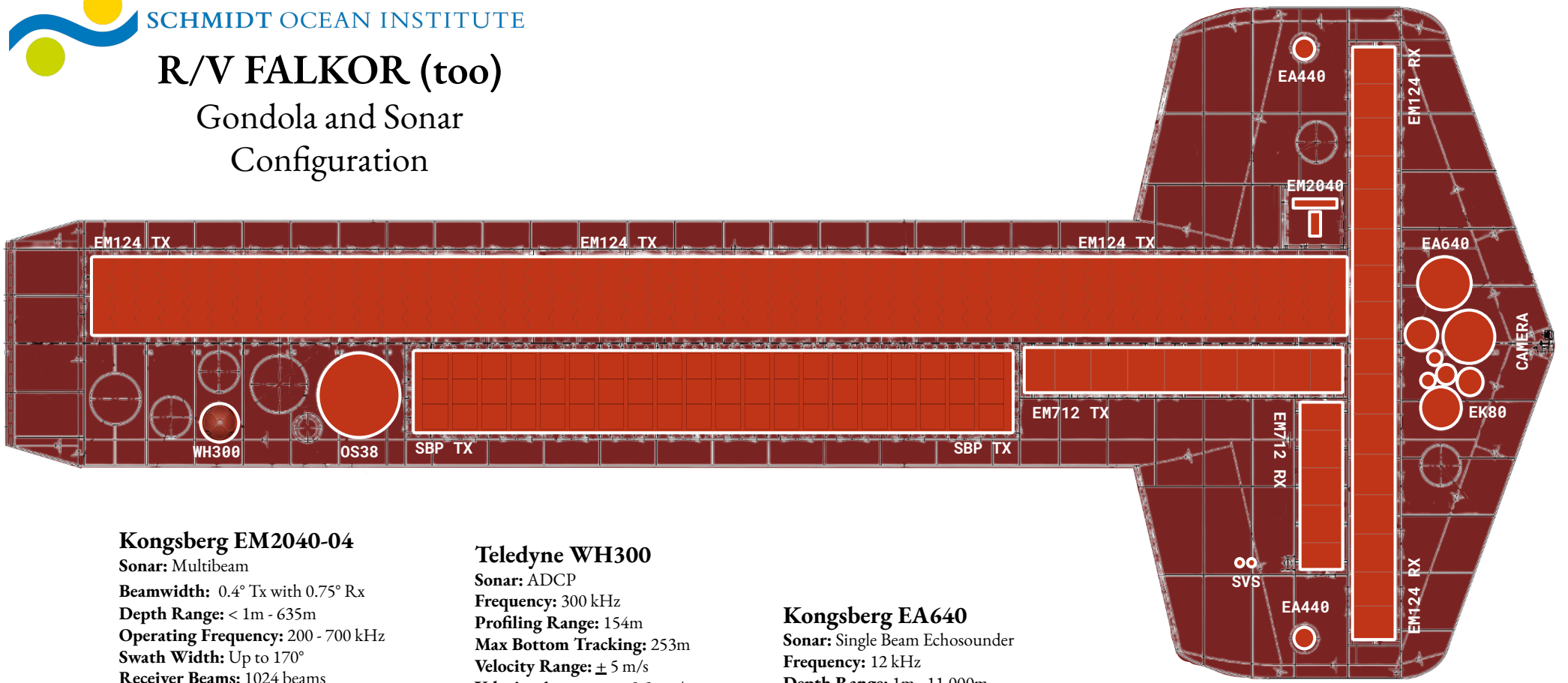
SCHMIDT OCEAN INSTITUTE

R/V FALKOR (too)

Gondola and Sonar Configuration



Kongsberg EM2040-04
Sonar: Multibeam
Beamwidth: 0.4° Tx with 0.75° Rx
Depth Range: < 1m - 635m
Operating Frequency: 200 - 700 kHz
Swath Width: Up to 170°
Receiver Beams: 1024 beams

