SeaBat T-Series Portable

SeaBat T20-P / T50-P High-Resolution Multibeam Sonar System

OPERATOR'S MANUAL

Part Number 1008755

Version 6

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Version

November 2015 Version 6

Teledyne RESON strives to maintain up-to-date information and may, as necessary, review and revise this manual. If the information contained in this manual is unclear, please contact your nearest Teledyne RESON office for clarification.

Software Release

1.1 (T50-P)
1.0 (T20-P)

This manual is consistent with the indicated release versions.

Electronic File Version

This manual is available from Teledyne RESON in the Adobe® Acrobat® Portable Document Format (PDF). The selected PDF process preserves the interactive index and cross-reference features of the original Microsoft Word document.

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PREFACE

How to Use This Manual

This manual is valid for SeaBat T-Series Portable systems with the indicated ***Software Release*** (see *Table 21* for a list of features). The manual is designed to accommodate both the first time user, who needs detailed instructions, and the experienced technician, who only requires a reference tool. It provides detailed procedures for the correct installation, operation, and maintenance of your Teledyne RESON system.

Read this manual thoroughly and follow the steps provided to maintain optimal safety standards and to obtain the best system performance.

Standards of Measurement

All physical measurements represented in this document are based on the metric system. All temperatures are represented in degrees Celsius.

Document Conventions

The following information will make it easier for the reader to interpret the text presented in this document.

Document Conventions

Convention	Definition
Hyperlink	Indicates a hyperlinked cross-reference. Click the word to be taken to the specified reference point.
Numbered list	Indicates stepwise instructions to be followed in a particular order.
Bulleted list	Indicates items of a list without any particular order.

Notes, Cautions, and Warnings

Notes, Cautions, and Warnings are included in this text to provide valuable information and to help the operator prevent damage to the sonar or to personnel. The following formats will be used:

NOTE
This is a Note. Notes provide explanatory information that may be useful to the operator, but is not necessarily vital to the operation of your Teledyne RESON system.

CAUTION
This is a Caution. Cautions provide important information regarding your Teledyne RESON system. Disregarding information provided in a Caution box may result in accidental misuse or damage to your Teledyne RESON system.

WARNING!
This is a Warning. Warnings provide important information regarding your Teledyne RESON system. Disregarding information provided in a Warning box may prove harmful to personnel working with or near the system.

Chapter Arrangement

All Teledyne RESON manuals are designed with the same basic structure. The following chapters are included in this document:

- ***Introduction*** provides a short summary of your SeaBat T-Series Portable sonar systems.
- ***Safety Precautions*** provides important safety information about your SeaBat T-Series Portable sonar systems.
- ***System Startup and Shutdown*** provides detailed information about how to start and shut down your SeaBat T-Series Portable sonar systems.
- ***System Configuration and Operation*** details are provided in the Sonar UI User Manual (see *Appendix H Reference Documentation*).
- ***Active Sonar Usage*** provides detailed information about the practical usage of your SeaBat T-Series Portable sonar systems.
- ***System Performance and Data Types*** provides information about the types of data produced by your SeaBat T-Series Portable sonar systems.

In addition to the above chapters, these appendixes have been included for reference:

- ***Appendix A***: Troubleshooting
- ***Appendix B***: Data Sheet
- ***Appendix C***: Installation Instructions
- ***Appendix D:*** Hydrodynamic Drag
- ***Appendix E:*** Network Configuration
- ***Appendix F:*** PPS In and Trigger In
- ***Appendix G:*** Interfacing Sensors To Teledyne PDS
- ***Appendix H***: Reference Documentation
- ***Appendix I***: SeaBat T-Series Portable System Options
- ***Appendix J***: Available Configurations
- ***Appendix K***: Conversion of Measurements
- ***Appendix L***: Warranty Information
- ***Appendix M***: Glossary of Terms

If you require additional information or need clarification of any part of this document, please contact Teledyne RESON Customer Support for assistance at support@teledyne-reson.com.

1 INTRODUCTION

1.1 System Overview

The SeaBat T20-P and T50-P are high-resolution multibeam sonar systems that measure relative water depths over a 140° or 165° wide swath perpendicular to the vessel's track. The multi-frequency systems provide high-resolution functionality with the 400kHz maximum frequency and long-range functionality with the 200kHz minimum frequency.

With its compact and waterproof portable sonar processor and its light-weight wet end, the SeaBat T-Series Portable sonar systems are designed for fast mobilization and ideal for use on the smallest of survey boats (see also *Appendix B Data Sheet*). The system wet end is depth rated to 50 meters.

Figure 1: SeaBat T20-P and T50-P Sonar Systems

For available configurations, see *Appendix J Available Configurations.*

For available options, see *Appendix I SeaBat T-Series Portable System Options*.

For available feature packages, see *Appendix J.2 Available Features.*

1.2 System Architecture

The SeaBat T-Series Portable multibeam sonar system consists of a portable sonar processor unit (PSP), a receiver unit (either EM 7219 or EM 7218), and a projector unit. User displays and system control originate within the customer-furnished laptop/PC.

For details on the various system components, see *Appendix C Installation Instructions.*

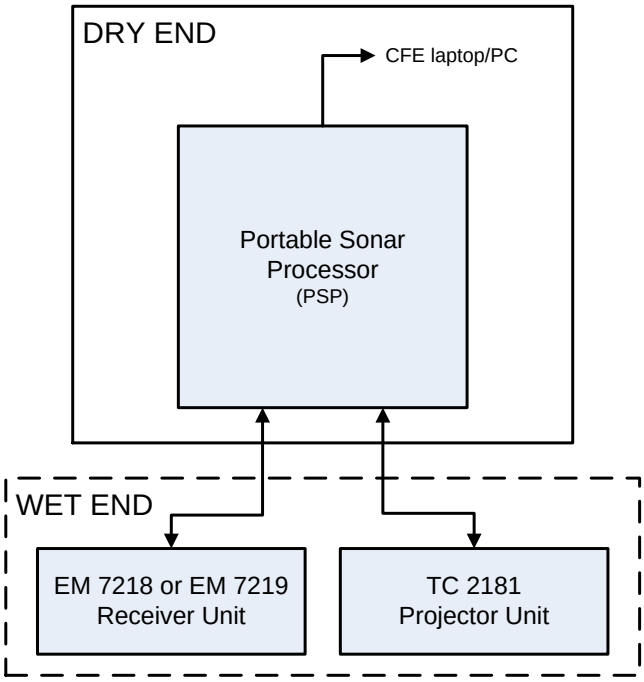


Figure 2: SeaBat T-Series Portable System Configuration[1]

1.3 System Operation

The projector unit of the sonar head assembly transmits a pulse of acoustic energy, which travels through the water and is reflected by the seafloor or any objects in its path. The reflected signal is received by the receiver unit of the sonar head assembly, digitized by internal electronics, and sent to the topside portable sonar processor for beamforming and processing. The sonar processor formats a digital output to be used by a peripheral data processing system while functioning as the interface between the operator PC and the sonar system. Available data packages are documented in the Data Format Definition Document (see *Appendix H: Reference Documentation*).

The CFE laptop/PC running the SeaBat User Interface receives beam data, water column data, bottom detection data etc. from the PSP and generates the wedge, water column, snippets, and sidescan displays as well as other displays for sensor monitoring and general system Built-In Test Environment overview.

[1] Data storage and user interfacing is carried out on separate customer-furnished PC.

1.4 System Features

The main features of the SeaBat T-Series Portable sonar systems are summarized below. Depending on options purchased, all features may not be available (see *Appendix J.2 Available Features).*

- **Resolution:** Dynamic, focused beamforming maintains ultra-high resolution, even at short ranges. A receiver sample rate of 34kHz (T20-P) and 34/66kHz (T50-P) provides unprecedented range resolution and complements the narrow beam, thus providing the user with ultimate data quality and resolution.
- **Fast update:** The entire 140° (or 165°) swath is illuminated with a single transmission at an update rate of up to 50Hz (range selection dependent), maintaining 100% bottom coverage, even at high speed.
- **Depth rating:** The SeaBat T-Series Portable sonar system wet end and cables are depth-rated to 50 meters.
- **Data output:** The SeaBat T-Series Portable sonar systems export the standard hydrographic records of bathymetry, side-scan, and snippets as well as water column data and other data for more scientific applications.
- **Beamforming:** The sonar processor performs initial signal processing, a combination of time delay and phase rotation beamforming.
- **Bottom detection:** The special bottom detection algorithm uses a combination of center-of-energy and phase-zero crossing algorithms to detect the bottom in each individual beam with the highest possible accuracy.
- **Multi-detect:** Providing up to five detections within each beam, including the full water column, this feature allows the surveyor to capture enhanced details from a single survey line over a complex feature, even in noisy environments.
- **Operator selectable operating mode:** The choice of five different beam modes allows the operator to select a beam mode appropriate to the application thereby optimizing sonar operation. Equi-Angle mode yields a swath of 165º, while the other four modes yield a swath of 140º or 150º in Equi-Distant mode for T50-P.
- **Beam distribution:** The three standard beam spacing choices are equiangular, intermediate, and equidistant. In addition, the optional FlexMode feature provides settings for alternative beam distribution. All options are dynamically focused.
- **Selectable beam density:** This feature allows the surveyor to generate optimized data volumes tailored to specific survey specifications by providing a choice of how many beams to form ranging from the maximum capability of the system down to just 10. The configuration can be changed on the fly.
- **Variable swath coverage:** This feature gives the operator control of the swath coverage. It includes swath width settings ranging from 45º to 140º (150º for T50-P) in Equi-Distant mode or 165º in Equi-Angle mode in increments of 5º as well as a choice of beam density mode.
- **Uncertainty output:** Uncertainty is computed for each sounding and presented graphically on various UI (user interface) displays.

- **Steerable swath:** This feature allows swath to be steered electronically.
- **Head tilt:** This feature makes it possible to operate with a physically rotated sonar head, which allows for very flexible and specialized applications of the SeaBat T-Series Portable sonar systems.
- **Tracker:** This feature is a complete automated mode of operation where the system sets sonar control parameters, including range, gain, power, and swath width based on the quality of the data being collected.
- **Real-time pipe detection and tracking:** This SeaBat feature automatically detects pipes within the multibeam swath, displays them to the user in real-time during survey, and sends the pipe positions to the data acquisition software. The feature builds on FlexMode for generating a high-density profile of the pipe. The majority of the beams are steered to the center of the detected pipe to track the pipe regardless of its location on the wedge display.
- **X-Range:** X-Range is a software and hardware feature using frequency modulated (FM) transmit pulses which provides extended range performance (across all frequencies) and significantly improves system immunity to external noise.
- **Full rate dual head:** FRDH uses X-range (FM) to achieve dual-head operation with the double effect of increased swath coverage and ping rate. With FRDH the systems are synchronized and ping simultaneously at a high rate.
- **On the fly frequency change:** The SeaBat T-Series Portable multi-frequency systems may be operated at the full range of frequencies without interrupting the survey.
- **On the fly beam mode selection:** Choice of beam mode (spacing and number of beams) can be done without interrupting the survey.
- **Real-time QC display:** The SeaBat T-Series Portable sonar systems generate a real-time display with an intensity image on the CFE monitor. Overlaid on this intensity image is the bottom detection display, giving the operator an excellent QC (quality control) tool.
- **Hardware sync pulse out:** A TTL pulse (synchronous with the transmit pulse) is available from the sonar processor.
- **1PPS pulse handling and time stamping:** Data time stamping is referenced to an incoming 1PPS and associated time message.
- **External trigger:** The system may be triggered using a standard 7k Center software remote command or by a TTL incoming trigger pulse.
- **Adaptive gating:** Three different gate settings are available for application to the bottom detection process: No Gates, Absolute Gates, and Adaptive Gates.
- **Beam data recording:** The SeaBat T-Series Portable sonar systems are capable of producing a stream of operator configurable beam data that may be written to a shared network drive on either the CFE laptop/PC's local hard drive or an optional NAS (Network Attached Storage) RAID hard disk array. Data logging software controls recording, playback, and data storage functions.

- **Built-In Test Environment (BITE):** BITE is an integral part of the SeaBat T-Series Portable sonar systems, monitoring the status of internal subsystems and the wet-end units.

1.5 Typical Applications

The SeaBat T-Series Portable sonar system is Teledyne RESON's latest addition to our class-leading portfolio of marine survey solutions. The system is built on world-class technology with the flexibility to evolve alongside your business. The powerful scalable feature set provides unmatched utility across a wide range of applications including:

- As-built surveys
- Breakwater mapping
- Coastal mapping
- Environmental research
- Habitat mapping
- Harbor mapping
- Hydrographic surveys to IHO Special Order and to U.S. Army Corps of Engineers Special Order
- Oil detection
- Pipeline inspection surveys
- Pipeline route surveys
- Pre- and post-dredging and condition surveys
- Revetment surveys
- River surveys
- Search and recovery
- Site clearance surveys
- Underwater inspection and object location

2 SAFETY PRECAUTIONS

WARNING!
If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Teledyne RESON assumes no liability if this product is operated in an unsafe manner.

CAUTION
Use of the equipment in a manner not specified by the manufacturer may affect warranty situation (see *Appendix L Warranty Information*).

2.1 Operator Safety

The SeaBat T-Series Portable system should be handled with attention to operator safety as well as protection of the hardware components. General precautions include:

- **DO NOT** connect or disconnect cables with the power on.
- **DO NOT** attempt to open and service the projector or receiver units.
- **DO NOT** attempt to open and service the portable sonar processor without specific instructions from Teledyne RESON.
- **DO NOT** operate the system while divers are in the water and closer than two meters from the projector and receiver units. High-powered ultrasonic energy can be hazardous to human physiology.

For safety reasons the SeaBat™ must be connected to protective earth. The protective earth pin in the mains AC and DC appliance inlets is the protective conductor terminal of SeaBat™.

WARNING!	
	This icon on any of the SeaBat components implies hazardous voltage on output connection.

2.2 Equipment Safety

Each SeaBat T-Series Portable component is sufficiently robust for shipboard storage while in its own transit case or shipping box, which may include handles and tie-down rings. Use appropriate discretion in lifting, as the case may be awkward and heavy.

2.2.1 Safe Handling

To ensure safe handling of the equipment:

- Inspect each transit case or shipping box for physical damage prior to opening, and each component for physical damage before installation.
- Use original shipping boxes to provide adequate packaging and shock absorption when shipping or storing the equipment.
- Do not drop the equipment.
- Do not connect or disconnect cables at the rear of the processor or from the sonar head assembly while the processor is running. This can damage the internal workings.
- Do not bend cables beyond the recommended limits.
- Do not place the sonar head in an area where the face may be scratched or damaged. If an array must be placed on the ground, it should be placed on a flat surface and covered with a protective padded sheet.
- Do not place liquids on or near the equipment.
- Ensure that the equipment is properly secured before putting out to sea.
- Do not block the airflow of the topside portable sonar processor.
- When the sonar head is in air and switched on, the transmit power should be switched off except when performing system checks, where power should be increased to a level which is audible for a short time only on a slow repetition rate. A higher setting may damage the transmit array ceramics. **The system should only be operated in air for very short periods of time**.
- Unused connectors should be sealed with dummy plugs.
- Do not exceed operating and storage temperature limits.

CAUTION
Do not operate transmitters in air except during system checks for short durations.

2.2.2 Cleaning and Maintenance

2.2.2.1 Projector and Receiver

The acoustic window molded over the front of the projector and receiver arrays is made of high-density polyurethane.

These recommendations are made to protect the arrays while in use or in storage.

- For cleaning, use a mild, nonabrasive soap, fresh lukewarm water, and a soft brush.
- Rinse the sonar with fresh water after every use.
- Do not clean the array or sonar by using hot or cold pressure washers. The high-velocity water spray will cut through the polyurethane or damage the interface between the polyurethane and the sonar metal housing.
- To scrape away marine growth from the arrays, use only a wooden tool.
- Do not apply any antifouling paint on the acoustic window unless the type is recommended by Teledyne RESON. The antifouling paint will affect the acoustic performance. Teledyne RESON recommends:
    - For high-frequency transducers (>100kHz) use International VC 17m.
    - For low-frequency transducers (<100kHz) use SigmaGlide.

NOTE
As these products are subject to technical modifications, it is recommended that the most up to date PDS[2] and MSDS[3] are acquired prior to commencing the coating work.

CAUTION
A long range of chemicals will destroy the polyurethane, which includes, but are not limited to: • Acids • Automotive brake fluid • Base • Grease • Halogenated hydrocarbons (carbon tetrachloride, trichloroethylene) • Hydraulic fluids • Ketones (MEK, acetone) • Nitro hydrocarbons (nitrobenzene, aniline) • Oil • Ozone • Petrol • Phosphate ester

[2] Product Data Sheet
[3] Material Safety Data Sheet

2.2.2.2 Wet-End Connectors

Use the wet connector lubrication kit (PN 1007252) to protect the wet-end connectors. Follow these guidelines:

- Lubricate female connectors and dummy plugs with a silicone oil or equivalent (silicone oil based). Observe the instructions provided with the lubrication kit.
- Lubrication intervals depend on mission type and frequency.
  - Lubricate every 5 matings.
  - Lubricate at regular intervals even if the connector is not mated/unmated, in particular for UUVs where the dive tends to rub and wash out the lubricant.
  - Lubricate twice a year when equipment is in storage.
- DO NOT grease mating surface.
- Avoid nicks and cuts around contacts as these are the sealing surfaces.
- Elastomers can be seriously degraded if exposed to direct sunlight or high ozone levels for extended periods of time.
- Do not overtighten bulkhead nuts.
- Grip main body of connector during mating or unmating. Do not pull on cable to disconnect.
- Avoid sharp bends at cable entry to connector.

2.2.2.3 Replacement of Battery on PC Motherboard

CAUTION
Battery to be changed by authorized personnel only. Noncompliance may affect warranty situation (see *Appendix L Warranty Information*).

Use only the correct type of onboard CMOS battery as specified by the manufacturer. Do not install the onboard battery upside down to avoid possible explosion.

2.3 Corrosion Avoidance

It is important that your SeaBat™ system be properly protected from the corrosive effects of the water in which the sonar head is submerged.

CAUTION
Aluminum components of your SeaBat system are not suitable for permanent installations on surface vessels. Aluminum components require regular cleaning with fresh water and sacrificial anodes must be inspected/renewed on a regular basis.

All aluminum housings are provided with ***zinc*** alloy sacrificial anodes to protect against galvanic corrosion while immersed in ***sea water***, or with ***magnesium*** anodes for use in ***fresh water***.

Take the following precautions to ensure the best usage of your SeaBat system's sacrificial anodes.

- Maintain electrical isolation between the sonar head and the mounting structure.
- Do not paint the anodes.
- Inspect the anodes periodically for cleanliness and good physical condition. Tighten or replace loose anodes immediately.

CAUTION
Sacrificial anodes, when new, have a thin coating to prevent them from oxidizing. The first time the anodes come in contact with water the coating will dissolve thereby making the anodes active. If the anodes are removed from the water, even for a short period of time, they will oxidize (in a matter of minutes) forming a layer that must be removed before the anodes and sonar head are placed in the water again.

2.4 Electrical Isolation

Electrical isolation for both titanium and aluminum components may be achieved by using nonconductive bushings, washers, and isolation plates to insulate them from the mounting brackets. Common nonconductive materials include Delrin, G-10/FR4 glass fiber sheets, and high-density polyethylene sheets.

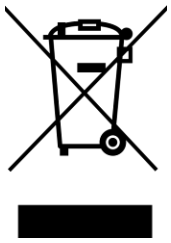
CAUTION
If the sonar head is not isolated from the mounting structure, galvanic corrosion will result in either the housing (aluminum housings) or in the mounting structure itself (titanium housings). Additionally, an undue amount of stress will be put on the affected sacrificial anodes, causing them to be used very quickly.

NOTE
Contact Teledyne RESON for additional information on schemes for electrical isolation.

2.5 Exposure to Sunlight

Do not allow the projector and receiver arrays to sit in direct sunlight when not in use, but cover the arrays with a bag. In addition to furthering corrosive effects, continued exposure to ultraviolet (UV) rays will damage the polyurethane array face.

2.6 Safe Disposal of Waste (WEEE Directive)



The use of the crossed-out dustbin logo indicates that this product is subject to directive 2002/96/EC, known as the Waste Electrical and Electronic Equipment Directive. The WEEE Directive specifies that used electric/electronic equipment may not be treated as household waste, but must be sorted separately for disposal. These rules concern all your Teledyne RESON products (computer, monitor, transducer, processor, probe, etc.) and also all accessories (keyboard, mouse, etc.). By ensuring this product is disposed of correctly, you will help protect the environment.

For more detailed information about the recycling of this product, please contact your local authority, your household waste disposal service provider, or Teledyne RESON Customer Support (support@teledyne-reson.com)

2.7 CE Marking

This product carries the CE mark which indicates that it conforms to the essential health, safety, and environmental requirements of the relevant European Directives.

- Directives
  - Electromagnetic compatibility (2004/108/EC)
  - Low Voltage Directive (2006/95/EC)
- Standards
  - EN 61326-1: 2006
  - EN 61000-3-2: 2006
  - EN 61000-3-3: 1995 + A1: 2001 + A2: 2005

3 SYSTEM STARTUP AND SHUTDOWN

3.1 Chapter Overview

This chapter includes detailed instructions on the following subjects (click the emphasized hyperlink to be taken to the section):

- ***System Startup Instructions:*** Consists of startup details.
- ***Starting the Sonar User Interface:*** Consists of a description of how to start the sonar system.
- ***System Shutdown Instructions:*** Consists of details on stopping the system.

NOTE
For information on installation (including configuration of hardware and dual head), see *Appendix C Installation Instructions*. For information on system configuration (including IO module configuration), refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*). For information on user interface navigation, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*). For information on the practical use of the sonar, see *section 5 Active Sonar Usage.* For technical specifications, see *Appendix B Data Sheet*.

3.2 System Startup Instructions

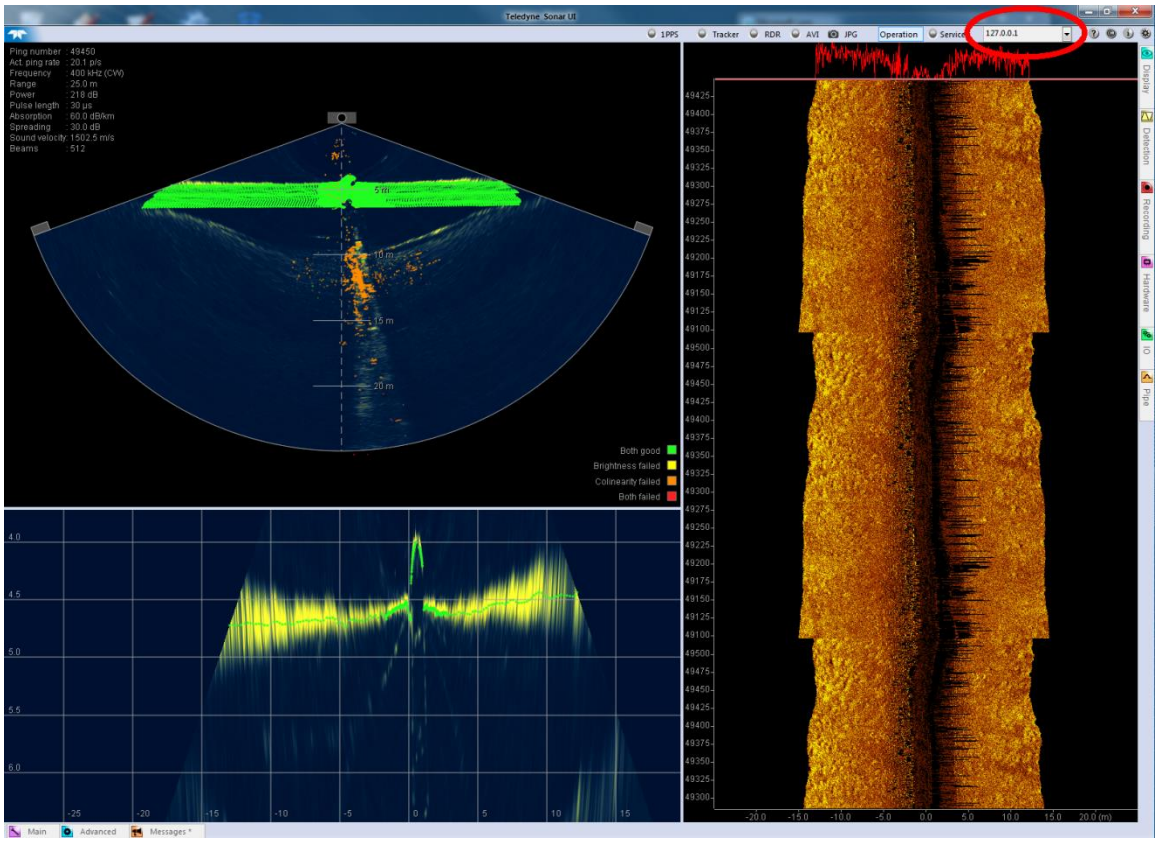
After the SeaBat hardware has been installed (see *Appendix C Installation Instructions*), the system may be started. To do this, press the power buttons on the portable sonar processor and the CFE laptop/PC.

NOTE
The portable sonar processor power button will be orange, when power is connected to the unit; it will turn blue, when the system is turned on.

3.3 Starting the Sonar User Interface

1. Double-click the Sonar UI icon on the laptop/PC to start the Sonar User Interface.

In the toolbar at the top of the user interface, click the sonar address drop-down menu (circled in red), and select the IP address of the connected PSP/sonar system from the list.



The sonar system can be identified by its serial number (prefixed with SN) next to the IP address. The serial number can be found on the front of the PSP.

NOTE
The laptop/PC and PSP should be directly connected using an Ethernet cable to the LAN 1 or LAN 2 port of the PSP, or through a Switch. (For further information, see *appendix C.4.3 Portable Sonar Processor Cable Connections*.) **By factory default, the PSP is set up with fixed IP addresses: 10.11.10.1 for LAN 1 and 10.11.10.2 for LAN 2.** If the PSP is configured to acquire an automatic IP address (assigned by a DHCP server), but fails, the two Ethernet ports will revert to the static IP addresses 10.11.10.1 (LAN 1) and 10.11.10.2 (LAN 2), both with subnet mask 255.255.255.0, after typically up to 1m30s of trying to acquire DHCP contact. Make sure that the laptop/PC IP address is set to an ***unused*** IP address within the 10.11.10.XXX subnet, subnet mask 255.255.255.0. ○ Recommended 10.11.10.3 for single-head systems ○ Recommended 10.11.10.5 for dual-head systems. For details on IP address configuration, see *Appendix E Network Configuration*.

The laptop/PC is now connected to a running sonar system.

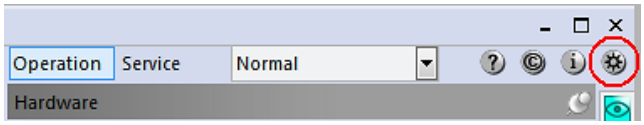
2. Check the state of the BITE LED on the front of the PSP.
   - Red, green or yellow solid is a sign that the sonar software is running and should be accessible.
   - No front light or a flashing red light is a sign that the sonar software is not running correctly.
     - Remove the power cable, wait 10 seconds, reconnect the power cable, and restart the PSP by pressing the power button.
3. Select the settings appropriate for the present survey mission. Refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

NOTE
For configuration of a dual head system, see *appendix C.7.9 Dual-Head Configuration*.

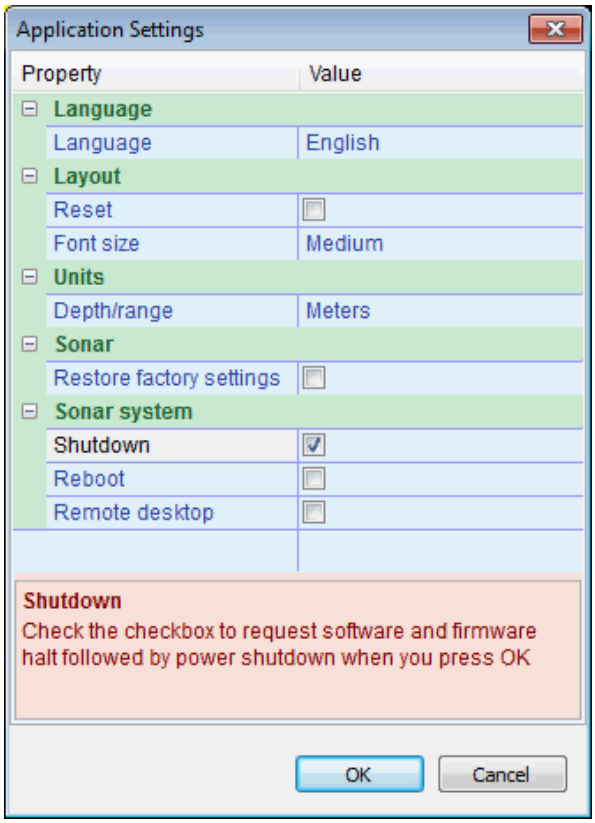
3.4 System Shutdown Instructions

CAUTION
Ensure that the portable sonar processor is shut down correctly.

1. Click the Application Settings button in the top right corner of the Sonar UI.



2. Select the Shutdown option in the Application Settings dialog to shut down the sonar system.



3. Click OK.

   This will shut down the PSP and thereby terminate the connection to the PSP/sonar system from laptop/PC.

4. Click the cross in the upper right corner of the Sonar UI to terminate the session.

   The Sonar UI will resynchronize to the PSP, once the system is started again.

4 SYSTEM CONFIGURATION AND OPERATION

NOTE
For information on system configuration and user interface navigation, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

4.1 Chapter Overview

This chapter includes instructions of the following subjects (click the emphasized hyperlink to be taken to the section):

- ***Remote Operation:*** Consists of instructions on how to control the sonar from a remote PC.

NOTE
For information on starting and stopping the SeaBat sonar system, see *section 3 System Startup and Shutdown*. For information on the practical use of the sonar, see *section 5 Active Sonar Usage.* For information on installation and details on the various system components, see *Appendix C Installation Instructions*.

4.2 Remote Operation

The 7k series software architecture is built on a client/server concept. The 7k Center running on the PSP controls the sonar, performs data processing, and exports data to external clients connected via TCP/IP or UPD/IP. The clients should control the 7k Center via remote SUI or use of customized control applications based on DFD. Refer to the appendix section in the Data Format Definition document for example code for writing the control application (see *appendix H.1 SeaBat T-Series Portable Documentation*).

5 ACTIVE SONAR USAGE

5.1 Chapter Overview

This chapter includes detailed instructions on the following subjects (click the emphasized hyperlink to be taken to the section):

- ***Enhancing Sonar Performance:*** Consists of examples on how to use the UI controls to enhance sonar performance.
- ***Enhancing System Efficiency:*** Consists of examples on how to use the automation, roll stabilization, and head tilt features.
- ***Compensation for Environmental Conditions:*** Consists of a thorough introduction into the environmental parameters that may affect sonar operation.
- ***Limitations:*** Consists of examples on the various physical limitations that may affect sonar operation.

NOTE
For information on starting, stopping, and setting up the SeaBat sonar system, see *section 3 System Startup and Shutdown*. For information on system configuration (including IO module configuration), refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*). For information on user interface navigation, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*). For information on installation and details on the various system components, see *Appendix C Installation Instructions*.

5.2 Enhancing Sonar Performance

5.2.1 Correct Range Setting

Select the appropriate range scale to keep the horizontal bottom image at or above the widest part of the sonar wedge as visualized in *Figure 3*:

If the Range is set too short the outer beams will be lost. If the Range is set too long, the results may be noisy data.

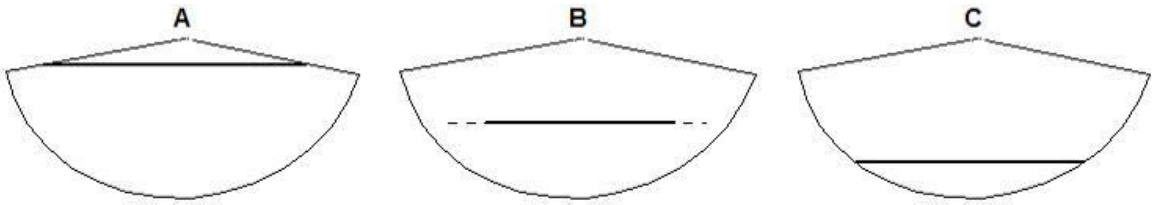


Figure 3: Range Setting Diagrams

- Diagram A depicts a proper range setting.
- Diagram B depicts an acceptable range setting for a swath that is beginning to fade due to the effects of signal loss in the outer swath.
- Diagram C depicts an incorrect range setting. Notice that the still-useable ends of the swath are being cut off by the limits of the range setting.

Note that the range setting affects ping rate: the longer the range, the lower the ping rate and thus the fewer along-track pings. Higher range settings are required for tilted heads (see also *section 5.3.4 below*).

NOTE
The Range adjusts itself automatically when Tracker is selected (see also *section 5.3.2 below*).

For additional examples on incorrect range settings and possible solutions, see *Table 1*.

Table 1: Incorrect Range Settings – Examples and Solutions

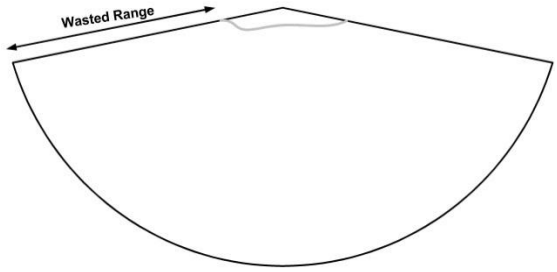


Figure 4: Range Setting – Too Long

With the Range set too long, the receivers are “open” for too long and the system is recording long after the acoustic returns from the seabed have been received. Spurious background noise can be amplified, especially when TVG is used, and this can give noisier data. The ping rate is also reduced thereby reducing sounding density. This should not be used to artificially reduce the ping rate, rather the Range should be set correctly, and the ping rate should be capped using Max rate. Refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*.)

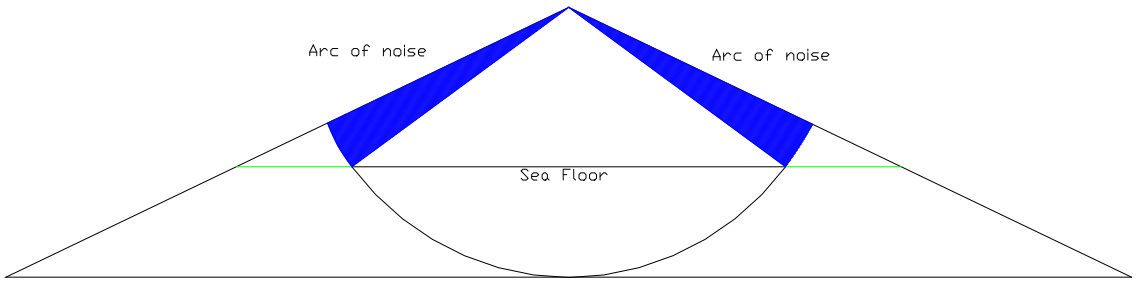


Figure 5: Range Setting – Too Short

With the Range set too short, the outer beams formed are not long enough to reach the seabed. With no seabed in these beams the bottom detection process can only lock onto the noise in the water column. An exception to this is if the seafloor to the outer parts of the swath is of no interest and the user wishes to concentrate on a smaller seafloor coverage thereby increasing the ping rate and hence sounding density. In this case the user should reduce the swath coverage of the sonar. Refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*.)

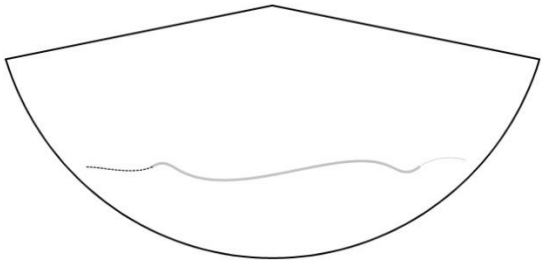


Figure 6: Range Setting – The Exception

If you are operating in relatively deep water to the limits of operation and the outer parts of the swath exceed the acoustic range of the sonar, the user should reduce the swath coverage to cover the seabed that is visible only. This will increase the ping rate and reduce noise picked up for these visible beams. Refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.2 Transmit Power

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

NOTE
The Power adjusts itself automatically when Tracker is selected (see also *section 5.3.2 below*).

5.2.2.1 Transmit Power OFF

If the Power is set to OFF, the system will not ping, but it will continue to receive data provided that the max ping rate is not set to 0.

With the transmit power OFF, the sonar system will act as a passive sonar by only receiving data. This is a feature that is very useful for monitoring the ambient water in order to assess the level of background noise and interference from the vessel itself.

5.2.2.2 Transmit Power and Pulse Type

Power level depends on pulse type:

- In **CW mode**, typically set Power at full for the most robust bottom detection at all ranges.
- In **FM mode**, the use of power may vary with range setting. Due to longer pulse lengths in this mode, more overall energy is transmitted into the water per ping than in CW mode.
    - Less power may be required at shorter ranges. Start with 200dB at minimum Range, and increase with Range.

5.2.3 Ping Rate

Set the Max rate at 50p/s to ensure unhindered operation of the sonar. Note that this is only a ping rate limiter.

The ping rate is automatically set by the range setting (or safe duty cycle limit) (see also *section 5.2.1 above*).

NOTE
If Max rate is set to 0, the system will not ping or receive data. If Max rate is set to a value higher than the range-determined ping rate (or the duty cycle-determined ping rate), the sonar will ping at the rate determined by the range setting (or calculated duty cycle). If Max rate is set to a value lower than the range-determined ping rate, the sonar will ping at the rate specified by Max rate.

In some instances it may be beneficial to force a lower ping rate than the normal rate associated with a particular range.

Examples of this would be instances when too much data is being received at short ranges; when the vessel is moving at a very slow rate and the operator wants to reduce the quantity of data generated; or when the sonar is operating in a high-reverb environment where echoes of the previous ping are contaminating the current ping.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.4 Receiver Gain

The Gain setting adjusts the amount of receiver gain applied to the returned signal (@ T = 0). Typically set between 20dB and 40dB.

The SeaBat system utilizes Time-Varied Gain (TVG) by applying a variable gain to the returned signal, based upon the formula in *Table 2*.

Table 2: TVG Formula

Receiver Gain = 2 α R_{km} + Sp log R_m + G
Where:
α = Absorption loss in dB/km
Sp = Spreading loss coefficient
R_{km} = Range in kilometers
R_m = Range in meters
G = Extra gain from RxGain menu item

NOTE
The Gain adjusts itself automatically when Tracker is selected (see also *section 5.3.2 below*).

For details on environmental conditions such as absorption and spreading, see *section 5.4 below*.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.5 Frequency Selection

- 400kHz for highest resolution at shorter ranges.
- 200kHz for greater range performance.

For general hydrographic surveys, the switch from 400kHz to 200kHz at either end of the scale in FM mode (or 420kHz to 190kHz in CW mode) may be necessary between

depths of 80m and 120m depending on conditions. Frequency selection between the upper and lower limits may be made in steps of 10kHz.

NOTE
Adjusting the frequency affects beam width. Reducing the frequency produces wider beams, increasing the frequency produces narrower beams.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.6 Pulse Length

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

NOTE
The Pulse Length adjusts itself automatically when Tracker is selected (see also *section 5.3.2 below*).

5.2.6.1 Pulse Length and Image Resolution

For a given power setting, a narrower pulse length will provide a higher resolution at a shorter range. A wider pulse length will provide better range but a lower resolution image.

In certain conditions, for example in turbid waters, the narrower pulse length may not operate well. In such circumstances, the wider pulse length may give better short-range performance. This may also be achieved by changing from higher to lower frequency operation.

5.2.6.2 Pulse Length and Pulse Type

The pulse length setting depends on pulse type (see *section 5.2.7 below*).

- In **CW mode**, typically set Pulse Length at 30µs (range is 30µs-300µs), and increase with Range. The shorter the pulse in CW mode, the higher the resolution. The longer the pulse, the greater the range performance but the lower the resolution.
- In **FM mode**, typically set Pulse Length at 1ms (range is 300µs-10ms), and increase with Range. Note that the length of the FM pulse does not affect resolution in the same way as it does for CW mode. At very short ranges a long pulse length can limit the ping rate due to the duty cycle protection mode.

5.2.7 Pulse Type

- **CW** (Continuous wave) is the traditional pulse type for multibeam survey.
    - Shorter pulses result in high resolution, but suffer in range performance.
    - Longer pulses increase range performance at the expense of resolution.

- **FM** (Frequency modulation or X-Range) is selected for greater range performance, FRDH operation, and instances where an increase in noise immunity may be required.
    - FM allows much longer pulses, and thus more energy, to be transmitted into the water, resulting in greater range performance whilst maintaining full resolution.
    - FM also provides better immunity to external noise and allows dual head sonars to ping at the same time, a feature known as Full Rate Dual Head (FRDH).

NOTE
Depending on purchased features, only CW mode may be available. X-Range is an optional add-on feature (see *Table 21*).

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.8 Vari-Swath

Vari-swath is a feature which allows the operator to select a swath width appropriate to the application in addition to electronically steering the swath.

Vari-swath is available with all beam modes and can be used in conjunction with roll stabilization and FlexMode[4]. For details on the use of the various beam modes, see *section 5.2.9 below*.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.8.1 Coverage Angle

The benefits of the variable swath feature are twofold:

- Increased sounding density in a small sector may be used when tracking pipes or other linear features, where the operator is not interested in data outside a defined sector. The increased sounding density helps define small targets.
- A reduced swath width allows an increase in ping rate for any given depth.

5.2.8.2 Beam Reduction

- With beam reduction enabled, only the beams necessary to fill the given swath are formed.
- With beam reduction disabled, all beams are compressed into the selected coverage angle.

[4] FlexMode is an optional add-on feature (see *Table 21*).

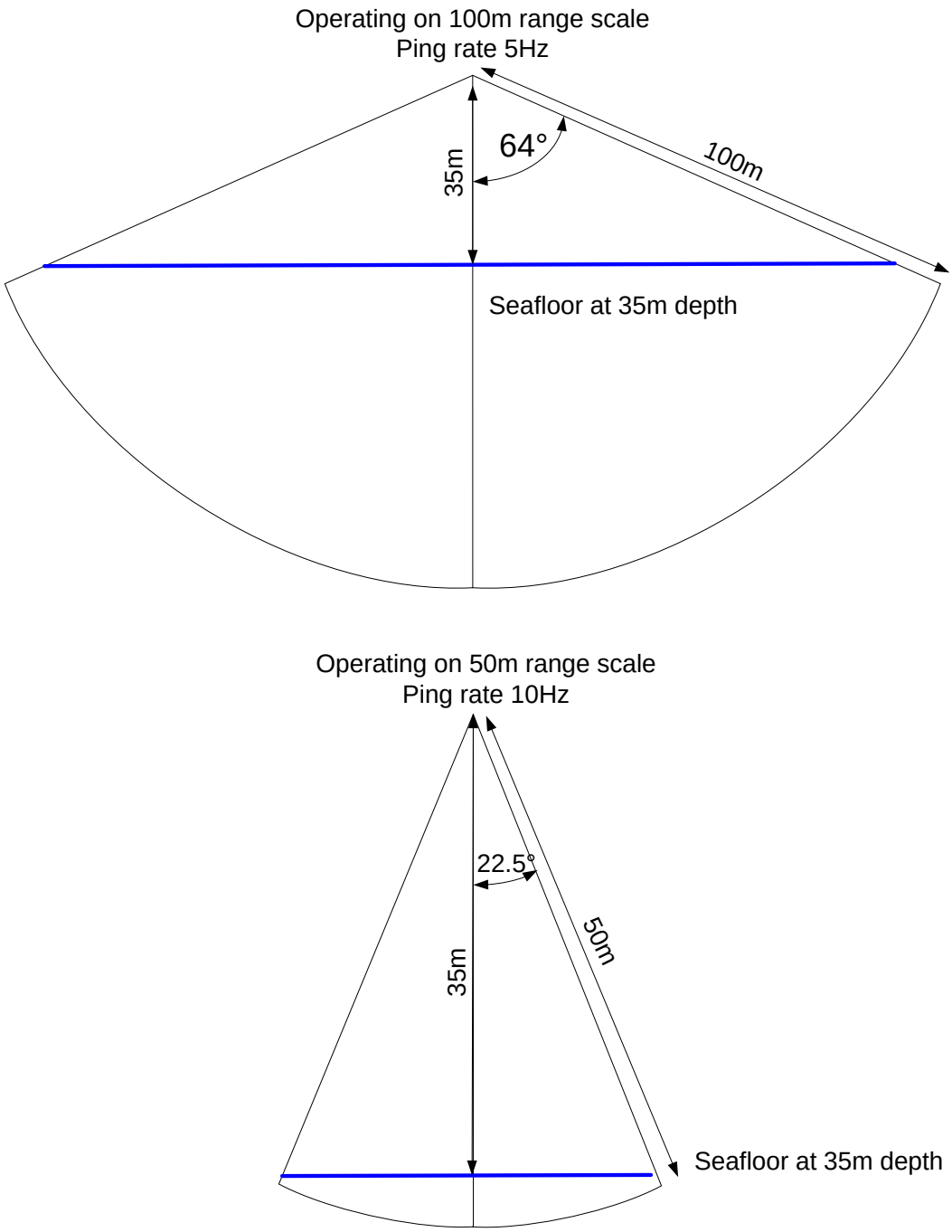
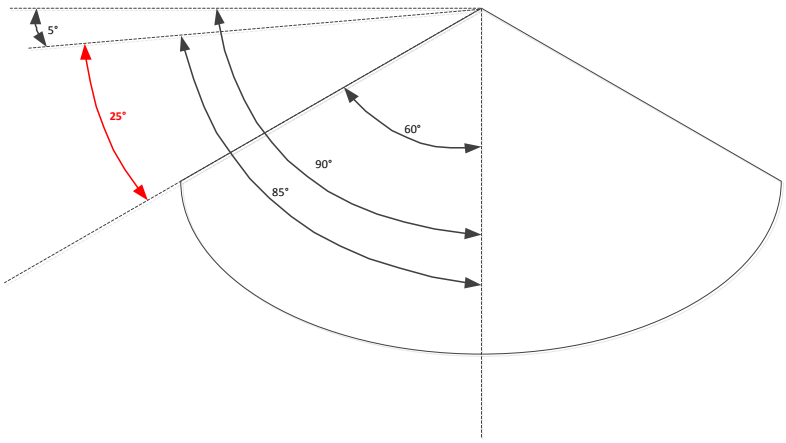


Figure 7: Example of Reduced Swath Width

5.2.8.3 Horizontal Steering

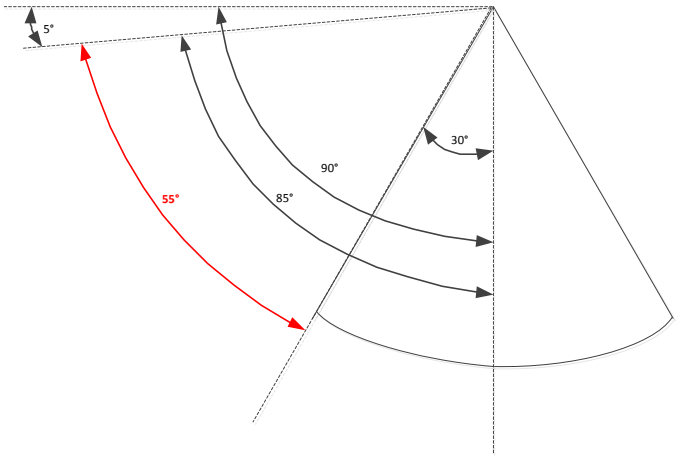
This setting allows the operator to steer the swath independently of the sonar head physical angle. The extent of steering is determined by the angle selected. The limitation is that the outer beam cannot be steered past 5° from the horizontal (see *Figure 8*). When the swath is steered this way, the individual beam widths increase with the steering angle. A beam steered at 60° is twice the width of a beam steered at 0°.

