

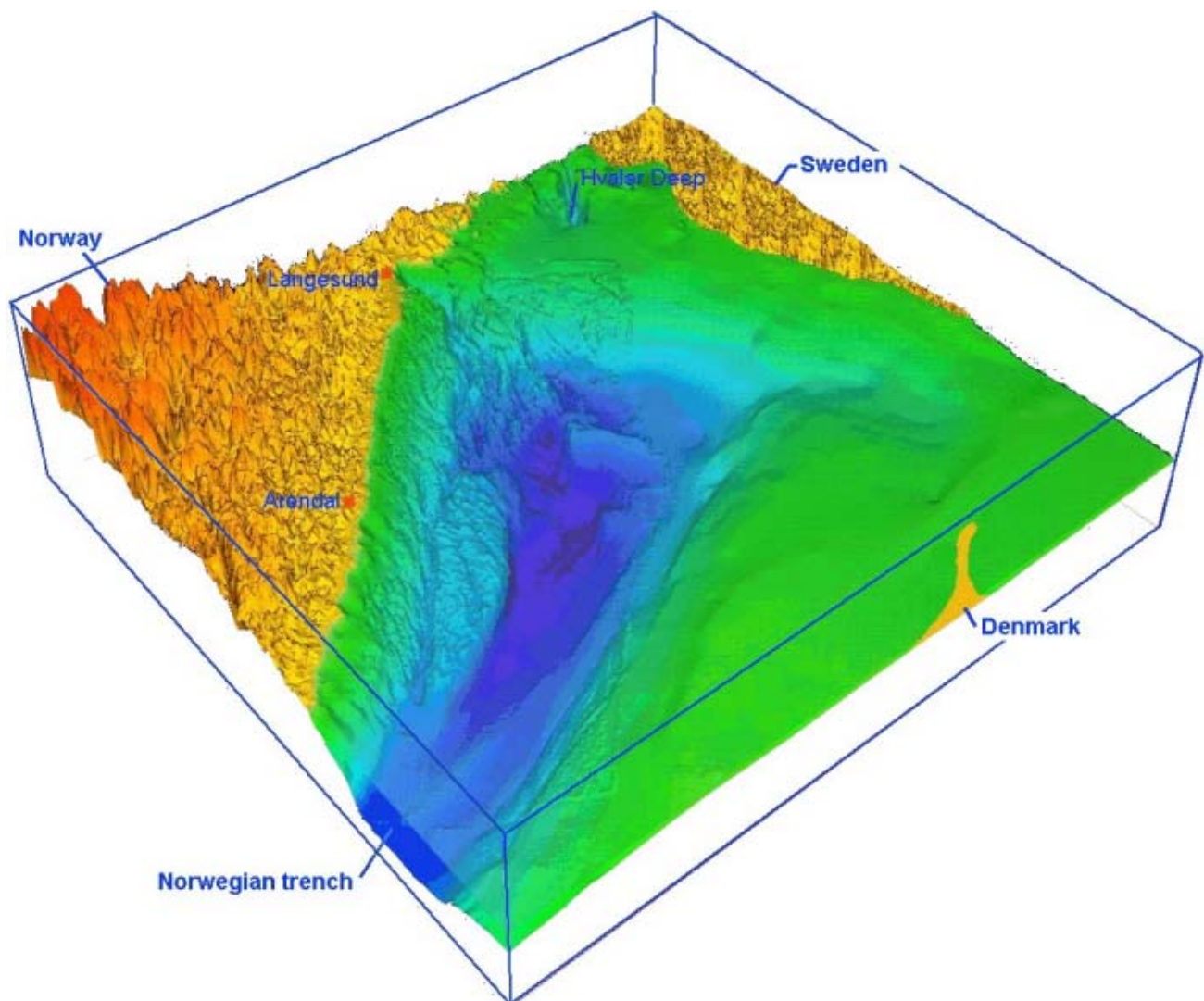


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Product Description

EM 1002

Multibeam echo sounder



855-160866

EM 1002 Multibeam echo sounder

Product description

This document presents a brief technical description of the EM 1002 multibeam echo sounder.

About this document

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	Minor changes.			
F	18.03.05	EB	KEN	FP
	Implementation of SIS (Seafloor Information System software) and HWS 10 (Hydrographic Work Station). Other minor corrections.			

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SYSTEM OVERVIEW

Key facts

The EM 1002 multibeam echo sounder is designed for high resolution seabed mapping from the shoreline and down to a depth of approximately 1000 m. The system is easy to install, even on small vessels. The EM 1002 has an accuracy surpassing the IHO standard, including the most stringent of the latest version, 4th edition.

The design of the EM 1002 is based on more than 50 years of hydrographic experience with echo sounders, sonars and underwater positioning for civilian and military use. Kongsberg Maritime is today a part of the Kongsberg Group, a world wide organisation supplying advanced instrumentation for civilian, research and military maritime communities.

The EM 1002 is a complete system with all necessary sensor interfaces, real-time compensation for vessel motion and raybending, data displays for quality control including sensor calibration, and data logging included as standard.

Post-processing software is available for both bathymetry and seabed classification.

The EM 1002 system has a maximum ping rate of more than 10 Hz, a large number of measurements per ping with 111 beams, 2x2 degrees beamwidth, and electronic roll stabilization.

Acrosstrack coverage is up to about 1500 m in deeper waters, and in shallow waters up to 10 times depth beneath the transducer. The angular coverage is fully adjustable, and for surveying to the water surface along shorelines, river banks and man-made structures, the angular coverage to one or both sides may be increased to 5 degrees above the horizontal.

The standard EM 1002 system has three different pulse lengths to maximize coverage in deeper waters.

The system's nominal sonar frequency is 95 kHz. This frequency allows for small dimensions, good range capability and high tolerance to turbid waters. Integrated seabed acoustical imaging capability (sidescan) is included as standard. A combination of phase and amplitude detection is used, resulting in a measurement accuracy practically independent of beam pointing angle.

System drawing

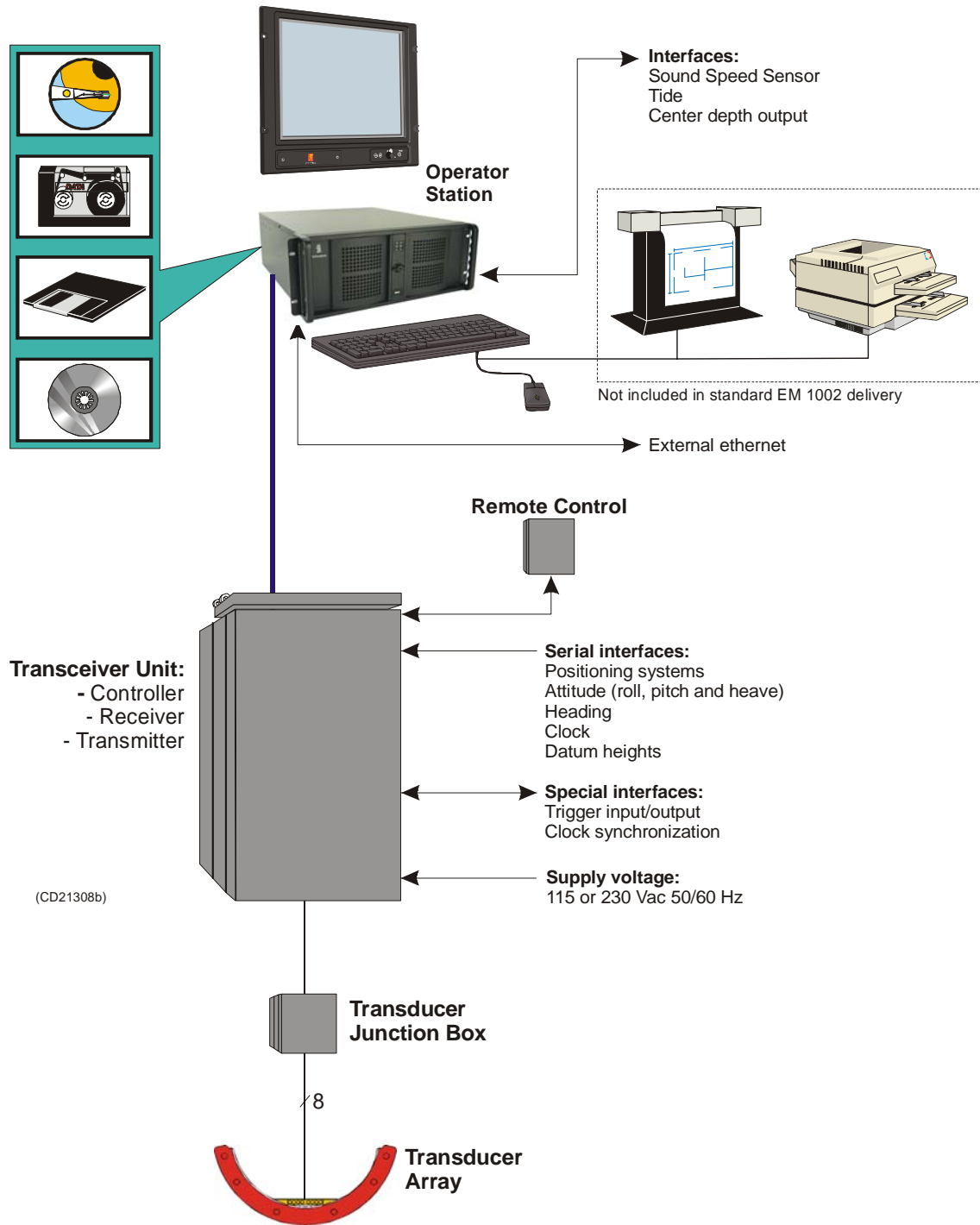


Figure 1 EM 1002 system units and interfaces

System Characteristics

Main units

The EM 1002 multibeam echo sounder consists of these main units:

- Transducer Array
- Transceiver Unit
- Operator Station

A complete mapping system will in addition include vessel motion sensor(s) and positioning system plus usually a postprocessing system and sound speed sensor(s).

