SeaBat T51-S/IDH T51-S
Subsea Deep High-Resolution Multibeam Sonar System

OPERATOR'S MANUAL



Part Number 1019520-DK

Version 2

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PREFACE – ABOUT THIS MANUAL

This manual is designed to give detailed procedures for the correct installation, operation, and maintenance of the SeaBat T51-S/IDH T51-S sonar system and is equally useful for both the first time user and the experienced technician.

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

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

Document Conventions

The following information will make it easier for the reader to interpret the document content.

Convention	Definition
Hyperlink	Indicates a cross-reference to Ctrl+Click to reach the specified item.
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 to provide valuable information and to help the operator prevent damage to the sonar or to personnel. These are the formats:

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

CAUTION
Caution boxes provide important information regarding your Teledyne RESON system. Disregarding Cautions may result in accidental misuse or damage to the system.

WARNING!
Warning boxes provide important information regarding your Teledyne RESON system. Disregarding Warnings may prove harmful to personnel working with or near the system.

Conversion of Units of Measurement

Metric Conversion

All measurements in this manual are referenced in metric terms.

Use this reference table to convert between metric (e.g. cm, m, and km) and imperial (e.g. in, ft, and yd) measurements.

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

Temperature Conversion

All temperatures in this manual are referenced in degrees Celsius.

This is the formula for converting Celsius (°C) to Fahrenheit (°F).

Formula: °F = 1.8 x °C + 32
Example:
If Temperature = 30°C, then:
°F = 1.8 x 30° + 32
°F = 86°

Glossary of Terms

Entry	Definition
7k	SeaBat 7000 series of multibeam sonars
AUV	Autonomous Underwater Vehicle
BITE	Built-In Test Environment
CE	Conformité Européenne
CFE	customer-furnished equipment
CW	Continuous wave
Cylindrical loss	The loss of sound by spreading in the form of a cylinder
DFD	Data Format Definition
DWG	Drawing
EA	Equiangular
ED	Equidistant
FM	Frequency modulation
FRDH	Full Rate Dual Head
IDH	Integrated Dual Head
LED	light-emitting diode
N/A	not available or not applicable
OM	Operator's Manual
PN	Part Number
QG	Quick Guide
RMA	Return Material Authorization
ROV	Remotely Operated Vehicle
Rx	Receiver
SNR	signal-to-noise ratio
Spherical loss	The loss of sound by spreading in the form of a sphere
SSP	Subsea Sonar Processor
SV	sound velocity (or surface vessel)
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
VAC	volts alternating current

Entry	Definition
VCC	Vehicle Control Computer
VDC	volts direct current
VDM	Vertical Detection Mode
WEEE	Waste Electrical and Electronic Equipment

TABLE OF CONTENTS

1 Introduction 1
1.1 System Overview 1
1.2 System Architecture 2
1.3 System Operation 2
1.4 System Features 2
1.5 Typical Applications 6
1.6 Available SeaBat T51-S/IDH T51-S Configurations 6
2 Safety Precautions 7
2.1 Operator Safety 7
2.2 Equipment Safety 7
2.2.1 Safe Handling 7
2.2.2 Cleaning and Maintenance 8
2.3 Corrosion Avoidance 9
2.4 Electrical Isolation 10
2.5 Exposure to Sunlight 10
2.6 Safe Disposal of Waste (WEEE Directive) 10
2.7 CE Marking 11
3 System Startup and Shutdown 12
3.1 Chapter Overview 12
3.2 Pre-dive Checks 13
3.3 System Startup Instructions 13
3.3.1 AUV System 13
3.3.2 ROV System 14
3.4 System Shutdown Instructions 14
3.4.1 AUV System 14
3.4.2 ROV System 15
3.5 Post-dive Checks 16
4 System Configuration with User Interface 17
4.1 Chapter Overview 17
4.2 Sonar User Interface (SUI) 18
4.3 Remote Operation 19
4.4 Remote Desktop Session 20
4.5 Folder Management 21
4.5.1 File Sharing on a Network 21
4.5.2 FTP Server 25
4.5.3 Verifying or Changing the Computer Name and/or Workgroup Name 25
5 UUV System Operation 28
5.1 Chapter Overview 28
5.2 AUV System Operation 29
5.3 ROV System Operation 29
6 Active Sonar Usage 30
6.1 Chapter Overview 30
6.2 Enhancing Sonar Performance 31
6.2.1 Correct Range Setting 31
6.2.2 Transmit Power 32
6.2.3 Ping Rate 33
6.2.4 Receiver Gain 33
6.2.5 Frequency Selection 34
6.2.6 Pulse Length 35
6.2.7 Pulse Type 35

6.2.8 Vari-Swath 36
6.2.9 Use of Beam Modes 38
6.2.10 Use of Gates 40
6.2.11 Maximizing Quality of Backscatter for Snippets Data 43
6.3 Enhancing System Efficiency 43
6.3.1 Multi-Detect Operation 43
6.3.2 Tracker Autopilot 44
6.3.3 Roll Stabilization 45
6.3.4 Head Tilt 46
6.3.5 Vertical Detection Mode (VDM) 47
6.4 Compensation for Environmental Conditions 47
6.4.1 Loss of Sound by Absorption 47
6.4.2 Loss of Sound by Spreading 49
6.4.3 Sound Velocity 50
6.5 Limitations 52
6.5.1 Cavitation 52
6.5.2 Machinery Noise 52
6.5.3 Interference from Other Sonar Systems 52
6.5.4 Speed 53
6.5.5 Air Bubbles 53
6.5.6 Environment 53
7 System Performance and Data Types 54
7.1 System Components 56
7.1.1 Subsea Sonar Processor SSP+ 56
7.1.2 EM7222-1 Receiver Unit 56
7.1.3 TC2190 Projector Unit 56
7.2 Selectable Beam Density 57
7.2.1 Beam Modes 57
7.2.2 Equi-Distant, Equi-Angle, and Intermediate Modes 58
7.3 Data Types 60
7.3.1 Bathymetry Data 60
7.3.2 Side-Scan Data 60
7.3.3 Snippets Backscatter Data 61
7.4 Real-Time Pipe Detection and Tracking 62
7.5 Multi-Detect 62
7.6 Vertical Detection Mode 63
7.7 X-Range Performance 63
7.8 Full Rate Dual Head 64
7.9 Quality 64
7.9.1 Brightness Test 64
7.9.2 Colinearity Test 65
7.9.3 Quality Filter 65
7.10 Uncertainty Estimation 66
7.11 Ping Rate Table 67
Appendix A Troubleshooting 68
A.1 System Error and Warning Messages 68
A.2 Error Messages 68
A.2.1 General System Startup Errors 68
A.2.2 Data Reading Errors 69
A.2.3 System Resource Errors 69
A.2.4 Input Signal (Timing and Triggers) Errors 69
A.2.5 Normalization Errors 70
A.3 Warning Messages 70
A.3.1 Configuration Warnings 70

A.3.2 Data Processing Warnings 70
A.3.3 BITE Data Warnings 70
A.3.4 Input Signal Warnings 71
A.3.5 System Stability Warnings 71
A.3.6 Data Subscription Warnings 71
A.3.7 Network Components Warnings 71
A.3.8 External Trigger Warnings 71
A.4 Error Messages – Master List in Alphabetical Order 72
A.5 Warning Messages – Master List in Alphabetical Order 75
Appendix B Installation Instructions 77
B.1 Components List 77
B.2 Installation Checklist 78
B.3 System Interfacing 79
B.3.1 AUV/ROV Installation 79
B.3.2 Interfacing Diagrams 79
B.4 SeaBat T51-S/IDH T51-S Cables 82
B.4.1 SeaBat T51-S/IDH T51-S Transducer Cables 82
B.4.2 SeaBat T51-S/IDH T51-S External Sensor Cable 82
B.4.3 UUV Interface Cable 82
B.4.4 Pin Designations for Host, AUX, LAN2, and SVP Connectors on SSP+ 83
B.5 SeaBat T51-S/IDH T51-S Installation 85
B.5.1 Subsea Sonar Processor SSP+ (PN 1012289-DK) 85
B.5.2 EM7222-1 Receiver Unit (PN 1019488-DK) 85
B.5.3 TC2190 Projector Unit (PN 1019037-DK) 86
B.5.4 Wet-End Cable Connections 86
B.5.5 Sonar Head Assembly Orientation 87
B.5.6 Sonar Reference Point 88
B.5.7 Wet-End Mounting 88
B.5.8 Hardware Settings 88
B.6 System Check 90
B.6.1 Configuration 90
B.6.2 Receiver and Projector Test 91
B.6.3 Receiver Test (performed in air or water) 91
B.6.4 Projector Test (always performed in water) 91
Appendix C PPS In and Trigger In 93
C.1 Electrical Specifications for PPS In and Trigger In 93
C.2 Typical PPS In and Trigger Performance 93
C.3 Hints and Advice 94
Appendix D Data Rates 95
Appendix E Network Configuration 96
E.1 System Network Configuration 96
E.2 Change IP Configuration 96
Appendix F Reference Documentation 98
F.1 SeaBat T51-S/IDH T51-S Documentation 98
F.2 SeaBat T51-S/IDH T51-S Design Documents 99
F.2.1 Receiver, EM7222-1 Outline Dimensions 100
F.2.2 Projector, TC2190 Outline Dimensions 101
F.2.3 Subsea Sonar Processor, Outline Dimensions 102
F.2.4 Cable Assembly, Receiver to SSP and Host Cable 103
F.2.5 Cable Assembly, Projector to SSP 104
F.2.6 Cable Assembly, Bulkhead Connector for ROV 105
F.2.7 Cable Assembly, AUX Pigtail 106
F.2.8 Cable Assembly, SSP to SVP 70 (optional) 107
F.2.9 Sonar Reference Point Definition 108

F.3 7kCenter Licenses – Copyright Information 109
Appendix G SeaBat T51-S/IDH T51-S System Options 114
G.1 Extended Warranty Contract 114
G.2 SeaBat Cables 114
G.3 Service Level Agreement 114
G.4 Sound Velocity Probe 114
G.5 System Integration and Training 115
G.6 Teledyne PDS Data Acquisition Software 115
Appendix H Standard Warranty Information 116
H.1 Limited Warranty 116
H.2 Warranty Exclusions 116
H.3 Warranty Disclaimer 116
H.4 Servicing During Warranty Period 116
Appendix I Support and Service 117
I.1 Teledyne RESON Support 117
I.2 Equipment Service Procedure 117
I.2.1 Policy for Servicing Equipment 117
I.2.2 Returning Equipment for Service 118

LIST OF FIGURES

Figure 1: SeaBat T51-S/IDH T51-S System Configuration....2
Figure 2: Range Setting Diagrams....31
Figure 3: Range Setting – Too Long....31
Figure 4: Range Setting – Too Short....32
Figure 5: Range Setting – The Exception....32
Figure 6: Example of Reduced Swath Width....36
Figure 7: Horizontal Swath Steering....37
Figure 8: Outer Beams for the Different Beam Modes with a Tilted Sonar Head....38
Figure 9: Graphic Illustration of FlexMode....40
Figure 10: Depth Gates, With No Roll....41
Figure 11: Depth Gates, With Roll....42
Figure 12: Depth Gates, With Roll and Motion Sensor Input....42
Figure 13: Depth Gate Tilt....43
Figure 14: Submerged Oil Detected by Multi-Detect....44
Figure 15: Swath under Zero Roll Conditions....45
Figure 16: Laterally Displaced Swaths under Roll Conditions....45
Figure 17: Swath under Roll Stabilization....45
Figure 18: Head Tilt Functionality....46
Figure 19: Head Tilt for Harbor Inspection....46
Figure 20: Head Tilt for Pipe Inspection....47
Figure 21: Acoustic Absorption Reference....49
Figure 22: Typical Sound Velocity Values....50
Figure 23: Subsea Sonar Processor....56
Figure 24: EM7222-1 Receiver Unit....56
Figure 25: TC2190 Projector Unit....56
Figure 26: Beam Density....58
Figure 27: Beam Spacing vs. Beam Angle....58
Figure 28: Beam Spacing....59
Figure 29: Across-Track Sounding Location on a Flat Bottom....59
Figure 30: Graphic Illustration of Snippets Data....61
Figure 31: SeaBat Real-Time Pipe Detection and Tracking....62
Figure 32: SeaBat FlexMode....62
Figure 33: Standard Detection....62
Figure 34: Multi-Detect with details of seeping gas bubbles....63
Figure 35: Multi-Detect....63
Figure 36: Vertical Detection of Quay Wall....63
Figure 37: Dual Head Synchronization of Pings....64
Figure 38: Brightness Test....65
Figure 39: Colinearity Flags....65
Figure 40: Typical AUV/ROV Installation....79
Figure 41: Bulkhead Cable Connections....79
Figure 42: T51-S/IDH T51-S AUV, Interfacing Diagram....80
Figure 43: T51-S/IDH T51-S ROV, Interfacing Diagram....81
Figure 44: SSP+ Pressure Bottle Connections....87
Figure 45: Configuration Check via Sonar UI Service Menu (example)....90
Figure 46: Required PPS Pulse Width....93
Figure 47: PPS In Delay....94
Figure 48: PPS/Trigger Signal....94

Figure 49: System Documentation Link (Example Only) 98
Figure 50: Receiver, EM7222-1 Outline Dimensions 100
Figure 51: Projector, TC2190 Outline Dimensions 101
Figure 52: Subsea Sonar Processor, Outline Dimensions 102
Figure 53: Cable Assembly, Receiver to SSP and Host Cable 103
Figure 54: Cable Assembly, Projector to SSP 104
Figure 55: Cable Assembly, Bulkhead Connector for ROV 105
Figure 56: Cable Assembly, AUX Pigtail 106
Figure 57: Cable Assembly, SSP to SVP 70 (optional) 107
Figure 58: Sonar Reference Point Definition 108

LIST OF TABLES

Table 1: SeaBat T51-S/IDH T51-S Feature Pack 2
Table 2: SeaBat T51-S/IDH T51-S Available Configurations 6
Table 3: Incorrect Range Settings – Examples and Solutions 31
Table 4: TVG Formula 34
Table 5: SeaBat T51-S/IDH T51-S System Performance 55
Table 6: Beam Modes with No. of Beams and Swath Coverage 57
Table 7: Ping Rate Table 67
Table 8: SeaBat T51-S/IDH T51-S Components 77
Table 9: Pin Designations for Host Connector (TIA/EIA 568B) mounted on SSP+ 83
Table 10: Pin Designations for AUX Connector mounted on SSP+ 83
Table 11: Pin Designations for LAN2 Connector (TIA/EIA 568B) mounted on SSP+ 83
Table 12: Pin Designations for SVP Connector mounted on SSP+ 84
Table 13: TIA/EIA 568B Overview 84
Table 14: SSP Technical Specifications 85
Table 15: EM7222-1 Receiver Unit Technical Specifications 85
Table 16: TC2190 Projector Unit Technical Specifications 86
Table 17: PPS In and Trigger In Signals 93
Table 18: Theoretical Max. Data Rates – SeaBat T51-S/IDH T51-S 95
Table 19: IP Configuration for SSP+ 96
Table 20: SeaBat T51-S/IDH T51-S Design Documents 99
Table 21: LAPACK – Copyright Information 109
Table 22: WinPCap – Copyright Information 110
Table 23: SVP Technical Specifications 115

1 INTRODUCTION

1.1 System Overview

The SeaBat T51-S/IDH T51-S is a new addition to the leading SeaBat product range engineered from the ground up to evolve with your business. The SeaBat T51-S/IDH T51-S sonar system is designed for mounting on an Unmanned Underwater Vehicle, an AUV or ROV.



- **SeaBat T51-S:** Combined with a Subsea Sonar Processor (SSP+), the T51-S sets a new standard in subsea high-resolution mapping. With the smallest receiver beamwidth available and wide swath capabilities, users no longer have to choose between exceptional resolution and operational efficiency.

  The SeaBat T51-S comes with the revolutionary high-frequency band of 700-800kHz which yields the highest level of detail while maintaining seven times water depth survey efficiency.

  In addition, SeaBat T51-S comes with a flexible 350-430kHz lower frequency range for the surveys requiring extended range performance.



- **Integrated Dual Head SeaBat T51-S:** The Subsea Sonar Processor's (SSP+) Integrated Dual Head (IDH) capability enables dual-head configurations using a single SSP+, saving valuable space on survey vessel.
- **Subsea Sonar Processor:** The SSP+ provides internal data storage for self-contained survey solution and interfacing via standard Ethernet to reduce integration time.

  All solutions include a powerful software feature set to increase operational efficiency, with the option for future feature expansions to grow with your needs.

For available configurations, see *section 1.6 below*.

For available options, see *Appendix G SeaBat T51-S/IDH T51-S System Options*.

1.2 System Architecture

The SeaBat T51-S/IDH T51-S sonar system consists of a Subsea Sonar Processor (SSP+), a receiver unit, and a projector unit. The receiver and projector units each connects to the SSP+ via a dedicated cable. With AUV operation, the SeaBat T51-S/IDH T51-S sonar system is installed and configured to operate autonomously requiring only a startup command to function. With ROV operation, user displays and system control originate within the customer-furnished survey laptop. To feed 22-60VDC power and control the operation of the sonar, the SSP+ provides an Ethernet and power input connector. Sensor data may be interfaced to the SSP+ via dedicated ports.

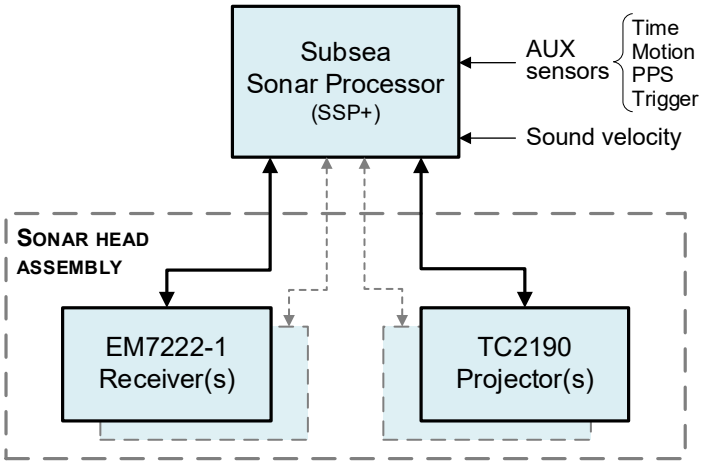


Figure 1: SeaBat T51-S/IDH T51-S System Configuration

1.3 System Operation

The projector unit of the sonar head assembly transmits a pulse of acoustic energy, which travels through the water medium and is reflected by the seafloor or any objects in its path. The reflected signal is detected by the receiver unit of the sonar head assembly, digitized by internal electronics, and sent to the SSP+ for beamforming and processing. The SSP+ can act as a single point of interfacing for sonar and sensor data for precise time stamping of these data prior to broadcast over standard Ethernet connection to the logging system.

1.4 System Features

Table 1: SeaBat T51-S/IDH T51-S Feature Pack

Feature	Base	Optional
Channel normalization	✓	
Constant seafloor spacing	✓	
Data logging internal to the SSP	✓	
Dual head, full rate		✓
Dual head, standard	✓	
FlexMode		✓
Head tilt	✓	
Manual gates	✓	
Max. 1024 beams	✓	

Feature	Base	Optional
Multi-detect		✓
On the fly frequency change	✓	
On the fly mode selection	✓	
Pipe detection and tracking[1]		✓
Quality filter	✓	
Roll stabilization	✓	
Sonar User Interface	✓	
Selectable beam density	✓	
Tracker	✓	
Uncertainty output	✓	
Variable frequency (for shallow system)	✓	
Vari-swath	✓	
Vertical detection mode	✓	
X-Range (FM)		✓

NOTE
The Base feature package can be upgraded after installation.

The main features of the SeaBat T51-S/IDH T51-S system are summarized below.

- **1PPS pulse handling and time stamping:** Data time stamping is referenced to an incoming 1PPS and associated time message.
- **Adaptive gating:** Three different gate settings are available to assist the bottom detection process: No Gates, Absolute Gates, and Adaptive Gates, thus minimizing data processing time. Adaptive gates adapt to the trend of the seafloor and maximize swath performance by directing the bottom detection algorithm to search for the seafloor where it is most likely to be found. The result is maximum swath coverage and ultra-clean data.
- **Beamforming:** The beamformer performs initial signal processing: a combination of time delay and phase rotation techniques to maximize performance.
- **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 robustness. Selection of amplitude or phase detection is automatic for each beam, based on signal analysis, generating optimal results over all seabed types.
- **Built-In Test Environment (BITE):** The Built-In-Test-Environment (BITE) is an integral part of the sonar processing unit which monitors the status of the internal electronic sub-systems and wet-end units. The BITE function is designed to inform the operator that the system is performing normally and, therefore, that vehicle time is being utilized effectively. In the event of any errors, the system will report this immediately for rapid troubleshooting.
- **Channel normalization:** This feature ensures equal performance across the receiver channels which minimizes side lobe levels in the beamforming process. The result is

[1] Includes FlexMode.

superlative beamforming with ultimate acoustic performance and maximum power in the main beams.

- **Constant seafloor spacing:** This feature yields equidistant spacing between beams, even on a sloping seafloor.
- **Depth rating:** The SeaBat T51-S/IDH T51-S system is depth rated to 6000m.
- **External trigger:** The system may be triggered using a standard 7k Center software remote command or by a TTL incoming trigger pulse, allowing the system to be used simultaneously alongside a multitude of other acoustic systems.
- **Fast update:** The entire swath is illuminated with a single transmission at an update rate of up to 50Hz (range selection dependent). This allows compliance with IHO SP44Ed 5 coverage requirements even at high speed.
- **FlexMode:** FlexMode allows the operator to select an ultra-high density sector and direct it anywhere in the swath while maintaining full swath coverage.
- **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.
- **Hardware sync pulse out:** A TTL pulse (synchronous with the transmit pulse) is available from the SSP for synchronization purposes, allowing the system to be used simultaneously alongside a multitude of other acoustic systems. This output is referred to as Trigger Out.
- **Multi-detect:** This feature provides multiple detections within each beam to capture highly detailed images of complex objects and seabed terrain. Easier and faster than water column processing, the feature reduces the need for collecting large water column sets.
- **Operator selectable beam density:** Within each beamforming mode, the operator has full control over how many beams to form, ranging from high density down to just a few. This produces highest detail where necessary, and allows improved efficiency at low altitudes by deploying fewer beams. A special option is the ability to define the desired spacing between beams on the seafloor. The system will “hold” this automatically, varying the number of beams as depth changes.
- **Operator selectable beamforming mode:** The operator is able to select from a number of different preset modes with up to 1024 beams, including Equi-Distant and Equi-Angle. Equi-Distant provides uniform data density across the swath and leads to greatest efficiency by minimizing overlaps, thereby minimizing the number of lines required to survey a given area.
- **Quality filters:** Real-time bottom detection quality tests are performed to speed up processing and reduce time and costs. The SeaBat system flags all soundings based on two tests: the first analyses proximity to neighboring soundings and the second tests the signal level of the bottom detection. If both tests are passed the sounding is flagged as high quality. If any test fails, the sounding is flagged and the user may accept or reject it in the postprocessing stage. The process is fully automated to generate the cleanest possible data automatically and speed up processing.
- **Real-time pipe detection and tracking:** This SeaBat feature automatically detects pipes within the multibeam swath, displays them in real time during survey, and generates pipeline deliverables directly from SeaBat. The feature builds on the robustness of FlexMode for relaying a high-density profile of the pipe. A special gating method focuses on the pipeline to improve the quality of detection of the pipe**.**
- **Resolution:** Dynamic, focused beamforming maintains ultra-high resolution, even at short ranges. A receiver sample rate of 34/66kHz provides excellent range resolution and

complements the narrow beam, thus providing the user with ultimate data quality and resolution.

- **Roll stabilization:** Dynamic roll stabilization may be selected for up to ±15° roll, ensuring that uniform coverage is maintained, independent of vehicle motion. This leads to maximum efficiency by minimizing the number of survey lines required for a given survey area.
- **Standard data output:** The SeaBat T51-S/IDH T51-S system exports bathymetry, side-scan, snippets backscatter, and water column backscatter in a standard format for easy interfacing. With multiple deliverables, the system adheres to the “survey once, use many times” philosophy, thereby optimizing vessel time.
- **Steerable swath:** The swath sector may be electronically steered to focus on a particular region of interest to achieve optimal performance, coverage, and data density.
- **Time stamping of sensor data:** Data time stamping of sensor data interfaced to the SSP (position, motion, and heading) is referenced to an incoming 1PPS and associated time message (serial or network), ensuring that each data is time stamped to UTC to better than 1 millisecond, prior to broadcast over standard Ethernet to the UUV logging system.
- **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.
- **Uncertainty output:** Uncertainty estimations are automatically calculated on a beam-by-beam basis and exported to allow for robust estimations of Total Propagated Uncertainty (TPU) in data acquisition and processing packages. This feature enables advanced statistical processing routines to perform optimally and thus speed up processing time while reducing manual efforts.
- **Variable swath coverage:** This feature allows the swath angle to be adjusted by the operator. Optimizing the swath ensures that the appropriate sector is insonified for the selected range, which maximizes ping rate and thus survey speed, and minimizes processing time and costs by providing the cleanest possible data.
- **Vertical detection mode:** Vertical structures pose an acoustically challenging environment for normal bottom detection methods. The SeaBat Vertical Detection Mode employs a unique method to produce improved detections of vertical structures such as quay walls. Any damage, anodes, or other smaller objects are also better detected with this feature.
- **Water column recording:** The SeaBat T51-S/IDH T51-S system is capable of recording water column data for advanced scientific research. The water column data may be written to an optional external Network Attached Storage (NAS) drive. Recorded data may be played back and analyzed using the standard operating software provided with the system.
- **Wideband projector:** The SeaBat T51-S/IDH T51-S uses the same projector (transmitter) TC2190 for a wide frequency range for mapping at high (400kHz) or ultra-high resolution (800kHz) without compromising swath width.
- **X-range:** X-Range is an optional 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.

NOTE
Some features may require operator intervention and as such may have limited functionality when in use in AUVs.