120° swath
Max steering 25°



With a swath of 120° the maximum steering angle is ±25° ((85°-(swath/2)).

60° swath
Max steering 55°



With a swath of 60° the maximum steering angle is ±55° (85°-(swath/2)).

Figure 8: Horizontal Swath Steering

5.2.8.4 Minimum Grazing Angle

The minimum grazing angle is a limitation for the non-equiangular beam modes of the sonar. This limitation is especially noticeable for a sonar with a tilted head (see *section 5.3.4 below*).

With a tilted head for the Equi-Angle beam mode, there is no minimum grazing angle and the outer beams can look 'upwards'. With a tilted head for the other beam modes the sonar is limited and cannot look 'upwards'.

For the beam mode Intermediate, the minimum grazing angle is 5°, and for Equi-Distant and FlexMode, the angle is 15°. For these three beam modes the outer beam cannot go higher. *Figure 9* provides a graphic illustration of the minimum grazing angle.

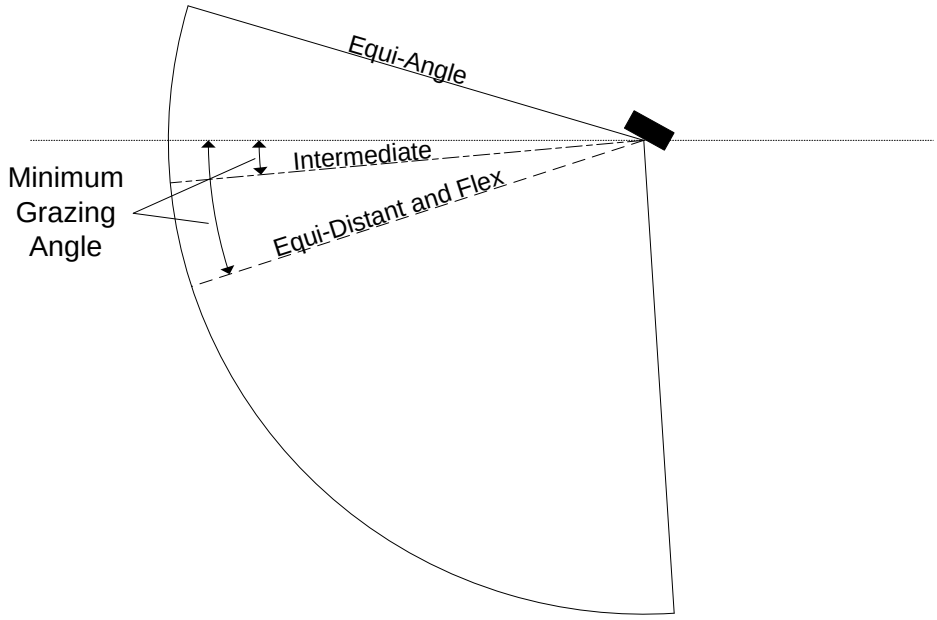


Figure 9: Outer Beams for the Different Beam Modes with a Tilted Sonar Head

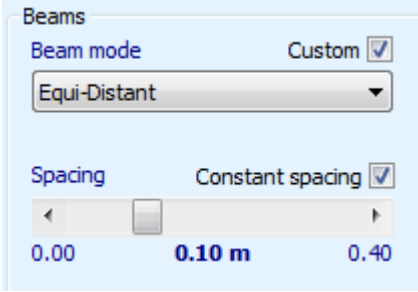
NOTE
When you want to look up with a tilted sonar head you have to select the Equi-Angle beam mode.

5.2.9 Use of Beam Modes

The following beamforming modes are available: Equi-Distant, Equi-Angle, Intermediate, and FlexMode (optional).

The system allows everything from high-density beams for exceptional image clarity and detail to just a few beams to deliver results faster. By deploying fewer beams in shallow water, the system allows the user to reduce storage requirements by gathering only the data you need. The system can also hold constant seafloor spacing between beams to provide the same high-quality results with minimal data volume.

In each mode (except FlexMode), the surveyor may choose the number of beams to be formed by using a slider. In Equi-Distant mode, an additional option is available which allows the surveyor to set the desired seafloor spacing with the slider. The system automatically detects the depth and sets the spacing as required by the surveyor. Adjustments may take place during survey: there is no requirement to interrupt the survey.



There is always a minimum number of beams that theoretically ensures “100% insonification” of the swath, which roughly speaking means that there are no gaps between beams; in other words, each beam adjoins or slightly overlaps its neighbor. IHO specifications no longer refer to the term “100% insonification”, as it cannot ever be proved conclusively; it is accepted that the situation may arise where “100% insonification” is not achieved.

5.2.9.1 Equi-Distant, Equi-Angle, and Intermediate Modes

- **Equi-Distant mode:** Up to 140° or 150° coverage angle. Typically the default mode for general purpose surveys where it is critical to maintain a certain number of hits per cell across the maximum possible swath. Provides high-density equidistant soundings across the entire swath.
- **Equi-Angle mode:** Up to 165° coverage angle. Typically used for tilted heads to inspect upwards, water column data recording, or for minimizing the amount of data being recorded. Provides an equiangular distribution with the fewest beams.
- **Intermediate:** Up to 140° or 150° coverage angle. Designed for general purpose surveys, tilted head modes, or dual-head operations. Provides high-density soundings over the entire swath.

In Equi-Distant mode the spacing is modified to maintain an equal horizontal distance between soundings on the seafloor assuming a flat bottom and in Equi-Angle mode the beam center-center angular spacing is constant across the swath. It is recommended that Equi-Distant mode be used for general survey applications where the requirement to achieve a specific number of sounding per cell in the across-track is critical, or where the seafloor is generally flat.

When surveying features such as wrecks and vertical structures such as harbor walls, Intermediate or Equi-Angle mode should be used in preference to Equi-Distant mode. In extreme conditions, using Equi-Distant mode over complex structures can cause magnified artifacts due to the large overlap between beams towards the edge of the sector.

In short, these are the pros and cons for the three modes, keeping in mind that in each case the negative effect is much more dramatic with a wide swath (see also *section 6.1.2 Equi-Distant, Equi-Angle, and Intermediate Modes*):

PRO	CON
• Equidistant spacing:	
○ Constant spacing even at large angles	○ Very large number of beams
• Equiangular spacing:	
○ Low number of beams	○ Very wide spacing at large angles
• Intermediate (compromise):	
○ Moderate beam number	
○ Moderate spacing at large angles	

5.2.9.2 FlexMode[5]

- Designed for pipeline or umbilical profiling. Provides equidistant beam spacing for the full swath coverage together with a high-density equiangular sector which may be steered toward the detail area of interest.
- In this mode the system is started with a 140° wedge and an alternative beam distribution is used which concentrates the majority of beams into a central sector.

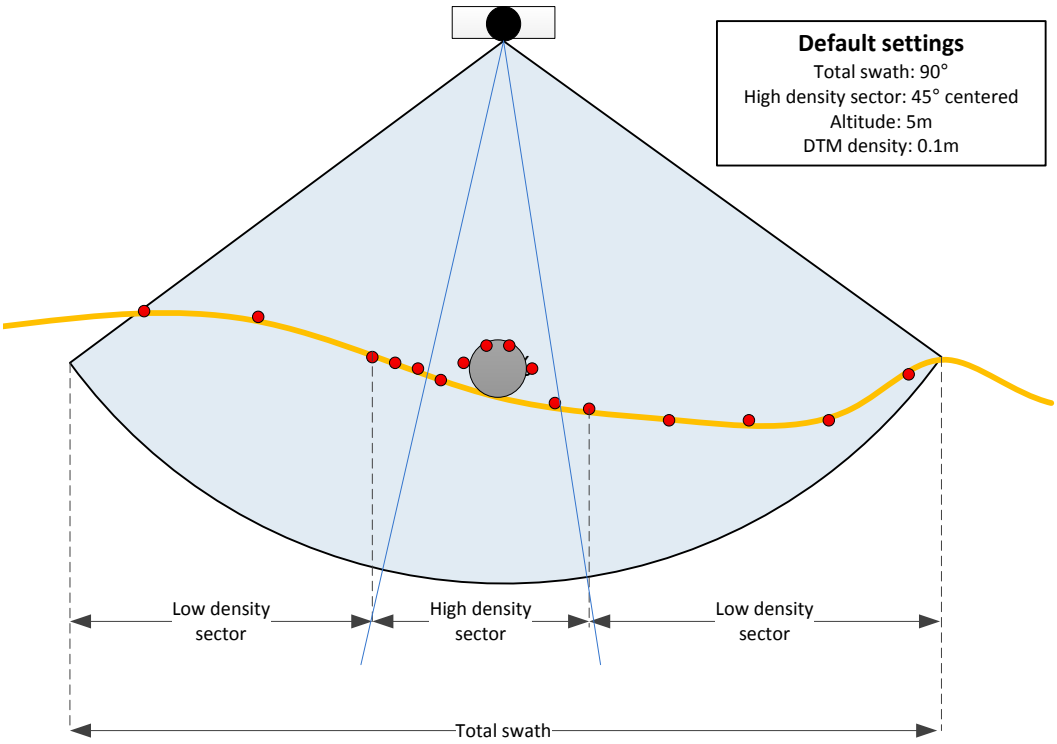


Figure 10: Graphic Illustration of FlexMode

FlexMode provides a combination of a high density of beams on and around the object location and a reduced density of soundings for the rest of the swath. The low-density spacing is defined by the operator (with the slider for Constant seafloor spacing) and the high-density spacing is computed by optimization based on survey parameters.

[5] FlexMode is an optional add-on feature (see *Table 21*).

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.10 Use of Gates

Applying range and/or depth gates to the bottom detection process aids in noise reduction and correcting for a tilted sonar head.

- **No Gates:** The bottom detection process searches the entirety of each beam for the bottom.
- **Absolute Gates:**
  - Depth: Forces bottom detection to occur within the Min/Max Depth limits set. If the seabed falls outside the limits, bathymetry data will fail and cannot be recovered.
  - Range: Forces bottom detection to occur within the Min/Max Range limits set. If the seabed falls outside the limits, bathymetry data will fail and cannot be recovered.
- **Adaptive Gates:** Forces bottom detection to occur around the seabed profile within an adaptive gating window typically set to 15-20% (of depth). This value should be increased over rougher terrain or over a rapidly changing seafloor where bathymetry is extreme in the vertical values.

5.2.10.1 Depth Gates

Use of a motion sensor is required to rotate the depth gates with the rolling motion of the vessel to ensure soundings are not clipped as the seabed rotates with respect to the sonar.

The depth gates, with no input from a motion sensor, will orient themselves parallel to the horizontal plane of the sonar head, as shown by the Min and Max Depth lines in *Figure 11*. In this series of illustrations, the bottom detect dots are shown as a horizontal line (Line A or B) with dashed lines representing depth gates above and below the bottom and no vessel roll present. Visualize the bottom as being in the ‘layer’ formed by the depth gates.

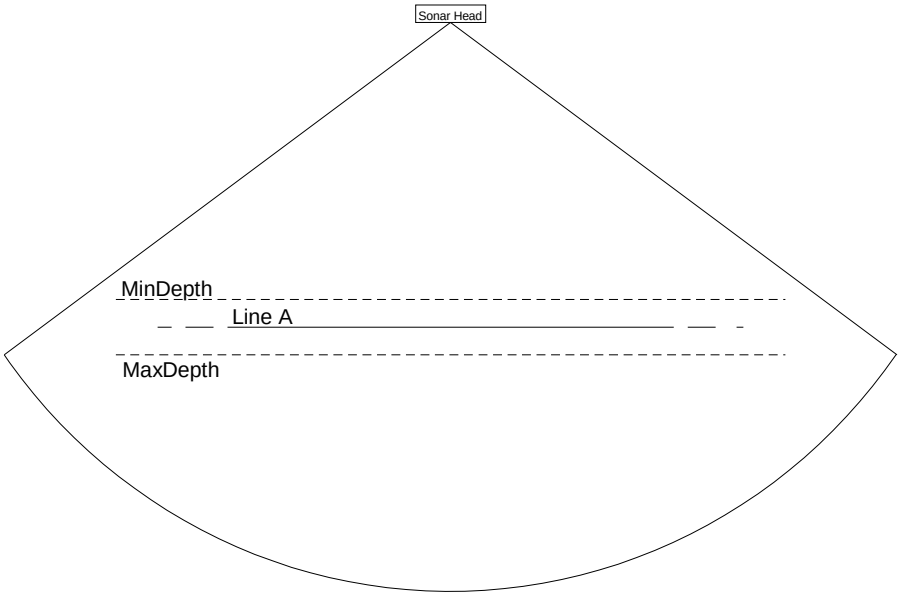


Figure 11: Depth Gates, With No Roll

Figure 12 shows the same bottom image with a small roll value to port. Notice that the ends of the swath have been cut off due to the action of the static depth gates (no motion sensor applied). In this figure, and all remaining figures in this discussion, the bottom is flat.

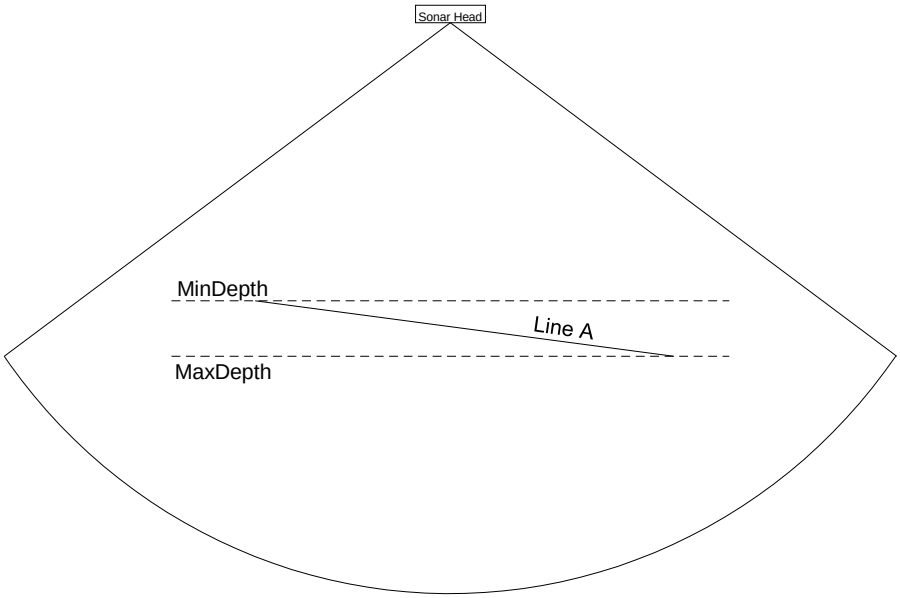


Figure 12: Depth Gates, With Roll

When controlled by a motion sensor, the depth gates will be parallel to the local horizontal plane of the earth even as the vessel rolls. *Figure 13* shows the same bottom image with dynamic depth gates applied.

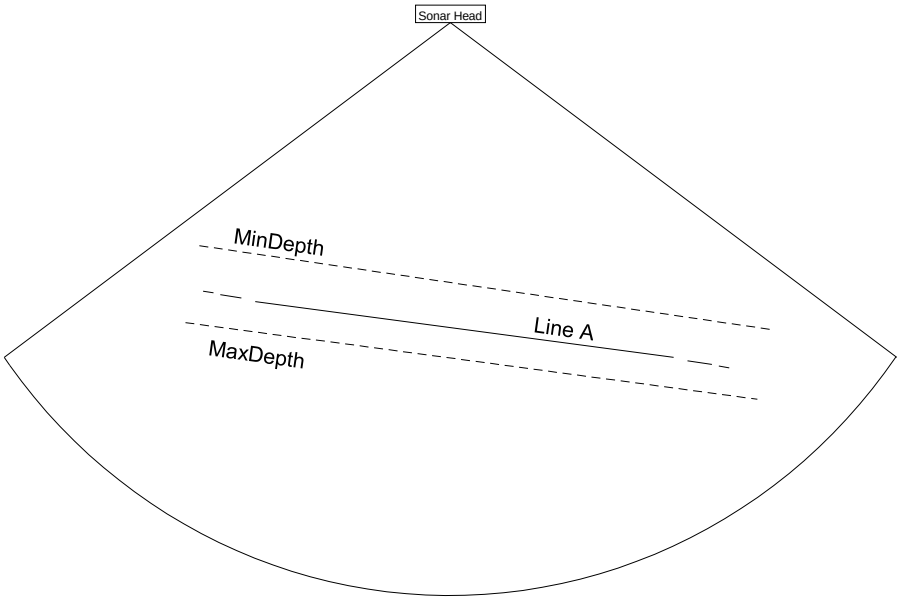


Figure 13: Depth Gates, With Roll and Motion Sensor Input

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.2.10.2 Depth Gate Tilt

Depth Gate Tilt is a feature that allows the operator to manually specify a tilt value for absolute gates. Tilted depth gates are beneficial when it is desirable to concentrate bottom detect operation efforts, e.g. on a sloping seafloor (see *Figure 14*).

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

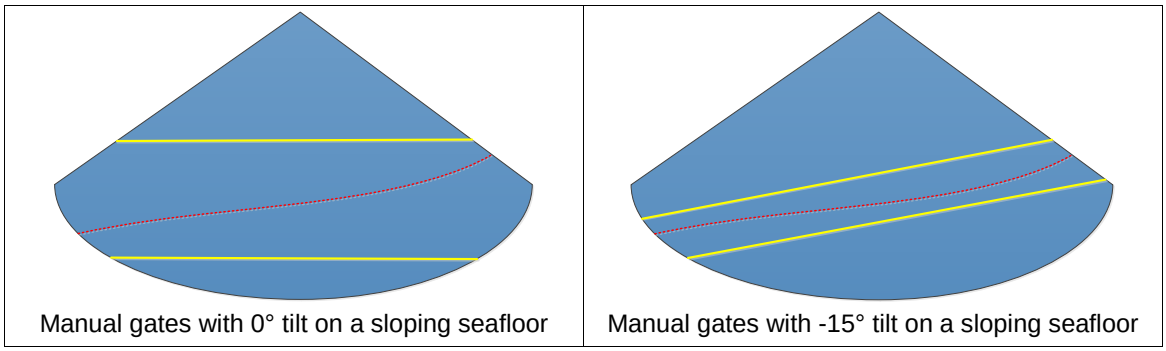


Figure 14: Depth Gate Tilt

5.2.11 Maximizing Quality of Backscatter for Snippets Data

There are a few survey practices that can be followed to maximize the quality of the backscatter signal[6]. For instructions on adjusting settings, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

- **Constant frequency:** Since the acoustic response from the sediment is frequency dependent, it is recommended to maintain the frequency constant over the survey area of interest.
- **CW mode:** For similar reasons, and to avoid the extra processing steps relating to FM signals, it is recommended to perform the survey using CW rather than FM. The emitted CW pulses durations should not be shorter than 100µs and source levels not below 210dB.

  Note that the information about the FM signal characteristics, including the equivalent CW pulse width necessary for footprint computation, are fully documented in record 7002 which is part of the default record set.
- **Intensity coloring of bottom detection points:** Extra attention should be paid to the risk of losing strong or weak signals during digitalization. It is recommended to use the intensity coloring of the bottom detection points in the SUI.
  - Orange or red dots: Saturated detection, too high intensity for correct digitalization which results in clipping of values.
  - Blue dots: Weak detection, too low intensity for correct digitalization which results in losing signals.
- **Constant settings:** Lastly, keeping the sonar settings relatively constant during the survey is a good practice to make sure that changes in the backscatter levels are only due to the environment.

5.3 Enhancing System Efficiency

5.3.1 Multi-Detect Operation[7]

Use of the Multi-detect feature is of great value in various applications both in terms of generated result and safety:

- Harbor surveys: safer detection
- Offshore and renewables: robust cable catenary determination
- Marine research: fish school detection
- Dredging: suspended sediment detection
- Energy industry: submerged oil detection

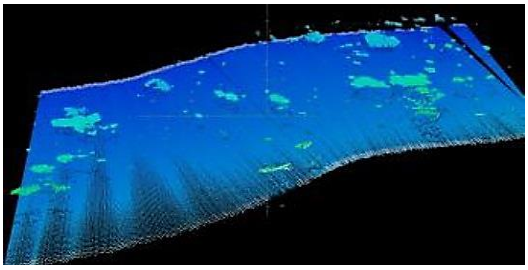


Figure 15: Submerged Oil Detected by Multi-Detect

[6] As highlighted in the report “Backscatter measurements by seafloor-mapping sonars” by the GeoHab Backscatter Working Group.
[7] Multi-detect is an optional add-on feature (see *Table 21*).

Control the sensitivity of the Multi-detect feature with three controls:

- **Object Sensitivity:** Increase to yield more detections on smaller objects; decrease to yield fewer detections and only on larger objects.
- **Amplitude Sensitivity:** Increase to cause more objects to be detected.
- **Max Detections:** Up to 5 detections generated per beam, starting with the strongest detection to the weakest detection.

NOTE
When the setting is 1, it returns the **strongest** detection, **not** the closest detection. If the surveyor wants to find weaker detections in the water column (e.g. the mast on a sunken ship), the detection setting should be >1.

When operating in harbor environments or over wrecks, where determination of least depth (or distance to object) is critical, these sonar controls are designed to increase safety of survey missions. The controls allow the surveyor to adjust detection sensitivity in order to detect weak reflecting objects in the water column closest to the sonar head assembly in addition to the main seafloor detection.

NOTE
The standard bottom detection is always generated, such that multiple detections are provided in addition to, rather than instead of, the standard detection.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.3.2 Tracker Autopilot

With “Tracker” enabled, all primary sonar control parameters such as range, power, gain, pulse length, and swath width are set by the system based on the quality of data being collected.

Furthermore, Tracker will adjust the TVG settings of Absorption and Spreading to optimize the quality of the outer beams, and open or close the swath angle accordingly; thereby ensuring that maximum swath width is delivered with the highest quality result.

As there is a slight delay while tracker is being activated or deactivated, enabling/disabling the feature should not be done in the middle of the survey line.

Once Tracker has been selected, no further operator input is required; however, user controls makes it possible for the surveyor to limit the degree of automation:

- Constant Swath for the Tracker to maintain. This allows constant line spacing to be planned independently of depth.
- Disable Tracker control of certain settings.

For instructions, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.3.3 Roll Stabilization

Roll stabilization is an important feature related directly to system efficiency which allows the swath width on the seafloor to be maximized, thus increasing line spacing and reducing vessel time.

Under zero roll conditions, the swath is vertical and the center of the swath is directly below the vessel.

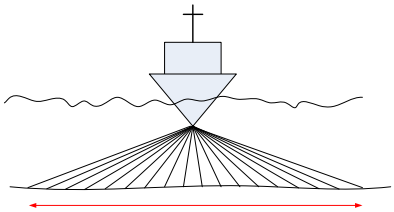


Figure 16: Swath under Zero Roll Conditions

When the vessel rolls the swath is rotated and the projected swath on the seafloor is laterally displaced.

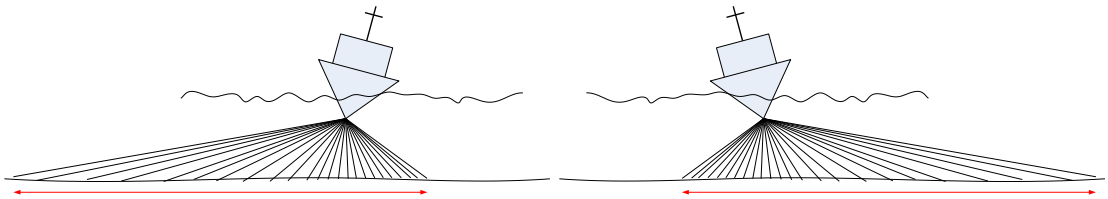
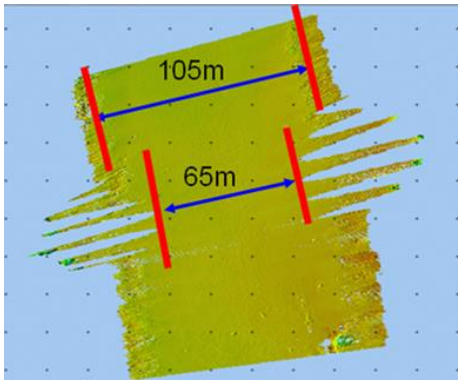


Figure 17: Laterally Displaced Swaths under Roll Conditions

This has the effect of reducing the usable swath width due to the distortions on the edge.



With the input from a motion sensor (and roll stabilization enabled) to steer each receive beam dynamically for every sample, the swath stays vertical irrespective of vessel motion thereby maximizing swath.

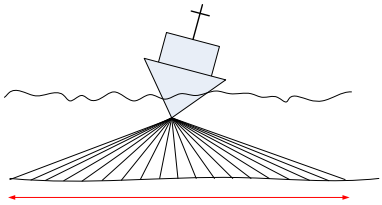


Figure 18: Swath under Roll Stabilization

It is recommended that the motion sensor data update rate is at least 50Hz and preferably 100Hz. In all cases the motion sensor update rate must meet or exceed 20Hz for roll stabilization to occur. Baud rate and protocol details can be set in Motion Stabilization, but it should be ensured that the baud rate is sufficient to allow the desired update rate.

NOTE
A warning will appear in the SUI, if the motion sensor update rate is lower than 20Hz.

For instructions on motion sensor configuration, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

For installation instructions, see *appendix C.5.2 Motion Sensor Input*.

5.3.4 Head Tilt

In certain applications it is desirable to physically rotate the sonar head. Instances of this are pipeline surveys where a dual head normally mounted on an ROV are inclined inwards to maximize the number of hits on a pipe. Another application is survey of harbor walls or other vertical structures where the desire is to increase coverage to one side and to survey as close to the waterline as possible.

For instructions on head tilt configuration, see *appendix C.7.8 Hardware Settings*, or refer to the Sonar UI User Manual (*see Appendix H Reference Documentation*).

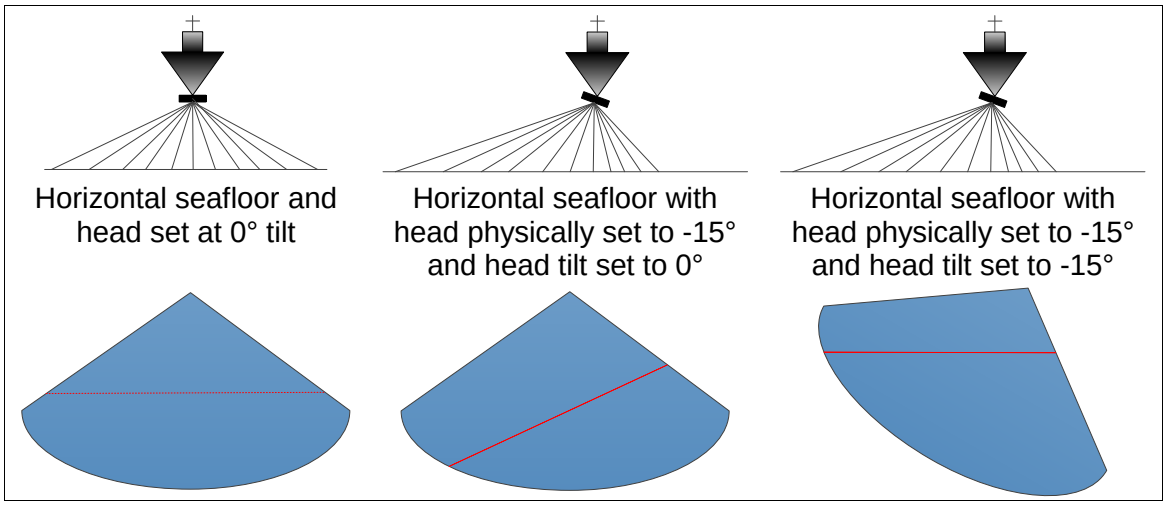


Figure 19: Head Tilt Functionality

5.3.4.1 Harbor Inspection (Quaysides, Breakwaters)

In this application a single head is typically tilted up to 30° (max. setting is +/-45°) from normal to register soundings as close to the waterline as possible.

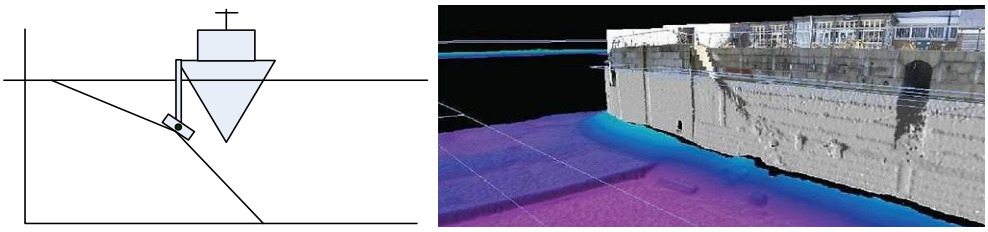


Figure 20: Head Tilt for Harbor Inspection

5.3.4.2 Pipe Inspection with Dual Head System

In this application each head is typically tilted up to 15° (max. setting is +/-45°) from normal, generally looking “in”.

For instructions on setting up a dual head system, see *appendix C.7.9 Dual-Head Configuration*, or refer to the Sonar UI User Manual (*see Appendix H Reference Documentation*).

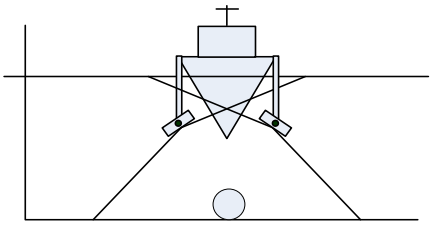


Figure 21: Head Tilt for Pipe Inspection

5.4 Compensation for Environmental Conditions

As sound propagates through the underwater environment, the energy is absorbed by the liquid caused by molecular interactions that convert acoustic energy into heat. A propagating sound field also spreads geometrically, which means that the sound pressure decreases with increasing distance from the sonar. Other mechanisms such as bubbles, plankton, tidal currents, currents from rivers etc. may influence sound propagation, but these mechanisms are difficult to measure and model, as they vary with time and only appear in a limited number of areas. However, as absorption and geometrical spreading exist everywhere in the underwater environment, they are considered to be the most important loss mechanisms.

In the SeaBat system it is possible to compensate for loss caused by absorption and geometrical spreading. In addition, the SeaBat system allows for changes in the speed of sound, a parameter which is important in the beamforming process.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.4.1 Loss of Sound by Absorption

The amount of loss of sound through absorption in water depends on the water conditions and the sound frequency. As sound moves through the water, the water absorbs it by converting some of the acoustic energy to heat. The absorption loss is proportional with the salinity of the water and the sound frequency: the higher the salinity or frequency, the greater the loss (see *Figure 22*). The figure also shows that an increased temperature will increase the absorption loss.

The amount of loss of sound may also be due to the absorption of the acoustic signal by suspended sediments.

The absorption loss value is part of the formula that the SeaBat system uses to calculate the amount of gain to apply to the sonar return signal (see *section 5.2.4 above*). If the

exact absorption loss value is not known, a value of 110dB/km for salt water and 70dB/km for fresh water is recommended for 400kHz operation, and a value of 50dB/km for salt water and 20dB/km for fresh water is recommended for 200kHz operation.

Figure 22 provides a general reference for acoustic absorption at different frequencies and salinity in three different temperature environments.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

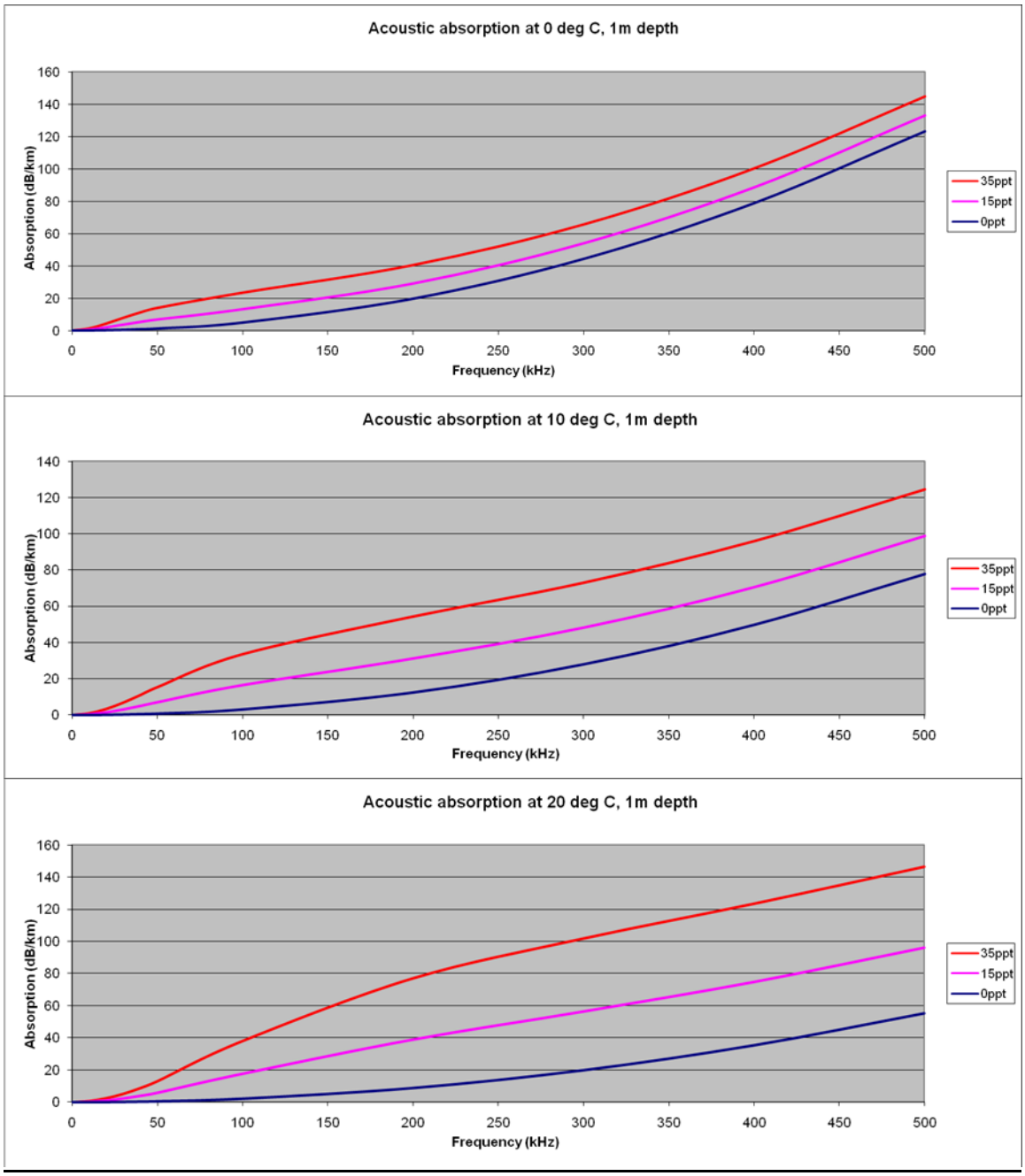


Figure 22: Acoustic Absorption Reference

5.4.2 Loss of Sound by Spreading

Spreading of sound through water may be the greatest contributor to the loss of sound. As sound moves away from its source in all directions, the acoustic pressures will decrease with range.

In deep water, where the acoustic propagation is not bounded by the sea surface or the seafloor, the spreading loss is spherical. In this case the pressure decrease is proportional to 1 divided by the range R from the sonar to a given object or surface. Thus, the acoustic pressure decays as 1/R. As the sound is scattered back to the sonar the backscattered field also decreases as 1/R. Consequently, for a two-travel path the acoustic pressure in a free field decays as $1/R^2$.

In shallow waters, on the other hand, the sound propagation is bounded by the sea surface and the seafloor, and the spreading loss is cylindrical. In cylindrical spreading the sound pressure only decreases as $1/R^{1/2}$, and the two-way travel path decays as 1/R.

In practical situations the transmission loss will lie between 20 and 40dB; in other words, the spreading loss will neither be perfectly spherical nor perfectly cylindrical. Finally, if the sonar operates very close to the seabed or very close to objects in general, near-field effects may yield a transmission loss less than 20dB.

The spreading loss value is part of the formula that the SeaBat system uses to calculate the amount of gain to apply to the sonar return signal (see *section 5.2.4 above*). If the exact spreading loss value is not known, an initial value of 30dB is recommended.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

5.4.3 Sound Velocity

Online sound velocity readings are crucial in the beamforming process to ensure that the beams are steered in the correct directions. Ensure that a real-time sound velocity probe (SVP) is set up to deliver the sound velocity at the sonar head.

Sound velocity varies with pressure, temperature, and salinity. An increase in these three levels increases the sound velocity. The sonar data presented in the SeaBat system is dependent on the sound velocity provided.

CAUTION
An online sound velocity probe must be used for providing up-to-date velocities to ensure optimum performance. A manual velocity may be entered instead but care should be taken to ensure the value entered is representative of the real velocity.

If the local sound velocity is not known, Teledyne RESON recommends a value of 1480 to 1500m/s for open sea areas and 1425m/s for fresh water. *Figure 23* provides a general reference for typical surface sound velocity at different temperatures and salinity.

For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

For installation instructions, see *appendix C.5.1 Sound Velocity Input*.

NOTE
In dual-head mode the sound velocity is sent from the master to the slave. Sound velocity records from other sources than the master are blocked.

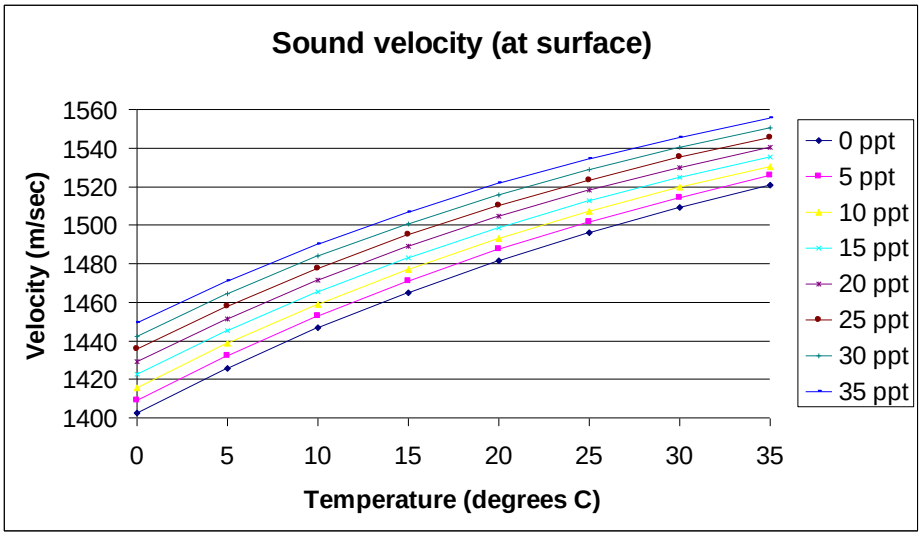


Figure 23: Typical Sound Velocity Values

5.4.3.1 Recommended Use of SVP Filter

The speed of sound impacts the beam angles. If a sonar ping is processed with a sound velocity value that is not reflecting the speed of sound right in front of the receiver, the beam angles will be wrong and hence the targets or bottom detects will have wrong coordinates.

Some software packages allows post-compensation of wrong sound velocity, but it is typically possible to avoid this extra complication of processing by setting a proper filter on the SVP data during real-time recording. For instructions on how to adjust this setting, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

- **No Filtering:** Although this setting does not filter data in the classical sense, it still ignores readings outside the range 1350m/s to 1800m/s.

  Use this filter if there is a requirement for immediate response to sound velocity changes. When using this filter any false reading will cause distinct false output. This filter may be preferred for certain scientific sonar work.

- **SVP Light:** Removes occasional false readings.

  Use this filter if there is a need for fast filter response, for instance in regions with mixing waters.

  If the SVP update rate is less than 10Hz it may be preferred to use this filter as the standard filter.

- **SVP Normal:** Removes single and double false readings and outliers, and smoothens the SVP value across 10 readings.

  The filter is recommended for most sonar work on systems using an SVP (SVP 70) with no internal filtering and an update rate of 10-20Hz.

NOTE
The SVP Normal filter is typically the best filter to use.

- **SVP 70 Wizard:** This filter only works with the SVP 70 if the internal SVP 70 filter is set to mode 1 (low pass filtering).

  Sensors with a low pass filter cause a special artifact in the output in case of outliers and invalid readings. The SVP 70 Wizard filter removes these artifacts and makes the system work well despite of the low pass filter.

  It is recommended to change the SVP 70 filter mode to 0 when convenient and reset the SVP Filter to SVP Normal.

For access to filtered and unfiltered values, please see the DFD messages R7510 and R7610. Refer to the Data Format Definition document for information (see *Appendix H Reference Documentation*).

5.5 Limitations

Physical limitations in the functionality of the system have to be taken into consideration when operating sonar systems, including SeaBat systems. Some of the limitations are absolutes; others can to some degree be overcome.

The following subsections provide examples of different kinds of limitations.

5.5.1 Cavitation

Some reduction in the transmitted source level is expected to be caused by cavitation. For means of compensating for this, see subsections in *5.2 above.*

5.5.1.1 Propeller Cavitation

Propeller cavitation can be a significant concern for two reasons. First, the frequency of propeller cavitation noise is in the operating frequency band of most sonar equipment. Second, the source levels of the propellers installed are expected to be high unless special quieting techniques have been implemented.

Propeller energy typically propagates to the forward area sonar systems via a direct or hull-grazing path. The other arrival path of propeller energy is by the bottom bounce path. This path will be more significant in shallow water depths (less than 500 meters). The potential impact can be further quantified for particular bottom depths of proposed operational test sites.

5.5.1.2 Appendage Cavitation

Appendage cavitation can result from rough or unfaired edges on the hull and can even be present at lower speeds. If the source is located near the sonar installation area, it can be a significant noise deficiency. It is difficult to predict the occurrence of appendage cavitation without under-hull drawings, pictures, or visual inspection of the ship when in dry-dock.

5.5.2 Machinery Noise

Machinery noise should not be a major factor for sonars that operate at frequencies above 5kHz. Mechanical machinery noise is usually prevalent at 2kHz and below, though it is occasionally detected at higher frequencies when fluid flow through pipes or cavitating pumps are involved.

Typically, the most important consideration for machinery noise is the proximity of the acoustic sensor to the machinery source. There has been one observed case where diesel engine piston frequency harmonics have been the controlling noise source at 12kHz, but in this situation, the engine room and the sonar compartment shared a common bulkhead. Normally, acoustic devices are sufficiently distanced from major machinery noise sources that machinery noise does not interfere.

A concern remains that there may be some auxiliary machinery (or other unusual equipment) located near the sonar that could produce noise interference. An inspection of the installation site and ship drawings to verify the position and proximity of all shipboard equipment should be conducted to determine if there is a potential for machinery interference prior to conducting at-sea testing. For means of compensating for this, see subsections in *5.2 above*.

5.5.3 Interference from Other Sonar Systems

Interference from other sonar systems can be seen as radial lines, typically moving away the minimum to maximum range scale as these pings are not correlated with the ping repetition rate of the SeaBat system. The most typical source of interference of this type is navigational sonars (often 50kHz systems) and Doppler velocity logs.

Synchronization of acoustic systems is one means to mitigate this effect. The most effective approach is to remove the source of interference entirely, either by moving the equipment away from the SeaBat or turning it off.

5.5.4 Speed

Hydrodynamic flow noise can be a concern when operating at higher speeds. Externally mounted acoustic sensors should have fairings that are as flush (or near-flush) mounted to the ship hull as is practically possible. This way the hydrodynamic flow-induced vibration noise should be minimal. For means of compensating for this, see subsections in *5.2 above*.

NOTE
A poorly designed sonar fairing can degrade the system performance by a factor of 4 for speeds above 8-10 knots. Typically, this noise source is the most common problem on all sonar installations.

5.5.5 Air Bubbles

Bubble sweep-down can be another potential noise problem. The significance of this problem is associated with the noise generated as the bubbles cascade along the hull after being ingested in the bow wave of the ship and, more importantly, with the baffling produced by the entrained air layer between the face of the sonar sensor and the water environment.

If air bubbles are present between the sonar and the water, the system will not function properly. This phenomenon is transient in nature occurring only for a few seconds per wave period. It is typically most prevalent on shallow draft ships and increases in intensity at higher sea states and ship speeds.

Modeling of this problem only indicates that air bubble noise may be present by determining the transmission vehicle of potential bubbles. Actual at-sea measurements are usually required to fully determine the presence and severity of bubble sweep-down. At-sea diver viewing has been very successful in the past to capture the bubble sweep-down characteristics of a particular ship hull on film.