Transducer array

The Transducer Array is used both for transmit and receive. It is semicircular with a radius of 45 cm and 160° angular extent. Its weight in water is approximately 90 kg. Eight 12.5 m long underwater cables connect the transducer to the Transducer Junction Box. The cables are fitted with connectors on the “dry” end. The cables from the Transducer Junction Box to the Transceiver Unit are 5 meters long.

The curved transducer makes the accuracy dependent upon variation in sound speed at the transducer depth. It is therefore recommended to install a sensor which allows real-time measurement of sound speed variation if this is expected. The system will take into account the sensor measurements in its calculations of beam pointing angles and raybending. The system is prepared for using an AML Smart Probe directly. Due to possible marine growth, and to ease of cleaning or servicing of the sensor, it would be advisable to mount the sensor in a tank inside the hull, and pump water taken from the transducer depth through the tank on permanent installations.

The Transducer Array may be mounted directly on the hull with fairings or for example on a mounting structure over the bow on small vessels.

Transceiver Unit

The EM 1002 Transceiver Unit contains the transmit and receive electronics and processors for beamforming, bottom detection, and control of all parameters with respect to gain, ping rate and transmit angles. It has serial interfaces for all time-critical external sensors such as vessel attitude (roll, pitch, heading and heave), vessel position, and external clock. The Transceiver Unit is a wall mounted cabinet with integrated shock and vibration absorbers. An Ethernet cable connects the Transceiver Unit to the Operator Station.

Operator Station

The Operator Station of the EM 1002 is the HWS 10 high performance dual-processor PC workstation. The operator software is the Seafloor Information System (SIS). The HWS 10 is dual bootable to either Linux® or Windows XP®.

SIS, as a minimum, allows setting the EM 1002 installation and runtime parameters, data logging and running self-test on the system without restrictions.

The SIS software also includes functionality for survey planning, 2D and 3D geographical display of the survey results, seabed image and water column displays, plus real-time data cleaning algorithms.

Alternatively, third-party software solutions can be used for the operator interface and real-time processing.

The HWS 10 is normally supplied with a 17.4" industrialized LCD monitor with a resolution of 1280x1024 pixels. Support for a second monitor is included. A spill-proof US keyboard and a standard optical mouse is normally supplied, but optionally a small IP 65 rated keyboard with integrated track stick can be delivered.

PERFORMANCE

Operational frequency

The nominal operating frequency of the EM 1002 multibeam echo sounder is 95 kHz. This frequency gives a good balance between small dimensions, narrow beams, good range capability and insensitivity to turbid waters.

Beamwidth

The alongtrack beamwidth is 3.3 degrees both on transmit and receive, which combined gives an effective alongtrack beamwidth of 2.3 degrees. Acrosstrack receive beamwidth is generally 2 degrees, increasing somewhat for beam pointing angles outside of the central ± 50 degrees sector. The transmit fan and the receive beams are electronically stabilized for roll. With the optional hull unit, mechanical pitch stabilization is also available. There are 111 receive beams per ping with a spacing which may either be set to equiangular or equidistant.

Transmission

The transmit fan is divided into three separate sectors if the angular coverage is larger than about 100 degrees. This avoids problems with multiple echos from normal incidence. Different frequencies are used for the inner and outer sectors. The three sectors are transmitted sequentially within each ping.

Three different pulse lengths are available, 0.2, 0.7 and 2.0 milliseconds. The longer pulse length is usually used for depths larger than about 500 m, and the shortest for depths less than about 150 m.

Swath width

The system has a swath width of up to about 1500 m in deeper waters, while in shallow waters the swath width may be up to 7.4 times water depth.

Depth accuracy

The system depth accuracy is very high due to the narrow beams and high range sampling rate used (12 kHz), but most importantly through using the advanced bottom detection. Near normal incidence a centre of gravity amplitude detection is employed, but for most of the beams the system uses phase detection. For every range sample an interferometric measurement of the angle of arrival of the returned bottom echo is done, and from all the bottom returns in a beam the exact range to the bottom in the beam centre is derived.

With high quality sensors it has been demonstrated that a total system accuracy of approximately 10 cm RMS is achievable in shallow waters.

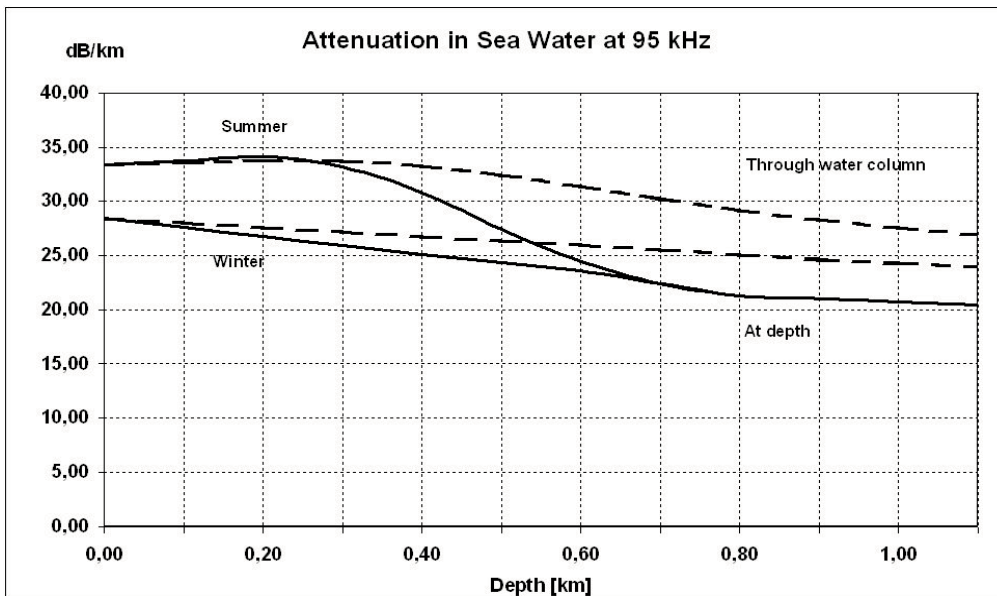
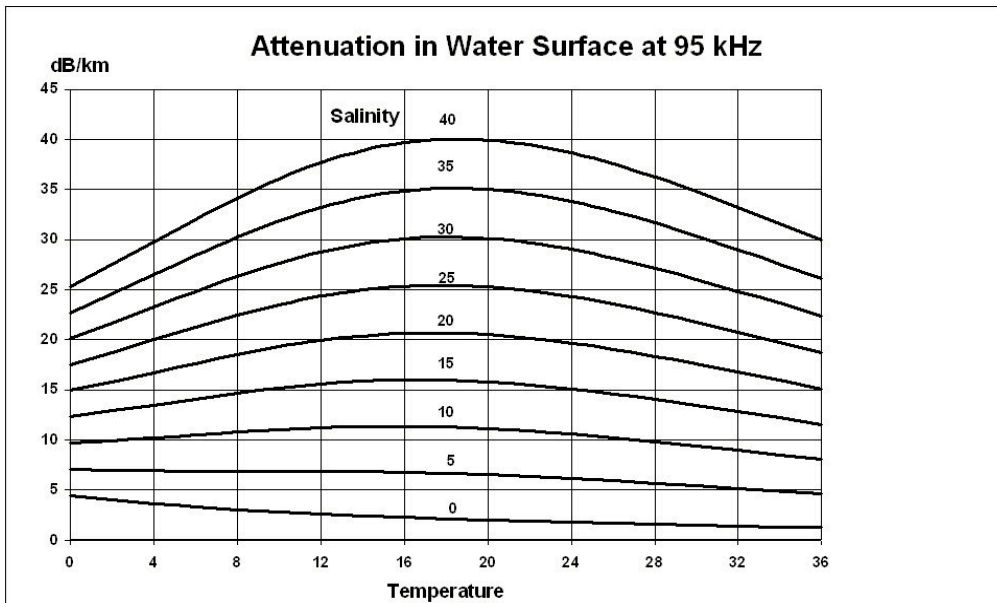
The expected total system RMS accuracy (assuming good external sensor data) is then:

- 0.2% of depth (from vertical up to 45 degrees)
- 0.3% of the depth (up to 60 degrees)
- 0.5% of the depth (between 60 and 70 degrees)

Note that the achievable accuracy may be limited by the selected pulse length (to 0.25 m for 1 ms pulse length, scaleable with pulse length).

