THE HUGIN 1000 AUV as sensor platform for seafloor mapping

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Content

• The HUGIN 1000 AUV in brief
• SAS/SSS in operation
• Multibeam Echosounders
• Forward Looking Sonar
• Other sensors and system news
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Kongsberg Maritime AS Site in Horten

Kongsberg Maritime AS

- World leading company within maritime electronics & hydroacoustics
- 3300 employees in 25 countries
- Horten site 340.
- More than 1100 abroad.

KM about 7,7 billion NOK operating revenue in 2007
EBITA 10,8 %

- More than 70% of op. revenue earned outside Norway
- The growth has continued in 2009
The Kongsberg Group
Kongsberg Maritime – Subsea Division

Underwater positioning

Naval sonar systems

Fisheries systems

AUV’s

Seabed mapping

Underwater surveillance
The HUGIN and REMUS AUV family

**HUGIN 1000**
Lightweight, compact, two-man portable AUV for coastal applications.

**HUGIN 3000**
Highly versatile, modular AUV for 600, 1500 or 3000 meter applications.

**HUGIN 4500**
Deep-water workhorse AUV for operations in up to 6000 meters of water.

**REMUS 100**

**REMUS 600**
Royal Norwegian Navy - AUV OPEVAL program

- **HUGIN I (2002-03) – development and demo**
  - Payload: Multibeam echo sounder, COTS SSS
  - Endurance: 5-8 hours, charge time 6-8 hours
  - MCM coverage rate: 0.2-0.6 km²/h, 20-40 cm resolution

- **HUGIN 1000 (2004-06) – reduced capability pilot system**
  - Payload: EdgeTech SAS or SSS, EM3000 MBE, CTD
  - Endurance: 12-18 hours, charge time 5 hours
  - MCM coverage rate: 0.8-1.6 km²/h, 10-30 cm resolution

- **HUGIN 1000-MR (2007-) – full-capability commercial delivery**
  - Payload: Kongsberg HISAS 1030, MBE, CTD
  - Endurance: 18-24 hours, charge time 5 hours
  - MCM coverage rate: 2-3 km²/h, <5 cm resolution
HUGIN 1000 main components

- Propeller
- Propulsion motor
- Control Container
- Link and transponder transducers
- SSS/SAS Container
- RF Link/DGPS
- Flashing light
- Payload Container
- Air bladder
- Drop nose
- Compass
- Altimetres
- Multibeam Echo Sounder transducer
- SSS/SAS transducer array
- Emergency Container
- DVL
- Transponder
- Main battery
- Control and Propulsion Section
- Modular Battery and Payload Transducer Section
- Payload/ Front Section
- Rudder
- Drop weight
- HPR transducer
- Depth sensor
Main sensors on HUGIN 1000 AUV
# Basic Payload Suite

<table>
<thead>
<tr>
<th>Payload</th>
<th>Capability</th>
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<tr>
<td>Hydro carbon sniffer</td>
<td>Leakage detection</td>
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<td>Forward sonar</td>
<td>Obstacle avoidance and leakage detection</td>
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<td>Cameras</td>
<td>Detailed visual inspection</td>
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<td>Side scan sonar or synthetic aperture sonar</td>
<td>Imagery for inspection, mapping of debris and change detection</td>
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<tr>
<td>Multibeam echo sounder</td>
<td>Bathymetry for inspection and ice surveillance (if upward MBE)</td>
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<tr>
<td>CTD</td>
<td>Conductivity, temperature, depth → sound speed, density</td>
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<tr>
<td>Sea current profiler</td>
<td>ADCP</td>
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- HUGIN has an open architecture for easy integration of payload for specific applications
RNoN testing
HUGIN
1000MR
outside
Bergen
April/May
2008
Payload sensors – MBES and HISAS 1030

EM 3002 transducer and processing unit

HISAS 1030 transducers on HUGIN 1000 mid section
Sensor: Imagenex DeltaT

- Frequency: 260 KHz
- Range: 100m (150m)
- Beam width: 120° x 20 °
- Number of beams: 120 (240,480)
- Power consumption: <5W
HUGIN 1000 with under ice operation for Finnish Navy

- HUGIN 1000 for Finnish Navy will get under ice operation capability. First vehicle delivered 2009.
- Under ice operation is tightly integrated with the anti-collision system
- HUGIN 1000 under ice functionality also suitable for arctic operations
HUGIN 1000 FLS
Pollution awareness

The HUGIN sensor suite include sensors for environmental pollution detection.

