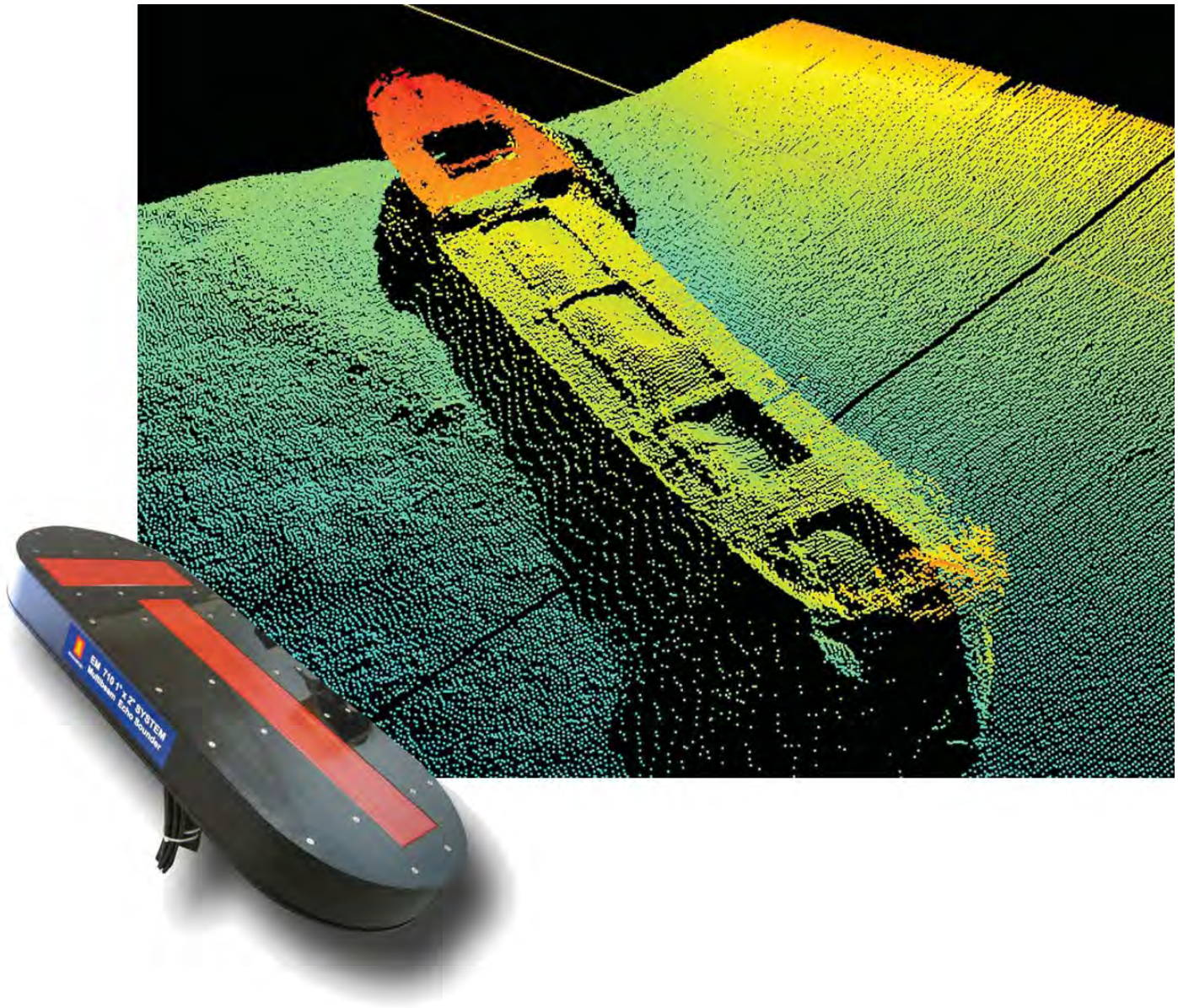
Product Description

KONGSBERG

EM 710

Multibeam echo sounder



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Product Description

Kongsberg Maritime

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Rev. A	January 2006	First version.
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Rev. F	March 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 46.

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System overview

Key facts

The EM 710 multibeam echo sounder is a high to very high resolution seabed mapping system capable of meeting all relevant survey standards. The system configuration can be tailored to the user requirements, allowing for choice of beamwidths as well as transmission modes. The minimum acquisition depth is from less than 3 m below its transducers, and the maximum acquisition depth is up to 2000 m.

Acrosstrack coverage (swath width) is up to 5.5 times water depth to a maximum of more than 2000 m. The sounding density is very high, allowing even the very demanding LINZ special order survey specification for object detection to be met in full.

There are three basic versions of the EM 710:

- EM 710 - Full performance version
- EM 710S - Continuous wave (CW) pulse forms only
- EM 710RD - Short CW pulse only, restricted to 600 m water depth.

The reduced performance versions EM 710S (shallow) and EM 710RD (reduced depth) are upgradable to full performance.

Innovative acoustic principles

The EM 710 operates at sonar frequencies in the 70 to 100 kHz range. The transmit fan is divided into three sectors to maximize range capability but also to suppress interference from multiples of strong bottom echos. The sectors are transmitted sequentially within each ping, and uses distinct frequencies or waveforms.

Both CW pulses of different lengths and even longer, compressible waveforms (chirps) are utilized. The alongtrack beamwidth depends upon the chosen transducer configuration with 0.5, 1 and 2° available as standard. Focusing is applied individually to each transmit sector to retain the angular resolution inside the near field. A ping rate of more than 30 per second is possible. The transmit fan is electronically stabilized for roll, pitch and yaw. The yaw stabilisation is accomplished by applying individual tilt control.

The EM 710 has a receive beamwidth of either 1° or 2°, according to the size of the chosen receiver transducer. The number of beams are 256 or 128 respectively, with dynamic focusing employed in the near field. The distribution pattern may be set to be either equiangular or equidistant. All receive beams are electronically roll stabilized.

High density beam processing mode provides up to 400 or 200 soundings per swath by using a limited range window for the detections, which in practice is equivalent to synthetically sharpening the beamwidth. In the high density mode more than one sounding may be created for each beam. In this mode, the size of each acoustic footprint is reduced to fit the higher sounding density. At the swath edges, the effective accuracy footprint is equivalent to a 0.2° beam for a 0.5° TX.

The system is able to generate two separate alongtrack swaths per ping, thus doubling the alongtrack sounding density. The system produces up to 800 soundings per ping in this mode.

The coverage may be limited by the operator either in angle or in swath width without reducing the number of beams. This can be used to increase the sounding density if a particularly high resolution survey is to be done.

A combination of phase and amplitude bottom detection algorithm is used, in order to provide soundings with the best possible accuracy.

Acoustical seabed imaging

Integrated seabed acoustical imaging capability is included as standard. Software to use this data for automatic seabed classification is available.

Water column backscatter

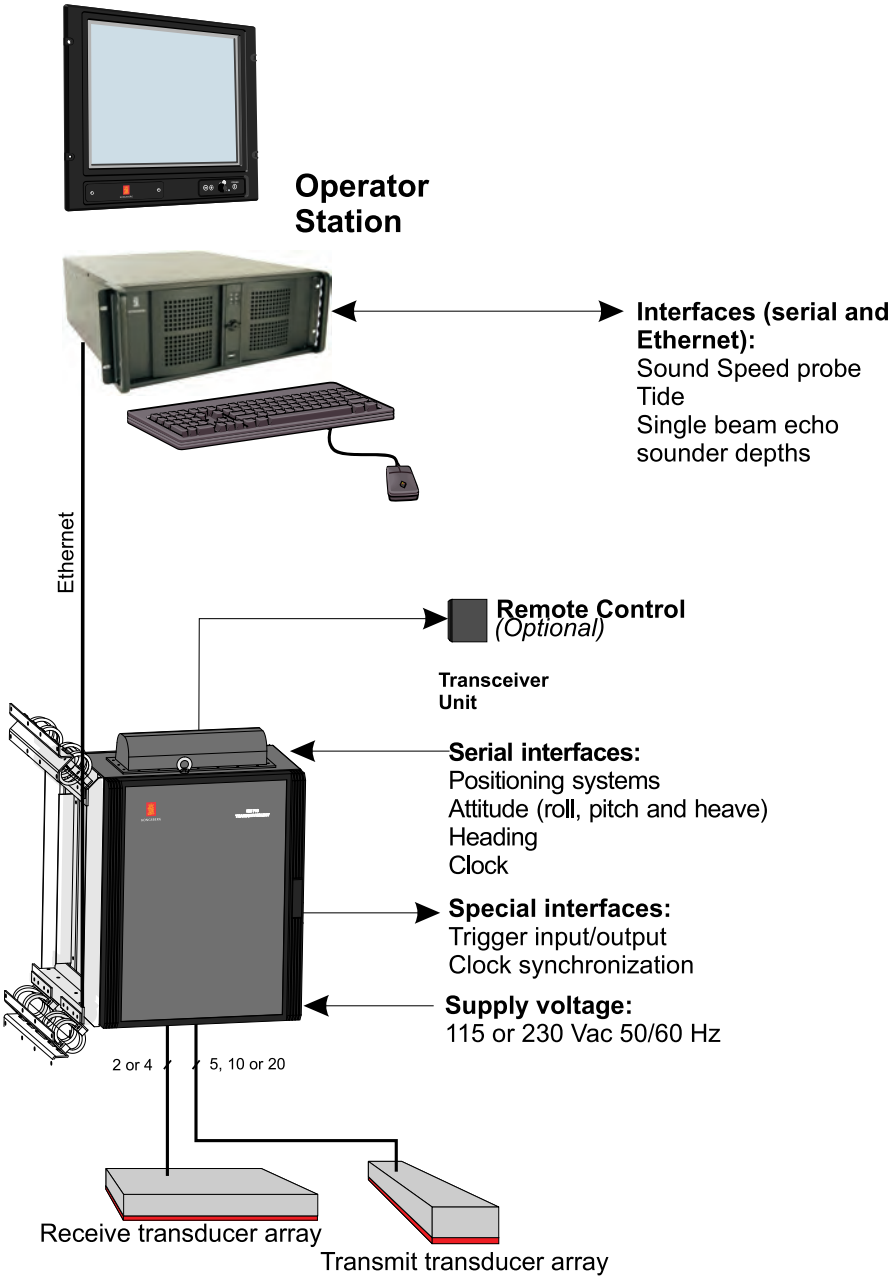
A real time display window for water column backscatter is available. Logging of water column data and of raw stave data (before beamforming) is a system option.

Operator software

The EM 710 is delivered as a complete stand-alone seabed mapping system. The Operator Station, a high-performance PC workstation, includes the necessary operator controls for setting up and running the system, data logging and system testing. The **Seafloor Information System** (SIS) by Kongsberg Maritime also includes an extensive set of graphical displays for data quality control, as well as system calibration and other tools which are required. SIS supports on-line real-time data cleaning to improve the overall survey efficiency.

Post-processing software for the EM 710 is available from both Kongsberg Maritime and third-party suppliers.

Figure 1 EM 710 system units and interfaces



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System characteristics

Main units

The basic EM 710 multibeam echo sounder consists four units:

- Transmit Transducer
- Receive Transducer
- Transceiver Unit
- Operator Station

A complete mapping system will in addition include a vessel motion sensor, heading sensor, sound velocity sensor(s) and a positioning system.

Transducers

The EM 710 transducers are intended for many years of trouble-free operation in rough seas. The transmit and receive transducers both have a width of 224 mm and a height of 118 mm. Their length depends upon the chosen beamwidth, either 970 mm for a 1° unit or 490 mm for a 2° unit. The weights are respectively 35 and 18 kg (excluding cables). The transducers have a maximum depth rating of 250 m.

A transmit beamwidth of 0.5° is achieved by mounting two 970 mm transmit transducers together alongship. Such a beamwidth reduction is not possible with the receive transducer.