The signal-to-noise ratio must be better than 10 dB.

- *Figure 2 (page 7) shows the absorption coefficient at 95 kHz as a function of water temperature, salinity and depth.*
- *Figure 3 (page 8) shows the expected instrument accuracy of the EM 1002. The total system error will in addition depend upon the quality of positioning, vessel motion and sound speed sensors.*
- *Figure 4 (page 9) shows the achievable swath width for different pulse lengths and bottom types as a function of depth. The calculations are made for an absorption coefficient of 30 dB/km. This is an average value for sea water. The achievable coverage is much larger in fresh and brackish water. This is due to the reduced absorption coefficient.*

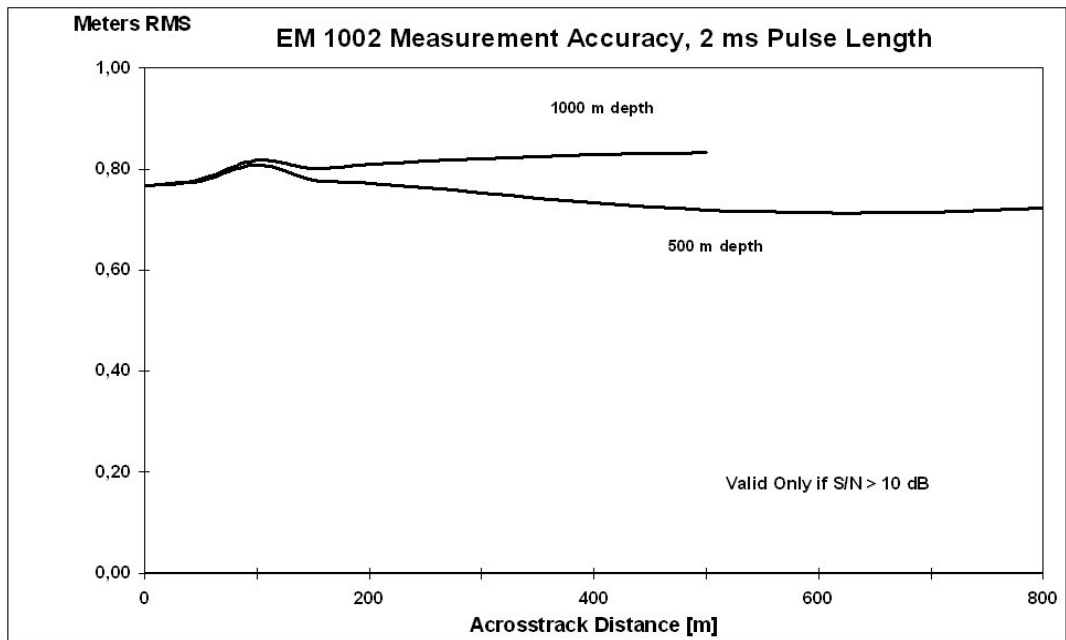
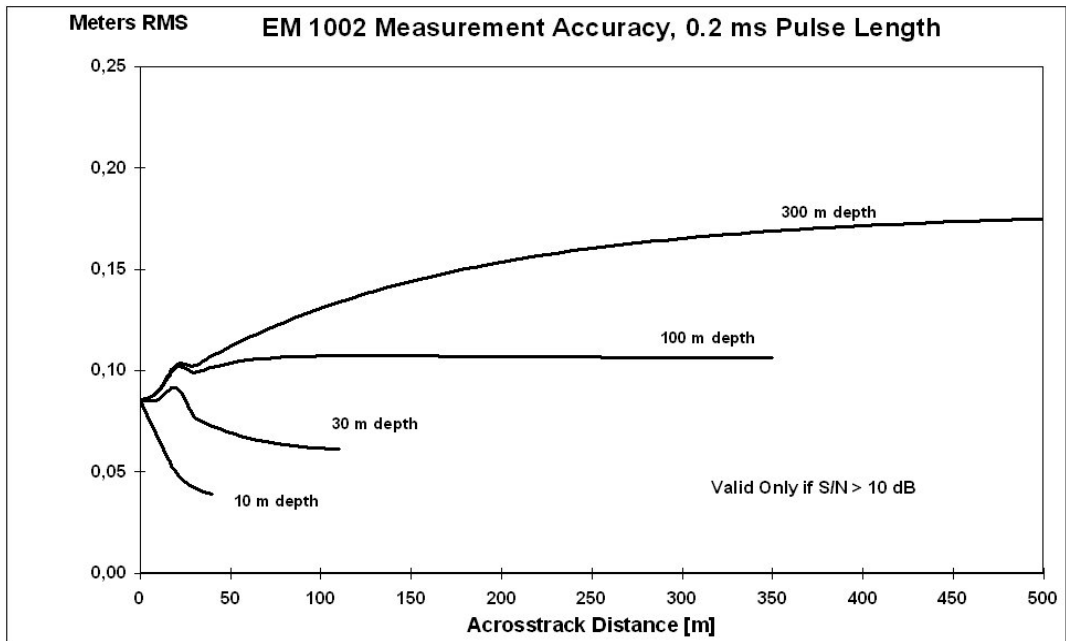


(CD4231)

Figure 2 Attenuation in water at 95 kHz

The top curve shows the attenuation as a function of temperature and salinity at the water surface.

The bottom curve shows the attenuation as a function of depth.



(CD4240)

Figure 3 EM 1002 accuracy

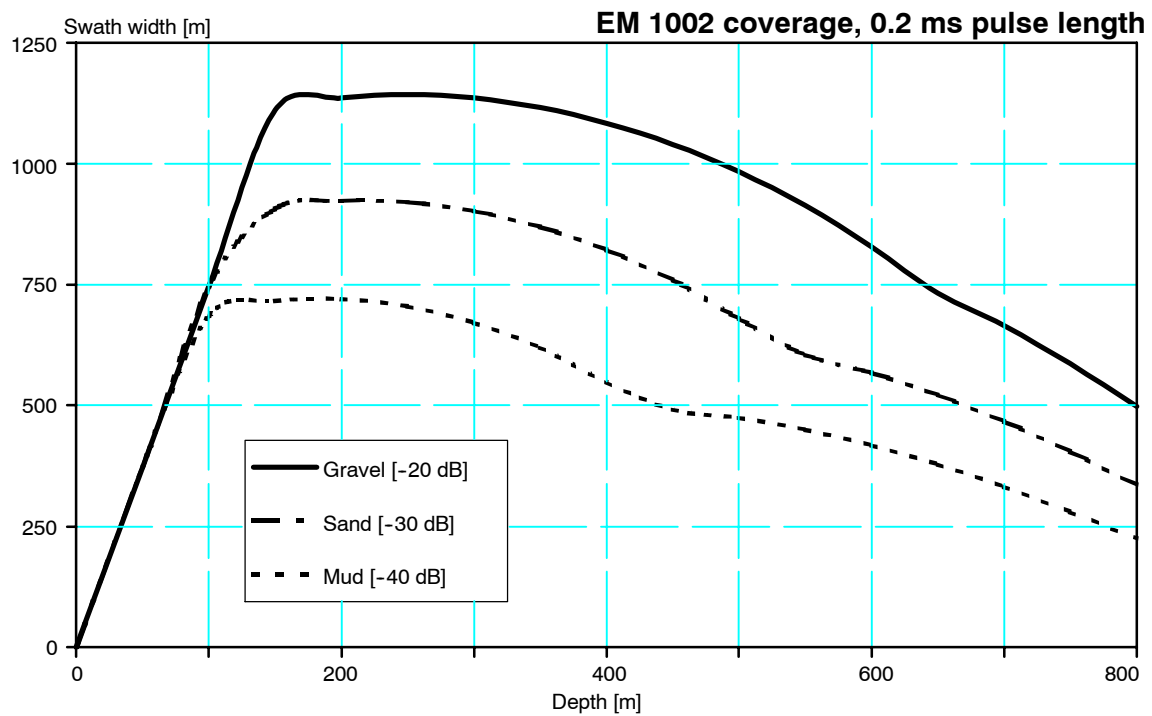
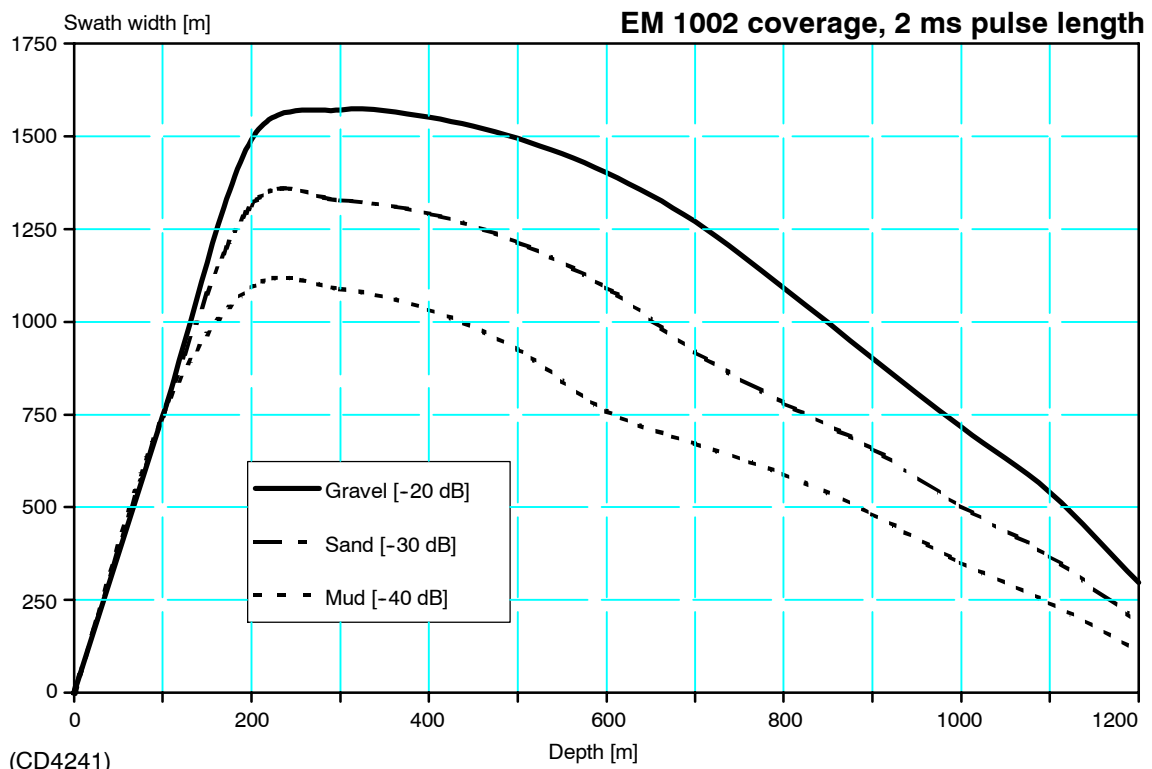


