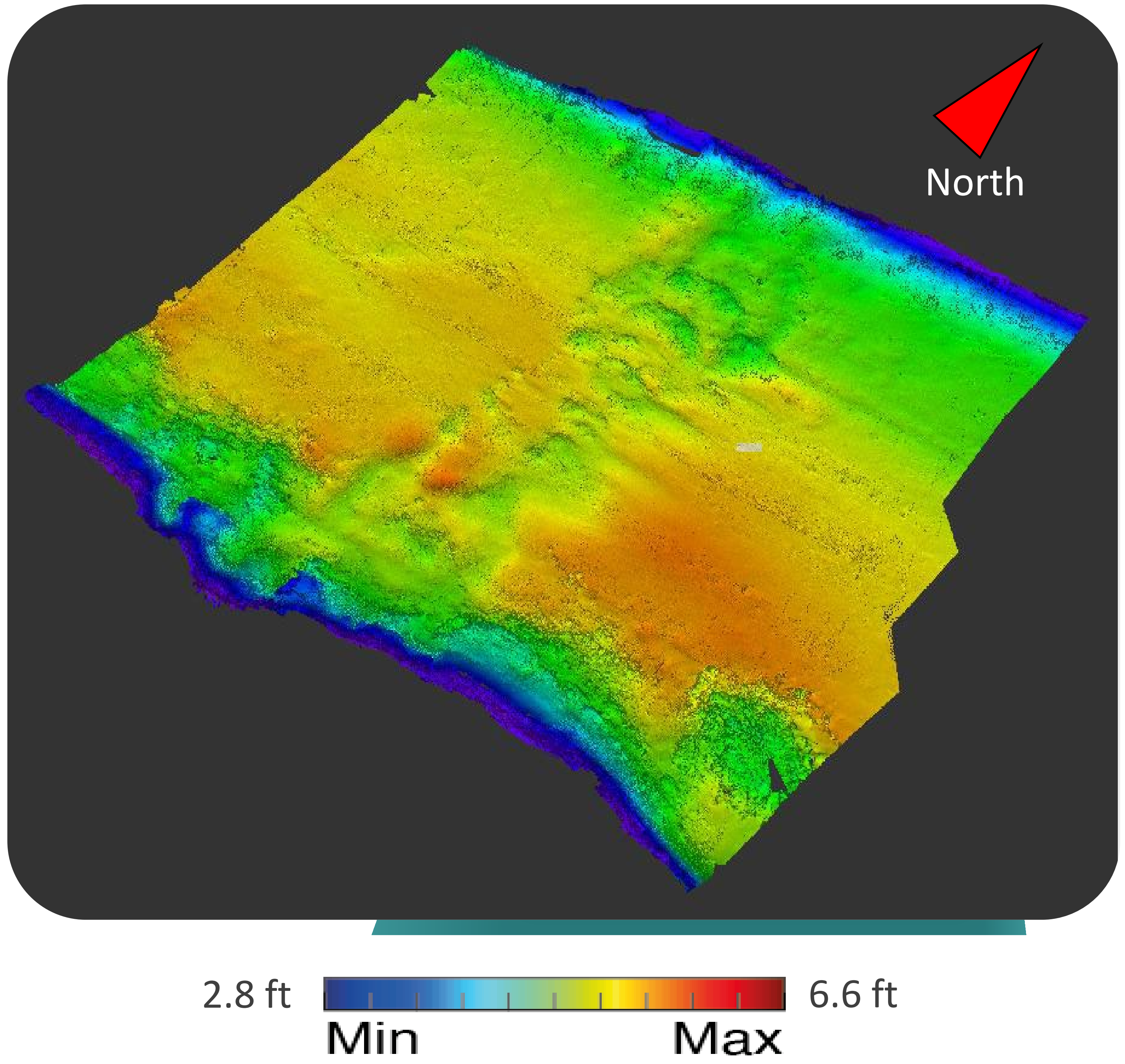
Material and Method

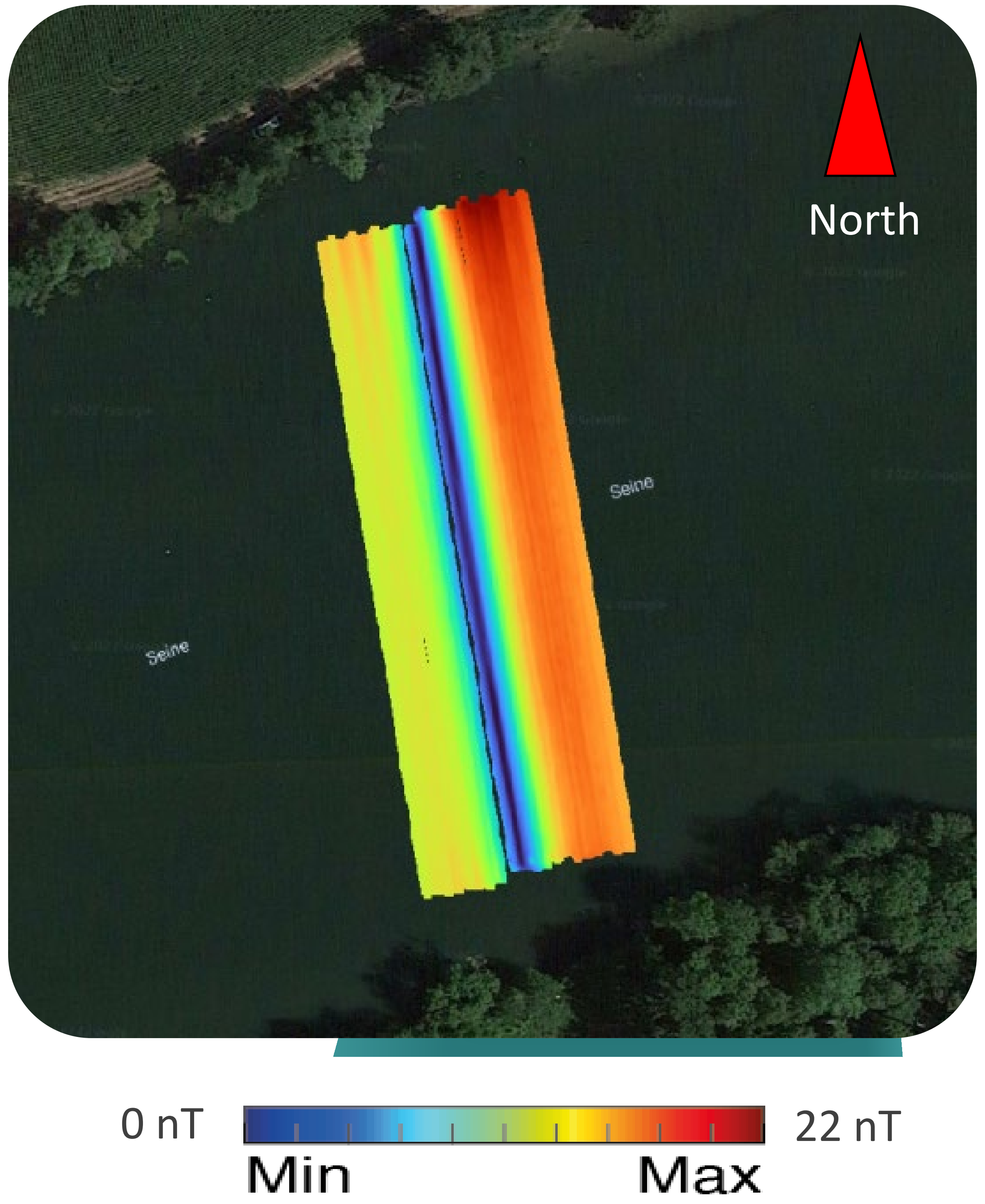
Automated, precise, reproducible and safe process compared to traditional tools

Case study: La Seine

Focus on the deepest river crossing (42ft) in an urban environment

Inspection parameters	
Pipeline's Nominal diameter (mm/inch)	900 / 35
Pipeline's steel grade / coating	X42 / PE
Water Column (m/ft)	9/30
Acquisition frequency (Hz)	2000
Inspected distance (m / feet)	120 / 361
Average velocity (km/h and mph)	7.2 / 4.5
Flight time (minutes)	37
Flight height (m / feet)	1 / 3.3
Current injection characteristics (A) / (V)	0.87 / 49