The transducers are supplied as standard with 15 m long underwater cables terminated with a surface connector directly pluggable into the Transceiver Unit. On special order underwater connectors or 25 meter cables may be supplied. Five or ten cables are used on the transmit transducer, two or four on the receive transducer, in accordance with the transducer length.

Transceiver Unit

The EM 710 Transceiver Unit contains all transmit and receive electronics, and the Processing Unit which performs the beamforming, bottom detection, and motion and sound speed corrections. It contains all interfaces for time-critical external sensors such as vessel attitude (roll, pitch, heading and heave), vessel position and external clock. More than one sensor of each type may be connected simultaneously, with one in use but all logged.

The Transceiver Unit comprises two 19” sub-racks contained in a cabinet designed for bulkhead or rack mounting. The 2° x 2° system comprises one 19" sub-rack which is mounted in a smaller cabinet. The number of circuit boards will depend upon the chosen transducer configuration. Twisted pair Ethernet is used for data communication with the Operator Station.

Operator Station

The Operator Station of the EM 710 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 710 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 industrialized LCD monitor with a resolution of 1280x1024 pixels. Support for a second monitor is included. A spill-proof US keyboard and a standard optical mouse is normally supplied.

Performance

Basic specifications

Introduction

The operating frequencies of the EM 710 multibeam echo sounder are in the 70 to 100 kHz range. The lower frequencies are used to maximize range capability for deeper waters and at maximum beam pointing angles, while the higher frequencies provide maximum resolution for the near vertical beams. The frequency range has been chosen carefully to achieve an optimum balance between small dimensions, narrow beams, and range and depth capability. It also provides backward comparison compatibility with the widely used 95 kHz EM 100/950/1000/1002 multibeam echo sounder family.

Echo sounder models

The EM 710 is a flexible system with different beamwidths being available, 0.5 by 1º, 1 by 1º, 1 by 2º and 2 by 2º (along by across respectively), to allow a trade-off between performance, transducer size and cost. A beamwidth of 1º at the EM 710 sonar frequency corresponds to a transducer length of about 1 m. A long transmit array is beneficial for higher resolution alongtrack and better range and depth capability. A long receive array gives better accuracy, improved acrosstrack resolution.

There are three basic versions of the EM 710 system, each with different range performances: EM 710, EM 710S and EM 710RD.

Table 1 Overview of the different EM 710 models

	Model	Transmit beamwidth	Receive beamwidth	Transmit waveforms
EM 710	EM 710 0.5° x 1°	0.5°	1°	CW + FM
	EM 710 1° x 1°	1°	1°	CW + FM
	EM 710 1° x 2°	1°	2°	CW + FM
	EM 710 2° x 2°	2°	2°	CW + FM
EM 710S	EM 710S 0.5° x 1°	0.5°	1°	CW
	EM 710S 1° x 1°	1°	1°	CW
	EM 710S 1° x 2°	1°	2°	CW
	EM 710S 2° x 2°	2°	2°	CW
EM 710RD	EM 710RD 1° x 2°	1°	2°	CW short
	EM 710RD 2° x 2°	2°	2°	CW short

The higher resolution models will have somewhat better sounding accuracy than the models with wider beams, especially in rugged terrain, and will have a better capability for object detection.

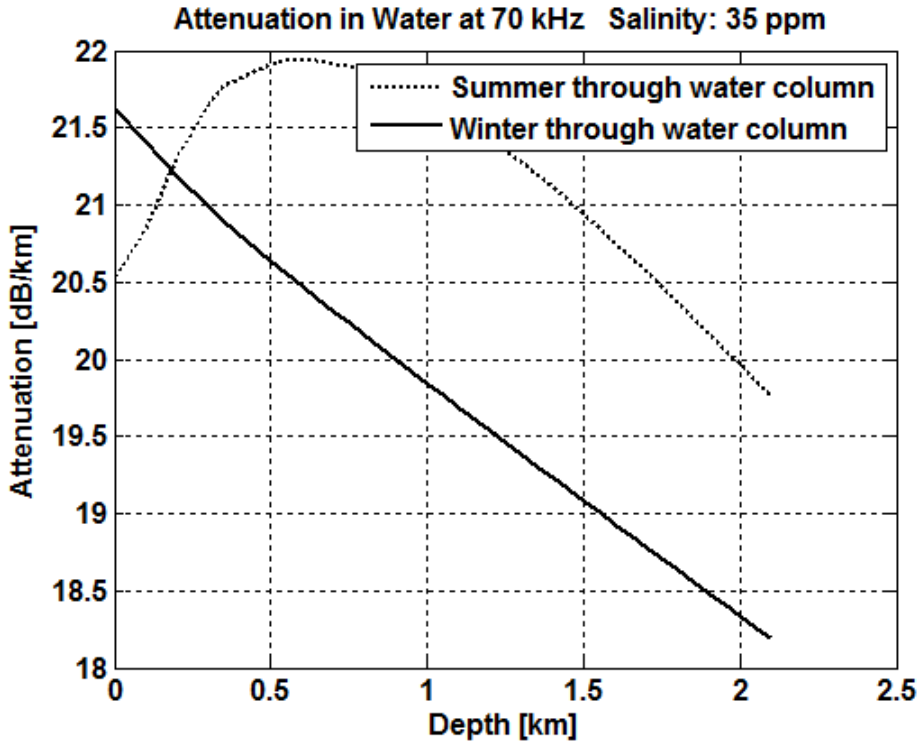
The depth capability of the EM 710 extends to about 2000 m with the 0.5 by 1º model. The transmit signal is then a pulse compressible signal (chirp) with a duration of up to 100 ms and a bandwidth of 500 Hz. With a 2 ms long CW pulse the depth capability will be in the order of 1000 m. With the highest resolution, which is achieved with a pulse length of 0.2 ms, 140º coverage is achievable to more than 100 m (depending on the model). These figures assume fairly standard ocean conditions with respect to bottom reflectivity, noise level, absorption coefficient and sound speed variations. Extreme conditions may lessen the achievable coverage, as may excessive ship noise levels and severe roll.

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 *EM 710 – attenuation at 70 kHz* on page 12 shows the attenuation in the water in dB versus water depth of the EM 710 signal at 70kHz. The attenuation curves are calculated for a salinity value of 35 ppm.

Figure 2 EM 710 – attenuation at 70 kHz



Swath width calculations

The calculation results, shown on the following pages, assume constant sound velocity throughout the water column, as well as combined observed ship and sea noise level of less that 40 dB (sea state 5 or lower limited by the system's internal noise). The depth dependent attenuation value for cold ocean is used in the calculations.

The coverage curves have been calculated for three bottom types, characterized by backscatter strengths of -20, -30, and -40 dB at 30° incidence angle. This corresponds to bottom surfaces composed theoretically of gravel, sand and mud respectively. Experience shows that most real-life bottoms will fall between the -30 dB curve and the -40 dB curve (the two lower ones).

In all coverage plots the same pulse length and the same bandwidth are used as when the echo sounder is operating in Auto mode. A wider swath can be achieved by selecting a mode with a longer pulse length than the auto mode does.

For the 0.5° x 1° model three sets of curves are provided. One set for three different noise levels and a bottom with backscatter strength of -30 dB. One set for two different attenuation coefficients and three bottom types. The last set is calculated for three bottom types and measured coverage is marked in the figure. The bottom type at the respective depth points is not known:

- *EM 710 FM sweep for 0.5° x 1°, Sand [-30 dB], calculated for 3 different noise levels* on page 13.
- *EM 710 FM sweep for 0.5° x 1° – cold and warm ocean* on page 14.
- *EM 710 FM sweep for 0.5° x 1° with measured coverage* on page 14.

In the following figures range performance is calculated for the system configurations shown in table *Overview of the different EM 710 models* on page 11:

- *EM 710 swath widths, FM sweep for 1° x 1°* on page 15
- *EM 710 swath widths, FM sweep for 1° x 2°* on page 15
- *EM 710 swath widths, FM sweep for 2° x 2°* on page 16
- *EM 710S swath widths, CW long pulse for 0.5° x 1°* on page 16
- *EM 710S swath widths, CW long pulse for 1° x 1°* on page 17
- *EM 710S swath widths, CW long pulse for 1° x 2°* on page 17
- *EM 710S swath widths, CW long pulse for 2° x 2°* on page 18
- *EM 710RD swath widths, CW short pulse for 1° x 2°* on page 18
- *EM 710RD swath widths, CW short pulse for 2° x 2°* on page 19
- *EM 710 swath widths, 0.5° x 1° – ice window* on page 19 is for a reinforced transducer.

Figure 3 EM 710 FM sweep for 0.5° x 1°, Sand [-30 dB], calculated for 3 different noise levels