Kongsberg EM712
Sonar: Multibeam
Beamwidth: 0.25° x 0.5°, full performance
Depth Range: 3m - 3,600m
Operating Frequency: 40 - 100 kHz
Swath Width: up to 5.5 times the depth
Receiver Beams: 1600 beams

Kongsberg EM124
Sonar: Multibeam
Beamwidth: 0.5° x 1°
Depth Range: 20m - 11,000m
Nominal Frequency: 12 kHz
Operating Frequency: 10.5 - 13.5 kHz
Swath Width: up to 6 times the depth
Receiver Beams: 1600 beams

Teledyne WH300
Sonar: ADCP
Frequency: 300 kHz
Profiling Range: 154m
Max Bottom Tracking: 253m
Velocity Range: ± 5 m/s
Velocity Accuracy: ± 0.5 cm/s

Teledyne RDI OS38
Sonar: ADCP
Frequency: 38 kHz
Max Profiling Range: >1,000m
Max Bottom Tracking: 1,700m
Velocity Range: ± 7 m/s
Velocity Accuracy: ± 0.5 cm/s

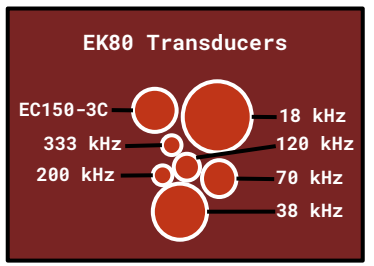
Kongsberg SBP 29
Sonar: Sub Bottom Profiler
Degree: 3° x 3°
Depth Range: 1m - 11,000m
Max Penetration: >200m
Operating Frequency: 2 - 9 kHz
Pulse Length: 2 to 100ms

Kongsberg EA640
Sonar: Single Beam Echosounder
Frequency: 12 kHz
Depth Range: 1m - 11,000m

Kongsberg EA440
Sonar: Hydrophone
Frequency: 10 - 90 kHz

Simrad EK80
W/ EC150-3C ADCP
Sonar: Mid-water echosounder
Frequency Range: 18 - 333 kHz

Valeport Mini SVS
Sonar: Sound Velocity
Frequency: 2.5 MHz
Range: 1375 - 1900 m/s



Diehl, 08/2024

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R/V FALKOR (too)

Gondola and Sonar Configuration

Seafloor Mapping

Multibeam technology sends hundreds of individual beams in a fan shape below the ship to paint a 3D image of the seafloor.

- **Shallow Water Multibeam:** 1m - 600m
- **Medium Water Multibeam:** 3m - 3,600m
- **Deep Water Multibeam:** 5m - 11,000m

Listening

Hydrophones act as our ears underwater, listening to nearby sounds, whether they be from ships, sonars, or marine life.

