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Underwater operations

Underwater services incorporating remotely operated vehicles can help minimise operational impacts at hydro plants while improving regulatory compliance



HYDROELECTRIC plants, pumped storage facilities and dams have a variety of maintenance applications ideally suited for remotely operated vehicles (ROVs). The applications are ideal for many reasons above and beyond the long penetrations and long bottom time capabilities of ROVs. Underwater services properly incorporating ROVs can increase the safety and inspection quality while decreasing outage times and working around operational constraints of the plant.

Remotely Operated Vehicles are tools; the correct tool must be used for the correct application. Furthermore, the ROV itself is merely a delivery platform for the payload of sensors and tools. Successful ROV operations include the proper sensors and tools for the task, the proper type and size of ROV, and experienced operators.

The following article covers several case studies from underwater and surface remote control service provider Hibbard Inshore that highlight different applications where ROVs offset costs, impacted operations or regulatory compliance, and provides an overview of the vehicles and sensors available.

LEAKING HEAD GATE WITH DAMAGED SEAL

Maintenance inspections come from simple operational needs. In this case, a head gate was leaking and the head gate seal was showing damage. The head gate seal rested on stainless seal plates bolted to

the face of the dam – these plates were thought to be the problem. An underwater inspection was needed to verify the cause of failure or determine another all together.

The choice for an ROV inspection was based upon several operational constraints of the plant. The generation schedule called for two of three units to be operational and the reservoir level was at a seasonal high point. The reservoir level put the inspection at about 67m of depth. The two adjacent units were able to be operated during the ROV inspection; therefore there was no operational impact on the plant.

The Inspection Class ROV had a payload including 500 watts of light and a high resolution colour zoom camera. The zoom feature gave close-up, highly detailed pictures of the bolt heads and plate joints showing deteriorated bolts and plates slightly raised from the face of the dam. The most important point was a single seal plate was completely missing. The dual imaging sonar heads on the ROV gave a very precise lateral and vertical position of the ROV relative to the structure such that the exact plate that was missing could be identified on the drawings. The missing plate potentially posed a hazard to the unit if it was located inside the trashrack structure, penstock or scroll cage. The ROV searched these structures to verify the seal plate was not a hazard to the plant. This hazard clearance inspection took the ROV inside the scroll cage to a depth of 122m.

The benefit to the plant came in several forms. The first was

minimising operational and generation impacts on the plant from the beginning. Subsequent benefits came in the form of certainty, the leaking head gate and damage seal turned out to be from a missing seal plate, and where the plate was missing from was also precisely known. Next, and perhaps most importantly, the safety of the unit was ensured by the fact that the missing plate was not in a position to get drafted into the unit and damage the wicket gates, shear pins or other turbine parts. Lastly, the cost of alternatives was significantly greater. To change a dive profile to include a penetration dive at a depth of 122m would have left the unit shut down for a significant amount of time while a saturation dive system was mobilised. The unit was back online again and generating without an extended outage.

FISHWAY INSPECTION

ROVs are very effective in shallow water applications where a mix of sensors gives a production advantage. This case study highlights how the sensor package and the deployment platform both created benefits. The sensor benefit came from the combination of a long range broad area sensor and a short range detail sensor. The sonar system was used as a broad area search tool and navigation tool whereas the video cameras were used as a shorter range detail sensor. A specific Inspection Class ROV was required that could handle the umbilical drag and minimum allowable flow rate in the structure.

The scope of the inspection was to search for any missing, damaged or displaced metal screens on the bottom of the fishway/fish ladder structures. The ROV would enter a chamber and set down. After a moment, the sonar scanned the entire chamber showing that the metal grates were in place. Then the ROV would fly and visually inspect much of the grating for the general condition of the tie down bolts, bars, and look for debris trapped under the screen that could lift a screen during high flow. The ultra low light level camera was of significant benefit due to the imaging range. In particular, the monochrome camera could see through the grates on the bottom of the chamber to spot debris buildup. Furthermore, one of the sonar heads was used to sound through the screens and determine the level of debris buildup in the chamber below. The sonar system also performed as a navigation tool, when deflected bars, or areas of debris buildup were located, the sonar would show the exact location of the ROV within the structure.

