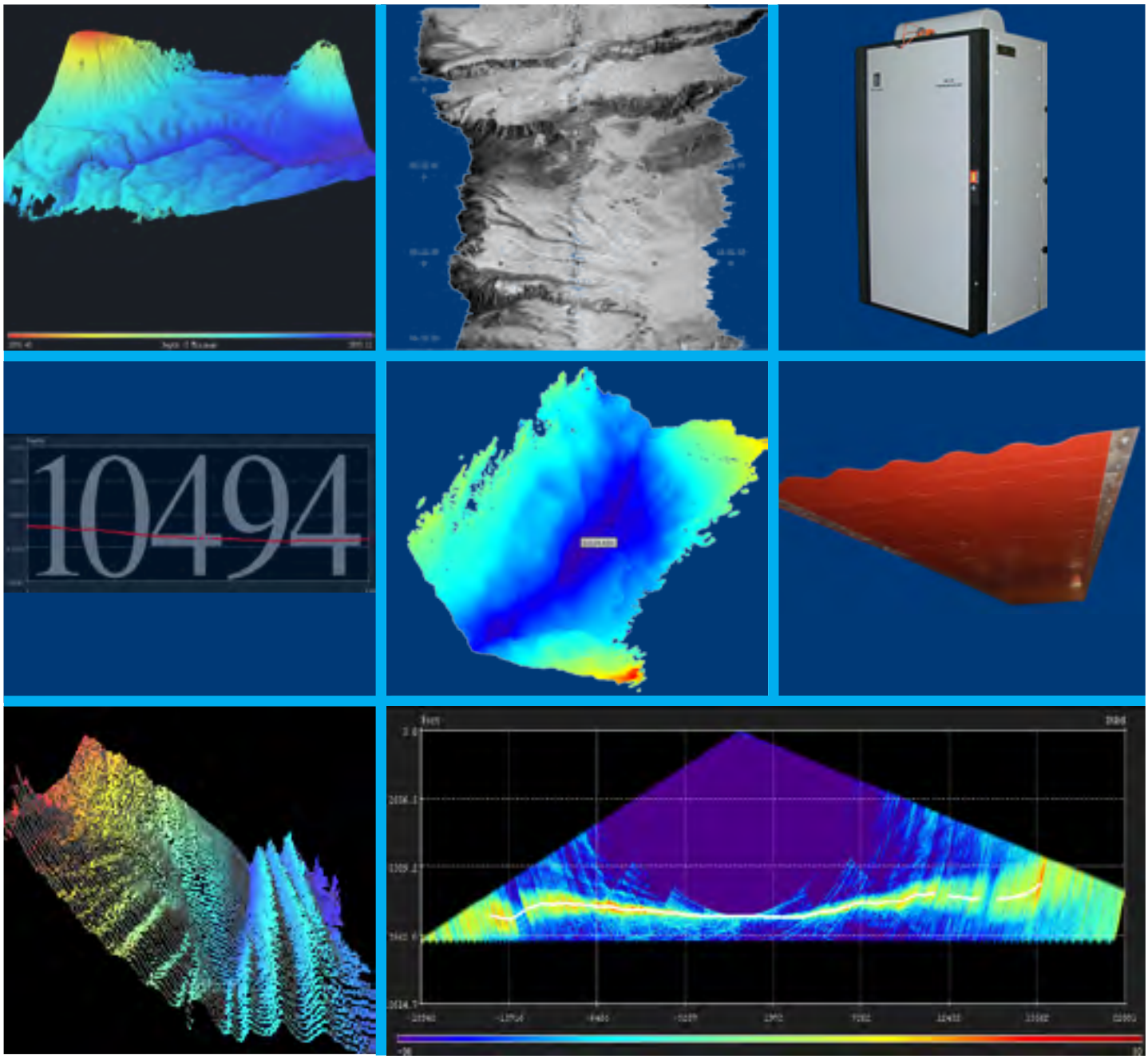
Product description

KONGSBERG

EM 122

Multibeam Echo Sounder



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Product Description

Kongsberg Maritime

302440/E

Document history

Document number: 302440		
Rev. A	January 2006	First version.
Rev. B	June 2006	Changed performance curve
Rev. C	May 2007	Changed drawing fig. 1, system units and interfaces. Minor changes in the text
Rev. D	July 2007	Minor changes in the technical specifications
Rev. E	February 2011	Updated coverage curves, drawing and text

Disclaimer

Kongsberg Maritime AS endeavours to ensure that all information in this document is correct and fairly stated, but does not accept liability for any errors or omissions.

Warning

The equipment to which this manual applies must only be used for the purpose for which it was designed. Improper use or maintenance may cause damage to the equipment and/or injury to personnel. The user must be familiar with the contents of the appropriate manuals before attempting to install, operate or work on the equipment.

Kongsberg Maritime AS disclaims any responsibility for damage or injury caused by improper installation, use or maintenance of the equipment.

Support

If you require maintenance on your equipment, contact Kongsberg Maritime AS using the following address:km.hydrographic.support@kongsberg.com. If you need other information about this product, or any other Kongsberg Maritime AS products, visit http://www.km.kongsberg.com.

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System overview

Key facts

The EM 122 is designed to perform seabed mapping to full ocean depth with an unsurpassed resolution, coverage and accuracy. The system is cost effective, reliable, and easily operated.

The design of the EM 122 is based on more than 60 years of hydrographic experience with echo sounders, sonars and underwater positioning for civilian and military use. It is the latest model in a series of deep sea multibeam echo sounders started with the EM 12 in 1990 and followed by the EM 121 and the EM 120, of which about 50 systems are operational. It uses the same transducers as in the EM 120 but with new electronics and software.

Compared with the EM 120, the EM 122 has up to four times the resolution in terms of sounding density through inclusion of multiping capability and more than twice the number of detections per swath. High density signal processing is a major improvement, to keep the acoustic footprint size small even for the outer beams in the swath. In typical ocean depths a sounding spacing of about 50 m across and along is achievable.

The achievable swath width of the EM 122 is in the order of 35,000 m, or about 25% more than possible with the EM 120. This is obtained by using long FM chirps which gains signal to noise ratio compared to CW pulses.

The EM 122 is a complete system. All necessary sensor interfaces, data displays for quality control and sensor calibration, seabed visualization, and data logging are a standard part of the system, as is integrated seabed acoustical imaging capability (sidescan).

Combined with a higher frequency multibeam echo sounder, such as the EM 710, the EM 122 will provide a total system solution that meets the strictest IHO requirements for all water depths. As proven with the EM 120, an accuracy of better than 0.2% of depth in deep waters is readily achievable with the EM 122.

Operating frequency and coverage sector

The nominal sonar frequency is 12 kHz with an angular coverage sector of up to 150 degrees and and 864 soundings per ping. Achievable swath width on a flat bottom will normally be up to six times (143º) the water depth. The angular coverage sector

is operator controllable or may be set to a fixed range. It may also be set to vary automatically with depth according to achievable coverage. This maximizes the number of usable beams. The sounding spacing is normally equidistant with equiangle available.

Transmission

The transmit fan is split in several individual sectors with independent active steering according to vessel roll, pitch and yaw. This place all soundings on a “best fit” to a line perpendicular to the survey line, thus ensuring a uniform sampling of the bottom and 100% coverage.

With multi-ping which gives two swath per ping the transmit fan is duplicated and transmitted with a small difference in alongtrack tilt. The applied tilt takes into account depth, coverage and vessel speed to give a constant sounding separation alongtrack.

The sectors are frequency coded or have FM chirps, and they are transmitted sequentially at each ping. The sector steering is fully taken into account when the position and depth of each sounding is calculated, as is the refraction due to the sound speed profile, vessel attitude and installation angles. The pulse length and range sampling rate are variable with depth (auto or manual) for best resolution.

In shallow waters due care is taken to the near field effects through nearfield focusing individually applied in the different sectors.

EM 122 applies one focus range for each of the transmit sectors which are used for shallow water environment. Dynamic beam focusing is used for the reception beams.

The ping rate is mainly limited by the round trip travel time in the water up to a ping rate of more than 5 Hz.

Functionality to limit Mammal Harassment

The maximum sound intensity generated by the EM 122 is about 210 dB re 1 µPa. Maximum intensity is encountered in a thin wedge extending below the ship with an angular coverage of about 150 degrees. The intensity level may be lowered by 10 or 20 dB by the operator, at the lowest level the intensity will be less than 180 dB re 1 µPa for ranges larger than 30 m from the transmit transducer. The EM 122 may be set in a mode to begin pinging with a flexible soft-start as a possible means of inducing marine mammals to leave the area of high intensity sound.

Transducer arrays

The EM 122 transducers are linear arrays in a Mills cross configuration with separate units for transmit and receive. The arrays are divided into modules. For both arrays 1 and 2 degrees beamwidths are standard options, and 4 degrees beamwidth is available for the receive array. The resulting array lengths are between 2 and 8 m.

The transmit array can also be delivered with a beamwidth of 0.5 degrees. Non-standard number of modules can be provided to optimize beamwidth in accordance with the vessel hull shape and size.

Post-processing

Postprocessing software is available from all major third-party suppliers.

Optional sub-bottom profiling

The receive transducer is wideband. In conjunction with a separate low frequency transmit transducer, the EM 122 may optionally be delivered with sub-bottom profiling capabilities with a very narrow beamwidth. This system is known as the SBP 120 Sub-Bottom Profiler.

The SBP 120 system capability includes the following items:

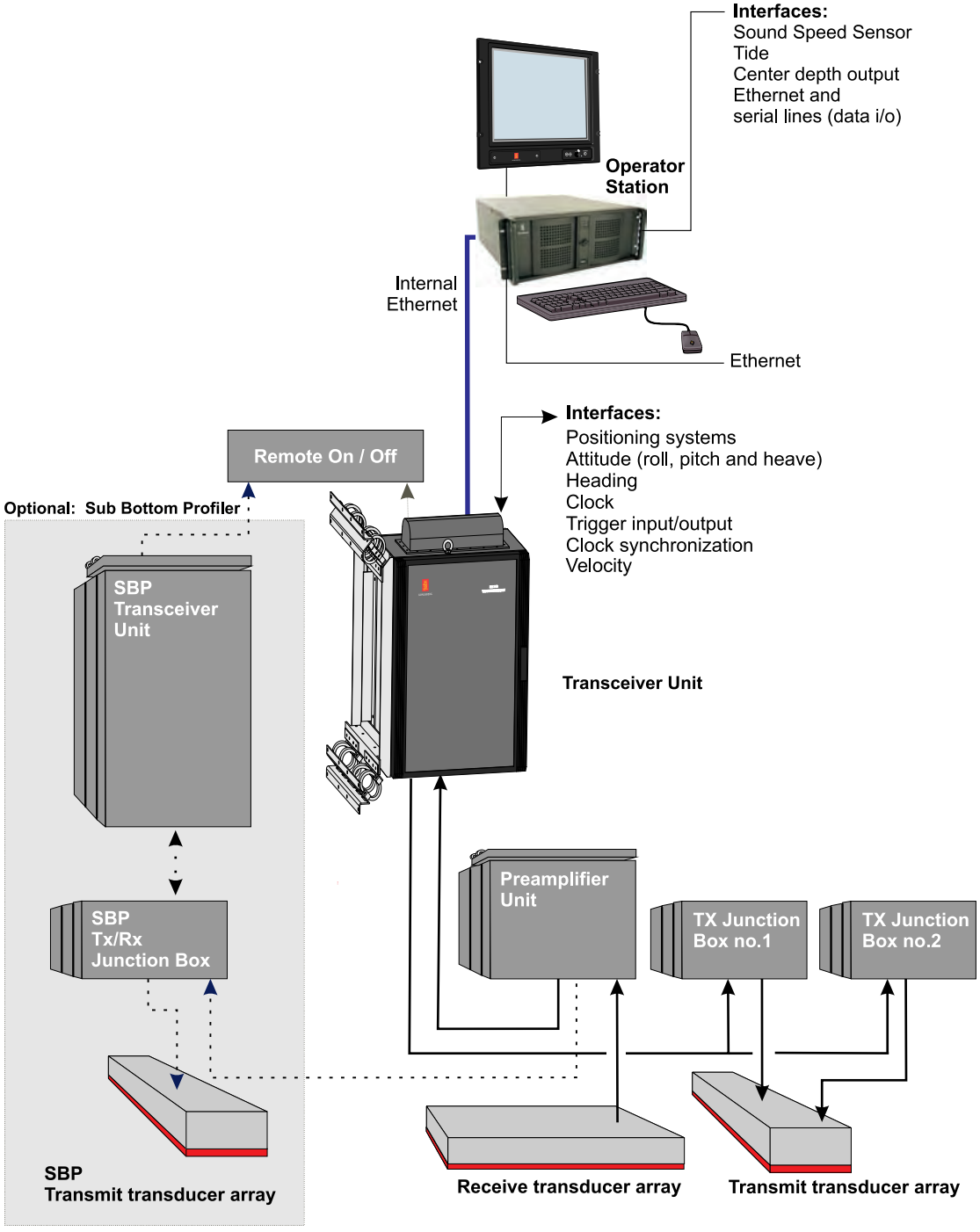
- An additional low frequency transmit transducer array, with the EM 122 hydrophone array being used for reception
- A preamplifier unit to separate the mulitbeam and sub-bottom profiler echoes
- A sub-bottom profiler transceiver unit
- Operator Station(s)

For further information about the SBP 120 system, refer to the applicable product description.

