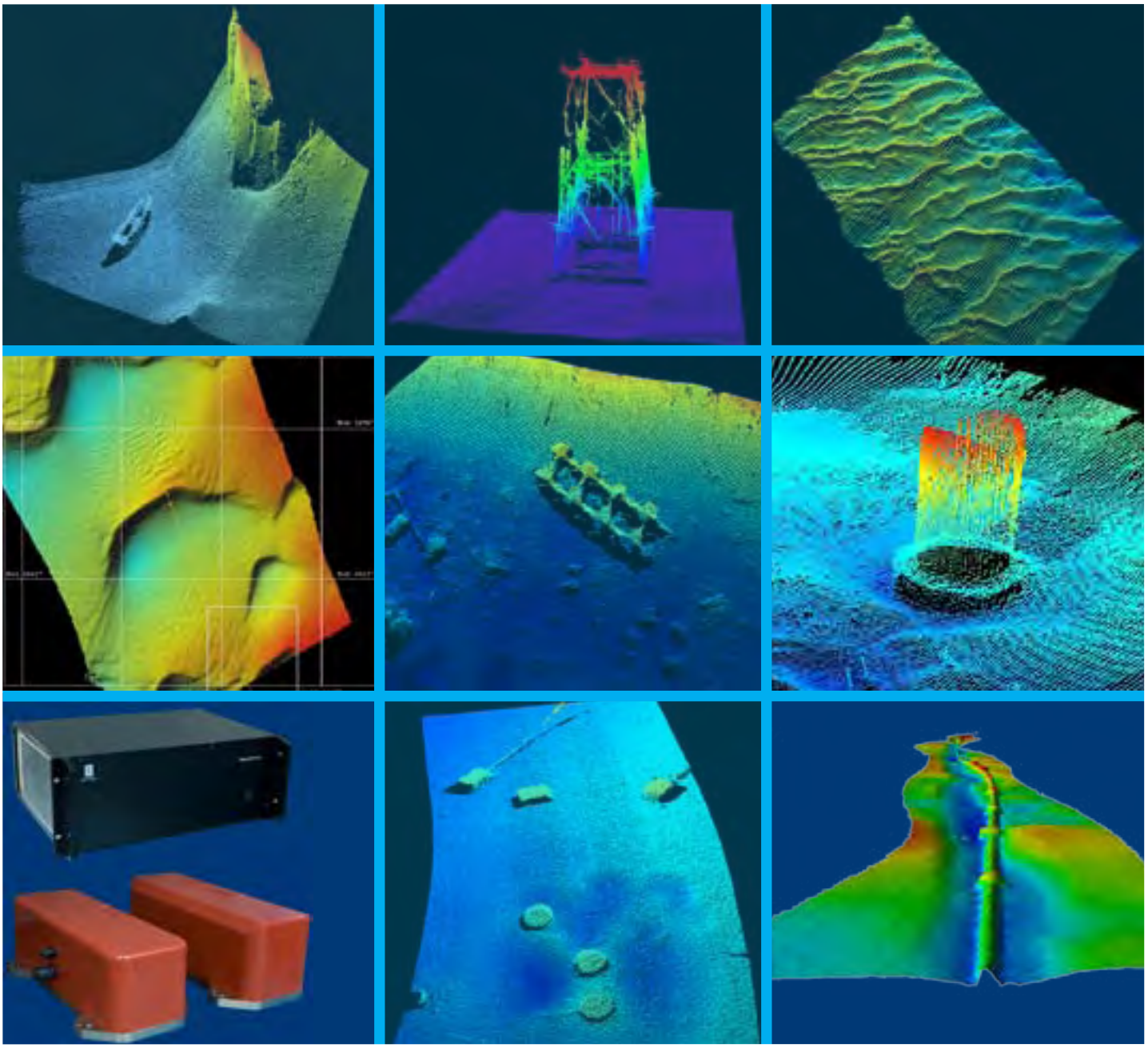
Product description

KONGSBERG

EM 2040

Multibeam Echo Sounder



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Product Description

344245/D

Revision status

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Rev.A	June 2010	First version.
Rev.B	February 2011	Overall revision.
Rev.C	March 2011	Updated coverage curves
Rev. D	February 2012	Overall revision

Disclaimer

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

Warning

The equipment to which this manual applies must only be used for the purpose for which it was designed. Improper use or maintenance may cause damage to the equipment and/or injury to personnel. 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 44.

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System overview

Key facts

- Frequency range from 200 to 400 kHz
- Dual swath capability, allowing sufficient sound density alongtrack at reasonable survey speed
- IEEE 1588 time synchronization system
- FM chirp allowing much longer range capability (depth and coverage) compared to CW pulses
- Complete roll, pitch and yaw stabilization
- Nearfield focusing on both transmit and receive
- Operates with very short pulse lengths – shortest pulse is 25 microseconds
- The depth rating of the subsea parts is 6000 metres
- Available with dual RX system, increasing the coverage to up to 200° (±100°)
- IHO-S44 special order compliant
- The EM 2040 has two TX array sizes:
  - EM 2040-04 (0.4 deg at 400 kHz)
  - EM 2040-07 (0.7 deg at 400 kHz)

The EM 2040 multibeam echo sounder is the first system to bring all the advanced features of deep water multibeams to the near bottom sounding environment.

The EM 2040 operating bandwidth is from 200 to 400 kHz, which is a full octave, and this is achieved using the standard transducers. Three standard modes are available. 300 kHz is used for normal operation, giving an optimum balance between high resolution, depth capability and tolerance of performance deteriorating factors such as water column sediments. 200 kHz is available for meeting requirements to operate at the standard hydrographic single beam frequency, but also to achieve the best depth capability. 400 kHz is provided for inspection work with the utmost resolution.

EM 2040 has the functionality of the lower frequency EM systems, and the small size and weight advantage of the high frequency systems, as well as beamwidth of 0.4 degrees.

The normally recommended survey frequency is 300 kHz. At this frequency the bandwidth used is more than 75 kHz with three angular sectors running at separate frequencies. With dual swath six frequencies are used. The minimum pulselength is 70 microseconds in three sectors, and reduced to 35 microseconds using one sector. With 35

μs pulse the range resolution (defined as cτ/2) is 26 mm. For deep waters FM chirp is employed with a bandwidth of 1.7 kHz. This allows a swath width in the order of 600 m and a depth capability of about 400 m in cold ocean waters.

The 200 kHz frequency mode is similar to the 300 kHz mode. It uses the same CW pulselengths, while the FM chirp pulselength is increased. The range and depth resolution is the same. Normally two sectors are used per swath, but single sector can also be used. At this frequency the absorption in the water is lower than at 300 kHz, resulting in increased swath width and depth capability. In cold ocean waters with FM chirp a swath width of 700 m can be expected and approximately 500 m depth capability.

The 400 kHz frequency mode is intended for high resolution inspection work. Very short transmit pulses and wide receiver bandwidth is used. The operator may select between one and three transmit sectors. With a single RX transducer the coverage limit is 120 degrees (±60°), and with dual RX the coverage is 180 degrees (±90°). The shortest pulse used is 25 μs giving a range resolution less than 20 mm (cτ/2). It is also possible to run dual swath, but not using the shortest pulselength.

The EM 2040 is modular, allowing the user to tailor the beamwidths to the operational requirements, 0.4 by 0.7° or 0.7 by 0.7°. The transmit fan is divided into three sectors pinging simultaneously at separate frequencies. This ensures a very strong and beneficial dampening of multibounce interference which on simpler systems often is seen at beam angles from 60 degrees and outwards. The EM 2040 has dual swath capability, allowing a sufficient sounding density alongtrack at a reasonable vessel speed.

EM 2040 also has a scanning mode, i.e. one sector is transmitted at a time, giving the possibility to use the shortest pulse length while still keeping the full swath coverage.

The standard depth rating of the EM 2040 subsea parts is 6000 m. The system is ideal for use on subsea vehicles such as AUVs or ROVs. All analog electronics are contained in the transducers, and communication to the topside Processing Unit is on standard Ethernet. For subsea vehicle use the Processing Unit may be installed in a pressure rated tank with an inner diameter as small as 230 mm.

For more information about the use of EM 2040 on ROVs and AUVs please see the following application notes (document numbers in brackets):

- High Resolution Bathymetry from ROV Mounted EM 2040 [368428]
- High Resolution Bathymetry from ROV Mounted EM 2040 and HAIN Inertial Navigation [368429]

Dual RX system

The transmit transducer has an angular coverage of 200° (±100°) as standard, allowing for a coverage of 5.5 times the water depth when matched with a single receive transducer. Adding a second receive transducer allows surveying to the water surface or up to 10 times water depth on a flat bottom.

The two RX transducers are normally mounted in a V-shape with approximately 35° inclination.

The pulse lengths and frequencies will be the same as for one RX transducer.

System characteristics

Main units

The EM 2040 consists of four main units:

- Transmit transducer
- Receive transducer(s)
- Processing Unit (PU)
- Operator Station (HWS)

A complete system for seabed mapping will in addition include a transducer mounting plate, a motion sensor, a heading sensor, a sound velocity sensor and a positioning system.

Transducers

The EM 2040 transducers consist of separate linear arrays for transmit and receive in a Mills cross configuration. The transmit array is electronically steerable alongtrack while the receive array is steerable athwartship. Both arrays contain all analog electronics and digital control units with Ethernet interfaces to the processing unit.

The transducers are made from composite ceramics, designed and tested to operate to a depth of 6000 m. The transmitter array consists of three separate line arrays, one looking straight downwards and the two others pointing 55° to each side.

The transducers have Ethernet data interfaces. The receiver uses Gbit Ethernet whilst the transmitter uses 100 Mbit Ethernet. The transmitter also has 48 VDC supply which is routed to the receiver. The interconnecting cable included also carries a synchronization signal.

The material in the transducer housing is Titanium.

The EM 2040 is delivered with a mounting plate with factory aligned guidances. It is recommended that the mounting plate is built into a steel casing and protected by a baffle for multipath reduction. Optionally, the transducers may be delivered mounted on a frame together with the motion sensor and a sound speed sensor, factory aligned for ease of mounting.

The EM 2040 is fully prepared for upgrading to cater for more demanding applications. Adding a second receive transducer increases the angular coverage to up to 200° (±100°).

Processing unit

The EM 2040 processing unit is basically a Compact PCI standard computer using a commercially available CPU board with an Intel dual core CPU, plus signal processing boards. Receive data from the Gbit link is match filtered by an FPGA board before transferred to the signal processing boards. The CPU board has serial interfaces for input of external time-critical sensors and Gigabit Ethernet for communication with the operator station. SATA interfaces are available for integrated data logging to a local hard disk (option intended for AUV use).

Currently the EM 2040 system requires one PU per RX transducer and one additional PU per RX transducer for dual swath capability.

