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Digital Simulation and the real world of Work ROVs

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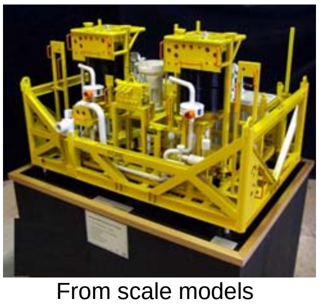
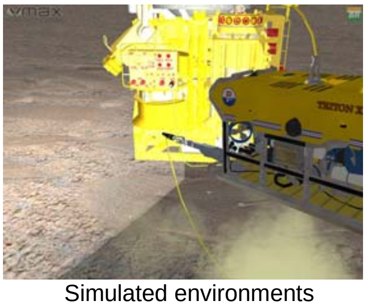
Abstract

Simulation has long been recognised as an effective training tool for work ROV operations. Until recently, the cost and complexity have been a disincentive for using it in routine operations. The Perry Slingsby V-Max simulator technology is changing this; and is now fitted as standard to almost every recent PSS ROV system. In the design office, the simulator is being used as a real-time design aid to verify operability from the earliest design concept through to the planning and training for the offshore operations. Finally, with the simulator built into every ROV, the operations crews are familiar with the operational tasks before they enter the water. All this leads to reduced vessel time, subsea time and risk.

Spatial awareness - from plastic models to 3-D physics-based simulation

At the start of the offshore oil industry in the early 70s engineers depended on beautifully constructed accurate scale models of offshore structures for spatial awareness. (These often ended up in the reception lobbies of the oil companies after their original purpose was done). The models helped engineers develop their detail drawings and the practice had a long overlap with 3-D CAD.





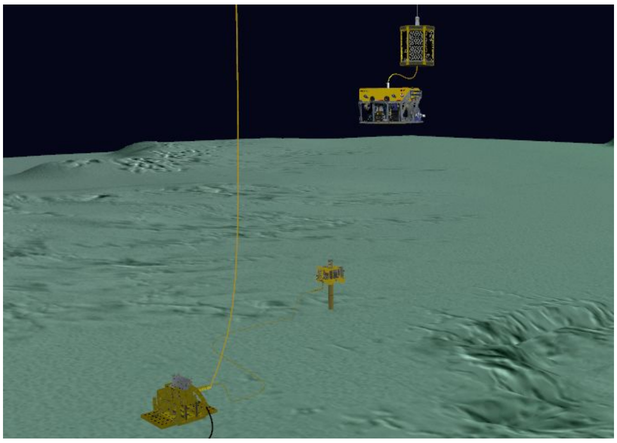
From scale models to Simulated environments

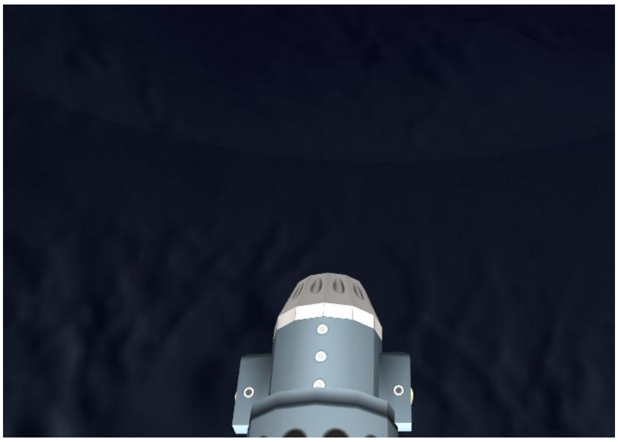
Once 3-D CAD models became manageable it was an obvious step to insert 3-D models of ROVs and plan operations. When used appropriately this is a considerable aid to operations. Applying rendering and other visualisation effects only improve this.

Underwater, visibility is rarely as clear as on CAD models! An obvious extension to the 3-D CAD environment was to use real-time position information of an ROV to show position within the model. This type of approach has been very successful for some operations, particularly when bathymetric data has been imported into the model.