Support

A world-wide marketing and service organization having many years of multibeam experience is in place for supporting the EM 122.

Figure 1 EM 122 system units and interfaces with optional SBP



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System characteristics

Main units

The EM 122 multibeam echo sounder consists of the following units:

- Transmit transducer array
- Receive transducer array
- Transceiver Unit
- Preamplifier Unit
- Operator Station
- Transmit transducer array
- Receive transducer array

A complete mapping system will also include the following additional units:

- Vessel motion sensor(s)
- Heading sensor
- Positioning system(s)
- Sound speed sensor(s)
- Post-processing system

Transducer arrays

The transmit transducer array contains up to 96 modules in accordance with the chosen beamwidth. Each module contains 18 elements arranged in rows of 6 elements. Each element is individually connected to its corresponding transmitter in the Transceiver Unit. It can thus be driven with an unique amplitude level and phase to allow forming of the required transmit sectors with individual steering.

The receive transducer contains up to 16 modules in accordance with the chosen beamwidth. Each module contains 8 transducer staves, and these have individual electrical connections to their corresponding preamplifiers in the Preamplifier Unit. Each stave can thus be given unique amplitude and phase weighting to allow forming of the required receive beams. The receiving hydrophones have a wide bandwidth and can be used also as receivers for the low frequency signals used by the EM 122 sub bottom profiler.

The flat and horizontally mounted transducers of the EM 122 makes the accuracy almost independent of variations in sound speed at the transducer depth, unless the roll and pitch are not too excessive.

Example with 1 m/s sound speed error: For a 70 degree steered beam and a 6 degree roll the error will be 0.23% of depth (angular error of 0.05 degrees). For a 60 degree beam, the error will be 0.06% of depth.

Installation of a sensor to allow real-time measurement of sound speed variation is recommended to avoid a reduction in angular coverage in heavy seas. The system will take into account the sensor measurements in its calculations of beam pointing angles and raybending. The system is prepared for using sound velocity probes from Valeport or AML (others can be added).

Transceiver Unit

The EM 122 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. The same cabinet is used for all combinations of beamwidths (except for 0.5 degree system which needs two TRUs). An Ethernet cable connects the Transceiver Unit to the Operator Station.

The receiver and A/D circuits in the EM 122 have an instantaneous dynamic range of more than 140 dB. The system applies the correct gain offsets after detections.

Raw sample data from the hydrophone channels or beamformed data (water column) are available from the system for data logging and display.

Preamplifier Unit

The EM 122 Preamplifier Unit contains the preamplifiers for the receive signals. The unit also provides the frequency splitting circuitry to feed low frequency signals to the optional SPB 120 Sub-Bottom Profiler.

Tx Junction box(es)

The Tx Junction box serves as an interface routing box for easy transmit transducer cable installation.

Operator Station

The Operator Station of the EM 122 is the Hydrographic Work Station (HWS) high performance PC workstation. The operator software is the Seafloor Information System (SIS) running under Windows XP or Win7.

SIS allows setting the EM 122 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.

The HWS is normally supplied with a 19” industrialized LCD monitor, keyboard and optical mouse. Support for a second monitor is included. Optionally the HWS can support up to 4 monitors.

The HWS is designed for supporting the demands for secure data storage, data presentation and generation of a digital terrain model.

Performance

Basic specifications

The normal operating frequency of the EM 122 multibeam echo sounder is 12 kHz. This frequency is standard for deep ocean echo sounding, and gives a good balance between reasonably small dimensions, narrow beams, and good range capability.

The swath width is typically 6 times the water depth to almost 4000 m depth. A swath width of about 30000 m is generally achievable for deep waters, depending upon bottom conditions and chosen system beamwidth. With a low noise vessel, a swath width of more than 40 km has been achieved.

The system versions with 1 or 2 degree receivers has 288 beams per swath and 576 beams per ping with multiping. The beam pointing angles are automatically adjusted according to achievable coverage or operator defined limits. Two swaths per ping is available to ensure 100% coverage and the same sounding density both along- and acrosstrack.

The beam spacing is normally equidistant, corresponding to 0.7% of depth with 90 degrees angular coverage, 1.2% with 120 degrees and 2% with 140 degrees. Equiangle beam spacing is also available. Using the high density mode, detections or soundings are derived from more than one point within a beam, up to 432 per swath and 864 per ping (with multiping). The number of range samples used per detection is then reduced, effectively corresponding to a decrease in acrosstrack beamwidth and hence higher resolution.

The resulting sounding density is 30% better than that achievable with the conventional equidistant mode, and the horizontal resolution is significantly improved for the outer parts of the swath, so that the resolution is almost uniform over the whole swath.

Operational modes

Deep waters

In deep waters the transmit fan is split into eight different sectors per swath, which are transmitted sequentially within the same ping. This method increases the system source level, and thus the maximum range- and coverage-capability significantly. It is also very important in maintaining high accuracy in the outer beams since it greatly reduces the detrimental interference from acoustic multiples or reflections.

By use of electronic beam-steering during transmission, the sectors are individually tilted alongtrack to take into account the vessel's current roll, pitch and yaw with respect to the survey line heading. The swath can then be stabilized to fall on a line perpendicular to the survey line. Pitch and especially yaw steering in individual sectors is required to guarantee 100% bottom coverage in deep waters.

With the large number of detections available per swath, the sounding density would be higher across than along. To counter this, the EM 122 implements multiping with two swaths per ping. The transmit beams are tilted a little differently alongtrack to ensure near constant sounding spacing of the swaths alongtrack. With a 0.5 degree transmit beam the multiping capability also ensures 100% bottom coverage, and even with a 1 degree beam the footprint overlap will be sufficiently small to a least provide some independence between the measurements.

While the normal pulse length is 15 ms, for deeper waters than about 2500 m, a significantly longer FM chirp pulse waveform will be used for the outer transmit sectors. Its bandwidth corresponds to the resolution of the 15 ms CW pulse, but its duration will allow pulse compression on reception and hence a gain in signal to noise ratio.

Shallow waters

For shallow waters a pulse length of 2 ms is used and the transmit fan is split in four sectors which are stabilized according to vessel roll, pitch and yaw. Note that yaw steering is of importance even at a few hundred meters depth, despite the higher ping rate which is obtained at shallow water. Near-field focusing is applied both on transmit and receive. For transmission a separate focus point is applied to each transmission sector, while dynamic beam focusing is used during reception. These techniques will in practice ensure that the acoustic footprint sizes are according to the beamwidths also inside the nearfield.

For intermediate waters a pulse length of 5 ms is also available to have an optimum range resolution at all depths.

Depth accuracy

The system depth accuracy is very high due to the narrow beams and high range sampling rate used (3 kHz), but most importantly through using the advanced bottom detection methods proven through many years of experience with the Kongsberg range of multibeam echo sounders. Near normal incidence a centre of gravity amplitude detection is employed, but for most of the beams the system uses phase detection.

From all bottom returns, inside a processing window inside a beam, the exact range and angle to the bottom in the centre of the processing window is derived.

The total system error will also depend upon the quality of the positioning, vessel motion and sound speed sensors.

The total system RMS accuracy (assuming good external sensor data and accurate aligned transducers and sensors) is expected to be better than:

- 0.2% of depth (from 0 degrees to 45 degrees re the vertical)
- 0.3% of depth (between 45 and 60 degrees)

- 0.6% of depth (between 60 and 70 degrees)

Note that the achievable accuracy is limited by the transmit pulse which is used (to 0.5 m for 2 ms pulse length, scaleable with pulse length or bandwidth). The signal-to-noise ratio must be better than 10 dB.

Even better accuracy has proven to be achievable. The following figures show examples of standard deviations as observed by the EM 122 installation onboard the Ifremer research vessel L'Atlante. The standard deviations versus beam angle at 2200 meters depth using CW pulses, and at 4500 meters using FM pulses are shown.

Figure 2 Observed standard deviation vs beam angle – 2200 meters depth – CW pulses

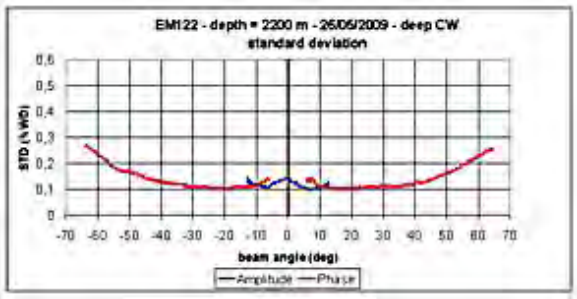
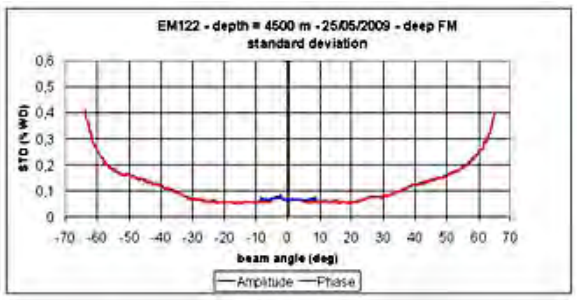


Figure 3 Observed standard deviation vs beam angle – 4500 meters depth – FM pulses



Transducer arrays for individual requirements

System accuracy, resolution and coverage capability improves with decreasing beamwidth, and a beamwidth of 1 x 1 degree with 8 m long transducer arrays is a standard option for the utmost performance. However, long arrays are expensive and may be difficult to install, especially with regard to the receive array which is long athwartship. The transducer array lengths may therefore be tailored to individual requirements. Transmit beamwidth is the most important performance factor, and 1 and 2 degrees transmit beamwidths are standard options, with 0.5 degree as possibility. For the receive array 1, 2 and 4 degrees are standard options. To cater for adaptions to specific vessels, the system software can be adapted to use tranducer arrays with a non-standard number of modules (increased delivery time may be expected).

Horisontal resolution

The horizontal resolution of EM 122 is much improved in relation to previous models, due to the introduction of focused beams (for both transmission and reception) and the new high density signal processing.

