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 (NSWCPC) 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
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
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 latitude/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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**RangeNav performance observations for a test in St. Andrews Bay at eight to 14 meters’ depth.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Observation</th>
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<tbody>
<tr>
<td>Static target position precision (repeatability)</td>
<td>0.5m average precision</td>
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<tr>
<td>Static target geo-referenced position accuracy (using GPS reference positions)</td>
<td>1.2m average discrepancy between acoustic and GPS positions (note 1)</td>
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<tr>
<td>Track Accuracy vs. GPS track (from pinger pole runs at 2.5 knots)</td>
<td>1.8m average discrepancy between acoustic and GPS positions (note 2)</td>
</tr>
<tr>
<td>Position accuracy at 10m error acceptance standard</td>
<td>97% of all theoretically available positions (1-sec update rate)</td>
</tr>
<tr>
<td>Position accuracy at 1m error acceptance standard</td>
<td>95% of all theoretically available positions (1-sec update rate)</td>
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<tr>
<td>Track acquisition distance from array</td>
<td>Good track was available up to 500m-1100m from the boundary of the array, depending on location.</td>
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<tr>
<td>Station spacing</td>
<td>250m station spacing was used and found adequate.</td>
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<tr>
<td>Position update rate</td>
<td>Pingers were operated at 1 message per second, yielding 1 fix per second.</td>
</tr>
<tr>
<td>Number of targets tracked</td>
<td>One target. Firmware upgrade to support simultaneous tracking of up to eight targets is pending.</td>
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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 sup-
port 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 haz-
ards, 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 fac-
tors, 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 experi-
enced 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 part-
ed 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 NSWC-PC developed
an interesting approach to system use and maintenance: Some loss of equip-
ment 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-
heritage 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 NSWC-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 approxi-
mately 100 meters.

An important characteristic of
RangeNav is that relative ease of
deployment and economy of compo-
nents support fairly tight listening sta-
tion spacing. While in typical deepwa-
ter 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 rela-
ible 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 fol-
lovs a slightly curved path. Thus, simi-
lar 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 usu-
ally 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 sys-
tem to work in very shallow water with
very high accuracy. Reviewing the sur-
vey shows that the error between the
global positioning system (GPS) and
and acoustic tracks was below one
meter. Position availability in the vari-
ous deployments has generally been
better than 95 percent of all ping trans-
missions 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. Particular
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 com-
 pact, radio frequency-integrated version
of the tracking range in Antarctica.
Eliminating cables and using tiny listen-
ing 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
group of projects to benefit from underwater
tracking range capabilities than was
previously possible.

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article in the Table of Contents to be
linked to the respective company's Web
site.

Marco Flagg is the
chief executive officer
and chief product ar-
thitect 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, accoun-
ting 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.