Figure 4 EM 1002 coverage

INSTALLATION

Introduction

The compactness of the EM 1002 multibeam echo sounder is a guarantee for a fast and easy installation.

Transceiver Unit and Operator Station

The Operator Station is usually mounted on a desk in the operation room and suitably tied down. The Transceiver Unit is intended to be mounted on a bulkhead in a room closer to the transducer to reduce the amount of cabling.

Transducer Array

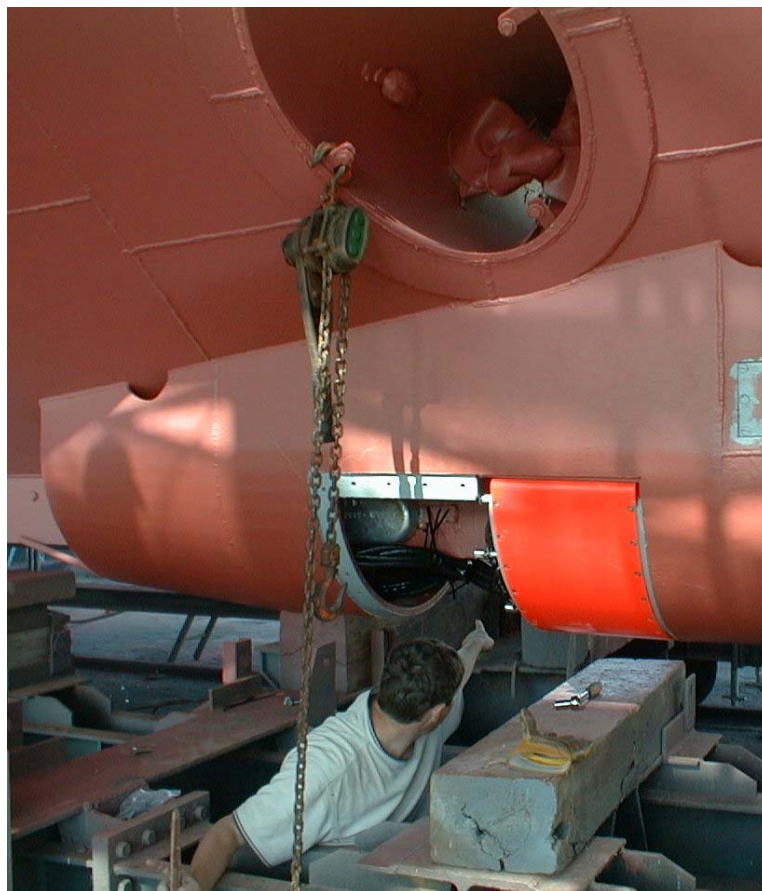
The transducer should be mounted in the forward part of the vessel, taking into account hull shape and potential aeration problems.

The EM 1002 Transducer Array is usually bolted onto a short tube fixed to the hull. A fairing will usually be added around the array to ensure a laminar water flow without any aeration problems. On small vessels it could be mounted on a structure on the bow, which has the advantage of allowing the transducer to be moved with the rest of the system between different vessels. Refer to figure 5 for an example.

The eight transducer cables have a standard length of 20 m, and are terminated with connectors which plug directly into the Transceiver Unit. Normally the cables would enter the hull through a tube which is fitted with a standard ship type cable gland (Brattberg or equivalent) to provide water tightness. The cable gland should be of the type having a certified pressure rating of 4 bars or more. If the tube ends below the waterline, classification requirements may require a double set of glands.



*Figure 5 Transducer array,
bow installation example*



*Figure 6 Typical blister installation on “Alis”.
Note the access hatch on the aft side of the transducer array.*



Figure 7 Open installation on “John Hall”

OPERATION

System features

The EM 1002 multibeam echo sounder is controlled from the HWS 10 Operator Station using a standard click and point graphical user interface. The software, Seafloor Information System (SIS), may either be run under the Microsoft Windows XP or Linux operating systems which are both installed on the HWS 10. As standard, the system software includes the necessary features for system installation, testing and running the multibeam, ping related displays (including water column display) and the capability of logging the acquired bathymetry data.

The EM 1002 system does not require operator intervention during normal operation, but tracks the bottom automatically while adjusting mode, gain and range dependent parameters as required. Before operation is started, the necessary external sensors, such as positioning and vessel motion sensors, are connected and calibration procedures followed in order to define the system and sensor installation parameters.

Parameters critical to data quality are password protected, and most of the parameters can be recalled from a disk file.

Seabed imagery data is available from the system as standard. The imagery data, representing the acoustic backscatter strength of the bottom in 0.5 dB resolution, is available in two forms, one with range resolution nominally corrected for the effect of incidence angle, the other given per beam as an absolute measure. The imagery data may be useful for object detection, but the most important application is probably geophysical for seabed characterization.

Quality control

Quality control of the acquired data is done through graphical displays. In addition a message window and alphanumeric displays are included to allow a quick overview of the system status, indicating any interface or hardware related problems. SIS provides the graphical displays required for real-time checking of the EM 1002. These include:

- Cross-track depth profiles
- Beam intensities and quality measures
- Time series display of beam samples and sensor values
- 3D waterfall display
- Sound speed profile display and editor

Graphical user interface

Using the SIS software, the operator will normally be viewing gridded data in a geographically oriented 2D or 3D display as his primary means of quality control of the survey. The grid has six levels of detail, allowing rapid zoom in and out. Previous survey results can be imported to allow visualisation of any differences between the current and old surveys in overlapping areas.

