CASE STUDY

**Combined Solution Methodology Aids Statoil with Subsea Tieback Design**

OLGA simulator and key optimization workflows define critical operating envelope

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**CHALLENGE**
Quantify flow assurance uncertainties to evaluate feasibility of a subsea tieback solution and select system design.

**SOLUTION**
Combine the OLGA* dynamic multiphase flow simulator with the risk management and optimization (RMO) workflow to evaluate and bracket flow assurance uncertainties through sensitivity analysis and probability distribution of key inputs.

**RESULTS**
The combined solution provided a systematic framework for identifying and bracketing major risk parameters, defining the operating envelope design.

"Combining the OLGA simulator with the RMO workflow has been essential in understanding uncertainties and risks related to flow assurance conditions in the pipeline. In addition, we have been able to optimize our concept feasibility evaluation and tieback design for the life of the field."

Henning Thode Holm
Senior Advisor
Pipeline and Transport Technology
Statoil

Statoil needed to evaluate the feasibility of a subsea tieback solution for a deepwater gas field, located at 2,600-m water depth, 110-km offshore of Tanzania. A complex seabed profile and long-distance requirements presented serious design and operational challenges regarding liquid handling and other flow assurance issues.

The field’s large-diameter, multiphase trunklines transport a combination of natural gas, condensate, water, and glycol. Statoil planned to evaluate pipeline uncertainties relating to seabed topography and liquid holdup to determine the feasibility of various development concepts.

Flow Assurance

Subsea tieback design of offshore Tanzania gas-condensate field.
**Combined solution**
The first stage of the project involved verification and history matching of the OLGA hydraulics flow model, prior to uncertainty evaluation. Laboratory-based, low-liquid-loading experiments were also undertaken. This provided a theoretical verification of the transition from low to high holdup, for low-liquid-loading flow in large-diameter pipes. Laboratory data was also compared with OLGA simulation data for steady-state and ramp-up conditions. The two sets of results matched within a reasonable tolerance.

The project team then combined the OLGA simulator with the RMO workflow to outline key flow assurance risks. Parameters such as production capacity, liquid content at turndown production, and arrival temperature were defined. These elements also depended on a significant number of uncertainty parameters, including pipeline routing, hydraulic roughness, reservoir fluid properties, ambient temperatures, and arrival pressures, as well as liquid processing and slug catcher drainage capacities.

Sensitivity studies were then undertaken to examine the effects of each parameter individually, followed by analyses to examine the overall effects of combined uncertainties.

Thousands of simulations were performed to determine where liquid accumulation starts, as well as to compare liquid content and flow rate distribution—underlining that overall uncertainty is significantly less for the flow rate than for the liquid content.

Additional simulations were performed to estimate the distribution of the required trunkline inlet pressure with different combinations of uncertainty parameter values.

**Design optimization**
Finally, the team clarified the capacity at maximum pressure drop, concluding that overall flow rate uncertainty is slightly higher for the required inlet pressure. This allowed systematic derivation of key uncertainties relating to pressure drop and capacity at high-gas flow rate, liquid holdup, and turndown flexibility at minimum flow.

The OLGA simulator allowed Statoil to quantify and visualize flow assurance uncertainties more systematically and study risks through an automated workflow, avoiding reliance on assumptions such as linear response variation or the decoupling of uncertainty contributions. Adopting this methodology increased confidence in the design, as well as the concept-selection process.

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**Risk management and optimization tornado charts to evaluate sensitivity to various flow assurance parameters.**

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