However, while helpful, CAD is often a misleading tool for planning intervention work operations with ROVs:

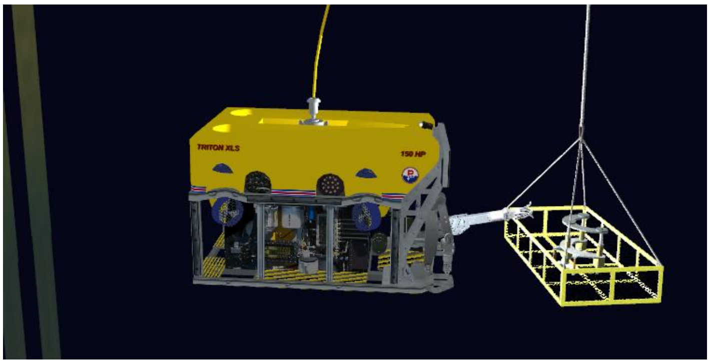
- It has perfect vision (real subsea conditions have limited vision)
- It is usually the “world” view (operator view from ROV is different)
- It ignores the effects of surface vessel motion and the tether dynamics
- It has no “physics” - objects have no weight or hydrodynamic behaviour


The ideal “world” view


What the ROV pilot sees

The area of “physics” is the big breakthrough that has made simulation so desirable for ROV operation planning and training.

The easiest example of this is that of an equipment basket hanging on a lift line which is a trivial task to show a grabbing operation in 3-D CAD but in a physics environment the basket will spin away from the user as soon as it is disturbed by a grabbing ROV manipulator arm.



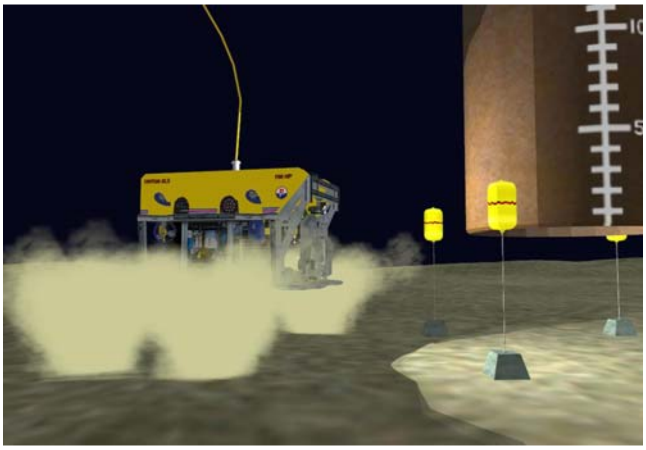
Basket operations

In the last ten years, simultaneous development of computer physics models and massively increased graphics processing power has meant that it is possible to create a simulated ROV experience that is as realistic and engaging as the real thing, including the effects of current, visibility, vessel motions, seabed interaction, cable dynamics and more.

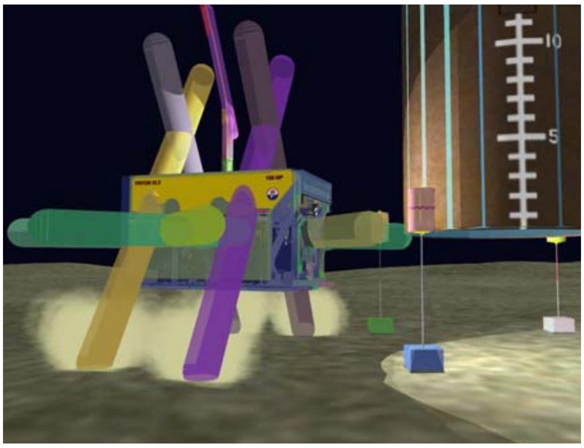
Simulating an ROV

When planning intervention operations, 3-D CAD models are readily available for structures and can be converted into the simulation environment. There are three parts to a simulation:

- Visual model which often uses flat images to replace complex non-essential details
- A collision model which defines how the objects interact. The collision model can have hard surfaces which will not give or soft surfaces (eg seabed) where an ROV in proximity will interact with its thruster wash etc.
- Adding mass, volume and motion properties to mobile objects



ROV interacting with seabed



The underlying collision model showing the thruster wash plumes

The ROV is an unusually good candidate for simulation.   All the interfaces between the operator and the subsea system are transmitted along a single umbilical.   Replacing the umbilical with a computer simulator means that none of the surface displays and controls change. The user sits in front of the normal screens and uses the normal controls – except that the responses and images come from a simulation computer.