The Processing Unit also supplies 48 Vdc power to the transducers.

Operator station

The Operator Station of the EM 2040 is the standard HWS (Hydrographic Work Station) high performance PC work station. The operator software is SIS (Seafloor Information System).

As a minimum, the unlicensed version of SIS allows for setting the EM 2040 installation and runtime parameters, logging and displaying data, as well as running the built in self tests.

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

Alternatively, third-party software solutions can be used for operator interface and real-time processing. Contact Kongsberg Maritime for information.

The HWS is normally supplied with a 19” industrialized LCD monitor with a resolution of 1280x1024 pixels. Support for up to four monitors is available. A spill proof US keyboard and a standard optical mouse is normally supplied, but optionally a small IP 65 rated keyboard with integrated track stick can be delivered.

Interfaces

For completeness, data input from an attitude sensor, a heading sensor and a positioning system is required, as is the sound speed profile of the water column between the transducers and the bottom. Sound speed at the transducer, clock and 1PPS are optional inputs.

The EM 2040 will be equipped to handle the IEEE 1588 time synchronization system, and to support the better time accuracy this provides. Multiple sensors supplying the same type of data may be logged. Data input is usually on serial line, but Ethernet input is also supported. The processing unit has full trigging capability and 1 PPS signal interface.

The formats currently supported by Kongsberg Maritime's range of multibeam echo sounders will be retained, likewise the time-tagging principles used. All data are time-tagged using the same clock reference as the multibeam.

Transmit signal characteristics

The signals employed are either CW pulses with effective pulse length from 25 to 600 µs or FM chirps with a pulse length up to 12 ms, the latter used to increase range capability. Increased coverage with more than 35% has been verified when switching from the longest CW pulse to FM pulse for the 300 kHz mode. The transmitted signals are shaded in time (tapered) to reduce out of band leakage, in practice the CW signal length is 50% larger than the effective pulse length. Power reduction of 10 and 20 dB is possible, selected by the operator.

Transmission beam

Three transmit sectors are normally used per swath. Shading is employed to reduce side lobes. Alongtrack steering of the sectors take into account both yaw and pitch to position the transmit footprints as closely as possible perpendicular to the survey line direction. The alongtrack beam is steerable within ±10º. The sectors will normally use different frequencies and they will transmit simultaneously.

To compensate for nearfield effects the transmission of the sectors are focused at the range determined from the previous ping. The focusing range will usually differ between the three transmit sectors.

Ping rate

The ping rate is normally only limited by the two-way travel time, with very little additional delay required. The maximum range required per ping is determined automatically, taking into account the need to sample the full width of the outermost beam as well as that the depth may increase on the next ping. Maximum ping rate is 50 Hz. This can be reduced by the operator or controlled by external sync.

Signal processing

To increase the transmit source level and to reduce the effect of multipaths, the EM 2040 uses several transmit sectors per swath. To avoid crosstalk between the sectors, high precision bandpass filters are implemented to match the transmitted signals. Also the transmit waveforms are formed to avoid out of band components. The receiver has a very high instantaneous dynamic range, removing the need for analogue gain control (TVG).

Beam characteristics

The beam forming uses split beam technology.

The beamforming uses real-time roll (i.e. the beams are fully roll stabilized) and dynamic focusing in the near-field region. Sound speed at the transducer depth is used as well; it may preferable be read from a real-time sensor, interpolated from the sound speed profile or from an operator entered value.

The beam spacing may be set to equidistant or equiangle. 256 actual beams are formed per swath for a 1 degree receiver, spaced over an angular sector which is configurable or derived from the actual coverage achieved.

When using high density processing more than one detection is derived from each beam. The spacing of the soundings is chosen so that equidistant sampling of the bottom is achieved. The high density mode is used to increase the number of soundings from the multibeam echo sounders with up to 400 soundings per swath.

While operating in the single sector mode the system may reduce the number of beams and number of soundings. The actual numbers depend on the pulse length.

Bottom detection

The phase difference between the halfbeams, 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.

When high density mode is enabled, the phase curve for a beam is used to derive more than one detection and not only at the centre of the beam. The detection window is shortened accordingly, and the spacing of the soundings is chosen so that equidistant sampling of the bottom is achieved. This mode is used to increase the number of soundings available from the multibeam echo sounders with up to 400 soundings per swath.

The footprint will typically be two times the across sampling distance.

Amplitude-based bottom detection is the alternative to phase detection when the number of samples is too small or the phase curve too noisy, typically at small incidence angles or depths.

Depth corrections

The bottom detection process determines the two-way travel time and angle to the bottom in a transducer fixed coordinate system. The sound speed at the transducer depth, the sound speed profile and the vessel attitude both at transmit and receive time are then employed to calculate the Cartesian coordinates of each sounding relative to the water surface and vessel heading. Attitude offsets, time delay and sensor locations including vessel travel are employed in this procedure. The refraction calculations are done using Snell's law assuming constant gradients within the layers defined by the sound speed profile, starting at the actual depth of the transmit transducer at the transmit time.

Seabed imagery

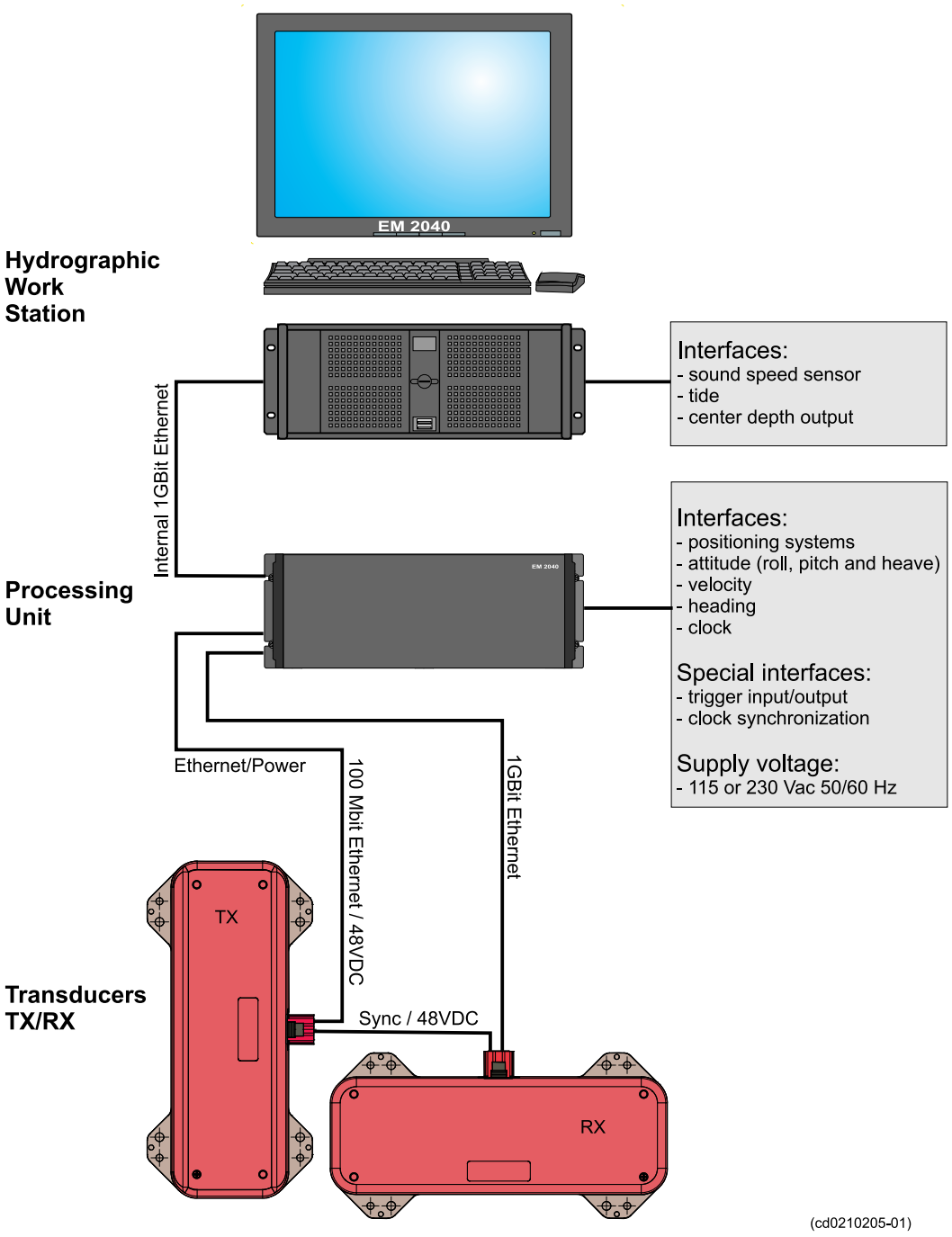
The principles used in the current Kongsberg Maritime multibeam echo sounders are retained in the EM 2040. This implies that each sounding will include a measure of the bottom's backscatter strength. Imagery data samples will be derived for every range sample giving a time continuous high resolution record across for each ping. The imagery record is extended over gaps due to missing beams and also beyond that of the outermost valid detection.

The backscattering calculation principles used in the current Kongsberg Maritime multibeam echo sounders are also retained. The fact that no TVG is applied in the receiver is compensated through the use of the same model as in the other Kongsberg multibeam echo sounders.

Water column data

The beam amplitudes from the water column can be displayed at the operator station. The data can optionally be logged to a separate file or logged together with the rest of the echo sounder datagrams.