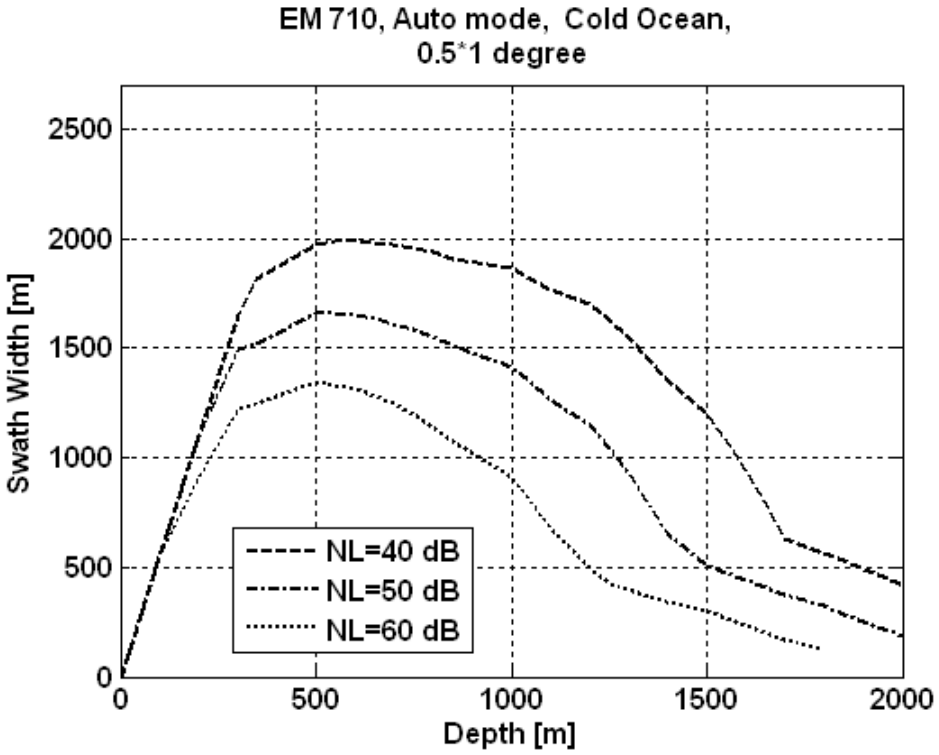


Figure 4 EM 710 FM sweep for 0.5° x 1° – cold and warm ocean

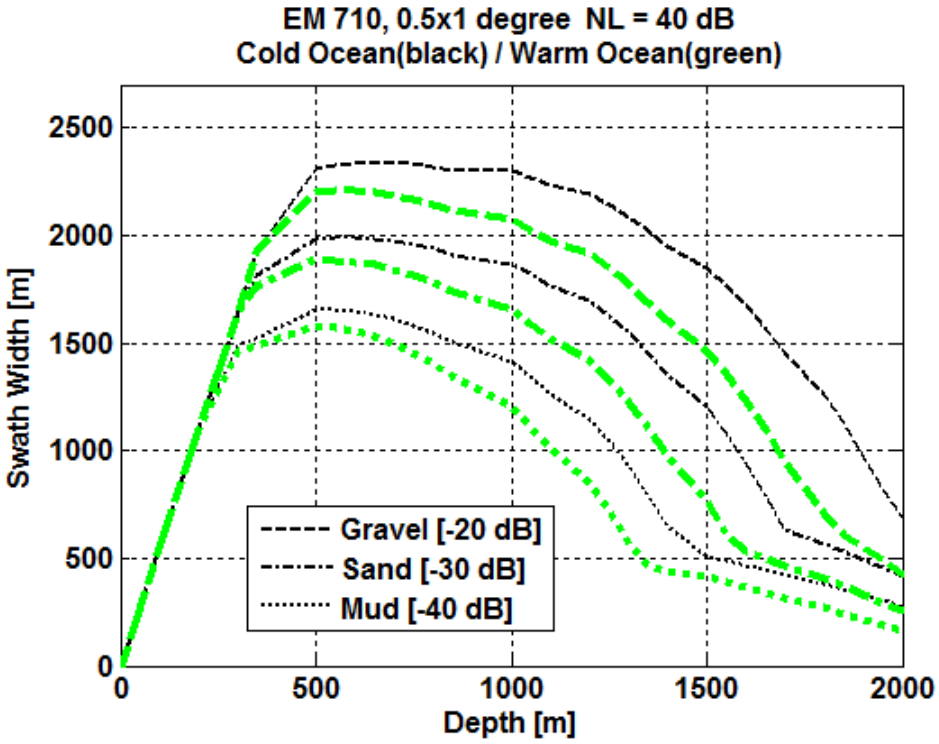


Figure 5 EM 710 FM sweep for 0.5° x 1° with measured coverage

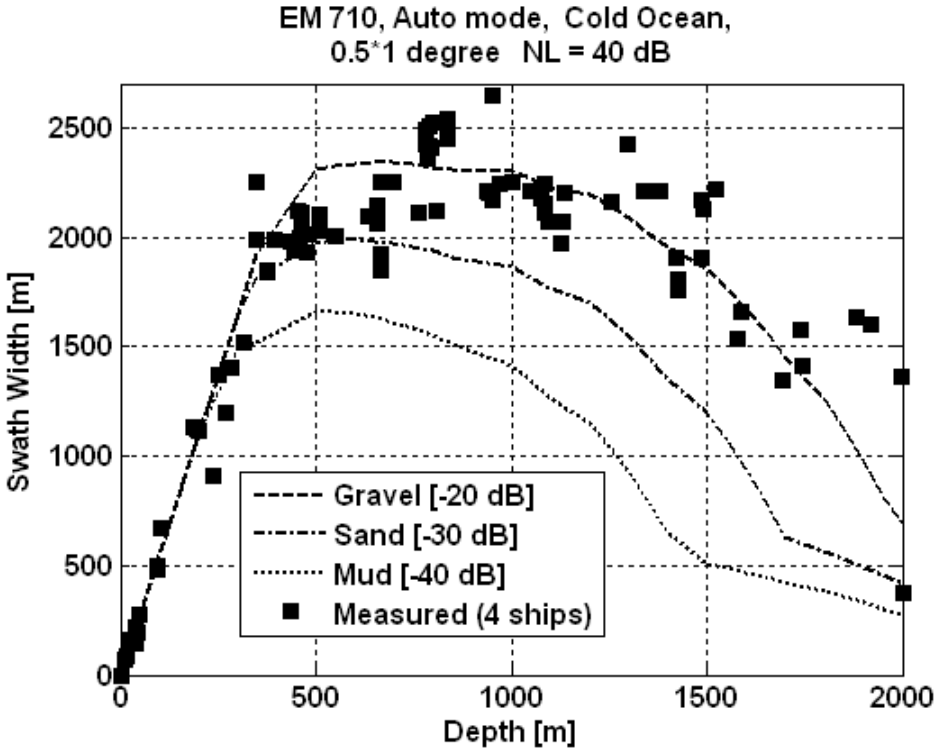


Figure 6 EM 710 swath widths, FM sweep for 1° x 1°

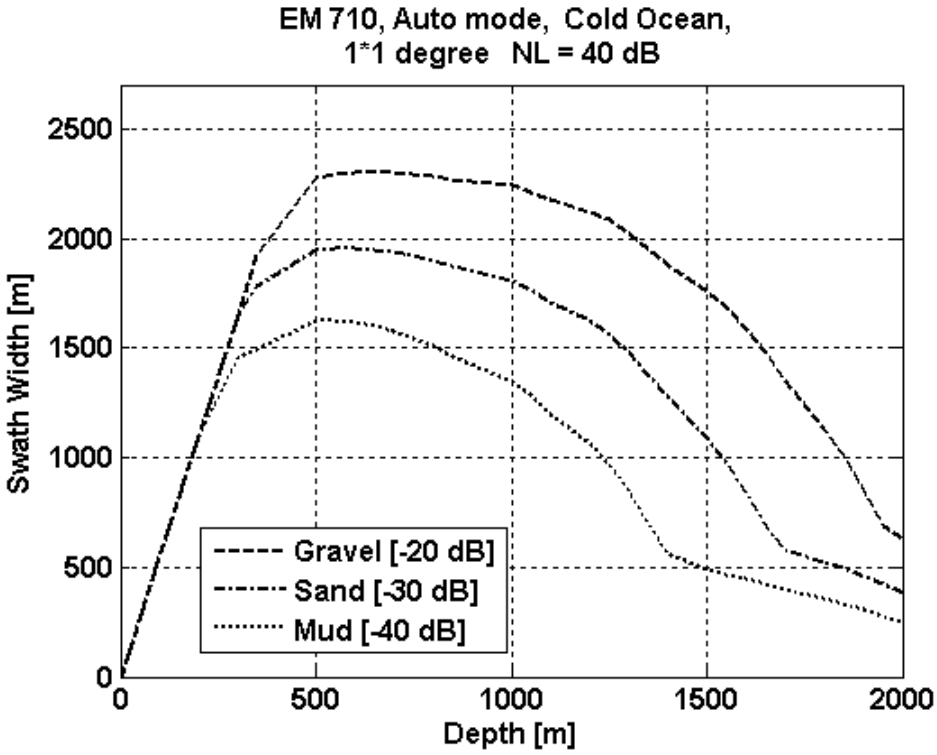


Figure 7 EM 710 swath widths, FM sweep for 1° x 2°

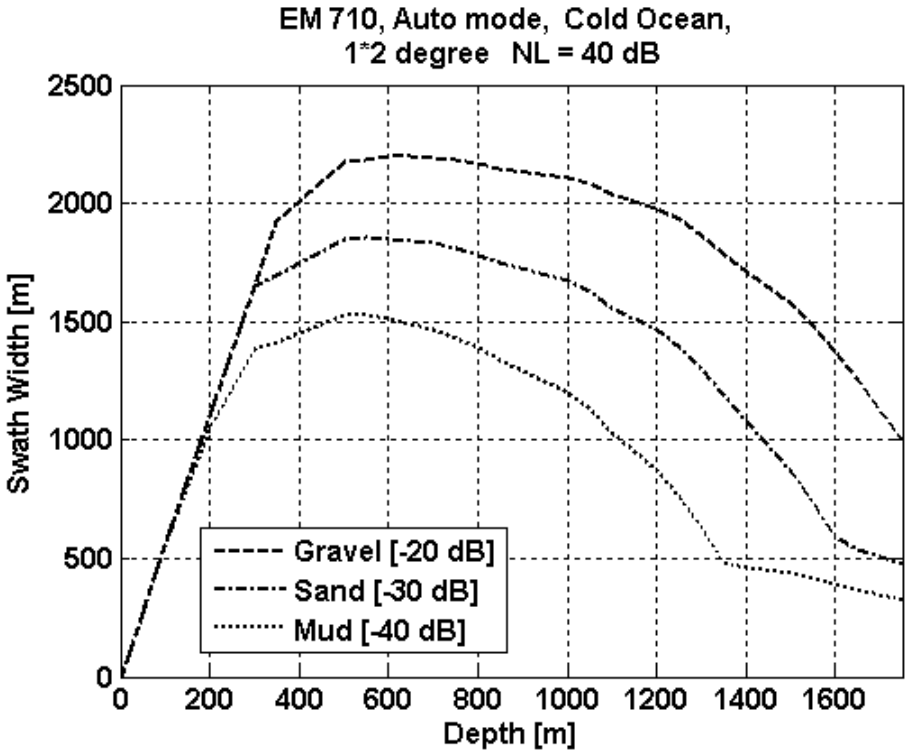


Figure 8 EM 710 swath widths, FM sweep for 2° x 2°

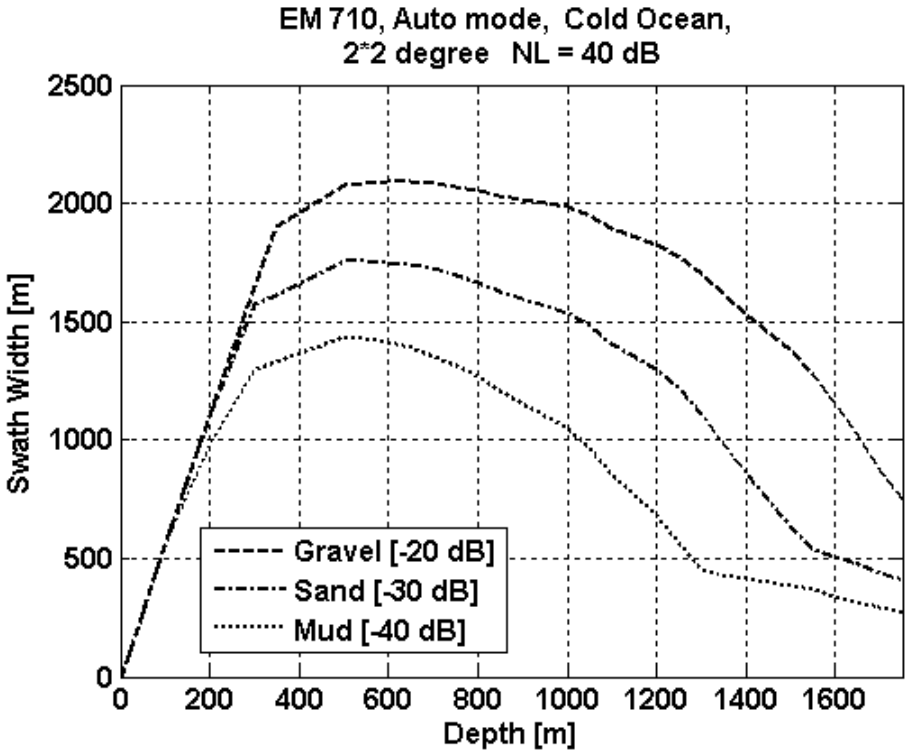


Figure 9 EM 710S swath widths, CW long pulse for 0.5° x 1°

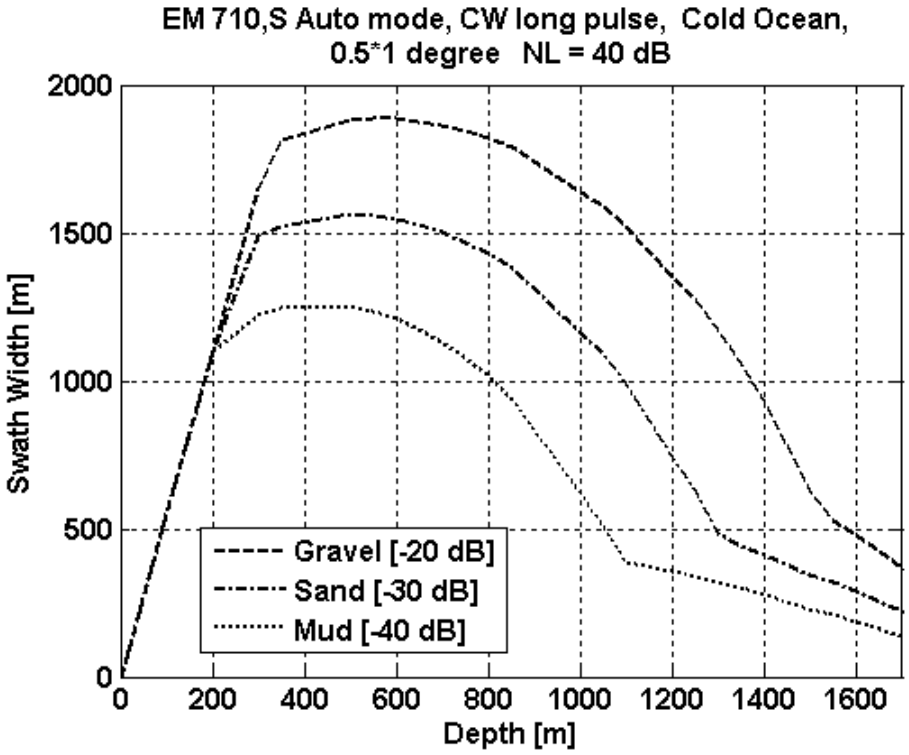


Figure 10 EM 710S swath widths, CW long pulse for 1° x 1°

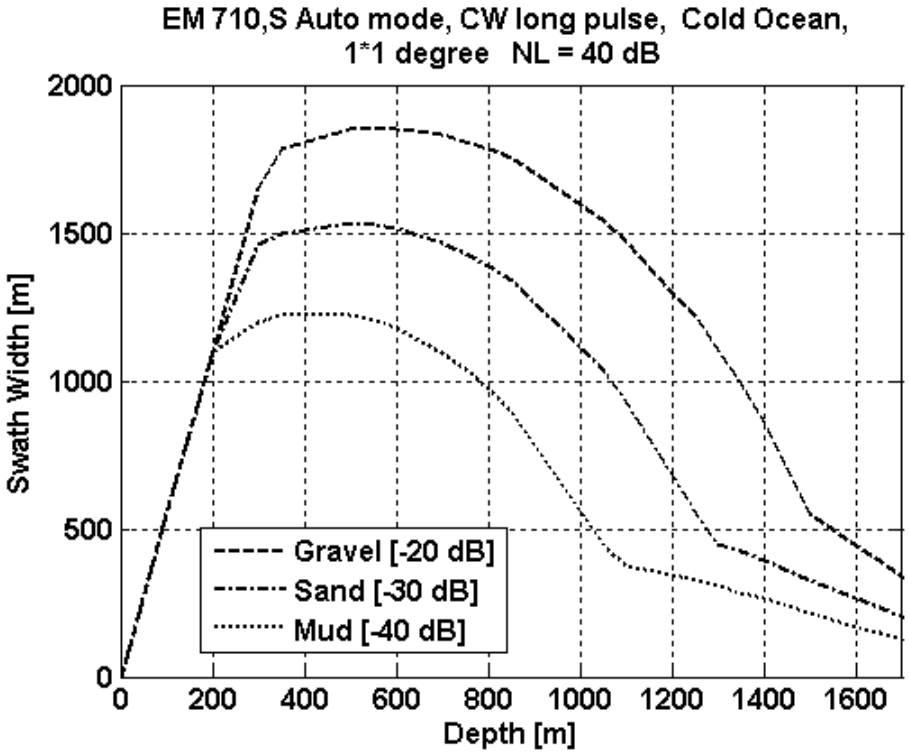


Figure 11 EM 710S swath widths, CW long pulse for 1° x 2°

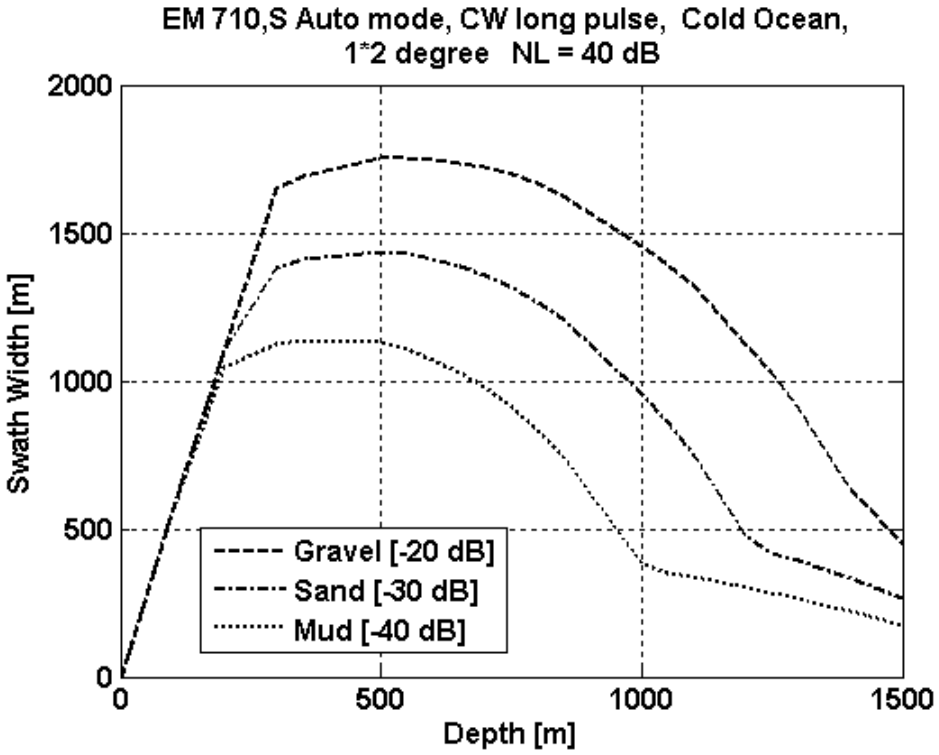


Figure 12 EM 710S swath widths, CW long pulse for 2° x 2°

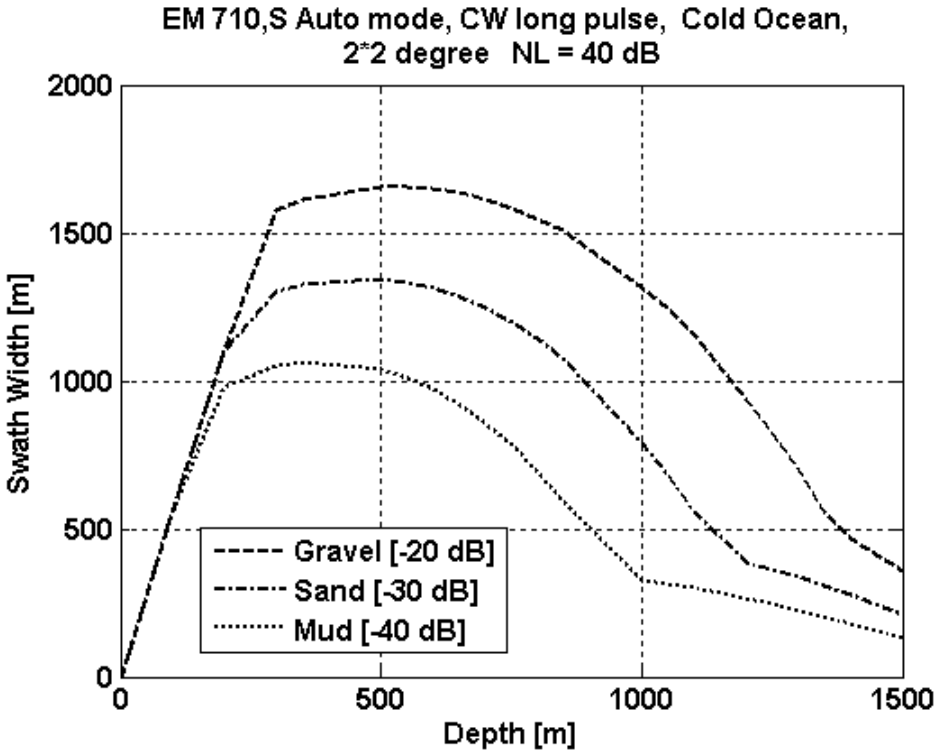


Figure 13 EM 710RD swath widths, CW short pulse for 1° x 2°

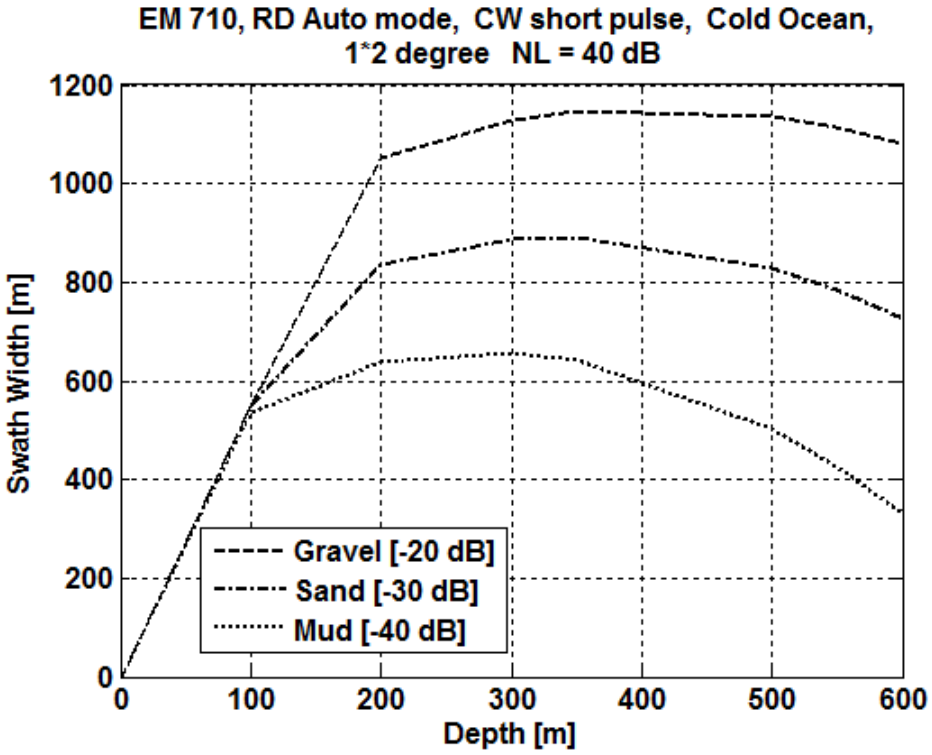


Figure 14 EM 710RD swath widths, CW short pulse for 2° x 2°

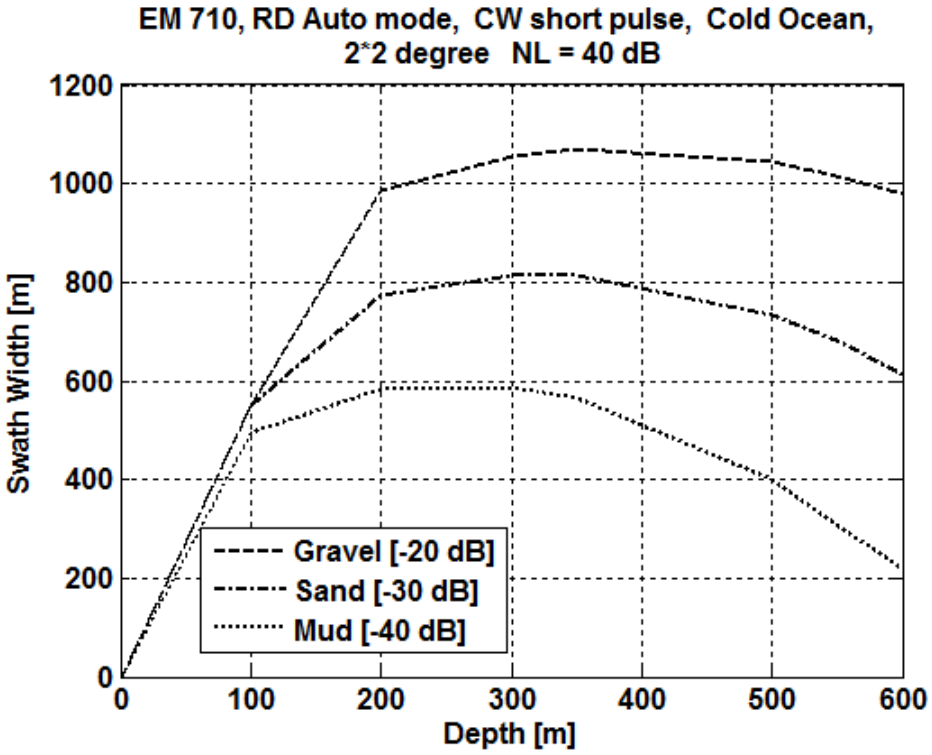
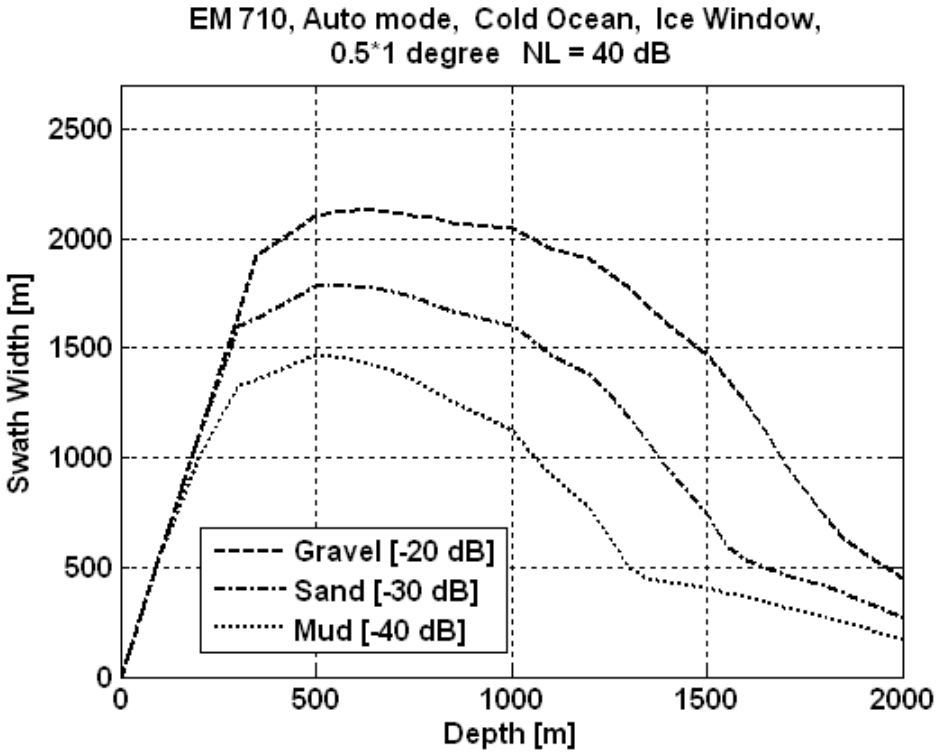


Figure 15 EM 710 swath widths, 0.5° x 1° – ice window



Depth accuracy

The depth sounding accuracy of EM 710 is very good thanks to precise digital beamforming, beam focussing and high sampling rate. But most important is the advanced bottom detection methods proven through many years of experience with the Kongsberg range of multibeam echo sounders.

Near normal incidence at center of gravity amplitude detection is used, but for the majority 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.

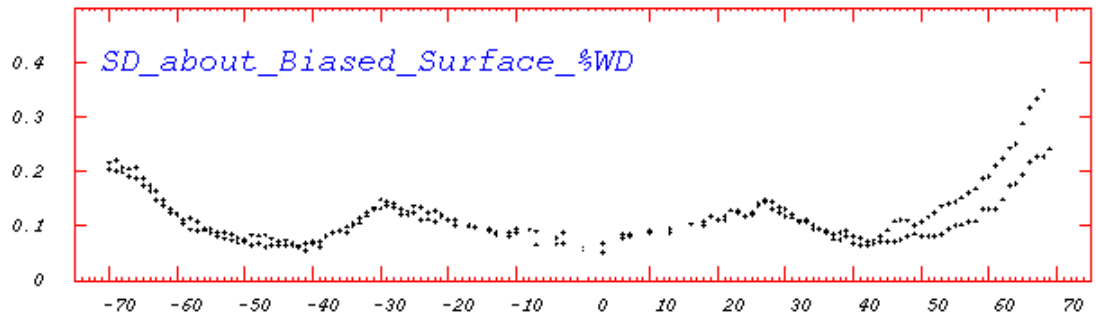
The expected total system RMS accuracy, assuming good quality external sensors, is then the largest number of 5 cm and:

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

These numbers are valid for signal to noise ratio better than 10 dB.

