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BIBBY HYDROMAP SURVEYS BRITISH WATERS

Featured Explorers

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Satellite image of the Thames Estuary with London Array (the largest offshore wind farm in the world) and neighbouring wind farm areas from NASA.

CURRENTS, BOMBS, AND ROVS:
BIBBY HYDROMAP SURVEYS BRITISH WATERS

by Dan Zlotnikov

When it comes to non-conventional renewable energy, the British Isles are a world leader. Consider the current boom in offshore wind farm projects fueled by the UK's strong coastal winds. To extract energy from the wind, enormous turbine towers are built based on a detailed understanding of the seabed at proposed sites. It's little wonder, then, that companies like Bibby HydroMap are seeing a growth in demand for undersea surveys.

Heather Carrigher, Marketing Manager at the Wirral-based company, notes that wind farm planners require multiple surveys of a site, both before construction and then at various points afterwards. Initially a broad geophysical survey is carried out, followed by more detailed work to determine the best possible positions for turbines. In fact, the survey company is typically involved throughout the entire life of a wind farm, right up to decommissioning, says Carrigher.

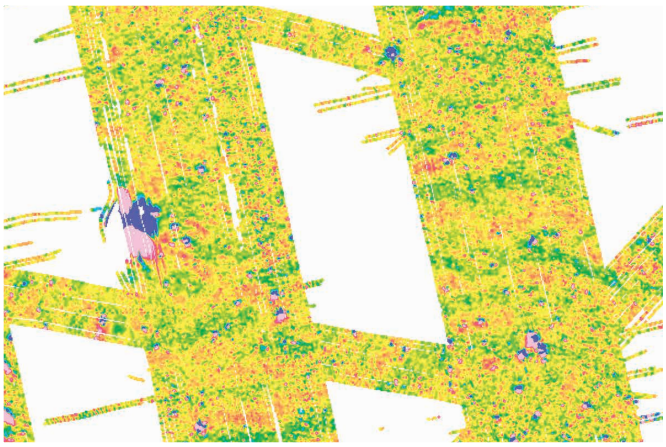
Prior to construction, however, project sites must be examined for unexploded ordnance (UXO). Even already-built facilities may require follow-up UXO surveys, as parts of the British coastline experience strong current, storms and tides that can move or uncover previously buried threats.

Some of the threats Bibby HydroMap looks for are relatively small and date back to the Second World War, such as 50-kg bombs and even 6.5-inch artillery shells. At the other end of the scale are devices that can do enormous damage:

Survey vessels have found bombs as big as 1,000 pounds, which can remain hazardous even after more than 70 years in the ocean.

If a piling boat were accidentally to drive a pile on top of a hidden bomb, the impact could trigger a detonation big enough to destroy the boat.

Time is money when it comes to subsea survey work as each project requires at least one specialized vessel. The size of the area to be surveyed is important, of course, but so is the level of granularity required. When a lower resolution is acceptable, the survey line spacing can be increased, lowering the overall number of line kilometres of data collected and reducing the cost to the client. The savings can be significant considering the large size of some of the sites surveyed, Carrigher points out.



A scan of the seafloor map, generated by Bibby HydroMap, shows possible UXO targets at the Humber Gateway wind farm site.

The UK is already home to the world's biggest offshore wind farm– the 630-megawatt London Array. In the third and latest round of site allocations planning approval has been granted to projects that are much larger. The installed power of some of these sites is 2,400 MW.

The scale of these projects will require the surveying of vast areas of ocean, and recent projects have produced 8,000 -10,000 line kilometres of magnetic survey data.

The company relied on spreadsheets and struggled with the massive volume of data before switching to Geosoft's Oasis montaj and UXO software, recalls Caroline Tweedle, Bibby HydroMap's senior geophysicist.

According to Tweedle, "the biggest advantage of the Geosoft software is the sheer volume of data it can handle, and how easily you're able to process the data. It's very fast, and you can get some nice preliminary results out very quickly."

Speed is of the essence when the on-site team is planning the next day's work and needs to know about current survey coverage, areas that need to have additional data collected or infill, and so on.

Tweedle also notes that Bibby HydroMap has been working closely with Geosoft staff on fine-tuning the application, and the company has been quick to respond to feedback.

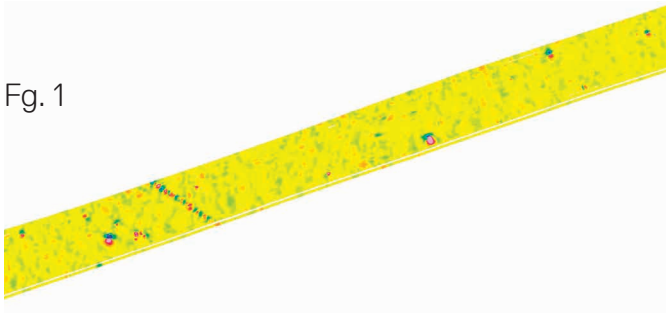
"Everybody has their own workflows, file types they work with and internal deliverables. Geosoft has welcomed our feedback and we've already seen some positive results with improvements rolled out in recent versions."

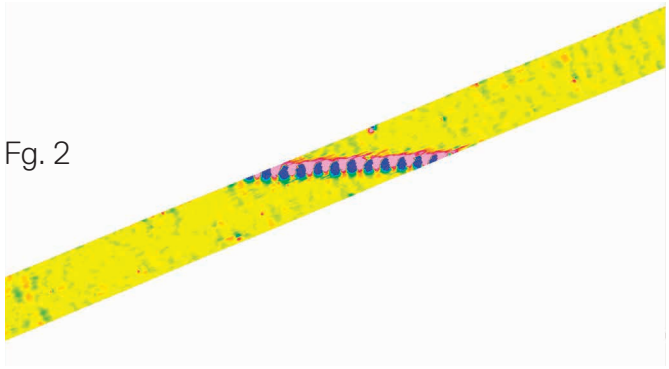
Bibby HydroMap's workflow improvements are not limited to its use of software: Tweedle points to the d'ROP, a remotely operated vehicle (ROV) developed by the company. The d'ROP differs from other ROV designs in that it is lowered on a heave-compensated winch from a surface vessel. The ship controls the ROV's depth and tows it forward, which leaves the onboard propellers to manage fine course corrections. The result is a platform capable of carrying a variety of sensors that can get close to the survey target (such as a pipeline) and stay on course even in difficult conditions. Also, the d'ROP was designed smaller than other ROVs since there is almost no need to expend power on propulsion.

"We can work in strong tidal conditions, shallow water, and with a much smaller boat than you'd usually have," says Tweedle, adding that, again, the wind farm operator can save a lot of money as a result.

The d'ROP was designed to survey buried cables in shallow waters – something the previously used systems had difficulty doing. Buried cables require that the sensors are operated close to the seabed, which can be challenging for some systems in strong tidal conditions. The d'ROP will be in demand in the coming years: in Britain alone, planning permission has been granted for 15.8 gigawatts of offshore wind capacity. "Enquiries continue to grow year on year," says Carrigher.

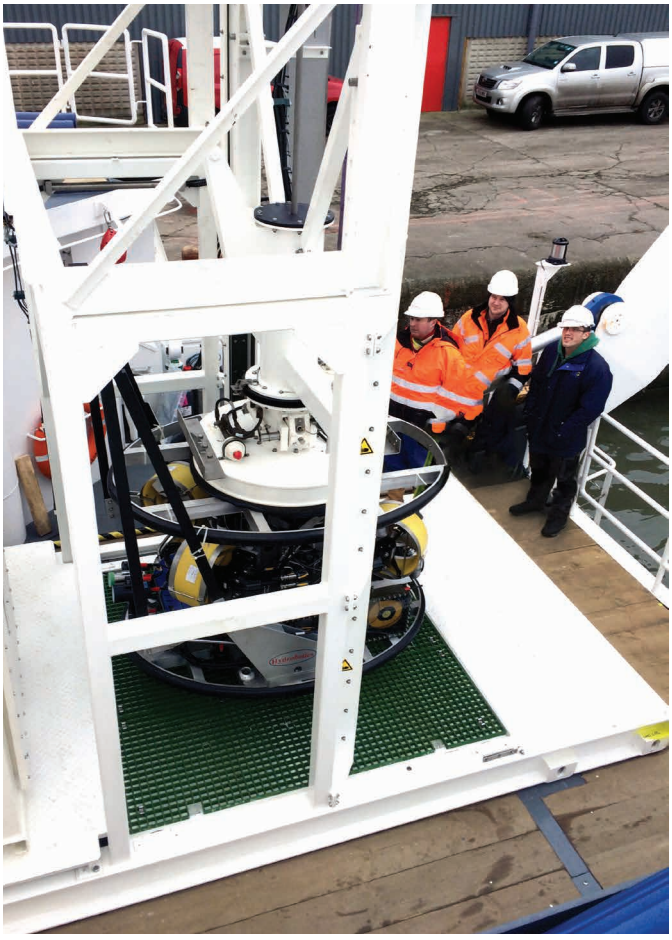
The work isn't limited to British waters: Bibby HydroMap has done work in areas as far away as Sweden and Lithuania. Nor is the company's work restricted to wind power. Surveys are under way for Port Meridian Energy, mapping out the proposed route for a natural gas pipeline





ABOVE: Fg. 1 shows several dipolar targets marking possible UXO and a cable crossing in the lower left. Fg. 2 shows several dipolar targets and a pipeline crossing in the middle of the image. Images provided by Bibby HydroMap.