The benefit of the deployment platform came from a capacity to carry the sensor package and the ability to handle high flow. The sensor package included a high resolution colour zoom camera, ultra low light level monochrome camera, dual imaging sonar system and multiple dimmable lighting circuits. This sensor payload required an Inspection Class ROV that had high thrust and a hydrodynamic shape to swim upstream about 304.8m in a stretch against a 0.6m/sec minimum flow. This is a case where a specific deployment platform was required to deliver the sensor payload as a result of the working conditions.

The benefit to the customer came in the detail of the inspection. The ROV's sensors gave superior visual imaging clarity and range and detailed quantitative results from the sonar. The sonar system provided precise locations of features and complete snapshots showing all screens in place. This produced a higher certainty of results than alternative methods.

ROV OPERATED BLANKING PLUG WITH SEAL INTEGRITY MONITOR

Although ROVs are generally thought of as inspection tools, there exist applications in which manipulators and tooling can also be used to offset cost and risk. A Vehicle Assisted Tool (VAT) was built to temporarily blank a 14" service water intake on the face of a dam. The VAT blanking plug was installed by the ROV in over 36.6m of water, then the ROV separated from the plug and visually verified that it was installed properly. The plug's internal camera showed that the water had been removed from inside the service water line and that the seal had integrity.

The choice to use an ROV was driven by both cost and risk. Two

aspects of risk to personnel were addressed. First, the differential pressure hazard to underwater personnel was eliminated by using an ROV. Second, the risk to personnel (and plant) was minimised by using an internal video camera on the blanking plug to verify that the plug was latched in place and had seal integrity. The cost offset came from the elimination of a chamber. This operation complied with EM 385-1-1 helping this facility, owned and operated by the US Army Corps of Engineers, to meet regulations.

