seebyte

Automating ROV Operations

Commercial in Confidence
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1 ROV Operations

The Remotely Operated Vehicle has truly revolutionised the way we interact with the subsea. From oil and gas operations, search and rescue missions, salvage operations, military explosive ordnance disposal tasks through to scientific missions, the ROV is the easiest and safest way to interact with the subsea environment enabling amazing feats of engineering and ingenuity.

From their initial development to their current form, ROVs have seen many changes and improvements. They have become more capable, going deeper and tackling a greater variety of tasks. Today, there is also a greater range of ROVs from small one man portable systems to large sophisticated work-class systems operating at 1000s of feet from dedicated offshore vessels.

These improvements have created a need for expert operators with intense training. Their skills are required as much to pilot the systems as they are to service and maintain them. But, ultimately, the bottom line is tied to how efficiently and expertly an operator can fly the ROV.

SeeByte has a long history of providing solutions to the ROV industry. Standard solutions like CoPilot can have a positive and direct impact in the operation of the ROV, while bespoke solutions can be tailored to specific needs.

These solutions have been designed to help deliver on the bottom line by helping improve ROV operations.

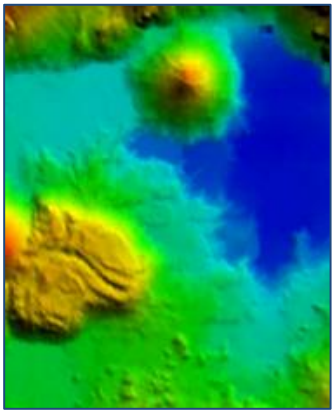
This paper outlines SeeByte's available autonomy solutions for inspections in both open water and constrained environments.

2 Surveys

Offshore subsea is one the most challenging environments to survey- dark, dangerous and often difficult to access Accurate positioning and high resolution surveys require a significant investment in technology and training as well as intricate operations. The ROV surveyor's standard tools today include acoustic positioning, be it USBL or LBL arrays, expensive INS equipped with state-of-the-art Fibre-optic or ring-laser gyros, precise depth sensors and Doppler. The ROV is also typically operated from a DP vessel so that it can follow it as it performs its mission. As well as navigation sensors the ROV is equipped with some of the most advanced payload sensors in the market. Video, multibeam and side-scan sonars are used to map the seabed.

The data from the navigation sensors can be used to position and geo-reference the payload data and accurate maps can be made in this way. The investment made to improve the accuracy of a survey is considerable, but desirable in order to expedite subsequent operations. Typically to date the survey has relied on expert piloting skills to maintain the ROV on a set course at a pre-determined speed, heading and height from the seabed. Often times the mission can be compromised if the ROV cannot be made to steer the course. CoPilot allows the ROV to maintain a pre-laid course and offers a stable platform from which to gather data. Stability is of paramount importance; CoPilot provides dynamic positioning and station-keeping with minimal hover footprintand as a result the quality of the data gathered using CoPilot is of superior quality.

Experiments showed that an ROV equipped with CoPilot maintains excellent heading and position control even when in transit. The performance of the ROV far surpassed the performance of an ROV pilot (up to 10 times better).



3 Inspections and Intervention

A successful inspection must gather the right information. A clear, consistent and comprehensive search is crucial in order for effective decisions to be made. The ROV crew must manoeuvre the ROV around the facilities being inspected and the data must be of sufficient quality to extract that information. It is also important that the whole structure is observed and no sections of the structure are missed out. To then carry out an intervention with a tool or manipulator the ROV requires careful control and must be stable throughout the intervention.

Using an ROV system equipped with no station keeping capabilities can present a significant challenge when it comes to gathering the data. Maintaining a stable position and heading is vital for these operations and doing so throughout the inspection job adds to the stress of the ROV pilot. Latest generation ROV systems equipped with CoPilot can simplify the process of observing stationary targets for prolonged periods of time. CoPilot allows pre-planning an inspection route. The ROV will run this route time and time again, each time it will provide a stable platform for the sensors. The data outputs will be repeatable and easily compared to those of previous jobs. CoPilot can also be relied upon to keep the ROV stable as it interfaces with the environment using tools or manipulators.