Alongtrack resolution

The size of the alongtrack acoustical footprint of the EM 122 transmit beam:

Table 1 Alongtrack acoustical footprint size, 120 degree swath width

Alongtrack footprint for EM 122						
Beamwidth [deg]	0.5		1.0		2.0	
Water depth [m]	Vertical	Outer edge	Vertical	Outer edge	Vertical	Outer edge
50	0.4	1.3	0.9	2.6	1.8	5.2
100	0.9	2.6	1.8	5.2	3.5	10.4
200	1.8	5.2	3.5	10.4	7.0	20.9
400	3.5	10.4	7.0	20.9	14.0	41.9
1000	8.8	26.1	17.5	52.2	35.1	104.4
2000	17.5	52.2	35.1	104.4	70.2	208.8
4000	35.1	104.4	70.2	208.8	140.4	417.6
8000	70.2	151.1	140.4	302.2	280.7	519.5

The alongtrack sounding density, or distance between two consecutive sounding profiles, is a function of the water depth, the swath width, and the vessel speed. One or two profiles are obtained per acoustic ping, so the sounding density is doubled. A narrower swath can be specified by the operator and gives a higher ping rate and thus improved sounding density. In practice, it is useful to apply alongship sampling of 2-3 times per acoustic footprint.

Table 2 Alongtrack profile density, single profile/ping

Calculated ping rate and alongtrack resolution for EM 122							
140 deg swath, one profile per ping							
			Alongtrack distance between profiles [m]				
Water depth [m]	Swath width [m]	Ping rate	4 kn	8 kn	12 kn	16 kn	20 kn
50	275	2.8	0.7	1.4	2.2	2.9	3.6
100	550	1.7	1.2	2.4	3.6	4.8	6.1
200	1100	0.9	2.2	4.4	6.6	8.8	11.0
400	2200	0.5	4.2	8.4	12.5	16.7	20.9
1000	5500	0.2	10.1	20.2	30.3	40.5	50.6
2000	11000	0.1	20.0	40.0	60.0	80.0	100.0
4000	22000	0.06	39.8	79.6	119.4	159.1	198.9
8000	30000	0.04	57.7	115.4	173.0	230.7	288.4

Table 3 Alongtrack profile density, two profiles per ping

Calculated ping rate and alongtrack resolution for EM 122

140 deg swath, two profiles per ping							
			Alongtrack distance between profiles [m]				
Water depth [m]	Swath width [m]	Ping rate	4 kn	8 kn	12 kn	16 kn	20 kn
50	275	2.8	0.4	0.7	1.1	1.4	1.8
100	550	1.7	0.6	1.2	1.8	2.4	3.0
200	1100	0.9	1.1	2.2	3.3	4.4	5.5
400	2200	0.5	2.1	4.2	6.3	8.4	10.4
1000	5500	0.2	5.1	10.1	15.2	20.2	25.3
2000	11000	0.1	10.0	20.0	30.0	40.0	50.0
4000	22000	0.06	19.9	39.8	59.7	79.6	99.5
8000	30000	0.04	28.8	57.7	86.5	115.4	144.2

Crosstrack resolution

The crosstrack resolution is determined by the sounding density and the effective acoustic footprint which is applied to each sounding. By the high density signal processing, the effective acoustic footprint is controllable and constant for all soundings derived from phase detections, which in practice means all soundings except for some few at the vertical or specular incidence angle. This is a great achievement, and gives a nearly constant physical size of sounding spots over the whole swath.

The normal setting is a crosstrack acoustic footprint size of 200% of the crosstrack sounding interval. The 1 and 2 degree receiver array versions have 432 soundings per profile, while the 4 degree receivers have 216 soundings per profile. Since the swath width is operator controllable, the sounding density can be completely controlled by the operator. Our calculations are made for a 140 degree swath width.

Table 4 Size of acoustic footprint in crosstrack direction, high density mode

Crosstrack – acoustic footprint sizes for EM 122

140 deg swath, one profile per ping					
Water depth [m]	1 deg RX center	2 deg RX center	90 deg	120 deg	140 deg
50	1	2	0.5	1	1
100	2	4	1.0	2	3
200	4	7	2.0	3	5
400	7	14	4.0	6	10
1000	18	35	9.0	16	25
2000	35	70	19.0	32	51
4000	70	140	37.0	65	102
8000	140	281	74.0	130	

Table 5 Spacing between neighbour soundings in crosstrack direction, high density mode

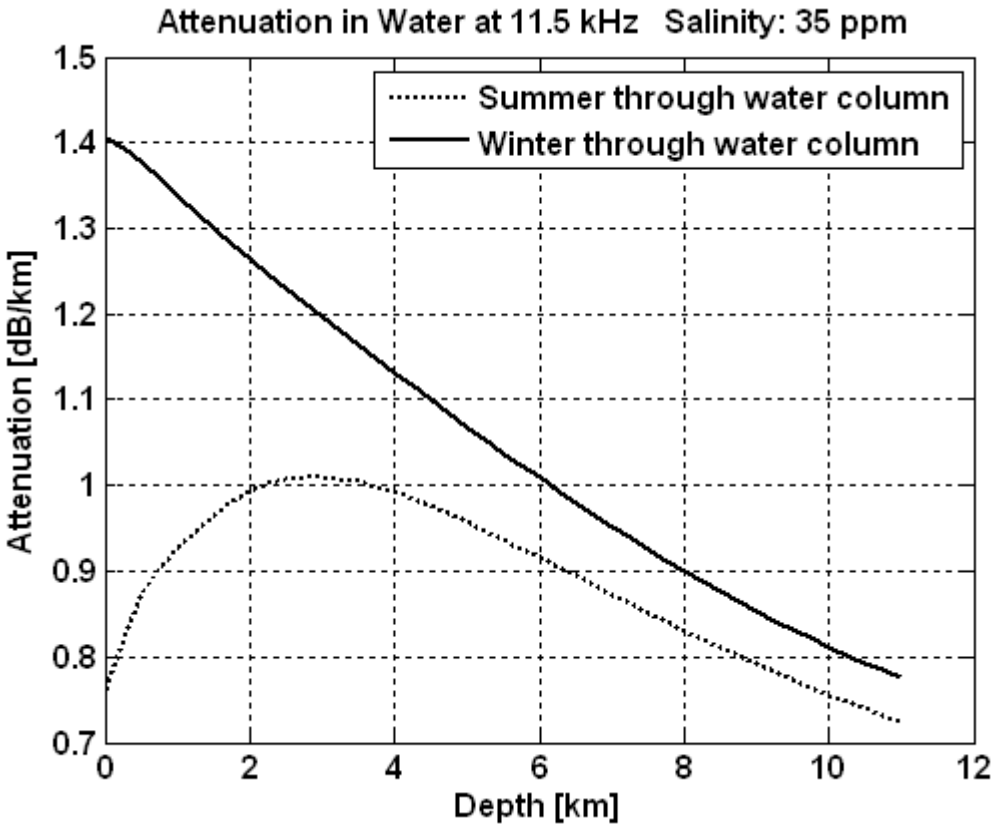
Crosstrack sounding density for EM 122			
432 soundings per profile			
	Swath widths		
Water depth [m]	90 deg	120 deg	140 deg
50	0.2	0.4	0.9
100	0.5	0.8	1.7
200	0.9	1.6	3.5
400	1.9	3.2	6.9
1000	4.6	8.1	17.4
2000	9.3	16.2	34.7
4000	18.5	32.4	69.3
8000	37.0	64.8	—

EM 122 swath width calculations

Attenuation curves

The signal attenuation is measured in units of decibels per unit length of a given medium (dB/km) and is represented by the attenuation coefficient (α) of the medium in question. The attenuation is frequency, temperature, salinity and depth dependent.

The figure below shows the attenuation through the water column in dB/km versus water depth of the EM 122 signal at 11.5 kHz. The attenuation figures are calculated for typical summer and winter conditions. Salinity is 35 ppm.



Coverage curves

Coverage curves have been calculated for the following EM 122 options:

- 0.5 by 1° system
- 1 by 1° system
- 1 by 2° system
- 2 by 2° system
- 2 by 4° system
- Cold ocean water
- Warm ocean water
- Vessel noise level (NL) of 45, 55 and 65 dB
- Three different bottom surfaces, characterized by backscatter strengths of -20, -30 and -40 dB. This corresponds to bottom surfaces composed theoretically of gravel, sand and mud respectively.

The coverage curves are presented in two different ways. Either three curves are presented together for three different bottom types and constant noise levels and absorption, or three curves with different noise level and one bottom type. All used parameters are plotted in the figure.

The calculation shown on the following pages assume constant sound velocity throughout the water column and a spectral isotropic noise level.

At the end of this section, a coverage curve is included that shows measured coverage from four ships equipped with EM 122. From one of the ships coverage values were also available when the ship operated a EM 120. See *Observed coverage, four EM 122 installations* on page 24.

EM 122 coverage; 0.5 by 1 degree system

Figure 4 Cold ocean water, NL = 45 dB

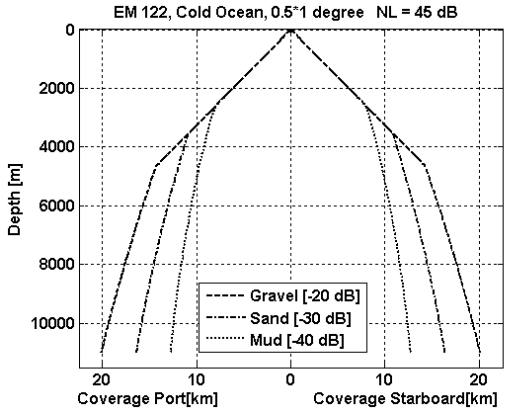


Figure 5 Warm ocean water, NL = 45 dB

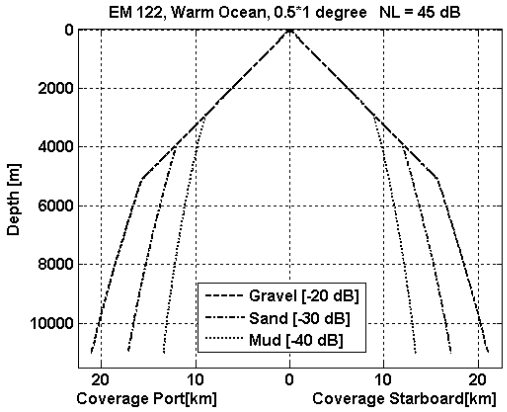


Figure 6 Cold ocean water, NL = 55 dB

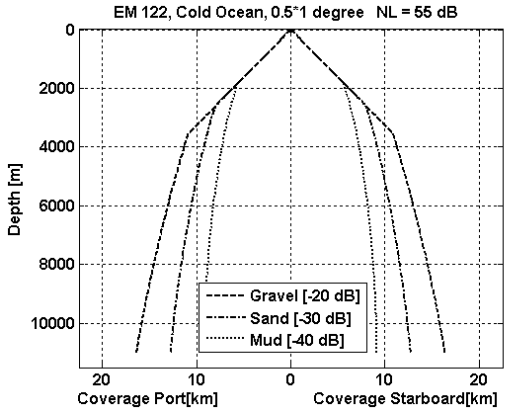


Figure 7 Warm ocean water, NL = 55 dB

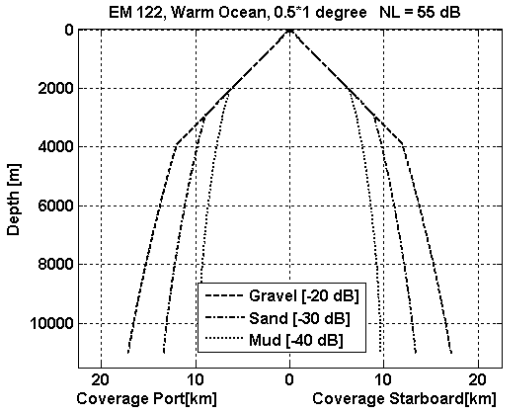


Figure 8 Cold ocean water, NL = 65 dB

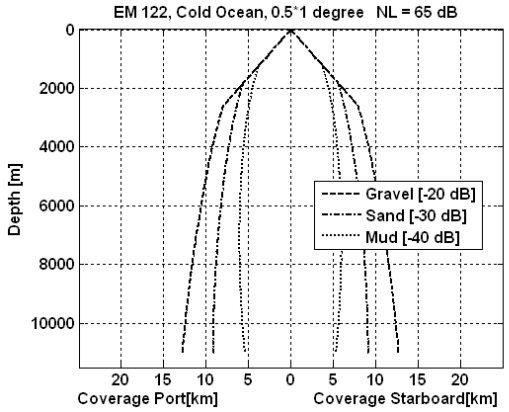
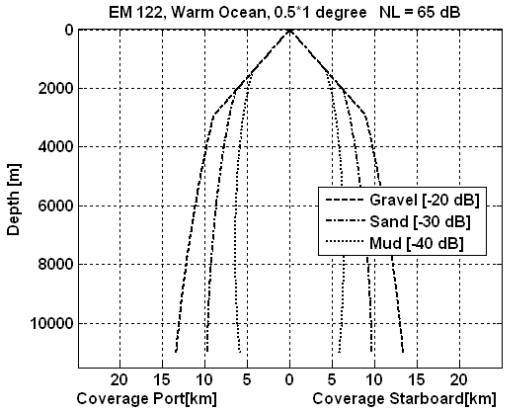


