Automating ROV Operations in aid of the Oil & Gas Offshore Industry

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SeeByte Whitepaper

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Context

The Remotely Operated Vehicle has been instrumental in the development of subsea fields. So much so that when new subsea infrastructure is designed an important requirement is to allow seamless ROV operations. From drilling (where the ROV is used to monitor the BOP and riser), through construction support (surveys, touch-down monitoring, interfacing), IRM (inspection, tooling, etc) and even in the decommissioning phase the ROV is the easiest and safest way to interact with the subsea environment enabling truly 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. There is also today 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 SeeTrack CoPilot can have a positive and direct impact in the operation of the ROV, bespoke solutions help deal with some 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.

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Awareness Made Easy

Construction Support

Offshore construction commands expensive vessels and highly trained crews, who are relied on to carry out real feats of engineering on each and every job. In construction the ROV units are often an important part of the operation itself and are required to move objects into position and observe the construction process. The costs involved are huge and, as construction jobs are normally contracted out on a lump sum, any delays caused by the ROV can have a significant impact on the bottom line.

Last generation ROVs can help make the process easier, equipped with station keeping functionality they can be used to hold station in a required position, but an ROV equipped with SeeTrack CoPilot can be made to keep station relative to a target of interest. Thus, when tracking and observing structures the ROV can be made to maintain its position relative to that structure. 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 speed up ROV operations. These savings in time ultimately impact the bottom line.

> *Experiments showed that an ROV equipped with SeeTrack 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 a simple to use interface.*

The bottom line: SeeTrack CoPilot has been shown to speed up ROV operations offshore, in some instances these operations can be halved in time. Savings through time efficiencies will directly impact the bottom line.

How will Construction Support operations improve in the future?

It is about integrating the ROV to the construction process. As the blueprints are developed and the work is planned the ROV plan should take form and the ROV should be able to automatically process that plan – eliminating any potential for human error. The ROV can automatically move to position (the pilot can supervise the process and change the plan if required) – integrating to the 3D simulation and updating the user as to where in the plan it is.

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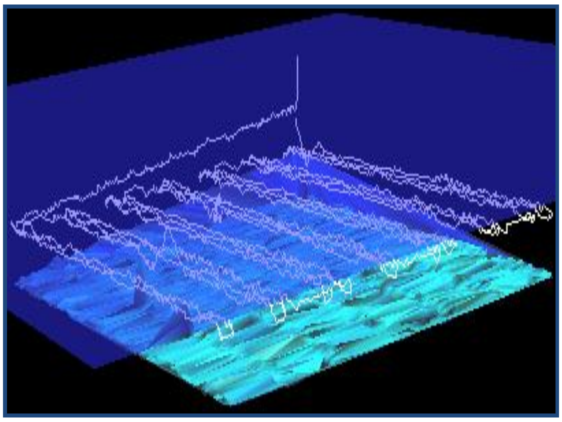
ROV Surveys

Offshore subsea is one the most challenging environments to survey. 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 in accuracy 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 investment can be compromised if the ROV cannot be made to steer the course. SeeTrack CoPilot allows the ROV to maintain a pre-laid course and offer a stable platform from which to gather data. Stability is of paramount importance, SeeTrack CoPilot provides it and as a result the quality of the data gathered using SeeTrack CoPilot is of superior quality.

> *Experiments showed that an ROV equipped with SeeTrack CoPilot maintain 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).*

The bottom line: An ROV equipped with SeeTrack CoPilot will be able to run smoothly through a pre-laid survey grid. As well as time savings the data will be gathered from a stable platform and thus it will maintain an even distribution over the survey area. SeeTrack CoPilot superior data products will require less post-processing.



How will Surveys be improved in the future?

SeeTrack CoPilot will enable the ROV to run the same survey line one year to the next. This will allow easier comparison of data sets. This feature alone will be instrumental in improving the analysis of data gathered to study the effects of scouring, mining or construction.

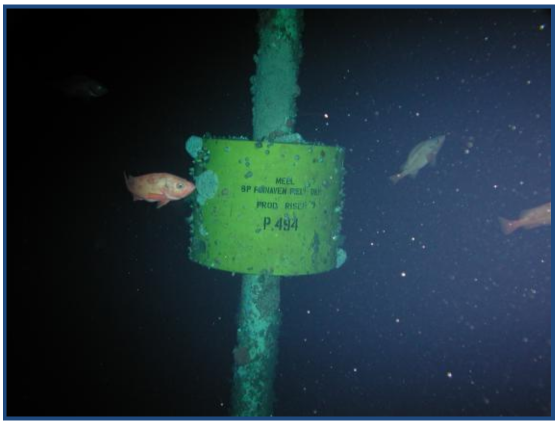
Inspection, Repair and Maintenance

A successful inspection must gather the right information. An 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.

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 station keeping can simplify the process of observing stationary targets for prolonged periods of time, but the value of this feature is limited to a small part of the IRM job. SeeTrack 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. Thus SeeTrack CoPilot is not limited to stationary targets. The ability to track targets and servo relative to them means that SeeTrack CoPilot can be used to run effective IRM from seabed to surface, including risers and anchor chains.

> *Results show that SeeTrack 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.*

The bottom line: An ROV equipped with SeeTrack CoPilot will help to ensure that there are no gaps in the data, the contractor will be able to carry out the whole inspection (including the risers) using a single tool. It is not uncommon for contractors to have to carry out a snag list of unfinished jobs at the end of Inspection job these can often represent up to 5% of the total job time. With SeeTrack CoPilot these snag lists have been shown to be significantly reduced leading to savings.



How will IRM improve?