1.5 Typical Applications

The SeaBat T51-S/IDH T51-S system provides support for a wide range of applications including:

- Breakwater mapping
- Coastal mapping
- Harbor mapping
- Hydrographic surveys to IHO Special Order and to U.S. Army Corps of Engineers Special Order
- Pipeline route surveys
- Out of Straightness (OOS) surveys
- As-built surveys
- Pipeline inspection surveys
- Pre- and post-dredging and condition surveys
- Revetment surveys
- River surveys
- Search and recovery
- Site clearance surveys
- Underwater inspection and object location

1.6 Available SeaBat T51-S/IDH T51-S Configurations

Table 2: SeaBat T51-S/IDH T51-S Available Configurations

PN	System	Frequency (kHz)	Depth rating (m)
88017094	SYS, SeaBat T51-S, Subsea, **deep single head**	350-430kHz and 700-800kH	6000
88017096	SYS, SEABAT T51-S IDH, SubSea, Deep, 6000M, **Integrated Dual Head**	350-430kHz and 700-800kH	6000

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 H Standard Warranty Information*).

2.1 Operator Safety

The SeaBat T51-S/IDH T51-S 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 SSP+ 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.

2.2 Equipment Safety

Each SeaBat T51-S/IDH T51-S 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 cases 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 from the SSP+ or from the sonar head assembly while the SSP+ 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 plastic sheet.
- Ensure that the equipment is properly secured before putting out to sea.

CAUTION
The projector **must** always be tested in water, whereas the receiver may be tested in air.

CAUTION
If the SSP+ is run on deck for the purpose of offloading data, Deck mode should be enabled in the Sonar UI. It is also recommended that a water bath, wet towels, or other heat mitigation solution is employed to prevent overheating of the computer electronics in the pressure housing. The temperature of the computer electronics can be monitored using the system's BITE feature while offloading data. A red LED indicator will notify the user that temperatures are approaching a critical level.

- Unused connectors should be sealed with dummy plugs.
- Do not exceed operating and storage temperature limits.

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.
- To limit the growth of biofouling, an antifouling paint should be applied on the acoustic window.
    - For high-frequency transducers (>100kHz), Teledyne Marine only recommends ClearSignal™, as other antifouling paints may affect acoustic performance.
    - ClearSignalTM is non-toxic and it carries no occupational or environmental hazards.
    - The product is designed to last the lifetime of the instrument it protects.
    - The coating has no negative effects on the performance properties of the sonar.
    - ClearSignal™ can only be applied by a certified provider.
      Teledyne Marine is the only company in mainland Europe to offer this service.

CAUTION
ClearSignal™ must not be applied by others than a certified 3rd party. Failure to comply may affect warranty situation (see *Appendix H Standard Warranty Information*). Please contact Teledyne RESON Support for assistance.

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

2.2.2.2 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 connectors are 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.

2.3 Corrosion Avoidance

All metal parts of the SeaBat™ exposed to seawater are made of corrosion-resistant alloys. This is to ensure long operational life of the system. Combining these noble and corrosion-resistant metals with less noble metals in a saline environment will cause a cathodic reaction.

We therefore recommend electrical isolation between the sonar head and mounting structure.

CAUTION
Damaged cables must be replaced (and not repaired). Otherwise the result may be corrosion and/or debonding. Noncompliance may affect warranty situation (see *Appendix H Standard Warranty Information*).

2.4 Electrical Isolation

Electrical isolation for titanium components may be achieved by using nonconductive bushings, washers, and isolation plates to insulate them from the mounting brackets. Materials such as FR4, G-10, and G-Etronax EP11 are ideal, as they combine high mechanical strength with a complete electrical isolation. Unreinforced plastic materials such as PVC, Delrin, and polyamide will work from an electrical point of view but offer limited mechanical strength and have a tendency to relax over time causing interfaces to become loose.

CAUTION
If the sonar head is not isolated, galvanic corrosion will result in the mounting structure.

NOTE
The complete, assembled sonar system exceeds 10 megaohm isolation from any pin to water.

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 2012/19/EU, 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 (reson-support@teledyne.com).

2.7 CE Marking

EC DECLARATION OF CONFORMITY

We Teledyne RESON A/S
Fabriksvangen 13
3550 Slangerup
Denmark

in accordance with the following directive(s):

2014/30/EU Electromagnetic Compatibility (EMC)

hereby declare that the following equipment:

SeaBat T-Series Subsea sonar system (deep or shallow, single or dual head),
SeaBat F-Series Subsea sonar system (deep or shallow)

is in conformity with the applicable requirements of the following standards:

REF. NO.	TITLE	EDITION/DATE
EN 60945 §9 and §10	Maritime navigation and radio communication equipment and systems - General requirements - Methods of testing and required test results.	2002
EN 60533	Electrical and electronic Installations in ships – Electromagnetic compatibility.	1999
IACS E10	Unified environmental test specification for testing procedure for electrical control and instrumentation equipment, marine computers and peripherals covered by classification.	2007
EN 61000-4-8	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques – Power frequency magnetic field immunity test.	1993 AMD 1: 2001
ISO 25862	Ships and marine technology – Marine magnetic compasses, binnacles and azimuth reading devices	2009

NOTE regarding EMC Compliance:

To ensure full EMC compliance with regards to conducted emission, a customer-provided filter should be placed close to the power source. (Please refer to appropriate Operator's Manuals.)

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all applicable essential requirements of the directives.

Location: Slangerup, Denmark

Date: 1 February 2021

Name: Ole Søe-Pedersen

Position: Vice President & General Manager

CE 21

Document No. CERT22224

Signature: _____

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):

- ***Pre-dive Checks:*** Consists of details on the procedure to follow prior to deploying the system.
- ***System Startup Instructions:*** Consists of startup details for both AUV and ROV systems.
- ***System Shutdown Instructions:*** Consists of details on stopping the system for both AUV and ROV systems.
- ***Post-dive Checks:*** Consists of details on the procedure to follow once the system has been recovered to deck.

NOTE
For information on installation (including configuration of hardware), see *Appendix B Installation Instructions*.
For a brief introduction to the Sonar UI, details on remote operation and folder management, see *section 4 System Configuration with User Interface*.
For information on UUV system operation, see *section 5 UUV System Operation*.
For information on system configuration and user interface navigation, refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*).
For information on the practical use of the sonar, see *section 6 Active Sonar Usage*.

3.2 Pre-dive Checks

Prior to deploying the SeaBat T51-S/IDH T51-S system into the water, perform the following checks.

1. Inspect all system cables for signs of chafing or damage.
2. Inspect the transducer arrays for any signs of damage or oil leakage.
3. Inspect the SSP+ for any signs of damage.

3.3 System Startup Instructions

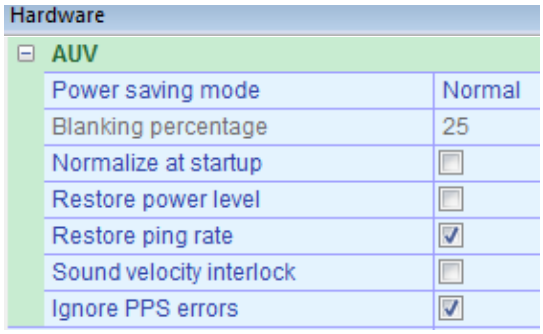
3.3.1 AUV System

After the SeaBat hardware has been installed (see *Appendix B Installation Instructions*), the system may be started.

1. Apply power to the SSP+. The SeaBat T51-S/IDH T51-S will automatically start the AUV operating system.
2. The 7k Center will start. Once started the 7k Center will configure itself to match the sonar operating parameters present when the system was last shut down. Thus, if the sonar was pinging when the system was last shut down, the sonar will resume pinging. The factory default power setting is Power OFF to prevent accidental damage of the projector.
3. Optional:
   a. Access the SSP+ operating system via remote control software and configure the system operating parameters as appropriate for the mission (see *section 4 System Configuration with User Interface*).
   b. Close the remote control software connection.
4. The system is ready to be deployed.

NOTE

Configurable in the AUV section of the Hardware pane:



- Power saving mode:
  - Normal
  - Range blank: reduce power consumption
- Blanking percentage
- Normalize at startup (default: enabled)
- Restore power level: use last session's setting
- Restore ping rate: use last session's setting
- Sound velocity interlock: prevent pinging when SV input is below 1401m/s (enabled as default)
- Ignore PPS errors

CAUTION

The SSP+ is designed for operation under water. Operation in air for extended periods of time will result in overheating and severe damage to the system.

NOTE

If the 7k Center is shut down during setup and test, it may be restarted by double-clicking the 7k Center icon on the control computer.

3.3.2 ROV System

After the SeaBat hardware has been installed (see *Appendix B Installation Instructions*), the system may be started.



1. Apply power to the SSP+.
2. Double-click the Sonar UI icon on the customer-provided computer/laptop to start the Sonar User Interface.
3. Connect to the SSP+.
4. Select the appropriate settings for the mission.
   (For further details, see *section 4.2 Sonar User Interface (SUI)*.)

3.4 System Shutdown Instructions

CAUTION
Simply cutting power to the SSP+ can result in corrupted data files and problems with restarting the SSP+ Windows® 7-based operating system. Follow the shutdown instructions in this section carefully to prevent this from happening.

3.4.1 AUV System

3.4.1.1 To shut down the system via the VCC:

1. Send remote control command 1000 to the 7k Center.
   Please refer to the Data Format Definition document for instructions (see *appendix F.1 SeaBat T51-S/IDH* T51-S Documentation).
2. Wait at least 15 seconds, and then remove power from the SSP.

3.4.1.2 To shut down the system via remote desktop:

1. Access the SSP+ operating system via remote control software.
2. Activate the 7k Center application window.
3. Press Esc (on the keyboard). This will initiate shutdown of the sonar.
4. Once the 7k Center application window has closed,
   - Follow regular Windows procedure to shut down the sonar, or
   - Click Start. In the Search Programs and Files, enter: “Shutdown –s –t 1” and press Enter on the keyboard. Wait for the remote desktop window to terminate.
5. Once the remote desktop window has terminated, power may be removed from the SSP+.

3.4.2 ROV System

CAUTION
Ensure that the SSP+ is shut down correctly.

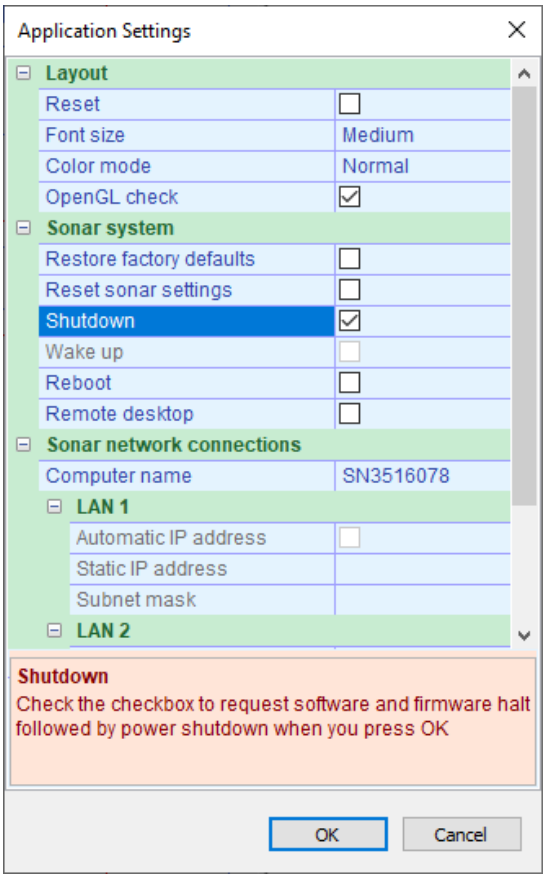
1. Click the Application Settings button in the top right corner of the Sonar UI.



2. Select Shutdown in the Application Settings dialog.
3. Click OK.

   This will terminate the connection to the SSP+/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 reload the same selection of sonar settings, once the system is started again.
5. To shut down the laptop/PC, press the power button (or follow Windows procedure).



3.5 Post-dive Checks

Once the SeaBat T51-S/IDH T51-S system is recovered to deck, perform the following checks.

1. Shut off all power to the SeaBat T51-S/IDH T51-S system.
2. Using fresh water, wash down all system components to minimize salt accumulation and the development of localized corrosion pits.

CAUTION
Do not use hot or cold pressure washers. The high-velocity water spray will cut through the polyurethane or damage the interface between the polyurethane and the metal housings.

3. If necessary, schedule troubleshooting and/or repair of the suspected unit.
4. Inspect all cables for signs of twisting or abrasion.
5. Inspect the cables, transducer arrays, and SSP+ for any signs of damage or oil leakage.

4 SYSTEM CONFIGURATION WITH USER INTERFACE

4.1 Chapter Overview

NOTE
With a **ROV system**, the Sonar UI is used for system configuration and operator control. Refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*). With an **AUV system**, the Sonar UI is needed for operator control during system setup and test only. Refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*). During **AUV system** operation, all communication will be between the SSP+ and the customer-provided Vehicle Control Computer. The output during operation is a data stream in accordance with the Data Format Definition document (see *appendix F.1 SeaBat T51-S/IDH T51-S Documentation*).

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

- ***Sonar User Interface (SUI):*** Consists of brief instructions on starting the Sonar User Interface.
- ***Remote Operation:*** Consists of instructions on how to control the sonar from a remote PC.
- ***Remote Desktop Session:*** Consists of instructions on how to establish a remote desktop session.
- ***Folder Management:*** Consists of instructions on file sharing and renaming of computer or workgroup.

NOTE
For more details on system configuration and user interface navigation, refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*). For information on starting, stopping, and setting up the SeaBat sonar system, see *section 3 System Startup and Shutdown*. For information on the practical use of the sonar, see *section 6 Active Sonar Usage.* For information on installation and details on the various system components, see *Appendix B Installation Instructions*.

4.2 Sonar User Interface (SUI)

After the SeaBat hardware has been installed (see *Appendix B Installation Instructions*), the system may be started.

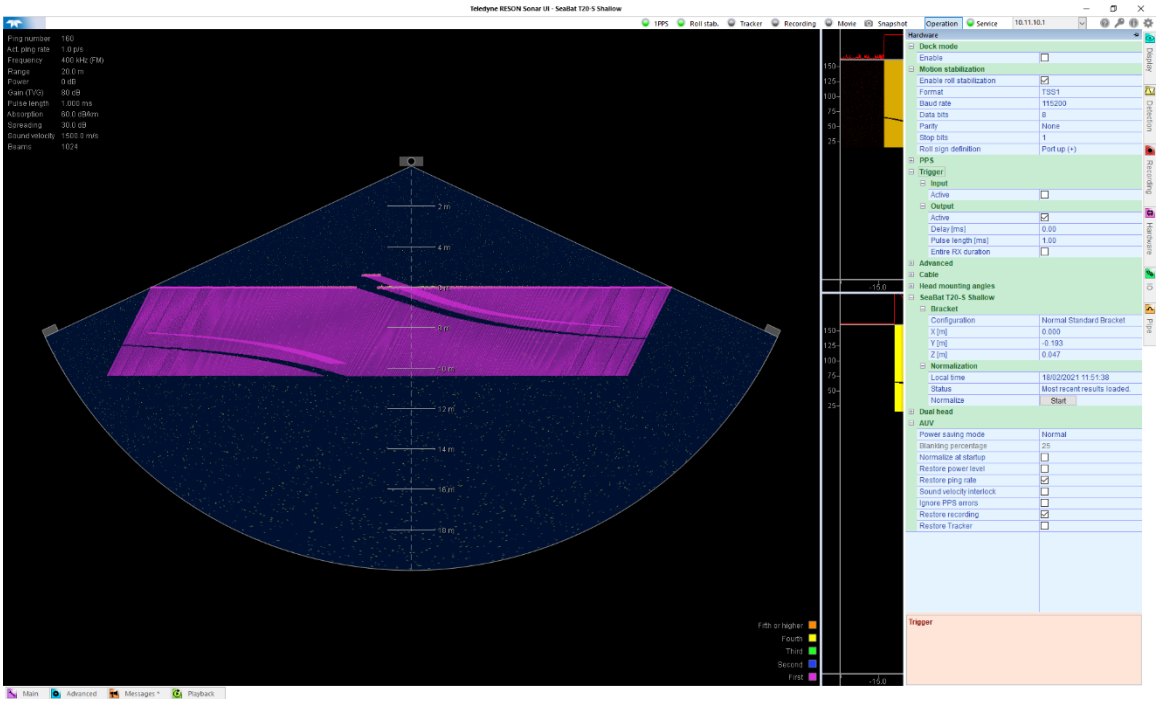
NOTE
As per the nature of AUV systems, during typical operations the Sonar UI will not be used; however, it may be used when monitoring or testing the system while the SSP+ is on deck.

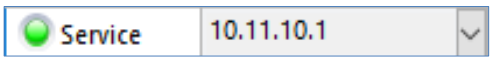
1. Double-click the Sonar UI icon on the customer-provided computer/laptop to start the Sonar User Interface.



2. In the top right corner of the UI, click the Sonar address drop-down menu, and select the IP address of the connected SSP+/sonar system from the list.

   The SeaBat T51-S/IDH T51-S system can be identified by its serial number next to the IP address. The serial number can be found on the front of the SSP+.





NOTE
The laptop/PC/vehicle controller and SSP+ should be directly connected using an Ethernet cable to the HOST or LAN 2 port of the SSP+, or through a Switch. (For further information, see *appendix B.5.4 Wet-End Cable Connections*.) **By factory default, the SSP+ is set up with fixed IP addresses: 10.11.10.1 for HOST and 10.11.10.2 for LAN 2.** If the SSP+ 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 (HOST) 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/vehicle controller IP address is set to an ***unused*** IP address within the 10.11.10.XXX subnet, subnet mask 255.255.255.0. ○ Recommended is 10.11.10.3 for single-head systems. ○ Recommended is 10.11.10.5 for dual-head systems. For details on IP address configuration, see *Appendix E Network Configuration*.

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

3. Select the settings appropriate for the present survey mission. Refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*).

   For information on pre- and post-dive checks and shutting down the sonar, see *section 3 System Startup and Shutdown*.

NOTE
For further information on system configuration and user interface navigation, refer to the Sonar UI User Manual (see *appendix F.1 SeaBat T51-S/IDH T51-S Documentation*).

4.3 Remote Operation

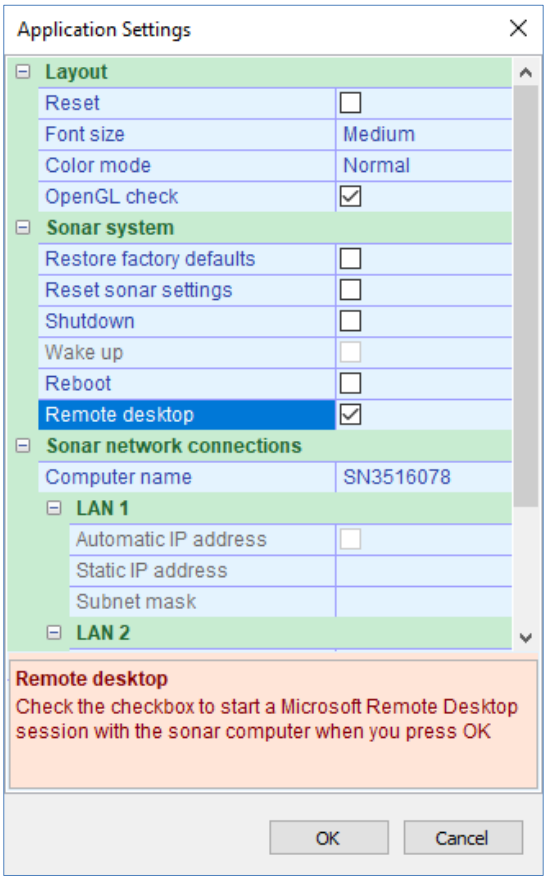
The 7k series software architecture is built on a client/server concept. The 7k Center running on the SSP+ controls the sonar, performs data processing, and exports data to external clients connected via TCP IP/UPD IP. The clients should control the 7k Center via remote SUI (ROV) or use of customized control applications based on DFD (AUV). Refer to the appendix section in the Data Format Definition document for example code for writing the control application (see *appendix F.1 SeaBat T51-S/IDH T51-S Documentation*).

4.4 Remote Desktop Session

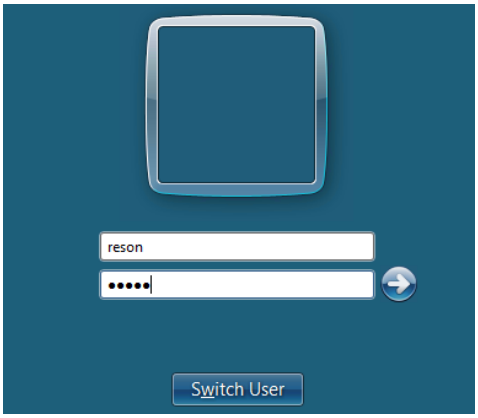
1. Click the Application Settings button in the top right corner of the Sonar UI.



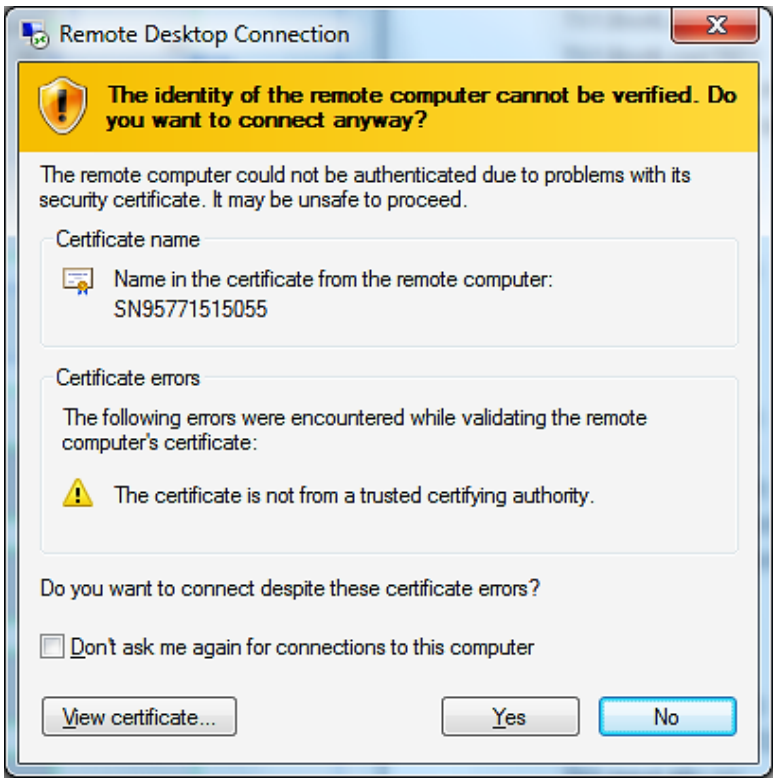
2. Select the Remote desktop option in the Application Settings dialog to establish a remote desktop session.
3. Click OK.



4. Enter credentials when prompted:
   - User: reson
   - Password: reppe
5. Click the arrow to accept your entry
   (or press Enter on the keyboard).



6. If the Remote Desktop Connection displays an identity warning, click Yes.



4.5 Folder Management

4.5.1 File Sharing on a Network

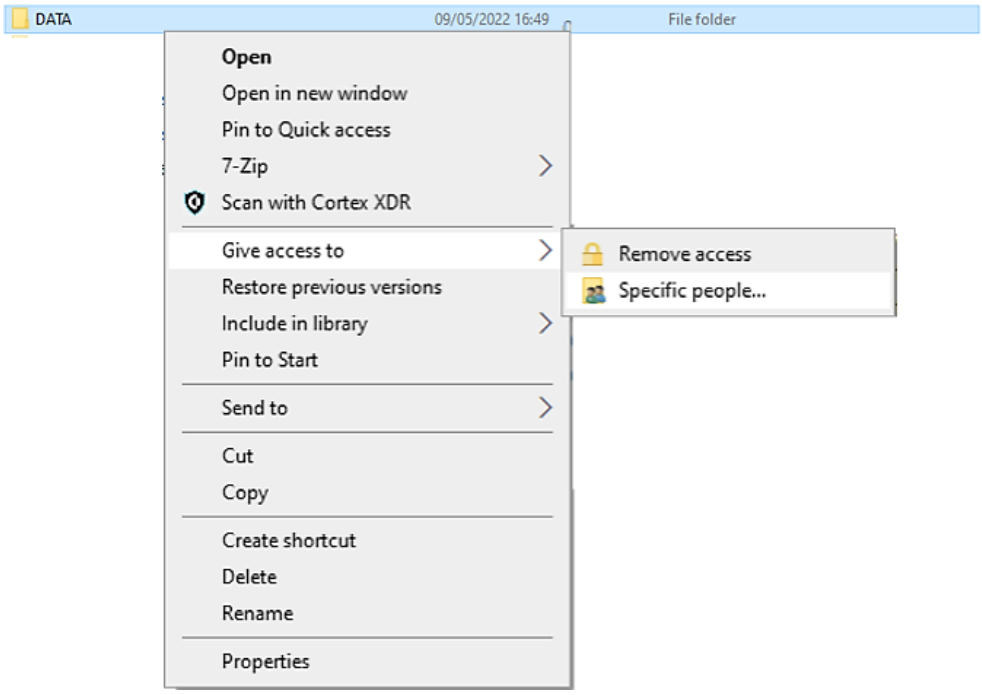
4.5.1.1 Sharing a Folder on a Network (default configuration from factory)

This section describes how to create a shared folder on the SSP+. Shared folders allow users to access and move data off the SSP+ to another network-connected PC.

NOTE
A network switch is recommended for ease of file sharing and high-speed data transfer reliability.

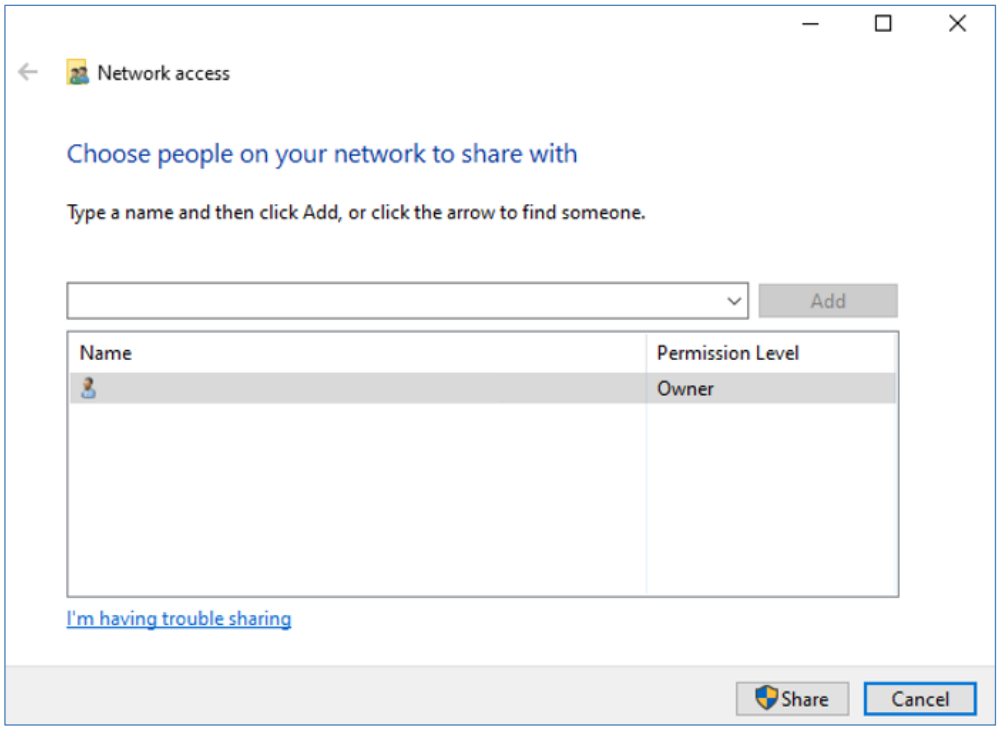
1. Establish a remote desktop session as described in *section 4.4 above*.
2. Once the remote desktop session has been established, go to My Computer on the SSP+ and open the D:\ drive.