In the case of the Perry Slingsby V-Max product, the simulator computer is a compact rack of blade computers where one blade simulates each visual display (camera, sonar, ROV data etc).   Previously the technology was at a prohibitive cost but is now at a level that most operators are choosing to have as standard fit in the ROV and are actively using it as an engineering and training tool.

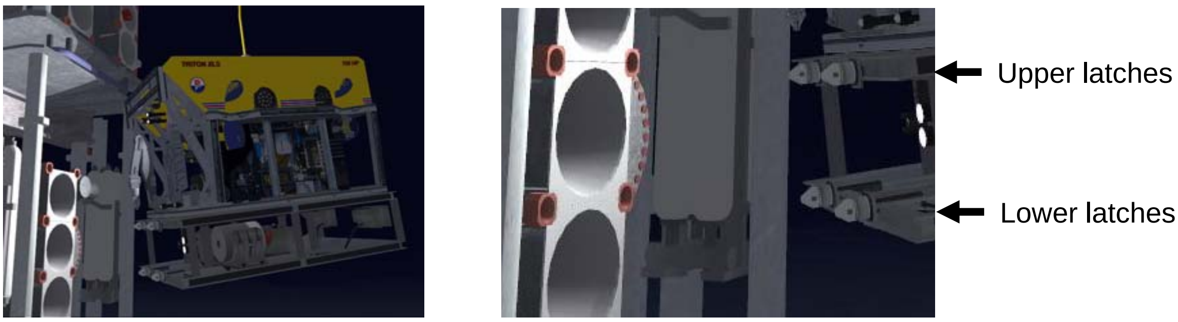
Simulation as an engineering planning tool

The simplest version of the simulator is as a single station computer used in the engineering office. This runs the same software as the full product but operated from a keyboard and joystick rather than a full console.

Desktop Simulator

3-D CAD developed models are imported into the simulation environment and tested by simulated ROV.   This allows the design engineer to test basic assumptions on operation viability at the earliest stage without bringing in the offshore operation personnel.

A specific example of this is an ROV workskid design developed at PSS Houston office which has a four position docking latch group on the front of the skid. The engineer tested the design on the simulator and realised that the necessary nose down trim of the operation made it extremely difficult to get the upper and lower pairs of docking latches simultaneously in position before locking the latches. The engineer revised the design so that the upper and lower latches could be set independently. The operation now engaged and set the upper latches then thrust down the ROV to align the lower latches before setting them.   This type of detail can slash hours from operations.



ROV component change workskid with quad group of docking latches

The same simulation model used on the desktop version can be shared with the full simulator.

Simulation as a training tool

Training simulators use a full ROV surface console.   There are several uses for a training console:

Office training consoles (for Triton XLS ROV)

ROV skill assessment. Spatial awareness and joystick operation are learned skills that are instantly obvious from a short session on the simulator console. Previously the skill level could not be objectively tested without sending personnel offshore.

Training. Due to the current large expansion in the worldwide ROV fleet, experienced ROV personnel are at a premium.   For example: docking a work class ROV to a Tether Management System (TMS) is generally considered one of the hardest routine offshore operation skills. Unlike basic flying which could, to a limited extent be learned on smaller observation class ROVs, work class ROV docking to a TMS has always had to be “learned on the job”. With the simulator, all the aspects of a TMS docking operation, including tether dynamics and surface vessel induced motions can be simulated and the necessary skill learned with nil equipment risk.

