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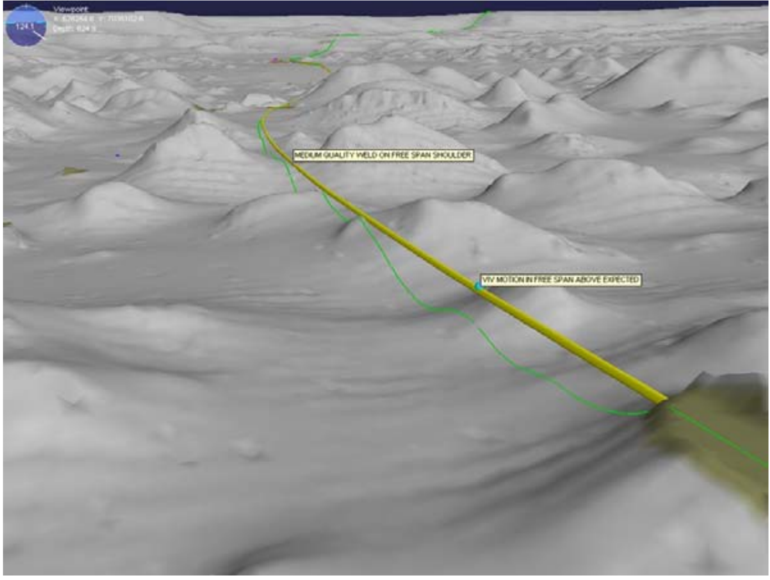

DROPS JIP Phase III

Q4/2024 - Q4/2026

Solving engineering challenges in global response analysis of subsea pipelines and cables by including 3D non-linear time domain VIV analysis of free spans.

Global response of subsea pipelines and cables in the operational phase is a complex and integrated process where different effects (operational conditions, waves, current, seabed interaction, etc.) all work together, hence affecting the global response of the product, and thereby its integrity, in a lifecycle perspective.

The development of SIMLA - a special-purpose computer program system for non-linear static and dynamic analysis of subsea pipelines and cables - was initiated in 2001. The main objective at that time was to be able to simulate a pipeline installation operation on a 3D seabed as physically correct as possible.

Through DROPS JIP Phase I (Dynamic Response of Offshore Pipelines on the Seabed) SIMLA became a full-featured engineering tool for 3D non-linear time domain on-bottom stability (OBS) analysis of subsea pipelines and cables, also considering curved routing and the real 3D seabed topography. The development performed as part of this Joint Industry Project (JIP) focused on the implementation of state-of-the-art hydrodynamic load models (ref. [1]) and the most robust and reliable pipe-soil interaction (PSI) models for both sand and clay. The development included several numerical improvements for the PSI models, hence creating efficient and numerically stable algorithms (ref. [2]). The value of being able to perform 3D non-linear time domain simulation of on-bottom stability scenarios is well documented through the work performed by IKM Ocean Design on early-phase design optimisation of the BM-C-33 gas export pipeline (ref. [3]).

Phase II of the DROPS JIP was kicked off in 2021 and addressed engineering challenges in on-bottom stability assessment of small diameter pipelines and cables on 3D seabed, focusing specifically on combined wave-current boundary layer and gap effects, and pipe-soil interaction. A second order irregular wave model improving the accuracy for intermediate/shallow water depths was also implemented.

Objectives for DROPS JIP Phase III

The scope of work in Phase III will include activities to further improve the new hydrodynamic load models for combined wave-current boundary layer and gap effects, hence taking the ground-breaking research on this topic from Phase II the required steps further towards use in engineering design.

The main objective of the planned Phase III of the DROPS JIP is to further enhance the ability of SIMLA to correctly simulate the physical behaviour of subsea pipelines and cables in the operational phase by including functionality to perform 3D non-linear time domain VIV (Vortex-Induced Vibrations) analysis of free spans (refs. [4-7]). The advantages with including VIV analysis of free spans in a general 3D non-linear time domain analysis tool can briefly be summarized as follows:

- VIV fatigue from combined steady current and wave-induced oscillatory flow can be calculated without questionable simplifications, and internal slug flow conditions may also be included.
- All load contributions included in the same time domain analysis, i.e. on-bottom stability and VIV of free spans can be assessed simultaneously.
- All non-linear structural effects (tension variation, contact, etc.) included in the same analysis.

The developed numerical models will be made available to the industry through the SIMLA computer program.

The following work packages are planned for Phase III, pending available budget and agreement in the JIP Steering Committee (SC):

WP1: Hydrodynamic load models for near-seabed scenarios

- Further improve the numerical load models developed in Phase II.
- Extend the work from Phase II on combined wave-current boundary layer and gap effects to be valid for irregular sea states.
- Continue the work on model validation (CFD, comparison with available laboratory test data, etc.).
- Verification and documentation through case studies.

WP2: 3D non-linear time domain VIV analysis of free spans

- Literature study, including screening of availability of laboratory test data.
- Improve modelling of structural damping in flexible flowlines and cables.
- Improve modelling of pipe-soil interaction on free span shoulders.
- Implement and validate VIV prediction in free spans for constant flow conditions.
- Case study in constant flow condition and comparison with present design practice based on DNV-RP-F105.

For subsea pipelines and cables with small diameters in shallow water, the vortex shedding process can be strongly affected by waves and near-seabed effects. Such complex interactions are less understood and data from laboratory tests are lacking. It is planned to develop a roadmap based on the results from WP1 and WP2 to also address some of these effects.

Deliverables

1) A new SIMLA release with functionality for advanced 3D non-linear time domain VIV analysis of free spans.

2) Improved hydrodynamic load models in SIMLA for near -seabed scenarios, with focus on combined wave-current boundary layer and gap effects.

3) Technical report on verification/validation of the improved hydrodynamic load models for near-seabed scenarios through case studies.

4) Technical report on 3D time domain VIV theory and models, including verification/validation through case studies.

5) One free server license of the latest official SIMLA release is provided to all sponsors during the project. All sponsors not having SIMLA at project kick-off will be offered licenses to further use of SIMLA after project termination by only paying the maintenance and support fee for the requested number of licenses.

Schedule and Participation Fee

Duration: Q4/2024 - Q4/2026

Sponsor fees per participant: 1500 kNOK for Energy companies, 500 kNOK for Contractors/Suppliers, 300 kNOK for Engineering companies.

References

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[3] Nystrøm, P. et al.; "On-Bottom Stability Optimisation of the BM-C-33 Pipeline Using 3D Non-Linear Time-Domain Analysis". ISOPE-2023-TPC-0983.

[4] Thorsen, M.J., Sævik, S., Larsen, C.M.; "A simplified method for time domain simulation of cross-flow vortex-induced vibrations". Journal of Fluids and Structures, Volume 49, August 2014, Pages 135-148.

[5] Ulveseter, J.V., Sævik, S., Larsen, C.M.; "Time domain model for calculation of pure in-line vortex-induced vibrations". Journal of Fluids and Structures, 2017.

[6] Kim, S., Sævik, S., Wu, J., Leira, B.J.; "Prediction of deepwater riser VIV with an improved time domain model including non-linear structural behavior". Ocean Engineering, 2021, Volume 236.

[7] Farantos, C.; "Improved VIV Prediction of Free Spanning Pipelines and Cables". Master thesis, NTNU, 2022.

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