System drawing



Performance

EM 2040 swath width calculations

Attenuation curves

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

The following figures show the attenuation in the water surface in dB versus water temperature of the EM 2040 signal at 200 kHz, 300 kHz and at 400 kHz. For each frequency the attenuation figures are calculated for a set of salinity values (salinity labels on top of each curve):

- *Attenuation at 200 kHz* on page 12
- *Attenuation at 300 kHz* on page 12
- *Attenuation at 400 kHz* on page 13

Figure 1 Attenuation at 200 kHz

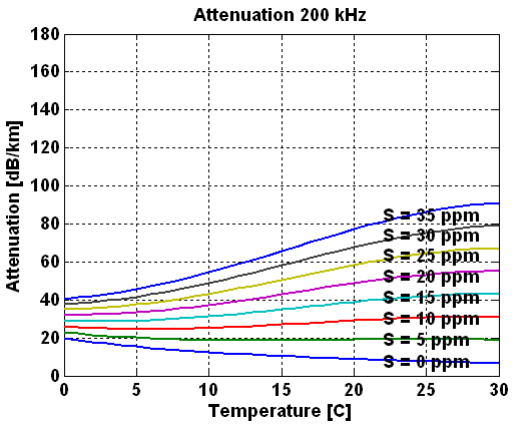


Figure 2 Attenuation at 300 kHz

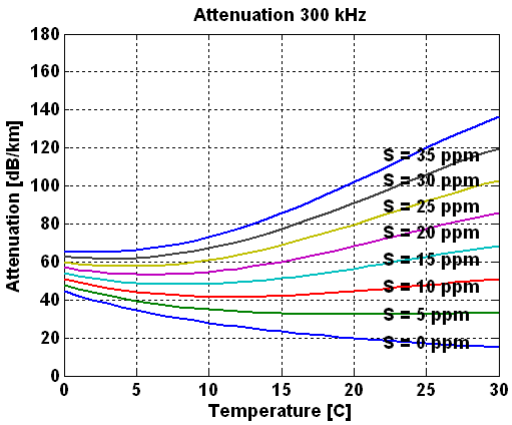
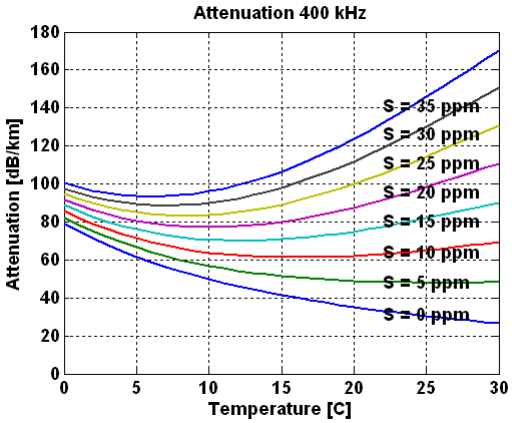


Figure 3 Attenuation at 400 kHz



Coverage curves

Introduction

The theoretical across track coverage is calculated. It depends on the depth, the frequency, the TX array size, the number of RX arrays, the attenuation in the water and the bottom type. The calculations shown on the following pages assume constant sound velocity throughout the water column and a spectral isotropic noise level of 44 dB for the 400 kHz mode, 46 dB for the 300 kHz mode, and 50 dB for the 200 kHz mode. The maximum system depth and swath width is highly dependent on the sonar frequency, the bottom type (backscatter strength), and the attenuation in the water.

The user can select between three frequency modes:

- 200 kHz
- 300 kHz
- 400 kHz

The echo sounder uses several transmit sectors. In dual swath mode up to 6 different frequencies are used simultaneously. Frequency range example:

- 300 kHz, dual swath, short pulse: 260-350 kHz
- 300 kHz, dual swath, long pulse: 265-290 kHz

The EM 2040 has two TX array sizes:

- EM 2040-04 (0.4 deg at 400 kHz)
- EM 2040-07 (0.7 deg at 400 kHz)

There is only one version of the RX transducer (0.7 deg at 400 kHz), but it can be used for:

- Single RX (one array, normally mounted horizontally)
- Dual RX (two arrays, normally mounted in a V-shape with approximately 35° inclination)

Dual RX system is calculated for ±80 deg coverage.

The first graphs shows the bottom type dependent coverage for cold ocean water, with three different bottom types, for the two TX array sizes, EM 2040–04 and EM 2040–07, and for single and dual RX

The next graph shows the dependency of the attenuation in the water column.

The last graphs shows example of measured coverage.

Coverage as function of bottom type

Coverage curves for Cold ocean water are calculated for three different bottom types. Curves for single and dual RX are put in the same figure. Dual RX is shown with the broadest line width (green). Separate curves are made for the two TX array sizes:

The coverage is calculated for three different bottom types:

- Rock (-10 dB)
- Sand (-25 dB)
- Mud (-40 dB)

EM 2040 coverage, 200 kHz mode

Figure 4 Bottom type dependent coverage, cold ocean water EM 2040-07

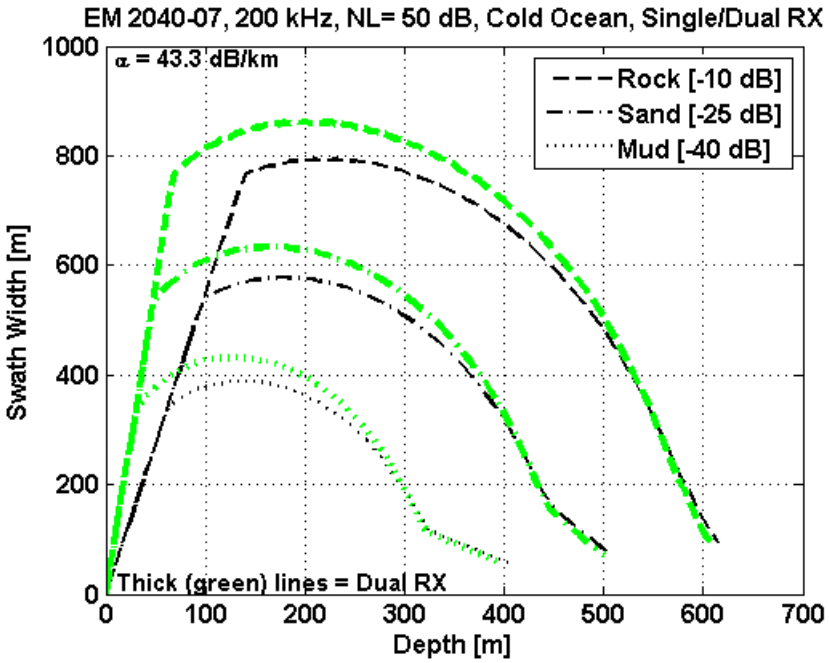
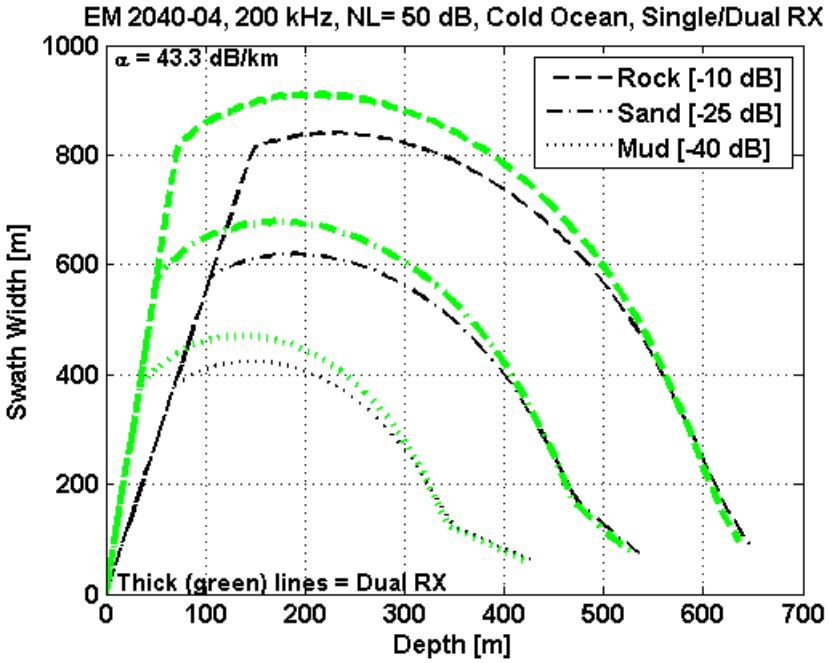


Figure 5 Bottom type dependent coverage, cold ocean water EM 2040-04



EM 2040 coverage, 300 kHz mode

Figure 6 Bottom type dependent coverage, cold ocean water EM 2040-07

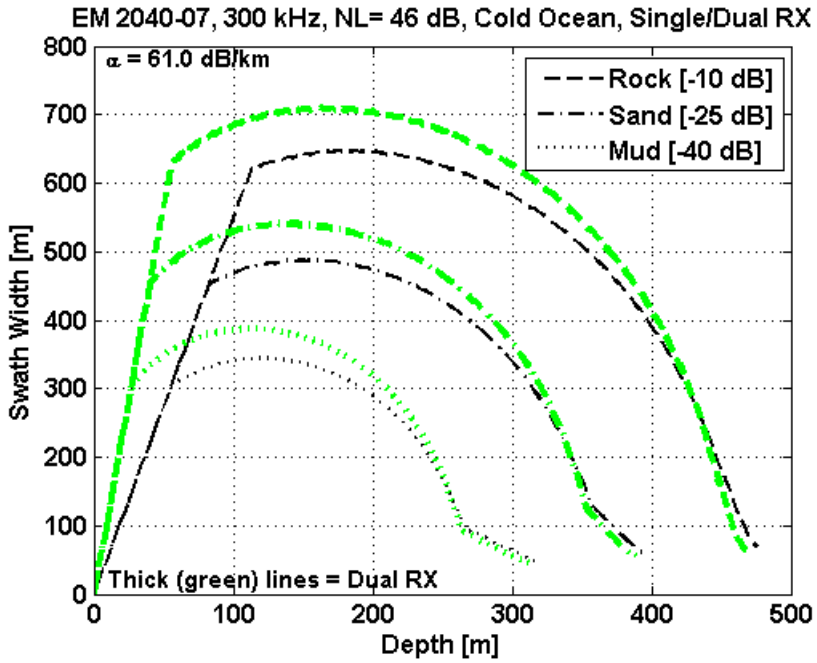
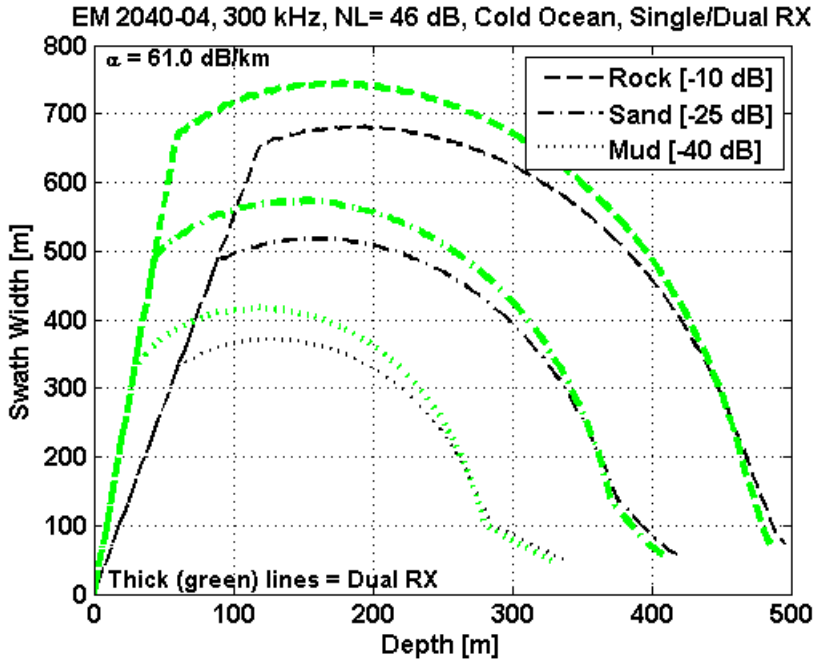


