Digital Twin Concept for Subsea Pipelines

A Novel Framework

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AGENDA

\# Overview of Digital Twin

\# Application of Digital Twin in Offshore Applications

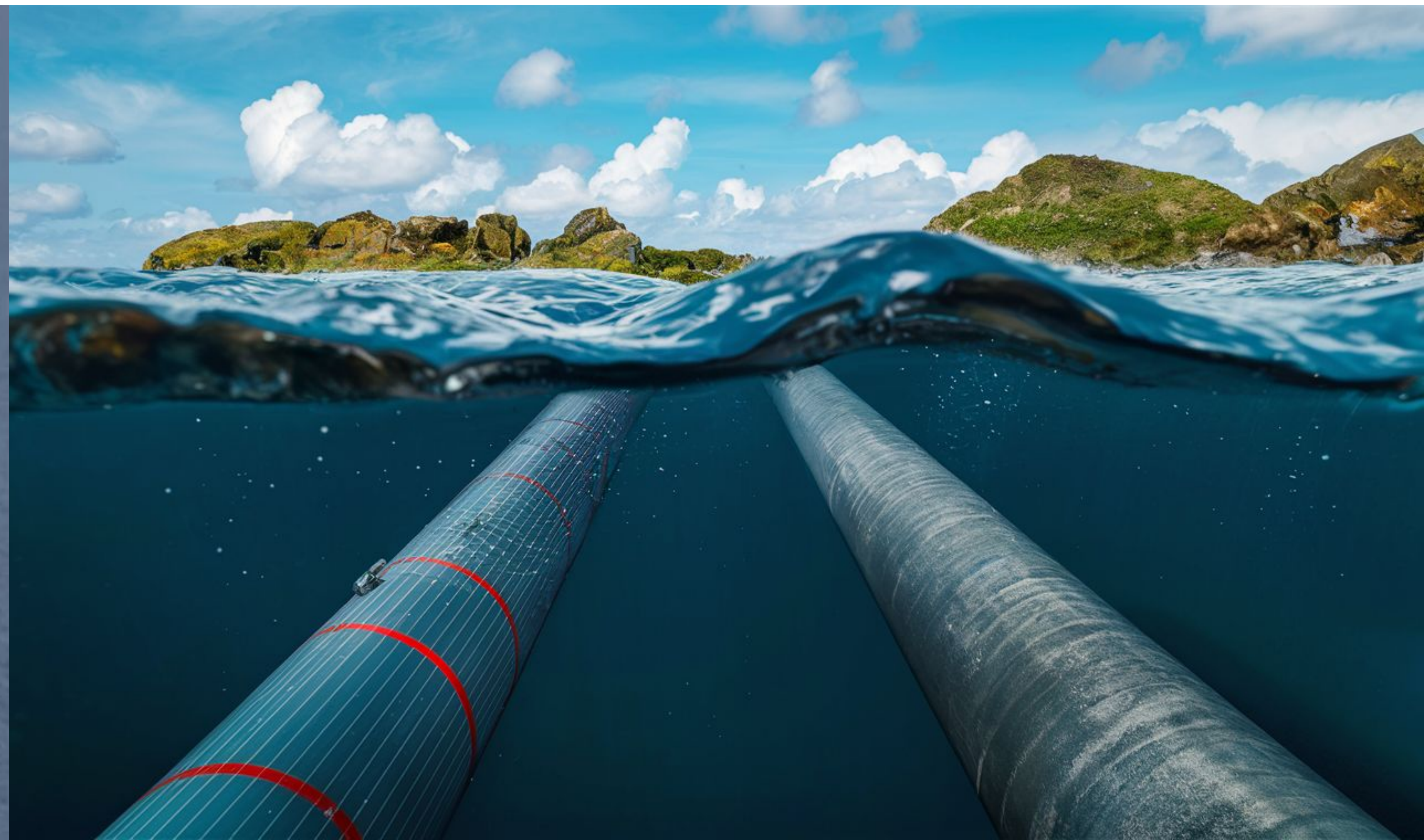
\# Case Study – Stress Prediction in Subsea Pipelines

\# Results & Discussions

Digital Twin – Introduction

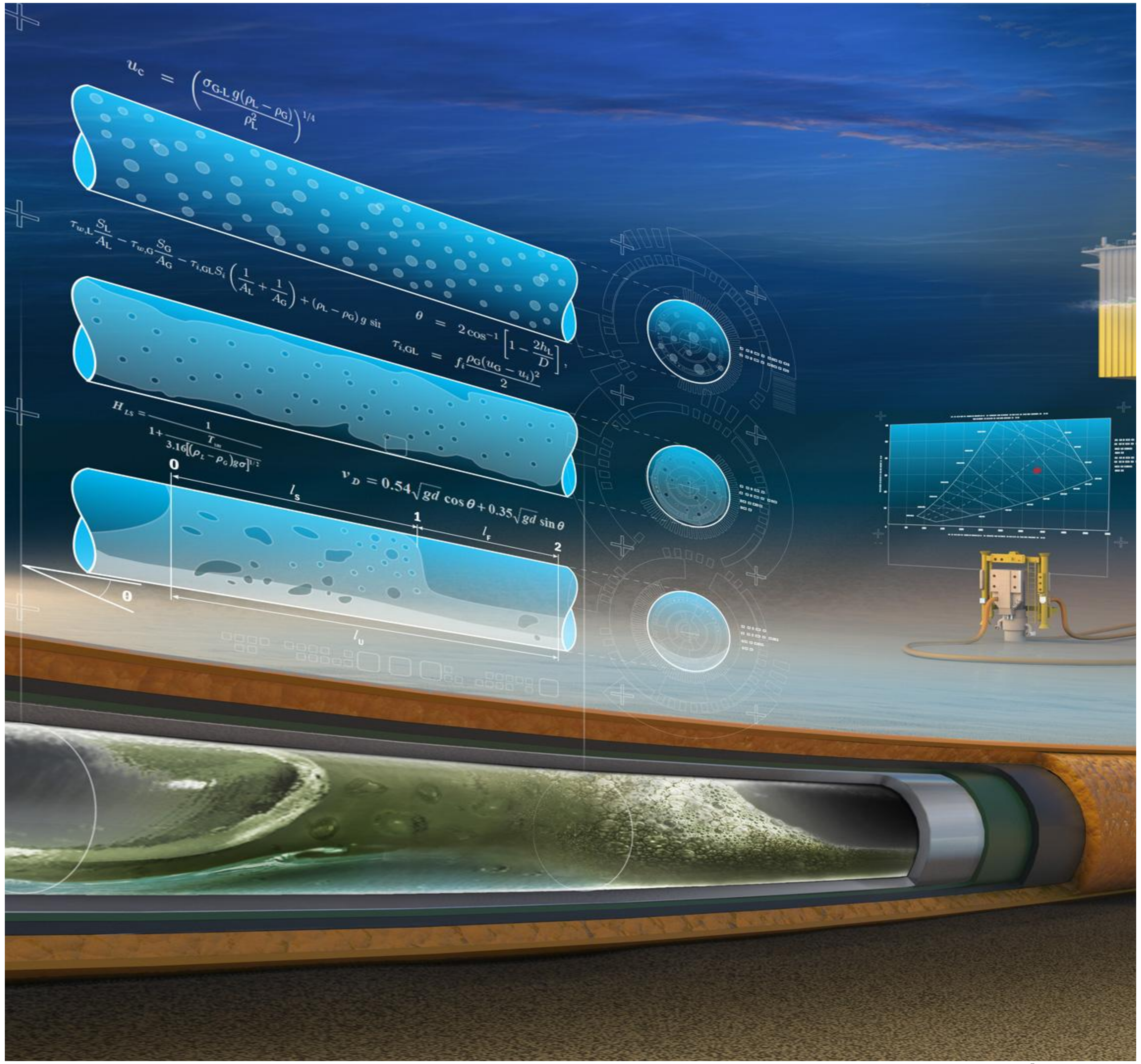
- Digital twin technology is a virtual representation of a physical object, system, or process.
- It combines real-time data, simulation, and analytics to create a digital replica that can be used for monitoring, analysis, and optimization.
- In the context of offshore Industry, digital twin technology is used to create a virtual model of the Assets, capturing physical characteristics, performance data, and environmental conditions.