- **Hydrophones:** 24 - 500 kHz

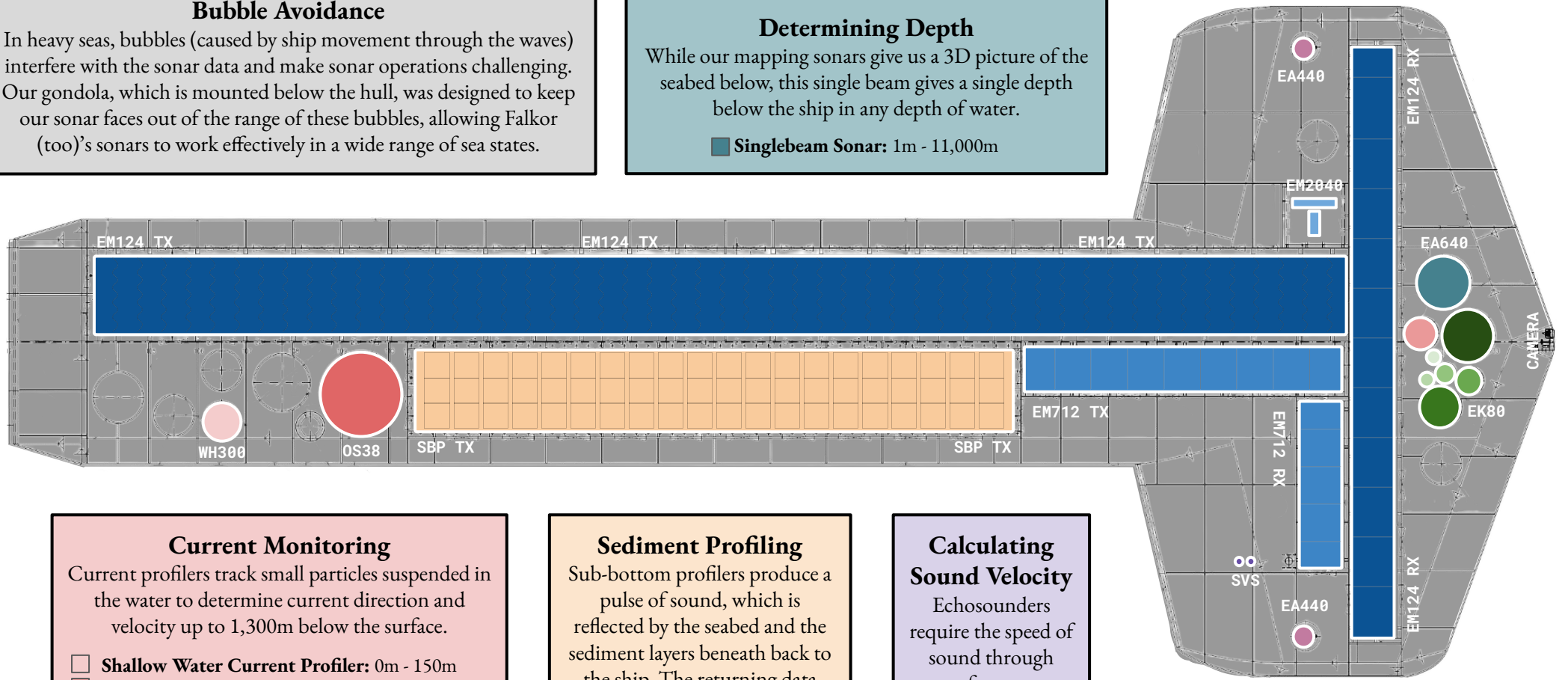
Bubble Avoidance

In heavy seas, bubbles (caused by ship movement through the waves) interfere with the sonar data and make sonar operations challenging. Our gondola, which is mounted below the hull, was designed to keep our sonar faces out of the range of these bubbles, allowing Falkor (too)'s sonars to work effectively in a wide range of sea states.

Determining Depth

While our mapping sonars give us a 3D picture of the seabed below, this single beam gives a single depth below the ship in any depth of water.

- **Singlebeam Sonar:** 1m - 11,000m



Current Monitoring

Current profilers track small particles suspended in the water to determine current direction and velocity up to 1,300m below the surface.

- **Shallow Water Current Profiler:** 0m - 150m
- **Medium Water Current Profiler:** 1m - 400m
- **Deep Water Current Profiler:** 1m - 1,300m

Sediment Profiling

Sub-bottom profilers produce a pulse of sound, which is reflected by the seabed and the sediment layers beneath back to the ship. The returning data reveals layers of sediment up to 200m below the seabed.

- **SBP 29:** 1m - 11,000m & up to 200m of sediment penetration.

Calculating Sound Velocity

Echosounders require the speed of sound through water for accurate depth and distance calculations. Falkor (too)'s SVS offer real time sound velocity at the sonar faces.

Fish-Finding

Our suite of midwater sonars help us identify biomass, both large and small, in the water around us.