With optimal installation and good oceanographic conditions even better system accuracy can be achieved as shown in *Example of total system accuracy for EM 710 0.5° x 1°. Courtesy of the University of New Brunswick.* on page 20

Figure 16 Example of total system accuracy for EM 710 0.5° x 1°. Courtesy of the University of New Brunswick.



Horisontal resolution

The horizontal resolution of EM 710 is much improved in relation to previous models, due to the introduction of focussed 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 710 transmit beam:

Table 2 Alongtrack resolution for the transmit beam

Alongtrack footprint for EM 710 [m]						
Beamwidth [degree]	**0.5° TX**		**1° TX**		**2° TX**	
Water depth [m]	Vertical	Outer edge	Vertical	Outer edge	Vertical	Outer edge
5	0.05	0.1	0.1	0.3	0.2	0.5
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	5.1	3.5	10.2	7.0	20.9
400	3.5	10.2	7.0	20.4	14.0	40.8
800	7.0	20.4	14.0	40.8	28.1	83.5
1600	14.0	40.8	28.0	81.7	56.1	163.4

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.

A narrower swath 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 3 Alongtrack distance for 120° swath width, single swath

Alongtrack distance between profiles [m]					
Water depth [m]	**Swath width [m]**	**Ping rate**	**4 knots**	**8 knots**	**12 knots**
5	17	22.0	0.1	0.2	0.2
50	173	5.2	0.4	0.8	1.2
100	350	2.7	0.8	1.5	2.3
200	693	1.4	1.5	2.9	4.4
400	1386	0.7	2.9	5.9	8.8
800	2300	0.4	5.1	10.3	15.4
1600	2300	0.2	10.3	20.6	30.9

Table 4 Alongtrack distance for 140° swath width, single swath

Alongtrack distance between profiles [m]					
Water depth [m]	**Swath width [m]**	**Ping rate**	**4 knots**	**8 knots**	**12 knots**
5	27	17.8	0.1	0.2	0.3
50	275	3.6	0.6	1.1	1.7
100	550	1.9	1.1	2.2	3.3
200	1099	1.0	2.1	4.1	6.2
400	2198	0.5	4.1	8.2	12.4
800	2300	0.2	8.6	17.2	25.7
1600	2300	0.1	17.2	34.3	51.4

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 for all soundings derived from phase detections. In practice this means all soundings except for some few at the vertical or specular incidence angle.