BELOW: The Bibby Athena crew inspects the d'ROP and winch prior to departure.



between the deepwater port and the shore facilities. Other industries served include subsea telecoms and power cables, ports and harbours, marine aggregates and civil hydrography programs.

Bibby HydroMap was founded in 1997 as Osiris Projects. It was acquired by the Bibby Line Group in 2012, and has since continued to grow both its workforce and fleet, employing 115 personnel and operating 5 specialist survey vessels.

Innovations in renewable and clean energy will doubtless continue to power Europe's demand for offshore projects. These in turn will drive innovations in everything from surveys to construction techniques. If service providers are to keep abreast of growing demand, they too will have to keep innovating and improving their offerings.

Judging by its track record, Bibby HydroMap is well positioned to do just that.

GOLDEN WEST INNOVATES IN UXO SURVEY AND CLEARANCE

by Dan Zlotnikov

War has always come with a heavy cost, all too often borne not just by those who lived through the conflict but by people who were not even born until long after its end. As the explosive remnants linger for decades, so do their debilitating effects.

Over the decades, groups large and small have focused their efforts on cleaning up unexploded ordnance (UXO) and other explosive remnants of war (ERW). Most tackle the problem in the most direct way: Surveying for UXO, digging them out of the ground, and safely destroying them. But there is another side to the work: Coming up with new, more effective ways of addressing the problem. For the past 17 years, this has been the stated goal of the Golden West Humanitarian Foundation, a small group of highly trained specialists focused on UXO-related research and development.

SUPPORTING ROLE

The foundation's team does engage in clearance work if a fellow organization comes across an unusual challenge or requires specialized assistance, however, Roger Hess, Director of Field Operations at Golden West, emphasizes that their primary role is enabling other groups' clearance operations.

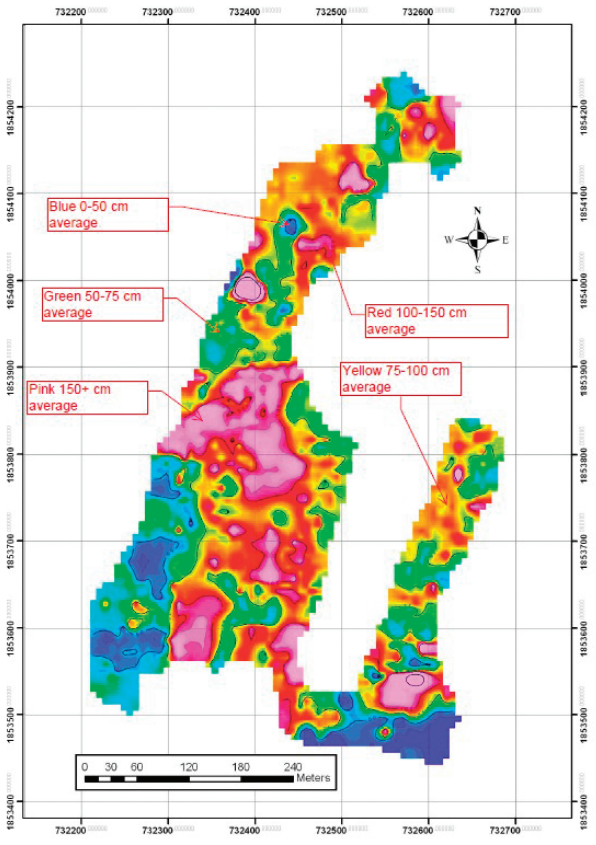
"You have very large organizations like Norwegian People's Aid, Mines Advisory Group, Halo Trust, etc., all doing fantastic things in clearance, and they employ thousands and thousands of people," he says.

Rather than competing with these groups for limited donor and government funding, Golden West created a small, specialized group that helps everybody, and is focused on innovating to find field supportable solutions that work in developing, post-war countries.

VERIFIABLE RESULTS

The first step in UXO clearance is finding the buried remnants, and the process is far from straightforward: Terrain conditions affect detector sensitivity and it takes a lot of practice to filter out as many inert objects as possible, while still ensuring no UXO are left behind.

Golden West's Detection Technology Manager Marcel Durocher points out that the configuration of detectors isn't always correct for the particular environment – but all too often device manufacturers simplify device operation by hiding the underlying assumptions from the user.



A target map produced in Oasis montaj shows the depths of the suspected UXO at the Vung Ha project site.

"The user just punches in the numbers and a pretty picture comes up. There's no understanding of what was involved in the processing. Sometimes it works out fine, but in other cases the assumptions are not valid for that particular environment and the results are not good."

Durocher, who introduced Geosoft's Oasis montaj and UXO software to Golden West when he joined the organization in 2006, says the latter offers much greater flexibility and allows users to calibrate the detectors to the circumstances.

"Oasis montaj provides more options on how to process the data and access to more predefined filters. You can also

input user-defined filters if you choose, which isn't possible in other software packages. It's more mature than anything else on the market," he says.

Ensuring survey results are consistent and verifiable is essential. "You're never remembered for what you've found; you'll always be remembered for what you'd missed," Durocher says.

The Golden West approach to surveys relies not only on operator expertise but also on a wealth of data produced by its Detection Research, Evaluation, and Development (DRED) facility – the only one of its kind in South-East Asia. At DRED, six lanes of different soil serve as a testing ground for detectors: Everything from clean sand to metal-rich laterite, and concealing devices ranging from antipersonnel mines 10 cm deep to 750 lb. bombs 400 cm deep.

"All landmines and most UXO still contain the original high explosive main charge, however the primary explosive has been removed from the detonator in the fuse assembly. There are no surrogates or simulated items; if something was missed by the detector then an actual landmine or UXO was missed," says Hess, explaining that some items have come from stockpiles while others were recovered from actual clearance operations and made safe by the Golden West team.

"The only difference between the DRED site and an actual clearance task is that the items will not explode in the DRED lanes; we refer to it as a 'Zero Excuse' approach," he concludes.

Durocher and his team have used the lanes to painstakingly test various detector configurations. One of the tools they use is a purpose-built, 4m-high PVC tower and a huge array of different targets.

"They will raise or lower the array with a target underneath it, log where it starts to pick it up, where it maxes out, then raise it back up and move it about 10cm and start the whole process again," says Hess.

Mapping the effectiveness of various sensor configurations involves hundreds of measurements. The result is a database that can be processed in Oasis montaj to produce 3D models of UXO responses for a wide range of munitions.

Once in the field, Golden West operators bury inert munitions of the type most likely to be found at the site. Each day, the operators must show that their equipment can consistently detect these reference targets.

Tests using the UPEX 740 detector – a very widely used device – has yielded another accomplishment: two configurations (a 2.4m octagonal and a 2x2m "Open Loop") outperformed the manufacturer-recommended configurations. Golden West took the results to Ebinger, the device's manufacturer, who then incorporated them into the product. Golden West also shared the results with other NGOs in the region, allowing them to boost sensitivity by up to 25% with a $10 investment in some PVC pipe.

Professional data-logging has been used in commercial survey tasks for over two decades in Europe and North America, however it's only recently been accepted into the Humanitarian Mine Action (HMA) scope.

"Marcel and I have proven many times that a few days of work by a small detection team that knows how to correctly use data-logging methods will keep a 12-man clearance team busy for a month, easily," says Hess.

Most of that time, however, will be spent digging up inert pieces of metal – Hess says that with modern technology, he still expects to see a 95% false positive rate. He offers the example of Vung Ha, a 27-hectare site in Vietnam. After the initial survey located over 26,000 potential targets, Durocher re-configured the detector loop; the second pass identified just 4,200 likely targets. Of those, just 507 were found to be actual UXO, fewer than 2% of the initial count. This result highlights another advantage to data-logging: The precise GPS-based identification of target positions meant only 10% of the total area had to be manually cleared, as compared to using mag-and-flag methods.