- **Sonars:** 16, 38, 70, 120, 200 & 333kHz

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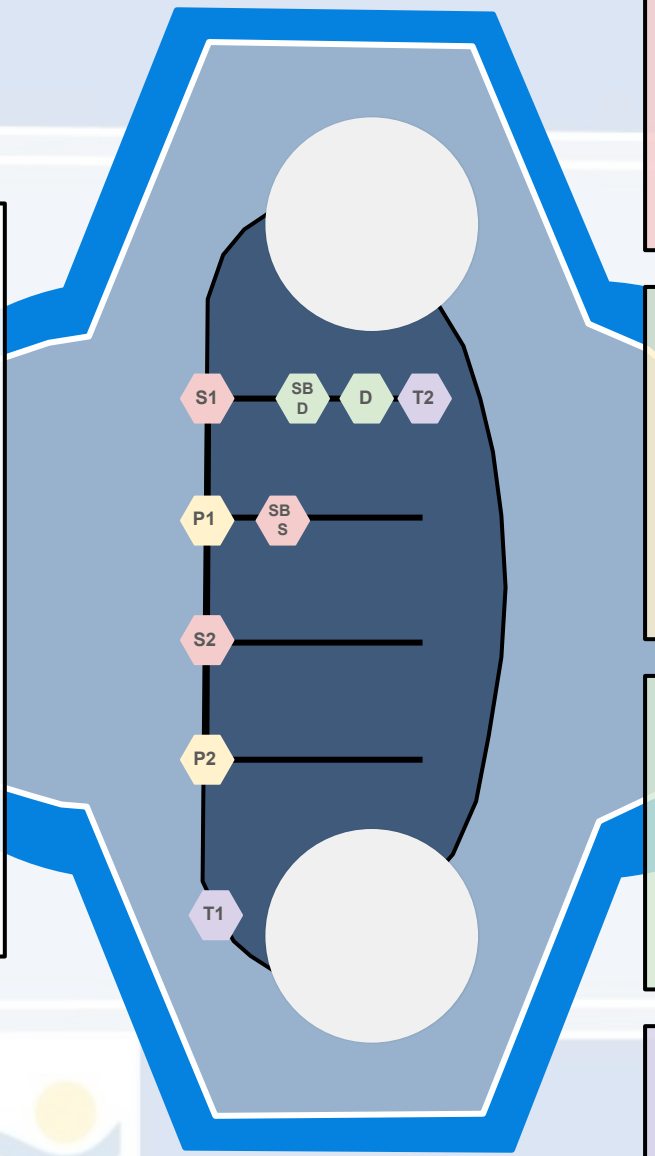
R/V FALKOR (too)

Scientific Antenna Configuration

Our ship utilizes top-of-the-line navigation systems crucial for supporting our scientific endeavors. Posmv and Seapath, acting as dual redundant systems, provide cm-level precision in positioning and highly accurate motion data essential for operating advanced scientific sensors like multibeam sonars and underwater vehicle tracking. Additionally, our DPSi1 serves as a robust backup, ensuring continuous sub-meter positioning capability. Supported by two network time servers, our navigation infrastructure maintains synchronized shipboard timing, pivotal for precise scientific data collection and analysis. These integrated technologies empower our scientific team with the reliability and precision needed to support shipboard scientific objectives.



Seapath

Manufacturer: Kongsberg
Model: Seapath 380
Antenna: Novatel GNSS 850 (S1 + S2)
Correction Antenna: Spotbeam (SB S)
Corrections: Fugro XP2
Accuracy: <20cm
IMU: Kongsberg MRU5+

Posmv

Manufacturer: Applanix
Model: Posmv Oceanmaster
Antenna: Trimble GA-830 (P1 + P2)
Correction Antenna: Internal Demodulator
Corrections: Fugro GPX XP
Accuracy: <20cm
IMU: Posmv IMU