Air bubbles mask some or all of the view of the sonar where the affected area will completely blank out. Common causes for bubble masking include:

- The vessel props when thrusting into reverse and pours a stream of bubbles over the sonar.
- The sonar has not been deployed deeply enough and there is bubble wash from the sea surface.
- Bubble ingestion as the vessel pitches into the sea.

5.5.6 Environment

A high-reverb environment where echoes of the previous ping are contaminating the current ping may prove to be difficult. For means of compensating for this, see *section 5.2.3 above*.

6 SYSTEM PERFORMANCE AND DATA TYPES

NOTE
There are several factors that can have a significant effect on acoustic performance. For this reason, product performance estimates are indicative of standardized conditions for temperature, salinity, bottom type or target strength, sound velocity, installation type, and assume no affect from adverse environmental conditions such as wind, precipitation, sea state, ambient or traffic noise, refraction, temporal changes or other surface effects. (Read also *section 5 Active Sonar Usage*.) To determine actual in-situ performance predictions requires a site or vessel survey and environmental measurements with performance modeling based on the resulting measurements. Costs for this survey may be quoted as part of a contract or independently.

The SeaBat T-Series Portable sonar systems produce four types of data, bathymetry, side-scan, snippets backscatter, and water column backscatter, suitable for the generation of high-resolution hydrographic charts that exceed international standards.

A single transmission from the projector unit illuminates the entire swath on the seafloor. The seabed return signal is received by the receiver unit, digitized, and transmitted to the sonar processor, where it is formatted for display and data output. Bottom detection bathymetry soundings, side-scan, and snippets are exported via gigabit Ethernet using TCP I/P protocol[8] to a customer-furnished laptop/PC or an external data collection system.

A Windows®-based user interface installed on the CFE laptop/PC controls the system, allowing the operator to select system configuration, data output, and storage options. This also provides built-in test environment (BITE) displays to assist the operator.

For system performance specifications, see *Appendix B Data Sheet.*

For available configurations, see *Appendix J Available Configurations*.

[8] UDP is also available.

6.1 Selectable Beam Density

Selectable beam density is a feature which allows the surveyor to decide how many beams to form ranging from the maximum capability of the system down to just 10. This allows the surveyor to be able to capture the highest detail using the highest beam density available, but alternatively maximize efficiency by using fewer beams in very shallow water where data volumes traditionally become large quickly due to high beam numbers and high ping rates.

A special mode is the ability to define the desired equidistant spacing between beams on the seafloor and keep it constant. The system will “hold” this automatically, as depth varies, within the constraints defined by the minimum and maximum number of beams.

Selectable beam density adds to the flexibility of the system with several benefits:

- Optimized data volumes tailored to survey purpose/specifications
- Save of up to 75% of data volume in very shallow water
- Faster processing
- Reduced time and costs from survey to deliverable

6.1.1 Beam Modes

Beam mode selection is made on the fly via the sonar user interface. For instructions, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*). Available selections depend on options purchased (see also *Table 21*).

Table 3: Beam Modes with No. of Beams and Swath Coverage

	No. of beams					**Swath**
	T20/T50	**T20**		**T50**		**T20/T50**
	Min.	**Std**	**Max.**[9]	**Std**	**Max.**	**Max.**
Equi-distant (with constant no. of beams)	10	256	512	512		140/150
Equi-distant (with constant beam spacing)	10	256	512	512		140/150
Intermediate	10	256	512	512		140/150
Equi-angle	10	256	512	512		165
FlexMode[10]	512	N/A	512	512		140/150

For examples on how to use this feature, see *section 5.2.9 Use of Beam Modes*.

[9] Max. Beams is an optional add-on feature for T20 (see *Table 21*).
[10] FlexMode is an optional add-on feature (see *Table 21*). FlexMode requires Max. Beam license.

6.1.2 Equi-Distant, Equi-Angle, and Intermediate Modes

As the beam steering angle increases from nadir, the number of beams per degree of swath stays constant for equiangular spacing while it increases for equidistant spacing. *Figure 24* presents the number of beams as a function of steering angle for a 1° nadir beam spacing.

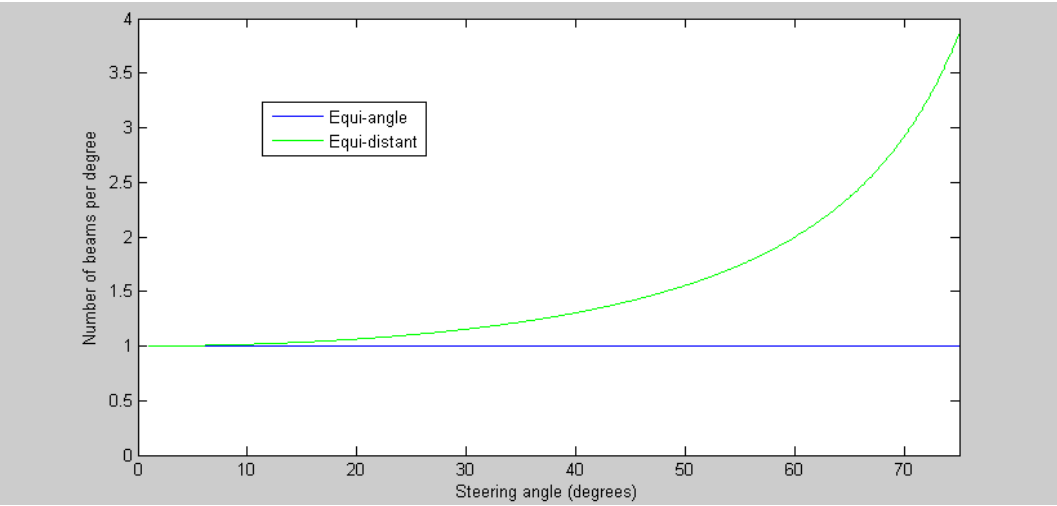


Figure 24: Beam Density

Figure 25 shows that the horizontal spacing of the Intermediate mode increases with beam angle, unlike Equi-distant mode where the spacing stays constant. However, the Intermediate mode increases the spacing much slower than the Equi-angle mode so the outer beam density is still quite good.

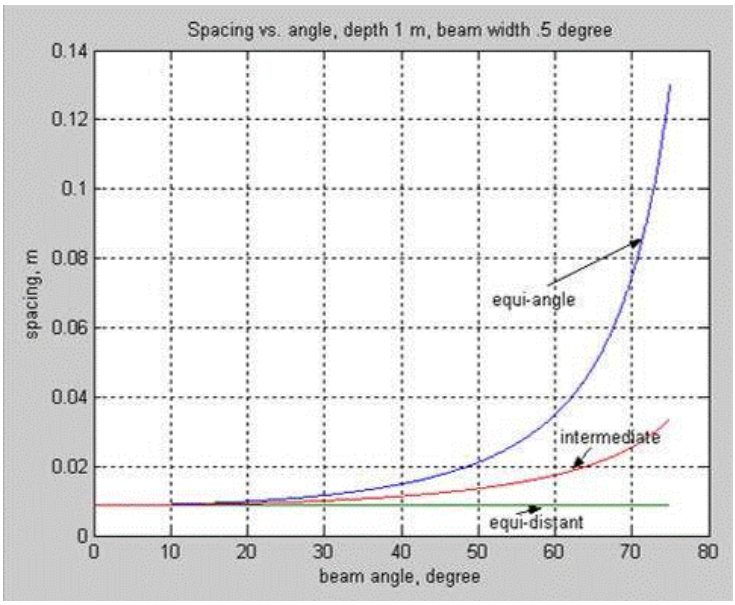


Figure 25: Beam Spacing vs. Beam Angle

Assuming a flat bottom and using the beam footprint generated by the nadir beam, it may be seen that the center-to-center spacing for each beam successively reduces as the departure from nadir increases until at ±65° the beam density is approximately 2.5 times greater than at nadir.

Assuming one sounding is generated from the intersection of the beam center with the seafloor, with equidistant spacing, the appropriate number of beams is formed to maintain this nadir sounding spacing across the entire swath. See also *Figure 26*.

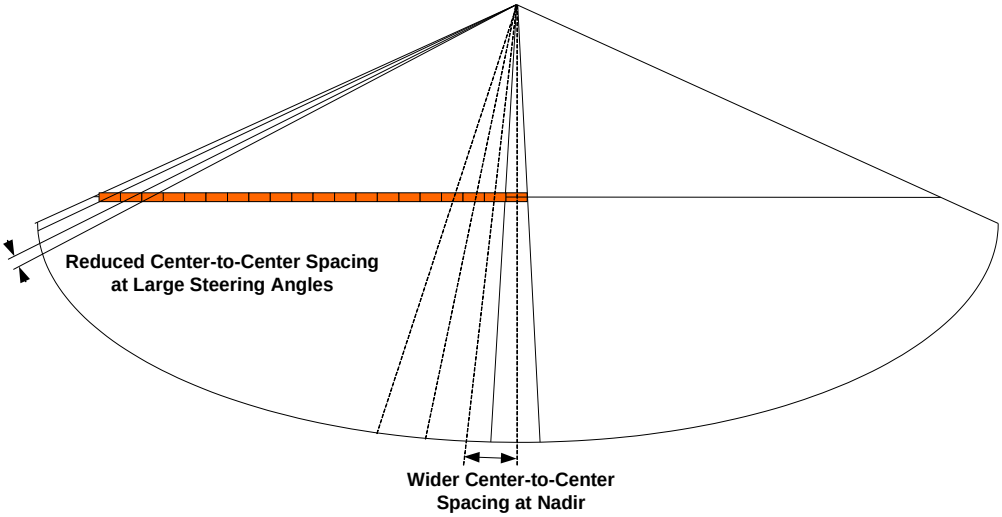


Figure 26: Beam Spacing

In order to achieve this uniform sounding spacing, it is necessary to decrease the beam center-to-center spacing which requires a significant increase in the number of beams formed.

The beamformer is able to generate a receive beam centered on any angle within the available swath and with equidistant spacing a set of coefficients is selected that form a set of receive beams that are centered on the midpoints of the footprints.

Figure 27 shows the difference in distribution between equiangular and equidistant spacing.

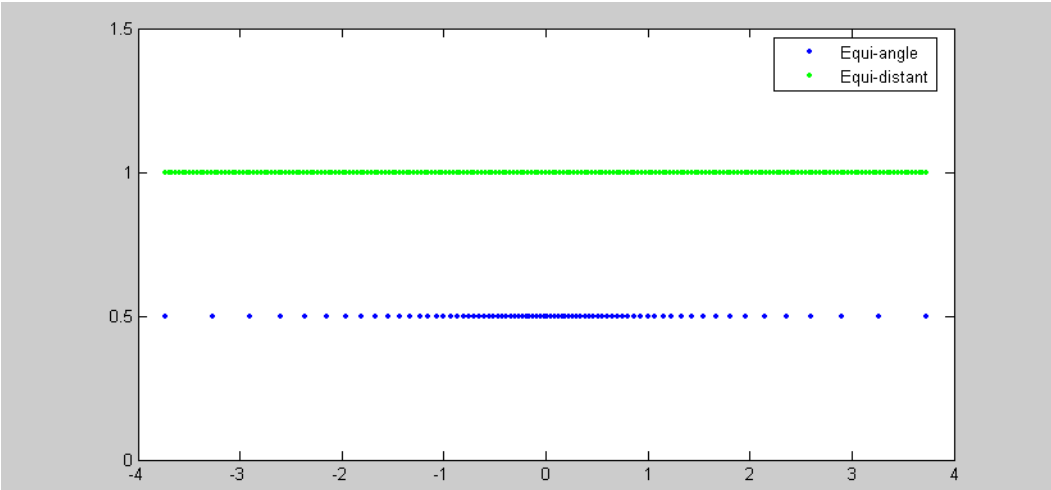


Figure 27: Across-Track Sounding Location on a Flat Bottom

6.2 Data Types

6.2.1 Bathymetry Data

The SeaBat T-Series Portable system generates between 10 and 256[11] or 512[12] soundings per ping.

The system broadcasts from the sonar processor to the data acquisition software, where they are corrected for mechanical offsets, motion, heading, refraction, tide or depth, and position. To perform these corrections, the appropriate sensors must be interfaced to the data acquisition software. For instructions on sensor configuration, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

Depending on the beam angle, bottom type, and signal characteristics, the bottom detection method employed may be magnitude center-of-energy, phase slope zero-crossing, or a blend of the two methods. The bottom detection method can vary from ping to ping and beam to beam.

6.2.2 Side-Scan Data

Side-scan swath is measured and displayed without degrading any of the traditional survey capabilities of the SeaBat.

NOTE
Side-scan cannot be used to measure accurate depths, but it can provide a more detailed picture of the seafloor. This image can be used together with bathymetry to identify features and to ensure that you do not miss any small but significant targets.

6.2.2.1 Side-Scan Process

The side-scan process averages adjacent pairs of beams to eliminate noise and then carries out a peak detection over beams from the left and right sides of the swath. The peak detection is done at the sample rate of the sonar.

The bathymetry and side-scan data are independent in the beamforming process and in how the output data is generated.

6.2.2.2 Side-Scan Data Output

The array of intensity values is a series of amplitudes, one for each sample interface for each side-scan beam. The number of intensity values reported in a side-scan packet is a function of range. The number of values per packet can be calculated using the following formula:

$$\left(\frac{Range}{½SoundVelocity}\right) * SampleRate = SamplesPerBeam$$

[11] For the T20 system, max. no. of beams: 256 (standard) or 512 (option).
[12] For the T50 system, max. no. of beams: 512.

Side-scan is one of the many records available for subscription from the 7k Center software. Refer to the 7k Data Format Definition for further information regarding side-scan data output (see also *Appendix H Reference Documentation*).

6.2.3 Snippets Backscatter

6.2.3.1 Snippets Backscatter Data

Snippets backscatter data is available from the SeaBat T-Series Portable. Each snippet consists of a windowed selection of amplitudes taken from the bottom detection point of each beam.

A snippets data sample contains backscatter data from the 'footprint' on the seabed illuminated by a single sonar ping. The number of snippets in a swath is a function of the number of sonar beams. The length of each snippet depends on the operating mode, beam number, and depth. All of these settings may be selected by the operator.

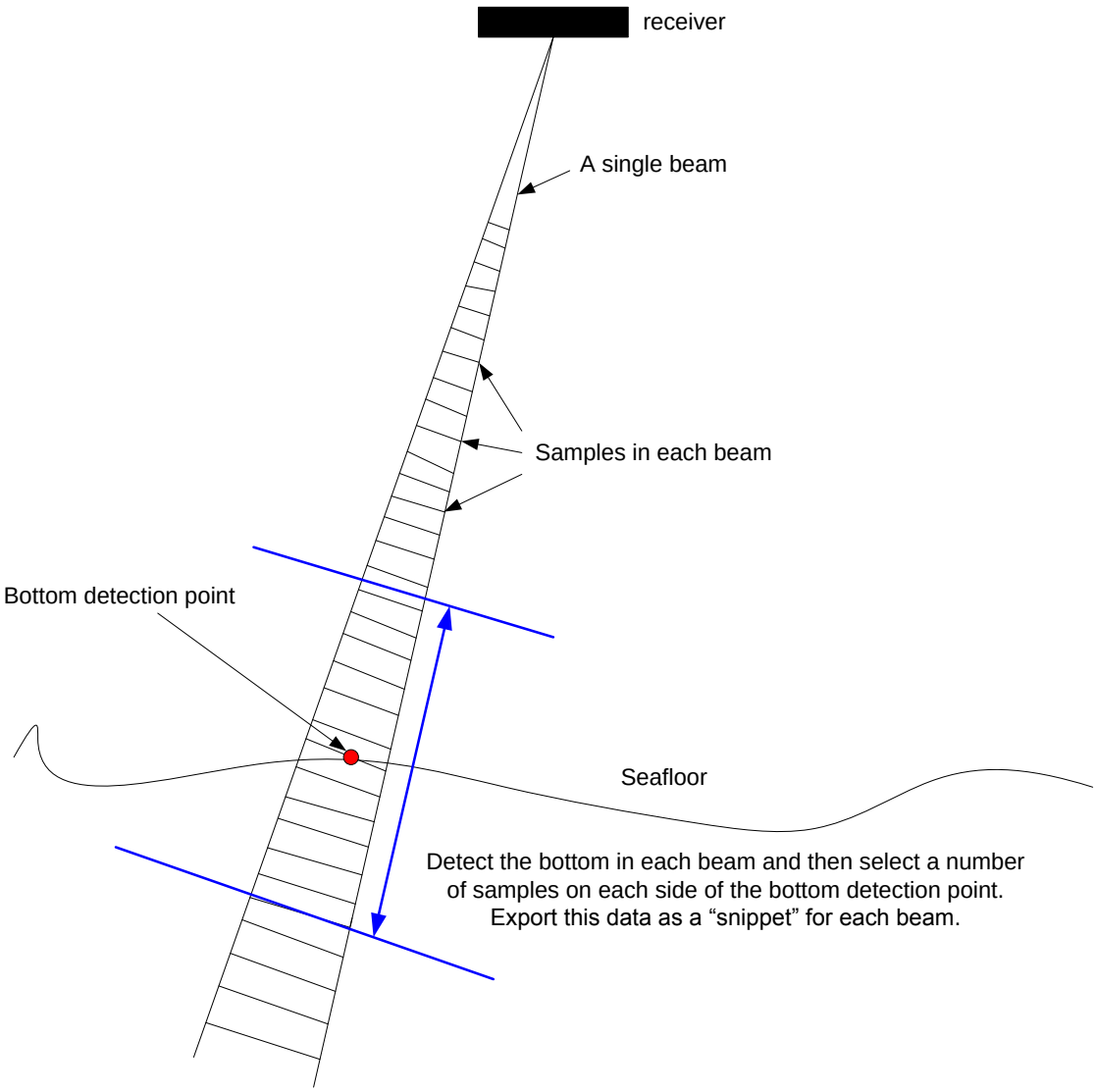


Figure 28: Graphic Illustration of Snippets Data

Each snippets data packet contains pertinent information such as time stamp, sequential ping number, sample rate, sound velocity, and operator settings such as power, gain, absorption, and range scale. Refer to the 7k Data Format Definition for further information regarding snippet data output (see also *Appendix H Reference Documentation*).

6.2.3.2 Normalized Backscatter Principles (T50)

An accurate calculation of the sediment backscattering strength requires a detailed knowledge of the sonar characteristics and of the environment.

Teledyne RESON's normalized backscatter process, available across the entire frequency range, is applied to the snippet record to generate a magnitude signal that is compensated for the characteristics of the sonar providing the operator with information that depends only on the environment (seafloor). (See also *section 5.2.11 Maximizing Quality of Backscatter for Snippets Data*.)

The beam patterns, source level, sensitivity, and gains of the T50 projector and receiver have been measured on several units in order to establish a generic set of parameters. During backscatter computation, all these parameters are taking into account to normalize the snippet magnitude signal expressed in the dB scale. The process uses an along-track flat bottom assumption and the actual pulse length to calculate the footprint size of each snippet sample. The correction related to this footprint size is documented separately, while a real slope correction will have to be applied by the postprocessing software.

While Teledyne RESON uses generic parameters to characterize the T50, we take great pride in our very tight manufacturing tolerances to ensure that these parameters truly represent each unit.

6.3 Real-Time Pipe Detection and Tracking[13]

Real-time pipe detection and tracking is a SeaBat feature which automatically detects pipes within the multibeam swath, displays them to the user in real time during survey, and exports the position of the pipe top to the data acquisition software. The feature builds on the robustness of FlexMode for generating a high density profile of the pipe.

The user enters the diameter of the pipe to be detected in the SeaBat User Interface and sets parameters to tune the pipe detection algorithm. When enabled, the real-time pipe detection algorithm computes the pipe position in the SeaBat's coordinate system and shows a circle representing the position in the swath to the operator. The detected pipe position is also sent to the data acquisition software.

[13] Pipe detection and tracking is an optional add-on feature (see *Table 21*).

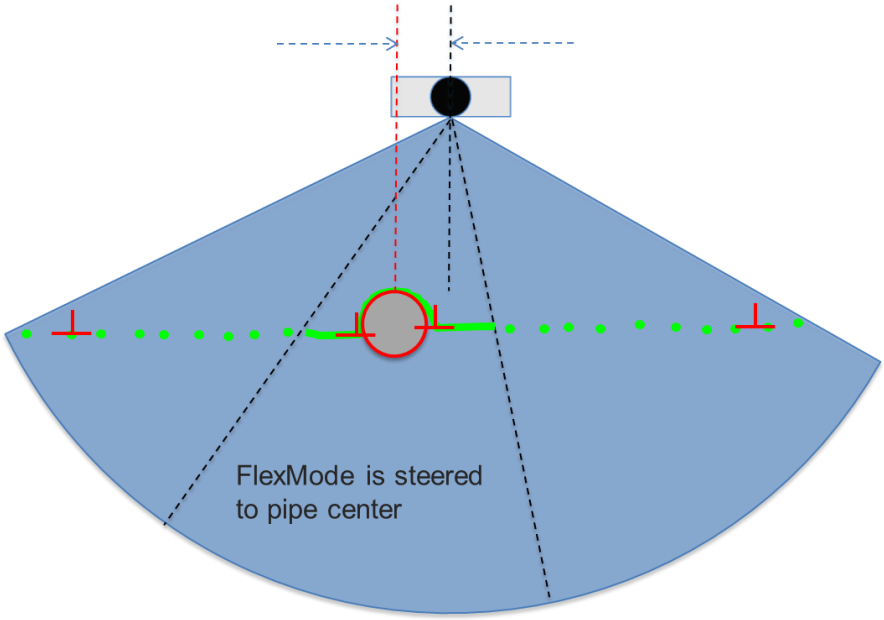


Figure 29: SeaBat Real-Time Pipe Detection and Tracking

Real-time pipe detection in the SeaBat system provides a unique advantage which improves the end product. Starting from the initial detected pipe position, the diameter of the pipe is used to assist the bottom detection in the vicinity of the pipe in subsequent pings to enhance bottom detection robustness, and thus the pipeline profile. This unique feedback loop from pipe position to the bottom detection algorithm results in much cleaner pipeline profiles and, therefore, much improved detected pipe positions. This is of particular advantage in instances of plastic coated (acoustically difficult) pipes where backscatter from the sides can be weak to the point that bottom detection performance is compromised, even though the sonar acoustically detects the pipe.

Benefits of the automated pipe detection and tracking in FlexMode include:

- Reduced manual pipeline processing effort
- Improved end product
- Reduced risk to subsea assets
- Reduced risk of operator error

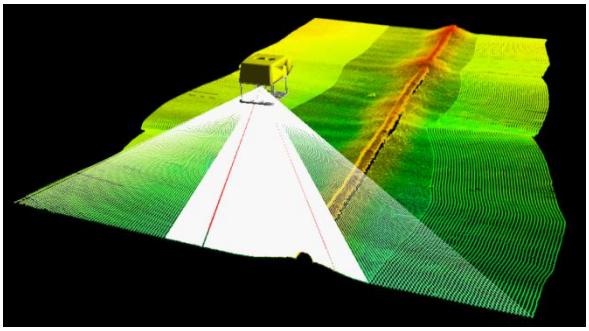


Figure 30: SeaBat FlexMode

6.4 Multi-Detect[14]

Multi-detect is a feature which provides multiple detections within each beam, including the full water column. It allows the surveyor to capture enhanced detail from a single survey line over a complex feature, or ensure that full detail is captured of any object in the water column, even in noisy environments. Up to five detections may occur anywhere within each beam. (See also *section 5.3.1 Multi-Detect Operation*.)

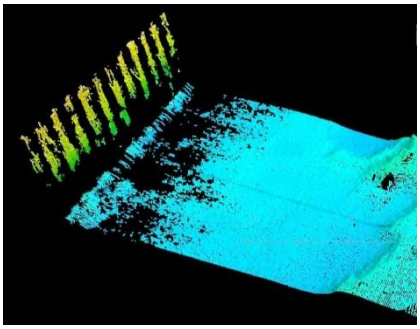


Figure 31: Standard Detection

NOTE
Multi-detect is not equivalent to multiple soundings across a beam footprint on the seabed.

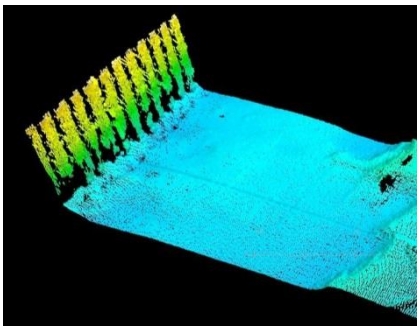


Figure 32: Multi-Detect with Enhanced Detail on Quay Wall

With the multi-detect feature you achieve:

- Enhanced detail over complex, small, and fine objects.
- Improved and faster decision making.
- Easier and faster water column processing.
- More project opportunities.

In the scenario in *Figure 33,* without multi-detect the sonar would detect either the anchor chain (blue dots) or the seabed (red dots) or flicker between the two features.

With multi-detect, the sonar can detect both the anchor chain and the seabed.

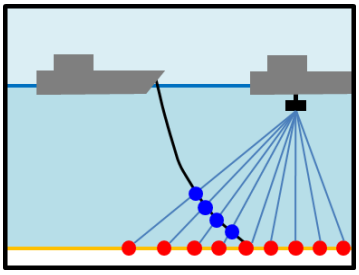


Figure 33: Multi-Detect

6.5 X-Range[15] Performance

X-Range is a feature that provides extended range performance at the full range of frequencies and also significantly improves system immunity towards external noise. The basis of the X-Range feature is a frequency-modulated (FM) transmission combined with advanced signal processing techniques to extract the maximum possible performance from the system.

[14] Multi-detect is an optional add-on feature (see *Table 21*).
[15] X-Range is an optional add-on feature (see *Table 21*).

6.6 Full Rate Dual Head[16]

The Full Rate Dual Head (FRDH) feature is superior to the standard dual head implementation by providing simultaneous pinging, whereas the standard dual head feature operates with alternate pings (see *Figure 34*).

The standard dual head implementation uses time multiplexing to achieve synchronized operation. The result is reduced ping rate per head and asymmetric seafloor swaths. FRDH uses X-Range (see *6.4 above*) to achieve dual head operation which has the double effect of range and ping rate increase. In FRDH the systems ping simultaneously at a high rate. (See also *section 5.3.4.2 Pipe Inspection with Dual Head System*.)

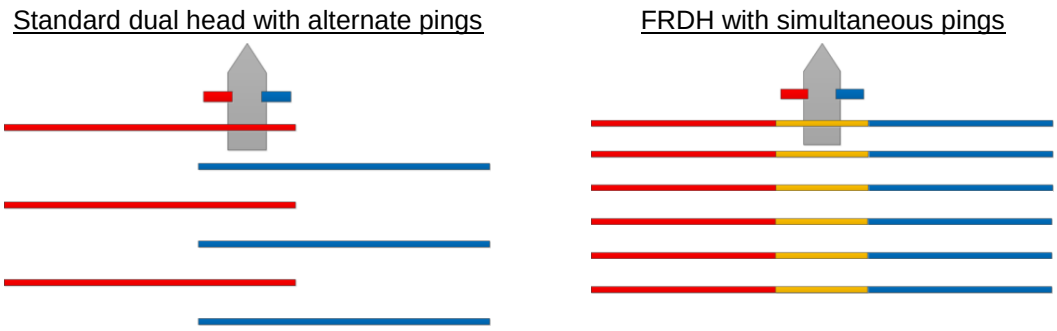
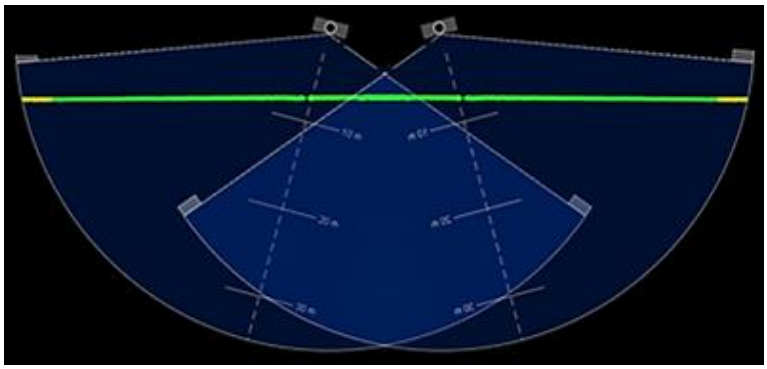


Figure 34: Dual Head Synchronization of Pings

For instructions on setting up a dual head system, see *appendix C.7.9 Dual-Head Configuration*, or refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

6.7 Sonar User Interface Dual Head Support



The Sonar UI supports dual-head mode in a single view[17], significantly simplifying operation of the system. To the user it is the equivalent of operating a single SeaBat system with ultra-wide swath.

For instructions on setting up a dual head system, see *appendix C.7.9 Dual-Head Configuration*, or refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

[16] FRDH is an optional add-on feature (see *Table 21*).
[17] Dual-head mode in a single view is not supported by the Legacy UI.

6.8 Quality

The quality of each bathymetric bottom detection point is evaluated by the sonar, which calculates its brightness and colinearity as described below. For instructions on how to customize some of the visual properties of the sonar image, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

6.8.1 Brightness Test

The brightness test measures the signal-to-noise ratio (SNR) of the signal strength (magnitude) near the bottom detection point (as determined by the bottom detection algorithm) versus the background noise in the rest of the beam.

The signal strength is the mean of the square of the sample intensity around the bottom detection point. The number of samples used is marked 'A' in *Figure 35* and is a small percentage of the total number of samples. The noise is based on a mean of the square of the samples in the second half of the "tail" of the detection window (marked 'B' in *Figure 35*) and the square of the samples in the "head" of the water column (before the first return – marked 'C' in *Figure 35*).

Beams, whose SNR is greater than a predetermined threshold, will be flagged as passing the brightness test.

For instructions on how to display the test results, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

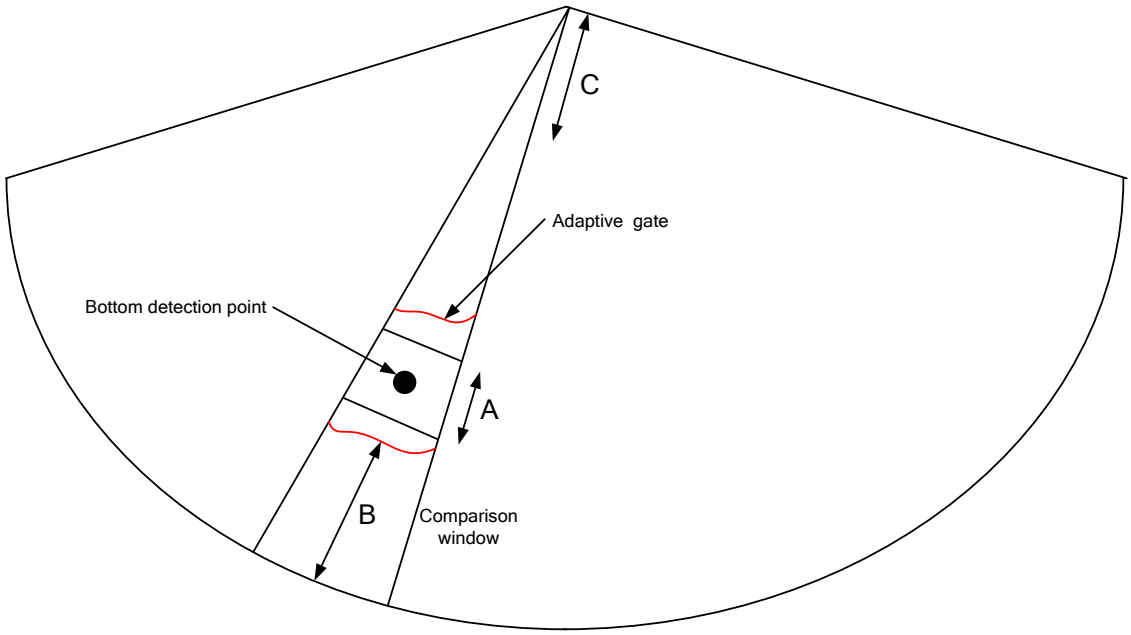


Figure 35: Brightness Test

6.8.2 Colinearity Test

In general terms, this test will pass if a bottom detection point sample number for a given beam falls on or near a line drawn through its neighboring beams' bottom detection points. This is achieved using a moving polynomial fit of the points on either side of each point. If a given point is within the window of the line fit, it is marked colinear.

This process is done in stages that begin with the central beams and moving outward on each side of the wedge in turn.

For instructions on how to display the test results, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

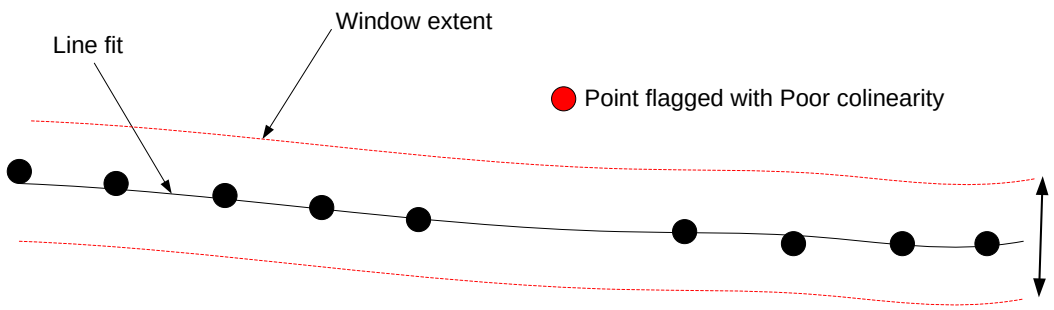


Figure 36: Colinearity Flags

6.8.3 Quality Filter

A quality filter makes it possible to not display or export bottom detection points which do not pass the quality criteria. Enabling the quality filter has the following effects:

- The corrected bathymetric data record will only contain the detection points that pass the quality filtering. A flag will be set in the record to indicate that the quality filter was applied.
- The dedicated snippets record will only contain the detection points that pass the quality filtering. A flag will be set in the records to indicate that the quality filter was applied.
- Only detections points that pass the quality filtering will be shown in the various displays.

For details on settings for the quality filter, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

6.9 Uncertainty Estimation

The calculation of Total Propagated Uncertainty (TPU) is used to aid the surveyor determine the sounding quality of the bottom detection point. The calculation is done by statistical methods, typically in the data acquisition software. One of the inputs into the TPU calculation is the sounding measurement error as computed in the sonar system.

Other error sources include position, draft, squat, load, tide geodetic calculations, lever arms calculations, timing offsets, speed, heading, attitude, and sound velocity.

In the sonar processor, the error associated with bottom detection is computed separately for amplitude, phase, and blended detection methods. This value is exported as a field in both raw and corrected bathymetry records.

The uncertainty value is normalized to the detection point by dividing the absolute range error (number of samples) by the detection point (fractional sample number). For example:

- Absolute range error: 0.8 samples
- Fractional sample number of detection point: 120.2
- Uncertainty = 0.8/120.2 = 0.006655574

When the Uncertainty option is active, a color legend is shown on the wedge display.

For instructions on how to display the uncertainty, refer to the RESON Sonar UI User Manual (see *Appendix H Reference Documentation*).

6.10 Ping Rate Table

Table 4: Ping Rate Table

Range setting (m) (slant range)	Theoretical max ping rate (1500m/s)[18]	Realized ping rate [Hz], nominal	
		200kHz, 256 EA beams	400kHz, 512 ED beams
5	150	50.0	50.0
8	93.7	50.0	50.0
10	75.0	50.0	45.6
15	50.0	36.5	33.0
20	37.5	28.7	25.9
25	30.0	23.7	21.1
30	25.0	20.0	18.0
35	21.4	17.5	15.4
40	18.8	15.4	13.6
50	15.0	12.4	11.0
75	10.0	8.5	7.3
100	7.5	6.4	5.5
125	6.0	5.0	4.4
150	5.0	4.4	3.7
175	4.3	3.7	3.1
200	3.8	3.3	2.6
250	3.0	2.5	2.1
300	2.5	2.1	1.8
350	2.1	1.8	n/a
400	1.9	1.7	n/a
500	1.5	1.3	n/a
750	1.0	0.9	n/a

NOTE
The table reflects the ping rate performance on a processor only running the 7kCenter.

[18] The ping rate is limited to 50p/s.

APPENDIX A TROUBLESHOOTING

A.1 System Error and Warning Messages

NOTE
Most errors and warnings do not result in a system failure. In the case of repeated errors or warnings, contact Teledyne RESON Customer Support (support@teledyne-reson.com).

This chapter contains a global list of error and warning messages generated by the 7k Center software. The messages appear in the Messages pane of the Sonar UI.

For instructions on how to monitor the system, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

General information (no error/warning) is marked with an i in the Messages pane.

A.2 Error Messages

NOTE
The error messages listed in this section are accurate up to the document release date. For a complete list of up-to-date error messages, contact Teledyne RESON Customer Support (support@teledyne-reson.com).

Errors are marked with a red ✖ in the Messages pane.

A.2.1 General System Startup Errors

Message	Description	Action
ADMXRC configuration failed	The software failed to detect or configure the primary processing card.	Check PCI bus drivers for ADMXRC card.
Could not create UDP server	Indicates a network resource was unavailable to the software from the operating system.	Check user permissions, network drivers.
Could not create TCP server		
Could not create PCI server	Software detected a failure to configure the main data acquisition and distribution module (PCI). This can be caused by errors in the configuration files, or corrupted installation.	Reboot the PC, call Teledyne RESON support.
Error creating PCI Reader thread		
Error creating PCI Copier thread		

Message	Description	Action
Create TCP socket failed, code…	Operating system did not allow creating of network resources.	Check Windows installation, user settings, and network resources.
Error creating non-sonar data reader thread	BITE module has failed to initialize.	Check Windows installation and resources.
Failed to allocate memory for ADMXRC read	The software could not allocate enough system memory to perform the operation.	Make sure no other software is running on the sonar processor. Reboot the system.
Failed to allocate memory for ADMXRC transfer		
Failed to set up DMA Card 0	The software could not access the processing card device.	Check ADMXRC drivers.
Failed to set up DMA Card 1		
Internal 7k Center error	One or more startup conditions have failed.	Check previous alarms or warnings and verify software installation.
Internal error, 7kCenter NOT fully operational		
Inbound memory initialization failed	PC resources are inadequate.	Check RAM or virtual memory resources
MMF Outbound memory creation …		
Required file: "7k_0.xml" or "7k.xml" Not found.	A critical startup configuration file was missing.	Reinstall the software.
Required file: "7k_Bite.htm" Not found.		
SET UP: FAILED TO LOAD BIT FILE "XXX" for Device <x>, Enumerator <x>		
Socket initialization failed, error code <x>	Windows has failed to allocate a network resource.	Check network permissions and resources or Reinstall operating system.

A.2.2 PCI Card Related (ADMXRC) Errors

The ADMXRC refers to the drivers that control the main processing unit within the sonar processor. This processing card sits on the motherboards PCI bus and acts as a signal processing layer between the hardware and software.

Message	Description	Action
2nd ADMXRC card not found	One or more of the processing cards has failed to initialize or is non-	Reboot sonar processor and try again.
ADMXRC card not found, ERROR =		

Message	Description	Action
ADMXRC.dll not found.	functional within the sonar processor.	
Configure FPGA failed.		
Incorrect ADMXRC board found, card_1		
Failed to set up DMA Card 0, ERROR =		
Failed to allocate memory for ADMXRC transfer.		
Failed to set ADMXRC clock, Card_1, ERROR =		
Failed to get ADMXRC space info, Card_1, ERROR =		
Failed to configure 1st FPGA with <x>, ERROR =		
Failed to find ADMXRC info, card_0, ERROR =		
Failed to set ADMXRC clock, Card_0, ERROR =		
Failed to get ADMXRC space info, Card_0, ERROR =		
Failed to find ADMXRC info, card_1, ERROR =		

A.2.3 Data Reading Errors

Message	Description	Action
DMA Transfer Timeout. <x> of <x> bytes received	This error generally indicates that the uplink from the receiver is interrupted at some point.	Check the BITE tab for receiver BITE values. Restore factory defaults. Reboot the PC.
FATAL: DMA Read size limitation reached.	A general error occurred while transferring data to the software.	Reboot the system.
Lost sync with DMA read		

A.2.4 System Resource Errors

Message	Description	Action
Error starting <name> thread.	A module has failed to start correctly.	Reboot the system.

A.2.5 Input Signal (Timing and Triggers) Errors

Message	Description	Action
Failed to register external trigger, ERROR =	External Trigger Firmware cannot be initialized or not supported.	Reboot the system. Contact Teledyne RESON Customer Support if the problem persists.
Failed to unregister external trigger, ERROR =		
FIRMWARE does not support External Trigger. Pinging is OFF		
External triggering has failed. Check/update software installation.		
FATAL ERROR: PPS Timestamp error Check 1 PPS input	The pulse is not being detected. Time stamping will be done using system time only. 1 millisecond accuracy not possible.	Check input signal cabling.

A.2.6 Calibration Errors

Message	Description	Action
Calibration Failed: Too much noise	Calibration has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.
Calibration Failed: Over 10% dead Rx channels.		
Calibration Failed: Magnitude Error		
Calibration Failed: Phase Error		
Calibration Error: Calibration might be invalid. Repeat the calibration.		

A.3 Warning Messages

NOTE
The warning messages listed in this section are accurate up to the document release date. For a complete list of up-to-date warning messages, contact Teledyne RESON Customer Support (support@teledyne-reson.com).

Warnings are marked with a yellow ! in the Messages pane.

A.3.1 Configuration Warnings

Message	Description	Action
7K Bite File cannot be Read	Software installation is corrupt.	Restore factory defaults. Reinstall software.
Cannot Read UDP Configuration file <x> Error		

Message	Description	Action
Cannot Open or Create UDP Configuration file		
UDP Configuration file not available		

A.3.2 Startup Warnings

Message	Description	Action
Failed to start PCI Reader thread	One or more PCI bus or network resources has failed to initialize.	Check user permissions and sonar processor network hardware.
Failed to start PCI Copier thread		
PCI interface status: Down		
TCP interface status: Down		
UDP interface status: Down		

A.3.3 Data Processing Warnings

Message	Description	Action
***** (xxx) Dropping out-of-order ping #<x>	The data processing chain has been delayed and stale data has been discarded.	Check sonar processor hardware and resources.
PING <x> :(Lost FPGA sync...sample	One or more pings have been lost due to an error on the uplink between the receiver and the software. The system is becoming unstable and data transfer is corrupted on the PCI bus.	Reboot. Check sonar processor hardware.
PING <x> :(Lost FPGA sync...sample		
DMA Transfer Timeout. <x> of <x> bytes received		

A.3.4 Data Recording Warnings

Message	Description	Action
WARNING: Critical Disk Level: RDR - Data recording stopped	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories, as well as permissions on target files/directories.
RDR - Already in Playback/Record mode.		
RDR Record failed - No Filename		
RDR Record failed - Set file name failed: <x>		
RDR - Data recording failed to start. filename:		
RDR - Data <x> failed to stop.		
RDR - <x> already in progress.		
RDR Playback failed - No Filename		

Message	Description	Action
RDR Playback failed - Set file name failed:		
RDR - Data playback failed, filename =		
RDR - Data delete failed: in Record/Playback mode.		
RDR Data delete failed - Filename not available		
RDR - Set new file name failed		
RDR - Set Data path Failed		
Disk Level Threshold: X%.		

A.3.5 BITE Data Warnings

Message	Description	Action
ERROR : NSD	An error has occurred in reading of BITE data. The data buffer has overflowed.	No action needed.
Non Sonar Data FIFO overflow (x packet)		

A.3.6 Input Signal Warnings

Message	Description	Action
Roll Compensation is not available.	The input data for motion is not available or the feature is not enabled.	Check device inputs and cabling.
Pitch Compensation is not available.		

A.3.7 System Stability Warnings

Message	Description	Action
WARNING: PPS Time-stamp error	The internal clock may not be disciplined properly resulting in incorrect time stamp of data.	Check 1PPS connections and GPS output. If uncorrected sonar data cannot be time stamped to 1 millisecond.
WARNING: Reduce Ping Rate or Range - DROPPING ping	The system is overloaded processing data. A ping has been lost because the processing queue is full.	Restart the software. Reboot PC.

A.3.8 Data Subscription Warnings

Message	Description	Action
Subscriber UDP sendto() failed	The software was unable to send data to a connected client.	Check network resources and user permissions.
Subscriber send() failed		
Subscribers outbound MMF buffer memory overwrite error!	The link to the user interface running on the sonar processor has detected a non-critical error.	Check system resources, shutdown all non-critical software applications. Reboot processor.
Subscribers outbound MMF buffer read error!		
Subscribers outbound MMF buffer memory overwrite error!		

