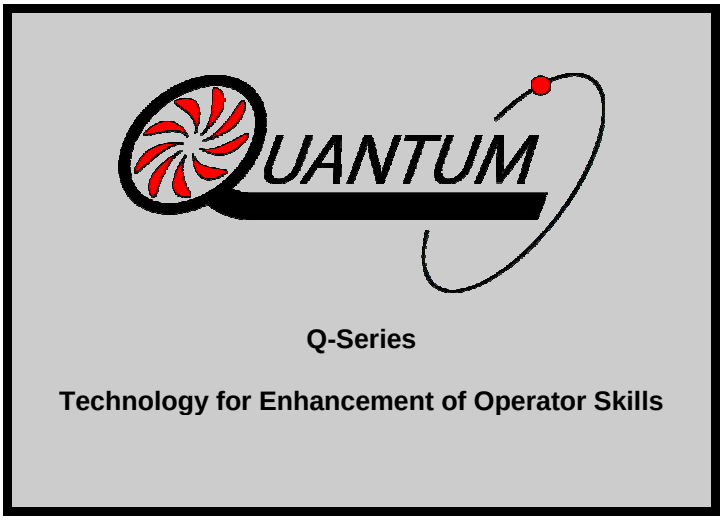

Q-Series

Technology for Enhancement of Operator Skills

Document: Q-EOS.doc

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1. EXECUTIVE SUMMARY

The skill of the Pilot is key to the success of any ROV operations. Whether simply flying from one location to another, TMS docking or undertaking complex manipulator tasks, the actions of the Pilot directly determine the time taken, the effectiveness and ultimately the cost of the operation. Unfortunately, as most ROV operating companies are painfully aware, there are very limited opportunities to develop these skills in the field.

The combination of an unskilled operator, poor or zero visibility, strong current and the presence of other underwater structures or objects presents a fairly bleak picture in terms of the odds of safely and successfully completing any planned operations.

Untrained Pilot	**Trained Pilot**
+	**+**
Poor/Zero Visibility	**Poor / Zero Visibility**
+	**+**
Strong Current	**Strong Current**
+	**+**
Manual Flight Controls	**SMDH "AutoROV™" and "VistaView™"**
=	**=**
Low Chance of Success	**Good Chance of Success**
+	**+**
High Risk of Damage	**Low Risk of Damage**
+	**+**
Long Time to Complete	**Quick Completion Time**
=	**=**
£££££ High Cost £££££	**Low Cost**

Figure 1 - Factors Influencing ROV Operational Costs

With this in mind, SMDH have developed a number of approaches which are aimed at improving these odds by targeting the risks which are directly influenced by ROV pilot competence.

The first approach is to improve the skills of the Pilot by providing training tools which can be used offline without even getting the ROV wet, or indeed without an ROV at all. A range of training simulator systems, generically known as "DriROV™", has been developed by SMDH to provide this capability.

The second approach is to provide the Pilot with a series of tools which can be used to assist when the ROV is on-line and in the water. These tools comprise AutoROV™, a set of automatic ROV flight controls and VistaView™, a facility whereby the Pilot can view a simulated real time 3D image of the operation from a remote "virtual" vantage point.