HUGIN can patrol the field and check for pollution, using sensors such as:

• Hydro carbon sniffer for leakage detection

• Sonar for leakage detection

• Camera
Payload sensors

- Falmouth Scientific Micro-CTD
- WetLabs FLNTU Turbidity and Fluorescence sensor
- Forward Looking Sonar - Imagenex DeltaT
Proven and new Sub Bottom Profiler
HUGIN SBP

- Civilian SBP integrated on HUGIN vehicles for geophysical survey:
  - EdgeTech 2200 SBP
  - EdgeTech 4500 DF SBP
  - Integrated on HUGIN 1000, HUGIN 3000 and HUGIN 4500

- Military SBP for 3-dimensional mapping of buried objects
  - EdgeTech BOSS
  - Integration design for HUGIN 1000 finished
3D multibeam sub bottom profiler

- Transducer wings required for multibeam sub bottom profiler

Bottom View
EdgeTech BOSS with 4 m wing span mounted on HUGIN 1000
Sequence of wing and projector deployment

Projector and Wings Stowed

Projector Deployed, Wings at 22.5 degrees

Projector Deployed, Wings at 45 degrees

Projector Deployed, Wings at 67.5 degrees

Projector and Wings Fully Deployed
An Image of a Buried Object is Generated at Each Aspect as the Sonar Passes the Target

- **3D matrix of pixels centered at focal points**
- **40 element hydrophone array**
- **Length of synthetic aperture**
- **History of hydrophone positions that form synthetic aperture**

Sonar is at center of image
Operations in Artic Environment
Operational concept for mapping in artic areas

- AUV is operated from ice breaker
- Ice breaker brings AUV into area of interest
- Large under ice areas are effectively mapped by the combination of ice breaker and long range AUV equipped with high area coverage rate sensors
- Ice breaker provides capability to recover the AUV in case of an emergency situation

(Picture of KV Svalbard. Shown for illustration purposes.)
Upward multibeam echo sounder

- Upward multibeam echo sounder is suited to measure
  - Ice topography
  - Ice thickness

- Ice thickness estimate requires integration with
  - Pressure sensor
  - CTD for water density

Kongsberg Maritime EM 3000 mounted on HUGIN 1000

Ice topography picture taken from Marcel Nicolaus and Sebastian Gerland, Norwegian Polar Institute. For illustration purposes.
Upward Doppler velocity log

- Upward Doppler velocity log (DVL) can be integrated to measure Doppler shift between AUV and ice directly.

- Upward DVL (in ADCP mode) can also measure current profiles above AUV.

Teledyne RDI DVL
HiPAP navigation and tracking concept

Ice breaker trajectory

AUV trajectory
Testing of equipment for through ice localization and communication

- In case of emergency, the support vessel can launch a helicopter or unmanned aerial vehicle (UAV) for AUV localization.

- For testing, a 100 bps WFS S1510 Radio Modem V2.2 was integrated in HUGIN 1000.
Fundamental requirement: **Proven, robust and high performing AUV platform.**

**Risk reduction in AUV under ice survey**

**Ship subsystems:**
- Communication and localization systems
- Launch and recovery system
- ROV
- UAV or helicopter

**AUV subsystems for under ice operations:**
- Redundancy, error detection and error handling
- Navigation
- Anti-collision
- Communication and localization systems
- Battery
- Launch and recovery

Photo: S. Gerland
For illustration purposes.
New Camera
Optical imaging for AUVs

- **Advantages:**
  - Mine detection, classification **and identification** on one vehicle
  - Optical imaging very useful to “train” SAS operators

- **Optical camera system** **TileFish**
  - Designed for HUGIN
  - Large optics
  - Highly sensitive camera
  - Strobed LEDs as light source
  - Maximum separation between LED panel and camera
  - Colour and/or monochrome
  - Design altitude 2-4 m (colour); 3-8 m (monochrome)
Optical camera on HUGIN 1000-HUS (FFI)

- High quality LED strobe. 3 – 6 m altitude.
- Still picture camera
TileFish camera examples: Marine life

TileFish camera on HUGIN 1000 (single images, no mosaic) Altitude 4 m
HUGIN AUV SYSTEM NEWS
HAVOPS Introduction

- HUGIN AUV & Vessel Operations Simulator (HAVOPS) is a complete simulation system for education and procedure training for personnel involved in AUV operations.

- Designed for operations with Kongsberg HUGIN 1000 AUV, survey vessel, and Kongsberg HiPAP system.

- Operators can safely plan and carry out AUV survey procedures under different conditions.

- Based on the existing HUGIN AUV simulator engine SimP, and Kongsberg’s renowned Ship Simulator technology.

- HAVOPS includes the following five physical components:
  - Bridge of the vessel
  - AUV operations room
  - AUV L&R station
  - Instructor/Debrief stations
HUGIN 1000 Portable System for Vessel of Opportunity

- 20 ft and 10 ft container for both transportation and ship installation
- Small system footprint – high degree of modularity and flexibility
- Ship requirements: Voltage + deck space
HUGIN 1000 Portable System
10 feet container with Top Side system
Complete Post Mission Analysis System
SUMMARY

- AUV`s with mine hunting capacity is available
- Multi role capabilities
- Flexible payload solutions
- Portable system solution
- Platform independent

- HISAS 1030 fullfil the most important MCM requirments;
  - Reliability, resolution and range

- SAS require stable vehicle motion
Thank you – questions?
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