Digital Twin – How it Works

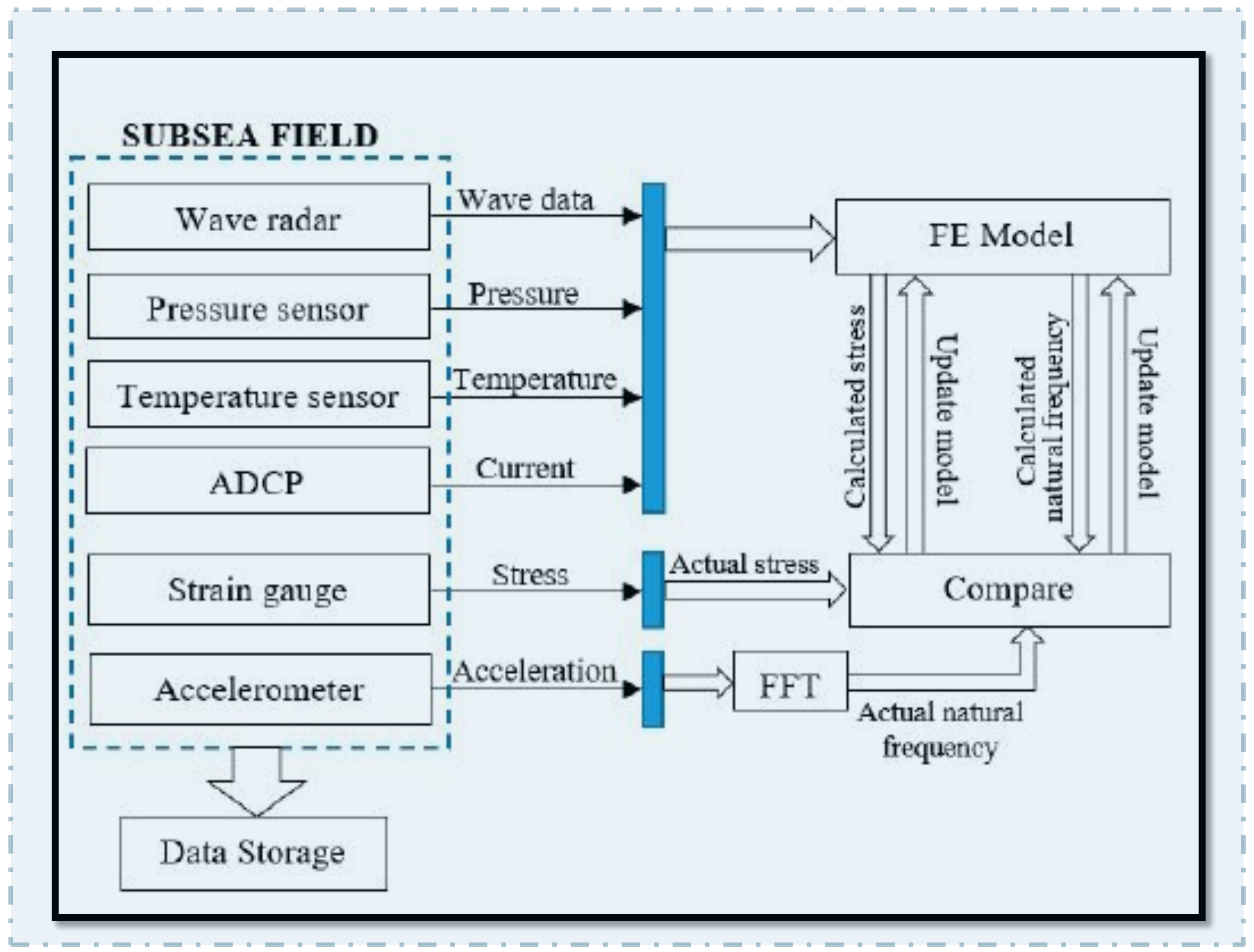
- Installation of Sensors
- Data Collection and Transmission
- Data Integration and Analysis
- Creation of Digital Twin
- Real-Time Monitoring and Predictive Maintenance.