Durocher notes that the Geosoft software greatly simplified the re-configuring process for the project.

"When you change the size of the loop, you have to change your target thresholds, and you can do that very easily in Geosoft. You can process the data, look at it, and if you're not happy, change the thresholds again, go back and process it, and you can do that in just a few minutes," he explains.

CHALLENGING CONDITIONS

When tips from local residents set Golden West on the trail of ammunition barges that were reportedly sunk in the Mekong and Tonlé Sap rivers, finding the wrecks was just part of the challenge. Hess describes the recovery as "brown water" work with good reason: The water is so murky that visibility drops to zero – "we train people by painting over their masks," says Hess – leaving divers completely dependent on their sense of touch. To make matters worse, the current keeps everything moving and the crews are constantly at risk from weeds, logs, or loose fishing nets – none of which they can see coming.

The underwater environment makes accurate survey data all the more vital: Qualified divers are in short supply and their time is best occupied with recovering actual UXO, rather than inert chunks of scrap.

Hess also points out that brown water surveys have a limited shelf life. "The next flood, high tide or storm may bring obstructions that were not there before; your window of opportunity to work is limited."

Yet the challenges of the brown water environment can yield spectacular results. According to Durocher, the very first search Golden West conducted on the Mekong located a sunken ammunition barge, from which divers recovered over 11 tonnes of ammunition.

UNDER THE SEA

Buoyed by the success of the brown water survey work – which the foundation developed with no external funding –

Golden West has now taken on an even greater challenge: Surveying the coastal waters of the Solomon Islands, where villagers have been living under UXO threat since the end of World War II.

The age of the munitions is in itself a cause for concern, explains Durocher. As salt water degrades their integrity, explosives – some of which are highly toxic – seep into the sea and poison the marine life and coral reefs.

The project will focus specifically on shallow waters, says Durocher, because people in the region have also been known to use found UXO for fishing – what Durocher and Hess call "fish bombers." At best, this method indiscriminately kills all sea life in a large area. At worst, Hess says, people mishandle unstable devices and "families get wiped out."

But marine surveys offer a whole new set of challenges, starting with the conductivity of salt water.

"In fresh water, we can use magnetics, electromagnetics, and sonar. But because salt water is conductive, electromagnetics are of limited usefulness," Durocher explains.

Ebinger, makers of the UPEX 740, have come up with an idea that may render pulse induction devices usable in salt water; testing the new device in the field is one of Golden West's goals for the project, says Hess, adding that a wide range of sensors and software packages are to be put through their paces. So little clearance work has focused on coastal seawater areas that we simply don't know what will work and the pitfalls may be.

"We can make our best guesses based on performance in other situations, but will it actually work, will we be able to accurately get the signals, log the signals, properly record where they were so we can find them again, that's the crucial question."

Golden West will be using Geosoft Oasis montaj, and its UXO Marine software, as the baseline against which they will judge the results.

The Solomon Islands project is still in its early stages, but it comes at a time of growing attention to similarly affected shallow coastal waters. As clearance activity in these challenging conditions increases, so will the importance of having the real-world performance data being gathered by Golden West.

EXPLOSIVE HARVESTING SYSTEM

One reason the Golden West name is so well known in South-East Asia is what may be one the group's biggest success to date: The Explosive Harvesting System (EHS).

Roger Hess, Golden West's Director of Field Operations, says he first came up with the concept while serving with the Explosive Ordnance Disposal (EOD) teams in the US Army.

"We had a support project in Rwanda with a $2.4M budget and spent $800,000 of it getting explosives there. That's when I came up with the idea of recycling the explosives which are already in-country," he says.

The need became all the more poignant after the September 11 attacks.

"The US government was putting about $500,000 every year into supplying explosive charges to Cambodia. After 9/11 that dried up because of security concerns, and in 2001-2002, almost all of the clearance operations in Cambodia were shut down because no one wanted to provide them with explosives to destroy the mines," explains Hess.

When Hess joined Golden West in 2004, he brought the concept of EHS to Golden West founder Joe Trocino, a chemist by training who had previously developed a low-cost binary explosive for UXO disposal. The EHS offered an elegant solution: Recover the main charge explosives from large capacity munitions and use it to make small disposal charges. In other words, use UXO to destroy UXO.

Previously, Cambodian clearance teams were buying commercial explosive booster charges designed for the mining and quarrying industry, paying up to $5 for each 200-300g charge. But because the operators weren't trained in proper application and the charges were not designed for this task, they would simply pile on more explosives to destroy the munition.

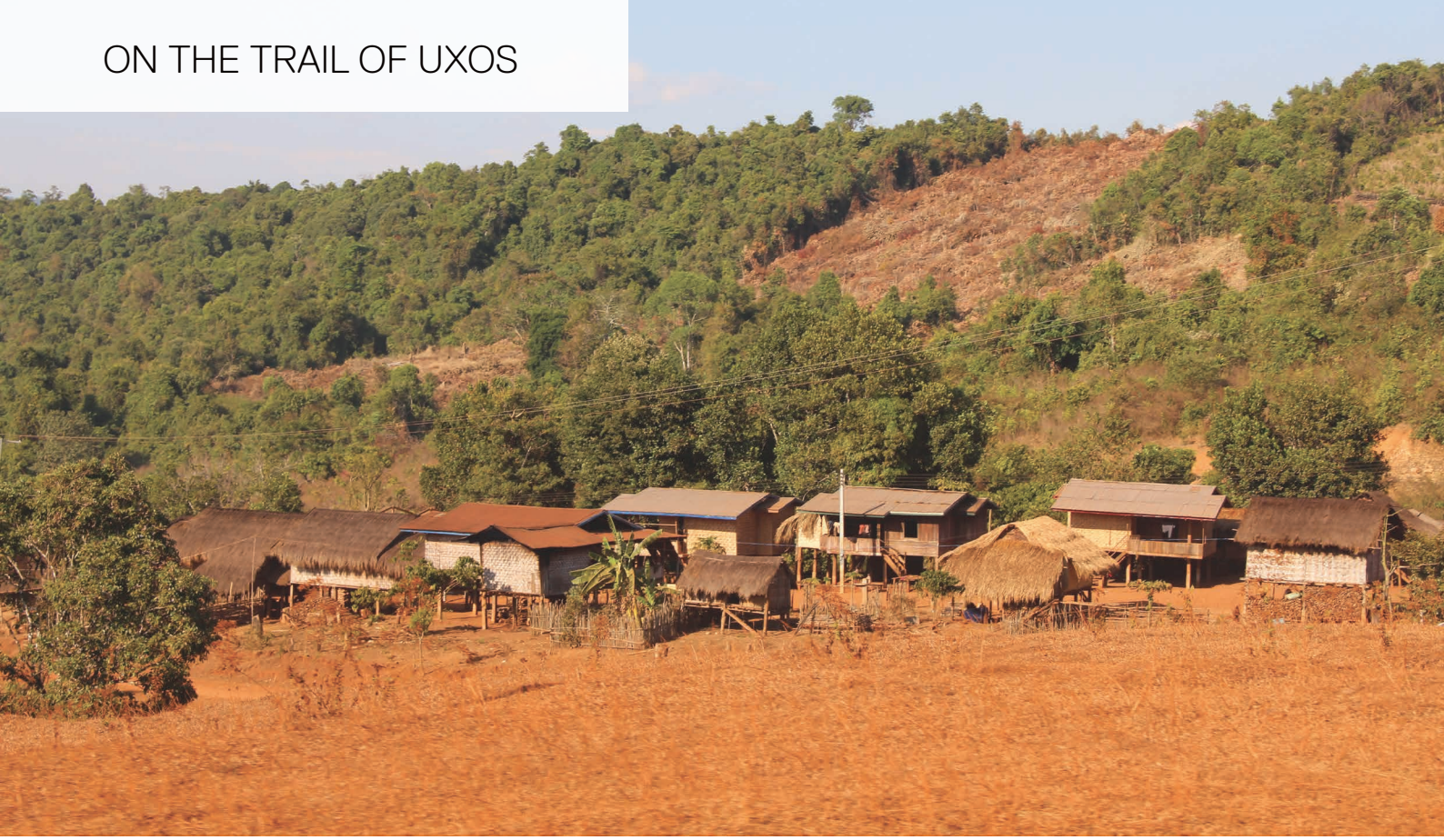
"They would maybe spend $30-$40 on a single shot, just to get rid of a projectile or a bomb," Hess says.

