Bringing added value to pipeline engineers worldwide

SAGE Profile has been specifically designed to assist pipeline engineers in the design, installation and analysis of offshore pipelines. The powerful finite element solver has been fine-tuned to provide an excellent tool for tasks like

- Pipeline route optimization
- Simulation of the pipelay process
- On bottom stress calculations
- Prediction of buckling
- Expansion analysis
- Free span evaluation

The SAGE Profile Graphical User Interface guides the engineer in a quick and user-friendly fashion through the different steps required to set-up and solve complex pipeline problems.

The computational engine enables full 3D pipeline stress analyses with the ability to handle large deformation problems like lateral buckling, and accurate modeling of the pipeline-soil interaction by using of advanced plastic soil models.

> **"Solid design.
> Reliable pipelines."**

Simulation results can be viewed and printed in different formats – in tables, graphs and in 3D illustrations.
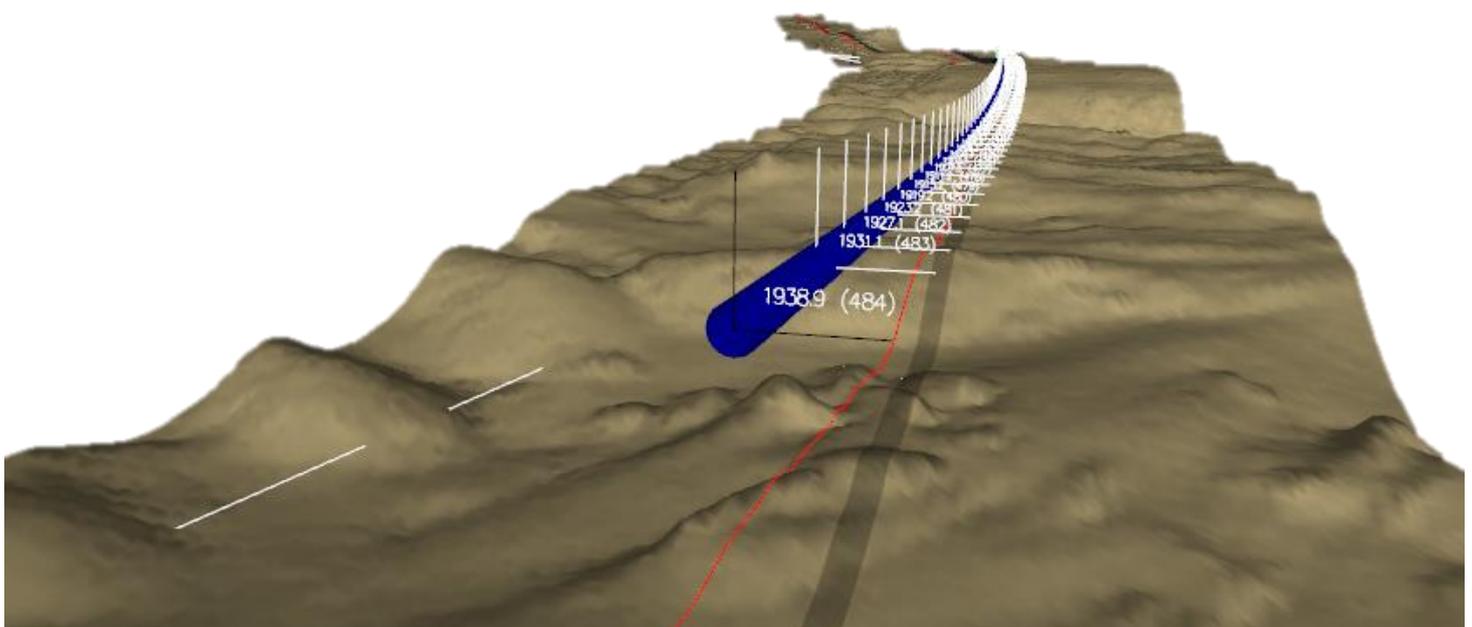
Simulation results can be cross-checked against the major design codes, including DNV-OS-F101, API1111, ASME 31.4 & 31.8. Free span evaluation can be performed according to DNV-RPF105.

Graphical user interface

The SAGE Profile Graphical User Interface has three main tabs, reflecting the natural flowchart associated with numerical simulations:

- Input tab designed for definition of all physical parameters.
- Calculation tab allowing definition of computational parameters and launching of the finite element simulations. Post-processing calculations like code and span checks can also be defined.
- Output tab enabling inspection of numerical simulation and/or post-processing results.

> **"SAGE Profile is the market leader software for subsea pipeline analysis"**

Input

The selected pipeline route can easily be modified. The seabed profile properties are automatically updated, which allows for fast and efficient route optimization.