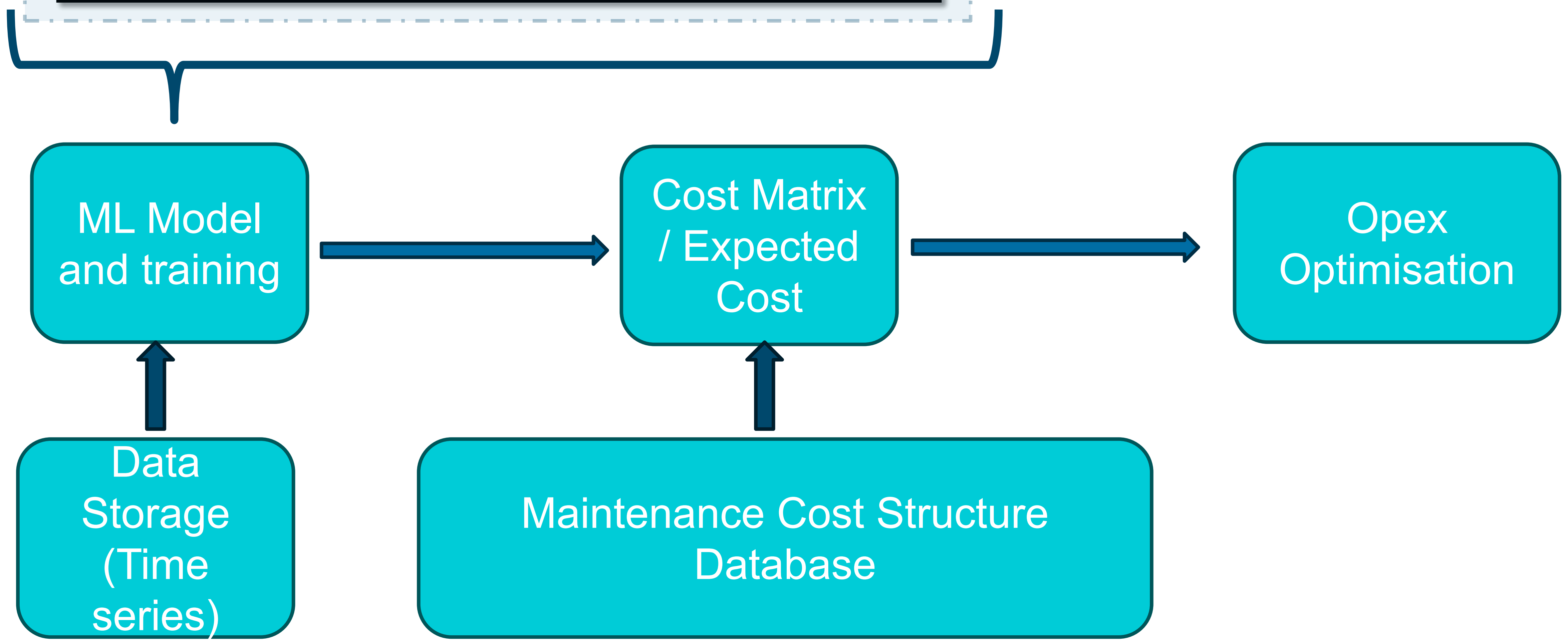
Source: SLB

Data Integration and Analysis (e.g. Fatigue or Predictive Maintenance)

- One of the components is a computational model of the asset which is normally a finite element (FE) model
- The computational model of the subsea pipeline is updated based on different field sensor data
- Both the data-driven and FE-based models can be used to predict the remaining fatigue life
- Knowledge of the RFL can enable efficient maintenance planning and avoid unpredicted shutdowns