According to Hess, Golden West designed smaller charges that direct maximum force into the target. Each 100g charge must fully penetrate an 8mm mild steel plate; Golden West perform random QC testing during production to make sure this standard is met or exceeded.

"If you know where to apply it to a munition, a single 100 gram charge can destroy a 500lb bomb, where people would previously use 2kg of explosives," he says.

The 7-person EHS operation produces over 3,000 charges per month, which are supplied to Cambodia's fully licensed and accredited NGOs free of charge. To date the facility has produced over 380,000 charges, and is currently supplying all of the explosives used by local and international NGOs conducting humanitarian landmine and UXO clearance Cambodia.

Three US MK-82 500 lb. bombs being remotely cut into sections as part of the explosive recovery process for the EHS.



ACCURATE DETECTION OF UNEXPLODED ORDNANCE (UXO)

by Dan Zlotnikov

When the Aqua Survey team headed into the mountains of southern Laos, it knew the challenges that lay ahead. The company's task: to pit its technical expertise and specialized detection equipment against what is commonly described as the most difficult UXO clearance area in the world.

The Ho Chi Minh Trail, a network of roads linking North and South Vietnam, stretches some 3,000 km across Laos and Cambodia. American forces seeking to cut off North Vietnamese supply lines during the Vietnam War bombed the trail heavily, dropping more than 3 million tons of ordnance on Laos alone, with many failing to detonate. Hidden under dense foliage and buried underground, these UXOs continue to maim and kill Lao civilians today.

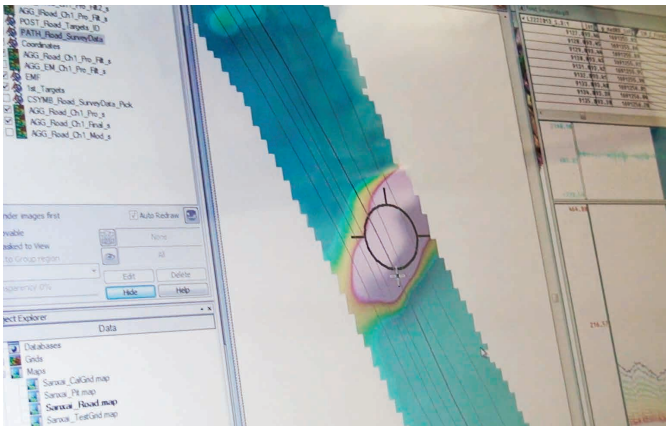
UXOs also pose an economic hazard: larger bombs can remain dormant for years until a heavy vehicle such as a bulldozer rolls over one. This ongoing threat means infrastructure projects such as roads and schools require costly bomb-clearing operations.

The first task of Aqua Survey, a Kingwood, New Jersey-based environmental survey company, was to survey a 1-mile stretch of dirt road. That might sound like an easy job to a lay person, but the region's unique challenges have foiled any number of previous attempts to clear it of old bombs. The challenge lies in the country's very soil, which is rich in aluminum and other metals,

"The soils were so conductive that a 250-lb. bomb would disappear in the background EM response at 1.2 metres," says Aqua Survey President Ken Hayes. "This compares with a detection range of 4 metres in the air."

PAGE TOP: A typical countryside village in Attapeu Province.

BELOW: A UXO target along the road to the animist village in the mountains of Attapeu Province.



The Aqua Survey team used an EM63 time-domain electromagnetic detector to record multiple-time gates which showed subtle changes in background conductivity. The readings were then processed through a proprietary utility, and the output was seamlessly imported into Geosoft UX-Detect for gridding, mapping and spatial refinement of target locations.

The scale of the country's UXO problem quickly became apparent: in the single mile of road Aqua Survey examined, scans located more than 700 dense metallic targets.

Hayes points to yet another challenge the team faced: many of the detected objects were not bombs but rather pieces of metallic debris strewn along the road. The next step was to identify the signatures most likely to be UXOs.

The final result, a list of 29 items most likely to be large, buried, bombs, was handed off to specialist teams tasked with UXO disposal.

The team's second project was at the Sepong gold-copper mine, also in southern Laos, where large bombs are found on a regular basis. Sepong posed a special sort of challenge in that the mine boasts some of the most conductive soil in the world. Strict safety procedures mean the mine has never had a bomb-related injury, though it paid the price in excavation time. Speeding up UXO identification would mean massive cost savings – a vital concern in a country where mining accounts for more than 10% of the economy. Here, too, Aqua Survey's expertise lived up to the challenge. Reconfiguring the equipment and adapting the software allowed the team to distinguish between responses from the ground and the bombs.

In a land where the ground itself holds both great promise and mortal danger, the dormant threat may have finally met its match.

BELOW: Aqua Survey team members Ken Hayes, Sean Scrivens and Joel Blake discuss the very metallic geology in the area being surveyed for UXO.

> "Using a combination of techniques, we generated a prioritized target list that isolated larger and higher conductance targets more likely to be munitions of concern."
>
> Ken Hayes, President, Aqua Survey

AUV MAGNETOMETERS A LEAP FORWARD IN SEABED SURVEYING

An Autonomous Underwater Vehicle-towed magnetometer proves itself in rough weather. The technique could reduce costs and time to complete seabed surveys — with improved accuracies.

By Graham Chandler

When Doug Hrvoic and his team were out on Lake Ontario to test a new AUV-magnetometer combination last September, they got a surprise bonus. An unexpected storm came up, allowing the unit to prove its utility for survey when the weather turns rough.

Hrvoic is president and owner of Marine Magnetics Corp in Markham, Ontario, a company which specializes in researching, developing and manufacturing marine magnetometers. He's working in partnership with Massachusetts-based AUV manufacturer OceanServer Technology Inc in an innovative approach to seabed surveys. The idea was to tow a small efficient magnetometer closely behind an AUV—the thinking was it should reduce the need for weather-dependent traditional boat-towed magnetometer arrays. Other devices, for example naval applications and emergency recovery floats, had been successfully deployed behind AUVs but it was first thought that electromagnetic interference would preclude their use as magnetometer tow vehicles.

But it was worth experimenting. "It's not a thing you'd normally do—you usually would get a lot of magnetic interference," says Hrvoic. As well, Marine Magnetics's Explorer magnetometer had been designed for towing behind a boat, so some adjustments first had to be made such as modifying the housing. "We customized the magnetometer to make it neutrally buoyant and other things that you don't do for a normal marine survey," he says. "Normally it's designed to be heavy so it sinks. Also we added some balancing weights so we could adjust trim to make it an easy load behind the AUV."

OceanServer's Iver2 AUV model was chosen for its design. "The Iver2 was designed to enable the integration of various sensors by a third party, and without direct involvement of the Iver developers," says Bob Anderson, president of OceanServer Technology. "From a hardware standpoint, one approach has been to tow a sensor in the water column behind the AUV, and to connect a tow cable/electrical interface cable to a rugged, waterproof connector on the back of the Iver antenna mast." That connector provides power and a serial communications port to the vehicle CPU he says. "Once the standard Explorer magnetometer was connected, it was a minor effort to provide the limited control interface and to log the data from the magnetometer."

With the hydrodynamics and connectivity challenges taken care of, the crucial question of electromagnetic interference came next: the towing distance was just five metres aft of the AUV. So the next step would be to collect data under real conditions. "I had a really good data set that we could use to truth and check the quality of the data from behind the AUV," says Hrvoic. "And also the magnitude of the error that the AUV might be creating, if any." Hrvoic's data set was from the bed of Lake Ontario, which was an ideal testing ground because of its extensive non-magnetic sediment cover, making for magnetic gradients on a smooth geological background. Man-made

objects show very clearly against it. Thus any error in the magnetometer data should show up precisely.

The schedule for serious testing had been arranged in advance but the late summer storm was unexpected. "I had [the AUV] shipped here for the weekend and we all had to converge at one spot," recalls Hrvoic. "Friday afternoon I was watching the weather and could see it could turn bad." So they decided to get a head start on the testing. It was 7 o'clock in the evening and winds were picking up but still only around 20 km/ph. The rain had started but conditions didn't appear too bad so they went out to their survey block near the Scarborough Bluffs marina. Soon it turned rougher. Waves were coming off the shore in all directions but they persevered and launched the AUV. Communicating with it from the bridge of their 28-foot survey vessel, they sent it off on its first mission in darkness. Its survey pattern was pre-programmed so the team returned to the dock while the AUV combination did its work three metres below the surface, including data sensing from its Klein side scan sonar which would be used to supplement the mag data.