3. Right-click on the folder to be shared, e.g. DATA, and select Give access to | Specific people.



NOTE
Data itself should **only** be saved to the D:\ drive.

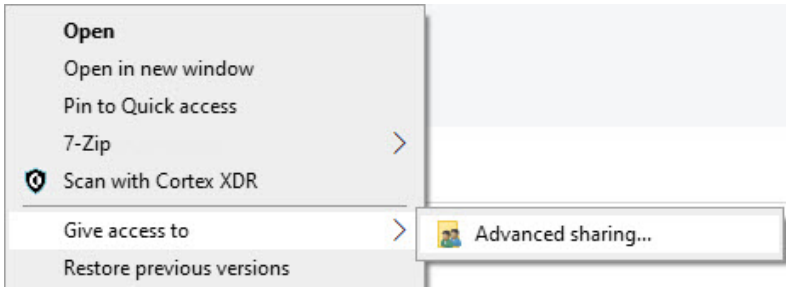
4. In the Network access dialog, enter a name and click add, or click the arrow to find someone.



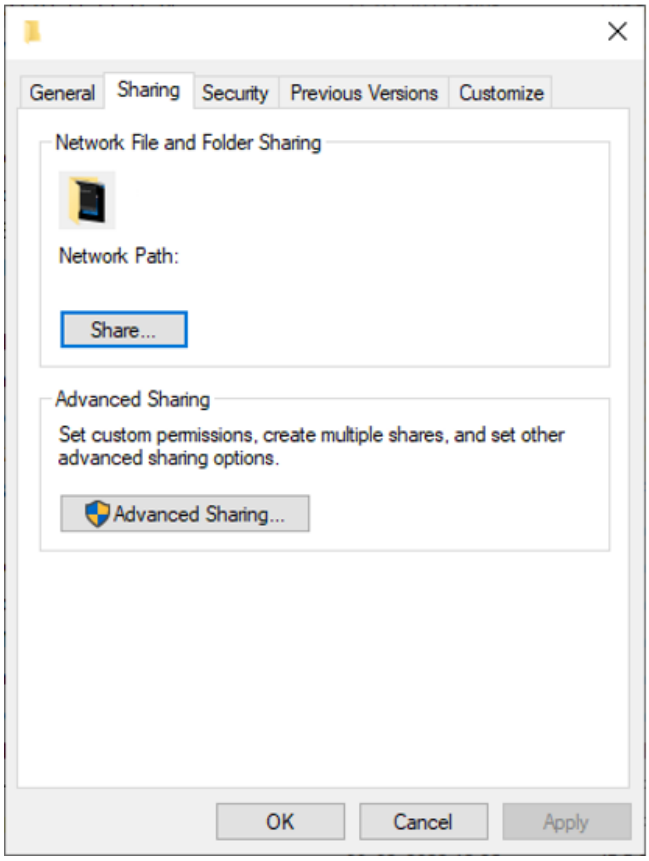
5. Click Share.

4.5.1.2 Sharing the D:\ Drive on a Network (default configuration from factory)

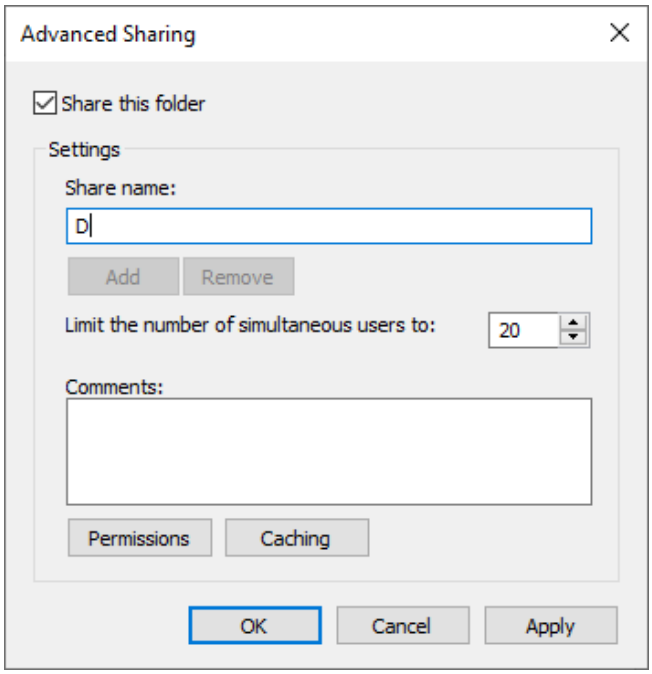
1. Establish a remote desktop session as described in *section 4.4 above*.
2. Once the remote desktop session has been established, go to My Computer on the SSP+.
3. Right-click on the D:\ drive, and select Give access to | Advanced sharing.



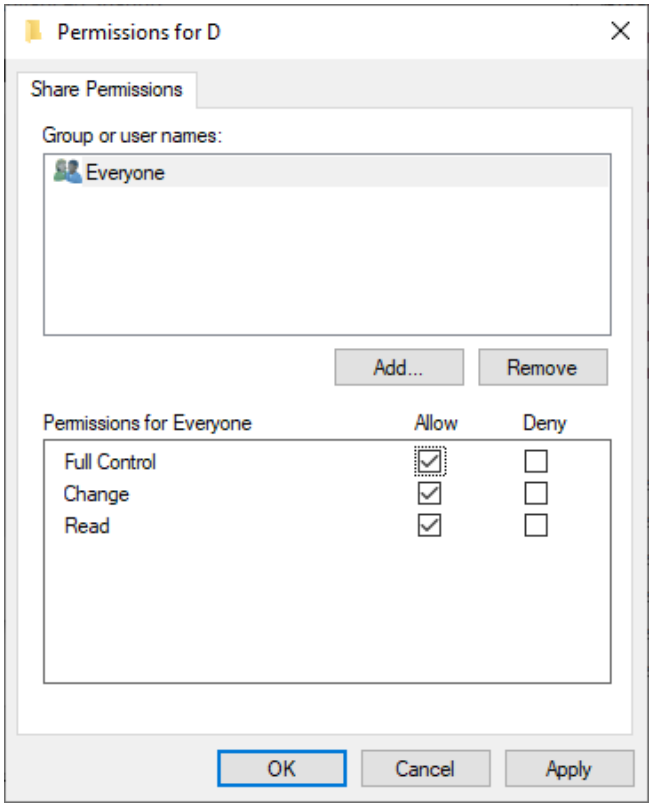
4. Go to the Sharing tab, and click the Advanced Sharing button.



5. In the Advanced Sharing dialog, select the Share this folder check box, and click the Permissions button.



6. In the Permissions dialog, assign the required permissions per group or user name.



7. Click Apply.

4.5.2 FTP Server

The SSP+ has an FTP server enabled. The root folder on the internal data drive D:\ is read/write accessible through any FTP client.

To access the FTP server, configure the FTP client using the information below:

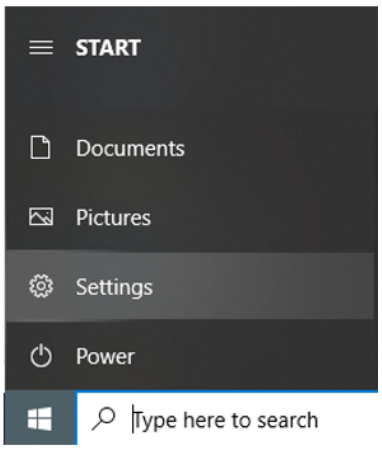
- Address FTP://SNWWYYXXX
  (SNWWYYXXX being SN plus the 7 digit serial number found on the front label of the SSP+. For the front label below, it would be FTP://SN4521009).
- User: reson
- Password: reppe

4.5.3 Verifying or Changing the Computer Name and/or Workgroup Name

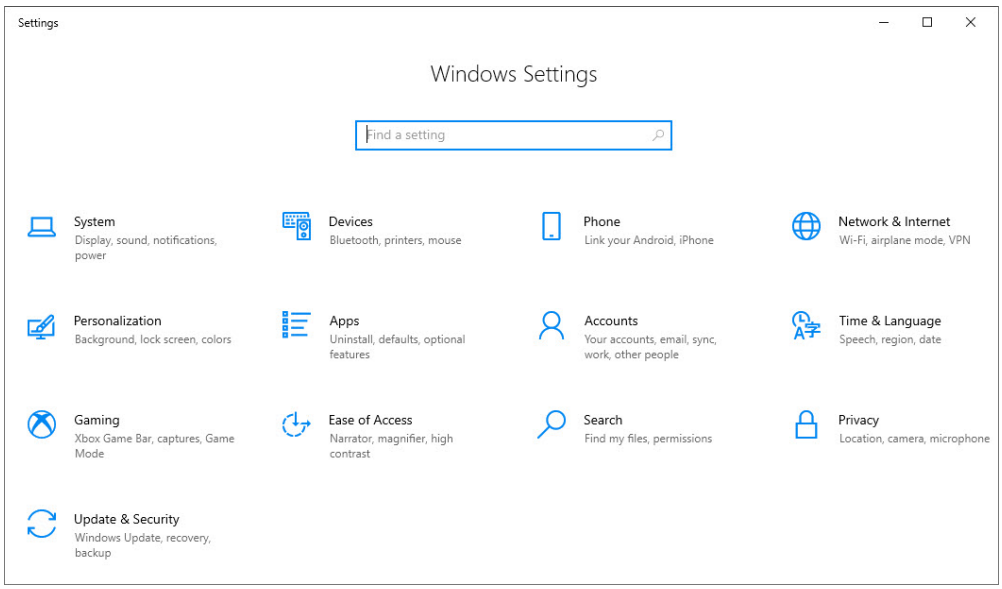
NOTE	
If changing the Computer Name, a restart of the SSP+ is required before the new name can take effect. By factory default, the computer name of the SSP+ is set to SN+serial number, which can be found on the serial number label next to the host connector, as marked on the example label to the right.	
CAUTION	
Changing the computer name will prevent IP-address configuration from the SUI (see *appendix E.2 Change IP Configuration*). For further information on system configuration and user interface navigation, refer to the Sonar UI User Manual (see *appendix F.1 SeaBat T51-S/IDH* T51-S Documentation).	

The default workgroup name for the SSP+ is *Workgroup* and can be found on the network workgroups. Use the following steps to verify or change the computer name and/or workgroup name.

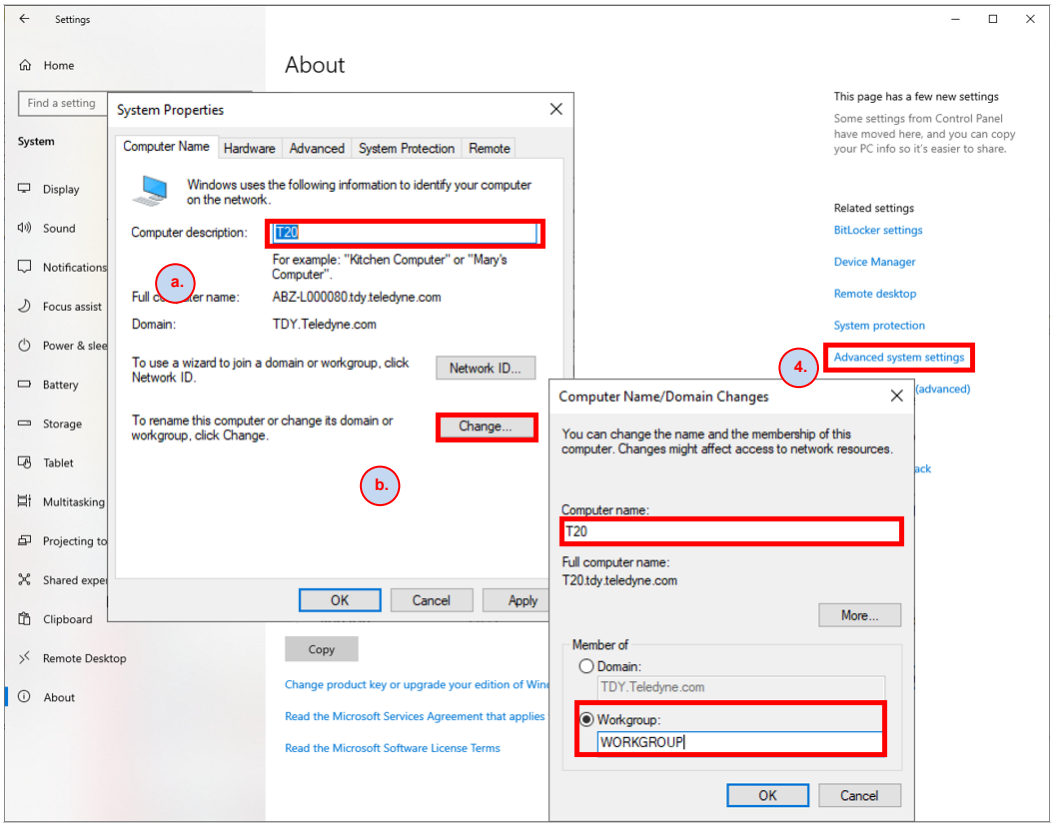
1. Establish a remote desktop session as described in *section 4.4 above*.
2. Once the remote desktop session has been established, go to the Windows Start menu and select Settings.



3. Select System and then About in the navigation pane to the left.



4. Select Advanced system settings on the right-hand side in the window to chance:
   a. Computer description.
   b. Computer name[2] and Workgroup name. Changing either of these names does not affect the IP address. (Changing the computer name might prevent the SUI dropdown menu from identifying the SSP+, if it is not prefixed with SN.)

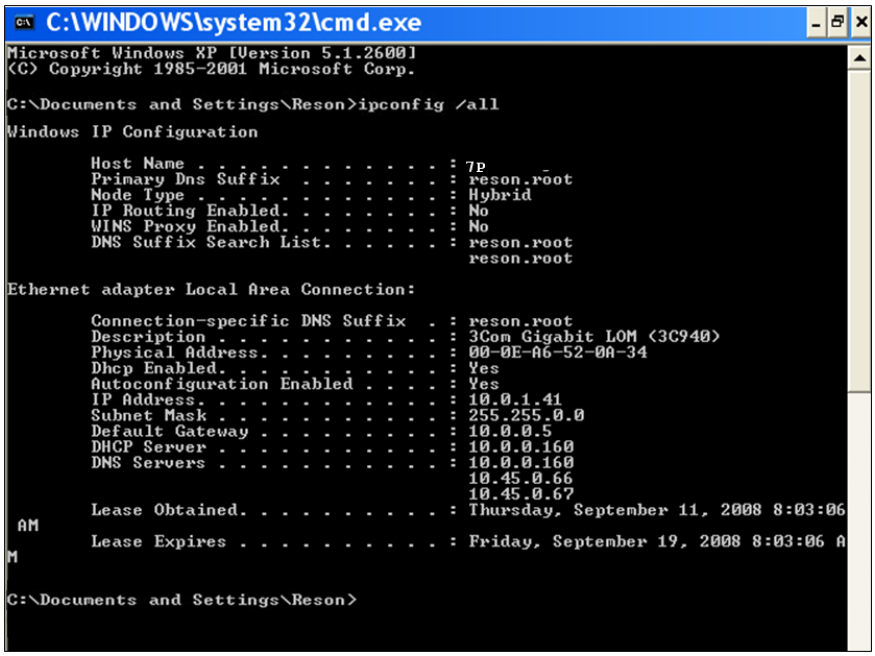


[2] Computer name is by default: SN xxxxxxx (7-digit serial number).

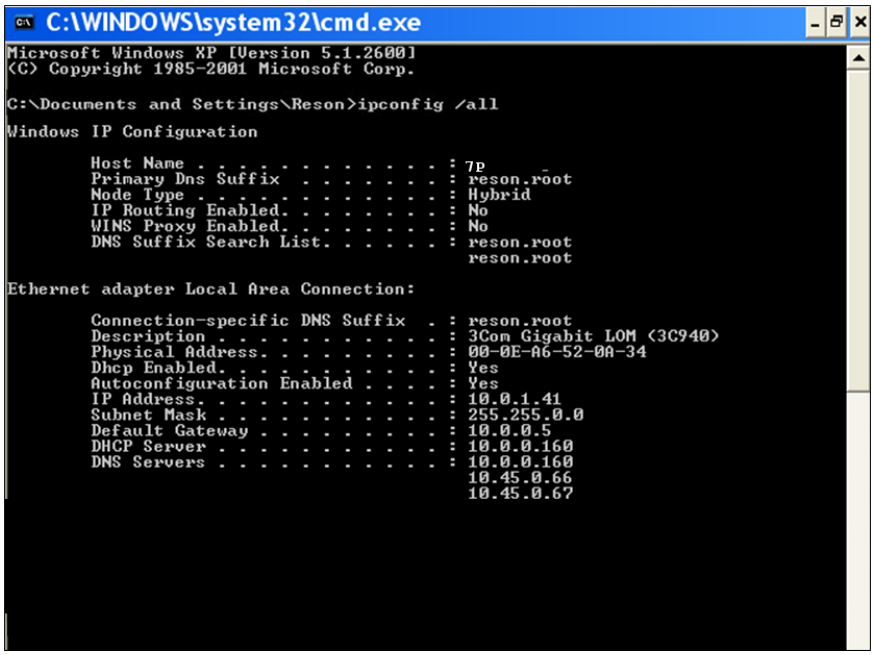
5. To view current IP address information, go to the Windows Start menu and enter CMD in the search field and press Enter.



6. In the command screen, enter ipconfig /all (be sure to enter a single space before /all) and press Enter.
   - The screen displays the connection status of all the network connections, including IP Addresses as shown in the following command screen sample.



   - If all connections are disconnected, only the Media State and MAC address for each connection display. The following command screen sample shows a typical disconnected SSP+.



5 UUV SYSTEM OPERATION

NOTE
With an **AUV system**, the Sonar UI is needed for operator control during system setup and test only (see also *section 4 System Configuration with User Interface*). With a **ROV system**, the Sonar UI is used for system configuration and operator control (see also *section 4 System Configuration with User Interface*).

5.1 Chapter Overview

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

- ***AUV System Operation:*** Consists of brief information on typical AUV operation.
- ***ROV System Operation:*** Consists of brief information on ROV operation.

NOTE
For information on system configuration and user interface navigation, refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*. For information on starting, stopping, and setting up the SeaBat sonar system, see *section 3 System Startup and Shutdown.* For information on the practical use of the sonar, see *section 6 Active Sonar Usage.*

5.2 AUV System Operation

The system will normally be operated autonomously. All communications will be via the Ethernet to/from the Vehicle Control Computer (VCC).

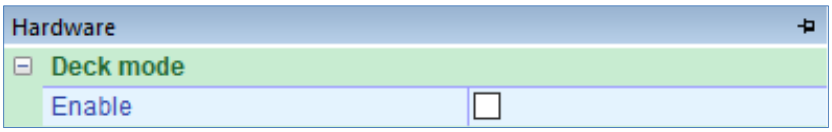
Normal mission sequence will be:

1. System installation, setup, and checkout – done through the Sonar UI (see *Appendix B Installation Instructions*, *section 3 System Startup and Shutdown*, and *section 4 System Configuration with User Interface*). Please also refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*).
2. Installation checkout – startup and diagnostics (BITE) performed by the VCC.
3. Power down and transit to deployment site (see *section 3 System Startup and Shutdown*).
4. Power up and repeat diagnostics (see step 2).
5. Vehicle deployment – sonar operates under control of the VCC.
6. Vehicle recovery – power down (see *section 3 System Startup and Shutdown*).
7. Data download – data is extracted from the disk drives for external analysis.

   If the SSP+ is run on deck, Deck mode should be enabled in the Sonar UI[3].

   a. Click the Hardware tab in the UI to open the Hardware pane.

   b. Click the check box Enable Deck mode.



   In this mode, no BITE will be available from the transmit module and receiver.
8. Disable Deck mode (clear the check box) to reboot the SSP+ to resume normal operation.

NOTE
During **AUV system** operation, all communication will be between the SSP and the customer-provided Vehicle Control Computer. The output during operation is a data stream in accordance with the Data Format Definition document (see *appendix F.1 SeaBat T51-S/IDH T51-S Documentation*).

5.3 ROV System Operation

NOTE
For information on system configuration and user interface navigation, refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*). 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 6 Active Sonar Usage.* For information on installation and details on the various system components, see *Appendix B Installation Instructions*.

[3] Please refer the Sonar UI User Manual for additional information.

6 ACTIVE SONAR USAGE

6.1 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 SUI 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 and user interface navigation, refer to the Sonar UI User Manual (see *Appendix F Reference Documentation*).
For information on the practical use of the sonar, see *section 6 Active Sonar Usage*.
For information on installation and details on the various system components, see *Appendix B Installation Instructions*.

6.2 Enhancing Sonar Performance

6.2.1 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 2*:

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.

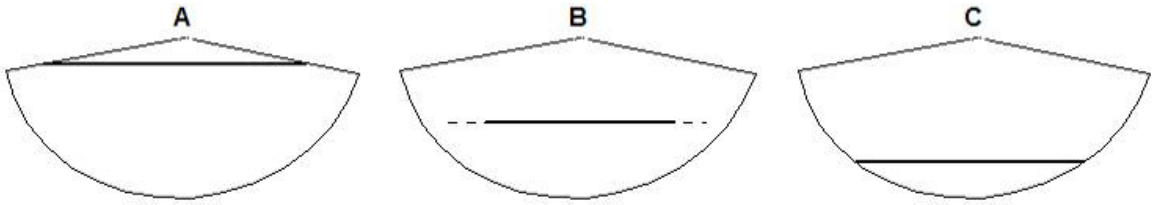


Figure 2: Range Setting Diagrams

- 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 6.3.4 below*).

NOTE
The Range adjusts itself automatically when Tracker is selected (see also *section 6.3.2 below*).

For additional examples on incorrect range settings and possible solutions, see *Table 3*.

Table 3: Incorrect Range Settings – Examples and Solutions

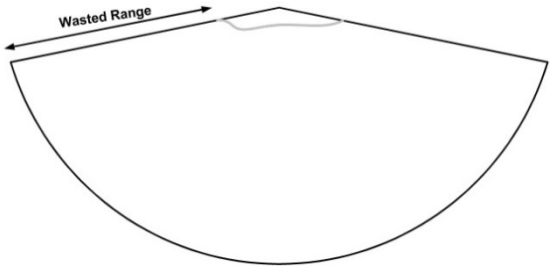


Figure 3: Range Setting – Too Long

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 Sonar UI User Manual (*see Appendix F Reference Documentation*.)

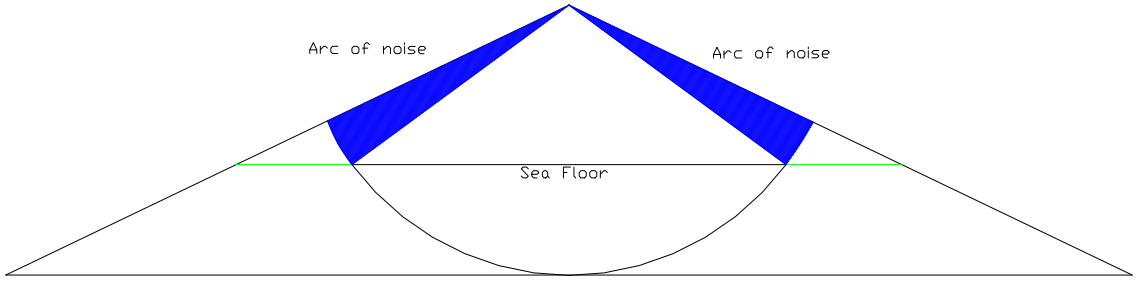


Figure 4: Range Setting – Too Short

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 Sonar UI User Manual (*see Appendix F Reference Documentation.*)

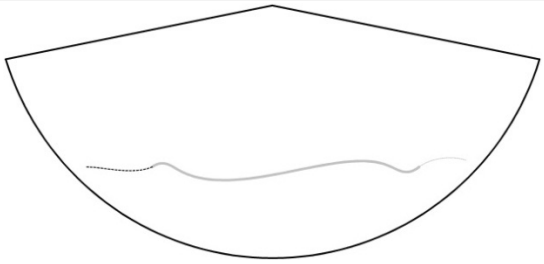


Figure 5: Range Setting – The Exception

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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

6.2.2 Transmit Power

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

NOTE
The Power adjusts itself automatically when Tracker is selected (see also *section 6.3.2 below*).

6.2.2.1 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.

6.2.2.2 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.

6.2.3 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 6.2.1 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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

6.2.4 Receiver Gain

The Gain setting adjusts the amount of receiver gain applied to the returned signal. Typically set between 20dB and 40dB.

NOTE
The Gain adjusts itself automatically when Tracker is selected (see also *section 6.3.2 below*).

The SeaBat system utilizes Time-Varied Gain (TVG) which counteracts the diminishing echo strength of signals that originate from farther away. The TVG data contains the applied gain at each range (sample) and is available in record 7010. Refer to the Data Format Definition document for information (see *Appendix F Reference Documentation*).

The generation of the TVG curve is based on the formula in *Table 4*.

Table 4: TVG Formula

$$\text{TVG} = \begin{cases} G_L & \text{for } R < R_L \\ G + S_P[\log_{10}(R) - 1] + 2(\alpha/1000)R & \text{for } R \geq R_L \\ 83 & \text{for } R \geq R_M \end{cases}$$

Where:

- α = Absorption loss in dB/km
- G = Extra gain from RxGain menu item
- G_L = An internally calculated gain applied until the TVG begins
- R = Range in meters
- R_L = Lowest range (in meters) from where the TVG formula operates
- R_M = Range in meters where the gain has reached highest possible value (which is 83dB)
- S_P = Spreading loss coefficient

NOTE

The values of R_L, G_L, and R_M are not accessible, but R_L is in generally limited to a few meters from the sonar. It is recommended to subscribe for record 7010 in order to obtain the TVG.