The future will see the introduction of automated ROV and Autonomous Inspection Vehicles. These systems will be autonomously coordinated using smart software solutions. The systems will be used to inspect and detect features automatically and in real time. As features are observed the ROVs will use SeeTrack CoPilot to automatically position themselves in the right place to carry out maintenance and/or repairs.

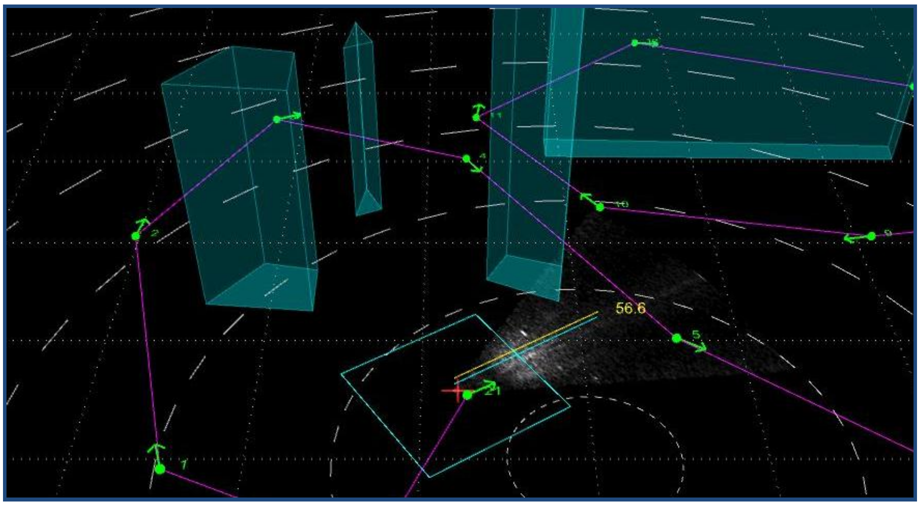
Improved User Interfaces for Improved Operations

SeeTrack CoPilot's intuitive interface can be used to manoeuvre the ROV around a field at the touch of bottom. Flying an ROV using SeeTrack 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. Last generation ROVs offer station keeping and 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 SeeTrack 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 on 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.

The bottom line: Get the best out of the ROV, no matter the experience of your crew!



Where is the technology heading?

Computer games provide a glimpse at the realm of the possible. Gods-eye, first and third person views and synthetic environments updated in real-time through intuitive interfaces for a new generation of ROV pilots. Also as the tasks are pre-programmed the pilot takes a less hand-on approach like the pilot in a commercial passenger jet much of the flight-path is pre-planned and automatically adjusted. The pilot will be required to supervise the process but not take over.

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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 SeeTrack 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
SeeTrack 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.	

What do I need to make SeeTrack CoPilot work?

SeeTrack 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:

- Teledyne RDI Workhorse Navigator Doppler Velocity Log
- Depth and North-Seeking Heading Gyros (information supplied at >= 3 Hz)
- Forward-look Sonar such as the BlueView P-Series sonars can be used to automatically follow or inspect objects
- INS and USBL systems can also be used if mid-water DP is required

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

SeeTrack CoPilot performs the following advanced functions:

- Navigation Computer: SeeTrack 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: SeeTrack 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: SeeTrack CoPilot processes the sonar data and identifies targets that the pilot can select to have the ROV follow or inspect them automatically.

SeeTrack 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

Detailed Sensor Specification

SENSOR	DESCRIPTION	SPECIFICATION	Notes
Doppler Velocity Log	Use acoustics to provide velocity vector measurements	Ping Rate: >= 5 Hz Min Altitude: <= 2 m Max Altitude: >= 30 m Velocity Res: <= 0.1cm/s Long Term Accuracy: <= ± 0.6% ± 0.2cm/s	
AHRS	Non-magnetic North Seeking Gyro with pitch and roll measurements.	Updates: >= 3Hz Heading Accuracy: 0.5 deg sec (lat) Pitch & Roll Accuracy: 0.1 deg	Magnetic Compasses are affected by ferrous materials and should not be relied on.
Depth	Pressure sensors used to measure the depth of the ROV.	Updates: >=3 Hz Typical accuracy: 0.01% FSR (full scale range)	The accuracy of the sensor will determine the performance
MBI Sonar	Multi-beam Imaging Sonar. High frame rate streaming imagery required to implement robust, reliable controls in dynamic environment. Sonar must have analytics interface to track structures.	Ping Rate: >= 5 Hz Field of View: 130 deg Number of Beams: 700+ Size: <180 cuin Low level software development kit access and tight integration with analytics	Mechanical scanner update rate/FOV too limiting for reliable target tracking and controls.
Acoustic Transponders	Provide position updates through Ultra Short Baseline (USBL) or Long Baseline (LBL) positioning method. Both can be configured to provide an absolute position.		The DP system does not require Acoustic Transponders to provide station-keeping. These need only be used where an absolute position measurement is required.
INS	Inertial Measurement Unit and navigation computer that provides Inertial Navigation solution with velocity vector and position measurements by integrating information from accelerometers, gyros and aiding sensors.	Update Rate: >= 5Hz	The INS must be aided by Acoustic Transponders or the navigation solution will drift exponentially. DVL aiding will restrict the drift to only a linear decay in accuracy. Absolute positioning sensors (eg LBL / USBL systems) will correct all drift components.

Note:

The sensor specifications are required to meet the needs of the automation routines. Other sensors and navigation solutions might be required to fulfil the actual job (for instance a survey will typically require an INS for positioning – though the survey mode does not require the same level of accuracy to provide accurate and smooth survey lines).