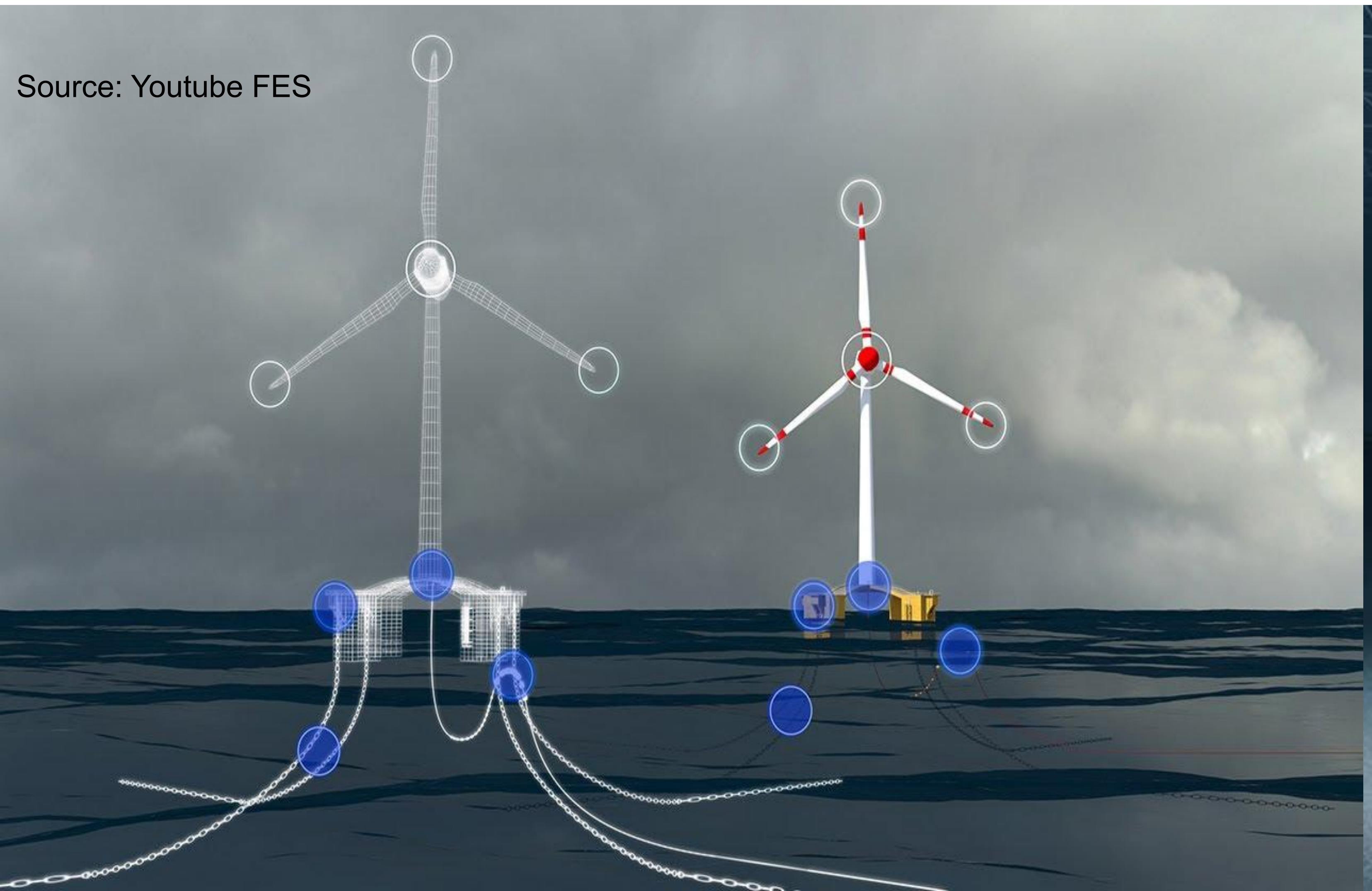


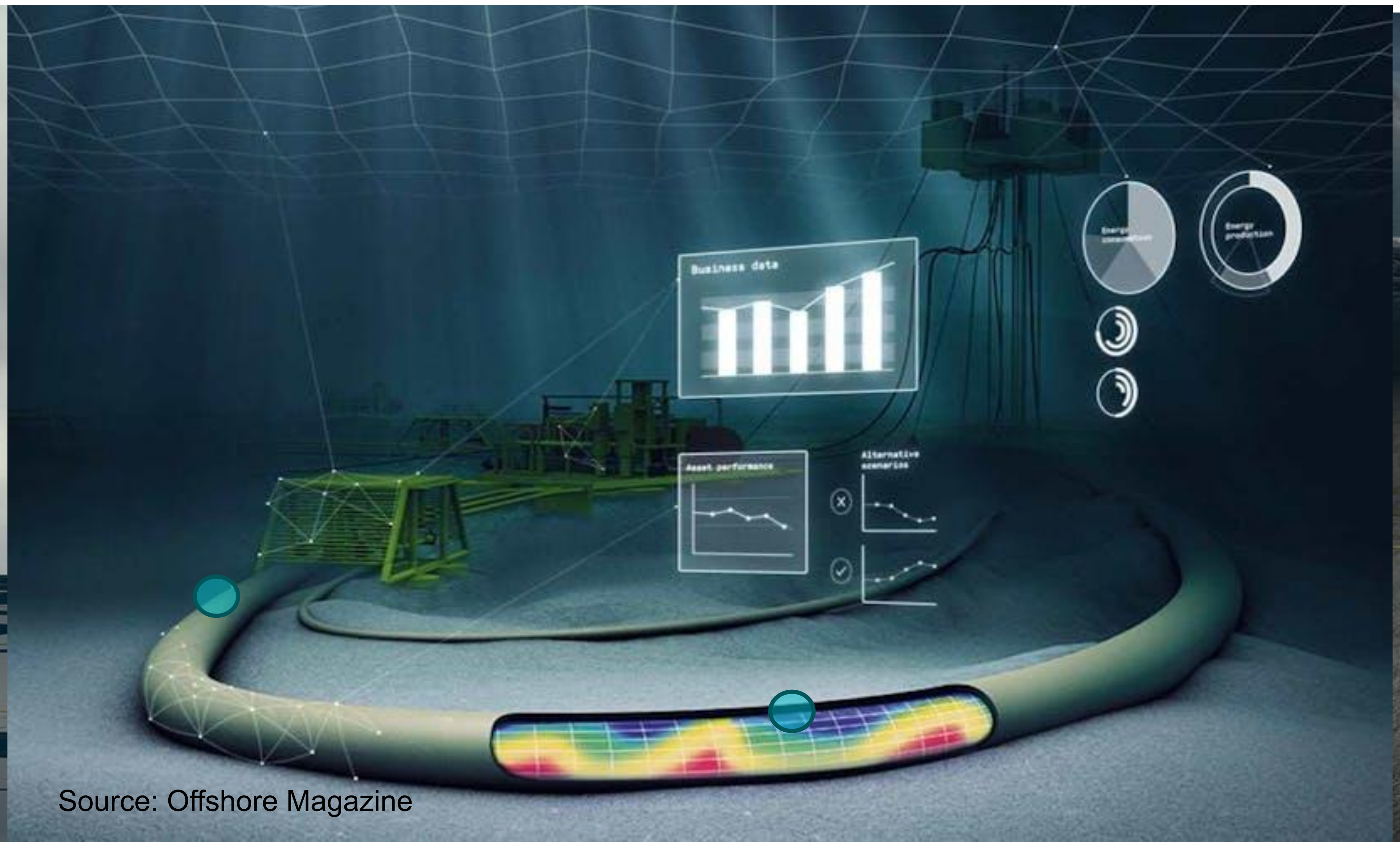
Bhowmik, S. "Digital twin of subsea pipelines: Conceptual design integrating IoT, machine learning and data analytics"

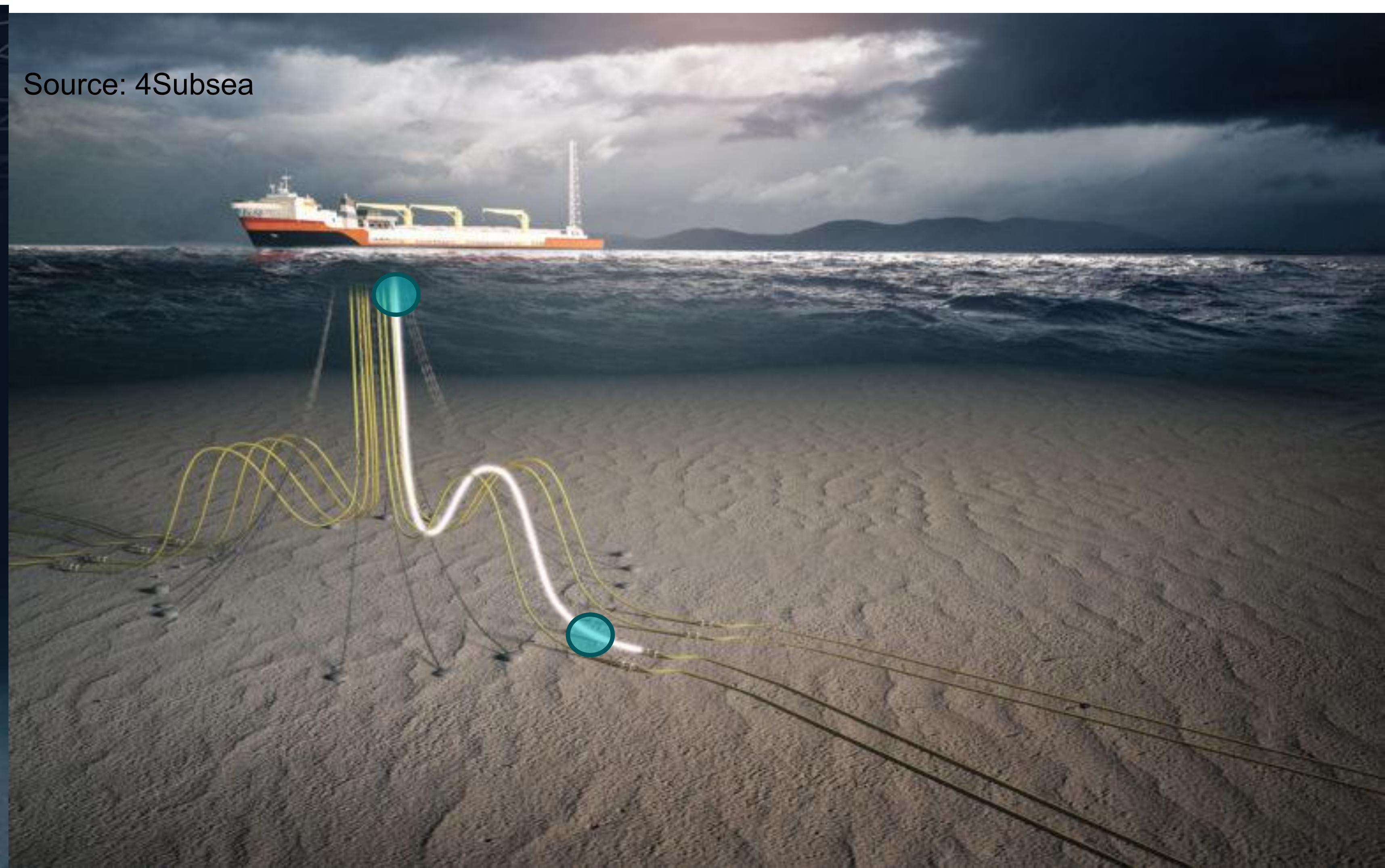


Challenges of Pre-trained Digital Twin Model

- Data acquisition at the right locations
- Quantity of sensors to equip the whole asset
- Change in environment post training is not captured
- Data transmission – volume and speed

