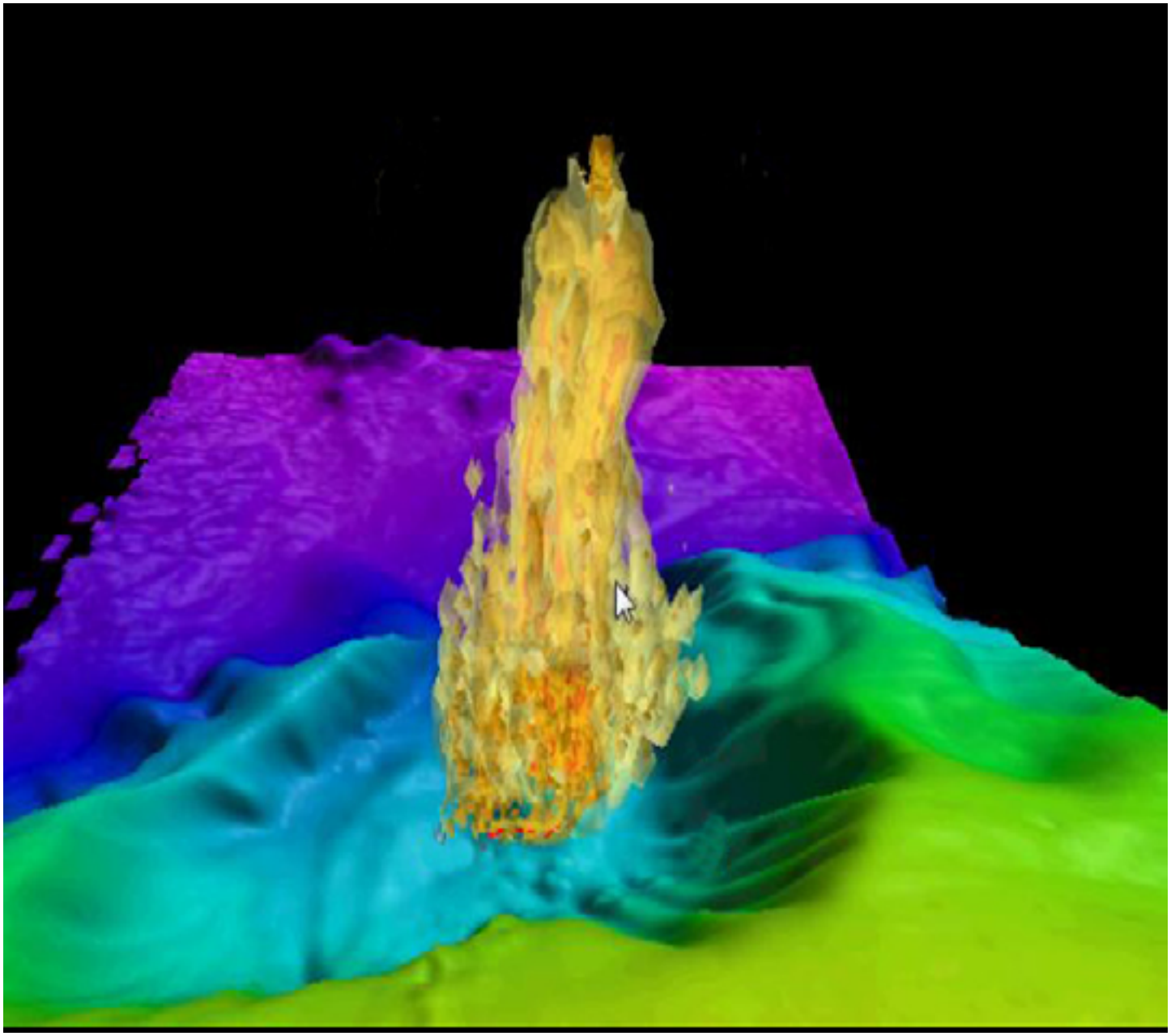
Product Description

KONGSBERG

EM 302
Multibeam echo sounder

Plumes located in water depths between 1200 and 1900 meters

and observed to rise about 500 meters making their heights between 700 - 1400 meters



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Kongsberg EM 302 Multibeam echo sounder

Product Description

Kongsberg Maritime

302675/C

Revision status

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Rev.C	02.03.2012	Overall revision

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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. All users must be familiar with the contents of the appropriate manuals before attempting to install, operate, maintain or in any other way 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 information

If you require maintenance or repair, contact one of our offices, distributors or dealers. You can also contact us using the following address: km.hydrographic.support@kongsberg.com. If you need information about our other products, visit http://www.km.kongsberg.com.
See also *Support information* on page 36.

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System overview

Key facts

The Kongsberg EM 302 multibeam echo sounder is designed to map almost all of the ocean floors excepting the deep trenches with an unsurpassed resolution and accuracy. The system is cost effective, reliable, and easy to operate. It is the better system in comparison to full ocean depth multibeam echo sounders such as the EM 122 when most mapping is done at depths less than 2-3000 m, and on smaller vessels where it would be impracticable to install the transducers of a full ocean depth system.

The design of the EM 302 is based upon more than 60 years of hydrographic experience with echo sounders, sonars and underwater positioning systems for civilian and military use. It replaces the highly regarded EM 300 introduced in 1996, of which more than 20 systems are operational. It has the same transducer dimensions as in the EM 300, but with new electronics and software.

Compared with the EM 300 the EM 302 has six times the resolution in terms of sounding density through inclusion of multiping capability and more than three times the number of detections per swath. The achievable swath width of the EM 302 is in the order of 8,000 m, or about 50% more than possible with the EM 300, using long FM (frequency modulated) chirps which gains about 15 dB in signal to noise ratio compared to CW (continous wave) pulses. In typical ocean depths a sounding spacing of better than 25 m across and along is achievable.

The EM 302 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).

Including a shallow water multibeam echo sounder with the EM 302 system can give a total system solution meeting the strictest IHO requirements for all depths. As proven with the EM 300, an accuracy of better than 0.2% of depth is readily achievable with the EM 302 over most of the swath for depths larger than about 100 m.

Operating frequency and coverage sector

The nominal sonar frequency is 30 kHz with an angular coverage sector of up to 140° and 864 soundings per ping. The 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. 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.

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 10 Hz.

Functionality to limit Mammal Harassment

The maximum sound intensity generated by the EM 302 is about 214 dB re 1 µPa. Maximum intensity is encountered in a thin wedge extending below the ship with an angular coverage of about 140° (intensity decreases from nadir). 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 mPa for ranges larger than 20 m from the transmit transducer. The EM 302 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 302 transducers are linear arrays in a Mills cross configuration with separate units for transmit and receive. The arrays are divided into modules.

For the transmit array 0.5, 1, 2 and 4° beamwidths are standard options, and for the receive array 1, 2 and 4°.

The resulting array lengths are between 0.8 and 6 m. The system can also be delivered with a non-standard number of modules to optimize beamwidth in accordance with the vessel hull shape and size.

Post-processing

Postprocessing software is available from both Kongsberg Maritime and third-party suppliers.