DPSi1

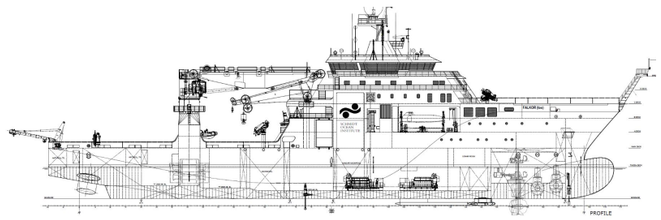
Manufacturer: Kongsberg
Model: DPSi1
Antenna: Novatel GPS-713-GGG-N (D)
Correction Antenna: Spotbeam (SB-D)
Corrections: Fugro MarineStar
Accuracy: <1m

Network Time Servers

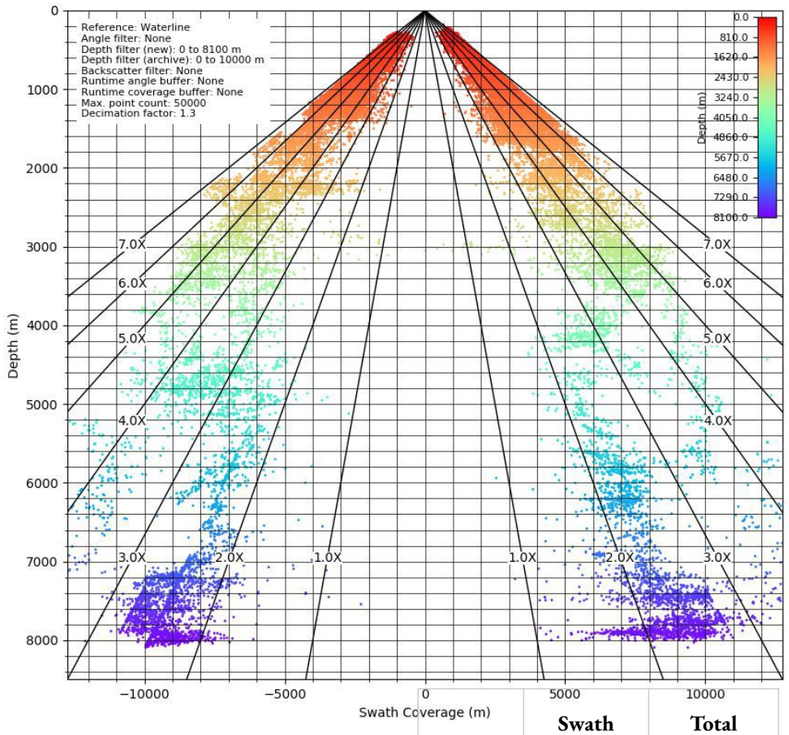
Manufacturer: Microsemi
Model: SyncServer S650
Antenna: Symmetricom AT575-142SYW (T1 + T2)
Accuracy: <0.0001 ms

FALKOR (too)

R/V Falkor (too)
Multibeam Swath Width vs. Depth
FKt230205L2 Systems Assessment Testing



