A simulation tool to optimise

In 2005, the three-year Joint Industry Project 'Offloading Operability'[1] was completed and was successful in its aim of developing a tool for the simulation of complex tandem offloading operations, including approach manoeuvres. Report examines this challenging project.

Offloading from an FPSO (left) and a buoy (right).

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As well as the development of the tool, research was executed into the interaction effects when two vessels are in close proximity. A method was developed to compute wind and current interaction. Wind tunnel tests were carried out to gather data regarding wind and current loads on vessels, both shielded and unshielded. Finally, an extensive set of model tests were conducted to gather a representative data set for various tandem offloading solutions and for the validation of the SHUTTLE tool.

This JIP was limited to three offloading systems: Single Point Mooring (SPM); a turret moored FPSO and a spread moored FPSO.

SHUTTLE comprises four main elements including the Graphical User Interface (GUI), which is used for preparation and to run the program, the fast-time ship manoeuvring module which simulates the approach manoeuvre; the offloading module and analyses and post-processing.

Graphical User Interface

The GUI can be used to build the database used for all the simulations. Definitions of the mooring system, floaters and vessels, towing lines and hawsers, environmental conditions and the tracks and auto-pilots (for manoeuvring and offloading), are all included in the SHUTTLE database.

And for some items that have to be defined a generic database is included in the tool, for example for line materials and floating structures. With this generic information directly available, it is possible to build up a database for a specific case relatively quickly.

Fast time ship manoeuvring

The ship manoeuvring model in the SHUTTLE tool is based on MARIN's SHIPMA model. During the simulations, the vessel is kept on track by an auto-pilot. This auto-pilot controls the propeller, rudder and when available, also tugs. In the ship manoeuvring mode, a combined offloading and ship manoeuvring run can be executed whereby

tandem offloading operations

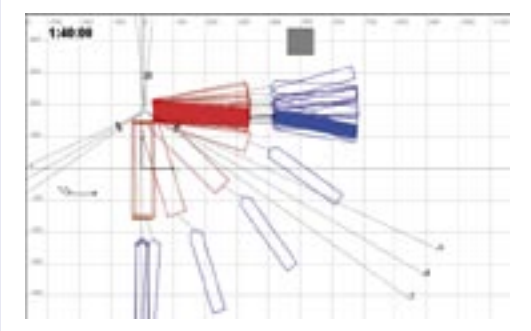
the approaching vessel will follow the FPSO if possible and make the approach.

Offloading module

The dynamic offloading analysis module is designed to evaluate the time-varying responses (export tanker motions, hawser and mooring line tensions, tug/thrusters loads) subject to either stationary or non-stationary environmental conditions, such as changing wind, waves and currents.

Combined wave and low frequency motions, the effects of varying wind, current direction and velocity, can be studied in detail with this dynamic analysis. Typical fishtailing behaviour and possible measures for reduction of this problem can be studied as well as recommended operational procedures in areas with rapid changes of the environment, offloading risks and large, relative motions.

An example of an offloading run is shown.



Result of an offloading simulation (wind squall).

With the SHUTTLE tool, the results of simulations can be analysed and presented in different ways, for instance with birds' eye view plots, movies, signal plots and statistical analyses.

Research into current and wind shielding

Together with the Dutch Aerospace Laboratory, a shielding model was developed to compute the wind and current loading when two vessels are in close proximity.

This shielding model is based on the assumption that the flow velocities (either wind or current) in one vertical plane in the wake behind the FPSO are known, either from wind tunnel tests or CFD. Assuming these velocities are available, analytical formulas from aerodynamics are used to describe the flow field further downstream.

With the velocities in the entire FPSO wake available, an export tanker sailing into the wake of the FPSO feels these distorted velocities instead of the undisturbed upstream boundary layer. The local flow velocity and direction on the position of the tanker is now used to compute the corresponding forces on the tanker. (Figure below schematises the shielding model)

A large number of wind tunnel tests were carried out to calibrate and validate the shielding model. Wind and current coefficients were measured for tankers and FPSOs with different types of deck equipment. The flow field in the wake directly behind the FPSO was measured and validation measurements were executed.

Model tests

Model tests were then carried out in MARIN's Offshore Basin in typical offloading environmental conditions to validate the SHUTTLE program. Detailed measurements were carried out of the motions of the floating systems, the forces in the mooring lines and in the hawser.

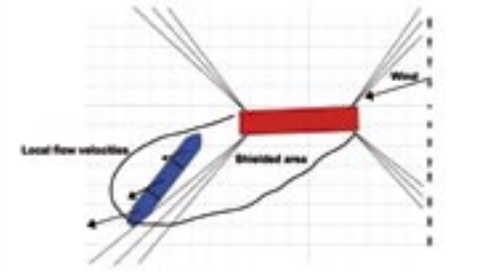
Three years on, the JIP participants are proud to see that SHUTTLE can reliably simulate complex offloading operations and predict the typical behaviour of vessels during offloading.

Offloading Operability 2

In 2007, "Offloading Operability 2" was started. This second phase will focus on side-to-side offloading of LNG. In addition, this phase will also include research into interaction effects and a further development of the SHUTTLE tool.

MARIN

[1] Bluewater Energy Services, Samsung, BP, Bureau Veritas, Shell, ChevronTexaco, Mineral Management Services (MMS), FMC Sofec, Health and Safety Executive (HSE), MARIN, IHC Gusto/SBM, APL, ExxonMobil, Prosafe, Petrobras



Definition of the shielding model.