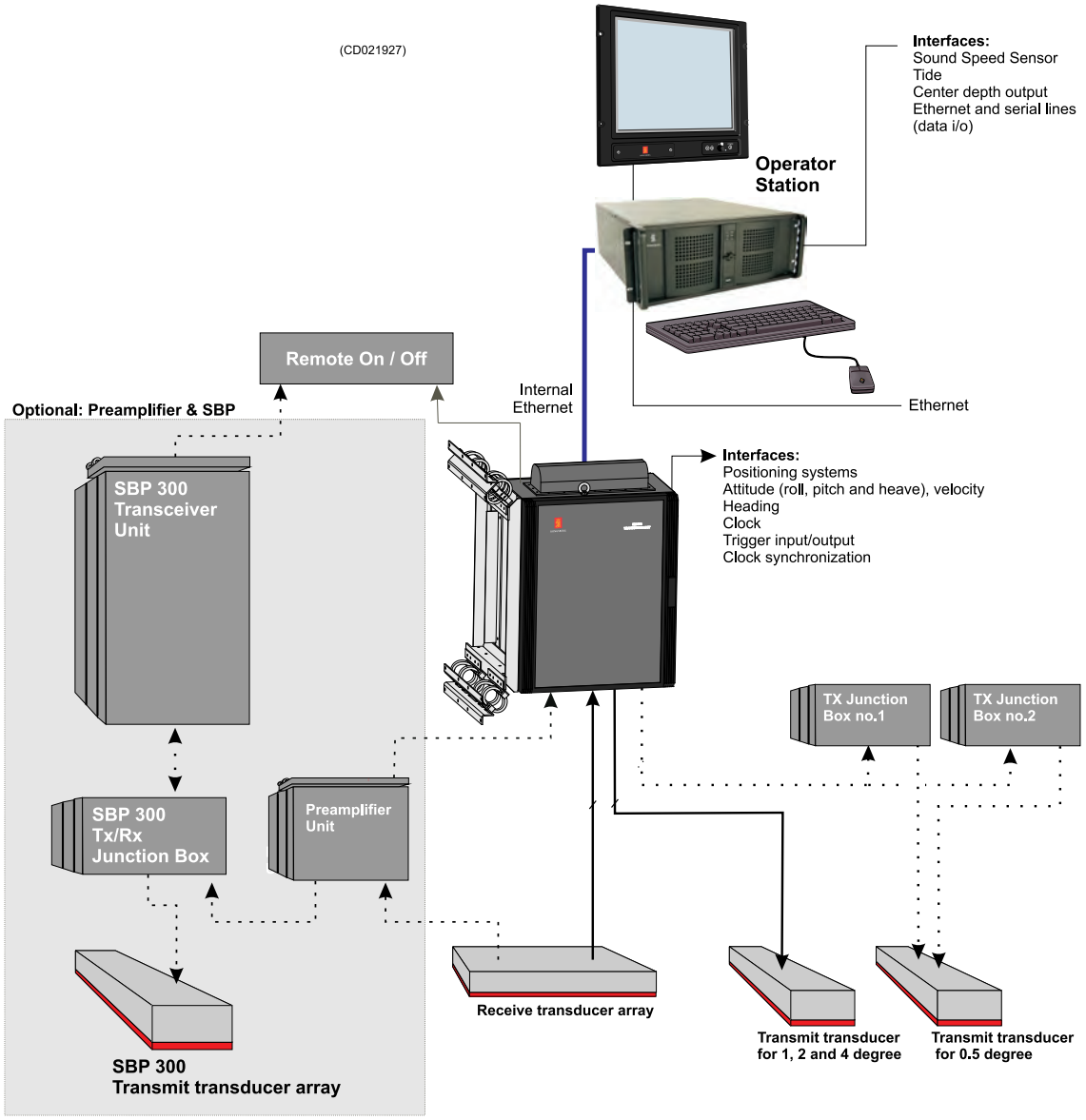
Optional sub-bottom profiling

The receive transducer is wideband. In conjunction with a separate low frequency transmit transducer, the EM 302 may optionally be able to deliver sub-bottom profiling capabilities with a very narrow beamwidth. This system is known as the **SBP 300 Sub-Bottom Profiler**. For more information, refer to the dedicated product information.

Support

A world-wide marketing and service organization having many years of multibeam experience is in place for supporting the EM 302.

Figure 1 EM 302 system units and interfaces with optional SBP 300



System characteristics

Main units

The EM 302 multibeam echo sounder consists of the following units:

- Transmit transducer array (with TX Junction Box for 0.5° TX array)
- Receive transducer array
- Transceiver Unit
- Preamplifier Unit (only if the sub-bottom profiler is connected)
- Operator Station

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

An extra low frequency transmit transducer and transceiver may be added for the optional high resolution sub-bottom profiling capability; the SBP 300.

Transducer arrays

The transmit transducer array contains up to 16 modules in accordance with the chosen beamwidth. Each module contains 108 elements arranged in rows of 6 elements. Each element is individually connected to its corresponding transmitter in the Transceiver Unit (pairs of elements may be connected in parallel through a junction box if the number of modules exceeds 8) 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 8 modules in accordance with the chosen beamwidth. Each module contains 16 transducer staves, and these have individual electrical connections to their corresponding preamplifiers in the Transceiver Unit. Each stave can thus be given unique amplitude and phase weighting to allow forming of the required receive beams.

The flat and horizontally mounted transducers of the EM 302 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 at transducer is recommended. 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.

Transceiver Unit

The EM 302 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. An Ethernet cable connects the Transceiver Unit to the Operator Station.

The receiver and A/D circuits in the EM 302 have an instantaneous dynamic range of more than 140 dB. The system applies the correct gain offsets after detections.

Raw sample data either from the hydrophone channels or from the beamformer output are available from the system for data logging and display.

Preamplifier Unit – only used together with SBP 300

The EM 302 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 300 Sub-Bottom Profiler.

TX Junction boxes – only for 0.5° TX array

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

Operator Station

The Operator Station of the EM 302 is the HWS (Hydrographic Work Station) high performance PC workstation. The operator software is the Seafloor Information System (SIS).

SIS allows setting of the EM 302 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, spill-proof US keyboard and a standard optical mouse. Support for a second monitor is included. Optionally up to 4 monitors may be connected.

The HWS is designed to be a good hydrographic work station supporting the demands for secure data storage, data presentation and generation of a digital terrain modul.

SBP 300 Sub-Bottom Profiler (optional)

The EM 302 system may be expanded to include an optional SBP 300 Sub-Bottom Profiler. The SBP 300 system capability includes the following items:

- An additional low frequency transmit transducer array, with the EM 302 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 300 system, refer to the applicable product description.

Performance

Basic specifications

The normal operating frequency of the EM 302 multibeam echo sounder is 30 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 5.5 times the water depth to about 1500 m depth. A swath width of up to about 8000 m is generally achievable for deep waters to 4000 m water depth, depending upon bottom conditions and chosen system beamwidths. At 6000 m water depth the coverage can still be more than 4000 m.

The system versions with 1 or 2° receivers has 288 beams per swath and 576 per ping with multiping with beam pointing angles being 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° angular coverage, 1.2% with 120° and 2% with 140°. 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, 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 302 implements multiping with two swaths per ping. The two transmit beams are tilted a little differently alongtrack to ensure near constant sounding spacing of the swaths alongtrack. With a 0.5° transmit beam the multiping capability also ensures 100% bottom coverage, and even with a 1° beam the footprint overlap will be sufficiently small to a least provide some independence between the measurements. (depends on the ships speed).

While the normal pulse length is 5 ms, for waters deeper than about 1000 m, when the signal to noise ratio will reduce coverage, an FM chirp will be used in the outer sectors. Its bandwidth corresponds to the resolution of the 5 ms CW pulse, but its duration will allow pulse compression on reception and hence a gain in signal to noise ratio of about 15 dB.

Shallow waters

For shallow waters a pulse length of 0.7 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 may be required even at a few hundred meters depth despite the higher ping rate the lesser depth allows. Nearfield focusing is applied both on transmit and receive. These techniques will in practice ensure that the footprint size is according to the beamwidth also inside the near field, enhancing shallow water resolution. For intermediate waters a pulse length of 2 ms is also available to have an optimum range resolution at all depths.

For transmission, a separate focus point is applied to each transmission sector, while dynamic beam focusing is used during reception

Depth accuracy

The system depth accuracy is very high due to the narrow beams and high range sampling rate used (3.25 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. The beam forming uses split beam technology. Near normal incidence a centre of gravity amplitude detection is employed, but for most of the beams the system uses phase detection. The phase difference between the half beams, which is a measure of the angle of arrival of the returned echo, is calculated. A curve fit is made to the resulting time series of phase, from which the zero phase crossing is found determining the range to the bottom in the centre of the beam.

In high density mode, several detections are made per beam, using a reduced number of samples (to further increase the resolution). 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) 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 0.25 m for 1 ms pulse length, scaleable with pulse length or bandwidth). The signal-to-noise ratio must be better than 10 dB.

Transducer arrays for individual requirements

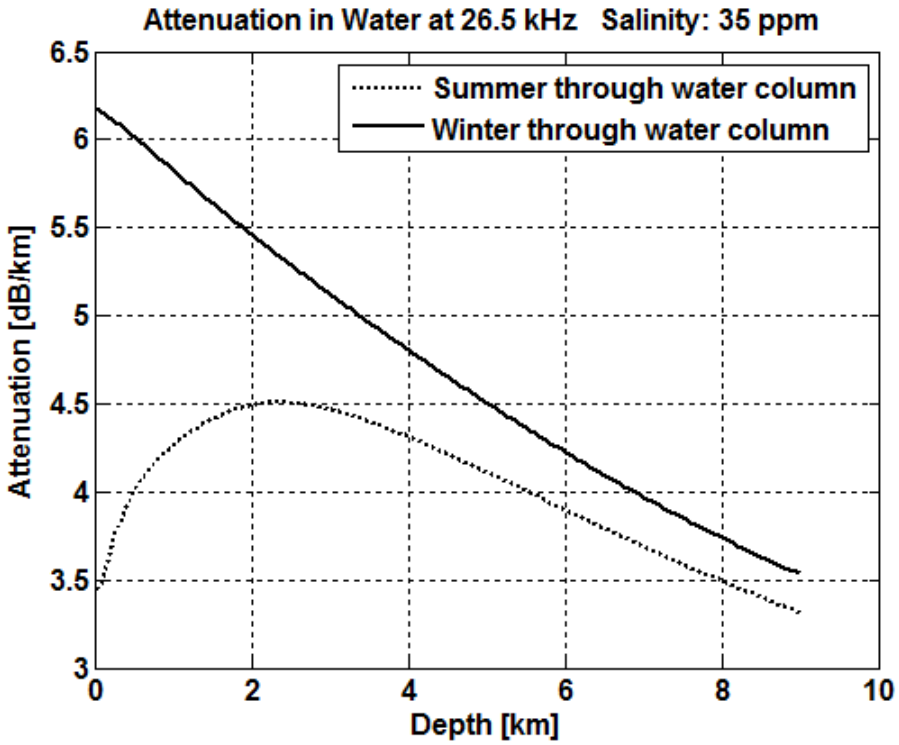
System accuracy, resolution and coverage capability improves with decreasing beamwidth, and a beamwidth of 0.5 x 1° with 6 m by 3.3 m long transducer arrays is a standard option for the utmost performance. However, long arrays are expensive and may be difficult to install, especially with regard to the receive array which is long athwartship. The transducer array lengths may therefore be tailored to individual requirements. (Increased delivery time may be expected).