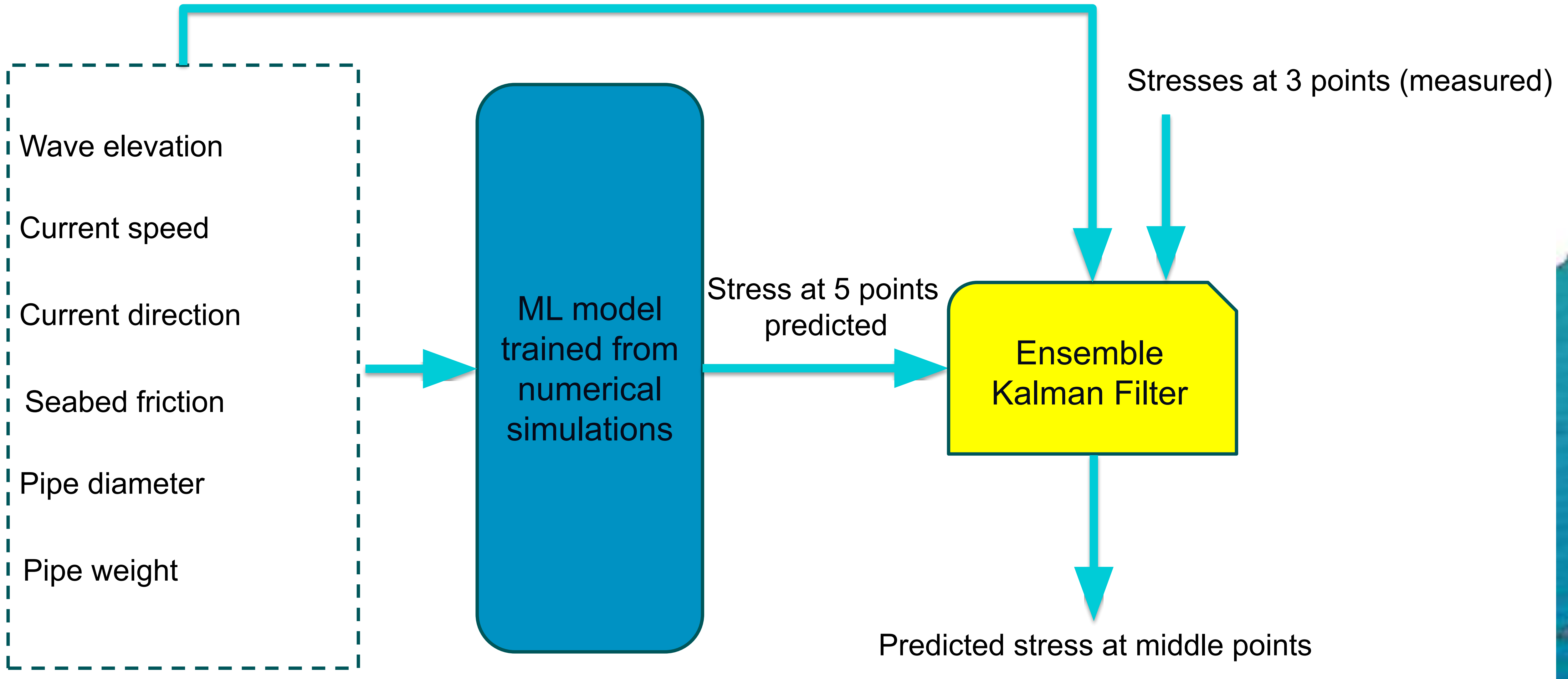

Source: Youtube FES

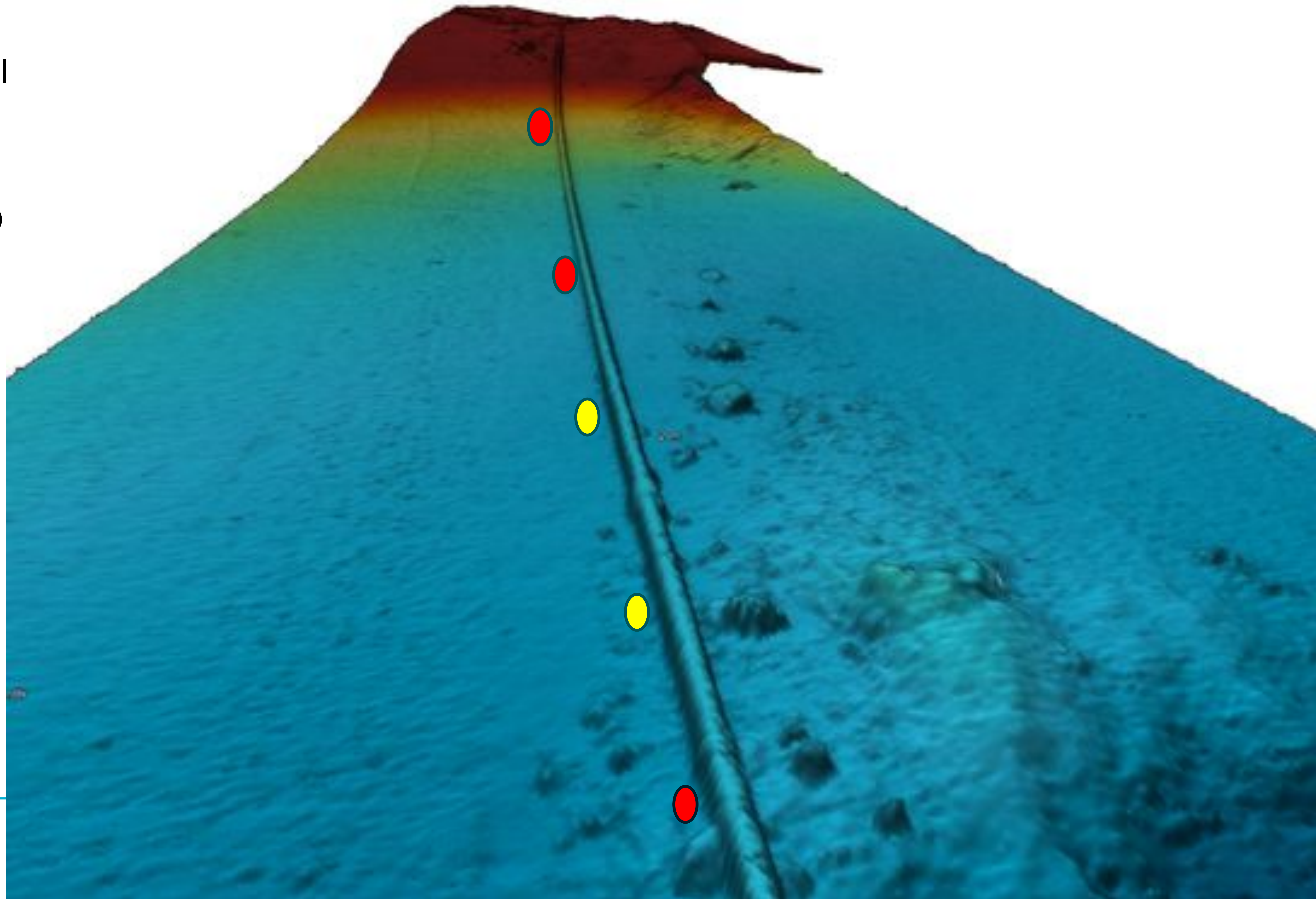

Source: Offshore Magazine


Source: 4Subsea

Novelty in Predicting Stresses

- Combining numerical simulations with measured data
- The physics driven ML model is built from numerical simulations
- The model is then calibrated and corrected online using
- The calibrated model is then used to estimate stress in