Operation planning. Once a design has passed the basic engineering stage and needs to be more formally assessed, the offshore operator staff can “fly” the operation from the console. This allows a proper assessment of timing and practicality.   Users can also plan necessary camera set-ups and develop the formal procedures for the subsequent offshore operations.

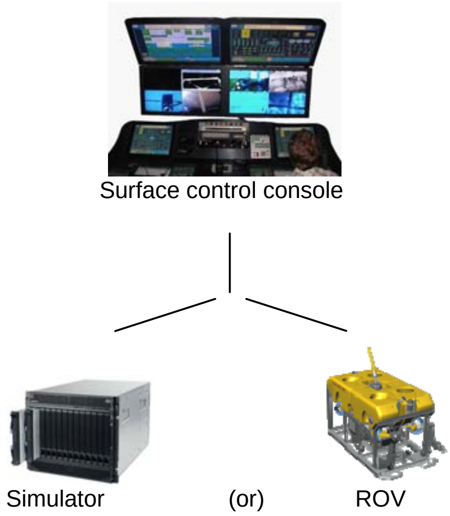
An example of the use of simulation to plan an operation was in the Mardi Gras shipwreck exploration. The Mardi Grass sunk approximately 200 years ago in the waters offshore Louisiana. The site had many interesting artefacts that had been surveyed and photographed. However before any recovery was performed, simulation was used to bring all these into a single model so that the whole site could be appreciated and the recovery operations planned.

Artefacts photographed on the sea floor
(photos courtesy of Texas A&M University)

Artefacts recreated in simulation environment
and ROV equipped with suite of recovery tools

Integrated simulator

The integrated simulator is part of the normal ROV system (has been fitted in most PSS ROVs in the last two years). When required (ROV on deck!), the crew switch to simulation mode and can practice training scenarios using the real console.

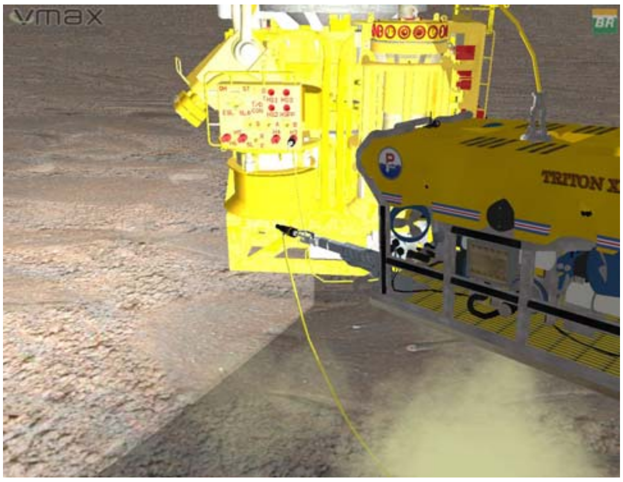


When a critical operation is planned, the ideal situation is to have operation crew who are involved in all stages from planning through to the actual operations. Ideally the crew should fully rehearse the operations on a training simulator in the office, and full scale dry or wet trials should have the same staff. However, in reality, operational circumstances usually end up with different ROV operator crew at that final operation.

This is where the integrated simulator can bring major benefits because the scenario can be loaded up on the actual ROV system by the final operation crew and a whole operation sequence can be run. (This is and task to perform during operation sail-out or weather waiting time). The operators can:

- Rehearse the operation sequence
- Learn how to navigate around the structures
- Plan the deployment positions of the ROV relative to the ships and other equipment

Using the integrated simulator (Triton XLX ROV)



Simulation of a complex umbilical jumper sequence

Conclusions

The potential benefits of ROV operation simulation are self-evident at all stages from engineering through planning and training to operations. The cost of the technology is now at a level where it can be (and, in Perry Slingsby's case, is) fitted as standard to work-class ROV systems. The benefits in operational equipment risk and reduced vessel time make the simulation an important tool to reduce operating cost.