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A MINE-HUNTING SONAR SYSTEM CARRIED ON A REMOTELY CONTROLLED AUTONOMOUS UNDERWATER VEHICLE

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SUMMARY

We will describe a mine-hunting sonar system, which is carried on an untethered Autonomous Underwater Vehicle (AUV): the Hugin. The Hugin Autonomous Underwater Vehicle (AUV) carries a wide-band sonar system. The AUV-borne sonar preprocessing includes output from beam-former + matched filter on a distance, bearing (r, Θ) format. Further post-processing is performed in the equipment on board the surface vessel

1. INTRODUCTION

We will describe a mine-hunting sonar system, which is carried on an untethered Autonomous Underwater Vehicle (AUV): the Hugin.

Advantages of this system are:

- An untethered vehicle allows for coverage of larger areas then a tethered system
- The ability to operate a sonar system beneath the thermocline may prove to be a substantial benefit where it is so pronounced as in the Baltic.
- The ability to maneuver the sonar platform in the depth dimension provides for added control of bottom reverberation.
- A significantly more stable platform is achieved when moving the sonar out of the surface wave zone. This will allow for processing of longer data series.
- The utilization of an unmanned vehicle provides for added personnel safety.

SYSTEM ARCHITECTURE

The general system overview is shown in Figure 1. The Hugin Autonomous Underwater Vehicle (AUV) carries a wide-band sonar system. There are two transmitter units: one in the bow and the other aimed sidewards. The receiver is a continuous conformal array shaped across the bow and along one side. The frequency band is continuous from 250 – 400 kHz. This configuration enables for both a forward- and side- looking sonar. The forward-looking sonar is used for search and detection of mines. The side looking sonar is used for mine classification, by means of high resolution of object and study of shadow properties.

The AUV-borne sonar preprocessing includes output from beam-former + matched filter on a distance, bearing (r,Θ) format.

OPERATIONAL MODES
SEARCH AND DETECTION

Figure 2 depicts the deep mine hunting sonar system in search mode. The HUGIN AUV moves through the water in front of a surface vessel. An active forward- and downward looking search sonar is mounted in the nose of the AUV. The AUV will maneuver at an altitude above the bottom that is suitable for sonar conditions. A safe distance to a potential mine detonation from both the surface vessel and the AUV itself is maintained.

Control of the AUV is performed through an acoustic link. Continuous transfer of sonar response from the AUV to the surface vessel is achieved through a dedicated high-speed acoustic link. Sonar response will be shown continuously on a sonar display where an operator will monitor the results and determine if- and when other measures such as entering an autonomous classification mode should be initiated.

Continuous sonar response as the output from a matched filter, is transferred through the data link to the operator. The position may be shown as

- range and bearing from vehicle
- range and bearing from own ship
- geographical coordinates (LAT/LON)
- coordinates in a local coordinate system
- an indication in a chart where background information such as
  - coastlines
  - bottom topography
  - known objects

is shown.

The operator will be given the options of

- identifying the reported detection with the added option of registering it in a database for later reference
- initiating an autonomous classification cycle chosen among an ensemble of preprogrammed cycles

An Autonomous Search and Detection Cycle (ASDC) is also implemented.
This may be advantageous for:

- Obtaining an overview of an area
- Enable safe coverage under acoustical conditions when telemetry is limited to short distances

A typical ASDC is

1. Sonar in search mode.
2. The AUV moves away from acoustic link coverage and follows a pre-programmed trajectory
3. Upon completion the AUV will return to the surface vessel end dump recorded data.

CLASSIFICATION

The classification sonar performs high resolution of objects and study of their shadow properties. As it is mounted as a side-line sensor the HUGIN craft must be maneuvered so as to bring the object in question in to the classification sonar's field of view at a suitable distance. The system may be outfitted with several strategies for achieving this.

Examples are:

1. Closing in on the object and making a 90° turn for classification, afterwards returning to set course.
2. Passing the object at a suitable distance whereupon the search is continued
3. Entering into an Autonomous Classification Cycle (ACC).

It must be emphasized that the system does not need to be limited to these examples and furthermore that it may well be reprogrammed to accommodate for future requirements during life cycle.

The operator may be given options of which several may be utilized in sequence

- Collect more classification snapshots.
- Resume search phase as was
- Enter new parameters and commence search phase

Presentation of classification information will of course reflect the characteristics of the ACC. However, the characteristics of the HUGIN vehicle are such that it must be in constant motion. Hence we will always be handling a sonar data set where we have some degree of multiple look and thereby 3D information.