A.3.9 Network Components Warnings

Message	Description	Action
TCP Server - Unknown packet type	A connected client has sent an unrecognized command to the software.	Review client software source code or definitions for correct implementation of Teledyne RESON 7k Data Format.
UDP Server - Unknown packet type		
TCP Server - Warning max connections reached	The network module has become saturated with client connections and will refuse any further connections.	Close some of the connected clients.
UDP Server - Warning max connection reached		

A.3.10 External Trigger Warnings

Message	Description	Action
Trigger out length (x) is invalid	An unsupported value was received for trigger setup.	Check settings in user interface.
Trigger out offset (x) is invalid		
Trigger out offset + length (x) exceed limit of 20ms		

A.4 Error Messages – Master List in Alphabetical Order

Message	Description	Action	Alarm Type
2nd ADMXRC card not found	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
ADMXRC card not found, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
ADMXRC configuration failed	The software failed to detect or configure the primary processing card.	Check PCI bus drivers for ADMXRC card.	General System Startup
ADMXRC.dll not found.	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Calibration Error: Calibration might be invalid. Repeat the calibration.	Calibration has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Calibration
Calibration Failed: Magnitude Error	Calibration has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Calibration
Calibration Failed: Over 10% dead Rx channels.	Calibration has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Calibration

Message	Description	Action	Alarm Type
Calibration Failed: Phase Error	Calibration has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Calibration
Calibration Failed: Too much noise	Calibration has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Calibration
Configure FPGA failed.	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Could not create PCI server	Software detected a failure to configure the main data acquisition and distribution module (PCI). This can be caused by errors in the configuration files, or corrupted installation.	Reboot the PC, call Teledyne RESON support.	General System Startup
Could not create TCP server	Indicates a network resource was unavailable to the software from the operating system.	Check user permissions, network drivers.	General System Startup
Could not create UDP server	Indicates a network resource was unavailable to the software from the operating system.	Check user permissions, network drivers.	General System Startup
Create TCP socket failed, code…	Operating system did not allow creating of network resources.	Check Windows installation, user settings, and network resources.	General System Startup
DMA Transfer Timeout. <x> of <x> bytes received	This error generally indicates that the uplink from the receiver is interrupted at some point.	Check the BITE page for receiver BITE values. Restore factory defaults. Reboot the PC.	Data Reading

Message	Description	Action	Alarm Type
Error creating non-sonar data reader thread	BITE module has failed to initialize.	Check Windows installation and resources.	General System Startup
Error creating PCI Copier thread	Software detected a failure to configure the main data acquisition and distribution module (PCI). This can be caused by errors in the configuration files, or corrupted installation.	Reboot the PC, call Teledyne RESON support.	General System Startup
Error creating PCI Reader thread	Software detected a failure to configure the main data acquisition and distribution module (PCI). This can be caused by errors in the configuration files, or corrupted installation.	Reboot the PC, call Teledyne RESON support.	General System Startup
Error starting <name> thread	A module has failed to start correctly.	Reboot the system.	System Resource
External triggering has failed. Check/update software installation.	External Trigger Firmware cannot be initialized or not supported	Reboot the system. Contact Teledyne RESON Customer Support if the problem persists.	Input Signal (Timing and Triggers)
Failed to allocate memory for ADMXRC read.	The software could not allocate enough system memory to perform the operation.	Make sure no other software is running on the sonar processor. Reboot the system.	General System Startup
Failed to allocate memory for ADMXRC transfer.	The software could not allocate enough system memory to perform the operation.	Make sure no other software is running on the sonar processor. Reboot the system.	General System Startup
Failed to allocate memory for ADMXRC transfer.	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to configure 1st FPGA with <x>, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card

Message	Description	Action	Alarm Type
Failed to configure 1st FPGA with <x>, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to find ADMXRC info, card_0, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to find ADMXRC info, card_1, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to get ADMXRC space info, Card_0, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to get ADMXRC space info, Card_1, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to register external trigger, ERROR =	External Trigger Firmware cannot be initialized or not supported.	Reboot the system. Contact Teledyne RESON Customer Support if the problem persists.	Input Signal (Timing and Triggers)
Failed to set ADMXRC clock, Card_0, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to set ADMXRC clock, Card_1, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to set up DMA Card 0	The software could not access the processing card device.	Check ADMXRC drivers.	General System Startup

Message	Description	Action	Alarm Type
Failed to set up DMA Card 0, ERROR =	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Failed to set up DMA Card 1	The software could not access the processing card device.	Check ADMXRC drivers.	General System Startup
Failed to unregister external trigger, ERROR =	External Trigger Firmware cannot be initialized or not supported.	Reboot the system. Contact Teledyne RESON Customer Support if the problem persists.	Input Signal (Timing and Triggers)
FATAL ERROR: PPS Timestamp error Check 1 PPS input	The pulse is not being detected. Time stamping will be done using system time only. 1 millisecond accuracy not possible.	Check input signal cabling.	Input Signal (Timing and Triggers)
FATAL: DMA Read size limitation reached.	A general error occurred while transferring data to the software.	Reboot the system.	Data Reading
FIRMWARE does not support External Trigger. Pinging is OFF	External Trigger Firmware cannot be initialized or not supported.	Reboot the system. Contact Teledyne RESON Customer Support if the problem persists.	Input Signal (Timing and Triggers)
Inbound memory initialization failed.	PC resources are inadequate.	Check RAM or virtual memory resources	General System Startup
Incorrect ADMXRC board found, card_1	One or more of the processing cards has failed to initialize or is non-functional within the sonar processor.	Reboot sonar processor and try again.	PCI Card
Internal 7k Center error	One or more startup conditions have failed.	Check previous alarms or warnings and verify software installation.	General System Startup
Internal error, 7kCenter NOT fully operational.	One or more startup conditions have failed.	Check previous alarms or warnings and verify software installation.	General System Startup

Message	Description	Action	Alarm Type
Lost sync with DMA read	A general error occurred while transferring data to the software.	Reboot the system.	Data Reading
MMF Outbound memory creation …	PC resources are inadequate.	Check RAM or virtual memory resources	General System Startup
Required file: "7k_0.xml" or "7k.xml" Not found.	A critical startup configuration file was missing or too many were found.	Reinstall the software.	General System Startup
Required file: "7k_Bite.htm" Not found.	A critical startup configuration file was missing or too many were found.	Reinstall the software.	General System Startup
SET UP: FAILED TO LOAD BIT FILE "<x>" for Device <x>, Enumerator <x>	A critical startup configuration file was missing or too many were found.	Reinstall the software.	General System Startup
Socket initialization failed, error code <x>	Windows has failed to allocate a network resource.	Check network permissions and resources or Reinstall operating system.	General System Startup

A.5 Warning Messages – Master List in Alphabetical Order

Message	Description	Action	Type
***** (xxx) Dropping out-of-order ping #<x>	The data processing chain has been delayed and stale data has been discarded.	Check sonar processor hardware and resources.	Data Processing
7K Bite File cannot be Read	Software installation is corrupt.	Restore factory defaults. Reinstall software.	Configuration
Cannot Open or Create UDP Configuration file	Software installation is corrupt.	Restore factory defaults. Reinstall software.	Configuration
Cannot Read UDP Configuration file <x> Error	Software installation is corrupt.	Restore factory defaults. Reinstall software.	Configuration
Disk Level Threshold: X%.	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
DMA Transfer Timeout. <x> of <x> bytes received	One or more pings have been lost due to an error on the uplink between the receiver and the software. The system is becoming unstable and data transfer is corrupted on the PCI bus.	Reboot. Check sonar processor hardware.	Data Processing
ERROR : NSD	An error has occurred in reading of BITE data. The data buffer has overflowed.	No action needed.	BITE Data
Failed to start PCI Copier thread	One or more PCI bus or network resources have failed to initialize.	Check user permissions and sonar processor network hardware.	Startup
Failed to start PCI Reader thread	One or more PCI bus or network resources have failed to initialize.	Check user permissions and sonar processor network hardware.	Startup

Message	Description	Action	Type
Non Sonar Data FIFO overflow (x packet)	An error has occurred in reading of BITE data. The data buffer has overflowed.	No action needed.	BITE Data
PCI interface status: Down	One or more PCI bus or network resources have failed to initialize.	Check user permissions and sonar processor network hardware.	Startup
PING <x> :(Lost FPGA sync...sample	One or more pings have been lost due to an error on the uplink between the receiver and the software. The system is becoming unstable and data transfer is corrupted on the PCI bus.	Reboot. Check sonar processor hardware.	Data Processing
PING <x> :(Lost FPGA sync...sample	One or more pings have been lost due to an error on the uplink between the receiver and the software. The system is becoming unstable and data transfer is corrupted on the PCI bus.	Reboot. Check sonar processor hardware.	Data Processing
Roll Compensation is not available.	The input data for motion is not available or the feature is not enabled.	Check device inputs and cabling.	Input Signal
Pitch Compensation is not available.	The input data for motion is not available or the feature is not enabled.	Check device inputs and cabling.	Input Signal
RDR - <x> already in progress.	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR - Already in Playback/Record mode.	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR - Data <x> failed to stop.	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording

Message	Description	Action	Type
RDR - Data delete failed: in Record/Playback mode.	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR - Data playback failed, filename =	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR - Data recording failed to start. filename:	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR - Set Data path Failed	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR - Set new file name failed	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR Data delete failed - Filename not available	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR Playback failed - No Filename	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR Playback failed - Set file name failed:	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
RDR Record failed - No Filename	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording

Message	Description	Action	Type
RDR Record failed - Set file name failed: <x>	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
Roll Compensation is not available.	The input data for motion is not available or the feature is not enabled.	Check device inputs and cabling.	Input Signal
Roll Compensation is not available.	The input data for motion is not available or the feature is not enabled.	Check device inputs and cabling.	Input Signal
Subscriber send() failed	The software was unable to send data to a connected client.	Check network resources and user permissions.	Data Subscription
Subscriber UDP sendto() failed	The software was unable to send data to a connected client.	Check network resources and user permissions.	Data Subscription
Subscribers outbound MMF buffer memory overwrite error!	The link to the user interface running on the sonar processor has detected a non-critical error.	Check system resources, shutdown all non-critical software applications. Reboot processor.	Data Subscription
Subscribers outbound MMF buffer read error!	The link to the user interface running on the sonar processor has detected a non-critical error.	Check system resources, shutdown all non-critical software applications. Reboot processor.	Data Subscription
TCP interface status: Down	One or more PCI bus or network resources has failed to initialize.	Check user permissions and sonar processor network hardware.	Startup
TCP Server - Unknown packet type	A connected client has sent an unrecognized command to the software.	Review client software source code or definitions for correct implementation of Teledyne RESON 7k Data Format.	Network Components
TCP Server - Warning max connections reached	The network module has become saturated with client connections and will refuse any further connections.	Close some of the connected clients.	Network Components
Trigger out length (x) is invalid	An unsupported value was received for trigger setup.	Check settings in user interface.	External Trigger

Message	Description	Action	Type
Trigger out offset (x) is invalid	An unsupported value was received for trigger setup.	Check settings in user interface.	External Trigger
Trigger out offset + length (x) exceed limit of 20ms	An unsupported value was received for trigger setup.	Check settings in user interface.	External Trigger
UDP Configuration file not available	Software installation is corrupt.	Restore factory defaults. Reinstall software.	Configuration
UDP interface status: Down	One or more PCI bus or network resources have failed to initialize.	Check user permissions and sonar processor network hardware.	Startup
UDP Server - Unknown packet type	A connected client has sent an unrecognized command to the software.	Review client software source code or definitions for correct implementation of Teledyne RESON 7k Data Format.	Network Components
UDP Server - Warning max connection reached	The network module has become saturated with client connections and will refuse any further connections.	Close some of the connected clients.	Network Components
WARNING: Critical Disk Level: RDR - Data recording stopped	The hard drive is getting full. One or more errors have occurred in conjunction with data recording.	Check user permissions and available disk space. Check file names and recording directories	Data Recording
WARNING: PPS Time-stamp error	The internal clock may not be disciplined properly resulting in incorrect time stamp of data.	Check 1PPS connections and GPS output. If uncorrected sonar data cannot be time stamped to 1 millisecond	System Stability
WARNING: Reduce Ping Rate or Range - DROPPING ping	The system is overloaded processing data. A ping has been lost because the processing queue is full.	Restart the software. Reboot PC.	System Stability

APPENDIX B DATA SHEET

B.1 High-Resolution Multibeam Echosounder

The new generation SeaBat T-Series Portable sonar line from Teledyne RESON builds on the field experience and feedback from many users around the world and brings unparalleled resolution and installation flexibility. The new multibeam bathymetry series is versatile, robust, and easy to use. Fast throughput of clean, precise data and imagery enhances decision-making processes for the widest variety of survey applications.

- **SeaBat T20-P – Superior acoustic quality engineered for the demanding marine environment:** The T20-P is a new addition to the leading SeaBat product range engineered from the ground up to evolve with your business. Combined with the Portable Sonar Processor the T20-P provides uncompromised survey data in a highly portable waterproof package designed for small vessel use.

  The solution includes a range of powerful software features at an attractive price, with the option for future feature expansions to grow with your needs.

  The SeaBat T20-P can be supplied in ruggedized flight cases with total weight and dimensions suitable for check-in on commercial airlines – and light enough to be transported by one person.

- **SeaBat T50-P – Unprecedented clean and ultrahigh data quality for faster operational surveys and reduced processing time:** The T50-P is a new addition to the leading SeaBat T-Series product range engineered from the ground up to evolve with your business. Combined with the Portable Sonar Processor the T50-P provides unprecedented survey data for faster operational surveys and reduced processing time.

  The SeaBat T50-P is fully frequency agile from 190 to 420kHz affording improved swath performance and reduced survey time under difficult conditions.

  The SeaBat T50-P is designed for fast mobilization on smaller vessels. The Portable Sonar Processor and sonar head form a compact system securing minimal interfacing and low space requirements.

B.2 SeaBat T-Series System Performance

Table 5: SeaBat T-Series System Performance

Parameters	400kHz	200kHz
Frequency range	190-420kHz (CW) / 200-400kHz (FM)	
Across-track receive beam widths* (nominal values)	**T20:** 1° **T50:** 0.5°	**T20:** 2° **T50:** 1°
Along-track transmit beam widths (nominal values)	1°	2°
Number of beams	**T20:** max. 256 (optional 512), min. 10 **T50:** max. 512, min. 10	
Max. swath coverage, **T20**	140° ED/165° EA	
Max. swath coverage, **T50**[19]	150° ED/165° EA	
Depth, typical[20]	0.5-180 meters	0.5-450 meters
Depth, max.[21]	300 meters	575 meters
Ping rate (range dependent)	Up to 50 pings/s	
Pulse lengths CW	**T20:** 30-300µs **T50:** 15-300µs	
Pulse lengths FM	300µs-10ms[22]	
Depth resolution	6mm	
Depth rating	50m	

* Receive center beam widths[23]:	T20: 1.07° (at 400) / 2.14° (at 200kHz) T50: 0.54° (at 400) / 1.07° (at 200kHz)

B.3 SeaBat T-Series Portable Physical Specifications

For physical specifications, see the various tables with technical data in *Appendix C Installation Instructions*.

[19] Seabed will not be 100% ensonified when exceeding approx. 140° in equi-distant mode.
[20] This is a depth range within which the system is normally operated, from the minimum depth to a depth value corresponding to the max. swath -50%.
[21] This is a single value corresponding to the depth at which the swath is reduced to 10% of its max. value.
[22] Max. 5ms at 66kHz for T50.
[23] Receive center beam width mean values from far-field simulation. All beam widths measured at -3dB, center beam unsteered, with a sound velocity of 1440m/s, 30dB Chebyshev shading applied.

APPENDIX C INSTALLATION INSTRUCTIONS

C.1 Components Checklist

Table 6: SeaBat T-Series Portable Components

Part Number	Description
85002319	Projector,TC2181, DF200/400kHz
85002436	Receiver, EM7219, 128Ch, 200-400kHz, TI (T20)
85002409	Receiver, EM7218, 256Ch, 200-400kHz, TI (T50)
85160031	Mounting bracket standard, T20, EM7219, TC2181
85160032	Mounting Bracket Standard, T20 Dual Head, EM7219/TC2181 (optional)
85160041	FAIRING ADD-ON, Mounting Bracket Standard, T20 (optional)
85160033	Mounting Bracket standard, T50, EM7218-TC2181, COMPOSITE
85160030	Mounting Bracket standard, EM7218-TC2181, Stainless steel (optional)
85160035	Mounting bracket standard, T50 Dual head, EM7218/TC2181 (optional)
85160040	FAIRING ADD-ON, Mounting Bracket Standard, T50 (optional)
1008414	ASSY, PSP, Portable Sonar Processor
1008775	CABLE ASSY, ISP/PSP to Rx, 10m, 7K (T20)
85002228	CABLE ASSY, ISP/PSP to DF-Tx, 10m, 7K (T20)
1008776	CABLE ASSY, ISP/PSP to Rx, 25m, 7K (T50)
85002229	CABLE ASSY, ISP/PSP to DF-Tx, 25m, 7K (T50)
89100063	SHIP CASE, KIT, STENCILED, WET END, T20
1010206	SHIP CASE, KIT, STENCILED, WET END, T50-P
89100067	SHIP CASE, KIT, STENCILED, DRY END, T-Series
1008978	Memory Stick, USB, 16 GB, tube, silver
1008979	Strap, black, TELEDYNE-RESON white logo
1008756	Quick Reference Guide, SeaBat T-Series Portable
1008951	Quick Installation Guide, SeaBat UI for T-Series Portable
1008876	Cable assy, RJ45 CAT5e shielded IP68 (5m)
1008877	Cable Assy, RS-232 extension, 5m, IP68 F, STD M, 9-pin
60000002	Cord, PWR 3-Cond, NEMA5-15P TO IEC
88100610	230 volt UK - power cable 2,5 m, Black
SB9999/00057	230 volt EU - power cable
1008664	Cable Assy, DC supply cable, 5m
1008075	COTS, Cable,Conf,RF,3m,BNC,M, BNC,M
1007252	Wet connector lubrication kit

NOTE
This component checklist constitutes the standard SeaBat T20-P or T50-P delivery. For precise information, refer to the packing list you received with your delivery.

C.2 Installation Checklist

NOTE
This checklist only covers the most basic, standard system installation. Depending on the system configuration or specific customer requirements, this list may or may not apply.

Follow these basic steps to install and configure your new SeaBat sonar system:

- Install the dry-end components:
  - Portable sonar processor
- Install the wet-end components:
  - Receiver unit
  - Projector unit
- Install and connect cables:
  - Portable sonar processor to receiver cable
  - Portable sonar processor to projector cable
  - Auxiliary sensor cables
  - Portable sonar processor power cable
  - Portable sonar processor to laptop/PC Ethernet cable
- Power up the system
- Test the system

For information on system configuration and operation, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

CAUTION
Before turning the system on, make sure that there is no significant difference between the temperatures of the equipment and environment in order to prevent condensation.

C.3 System Interfacing

C.3.1 Single-Head Interfacing Diagram

Please refer to the single-head interfacing diagram in *Figure 37: T20-P, single-head interfacing diagram* or *Figure 38: T50-P, single-head interfacing diagram*.

For further details, please refer to:

- *Appendix C.4 Dry-End Installation*
- *Appendix C.7 Wet-End Installation*, incl.
    - *C.7.8 Hardware Settings*
- *Section 3.3 Starting the Sonar User Interface*

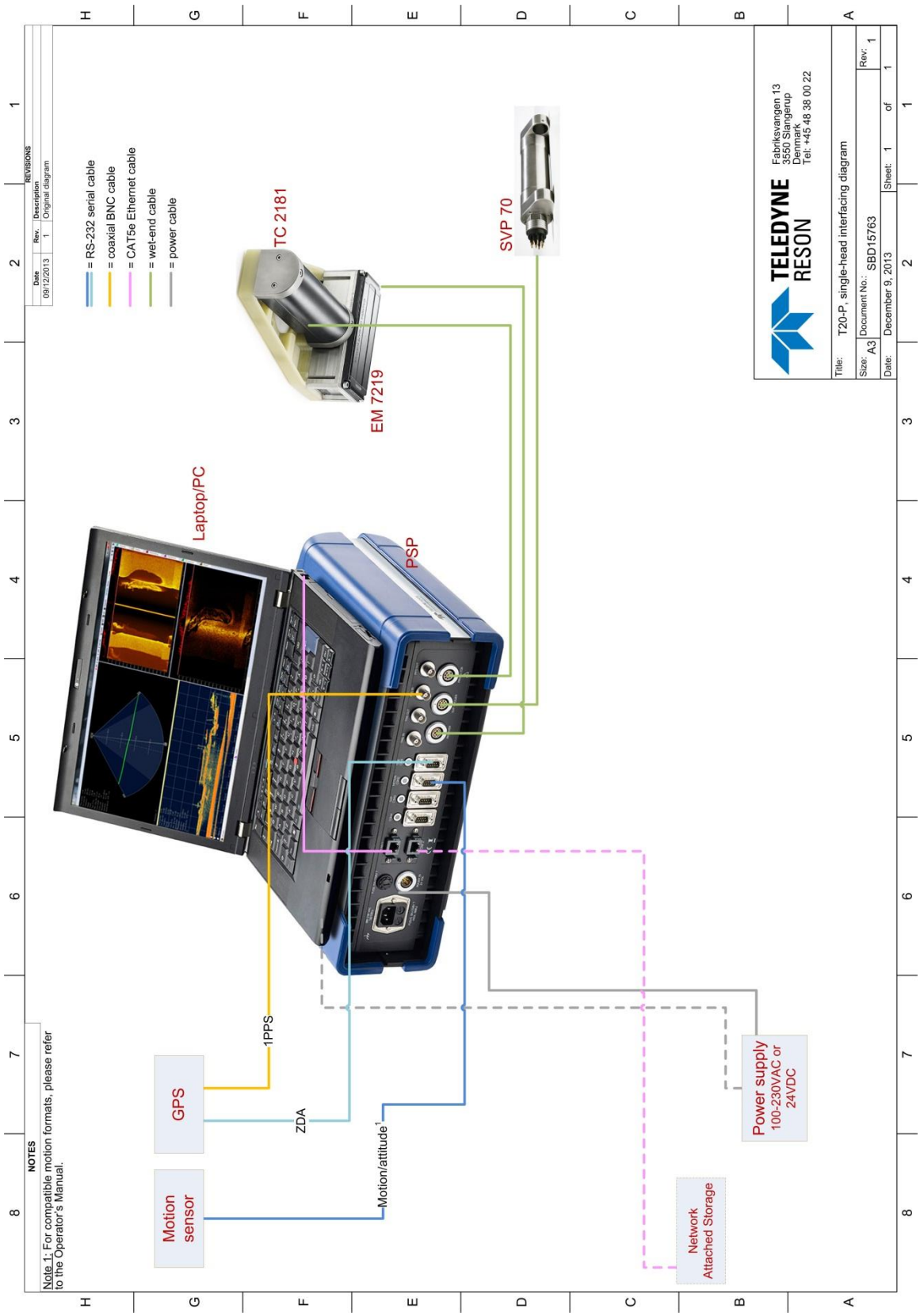


Figure 37: T20-P, single-head interfacing diagram

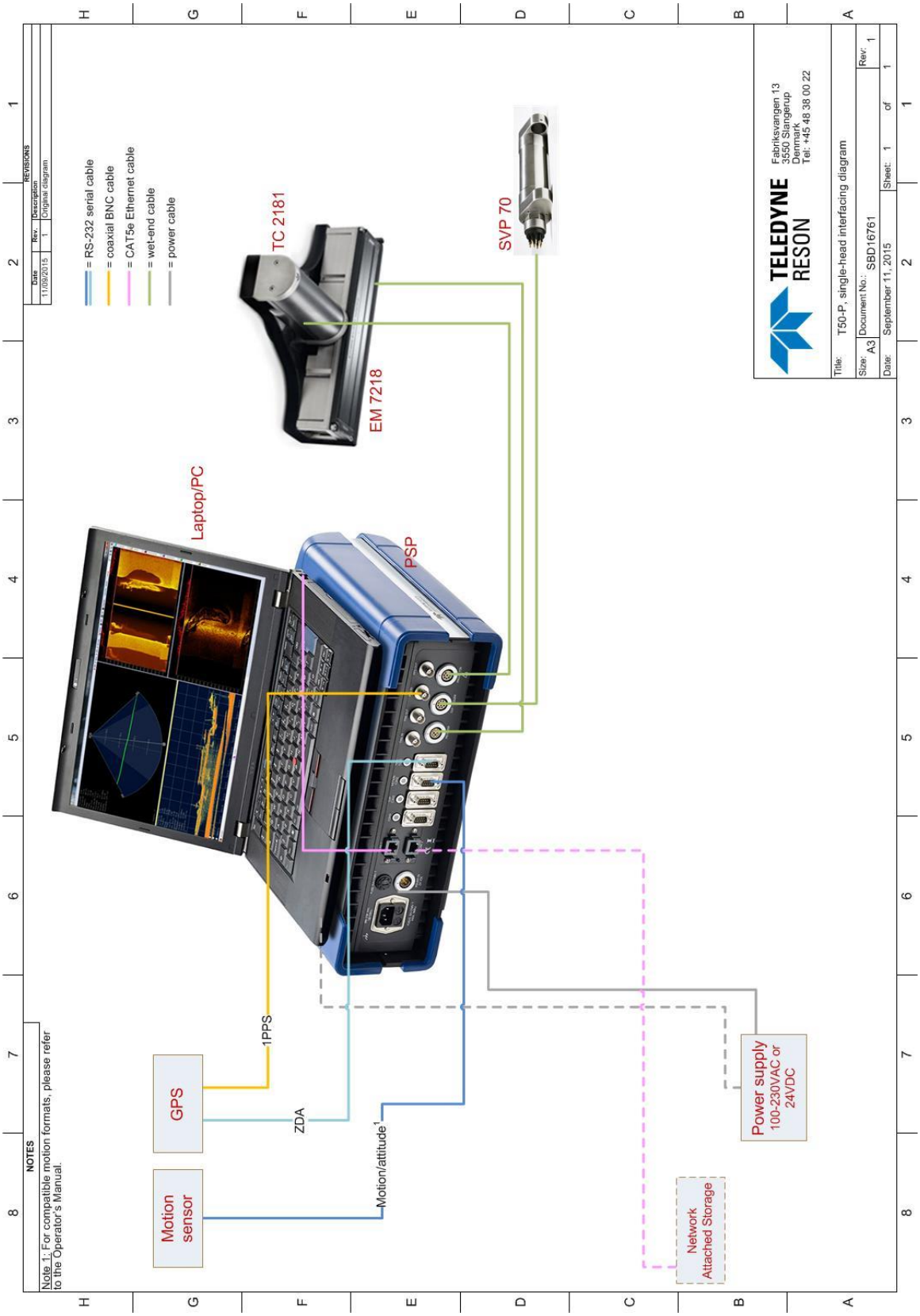


Figure 38: T50-P, single-head interfacing diagram

C.3.2 Dual-Head Interfacing Diagram

Set up each system separately starting with the master.

Please refer to the dual-head interfacing diagram in *Figure 39: T20-P, dual-head interfacing diagram* or *Figure 40: T50-P, dual-head interfacing diagram*.

For further details, please refer to:

- *Appendix C.4 Dry-End Installation*
- *Appendix C.7 Wet-End Installation*, incl.
    - *C.7.8 Hardware Settings*
    - *C.7.9 Dual-Head Configuration*
- *Section 3.3 Starting the Sonar User Interface*

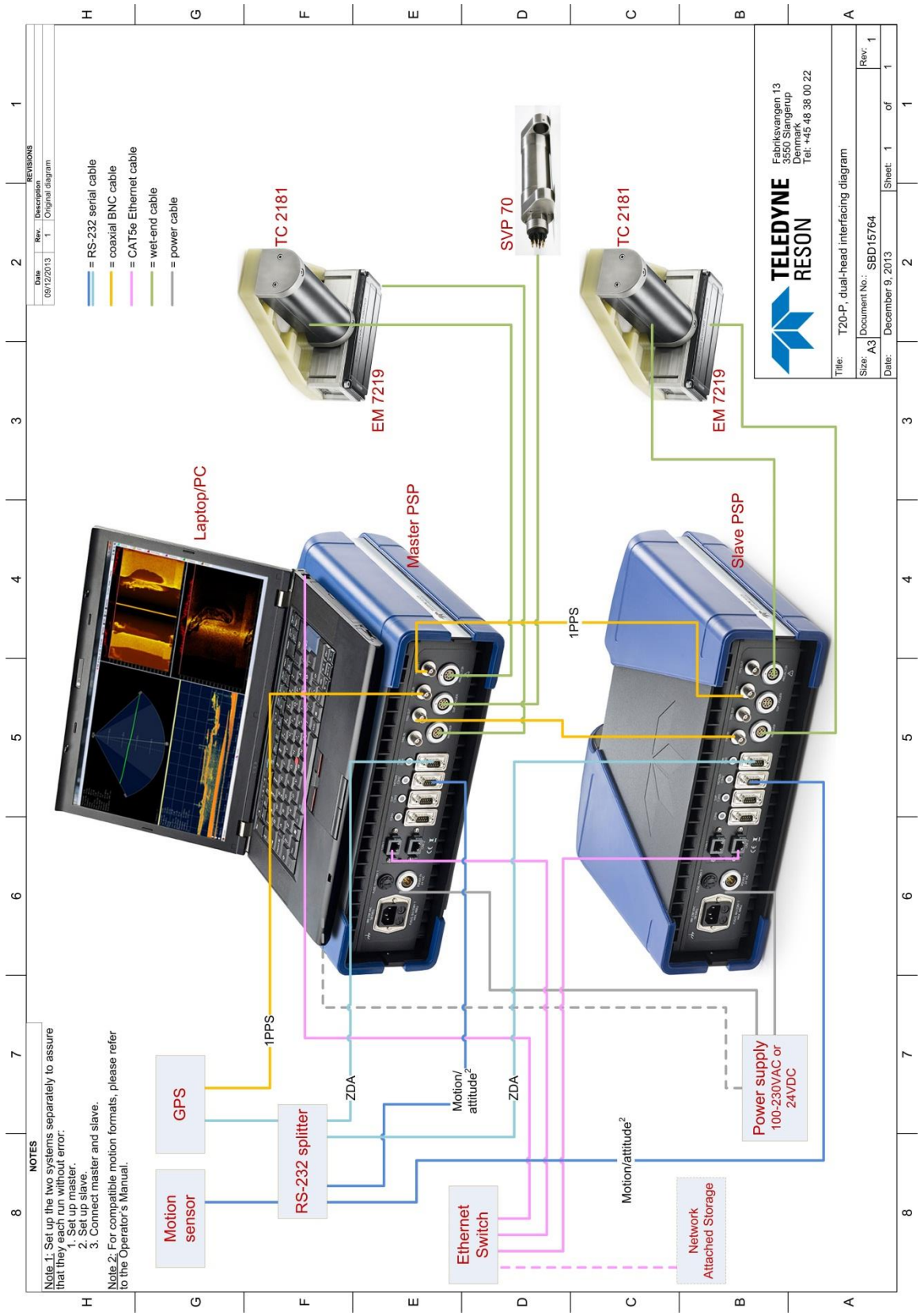


Figure 39: T20-P, dual-head interfacing diagram

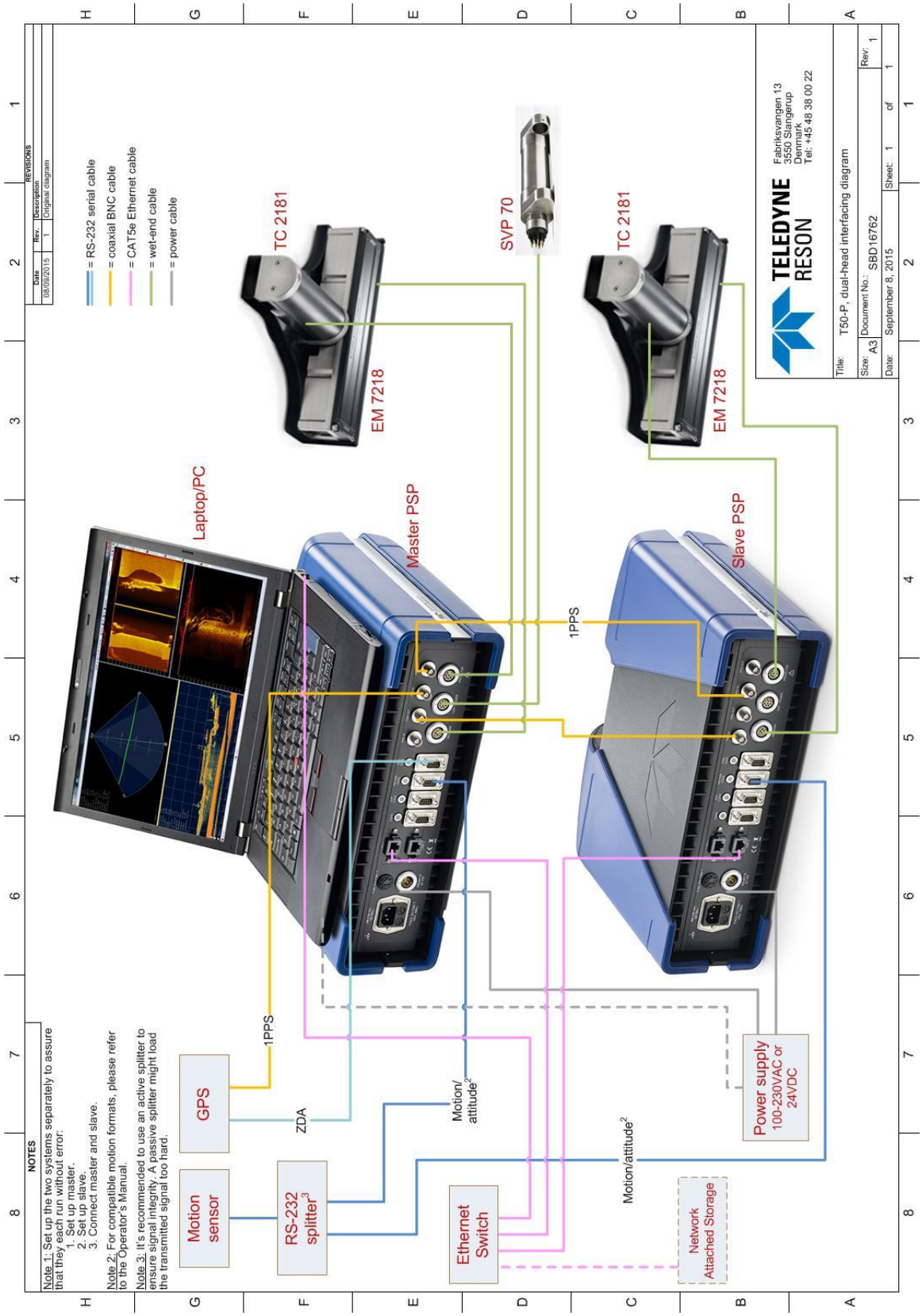


Figure 40: T50-P, dual-head interfacing diagram

C.4 Dry-End Installation

C.4.1 Portable Sonar Processor

The portable sonar processor (PSP) is a standalone unit, which will run the 7kCenter and 7k IO module and handle beamforming and bottom detection. Sensor interfaces from SVP and external time must be interfaced to the PSP. Position, motion, and heading may be interfaced as well for single-point time-stamping.

Figure 41: Portable Sonar Processor

Table 7: Portable Sonar Processor Technical Specifications

Specification	Value
Power requirements	100-230VAC, 50/60Hz or 24VDC[24]
Power consumption	T20-P: Approx. 110W avg. (Peak 350W) T50-P: Approx. 135W avg. (Peak 350W)
Fuses for 100-230VAC Fuse for 24VDC	Max. 4A/250V T Max. 15A/250V T
Data communication, 2x	Gigabit Ethernet
Mounting	Rack available
Dimensions	Height: 130.8mm Width: 424.0mm Depth: 379.3mm
Weight (excl. cables)	14.0kg
Temperature	Operating: -5° to +40°C Storage: -30° to +70°C
Humidity	Max. 95% RH noncondensing
Ingress protection	IP66[25] (dust tight and protected against water jets)
Vibration	±1mm at 7m/s^2

[24] The PSP power input requirement of 24VDC is continuously. Therefore, the sonar system may need to be connected to a dedicated battery (e.g. separate from the engine start battery) to avoid outage of the sonar system.
[25] RJ45 connectors, RS-232 ports, and mains power inlets must have connector caps or external cables mounted to ensure the unit is tight to the stated IP class.

The PSP offers a flexible platform for a number of functions:

- Receives digitized sonar data from the receiver unit.
- Receives operational settings remotely from the SeaBat User Interface installed on the customer-furnished laptop/PC.
- Provides beamforming and initial processing of acoustical data.
- Controls, formats, and generates data to external systems. This can include making beamformed data and preprocessed image data available to external systems over a fast Ethernet connection (1Gb).
- Performs built-in test routines and alerts the operator to any abnormal conditions.
- Provides an interface for a sound velocity sensor, so that range measurements and receiver beamforming can be conducted correctly.
- Provides an interface for a PPS timing interface so that accurate time stamping of data can be made.
- Packages and time tags survey critical sensor data. The sensor data can be broadcasted as documented in the Data Format Definition Document (see *Appendix H Reference Documentation*.
- Generates the various data telegrams to be recorded by data acquisition systems.
- Supports optional beam data storage on a CFE NAS unit (or the CFE laptop/PC) easily configured from the SeaBat User Interface, with a shared folder on a network as only requirement.

CAUTION
The PSP is designed and assembled specifically to accommodate the software packages provided by Teledyne RESON and installed at the factory. Installing additional software on this machine can result in decreased performance and/or system malfunction. Do **not** open, change, add, or remove anything (incl. software) on the PSP. Noncompliance may affect warranty situation (see *Appendix L Warranty Information*).

After the PSP is installed, the only interaction required should be to press the power switch and energize the system.

C.4.2 Portable Sonar Processor Mounting

The outer cabinet of the PSP is covered with EPDM rubber, which protects the unit from small bumps etc. and gives the unit a non-slip surface. Mounds on the bottom fit into the recesses on the top making it possible to stack one unit onto another, which makes dual head operation attainable even on a small survey boat.

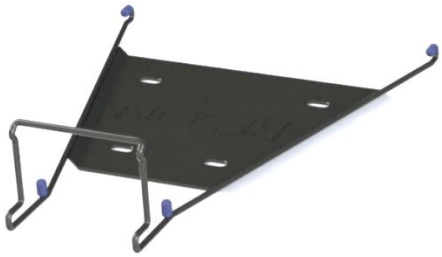
Figure 42: Portable Sonar Processor – Bottom Mounds and Top Recesses

- Mount the PSP within easy reach of operator workstation connections, interconnect cables, and power switch.
- Allow clearance around the unit to provide adequate air circulation.

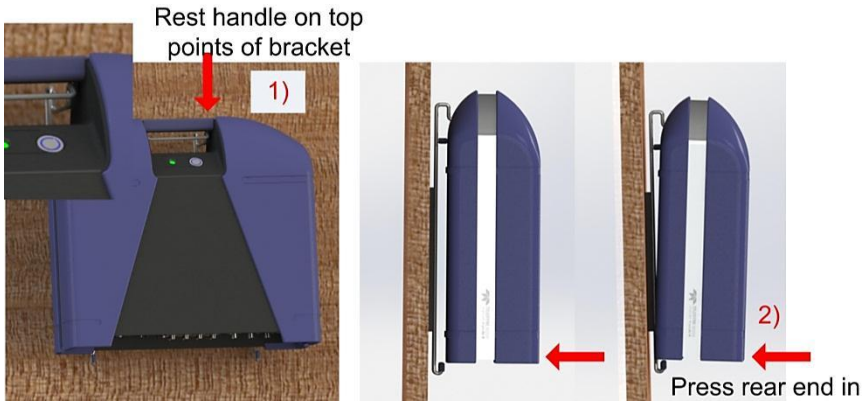
  The unit's cooling system lies between the inner and outer cabinet. A low-profile fan forces inflow of cold air at the top and outflow of warmer air at the bottom (see *Figure 43*).

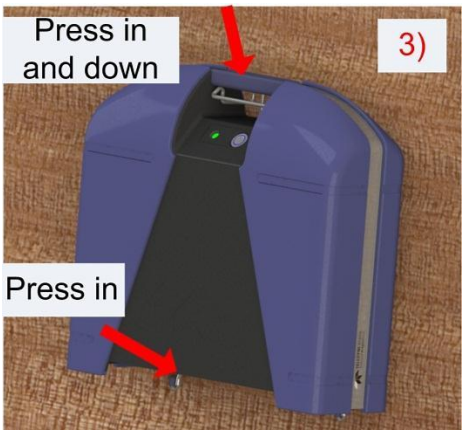
Figure 43: Portable Sonar Processor – Cooling

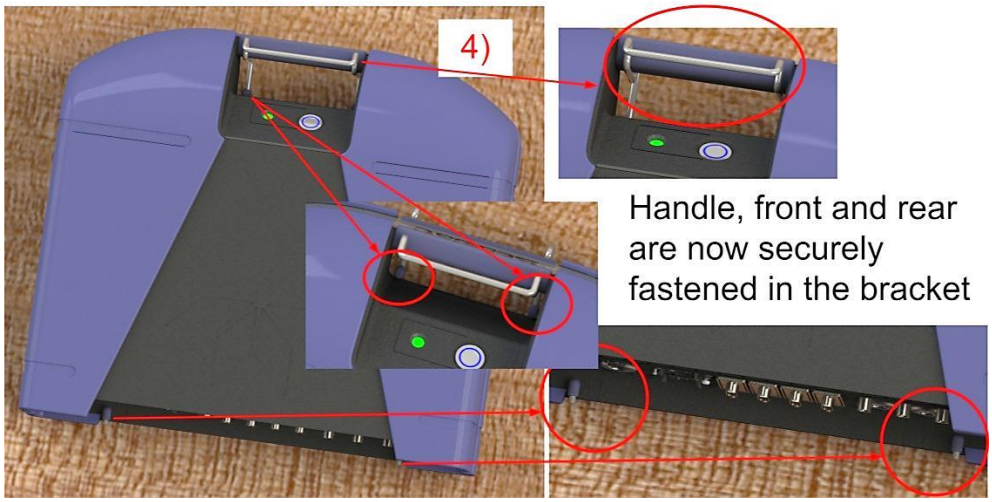
A bracket is available for mounting the PSP in a fixed location, horizontally or vertically.



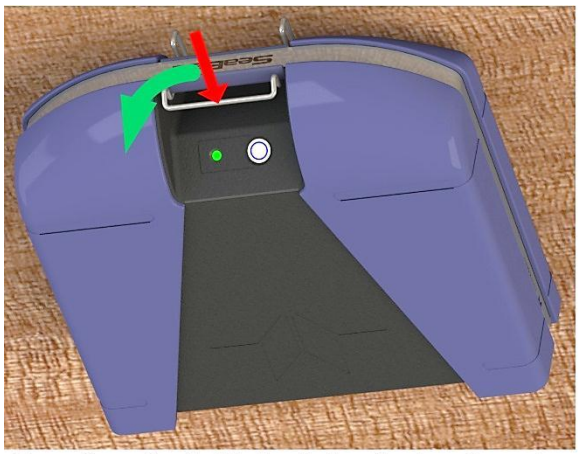
1. Use the four mounting holes on the flat plate for mounting the bracket on the desired surface and secure with appropriately sized screws.
2. To place the PSP cabinet in the bracket:





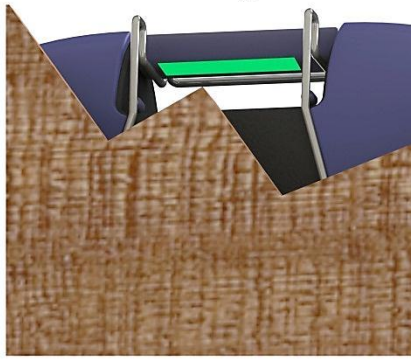


3. To release the PSP cabinet from the bracket:



Place fingertips behind or below the handle and press with thumb on the steel spring to release the handle. Now, lift the cabinet out of the bracket in the direction of the green arrow.
Careful: Only use fingertips to allow room for fingers and steel spring.

For safe removal:
Use fingertips only in
this region



C.4.3 Portable Sonar Processor Cable Connections

All dry-end cables provided by Teledyne RESON come with factory-installed connectors to be attached at the appropriate port(s) on the rear panel of the PSP.

CAUTION
Do not disconnect any cables from the rear of the PSP while the unit is running. This can damage the internal workings of the unit.

The critical connections are clearly marked on the PSP and shown in *Figure 44*.

(1) Mains power input 100-230VAC ⚠
(2) Power in 24VDC (max. 34VDC)
(3) Ethernet for laptop/PC
Ethernet for dual head sync/NAS
(4) COM4 port w/LED (RS-232) (ship's heading)
(5) Alternate SVP serial port w/LED
(6) Motion sensor serial port w/LED
(7) Time marker serial port UTC/ZDA w/LED
(8) Receiver connection
(9) Main SVP serial port with power
(10) Projector connection ⚠
(11) Trigger in
(12) Trigger out
(13) 1PPS in
(14) 1PPS out (double synchronized to 1PPS in)

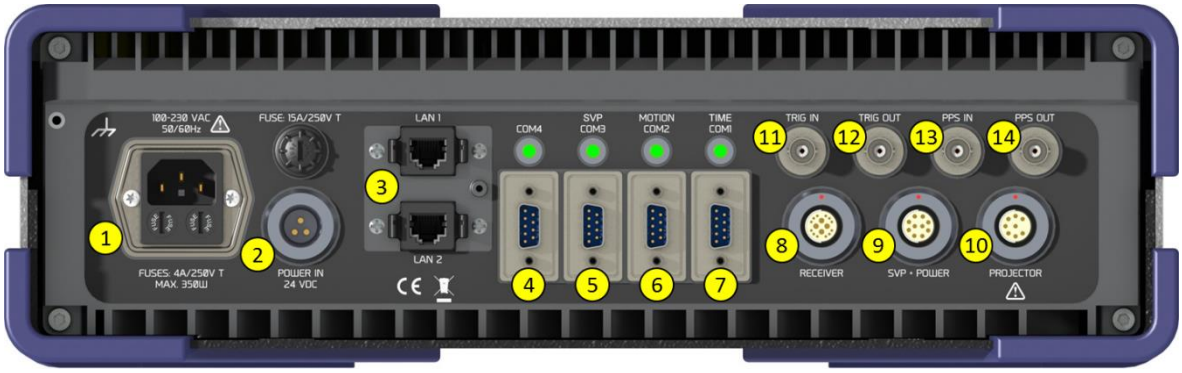


Figure 44: Portable Sonar Processor Cable Connections

WARNING!
For safety reasons the SeaBat™ must be connected to protective earth. The protective earth pin in the mains appliance inlet is the protective conductor terminal of SeaBat™.

NOTE
The four COM port LEDs (items 4-7) are powered by the RS-232 lines and will therefore be lit when these lines are active, even if the PSP is not connected to power.

NOTE
If a power failure occurs on the mains input the sonar may shut down. To recover from the shutdown, press the power button on the PSP.

CAUTION

To disconnect the **projector/receiver/SVP cable** from the PSP, hold on the groove part of the connector (at the arrow) and pull gently outwards.

Do **not** pull directly on the cord, as this will damage both the cables and the PSP.

WARNING!

The projector connection must be handled with great care as the output power voltage is hazardous to human safety.

Do **not** pull out the cable with power on.

The mains power 100-230VAC input must be handled with great care as the input power voltage is hazardous to human safety.

The PSP has been tested to comply with IP66[26] standards. However, various standards (e.g. ISO 13297) containing further restrictions and/or requirements may be applicable to the use of this equipment.

Do **not** pull out the cable with power on.