Figure 9 Warm ocean water, NL = 65 dB



EM 122 coverage; 1 by 1 degree system

Figure 10 Cold ocean water, NL = 45 dB

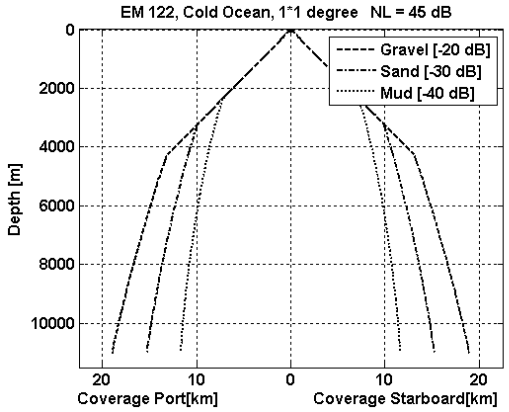


Figure 11 Warm ocean water, NL = 45 dB

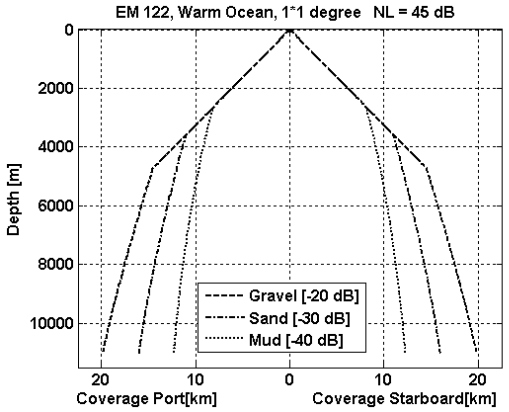


Figure 12 Cold ocean water, NL = 55 dB

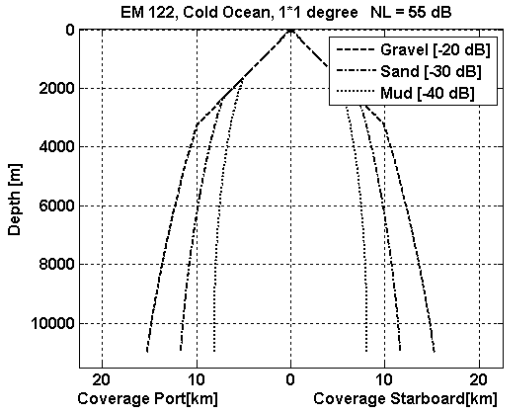


Figure 13 Warm ocean water, NL = 55 dB

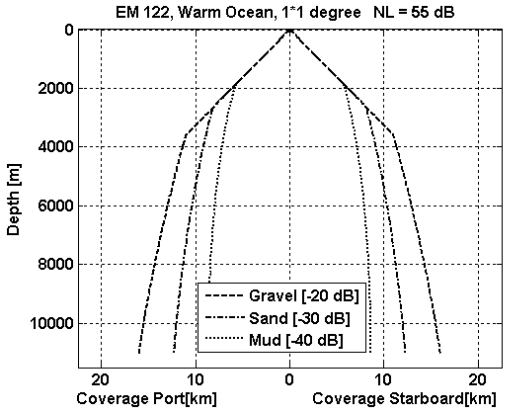


Figure 14 Cold ocean water, NL = 65 dB

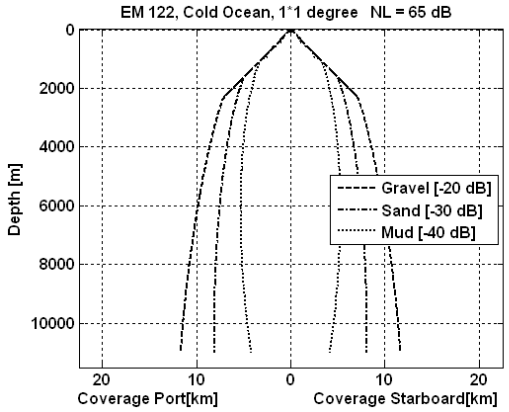
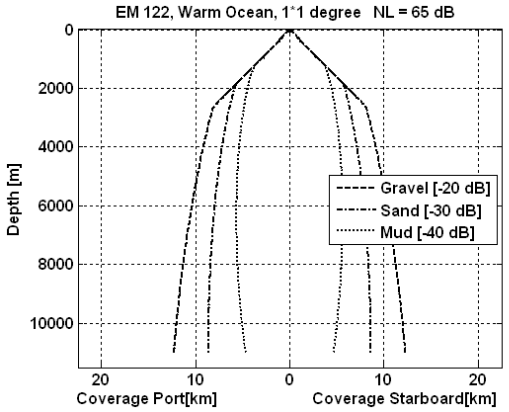


Figure 15 Warm ocean water, NL = 65 dB



EM 122 coverage; 1 by 2 degree system

Figure 16 Cold ocean water, NL = 45 dB

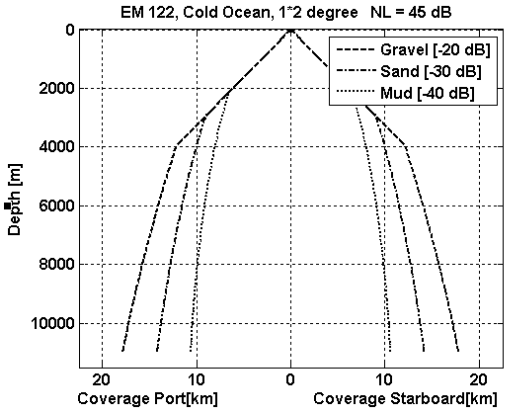


Figure 17 Warm ocean water, NL = 45 dB

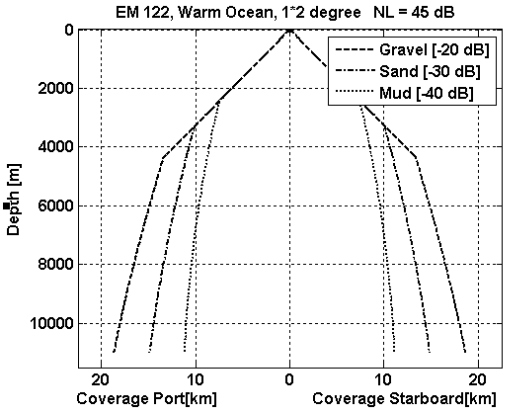


Figure 18 Cold ocean water, NL = 55 dB

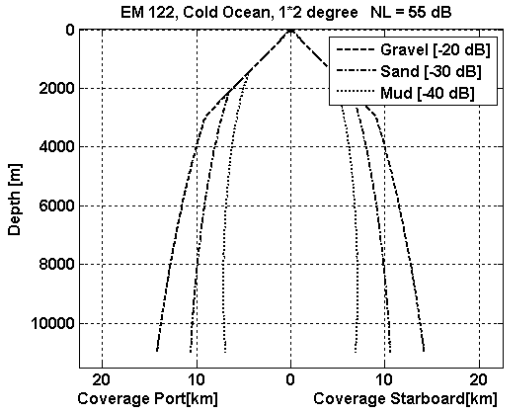


Figure 19 Warm ocean water, NL = 55 dB

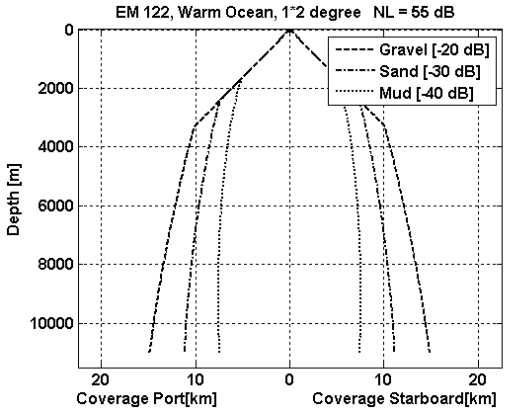


Figure 20 Cold ocean water, NL = 65 dB

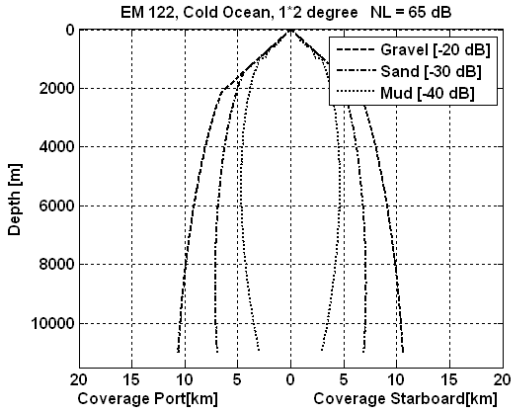
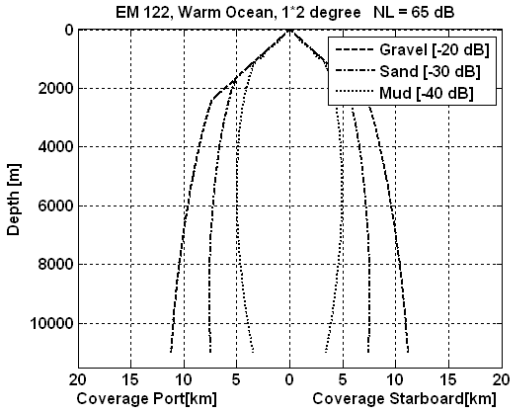