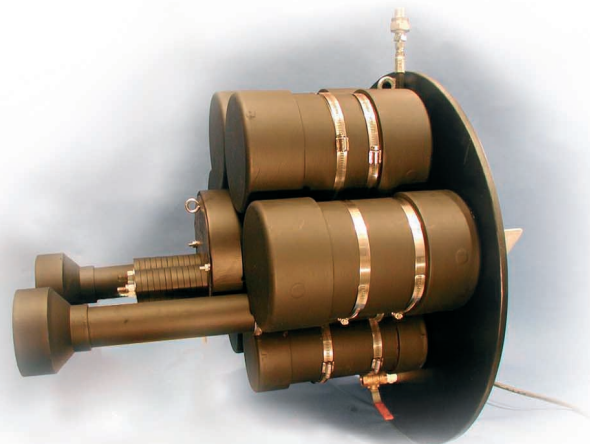
LONG RANGE TAILRACE, PRESSURE SHAFT AND PENSTOCK INSPECTION

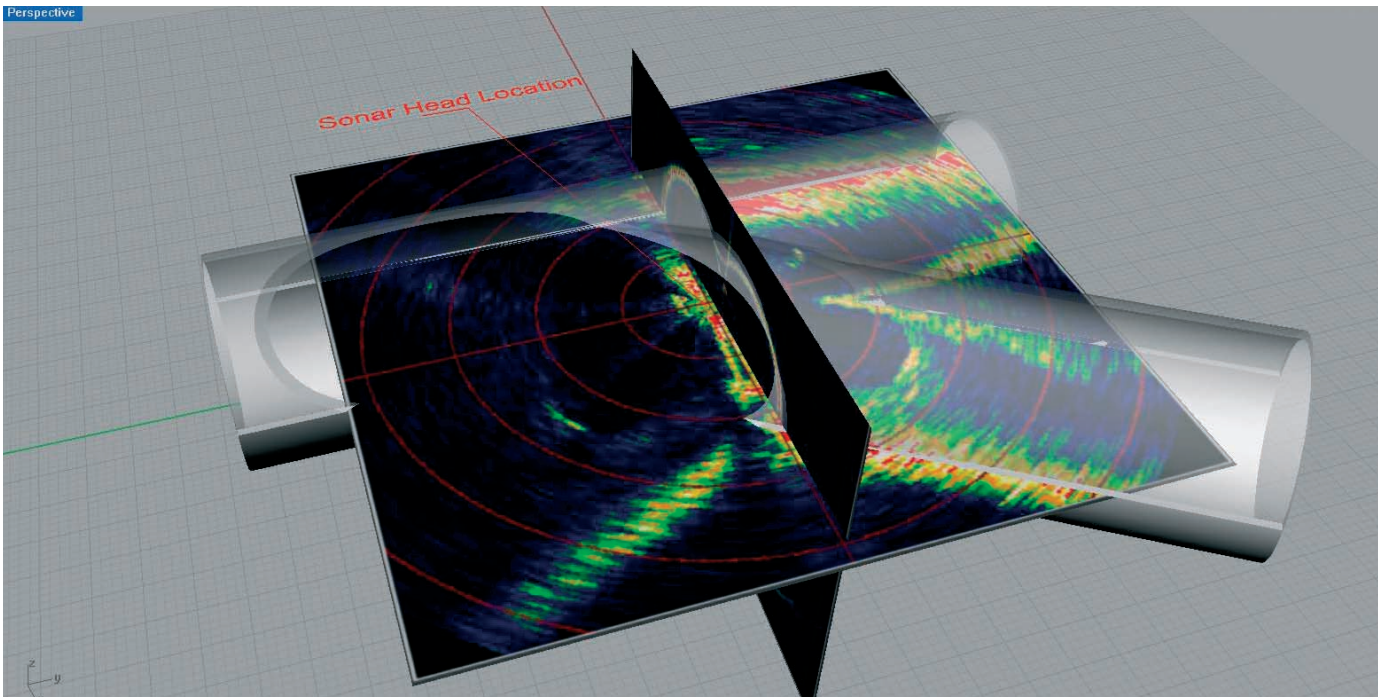
The previous case studies have highlighted routine hydroelectric maintenance using inspection class ROVs. Pumped storage and hydroelectric plants with high heads and long penstocks or power tunnels present different operational, safety and productivity challenges.

The main challenge to these structures was the fact that until recent technology was available, the only service option was dewatering. Dewatering poses significant hazards of failure to the plant as well as the cost of lost generation and long outages. Manned inspection of this dewatered structure would have created confined access risks and inspection difficulties. For example, the pressure shaft was 304.8m tall which would have required significant scaffolding or line work. Lastly, walking in the tunnel would have presented inspection difficulty in seeing the crown through the ambient vapour. The ROV option negated all of the manned entry risk, structural risk, and loss of revenue from lowering the reservoir. The outage time was also greatly decreased.

This case involved a pumped storage plant that included a pressure shaft of approximately 304.8m in height, and it had about 1.6km of tunnel to the turbine shutoff valves. The entire inspection was completed in about 20 hours reducing the plant outage to two days. A large Inspection Class ROV with long tunnel capabilities was chosen for the task of sensor delivery. The inspection included high resolution video transmitted by fibre optics to the surface. The imaging sonar system included two sonar heads that worked in a complimentary fashion to take cross sections and image ahead of the ROV to search for features before they were in visual range of the video camera. Even in zero visibility as is the case with large effluent outfalls, the sonar system can complete a detailed inspection. The sonar system was crucial to the inspection process because the combination of sensors provided both long range and short range feature detection that increased both the speed and quality of data recorded. The sonar system was capable of detecting spalls, joints, cracks, debris and many other features far ahead of the ROV. The sonar also created centimetre accurate cross sections that showed debris buildup and depth of spalls, and as well as this the system was also used to navigate through bifurcations and chambers.