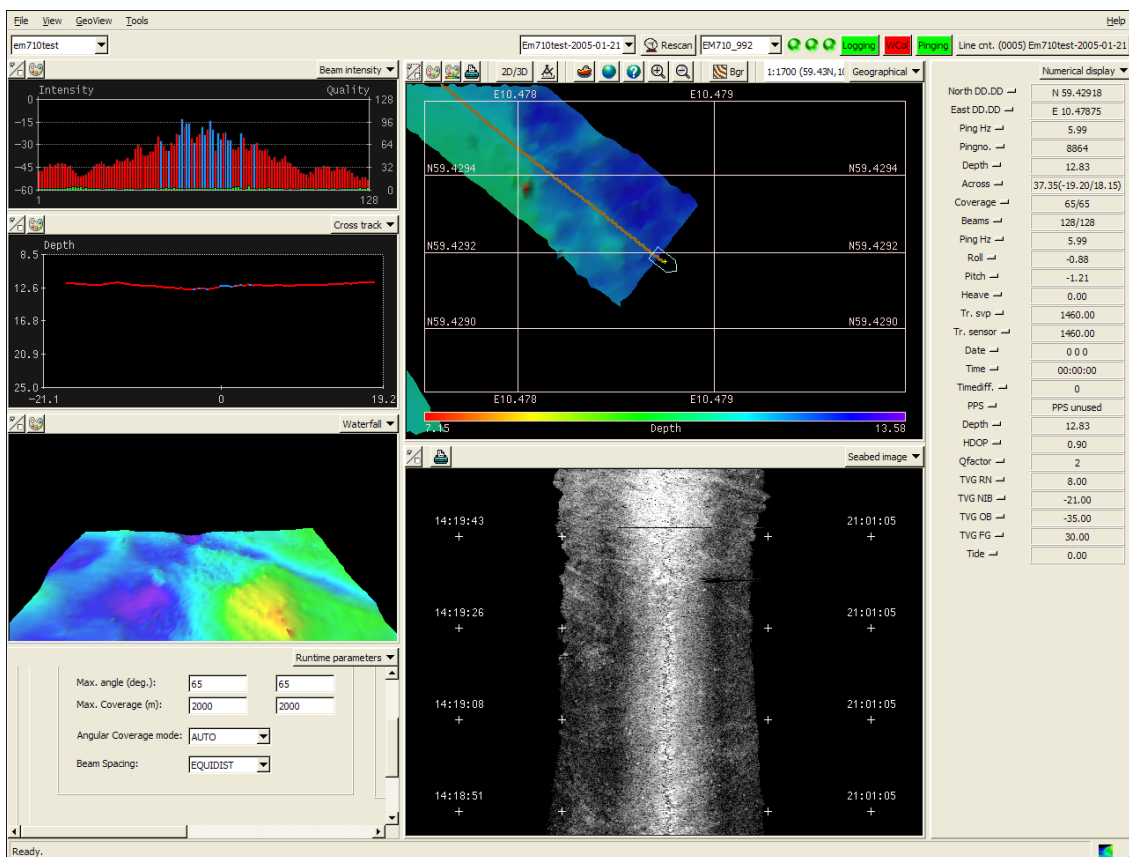


Figure 8 Example of SIS graphical user interface

The grid may also be utilized for real-time data cleaning. Based upon a set of user defined rules, outliers in a grid cell, whether from old or new survey lines, are flagged. The flags may be retained or updated through the processing. Optionally the CUBE data-cleaning package from the Center for Coastal and Ocean Mapping Center at the University of New Hampshire is also available in SIS.

Among other features included are:

- System (sensor) calibration
- Planning of surveys
- Real time cleaning of data, for separate survey lines or for the complete survey area
- Helmsman Display
- Full use of the chosen operating system for data export, plotting and printing

Electronic chart data can be displayed as a background in the geographical displays.

While SIS is the standard solution for operator software, the system is prepared for support of third party software solutions. Such software, for example QINSY or Hypack, may be used as a complement to SIS or as a replacement for SIS.

Data logging

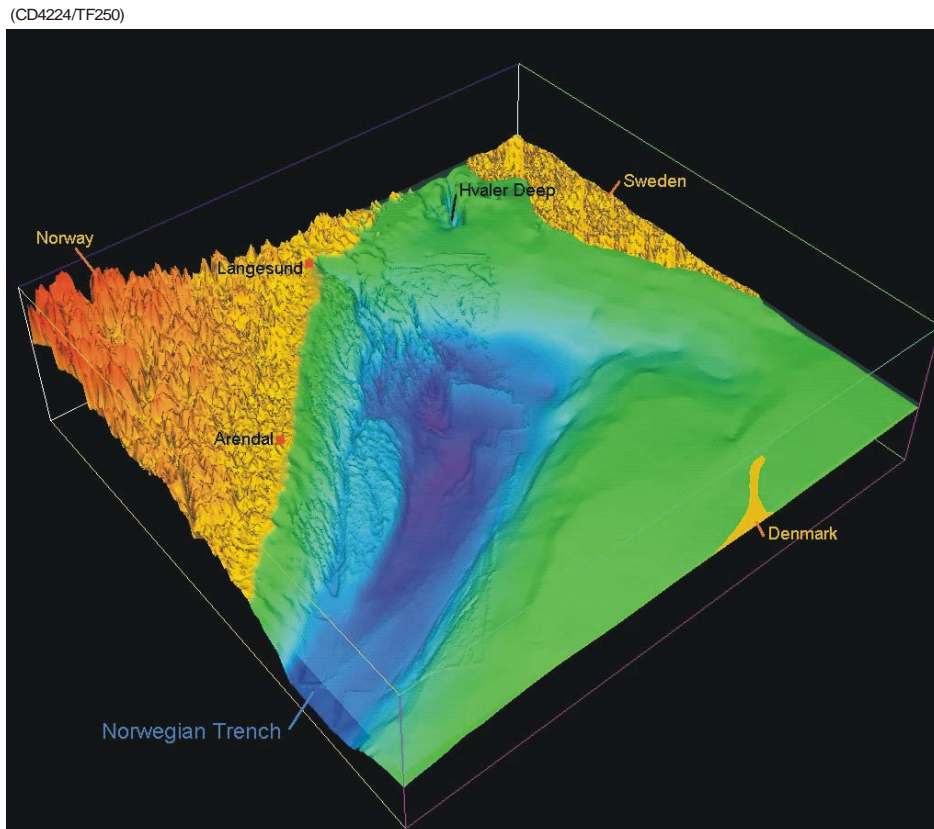
It is of the utmost importance to ensure that all survey related data is logged in a safe way. The data is always stored on disk and the geographical displays take data only from disk. In this way, what the operator sees is what is safeguarded and already stored. As standard the HWS 10 runs two high performance SerialATA disks connected in a RAID1 array, i.e. one disk may fail without loss of data. The disks are mounted in mobile storage bays, thus they may be removed for security reasons or for transporting the acquired data. The stored data may be written to DVD at any time. The Firewire, SCSI and USB interfaces may be used for transfer of data to external storage devices, such as disk or tape, according to user preferences. All data are also available on an external Ethernet.

The logged data sets include:

- Raw sensor data
- Beam ranges and beam pointing angles
- Depth datagrams
 - In each depth datagram range/angle data from one ping have been merged with motion sensor data and the current sound velocity profile to derive a rigorous solution for vessel motion and raybending, calculating sounding depth and position as Cartesian coordinates. The depth datagrams are suited for immediate presentation in the geographical display.

- Seabed image data
- System parameter settings

The gridded data (terrain model) is also available for logging. The data formats are public and published on the Kongsberg Maritime web site, ensuring that EM 1002 is a truly open solution, allowing third party or own software to be developed for data processing.



Survey of the Norwegian Trench in the Skagerrak performed by Geological Survey of Norway.

Figure 9 EM 1002 survey example

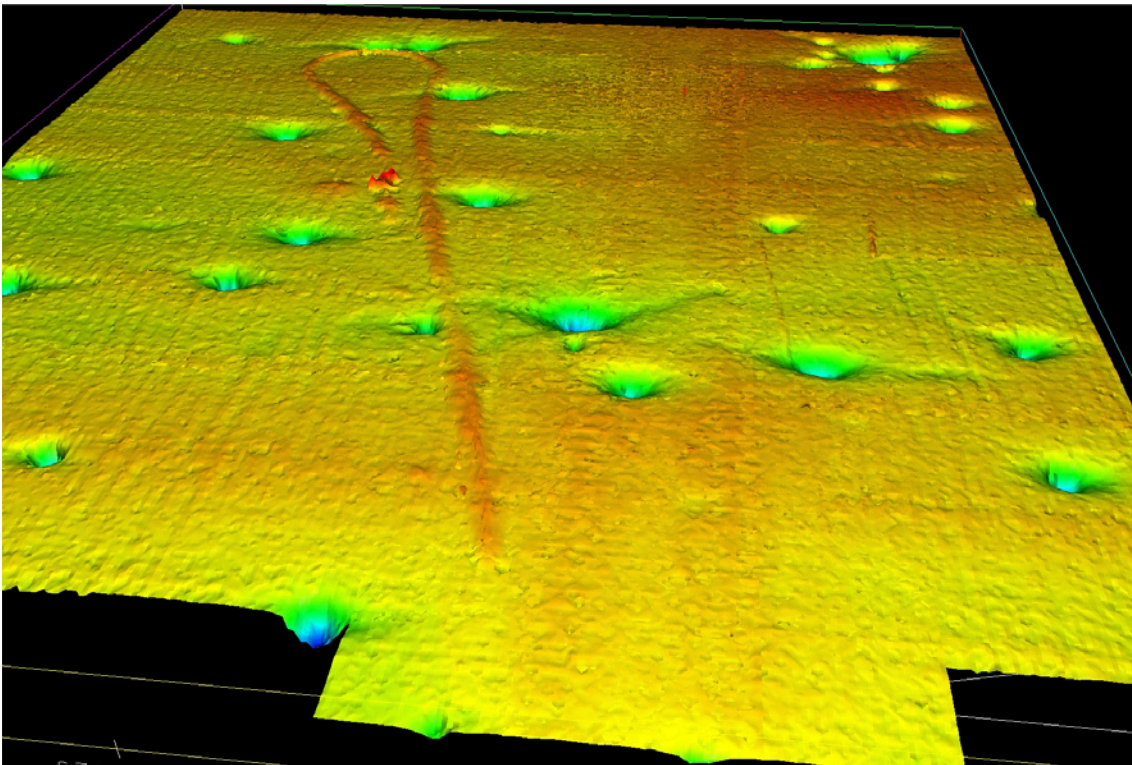


Figure 10 EM 1002 survey of the Troll oil field off the western coast of Norway, performed by Fugro-Geoteam AS

POST-PROCESSING

Post-processing options

The high quality data produced by the EM 1002 multibeam echo sounder is an excellent basis for producing a complete description of the seabed in the form of charts, 3D displays, combined bathymetry and acoustic imagery, seabed classification, etc. Kongsberg Maritime can deliver a complete set of products for post-processing EM 1002 bathymetric data. Interfaces to other post-processing software is also available.