For details on environmental conditions such as absorption and spreading, see *section 6.4 below*.

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

6.2.5 Frequency Selection

- 700-800kHz for highest resolution at short ranges.
- 350-430kHz for greater range performance.

For general hydrographic surveys, the switch from 700-800kHz to 350-430kHz may be necessary to maintain optimal swath coverage between depths of 60m and 100m depending on conditions.

Variable frequency selection for CW pulses can be made in steps of 10kHz. The optional add-on X-Range license will enable FM chirp pulses for longer ranges than standard CW pulse type.

NOTE

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

SeaBat also includes a Ping Sequencing option, whereby the system cycles through different frequencies each time. At each ping it produces standard outputs: bathymetry, (normalized) snippets backscatter, or water column backscatter.

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

6.2.6 Pulse Length

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

NOTE
The Pulse Length adjusts itself automatically when Tracker is selected (see also *section 6.3.2 below*).

6.2.6.1 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.

6.2.6.2 Pulse Length and Pulse Type

The pulse length setting depends on pulse type (see *section 6.2.7 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.

6.2.7 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 1*).

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

6.2.8 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 6.2.9 below*.

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

6.2.8.1 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.

6.2.8.2 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.

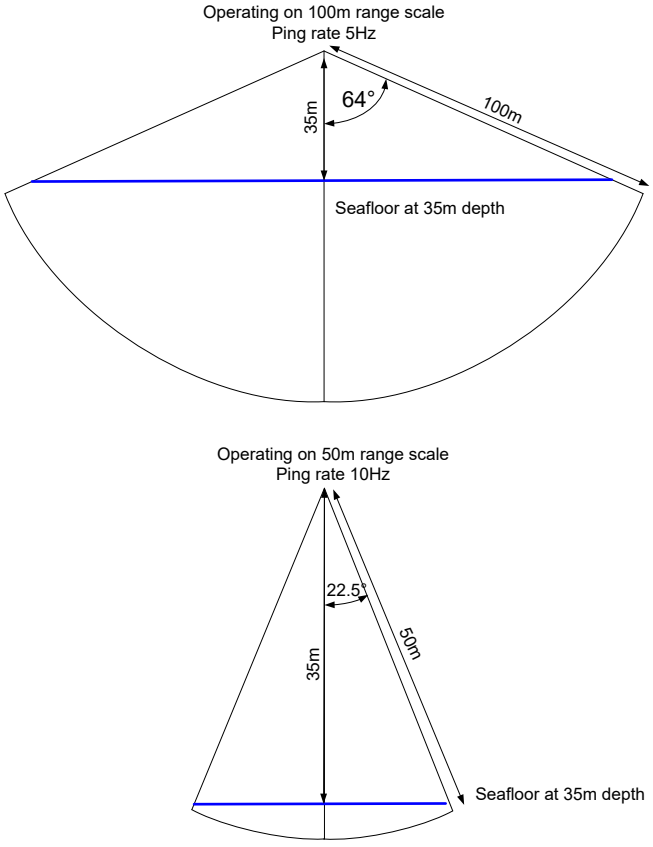


Figure 6: Example of Reduced Swath Width

[4] FlexMode is an optional add-on feature (see *Table 1*).

6.2.8.3 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 7*). 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°.

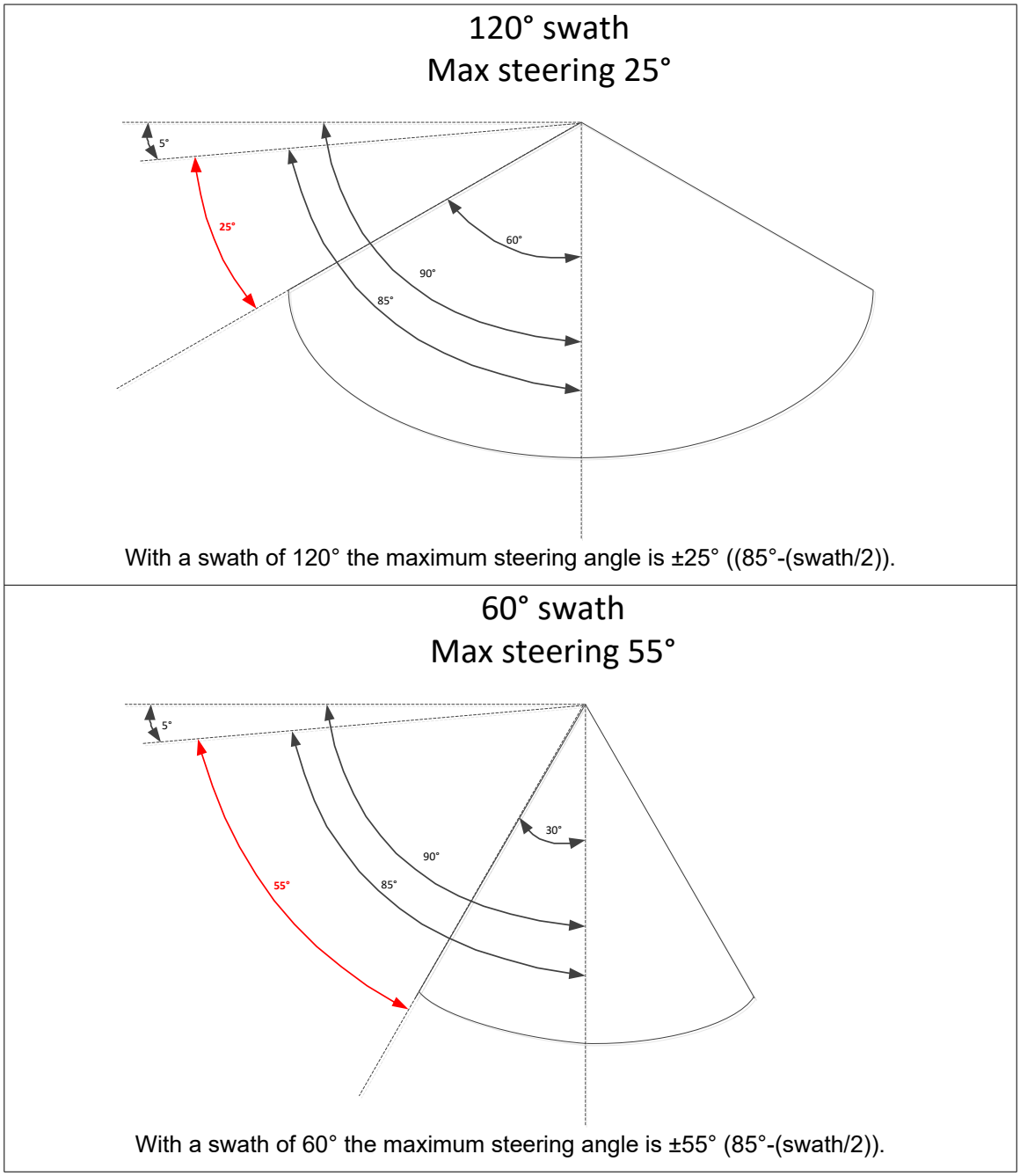


Figure 7: Horizontal Swath Steering

6.2.8.4 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 6.3.4 below*).

With a tilted head for 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 8* provides a graphic illustration of the minimum grazing angle.

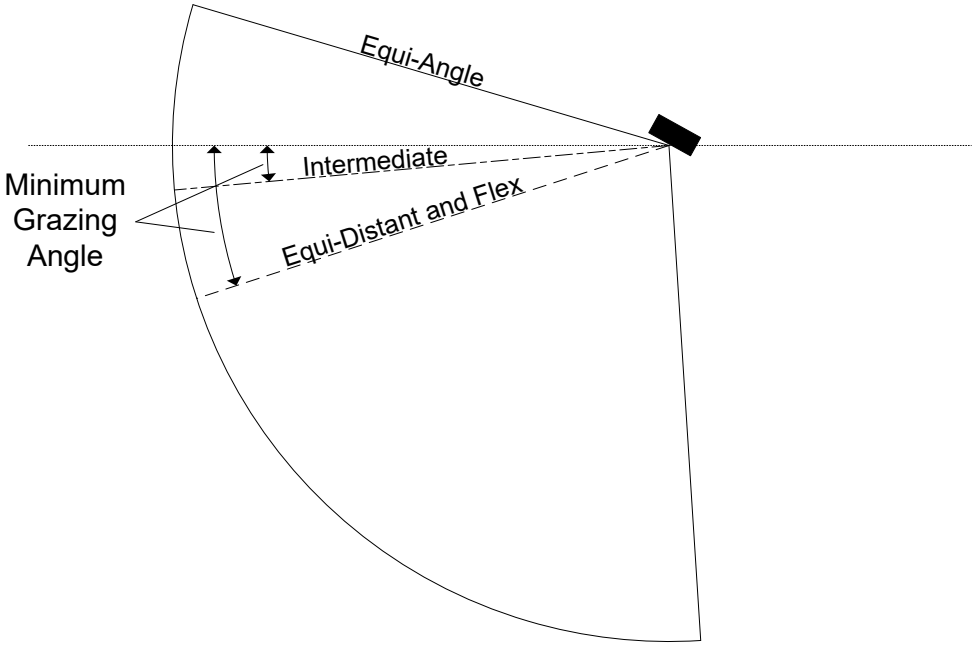


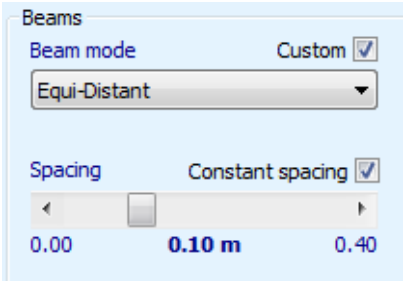
Figure 8: Outer Beams for the Different Beam Modes with a Tilted Sonar Head

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

6.2.9 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.

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

- **Equi-Distant mode:** Up to 140°/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 170° 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 170° 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; 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 7.2.2 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	

6.2.9.2 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.

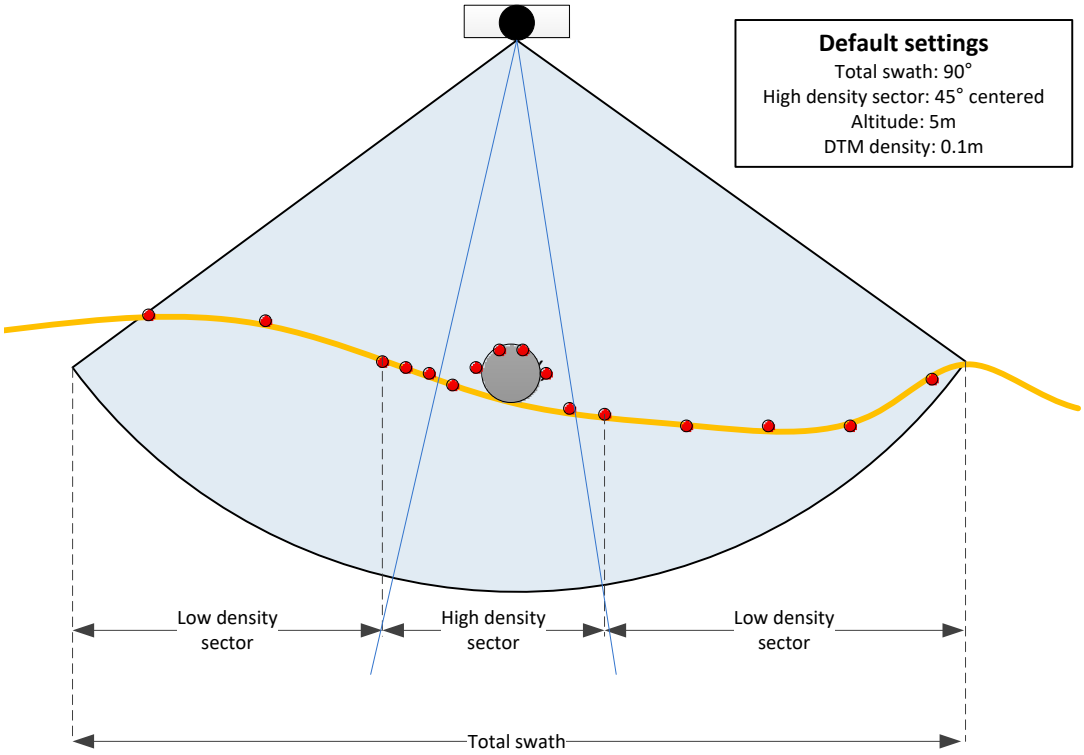


Figure 9: Graphic Illustration of FlexMode

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.

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

6.2.10 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.

[5] FlexMode is an optional add-on feature (see *Table 1*).

- 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 sea floor where bathymetry is extreme in the vertical values.

6.2.10.1 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 10*. 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.

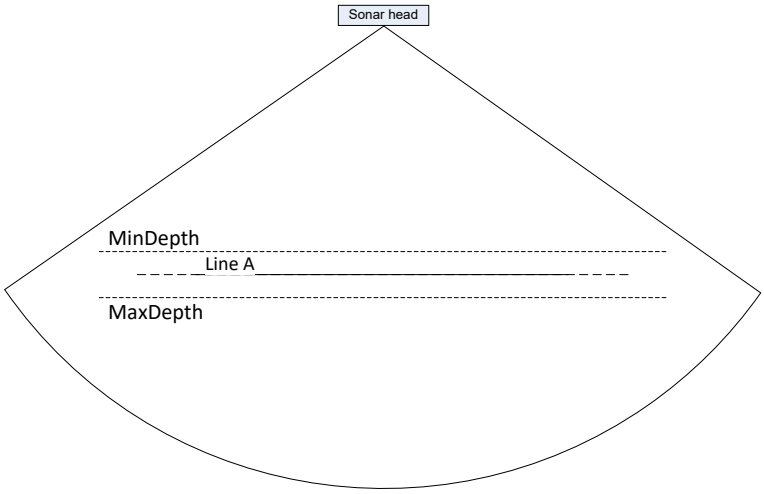


Figure 10: Depth Gates, With No Roll

Figure 11 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.

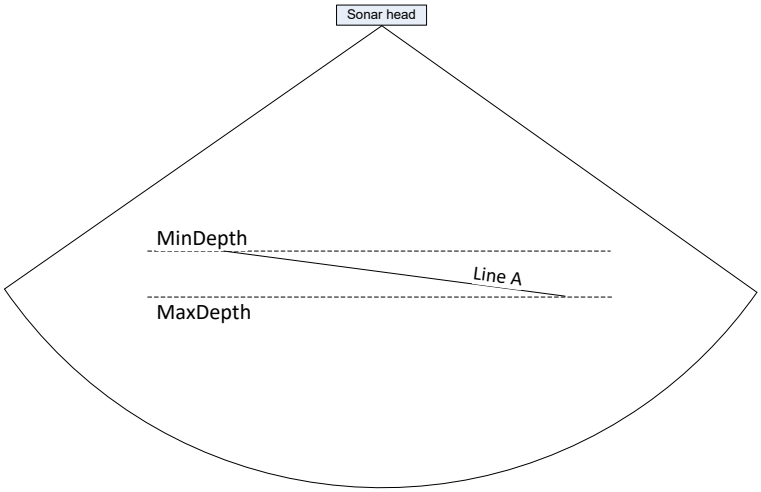


Figure 11: Depth Gates, With Roll

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 12* shows the same bottom image with dynamic depth gates applied.

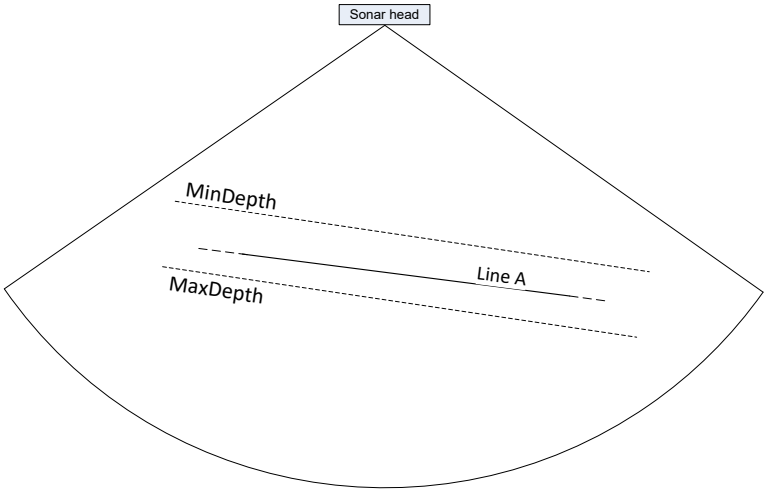


Figure 12: Depth Gates, With Roll and Motion Sensor Input

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

6.2.10.2 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 13*).

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

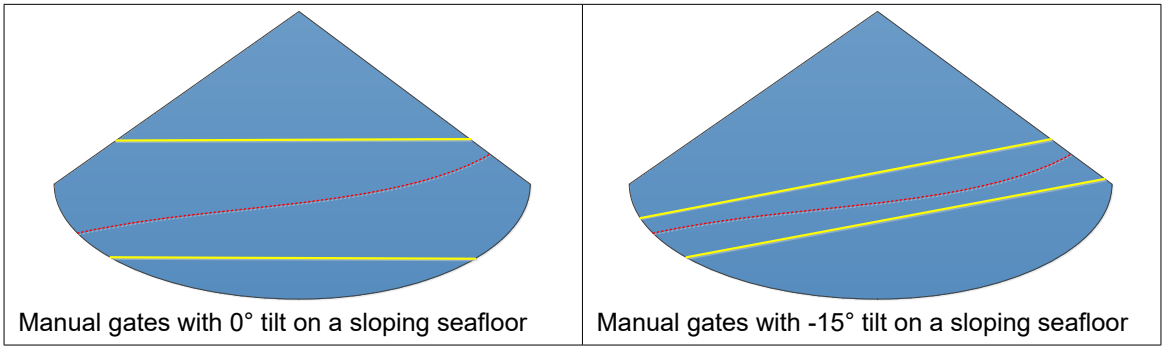


Figure 13: Depth Gate Tilt

6.2.11 Maximizing Quality of Backscatter for Snippets Data

A few survey practices can be followed to maximize the quality of the backscatter signal[6]. For instructions on adjusting settings, refer to the Sonar UI User Manual (*see Appendix F 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.

6.3 Enhancing System Efficiency

6.3.1 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:

[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 1*).

- 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

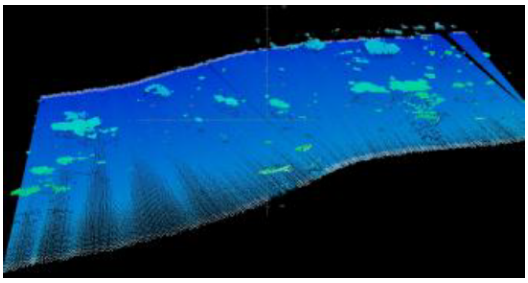


Figure 14: Submerged Oil Detected by Multi-Detect

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

- **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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

6.3.2 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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

6.3.3 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.

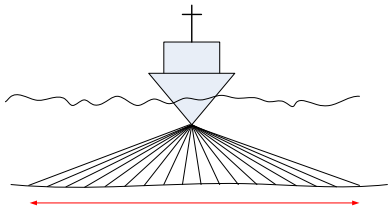


Figure 15: Swath under Zero Roll Conditions

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

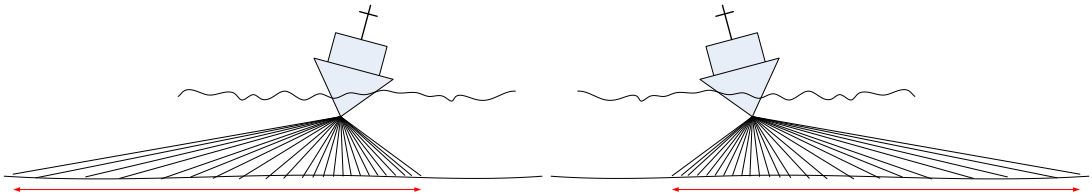
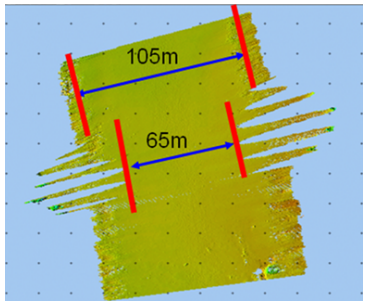


Figure 16: Laterally Displaced Swaths under Roll Conditions

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.

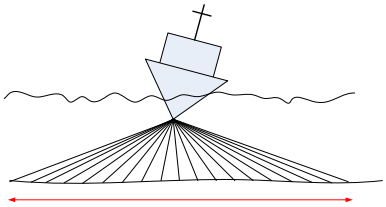


Figure 17: Swath under Roll Stabilization

It is recommended that the motion sensor data update rate is at least 50Hz and preferably 100Hz. 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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

6.3.4 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 survey as close to the waterline as possible.

NOTE
EA beams are recommended when using head tilt, as ED beams are still formed assuming a horizontal seafloor.

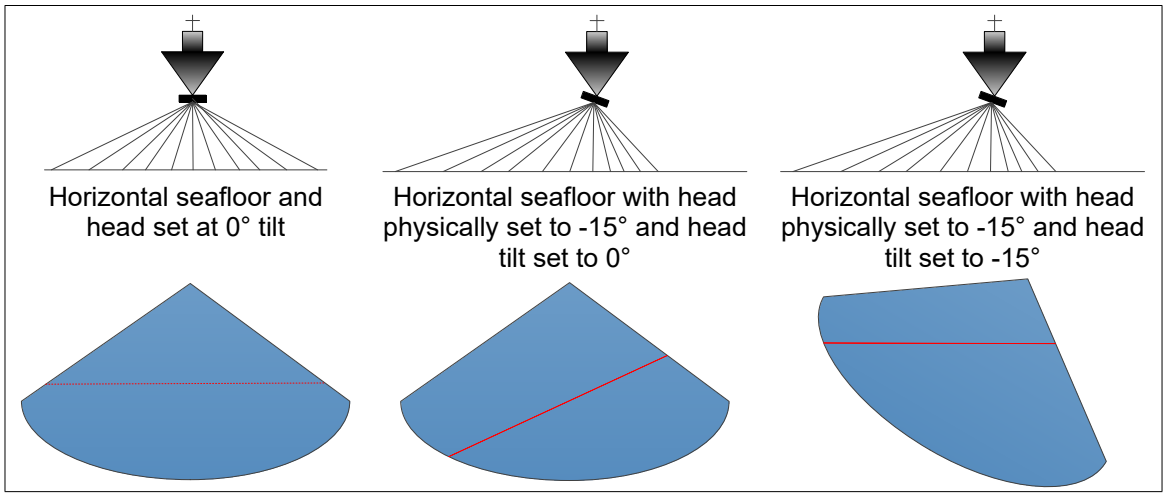


Figure 18: Head Tilt Functionality

6.3.4.1 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.

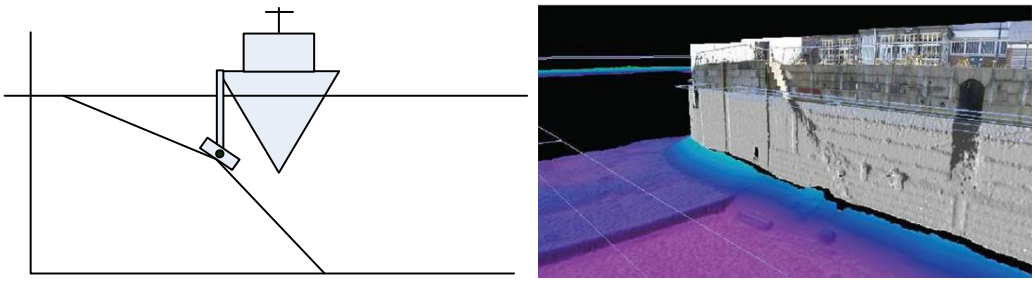


Figure 19: Head Tilt for Harbor Inspection

6.3.4.2 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”.

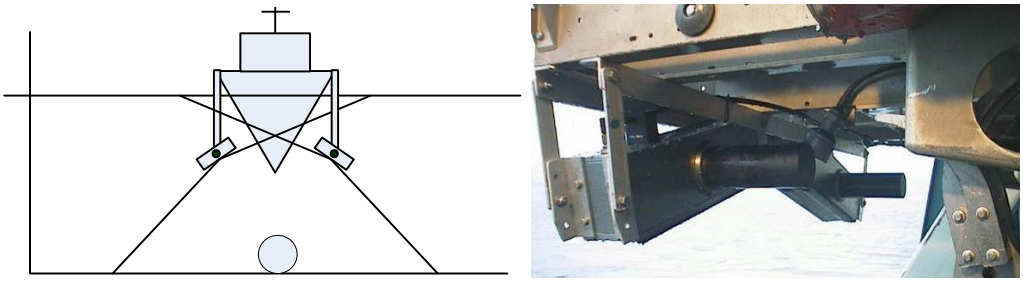


Figure 20: Head Tilt for Pipe Inspection

6.3.5 Vertical Detection Mode (VDM)

Multipath of the acoustical signal around vertical structures can pose a challenge to the detection capabilities of a multibeam echosounder. This is particularly true for quay walls made from corrugated sheet piling. Vertical Detection Mode (VDM) offers an improved detection under these circumstances.

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

6.4 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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

6.4.1 Loss of Sound by Absorption

As sound moves through the water, some of the sound energy is converted into to heat by absorption. The absorption loss depends on the salinity and temperature of the water as well as the depth. Finally, it also depends on the acoustic frequency. *Figure 21* shows the absorption loss for three different salinities and three different temperatures at an average depth of 20 meters[8].

[8] Note, that absorption and attenuation of sound in the water column caused by microbubbles and species such as, e.g., plankton and fish is not included in this consideration.

If the exact absorption loss value is not known, these are the recommended approximate values:

- 400kHz operation:
  - 110dB/km for salt water
  - 70dB/km for fresh water
- 800kHz operation:
  - 250dB/km for salt water
  - 200dB/km for fresh water

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 6.2.4 above*).

Ideally, the purpose of the TVG is to ensure the receive gain increases with a rate that compensates for the continuously decaying intensity of the received sound field - a decay which is caused by geometrical spreading and sound absorption. Meanwhile, the TVG does not need to perform an exact compensation. In practice, the purpose of the TVG is only to ensure that the received signals continuously are within the dynamic range of the receiver. Therefore, the applied settings for the absorption and spreading only need to be approximate.