Attenuation curve

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 *Attenuation at 26.5 kHz* on page 15 shows the attenuation in the water in dB versus water depth of the EM 302 signal at 26.5 kHz. The attenuation curves are calculated for a salinity value of 35 ppm.

Figure 2 Attenuation at 26.5 kHz



Calculated range performance

In the following figures range performance is calculated for 5 different system configurations:

- *EM 302 swath coverage 0.5x1° transducers* on page 16
- *EM 302 swath coverage 1x1 ° transducers* on page 17
- *EM 302 swath coverage 1x2 ° transducers* on page 17
- *EM 302 swath coverage 2x2 ° transducers* on page 18
- *EM 302 swath coverage 2x4 ° transducers* on page 18
- *EM 302 swath coverage 4x4 ° transducers* on page 19

The calculations are done for three different bottom types, a noise spectral level of 40 dB re 1µPa and an attenuation level for warm ocean as a function of depth, ref. figure *Attenuation at 26.5 kHz* on page 15. The effect of different attenuation coefficient is shown in figure *EM 302 swath coverage 1x2 ° transducers, cold and warm ocean* on page 19 where the calculations are done for both warm and cold ocean. The effect of

increased noise level is shown in figure *EM 302 swath coverage 1x2 ° transducers, noise spectral level 40 and 55 dB* on page 20 where the calculations are done for a noise level of 40 and 55 dB.