C.4.4 Portable Sonar Processor Power Button and BITE LED

A BITE LED and the power button are located on the front of the PSP.

- **Power button light indicator:**
  - Blue: when turned on
  - Orange: on standby
  - No light: not connected to power
- **BITE LED:**
  - No light: 7kCenter not started
  - Green: Normal (everything in order)
  - Yellow: BITE warning (investigate UI on surveyor laptop/PC to find the cause)
  - Red: BITE error (investigate UI on surveyor laptop/PC to find the cause)
  - Red flashing: 7kCenter not responding

[26] Provided that connector caps or external cables are mounted.

C.5 Auxiliary Sensors

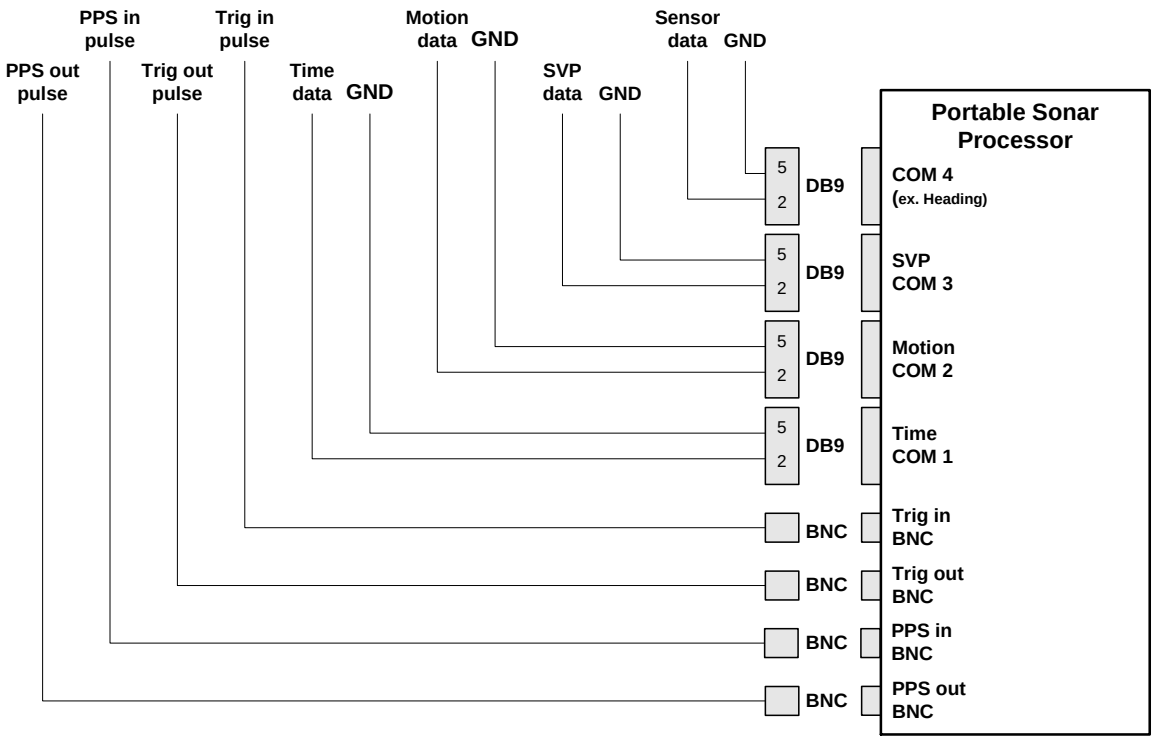


Figure 45: SVP, Motion, and Time Standard Connections

The portable sonar processor uses DB9 connectors as inputs for COM1 to COM4. Handshake and control wires have been looped to ensure that sensor devices with flow control/handshake can send data to the portable sonar processor.

NOTE
The auxiliary sensors required depend on the application for which the sonar is used; an accurate online sound velocity value is always required.

CAUTION
If you need to use the same sensor for dual-head systems, a RS-232 external splitter with buffer should be used to ensure that the signal levels are at an acceptable level. It is not recommended to use simple Y-splice cables for splitting external sensors to the two systems.

C.5.1 Sound Velocity Input

To connect a sound velocity probe to the portable sonar processor, follow these steps:

1. Using a DB9 female connector, connect the SVP data to pin 2 and ground to pin 5.
2. Connect the DB9 to the port marked SVP COM3 on the rear panel of the portable sonar processor (see item 5 in *Figure 44*).

   or

3. Connect a Teledyne RESON standard SVP cable with a Fischer connector to the port marked SVP + POWER (see item 9 in *Figure 44*).

Table 8: Portable Sonar Processor Port “SVP COM3”

DB9 Pin	RS-232
1-4-6	Shorted internally
2	RxD
3	TxD
5	GND
7-8	Shorted internally
9	-

C.5.2 Motion Sensor Input

CAUTION
The motion port (DB9) is split internally in the portable sonar processor, so it cannot be split further externally without risk.

To connect a motion sensor to the portable sonar processor, follow these steps:

1. Using a DB9 female connector, connect the motion data to pin 2 and ground to pin 5.
2. Connect the DB9 to the port marked Motion COM2 on the rear panel of the portable sonar processor (see item 6 in *Figure 44*).

Table 9: Portable Sonar Processor Port “Motion COM2”

DB9 Pin	RS-232
1-4-6	Shorted internally
2	RxD
3	TxD
5	GND
7-8	Shorted internally
9	-

C.5.3 Time Input

To connect an external clock to the portable sonar processor, follow these steps:

1. Using a DB9 female connector, connect the time data to pin 2 and ground to pin 5.
2. Connect the DB9 to the port marked Time COM1 on the rear panel of the portable sonar processor (see item 7 in *Figure 44*).
3. Using a BNC male connector, connect the 1PPS pulse to the port marked PPS IN on the rear panel of the portable sonar processor for setting the internal clocks of the sonar.

Table 10: Portable Sonar Processor Port “Time COM1”

DB9 Pin	RS-232
1-4-6	Shorted internally
2	RxD
3	TxD
5	GND
7-8	Shorted internally
9	-

C.6 SeaBat T-Series Portable Cables

A standard cable set is provided to connect the SeaBat T-Series Portable system components.

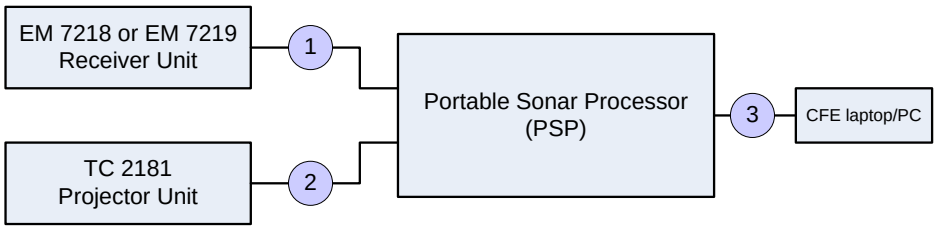


Figure 46: SeaBat T-Series Portable System Cables

- **Receiver to PSP (1):** This cable allows power and data to be passed between the receiver and PSP. The cable has a standard length of 10 meters for T20-P, 25 meters for T50-P, and a minimum bend radius of 100mm.
- **Projector to PSP (2):** This cable allows power and data to be passed between the projector and PSP. The cable has a standard length of 10 meters for T20-P, 25 meters for T50-P, and a minimum bend radius of 73mm.
- **PSP to laptop/PC or Gb Ethernet switch (3):** This cable ensures IP68 sealing of the LAN 1 and LAN 2 interfaces on the PSP. The cable is a CAT 5e shielded cable for data connection between the PC and the PSP. The cable has a length of 10 meters (two cables are supplied with the system).
- **AC or DC power cables (4):** Power supply is fed through either a 2.5m long 100-230VAC cable[27] or a 5m long 24VDC supply cable[28].

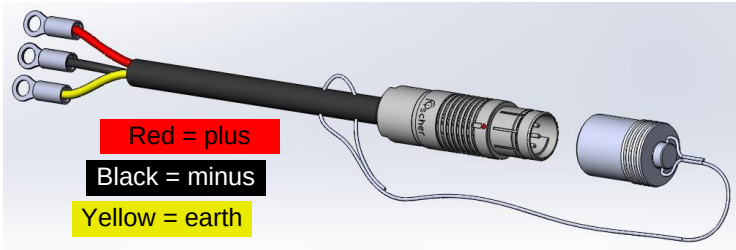


Figure 47: Wiring – DC Supply Cable

CAUTION
The units must **not** be suspended from their cables. Ensure that strain relief on the cable (cable grip) is used. If the cable is very long, use an external wire or cable covered with steel flex.

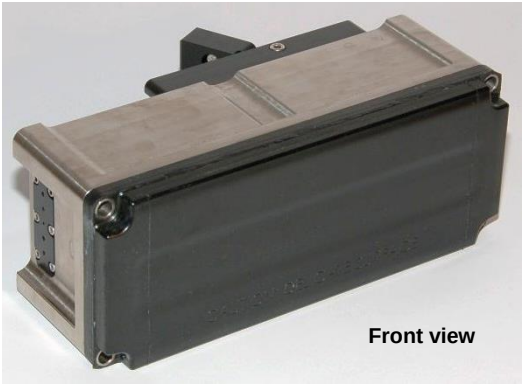
For cable options, see *appendix I.3 SeaBat Cables*.

[27] COTS cable
[28] The PSP power input requirement of 24VDC is continuously. Therefore, the sonar system may need to be connected to a dedicated battery to avoid outage of the sonar system.

C.7 Wet-End Installation

C.7.1 EM 7219 Receiver Unit (PN 85002436)

The EM 7219 receiver unit operates at multiple frequencies between 200kHz and 400kHz.



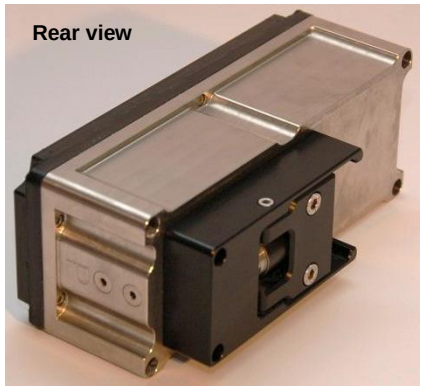


Figure 48: EM 7219 Receiver Unit

Table 11: EM 7219 Receiver Unit Technical Specifications

Specification	Value
Material	Titanium (grade 2) lid Polyurethane acoustic window
Dimensions	Height 123.2mm Length: 254.0mm Depth: 102.0mm
Weight	Air: 5.0kg Water: 2.2kg
Temperature	Operating: -2° to +36°C Storage: -30° to +55°C

The EM 7219 receiver unit mounts to the vessel or mounting bracket with four M8 screws already in place in the receiver.

For ease of mounting, the ends of the housing are labeled P and S for Port and Starboard, respectively. The connector is placed on the port side.

CAUTION
Installation of unit shall ensure free access to water inlet holes (located on the starboard side) for pressure equalization.

C.7.2 EM 7218 Receiver Unit (PN 85002409)

The EM 7218 receiver unit operates at multiple frequencies between 200kHz and 400kHz.

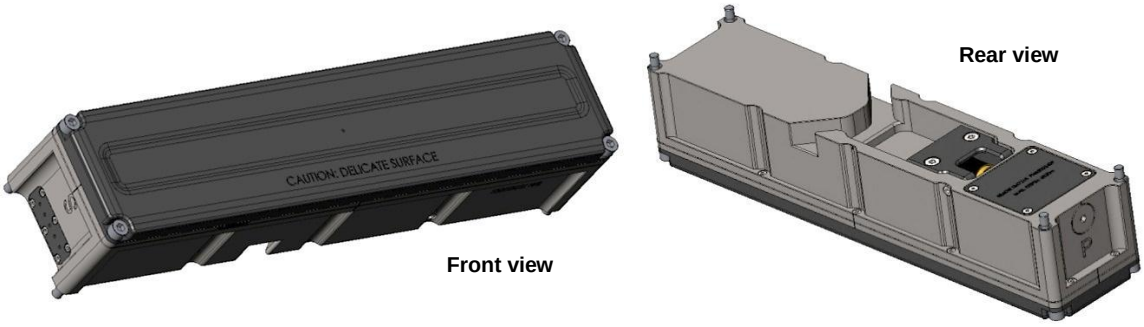


Figure 49: EM 7218 Receiver Unit

Table 12: EM 7218 Receiver Unit Technical Specifications

Specification	Value
Material	Titanium (grade 2) lid Polyurethane acoustic window
Dimensions	Height 90.7mm Length: 460.0mm Depth: 102.0mm
Weight	Air: 8.2kg Water: 3.9kg
Temperature	Operating: -2° to +36°C Storage: -30° to +55°C

The EM 7218 receiver unit mounts to the vessel or mounting bracket with four M8 screws already in place in the receiver. The cable can be arranged as needed in the grooves designed specifically for this purpose.

For ease of mounting, the ends of the housing are labeled P and S for Port and Starboard, respectively. The connector is placed on the port side.

CAUTION
Installation of unit shall ensure free access to water inlet holes (located on the starboard side) for pressure equalization.

C.7.3 TC 2181 Projector Unit (PN 85002319)

The TC 2181 projector unit operates at multiple frequencies between 200kHz and 400kHz. With the min. 200kHz frequency the unit produces a narrow beam approx. 2° along-track by 142° across-track, and with the max. 400kHz frequency a narrow beam approx. 1° along-track by 145° across-track. The entire swath is illuminated in one transmission, with the maximum ping rate of 50Hz, providing 100% bottom coverage even at high vessel speed.

NOTE
TC 2181 projectors labeled “SV2/T” are compatible with SeaBat 7125 SV2 and SeaBat T-Series Portable systems. Look for the label “SV2/T” below the part no. on the housing.

Figure 50: TC 2181 Projector Unit

Table 13: TC 2181 Projector Unit Technical Specifications

Specification	Value
Material	Titanium (grade 2) lid Epoxy acoustic window
Dimensions	Height: 86.6mm Width: 93.1mm Depth: 280.0mm
Weight	Air: 5.4kg Water: 3.4kg
Temperature	Operating: -5° to +40°C Storage: -30° to +70°C

The TC 2181 projector unit mounts to the vessel or mounting bracket with M8 Hex screws already in place in the projector. The cable can be arranged as needed in the grooves designed specifically for this purpose.

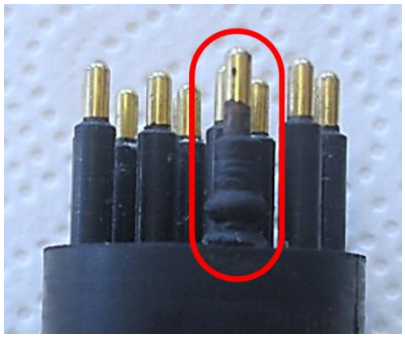
C.7.4 Wet-End Cable Connections

CAUTION

Female connectors must be lubricated at least every 5 matings to avoid damaged male connectors (as shown here).

Follow the instructions provided with the wet connector lubrication kit (see the components checklist in *appendix C.1 above*).

Noncompliance may affect warranty situation (see *Appendix L Warranty Information*).



- The cable connections to the wet-end units should be made prior to immersing the units in water.

WARNING!

The projector connection must be handled with great care as the output power voltage is hazardous to human safety.

Do **not** pull out the cables with power on.

Output voltage: $280V_{rms} \approx 800V_{p\text{-}p}$

- A light lubrication coating on the connector face will ensure sealing (see *section 2.2.2.2 Wet-End Connectors*).
- Unused connectors should be sealed with dummy plugs.
- Verify that all cables are securely fastened and that strain relief is provided to prevent cable damage.

CAUTION

Take care to avoid impact to the faces of projector and receiver units, as damage could degrade system performance.

CAUTION

To reduce the amount of radiated emission, the cables for receiver, projector, and SVP must be bundled tightly together onboard the vessel.

C.7.5 Sonar Head Assembly Orientation

The sonar head assembly should be mounted with the faces of the arrays oriented vertically downwards. Ideally, the receiver is mounted across track, while the projector is mounted along track and aft of the receiver. If necessary, the projector may be oriented forward or the head rotated away from vertical with allowances made in the processor setup and data acquisition software.

CAUTION
An alternate mounting makes the projector more susceptible to impact damage and collection of trailing debris.

- The faces of the projector and receiver must be aligned in the vertical (“Z”) plane within +/-2.0mm.
- The alignment along-ship (“Y”) plane and across-ship (“X”) plane should be within +/-250.0mm.

The actual sonar head assembly installation must be reflected in the user interface settings (see *appendix C.7.8 below* or refer to *Appendix H Reference Documentation*).

C.7.6 Sonar Reference Point

The following axis convention is applied for the sonar reference point convention:

- X = across ship, points to starboard: + Starboard
  - Port
- Y = along ship, points forward: + Forward
  - Aft
- Z = vertical, points up: + Up
  - Down

There is a single sonar reference point to which all output is related. This point is normally defined in the data acquisition software as a node or offset point. The point is in the center of the receiver face in both X and Z directions and in the center of the projector in the Y direction.

For details, refer to:

- For **T20**: *Figure 79: T20 Bracket Installation: Sonar Reference Point*.
- For **T50**: *Figure 82: T50 Bracket Installation: Sonar Reference Point*.

It is important to note that the sonar reference point may not be a physical point on the sonar system.

C.7.7 Wet-End Mounting

- Take care that the sonar head assembly is electrically isolated from the structure to avoid corrosion problems.
  - Both systems include a mounting bracket that's intended for mounting flat or via a pole on the ship's hull, or on a pole over the side. See also *appendix H.2 SeaBat T-Series Portable Design Documents*).

    T20 Bracket:
    EM 7219 receiver
    TC 2181 projector

    T50 Bracket:
    EM 7218 receiver
    TC 2181 projector

  - For straightforward positioning of the receiver, both bracket and receiver are marked with P and S for Port and Starboard, respectively.

    <u>Plane surface installation:</u>

    a) Use the 4 x Ø13.5 mounting holes to mount the bracket directly on the ship's hull or similar (T20, see *Figure 78*; T50, see *Figure 81*).

    b) Secure with 4 x M12 screws (from the inside of the bracket). Length of screws depends on each individual installation.

    c) Mount the wet-end components and secure with the screws already in place in the units.

    <u>Pole mount installation:</u>

    a) Mount the wet-end components on the bracket and secure with the screws already in place in the units.

    b) Align the holes of the pole flange with the four holes around the cable ring of the bracket (T20, see *Figure 78*; T50, see *Figure 81*).

    c) Secure with 4 x M12 screws (from the outside of the bracket). Length of screws depends on each individual installation.

CAUTION
Make sure that the screw length does not exceed 24mm from entry of bracket.

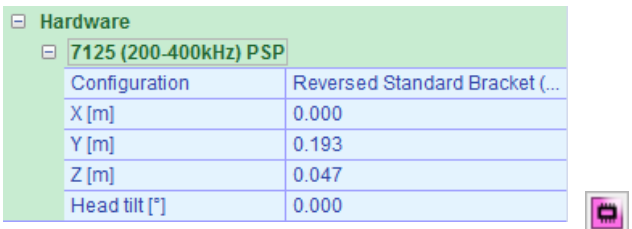
- The head should be immersed in water to a depth of at least 0.8m. This ensures that noise from surface waves and turbulence generated by the mounting structure does not degrade performance.
- Mounting on a surface vessel may be over the side, over the bow, hull mount, or through a moon pool.
- Ensure that submersion depth is sufficient to avoid shadows from the keel, hull, or other obstacles.

NOTE
Fairings can be used to improve hydrodynamic performance (see *Appendix D Hydrodynamic Drag* and *appendix H.2 SeaBat T-Series Portable Design Documents*). The sonar head is not designed to be hydrodynamic at speeds in excess of two knots. Vibration and oscillation will become evident, if the projector and receiver are not rigidly mounted. To minimize the unsupported length, place a support as close to the waterline as possible.

C.7.8 Hardware Settings

The Hardware settings controls the one-time transmit array and projector settings. These settings should be set to reflect the initial installation of your system and should not require modification unless the physical installation changes.

For instructions on navigating the user interface, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).



Click the Hardware tab to the right in the user interface to access the Hardware settings.

For details on sonar head assembly orientation, see *appendix C.7.5 above.*

Select as appropriate either one of the preset mounting bracket configurations or enter custom values.

- **Preset Configurations:**
  - Normal: To be used when the sonar head is installed with the receiver forward and projector aft, that is when the indication for port ("P") on the receiver/bracket is to the port side.
  - Reversed: To be used if the sonar head is rotated 180 degrees and the indication for port ("P") on the receiver/bracket is to the starboard side. This option reverses the beams thereby normalizing the image and the generated data output.
- **Customer Configuration:**
  - For nonstandard installations, the XYZ offset of the receiver reference point to the projector reference point must be defined. For details on reference points, see *appendix C.7.6 above*.

CAUTION
Incorrect offset settings could severely affect data quality.

- **Head Tilt:**
  - The Head tilt feature allows the user to normalize the display, gates, and bottom detect processing to reflect the physical orientation of the sonar head. For examples on how to use this feature, see *section 5.3.4 Head Tilt*.
  - The angular value is entered in degrees (+ Port up/- Port down) and must be between -45° and 45° in increments of 0.5°.

C.7.9 Dual-Head Configuration

To increase coverage, two complete sonar systems can be used. One is designated "Master" and the other "Slave". The "master" processor dictates when the "slave" sonar will cycle, and so the Range, Power, Gain, and Pulse Length settings from the "master" are mirrored on the "slave".

For details on startup, see *section 3.2 System Startup Instructions*.

NOTE
In order to assure a proper setup for both systems, it is advisable to: 1. First set up the two systems separately (See *section 3.3 Starting the Sonar User Interface*): a. First the "master". b. Then the "slave". If the IP addresses differ from the scheme in *Appendix E Network Configuration*, configure the "master" and "slave" as stated in *Table 14: IP Configuration for Master PSP* and *Table 15: IP Configuration for Slave PSP*, respectively. 2. Set up the dual-head system after having established that the two systems run without errors.

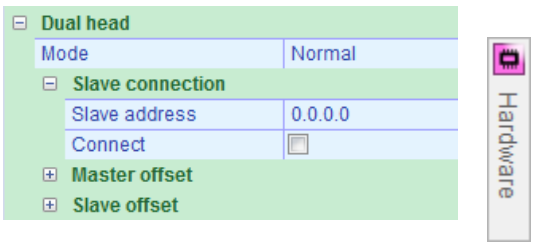
1. Hook up both systems to an Ethernet Switch with a patched Ethernet cable (for both standard dual head and FRDH[29]).
2. Connect the laptop/PC to the Ethernet Switch with an Ethernet cable.
3. Connect Trig Out on the "master" processor to Trig In on the "slave" processor with a coaxial (BNC-BNC) cable (only for FRDH; not for standard dual head).
4. Connect PPS In on the "master" processor to the GPS with a coaxial (BNC-BNC) cable.
5. Connect PPS Out on the "master" processor to PPS In on the "slave" processor with a coaxial (BNC-BNC) cable.
6. Connect Time and Motion data to the appropriate COM ports on the two processors via a RS-232 splitter box.
7. Configure the master processor:
    a. In the toolbar at the top of the user interface, select the "master" IP address from the sonar address drop-down menu.
    b. Set up attitude, time, and sound velocity in the IO Module pane.
    c. Set up roll stabilization in the Hardware pane.
    d. Set up the file storage path in the Recording pane.
    e. Set up the IP addresses according to *Table 14: IP Configuration for Master PSP*.

[29] FRDH is an optional add-on feature (see *Table 21*).

8. Configure the slave processor:
   a. In the toolbar at the top of the user interface, select the “slave” IP address from the sonar address drop-down menu.
   b. Set up time[30] in the IO Module pane.
   c. Set up roll stabilization in the Hardware pane.
   d. Set up the file storage path in the Recording pane.
   e. Set up the IP addresses according to *Table 15: IP Configuration for Slave PSP*.
9. Check that time is synchronized.
   (As some applications do not pick up time changes while running, it may be necessary to stop the applications from the 7k Control Center and restart.)

NOTE
If time synchronization is not done in this order, the embedded slave display (in the Master UI) may not update.

10. Shut down and restart UI.
11. Connect to the master processor via the sonar address drop-down menu in the toolbar.
12. Under Dual head in the Hardware pane, select the appropriate Slave IP address.



Click the Hardware tab to the right in the UI to access the Dual Head settings.

13. Select the Connect check box to start dual-head operation.

[30] Attitude and sound velocity are distributed to the ”slave” by the ”master”.

NOTE

The Slave IP address should not be the same as the Master IP address.

On delivery of a dual-head system, the IP addresses of the two Ethernet connections (item 3 in *Figure 44*) are 10.11.10.3 and 10.11.10.4 on the "slave" processor and 10.11.10.1 and 10.11.10.2 on the "master".

If you need to set up two single-head systems as dual head, you have two options:

a) Change the IP address of the "slave" system to 10.11.10.3 and 10.11.10.4.

or

b) Connect the Ethernet Switch to the **top LAN 1** port on the "master" and to the **bottom LAN 2** port on the "slave", if the IP addresses of the two single-head systems are the same as on delivery: 10.11.10.1 and 10.11.10.2.

For details on IP address configuration, see *Appendix E Network Configuration*.

For instructions on navigating the user interface, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

For examples on this feature, see *section 5.3.4.2 Pipe Inspection with Dual Head System*.

NOTE

Start the "slave" UI, if the BITE Service page on the "master" UI is green despite a red LED.

Some "slave" IO module errors are only visible on a separate "slave" UI, but will be reflected by the BITE LED.

C.8 System Check

Once the SeaBat T-Series Portable has been installed, follow these steps to ensure that the system is working properly. For information on the settings, refer to the RESON Sonar UI User Manual (*see Appendix H Reference Documentation*).

1. Press the power button on the front of the portable sonar processor; the light indicator will switch from orange to blue (see also *appendix C.4.4 above*).
2. Ensure that all system cable connections are mated properly.
3. Verify the main power is available.
4. Energize the laptop/PC.
5. Start the sonar by double-clicking the Sonar UI icon on the operator desktop and select the correct IP address in the toolbar (see also *section 3.3 Starting the Sonar User Interface*).
6. Verify that the Power setting on the Main pane is set to OFF.
7. Once the system has been energized, follow these steps to verify that the system is operating correctly:
    a. Set the Range to 150.
    b. Set Max rate (on the Advanced pane) to 4.
    c. Set the Gain to 30.
    d. Select Blue-Yellow from the Sonar Palette drop-down menu on the Display pane.
    e. Perform a receiver check by vigorously rubbing the face of the receiver unit with fingertips while monitoring the display. A noise pattern should be barely visible on the display.
    f. Gradually increase the Power setting on the Main pane while an assistant presses an ear against the projector face. Continue to increase the power until the assistant can hear pings (ticking sounds) emitting from the front of the projector to just below FULL for a very short period.
    g. Turn transmit Power to OFF as soon as possible.

CAUTION
Transmitting into air for any period of time may result in the damage of the ceramics of the projector and will result in degraded performance.

APPENDIX D HYDRODYNAMIC DRAG

Hydrodynamic drag has been determined for the T20 and T50 sonar head assemblies in brackets mounted on a short pole traveling through the water at a speed of 10 knots.

D.1 Drag Simulation Setup

- Sonar head assemblies:
  - T20 single head **with** front fairing (*Figure 52* and *Figure 53*) or **without** front fairing (*Figure 54* and *Figure 55*).
  - T20 dual head **with** front fairing (*Figure 57* and *Figure 58*) or **without** front fairing (*Figure 59* and *Figure 60*).
  - T50 single head **with** front fairing (*Figure 62* and *Figure 63*) or **without** front fairing (*Figure 64* and *Figure 65*).
  - T50 dual head **with** front fairing (*Figure 67* and *Figure 68*) or **without** front fairing (*Figure 69* and *Figure 70*)
- Pole mount: 350mm long, 100mm diameter pole attached to the mounting flange of the brackets. The pole mount itself also causes drag.
- Speed: 10 knots.
- Finite Element simulation tool: ANSYS was used to determine the drag and evaluate water flow around the sonar heads and brackets.

NOTE
Cable routing and accessory parts like a SVP or a motion sensor added to the bracket will influence drag.

D.2 Drag Simulation Conclusions

- The front fairings help reduce drag and keep a steady and clean water flow around the receiver and projector arrays. Need of fairing depends on survey and transit speed.
- The hydrodynamic drag on the system is a combination of skin friction and pressure drag. Both are within reasonable speed proportional to square of speed. With this it is possible to estimate drag figures for speeds that differ from 10 knots.
- The drag figures are relevant for a pole mount over the side, a sonar head installation through a moon pool, or a sonar head mounted on an adapter bracket under the hull of the survey vessel.
- In general, Teledyne RESON recommends the use of the optional fairing to maintain a steady water flow around the array and reduce load on the pole/bracket.

D.3 Drag Simulation Results

D.3.1 T20 Single Head Drag

Figure 52 illustrates the flow at 10 knots around the T20 single head with front fairing. The drag on the pole, sonar head, and bracket is in the region of 490N. The same situation without front fairing is shown in *Figure 54*.

Figure 51: T20 Sonar Head Assembly in Bracket with Optional Front Fairing

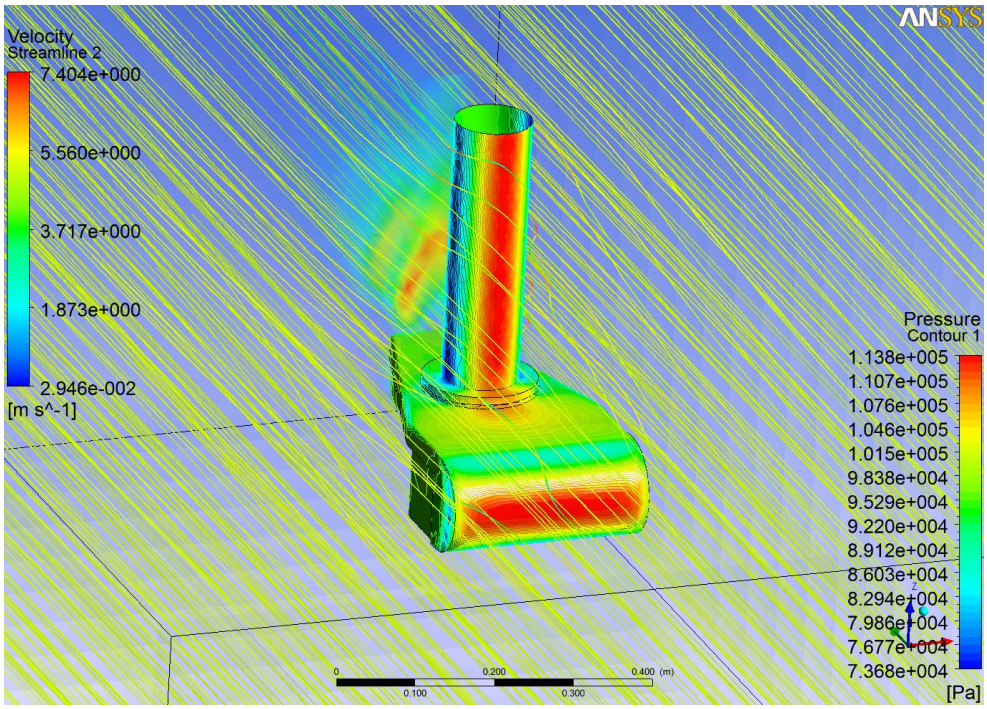


Figure 52: Flow at 10 knots around Single T20 with Fairing

Figure 53 is a cross section of the symmetry plane of the T20 single head. The front fairing and bracket assure a steady water flow around the receiver and projector. The same situation without front fairing is shown in *Figure 55*.

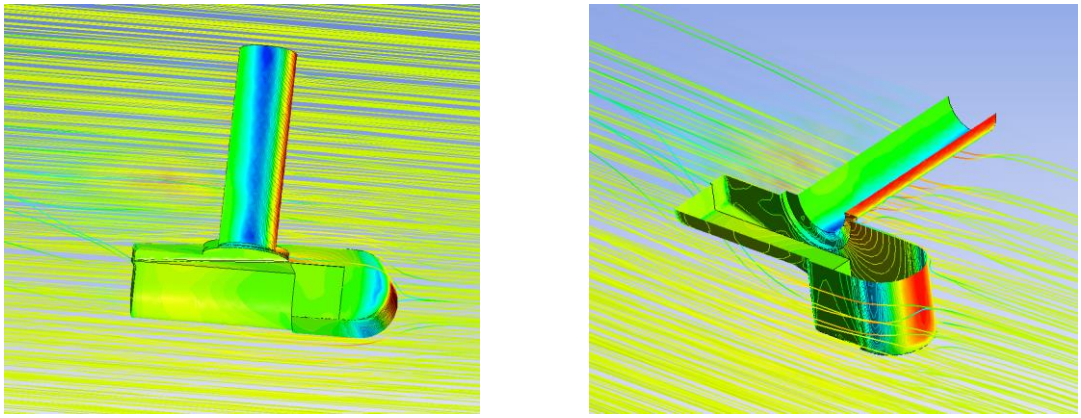


Figure 53: Flow around Single T20 with Fairing, Cross Section of Symmetry Plane

Figure 54 illustrates the flow at 10 knots around the T20 single head without front fairing. The drag on the pole, sonar head, and bracket is in the range of 650N. The same situation with front fairing is shown in *Figure 52*.

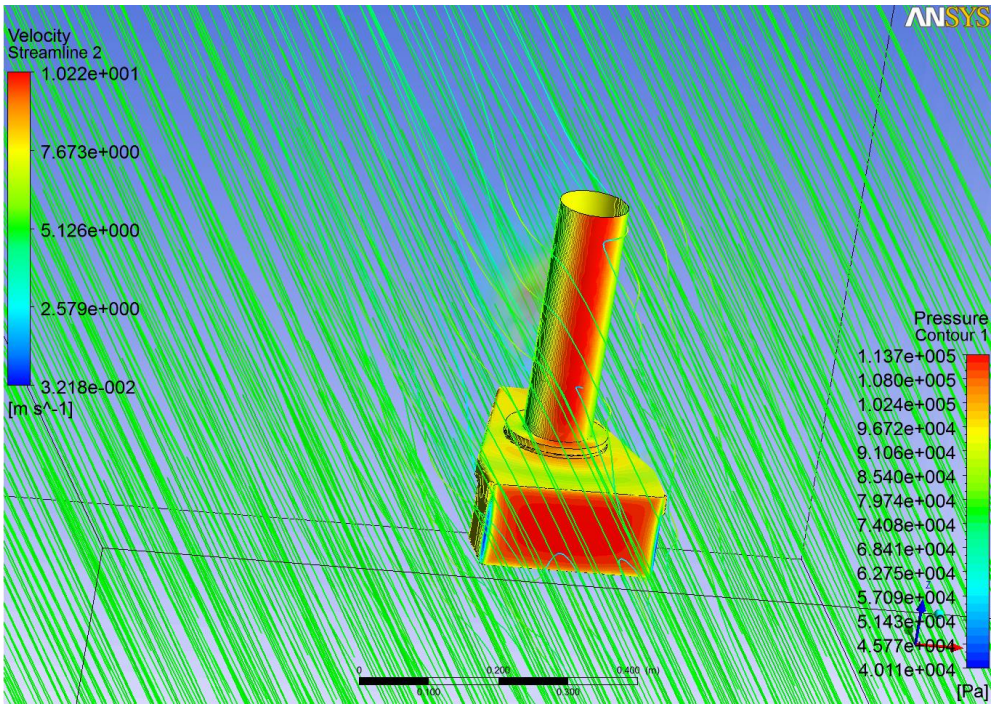


Figure 54: Flow at 10 knots around Single T20 without Fairing

Figure 55 is a cross section of the symmetry plane of the T20 single head. Without the front fairing the flow is still reasonable, but not as steady as with the fairing in front of the receiver. The same situation with front fairing is shown in *Figure 53*.

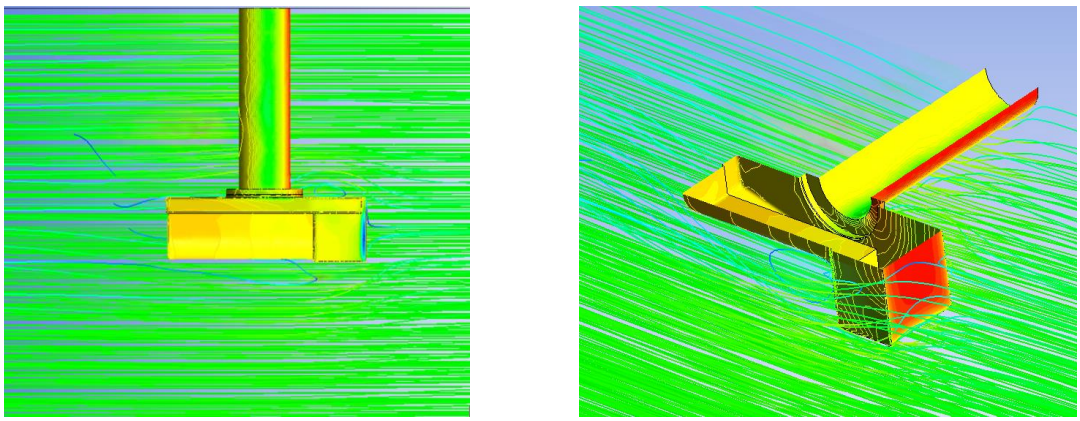


Figure 55: Flow around Single T20 without Fairing, Cross Section of Symmetry Plane

D.3.2 T20 Dual Head Drag

Figure 57 illustrates the flow at 10 knots around the T20 dual head with front fairings. The drag on the pole, sonar heads, and bracket is in the region of 1100N.
The same situation without front fairings is shown in *Figure 59*.

Figure 56: T20 Dual Sonar Head Assembly in Bracket with Optional Front Fairing

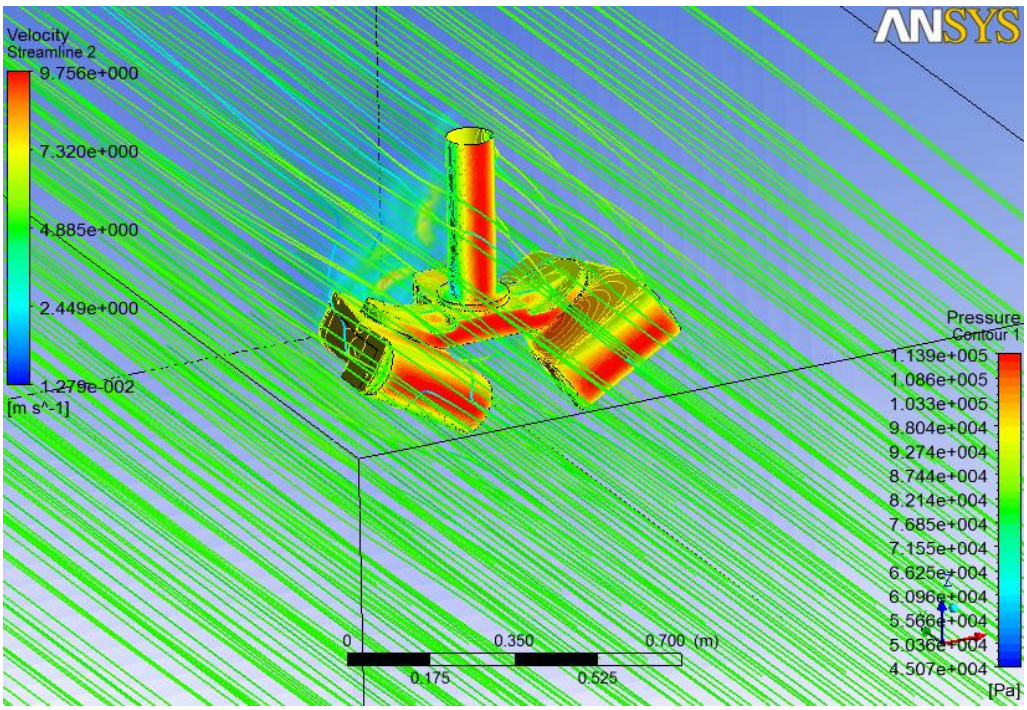


Figure 57: Flow at 10 knots around Dual T20 with Fairings

Figure 58 is a cross section of the symmetry plane of the T20 dual head. The front fairings and bracket assure a steady water flow around the receivers and projectors. The same situation without front fairings is shown in *Figure 60*.

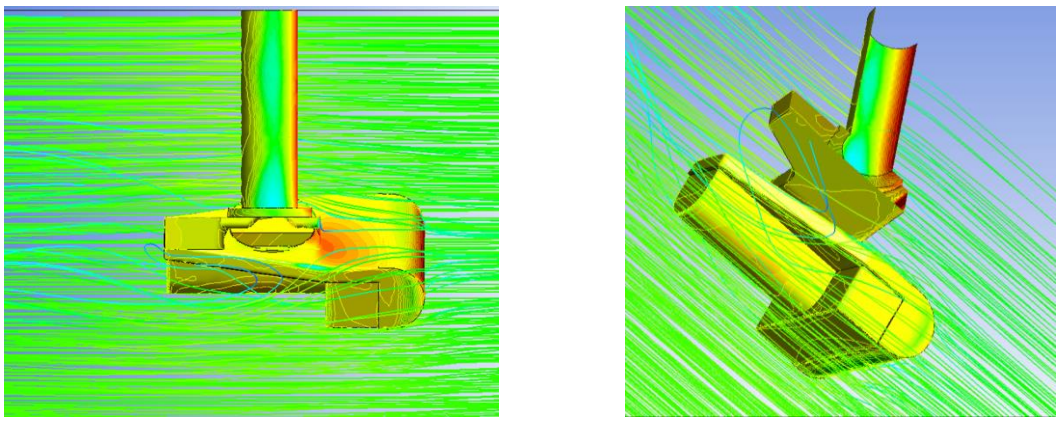


Figure 58: Flow around Dual T20 with Fairings, Cross Section of Symmetry Plane

Figure 59 illustrates the flow at 10 knots around the T20 dual head without front fairings. The drag on the pole, sonar heads, and bracket is in the region of 1550N. The same situation with front fairings is shown in *Figure 57*.

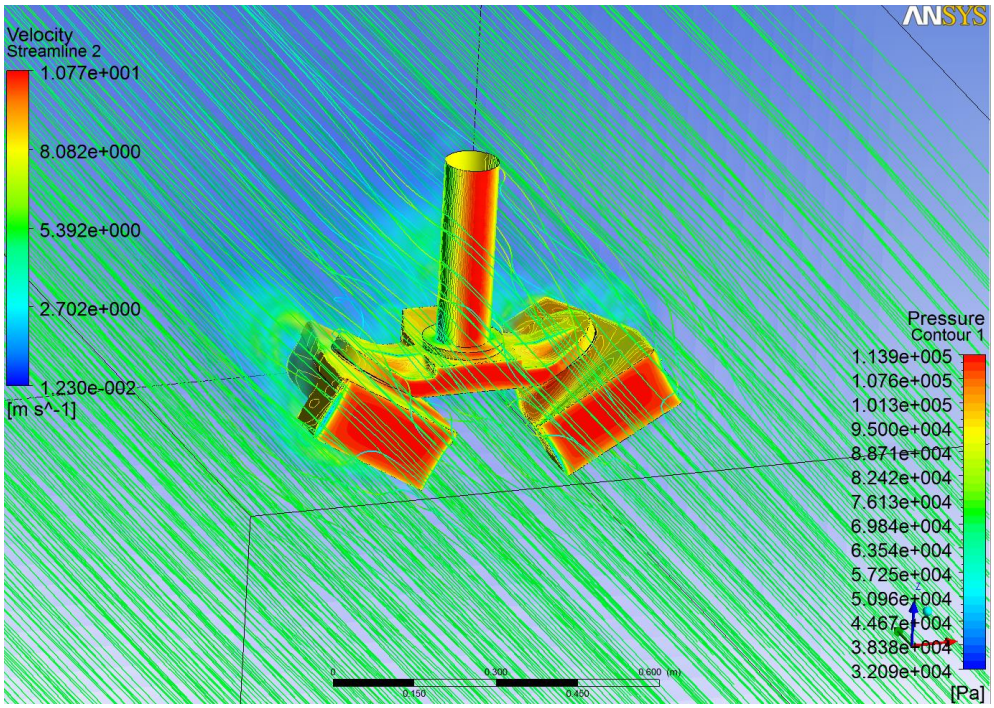


Figure 59: Flow at 10 knots around Dual T20 without Fairings

Figure 60 is a cross section of the symmetry plane of the T20 dual head. Without the front fairings the flow is still reasonable, but not as steady as with the fairings in front of the receivers. The same situation with front fairings is shown in *Figure 58*.

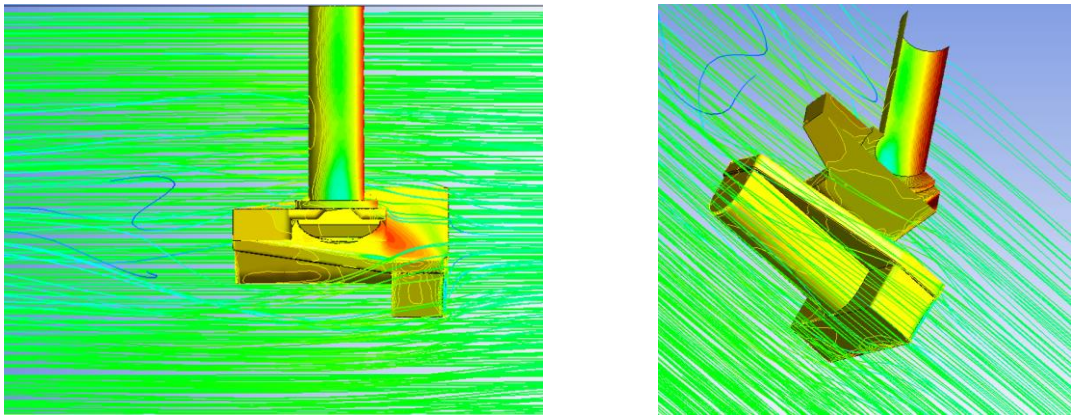


Figure 60: Flow around Dual T20 without Fairings, Cross Section of Symmetry Plane

D.3.3 T50 Single Head Drag

Figure 62 illustrates the flow at 10 knots around the T50 single head with front fairing. The drag on the pole, sonar head, and bracket is in the region of 650N.
The same situation without front fairing is shown in *Figure 64*.