The software allows creating *any* sequence of numerical simulations to reflect the subsequent phases in the design life of the pipeline. (laydown, empty, hydro-testing,…). SAGE Profile therefore offers powerful capabilities to introduce a wide panel of load scenarios covering residual lay tension, internal and external pressure, point loads, current and wave actions, trenching and backfilling operations, internal corrosion, temperature profiles, …

Input related features:

- Seabed definition using KP Elevation or Easting Northing Elevation profiles or full bathymetry.

- Pipeline route definition as list of Intersection Points or Easting Northing elevation data.

- Seabed modification module, allowing filling gaps in the seabed profile or cut steep slopes for free span rectification.

- Soil properties along the route defined by tapping into Fugro's vast experience in geotechnics.

- Pipe soil interaction modeled using enhanced soil springs.

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- Plastic vertical spring defined as piecewise linear curve or according to DNV-RP-F105.

- Axial and lateral soil springs defined using peak and residual friction factors, adhesion and mobilization distance, capturing plastic unloading and berm formation

- Backfill soil spring according for representing the uplift resistance provided by the backfill soil on top of a buried pipeline

- Modelling of thin walled pipes or fully bonded pipe-in-pipe systems. Pipe properties including corrosion and concrete weight coatings can be defined.

- Pipe bending non-linearities can be taken into account using Ramberg-Osgood coefficients.

- Pipeline residual lay tension can be varied along the route

- Option to apply point loads, line loads, pressures and temperature profiles, current and wave actions, trenching and backfilling operations, internal corrosion, …

- Load patterns are defined as reusable components that can be easily copied when defining additional phases. This flexibility allows the user to easily define heat-up and cool-down cycles or compare the effects of varying load scenario on the pipeline.

- Definition of boundary conditions to include anchor systems and end termination units in the finite element model

- Input Summaries can be generated in a compatible MS Word file or MS Excel format

Calculation

The Calculation tab allows specifying the numerical parameters required to perform a finite element simulation. For the convenience of the user, SAGE Profile uses Smart Settings, in order to suggest default values that will result in a stable calculation.

The user has the possibility to locally reduce the mesh density or vary the KP-range when detailed analysis is required.

.Main Calculation features include:

- Definition of simulations on various route lengths with varying element lengths

- Queuing analyses to enable simulation in batch mode

- Definition of post-processing integrity checks against major code and span checks including DNV-OS-F101, API1111, ASME 31.4 & 31.8. Free span evaluation can be performed according to DNV-RP-F105.

- Monitoring specific parameters at any node versus time.

Output

SAGE Profile allows displaying the results in different formats – tabulated numerical results, 2D plots or full 3D illustrations where a parameter is shaded onto the pipeline.

If code and/or span check results are available, they can be inspected and exported in tabular format.

Plot definitions can be reused and shared amongst projects: for each project, similar charts can hence easily be produced.

The Main Output features include:

- Results of different simulations can be plotted simultaneously

- Code and span checks results enable to assess whether the pipeline design is code compliant.

- Plot definitions can be reused, allowing the user to quickly reproduce complex graphs.

- Any output parameter can be plotted on any axis, allowing plots of KP versus elevation, force displacement, load versus time,...

- Printing templates can be defined by the user. These templates include frames, Q&A boxes and client logos.

