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SEA TECHNOLOGY

MARCH 2009

SINGLE ISSUE PRICE \$4.50

www.sea-technology.com

WORLDWIDE INFORMATION LEADER FOR MARINE BUSINESS, SCIENCE & ENGINEERING



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RangeNav: First Easy to Use Portable Tracking Range

Desert Star's Portable Tracking Range Makes its Mark With the U.S. Navy

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By the time the U.S. Coast Guard began chasing a shrimp boat that had ignored the U.S. Navy's Notice to Mariners, which warned them to avoid tracking range equipment at the bottom of St. Andrews Bay in Panama City, Florida, it had already dragged its bottom trawling gear all the way through the 28,000 feet of cable linking 27 acoustic listening and processing stations covering 247 acres. The concern was that this entire array, deployed in a short period of just four hours the previous afternoon, was now seriously scrambled.

As operational emphasis is shifting toward littoral waters, the U.S. Navy and other organizations' need for a fully portable underwater tracking range capability has grown. Tracking ranges provide precision positioning capabilities over large sections of the seafloor for a variety of purposes. In addition to submarine

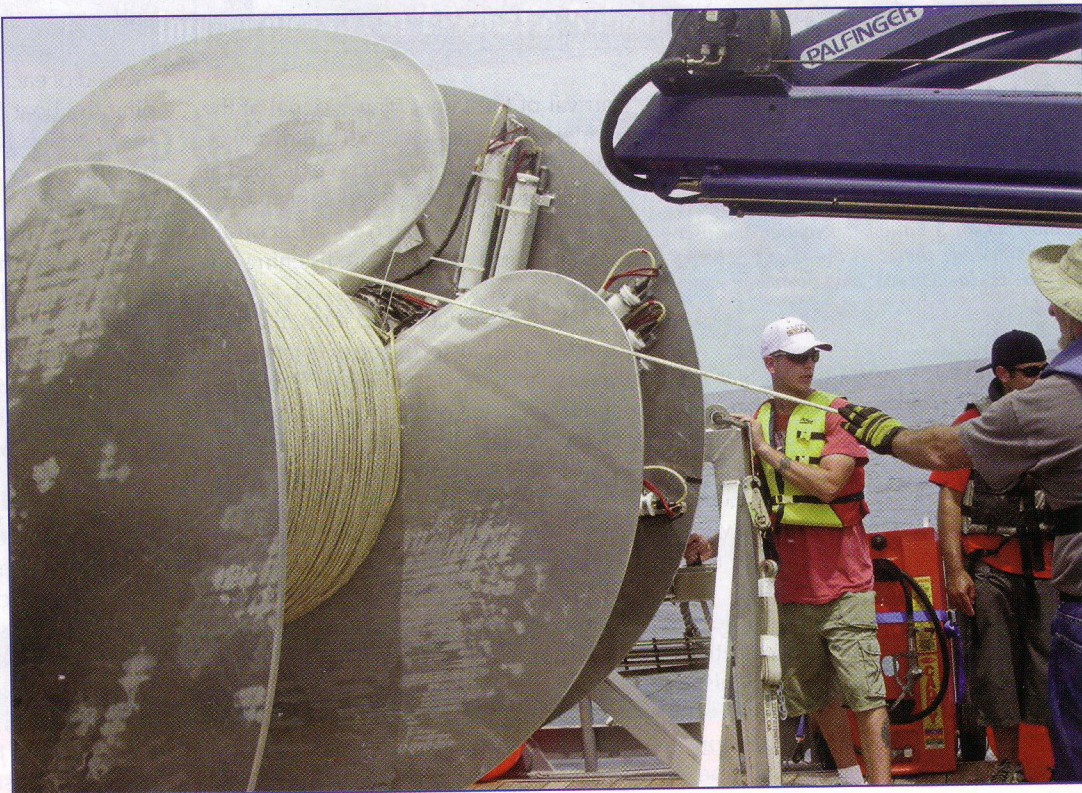
tests and exercises typical for the deep "blue water" ranges, the applications can now cover anything from the testing of unmanned underwater vehicles (UUV) and equipment to the training of combat divers to the survey and cleanup of unexploded ordnance at offshore or inland water training sites and in war zones.