Figure 7 Bottom type dependent coverage, cold ocean water EM 2040-04



EM 2040 coverage, 400 kHz mode

Figure 8 Bottom type dependent coverage, cold ocean water EM 2040-07

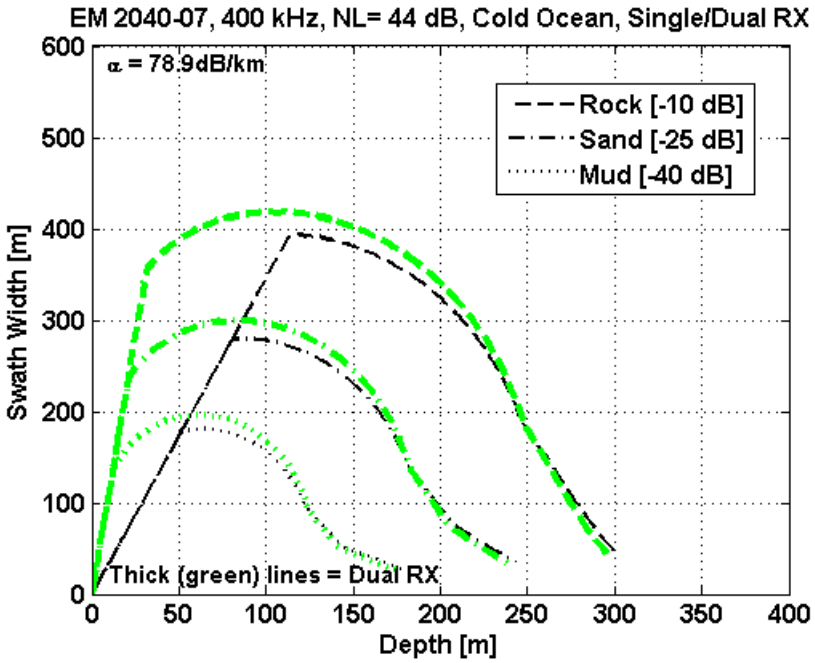
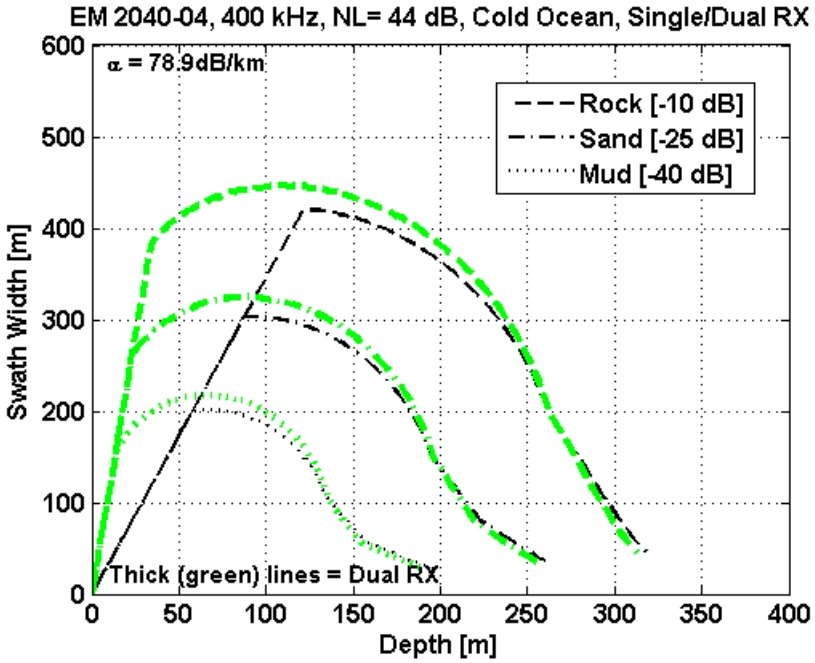


Figure 9 Bottom type dependent coverage, cold ocean water EM 2040-04



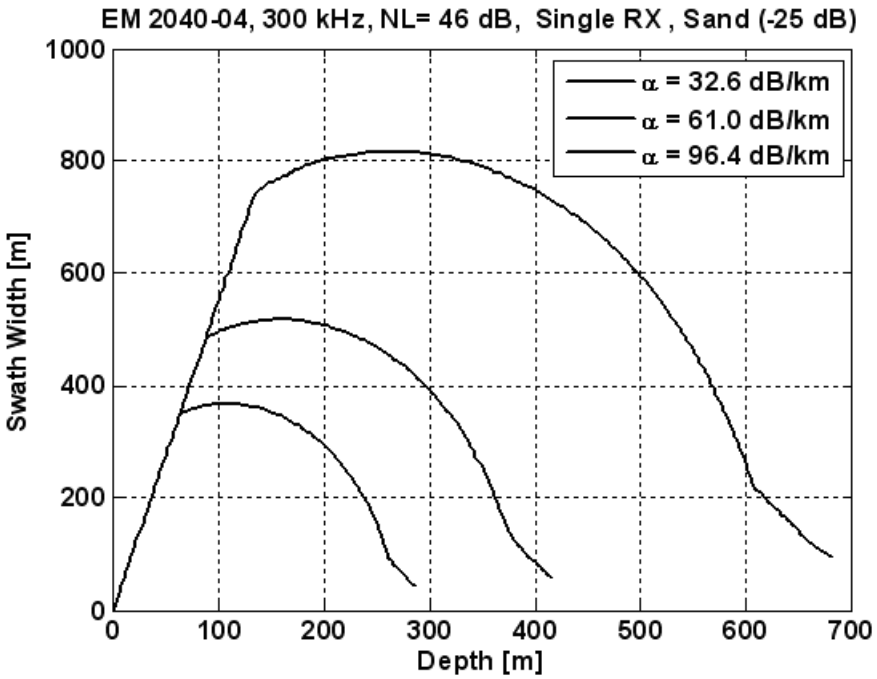
Coverage dependent of the water column attenuation

In the next figure, the coverage for the 300 kHz mode, sandy bottom, is calculated for three different absorption coefficients

- Cold fresh water (4 deg C and 0 ppm salinity), 32.6 dB/km
- Cold ocean water (4 deg C and 35 ppm salinity), 61.0 dB/km
- Warm ocean water (20 deg C and 35 ppm salinity), 96.4 dB/km

The graph shows that the coverage is highly dependent on the attenuation in the water column

Figure 10 Example of the effect of the absorption coefficient, 300 kHz mode, sandy bottom



Measured coverage

The swath coverage and the accuracy of the EM 2040 were tested during a NAVO Customer Acceptance Test close to Sidney, Victoria Island, BC, Canada. The EM 2040 was mounted on the CHS vessel Otter Bay. The tested system was an EM 2040–04 with single RX array. The survey speed was 6 knots.

Figure 11 Example of swath coverage measured at a 370 meter deep slope. Bottom type: Rock. The measured coverage matches well with the theoretical curves for Rock (-10 dB BS).

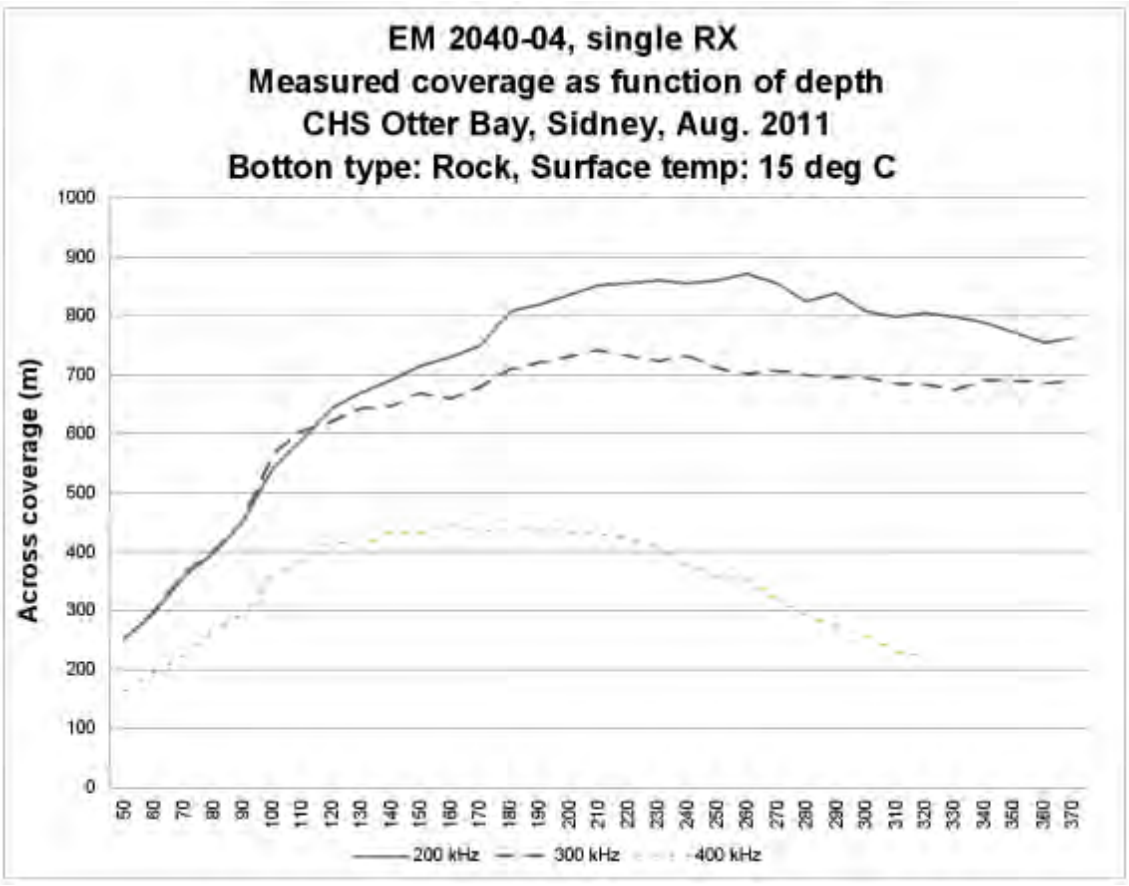
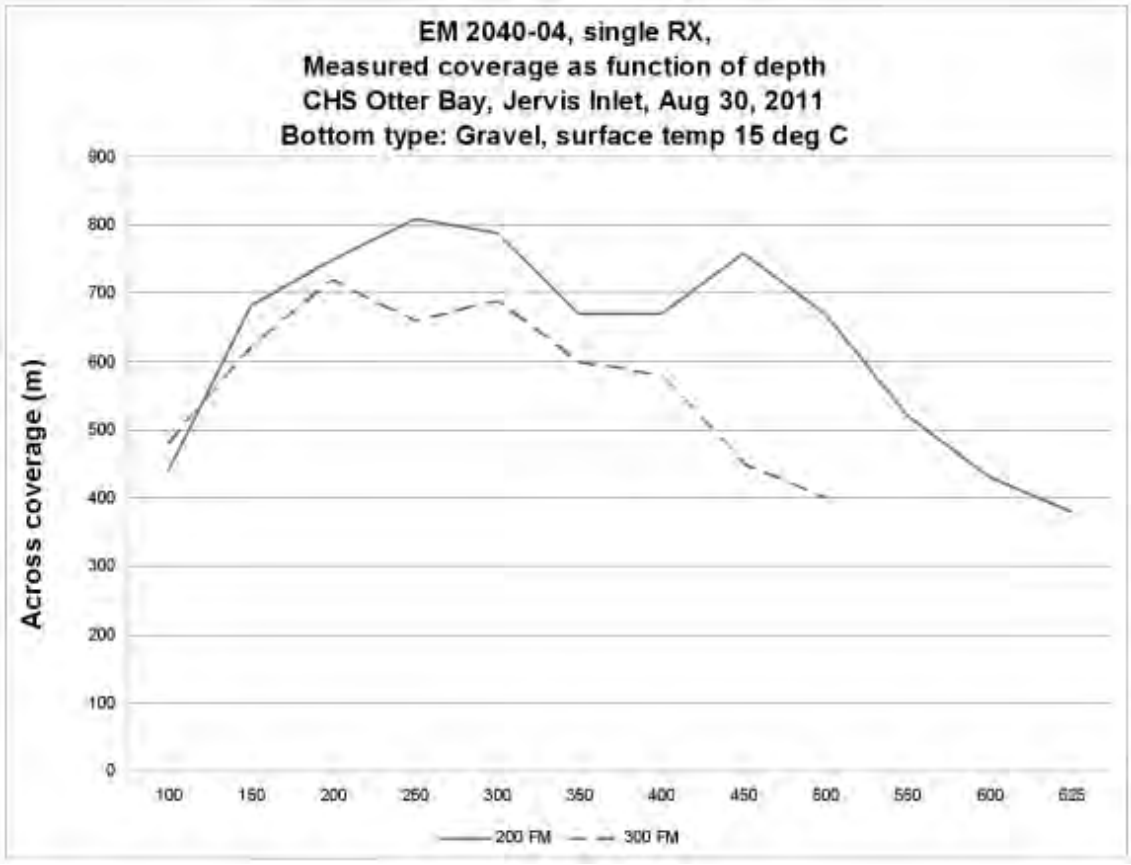