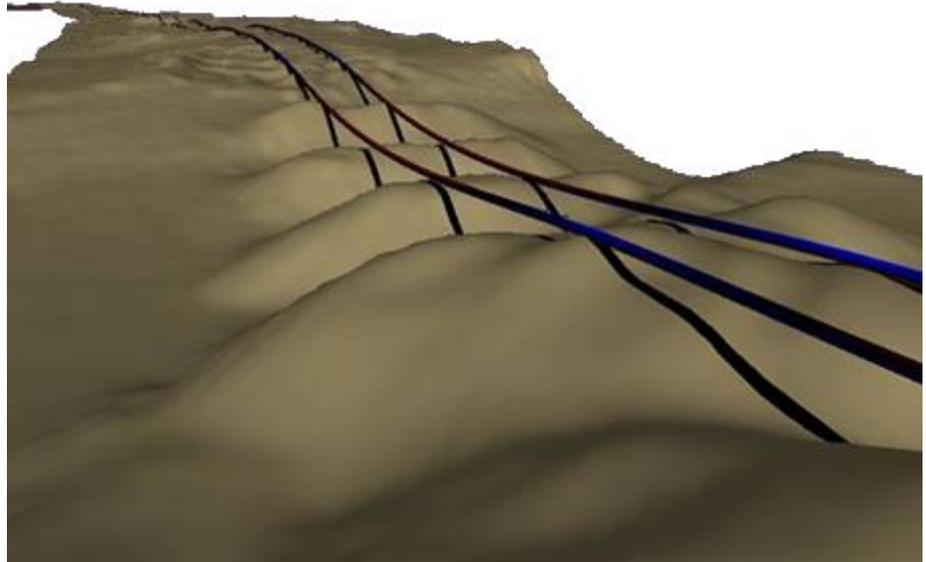- Option to export numerical results in CSV file format.
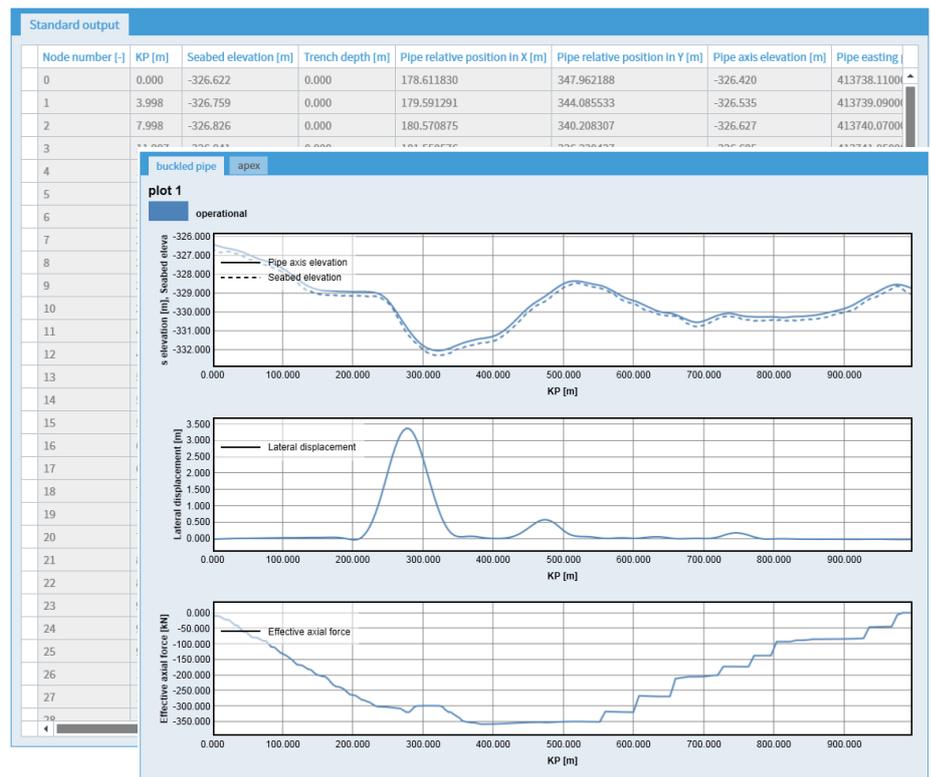
Computational Engine

SAGE Profile uses a powerful transient dynamic, explicit finite element solver.

"Capabilities include 3D analysis, non-linear soil properties, touch-down and lift-off modeling, non-linear pipe material in bending and large deformation analysis."

Computational features include:

- 6 degrees of freedom (DOF) two-nodes beam elements assuming a single circular cross-section

- Realistic pipe laying procedure on a full 3D Digital Terrain Model (DTM), using an elegant and realistic approximation of the real lay method.

- Innovative algorithms to obtain stable solutions for highly non-linear pipeline problems

- Running of simulations in graphical mode or text mode;

- Explicit solver can cope with non linearities in constitutive laws for steel and soil, large displacements, contact and pipe soil interaction

- Multithreading capabilities to computation time

Up to Standards

Code Compliance

Since safety and reliability is of paramount importance, SAGE Profile supports the limit state design checks for the latest editions of all major offshore pipeline standards. The pipeline engineer can quickly assess whether his design is compliant with DNV-OS-F101, API1111, ASME 31.4 & 31.8, BS8010 or Lloyds rules.

Free Span Analysis

An updated and enhanced span check is available to analyze free spanning pipelines according to DNV-RP-F105. Free spanning pipes are automatically detected, and SAGE Profile evaluates whether a span is vulnerable to vortex induced vibrations or not.

Moreover, the span check performs a fatigue screening and calculates the maximum allowable span length. An estimation of the VIV amplitudes, stress ranges and remaining fatigue lifetime is provided as well.

When to use SAGE Profile?