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

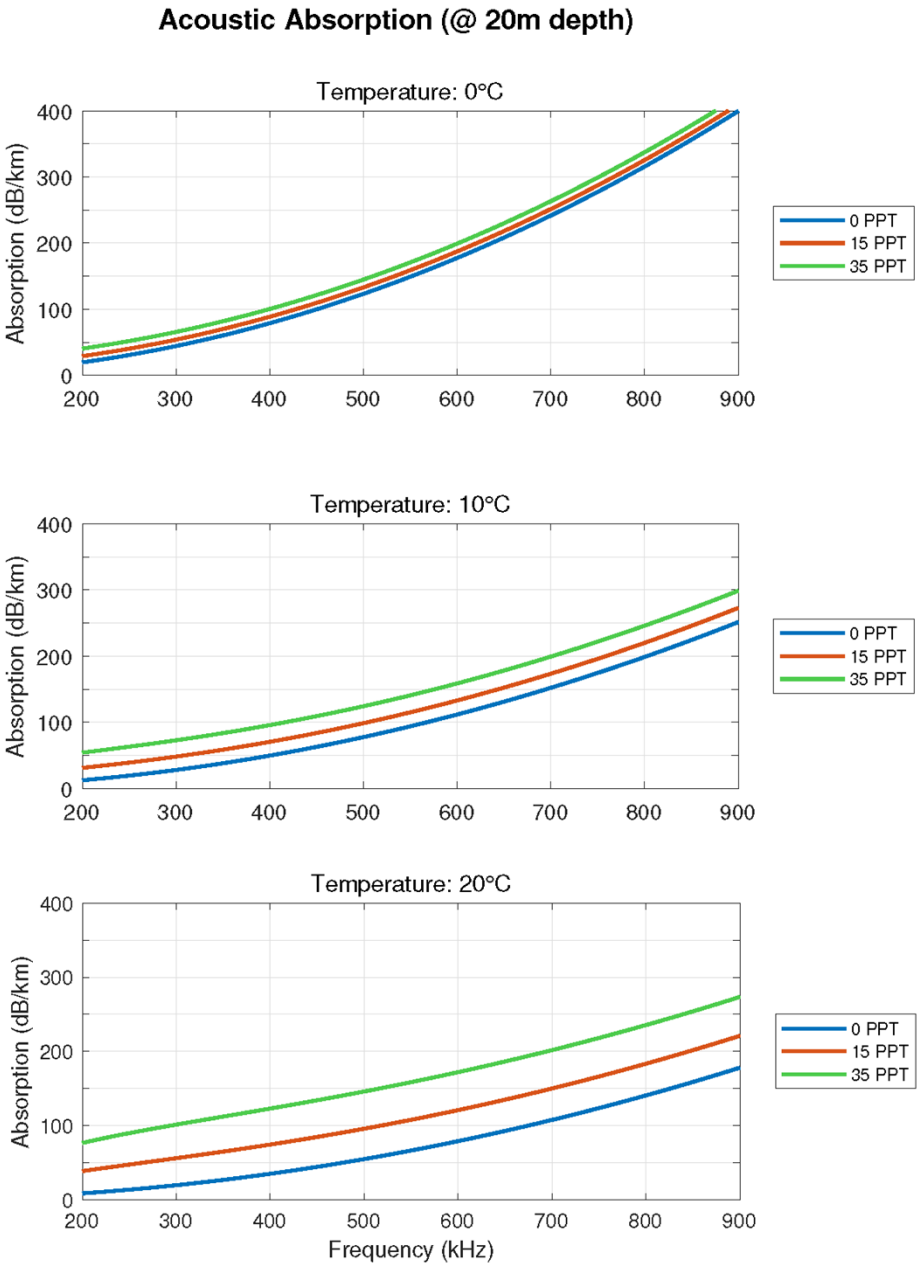


Figure 21: Acoustic Absorption Reference

6.4.2 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 $1/R^{½}$, 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 6.2.4 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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

6.4.3 Sound Velocity

For installation instructions, see *Table 12* in *appendix B.4.4 Pin Designations for Host, AUX, LAN2, and SVP Connectors*.

6.4.3.1 Sound Velocity and Performance

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 22* provides a general reference for typical surface sound velocity at different temperatures and salinity.

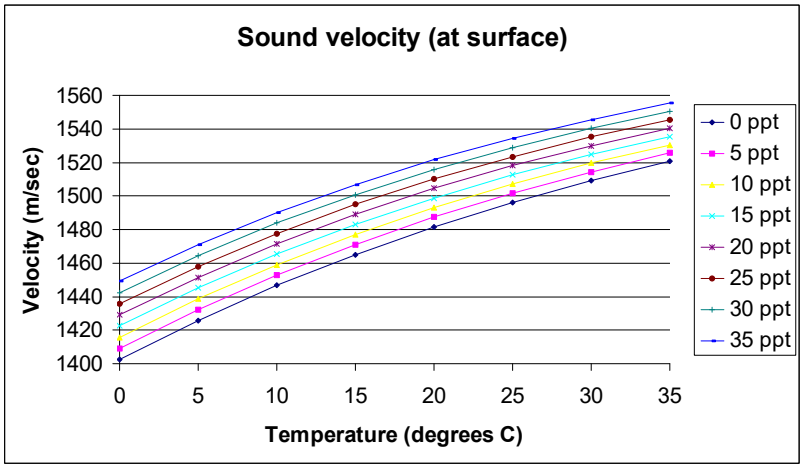


Figure 22: Typical Sound Velocity Values

6.4.3.2 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 Sonar UI User Manual (*see Appendix F 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 F Reference Documentation*).

6.5 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.

6.5.1 Cavitation

Some reduction in the transmitted source level is expected to be caused by cavitation. For means of compensating for this, see subsections in *6.2 above.*

6.5.1.1 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.

6.5.1.2 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.

6.5.2 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 *6.2 above*.

6.5.3 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.

6.5.4 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 *6.2 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.

6.5.5 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.

6.5.6 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 6.2.3 above*.

7 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 6 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 T51-S/IDH T51-S sonar system produces 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 SSP+, where it is formatted for data and display output. Sonar data is stored locally or displayed remotely via the Ethernet connection TCP/IP connection (see *section 4.3 Remote Operation*).

A Windows®-based user interface 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 available configurations, see *section 1.6 Available SeaBat T51-S/IDH T51-S Configurations*.

NOTE
Refer to the Data Format Definition document (see *appendix F.1 SeaBat T51-S/IDH T51-S Documentation*): • For information on the data records. • For information on externally controllable sonar operating parameters.

Table 5: SeaBat T51-S/IDH T51-S System Performance

Parameters	350-430kHz	700-800kHz
Frequency range	350-430kHz (CW) 400kHz (FM)	700-800kHz (CW) 775kHz (FM)
Across-track receive beam widths (nominal values)	0.5°	0.25°
Along-track transmit beam widths (nominal values)	1°	0.5°
Number of beams	Max. 1024, min. 10	
Max. swath coverage	150° ED/170° EA	
Depth, typical[9]	**CW:** 135m **FM:** 160m	**CW:** 75m **FM:** 75m
Depth, max.[10]	**CW:** 225m **FM:** 270m	**CW:** 110m **FM:** 135m
Ping rate (range dependent)	Up to 50 pings/s	
Pulse lengths CW	Single head: 30-300µs Dual head: 30-300µs	
Pulse lengths FM	Single head: 300µs-10ms[11] Dual head: 300µs-5ms	
Depth resolution	6mm	
Depth rating	6000m	
Temperature	Operating: -2ºC to +36ºC Storage: -30ºC to +55ºC	

[9] 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%.
[10] This is the single value corresponding to the depth at which the swath is reduced to 10% of its max. value.
[11] Max. 5ms at 66kHz sampling rate.

7.1 System Components

7.1.1 Subsea Sonar Processor SSP+

The Subsea Sonar Processor (SSP+) is a high-performance unit offering a highly flexible platform that supports a number of functions, including highly accurate time-stamping, interfacing and time-stamping of external sensors, and optional beam data storage on an external Network Attached Storage (NAS) drive. It is housed inside a 6000m depth rated, titanium bottle.

For physical specifications, see *appendix B.5.1 Subsea Sonar Processor SSP+ (PN 1012289-DK)*.



Figure 23: Subsea Sonar Processor

The SSP+ performs the following functions:

- Receives digitized sonar data from the receiver.
- Receives operational settings from external control system.
- Provides beamforming and initial processing of acoustical data.
- Controls, formats, and generates data to external systems.
- Provides an interface and single-point time-stamping source for:
  - 1PPS and time recovery message
  - Position
  - Heading
  - Motion
  - Sound velocity sensor

7.1.2 EM7222-1 Receiver Unit

The EM7222-1 receiver unit operates at multiple frequencies between 350-430kHz and 700-800kHz.

For physical specifications, see *appendix B.5.2 EM7222-1 Receiver Unit (PN 1019488-DK)*.



Figure 24: EM7222-1 Receiver Unit

7.1.3 TC2190 Projector Unit

The TC2190 projector unit operates at multiple frequencies between 400kHz and 800kHz. The entire swath is illuminated in one transmission, with the maximum ping rate of 50Hz, providing 100% bottom coverage even at high vessel speed.

For physical specifications, see *appendix B.5.3 TC2190 Projector Unit (PN 1019037-DK)*.



Figure 25: TC2190 Projector Unit

7.2 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

7.2.1 Beam Modes

Beam mode selection is made on the fly via the sonar user interface. For instructions, refer to the Sonar UI User Manual (*see Appendix F Reference Documentation*). Available selections depend on options purchased (see also *Table 1*).

Table 6: Beam Modes with No. of Beams and Swath Coverage

	No. of beams			Swath
	Min.	Std.	Max.	Max.
Equi-distant (with constant no. of beams)	10	1024		150
Equi-distant (with constant beam spacing)	10	1024		150
Intermediate	10	1024		170
Equi-angle	10	1024		170
FlexMode[12]	1024	1024		150

For examples on how to use this feature, see *section 6.2.9 Use of Beam Modes*.

[12] FlexMode is an optional add-on feature (see *Table 1*).

7.2.2 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 26* presents the number of beams as a function of steering angle for a 1° nadir beam spacing.

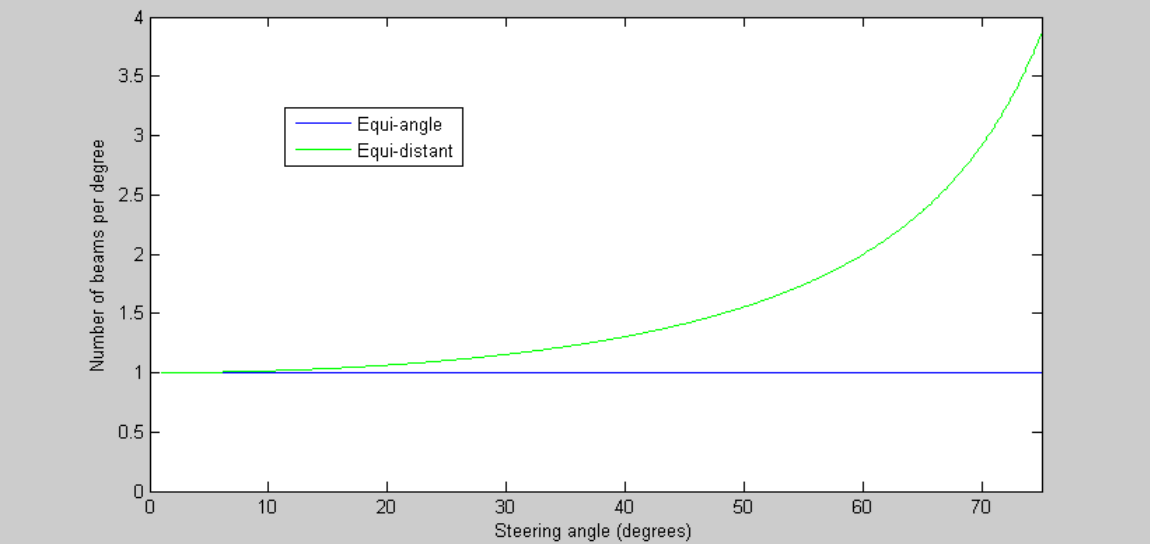


Figure 26: Beam Density

Figure 27 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.

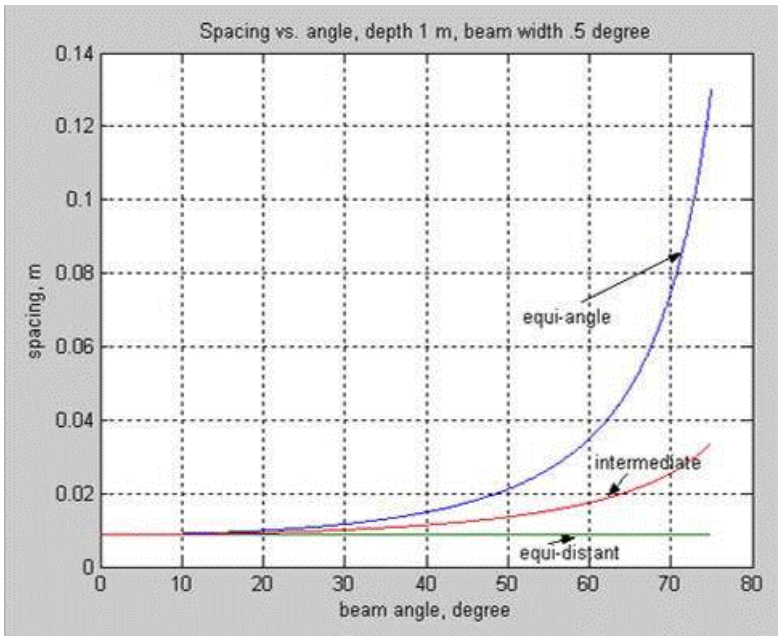


Figure 27: Beam Spacing vs. Beam Angle

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 28*.

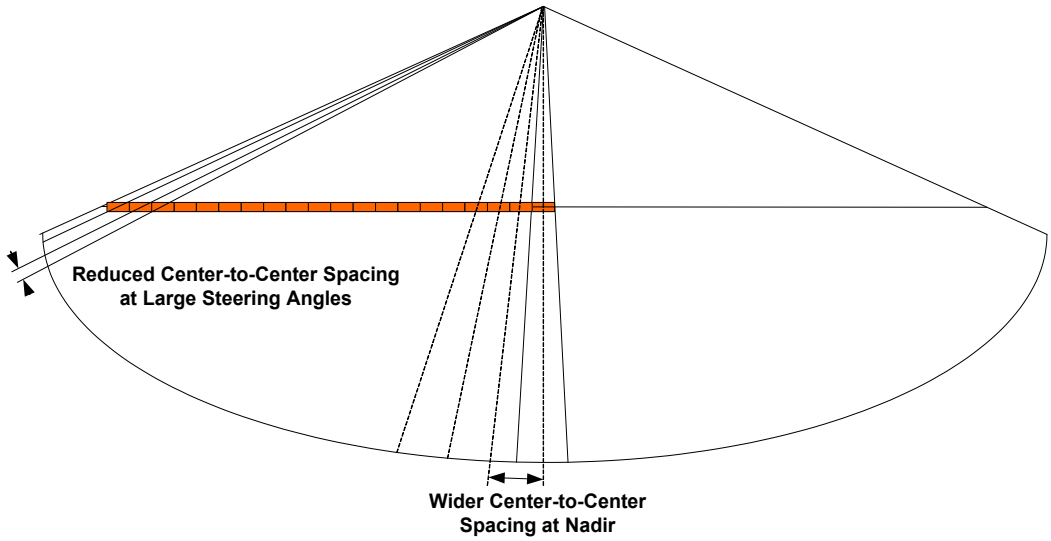


Figure 28: Beam Spacing

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 29 shows the difference in distribution between equiangular and equidistant spacing.

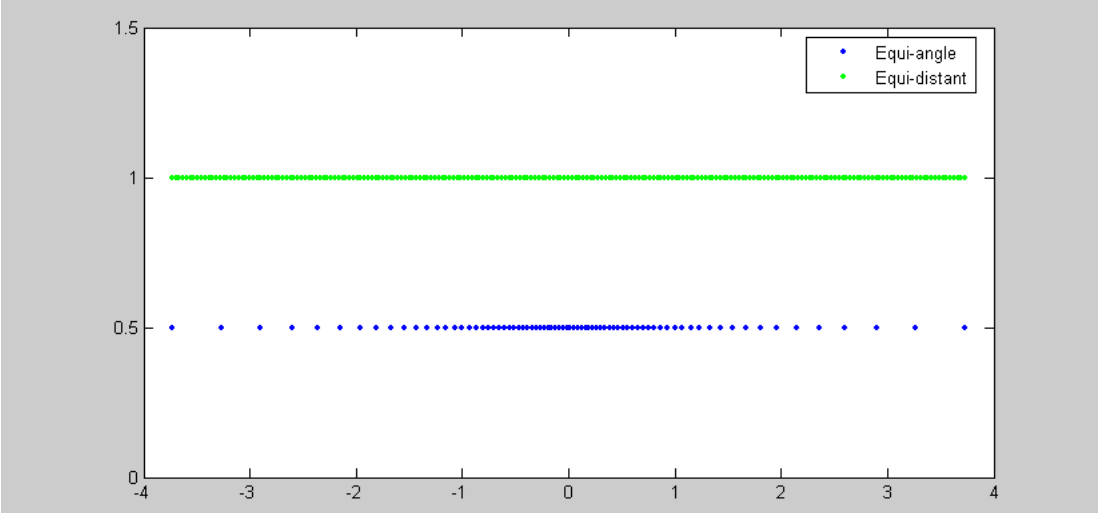


Figure 29: Across-Track Sounding Location on a Flat Bottom

7.3 Data Types

7.3.1 Bathymetry Data

The SeaBat T51-S/IDH T51-S system generates between 10 and 1024 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 Sonar UI User Manual (*see Appendix F 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.

7.3.2 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.

7.3.2.1 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.

7.3.2.2 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:

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

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 F Reference Documentation*).

7.3.3 Snippets Backscatter Data

Snippets backscatter data is available from the SeaBat T51-S/IDH T51-S. 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.

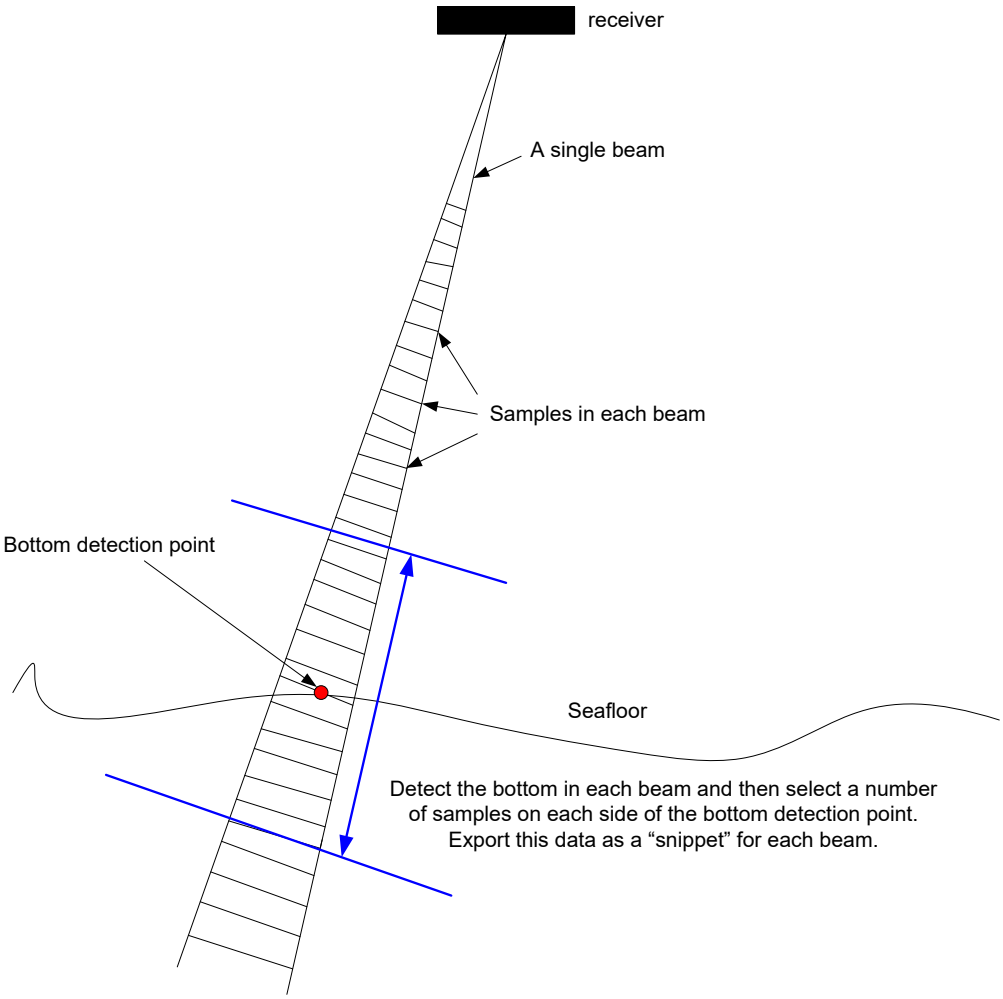


Figure 30: Graphic Illustration of Snippets Data

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 F Reference Documentation*).

7.4 Real-Time Pipe Detection and Tracking[13]

Real-time pipe detection and tracking is a SeaBat feature that 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 UI 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.

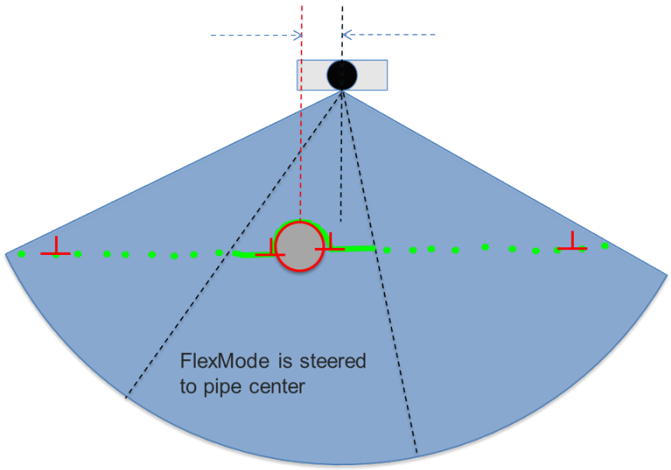


Figure 31: SeaBat Real-Time Pipe Detection and Tracking

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 near 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

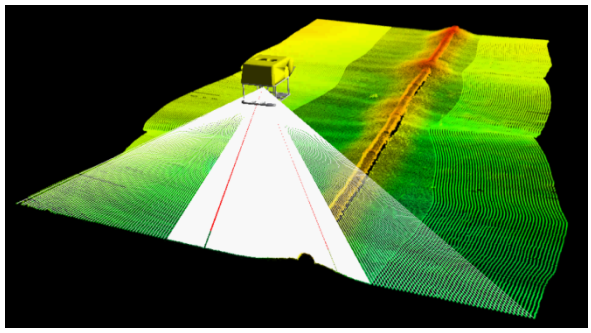


Figure 32: SeaBat FlexMode

7.5 Multi-Detect[14]

Multi-detect is a feature that 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 *6.3.1 Multi-Detect Operation*.)

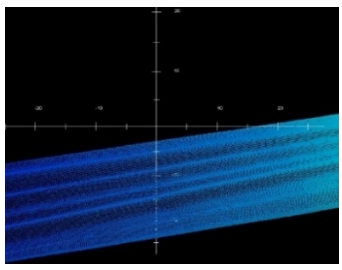


Figure 33: Standard Detection

[13] Pipe detection and tracking is an optional add-on feature (see *Table 1*).
[14] Multi-detect is an optional add-on feature (see *Table 1*).

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

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 35*, 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.

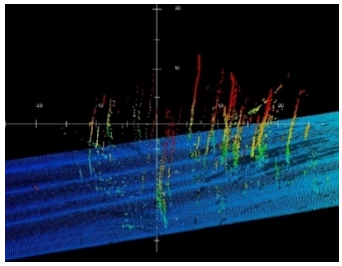


Figure 34: Multi-Detect with details of seeping gas bubbles

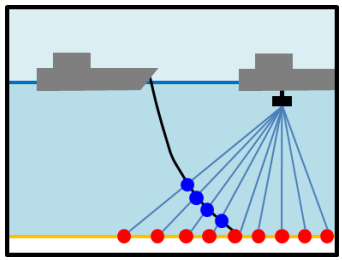


Figure 35: Multi-Detect

7.6 Vertical Detection Mode

Vertical Detection Mode (VDM) is a feature that provides optimized detection performance on vertical structures, such as quay walls.

When enabled, the detection algorithm will automatically identify vertical structures and provide the best possible detection data quality of the structure. It will also reveal features, or any anomaly present on its surface. VDM is available for all SeaBat T-Series systems and works irrespective of beam mode, single or dual head, head tilt or sonar settings.

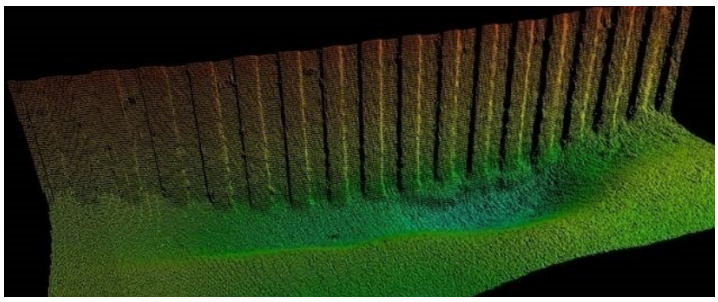


Figure 36: Vertical Detection of Quay Wall

7.7 X-Range[15] Performance

X-Range is a feature that provides extended range performance at the full range of frequencies and 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.

[15] X-Range is an optional add-on feature (see *Table 1*).

7.8 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 37*).

The standard dual head implementation uses time multiplexing to achieve synchronized operation. The result is reduced ping rate per head and asymmetric sea floor swaths. FRDH uses X-Range (see 7.7 above) to achieve dual head operation, which has the double effect of range, and ping rate increase. In FRDH the systems are synchronized and ping simultaneously at a high rate. (See also *section 6.3.4.2 Pipe Inspection with Dual Head System*.)