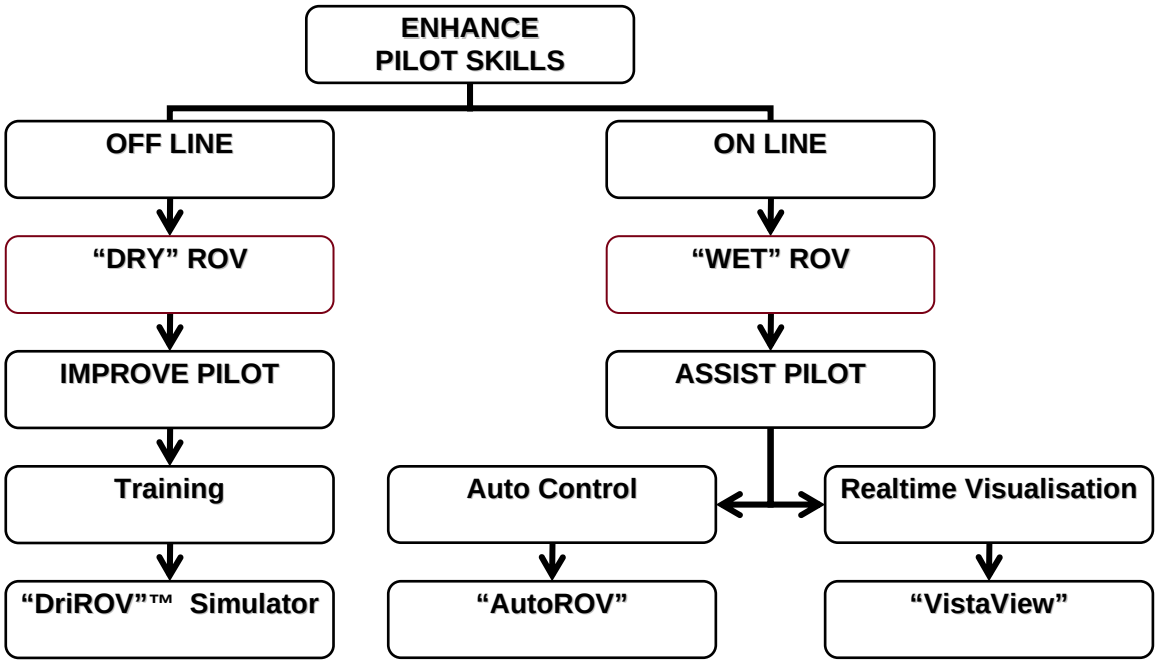

Figure 2 – Pilot Skill Enhancement

It is our aim to provide customers with maximum flexibility, so all these features are available in a wide range of configurations. For example, in the case of DriROV™, we are able to offer training using our own in-house facility, or alternatively provide one of several different styles of simulator to the end user, including an option where the simulator is fully integrated into the ROV control system.

Given today's market conditions and the general shortage of experienced ROV pilots, these new facilities provide a variety of ways of enhancing the skills of operators at all levels and also providing them with control system features which will help them to maximise these skills.

SMDH use the abbreviation Q-EOS, or "Q-Series Enhancement of Operator Skills", as an umbrella term to refer to these features.

2. SMDH DriROV™ RANGE OF PILOT TRAINING SIMULATORS

2.1 Introduction

2.1.1 Summary

The DriROV™ range of training simulators provides facilities for ROV pilots to gain hands-on experience on the sticks using a simulated "virtual" model of the ROV and the environment in which it will operate without requiring access to a "real" ROV. The main obvious benefit of this is that pilot training can take place at a fraction of the cost of training on a live ROV system.

The "virtual" ROV is based on a computer generated model of the ROV which can be controlled by the pilot in a similar way to the "real" ROV. The virtual ROV responds to commands from the pilot, water currents and interaction with underwater objects. The pilot receives feedback from virtual camera images, sonar and simulated instrumentation data which are generated by the simulation software. The model also includes simulation of the manipulator(s), TMS, tether and umbilical.

The trainee pilot is presented with a user interface which mimics as closely as possible that of the host ROV (see later for different options). An instructor configures and controls the simulation from a separate instructor's console. This console is used to monitor the trainee's performance and to modify the operating scenario and environmental parameters as required. Simulated fault and failure conditions can also be generated by the instructor and the subsequent response of the pilot assessed. Record and playback facilities allow later analysis of the simulation to reinforce the impact of the training.

DriROV™ is extremely flexible in that it can be used to train basic skills to new pilots or equally to hone the skills of even the most advanced pilot by rehearsing complex operations to maximise the chance of mission success. The ability to practice manipulator based operations without the risk of causing damage to "real" hardware is one of the most powerful aspects of the system.

The system can also be used for mission planning, mission rehearsal, evaluation of new tools or to assess the effects of changes to vehicle configuration such as adding a tooling skid.

The core of the DriROV™ system is the same across the range of simulators available, though the user interface and the facilities available can be tailored to suit customer requirements and the intended application.

The system is designed in a modular way so that it can be configured or expanded to suit specific requirements. In its most basic form, the system features a simple pilot interface. Additional functionality such as co-pilot controls, video distribution, video recording and power system displays can be added as required to allow full simulated team interaction. Other modules such as alternative manipulator controls and additional camera images can also be easily "bolted on" to extend the system capability.