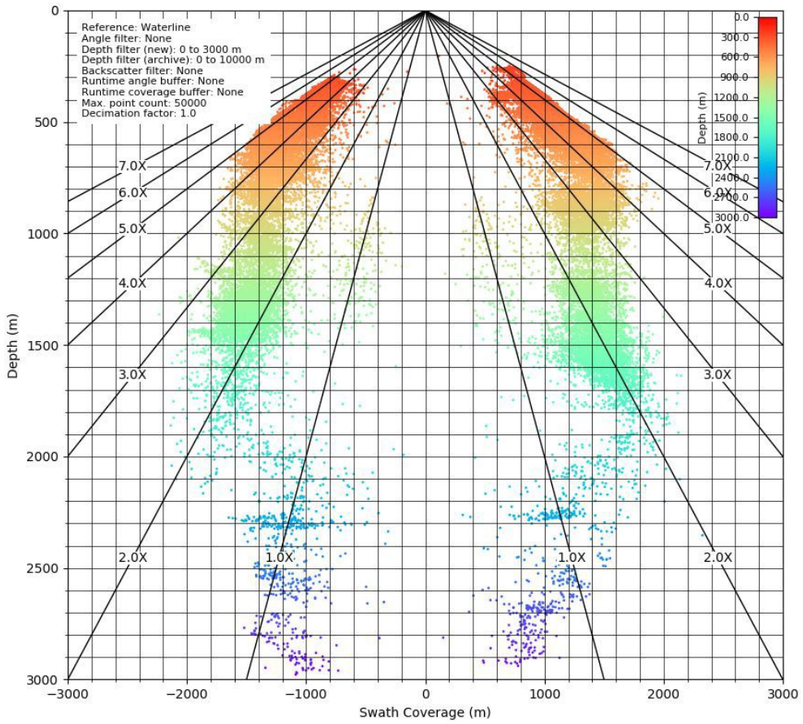
EM124 (Full Ocean Depth)



Beam Width: 0.5° Tx by 1° Rx
Depth Range: 20m - 11,000m
Falkor (too) Operating Range: 1,000m - 11,000m
Nominal Frequency: 12 kHz
Operating Frequency: 10.5 - 13.5 kHz
Swath Width: up to 6 times the depth
Receiver Beams: 1600 beams

Depth	Swath Width (m)	Total Coverage (m)
500	1250	2500
1000	2500	5000
1500	4000	8000
2000	5000	10000
2500	6250	12500
3000	7000	14000
3500	8000	16000
4000	9000	18000
4500	9500	19000
5000	10000	20000
6000	11000	22000
7000	12000	24000
8000	9000	18000

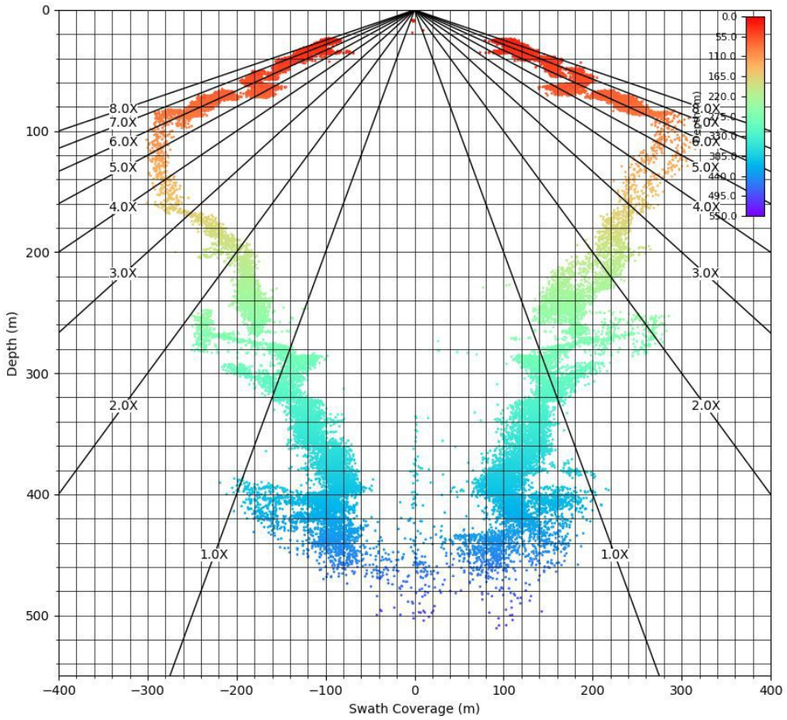
EM712 (Cont. Shelf/Slope)



Beam Width: 0.25° Tx by 0.5° Rx
Depth Range: 3m - 3,600m
Falkor (too) Operating Range: 100m - 2,000m
Operating Frequency: 40 - 100 kHz
Swath Width: up to 5.5 times the depth
Receiver Beams: 1600 beams