Classification data may be presented as

- Single snapshots.
- Merging if several snapshots by image processing methods.
- Classification information may be merged with previous information such as
  - coastlines
  - bottom topography
  - known objects

KEY PARAMETERS

Sonar system	
Frequency range	250 – 400 kHz
Maximum source level	215 dB re 1 µP @ 1 m

Data link	
Frequency range	90 – 165 kHz
Acoustical output power (continuous)	20 W
Data transfer rate	100 kbit/s

Power budget

	Peak	Average
Search sonar transmitter	1430 W	29 W
Search sonar receiver		100 W
Classification sonar transmitter	160 W	3.2 W
Classification sonar receiver		200 W

5. FIGURES

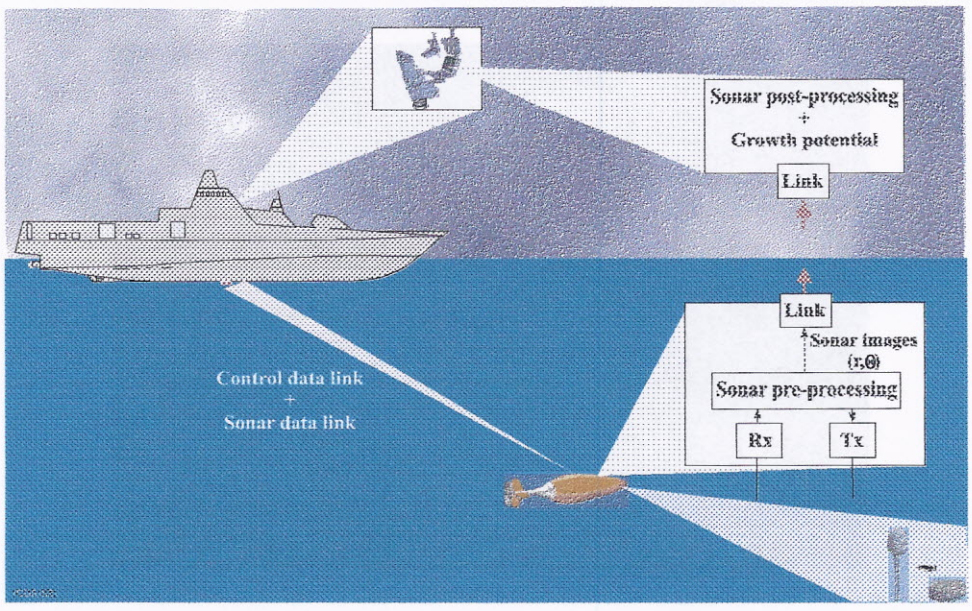

Figure 1 General system overview.

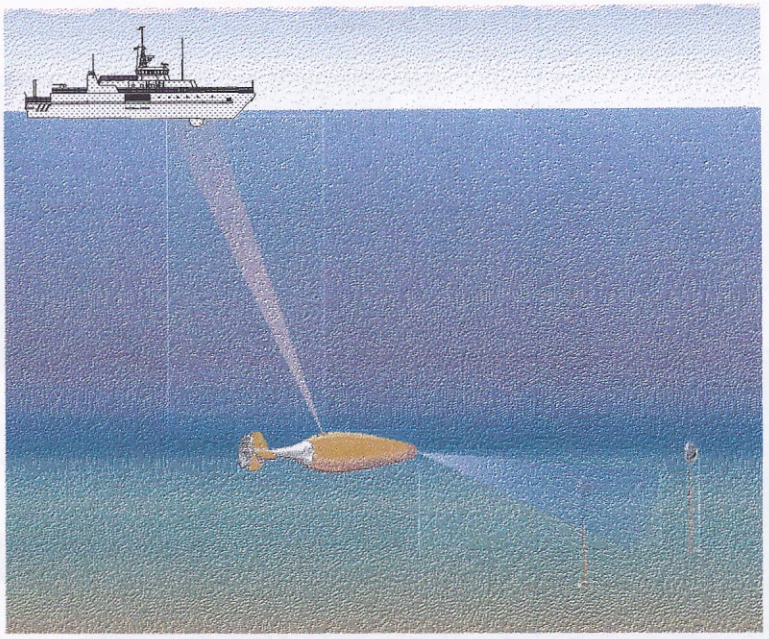

Figure 2 The system in search mode.

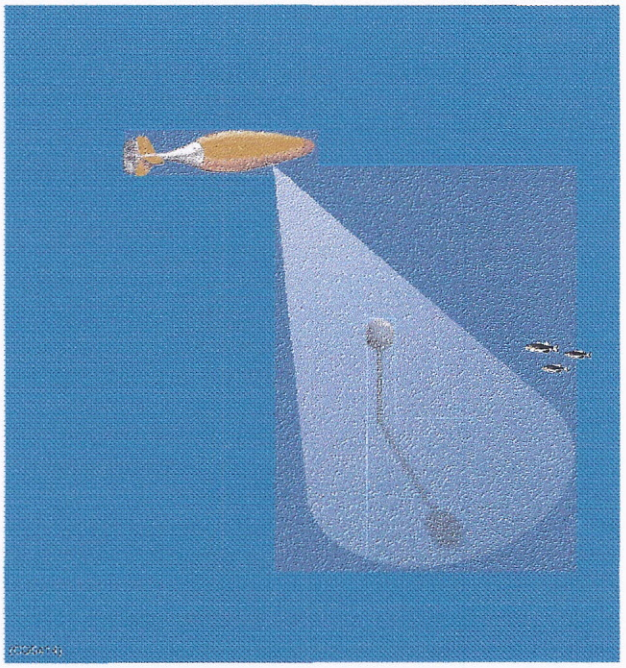

Figure 3 The system in an Autonomous Classification Cycle