Brief descriptions

The **Neptune** software is used for post-processing of bathymetric data. Such post-processing involves cleaning and filtering of position data, analysis and corrections for depth data, tidal height adjustment, automated data cleaning based upon statistical rules, manual editing, controlled data thinning, and export of the final sounding data to further processing.

The **Poseidon** software is used for post-processing of seabed image data into seabed image mosaic map overlay. This involves merging of data from overlapping survey lines, applying systematic corrections which are required, filtering and interpolation.

The **Triton** software is used for seabed sediment classification. This process extracts signal features from the seabed image data, and applies this data to a statistical classification procedure in order to obtain the best estimate for seabed sediment type as a function of position in the form of a map overlay. The classifier can be trained and adapted to local conditions by use of a training module to correlate acoustical signature to ground truth information.

Software to be used for digital terrain modelling and plot generation can be delivered integrated with Neptune to derive a digital terrain model from an interpolation of the cleaned sounding data. From the terrain model contour maps, 3D plots, depth profiles along specified routes, fairsheets, volume calculations, etc, are easily produced. This additional third-party software is usually the **Cfloor** system.

CUSTOMER SUPPORT

Introduction

As a major supplier of multibeam echo sounders with many years of experience, Kongsberg Maritime has developed a marketing and service organization tuned to customer needs.

Installation

As part of the discussions with the client Kongsberg Maritime will - free of charge and without any obligations - give advice regarding the practical installation of the EM 1002 system. We will also - upon request - prepare proposals for the supply of complete instrument packages and/or systems. A project manager will usually be appointed to supervise the delivery, installation and testing of larger instrumentation systems.

The installation and final testing of an EM 1002 system should be done according to Kongsberg Maritime's documentation. If required, Kongsberg Maritime field engineers can be made available to:

- Supervise the installation.
- Perform the measurement of final location and attitude of the transducers and/or sensors.
- Perform system check-out and final testing.

Documentation and training

The EM 1002 is delivered with complete documentation for installation, operation and maintenance. If required, the manuals are prepared to reflect the actual system on the client's vessel.

Kongsberg Maritime can conduct the training of operators and maintenance personnel to the extent required by the client. Such training courses can take place on the vessel, on any of Kongsberg Maritime's facilities, or any other location decided by the client.

Service

The Kongsberg Maritime service department has a 24 hour duty arrangement, and can thus be contacted by telephone at any time. The service department will assist in solving all problems that may be encountered during the operation of the system, whether the problem is caused by finger trouble, insufficient documentation, software bugs or equipment breakdown.

FEMME

A forum for users of Kongsberg Maritime's multibeam echo sounder systems (FEMME), with the aim of improving communication both between the users and Kongsberg Maritime, but also between the system users, is arranged at approximately 18 months intervals. Close to 100% user participation has been experienced at these meetings.

Warranty and maintenance contract

The normal warranty period of the EM 1002 is 24 months after delivery.

A system maintenance contract tailored to fit the needs of the client is available. This contract can be defined so that it covers repair work only, or complete support for preventive maintenance, repair work, and system upgrading of both hardware and software as the system design is improved by Kongsberg Maritime.

The maintenance contract could also include upgrading of spare parts and documentation, and repeated or additional training courses.

SCOPE OF SUPPLY AND OPTIONS

Standard system

A basic EM 1002 multibeam echo sounder delivery includes:

- 1 Operator Station HWS 10 with 17.4” LCD monitor.
- 2 EM 1002 Transducer Array.
- 3 Transceiver Unit.
- 4 Signal and control cables between cabinets. Standard length is 5 m.
- 5 All system software.
- 6 System manuals covering system installation, operation and maintenance.

Options

System options available include:

- Longer cables between the Transducer Array and the Transceiver Unit.
- Raw data recorder.
- Helmsman Display and/or additional monitors.
- Postscript colour graphic printer/plotter.
- High resolution grayscale recorder for continuous seabed image hardcopy.
- Spare parts.

System integration

Complimentary to the EM 1002, the following software products may be delivered:

- **Neptune** for post-processing of bathymetric data.
- **Cfloor** integrated with Neptune for digital terrain modelling.
- **Triton** for seabed classification.
- **Poseidon** for seabed image mosaicing.

Additionally Kongsberg Maritime may deliver the EM 1002 as part of a complete survey system. This may include integration with single beam echo sounders and/or other multibeam echo sounders for seamless coverage of any depth range.

An integrated system may share electronic chart display (ECDIS), dynamic positioning and vessel management systems, and third-party equipment such as sound speed sensors, vessel motion sensor and positioning systems.

TECHNICAL SPECIFICATIONS

Note

Kongsberg Maritime is engaged in continuous developments of its products and reserves the right to alter specifications without prior notice.

Interfaces

- Serial lines with operator adjustable baud rate, parity, data length and stop bit length for:
 - Motion sensor (roll, pitch, heave and optionally heading) in format supported by sensors from Applanix, iXSEA, Kongsberg Seatex and VT TSS
 - Heading (gyrocompass) in either NMEA 0183 HDT or SKR82/LR60 or Sperry Mk39 format
 - Positions in either Simrad 90, NMEA 0183 GGA or GGK format
 - External clock in NMEA 0183 ZDA format
 - Sound speed at transducer
 - Sea level height (tide)
 - Single beam echo sounder depths
 - Output of depth straight down in NMEA 0183 DPT format
- Interface for 1PPS (pulse per second) clock synchronisation signal
- SCSI interface intended for tape drive
- Firewire interface for external data storage device (tape or disk)
- USB 2.0 interfaces for data storage, printing or plotting
- Parallel interface for Postscript colour graphics printer/plotter
- Ethernet interface for input of sound speed profile, tide and echo sounder depths, and output of all data normally logged to disk

Physical specifications

Transducer Array

- **Height:** 398 mm
- **Width:** 887 mm
- **Length:** 473 mm
- **Weight:** 130 kg (90 kg in water)

Transceiver Unit

- **Height:** 1110 mm
- **Width:** 600 mm
- **Depth:** 670 mm
- **Weight:** Approximately 60 kg

Operator Station

- **Height:** 127 mm
- **Width:** 427 mm (excluding rack fixing brackets)
- **Depth:** 480 mm (excluding handles and connectors)
- **Weight:** Approximately 20 kg

LCD monitor

- **Height:** 400 mm (excluding mounting brackets)
- **Width:** 460 mm (excluding mounting brackets)
- **Depth:** 71 mm (excluding mounting brackets)
- **Weight:** 9.2 kg

Power requirements

- **Fuse:** The single phase supply must be protected with 16A slow-blow fuses.
- **Operational voltage and frequency:**
 - **Transceiver Unit:** 115 or 230 Vac ($\pm 10\%$), < 500 W, 47 to 63 Hz
 - **Operator Station:** 110 or 240 Vac ($\pm 10\%$), < 250 W, 47 to 63 Hz
 - **LCD monitor:** 110 or 240 Vac ($\pm 10\%$), < 60 W, 47 to 63 Hz

Note

*For 110 Vac operation, please contact
km.hydrographic.support@kongsberg.com*

- **Acceptable transients:**
 - **Short time (max 2 sec):** $\pm 25\%$, 42 to 69 Hz
 - **Spikes (max 50 μ S):** < 1000 V
- **Power interrupts:** Menu settings, all parameters and the sound speed profile are stored on the Operator Station's harddisk during operation, so operation can continue after power interruption. However, the file system may be damaged, so the use of an uninterruptable power supply (UPS) is highly recommended.

Restrictions for use - limitations

No specific restrictions apply.

Surface finish

All cabinets are painted. System units exposed to salt water must be treated accordingly.