Results show that CoPilot could be relied to take still picture of riser buoyancy modules at least as much

as five times faster than conventional means. Each of the pictures was right first time, every time.

4 Work-class ROV Operations

Offshore work-class ROV operations command expensive vessels and highly trained crews, who are relied on to carry out real feats of engineering on each and every job. From drill rig support, through construction to Inspection Repair Maintenance (IRM), the ROV units are often an important part of the operation itself and are required to survey, support the construction process and maintain critical infrastructure. The costs involved are substantial and any delays caused by the ROV can have a significant impact on the bottom line of any operation.

A new generation of ROVs can help make the process easier. Equipped with CoPilot they can be used to hold station in a required position and also relative to the infrastructure. The functionality that allows moving the system to desired coordinates and to track structures at the touch of a button can be relied upon to make operations more consistent, speed up the ROV mission and improve the data products. All of these benefits help to improve the bottom line.

Experiments showed that an ROV equipped with CoPilot was capable of carrying out transit operations (moving from one location to another in the field) in less than half the time than was possible using conventional means. This was possible thanks to the intuitive, simple to use interface.

5 Improved User Interfaces for Improved Operations

CoPilot's intuitive interface can be used to manoeuvre the ROV around the workspace at the touch of bottom. Flying an ROV using CoPilot is so easy that novice pilots think it's meant to be easy. It enables all users to get the best out of the ROV, no matter their experience. This is not to say that experience doesn't matter. Experience for ROV pilots counts for a lot. It is not just about the piloting, it's about doing a job and doing it right. Experienced pilots are not only capable of flying the ROV, they also know what it takes to finish the job. Novice pilots on the other hand spend much of their energy and focus in the action of piloting. As the energy is spent on flying the ROV smoothly other important tasks can be forgotten and this can often lead to unwanted situations.

Due to the pressures of the job and the requirement to perform when the mission is in process the piloting is often left to the most experienced pilot. Thus experience is hard to come by if you are a novice pilot. New generation ROVs with CoPilot help the pilots deal with some of the stress. The ROV pilot can choose to put the ROV into hover and use that time to gather his bearings. As a result some unwanted situations are avoided, but while this is happening the ROV must remain static and valuable time is lost.

With CoPilot the ROV pilots can easily tailor missions, interact effectively with their environment and get the best data and the required information. This means more time can be spent performing the actual job instead of the action of piloting itself, confidence on the job also helps to keep stress down and will mean that inexperienced ROV crews can achieve more, faster.

6 What does Automating ROV Operations mean?

It's about introducing modes of operation where the pilot can take a supervisory role by instructing the ROV to perform actions without having to manually move the joystick and compensate for each little thing that the environment throws at him. SeeByte's CoPilot offers the widest range of useful operation modes and it can be retrofitted into existing and new ROVs. No other system comes close.

	Station-Keeping	Cruise-control	Survey-Control	MBI Sonar track	Mid-Water DP
CoPilot	•	•	•	•	•

Mode	**Description**	**Offshore Uses**	**Sensors Required**	**Optional Sensors**
Station-keeping	Use of motion sensors and heading reference systems to keep ROV stationary without direct pilot control.	Minimum specification. Inspection and Intervention.	Doppler Velocity Log, AHRS, Depth.	LBL / USBL acoustic positioning systems for absolute positioning reference
Cruise-control	Use of motion sensors and heading reference systems to keep ROV on constant velocity vector without direct pilot control.	Pipeline and cable inspections. Ensures stability of platform for survey sensors (eg MBES, SBP, SSS).	Doppler Velocity Log, AHRS, Depth.	MBI (This makes pipeline tracking simple and accurate)
Survey-control	Use of motion sensors and heading reference systems to make ROV follow a predetermined set of waypoints without direct pilot control. The navigation system should display the trajectory of the ROV over the survey plan. Plans can be changed on site.	Route and pre-lay surveys. Ensures stability of platform for survey sensors (eg MBES, SBP, SSS).	Doppler Velocity Log, AHRS, Depth, Acoustic Beacons.	
MBI Sonar-track	Use of motion sensors, heading reference systems and Multibeam Imaging sonar to manoeuvre the ROV relative to the ground or a structure. The navigation system should show the ROV trajectory and the MBI sonar data.	Touch –down monitoring, Inspection (Risers, Chains, Flow Lines, manifolds, wells, ...), Intervention (Repair, Maintenance) and Decommissioning. This mode can provide DP in the mid-water relative to a target.	Doppler Velocity Log, AHRS, Depth, MBI Sonar.	LBL acoustic positioning / INS (Inertial Navigation System) to provide absolute reference for multi beam imaging data
Mid-water	Use of motion sensors and heading reference systems to fulfil any of the Dynamic Positioning modes at heights where there is no Doppler Lock.	When work is distributed along a large field. This mode is useful as a transit mode to save time by not having to take ROV system all the way to surface.	INS, AHRS, Depth, LBL / USBL acoustic positioning.	

