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3d Sonar for Navigation and Obstacle Avoidance

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1 INTRODUCTION

In this changing environmental world of Global Warming, energy exploration and eco-tourism, new [unexplored and uncharted] waters are being opened up on a regular basis.

Figure 1. Victim of an accident in the ice

Here we take the opportunity to look at how an existing technology can be adapted as a useful, important and standard part of the bridge navigation inventory.

Figure 2. Victim of the poor navigation

FarSounder is a developer and manufacturer of 3D Forward Looking Sonar systems for use as ship borne navigation devices as well as ship borne/shore side security devices. This three dimensional sonar technology offers a paradigm shift in how mariners navigate on the water by economically, accurately and efficiently delivering to mariners the critical information they need to safely navigate their vessels. By providing a real-time, 3D picture of the depths immediately ahead of a vessel, this technology can enable marine vessel operators to avoid costly, dangerous and environmentally damaging collisions and groundings. The introduction of a navigation grade sonar system has an important equivalence to the introduction of marine radar systems during the later part of the 20th century. With the introduction of this enabling technology, these new systems are already changing the way mariners navigate through the oceans.

2 CURRENT NAVIGATION TECHNOLOGIES

Current navigation technologies, such as GPS, RADAR and electronic charts, are widely accepted and are now required equipment on most classes of vessels. Until now, state-of-the-art navigation has been to rely on historical charts, GPS systems, and depth sounders to determine position and water depth under the ship. Chart data is often inexact as coastlines and shipping channels can shift. Transient objects such as sandbars, lost shipping containers, ship wrecks, whales, floating logs and other debris are not shown on charts. Additionally, many charts can be based on data that is 60 years old or more and predate GPS. This means that even "charted" obstacles are not necessarily where the chart places them.

While an echosounder will tell the ship how deep the water was they just passed through, it can do

nothing to warn of the dangers ahead. The radar can only tell the user about objects above the water and give no indication of water depth.

The introduction of and use of navigation grade Forward Looking Sonar is not meant to replace these valuable devices, but rather to augment the mariner's box of navigation tools by offering a real time picture of the waters ahead of the vessel. This further enables the mariner to make critical navigation decisions giving a more complete understanding of the real time scenario.

3 CURRENT SONAR TECHNOLOGIES

Until the advent of these new 3D systems, vessel operators were limited to one- or two-dimensional views, with limited distance capabilities, limited performance in shallow waters, and a narrow field of view. Usually these products are from a recreational, fishing specific or hydrographic market, and therefore not suited for commercial applications or useful navigational purposes; yet they may still be marketed and sold for this purpose. At the other end of the spectrum there are military grade sonar systems, that again, are designed for a specific market capability. They also tend not to be commercially viable navigation options for a commercial vessel operator.

Although customers of these other systems understand the need, these products do not solve the problem.

4 PRINCIPLE OF OPERATION

The 3D sonar is comprised of a phased array transducer that will usually be mounted in the bow or stem of the vessel, facing forward. This in turn is connected by a special cable to a junction box and from there to the processor on the bridge.

Figure 3. Full sonar set

The forward looking horizontal field of view is a practical 60° to 90° with a range of ¼ nm. Development is currently underway to introduce ½ nm system during mid 2009. Vertical field of view is approximately 10° up to the surface and 50° down. The whole volume is pinged every second with an overall refresh of around 1.5 to 2 seconds giving a virtual real time presentation.

Figure 4. Transducer usually is mounted in the bow

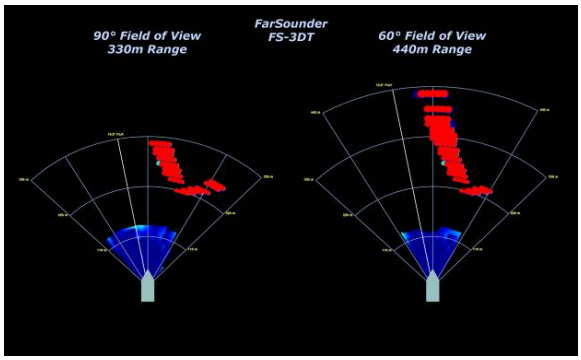

Figure 5. Sonar display 2D view

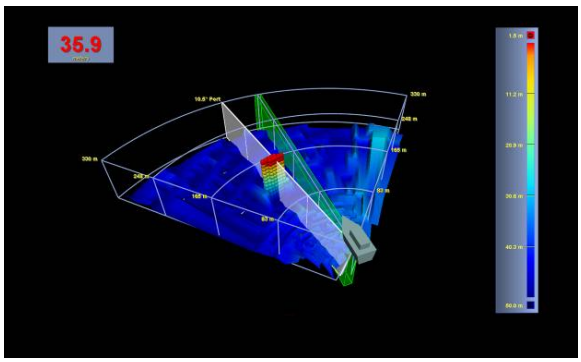

Figure 6. Sonar display 3D view

Figure 7. Breakwater in front

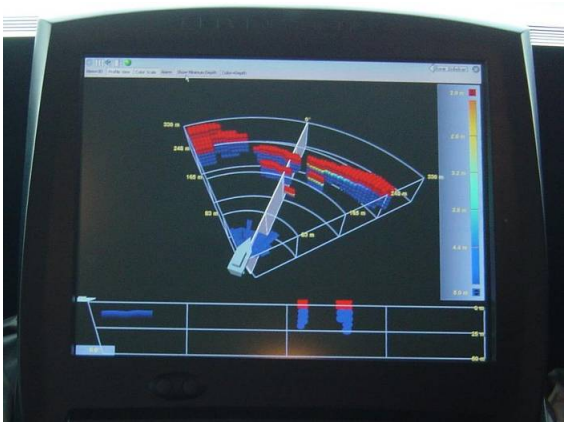

Figure 8. Barrier echogram in 3D

The advantage of three dimensions is that the vertical dimension of depth is now added to the range and bearing information.