DriROV™ is currently available in 3 basic configurations as described below.

2.1.2 Portable System

This configuration is intended for providing training facilities in a location of opportunity such as a spare office on-board or at base. The system is housed in a series of transportable cases and a desktop training console. Typically the functionality of the portable system is minimised in terms of available camera views etc to minimise the amount of hardware required whilst maintaining portability and functionality.

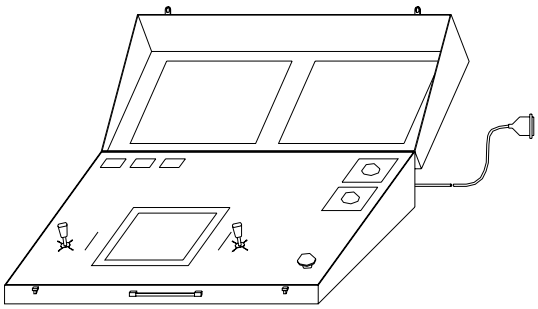

Figure 3 – Portable Desktop Pilot Interface

2.1.3 Free Standing System

This system is intended for installation in a permanent or semi-permanent location such as a base training facility, workshop or even an office space on board the vessel or rig. The configuration can vary from a simple, lightweight easily transportable system to a full size replica of the host ROV control console.

Figure 4 – Typical Transportable Freestanding System

2.1.4 Integrated System

The integrated system is fitted as an integral part of a working ROV control console. The system utilises the primary ROV controls and displays as its user interface and operates in the background to generate the virtual ROV and its environment. Conceptually, the ROV control desk can simply be switched between operation of the "Real" ROV and operation of the "Virtual" ROV. This system allows pilot training, practice or rehearsal to take place during downtime or time spent WoW using the "Virtual" ROV. This system could also be used during periods when the control cabin or console is ashore or on standby.

Figure 5 – Integrated System

2.2 System Description

2.2.1 General

Fundamentally the basic Simulator comprises four main elements:

- Topside ROV Control System
- Pilot User Interface
- ROV Simulation Package
- Instructor Interface

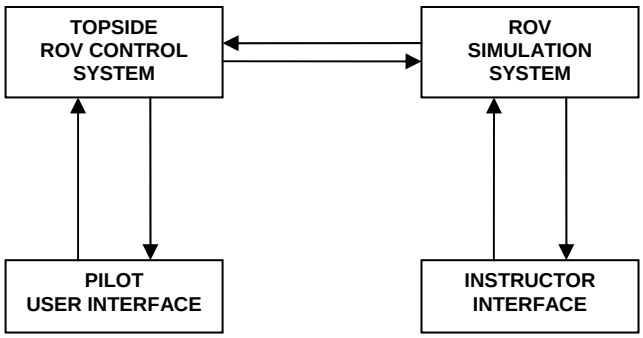

Figure 6 – Schematic of SMDH DriROV Pilot Training Simulator

Other elements can also be added to this basic system such as co-pilot functionality, power system emulation, audience viewing capability etc.

2.2.2 Topside ROV Control System

The simulator topside control system is similar to that used in the ROV control system and comprises the control PCs, network hardware, ROV/TMS control software and image distribution functionality. With the integrated DriROV system, the actual ROV/TMS topside control system is utilised.

The topside control system communicates with the Pilot User Interface in a similar way to the "real" system. It also communicates with the ROV Simulation System which replaces and emulates the behaviour of the ROV and TMS.

2.2.3 Pilot User Interface

The actual configuration of the Pilot User Interface depends on the choice of portable, freestanding or integrated system (see above). However, whichever system is used, the basic principle is to mimic as closely as possible the ROV pilot controls. Appropriate manipulator controls would also normally be provided as part of the pilot user interface.

2.2.4 ROV Simulation System

The ROV simulation system comprises a number of powerful networked PCs which run the ROV simulation software including camera and sonar image generation.

The virtual ROV model is controlled from the Pilot User Interface via the Topside ROV control system. Feedback from the virtual ROV is presented to the Pilot as data on the ROV Pilot graphics screen and as images on the TV and sonar displays.

The virtual ROV system model is specifically configured to match the characteristics and specification of the host ROV system and TMS.

Mamipulator simulation is a standard feature of the system and a wide range of simulated models is available for manipulators from various manufacturers.