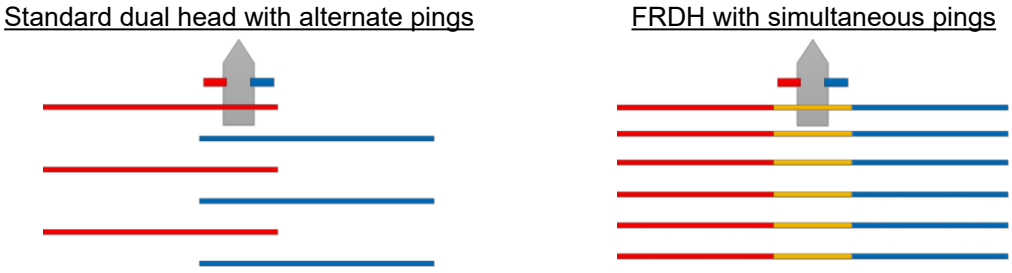


Figure 37: Dual Head Synchronization of Pings

7.9 Quality

The quality of each bathymetric bottom detection point is evaluated by the sonar. For instructions on how to customize some of the visual properties of the sonar image, refer to the Sonar UI User Manual (*see Appendix F Reference Documentation*).

7.9.1 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 38* 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 38*) and the square of the samples in the “head” of the water column (before the first return – marked ‘C’ in *Figure 38*).

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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

[16] FRDH is an optional add-on feature (see *Table 1*).

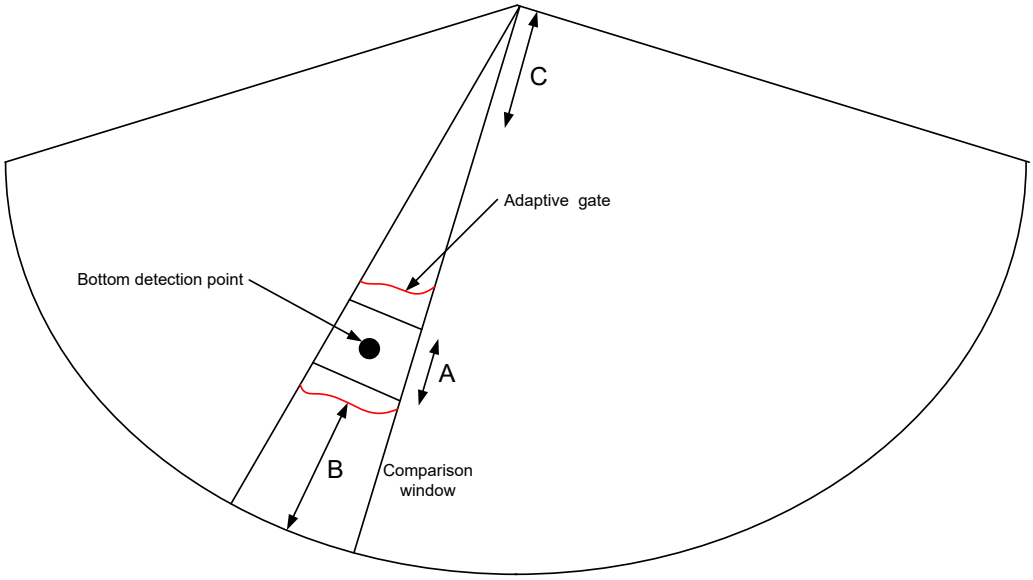


Figure 38: Brightness Test

7.9.2 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.

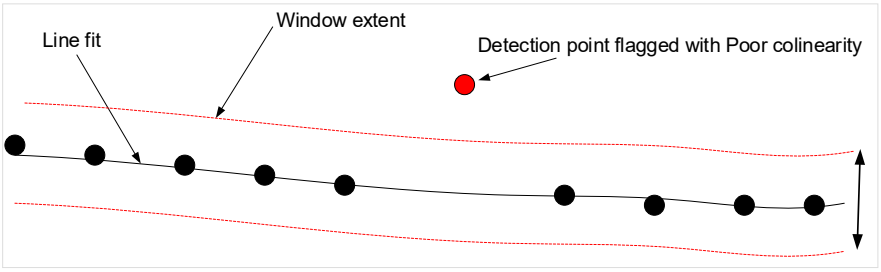


Figure 39: Colinearity Flags

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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

7.9.3 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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

7.10 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 input 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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

7.11 Ping Rate Table

Table 7: Ping Rate Table

Range setting (m)	Theoretical max ping rate (1500m/s)[1]	Ping rate [Hz]		
		Single head	Integrated Dual Head (IDH)	Two processor Dual Head (FRDH)
5	150	50	50	50
7	107.1	50	50	50
10	75.0	50	50	45.4
15	50.0	43.6	41.6	34.5
20	37.5	33.8	32.4	27.8
25	30.0	27.6	26.5	23.3
30	25.0	23.3	22.5	20.0
35	21.4	20.2	19.5	17.6
40	18.8	17.8	17.2	15.9
50	15.0	14.4	13.9	13.0
70	10.7	10.4	10.1	9.5
100	7.5	7.3	7.1	6.7
140	5.4	5.3	5.1	4.8
160	4.7	4.6	4.5	4.2
180	4.2	4.1	4.0	3.7
200	3.8	3.7	3.6	3.4
250	3.0	3.0	2.9	2.7
300	2.5	2.5	2.4	2.3

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

[1] The ping rate is limited to 50p/s (see *Table 4*).

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 (reson-support@teledyne.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 Sonar UI User Manual (*see Appendix F Reference Documentation*).

General information (no error/warning) is marked with an 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 (reson-support@teledyne.com).

Errors are marked with a red in the Messages pane.

A.2.1 General System Startup Errors

Message	Description	Action
Could not create UDP server Could not create TCP server	Indicates a network resource was unavailable to the software from the operating system.	Check user permissions, network drivers.
Could not create PCI server Error creating PCI Reader thread 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.
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.
Internal 7k Center error Internal error, 7kCenter NOT fully operational	One or more startup conditions have failed.	Check previous alarms or warnings and verify software installation.
Inbound memory initialization failed MMF Outbound memory creation …	PC resources are inadequate.	Check RAM or virtual memory resources

Message	Description	Action
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 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 to try and localize the failure to a component. Check uplink cable connections. Check temperature of the SSP via BITE. 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.2.3 System Resource Errors

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

A.2.4 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 =		
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.2.5 Normalization Errors

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

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 (reson-support@teledyne.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		
Cannot Open or Create UDP Configuration file		
UDP Configuration file not available		

A.3.2 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.
DMA Transfer Timeout. <x> of <x> bytes received		

A.3.3 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.3.4 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.

A.3.5 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.3.6 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!		

A.3.7 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.3.8 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
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. Check uplink cable connections. Check temperature of the SSP via BITE. Restore factory defaults. Reboot the PC.	Data Reading
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)

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Uncontrolled Technology Subject to Restrictions Contained on the Cover Page.

Message	Description	Action	Alarm Type
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 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)
Inbound memory initialization failed.	PC resources are inadequate.	Check RAM or virtual memory resources	General System Startup
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
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
Normalization Error: Normalization might be invalid. Repeat the normalization.	Normalization has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Normalization
Normalization Failed: Magnitude Error	Normalization has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Normalization

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Message	Description	Action	Alarm Type
Normalization Failed: Over 10% dead Rx channels.	Normalization has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Normalization
Normalization Failed: Phase Error	Normalization has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Normalization
Normalization Failed: Too much noise	Normalization has failed.	Check BITE page and hardware and cable installation to the receiver. Check environmental noise. Contact Teledyne RESON Customer Support.	Normalization
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

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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
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
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
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
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

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Message	Description	Action	Type
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
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 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: 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

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APPENDIX B INSTALLATION INSTRUCTIONS

B.1 Components List

Table 8: SeaBat T51-S/IDH T51-S Components

Part Number	Description
1019037-DK	Projector, Bathy, DF400/800kHz, TC2190, T51 S, D6 (2 units for IDH)
1019488-DK	Receiver EM7222-1, 512CH, 400-800kHz, Ti, 6000m (2 units for IDH)
1012289-DK	Subsea Sonar Processor SSP+, 6000m, Ti, high performance
85001850-5	S_ASSY, CABLE, HD-PV, TX, 3m, 7K (deep) (2 units for IDH)
85002393	Cable,Conf.,GB ethernet+POWER,3m,DIL13F,DIL13M (Rx-SSP) (2 units for IDH)
85002393	Cable,Conf.,GB ethernet+POWER,3m,DIL13F,DIL13M (host)
1007294-DK	Cable,Conf.,GB ethernet + POWER,1m,SUBCONN DBH13F, RJ45,BRASS (2 units for IDH)
1009794-DK	Cable assy, MHDG-12-CPP Ti, with 5m 12xAWG20 PU cable (AUX pigtail)
1014437-DK	SHIP CASE, KIT, STENCILED, SSP
1014438-DK	SHIP CASE, KIT, STENCILED, WET END
1008978-DK	Memory Stick, USB, >=16 GB, Crosair V3, tube, silver, Manuals and recovery
1008979-DK	Strap, black, Teledyne Marine white logo
1019519-DK	Quick Reference Guide, SeaBat T51-S
1008951-DK	Quick Installation Guide, SeaBat UI for T-Series
1012116-DK	Quick Installation Guide, SeaBat Updater
1015492-DK	QUICK GUIDE, Installation, T/F-Series Subsea Integration to AUV/ROV electronics pod
1007252-DK	Wet connector lubrication kit

B.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 wet-end components:
  - Transducer arrays
  - SSP+
- Install and connect cables:
  - Projector to SSP+ cable
  - Receiver to SSP+ cable
  - Auxiliary sensor cables
  - SSP+ to UUV cable
- Power up the system
- Test the system

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

B.3 System Interfacing

B.3.1 AUV/ROV Installation

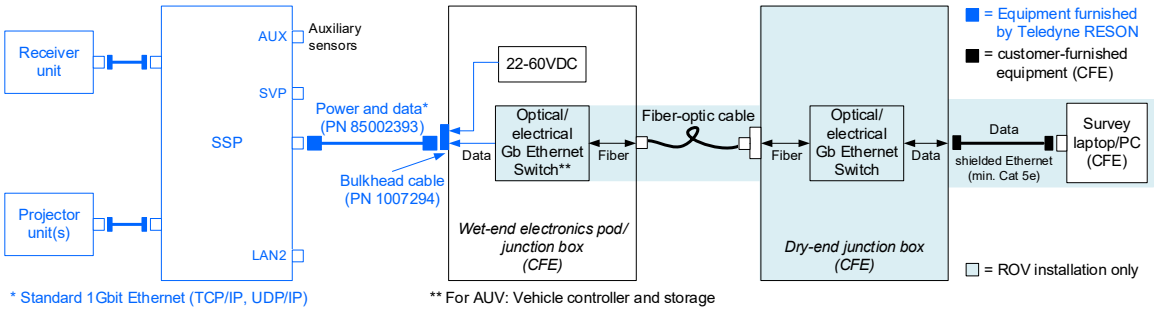


Figure 40: Typical AUV/ROV Installation



Figure 41: Bulkhead Cable Connections

Refer also to *Appendix F Reference Documentation*.

B.3.2 Interfacing Diagrams

Please refer to the appropriate interfacing diagram:

- *Figure 42: T51-S/IDH T51-S AUV, Interfacing Diagram*
- *Figure 43: T51-S/IDH T51-S ROV, Interfacing Diagram*

For further details, please refer to:

- *Appendix B.4 SeaBat T51-S/IDH T51-S Cables*, incl.
  - *B.4.4 Pin Designations for Host, AUX, LAN2, and SVP Connectors*
- *Appendix B.5 SeaBat T51-S/IDH T51-S Installation*, incl.
  - *B.5.4 Wet-End Cable Connections*
  - *B.5.8 Hardware Settings*
- *Section 4.2 Sonar User Interface (SUI)*

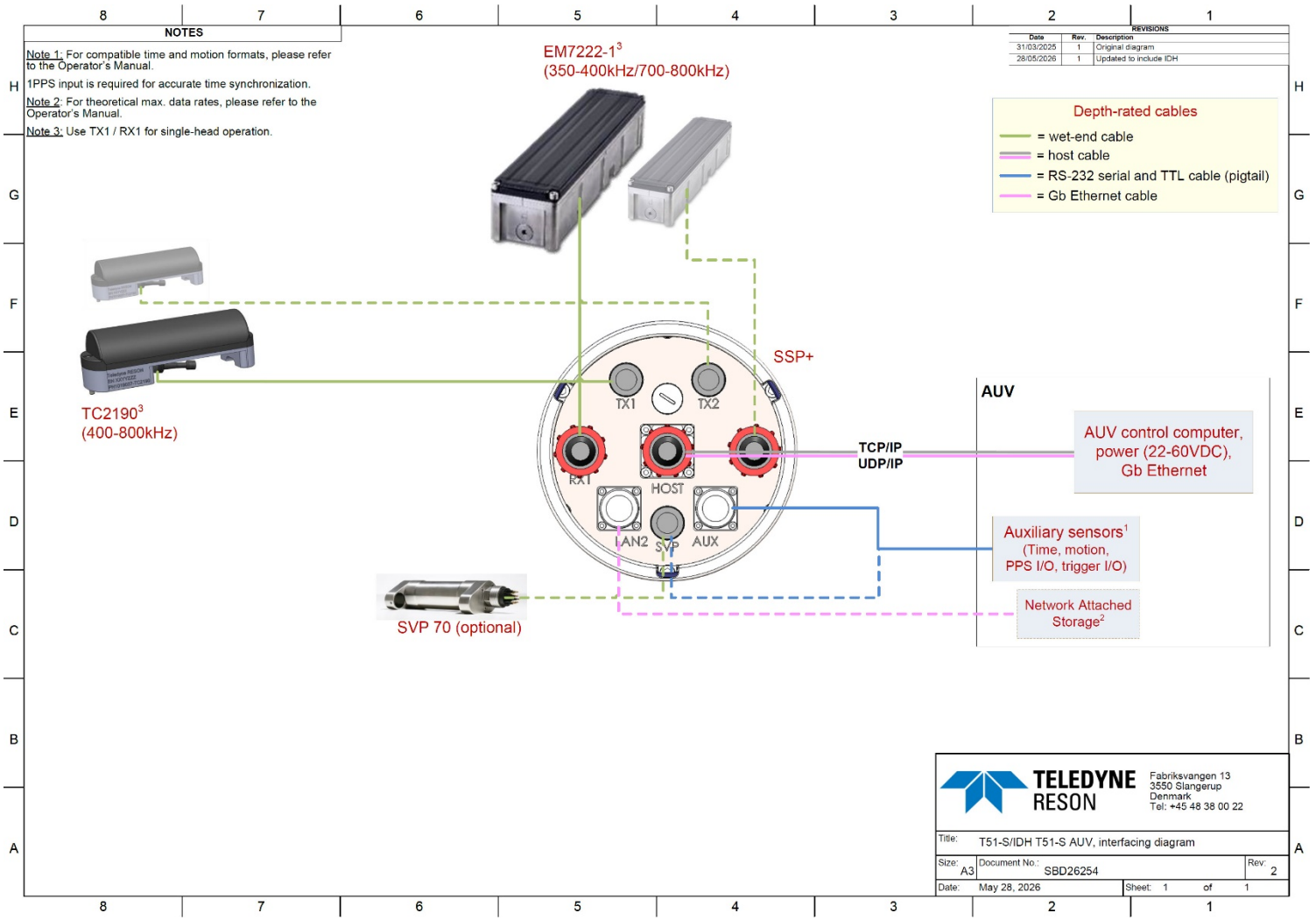


Figure 42: T51-S/IDH T51-S AUV, Interfacing Diagram

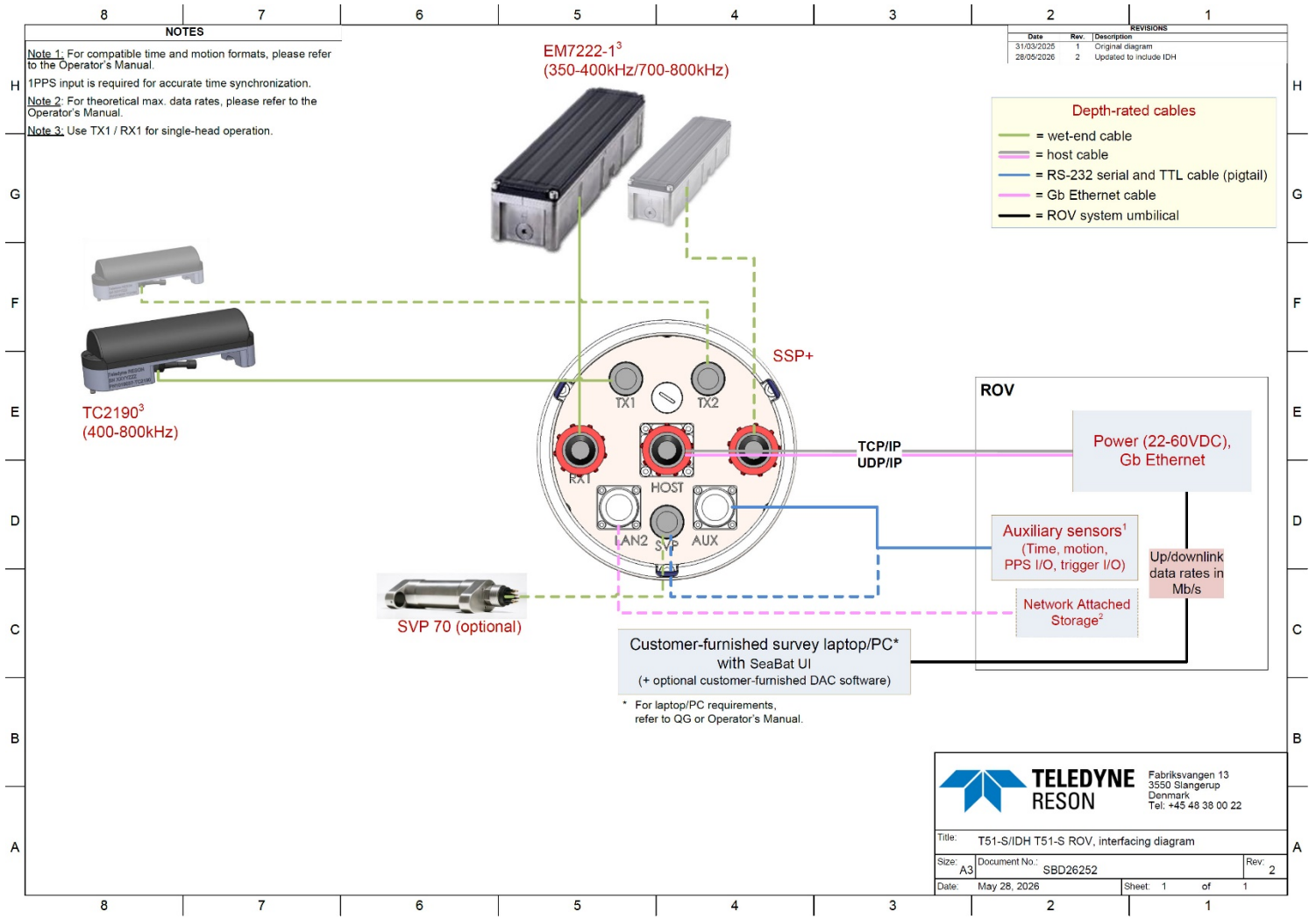


Figure 43: T51-S/IDH T51-S ROV, Interfacing Diagram

B.4 SeaBat T51-S/IDH T51-S Cables

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.

NOTE
General Sonar Isolation Specifications • Any pin to wet-end exterior: minimum 10MΩ // maximum 10nF. • All cable shields to exterior: minimum 10MΩ // maximum 10µF. • The sonar components use 100MΩ leakage resistors to avoid static electricity building up. Consequently, customers' ground fault detector thresholds should accommodate the corresponding resistive leakage and AC currents: • From the power supply and signal pins to the wet-end exterior, as well as • From the cable shields connections to the wet-end exterior.

B.4.1 SeaBat T51-S/IDH T51-S Transducer Cables

A standard cable set is provided to connect the SeaBat T51-S/IDH T51-S system components.

- **Projector to SSP+ cable:** This cable allows power and data to be passed between the projector and SSP+. It has a standard length of three meters and a minimum bend radius of 63.5mm.
- **Receiver to SSP+ cable:** This cable allows power and data to be passed between the receiver and SSP+. It has a standard length of three meters and a minimum bend radius of 100.0mm.

B.4.2 SeaBat T51-S/IDH T51-S External Sensor Cable

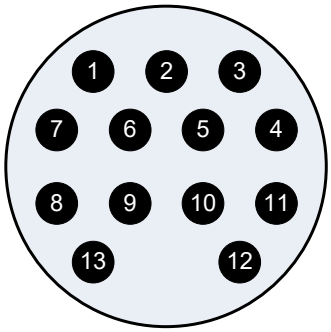
- **AUX pigtail cable:** This cable interfaces external sensors with the SSP+. It has a standard length of five meters and a minimum bend radius of 105.0mm.

B.4.3 UUV Interface Cable

- **SSP+ to UUV host cable:** A host cable allows for power and data to be passed between the SSP+ and the UUV system. This cable is three meters in length and has a minimum bend radius of 100.0mm.

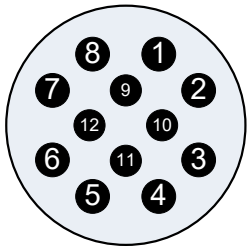
B.4.4 Pin Designations for Host, AUX, LAN2, and SVP Connectors on SSP+

Table 9: Pin Designations for Host Connector[17] (TIA/EIA 568B) mounted on SSP+

Pin	Wire Color	RJ-45 Pin No.	Signal	
1	Black		Supply RTN	
2	Orange		GND Shield	
3	White		Supply RTN	
4	Brown	8	BI_DD-	
5	White/brown	7	BI_DD+	
6	Blue	4	BI_DC+	
7	White/blue	5	BI_DC-	
8	Orange	2	BI_DA-	
9	White/orange	1	BI_DA+	
10	Green	6	BI_DB-	
11	White/green	3	BI_DB+	
12	Red		Positive supply (22-60V)	
13	Green		Positive supply (22-60V)	Pins 1, 3, 12, 13 must all be used.

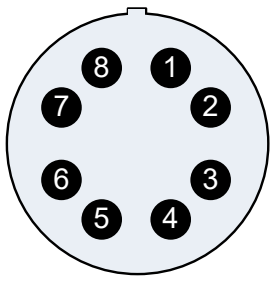
Please also refer to *Figure 53: Cable Assembly, Receiver to SSP and Host Cable*.

Table 10: Pin Designations for AUX Connector[18] mounted on SSP+

Pin	Signal		Pin	Signal	
1	AUX +12V Out (8W)		7	AUX RTN	
2	TX	(I/O COM 4)	8	Trigger Out	
3	Motion/Attitude RS-232 RTN	(I/O COM 2 + 4)	9	Trigger In	
4	Motion/Attitude RS-232 In	(I/O COM 2)	10	Trigger I/O RTN	
5	Time/PPS I/O RTN	(I/O COM 1)	11	PPS Out	
6	Time RS-232 In	(I/O COM 1)	12	PPS In	

Please also refer to *Figure 56: Cable Assembly, AUX Pigtail*

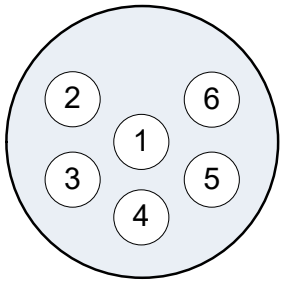
Table 11: Pin Designations for LAN2 Connector[19] (TIA/EIA 568B) mounted on SSP+

NETG Pin	Wire Color	RJ-45 Pin No.	Signal	
1	White/orange	1	BI_DA+	
2	Orange	2	BI_DA-	
3	White/green	3	BI_DB+	
4	Green	6	BI_DB-	
5	White/brown	7	BI_DD+	
6	Brown	8	BI_DD-	
7	White/blue	5	BI_DC+	
8	Blue	4	BI_DC-	

[17] Host connector: MacArtney Subconn DBH13M
[18] AUX connector: Teledyne IMPULSE MHDG-12-FCR
[19] LAN2 connector: Teledyne IMPULSE NETG-FCR

Table 12: Pin Designations for SVP Connector[20] mounted on SSP+

Pin	Signal	
1	RS-232 RTN	(I/O COM 3)
2	RS-232 In	(I/O COM 3)
3	RS-232 Out	(I/O COM 3)
4	SUPPLY +12V Out (2W)	
5	N/A	
6	SUPPLY RTN	



Please also refer to *Figure 57: Cable Assembly, SSP to SVP 70 (optional)*

Table 13: TIA/EIA 568B Overview

RJ-45 Pin	TIA/EIA Pair	1000BASE-T Signal ID	Color Coding	Pin Nos. on RJ-45 Plug
1	2	BI_DA+	White/ orange	
2	2	BI_DA-	Orange	
3	3	BI_DB+	White/ green	
4	1	BI_DC+	Blue	
5	1	BI_DC-	White/ blue	
6	3	BI_DB-	Green	
7	4	BI_DD+	White/ brown	
8	4	BI_DD-	Brown	

[20] SVP connector: Teledyne IMPULSE MCBH-6-FS

B.5 SeaBat T51-S/IDH T51-S Installation

B.5.1 Subsea Sonar Processor SSP+ (PN 1012289-DK)

Table 14: SSP Technical Specifications

Specification	Value
Power requirements	22-60VDC
Power consumption	Average 110W. Peak 300W.
Data communication	Gigabit Ethernet
Dimensions (excl. connectors)	Length: 494mm Diameter: 174mm
Weight (excl. cables)	Air: 24.4kg Water: 10.2kg
Temperature	Operating:-2° to +36°C (submerged) Storage: -30° to +70°C



- The SSP+ pressure housing should be mounted in a convenient location within easy reach of the projector/receiver to SSP+ cables.
- The SSP+ housing may be secured with straps.

CAUTION
The SSP+ should be mounted horizontally with a free flow of water around the unit.
CAUTION
DO NOT OPEN the pressure housing. The SSP+ pressure housing is nitrogen-filled and sealed.

B.5.2 EM7222-1 Receiver Unit (PN 1019488-DK)

Table 15: EM7222-1 Receiver Unit Technical Specifications

Specification	Value
Material	Titanium (grade 2) lid Polyurethane acoustic window
Dimensions	Height 86.8mm Length: 460.0mm Depth: 102.0mm
Weight	Air: 8.7kg Water: 5.3kg
Temperature	Operating: -2° to +36°C Storage: -30° to +70°C



- The EM7222-1 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.
- 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
Ensure free access to water inlet holes (on starboard side) for pressure equalization.

