Improved Capabilities of Submarines Using Multibeam Echo Sounders

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Abstract — Multibeam data of the seafloor and the water column are beneficial for submarine applications like terrain contour matching, mission planning and bottoming procedures. For onboard interoperability, multibeam echo sounders should be based upon the DDS middleware standard. Additionally, future multibeam echo sounders should include "multibeam apps" which can be installed on processing environments provided by system integrators.

1 Introduction

In order to accomplish their various missions successfully, submarines include several types of sonar systems like flank array sonars, intercept sonars or mine avoidance sonars.

In recent tenders for submarine new buildings and retrofits, also multibeam echo sounders (MBES) have been requested. They may replace the single-beam echo sounders usually installed on submarines.

2 Features of multibeam echo sounders

Multibeam echo sounders are very popular in the commercial maritime business, being widely used on all kinds of research vessels and survey vessels. Multibeam echo sounders provide very accurate high-resolution data:

- Bottom depth data
- Side scan data
- Bottom backscatter data
- Water column imaging (WCI) data

Due to their common use in the civil business, they are cost-efficient, especially compared to systems which are solely dedicated to military use.

Compared to other active sonar systems like obstacle avoidance sonars, multibeam echo sounders insonify a swath below the submarine which has a small beam width in the along-track direction. This results in a low probability of intercept during operation.

3 Benefits of multibeam data

Accurate and up-to-date multibeam data of the seafloor and the water column are beneficial for the following submarine applications:

- Terrain contour matching
- Covert ISR missions in hostile waters
- Mission planning in confined waters
- Sonar performance predictions
- Bottoming procedures

3.1 Terrain contour matching

Terrain contour matching (TERCOM) compares pre-recorded bottom maps with bottom data, acquired during the mission. Such data can be provided by multibeam echo sounders. TERCOM can significantly increase navigation accuracy of a submarine, compared to solely using an inertial navigation system (INS).

3.2 Covert ISR missions in hostile waters

Covert intelligence, surveillance and reconnaissance (ISR) missions in unknown hostile waters require a precise knowledge of the bottom topography. Especially in areas where nautical charts are not available, multibeam data are of great importance.

3.3 Mission planning in confined waters

In order to avoid hazardous situations, mission planning in confined and shallow waters requires precise seafloor information. Multibeam echo sounders can provide the required data.

3.4 Sonar performance predictions

Sonar performance predictions are essential for an overview of the true situation. They require information on the bottom topography which can be provided by multibeam echo sounders.

3.5 Bottoming procedures

The risk of damaging a submarine during bottoming is high, especially in uncharted or inaccurately charted areas with a rugged topography. Objects lying on a flat and sandy bottom are difficult to detect with a conventional echo sounder, leading to an increased risk.

Bathymetric multibeam data and WCI data, based upon cyclical transmit swath steering, can provide detailed information on the seabed within a dedicated area below the submarine before bottoming is started. This information increases the safety of the submarine especially in unknown waters.

3.6 Water column imaging

Water column imaging (WCI) is a standard functionality of modern MBES. WCI data are very helpful for identifying objects on the bottom or in the water column beneath a submarine.

Figure 1 shows high-resolution WCI data with a gas flare from the North Sea, acquired by an ELAC SeaBeam 3050 medium-depth multibeam echo sounder on the German research vessel POSEIDON in October 2017.

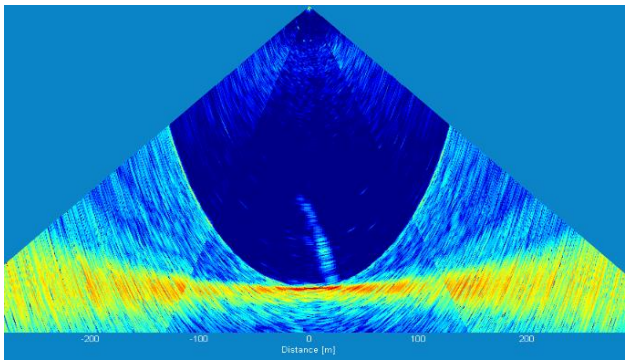

Fig. 1. WCI data from the North Sea including a gas flare

3.7 Cyclical transmit swath steering

Modern MBES provide an automatic cyclical steering of the transmitted swaths from bow to aft and vice versa. Herewith, an area below the submarine can be automatically insonified, without requiring any movement of the submarine.

4 System architecture

4.1 Interoperability

Interoperability of all systems onboard a submarine is essential. Therefore, the MBES must have at least an interface to the combat management system (CMS) for data exchange and for receiving control messages like the captain's key message, initiating an immediate disruption of active pulse transmission.

Additionally, it is preferable to integrate the user interface for multibeam control into the existing on-board consoles.

4.2 Open system architecture

For an extensive interoperability, it is advantageous if the interfaces and the internal structure of the MBES are based upon an open system architecture. A common middleware standard is the Data Distribution Service for Real-Time Systems (DDS), released by the Object Management Group (OMG).

DDS defines a data-centric publish-subscribe (DCPS) service for efficiently distributing data between participants in a distributed application.

4.3 Processing environments

There is an increasing trend that system integrators provide an open system architecture processing environment which should be used by all onboard sonar systems. An example is the Acoustics Rapid COTS Insertion (ARCI) environment from Lockheed Martin.

On the processing environments, "big sonar data" are available, comprising all sonar information for maximum customer value of current and future applications.

Comprehensive onboard processing environments call for a new MBES system architecture in the future: Smart hydroacoustic transducers will include signal conditioning with minimum information loss. The other multibeam functions will be included in software applications ("apps"), installed on the processing environment. Figure 2 shows an example of a future MBES system architecture.

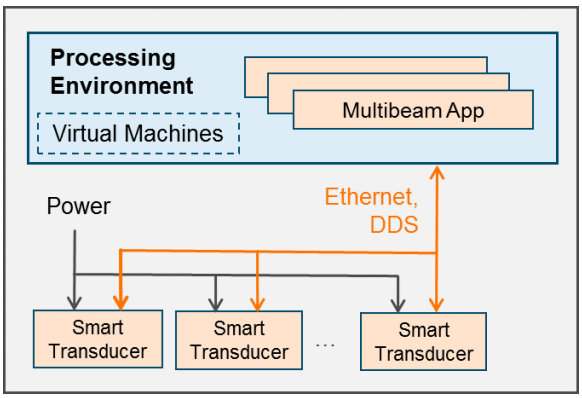

Fig. 2. Example of a future MBES system architecture

4.4 Ruggedizing

MBES are usually COTS products which are installed on commercial vessels. For submarines, ruggedized MBES versions have to be utilized, being compliant with the environmental requirements concerning temperature, shock, vibrations and own noise. The hydro-acoustic transducers must be pressure-tight and, if necessary, the shape of the transducers must be adapted to the submarine's hull.

If an existing open system processing environment is utilized, then the costs for ruggedizing electronic devices are eliminated.

5 Conclusions

MBES have high benefits for the operational capabilities of submarines. The trend towards open system processing environments will increase the benefits and integration of multibeam data into the overall onboard systems.

In the future, there may be "multibeam apps" available on the market which utilize already existing onboard sonar transducers instead of specific multibeam transducers.

References

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