SIDE SCAN SONAR SUITABLE FOR AUV APPLICATIONS

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ABSTRACT

This paper outlines the key elements of a side scan sonar suitable for AUV applications. The basic frameworks of the AUV-specific hardware and software elements are described. The sonar system has been integrated with a number of different AUV platforms with excellent results. A few of the existing AUV/Sonar configurations are described.

INTRODUCTION

AUVs are becoming a prevalent tool for hydrographic, scientific and military missions. As AUVs become more advanced and move from prototypes to production, they will require greater performance from the sensor payloads they carry. Low cost, low power consumption, small size, flexibility in system integration and high quality data are the main requirements of any sensor package intended for use on an AUV. The Sea Scan PC (SSPC) side scan sonar system is an off-the-shelf system which readily meets the above requirements and, with over 100 systems in the field, has the proven reliability an AUV sensor package must provide.

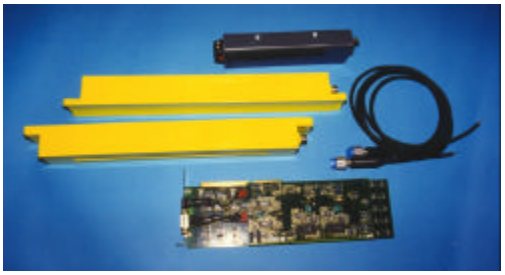

Figure 1 Modular components of the Sea Scan PC sonar for AUV Applications

Sea Scan PC is the 2nd generation of the microcomputer based side scan sonar systems developed by Marine Sonic Technology, Ltd. Sea Scan 1000, developed in 1988 was the first system of its kind to use a micro-computer for all control, display and storage of side scan sonar data. The system was enhanced in 1992 to incorporate the ISA bus architecture of IBM compatible computers (see figure 1).

The same requirements found in the AUV platform, such as low cost, low power consumption, small size, and flexibility in system integration are encountered in the PC arena. It was with these considerations in mind that the Sea Scan PC was designed.

HARDWARE

ISA I/O CARD

The SSPC card is the central component in the Sea Scan system. The card handles all control features of the sonar via Windows based software running aboard the host computer. Time varying gain (TVG), power multiplexing and signal de-multiplexing, signal detection and digitization, and data transferal to memory are performed within the I/O card. Due to the compatibility of the ISA bus and the PC104 standard, the SSPC card is easily interfaced to an embedded host computer resident in the AUV. The SSPC card, which supplies all power to the transmit and receive amplifier electronics, consumes between 8 and 12 watts from the ISA bus. The typical figure is 10 watts with the upper and lower limits resulting from certain speed and range combinations.

TRANSDUCER & ELECTRONICS PACKAGE

The Sea Scan follows the transmit and receive methodology refined by the medical ultrasound industry. Using solid analog design practices and modern electronic components, the system transmits high instantaneous power, broadband pulses (5-7 cycles in length) at the chosen transmit frequency (150, 300, 600 or 1200 kHz) and receives the scattered signals with very low noise pre-amplification circuitry. Short pulse techniques provide the ability to detect and image very small targets, while the low duty cycle minimizes power consumption. The total pulse lengths are 5, 3.5, 1.75 and 0.9 cm for the 150, 300, 600 and 1200 kHz systems respectively. The transducers are machined out of solid PVC, making them durable, near

Figure 2 Possible configuration in which the transducers and transmit/receive electronics are housed in the same unit.

neutrally bouyant and easily configured to any mounting situation (see figure 2).

Both the electronics package and the transducers are compact in size and simple in design, accommodating the numerous configurations that will be required by the growing diversity of AUV missions.

SOFTWARE

The software for the Sea Scan PC was originally developed as a stand-alone sonar acquisition and review application. However, given the very nature of a PC-based design, the core capabilities of the application are highly malleable, allowing for a high degree of flexibility and scalability.

In terms of flexibility, as in other development efforts, only minor modifications to our existing capability were required to meet the immediate prototype development needs of the AUV community.

An *Automation Layer* was added to the sonar data acquisition software that enables the sonar data to be collected automatically without operator intervention. The two key elements in this layer are a fuzzy-logic based automatic gain processor and automatic data storage capability. The automatic gain processor was already a proven core capability of the Sea Scan PC system; however, for the AUV community, the process was enhanced and further automated.