B.5.3 TC2190 Projector Unit (PN 1019037-DK)

Table 16: TC2190 Projector Unit Technical Specifications

Specification	Value
Material	Base: PVC Epoxy/polyurethane acoustic window
Dimensions	Height: 87.5mm Length: 280.0mm Depth: 91.0mm
Weight	Air: 2.15kg Water: 0.72kg
Temperature	Operating: -5° to +40°C Storage: -30° to +55°C

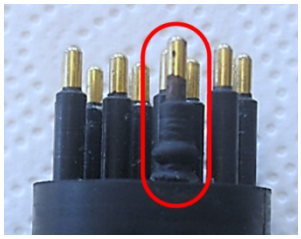


- The TC2190 projector unit mounts to the vessel or mounting bracket with M8 Hex screws already in place in the projector.

B.5.4 Wet-End Cable Connections

NOTE
The transmitter cable may induce an H-field onto the host power wires due to the high transmit power level of the sonar. This interference depends on the external cable routing. Therefore, for full EMC compliance to conducted emission standards, it may be required that the installation includes a customer-provided filter, e. g. TE Connectivity 20EQ1. The filter must be placed close to the power source in order to minimize the risk of inducing noise on the inlet side of the filter.

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



- The cable connections from the receiver and projector units to the SPP+ should be made prior to immersing the units in water.
- A light lubrication coating on the female 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 projector unit and receiver unit faces, as damage could degrade system performance.

To avoid damage to the system components, the SSP+ connections **must** be made according to the labelling on the bottle:

- **TX1/TX2:**
  TC2190, multi-frequency projector(s)

NOTE
For single-head operation, use TX1.

- **RX1/RX2:**
  EM7222-1, multi-frequency receiver(s)

NOTE
For single-head operation, use RX1.

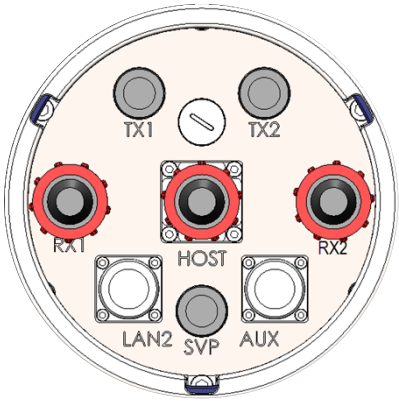


Figure 44: SSP+ Pressure Bottle Connections

CAUTION
To disconnect wet-end cables from the SSP+, first unscrew the locking sleeves before pulling the cables out.

CAUTION
Do not bend the cables beyond the recommended limits when positioning the cables. These cables are very stiff, and a smaller bend radius will damage the cable.

CAUTION
 Do **not** open the Fill valve (for Teledyne RESON use only). Noncompliance will affect warranty situation (see *Appendix H Standard Warranty Information*).

B.5.5 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 relative distance between the projector and receiver face (i.e. Z-value) needs to be known with an accuracy better than 2mm.
- The projector and receiver (seen from the respective reference points) must not be further than 250mm apart in the XY plane.

The actual sonar head assembly installation must be reflected in the user interface settings (see *appendix B.5.8 below* or refer to *Appendix F Reference Documentation*).

B.5.6 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.

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

B.5.7 Wet-End Mounting

- The SSP+ pressure housing should be mounted horizontally with a free flow of water around the unit.

CAUTION
When operating within 10°C of the upper limit (which is +36°C) it is advised to keep the SSP+ horizontal and in free water flow to improve the thermal performance.

- Take care that the sonar head assembly and SSP+ are electrically isolated from the structure to avoid corrosion problems.

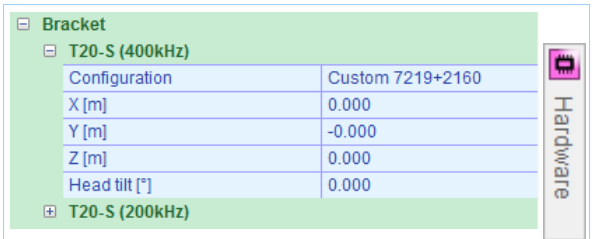
NOTE
The complete, assembled sonar system exceeds 10 megaohm isolation from any pin to water.

- The head should be immersed in water to a depth of at least 0.8m. This ensures that noise from surface waves does not degrade performance.

B.5.8 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 Sonar UI User Manual (see *Appendix F 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 B.5.5 above*.

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

- **Preset Configurations:**

NOTE
Preset configurations can only be used with Teledyne RESON standard brackets for receiver and projector(s). If a standard bracket is not used the customer configuration should be used instead.

  - Normal: When the receiver is mounted with the connector to the port side, the Configuration selection should be Normal.
  - Reversed: When the receiver is mounted with the connector to the starboard side, the Configuration selection should be Reversed (see *appendix B.5.5 Sonar Head Assembly Orientation*). 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 B.5.6 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 6.3.4 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°.

B.6 System Check

Once the SeaBat T51-S/IDH T51-S has been installed, follow these steps to ensure that the system is working properly. For information on the settings, refer to the Sonar UI User Manual (see *appendix F.1 SeaBat T51-S/IDH T51-S Documentation*).

NOTE
Communication with the SSP+ requires the use of a secondary computer via an Ethernet cable.

B.6.1 Configuration

Confirming that the system has booted up in the right configuration demonstrates that communications between wet end and processors are functional, and that the ID chip from the receiver and projector are read correctly.

- The configuration is presented in the top of the Sonar UI window.
- The serial numbers are displayed in the Service menu under the Config tab. Find the serial numbers on the units:
  - Receiver and projector: stamped into the housings.
  - SSP+: on the front label.

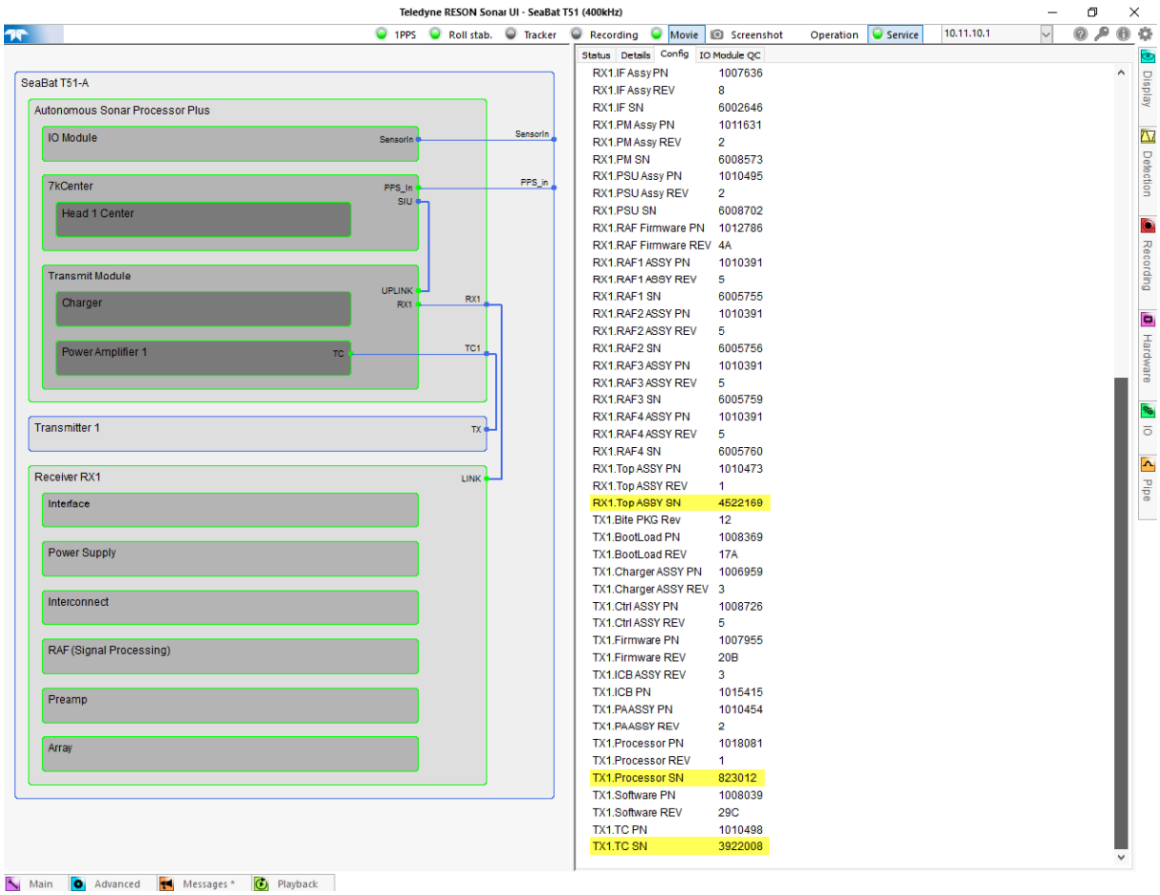


Figure 45: Configuration Check via Sonar UI Service Menu (example)

B.6.2 Receiver and Projector Test

The following steps explain how to test the receiver and projector.

CAUTION
The projector **must** always be tested in water, whereas the receiver may be tested in air.

1. Ensure that all system cable connections are mated properly.
2. Apply power to the system. The Windows® operating system will boot up and the 7kCenter (sonar control software) will start automatically.
3. Start the Sonar UI by double-clicking the icon on the operator desktop and select the correct IP address in the toolbar (*see section 4.2 Sonar User Interface (SUI)*).
4. Verify that the Power setting on the Main pane is set to OFF.

B.6.3 Receiver Test (performed in air or water)

CAUTION
If tested in air, ensure that the projector is submerged. The projector must **not** ping in air.

5. Once the system has been energized, follow these steps to verify that the system is operating correctly:
    a. Set transmit Power to OFF.
    b. Set Range to 150.
    c. Start pinging the transmitter by setting Max Rate on the Main pane.
    d. Set Gain to 30.
    e. Select Blue-Yellow from the Sonar Palette drop-down menu on the Display pane.
    f. 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, and this confirms that the receiver is operable.

B.6.4 Projector Test (always performed in water)

CAUTION
The SSP+ is designed for operation under water. Operation in air for extended periods of time will result in overheating and severe damage to the system. Transmitting into air for any period of time may result in the permanent damage of the ceramics of the **projector** and consequently degraded performance. For *dual head* systems, test each projector separately. Always perform this test with the receiver and projector in water. A small container will suffice, as long at the units are fully submerged.

6. Once the system has been energized, follow these steps to verify that the system is operating correctly:

    For single-head systems:

    a. Set Range to the lowest value, 3/5m, on the Main pane.
    b. Set Gain to 83dB.
    c. Verify that the wedge is updating.
    d. Set transmit Power to OFF.
    e. Set Pulse Length to 150µs (CW).

f. Set Power to the lowest value.
g. Verify that echoes are present in the wedge display.
h. Set transmit Power to OFF.
i. Shut down the system.

For IDH systems:

a. Set Range to the lowest value, 3/5m, on the Main pane.
b. Set Gain to 83dB.
c. Verify that the wedge is updating.
d. Set transmit Power to OFF:
e. Disconnect TX2 projector cable.
f. Set Pulse Length to 150µs (CW).
g. Set Power to the lowest value.
h. Verify that echoes are present in the wedge display.
i. Set transmit Power to OFF.
j. Disconnect TX1 projector cable.
k. Set Pulse Length to 150µs (CW).
l. Set Power to the lowest value.
m. Verify that echoes are present in the wedge display.
n. Set transmit Power to OFF.
o. Shut down the system

APPENDIX C PPS IN AND TRIGGER IN

C.1 Electrical Specifications for PPS In and Trigger In

Table 17: PPS In and Trigger In Signals[21]

Parameter	Min.	Typical	Max.	Unit	Note
Absolute maximum[22] 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[23])		0			
Input delay		400	1000	ns	Pulse 0V to 2V, 50 Ohm

C.2 Typical PPS In and Trigger Performance

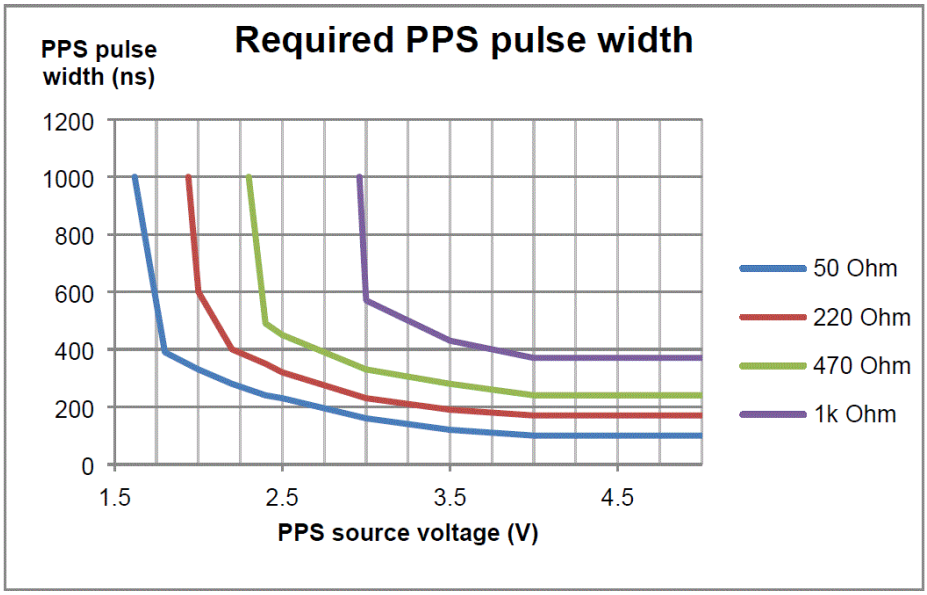


Figure 46: Required PPS Pulse Width

[21] Measured at the BNC terminals.
[22] Voltages beyond maximum limits may cause permanent damage to the input.
[23] Completely unconnected input guaranteed to be low.

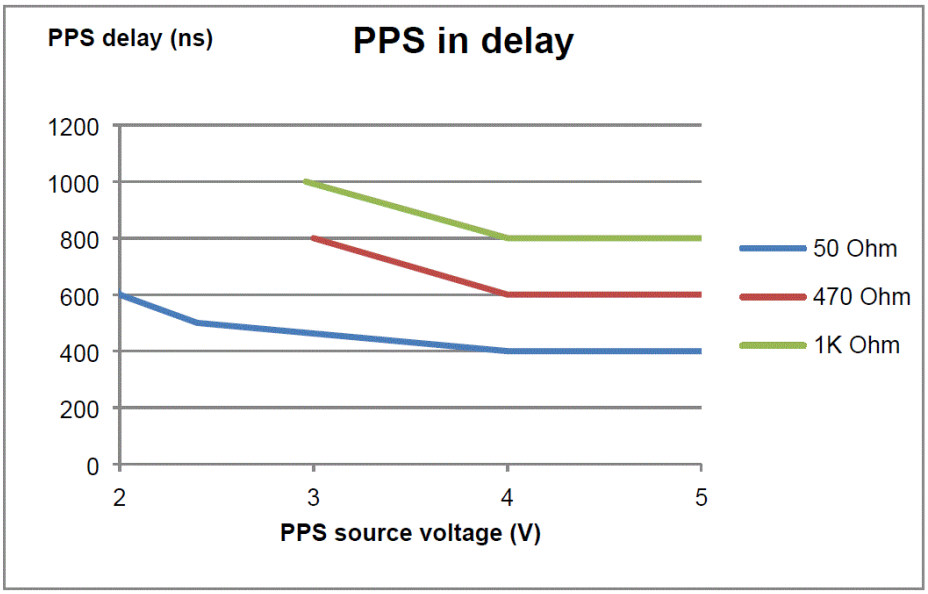
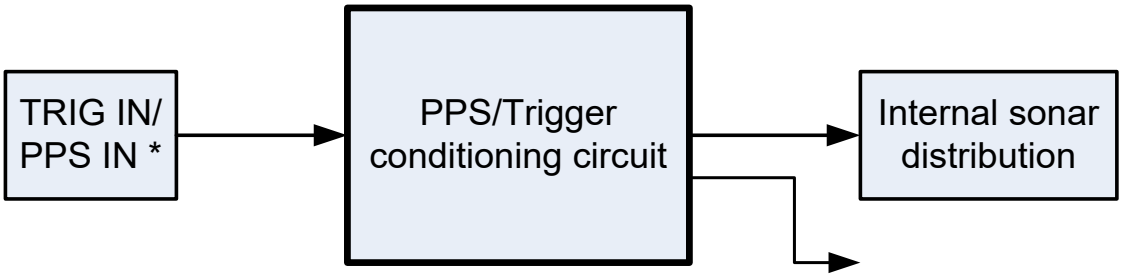


Figure 47: PPS In Delay

C.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 17*.
- 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 48: PPS/Trigger Signal

APPENDIX D DATA RATES

Table 18: Theoretical Max. Data Rates – SeaBat T51-S/IDH T51-S

System and number of beams	**Utilized storage GB/hour**	**Max. data rate Mb/s**	**Utilized storage GB/hour**
T51-S, 256 beams 34kS/s	~130	~300	~5
T51-S, 512 beams 34kS/s	~250	~550	~6
T51-S, 1024 beams 34kS/s	N/A	N/A	~8
T51-S, 256 beams 50kS/s	~180	~400	~6
T51-S, 384 beams 50kS/s	~270	~600	~7
T51-S, 1024 beams 67kS/s	N/A	N/A	~9
Records/data: Survey + interfaced sensor data:	Incl. water column		Excl. water column

Notes:

1024 beams exceed the Ethernet data bandwidth.

Uncontrolled Technology Subject to Restrictions Contained on the Cover Page.

APPENDIX E NETWORK CONFIGURATION

E.1 System Network Configuration

The Subsea Sonar Processor (SSP+) is at delivery configured as follows:

Table 19: IP Configuration for SSP+

Network port	LAN 1/Host	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 Sonar User Interface (SUI) should in standard systems be configured in the IP range 10.11.10.3-10.11.10.255 in the same subnet as the SSP+.

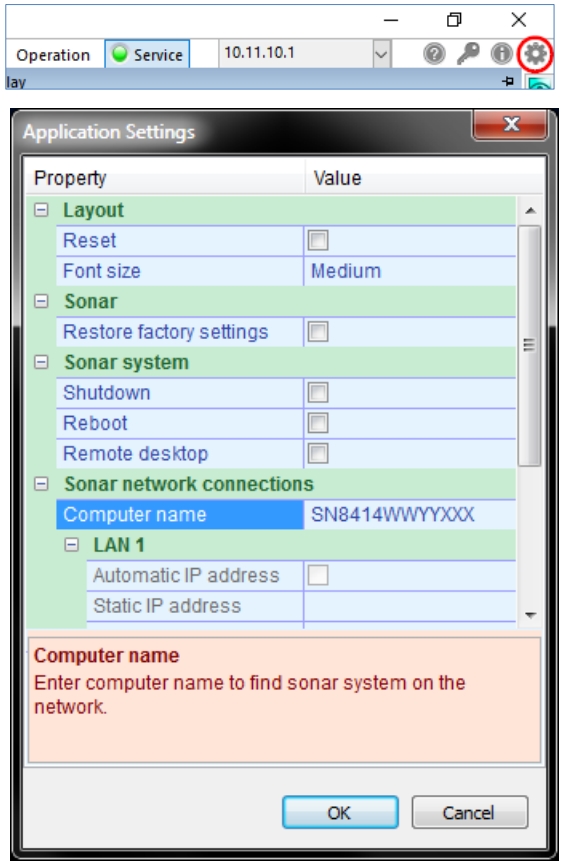
E.2 Change IP Configuration

The IP configuration can be changed from the SUI installed on the CFE 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 SSP+.

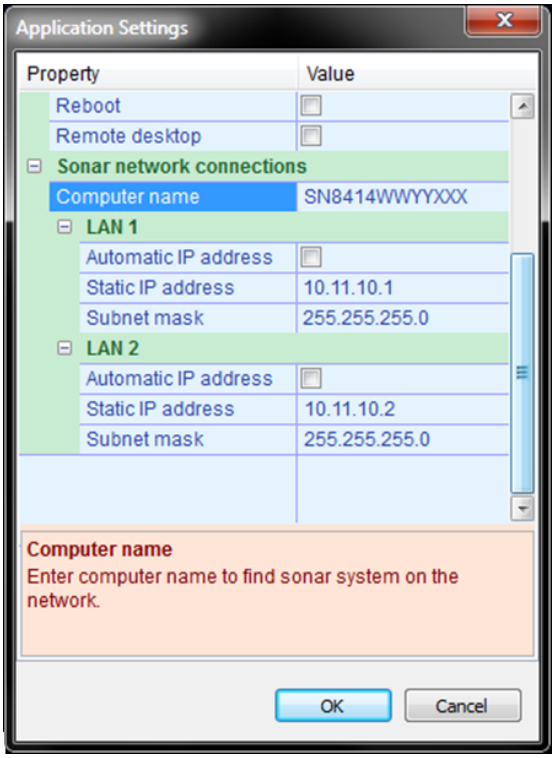
   Please find the serial number on the label on the SSP+.





4. Press Enter on the keyboard.

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



Manual or automatic configuration of LAN 1 and LAN 2:

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 SSP+.

   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 SSP+ 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.

2. After configuring the desired IP addresses, click OK.

NOTE
If you change the IP addresses (within the same subnet), the connection to the SSP+ will be lost. Shut down the UI and restart to re-establish the connection.
NOTE
The connection from the SUI to the SSP will be lost if the SSP moves to another SUBNET than the one the CFE laptop/PC is located on. In that case, change the CFE laptop/PC IP address to a valid IP address within the same subnet, 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 SSP and the CFE 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 REFERENCE DOCUMENTATION

F.1 SeaBat T51-S/IDH T51-S 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 T51-S/IDH T51-S Operator's Manual	OM26239	Version 2 or higher
SeaBat T51-S/IDH T51-S Quick Reference Guide	QG26238	Version 2 or higher
SeaBat UI for T-Series Quick Installation Guide	QG15552	Version 3 or higher
SeaBat Updater Quick Installation Guide	QG18505	Version 3 or higher
T/F-Series Subsea Integration to ROV electronics pod Installation Quick Guide	QG21497	Version 2 or higher
Sonar UI User Manual	OM14950	Version 1.6.0 or higher
Data Format Definition[24]	DFD20723	Version 3.18 or higher

Each system contains a link in the Start menu to system documentation (as shown in the example in *Figure 49*.

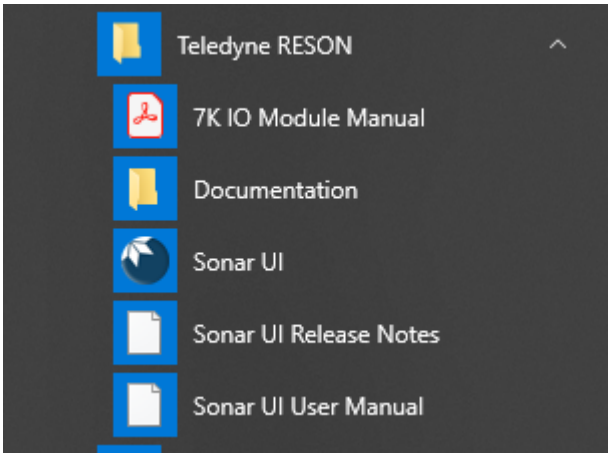


Figure 49: System Documentation Link (Example Only)

[24] Also available here: https://github.com/Teledyne-Marine/access

F.2 SeaBat T51-S/IDH T51-S Design Documents

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

Table 20: SeaBat T51-S/IDH T51-S Design Documents

Document Title	Document Number
Receiver, EM7222-1, Outline	22252
TC2190 Outline dimension	26243
Subsea Sonar Processor, Outline	85002507M011
Ethernet cable, Subconn DIL13M w. DIL13F (Rx to SSP cable and host cable)	85002393 0040360000-052
CABLE ASSY, HD-PV, MCIL-6-FS,TX, 7K	85001905B011
Ethernet cable, Subconn DBH13F Brass. w. DDC13M (Bulkhead connector)	1007294 0040360000-053
Cable Assy, MHDG-12-CPP, 12c AWG#20, Pigtail, 5m	1009794 PARTD17002
Cable Assy, MCIL-9-FS to MCIL-6-MP, for SVP70 to wet SVP interface (optional)[25]	PARTD16102
T51-S Wet End Sonar Ref Point Definition	26389

[25] SVP 70 cable options:
PN 1009571: 1m
PN 1009791: 3m (standard length)
PN 1009792: 5m