Multibeam bathymetry of the riverbed

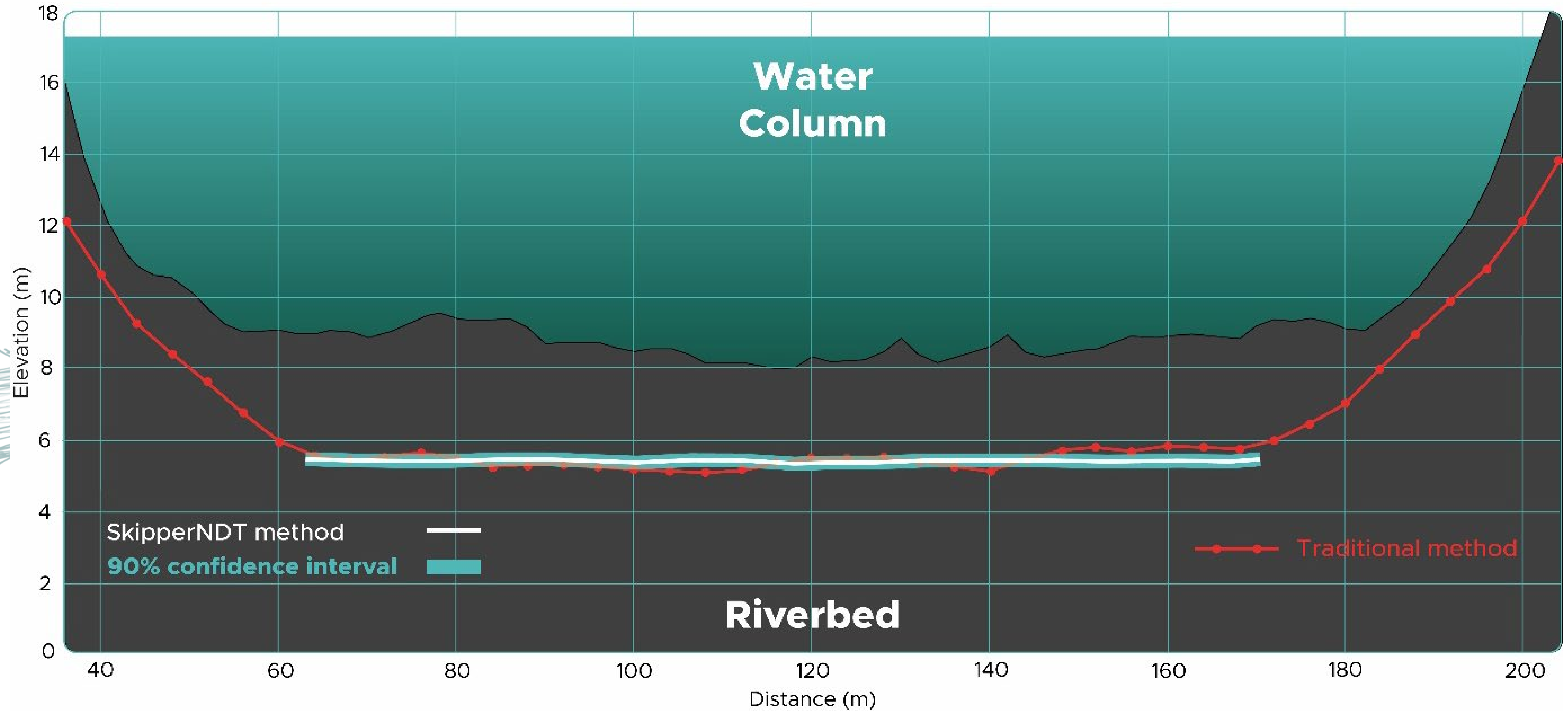
Topographical irregularities above the pipeline trajectory that are most certainly due to the embankment after the pipe-laying.

Total Magnetic Intensity of the ROW

Clear magnetic anomaly with a spreading pattern proportional to the total centerline / sensor distance.

Case study: La Seine

Elevation profile compared with traditional method: 1.2'' VS 8.6''



Accurate and precise 3D measurements

Elevation profile correctly measured at 42.6 ft maximum distance from sensor to centerline

Unlocked XY-positioning capabilities compared to the traditional “straightness assumption”

Data spacing

- Traditional method : 6.5 to 13 ft
- Magnetic mapping : 19.6''