Figure 12 Example of swath coverage from a deeper slope. The across coverage has a dip around 350-400 m depth caused by irregular bottom. Bottom type: Gravel.



Courtesy of NAVO and CHS.

Depth accuracy

The depth sounding accuracy of EM 2040 is very good thanks to narrow transmit and receive beams, large transmit bandwidth and matching receivers. This is combined with precise digital beamforming, range dependent beam focusing and a high sampling rate. Important is also the advanced bottom detection methods proven through many years of experience with the Kongsberg range of multibeam echo sounders. The predicted system depth errors are in the order of 0.1% of depth, limited in very shallow waters to about the range sampling distance.

Near normal incidence a centre 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 size of the detection windows is tuned according to the across sampling density, to minimize overlap between soundings.

In addition to the echosounder itself, the total system accuracy will also depend upon the quality of the installation, the external sensors (position, velocity, motion and sound speed) and the oceanographic conditions. Varying sound velocity layers in the water column in the survey area may degrade the result.

The expected total system RMS accuracy, assuming a correct calibrated installation, good quality external sensors and acceptable oceanographic and weather conditions, is expected to be better than the largest number of 5 cm (normally limited by heave sensor) and:

Short and medium CW pulses:

- 0.10% of the depth (from vertical up to 45 degrees)
- 0.15% of depth (up to 60 degrees)
- 0.30% of the depth (up to 70 degrees)

Long CW and FM pulses:

- 0.15% of the depth (from vertical up to 45 degrees)
- 0.25% of depth (up to 60 degrees)
- 0.40% of the depth (up to 70 degrees)

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

Please be aware that with optimal installation and good oceanographic conditions even better accuracy can be achieved, as shown in the examples in the following figures:

- *300 kHz mode, short pulse, 140 deg swath, 20 m depth (0.15% = 3 cm at 20 m depth)* on page 22
- *300 kHz mode, single sector, short pulse, 120 deg swath, 50 m depth* on page 22
- *400 kHz mode, short pulse, 120 deg swath, 50 m depth* on page 22
- *400 kHz mode, single sector, short pulse, 80 deg swath, 50 m depth* on page 23
- *200 kHz mode, short pulse, 140 deg swath, 50 m depth* on page 23

Measured standard deviation

Survey examples from NAVO Sea Acceptance Test, showing measured standard deviation in percentage of depth:

Figure 13 300 kHz mode, short pulse, 140 deg swath, 20 m depth (0.15% = 3 cm at 20 m depth)

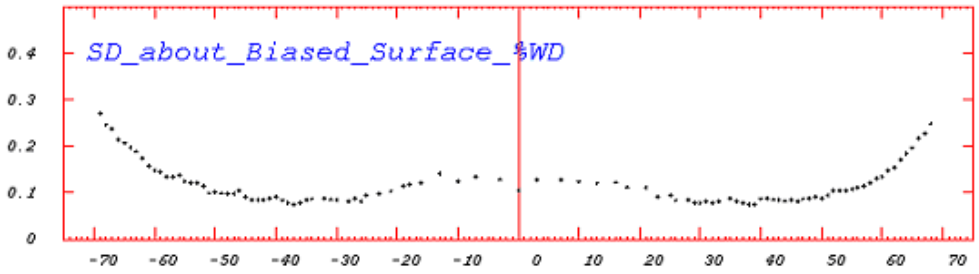


Figure 14 300 kHz mode, single sector, short pulse, 120 deg swath, 50 m depth

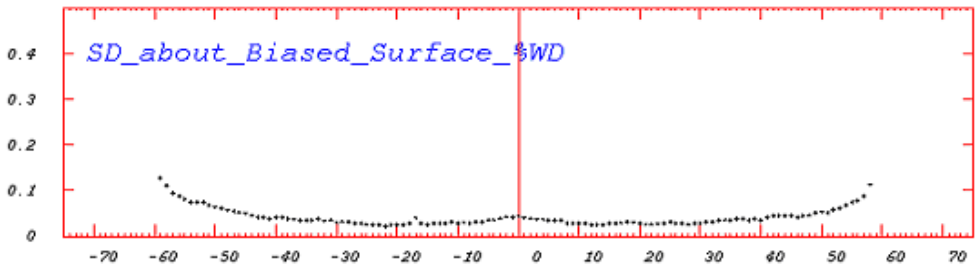


Figure 15 400 kHz mode, short pulse, 120 deg swath, 50 m depth

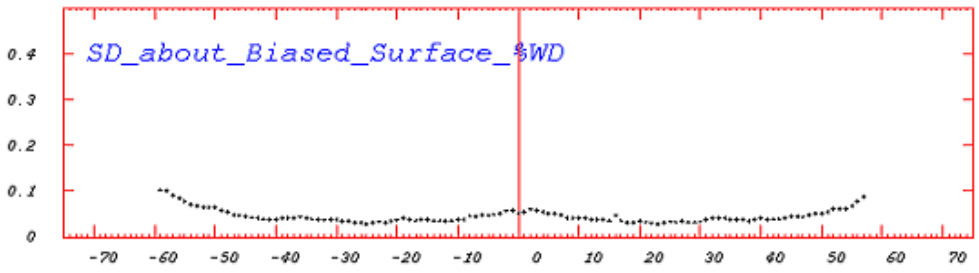


Figure 16 400 kHz mode, single sector, short pulse, 80 deg swath, 50 m depth

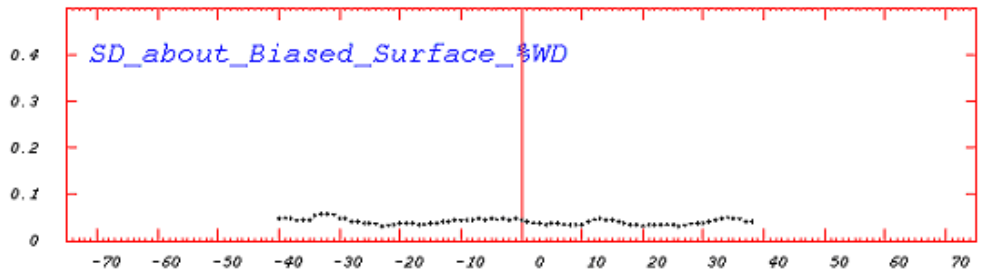
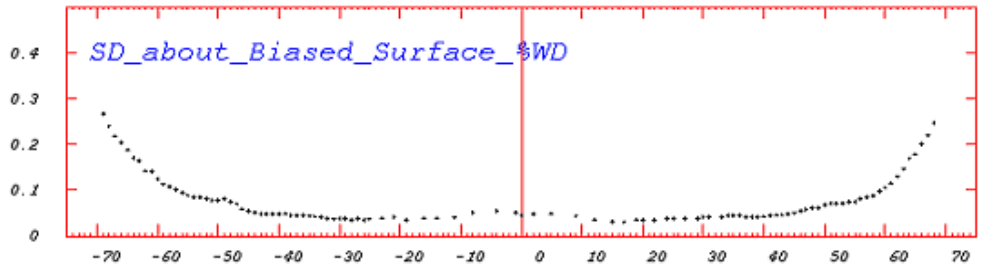


Figure 17 200 kHz mode, short pulse, 140 deg swath, 50 m depth



Courtesy of NAVO, CHS and UNB

Horizontal resolution

The depth dependent horizontal resolution depends on

Alongship

- TX beam width (defines footprint along)
- Vessel speed (sample density along)
- Swath rate (sample density along)

Across ship

- Number of RX soundings (defines the sample density across)
- Detection window size (defines the footprint across)

The swath rate depends on depth and swath width. In dual swath mode two swaths are made per ping, then the swath rate is two times the ping rate.

The across ship footprint is defined as two times the across sampling distance. This matches a normal bottom detect range window.