Figure 21 Warm ocean water, NL = 65 dB



EM 122 coverage; 2 by 2 degree system

Figure 22 Cold ocean water, NL = 45 dB

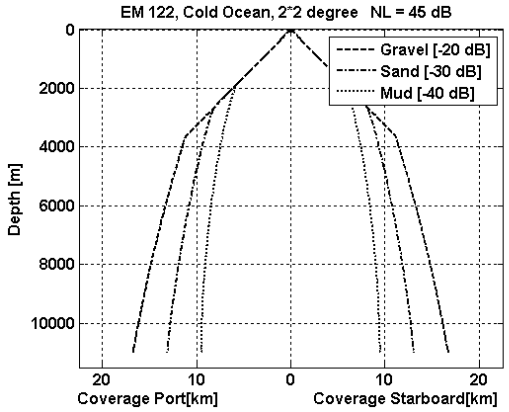


Figure 23 Warm ocean water, NL = 45 dB

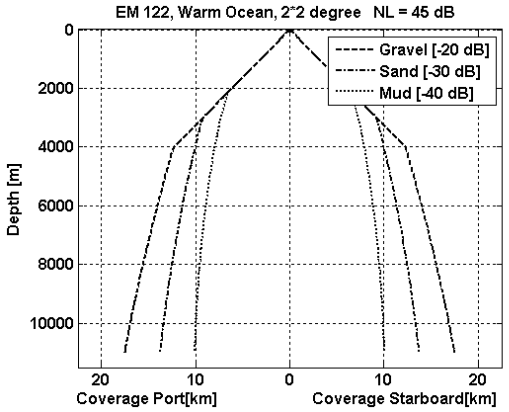


Figure 24 Cold ocean water, NL = 55 dB

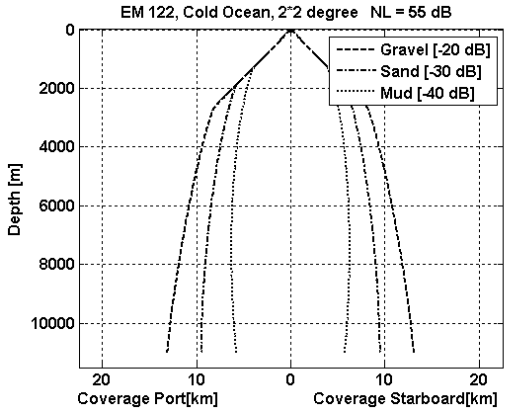


Figure 25 Warm ocean water, NL = 55 dB

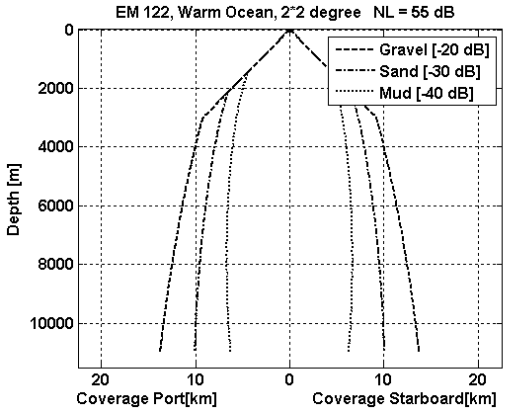


Figure 26 Cold ocean water, NL = 65 dB

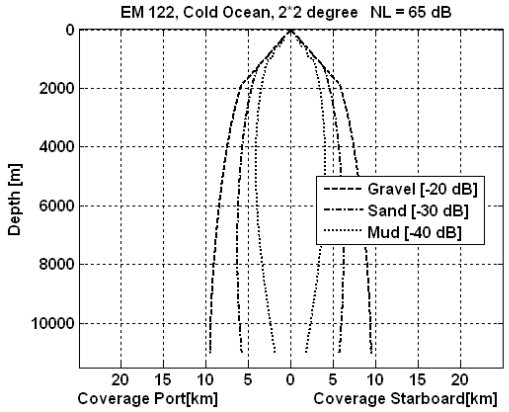
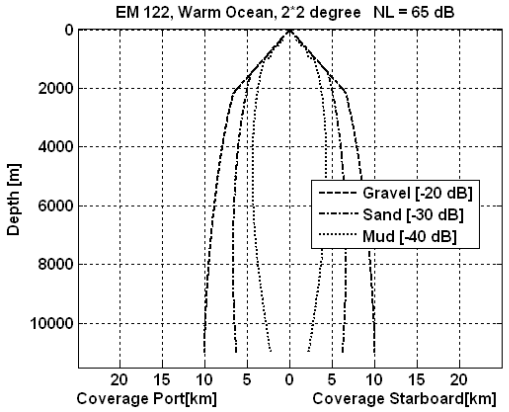


Figure 27 Warm ocean water, NL = 65 dB



EM 122 coverage; 2 by 4 degree system

Figure 28 Cold ocean water, NL = 45 dB

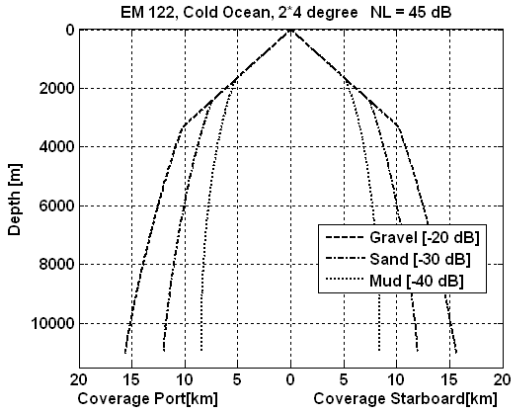


Figure 29 Warm ocean water, NL = 45 dB

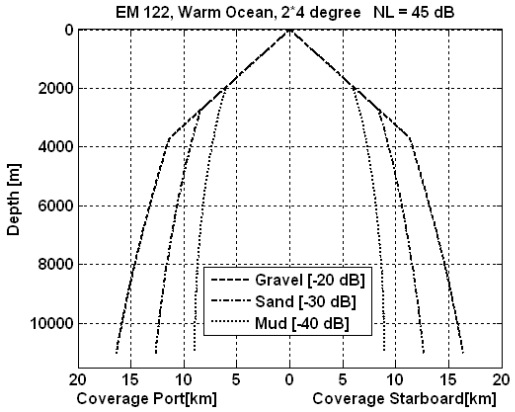


Figure 30 Cold ocean water, NL = 55 dB

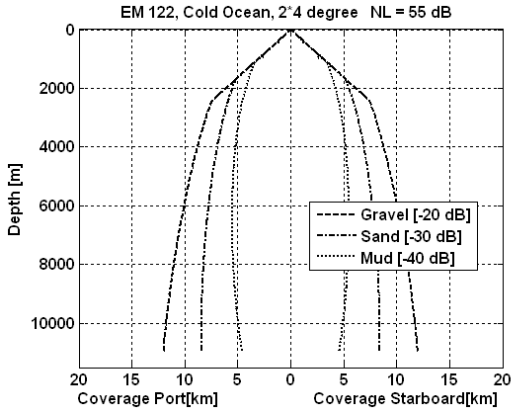


Figure 31 Warm ocean water, NL = 55 dB

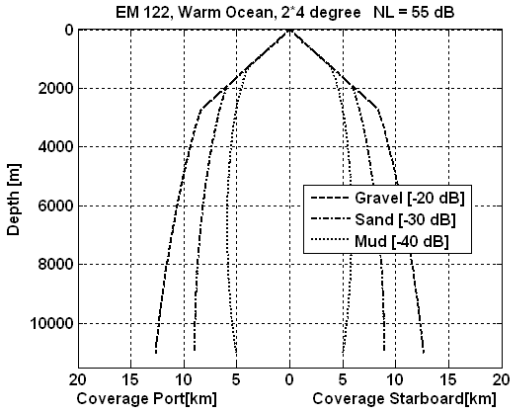


Figure 32 Cold ocean water, NL = 65 dB

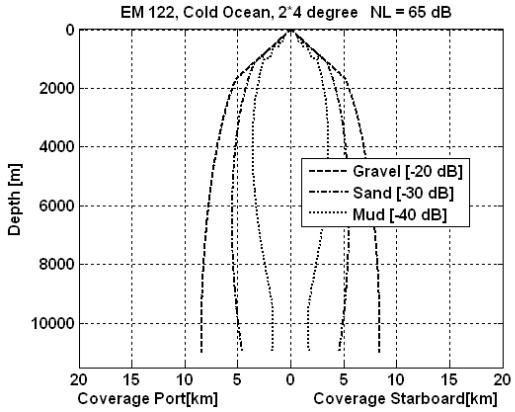


Figure 33 Warm ocean water, NL = 65 dB

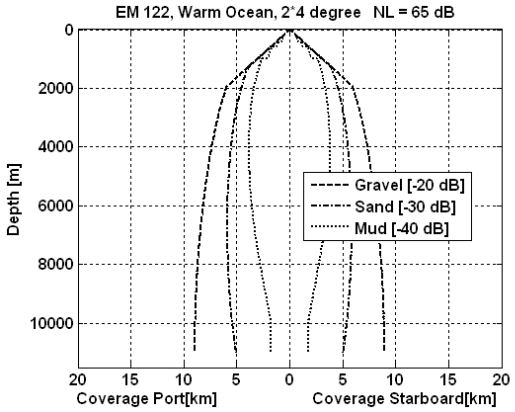
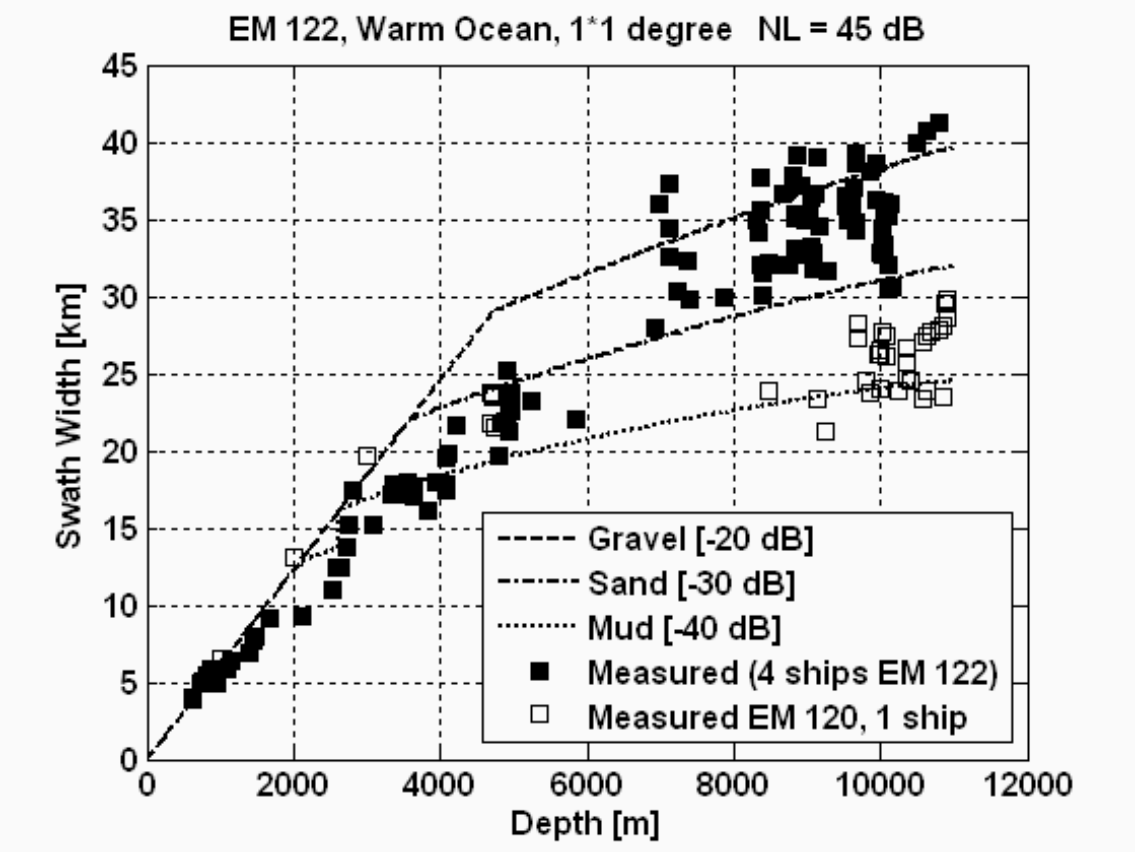


Figure 34 Observed coverage, four EM 122 installations



Installation

Introduction

The compactness of the EM 122 multibeam echo sounder is a guarantee for a fast and easy installation.

Operator Station and electronic cabinets

The Operator Station is usually mounted in a rack or placed on an appropriated working table in the operation room and suitably secured. The TX Junction Box(es) and the Preamplifier Unit are intended to be mounted on a bulkhead in a room close to the transducers to reduce the amount of cabling. The Transceiver Unit is usually installed in the same room, but may be moved elsewhere to allow for easier access.

Transducer arrays

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

The transducer modules are fixed to a frame with bolts from the front. The frames may either be mounted directly on or recessed into the hull, or within sea chests. The latter solution may be somewhat more expensive, but will ensure that the transducers are properly mounted within the tolerances required. A fairing will usually be added around the transducers to ensure a laminar water flow without any aeration problems. Ice protection windows may be added if required, but angular coverage may then be restricted.