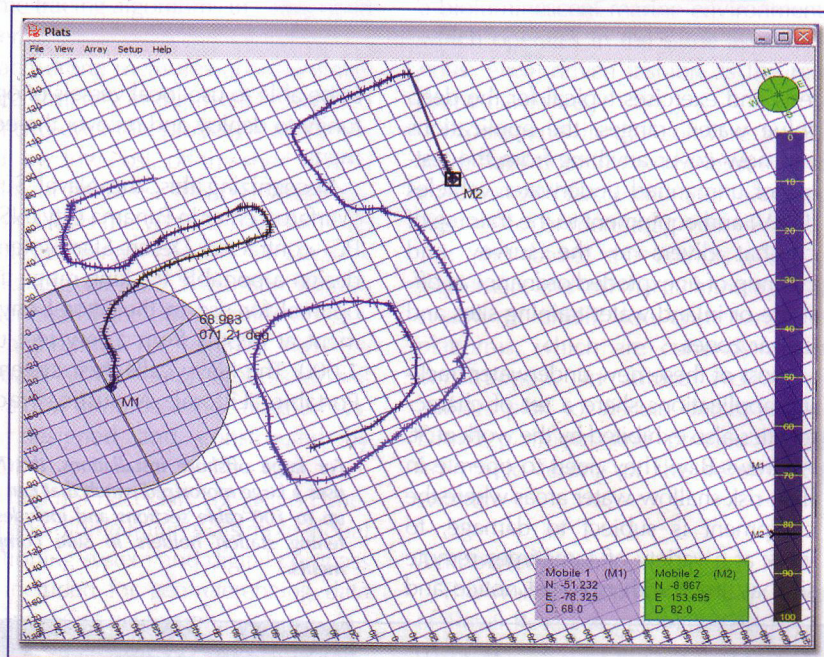
Most of these new underwater tracking applications share a set of characteristics also exhibited by the work at St. Andrews Bay: They need to operate in high-risk shallow-water areas where the equipment is subject to damage, to work at a variety of sometimes remote sites at times with minimal notice and

to be able to use local vessels of opportunity to deploy and recover the equipment.

Recognizing this, the Naval Surface Warfare Center in Panama City (NSWC-PC) contracted Desert Star Systems to design a portable tracking range that is optimal for use in the littoral environment at depths from a few feet up to 1,000. The Navy calls their system the Portable Littoral Acoustic Tracking

For large offshore installations, the Navy uses a large motorized winch that can hold up to 100 cable sections and includes listening station holders in side compartments.





(Top) A spur-of-the-moment decision to track the Bluefin (Cambridge, Massachusetts) autonomous underwater vehicle.

(Bottom) The RangeNav software works at the click of a button. Thereafter, the user can fine-tune things as the target is being tracked, either in real time or post-processing.

System (PLATS), while Desert Star now markets it under the name RangeNav™. A key requirement was that this range should resemble a Chevy more than a Cadillac (i.e., it should be inexpensive and easy to use rather than showy, yet robust enough to survive the many knocks of a rough deployment).

A number of underwater listening stations linked by cable (or sometimes radio link) listen for the signals of acoustic pingers deployed on the tracked target(s). The target position is computed by triangulating the time of

arrival of the target pinger signal at the various listening stations. The advantage is that this topology can be extended at will, covering larger and larger areas well beyond the reach of an acoustic signal by just adding more listening stations.

Yet, in their traditional form, tracking ranges are also expensive and, by necessity, fixed installations. The large amount of acoustic data from the hydrophones is transmitted by fiber optic cable to a shore-based range house, where a powerful array or super-computer processes the data.

RangeNav uses a different approach. Acting on commands from the surface station, each listening station processes the acoustic signals using a digital signal processor chip, detecting time of arrival and decoding depth telemetry for up to eight targets. It constructs a small ping identifier packet, which is

then transmitted to a computer at a surface station on an anchored vessel or the shore. The drastic reduction of the data volume and shore processing power requirement achieved by this in-station processing approach eliminates the need for fiber optic transmissions, allowing plain copper cables and rubber-molded connectors to suffice. A capable notebook computer is also sufficient to process the ping identifier packets and produce the tracking screen.