The following tables are made for cold ocean water, sandy bottom, 400 soundings/swath with an estimated swath rate:

- *EM 2040-04, along and across footprint and sample distance for 300 kHz, dual swath, single RX, BS -25 (sand)* on page 24
- *EM 2040-07, along and across footprint and sample distance for 300 kHz, dual swath, single RX, BS -25 (sand)* on page 25
- *EM 2040-04, along and across footprint and sample distance for 400 kHz, dual swath, single RX, 120 degree sector* on page 26

Table 1 EM 2040-04, along and across footprint and sample distance for 300 kHz, dual swath, single RX, BS -25 (sand)

	Across					Along			
Depth	Cover-age	Cover-age	Swath rate	Sample distan-ce	Foot-print	Foot-print at vertical	Foot-print outer edge	Sample distan-ce	Sample distan-ce
m	degree	m	Hz	m	m	m	m	m	m
5	140	27.5	47.1	0.07	0.14	0.04	0.13	0.04	0.09
10	140	54.9	29.3	0.14	0.27	0.09	0.26	0.07	0.14
20	140	109.9	16.7	0.27	0.55	0.17	0.51	0.12	0.25
50	140	274.7	7.3	0.69	1.37	0.44	1.28	0.28	0.57
100	135	482.8	4.3	1.21	2.41	0.87	2.28	0.48	0.96
200	103	502.9	3.7	1.26	2.51	1.75	2.8	0.56	1.12
300	65	382.2	3.4	0.96	1.91	2.62	3.10	0.61	1.22
								4 knots	8 knots

With wider TX beam, the alongship footprint is extended:

Table 2 EM 2040-07, along and across footprint and sample distance for 300 kHz, dual swath, single RX, BS -25 (sand)

	Across					Along			
Depth	Cover-age	Cover-age	Swath rate	Sample distan-ce	Foot-print	Foot-print at vertical	Foot-print outer edge	Sample distan-ce	Sample distan-ce
m	degree	m	Hz	m	m	m	m	m	m
5	140	27.5	47.1	0.07	0.14	0.09	0.26	0.04	0.09
10	140	54.9	29.3	0.14	0.27	0.17	0.51	0.07	0.14
20	140	109.9	16.7	0.27	0.55	0.35	1.02	0.12	0.25
50	140	274.7	7.3	0.69	1.37	0.87	2.55	0.28	0.57
100	135	482.8	4.3	1.21	2.41	1.75	4.56	0.48	0.96
200	103	502.9	3.7	1.26	2.51	3.49	5.61	0.56	1.12
300	65	382.2	3.4	0.96	1.91	5.24	6.21	0.61	1.22
								4 knots	8 knots

At 400 kHz with narrow beams and 120 degree sector, sample distance and footprints are reduced:

Table 3 EM 2040-04, along and across footprint and sample distance for 400 kHz, dual swath, single RX, 120 degree sector

	Across					Along			
Depth	Cover-age	Cover-age	Swath rate	Sample distan-ce	Foot-print	Foot-print at vertical	Foot-print outer edge	Sample distan-ce	Sample distan-ce
m	degree	m	Hz	m	m	m	m	m	m
5	120	17.3	60.3	0.04	0.09	0.03	0.07	0.03	0.07
10	120	34.6	40.3	0.09	0.17	0.07	0.14	0.05	0.10
15	120	52.0	30.2	0.13	0.26	0.10	0.21	0.07	0.14
20	120	69.3	24.2	0.17	0.35	0.14	0.28	0.09	0.17
40	120	138.6	13.5	0.35	0.69	0.28	0.56	0.15	0.31
60	120	207.8	9.3	0.52	1.04	0.42	0.84	0.22	0.44
80	120	277.1	7.1	0.69	1.39	0.56	1.12	0.29	0.58
								4 knots	8 knots

EM 2040 object detection capability

In general, the object detection capabilities of multibeam echo sounders are given by two requirements:

A That the object is sufficiently large to be detected within a sounding

B That there are a sufficient number of soundings hitting the object to avoid filtering the object as noise during the processing

A general rule-of-thumb for the first requirement for an object lying on the bottom is that the object size must not be smaller than approximately 50% of the beam footprint (as defined either by angular beamwidth or detection window length). In accordance with the LINZ hydrographic specification the latter requirement is met by demanding that the sounding boresight spacing is not less than half the object size both across and along.

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

The error sources of multibeam bathymetry lies within the echo sounder itself, the motion sensor, within position determination and in the sound speed. With the assumed accuracy of the motion sensor and within a coverage sector limited to 5 times water depth, it can be expected that the maximum error depends on the pulse length employed (disregarding sound speed errors).

With the sampling rate matching the pulse length specified, the accuracy can then be expect to be better than $c\tau/4$, i.e. less than 10 mm for a 25 µs pulse, provided that a sufficient signal to noise ratio is obtained (not less than 10 dB).

The EM 2040 is well suited for surveys meeting the IHO-S44 special order. Depending on which version of EM 2040 is selected, different capabilities for object detection are obtained.

IHO special order requires that objects down to 1 m^3 shall be detected, whilst the IHO order 1 requires that objects down to 2 m^3shall be detected to 40 m water depth.

LINZ raises an additional condition or clarification. The object shall have at least 9 hits, 3 along and 3 across. The reason for this is that automatic algorithms for cleaning of bathymetric data will remove isolated soundings, but accept a cluster of soundings.

Equidistant pattern of soundings is ideal for object detection. Also the refined and small acoustic footprint which is obtained with the high density signal processing favour object detection.

A necessary feature for reliable object detection in rough sea conditions is active stabilization of the beams for ship pitching and yawing. For the EM 2040 full vessel movement compensation is built in, including yaw compensation, and beam focusing is standard both on transmit and receive. For depths exceeding 20 m using a small boat in croppy seas, beam stabilization is an important requirement.

Object detection simulation

For the EM 2040 simulations whereby an object is placed in the outmost of the beams have been carried out. Three swath widths have been simulated.

Four cases have been assessed:

- 1 m^3 cube, single swath
- 2 m^3 cube, single swath
- 1 m^3 cube, dual swath
- 2 m^3 cube, dual swath

These cases are calculated for an EM 2040–04 and an EM 2040–07.

In the following figures a square with colour code for swath width is drawn when the criteria for detection are fulfilled. The figures show that for an EM 2040–07 transducer the 1 m^3 cube object is not detected neither at depth 30 m at survey speed 16 knots, nor at depth 40 m with survey speed 12 and 16 knots, even with 90 degrees swath. When including dual swath the object will have enough hits width 90 degrees swath width to be detected at both 30 and 40 meters up to 16 knots survey speed.

An EM 2040–04 system operating in single swath will also have problems detecting the 1 m^3 cube at high survey speed. Dual swath ensures detection of the 1 m cube.

Object detection EM 2040–04, single and dual swath

Figure 18 1 m³ cube, single swath

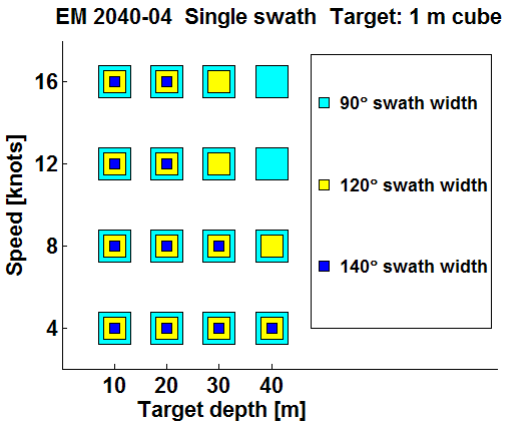


Figure 19 1 m³ cube, dual swath

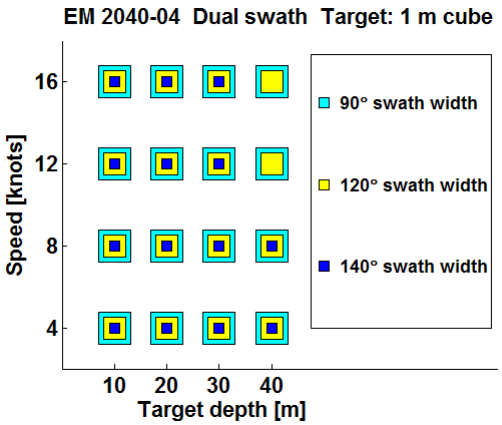


Figure 20 2 m³ cube, single swath

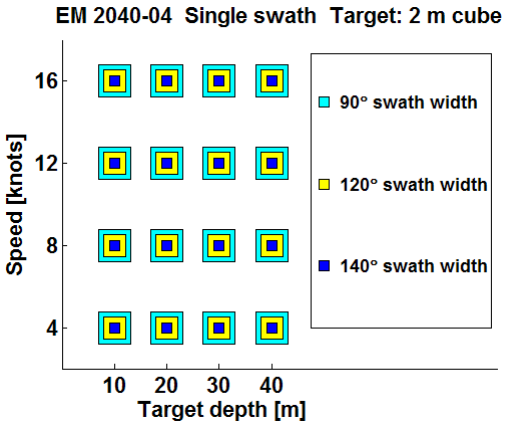
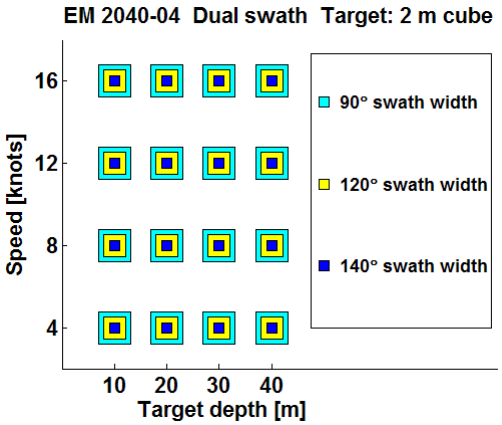


Figure 21 2 m³ cube, dual swath



A square is plotted when the object is detected at depth and survey speed given by the axes.

- Largest outer square states object detection using 90˚ swath width
- Mid square states object detection using 120˚ swath width
- Smallest inner square states object detection using 140˚ swath width
- No square states no object detection at given swath width, depth and survey speed

The size of the object to detect and single or dual swath is shown in the title of each figure.