VAT Hydraulic Latching Blanking Plug with internal video camera





OXYGEN DIFFUSER ARRAY

Repetitive tasks in deep water are another application in which ROV work is effective. The primary advantages in this case were the value for money compared to the alternatives. The task was the cleaning of hundreds of oxygen diffuser heads in a hydroelectric forebay at 42.7m of depth. The depth and bottom time needed for the work would have required multiple chambers and a sizeable dive team. The diffuser heads contained a very delicate membrane that had to be cleaned; hand brushing had a high incidence of damage. The solution was a low water pressure jet to 'blow' the silt off of the top of the diffuser. The ROV's production rate cleaned three arrays per day which could complete the entire facility in a week. The advantage of this method was the no contact cleaning method prevented future repair costs and offset large manpower and chamber operations.

SONAR MODEL OF DEBRIS BUILDUP IN FRONT OF LOWER OUTLET INTAKE

Sensor performance alone is often an advantage. This application focuses on the numerical results produced by the sonar system and the resulting CAD model. A lower outlet intake in the forebay of a hydroelectric project needed the debris buildup measured. The debris measurement and volume calculation was needed to determine if dredging was necessary. The first part of the inspection included a visual of the trash rack, concrete structures, and debris type. The ROV then took sonar scans at a number of locations to get profiles of the debris slopes around the intake. All of this information was gathered in one day in 67m of water with a two man ROV crew. The resulting CAD model showed how much debris obscured the intake and the slope of the debris to the sides of the intake wing walls. This precise information gave the customer the necessary information to schedule and plan the future maintenance of the structure. The advantages of this method were in the data quality, short onsite time, usefulness of finished product, and offset of costly alternatives.

TECHNOLOGY SUMMARY

The nomenclature for the technology classification does not follow the offshore system. For the purposes of the inshore industry, ROV's are broken down into the following categories: Small Limited Access, Inspection Class, Large Inspection/Light Work Class, and Specialty.

Superimposed sonar views with CAD of bifurcation

The Small Limited Access Class – 25lbs± (11kg) – consists of suitcase sized ROV's that are dimensionally compact. These ROVs work well in small spaces but are limited to very low current, shorter penetrations, and lighter sensor payloads. Inspection Class – 100-250lbs (45-113kg) – ROVs are capable of full sensor payloads and various models handle flow, longer penetrations, light electric manipulator tasks, and Vehicle Assisted Tools. The Large Inspection Class/Light Work Class – 500-1500lbs (227-680kg) – ROVs are capable of deep depths, extensive sensor payloads, the highest currents, hydraulic manipulator tasks and VATs requiring substantial supply power. The Specialty Class consists of bespoke ROVs designed for tasks such as long tunnels. Hibbard Inshore operates several specialty custom long tunnel inspection ROVs that are capable of 1m+ (1.6km) penetrations in smaller pipes to many miles of penetration in tunnels. Not to be excluded are crawler ROVs, these negatively buoyant tracked vehicles crawl on tracks or wheels and can operate both when submerged or in the dry. A variety of platforms are available for almost any application.

The most common sensors on ROV's include a video camera, magnetic compass, depth gauge and lights. Effective inspections require a number of other sensors. A well outfit vehicle should have a video overlay which displays date, time, depth, heading, user text, pitch, roll, and camera position. This information gives the video record far more value. The most critical sensor on an ROV is the sonar system. When a properly outfit sonar system is installed on an ROV, far more inspection quality, navigation certainty, and production rate is possible. Dual sonar head systems provide the quantitative information needed for structural inspection particularly in complex environments with low visibility.

There are many auxiliary sensors that can be mounted on an ROV for specific tasks, these include acoustic positioning systems (only work in open water), Ultra-sonic Thickness Gauge, CP Probes, Scaling Lasers, Digital Still Cameras, Electronic Scanning Sonar Systems (video like picture), etc. The total sensor package is designed to meet the goals of the inspection and scope of the work. **IWP&DC**

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