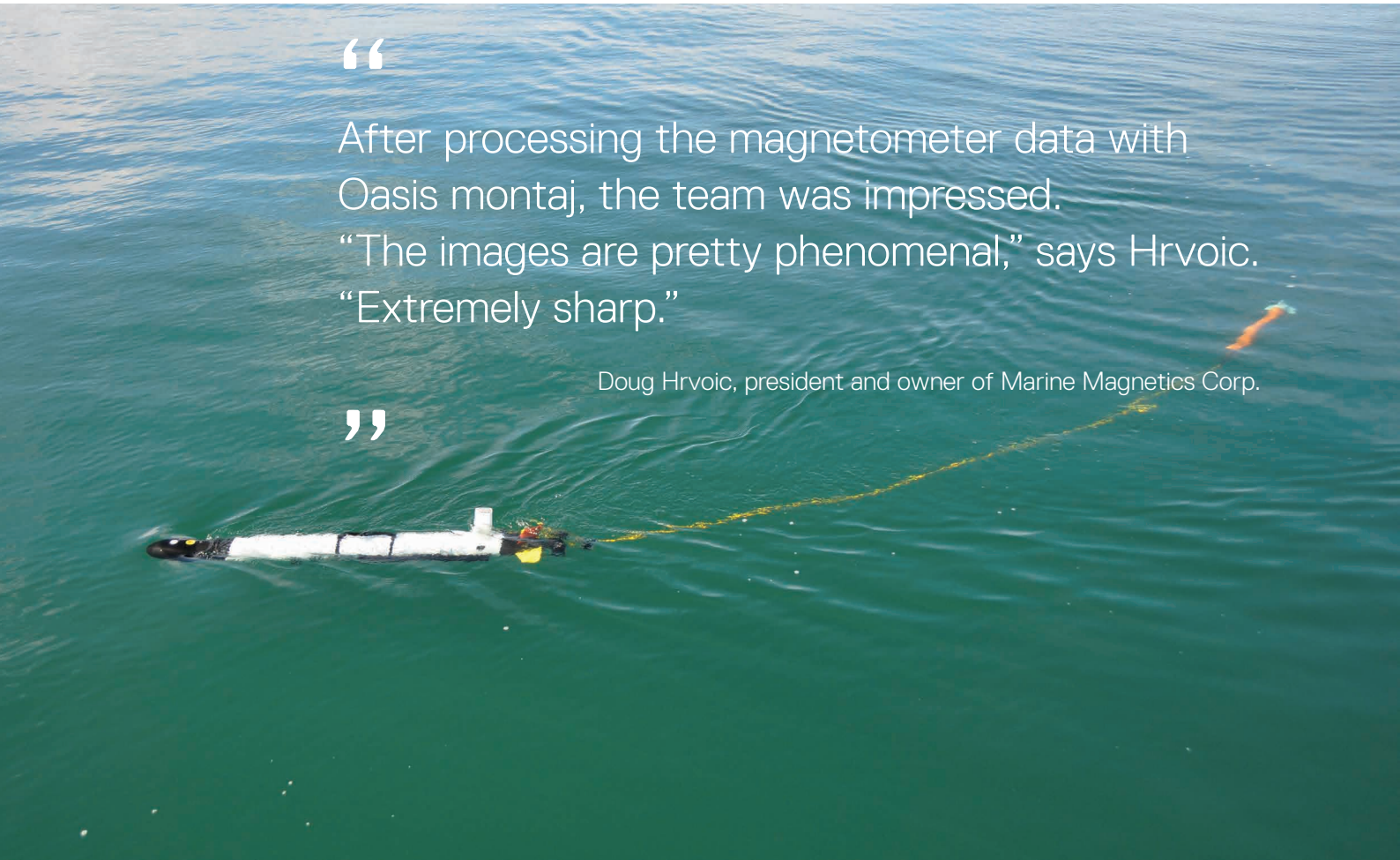
"The survey block would take five or six hours, broken up into one-hour sections," says Hrvoic. "We didn't want it to go too far without checking on it so we came back after an hour and it was where it was supposed to be." By then the weather service had issued a strong wind warning, waves were hitting two metres in heavy rain, and thunderstorms had moved in, "so it was getting to the point where I didn't feel comfortable being out any more." They retrieved the AUV and magnetometer at a pre-programmed pickup point, which they found easy despite the storm. "I thought it would be hard to get close and we would be banging around," recalls Hrvoic. "But literally to get this thing out of the water the engineer just reached down with one hand and hauled it out—completely painlessly. That was a worry working in rough weather."

Pre-programming was a definite plus, and Hrvoic says an added advantage of the Iver2 is its Iridium satellite system option, which they didn't have for the test. "The satellite system allows you to send and receive messages from the AUV," he says. "If we had that we could get feedback in from onshore letting us know everything is fine and then we could send a message to it to proceed."

After processing the magnetometer data with Oasis montaj, the team was impressed. "The images are pretty phenomenal," says Hrvoic. "Extremely sharp." A number of targets they located were truthed with the OceanServer Mosaic side scan data as well as their existing set. He says because the survey area was close to a marina, there was a lot of junk around—some of it natural and some man-made—but "the mag picture clearly identified things that were man-made and those that were not."

Hrvoic likes the accuracy and maneuverability of the Iver2 platform. "We collected 10-metre survey lines," he says. "It travelled at 2.5 knots, and spent so little time in turnaround. It is more efficient than a boat that is going maybe twice its speed. The survey lines it collected and the altitude it maintained were perfect. When you tow survey lines with a boat you are going left and right and kind of snaking along. This thing collected perfect survey lines under pretty bad conditions—where I would never survey with a boat."

And the convenience he reckons is unsurpassed when compared with boat tow. "All we did was check every hour and then push the button to send it on its next mission," he says. "And downloaded the data every hour." That can be relaxed too: the Iver2's endurance is eight hours and it can store a whole eight hours of data. "You could set it up in



"After processing the magnetometer data with Oasis montaj, the team was impressed. "The images are pretty phenomenal," says Hrvoic. "Extremely sharp."

Doug Hrvoic, president and owner of Marine Magnetics Corp.

the morning and retrieve it in the evening. Or the opposite. Come back when you wake up in the morning."

A major selling point he figures is that the AUV data set is far better quality than they had recorded in the area with the earlier boat tow. "It blew away my expectations," he says. "I thought there would be a bit more error with the AUV but it was just the opposite."

Hrvoic sees no reason why AUV-towed couldn't eventually dominate over traditional boat towed systems.

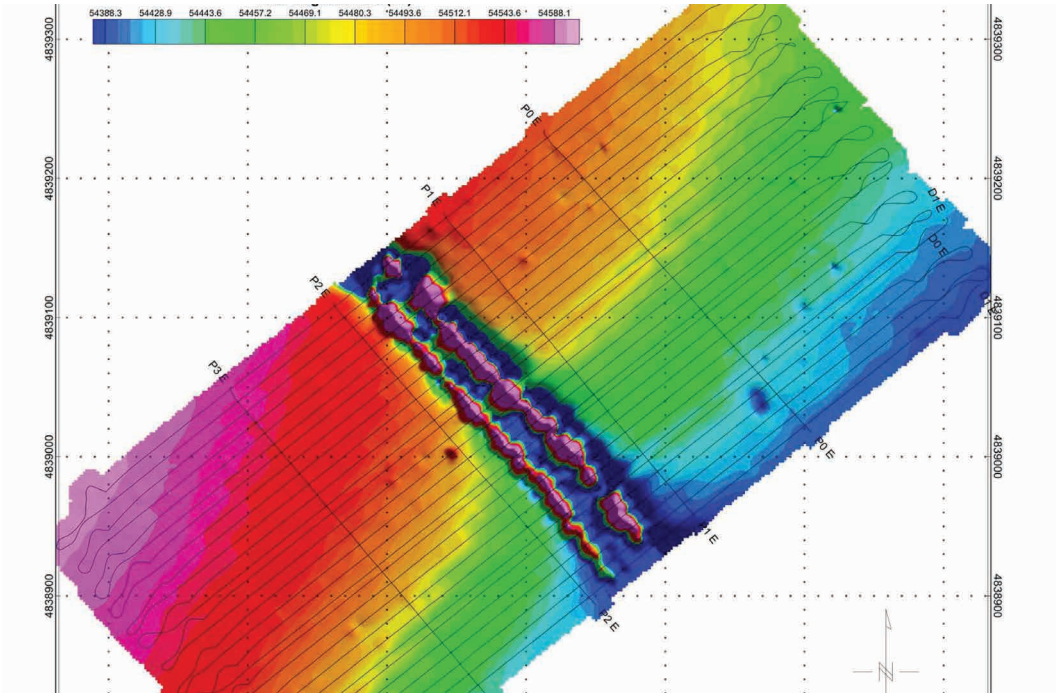
"In the end it's cheaper and you don't have to worry about weather, a major consideration with a boat towed survey," he says. "And the quality of the data is really a leap forward over any kind of boat towed method. There's no human being that can drive a boat the way an AUV can drive itself."