Shallow water operation is also greatly improved. With bottom mapping capability of 8 x the depth of water (in practice 10 – 12 x), “in water” targets can still be detected to the full range of the system.

An easy to use man machine interface allows for easy interpretation of essential data.

In a comparison of the visual picture vs sonar, the below example shows a breakwater as seen through the bridge windows and the same view on the 3D Forward Looking Sonar.

It is clear on the sonar display that there are other obstacles in front of the breakwater but below the surface.

5 ENVIRONMENTAL CONCERNS

Shipstrike is the largest killer of the endangered Right Whale and the Great Whale. At certain times of the year during migration patterns, certain ocean areas are now restricted for passage or by significantly reduced speeds.

Figure 9. Victim of the ship strike

Figure 10. Victim of the bow strike

It is also commonly reported that sonar is harmful to marine mammal life, and it needs to be clarified that this is often in relation to low frequency and high power systems used predominantly for military applications.

FarSounder sonar systems should not be confused with these other sonar systems.

"NOAA's Ocean Acoustics Program (NMFS Office of Science and Technology) has assessed the technical specifications of the current version of the FarSounder sonar technology and concurs that, based on the sound source level, signal duration, directionality, and operational frequency band, there are no anticipated injurious effects on marine mammals or other marine species from it's deployment."

“The FarSounder, high frequency, active sonar technology may provide an effective tool in alerting mariners to the presence of submerged, or surfacing, animals in sufficient time to avoid collisions.”

Figure 11. Quieter than a dolphin and in the same frequency range as other accepted marine electronics

6 INTEGRATION

3D sonar data can now be integrated into today’s sophisticated bridge management systems and was the next logical step. Today’s IBS can now have sonar overlay as an option to the radar overlay on the electronic chart.

With the advent of Voyage Data Recorders, more and more recording capability is often sought. Sonar

data is no different and can also be archived, either directly or in conjunction with the VDR.

7 LIMITATIONS AND EXPECTATIONS

Targets such as containers, whales, rocks, reefs, ice/icebergs, other vessels, buoys, pilings, etc. (to an 8 dB target), are the benchmarks for the types of targets that can be expected to be detected.

Limitations for commercial vessel operators of all classes are usually related to speed and range. Larger vessels and High Speed vessels need sufficient time to evaluate potential dangers and act accordingly, although for vessels at manoeuvring speeds, the range requirement is significantly less.

Current vessel speed for both the ¼ and ½ nm systems is up to 20 to 25 knots. Future research and development over the next 1.5 to 2 years anticipates ranges of 1 to 2 nm and a speed up to 35 knots.

Figure 12. Catamaran equipped with 3D sonar

Figure 13. Transducer installed on the bow of a hulk

8 CHALLENGES

In regards to the development of a long range/high speed navigation sonar as discussed above, there are specific physical (scientific) challenges that must be dealt with that are of minimal effect on the current shorter range systems.

For instance, there is a trade-off in choosing an appropriate frequency which will still offer enough signal to noise ratio (SNR) to counter the effects of long range attenuation of the system.

At higher speeds, a challenge to overcome may be hull specific in dealing with high speed flow noise issues. Therefore, the form factor of the Transducer Module and how it is mounted must be carefully chosen for different high speed hull types.

At short ranges it may be appropriate to regard the Sound Speed Profile as a constant (for navigation grade sonars, not necessarily for security sonar systems). At longer ranges, a vertically varying sound speed profile must be compensated for.

The resolution of Long Range Targets is also a challenge and requires an added level of Bathymetric Testing and Ground Truthing as well as compensation in the Fixed Frame of Reference.

9 OTHER APPLICATIONS

Future Security Applications: One of the greatest threats to passenger vessels is an attack by swimmers, divers, or other underwater threats. Various technologies enable surveillance and deliver security against air and land attacks, but there is a lack of a low-cost practical and effective solution to detect or deter an underwater based attack, particularly one by swimmers. Underwater security is one of the most technologically challenging. Threats below the water are difficult to address.

There is a current need in the industry for an accurate, easy to use, low cost system with 360-degree sector coverage. Three dimensional forward-looking sonar technology can be very effectively applied to solve this need and to combat these possible attacks.

10 CONCLUSION

The need for a navigational solution to groundings and collisions has been recognized for hundreds, if not thousands of years. We expect that navigation grade sonar will become increasingly attractive to operators of all large ships. Three dimensional sonar technology represents an extraordinary advance in sonar technology, and represents a revolutionary change in the way vessels navigate.

Link to download a demo of the operator software http://www.farsounder.com/products/demo