A blister or gondola installation will usually help in avoiding air bubble blockage of the transducers and may contain additional transducers for other systems.

The cables from the modules have a standard length of 25 m, and are terminated with connectors which plug directly into the Preamplifier Unit cabinet or Tx Junction box(es). Normally the cables enter the hull through tubes which are fitted with standard ship type cable glands (Roxtec or equivalent) to provide water tightness. The cable glands should be of the type having a pressure rating of 4 bars or more. The glands should be installed above the vessel water-line. If the tubes end below the water-line, classification requirements may require a double set of glands.

Ice Protection Windows

Two types of acoustic protection windows can be offered:

- Light ice class
- Ice breaker version

In both cases the protection for the TX array is a reinforced structure which is potted by a material which is acoustically transparent, and titanium for the RX array. The difference in strength, dimensions and cost is however substantial. Unless the vessel is carrying out operations in significantly ice infested waters, it is recommended not to use any protection on the outside of the transducer arrays.

Note

All ice protection windows provided by Kongsberg Maritime are pressure tested and comes with a certificate.

Figure 35 The blister for the EM 122 transducer arrays

Figure 36 Transducer element installation for the EM 122

Figure 37 Flush installation blister for the EM 122

Operation

System features

The EM 122 multibeam echo sounder is controlled from the HWS Operator Station using a standard click and point graphical user interface. The software, Seafloor Information System (SIS), run under Microsoft Windows on the HWS. 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 122 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.

The SIS system includes optionally an automatic calibration facility. Parameters critical to data quality are password protected, and 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 0.1 dB resolution, is available in two forms, one with down to 0.4 meter range resolution nominally corrected for the effect of incidence angle, the other given per beam without corrections for incidence angle applied. The imagery data may be useful for object/wreck detection, but the most important application is probably geophysical for characterization of the seabed.

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 122. These include:

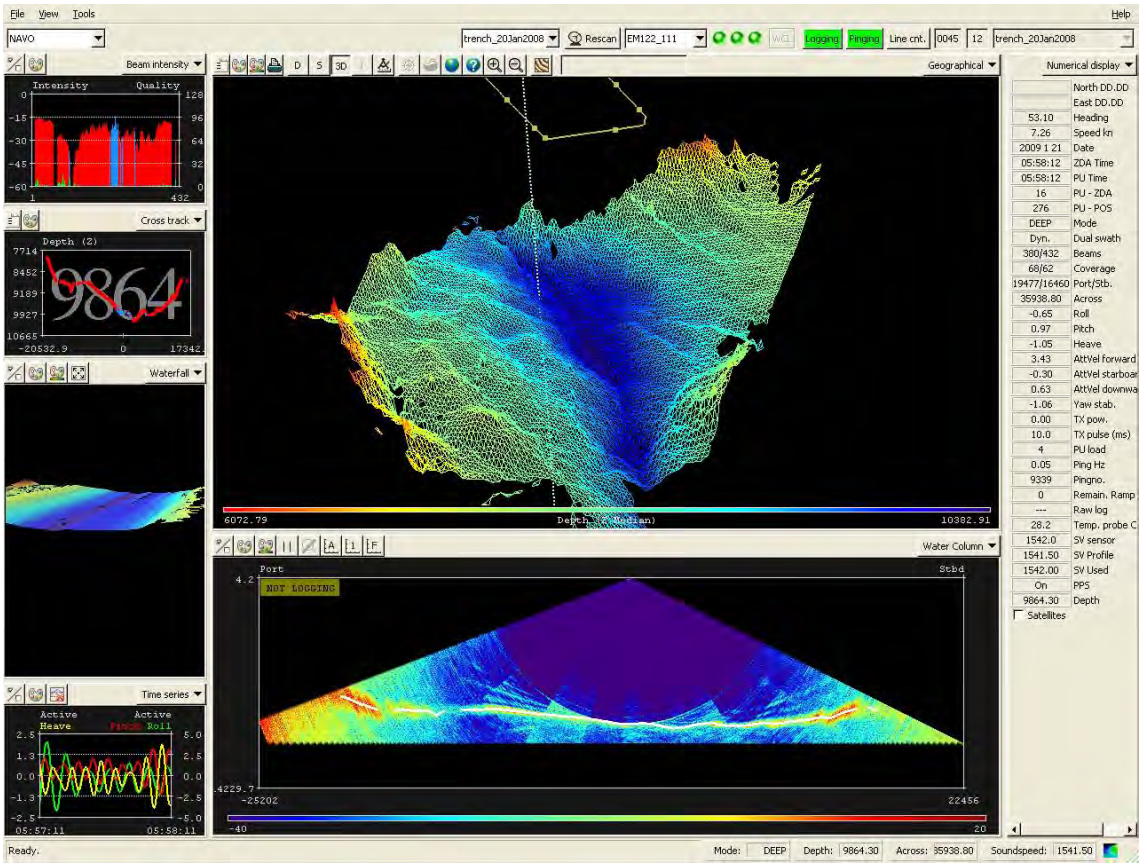
- Cross-track depth profiles
- Beam intensities and quality measures
- Time series display of beam samples and sensor values
- 3D waterfall display

- Sound speed profile display and editor
- Water column display
- Stave display

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 several 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 38 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.

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 operating system for data export, plotting and printing

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

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. The disks are optionally mounted in mobile storage bays, and may thus be removed for security reasons or for transporting the acquired data. The stored data may be written to DVD at any time. The Firewire, SATA and the 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 datagram

  - In each depth datagram range/angle data from one ping have been merged with position and 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 datagram are suited for immediate presentation in the geographical display.
- Seabed image data
- System parameter settings
- Beamformed water column data (licence required)

The gridded data (terrain model) is also available for export. The data formel is specified in the SIS operator manual.

The data formats are public and published on the Kongsberg Maritime web site, ensuring that EM 122 is a truly open solution, allowing third party or own software to be developed for data processing.

Post processing

Post-processing options

The high quality data produced by the EM 122 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 122 bathymetric data. Interfaces to other post-processing software is also available.

Caris HIPS/SIPS post processing

Caris is a well known suite of programs for processing of hydrographic data, developed and maintained by the Canadian company Caris. Caris can offer a complete processing environment, taking care of all steps until the final mapping products - both on paper and electronic form (S-57). Caris HIPS can import data from SIS and is integrated with CUBE (Combined Uncertainty and Bathymetry Estimator, by University of New Hampshire).

IVS 3D, Fledermaus, 3D visualization and analysis software

Fledermaus is a high capacity, interactive software for visualizing large geographical data sets, developed and maintained by the Canadian company IVS 3D (Interactive Visualisation Systems). It also has interactive 3D functionality for editing soundings, and is integrated with CUBE. It is an efficient tool for inspecting survey results, can also create fly-through videos.

Geocap Seafloor

Geocap Seafloor is a software package for multibeam data processing and seabed mapping. It offers a full range of bathymetric processing covering everything from interfacing sensor data to final plot generation. The system has advanced processing, mapping and presentation features, including colours and sophisticated 3D functionality. Geocap Seafloor is developed by the Norwegian company Geocap AS.

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 122 system. We will also - upon request - prepare proposals for the supply of complete instrument packages and/or systems. A project manager will be appointed to supervise the delivery, installation and testing of larger instrumentation systems.

The installation and final testing of an EM 122 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 system check-out and final testing

Documentation and training

The EM 122 is delivered with complete documentation for installation, operation and maintenance. If required, the manuals may optionally be modified 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 or by a dedicated support e-mail address 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 – Forum for exchange of mutual multibeam experience

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 24 months intervals. Close to 100% user participation has been experienced at these meetings.

Warranty and maintenance contract

The normal warranty period of the EM 122 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 a life-time warranty of transducers, upgrading of spare parts and documentation, and repeated or additional training courses.

Scope of supply and options

Standard system

A basic EM 122 multibeam echo sounder delivery includes:

- Operator Station HWS with 19” LCD monitor
- Transducer modules. These include necessary transducer cables (25 m length) and mounting frames in accordance with chosen beamwidths
- Preamplifier Unit
- Transceiver Unit
- TX Junction Box(es)
- Signal and control cables between cabinets. Standard length is 5 m
- Ethernet cable (Gigabit) between Transceiver Unit and Operator Station.
- All system software
- System manuals covering system installation, operation and maintenance

Options

System options available include:

- Sea chests for transducers
- Ice protection windows, light ice class or icebreaker strength
- Non-standard number of transducer modules
- Raw data logger
- Helmsman Display and/or additional monitors
- Automatic calibration software
- Postscript colour graphic printer/plotter
- High resolution grayscale recorder for continuous seabed image hardcopy
- Spare parts
- SBP 120 Sub-Bottom Profiler system
  - Customized documentation

External sensors

A number of external sensors are required for the EM 122, to provide the following data:

- Vessel position

- Vessel heading
- Vessel motion: heave, roll, pitch and velocity
- Sound velocity at the transducer
- Sound velocity profile through the water column

A complete suite of sensors can be offered. Preferred suppliers are Kongsberg Seatex, Applanix, AML and Valeport.

Data Processing softwares

Complimentary to the EM 122, the following software products may be delivered:

- Cfloor
- Fledermaus interactive 3D visualization
- CARIS HIPS/SIPS post processing

Additionally Kongsberg Maritime may deliver the EM 122 as part of a complete scientific suite. This may include integration with single beam echo sounders and/or other multibeam echo sounders for seamless coverage of any depth range.

An integrated scientific suite 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 the main suppliers like Applanix , iXSEA, Coda, Kongsberg Maritime

  - Heading NMEA 0183 HDT or SKR82/LR60 or EM attitude format

  - Positions in either Simrad 90, NMEA 0183 GGA or GGK format

  - External clock in NMEA 0183 ZDA format, Trimble UTC

  - 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
- Ethernet interface for velocity input needed for Doppler compensation in chirp mode.
- HWS interfaces:
  - Ethernet interface for input of sound speed profile, tide and echo sounder depths, and output of all data normally logged to disk
  - Firewire interface for external data storage, printing or plotting
  - Parallel interface for Postscript colour graphics
  - Printer/plotter

Physical specifications

Transmit transducer

- Module:
  - Length: 179 mm / 131.4 mm
  - Width: 760 mm (780 mm with frame)
  - Height: 197 mm (261.5 mm with 1 degree frame, 249.5 mm with 2 degrees frame)
  - Weight: 58 kg
- Frame length:
  - 15200 mm (0.5 degree)
  - 7770 mm (1 degree)
  - 4020 mm (2 degrees)

Receive transducer

- Module:
  - Length: 447 mm
  - Width: 342 mm (420 mm with frame)
  - Height: 120 mm (177 mm with frame)
  - Weight: 24 kg
- Frame length:
  - 7200 mm (1 degree)
  - 3600 mm (2 degrees)
  - 1808 mm (4 degrees)

Receive transducer ice window

- Tx – Weight in air/water: 200 kg / 55 kg
- Rx – Weight in air/water: 530 kg / 412 kg (1 degree)
- Rx – Weight in air/water: 310 kg / 241 kg (1 degree)

Transceiver Unit

- Height: 1107 mm
- Width: 540 mm
- Depth: 750 mm
- Weight: Approximately 200 kg

Preamplifier Unit

- Height: 920 mm
- Width: 600 mm
- Depth: 630 mm
- Weight: Approximately 96 kg

TX Junction Box

- Height: 440 mm
- Width: 500 mm
- Depth: 303 mm
- Weight: Approximately 15 kg

Operator Station

- Height: 4U — 178 mm
- Width: 427 mm (excluding rack fixing brackets)
- Depth: 480 mm (excluding handles and connectors)
- Weight: Approximately 20 kg
- Power: 115 Vac (60 Hz) and 230 Vac (50 Hz), < 250 W

19” inch LCD monitor

- Height: 444 mm (excluding mounting brackets)
- Width: 483 mm (excluding mounting brackets)
- Depth: 68 mm (excluding mounting brackets)
- Weight: 12 kg (approximately with bracket)
- Power:115 Vac (60 Hz) and 230 Vac (50 Hz), 100 W (max)

Dual swath restrictions

In shallow water dual swath is switched off to get enough separation between the transmitted pulses. Dual swath is turned off below 30 meter, and turned on at 50 meter. This hysteresis is used to get stable operation when the water depth is fairly constant.