Depth	Swath Width (m)	Total Coverage (m)
250	600	1200
500	1000	2000
750	1300	2600
1000	1400	2800
1250	1500	3000
1500	1500	3000
1750	1600	3200
2000	1400	2800
2250	1000	2000
2500	1000	2000
2750	1200	2400
3000	1200	2400

EM2040 (Coastal)



Beam Width: 0.25° Tx by 0.5° Rx
Depth Range: < 1m - 635m
Falkor (too) Operating Range: 10m - 300m
Operating Frequency: 200 - 700 kHz
Swath Width: Up to 170°
Receiver Beams: 1024 beams

Depth	Swath Width (m)	Total Coverage (m)
50	100	200
100	280	560
150	280	560
200	200	400
250	180	360
300	160	320
350	120	240
400	80	160
450	80	160
500	50	100

Schmidt Ocean Institute

R/V *Falkor (too)* Survey Plan Template Information

Email to mt@falkortoo.org & leadtech@falkortoo.org

The following document is intended to guide science parties into giving key information needed during a multibeam survey so the survey goals can be best met by the ship's crew. The information below is not required, but is intended to serve as a guide. Everything in italic should be removed and replaced with information provided by the science party.

Survey Info

Date of Survey:

Estimated Start Time of Survey:

Requested Sonar: *See System Descriptions below for specifications.*

Requested Survey Speed:

- *FKt normal survey speed: 6 knots*
- *FKt high resolution survey speed: 4 knots*
- *FKt max distance coverage survey speed: 8 knots*

Description of Survey

This is an opportunity to explain the goals and objectives of the survey, which may include/ answer the following prompts:

- *Description of the feature/survey area*
- *Are the goals of the survey to explore an unknown region, to achieve the highest resolution possible, to achieve the highest coverage possible, or a combination?*
- *Has the survey area been previously surveyed? Is our goal to expand coverage or increase resolution? Mapping sonar/ resolution is helpful if known.*
- *Depth Ranges of the area if known to aid in choosing the sonar.*
- *What features, if any, should be prioritized, ex. keeping a ridge line centered.*
- *Are there any hazards to navigation that would alter how the survey is conducted, for example, rocks, uncharted areas, etc.*

Survey Procedures

If you have preferences for how the survey will be carried out, you can explain them here:

- *What support (if any) will we receive from the science party during the survey?*
- *By default, we log the 'start/ end of survey' as well as major settings changes. If you have any specific requirements (ie. line start/stop) please specify.*
- *How would you prefer the ship to handle turns in the survey?*
- *By default, we try to start new lines during turns so the turn data is easier to edit out during post processing, please specify if you want line changes handled a certain way.*
- *If the line coverage is different from planned, for this survey do you want us to 'edge map' to eliminate holes or stick to the line plan specified.*
- *If the ETA to the end of the survey is different than planned, would you like the ship to finish the survey or maintain the planned schedule?*
    - *If the survey ended early, should we continue mapping until the scheduled time?*
    - *If the survey won't be finished by the scheduled time, should we stay longer to finish the survey or break off at the expected time?*

Waypoints

- *Waypoint Number, Latitude, Longitude*
    - *D.DDD is preferred*
    - *If possible, providing the waypoints in a separate txt or csv document will speed up the process of distributing to the bridge/multibeam systems.*
- *An example is below:*

Waypoint #	*Latitude (d.dddd)*	*Longitude (d.dddd)*
1	*10.1234*	*-89.9876*
2	*10.5678*	*-89.5432*
3	*10.9012*	*-89.1098*
4	*10.345*	*-89.7654*

Map

- *If previous multibeam data or satellite data is available a map with our projected survey lines is helpful.*