This is a great achievement, and gives a nearly constant crosstrack 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° receiver array versions have 400 soundings per profile, while the 2° receivers have 200 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 90°, 120° and 140° swath width.

Table 5 Size of acoustic footprint in crosstrack direction, high density mode.

Size of acoustic footprint - crosstrack						
	Swath width			**Swath width**		
Water depth [m]	90°	120°	140°	90°	120°	140°
5	0.05	0.09	0.14	0.10	0.18	0.28
50	0.50	0.88	1.38	1.00	1.75	2.75
100	1.00	1.75	2.75	2.00	3.50	5.50
200	2.00	3.50	5.50	4.00	7.00	11.00
400	4.00	7.00	11.00	8.00	14.00	22.00
800	8.00	14.00	-	16.00	28.00	-
1600	16.00	-	-	32.00	-	-
	One degree RX			**Two degree RX**		

Table 6 Spacing between neighbour soundings, crosstrack direction, high density mode

Spacing - neighbour soundings crosstrack						
	Swath width			Swath width		
Water depth [m]	90°	120°	140°	90°	120°	140°
5	0.03	0.04	0.07	0.05	0.09	0.14
50	0.25	0.44	0.69	0.50	0.88	1.38
100	0.50	0.88	1.38	1.00	1.75	2.75
200	1.00	1.75	2.75	2.00	3.50	5.50
400	2.00	3.50	5.50	4.00	7.00	11.00
800	4.00	11.00	-	8.00	14.00	-
1600	8.00	-	-	16.00	-	-
	One degree RX			Two degree RX		

EM 710 object detection capability

There is increased interest for surveys performed according to IHO-S44 order 1 or special order. EM 710 is well suited for such surveys. Depending upon which version of EM 710 is selected, different capabilities for object detection are obtained.

IHO special order requires that objects of a 1 m size and larger shall be detected, while IHO order 1 requires that objects of a 2 m size and larger shall be detected to about 40 m depth.

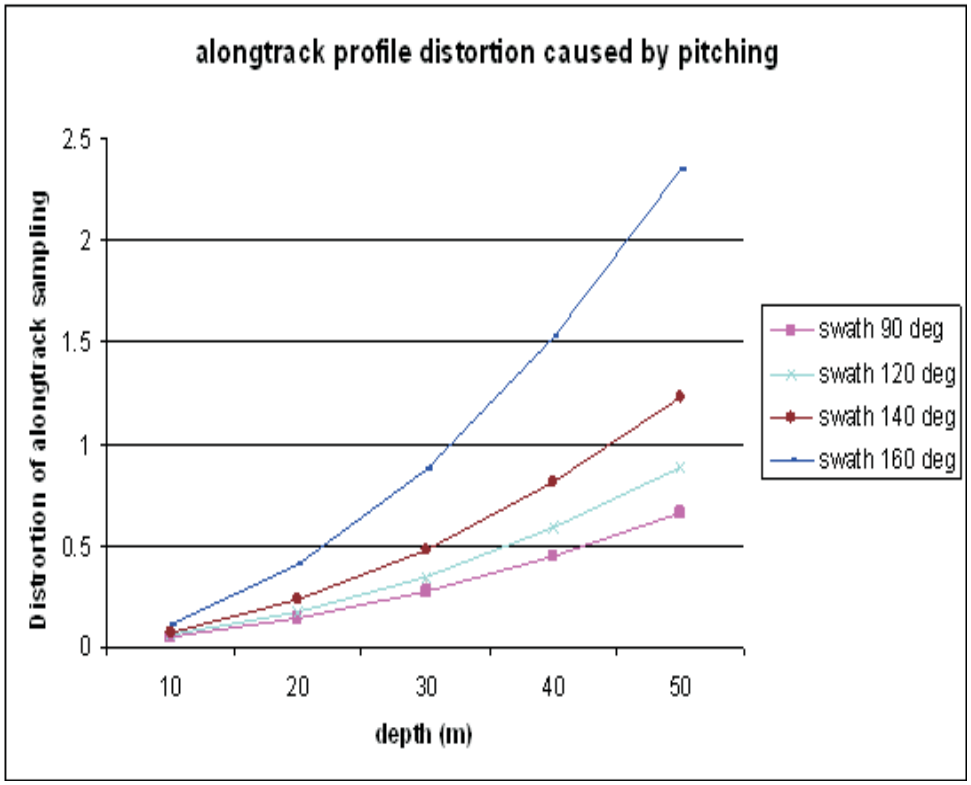
LINZ raises an additional condition or clarification; that the object should have at least 9 hits, 3 along and 3 across. The idea behind this is that automatic algorithms for cleaning of bathymetric data will remove isolated soundings but accept a cluster of soundings. By experience we know that the acoustic footprint on the object cannot be more than 150% of the object size for reliable detection.