Object detection EM 2040–07, single and dual swath

Figure 22 1 m³ cube, single swath

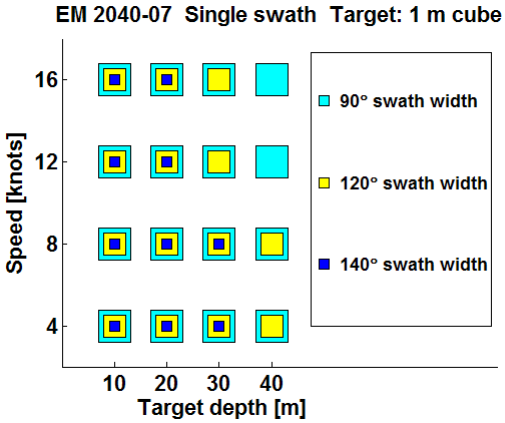


Figure 23 1 m³ cube, dual swath

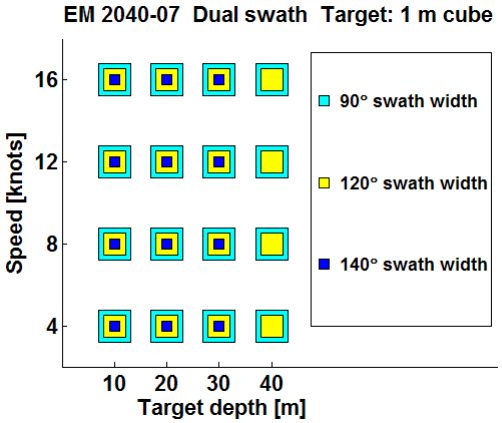


Figure 24 2 m³ cube, single swath

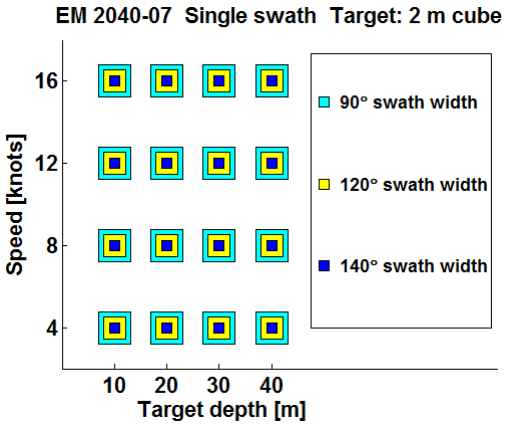
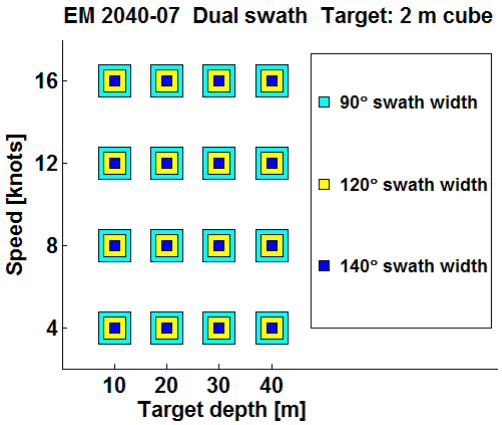


Figure 25 2 m³ cube, dual swath



A square is plotted when the object is detected at depth and survey speed given by the axes.

- Largest outer square states object detection using 90˚ swath width
- Mid square states object detection using 120˚ swath width
- Smallest inner square states object detection using 140˚ swath width
- No square states no object detection at given swath width, depth and survey speed

The size of the object to detect and single or dual swath is shown in the title of each figure.

Installation principals

The compactness of the EM 2040 multibeam echo sounder is a guarantee for a fast and easy installation. For a surface vessel, the Operator Station and the Processing Units are placed inside the vessel whilst the transducer arrays are mounted so that they are always submerged in water.

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 19” industrial LCD monitor, a keyboard and an optical mouse. A bracket for the monitor is included for table top, bulkhead and roof mounting.

Processing units

One Processing Unit is required per RX transducer and one additional PU is required per RX transducer for dual swath capability.

The Processing Units (PUs) may be mounted in a standard 19” rack, requiring 4U (4 rack height units) per PU.

On large vessels the PUs may have to be mounted closer to the transducer arrays than the Operator Station due to restricted length of the cable connecting the two units (15 m standard length, optional 30 and 50 m).

Solutions for mounting the Processing Units in an underwater vehicle is available.

Transducer array installation

Correct location, orientation and alignment of the system’s transducer is vital for the performance of the EM 2040. A transducer mounting plate is provided with the system to ensure accurate relative orientation of the transducers. Further, the transducer arrays must be mounted such that the water in front of the arrays is not aerated.

The transducers can be rotated 180° to ease cabling. Installation parameters must be set accordingly.

Kongsberg Maritime's recommendations for optimal installation of the EM 2040 system is described in this section.

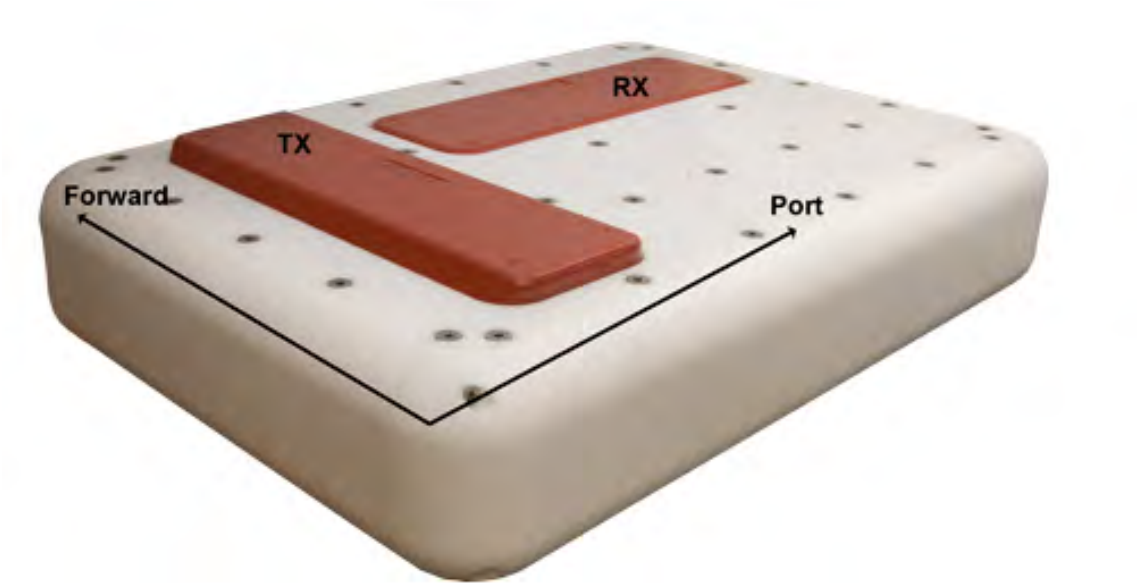
To ease installation, as well as ensuring that the relative alignment between the transducers are determined within the required accuracy, a Kongsberg Maritime fabricated mounting plate is delivered with the EM 2040 transducer arrays. The mounting plate is fitted with a guidance system that ensures that the transducer arrays are aligned within the required accuracy.

The requirement for knowing the relative heading between the EM 2040 RX and TX transducers are extremely strict, and can only be met using high precision land survey methods and equipment. Also the mechanical mounting of the arrays must be carried out with this requirement in mind. The slightest slack will degrade the system performance.

We strongly advise using the mounting plate that is provided.

Mounting examples

Figure 26 Example of EM 2040–07 mounting in prefabricated baffle



Mounting of dual RX system

In a dual RX installation the two RX transducer arrays may be positioned on each side of the keel with a roll angle of 35 to 40 degrees. To be able to cover ± 100 degrees the roll installation angle should not be less than 35 degrees. To obtain overlap between the two RX arrays at shallow depths, the roll installation angle should not be more than 40 degrees, and the across distance between the two RX arrays should be as small as possible.

Figure 27 Example of dual RX

Subsea vehicle installation

The Kongsberg EM 2040 may just as well be used on a subsea vehicle (ROV or AUV) as on a surface vessel. In principle the only difference is that an additional sensor is required to measure the vehicle's depth.

EM 2040 TX and RX data is provided from the transducer arrays to the Processing Unit on high speed Ethernet links, well suited for fiber links.

EM 2040 on ROV – Remotely Operated Vehicle

- The Processing Unit can be installed on the mother vessel, provided EM 2040 data can be transferred over the ROV umbilical at sufficient data rate.
- A multiplexer system must be used to transfer the required data between the ROV and the mother vessel, including the high speed EM 2040 data.
- The EM 2040 operator system will be the same as for a ship mounted system.

EM 2040 on AUV – Autonomous Underwater Vehicle

- The Processing Unit must be installed in a pressure rated tank.
- 48 VDC must be provided to the Processing Unit.
- EM 2040 control and data logging must be handled by the AUV control software.

For more information about the use of EM 2040 on ROVs and AUVs please see the following application notes (document numbers in brackets):

- High Resolution Bathymetry from ROV Mounted EM 2040 [368428]
- High Resolution Bathymetry from ROV Mounted EM 2040 and HAIN Inertial Navigation [368429]

Figure 28 Example of installation on ROV

Operational principals

System features

The EM 2040 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 2040 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 2040 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.

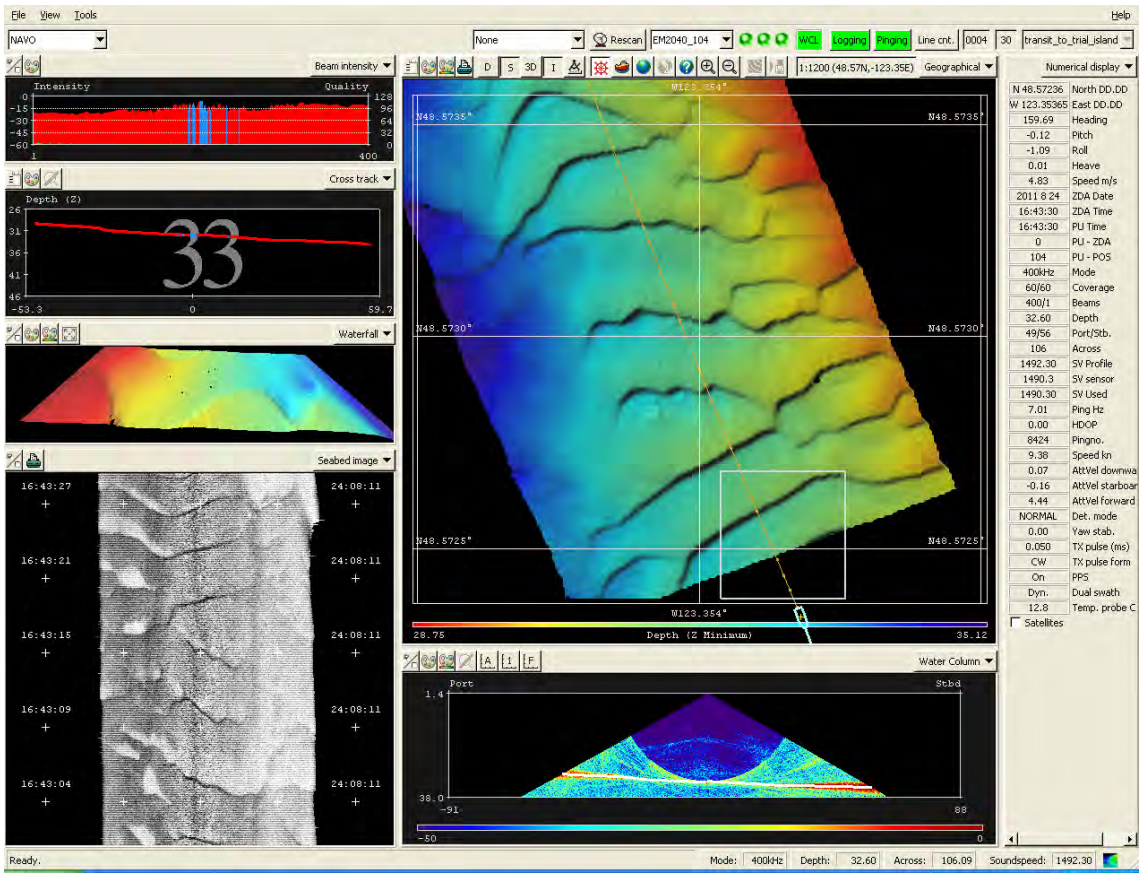
A planning module makes it possible to define and edit planned lines, make parallel lines, define survey regions, etc. Plans can be imported and exported between systems.