Environmental specifications

- **IP rating:**
 - **Transceiver Unit:** IP54
 - **Operator Station:** IP22
 - **LCD Monitor:** IP22
- **Operating temperatures:**
 - **Transceiver Unit:** 0 to $+45^{\circ}\text{C}$
 - **Operator Station:** 5 to $+55^{\circ}\text{C}$
- **Storage temperatures:**
 - **Transceiver Unit:** -30 to $+70^{\circ}\text{C}$
 - **Operator Station:** -30 to $+70^{\circ}\text{C}$

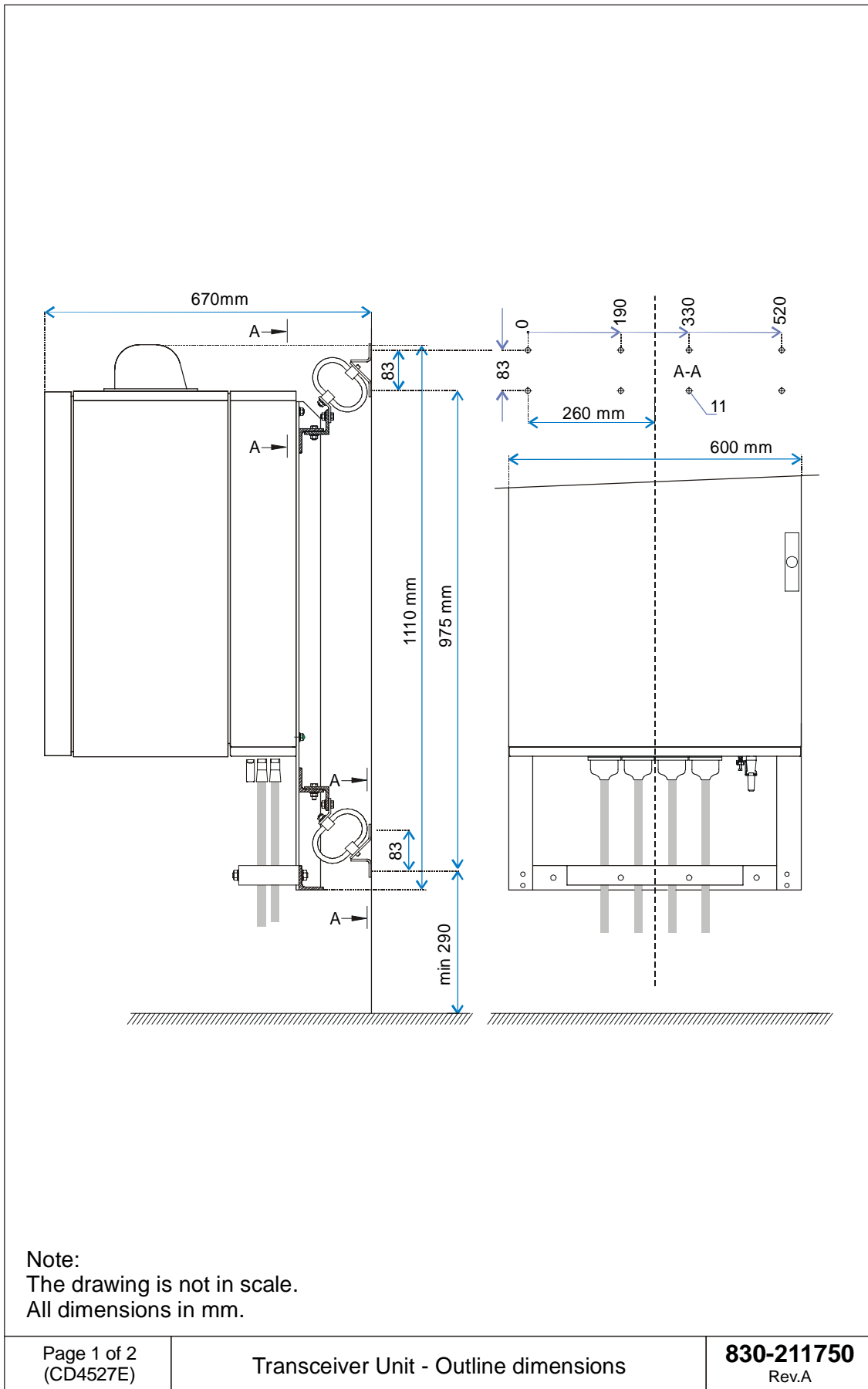
System performance

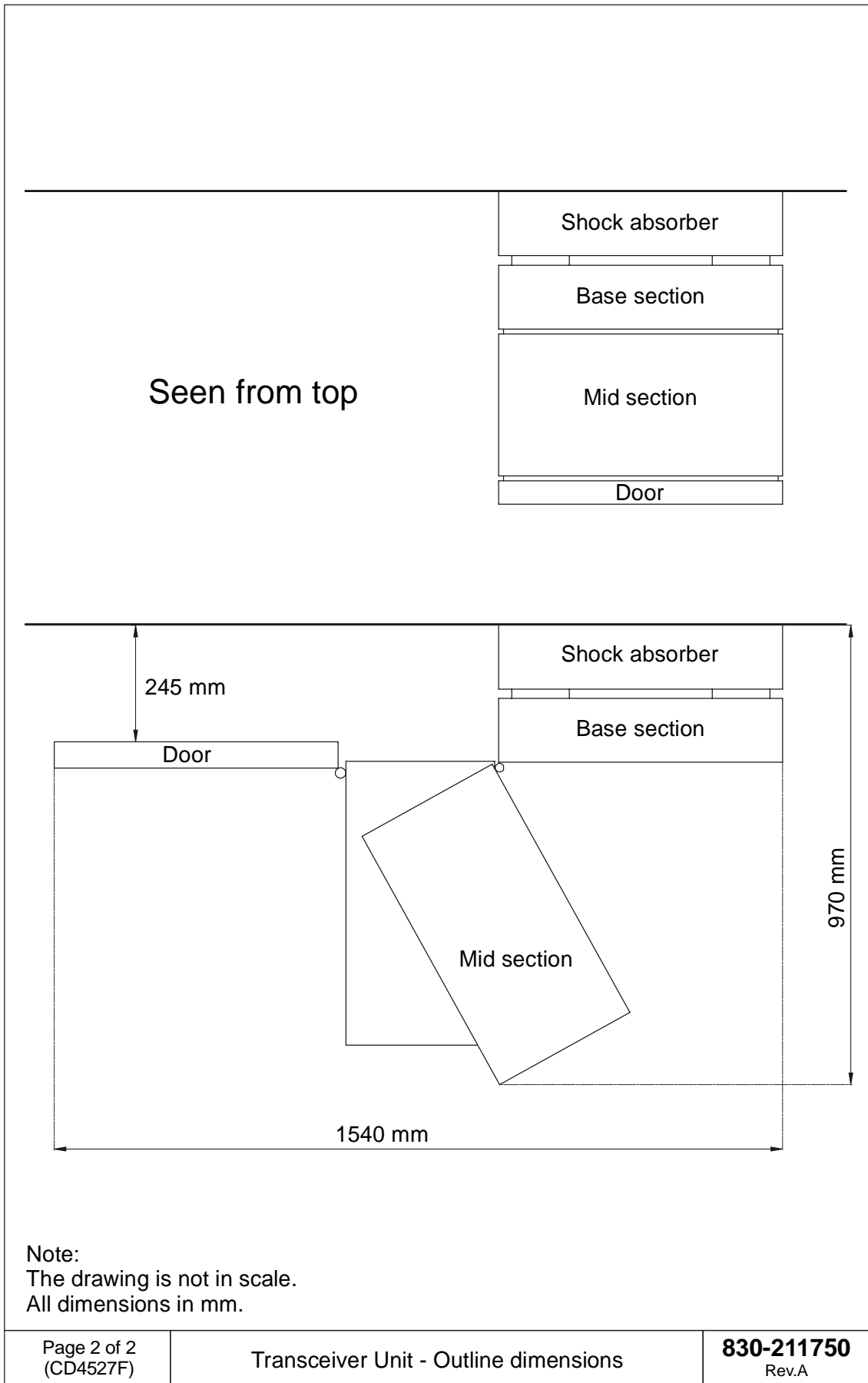
- **Main operational frequency:** 95 kHz
 - Frequencies in the range of 92 and 98 kHz are actually used.
- **Maximum ping rate:** >10 Hz
- **Number of beams per ping:** 111
- **Beamwidth:**
 - Alongtrack: 2.3 degrees
 - Acrosstrack: 2 degrees