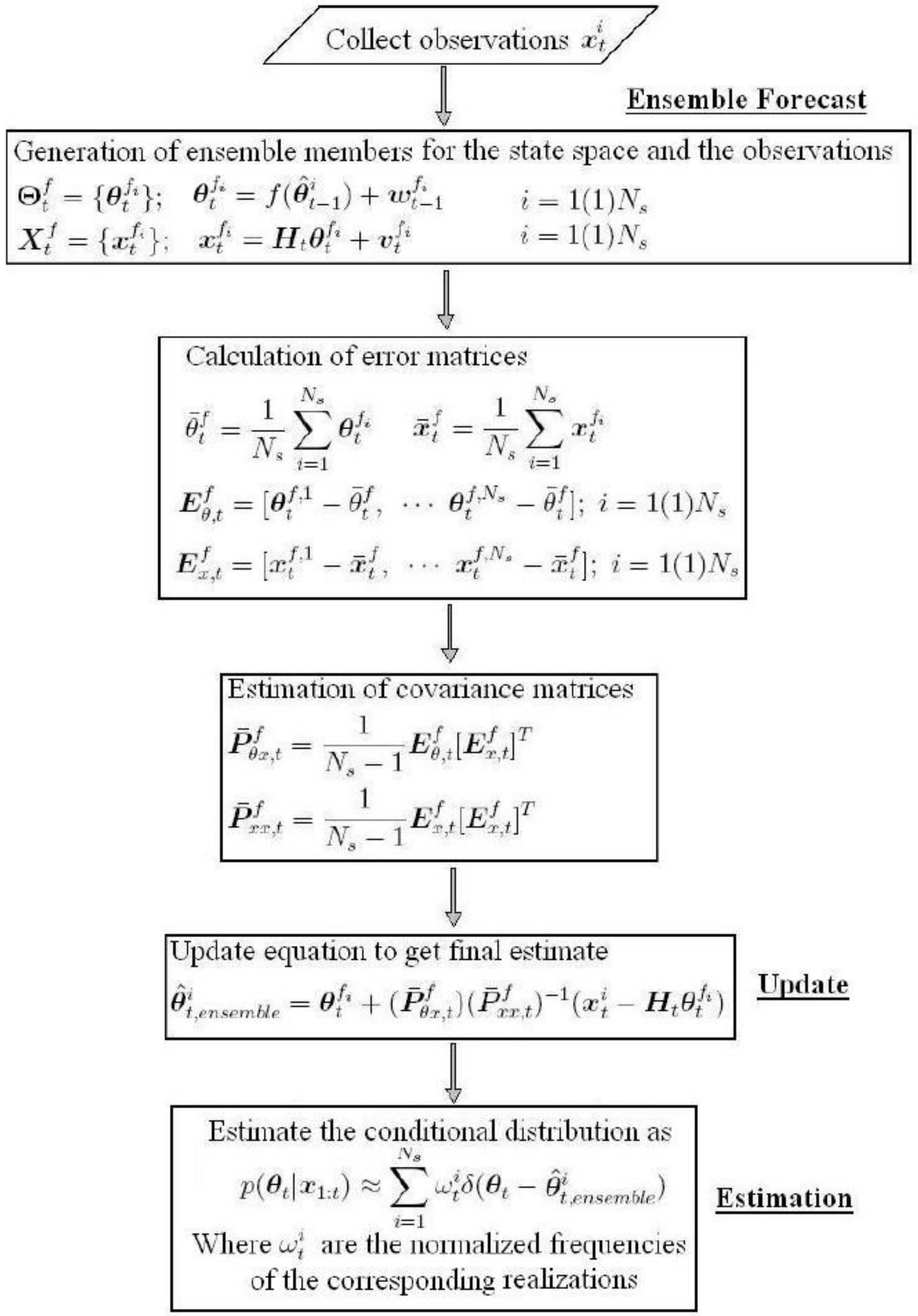




Novelty in Predicting Stresses

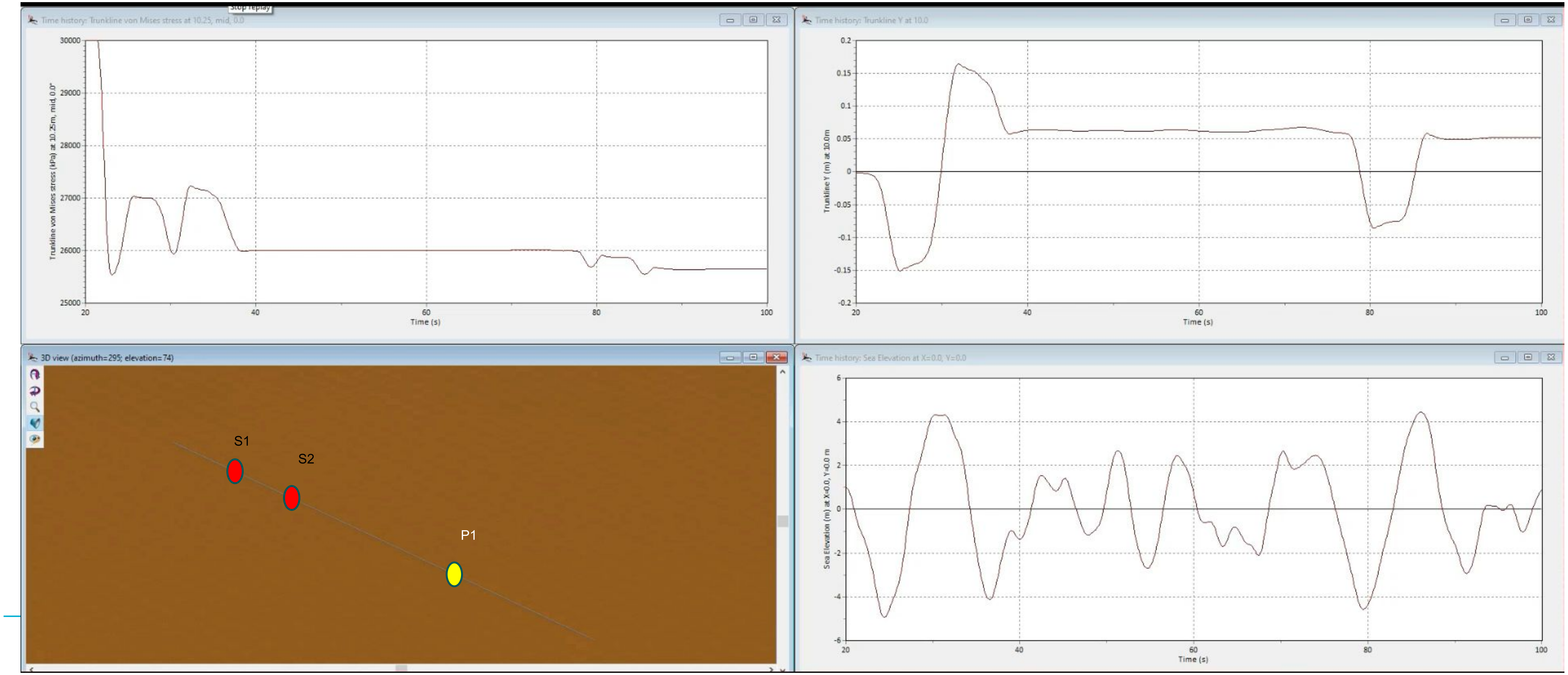
Data assimilation

- The core idea is to correct the prediction of the pre-trained model based on sparse measurements
- The pre-trained deep learning model acts as a base model representing the dynamic system
- Real-time measurements are then used to correct the model estimations of the system
- The differences are due to the imperfectness of the real system compared to the perfect model