Which, although the resolution is the same, vastly reduces errors caused by erratic positioning and noise levels. And that in turn reduces data processing times. "Because there was so little error it didn't take that much to do the processing," he says. "We had to do the regular steps like lag correction and diurnal as with any mag survey. It's the method-caused error that's being reduced."

Anderson agrees survey accuracy is a major factor in using the AUV, along with reduced costs. "An AUV system, which includes a mission planning GUI such as the OceanServer VectorMap software program, can predictably follow a defined sub-sea course that covers the area of interest at the optimum track spacing, height from bottom and speed over the bottom," he says. "Once launched, the operator is free to review previously collected data or to plan future missions. Towing a device with a boat requires more on-site equipment, two skilled operators, and constant attention to safely maintaining the proper positioning of the towfish."

The combination will be especially useful in marine UXO detection, figures Hrvoic. "It is all boat towed surveys right now and you need very high resolution, which is more difficult with boat survey because you need tighter survey lines and to be more precise when driving." In UXO surveys for the extensive wind farms in the North Sea for example, operations are continually curtailed due to rough and windy conditions—as these areas are typically chosen for their high wind exposure. He also sees AUVs as useful for anyone doing surveys in shallow waters, i.e. 100 metres or less; often archaeological surveys are in this range.

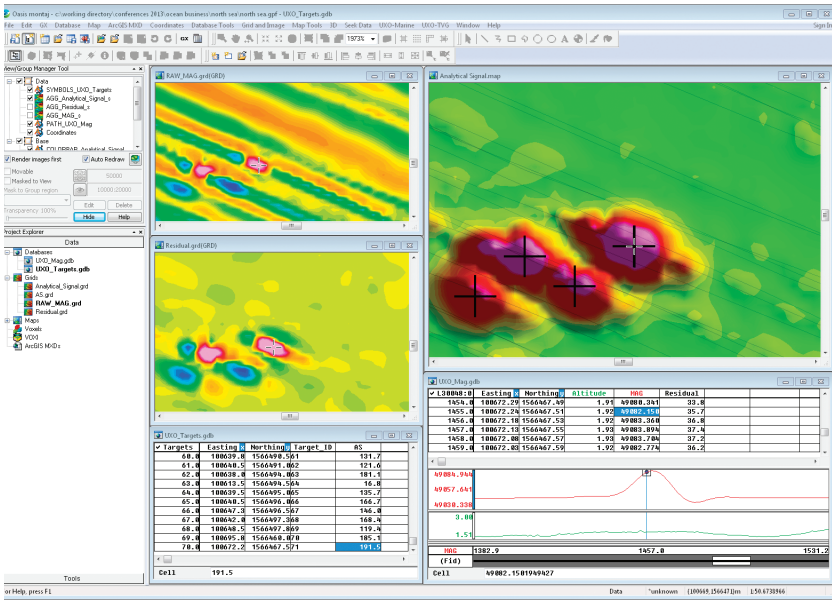
Hrvoic says R & D on the system is now complete. "This is a product now," he says. Together with OceanServer Technology, "we are promoting it as a leap forward in survey.



ABOVE: Iver2-collected Explorer magnetometer dataset, showing two large steel water intake pipes over a smooth regional gradient background. The survey track is shown as a solid black line. The uniformity of the regional gradient illustrates the high accuracy of the data, showing no signs of heading shifts or motion induced error. Several small magnetic targets are clearly visible and can be correlated with the simultaneously collected side scan sonar data. For example, the anomaly at around 641475E 4839125N is visible in the side scan record as a small partially buried anchor. BELOW: Use of Autonomous Underwater Vehicle-towed magnetometers could reduce costs and time to complete seabed surveys, with improved accuracies.

VISUALIZATION AND ANALYSIS OF MARINE MAGNETICS

> “Oasis montaj with the UXO Marine extension is the best tool on the market for efficiently dealing with large-scale marine UXO surveys on a daily basis.”
>
> Dr. Kay Winkelmann, Consulting Engineer for UXO Detection



Use UXO Marine to:

- Automatically position all sensors in multi-sensor arrays and apply navigation corrections.
- Drape survey lines to constant “altitude” above sea floor.
- Ensure data quality through instrument tests and other QA/QC processes.
- Enhance data with filtering and residuals for noise and background removal.
- Pick targets automatically from profiles or gridded data using specialized Analytic Signal tools.
- Interactively add, delete or move targets in profile or map views.
- Automatically analyze targets for data locations, depths, and ferrous weights.
- Produce specialized reports and maps.

Geosoft UXO Marine provides comprehensive processing and visualization of magnetic data for location and analysis of underwater cables, pipelines, and unexploded ordnance (UXO).

Magnetic surveys are a cost-effective method for detecting buried UXO not visible on the seabed, in a variety of marine environments. More complex than land-based site investigation surveys, there are many variables affecting the collection and interpretation of marine magnetic data.

UXO Marine provides a dedicated workflow and specialized tools to process and visualize magnetic data for effective detection and analysis of targets in marine site investigation surveys. Marine surveyors working with individual sensors and multi-sensor arrays, as well as gradiometers such as the Marine Magnetics Seaquest (multiple gradients), or the Geometrics TVG (horizontal gradient), can use UXO Marine to rapidly and reliably convert high volumes of magnetic data into accurate target detection, mapping, and analysis.

Data can be processed in profile form for wide line spacings (often the case in gradient surveys), or in 2D grids for surveys with full area coverage. The ability to calculate analytic signal from any combination of measured and calculated gradients helps to reduce noise and produce a cleaner analytical signal for automated and manual target picking. The magnetic anomalies for selected targets are modelled to estimate the target locations and depths. Apparent size and weight calculations help to further characterize UXO targets for informed decisions.

UXO Marine includes tools for quality assurance (QA) and quality control (QC) while surveying, and after the survey is complete. Sensor positioning is corrected in a number of ways. Geophysical correction tools identify and remove noise from background geology or instrument-inherent sources.

EFFECTIVE ENVIRONMENTAL INVESTIGATIONS AND REMEDIATION

Production mapping streamlines environmental site assessments

Production mapping software is significantly improving efficiencies in the Survey Products Group of US-based W.L. Gore & Associates, Inc. Gore's customized application of robust mapping software has eliminated repetitive tasks in the production of maps and, at the same time, improved the visualization of data for more effective client presentations.

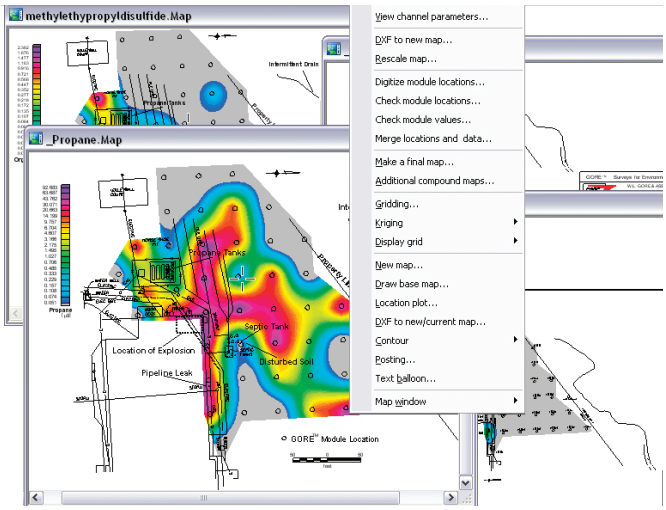
Within the Survey Products Group service portfolio, Gore conducts environmental site assessments with clients and regulators, to locate, identify and delineate sub-surface contaminants. Subsequent sampling, remediation and monitoring programs are focused in a cost-effective and timely manner. The company uses a high-performance storage database, as well as software tools for analyzing, visualizing and managing large volumes of multi-disciplinary data sets. The end result aids the environmental consultant in developing a robust conceptual site model, which leads to accurate selections of subsequent soil or groundwater sampling locations, and optimization of remediation programs.