Figure 61: T50 Sonar Head Assembly in Bracket with Optional Front Fairing

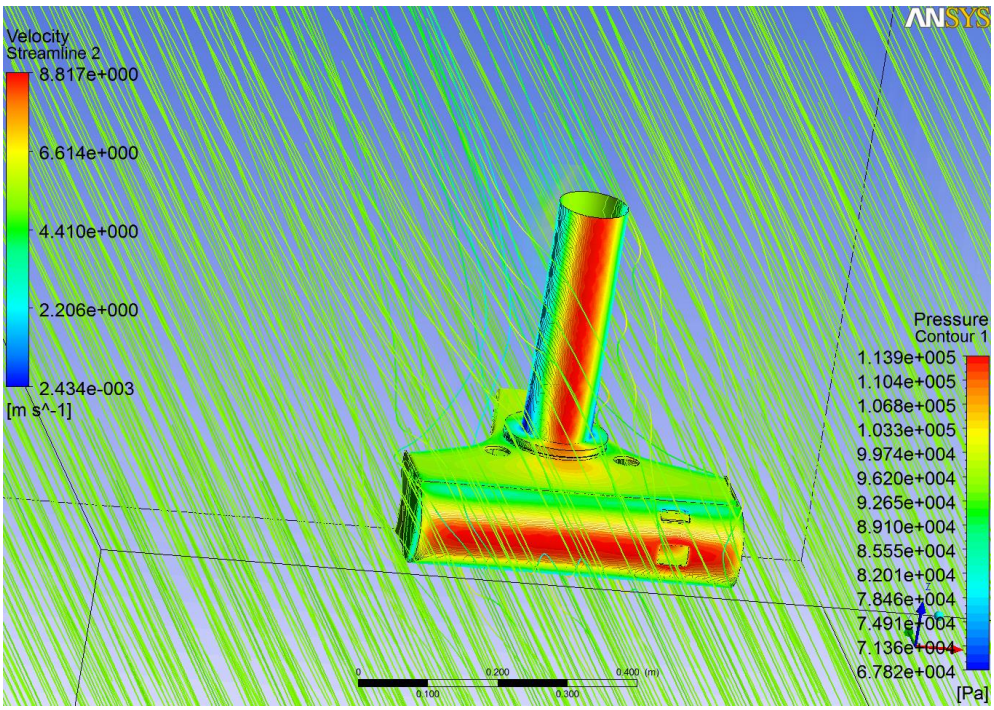


Figure 62: Flow at 10 knots around Single T50 with Fairing

Figure 63 is a cross section of the symmetry plane of the T50 single head. The front fairing and bracket assure a steady water flow around the receiver and projector. The same situation without front fairing is shown in *Figure 65*.

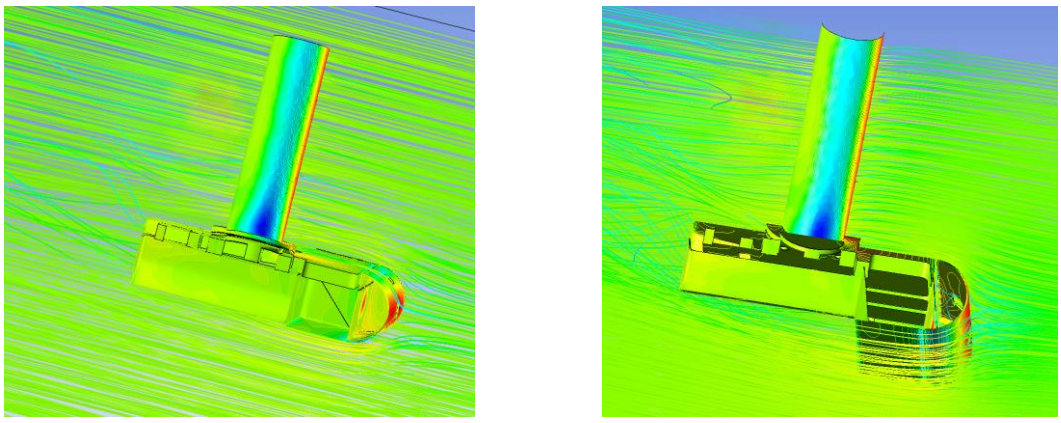


Figure 63: Flow around Single T50 with Fairing, Cross Section of Symmetry Plane

Figure 64 illustrates the flow at 10 knots around the T50 single head without front fairing. The drag on the pole, sonar head, and bracket is in the region of 1000N. The same situation without front fairing is shown in *Figure 62*.

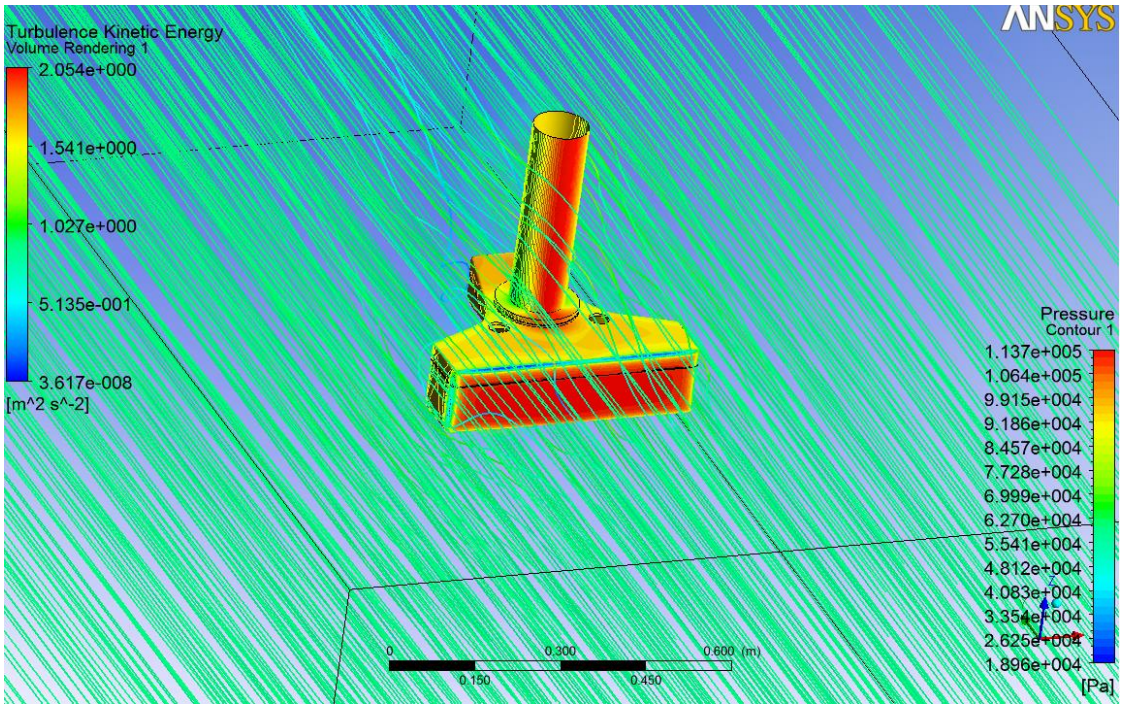


Figure 64: Flow at 10 knots around Single T50 without Fairing

Figure 65 is a cross section of the symmetry plane of the T50 single head. Without the front fairing the flow is still reasonable, but not as steady as with the fairing in front of the receiver. The same situation with front fairing is shown in *Figure 63*.

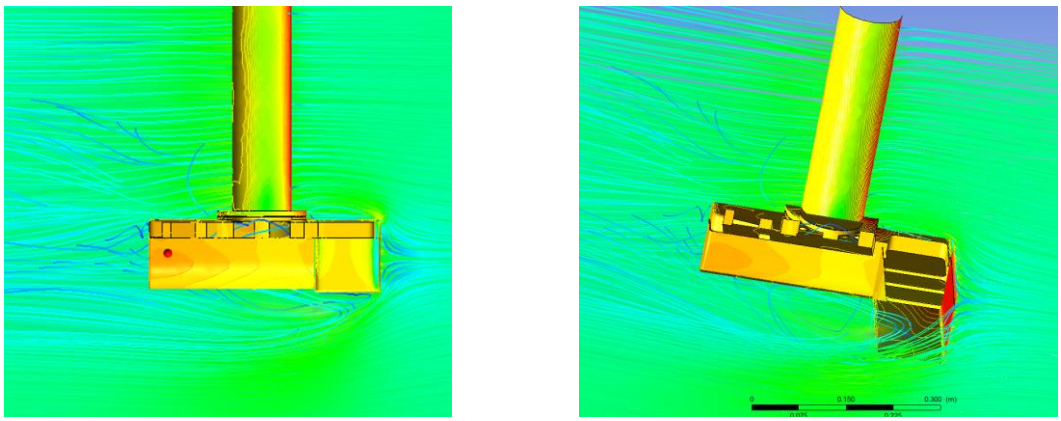


Figure 65: Flow around Single T50 without Fairing, Cross Section of Symmetry Plane

D.3.4 T50 Dual Head Drag

Figure 67 illustrates the flow at 10 knots around the T50 dual head with front fairings. The drag on the pole, sonar heads, and bracket is in the region of 1530N.
The same situation without front fairings is shown in *Figure 69*.

Figure 66: T50 Dual Sonar Head Assembly in Bracket with Optional Front Fairing

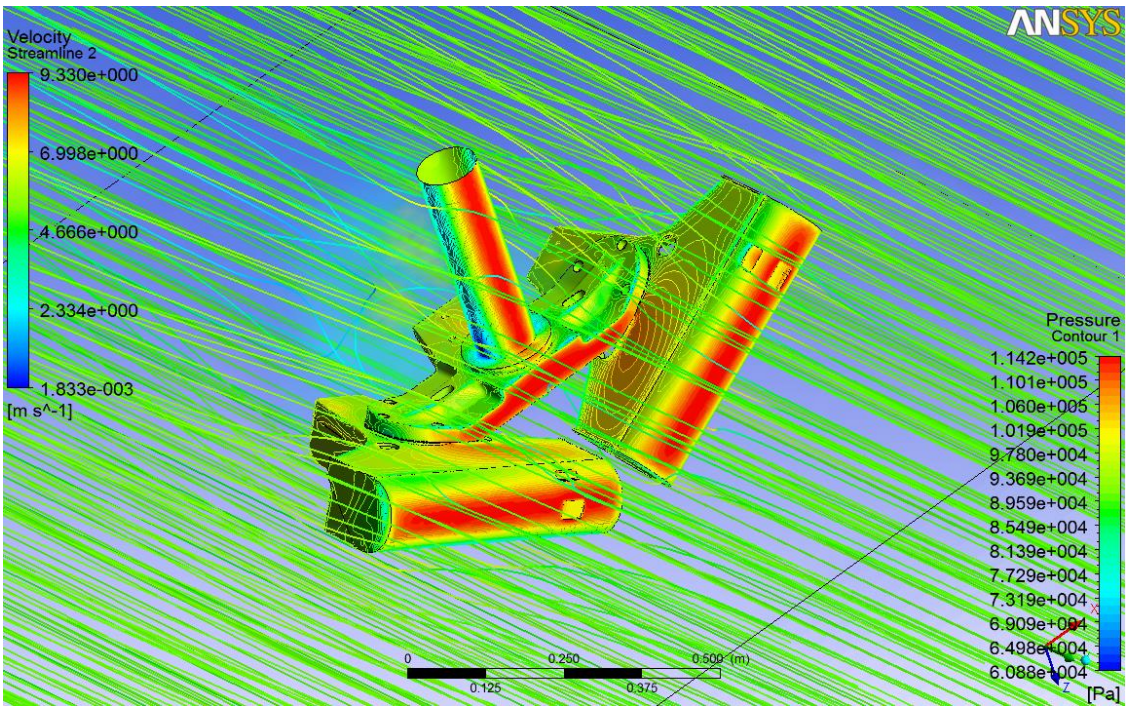


Figure 67: Flow at 10 knots around Dual T50 with Fairings

Figure 68 is a cross section of the symmetry plane of the T50 dual head. The front fairings and bracket assure a steady water flow around the receivers and projectors. The same situation without front fairings is shown in *Figure 70*.

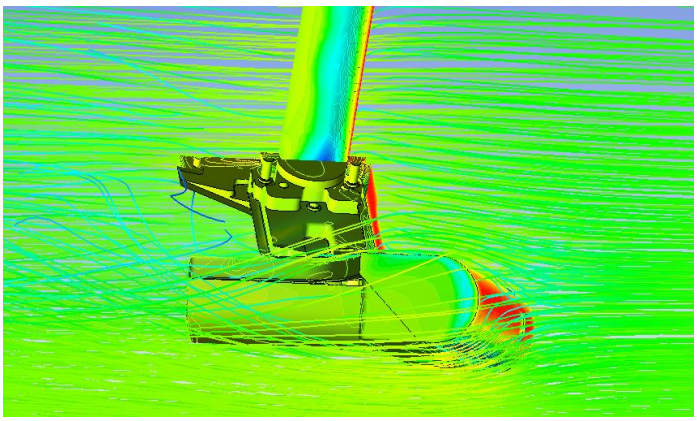


Figure 68: Flow around Dual T50 with Fairings, Cross Section of Symmetry Plane

Figure 69 illustrates the flow at 10 knots around the T50 dual head without front fairings. The drag on the pole, sonar heads, and bracket is in the region of 2250N. The same situation with front fairings is shown in *Figure 67*.

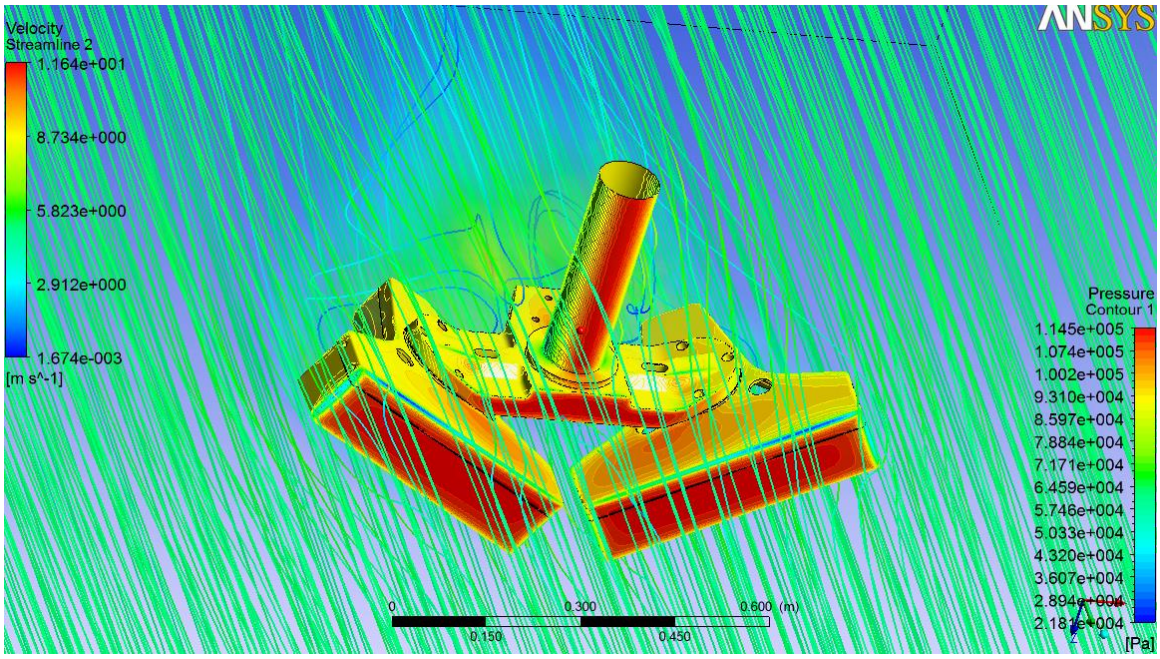


Figure 69: Flow at 10 knots around Dual T50 without Fairings

Figure 70 is a cross section of the symmetry plane of the T50 dual head. Without the front fairings the flow is still reasonable, but not as steady as with the fairings in front of the receivers. The same situation with front fairings is shown in *Figure 68*.

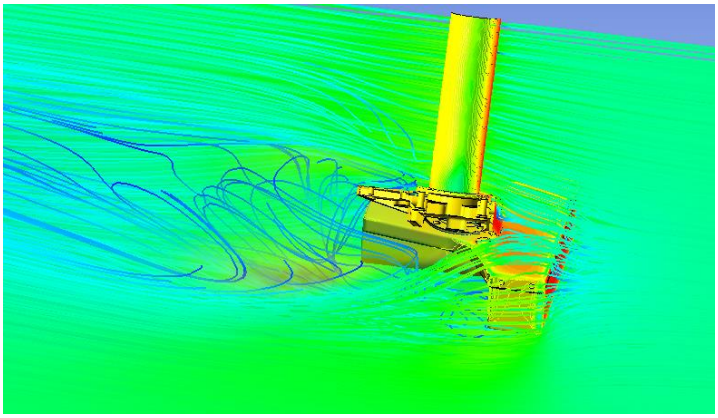


Figure 70: Flow around Dual T50 without Fairings, Cross Section of Symmetry Plane

APPENDIX E NETWORK CONFIGURATION

E.1 Single-Head System Network Configuration

The Portable Sonar Processor (PSP) is at delivery configured as follows:

Table 14: IP Configuration for Master PSP

Network port	LAN 1	LAN 2
IP address	10.11.10.1	10.11.10.2
Subnet mask	255.255.255.0	255.255.255.0

The CFE laptop/PC which runs the SeaBat User Interface (SUI) should in standard (single-head) systems be configured in the IP range 10.11.10.3-10.11.10.255 in the same subnet as the PSP.

E.2 Dual-Head System Network Configuration

For PSPs delivered as part of a dual-head system, the master processor is configured as stated in *Table 14*, and the Slave processor as stated in *Table 15*.

Table 15: IP Configuration for Slave PSP

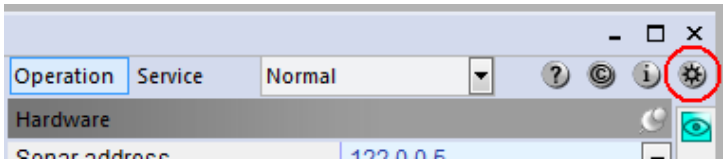
Network port	LAN 1	LAN 2
IP address	10.11.10.3	10.11.10.4
Subnet mask	255.255.255.0	255.255.255.0

The CFE laptop/PC which runs the SUI should in dual-head systems be configured in the IP range 10.11.10.5-10.11.10.255.

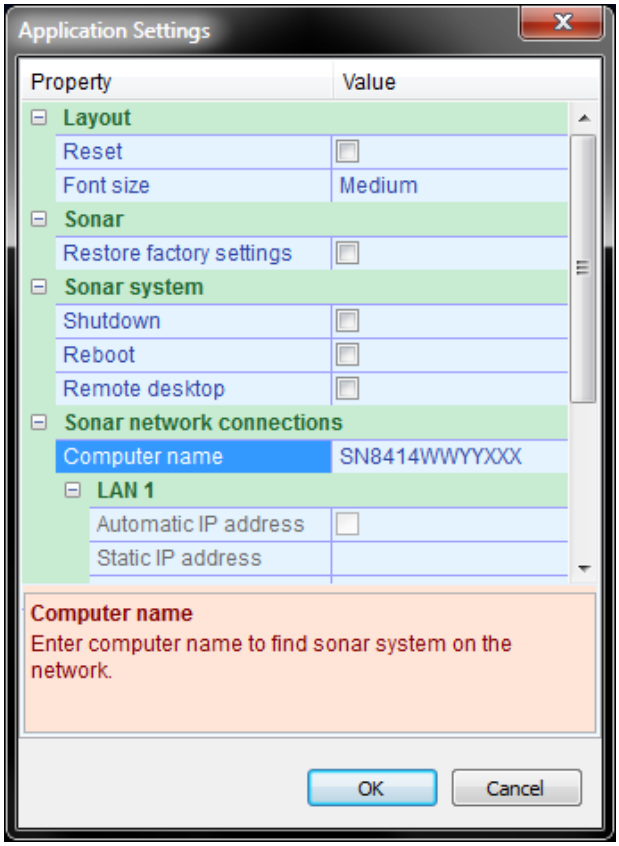
E.3 Change IP Configuration

The IP configuration can be changed from the SUI installed on the laptop/PC:

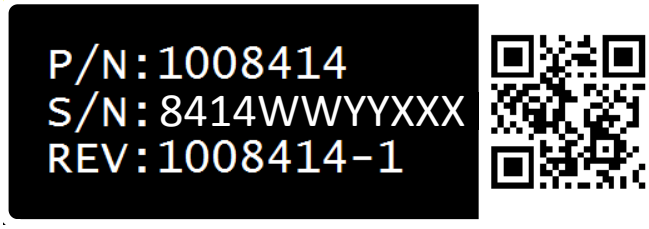
1. Click the Application Settings button in the top right corner of the Sonar UI.



2. Unfold the Sonar network connections setting.
3. If the connection has been established, the Computer name is already stated; if not, enter SN+serial number of the PSP.

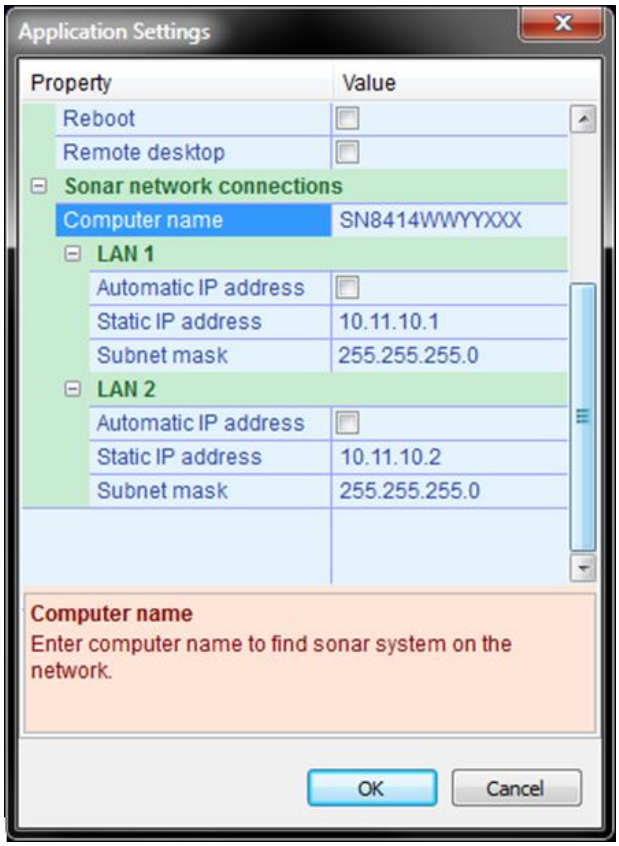


Please find the serial number on the front label on the PSP.



4. Press Enter on the keyboard.

   After a few seconds the Configuration of LAN 1 and LAN 2 will be populated.



   <u>Manual or automatic configuration of LAN 1 and LAN 2:</u>

   Both LAN 1 and LAN 2 can be configured to obtain a manual fixed IP address or an IP address automatically from a DHCP (Dynamic Host Configuration Protocol) server.

   a. The manual fixed IP setting is freely configurable for LAN 1, but for LAN 2 the range is limited to 10.11.10.2 to 10.11.10.9 with subnet mask 255.255.255.0.

      If the IP for LAN 2 is configured outside this range it will revert to 10.11.10.2 with subnet mask 255.255.255.0 after the next reboot of the PSP.

      The factory default setting is 10.11.10.1 for LAN 1 and 10.11.10.2 for LAN 2, each with subnet mask 255.255.255.0.

   b. If Automatic IP address is selected, the PSP will request an IP from a DHCP on the network; if none is given, it will revert to alternative IP addresses, 10.11.10.1 for LAN 1 and 10.11.10.2 for LAN 2. The timeout before reverting is up to 1m30s.

5. After configuring the desired IP addresses click OK.

NOTE
If you change the IP addresses (within the same subnet), the connection to the PSP will be lost. Shut down the UI and restart to re-establish the connection.

NOTE
The connection from the SUI to the PSP will be lost if the PSP moves to another SUBNET than the one the laptop/PC is located on. In that case, change the laptop/PC IP address to a valid IP address within the same subnet, and restart the SUI, and establish connection as described in *section 3 System Startup and Shutdown*.

NOTE
The outlined procedure should work even with an IP address configured in another subnet. In the event of a problem, connect a cable directly between the LAN 2 port on the PSP and the laptop/PC, change the laptop/PC to IP address 10.11.10.10 with subnet 255.255.255.0, and restart the SUI. It might be necessary to reboot the laptop/PC as well.

APPENDIX F PPS IN AND TRIGGER IN

F.1 Electrical Specifications for PPS In and Trigger In

Table 16: PPS In and Trigger In Signals[31]

Parameter	Min.	Typical	Max.	Unit	Note
Absolute maximum[32] signal voltage	15			V	
Absolute maximum reverse signal voltage			-1	V	
Low voltage threshold	1	1.6		V	
High voltage threshold		1.6	1.8	V	
Input current (high) @2V @3V @5V @15V		 7 8 10 20		 mA mA mA mA	
Input current (low[33])		0			
Input delay		400	1000	ns	Pulse 0V to 2V, 50 Ohm

[31] Measured at the BNC terminals.
[32] Voltages beyond maximum limits may cause permanent damage to the input.
[33] Completely unconnected input guaranteed to be low.

F.2 Typical PPS In and Trigger Performance

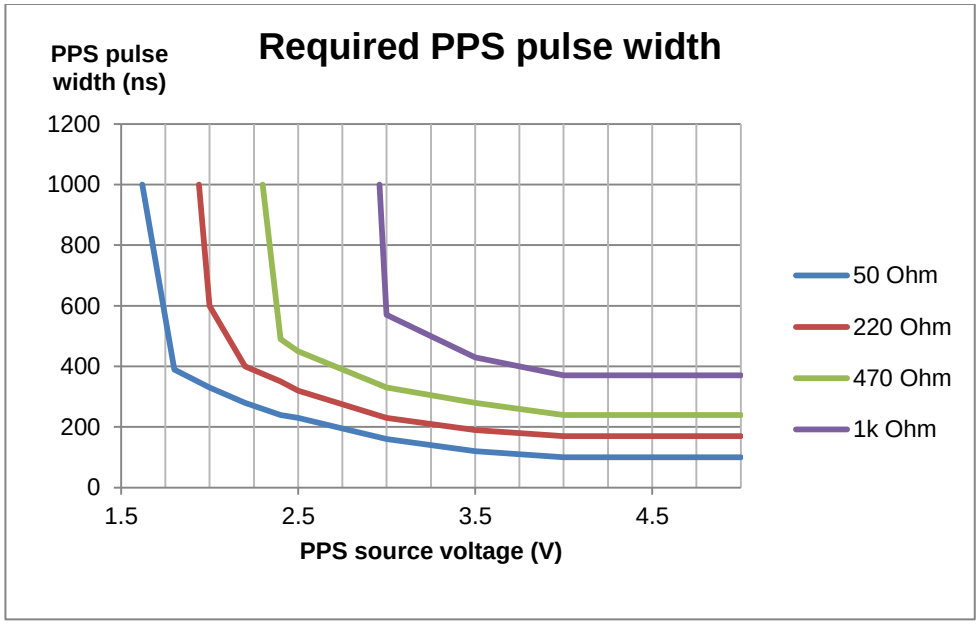


Figure 71: Required PPS Pulse Width

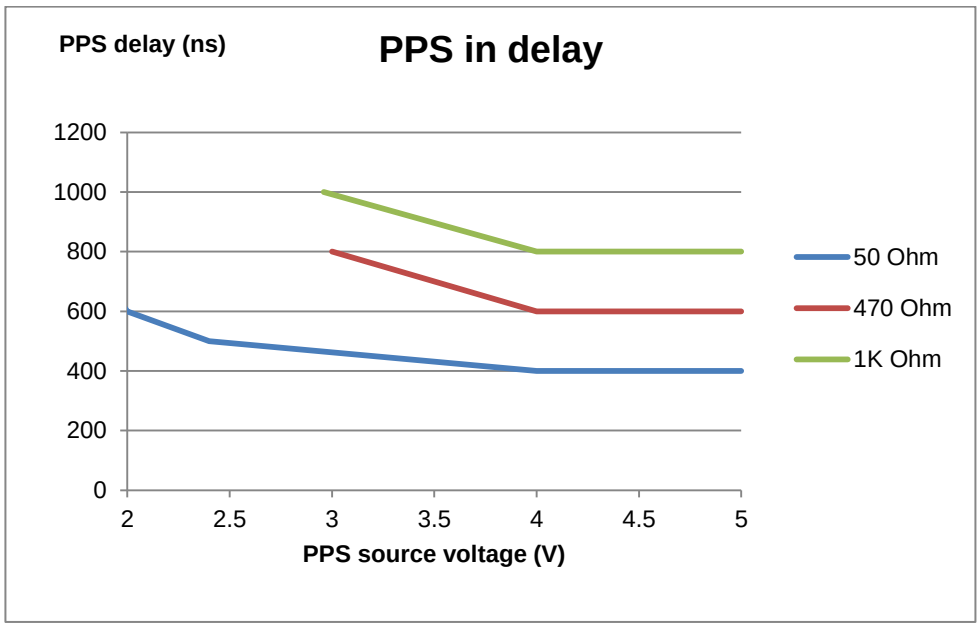
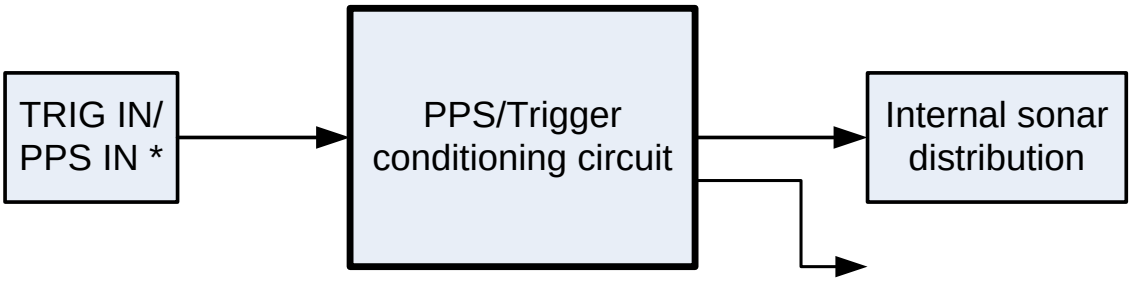


Figure 72: PPS In Delay

F.3 Hints and Advice

- The PPS and trigger inputs work with regular CMOS TTL outputs.
- The drive capability of a standard TTL output is inadequate to drive PPS and trigger high.
- When more systems use the same PPS source using BNC-T-adaptors it should be verified that its drive capability is sufficient.
- For distribution of the PPS pulse, "PPS out" may be used instead of the BNC-T-adaptor.
- Make sure the PPS source output is in accordance with the specifications listed in *Table 16*.
- Operation is ensured if the source resistance is less than 470 Ohm, the drive voltage is greater than 3V, **and** the pulse width is greater than 1µs.

The PPS/trigger described is the externally available signal. The signal is conditioned before it is internally distributed.



* The TRIG IN//PPS IN (or 1PPS) ports are clearly marked on the rear panel of the sonar processor.

Figure 73: PPS/Trigger Signal

NOTE
The pulse width reported by the IO module is NOT the pulse width of the incoming signal at the TRIG IN/PPS IN[34] ports.

[34] The “PPS IN” connection may also be called “1PPS”.

APPENDIX G INTERFACING SENSORS TO TELEDYNE PDS

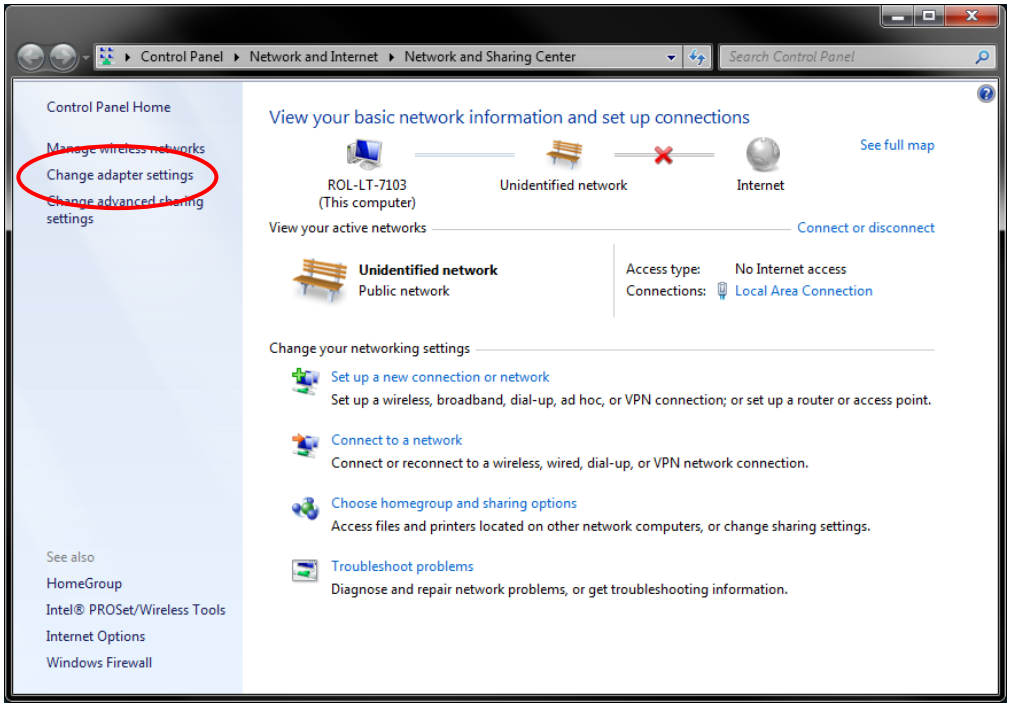
G.1 Establishing a Connection to the PSP

1. Connect the laptop/PC to the Portable Sonar Processor (PSP) using an Ethernet cable. The cable should be connected to the LAN 1 or LAN 2 port of the PSP, or through a switch.
2. Ensure that the IP address of the PSP is on the same range as the address of the acquisition laptop/PC.

   For example, if 10.11.10.2 is assigned to the PSP, the laptop/PC should use 10.11.10.3. Both systems should use the same subnet mask.

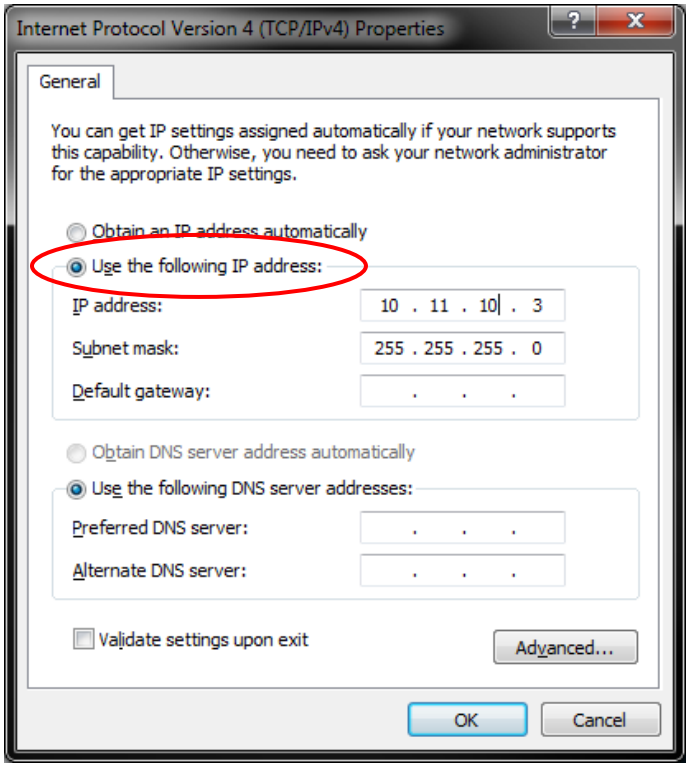
NOTE
If the PSP is configured to acquire an automatic IP address (assigned by a DHCP server), but fails, the two Ethernet ports will revert to the static IP addresses 10.11.10.1 (LAN 1) and 10.11.10.2 (LAN 2), both with subnet mask 255.255.255.0, after typically up to 1m30s of trying to acquire DHCP contact (see also *Appendix E Network Configuration*).

3. To assign an IP address to the laptop/PC, navigate to Control Center > Network and Internet > Network and Sharing Center.
4. Select Change adapter settings in the navigation pane.

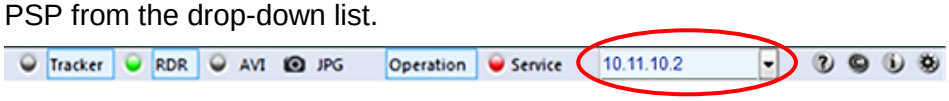


5. Open the Local Area Connection.
6. Select Properties.
7. Select Internet Protocol Version 4 (TCP/IPv4).

8. Select Properties.



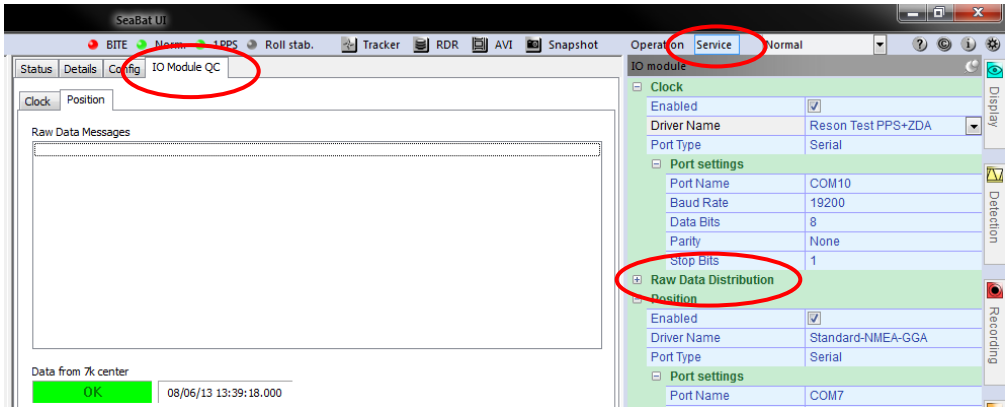
9. Select Use the following IP address and configure the IP address and subnet mask accordingly.
10. Start the PSP.
11. Launch the Sonar UI on the acquisition laptop/PC.
12. In the toolbar at the top of the user interface, select the IP address of the PSP from the drop-down list.



G.2 Interfacing to Teledyne PDS

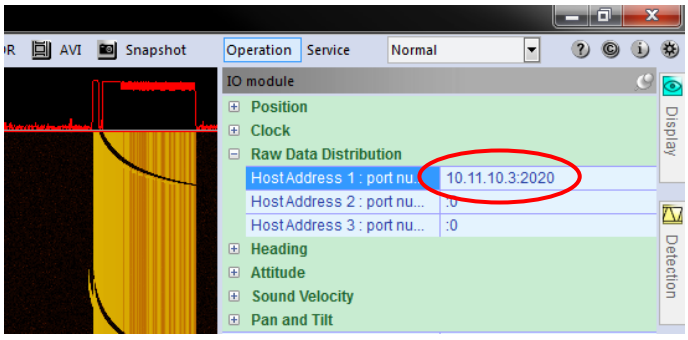
G.2.1 Configuring the Sonar UI to Output Data

1. Configure the sonar's supporting sensors (Clock, Position, Sound Velocity, etc.) in the I/O Module tab.
2. From the Service menu, select the IO Module QC tab to verify that all sensors are interfaced correctly.



3. Expand the Raw Data Distribution options.
4. Enter the IP address of the laptop/PC and define a Base Port Number.

   The Base Port Number can be any number, e.g. 2020.

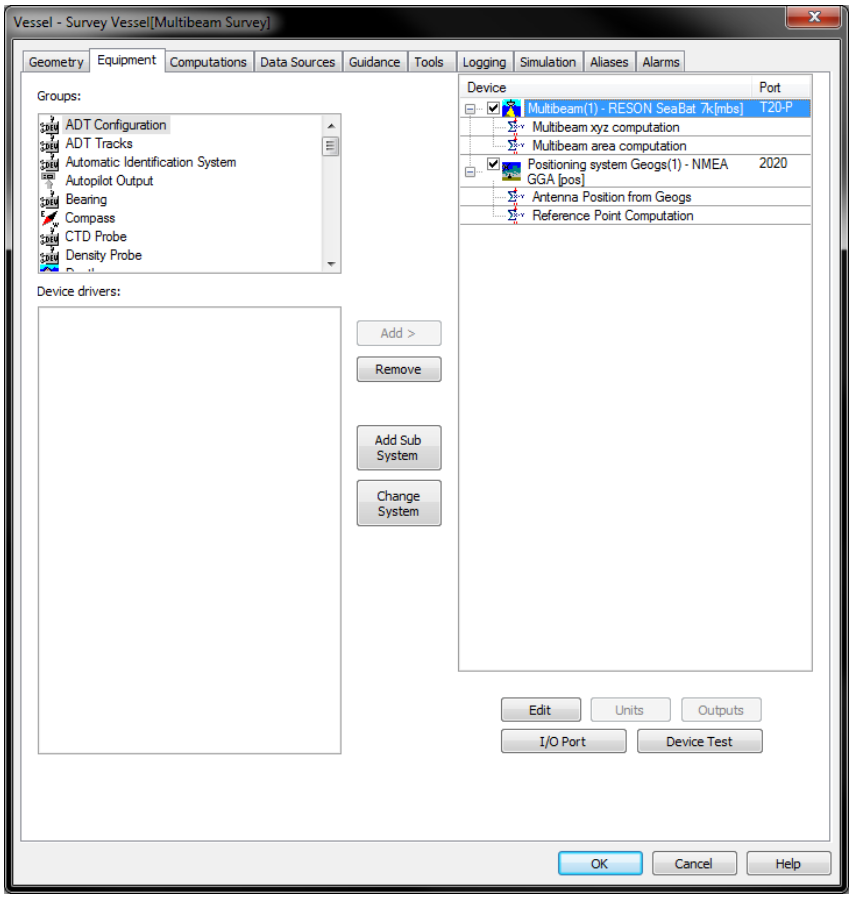


5. The Base Port Number automatically determines the port numbers of all other sensors:

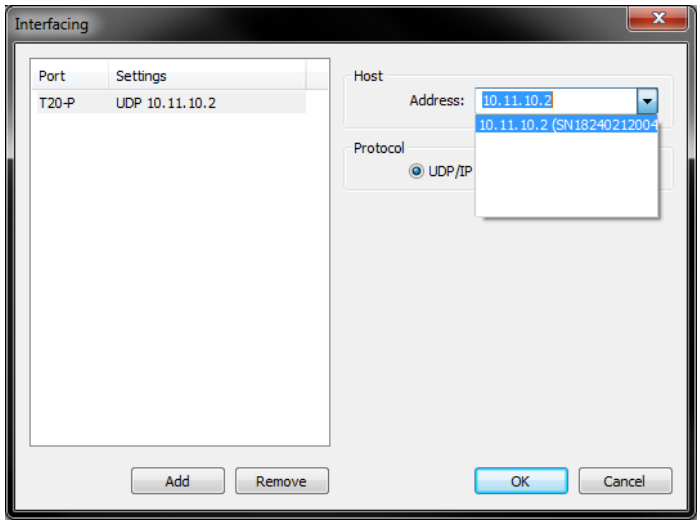
Device ID	Port number	Example
VRU	Base port number	2020
Positioning System	Base port number + 2	2022
Compass	Base port number + 4	2024
Sound Velocity	Base port number + 6	2026
External Clock	Base port number + 8	2028
Pan and Tilt	Base port number + 10	2030

G.2.2 Configuring Teledyne PDS

1. Open your project in Teledyne PDS Control Center and go to Vessel Configuration > Equipment.
2. Add a Multibeam Device and click the I/O Port button.

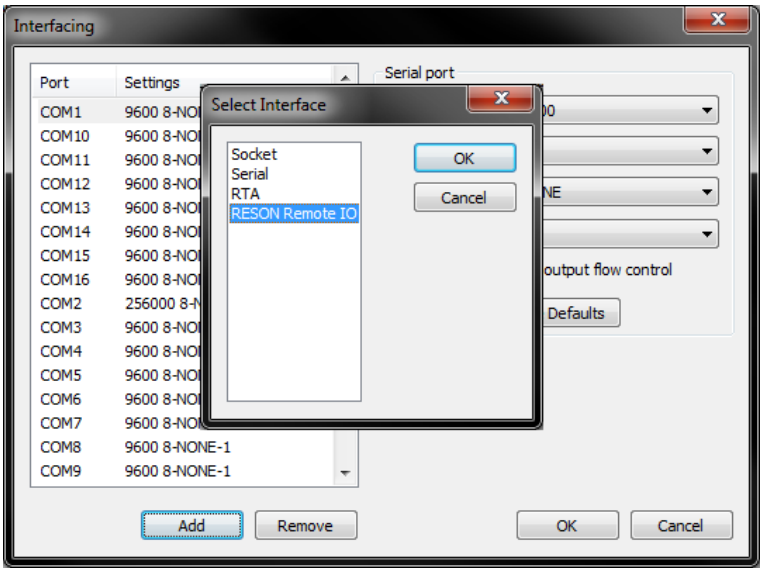


a. Add a New Network Port and give it a name (e.g. T20-P).

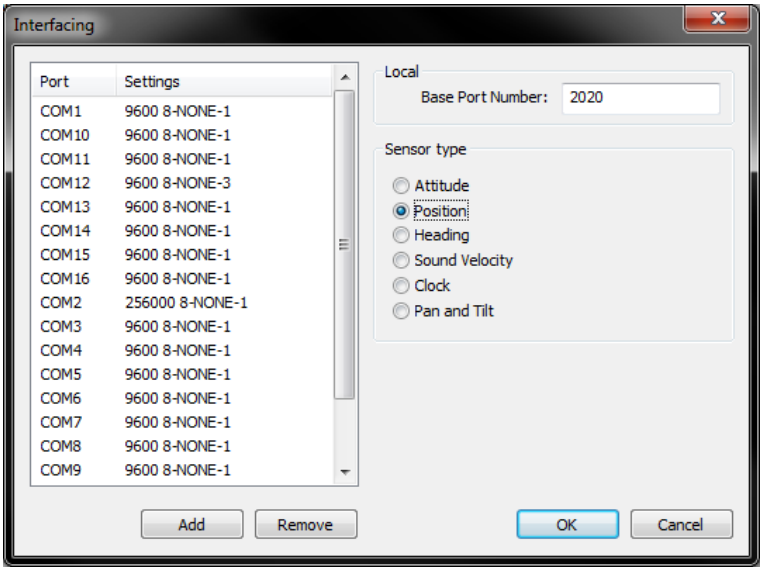


b. Then enter the IP address of the PSP (10.11.10.2 in this example).