FM mode is used to extend the maximum range capability. Since the relative ping rate increases at large depths (caused by reduced angular coverage), the need for dual swath decreases with depth. In the Very Deep mode (i.e. from 9000 meters) long FM pulses are prioritized, so dual swath is not available in this mode.

Surface finish

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

Power requirements

Fuse

- The single phase supply must be protected with minimum 16A slow-blow fuses (230Vac)

Operational voltage and frequency

- AC voltage: 115/230 Vac ±10%, 47 – 63 Hz

Acceptable transients

- Short time (max. 2 sec): ± 20%, 42 – 69 Hz
- Spikes (max. 50µs): < 1000 V

Transceiver Unit

- 0.5° x 1°: < 2000W
- 1° x 1°: < 2000W
- 1° x 2°: < 1900W
- 2° x 2°: < 1200W
- 2° x 4°: < 1200W
- The single phase supply must be protected with 16A slow-blow fuses.

Operator Station: < 250W

LCD monitor: < 60W

Preamplifier Unit: < 300W

Tx Junction Box: None

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.

Environmental and EMC specifications

Environmental and EMC specifications

Reference standards

- IEC 60945, IACS E10
- EMC Noise emission: EN61000-6-4
- EMC Noise immunity: EN61000-6-2

IP grade

- Operator Station(HWS) and LCD monitor: IP22
- Transceiver Unit: IP54

TRU

- **Vibration:**
  - 5–150 Hz
  - 1 g
- **Shock:**
  - Peak acceleration: 15 g
  - Half sine pulse
  - Duration: 11 ms
- **Storage Temperature:**
  - -30 to +70ºC for TRU
  - -20 to +60ºC for TD
- **Operation Temperature:**
  - - 5 to +50ºC for TRU and TD
  - 0 to +50ºC for HWS
- **Humidity:** @55ºC : 95%RH
- **Power Supply variation:** @115V/230V and @60/50Hz
  - Voltage ±10%
  - Frequency ± 5%

System performance data

System performance data

- Main operational frequency: 12 kHz

  - Frequencies in the range of 10.5 to 13.5 kHz are employed to code the different transmit sectors.
- Maximum ping rate > 5 Hz
- Beamwidths: 0.5x1, 1x1, 1x2, 2x2 or 2x4 degrees

  - Other beamwidth combinations are possible in accordance with the number of transducer modules installed.
- Beam spacing: Equidistant, equiangle or in between
- Coverage sector: Up to 150 degrees
- Transmit beam steering: Stabilized for roll, pitch and yaw
- Receive beam steering: Stabilized for roll
- Depth range from transducers: 20 to 11.000 metres
- Pulse forms:
  - 2, 5, 8 and 15 ms CW pulse and
  - FM chirp: 25 – 100 ms
- Range sampling rate: >3 kHz (25 cm)

	Number of beams and soundings			
System version	0.5 x 1 and 1 x 1	1 x 2	2 x 2	2 x 4
Number of beams/swath	288	288	288	144
Number of soundings/swath	432	432	432	216
Number of swaths	2	2	2	2
Number of soundings/ping Dual swath	864	864	864	432

Doppler shifts

All new generation of multibeam echo sounders from Kongsberg Maritime have an extended range performance by use of a frequency modulated transmitter pulse (FM), also called chirp pulse. In the FM mode, the Doppler shift made by the movements of the survey vessel relative to the bottom, causes a range error. This error must be corrected.

The following motion sensors have specifications that fullfills our requirements for doppler shift corrections:

- Applanix Pos MV
- Coda Octopus F180
- Kongsberg Maritime Seapath 200 and 300
- IXSEA Phins

Requirements for the velocity input via ethernet

- Velocity: 0.03 m/s RMS
- Roll, pitch and yaw rate: 0.03 deg/s RMS
- Latency: Maximum 5 ms
- Update rate: 100 Hz

Outline dimensions

Figure 39 Outline dimensions Transceiver unit

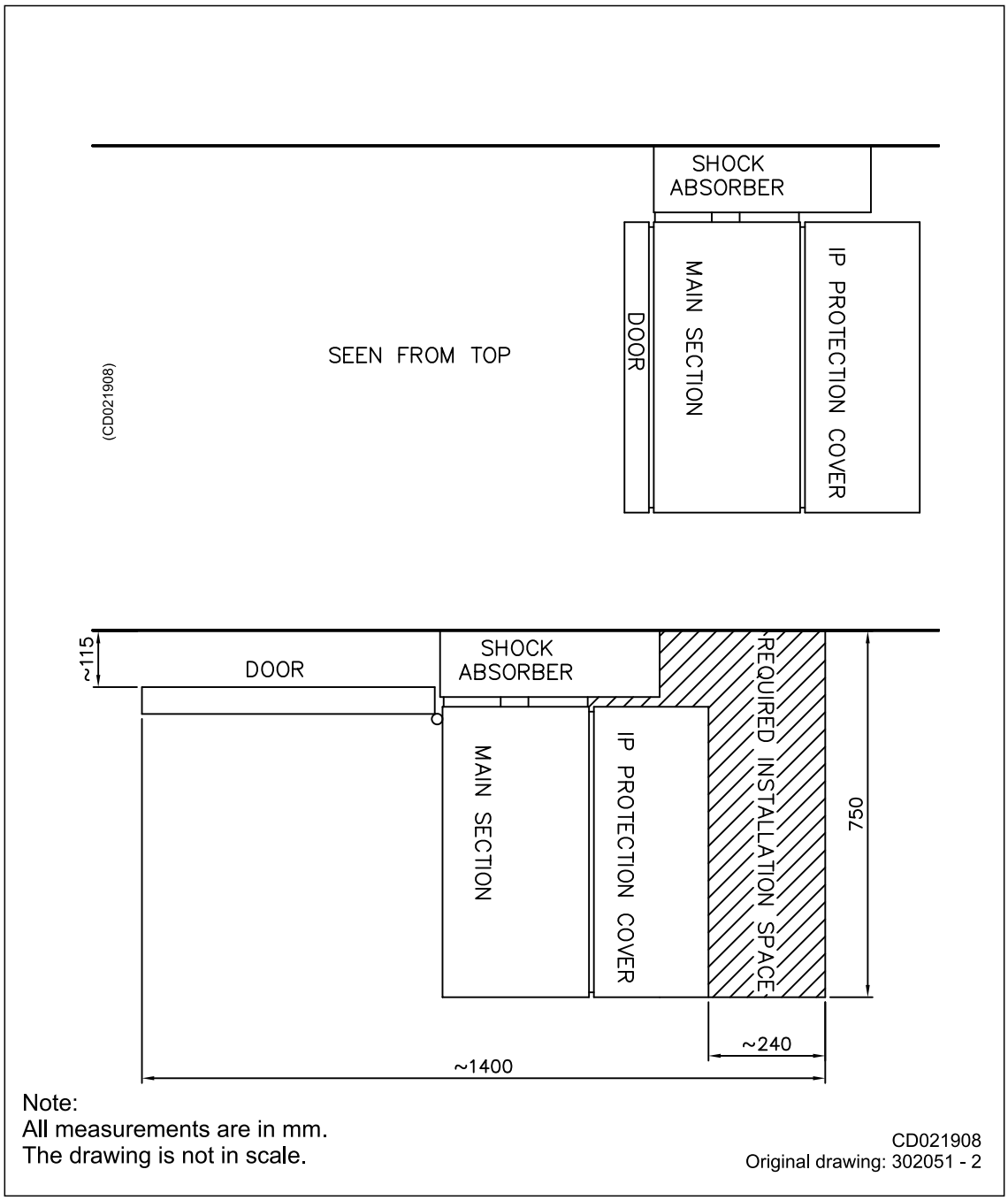


Figure 40 Outline dimensions Transceiver unit

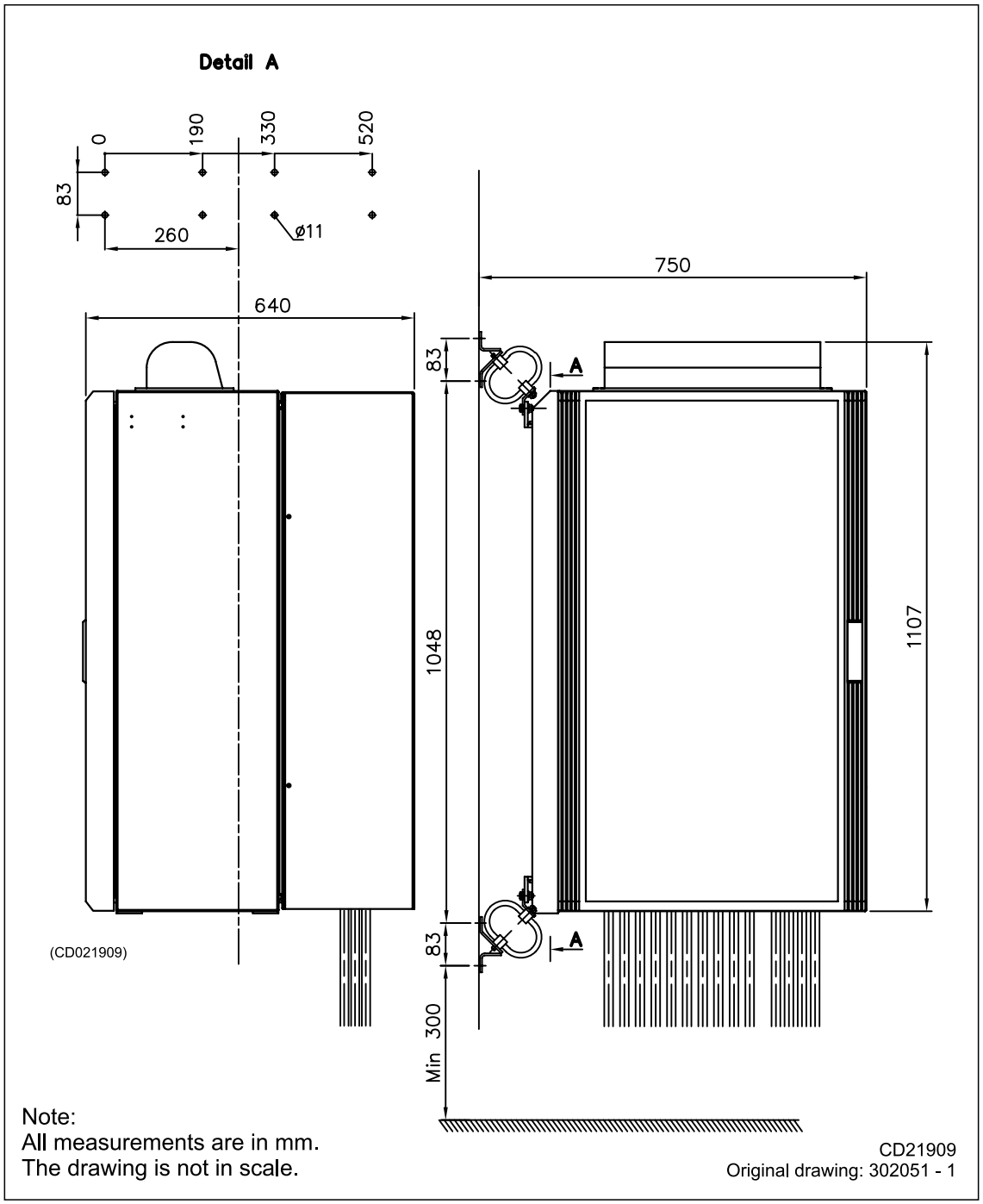
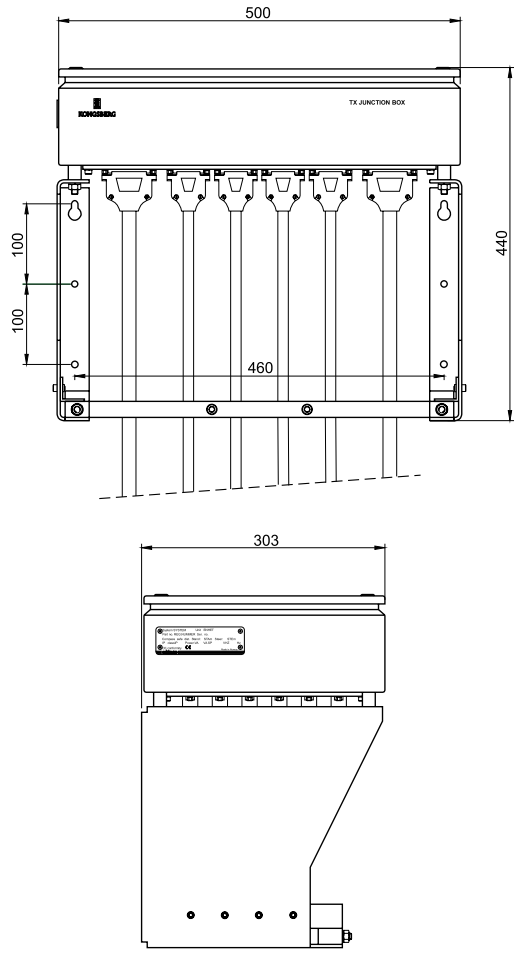