Note

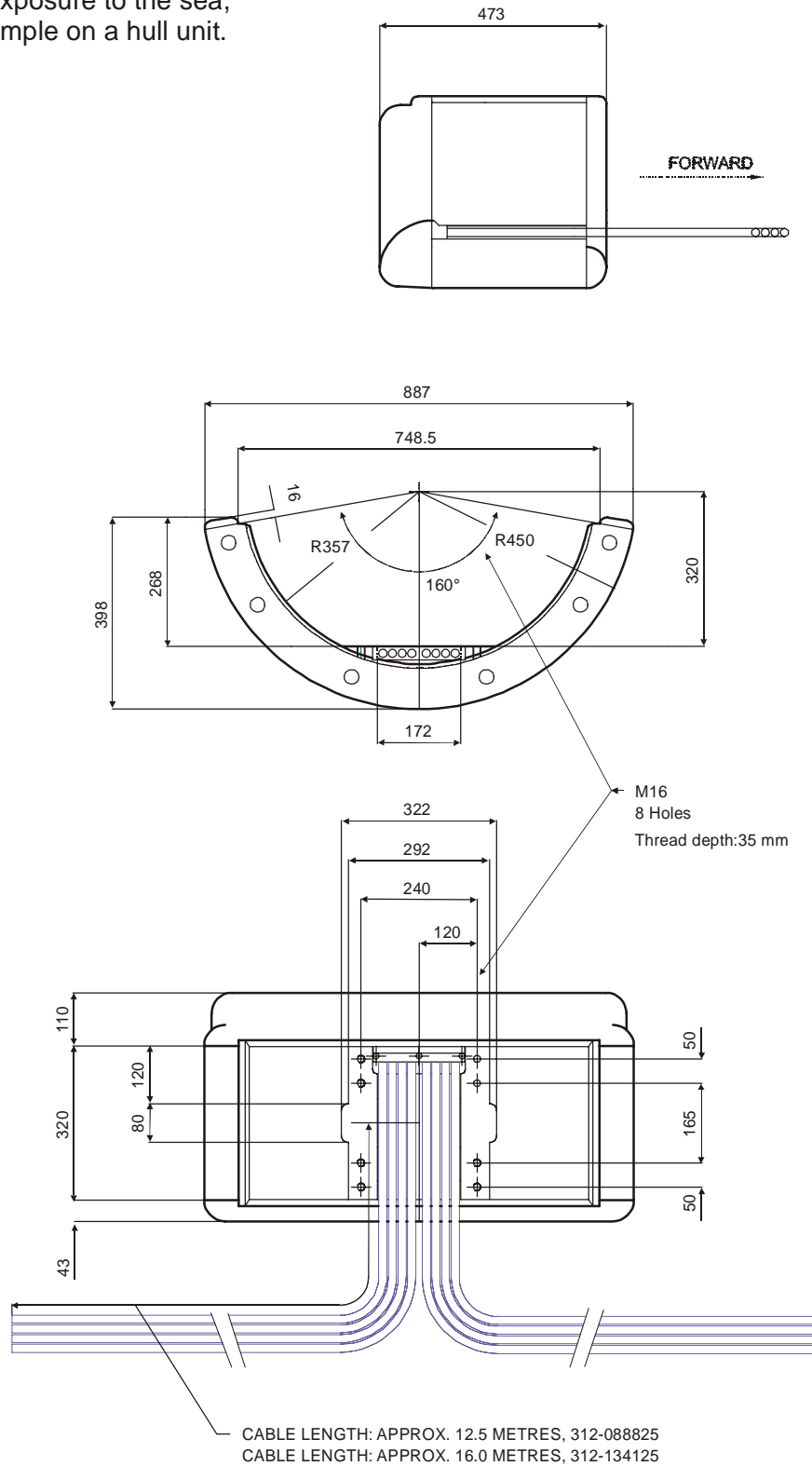
Acrosstrack receive beamwidth is generally 2 degrees, increasing somewhat for beam pointing angles outside of the central ± 50 degrees sector. The beamwidth is 2.5 degrees at 70 degrees and 2.8 degrees at 75 degrees beam pointing angle.

- **Beam spacing:** Equidistant and equiangle
- **Coverage sector:** Up to 150 degrees (usable up to 190 degrees)
- **Depth range from transducers:** 2 to 1000 metres
- **Pulse length:** 0.2, 0.7 or 2 ms
- **Range sampling rate:** 12 kHz





This drawing presents the transducer array prepared for open exposure to the sea, for example on a hull unit.



Revision: D CD4871 (&488)	Transducer array, Outline dimensions	830-088179 Rev.D
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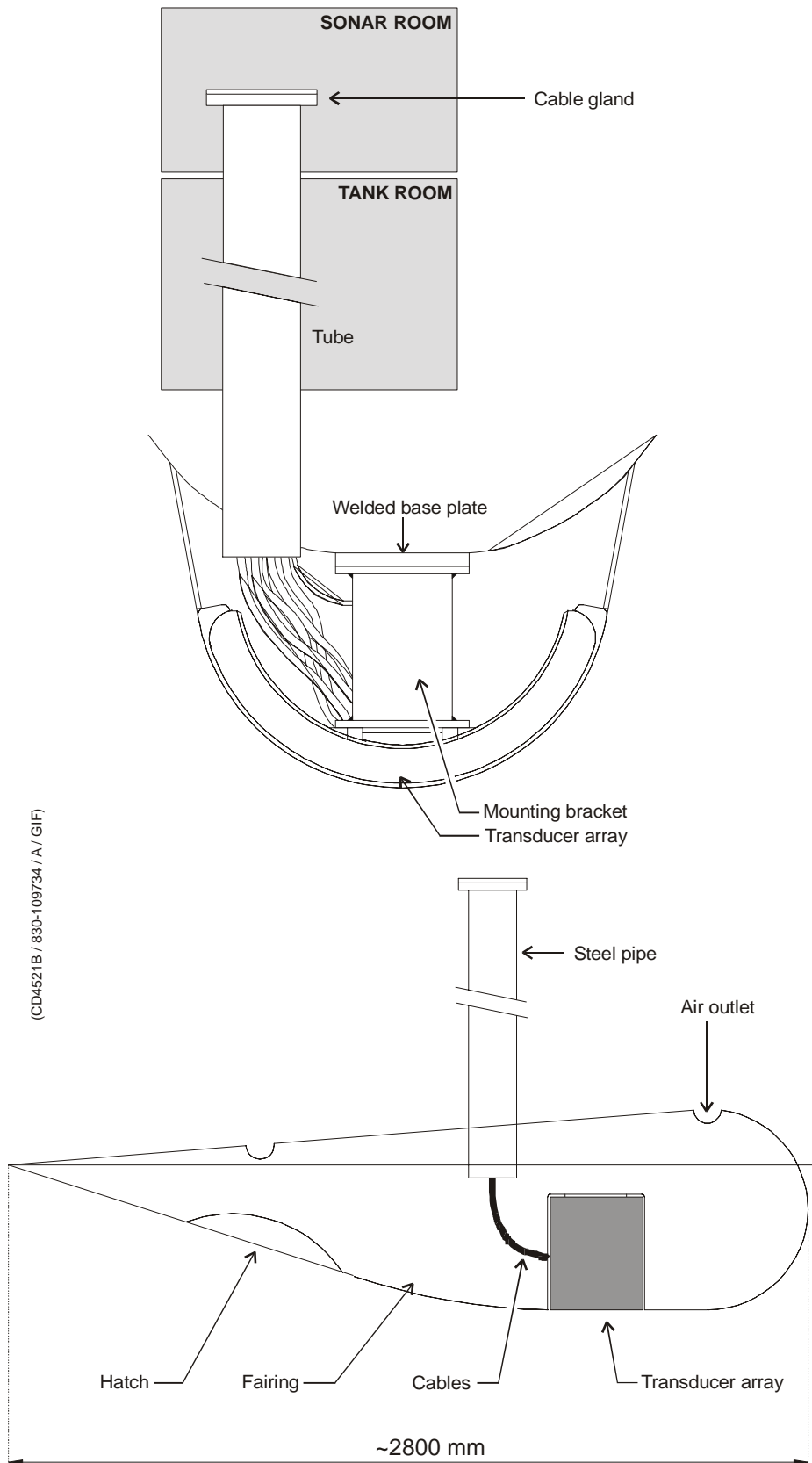


Figure 11 Arrangement drawing, example

COMPANY PROFILE

Kongsberg Maritime

Kongsberg Maritime is a leading supplier of advanced maritime automation and instrumentation systems. The company has approximately 2400 employees and an annual turnover of MNOK 3.700 (year 2004). Kongsberg Maritime owns subsidiaries in Canada, Italy, the Netherlands, Germany, Sweden, Singapore, China, Korea, the UK and the USA in addition to four locations in Norway. Decentralisation lets subsidiary company optimise customer relationships while providing maximum flexibility in relation to product design, production and marketing. Kongsberg Maritime currently exports its products to all of the world's major markets.



Figure 12 Kongsberg Maritime's facilities in Horten.

Kongsberg Maritime's main office is situated in Horten, Norway. The **Hydroacoustics** department responsible for the design and production of the EM 1002 is also located in Horten, close to the Oslo fjord. Sharing premises with Simrad AS, producer of echo sounder and sonars for the world's fishing fleet, the companies also share more than 50 years of experience in single and multibeam echo sounding, sonar technology and underwater communication and instrumentation.

Kongsberg Maritime's location close to the waterfront provides excellent surroundings for the design, test and manufacturing of the advanced products. Two in-house test tanks, a sea based test station as well as two vessels are available for extensive testing and quality control.



Figure 13 The test and demonstration yacht "M/K Simrad Echo"

The product range provided by Kongsberg Maritime in Horten includes:

- Single and multibeam echo sounders for hydrographic use
- Underwater communication
- Underwater positioning reference systems (including the highly accurate HiPAP® system)
- Naval sonars and echo sounders (hull mounted and towed systems)
- Oil and gas simulator systems

Kongsberg Maritime is fully owned by the **Kongsberg Group**.

Kongsberg Group

Kongsberg Gruppen ASA (the Kongsberg Group) is one of Norway's leading high-technology companies. With an annual turnover of approximately MNOK 6.400 (in 2004), it is listed at the Oslo Stock Exchange. The largest shareholder is the Norwegian Ministry of Industry and Energy holding 51% of the shares. The rest is publicly owned.

The Kongsberg Group operates through two major business areas:

- Kongsberg Defence & Aerospace AS
- Kongsberg Maritime AS

These companies are fully owned by the Kongsberg Group. Kongsberg Defence & Aerospace is engaged in defence activities, while the commercial market activities are allocated within Kongsberg Maritime.

The Kongsberg Group is represented world wide.

For more information, visit www.kongsberg.com

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