Figure 3 EM 302 swath coverage 0.5x1° transducers

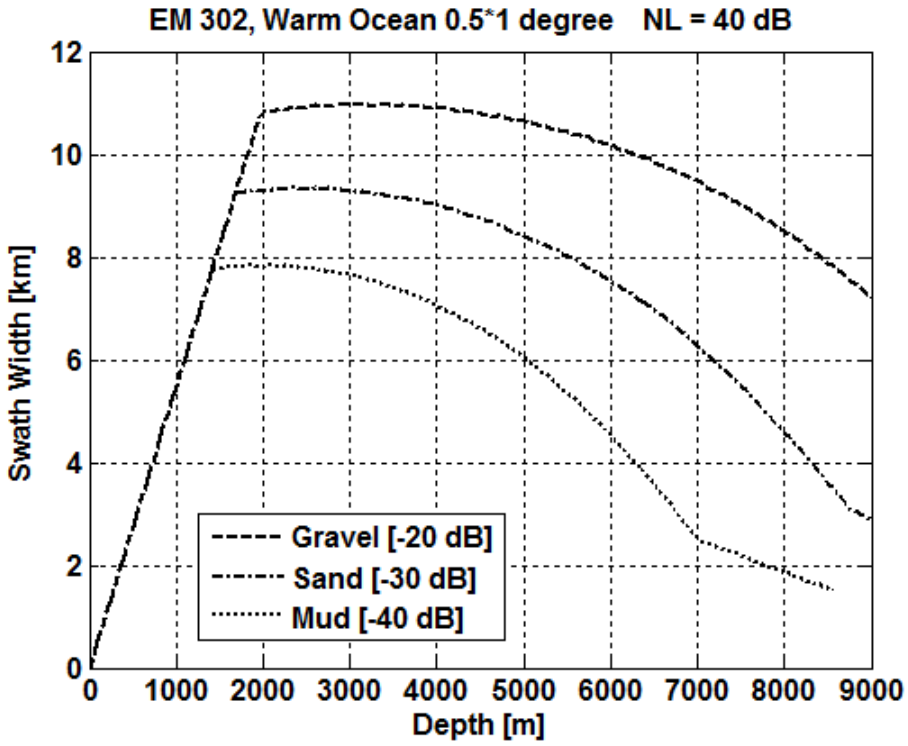


Figure 4 EM 302 swath coverage 1x1 ° transducers

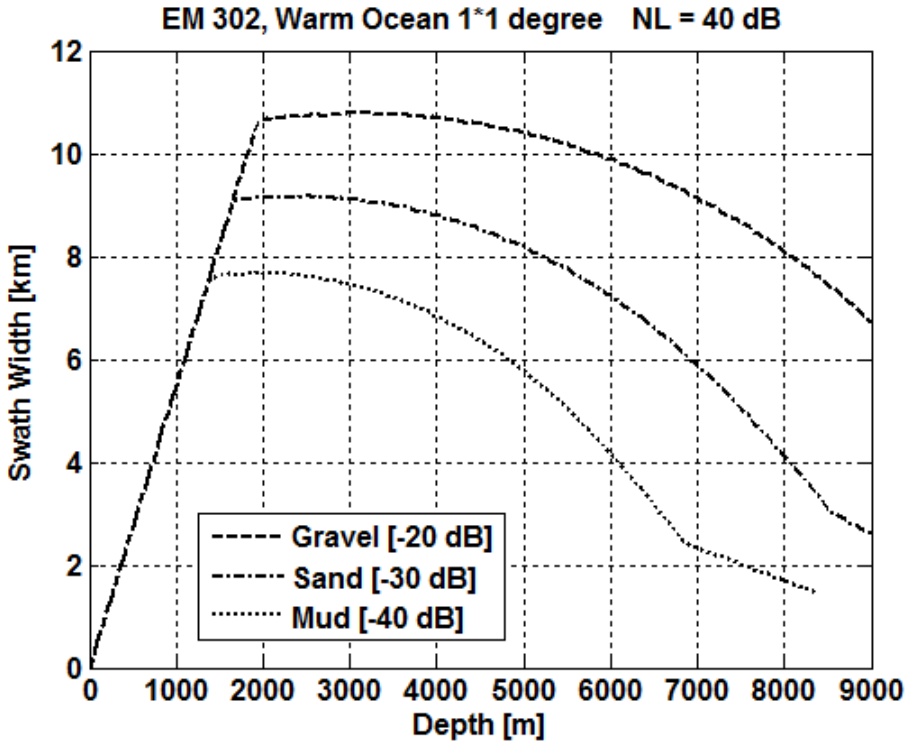


Figure 5 EM 302 swath coverage 1x2 ° transducers

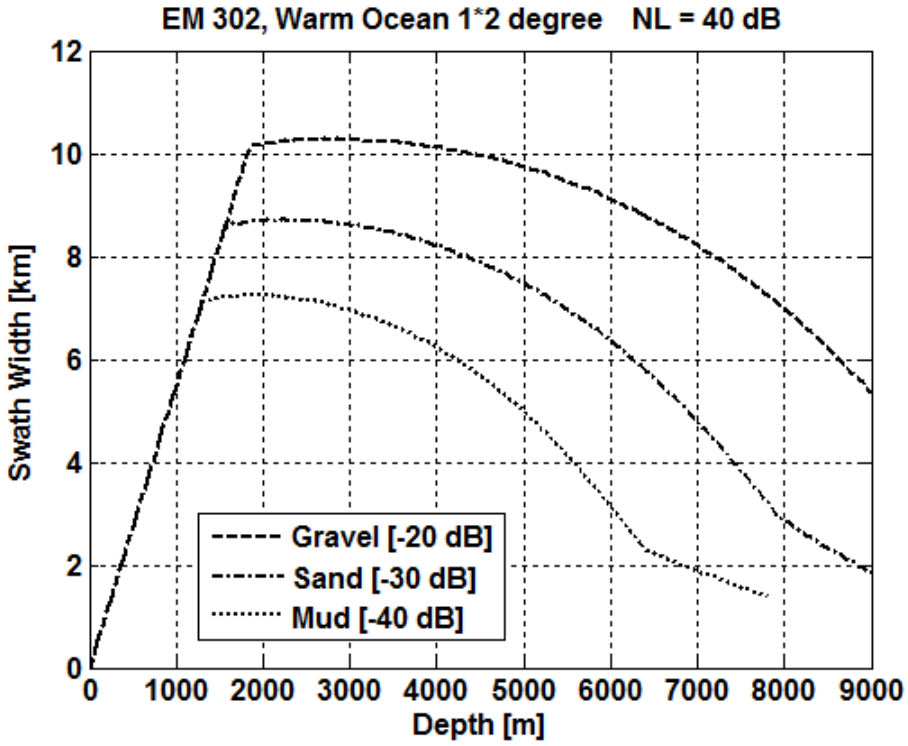


Figure 6 EM 302 swath coverage 2x2 ° transducers

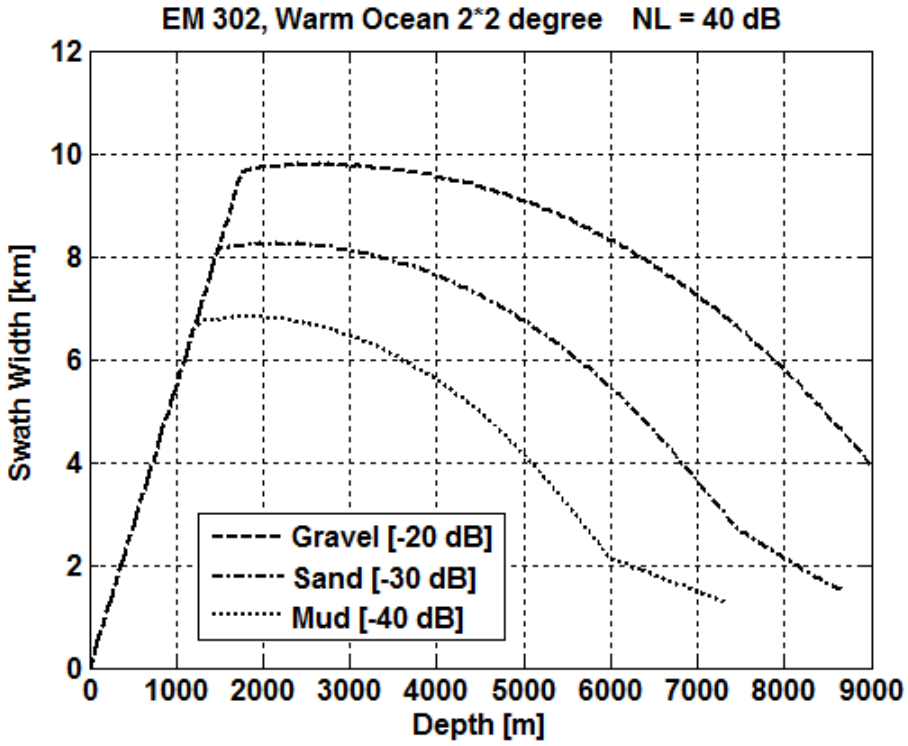


Figure 7 EM 302 swath coverage 2x4 ° transducers

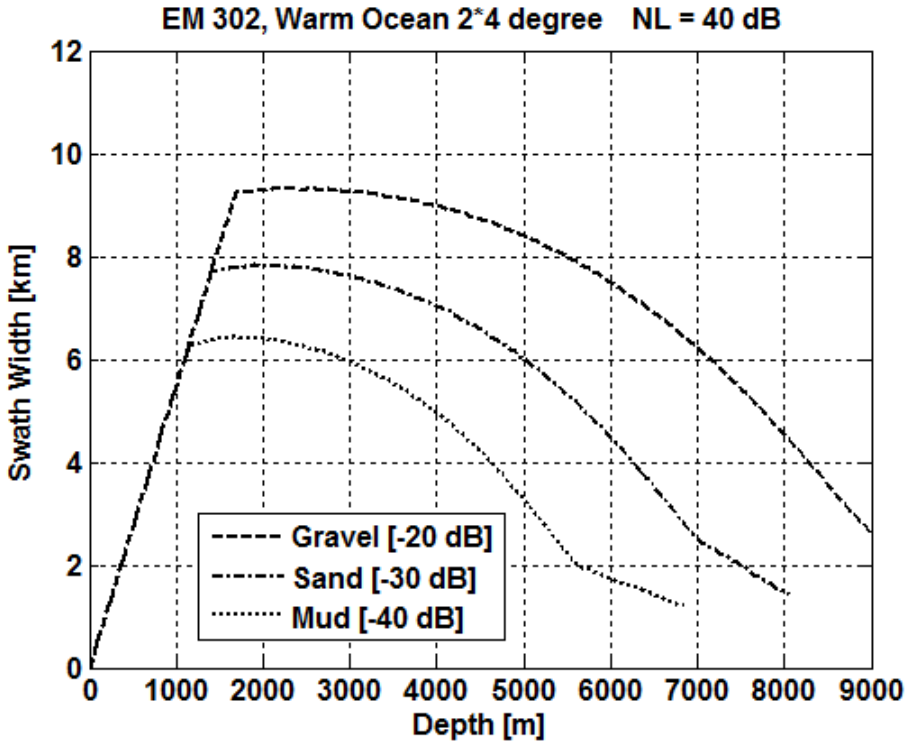


Figure 8 EM 302 swath coverage 4x4 ° transducers

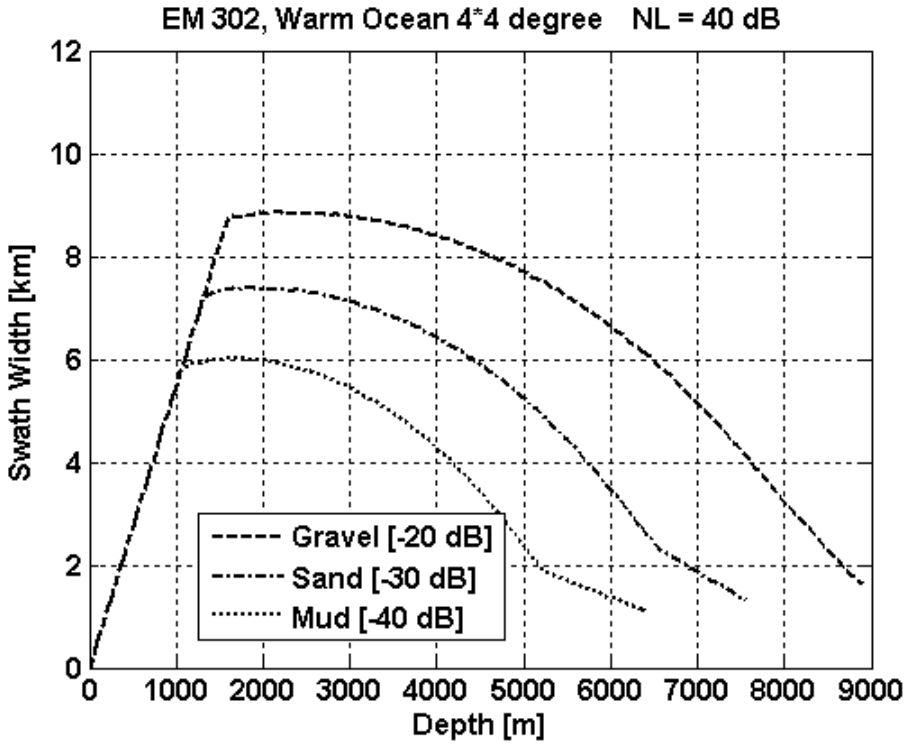


Figure 9 EM 302 swath coverage 1x2 ° transducers, cold and warm ocean

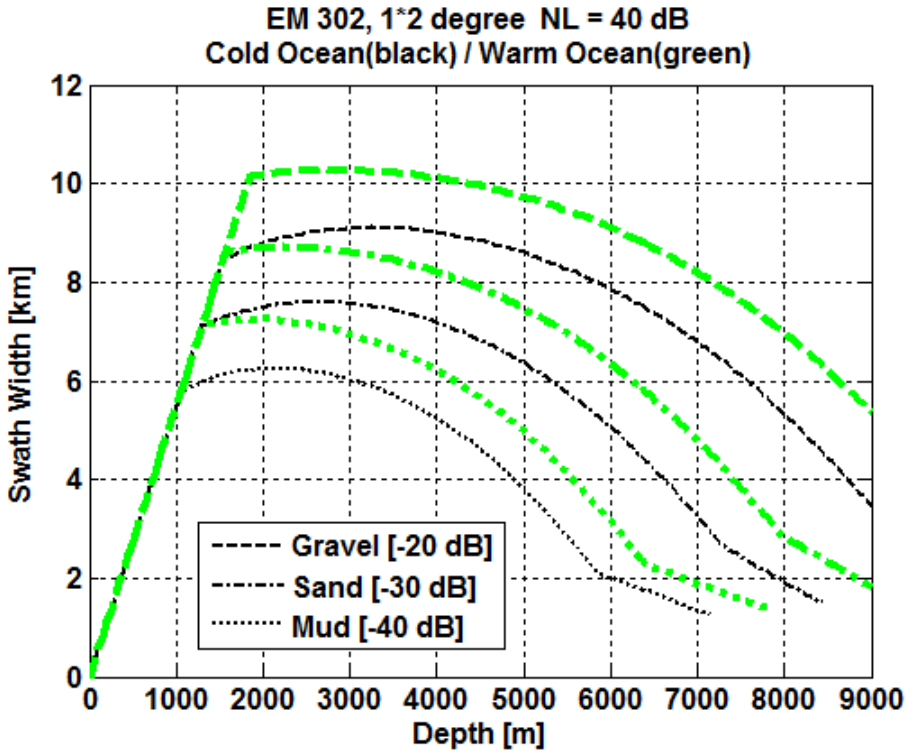
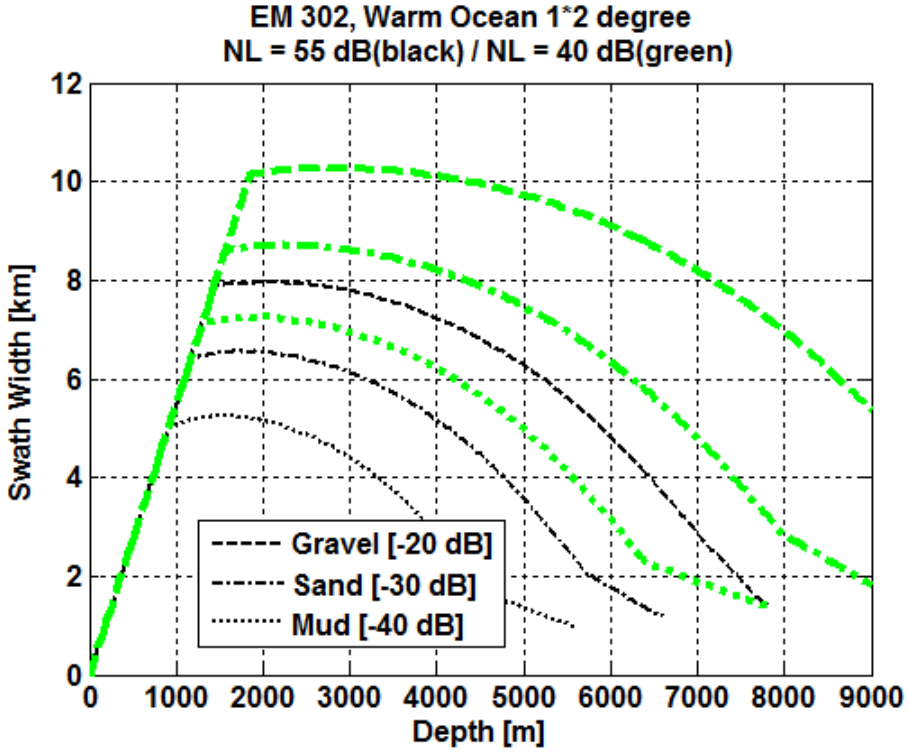


Figure 10 EM 302 swath coverage 1x2 ° transducers, noise spectral level 40 and 55 dB



Horisontal resolution

The horizontal resolution of EM 302 is much improved in relation to previous models, due to the introduction of focused beams (for both transmission and reception) and the high density signal processing.

Alongtrack resolution

The size of the alongtrack acoustical footprint of the EM 302 transmit beam:

Table 1 Alongtrack for 140 ° swath width

Alongtrack footprint for EM302								
Beamwidth [°]	**0.5**		**1.0**		**2.0**		**4.0**	
Water depth [m]	Vertical	Outer edge	Vertical	Outer edge	Vertical	Outer edge	Vertical	Outer edge
50	0.4	1.3	0.9	2.6	1.7	5.1	3.5	10
100	0.9	2.6	1.7	5.1	3.5	10	7	20
200	1.7	5.1	3.5	10	7	20	14	41
400	3.5	10	7	20	14	41	28	82
1000	8.7	26	18	51	35	102	70	205
2000	18	51	35	102	70	204	140	409
4000	35	102	70	204	140	408	280	818
6000	52	153	105	306	210	613	420	1226

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. Two profiles can be obtained per acoustic ping, then 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 302							
140 ° swath, one profile per ping							
			Alongtrack distance between profiles [m]				
Water depth [m]	swath with depth [m]	Ping rate	4 kn	8 kn	12 kn	16 kn	20 kn
50	275	3.2	0.7	1.2	1.9	2.5	3.1
100	550	1.8	1.1	2.2	3.3	4.4	5.6
200	1100	1.0	2.1	4.2	6.3	8.4	10.5
400	2200	0.5	4.1	8.2	12.2	16.3	20.4
1000	5500	0.2	4.1	8.2	12.2	16.3	20.4
2000	8000	0.1	15.2	30.5	45.7	60.9	76.2
4000	8000	0.06	19.2	38.5	57.7	76.9	96.2
6000	8000	0.04	24.5	49.0	73.4	97.9	122.4

Table 3 Alongtrack profile density, two profiles/ping

Calculated ping rate and alongtrack resolution for EM 302							
140 ° swath, two profiles per ping							
			Alongtrack distance between profiles [m]				
Water depth [m]	swath with depth [m]	Ping rate	4 kn	8 kn	12 kn	16 kn	20 kn
50	275	3.2	0.3	0.6	0.9	1.2	1.5
100	550	1.8	0.6	1.1	1.7	2.2	2.8
200	1100	1.0	1.1	2.1	3.2	4.2	5.3
400	2200	0.5	2.0	4.1	6.1	8.2	10.2
1000	5500	0.2	5.0	10.0	15.0	20.0	25.0
2000	8000	0.1	7.6	15.2	22.8	30.5	38.1
4000	8000	0.06	9.6	19.2	28.8	38.5	48.1
6000	8000	0.04	12.2	24.5	36.7	49.0	61.2

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° receiver array versions have 432 soundings per profile, while the 4° 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° swath width.

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

Crosstrack — acoustic foot print sizes for EM 302					
	432 soundings/profile				
Water depth [m]	1 ° RX center	2 ° RX center	90 °	120 °	140 °
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	-
4000	70	140	37.0	-	-
6000	105	211	56.0	-	-

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

Crosstrack sounding density for EM 302			
	432 soundings/profile		
	Swath widths		
Water depth [m]	90 °	120 °	140 °
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	-
4000	18.5	-	-