Figure 41 Outline dimensions Tx Junction Box



Note:
All measurements are in mm.
The drawing is not in scale

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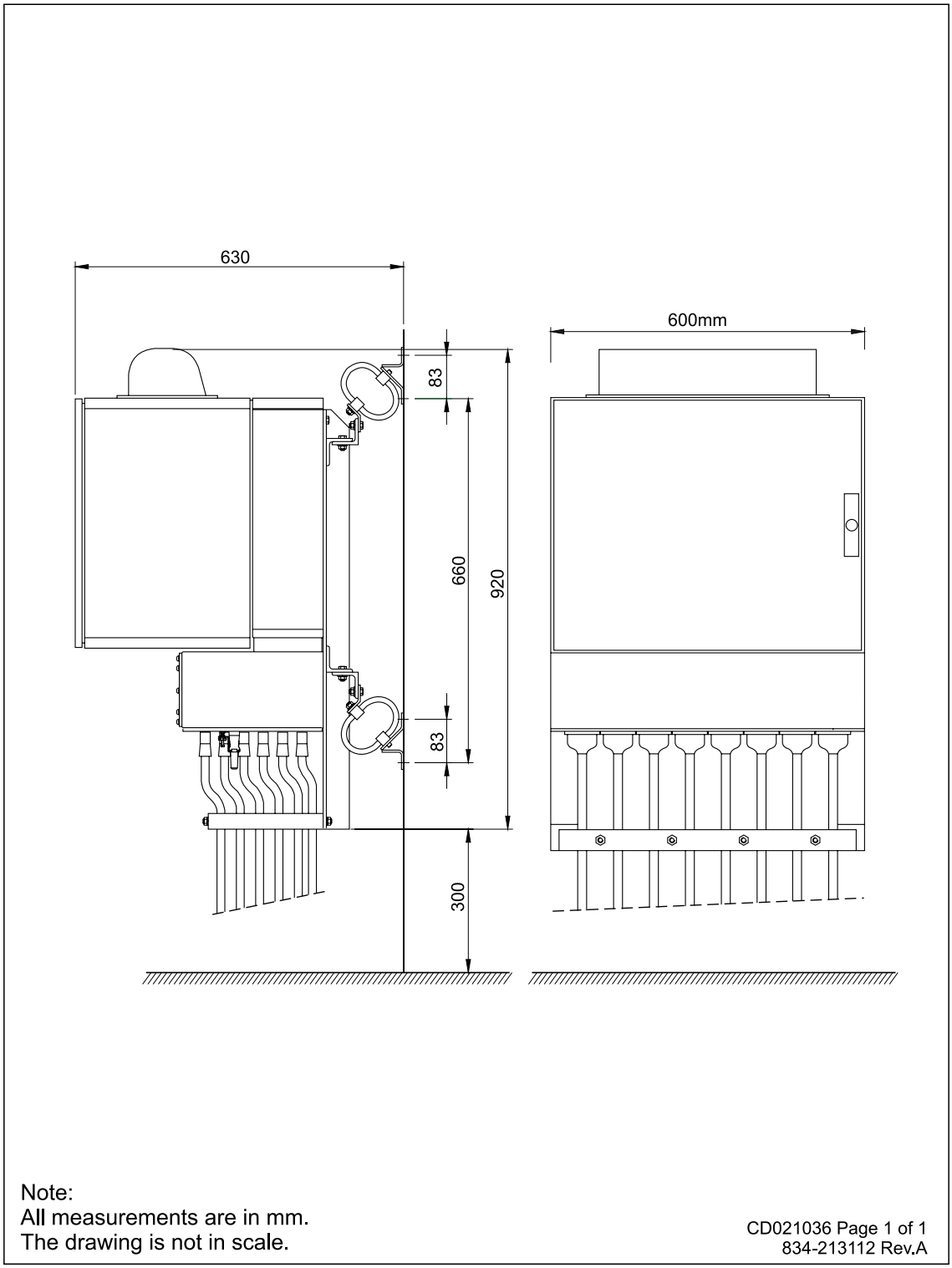
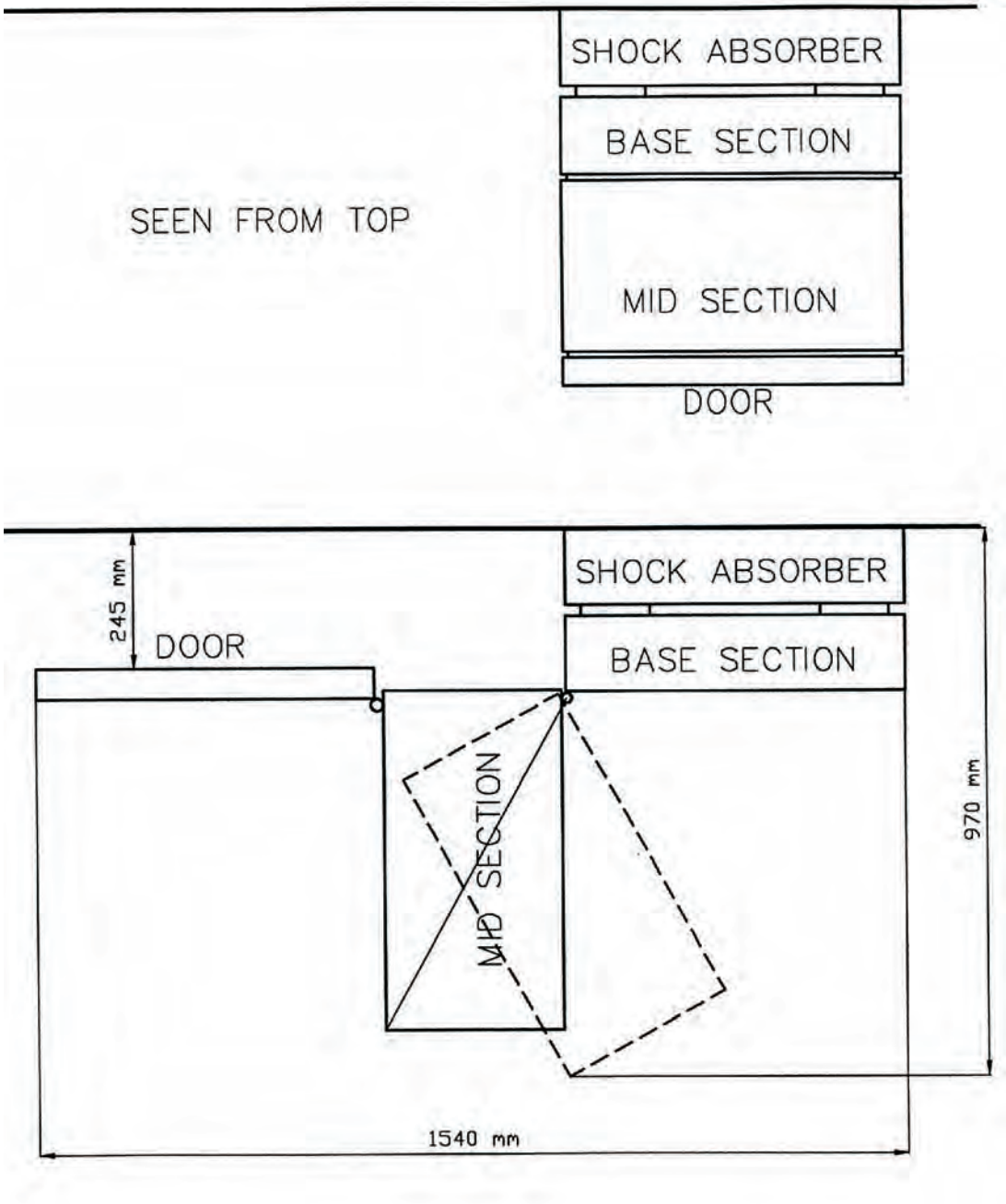
Figure 42 Outline dimensions Rx Preamplifier Unit





Note:
All measurements are in mm.
The drawing is not in scale.

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Company profile

Kongsberg Maritime

Kongsberg Maritime is a leading supplier of advanced maritime automation and instrumentation systems. We deliver systems for dynamic positioning and navigation, marine automation, cargo management and level sensors, maritime training simulators and position reference systems. Important markets include countries with large offshore and shipyard industries. The company has approximately 3100 employees and an annual turnover of MNOK 6.657 (year 2009). Kongsberg Maritime also operates through a number of domestic and international subsidiaries, which all are leaders within their field. Decentralisation lets subsidiary company optimize 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.

Kongsberg Maritime's main office is situated in Horten, Norway.

Figure 43 Kongsberg Maritime's facilities in Horten

The premises located at Strandpromenaden in Horten houses the hydroacoustic activities. The professionals in this facility share more than 60 years of experience in single and multibeam echo sounding, sonar technology and underwater communication and instrumentation. The facility'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, quality control, training and demoes.

Figure 44 The test and demonstration vessel "M/K Simrad Echo"

The product ranges provided by Kongsberg Maritime's Strandpromenaden facility in Horten include:

- Single and multibeam echo sounders for hydrographic applications
- Underwater communication
- Underwater positioning reference systems (including the highly accurate HiPAP® system)
- Naval sonars and echo sounders (hull mounted and towed systems)
- The world renowned HUGIN remotely operated vehicle
- Sonars, echo sounders and catch monitoring systems for the world's professional fishing and scientific communities
- Scientific multibeam echo sounders and sonars for the international fishery research community

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

Visit Kongsberg Maritime at http://www.km.kongsberg.com.

Kongsberg Group

Kongsberg Gruppen ASA (the Kongsberg Group) is one of Norway's leading high-technology companies. With an operating revenue of MNOK 13.816 (in 2009), 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 Kongsberg Group operates through the following major business areas:

- Kongsberg Maritime
- Kongsberg Oil & Gas Technologies
- Kongsberg Protech Systems
- Kongsberg Defence Systems

These companies are fully owned by the Kongsberg Group. The Kongsberg Group is represented world wide.

Visit the Kongsberg Group at http://www.kongsberg.com.