It is easy to see that equidistant pattern of soundings is ideal for object detection, as well as the controlled and small acoustic footprint which is obtained with the high density signal processing.

A necessary feature for reliable object detection in waves, is active stabilisation of the beams for ships pitching. At least for depths of more than 20 m in croppy seas and with a small boat, this is an important requirement.

The figure is calculated for a modest ±3° of pitch and the wave period is sinusoidal with a 3 second period.

Figure 17 Non stabilized transmit beam. Alongtrack position shift between soundings caused by waves.



Since EM710 applies active pitch (and roll) stabilisation, vessel motions will not be a problem for the system.

The diagrams below indicate what level of object detection capability will be obtained by the different versions of EM 710, for different vessel speeds and swath widths. Green means it will comply and red not comply.

Table 7 EM 710 - 0.5° x 1°

Special order 20 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Special order 40 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Order 1 - 20 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Order 1 - 40 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Table 8 EM 710 - 1° x 2°

Special order 20 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Special order 40 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Order 1 - 20 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Order 1 - 40 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Table 9 EM 710 - 2° x 2°

Special order 20 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Special order 40 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Order 1 - 20 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

Order 1 - 40 m				
Water depth [m]	4 knots	8 knots	12 knots	16 knots
90				
120				
140				

The 1° x 1° version of EM 710 with 2 profiles per ping will have the same capability for object detection as the 0.5° x 1° version.

Figure 18 1 m cubic object used for verification of object detection performance.

Figure 19 Raw soundings on the 1 m cube, depth 32 m, crosstrack distance 57 m.

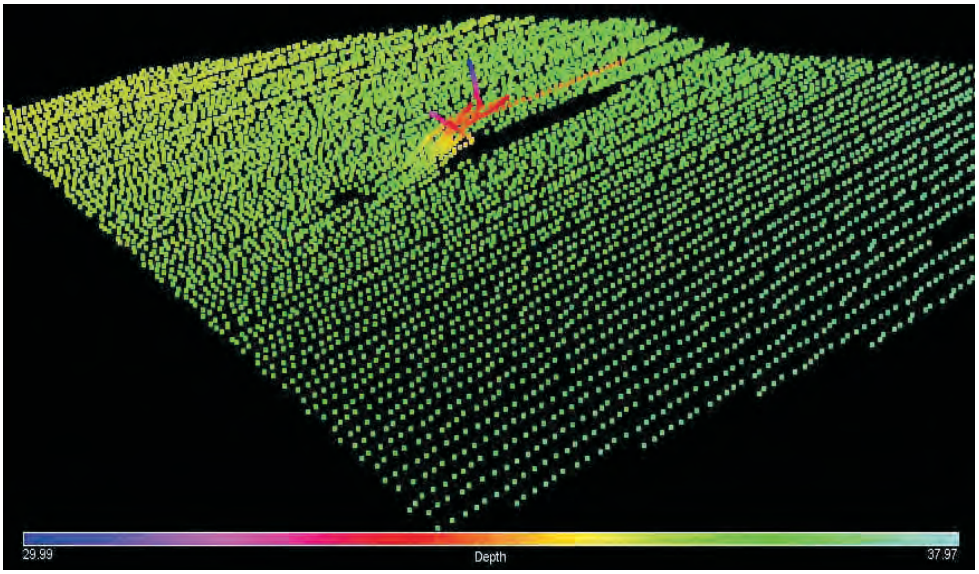


Figure 20 Sun illuminated terrain model, one EM 710 2° x 2° survey line. Courtesy of University of New Brunswick.

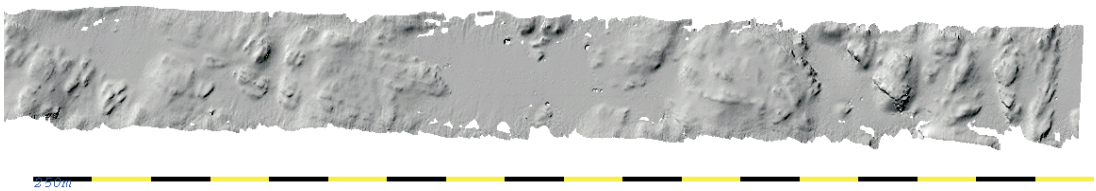
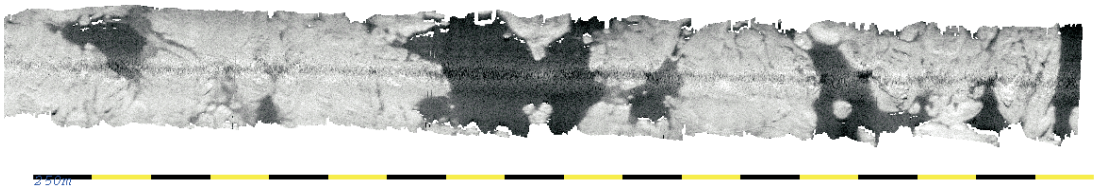


Figure 21 Co-registered seabed imagery of the same survey line. 24



Acoustic seabed imagery

Introduction

The EM 710 produces two datasets with different resolution and characteristics which both represent the acoustic backscatter properties of the seafloor. Both datasets are produced as one crosstrack profile of seabed backscatter. Beamforming is applied before extracting the backscatter properties, in order to improve the signal to noise ratio and to eliminate artefacts in the data. The data set formats by the EM 710 are documented in the EM series Datagram Formats, published in the webpage www.kongsberg.com under multibeam echosounders.

The Seabed Imagery

The dataset from the Seabed Imagery has the highest resolution of 5 cm in range. Each sample represents the measured backscatter coefficient for the specific spot on the seabed, with 0.1 dB resolution. The number of samples depends upon the swathwidth. It will be in the order of 10-15 times the width of the swath in meters. The seabed imagery data is compensated for:

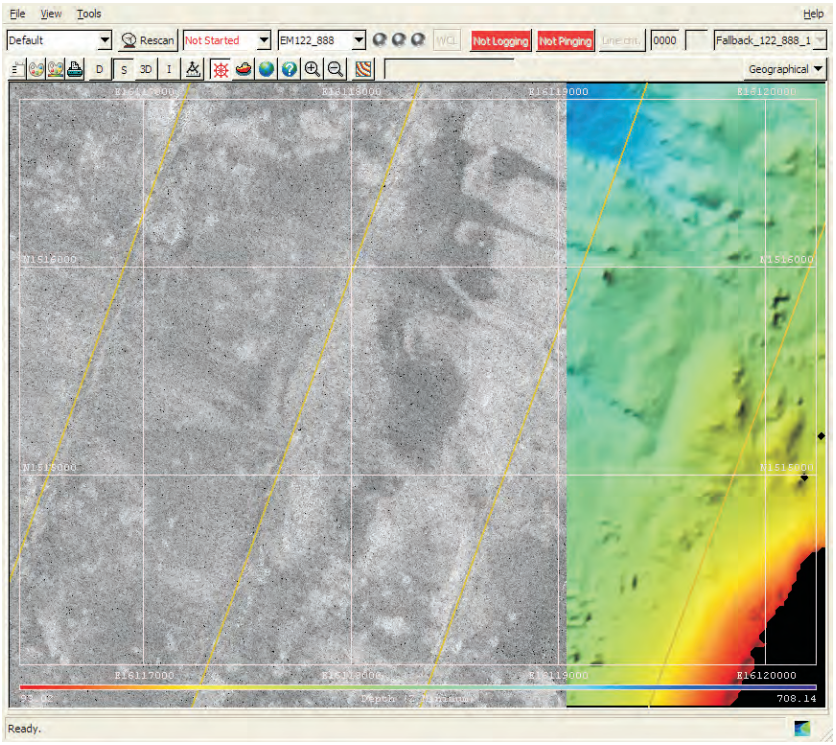
- Transmit power
- transmit pulse length
- receiver sensitivity
- beam pattern
- bandwidth
- spherical spreading
- acoustic losses in the water column
- incidence angle with the seafloor for a flat bottom assumed.

For the correct geo referencing of each data value, each sample is referred to an acoustic beam, for which the correct x, y, z value is calculated taking into account the orientation of the transducer array both on transmit and receive time, acoustic raybending/ refraction, and heading information.

For furter details, see EM technical note Backscattering and Seabed Image reflectivity by Erik Hammerstad, published in the webpage www.kongsberg.com under multibeam echosounders.

The other dataset is the Seabed reflectivity, which has a lower resolution. One value per beam is included as part of the depth datagram, also this with 0.1 dB resolution. For this data set, no corrections applied for incidence angle with the seafloor, but all the other corrections above are applied. The value which is presented, is a average estimate of the maximum value inside the beam.

Figure 22 Seabed picture of sand area



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Installation principals

Introduction

The compactness of the EM 710 multibeam echo sounder is a guarantee for a fast and easy installation.

Operator Station

The Operator Station is a ruggedized PC workstation, prepared for mounting in a standard 19” rack (requires 4 rack height units). It is supplied with a rackable 19” industrial LCD monitor, a keyboard and an optical mouse. A bracket for the monitor is included for table top, bulkhead and roof mounting.

Transducer arrays

The transducers should be mounted in the forward part of the vessel, taking into account hull shape, potential aeration problems and ease of cable installation. A mounting frame is normally required.

A fairing will usually be added around the transducers to ensure laminar water flow without any aeration problems. A blister or gondola installation may help in avoiding air bubble blockage of the sound path under the transducers by aerated water. Blisters and gondolas may also contain additional transducers for other systems.

The cables connecting the transducers to the Transceiver Unit have a standard length of 15 m, and are terminated with connectors which plug directly into the cabinet. Normally, in a permanent installation, 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 diver replacement of transducer is envisioned. If the tubes end below the water-line, classification requirements may require a double set of glands.

After installation it is necessary to measure the location of the transducers and their angular orientation in the vessel coordinate system accurately.

Do not ping when the vessel is in dry dock. The system is not harmed if pinging due to sudden placement of the system out of the water due to ship own movement.

Portable mounting

For a portable 2º by 2º EM 710 model, Kongsberg Maritime can offer a standard mounting arrangement. This will have the transducers mounted, including a surrounding fairing, ready to be fitted to a mounting stand either going over the bow or over the side. To lessen the effort with respect to surveying of the transducers' location and orientation and to improve the system accuracy, it may be best to fit the motion sensor to the mounting arrangement close to the transducer. This will however still require a survey of the mounting frame location and orientation with respect to vessel heading and location of the positioning system (i.e. GPS antenna). To avoid such a survey completely, the mounting arrangement must include a sufficiently accurate heading sensor and the positioning system must give the position of the multibeam, i.e. the GPS antenna should also be fixed to the mounting arrangement, for example at the top of the pole holding it.

Figure 23 Installation of the 2° x 2° transducer array on "HMS Endurance"

Figure 24 Installation of the Transceiver Unit on "HMS Endurance"

Figure 25 0.5° EM 710 TX transmit array

Figure 26 1° RX receive array

Canadian Hydrographic Services survey vessel CCG Matthew

Figure 27 Transportable EM 710 1° x 2° array

Operational principals

System features

The EM 710 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 710 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 710 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.