3. Similarly, add a Positioning sensor and click the I/O Port button.
   a. Add a New Network Port and select the RESON Remote IO option.

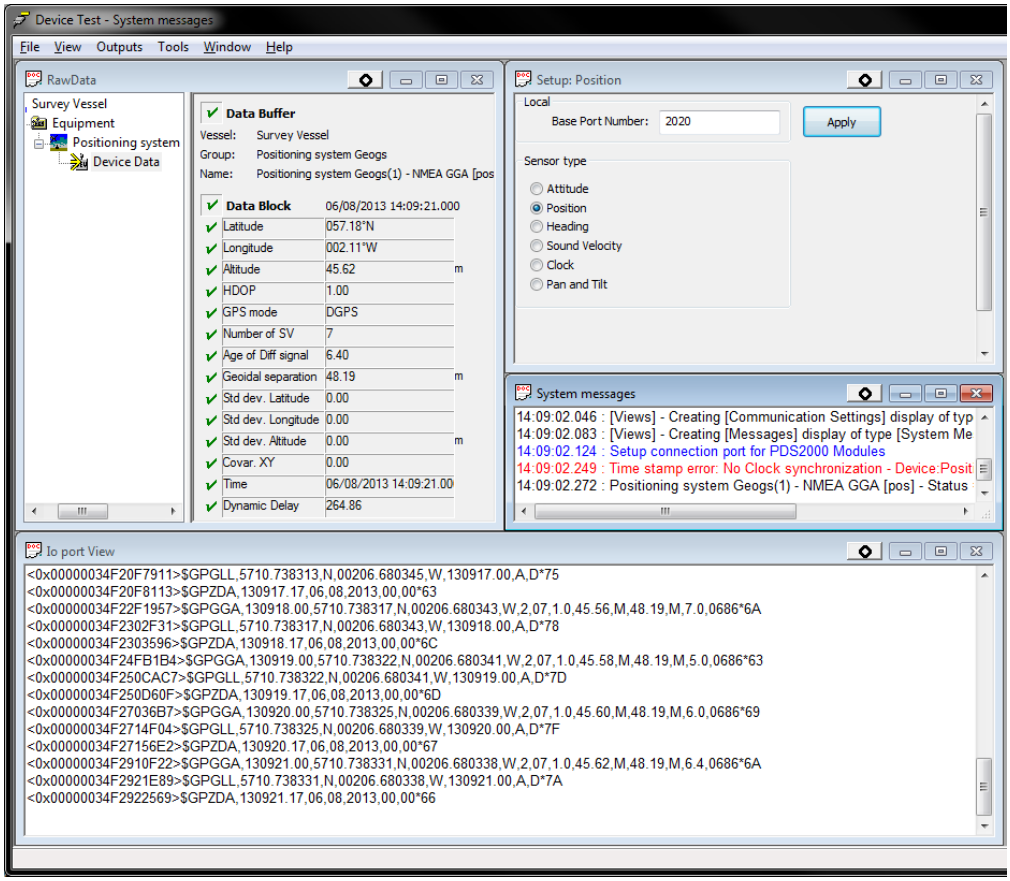


   b. Give it a name (e.g. Position) and select Position as the Sensor type.



   Ensure that 2020 is entered as the Base Port Number. The Base Port Number must match the Base Port Number defined in the Sonar UI Raw Data Distribution setting (see *appendix G.2.1 above*).

4. Test both devices to ensure that that valid data is being transferred,



5. Repeat Step 3 for any additional supporting sensors, e.g. Attitude and Compass.

NOTE
For further information on Teledyne PDS, please refer to the appropriate manual or http://www.teledyne-pds.com/.

APPENDIX H REFERENCE DOCUMENTATION

H.1 SeaBat T-Series Portable Documentation

In addition to this document, the following SeaBat documentation is available in Adobe Portable Document Format (.pdf) for printing.

Document Title	Document Number	Document Description
SeaBat T-Series Portable Operator's Manual	OM15320	Version 6 or higher
SeaBat T-Series Portable Quick Reference Guide	QG15321	Version 4 or higher
Sonar UI User Manual	OM14950	Version 1.0.6 or higher
Data Format Definition Document	11542	Version 2.22 or higher

Each system contains a link in the Start menu to system documentation (as shown in the example in *Figure 74*).

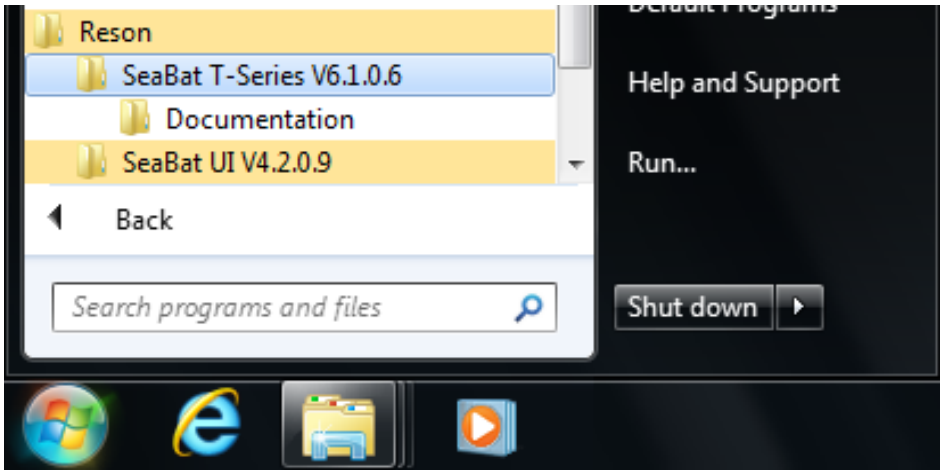


Figure 74: System Documentation Link (Example Only)

H.2 SeaBat T-Series Portable Design Documents

The following design documents and drawings are provided for reference purposes.

Document Title	Document Number
Receiver, EM7219, Outline (for T20 system)	85002436M011
Receiver, EM7218, Outline (for T50 system)	85002409M011
Projector, TC 2181 Outline	85002319M011
Mounting bracket standard, EM7219, TC2181 (installation drawing)	85160031M011
Sonar reference point, T20 Std Bracket	85160031M021
T20 sonar head with bracket and fairing	85160041M011
Mounting bracket standard, T50, Outline (EM7218/TC2181 installation drawing)	85160033M011
Sonar reference point, T50 Std bracket	85160033M021
Fairing add-on, T50, Outline	85160040M011
Mounting bracket, T20 dual head, Outline	85160032M011
Sonar reference point, T20 Dual head bracket	85160032M021
Mounting bracket, T20 dual head, Outline with fairing	85160032M031
Mounting bracket, T50 dual head, Outline	85160035M011
Sonar reference point, T50 Dual head bracket	85160035M021
Mounting bracket, T50 dual head, Outline with fairing	85160035M031
DC Supply Cable	PARTD15304
CABLE ASSY, Conf., Power + GB ethernet, Xm, DIL13F, FISCHER SS105A110, With Lubrication and Dummy Plug	PARTD15415
Cable Assembly, Transceiver to DF Transmitter	85002228B011
Cable Assembly, SVP70 to Transceiver	85002222B011
Cable Assembly, SVP71 to Transceiver	85002225B011

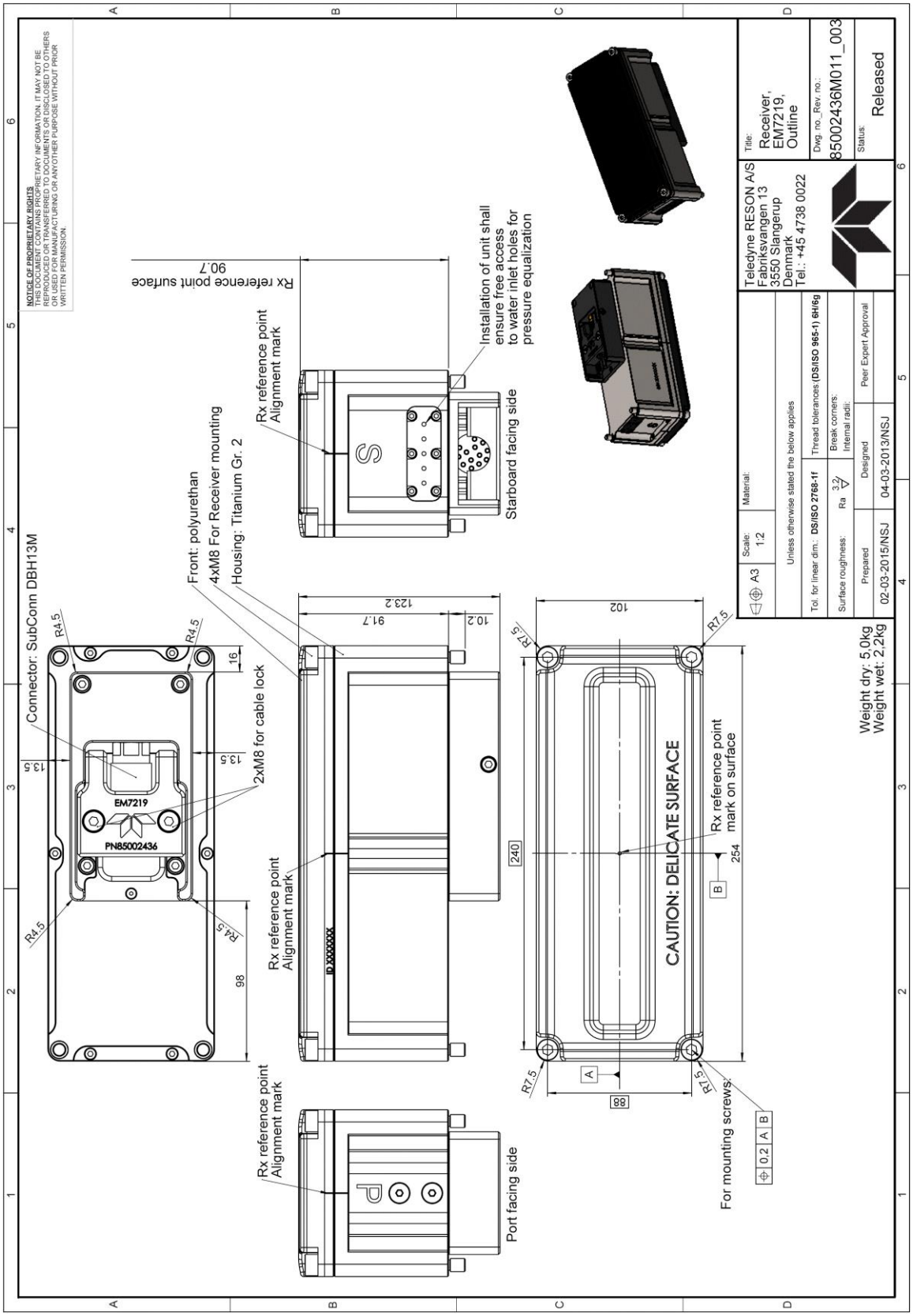


Figure 75: Receiver, EM 7219 Outline Drawing

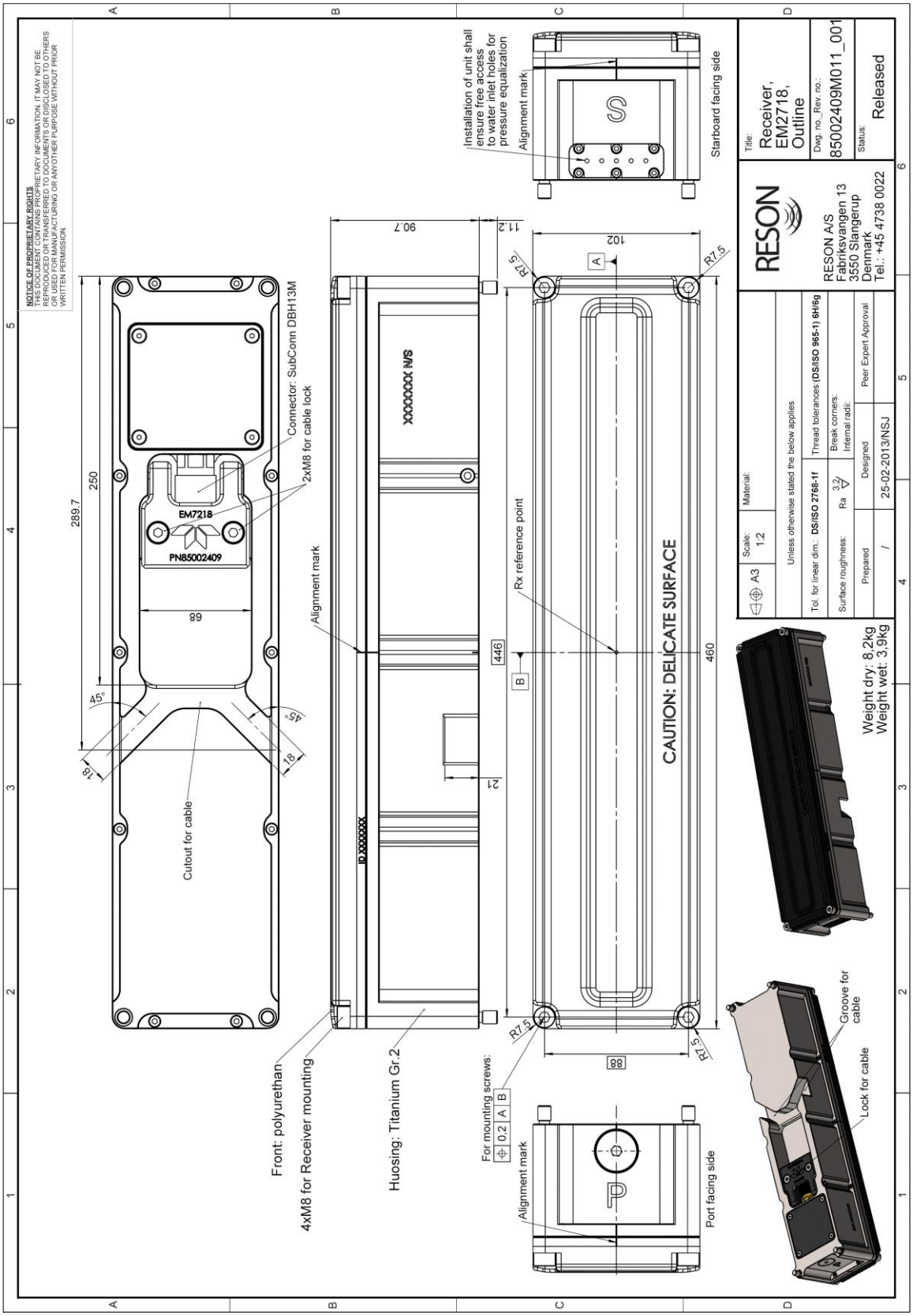


Figure 76: Receiver, EM 7218 Outline Drawing

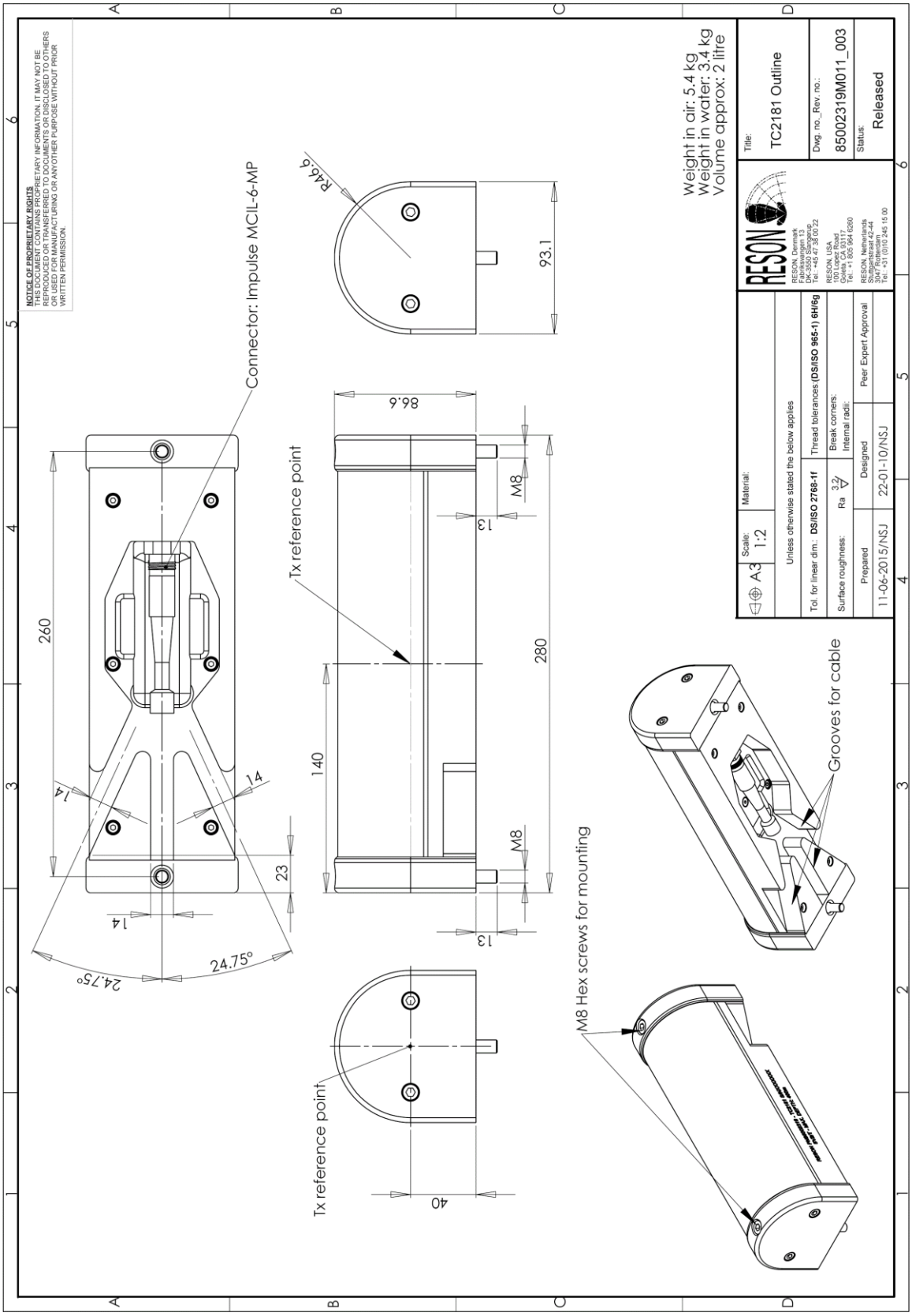


Figure 77: Projector, TC 2181 Outline Dimension

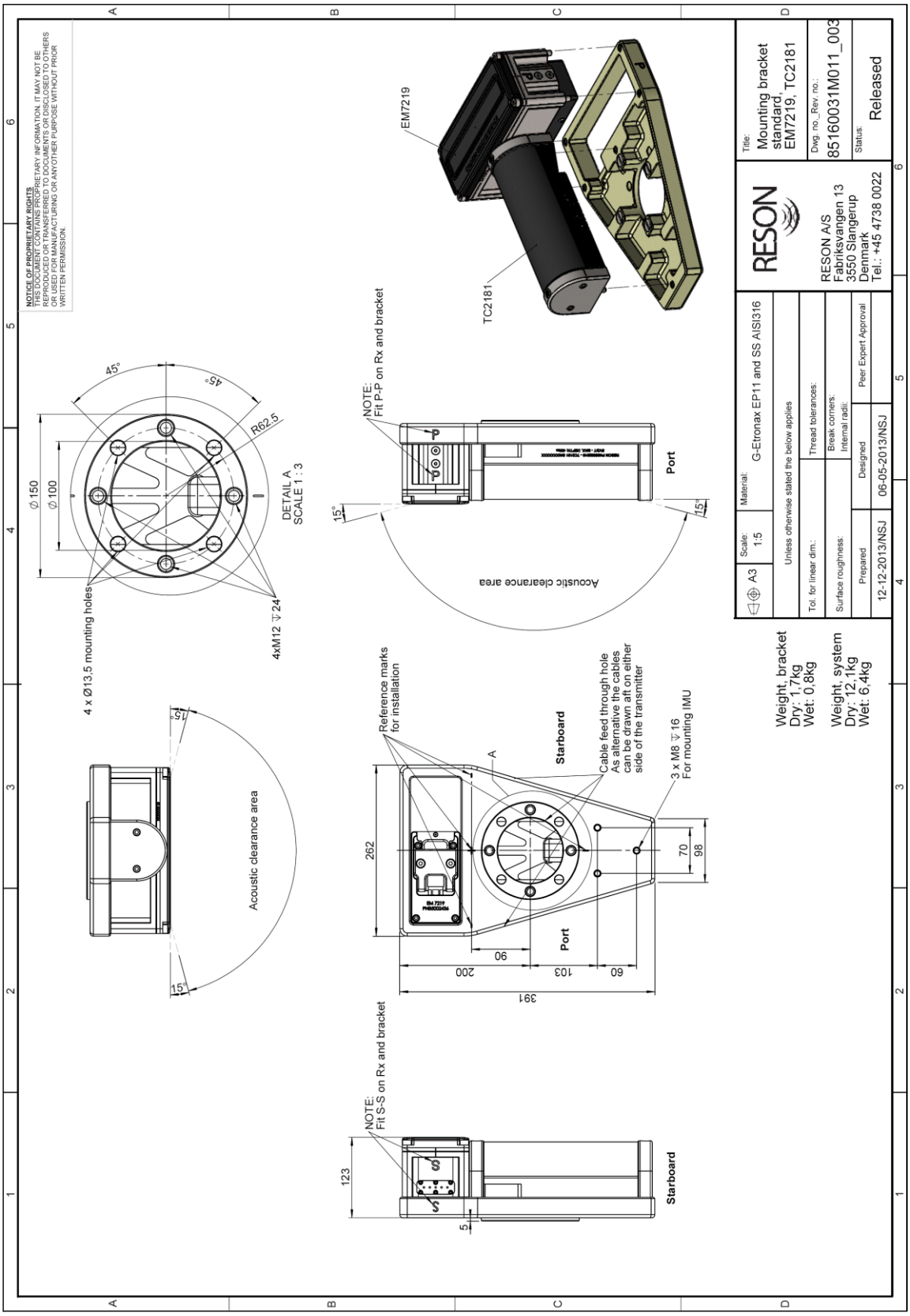


Figure 78: T20: Receiver EM 7219 and Projector TC 2181, Bracket Installation

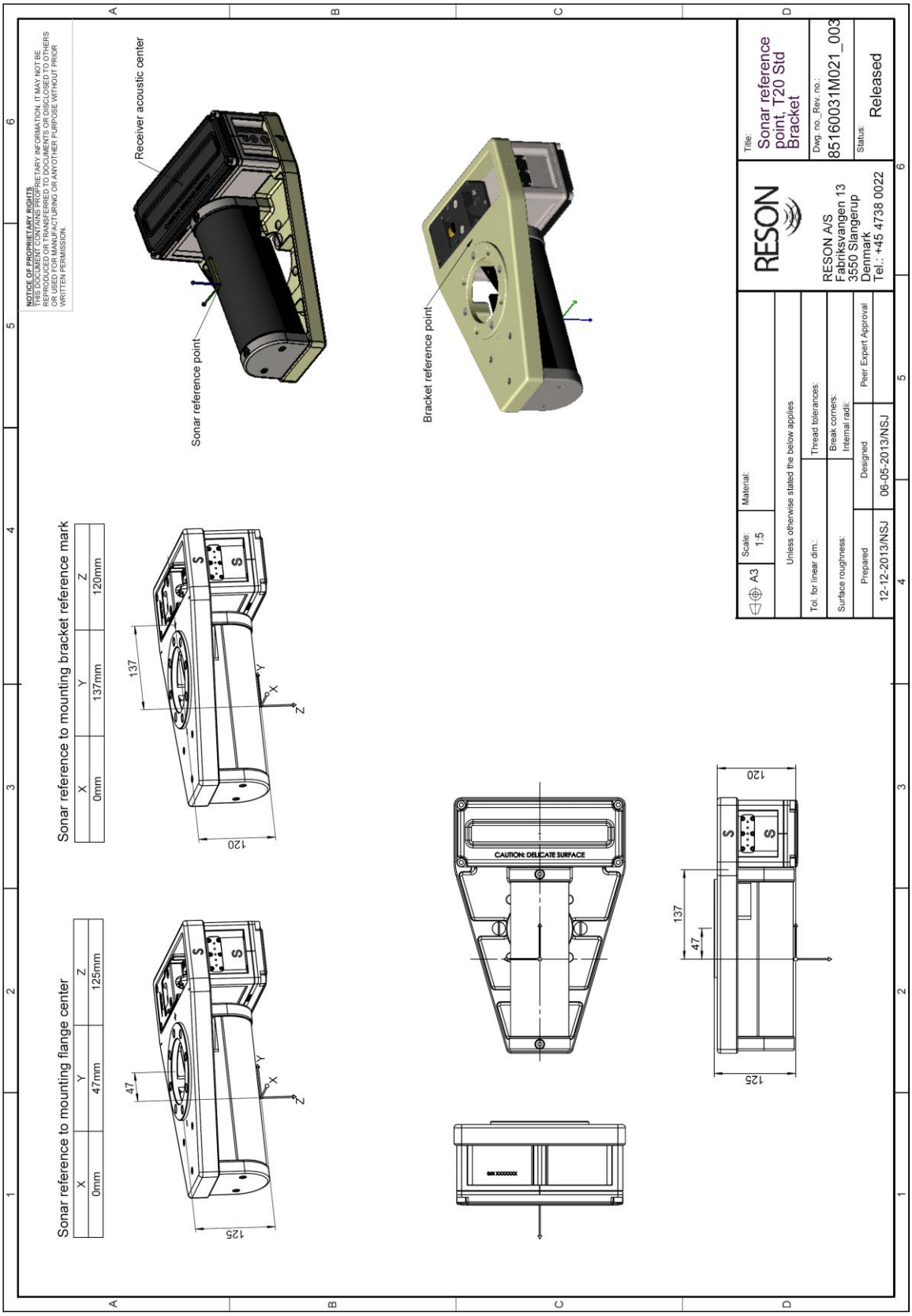


Figure 79: T20 Bracket Installation: Sonar Reference Point

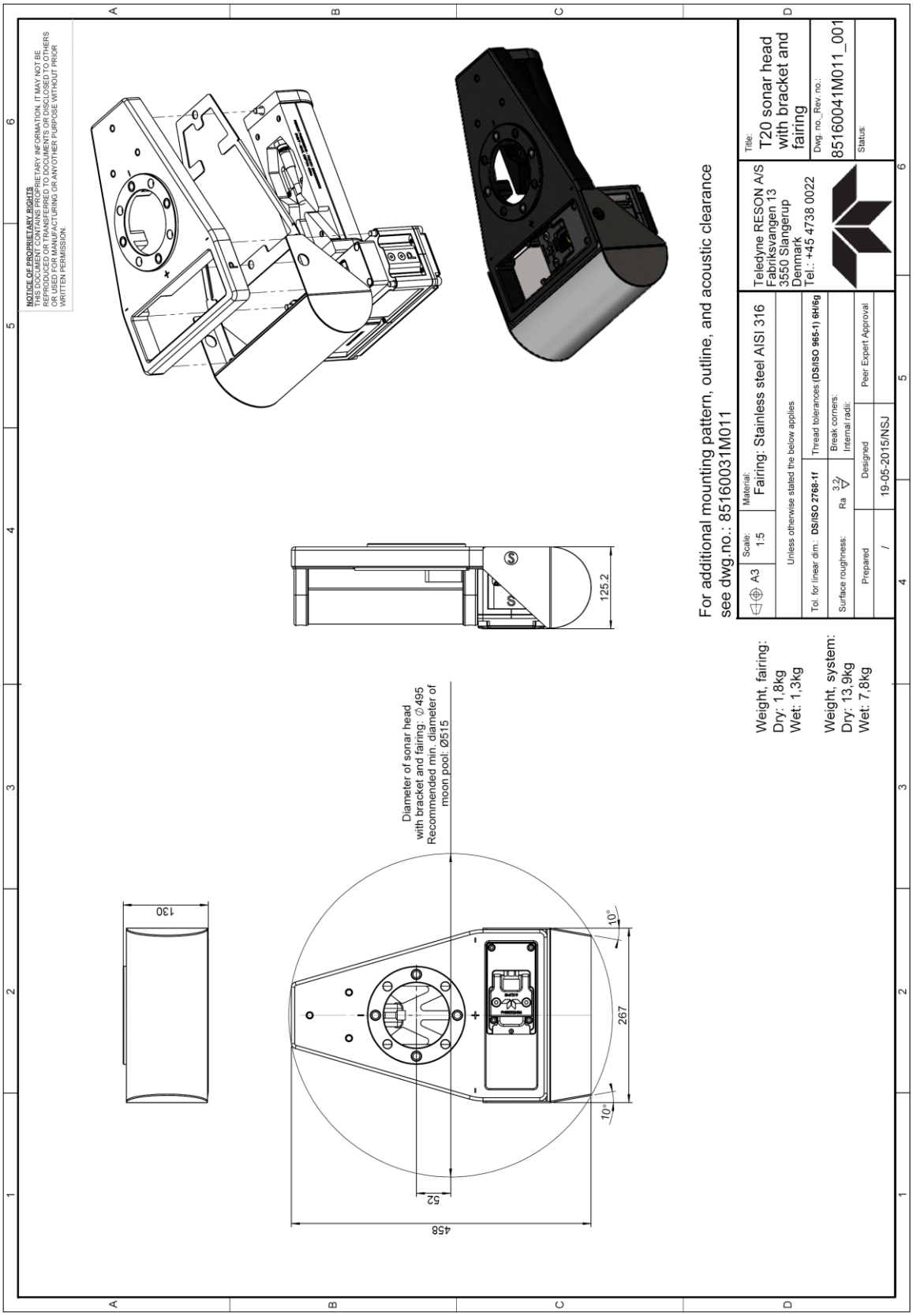


Figure 80: T20 Bracket Installation with Fairing (optional)

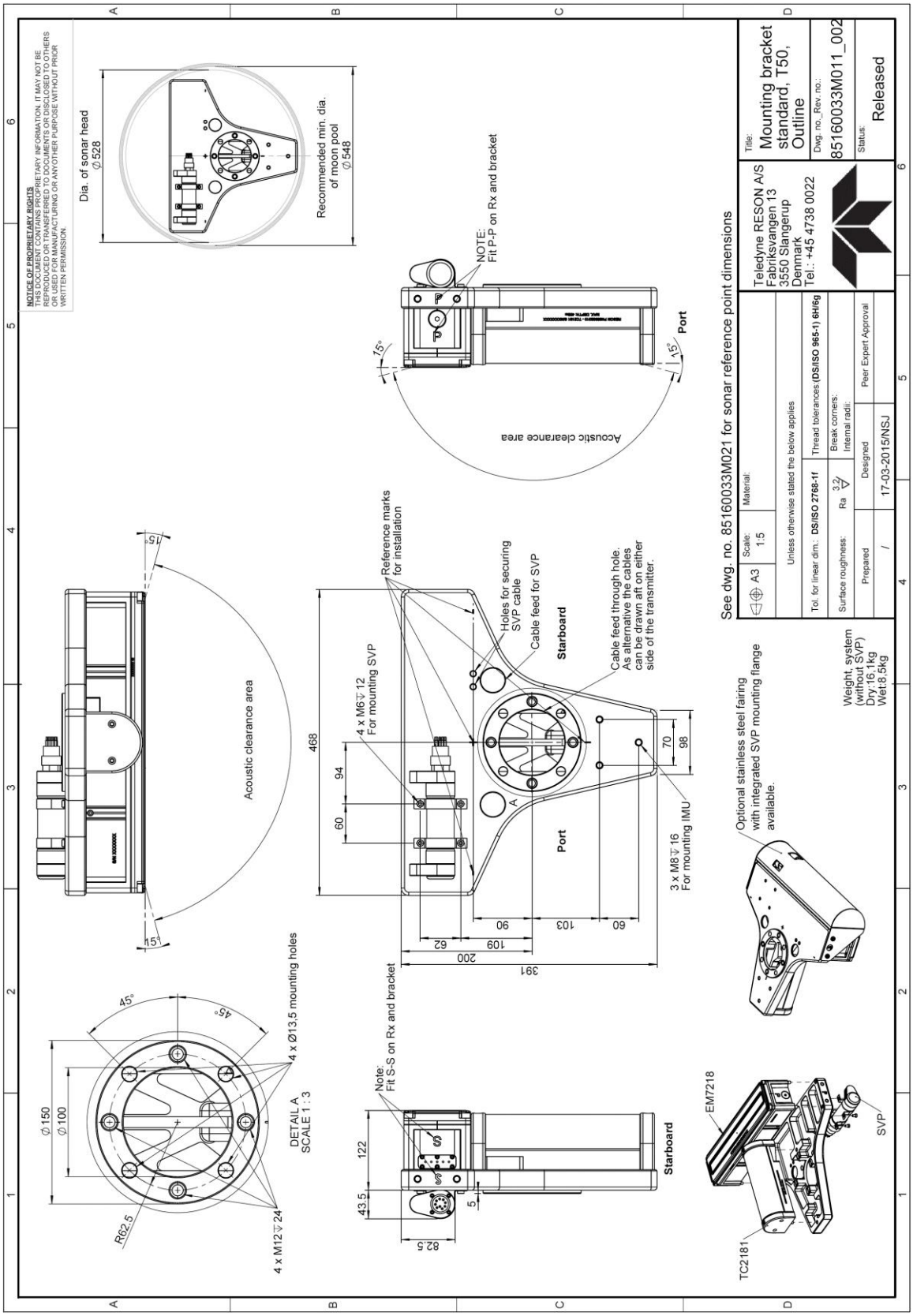


Figure 81: T50: Receiver EM 7218 and Projector TC 2181, Bracket Installation

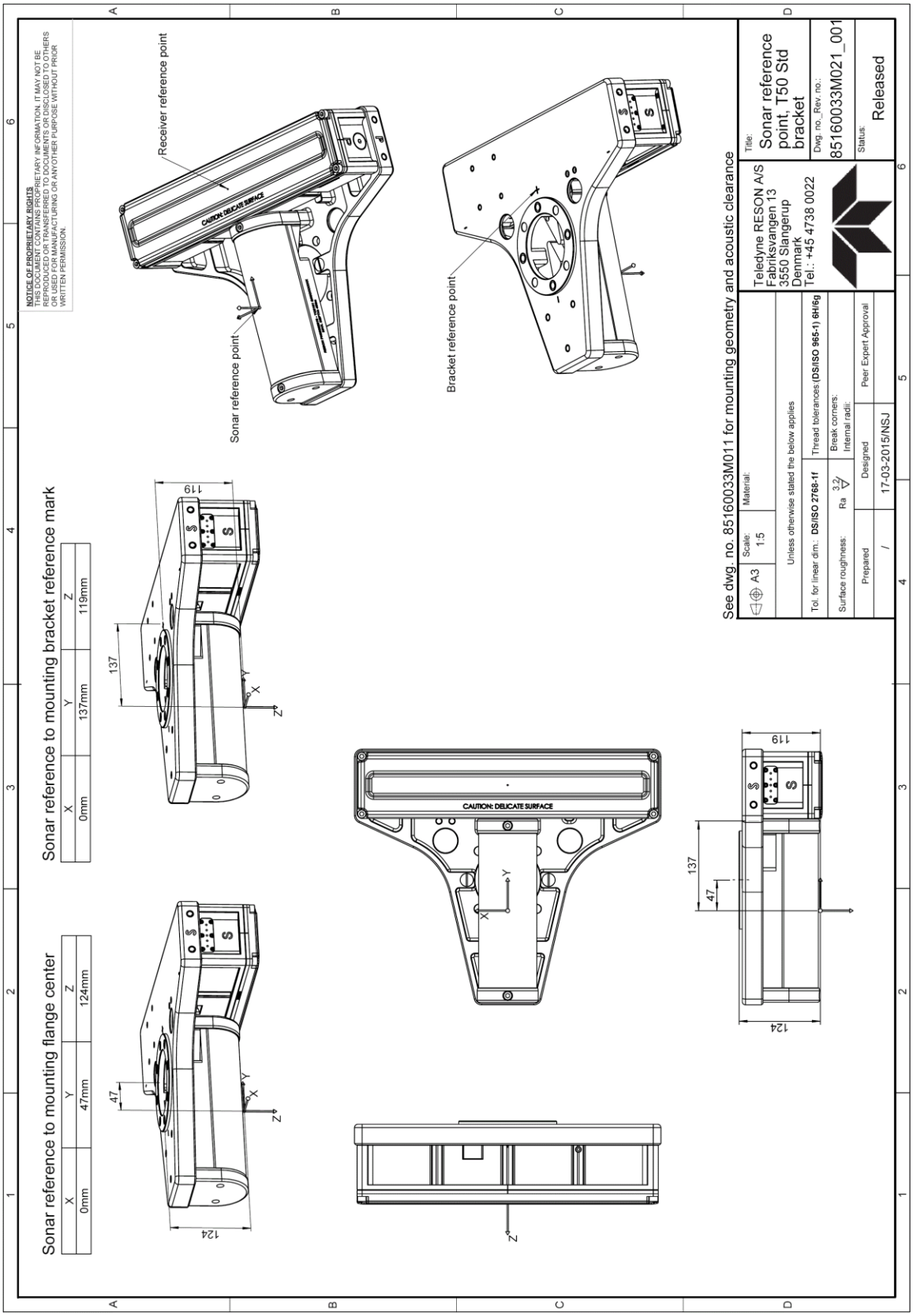


Figure 82: T50 Bracket Installation: Sonar Reference Point

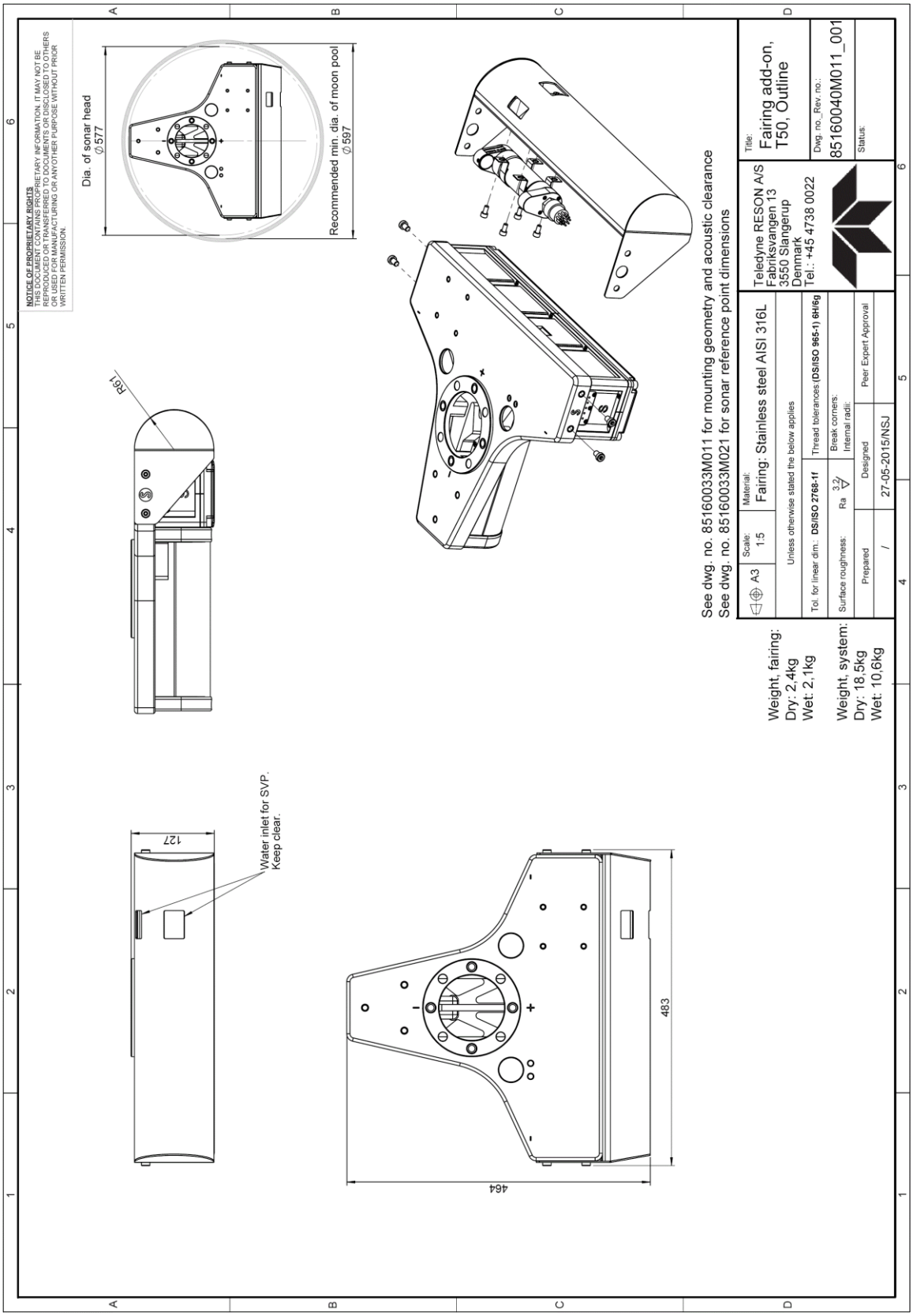


Figure 83: T50 Bracket Installation with Fairing (optional)

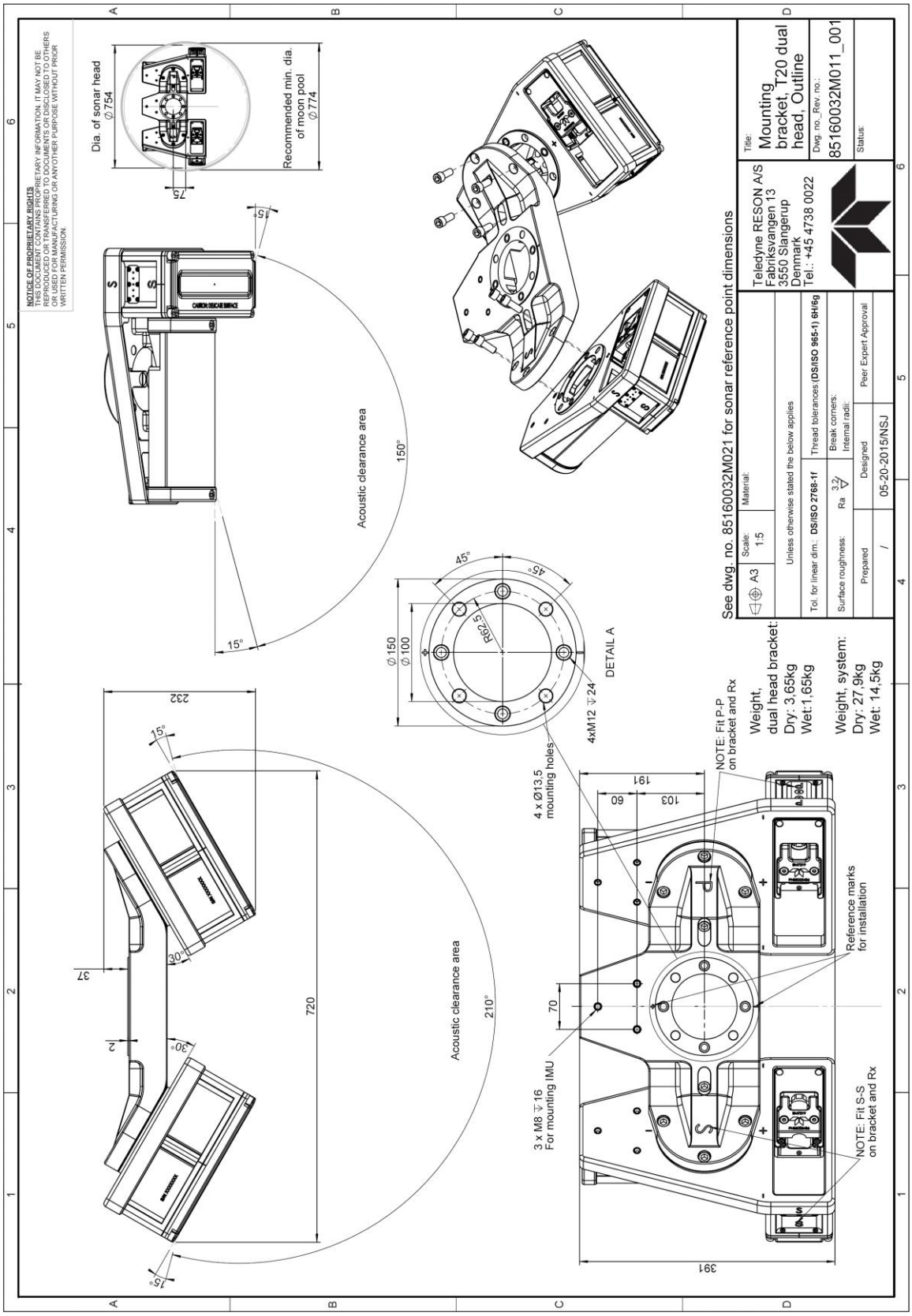


Figure 84: T20 Dual Head Bracket Installation (optional)