A *Host-Remote Interface Layer* was then added that allows a *Remote* computer to control the *Host* Sea Scan PC computer over an RS232 serial line. The *Host* computer is a self-contained Sea Scan PC data acquisition system. In a typical AUV configuration, the *Remote* computer is the AUV control system.

AUV/SONAR SOFTWARE INTERFACE CONSIDERATIONS

The AUV developers were primarily interested in the following issues:

- **Collection of high quality geo-referenced sonar imagery.**

  The sonar data acquisition process was already highly integrated with the navigation. Any item in the sonar imagery can be directly correlated with a geographic position. The Sea Scan PC simply accepts navigational and fathometer information from the AUV control system instead of directly from an external navigational system.

- ***In situ* control and monitoring of data acquisition process.**

  Over the past few years, an open *Host-Remote Communications Protocol* has been developed in conjunction with the AUV community. The *Host-Remote Communications Protocol* provides the AUV control system a flexible and scalable control and monitoring capability over the sonar data acquisition process. The Sea Scan PC sensor package may be treated as a highly integrated extension of the AUV control system. In this case, the AUV control system controls and monitors all aspects of the sonar data acquisition process very closely. However, the AUV control system may also treat the Sea Scan PC data acquisition system as a black box sensor package with automated capabilities. The Sea Scan PC provides *in situ* status information either upon request from the AUV control system or at timed intervals.

- **Quick and simple method to offload the sonar imagery at the end of a mission.**

  Being a PC-based system, the AUV developers have been able to leverage the existing data transfer and networking capabilities of the host operating system to offload the data in a quick and efficient manner. One method currently in use incorporates the AUV as a computer on a dockside LAN. At the end of the mission, the AUV computer is plugged in via an external Ethernet connection and the data is instantly accessible external to the AUV.

- **Compilation and review of geo-referenced sonar imagery.**

  The sonar imagery may be instantly reviewed with the Sea Scan PC Review application. A full description of the capabilities of the Sea Scan PC Review is beyond the scope of this paper; however, in summary the Review application provides complete playback capability of the sonar imagery collected during the AUV mission. The geo-referenced sonar data files are also GIS-ready. Upon being rectified for orientation and track curvature, the geo-referenced sonar imagery may be imported into a GIS platform, such as *ArcView*, with an accompanying image catalog. Without complete rectification for track curvature, the correctly oriented sonar imagery may be directly imported into a GIS platform as GeoTIFFs.

Future Software Considerations

The current *Host-Remote Communications Protocol* allows the *Remote* AUV control system to interface with the *Host* Sea Scan PC sonar system over a serial line. Although not absolutely necessary, this setup favors a configuration with two separate computers. As the system evolves and matures, the *Host-Remote Communications Protocol* will be expanded to accommodate network communications. Furthermore, some developers in the AUV community are looking toward a smaller software package that can run on the same computer as the AUV control system. The AUV developers would like to maintain all of the existing capabilities of the sonar data acquisition system but within a smaller software footprint. The future system will meet the needs of both AUV research and development, with regard to prototype testing, and AUV production.

Configurations

Recently, the Sea Scan PC sonar system has been deployed on several AUV systems with varying configurations.

REMUS

REMUS is a vehicle being developed by the Oceanographic Systems Laboratory, Woods Hole Oceanographic Institute in Woods Hole, MA (see figure 3).

REMUS is a small, dry volume AUV designed to perform a wide variety of missions. The dry volume, in which space is at a premium, contains both the SSPC I/O card and the transmit and receive amplifying electronics. The transducers, which are attached to the outside of the hull, have a 1" x 14" footprint and are slightly over an inch thick. The sample images (see figure 6) were imaged with REMUS.

Figure 3 REMUS

LEMMING

Lemming is a near-shore, bottom crawling vehicle, being developed by Foster-Miller, in Waltham, MA. Lemming is a tracked vehicle, which has very little hull volume in which to contain sensor packages. In order to test the feasibility of gathering meaningful sonar data from a bottom crawling, tracked vehicle, Lemming was fit with a set of prototype 600 kHz transducer modules (see figure 4).