A range of generic models are available for use with the system such as cutters, cleaning tools, torque tools, standard rigging, work baskets etc. Additional tools can also be provided on request.

Other man-made subsea objects such as valves, manifolds, BOP stacks, pipelines and templates can be imported into the system. A range of generic objects are supplied with the system as standard.

The basic simulation software is configured primarily for pilot training. The system can easily be upgraded to include full mission planning and rehearsal functionality.

2.2.5 Instructor Interface

The Instructor Interface typically runs on a laptop and is used to control and monitor the simulation. A 3D virtual view of the ROV and its surroundings allows the instructor to view the behaviour of the ROV as it responds to commands from the Pilot.

The instructor is also able to generate fault scenarios, modify environmental parameters and adjust the simulation scenario whilst monitoring the pilot's response to such changes.

The record and playback facility is also controlled from the Instructor Interface.

2.3 DriROV Features

- Training of basic pilot skills through to complex manipulator based tasks
- Full ROV, TMS, tether and umbilical dynamic simulation
- Optional mission planning and rehearsal modes
- Full range of configurations from desktop to full size console replica
- Control cabin integrated option
- Scenario recording and playback
- Up to 4 simultaneous camera views from ROV
- Up to 2 simultaneous camera views from TMS
- Virtual sonar image generation
- Wide range of alternative manipulator simulation models available
- Available as pilot only or pilot & copilot operation for team training
- Modelling of proposed changes to vehicle configuration.

3. SMDH AUTOROV™

3.1 General

The AutoROV feature refers to a suite of automatic control routines which provide the following automatic control functions.

3.2 Auto Depth

ROV automatically remains at a constant water depth.

Feedback from a bathy, digiquartz or standard submerged depth sensor would normally be used as the control variable.

This function incorporates a nudge feature to modify the current setpoint.

3.3 Auto Altitude

ROV automatically remains at constant distance from the seabed (Auto Hover).

Feedback from an altimeter, DVL or bathy would normally be used as the control variable.

This function incorporates a nudge feature to modify the current setpoint.

3.4 Auto Heading

ROV automatically maintains a constant heading.

Feedback from an on-board flux-gate or gyro would normally be used as the control variable.

This function incorporates a nudge feature to modify the current setpoint.

3.5 Auto Hold

When activated, the ROV maintains current position in X and Y.

(Note - Z position is controlled by Auto Depth / Altitude.)

Data from DVL and HPR (or similar) is required for this facility. INS is required in deeper water where range is too great for DVL. INS can also be used in addition to DVL and HPR to improve performance

This function incorporates a nudge feature to modify the current setpoint.

3.6 Auto Step

ROV moves a user input distance in X and/or Y direction.

Data from DVL and HPR (or similar) is required for this facility. INS is required in deeper water where range is too great for DVL. INS can also be used in addition to DVL and HPR to improve performance

This function incorporates a nudge feature to modify the current setpoint.

3.7 Auto Home

ROV automatically returns to preset “home” position.

Data from DVL and HPR (or similar) is required for this facility. INS is required in deeper water where range is too great for DVL. INS can also be used in addition to DVL and HPR to improve performance

In the standard system, this feature works on relative positions rather than absolute positions. An advanced option is available whereby absolute coordinates can be utilised, however this facility also requires the integrated survey option.

3.8 Auto Track

ROV automatically follows pipe / cable using TSS or equivalent.

Requires tracking device (TSS or similar) to provide control input.

3.9 Auto Route (under development)

ROV automatically follows pre-programmed route of waypoints.

Requires integrated survey system.

3.10 Other Auto ROV Functions

3.10.1 General

The standard ROV is also supplied with a number of integral control facilities as standard as follows.

3.10.2 Selectable Thruster Plane Priority

Vertical thrusters are selected to take priority over horizontals or vice versa.

3.10.3 Control Reversal System

Joystick commands are reversed for TDU deployment at rear of ROV etc

3.10.4 Lost Thruster Compensation

If a thruster fails, it can be isolated and the control system will modify control algorithms to compensate.

3.10.5 Pitch, Roll, Horizontal and Vertical Trims

P&R trims are set via touch screen to compensate for offset payload etc.

H&V trims are set via sliders on desk to compensate for dynamic effects of current, tether drag etc.