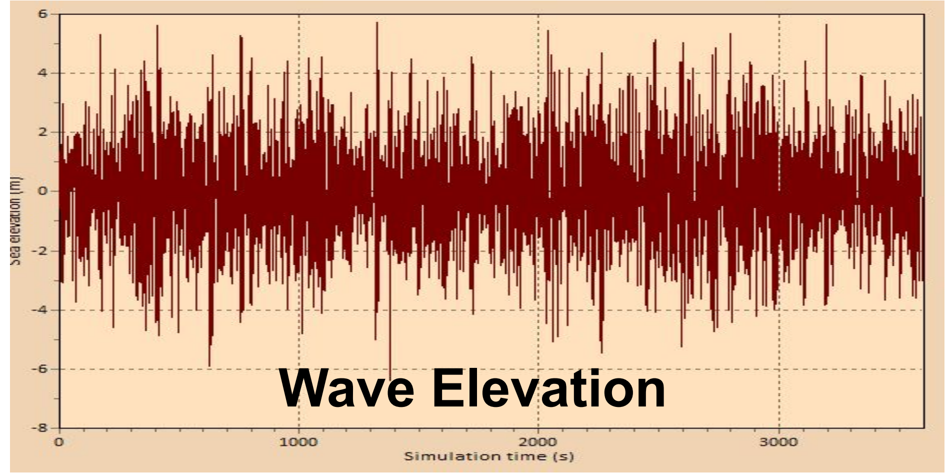
Case Study – Subsea Pipeline

- Rigid steel pipe of 30in diameter 1 km long
- Water depth of 40m
- Waves of 7m Hs and 9 sec Tp, current of 1m/sec, applied in the perpendicular direction



Case Study – Stress Prediction

Input Data



Current Speed,
Block current 1 m/s

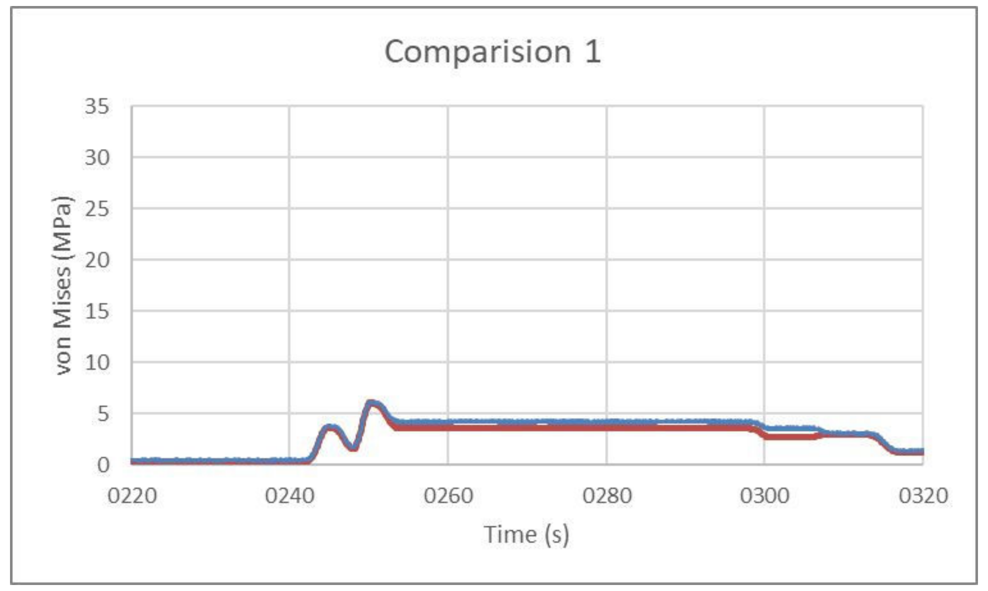
Current Direction,
90 deg to the pipeline axis