Deployment and Operation

There is a standing joke in the tracking range community stating that "Every tracking range is portable ... once!" Despite all efforts, it frequently turns out that portable ranges are, in fact, not so easy to deploy, calibrate, operate and, in particular, recover after the job is done. Desert Star was well aware of these pitfalls and designed RangeNav so that deployment would be as simple and reliant on local resources as possible and operation would not require a team of specialists. But still, the jury was out if these goals could in fact be achieved. When testing in the San Luis Reservoir in California, equipment was staged on the deck of a 20-foot pontoon boat. Individual 275-meter reels of cable linking the listening stations were mounted one at a time on a small electric winch and the cable was deployed and recovered.

To connect a new listening station at the end of each cable run required stopping the boat for a minute, which was easy enough in calm weather, but drift became a problem when the wind picked up. In this case, a number of cable sections and stations were staged in a figure eight configuration on deck. The small cable-laying vessel could proceed on its course while the cable was lowered over the stern without a need to stop at the junctions. Another option was to use a large winch similar to the one NSWC-PC uses, which can hold 100 cable sections.

Deployment would start at the head end of the cable, which is transferred by small boat to the moored range control vessel and connected there. The deployment vessel then would proceed at a steady speed along a designated track as cable is paid out. As each station is lowered, it would be immediately activated by the already running surface control station. In less than a

Parameter	Observation
Static target position precision (repeatability)	0.5m average precision
Static target geo-referenced position accuracy (using GPS reference positions)	1.2m average discrepancy between acoustic and GPS positions (note 1)
Track Accuracy vs. GPS track (from pinger pole runs at 2.5 knots)	1.8m average discrepancy between acoustic and GPS positions (note 2)
Position data availability at 10m error acceptance standard	97% of all theoretically available positions (1-sec update rate)
Position data availability at 1m error acceptance standard	95% of all theoretically available positions (1-sec update rate)
Track acquisition distance from array	Good track was available up to 500m-1100m from the boundary of the array, depending on location.
Station spacing	250m station spacing was used and found adequate.
Position update rate	Pingers were operated at 1 message per second, yielding 1fix per second.
Number of targets tracked	One target. Firmware upgrade to support simultaneous tracking of up to eight targets is pending.

RangeNav performance observations for a test in St. Andrews Bay at eight to 14 meters' depth.

minute, its status would be established. If there was a problem, the deployment vessel would back up to retrieve and replace the last station or cable section—an occurrence that might happen once or twice in a run of 30 or 40 stations and is quickly resolved. Overall, experience has shown that it takes about 10 minutes to deploy one 275-

meter cable section and listening station, meaning that a 48-station array can be deployed in an eight-hour workday. Recovery is the reverse process and is generally somewhat faster.

Once deployed, the array's self-survey function completes an acoustic survey within five minutes for a 30-station array. Each station is equipped to transmit as well as receive acoustic signals. Station spacing is measured with about 0.1-meter precision, and relative station positions are then triangulated. If geo-referenced positions (using lati-

tude/longitude or a universal transverse mercator) are needed for the job, as is often the case, the acoustic self-survey is followed up with a pinger pole survey, where a pole with a differential global positioning receiver on top and an acoustic pinger on the bottom is mounted on a boat and slowly transitioned through the array. The data are then post-processed, yielding the listening station geo-coordinates.

To date, the goal of true portability and operation without manufacturer support has been mostly, though not



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entirely, achieved. Deployments have used contracted vessels and crews and over time, more and more of the operating duties have been performed by Desert Star customers. However, at least some on-site manufacturer support remains necessary. Desert Star will continue on the path of simplification so that a tracking range capability will be both available and practical for the greatest possible number of customers and applications.

Damage and Repairs at Sea

A portable shallow-water tracking range will be subject to numerous hazards, ranging from wreckage on the seafloor that can snag the cables to the pronounced effect of storms in shallow water to interference by other vessels. During its first four deployments, RangeNav encountered all these factors, and the system must be able to cope with these scenarios so it can be reused.