7 Typical Performance

The performance of CoPilot is a function of the ROV under control and the sensors mounted on board. The values below show the station-keeping performance demonstrated during trials conducted by Chevron Deepwater Exploration and Production on the Discoverer Deep Seas. These are typical of a work-class ROV system and an improvement over manual piloting.

	North (meters)		East (meters)		Depth (meters)		Heading (degrees)	
	Std	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**
Pilot	0.4336	0.1430	0.1681	0.0593	0.1752	0.3718	3.3436	-4.2526
CoPilot	0.0251	-0.0050	0.0174	0.0002	0.0690	0.2820	0.4548	-0.2253

The table below shows how using the CoPilot software operations can be done quicker. These results were obtained during trials conducted by BP in the Gulf of Mexico. The pilot performances were estimated based on an average experience of seven years of piloting.

Task	**CoPilot**	**Unassisted Pilot**
Still Pictures	30 sec	10 min
Transit for 17m	50 sec	2 min
Manipulator Shackle	2 min	20 min
Docking	2 min	5 min

8 What do I need to make CoPilot work?

CoPilot is a very sophisticated software system using the latest advances in signal and image processing theory. To do it justice the ROV must also be equipped with sophisticated sensors. The sensors typically employed are:

- Doppler Velocity Log (DVL)
- Depth and North-Seeking Heading Gyros (information supplied at >= 3 Hz)
- Forward-look Sonar to automatically follow or inspect objects
- INS and USBL systems can also be used if mid-water DP is required

CoPilot also required access to the ROV's thrusters' control systems (analogue joystick port or digital command stream) with updates at 5Hz minimum.

CoPilot performs the following advanced functions:

- Navigation Computer: CoPilot is equipped with a sophisticated navigation computer that fuses the outputs from all the navigation sensors. The information is used to accurately manoeuvre the ROV in both relative and world coordinates. It is also stored as a time stamped list of positions and attitudes that can be used to reconstruct the trajectory of the ROV and as a survey string.
- Autonomous Guidance: Copilot used the navigation information to send automatic commands to the ROV and provide the user with a huge variety of fly-modes suitable for varied applications.

- Target Relative Control: CoPilot processes the sonar data and identifies targets that the pilot can select to have the ROV follow or inspect them automatically.

CoPilot can be retro-fitted into existing ROVs and equipped in new ROVs. The team will require access to the ROV and the ROV must be operated in the water in order for the software to learn the ROV's behaviour.

If in doubt about any of the functionality the interested reader may contact the SeeByte team at sales@seebyte.com

9 Where can I find CoPilot?

Are you considering acquiring a new ROV? SeeByte's CoPilot system is readily available on new ROVs from leading manufacturers:

- VideoRay offer the VideoRay CoPilot RI platform a one-man portable platform capable of navigating and performing inspections and surveys which would normally require a much larger system.
- Seatronics Predator offers CoPilot as a standard option. This system can be bought or rented and it is ideal for Explosive Ordnance Disposal, Salvage and Inspection work.
- SMD's fleet offer DVECS-S powered by CoPilot as a standard feature of their workclass ROV fleet.