The cost of groundwater cleanup and long-term monitoring programs can be in the millions of dollars," says Jay Hodny, Ph.D., Product Specialist at Gore. "It's not uncommon for a groundwater monitoring program to require regular sampling for over 20 years. If we can accurately locate the contaminant plume early in the investigation, and ultimately drill fewer monitoring wells, we deliver real value. Greater accuracy is the difference between installing and sampling 5 monitoring wells, versus 50, for 20 or 30 years."

Gore's Survey Products Group uses a custom solution based on Geosoft's robust mapping software to eliminate repetitive map production tasks and improve the visualization of data, providing a more effective presentation for the client.

Hodny combines CAD-based sitemaps, illustrating the sample locations, along with the analytical data in an integrated software environment. He utilizes robust contouring algorithms and map editing and visualization tools to generate accurate assessment maps of volatile and semi-volatile organic compounds present in the subsurface soil gas. Data retrieved from the GORETM Module, Gore's patented, waterproof, vapour-permeable sampler, can create a volumous data matrix for larger projects, such as large military bases that utilize hundreds or thousands of the samplers. Having production mapping tools saves time and improves efficiencies by quickly producing contour maps of relevant compounds across the survey area.

"I can take a full suite of 90 different compounds, and quickly produce informative maps for any of the compounds of interest," Hodny says. "If I had to do that one map at a time, you can imagine how long that would take me."



> "If I had to do that one map at a time, you can imagine how long that would take me."
>
> Dr. Jay Hodny, Amplified Geochemical Imaging LLC (AGI) (formerly, W.L. Gore & Associates)

Gore's mapping solution automates several repetitive mapping tasks, such as creating title blocks, plotting north arrows, and using archived digital data. Geosoft Custom Solutions professionals learned Hodny's mapmaking routine, and built in automated functions that minimized his tasks from 50 steps down to 10. The customized software saves Hodny a tremendous amount of time, which enables him to handle a greater number of survey projects, without sacrificing quality, while providing a standardized deliverable to the client.

"Geosoft automated 90 per cent of my map-making, but they made the program flexible so that I can stop at any time, do something unique to the maps, and then continue, while still having access to the full functionality of the Oasis montaj package," Hodny says. "I can create one map of one compound, and then tell Oasis montaj to make maps of all the other compounds requested by the client. Before the automation, I completed around one project per day. Now, I can generate three or four completed reports, with maps, in the same time period, delivered to the client electronically. The Geosoft montaj mapping environment also allows me to combine compound data from multiple surveys at a site, into one set of map compositions easily, for a more comprehensive understanding of the subsurface contamination."

HUNTING FOR A LOST SHIP

Archaeologists use geophysics to focus their search for a historically important Dutch slave ship wrecked off the Cape in 1766

By Graham Chandler

At the southern tip of the African continent about 175 kilometres southeast of Cape Town lies a wetland estuary system which has been of considerable interest to BirdLife International for preserving the breeding grounds of the endangered Damara Tern. But this complex system, the southernmost estuary in Africa, is also of considerable interest to archaeologists and historians, especially near the mouth of its main river, the Heuningnes.

Two hundred and forty-three years ago, in March 1766, the 450-ton Dutch slave ship Meermin ("Mermaid") ran aground off Cape Agulhas near here after her cargo of 140 Madagascan slaves revolted in a valiant bid for freedom. A series of events culminating in an unsuccessful attempt to man the Dutch East India Company (VOC) vessel resulted in her drifting with no anchor and hitting a sandbank. Authorities recaptured most of the slaves, but the master shipwright sent from Cape Town to inspect the wreck declared the Meermin a write-off, citing extensive structural damage. Already the shifting sands had begun to build a sandbank on the vessel's stern side. Any useful goods were removed, much of them auctioned right on the beach and she was left to the whims of the capricious shifting sands.

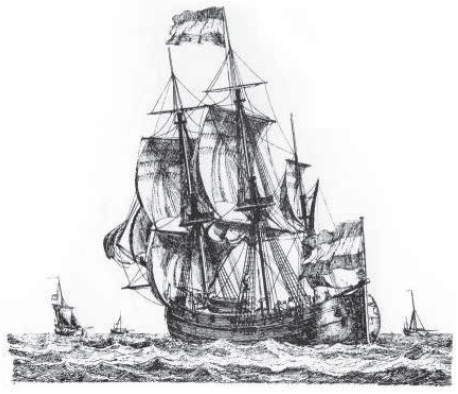
The Meermin has captured the attention of historians. She was a hoeker, a type of ship with 14th century roots. The name is derived from the ships' design function: using baited hooks on lines to catch cod and haddock.

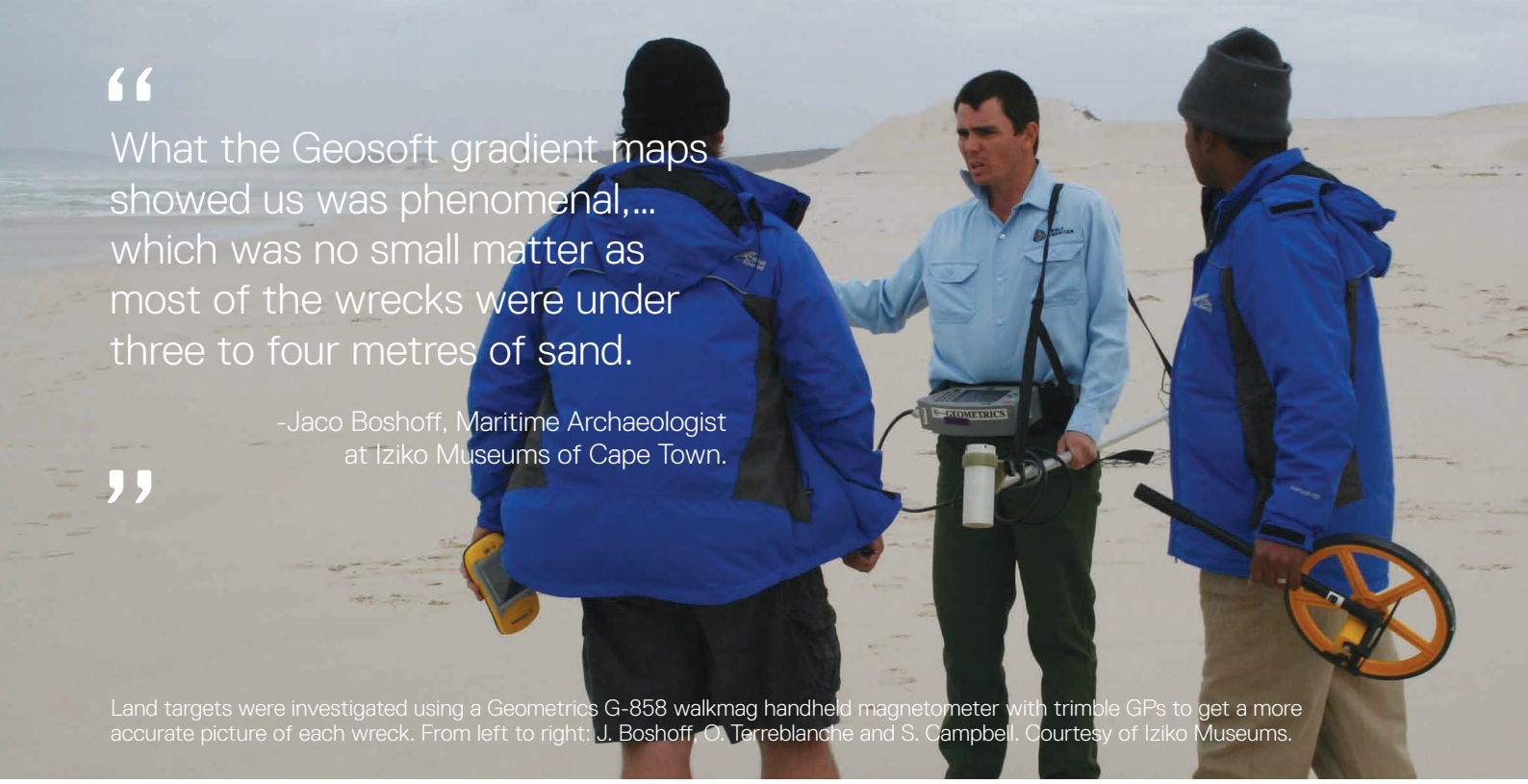
The first hoekers had just one or two masts, but in the 17th century the VOC built several as cargo carriers with three masts – the Meermin was one of these rare models.