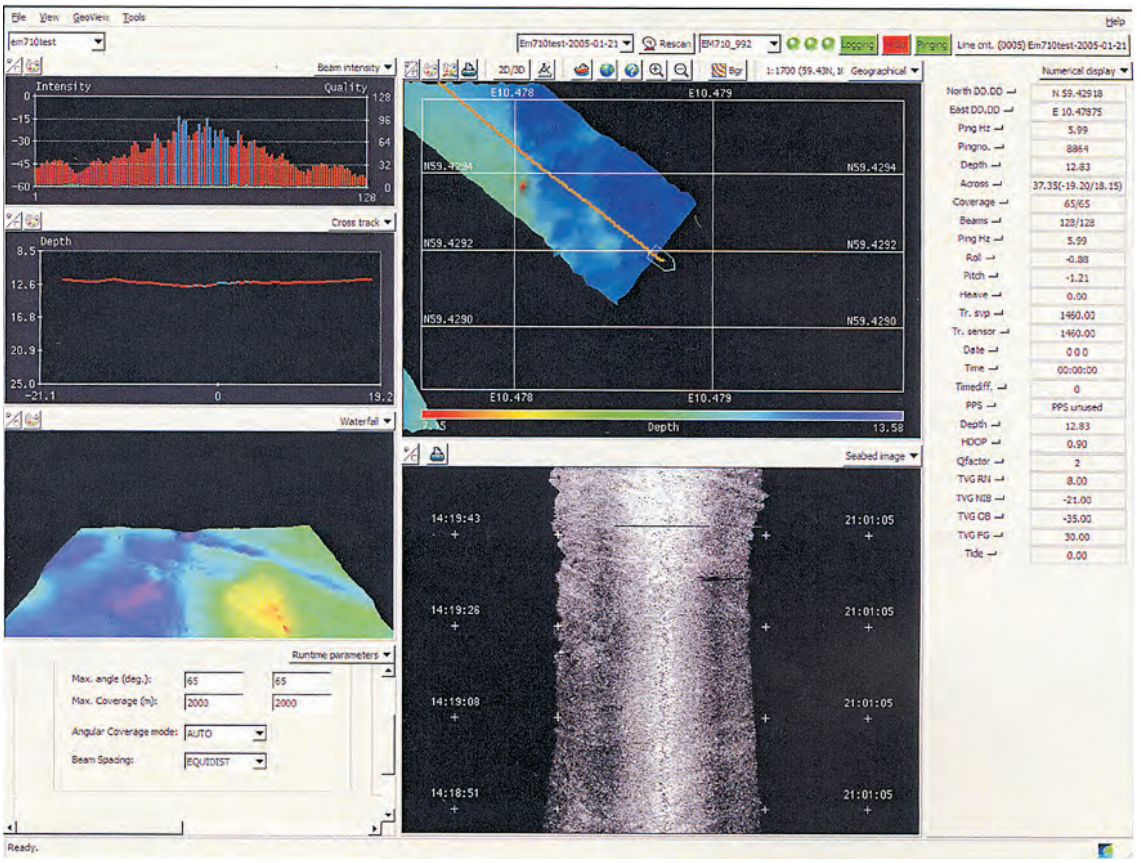
A planning module makes it possible to define and edit planned lines, make parallel lines, define survey regions, etc. Plans can be imported and exported between systems.

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 28 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 710 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 710 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 710 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 710 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 710 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 710 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 710 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 710 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 710 multibeam echo sounder delivery includes:

- Operator Station HWS with 19” LCD monitor
- SIS Operator sw
- Transceiver Unit configured according to chosen model
- Transducers in accordance to chosen model
  - Transmit transducer
  - Receive transducer
  - Transducer cables (15 m length)
- Signal and control cables
  - Ethernet cable (Gigabit) between Transceiver Unit and Operator Station
- Remote control unit for Transceiver Unit
- All system software
- Technical manuals covering system installation, operation and maintenance

Options

System options available include:

- Mounting arrangement for over-the-bow mounting of 2° by 2° model transducers which may include integrated motion sensor, heading sensor and positioning sensor
- Non-standard cable lengths (25 meter cables) or connectors
- Helmsman Display and/or additional monitors
- Various software options (Water column data logging, automatic calibration)
- Removable disks
- IP65 integrated keyboard and pointing device
- Spare parts
- Reinforced transducer with strengthen mounting frame

System integration

The EM 710 system as presented in this product description is prepared for integration with other sensors to form a complete seabed mapping and inspection system. Kongsberg Maritime can supply the EM 710 either as a sub-system for integration by the user or other parties, or we can offer complete system solutions tailored to the user's need.

Dual frequency system solutions can be formed by combining the EM 710 with a lower frequency multibeam echo sounder such as the EM 122 / EM 302.

Additionally Kongsberg Maritime may deliver the EM 710 as part of a complete survey system. This may include integration with single beam echo sounders and/or other multibeam echo sounders for seamless coverage of any depth range.

Technical specifications

Note

Kongsberg Maritime is engaged in continuous development 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 Octopus, Kongsberg Seatex
  - Heading (gyrocompass) in either NMEA 0183 HDT, SKR82/LR60 or Sperry Mk39 format
  - Position in either Simrad 90, NMEA 0183 GGA or GGK format
  - External clock in NMEA 0183 ZDA format
  - Sound speed at transducer
  - Sea level height (tide)
  - Single beam echo sounder depths
  - Output of depth straight down in NMEA 0183 DPT format
- Interface for a 1PPS (pulse per second)
- Clock synchronisation signal
- Firewire interface for external data storage device
- USB 2.0 interfaces for data storage, printing or plotting
- Parallel interface for PostScript colour graphics, printer/plotter
- Ethernet interface for velocity input needed for Doppler compensation in chirp mode.
- Ethernet interface for input of sound speed profile
- Tide and echo sounder depths, and output of all data normally logged to disk

Physical specifications

Operator Station

- **Height:** 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 bracket)
- **Width:** 483 mm (excluding mounting bracket)
- **Depth:** 68 mm (excluding mounting bracket)
- **Weight:** 12 kg (approx w/bracket)
- **Power:** 115 Vac (60 Hz) and 230 Vac (50 Hz), 100 W (max)

Transceiver Unit (version for bulkhead mounting)

- **Height:** 841 mm
- **Width:** 540 mm
- **Depth:** 750 mm (nominal including shock absorbers)
- **Weight:** 127 kg (0.5° by 1°) or 116 kg (1° by 1°) 111 kg (1° by 2°), 106 kg (2° by 2°)
- **Power:** 115 Vac (60 Hz) and 230 Vac (50 Hz), < 900 W

Transceiver Unit – 2° x 2° system (version for bulkhead mounting)

- **Height:** 573 mm
- **Width:** 540 mm
- **Depth:** 750 mm (nominal including shock absorbers)
- **Weight:** 83 kg
- **Power:** 115 Vac (60 Hz) and 230 Vac (50 Hz)

Transducer, 0.5° version

- **Length:** 1940 mm
- **Width:** 224 mm
- **Height:** 118 mm
- **Frame:** 68 kg
- **Weight Tx:** 196 kg (2 modules each with 10 cables)

Transducer, 1°

- **Length:** 970 mm
- **Width:** 224 mm

- **Height:** 118 mm
- **Frame:** 36 kg
- **Weight Rx:** 56 kg (incl. 4 cables)
- **Weight Tx:** 98 kg (incl. 10 cables)

Transducer, 2°

- **Length:** 490 mm
- **Width:** 224 mm
- **Height:** 118 mm
- **Frame:** 18 kg
- **Weight Rx:** 28,5 kg (with 2 cables)
- **Weight Tx:** 50 kg (with 5 cables)

The transducers have a maximum depth rating of 250 m.

Environmental and EMC specifications

Reference standards

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

IP grade

- Operator Station(HWS) and LCD monitor: IP22
- Transceiver Unit: IP44

Table 10 Temperature

Unit	Storage	Operating
Operator station(HWS) and monitor	-30 to +70ºC	+5 to +50ºC
Tranceiver	-30 to +70ºC	-5 to +50ºC
Transducer	-30 to +70ºC	-5 to +50ºC

Humidity

- Humidity: @40ºC : 93% RH. The system can be operated until 1 hour with 100 % RH.

Vibration

- 5–150 Hz
- 1 g

Shock

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

Power Supply

- Power Supply variation: @115V/230V and @60/50Hz
- Voltage ±10%
- Frequency ± 5%

Salinity

- Transducers can operate in waters with salinities in the range 0 ppt to 50 ppt

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.

System performance data

- Maximum ping rate: More than 30 Hz
- Number of swaths per ping: 2

Number of beams and soundings		
System version	0.5 x 1 and 1 x 1	1 x 2 and 2 x 2
Number of beams/swath	256	128
Number of soundings/swath	400	200
Number of soundings/ping	800	400

- Beamwidths: 0.5º x 1º, 1º x 1º, 1º x 2º or 2º x 2º
- Beam spacing: Equidistant, Equiangle, High Density
- Coverage sector: Up to 140°
- Transmit beam steering: Stabilized for roll, pitch and yaw
- Receive beam steering: Stabilized for roll
- Depth range from transducers: 3 to approximately 2,000 metres
- Pulse lengths: 0.2, 0.5 and 2 ms CW plus FM (chirp) up to 120 ms
- Range sampling rate: 15 kHz (5 cm) at data output
- Source level:
  - 1° TX: Up to 225 dB re 1mPa ref 1 m
  - 0.5° TX: Up to 231 dB re 1mPa ref 1 m.

Dual swath restrictions

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 modes long FM pulses are prioritized, so dual swath is not available in these modes.

Table 11 Transmit pulses

EM 710 transmit pulses			
Transmit mode	**Wave form / Frequency range used**	**Pulse length [msec]**	**Approximate depth range [m]**
Very Shallow	CW 65 - 105 kHz	0.2	< 100
Shallow	CW 70 - 90 kHz	0.5	< 200
Medium	CW 70 - 80 kHz	2.0	< 300
Deep	CW + Chirp 70 - 80 kHz	2 / 20	< 500
Very Deep	Chirp 70 - 80 kHz	20 - 40	< 1000
Extra Deep	Chirp 70 - 80 kHz	60 - 120	

Reduced power output (Mammal protect)

Maximum intensity is encountered in a thin wedge extending below the ship with an angular coverage of about 140°. The intensity level may be lowered by 10 or 20 dB by the operator. The EM 710 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.

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, cases a range error. This error must be corrected. The following motion sensors have specifications that fullfills our requirements for doppler shift corrections:

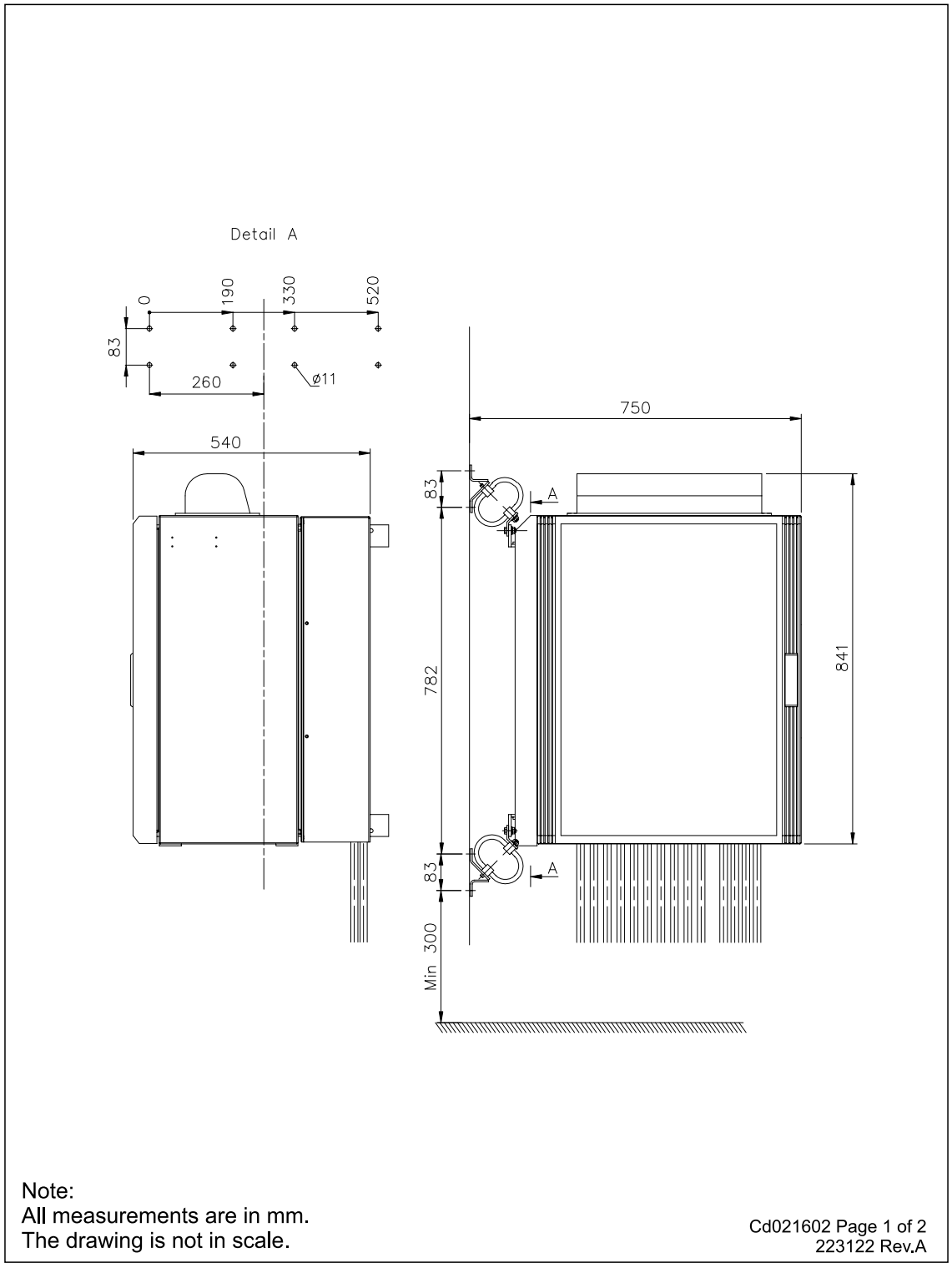
- Kongsberg Maritime – Seapath series
- Applanix – Pos MV
- Coda Octopus – F180
- IXSEA – Phins