The SSPC I/O card was installed in a computer attached to the vehicle by a tether.

Figure 4 Lemming

After clear images of objects on the bottom and within the water column were obtained, the second iteration, with the transducers mounted within the tracks, was begun. Having the transducer within the track volume allows the vehicle to be turned over in the surf without damaging the imaging equipment. A simple reorientation of the vehicle control system and it is on the move again.

FETCH!

This AUV was designed by Sias Patterson, Inc. in Gloucester Point, VA. Fetch! is also a dry volume vehicle which houses the SSPC I/O card and transmit/receive electronics package within the dry volume (see figure 5).

Figure 5 Fetch!

Due to time constraints the same prototype 600 kHz transducer module that was used on the Lemming vehicle, was attached to the nose cone of the Fetch! vehicle in a Narwhal style configuration. This setup turned out to be quite convenient and collected excellent side scan data.

CONCLUSION

Working closely with the AUV community, coupled with a strong commitment to sonar research and development, has resulted in an adaptable and scalable sonar system suitable for AUV applications. This system is the first of many steps in the ongoing evolution of AUV/Sonar integration. With the increasing demand for high quality coastal imagery and the AUV as an ideal sonar platform, a special partnership has been forged between the sonar and AUV communities. In this case, the result has been a power efficient device that has the range resolution required to create high quality clear images of the seafloor at ranges suitable for an AUV's limited mission duration.

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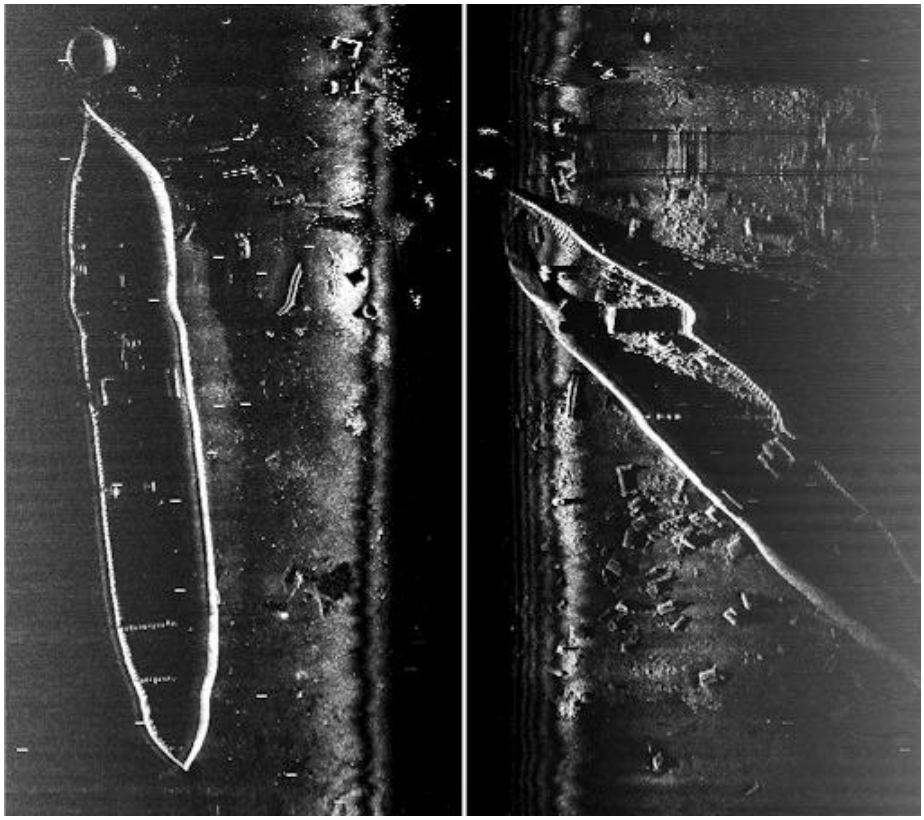

Figure 6 Sonar data collected by REMUS at the AUV Fest held by the US Navy in Gulfport, Mississippi (September 1997) showing two Liberty ships.