Popular with the VOC for a short period from about 1665 to 1670, the hoekers' construction allowed it to withstand the warping effects of the eastern waters better than the 'fluits' – the ship type of choice until then. "The VOC stopped using hoekers towards the end of the 17th century," explains Jaco Boshoff, maritime archaeologist at Iziko Museums of Cape Town. "But they constructed some periodically mainly for use at their colonies as multi-purpose vessels." He says four hoekers were constructed in the second half of the 18th century for the Cape service. "One needs to add that vessels stationed at the Cape were used for multiple tasks like transport of timber from Table Bay to False Bay, the provisioning of the various company outposts and then of course for obtaining slaves especially from Madagascar," he says. "In fact the request for a new vessel from the government at the Cape in 1759 to their masters in Holland mentions the slave trade with Madagascar as one of the main functions for the new vessel."

Boshoff says the historical significance of the Meermin grounding event and what it means for a South Africa in transition had not been recognized or received any attention until recently. So about five years ago, the Meermin Project was launched by Iziko Museums of Cape Town. "The project is important in the context of a changing South Africa and what meaning it should have for maritime archaeology for the country," he says.

He has his work cut out for him. "The area where the wreck of the Meermin is most likely to be found is in the mouth of the Heuningnes estuary as it is the only river mouth in the bay," he says. The problem he faces is that the estuary has changed massively since the time of the grounding, including some due to relatively recent man-made changes. "In 1939 the then Department of Forestry started with a dune reclamation project in the Heuningnes estuary area," he explains. "It was at the behest of the local farmers as the river mouth used to close up periodically, flooding the hinterland and destroying crops and grazing areas." The region had already been known for its dynamic





> What the Geosoft gradient maps showed us was phenomenal,... which was no small matter as most of the wrecks were under three to four metres of sand.
>
> -Jaco Boshoff, Maritime Archaeologist at Iziko Museums of Cape Town.

Land targets were investigated using a Geometrics G-858 walkmag handheld magnetometer with trimble GPs to get a more accurate picture of each wreck. From left to right: J. Boshoff, O. Terreblanche and S. Campbell. Courtesy of Iziko Museums.

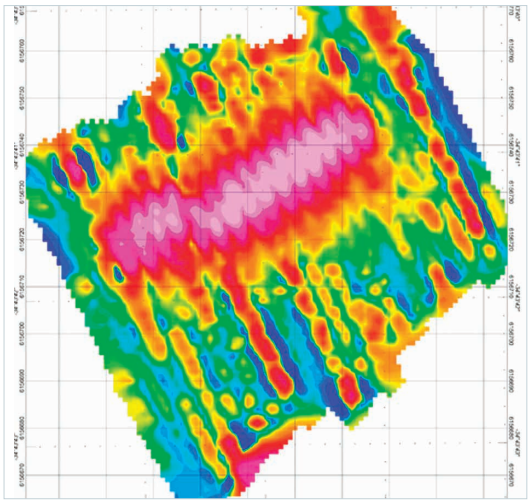
sand movement patterns, but with the reclamation project the river mouth became restricted to one location in order to prevent it from silting up. "It's a different environment from the one of 1766," he says.

Which creates several problems for archaeologists searching for the wreck. Complicating the search is that there have been several wrecks historically recorded in the area and none has an accurately described location. Moreover, the river mouth has closed up several times in the past and reopened at different locations. "Its historical position varied from two kilometres to the west to 1.6 kilometres to the east of its current position," says Boshoff. "Nowadays it is restricted to an area of about 500 metres."

A marine magnetometer survey to locate the wrecks was first attempted but proved of limited value: very shallow waters near the coast preclude small watercraft from approaching within 200 metres of shore. An airborne magnetometer survey became the tool of choice. Flying on board a Cessna navigated by SATLOC GPS, with a Geometrics 823 Cesium vapour magnetometer having an instrument resolution of 0.001 nT and a total noise envelope on collected airborne data not exceeding 0.5 nT sampled at ten times a second, data were collected. "A SATLOC real-time differential GPS recording once a second to an accuracy of less than three metres in X and Y and five metres in Z was utilized," explains Boshoff. Flying at 130 knots at a height of 30 metres above ground, lines were spaced 40 metres apart while data were digitally recorded. He says a base station for differential correction wasn't needed. "It records its position relative to the WGS84 [World Geodetic System 1984] Spheroid. This can be converted, if required, to other popular co-ordinate systems." At the start and end of each flight, the pilot flew over a known point to verify the GPS position, which was plotted out after each day's flying.

The airborne survey delivered 22 potential targets, most of them on the beach. As the data at first were provided on contour maps only, "I contacted Anglo American Corporation South Africa and they analyzed the data with Geosoft Oasis montaj," says Boshoff. "What I liked about it was firstly the fact that I could download a viewer without purchasing the program, enabling me to read the processed data. As an archaeologist and not a geophysicist it was a learning curve made easier by montaj magnetic intensity maps." Through the analysis done in Geosoft they were able to eliminate several of the targets as unlikely or of natural magnetism.

For the layman, Boshoff explains how magnetic anomalies can arise from wooden ships. "Iron fastenings were used extensively in wooden ships," he says. "This combined with the possible presence of anchors and cannon give fairly good signatures." He says even when objects like cannon and anchors are not present one can still pick up the fastenings that seemed to give a good signature as an assemblage rather than individual objects.



Geosoft gradient maps were used to decide where to excavate. Courtesy of Anglo American corporation.

The data thus processed from the airborne survey revealed that 11 of the 22 targets – six on land and five underwater – had potential to be the Meermin. The six land targets were further investigated using a highly sensitive handheld magnetometer to get a more accurate picture of each wreck. "We used a Geometrics G-858 Walkmag with Trimble GPS and post processing of the positions to get it to differential," says Boshoff. Line spacings depended on the size of the target but were typically two metres over each target. Again, Oasis montaj was used to process these data.

"What the Geosoft gradient maps showed us was phenomenal," he enthuses. "In one case we had a longitudinal anomaly that turned out to be a ship's keel."

Signatures were incredibly accurate he says. They used the gradient maps to decide where to excavate, "which was no small matter as most of the wrecks were under three to four metres of sand."

So the next step was to determine the depth of the sand deposit over the targets. This was done using a water probe system whereby seawater was pumped through a four metre long steel pipe. "The sand depth on most sites was found to be between three and four metres," says Boshoff. "This presented a serious difficulty as shoring up an excavation is dangerous and not feasible in a wet sand environment. One has to keep in mind that these sites can only be accessed during spring low tide. Your window of operation is therefore limited to a maximum of three to four hours." This was clearly not doable so a backhoe was brought in. There was little chance of damaging the wrecks. "As we knew how deep the deposit on any given site was, it was relatively easy to control the action of the backhoe," explains Boshoff.

It's a measure of the signature accuracy from Geosoft that, using the backhoe, all six targets revealed wreck assemblages. None was proved to be the Meermin but all were previously unknown wrecks, ranging in date from late 19th century to possibly late 18th century, judging from construction details.

How did they know none of the wrecks was the Meermin? "We are fortunate that a ship's draft for the Meermin exists in the collection of the Netherlands Maritime Museum in Amsterdam," says Boshoff. "This draft is one of the main tools for identifying the wreck of the Meermin as we can use the construction details and compare them with the wreckages found." Another strategy they use is analyzing the wood, as they know what types of timber the Dutch used in their ship construction. For example, "most of the wrecks found so far have been mainly pine construction. This is evident in all the construction details sampled including outer hull planking, frames, knees and keelsons," he says. "If a wreck is predominantly pine it rules that wreck out as being the Meermin. Only two wreck assemblages have any evidence of oak, but unfortunately so far, they do not measure up as the structures do not fit the measurements on the draft."

There's still much work to be done on these new finds. "We have not quite established the identity of the wrecks, bar one that was indicated on an old chart," says Boshoff. "One is potentially very significant as it could possibly be that of another slave ship that wrecked in the area in 1794." He says further analysis such as DNA and dendrochronology [tree ring dating] might prove or disprove that assumption. However, as with most archaeological projects, more funding would be needed to complete these tests.

With six of the 11 promising targets excavated, there now remain the five underwater sites to investigate and narrow the search for the Meermin. For these, Boshoff says they'd like first to do an airborne gradiometer survey to help with more accurate positioning and higher target resolution. The finer resolution will be more important for the underwater sites than were the land sites, as they hope to use a diver operated magnetometer to run across them.

As the potential sites are ticked off, excitement grows. "We hope to do the gradiometer survey at the beginning of 2010 and a follow up field survey towards the end or middle of 2010 as funds, weather and other external factors allow," says Boshoff.

Keel section being excavated by J. Boshoff and S. Campbell after pinpointing the position with the gradient map at right. Courtesy of Iziko Museums.

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