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 29 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 2040 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 2040 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 2040 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.

HYPACK

HYPACK by Hypack Inc. is a widely used hydrographic software package. It provides the tools necessary to complete hydrographic, side scan and magnetometer survey requirements. HYPACK provides tools to design the survey, collect data, apply corrections to soundings, remove outliers, plot field sheets, export data to CAD, compute volume quantities, generate contours, create side scan mosaics and create/modify electronic charts.

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 2040 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 2040 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 2040 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 2040 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 2040 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 2040 Multibeam echo sounder delivery includes:

1 Operator Station HWS with 19” LCD monitor

2 Processing Unit configured according to chosen model

3 Transducer arrays according to chosen model
- Transmit transducer
- Receiver transducer(s)
- 15 m transducer cables (standard length)

4 Transducer mounting plate

5 Signal and control cables (standard length)
- Transducer cables
- Ethernet cable between Processing Unit and Operator Station (5 m length)
- Power cables (115 and/or 230 Vac)

6 All system software

7 Technical manuals covering system installation, operation and maintenance

Options

System options available include:

- Mounting arrangement for over-the-side mounting of transducers which may include integrated motion sensor, heading sensor and position sensor
- 30 m or 50 m transducer cables
- Non-standard connectors
- Helmsman Display and/or additional monitors
- Various software options
- Removable disks
- IP65 integrated keyboard and pointing device
- Spare parts

System integration

The EM 2040 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 2040 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.

Additionally Kongsberg Maritime may deliver the EM 2040 as part of the complete survey system. This may include integration with single beam echo sounders and/or other multibeam echo sounders, such as EM 710, EM 302 or EM 122, 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 communication parameters for:
  - Motion sensor (roll, pitch, heave and optionally heading) in format supported by sensors from the main suppliers like Kongsberg Seatex, Applanix, iXSEA, Coda Octopus and VT TSS
  - Heading (gyro compass) in either NMEA 0183 HDT, SKR82/LR40 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
  - Output of depth straight down in NMEA 0183 DPT format
- Interface for 1PPS (1 pulse per second) signal
- Clock synchronization signal
- Firewire interface for external data storage, printing or plotting
- Parallel interface for post script colour graphics
- Printer/plotter
- Ethernet interface for velocity input required for Doppler compensation in chirp mode. Formats by the following sensors are supported:
  - Kongsberg Seatex Seapath
  - Applanix POS MV
  - CodaOctopus F180
  - IXSEA Phins
- Ethernet interface for input of sound speed profile
- Tide and echo sounder depths

- Output of all data normally logged to disk

Physical specifications

Transmit transducer, EM 2040-04

- **Length:** 727 mm
- **Width:** 142 mm
- **Height:** 150 mm
- **Volume:** 15 liters
- **Weight:** 45 kg in air / 30 kg in water

Transmit transducer, EM 2040–07

- **Length:** 407 mm
- **Width:** 142 mm
- **Height:** 150 mm
- **Volume:** 8.6 liters
- **Weight:** 24 kg in air / 16 kg in water

Receive transducer

- **Length:** 407 mm
- **Width:** 142 mm
- **Height:** 136 mm
- **Volume:** 7.8 liters
- **Weight:** 23 kg in air / 16 kg in water

Processing Unit (4U 19” rack mounted)

- **Width:** 447 mm (19” rack)
- **Height:** 178 mm (4U)
- **Depth:** 345 mm
- **Weight:** 15 kg

Note

More than one processing unit may be necessary, depending on number of receive arrays and dual swath capability.

Hydrographic Work Station (4U 19” rack mounted)

- **Width:** 427 mm
- **Height:** 178 mm
- **Depth:** 480 mm

- **Weight:** 20 kg

19” monitor

- **Width:** 483 mm
- **Height:** 444 mm
- **Depth:** 68 mm
- **Weight:** 12 kg

Transducer mounting plate, EM 2040–07

- **Length:** 614 mm
- **Width:** 407 mm
- **Height:** 139 mm, including support pillars
- **Weight:** 16 kg in air

Transducer mounting plate, EM 2040–04

- **Length:** 615 mm
- **Width:** 725 mm
- **Height:** 139 mm, including support pillars
- **Weight:** 23 kg in air

Power requirements

Power supply, hull mounted system

Voltage	Frequency
115 Vac ±10%	60 Hz ±5%
230 Vac ±10%	50 Hz ±5%

Power supply, AUV use

Voltage
48 Vdc ±10%

Power consumption, hull mounted system

Unit	Power
One processing unit, incl. 0.4 by 0.7° transducers	< 300 W
One processing unit, including 0.7 by 0.7° transducers	< 275 W
Operator station	< 250 W
Monitor	< 100 W

Power consumption, AUV use

Unit	Voltage	Current
Processing unit	48 Vdc	< 5 A
0.7 deg RX transducer	48 Vdc	< 0.6 A
0.7 deg TX transducer	48 Vdc	< 0.25 A (CW mode) < 0.5 A (FM mode)
0.4 deg TX transducer	48 Vdc	< 0.5 A (CW mode) < 1.0 A (FM mode)

Environmental and EMC specification

Reference standards

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

Temperature (°C)

Unit	Storage	Operating
Operator station (HWS) and monitor	-30 to 70	5 to 50
Processing unit	-30 to 70	0 to 50
Transducers	-10 to 50 (Preliminary values)	-5 to 40

Humidity

- 5 to 95% relative, non-condensing

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.

Vibration

- 5–150 Hz
- 1 g

Shock

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

IP grade

- Processing unit, Operator station (HWS) and monitor: IP 22

System performance data

- **Frequency range:** 200 – 400 kHz
- **Max ping rate:** 50 Hz
- **Swath coverage sector:** Up to 140 deg, 5.5 times water depth (single RX) / 200 deg, 10 times water depth (dual RX)
- **Sounding patterns:**
  - Equiangular
  - Equidistant
  - High density
- **Roll stabilized beams:** Yes, ±15º
- **Pitch stabilized beams:** Yes, ±10º
- **Yaw stabilized beams:** Yes, ±10º
- **Output sample rate:** Up to 60 kHz (1.25 cm)

Table 4 Available beam widths

	200 kHz	300 kHz	400 kHz
Tx (EM 2040-07)	0.75°	0.5°	0.4°
Tx (EM 2040-04)	1.5°	1°	0.75°
Rx	1.5°	1°	0.75°

The transmit and receive fans may be electronically stabilized for pitch movements in order to always point vertically. The receive beams are electronically stabilized for roll. Roll, pitch, yaw, heave and the applied stabilization are fully taken into account when calculating sounding depths and positions. In the near field the receive beams are dynamically focused to maintain angular resolution even at very short ranges.

Table 5 Angular coverage across

Mode	Single RX	Dual RX
200 and 300 kHz	Up to 140°(±70°)	Up to 200°(±100°)
400 kHz	Up to 120°(±60°)	Up to 180°(±90°)

Transmitter

- 3 line arrays
- Array mounting roll angles: -55°, 0° and +55°
- Beamwidth along: 0.4 or 0.7 deg @ 400 kHz
- Source level:
  - EM 2040–04: Up to 218 dB re 1 µPa @ 1 m
  - EM 2040–07: Up to 212 dB re 1 µPa @ 1 m
- Electronic steering along: ±10°
- Angular coverage across: 200° (180° in 400 kHz mode)

Figure 30 TX transmission sector

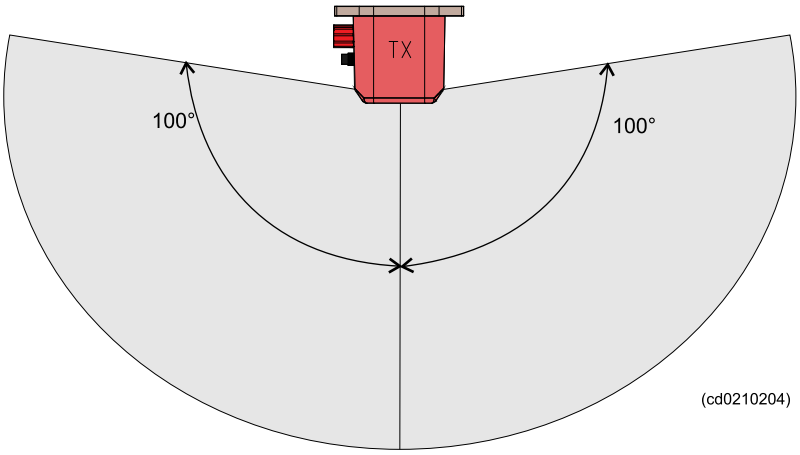


Table 6 Pulse lengths

	200 kHz		300 kHz		400 kHz	
	CW	FM	CW	FM	CW	FM
Normal mode	70/200/600 µs	3/12 ms	70/200/600 µs	2/6 ms	50/100/200 µs	N/A
Single sector mode	35/70/150 µs	1.5 ms	35/70/150 µs	1.5 ms	25/50/100 µs	N/A

Table 7 Max number of soundings per ping (dual swath)

	200 kHz	300 kHz	400 kHz
Single system	800	800	800
Dual system	1600	1600	1600

Note

Single sector mode and short pulse length may give reduced number of soundings.

Table 8 Max depth and coverage, EM 2040-04

	Cold ocean		Cold fresh water	
Operating frequency	**Max depth**	**Max coverage**	**Max depth**	**Max coverage**
200 kHz	635 m	890 m	1360 m	1900 m
300 kHz	480 m	740 m	740 m	1120 m
400 kHz	315 m	430 m	430 m	540 m

Table 9 Max depth and coverage, EM 2040-07

	Cold ocean		Cold fresh water	
Operating frequency	**Max depth**	**Max coverage**	**Max depth**	**Max coverage**
200 kHz	600 m	850 m	1300 m	1780 m
300 kHz	465 m	705 m	700 m	1060 m
400 kHz	300 m	410 m	375 m	510 m

Note

The calculated coverage is based on NL=44 dB for the 400 kHz mode, NL=46 dB for the 300 kHz mode and NL=50 dB for the 200 kHz mode. Backscatter strength used is BS=-10 dB.

Restriction for use – limitations

Do not ping in dry dock.

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 31 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 32 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.

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