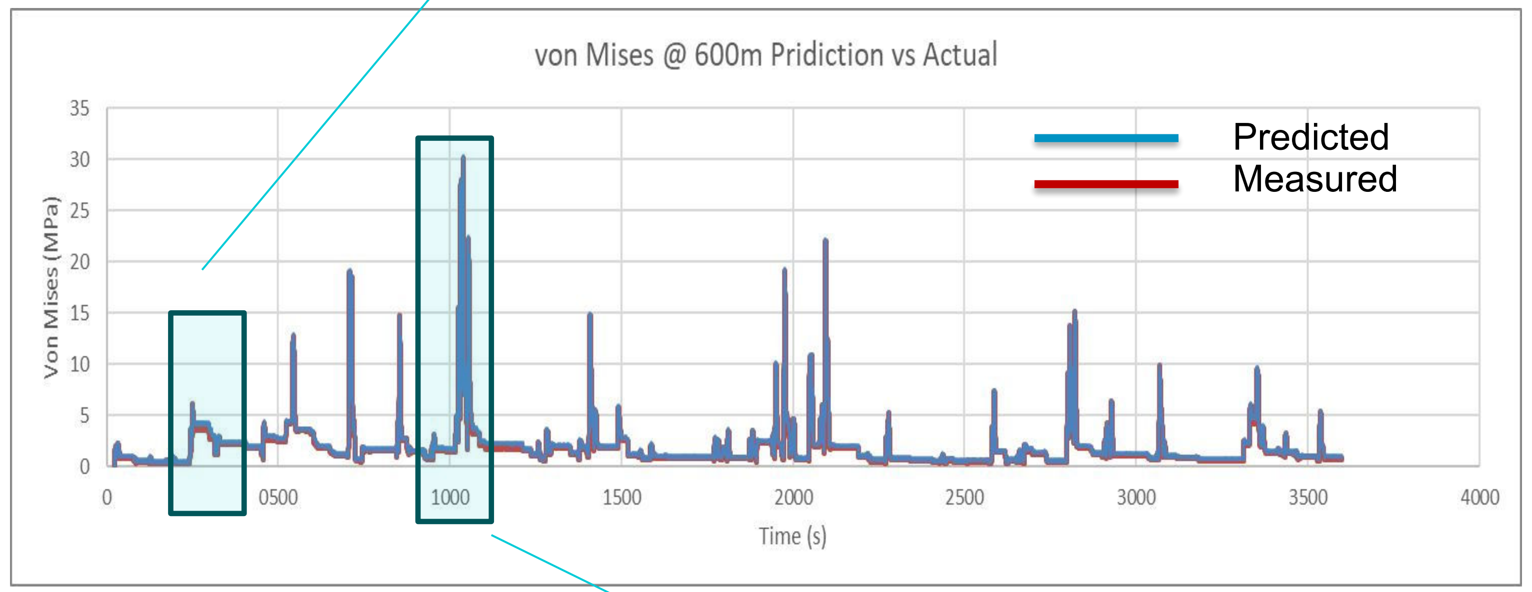
Seabed Friction 0.6

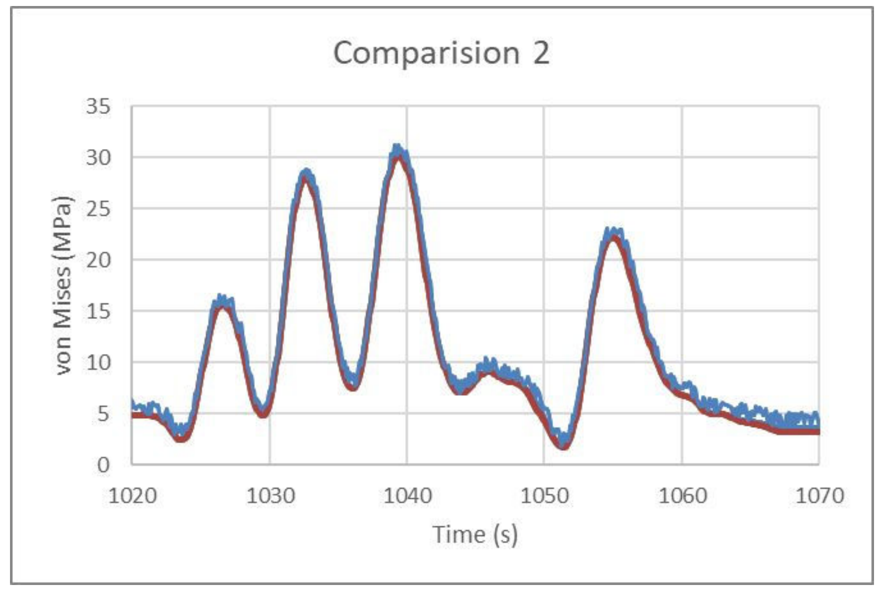
Pipe Diameter – 40”

Pipe dry weight – 890 kg/m

Input → Proposed architecture → Prediction



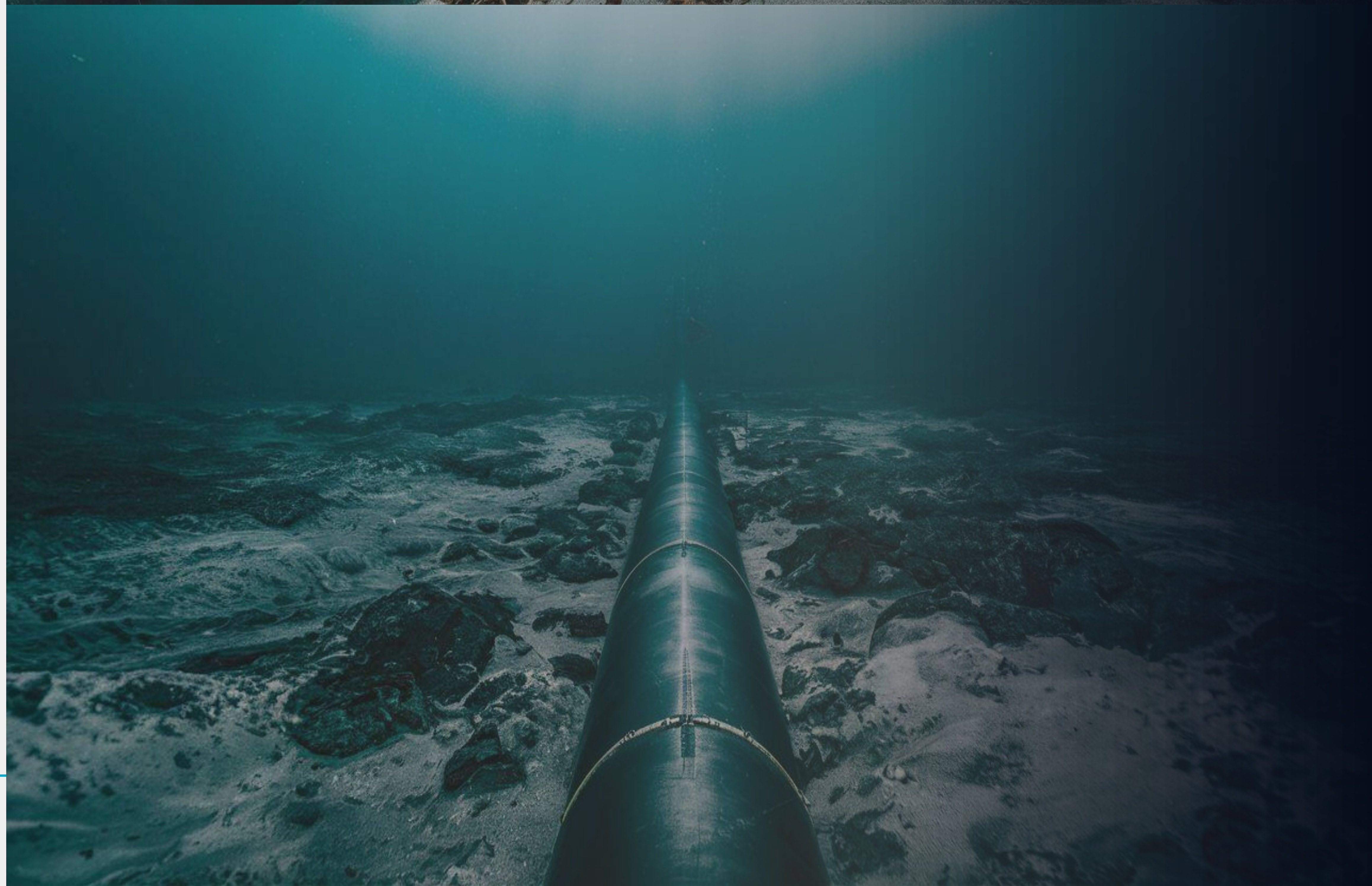




Predicted stress values are within 4% of the measured stresses.

Summary

- A novel approach of combining numerical simulations with measured data is presented to predict stresses in real-time.
- Accuracy greater than 95 % is achieved on the test case presented for a subsea pipeline
- Real-time monitoring helps in the reduction of ROV inspection and aids the predictive maintenance schedule
- Tracking stress and fatigue improves useful remaining fatigue life using actual loading condition
- The framework presented is generic and can be extended to various subsea applications
- The system relies on the accuracy of sensor data and transmission interval which is a challenge as we venture into deeper waters



Questions...

Contact us

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