Accuracy

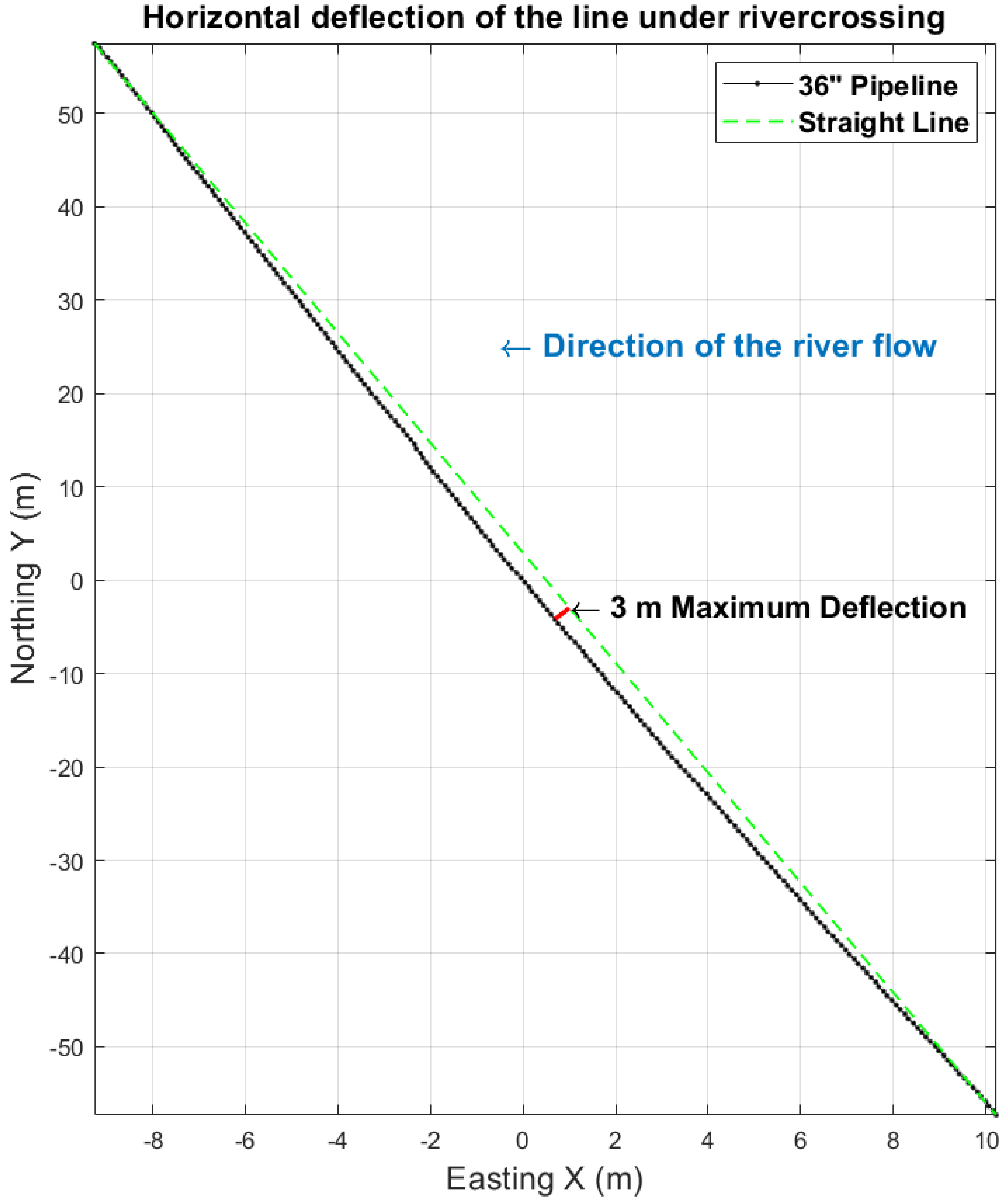
- Average elevation value are equal for both methods at 16.4 ft AMSL