4000	27.8	-	-

Installation principals

The compactness of the EM 302 multibeam echo sounder is a guarantee for a fast and easy installation.

Operator station

The Operator Station is 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 array installation

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 transmit array contains 2, 4, 8 or 16 transducer modules depending on chosen beamwidth with each module being connected through 3 underwater cables. The receive array contains 2, 4 or 8 transducer modules depending on chosen beamwidth with each module being connected through a single underwater cable.

The cables from the modules have a standard length of 15 m, and are terminated with connectors which plug directly into the Transceiver Unit (via a junction box if more than 8 modules are used for the transmit array, and via a Preamplifier Unit if the SBP

300 Sub-Bottom Profiler is also installed). As an option the cables from the modules can be 25 meter long. Normally the cables would 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.

Figure 11 EM 302 Transducer element installation

Figure 12 EM 302 Transducer element installation in gondola

Figure 13 Transducer element installation EM 302

Ice protection window

Two types of acoustic protection windows can be offered:

- Light ice class
- Ice breaker version

The protection for the arrays is a reinforced structure which is potted by a material which is acoustically transparent. Unless the vessel is really carrying out operations in ice infested waters, it is recommended not to use any protection on the outside of the transducer arrays.

Figure 14 EM 302 Transducer element installation with ice window

Operational principals

System features

The EM 302 multibeam echo sounder is controlled from the HWS Operator Station using the Seafloor Information System – SIS software. 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 302 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 system includes an automatic calibration facility

Parameters critical to data quality are password protected and can be recalled. Seabed imagery data is available from the system as standard. The imagery data, representing the acoustic backscatter strength of the bottom, is available in two forms. One nominally corrected for the effect of incidence angle (seabed image data), the other given per beam as an absolute measure (beam intensity). The imagery data may be useful for object detection, but the most important application is probably geophysical for seabed characterization.

Seafloor Information System — SIS

Seafloor Information System (SIS) is a real time software designed to be the user interface and real time data processing system for all hydrographic instruments produced by Kongsberg Maritime AS. SIS is included on all deliveries of multibeam echo sounders from Kongsberg Maritime.

The main task for SIS is to be an intuitive and user friendly interface for the surveyor, providing the functionality needed for operation of the multibeam echo sounder and running a survey efficiently. SIS includes the necessary features for system installation, testing and operating the multibeam echo sounder, ping related displays (including water column display) and the capability of logging the acquired bathymetry data.

SIS runs under the Windows XP or Win7 operating system with the HWS (Hydrographic Work Station) operator PC hardware. Up to four screens can be used on one HWS, and SIS can also show geographical displays on several remote PCs in the network.