Speed and distance

1 Kilometer = 0.539 Nautical Miles

Rounded time

Speed in knots	1 Km Time in mins
.5	66
1	33
2	17
3	11
4	8
5	6.5
6	5.5

Additional Tools:

System Descriptions

EM2040

Beam Width: 0.4° Tx with 0.75° Rx
Depth Range: < 1m - 635m
Falkor (too) Operating Range: 50m - 200m
Operating Frequency: 200 - 700 kHz
Swath Width: Up to 170°
Receiver Beams: 1024 beams

- Our EM2040 is our shallow water multibeam that is generally used in less than 100m of water. For surveys this shallow, we will be syncing the EM2040 with our SU90 (forward facing sonar) with Konsberg's KSYNC to ensure safe navigation of the vessel.
- For shallow water mapping (less than 100m), we require a line plan that will ensure we stay within the swath of our mapping data and must be organized clearly with the bridge prior to the survey. Near coastal mapping in shallow water must be done during the day and with clearance from the Captain.

EM2040 Estimated Depth x Swath Width
Assuming fully open beam angles and flat terrain in a 200kHz setting.

Depth	Swath Width (m)	Total Coverage (m)
50	100	200
100	280	560
150	280	560
200	200	400
250	180	360
300	160	320
350	120	240
400	80	160
450	80	160
500	50	100

EM712

Beam Width: 0.25° Tx by 0.5° Rx, full performance
Depth Range: 3m - 3,600m
Falkor (too) Operating Range: 100m - 1,500m
Operating Frequency: 40 - 100 kHz
Swath Width: up to 5.5 times the depth
Receiver Beams: 1600 beams

- Our EM712 is our shallow- mid water multibeam that does best in 100m- 1500m of water.
- The ADCP often causes interference with the EM712, so those should be secured during EM712 surveys.
- The SU90 causes interference with the EM712, so that should be secured during EM712 surveys. In some cases, if the Bridge requires the SU90, we may need to use the EM124 for that survey.
- Performance of the 712 is affected by water depth, vessel noise, sonar cross talk, and sea state. In general, it has to be monitored more closely than our other sonars.
- For features ranging in depth from 300-2000m, we recommend running the EM712 and EM124 synchronized. This also gives the bridge the opportunity to run the SU90 sync'd with EM124.
- For line planning purposes, you can estimate a line spacing of 3x the water depth for the EM712.

EM712 Estimated Depth x Swath Width

Assuming fully open beam angles and flat terrain.

Depth	Swath Width (m)	Total Coverage (m)
250	600	1200
500	1000	2000
750	1300	2600
1000	1400	2800
1250	1500	3000
1500	1500	3000
1750	1600	3200
2000	1400	2800
2250	1000	2000
2500	1000	2000
2750	1200	2400
3000	1200	2400

EM124

Beam Width: 0.5° Tx by 1° Rx
Depth Range: 20m - 11,000m
Falkor (too) Operating Range: 1,500m - 11,000m
Nominal Frequency: 12 kHz
Operating Frequency: 10.5 - 13.5 kHz
Swath Width: up to 6 times the depth
Receiver Beams: 1600 beams

- Our EM124 is our mid- deep water multibeam that can be synchronized to work with our Sub Bottom Sonar between pings to simultaneously log multibeam and sub bottom data.
- The EM124 does not receive interference from the ADCPs or SU90, which allows those to also be running simultaneously without losing ping density from synchronizing multiple echosounders.
- For line planning purposes, in general you can estimate line spacing of 4x the water depth for the EM124.

EM124 Estimated Depth x Swath Width

Assuming fully open beam angles and flat terrain.

Depth	Swath Width (m)	Total Coverage (m)
250	1000	2000
500	1250	2500
1000	2500	5000
1500	4000	8000
2000	5000	10000
2500	6250	12500
3000	7000	14000
3500	8000	16000
4000	9000	18000
4500	9500	19000
5000	10000	20000
6000	11000	22000
7000	12000	24000
8000	9000	18000