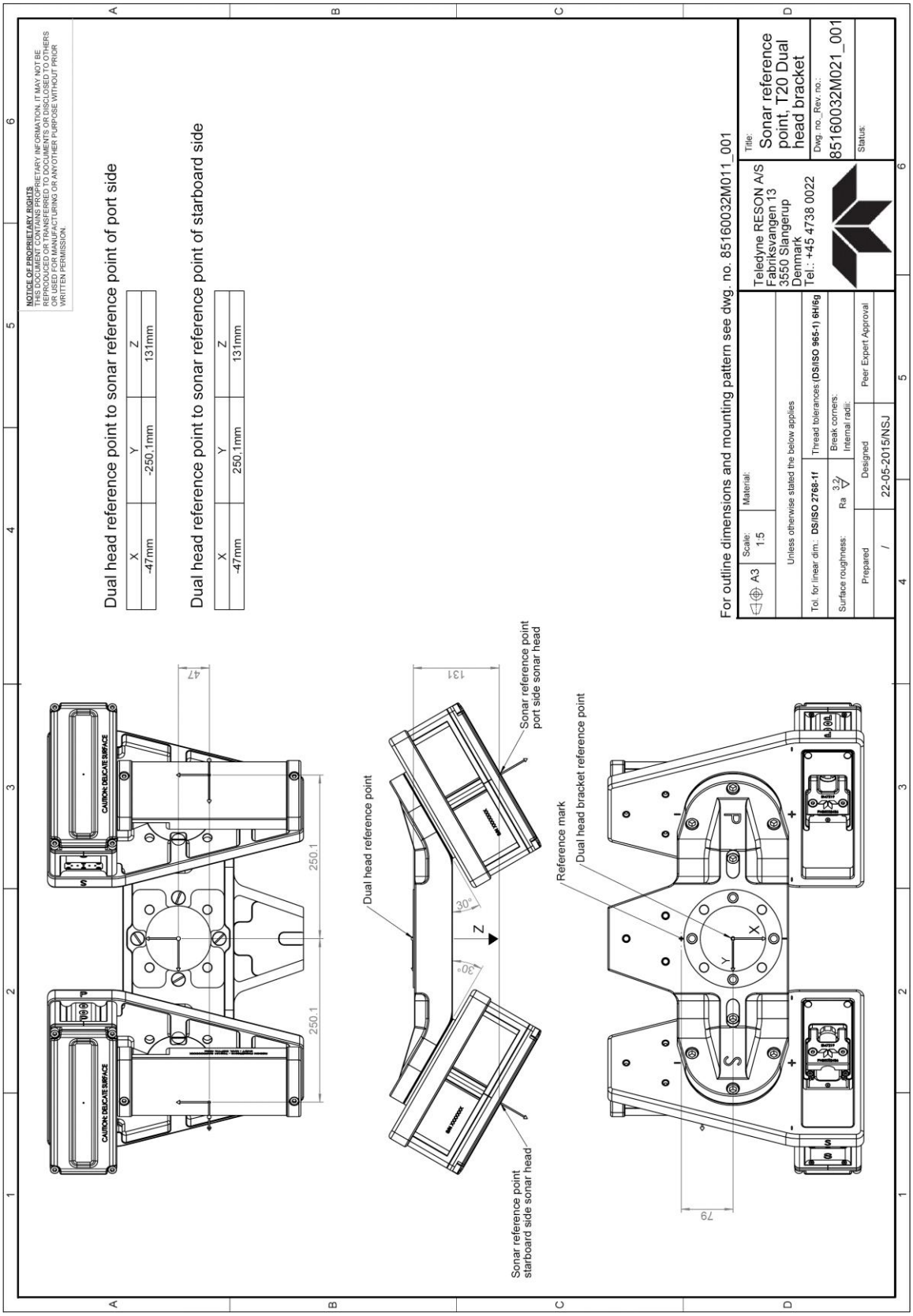


Figure 85: T20 Dual Head Bracket Installation (optional): Sonar Reference Point

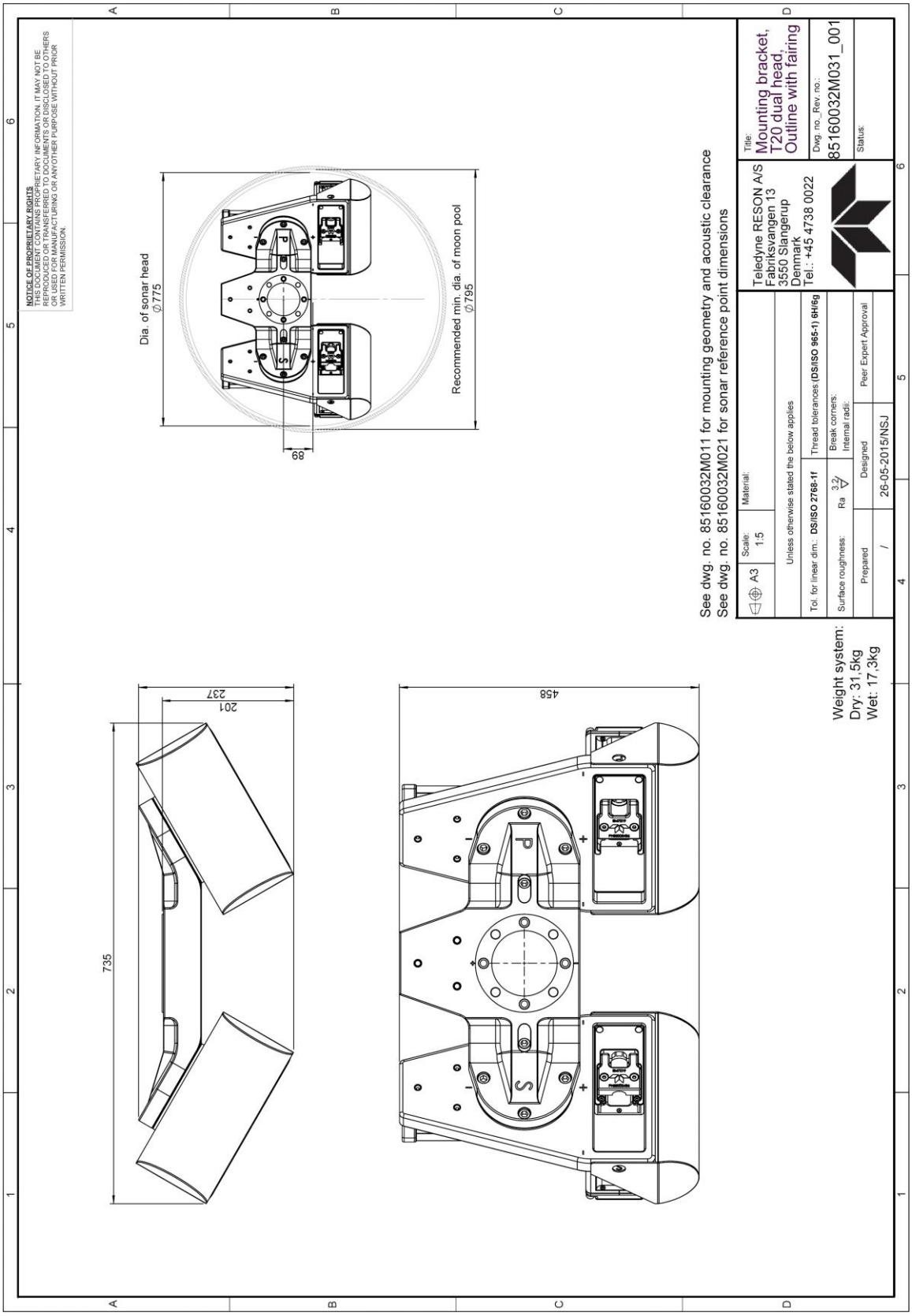


Figure 86: T20 Dual Head Bracket Installation with Fairing (optional)

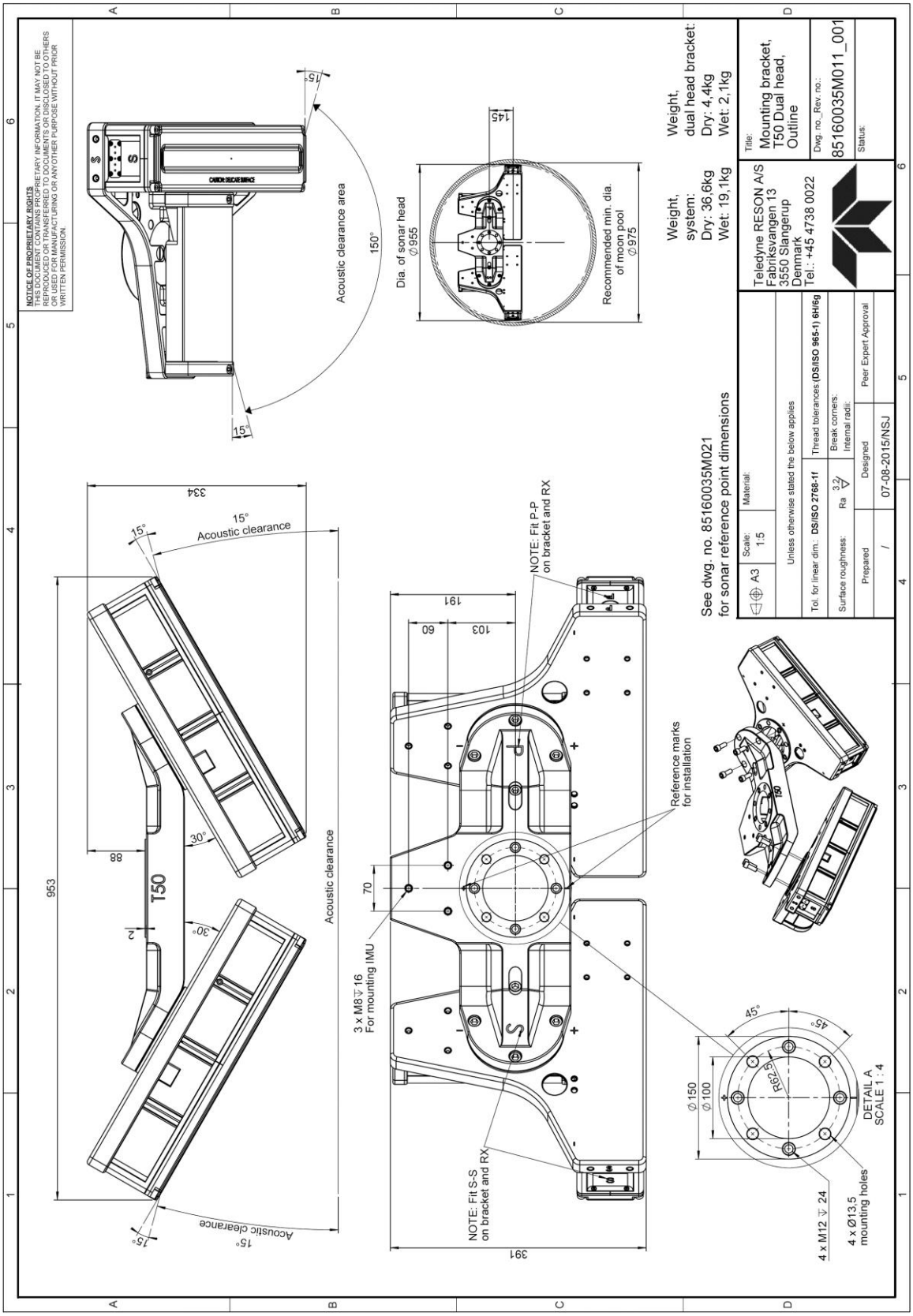


Figure 87: T50 Dual Head Bracket Installation (optional)

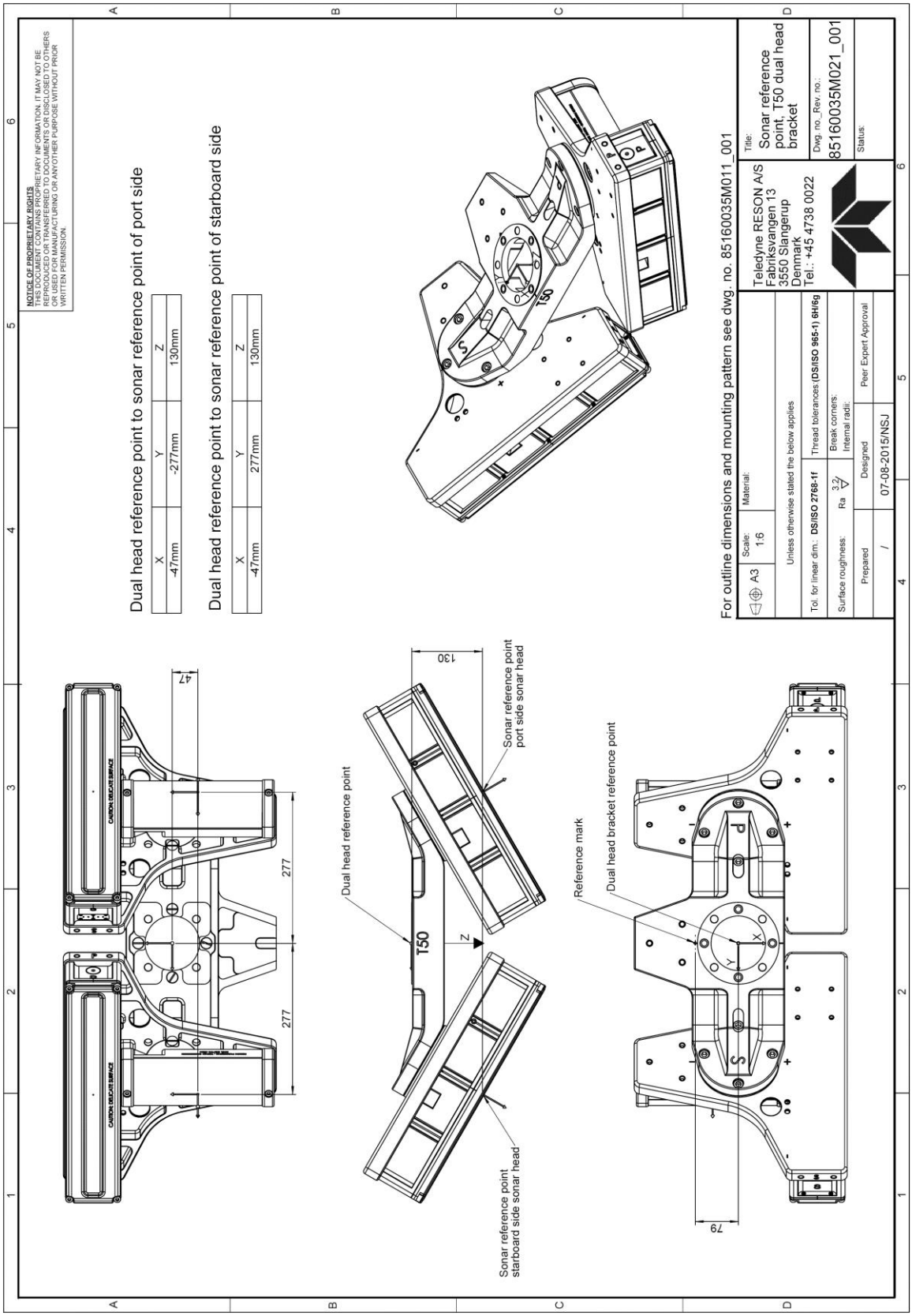


Figure 88: T50 Dual Head Bracket Installation (optional): Sonar Reference Point

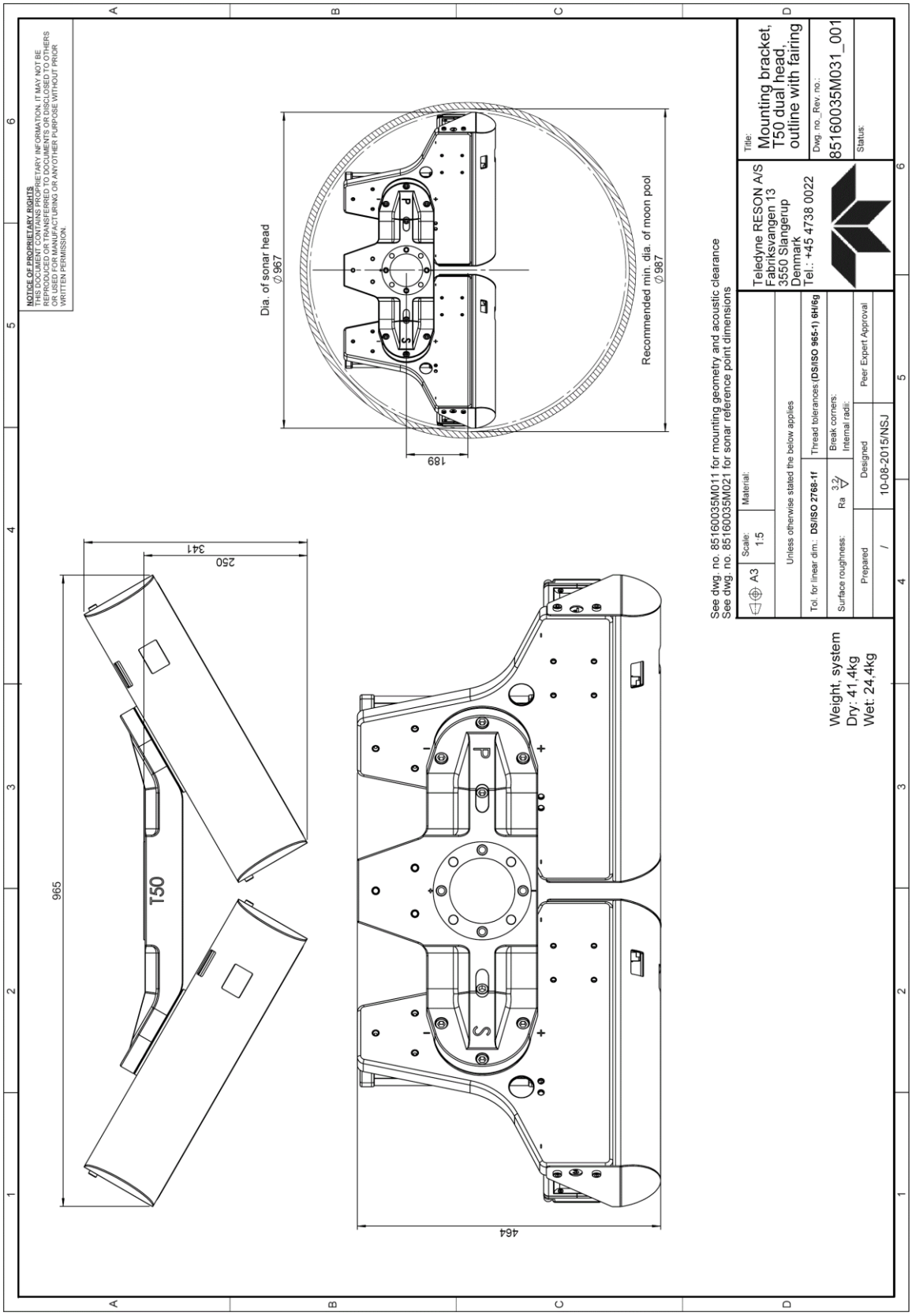


Figure 89: T50 Dual Head Bracket Installation with Fairing (optional)

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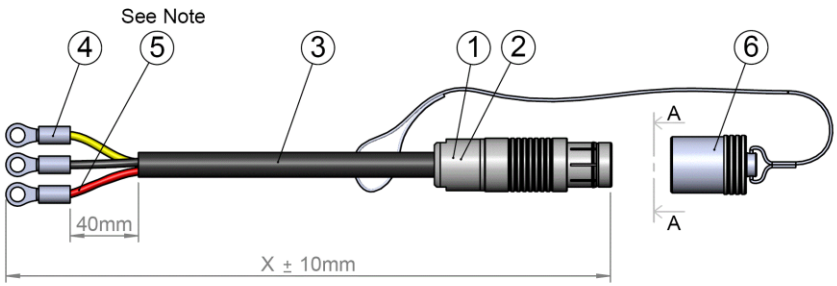

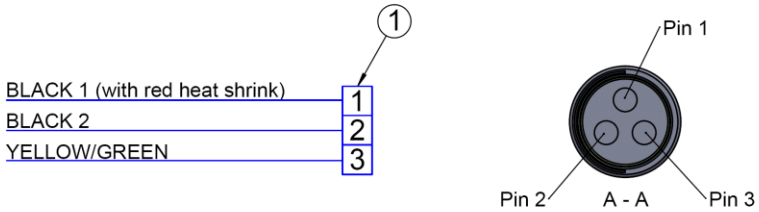

Note: Add Red heat shrink tube (Item 5) to the wire named "Black 1"

A4	Scale: 1:2	Material:	RESON	Title: DC Supply Cable, Xmm
Unless otherwise stated the below applies				
Tol. for linear dim.: **DS/ISO 2768-1f**		Thread tolerances:**(DS/ISO 965-1) 6H/6g**	RESON A/S Fabriksvangen 13 3550 Slangerup Denmark Tel.: +45 4738 0022	Dwg. no._Rev. no.: PARTD15304-2
Surface roughness: Ra 3.2		Break corners: Internal radii:		
Prepared	Designed	Peer Expert Approval		Status: Released
/	2013-02-13 / MSE			

Figure 90: Cable Assembly, DC Supply Cable

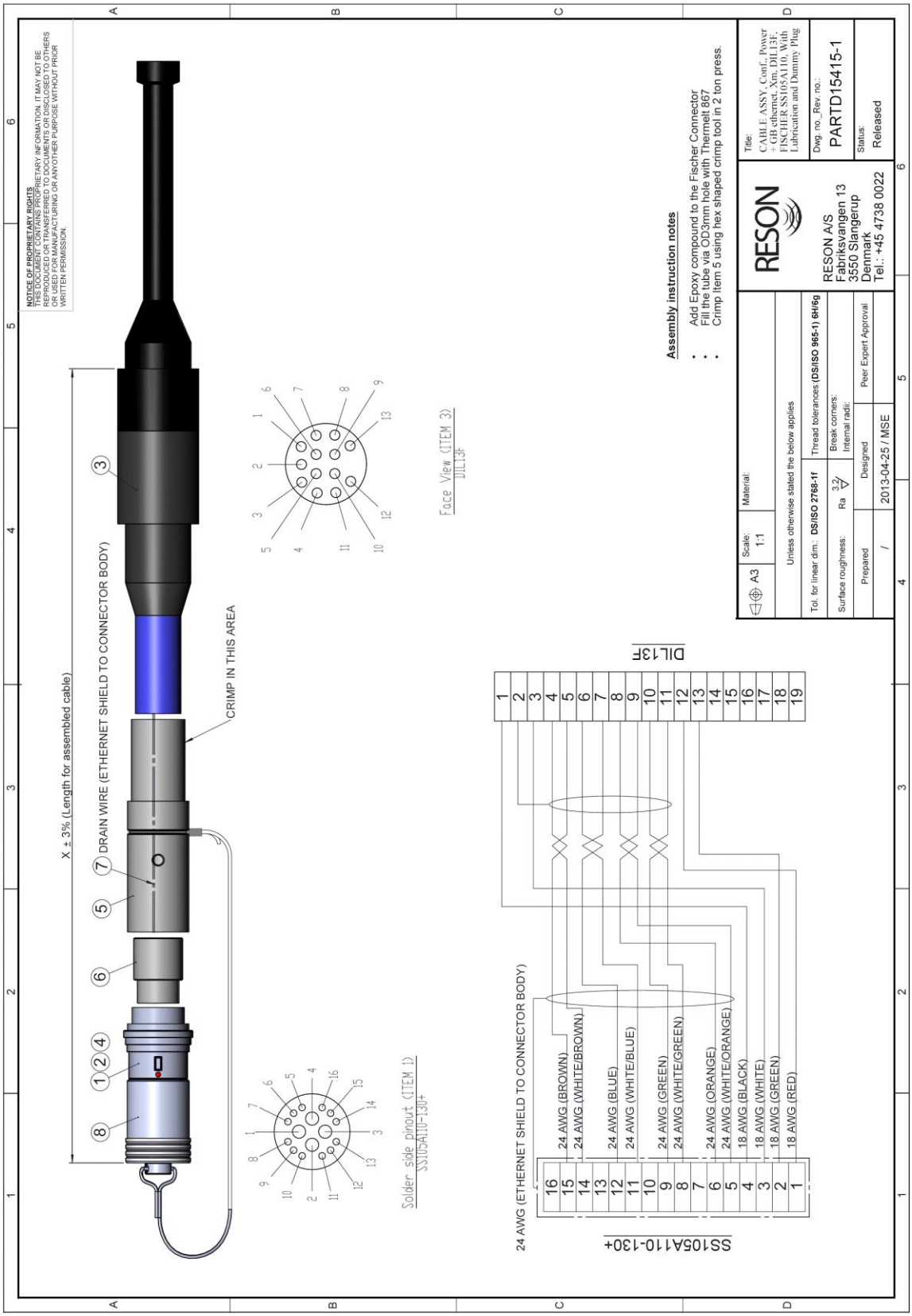

Figure 91: Cable Assembly, Portable Sonar Processor to Receiver

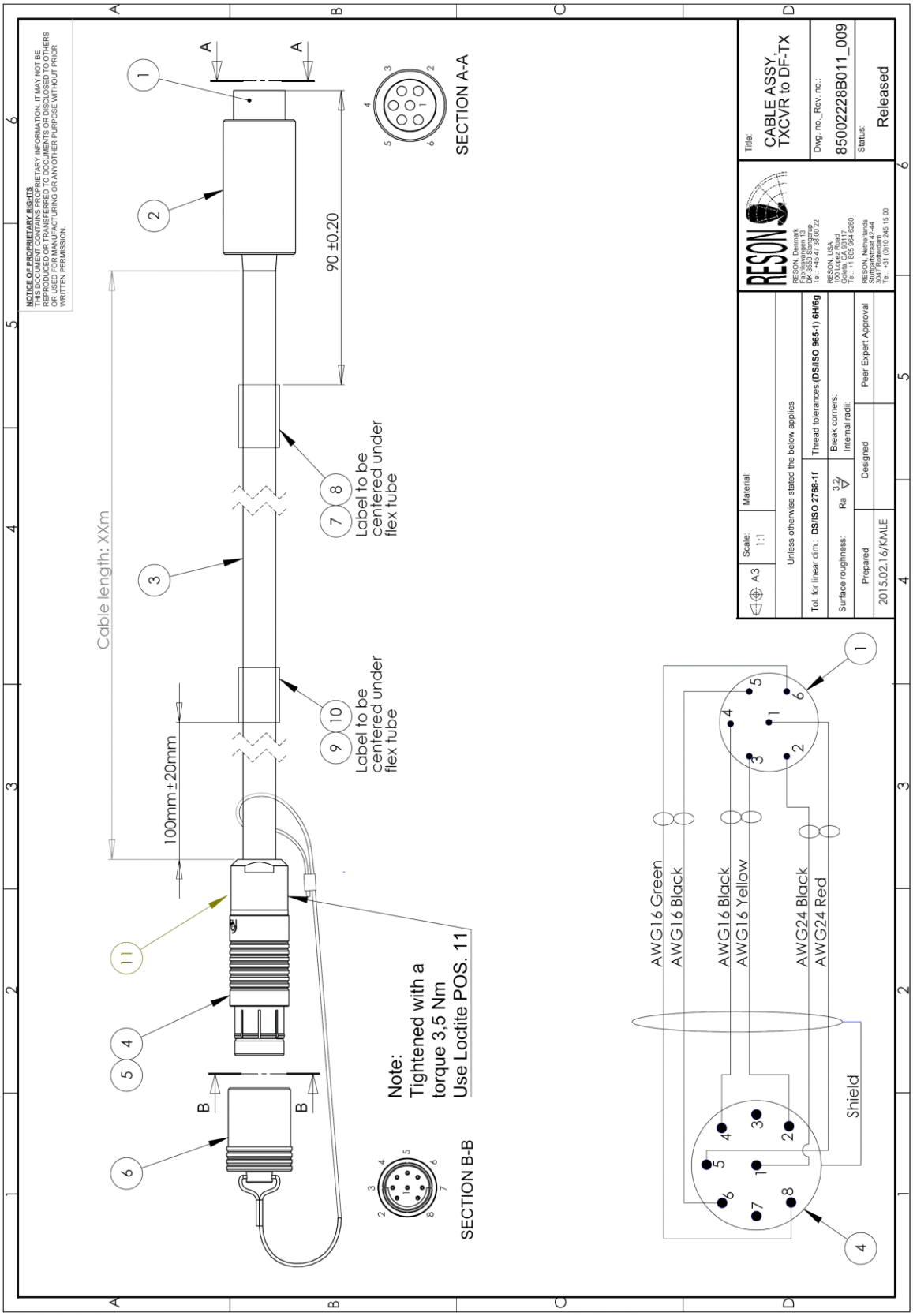

Figure 92: Cable Assembly, Portable Sonar Processor to Projector

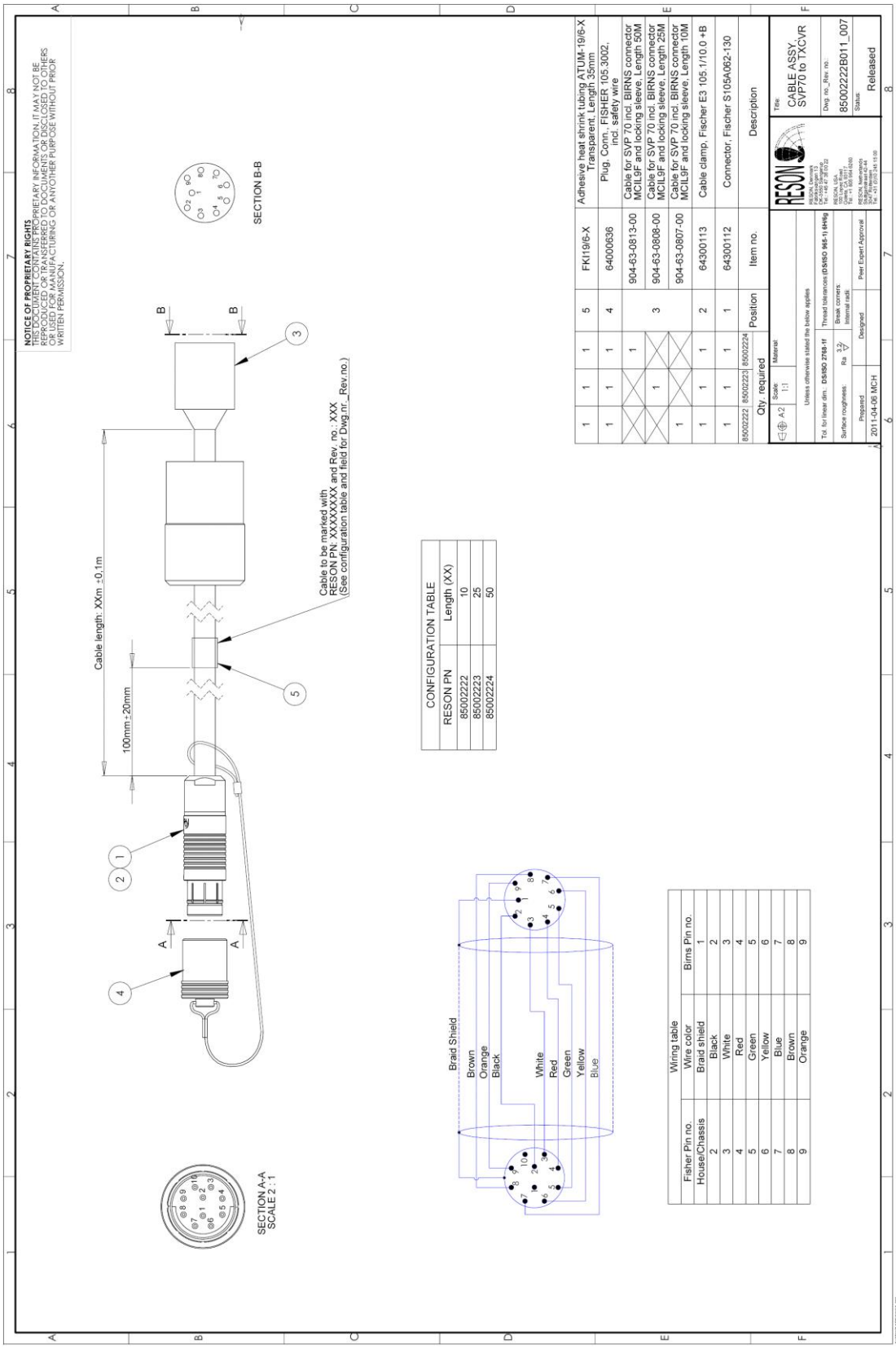

Figure 93: Cable Assembly, Portable Sonar Processor to SVP 70 (optional)

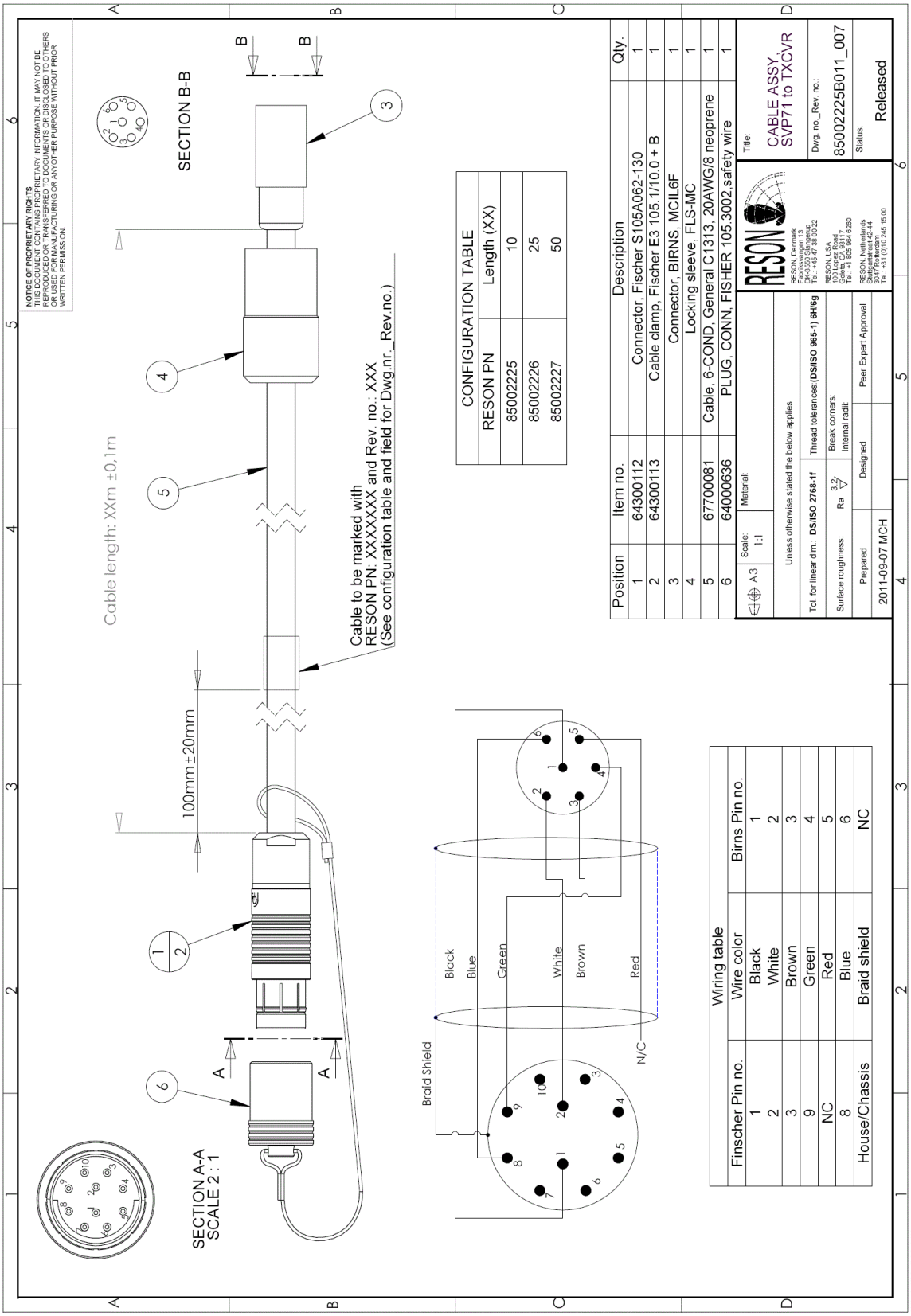

Figure 94: Cable Assembly, Portable Sonar Processor to SVP 71 (optional)

H.3 7kCenter Licenses – Copyright Information

Table 17: LAPACK – Copyright Information

```
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APPENDIX I SEABAT T-SERIES PORTABLE SYSTEM OPTIONS

The following options are available with the SeaBat T-Series Portable systems. If you require more detailed information about any of these options, please contact Teledyne RESON Sales for assistance.

- Extended Warranty Contract
- Fairings
- SeaBat Cables
- Service and Support Agreements
- Sound Velocity Probe
- System Integration and Training
- Teledyne PDS Data Acquisition Software

I.1 Extended Warranty Contract

All SeaBat T-Series Portable systems are provided with a standard three-year warranty[35] (see *Appendix L Warranty Information*). This option provides the user with the possibility of purchasing additional annual support.

I.2 Fairings

Fairings for the wet-end brackets are available for purchase.

I.3 SeaBat Cables

Additional cables in various lengths are available for purchase.

I.4 Service and Support Agreements

Service and Support Agreements (SSA) run for annual terms of 12 months at a time, and cover a wide range of services as listed here:

- Annual system health check
- Backup system (availability depending on system)
- Factory refurbishment (preventive maintenance procedure)
- Product and software fault repair services
- Software and firmware updates
- Spare part allowance
- Telephone and email support

[35] SeaBat T-Series Portable systems delivered prior to April 1, 2015, come with a one-year warranty.

I.5 Sound Velocity Probe

To ensure proper beam steering, the sonar requires the input of the local sound velocity in the area of the transmitter and receiver arrays. The sound velocity probe (SVP) is used to continuously report this value to the sonar processor unit. The unit described below may be purchased from Teledyne RESON as an option, or a SVP of similar specifications may be supplied by the customer.

Table 19: SVP Technical Specifications

Specification	Value
Type	SVP 70
Sound velocity	Range: 1350-1800m/s Resolution: 0.01m/s Accuracy: ±0.05m/s (0-50m) Accuracy: ±0.25m/s (0-6000m)
Sampling rate	20Hz and lower, programmable
Depth	6000m
Baud rate	2400-115200
Supply	9-55VDC
Power	2W
Housing	Titanium
Dimensions	Diameter: 44mm (max) Length: 165mm (excl. connector) End cap height: 69mm (max)
Weight	1.0kg (excl. cable)
Temperature	-20° to +55°C

For further information, please refer to the appropriate manual.

I.6 System Integration and Training

Onsite installation, integration with a bathymetric data acquisition system, calibration, and training of operating personnel are available from Teledyne RESON.

I.7 Teledyne PDS Data Acquisition Software

Teledyne PDS software provides a wealth of displays and data processing options. The PDS software will be configured to run on the CFE laptop/PC with a TCP I/P or UDP interface. PDS also handles all commonly interfaced sensors.

For further information, please refer to the appropriate manual or http://www.teledyne-pds.com/.

APPENDIX J AVAILABLE CONFIGURATIONS

J.1 SeaBat T-Series Portable Configurations

The SeaBat T-Series Portable configuration is for mounting on a small surface vessel and designed with hassle-free installation, ease of use, and portability in mind.

The SeaBat T-Series Portable line is available in various configurations:

Table 20: Available Configurations

Configuration	Frequency (kHz)	Depth rating (meters)
SeaBat T20-P single head – variable frequency	190-420	50
SeaBat T20-P dual head – variable frequency	190-420	50
SeaBat T50-P single head – variable frequency	190-420	50
SeaBat T50-P dual head – variable frequency	190-420	50

J.2 Available Features

Each SeaBat T-Series Portable configuration is available with a standard set of features which can be upgraded with various options, the license to each of which will be installed on the system you have purchased.

Table 21: SeaBat T-Series Portable Available Features

Feature	Base	Optional
Channel normalization	✓	
Dual head, full rate (FRDH)[36] (T20 /T50)		✓
Dual head[37] (T20 / T50)	✓	
FlexMode		✓
Head tilt	✓	
Manual gates	✓	
Max. 256 beams	✓	
Max. 512 beams	✓ T50	✓ T20
Normalized backscatter		✓ T50
Multi-detect		✓
On the fly frequency change	✓	
On the fly mode selection	✓	
Pipe detection and tracking[38]		✓
Quality filter	✓	
Roll stabilization	✓	
SeaBat User Interface	✓	
Selectable beam density	✓	
Tracker	✓	
Uncertainty output	✓	
Variable frequency	✓	
Vari-swath	✓	
X-Range (FM)		✓

NOTE
The Base feature set can be upgraded after installation.

[36] Includes X-Range.
[37] Two portable sonar processor units are required for dual-head operation.
[38] Includes FlexMode.

APPENDIX K CONVERSION OF MEASUREMENTS

K.1 Metric Conversion

All measurements in this manual are referenced in metric terms. To convert measurements from metric (e.g. cm, m, and km) to imperial (e.g. in, ft, and yd), utilize the following reference table:

Table 22: Metric Conversion Table

Metric Unit	Imperial Unit
Millimeter (mm)	0.0394in
Centimeter (cm)	0.3937in
Meter (m)	1.0936yd
Kilometer (km)	0.6214mi
Kilogram (kg)	2.2046lb

K.2 Temperature Conversion

All temperatures in this manual are referenced in degrees Celsius. The formula for converting Celsius (°C) to Fahrenheit (°F) is as follows:

°F = 1.8 x °C + 32

Example: If Temperature = 30°C, then:

°F = 1.8 x 30° + 32

OR

°F = 86°

APPENDIX L WARRANTY INFORMATION

L.1 Three-Year Limited Warranty

Teledyne RESON warrants your Teledyne RESON system against defects in materials and workmanship for a period of three years from acceptance of the system. During the warranty period, Teledyne RESON will, at its option, either repair or replace components which prove to be defective.

The warranty period begins on the day the system is accepted by the customer. Your Teledyne RESON system must be serviced by the Teledyne RESON office that sold it. The customer shall prepay shipping charges (and shall pay all duty and taxes) for products returned for service. Teledyne RESON shall pay for the return of the products to the customer, not including any duty and taxes.

NOTE
The three-year warranty is effective for all deliveries **after** April 1, 2015, and applies to these standard sonar systems: • SeaBat T20-P (PN 88017020) • SeaBat T50-P (PN 88017002) The warranty does **not** apply to: • Peripheral equipment (such as SVP 70 or 3rd party hardware) • Deliveries **prior** to April 1, 2015 (These deliveries are sold with one-year warranty.)

L.2 Exclusions

The warranty on your Teledyne RESON system shall not apply to defects resulting from:

- Improper use.
- Improper or inadequate installation or maintenance by the customer.
- Unauthorized modifications, alterations, or repairs.
- Accidental damage.
- Improper storage or transportation.
- Operation outside the environmental specifications of the product.
- Improper site preparation or maintenance.
- Opening of any parts of the equipment by anyone other than a Teledyne RESON authorized service facility.
- Service provided by anyone but a Teledyne RESON authorized service facility (see *section L.6 below*).

L.3 Warranty Limitations

The warranty set forth above is exclusive and no other warranty, whether written or oral, is express or implied. Teledyne RESON specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

L.4 Servicing During Warranty Period

If your system should fail during the warranty period, please contact your nearest Teledyne RESON representative immediately (see *section L.6 below*) to protect your warranty rights.

L.5 Equipment Return Procedure

Before returning any equipment for service, you must follow the Teledyne RESON equipment return procedure stated below:

1. Contact a Teledyne RESON office to obtain an approved Return Material Authorization (RMA) number.
2. Follow the instructions in the supplied document and pack the equipment in the original shipping containers.
3. Ship the equipment to your Teledyne RESON representative to the applicable address.
4. Ensure that the RMA number is included on all shipping documents and, most importantly, marked on the shipping container's address label.
5. Include a note with a brief, but thorough, description of the problem.

L.6 Service

If you are experiencing difficulty with your Teledyne RESON system, please contact Teledyne RESON Service Department at one of the following addresses for further instructions:

DENMARK
Teledyne RESON A/S
Fabriksvangen 13
3550 Slangerup
Denmark
Tel: +45 20 999 088
e-mail: support@teledyne-reson.com

NETHERLANDS
Teledyne RESON B.V.
Stuttgartstraat 42-44
3047 AS Rotterdam
Netherlands
Tel: +45 20 999 088
e-mail: support@teledyne-reson.com

UNITED STATES
Teledyne RESON, Inc.
100 Lopez Road
Goleta, CA 93117
USA
Tel: +1 805 964 6260
e-mail: support@teledyne-reson.com

Teledyne PDS support
Tel: +31 10 245 15 00
e-mail: pds@teledyne-reson.com

APPENDIX M GLOSSARY OF TERMS

Entry	Definition
7k	SeaBat 7000 series of multibeam sonars
BITE	Built-In Test Environment
CE	Conformité Européenne
CFE	customer-furnished equipment
COTS	commercial off-the-shelf
CW	Continuous wave
Cylindrical loss	The loss of sound by spreading in the form of a cylinder
DAC	data acquisition system (or software)
DFD	Data Format Definition
DHCP	Dynamic Host Configuration Protocol
DTM	DTM density (Digital terrain model) specifies the spacing of footprints in the low density sectors when operating in FlexMode
DWG	Drawing
EA	Equiangular
ED	Equidistant
FRDH	Full Rate Dual Head
FM	Frequency modulation
GUI	Graphical User Interface
IP	IP Code, Ingress Protection Rating is a classification system that rates to what degree an enclosure is protected against the intrusion of solid objects (incl. dust) and water
LED	light-emitting diode
MBES	Multibeam Echosounder
N/A	not available or not applicable
NAS	network-attached storage
NS	nadir search
PLD	Product Leaflet Document
PN	Part Number
PSP	Portable Sonar Processor
PSU	Power Supply Unit

Entry	Definition
RH	relative humidity
RMA	Return Material Authorization
ROV	Remotely Operated Vehicle
Rx	receiver
SB	SeaBat
SBES	Singlebeam Echosounder
SNR	signal-to-noise ratio
Spherical loss	The loss of sound by spreading in the form of a sphere
SV	sound velocity (or surface vessel as in SB 7125 SV)
SVP	Sound Velocity Probe
TBD	To Be Defined
TPU	Total Propagated Uncertainty
TVG	Time-Varied Gain is a control intended to vary the gain of an amplifier over a predetermined time period (usually from a low to a high gain state)
Tx	transmitter
UI	user interface
UUV	Unmanned Underwater Vehicle
WEEE	Waste Electrical and Electronic Equipment
ZDA	Time and date identifier

SeaBat T-Series Portable Operator's Manual

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