In the case of the shrimp boat encounter, the system indeed experienced a short-circuit, but its self-analysis function also localized the fault. The next station upstream was instructed to ping, allowing a diver to quickly locate the station on the seafloor with a homing device. The diver then followed the cable to the fault, and within minutes the suspect station was pulled to the surface. The attached connector had been damaged and subsequently burned. The damaged gear was quickly swapped out, and soon the system was operational again. Less dramatic occurrences had similar outcomes, and in one case all four tracking range cables that ran to a moored control ship parted in a storm after the vessel's anchor line had snapped, the 2,500-pound breaking strength of the RangeNav cables being no match for a heaving 100-foot work boat. It is with these experiences that NSW-PC developed an interesting approach to system use and maintenance: Some loss of equipment is now figured into each deployment with an expectation of higher loss ascribed to operations where hazards are greater, such as when deploying across a reef. The Navy will store damaged inventory but then send it for replacement or service in bulk to replenish inventory losses. As originally intended, RangeNav is operated as a semi-disposable system, one with moderate costs and quick on-site repair

capabilities that support use in the high-hazard littoral environment.

Performance Review

The key performance parameters for any underwater tracking range include the tracking accuracy, the reliability and the frequency with which position fixes are available.

RangeNav's first four deployments following delivery to NSW-PC in 2007 provided the opportunity to test and characterize these parameters. Work was conducted at St. Andrews Bay as well as offshore both Panama City in the Gulf of Mexico and Florida's Atlantic Coast.

Depth was site specific and ranged from about three meters to approximately 100 meters.

An important characteristic of RangeNav is that relative ease of deployment and economy of components support fairly tight listening station spacing. While in typical deepwater ranges, the hydrophone grid spacing may be in the kilometer range, RangeNav uses a typical spacing of 250 meters, which is reduced down to around 100 meters for very shallow water and can be increased to 1,000 meters for deeper littoral waters. The tight spacing is necessary because reliable sound propagation distance is limited in shallow water.

Nonuniformity of the water, such as a cooling with depth, means that sound does not travel in straight lines but follows a slightly curved path. Thus, similar to trying to pitch a baseball in a low-ceiling garage, the maximum distance is limited, as all rays will eventually hit the sea surface or the seafloor. Desert Star's empirical measurements show that a spacing of 25 times the depth is conservative, 50 times the depth is usually supported and 100 times the depth tends to be unreliable.

A recent deployment with the U.S. Army Corps of Engineers, testing the system for its applicability to map small unexploded ordnance, required a system to work in very shallow water with very high accuracy. Reviewing the survey shows that the error between the global positioning system (GPS) and acoustic tracks was below one meter. Position availability in the various deployments has generally been better than 95 percent of all ping transmissions with a ping rate of once per second.

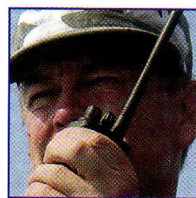
Summary and Outlook

Through several deployments, RangeNav has proven to be an effective portable tracking range capability for the littoral environment. Particularly noteworthy are current programs to develop a task-optimized version of the tracking range, including a system code named NOMAD (Nautical Ordnance Mapping and Identification system) specifically designated to support the survey and cleanup of munitions and explosives of concern underwater.

In another project named Southstar™, Desert Star recently joined a scientific customer to test a very compact, radio frequency-integrated version of the tracking range in Antarctica. Eliminating cables and using tiny listening stations, this system was small enough to be carried as checked luggage and provided first tests of precision under-the-ice navigation for a small robotic vehicle. The tests succeeded, and next season this wireless tracking range may become the main navigation capability for the robot. Overall, the significance of the RangeNav work is that its relative simplicity, compactness and affordability allow a much greater pool of projects to benefit from underwater tracking range capabilities than was previously possible. ■

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Marco Flagg is the chief executive officer and chief product architect for Desert Star Systems. During his 15 years of experience in the industry, he has enjoyed assisting customers in remote locations. This has, at times, gotten him into dicey situations (stuck 17,000 feet below the ocean, attacked by a great white shark, etc.).



Thomas Gray, accounting manager and chief financial officer of Desert Star, joined the company two years ago and quickly rose through its small ranks. He manages sales and marketing for the company while also frequently providing on-site training. Gray generally prefers to stay on the outside of sharks and only goes a few meters below the ocean.