The Kongsberg Maritime echo sounders are complete systems. All necessary sensor interfaces, data displays for quality control and sensor calibration, seabed visualization, and data logging are standard parts of the systems, as is integrated seabed acoustical imaging capability (sidescan).

The available features of SIS are:

- Screen layout with up to seven simultaneous display windows defined by the user
- Real time data cleaning of bathymetric data
- Enhanced functions for visual and automated data quality control
- Geographical displays for sound speed at sonar head and sound speed profile
- Built in self tests of the multibeam echo sounder and continuous monitoring the quality of input data. Error situations are logged, and user notifications are given advising what action to take.
- High resolution seabed image mosaic can be viewed in the Geographical view
- Unique features for plotting of scaled maps in size up to A0
- Imaging of acoustic reflectors in the water column (fish, biomass, etc.)
- Real time computation of the mean sea level using a geoid model
- Real time compensation for tide
- Fully operational when echo sounder is mounted on ROV/AUV
- Post processing of GNSS raw position data using Precise Point Positioning

Basic version – Instrument control

With the basic/instrument control version of SIS you can select which instrument to operate, turn it on/off, store data on/off, change setup and operating parameters and export data. There are graphical windows for quality checking of sensor input and the data produced. Sound speed at sonar head and sound speed profile input are interfaced and handled correctly in real time.

Multibeam echo sounders have built-in tests which can be activated to verify that the hardware is working correctly. In addition SIS constantly monitors input data to ensure the data quality. Error situations are logged and user notifications are given with advice of what action the operator should take.

Multibeam echo sounder support

Licensed multibeam support gives access to:

- More QA views for the multibeam data
- System calibration
- Visualisation of high resolution seabed backscatter data
- Visualisation of seabed imagery date in the Geographical view
- Plotting of survey results with full plotter resolution

- Support for remote Helmsman Display, connected via Ethernet

Real time data cleaning

SIS includes highly efficient algorithms for automatic flagging of soundings which should be eliminated from the survey. The soundings are not removed, simply flagged as invalid so it is always possible to reverse the decision easily. For the majority of user needs, this processing will be satisfactory so that further processing is made either not necessary or at least substantially reduced. The terrain model is generated in real time from input of all soundings available in one area, not just the current soundings, but all previous soundings in that area.

Water column imaging

The EM 302 have built-in support for imaging of acoustic reflectors also in the water column. Such reflectors are for example fish or other biomass, but can also be submerged buoys or moorings.

SIS Objects

An addition to SIS makes it possible to add markers during survey. The user can define a set of lines, points, images and text to be displayed, and then the user can add such objects during survey. Such markers can be bouys, wreaks, shoals, coastlines, dryfall, etc. These objects can be exported to xml-files, and they can be read and displayed as background information later.

Geographical window

The Geographical window in SIS can display a terrain model in 2D and 3D mode. In 2D mode background maps can be displayed (DXF, C-MAP, KSGPL ascii files, GeoTIFF are supported), planned survey lines, a user defined vessel symbol, raw (limited) soundings and gridded (unlimited) terrain model. In 3D mode the seafloor surface can be viewed from different angles and in different resolutions, the light source can be shifted, and the surface can be rotated around all axis to obtain the best view.

The Geographical window can be zoomed and panned, and it can be set to follow the ship’s position automatically.

Grid model from previous surveys can be imported and used as background information or used for comparison purposes.

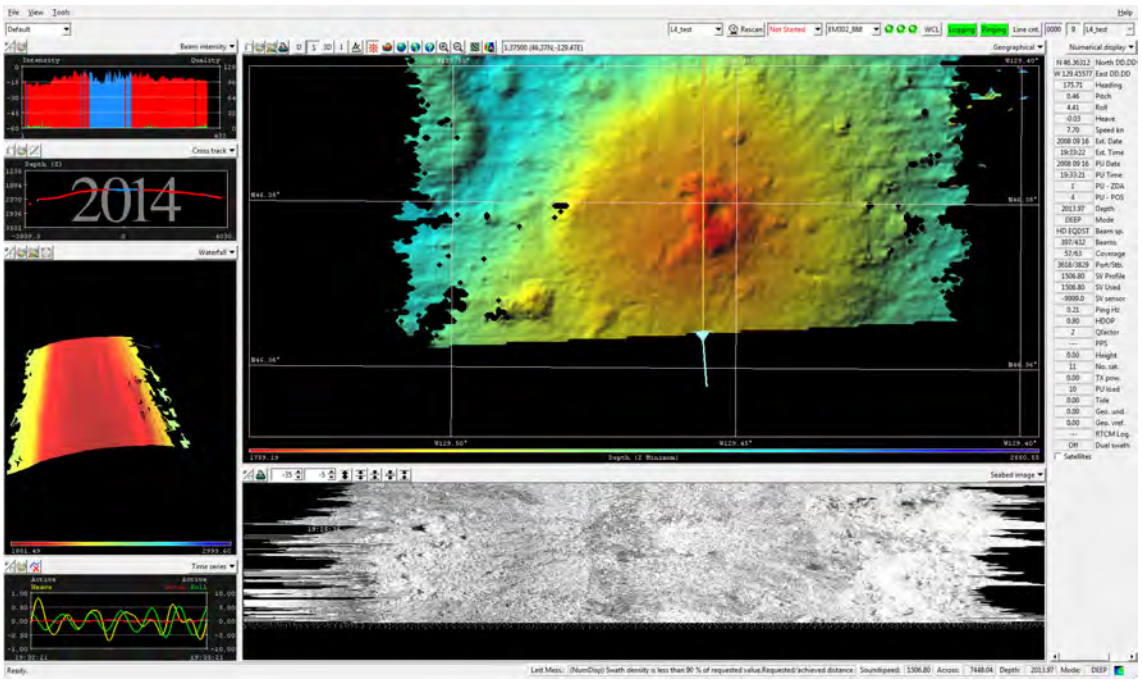
A planning module makes it possible to define and edit planned lines, make parallel lines, define survey regions, etc. Plans can be imported and exported between systems.

SIS has an unique plotting module which not only makes screendumps, but properly scaled maps of the selected area to a postscript plotter of any size up to A0. Screendumps are of course also available simply by pressing Ctrl+S at any time.

Graphical user interface

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

Figure 15 Example of SIS graphical user interface



The available windows in SIS are:

- Beam intensity
- Calibration
- Colour coded depth
- Cross track
- Geographical
- Helmsman Display
- Installation parameters
- Message service
- New survey
- Numerical display
- Planning module
- PU sensor status
- Runtime parameters
- Runtime Parameters Mini

- Scope display
- Seabed image
- Sensor Layout
- Sound velocity profile
- Stave display
- Survey administration
- Time series
- Waterfall
- Water column

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 the 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 datagrams:

  In each depth datagram range/angle observations from one ping have been merged with motion sensor data and current sound velocity profile to derive a rigorous solution for vessel motion and ray bending, 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
- Water column data

The data formats are public and published on the Kongsberg Maritime web site, ensuring that the EM 302 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 302 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 302 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).

QPS Fledermaus interactive 3D visualization

Fledermaus by QPS is a high capacity, interactive software for visualizing large geographical data sets, developed and maintained by the US based company IVS (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 302 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 302 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 302 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 302 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.

Support information

If you need technical support on the EM 302 system you must contact a Kongsberg Maritime office. A list of all our support offices is provided on http://www.km.kongsberg.com.

You can also contact our main support office in Norway.