Velocitiy input requirements 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

Transceiver Unit Outline dimensions

Figure 29 Transceiver Unit 0.5° x 1° system – Outline dimensions sheet 1



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

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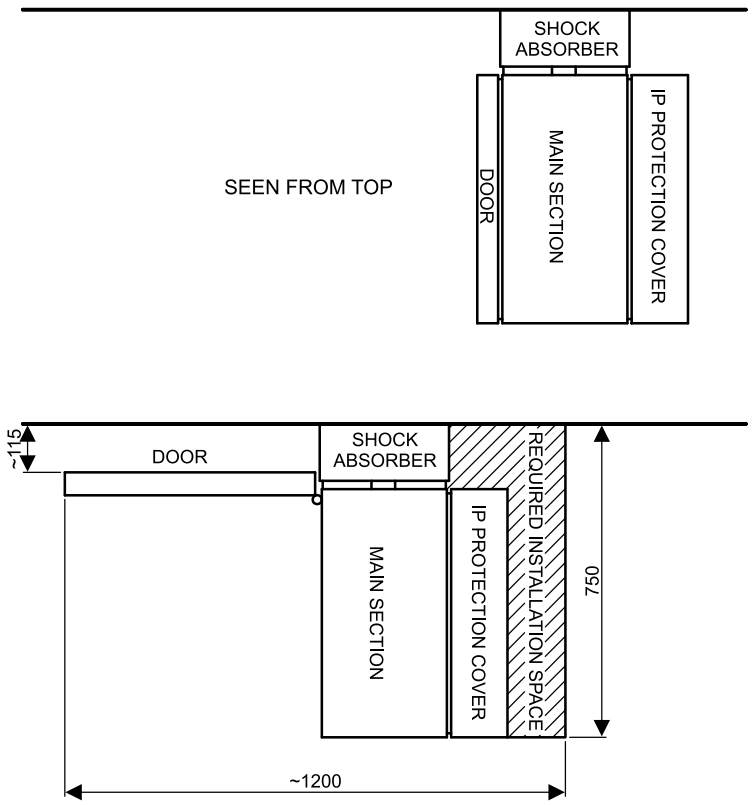
Figure 30 Transceiver Unit 0.5° x 1° system – Outline dimensions sheet 2



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

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Figure 31 Transceiver Unit 2° x 2° system – Outline dimensions sheet 1

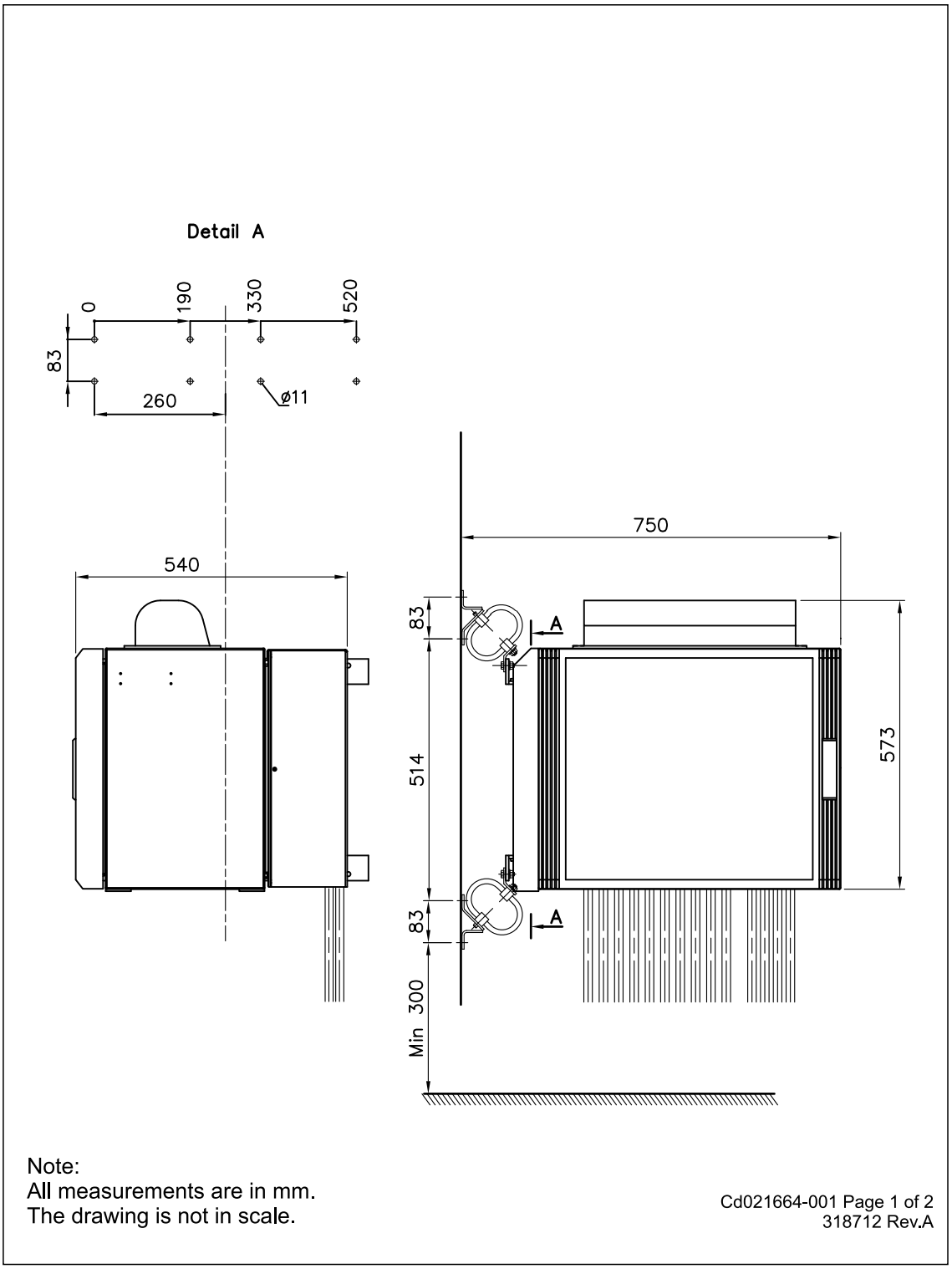
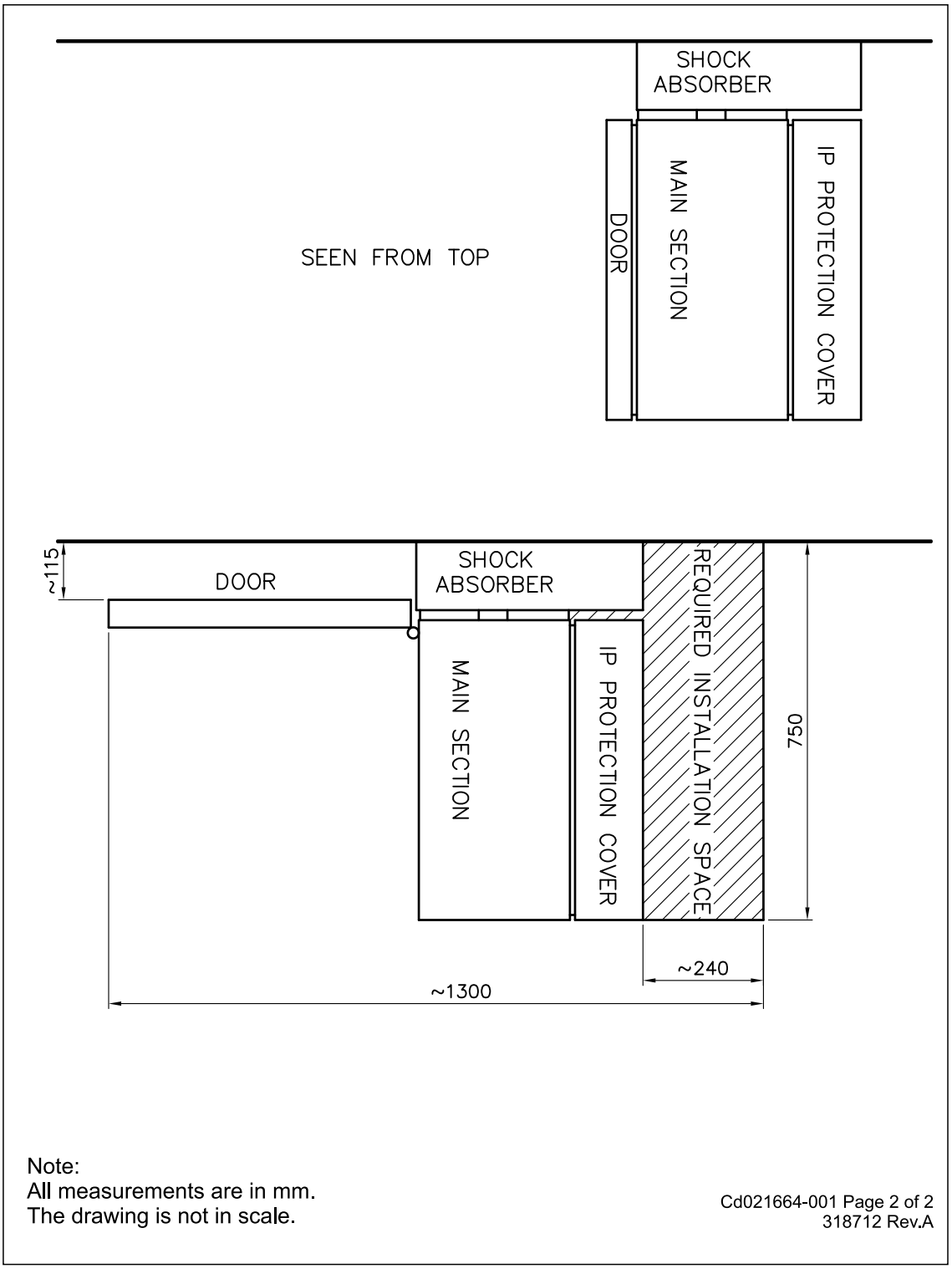


Figure 32 Transceiver Unit 2° x 2° system – Outline dimensions sheet 2



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 33 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 34 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.