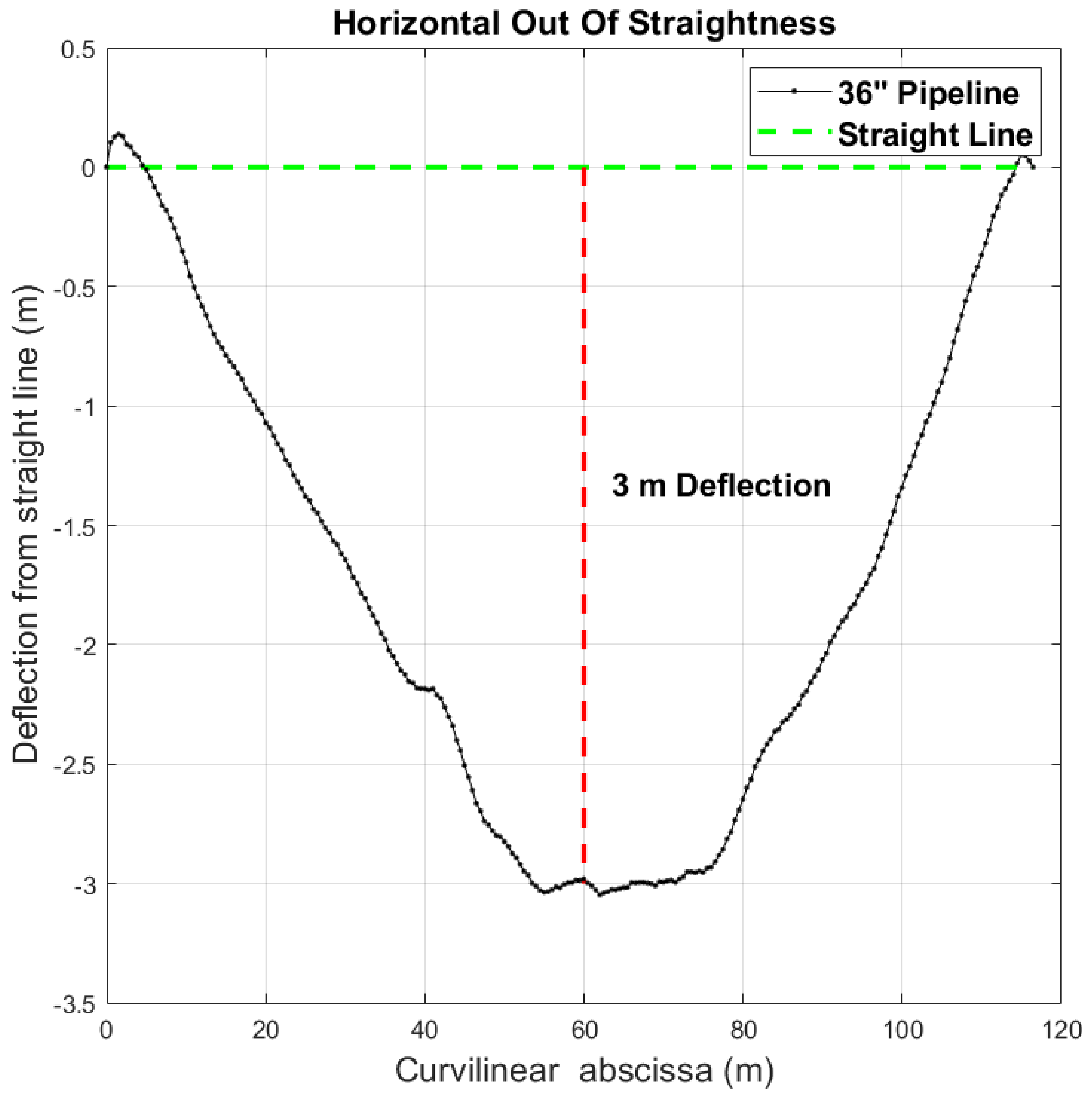
Precision

- Traditional method : 8.6'' STD
- Magnetic mapping : 1.2'' STD

Case study: La Seine

Planimetric analysis and Out-Of-Straightness





DISCUSSION / CONCLUSION

New suitable tools are available for contactless inspections in a geohazard context

- The accent is put on predictive statistical models that allow proactive geohazard management.
- Newly available tools for in situ inspections can contribute to the current strategy either by monitoring ongoing geohazard or by helping with the mitigation.
- They should be considered as other tools in the toolbox: a screening tool for Bending Strain Assessment in geo/hydro-technical issues.
- The objective is to reduce the cost of quick assessment and reduce human risks in challenging terrains.

Performance

Accurate, precise and consistent positioning tool over several river crossings and on-land inspections.

Range

Maximum tested range of 42.6 ft sensor/pipe distance.
No error factor to be applied with the depth.
No theoretical limitations other than signal strength.

Speed

Reduces significantly the inspection time without interfering with pipeline operating conditions.

Safety

No personnel is deployed underwater or dangerous RoW, increasing safety and simplifying logistics.

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