- **Address**: Strandpromenaden 50, 3190 Horten, Norway
- **Telephone**: +47 33 02 38 00
- **Telephone, 24h**: +47 815 35 355
- **Telefax**: +47 33 04 76 19
- **E-mail address**: km.hydrographic.support@kongsberg.com
- **Website**: http://www.km.kongsberg.com

Scope of supply and options

Standard system

A basic EM 302 multibeam echo sounder delivery includes:

- Operator Station HWS with 19” LCD monitor
- Transducer modules. These include necessary cables and mounting frames in accordance with chosen beamwidths
- Transceiver Unit
- Signal and control cables between cabinets. Standard length is 5 m
- 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 recorder
- Removable hard disks.
- Helmsman Display and/or additional monitors
- Postscript colour graphic printer/plotter
  - Automatic calibration software
- Spare parts
- Preamplifier Unit
- SBP 300 Sub-Bottom Profiler system
- Customized documentation

External sensors

A number of external sensors are required for the EM 302, 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 302, the following software products may be delivered:

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

Additionally Kongsberg Maritime may deliver the EM 302 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
- Firewire interface for external data storage device
- eSATA and Firewire interface for external data storage device (tape or disk)
- USB 2.0 interfaces for data storage, printing or plotting
- Ethernet interface for velocity input needed for Doppler compensation in chirp mode.
- Gbit Ethernet interface for input of sound speed profile, tide and echo sounder depths, and output of all data normally logged to disk

Physical specifications

Transmit transducer – TX

Module:

- **Length:** 371.5 mm
- **Width:** 350 mm (480 mm with frame)
- **Height:** 160 mm (197 mm with frame)
- **Weight in air/water:** 37 kg / 17 kg

TX array weight

- 0.5° – 592 kg (16 TX modules)
- 1° – 296 kg (8 TX modules)
- 2° – 148 kg (4 TX modules)
- 4° – 74 kg (2 TX modules)

Frame length:

- 0.5° – 5960 mm
- 1° – 2992 mm
- 2° – 1505 mm
- 4° – approximately 800 mm

Frame weight

- 0.5° – 600 kg
- 1° – 185 kg
- 2° – 95 kg
- 4° – approximately 60 kg

Receive transducer – RX

Module:

- **Length:** 406 mm
- **Width:** 300 mm (330 mm with frame)
- **Height:** 160 mm (197 mm with frame)
- **Weight in air/water:** 19 kg / 6.5 kg

RX array weight

- 1° – 152 kg (8 RX modules)
- 2° – 76 kg (4 RX modules)
- 4° – 38 kg (2 RX modules)

Frame length

- 1° – 3271 mm
- 2° – 1643 mm
- 4° – 829 mm

Frame weight

- 1° – 152 kg
- 2° – 75 kg
- 4° – 38 kg

Ice protection window (ice breaker version)

- **RX – weight in air per section:** 32 kg
- **TX – weight in air per section:** 58 kg

Transceiver Unit

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

Preamplifier Unit

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

TX Junction Box (for 0.5° TX)

- **Height:** 440 mm
- **Width:** 600 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

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 requirements

- **Fuse:** The single phase supply must be protected with minimum 16A slow-blow fuses (230 Vac).
- **Operational voltage and frequency:**
  - **Transceiver Unit:** 115 or 230 Vac (±10%), < 2000 W, 47 to 63 Hz
  - 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 (230 Vac supply) slow-blow fuses.
  - **Operator Station:** 110 or 230 Vac (±10%), < 250 W, 47 to 63 Hz
  - **LCD monitor:** 110 or 230 Vac (±10%), < 60 W, 47 to 63 Hz
  - **Preamplifier Unit:** 110 or 230 Vac (±10%), < 300 W, 47 to 63 Hz
  - **TX Junction Box:** None

    Note

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

- **Acceptable transients:**
  - **Short time (max 2 sec) :** ±25%, 42 to 69 Hz
  - **Spikes (max 50 µS) :** < 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.

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 and Extra Deep mode (i.e. from 3300 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.

Environmental and EMC specifications

The system meets all requirements of the EC EMC directive.

Reference standards

- IEC 60945
- EMC Noise emission: EN61000-6-4 (EC EMC directive)
- EMC Noise immunity: EN61000-6-2 (EC EMC directive)

Temperature (°C)

Unit	Storage	Operating
Operator station (HWS) and monitor	-30 to 70	5 to 50
TRU	-30 to 70	-5 to 50
Transducers	-30 to 70	-5 to 50

Note

To extend the lifetime of the equipment, it is recommended to mount the units at locations having sufficient ventilation. The temperature should not be high, i.e. more than 30°C, over long periods of time.

Humidity (IEC 60945)

- @40º C : 93% relative, non-condensing

Vibration (IEC 60945)

- 5–150 Hz
- 1.23 g rms
- 2 hours duration

Shock (KM additional specification)

- Peak acceleration: 15 g
- Half sine pulse
- Duration 11 ms

IP grade (KM additional specification)

- Operator station (HWS) and monitor: IP 22
- Transceiver, optional preamplifier unit and optional junction box: IP44

System performance data

- **Main operational frequency:** 30 kHz
  - Frequencies in the range of 26 to 34 kHz are employed to code the different transmit sectors.
- **Maximum ping rate:** > 10 Hz
- **Number of beams per swath:** 288 (in between and equiangle modes)
  - Number of soundings per swath: 432 (high-density mode)
  - Number of swaths per ping: 1 or 2
- **Beam spacing:** In between equiangle and high-density (equidistant)
- **Coverage sector:** Up to 140°
- **Transmit beam steering:** Stabilized for roll, pitch and yaw
- **Receive beam steering:** Stabilized for roll
- **Depth range from transducers:** 10 to 7000 meters
- **Pulse forms:** 0.7, 2 and 5 ms CW pulse FM chirp 40 – 200 ms.
- **Range sampling rate:** 3.25 kHz (23 cm)

Number of beams and soundings			
System version	0.5 x 1 and 1 x 1	1 x 2 and 2 x 2	2 x 4 and 4 x 4
Number of beams/swath	288	288	144
Number of soundings/swath	432	432	216
Number of swaths/ping	2	2	2
Number of soundings/ping (Dual swath)	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 FM mode, the Doppler shift made by the movements of the survey vessel relative to the bottom, cases a range error. This error must be corrected. The following motion sensors have specifications that fulfills our requirements for Doppler shift corrections:

- Kongsberg Maritime – Seapath series
- Applanix – Pos MV
- Coda Octopus – F180
- IXSEA – Phins

Velocitiy input via Ethernet (used for FM doppler correction)

Requirements:

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

Dimensions

Figure 16 Outline dimensions Transceiver unit

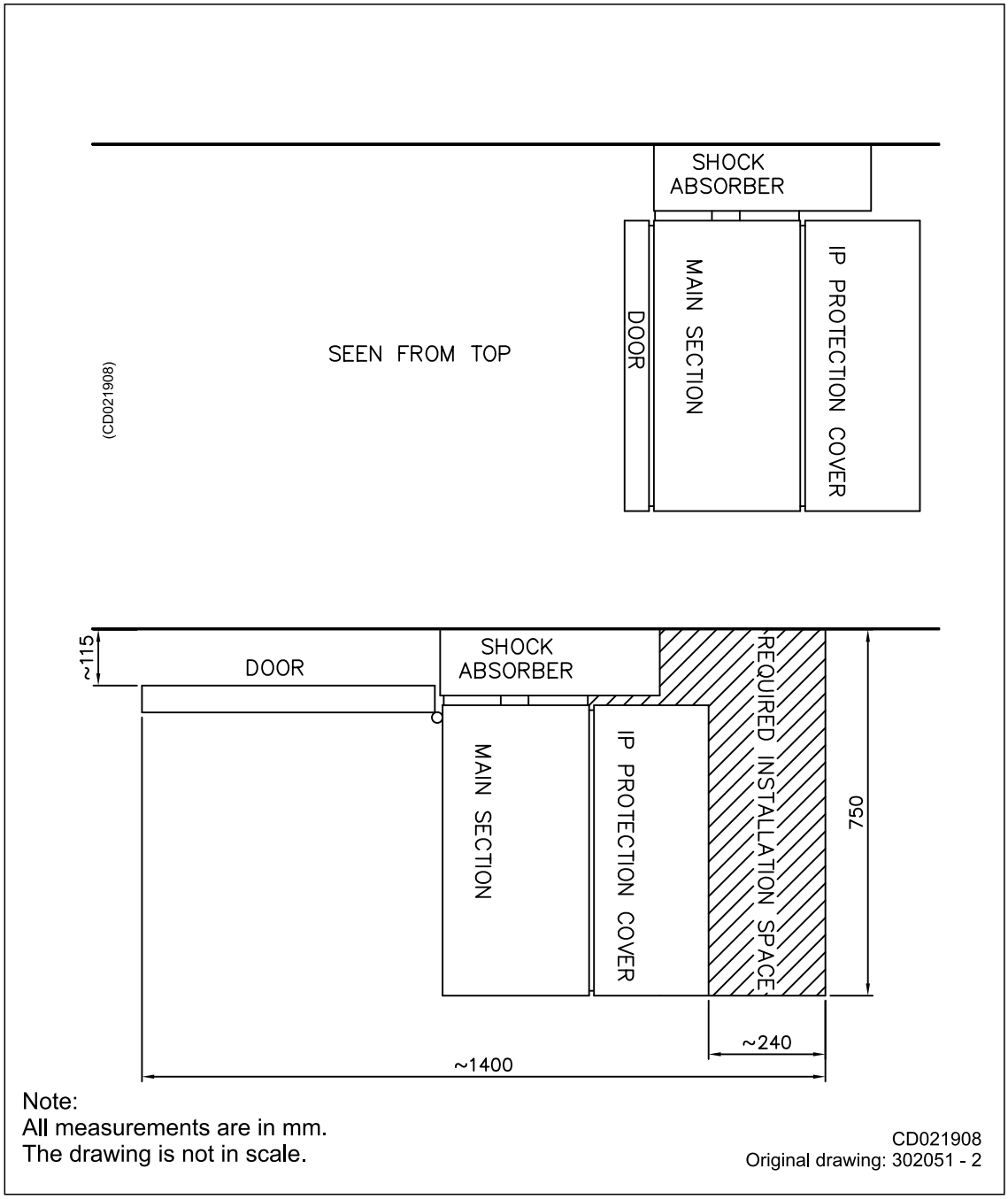


Figure 17 Outline dimensions Transceiver unit

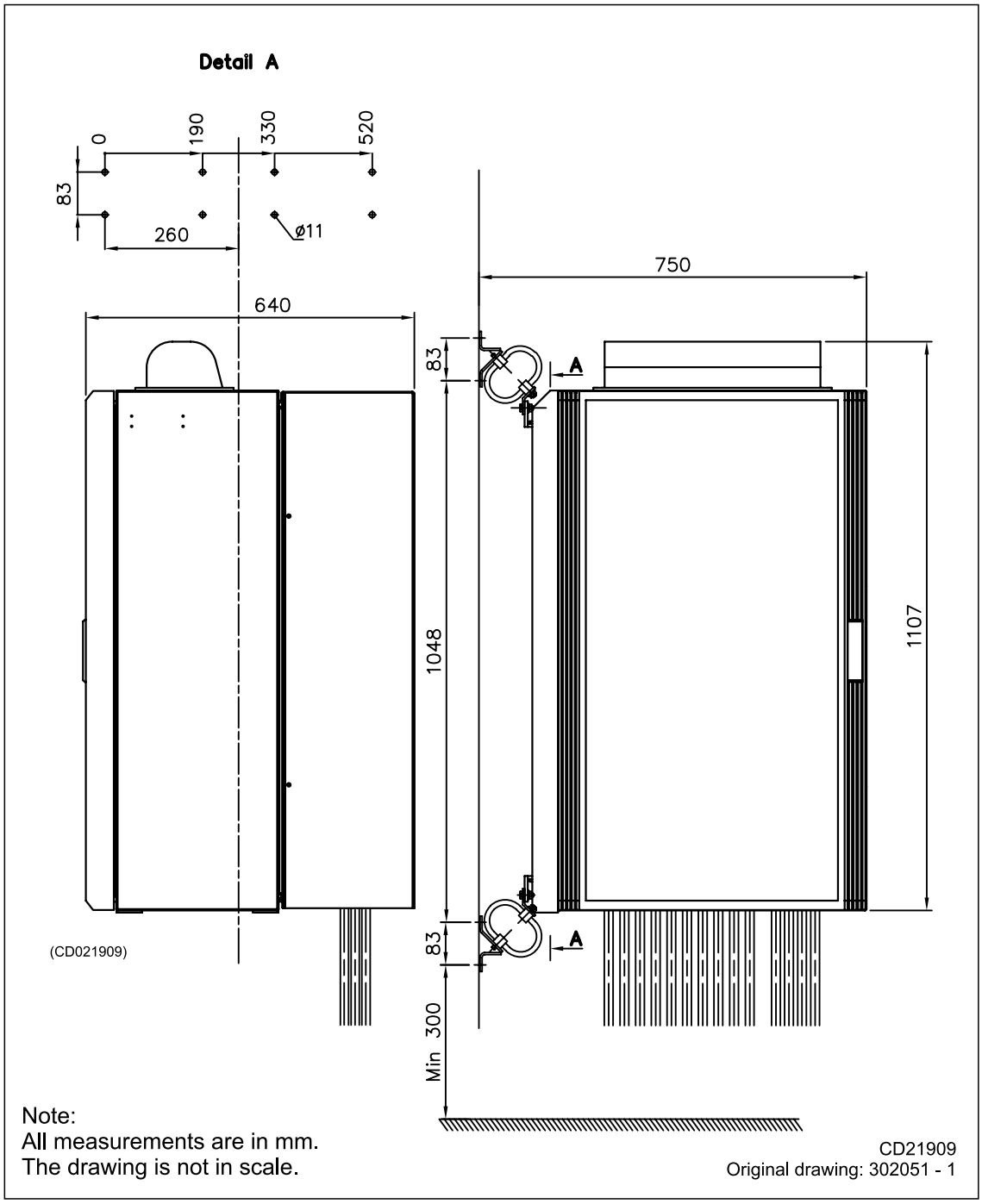
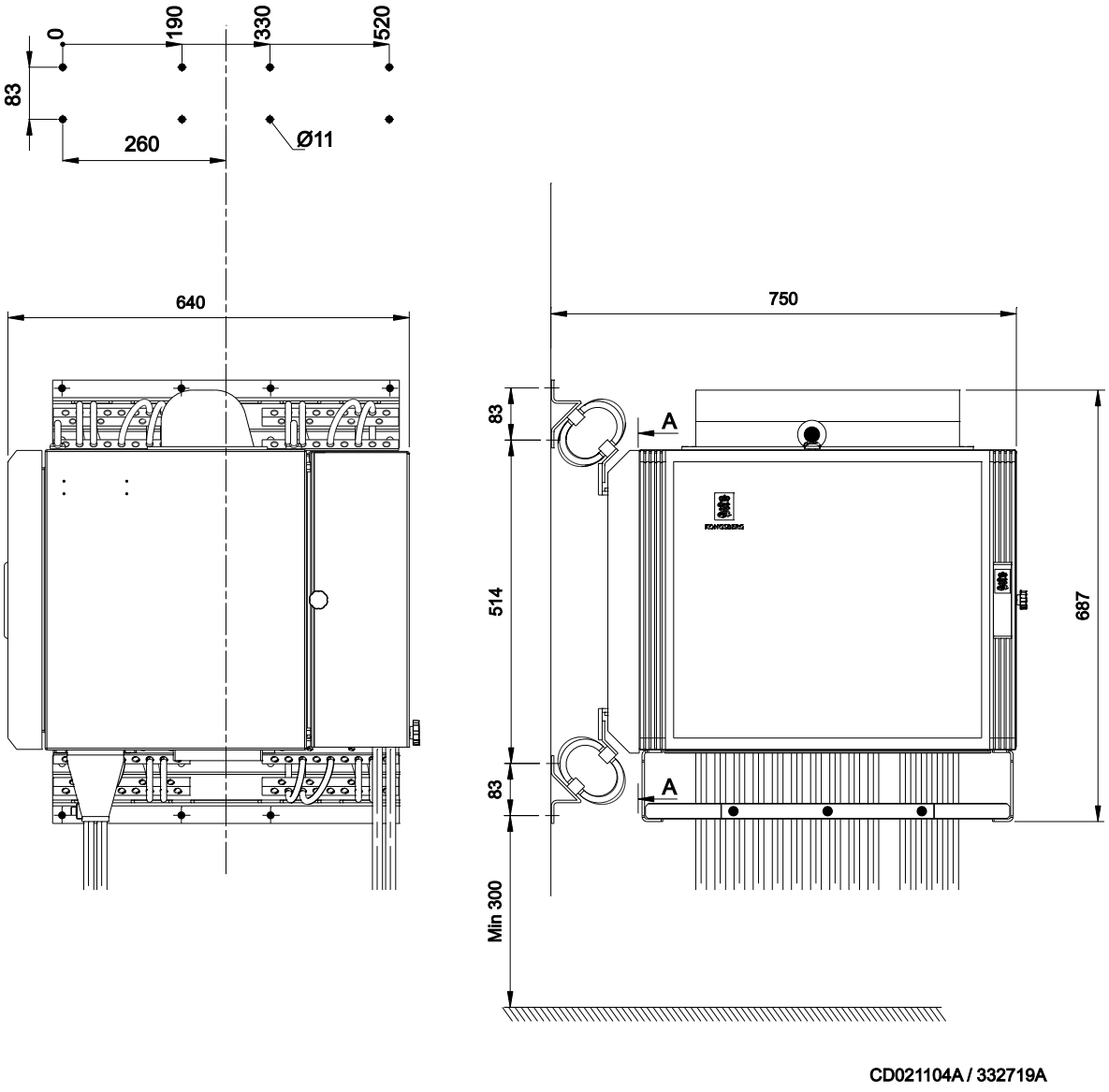


Figure 18 Outline dimensions Preamplifier unit



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 3700 employees and an annual turnover of MNOK 6.286 (year 2010). 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 Subsea main office is situated in Horten, Norway.

Figure 19 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 demonstrations.

Figure 20 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 KONGSBERG.

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

Kongsberg Gruppen

Kongsberg Gruppen ASA (KONGSBERG) is one of Norway's leading high-technology companies. With an operating revenue of MNOK 15.497 (in 2010), it is listed at the Oslo Stock Exchange. The largest shareholder is the Norwegian Ministry of Industry and Energy holding 51% of the shares. KONGSBERG 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 KONGSBERG. The company is represented world wide.

Visit KONGSBERG at http://www.kongsberg.com.