SAGE Profile provides a competitive advantage whenever fast, efficient pipeline simulations are required for:

- Pipeline route optimization
- Seabed roughness assessments
- Simulation of the pipelay process
- On-bottom stress analysis
- Thermal expansion analysis
- Upheaval/lateral buckling
- Free span evaluation
- Susceptibility to pipeline walking
- VIV and Fatigue estimation
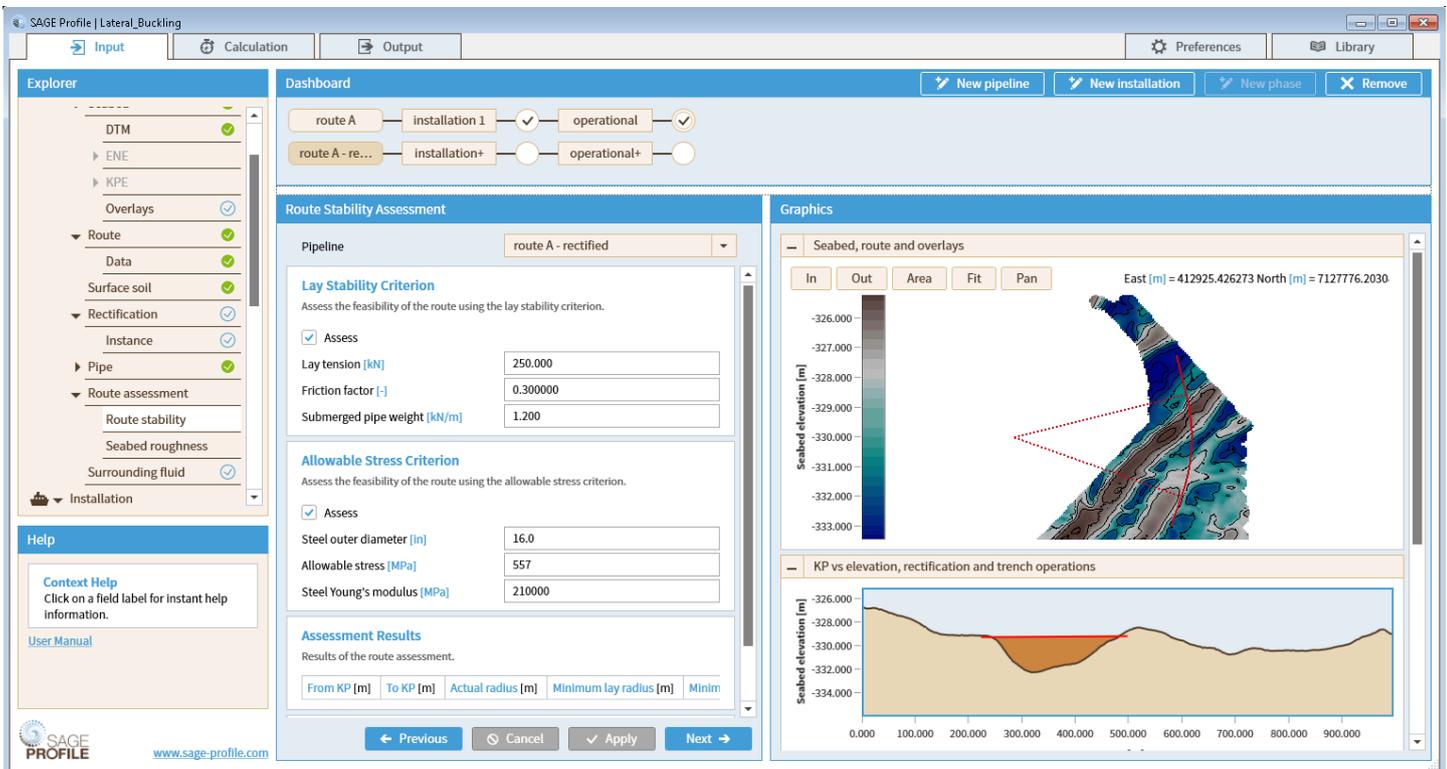
The Graphical User Interface streamlines the harvesting of input data to quickly set-up the model. In addition, it provides powerful visualization and reporting tools for interpreting output from the finite element engine.

A major advantage of SAGE Profile is the accurate modeling of the pipe soil interaction and clear visualization of the effects on the pipe response (like virtual anchor length, buckling locations and frequency, effect of the end terminations, ...).

In areas where the pipe spans a depression or passes over a sand wave, SAGE Profile can account for pipe settlement into the span shoulders. The plastic soil models provide a realistic indication of pipe embedment in all load cases.

SAGE Profile produces printout of input and output data in graphical or tabular format suitable for engineering proposals, verification purposes and reporting.

Validity and Quality Assurance

SAGE Profile was developed by Fugro GeoConsulting Belgium (FGCB). FGCB has been approved by Lloyds Register Quality Assurance in accordance with ISO 9001:2000.

The Software Verification and Validation Report includes more than 50 test sets and worked solutions and cover all SAGE Profile features. All SVVRs are provided together with the software package.

In addition, Bureau Veritas scrutinized the Software Verification and Validation Reports, and performed independent test problems to certify the software suite.

System Requirements

SAGE Profile runs on MS Windows 7 SP1/8/8.1/Server 2012 operating systems together with the following hardware requirements:

- 1 GHz processor (4 cores strongly recommended)
- 2 GB RAM
- 512 Mb graphics card with hardware acceleration support for OpenGL
- Screen resolution 1280x720 pixels (1600x900 recommended)