DVL = Doppler Velocity Log – Works up to 200m from seabed. Data used to calculate relative position and movement of ROV.

INS = Inertial Navigation System - required where DVL can't see seabed. INS + DVL provides improved accuracy.

HPR = used here generically to refer to an acoustic positioning system.

4. SMDH VistaVIEW™

4.1 Introduction

VistaVIEW provides the pilot with a realtime visualisation of the ROV operation from a remote "virtual" viewpoint.

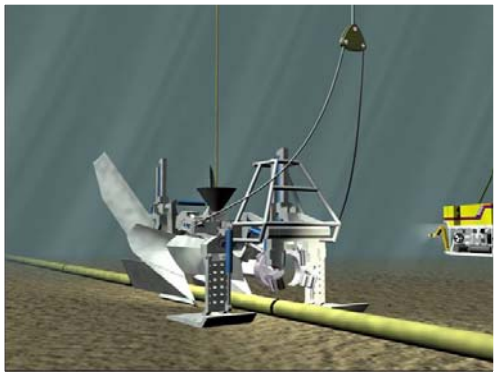

Figure 7 – VistaVIEW applied to a Pipe Trenching System

ROV & TMS position, orientation and movement are displayed in real time in 3D on a console monitor display. Tether and umbilical behaviour are modelled based on cable lengths out, tension and DVL feedback of current. The "virtual" viewpoint position can be varied by the pilot to suit the scenario and to provide the optimum view. Seabed features, subsea objects and structures can also be displayed assuming the necessary data is available.

VistaVIEW™ provides essential perspective in low / zero visibility conditions so that the pilot has a realtime view of the scenario. Anyone who has flown an ROV will appreciate that once visibility is lost in low vis conditions, it is very easy to lose a sense of where the vehicle is in relation to other underwater objects. VistaVIEW effectively provides a clear view, irrespective of visibility, thus providing the pilot with visual confirmation of ROV position and orientation.

4.2 Principle of Operation

VistaVIEW is fitted as an integrated component of the main control console. This includes dedicated PC hardware whose purpose is solely to generate the VistaVIEW image. Typically the image would be provided as an available image on the video distribution system so that it can be displayed in a convenient location on the video wall.

VistaVIEW requires data from the ROV control system and the ROV & TMS acoustic positioning systems to generate the simulated image. The functionality and accuracy of VistaVIEW depends on the scope of instrumentation and surveillance equipment fitted to the ROV and TMS. Full functionality of VistaVIEW requires survey package integration.

NB Vista = "A distant view or prospect, especially one seen through an opening……".

5. SMDH TRAINING FACILITIES

As part of our ongoing commitment to providing the best possible level of customer support, SMDH have now committed to developing an in-house training facility for the purpose of training customer's personnel.

This facility will include a full size DriROV simulator which can be configured to emulate any SMDH supplied WROV system. Full functionality will be provided including CoPilot Controls, Video Distribution, AutoROV and VistaVIEW so that all aspects of the system including team interaction can be addressed.

In addition to the Virtual Training Simulator, a range of actual ROV hardware will be provided to demonstrate operation and maintenance of the "real" ROV. This hardware will include:

- Subsea Electronics Pod Chassis
- Fibre Optic Mux System
- Intelligent Valve Pack
- Intelligent Junction Box
- Lamp Dimming System
- Training Network

Other ROV hardware such as thrusters, tether samples, terminations, compensators etc will also be available as part of the training facility.

A range of training courses will be offered which will utilise part or all of these available facilities according to requirements. Alternatively the facility could be hired on a daily basis.

SMDH also incorporates another company (Bywell Subsea) which provides personnel for offshore operations. Another option which could be discussed is the provision of "Q-EOS" trained pilots through Bywell Subsea.

6. BUDGET PRICES

6.1 DriROV Systems

ITEM	BUDGET PRICE
Portable System o Portable Desktop Control Console o Touchscreen ROV pilot interface o Single Virtual Camera Display* o Virtual OA Sonar Display o Pilot ROV Controls and twin TFT displays Note*: Several virtual camera views are available but only one can be viewed.	TBA
Freestanding Lightweight System o Lightweight, transportable console / desk o 6 x monitor video wall o PC based video distribution system o 4 x simultaneous virtual camera displays on video wall o Virtual OA sonar display o Pilot ROV controls o Provision for integration of VistaView	TBA
Freestanding Replica Console System o Full size replica ROV control console / desk o 8 x monitor video wall o PC based video distribution system o 4 x simultaneous virtual camera displays o Virtual OA sonar display o Pilot ROV controls o Provision for integration of VistaView o Provision for integration of CoPilot controls for team training	TBA
Integrated System Simulator system integrated into existing control console o 4 x Simultaneous Virtual Camera Displays o 1 x Virtual OA Sonar Display o Pilot ROV Controls o Provision for integration of VistaView o Provision for integration of CoPilot controls	TBA
Optional Mission Planning and Rehearsal Functionality	TBA

Notes

1. All DriROV systems include:

   - ROV and TMS functionality
   - Manipulator simulation with interface to various topside controllers
   - Pilot and/or copilot training mode
   - Bespoke ROV and TMS virtual models to suit specific ROV
   - Selection of generic ROV tools
   - Selection of typical subsea object models
   - Instructor Interface
   - Topside ROV Control System
   - Pilot User Interface
   - Provision for Power System emulation.

2. Software licences are provided for operation of a single DriROV system. Pricing is negotiable for customers who require more than one simulation system based on the same vehicle systems.

3. It is recommended that a manipulator consolette representative of the fitted manipulators is purchased. The cost of this depends on the choice of manipulator. For example a Rigmaster typically uses a fairly simple “switch” box controller, whereas an Orion / Titan 4 uses a sophisticated master arm controller. We would be happy to quote for controllers for specific arms on request.

6.2 DriROV Training Facility @ SMDH

ITEM	**BUDGET PRICE**
Typical 5 day ROV training course for 6 trainees at SMDH including full use of DriROV simulator.	TBA
Notes 1. The above rates include: o Supervision / training by SMDH instructor o Full use of simulator 2. Simulator Functionality includes: o Full sized DriROV simulator with pilot and copilot controls o Quantum WROV and tophat TMS simulation o 8 Monitor video wall o Virtual sonar display o 4 x simultaneous camera displays o Video distribution system o Schilling Titan / Orion & Rigmaster manipulator simulation o Range of ROV tools including cable cutter etc. o Range of example subsea objects (BOP, pipe, template etc) 3. Various training options are available including hire of the simulator facility on a day rate or provision of trained pilots through Bywell Subsea. We would be happy to discuss training to suit the requirements of the individual customer.	

6.3 AutoROV Features

The AutoROV control features are generally included as part of the main equipment supply.

For example, Auto Hold, Auto Step and Auto Home are provided as standard where DVL or INS integration is offered as an option with the system.

Auto Depth, Auto Altitude and Auto Heading are provided as standard on all systems.

Other automatic control routines such as Selectable Thruster Plane Priority, Control Reversal and Lost Thruster Compensation are also provided as standard with all systems.

Auto Track is provided as part of the integration where a TSS or similar tracking system is offered as an option.

Auto Route[1] is offered as a standard part of our integral survey and positioning software.

ITEM	**BUDGET PRICE**
Auto Depth	Part of Standard “Auto ROV Pack” (Included with each ROV)
Auto Altitude	Part of Standard “Auto ROV Pack” (Included with each ROV)
Auto Heading	Part of Standard “Auto ROV Pack” (Included with each ROV)
Auto Hold	Part of optional “DVL/INS Integration Pack”
Auto Step	Part of optional “DVL/INS Integration Pack”
Auto Track	Part of optional “Tracker Integration Pack”
Auto Home	Part of optional “DVL/INS Integration Pack”
Auto Route[1]	Part of optional integrated “Survey / Positioning Pack”
Other Auto Control o Selectable Thruster Plane Priority o Control Reversal o Lost Thruster Compensation o H,V,P & R Trim	Part of Standard “Auto ROV Pack” (Included with each ROV)

Note 1 – Under development

6.4 VistaView

ITEM	**BUDGET PRICE**
Vistaview System	TBA
Notes 1. Vistaview system also requires survey and positioning system integration as a prerequisite. 2. Vistaview requires DVL/INS integration and HPR integration. 3. Vistaview is only available if the customer has a DriROV simulator for the same type of vehicle.	