F.2.1 Receiver, EM7222-1 Outline Dimensions

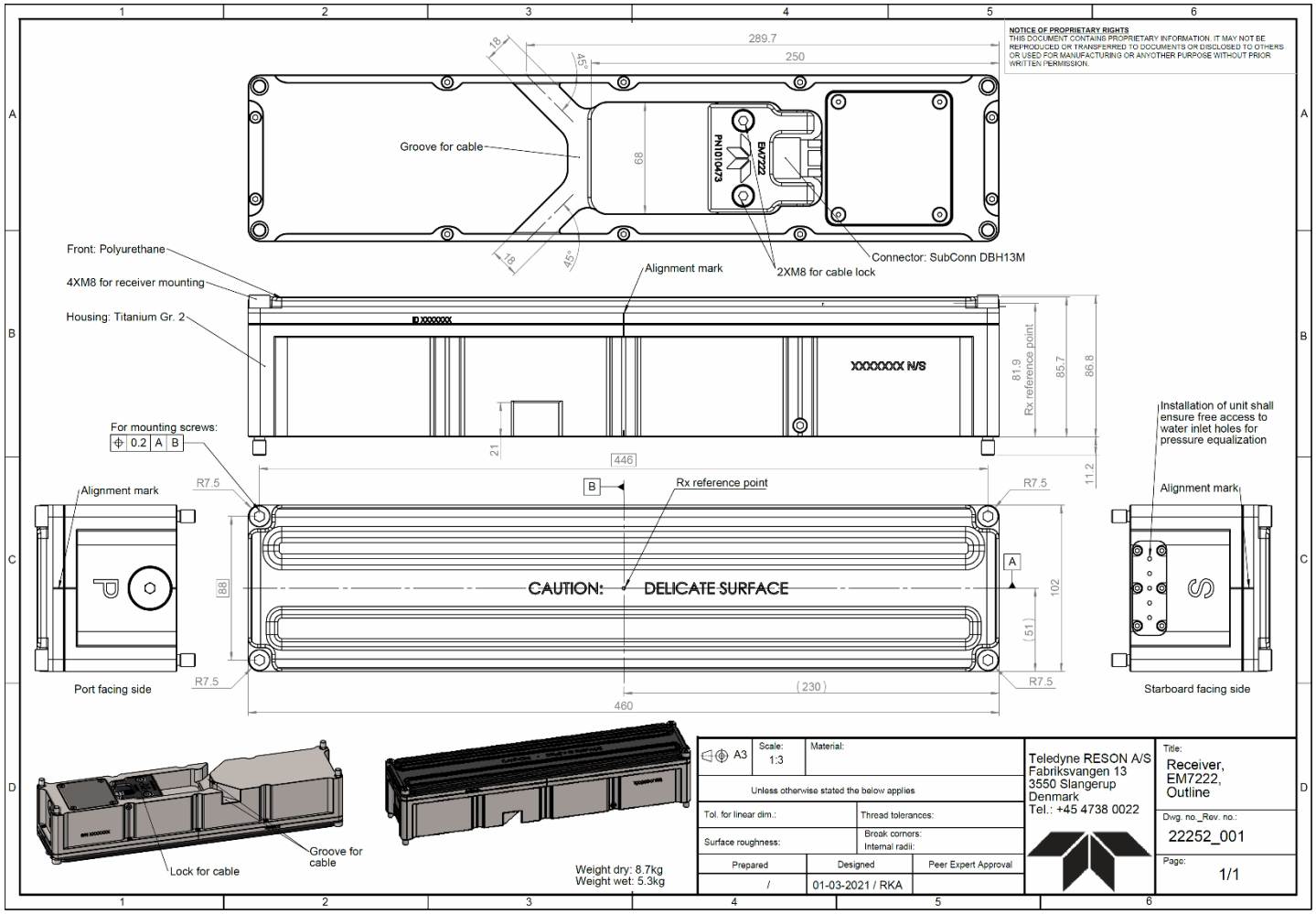


Figure 50: Receiver, EM7222-1 Outline Dimensions

F.2.2 Projector, TC2190 Outline Dimensions

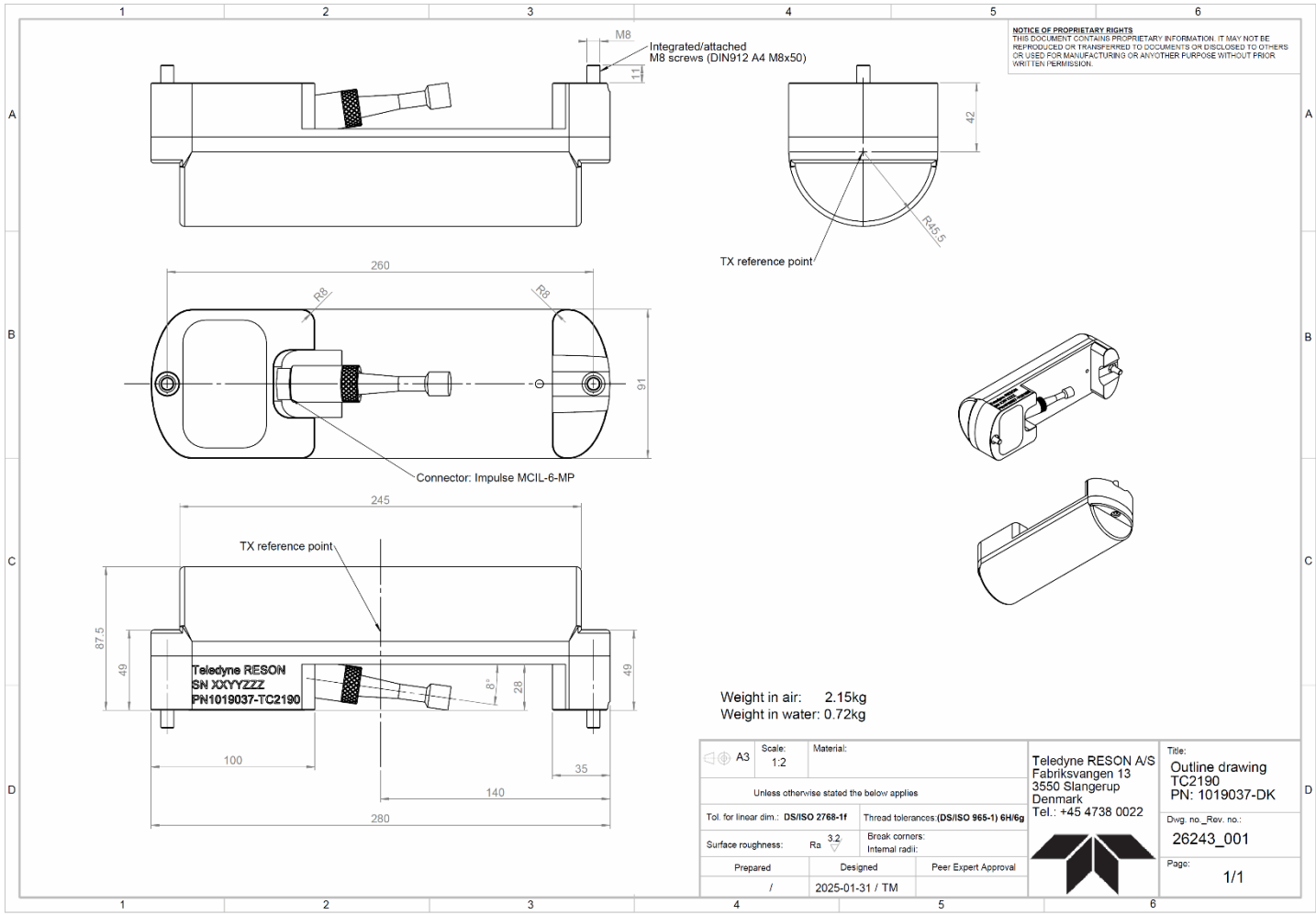


Figure 51: Projector, TC2190 Outline Dimensions

F.2.3 Subsea Sonar Processor, Outline Dimensions

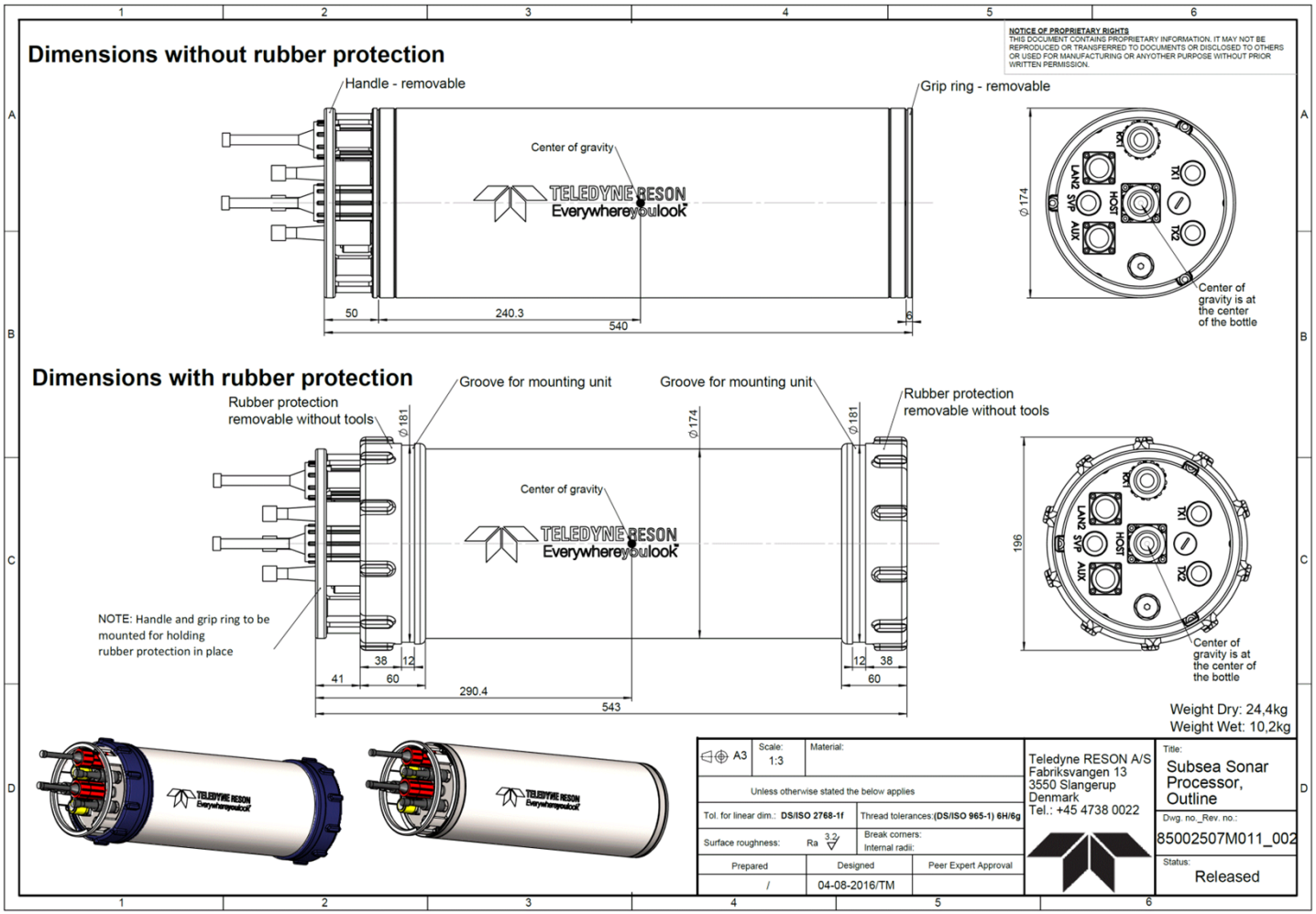


Figure 52: Subsea Sonar Processor, Outline Dimensions

F.2.4 Cable Assembly, Receiver to SSP and Host Cable

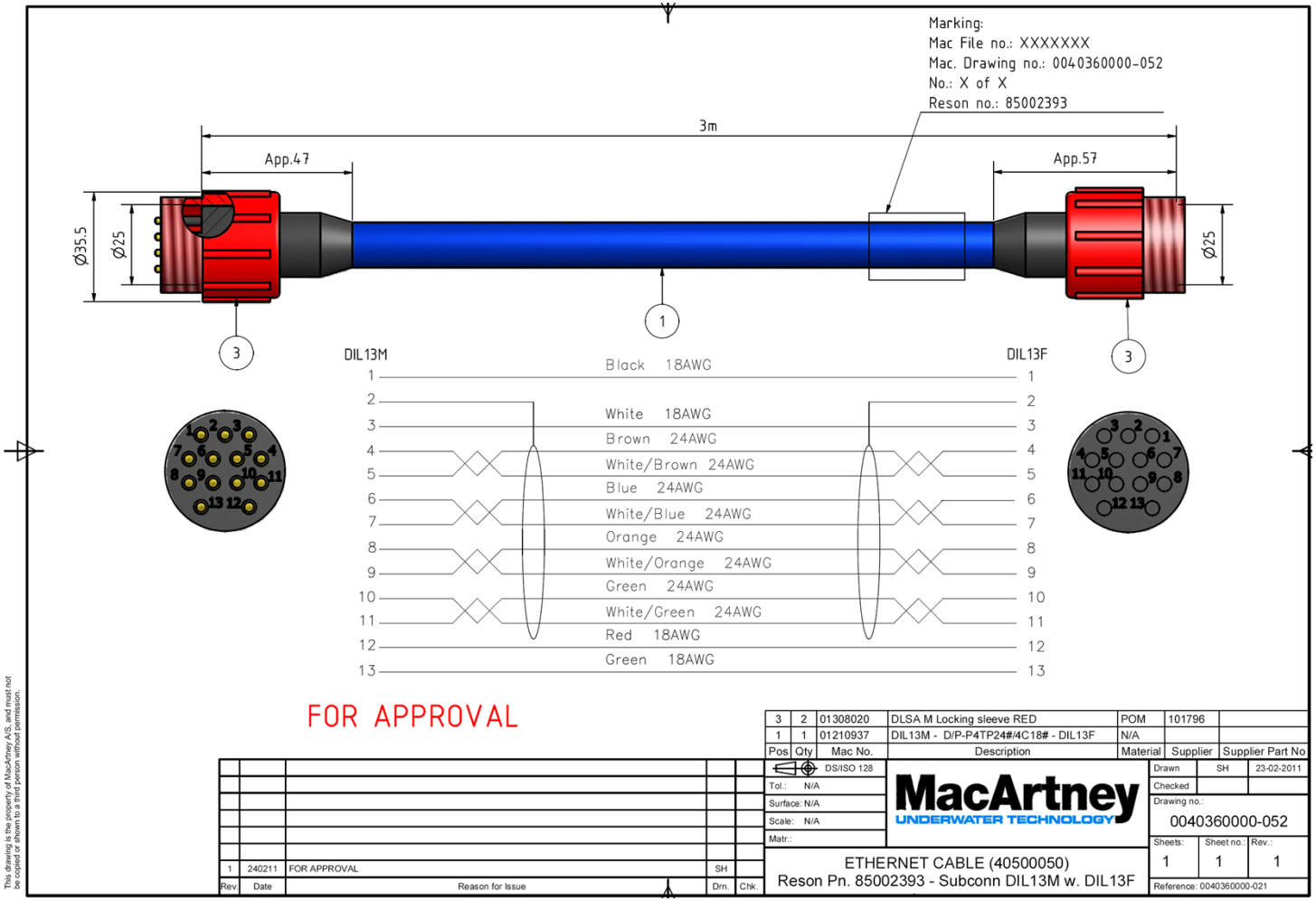
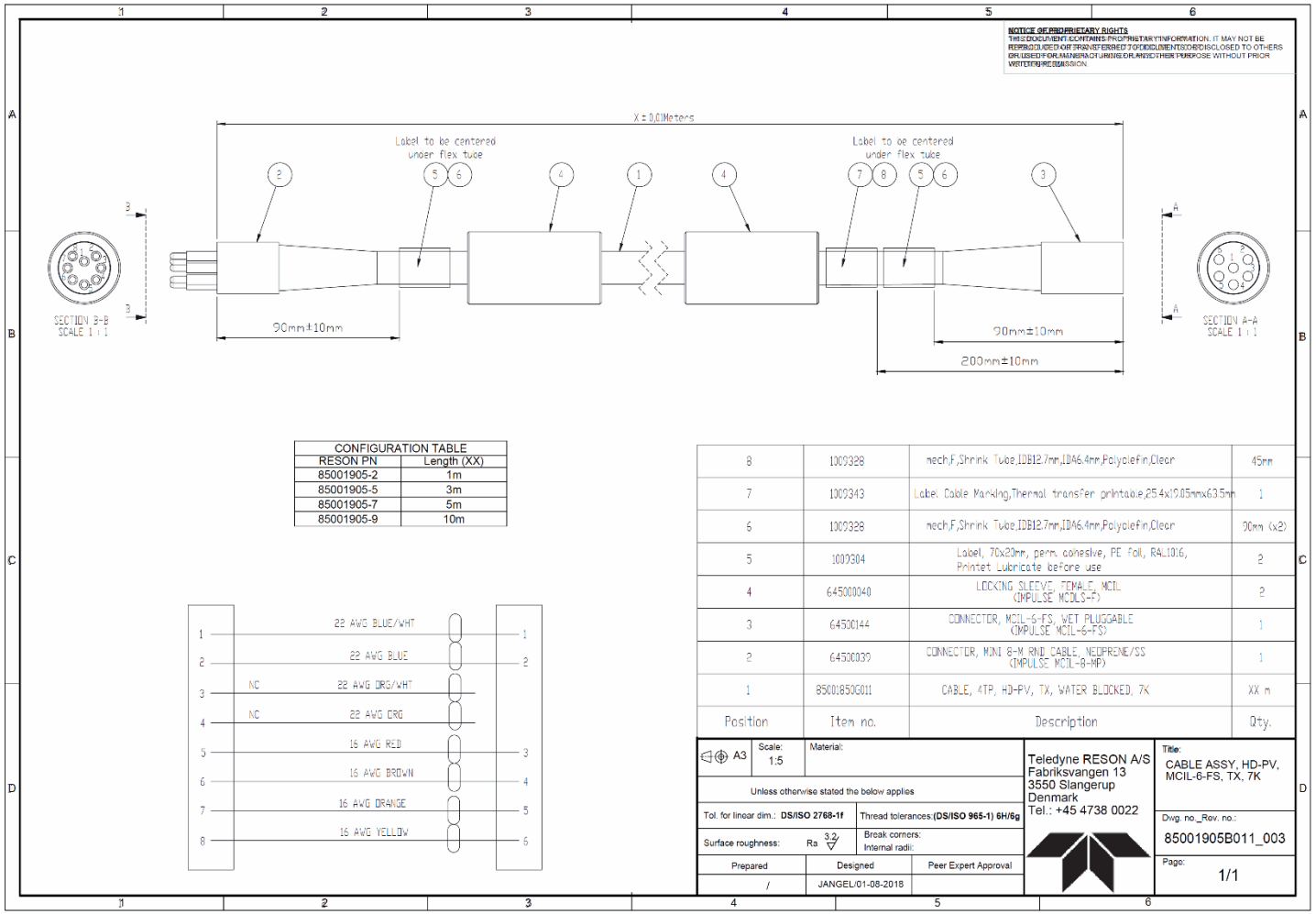


Figure 53: Cable Assembly, Receiver to SSP and Host Cable

F.2.5 Cable Assembly, Projector to SSP



CONFIGURATION TABLE	
RESON PN	Length (XX)
85001905-2	1m
85001905-5	3m
85001905-7	5m
85001905-9	10m

Position	Item no.	Description	Qty.
8	1009328	mech,F,Shrink Tube,IDB12.7mm,IDA6.4mm,Polyolefin,Clear	45mm
7	1009343	Label Cable Marking,Thermal transfer printable,25.4x12.05mmx63.5mm	1
6	1009328	mech,F,Shrink Tube,IDB12.7mm,IDA6.4mm,Polyolefin,Clear	90mm (x2)
5	1009304	Label, 70x20mm, perm. cohesive, PE foil, RAL1016, Printet Lubricate before use	2
4	64500040	LOCKING SLEEVE, FEMALE, MCIL (IMPULSE MCDLS-F)	2
3	64500144	CONNECTOR, MCIL-6-FS, WET PLUGGABLE (IMPULSE MCIL-6-FS)	1
2	64500039	CONNECTOR, MINI 8-M RND CABLE, NEOPRENE/SS (IMPULSE MCIL-8-MP)	1
1	85001850G011	CABLE, 4TP, HD-PV, TX, WATER BLOCKED, 7K	XX m

Figure 54: Cable Assembly, Projector to SSP

F.2.6 Cable Assembly, Bulkhead Connector for ROV

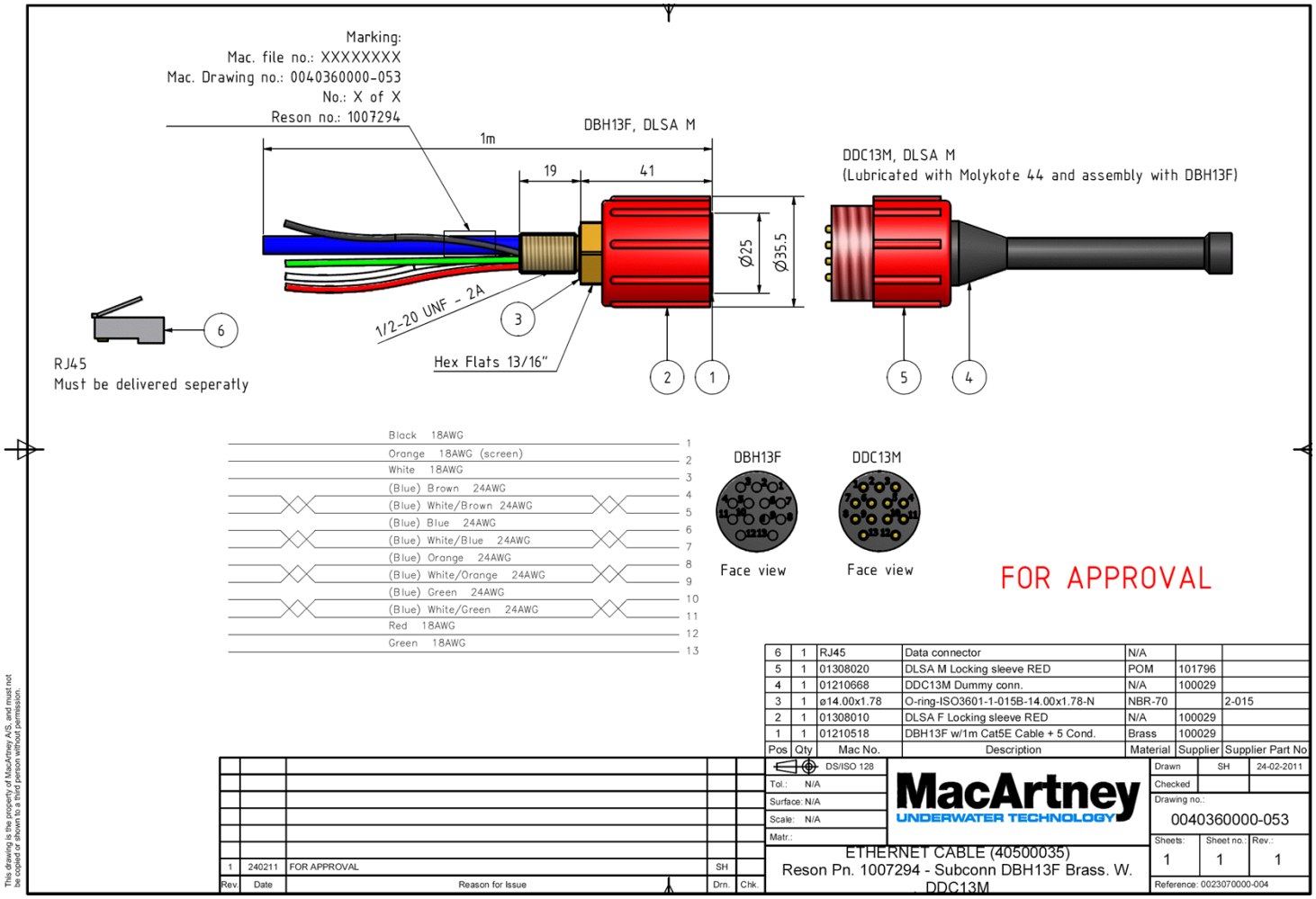
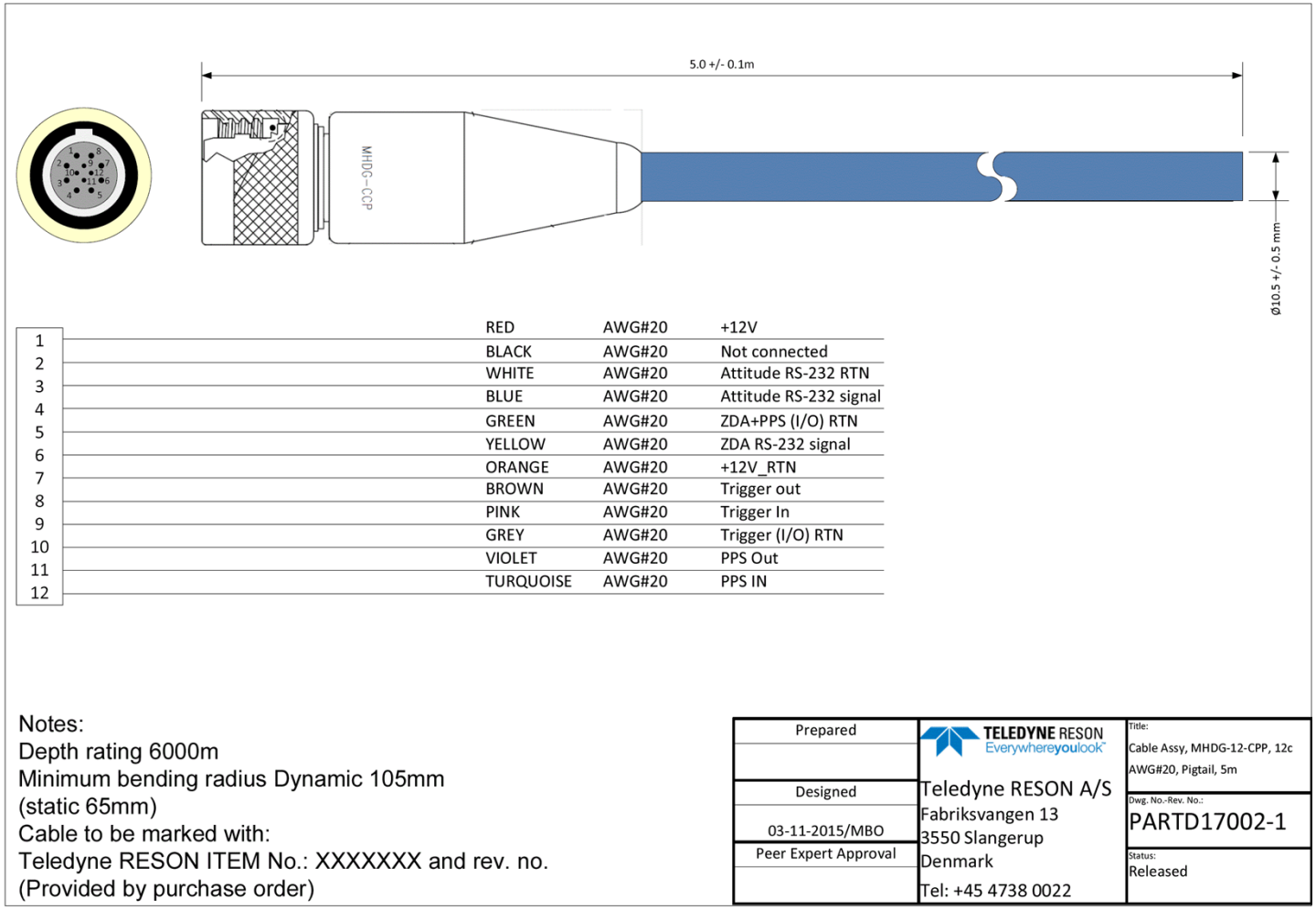


Figure 55: Cable Assembly, Bulkhead Connector for ROV

F.2.7 Cable Assembly, AUX Pigtail



1	RED	AWG#20	+12V
2	BLACK	AWG#20	Not connected
3	WHITE	AWG#20	Attitude RS-232 RTN
4	BLUE	AWG#20	Attitude RS-232 signal
5	GREEN	AWG#20	ZDA+PPS (I/O) RTN
6	YELLOW	AWG#20	ZDA RS-232 signal
7	ORANGE	AWG#20	+12V_RTN
8	BROWN	AWG#20	Trigger out
9	PINK	AWG#20	Trigger In
10	GREY	AWG#20	Trigger (I/O) RTN
11	VIOLET	AWG#20	PPS Out
12	TURQUOISE	AWG#20	PPS IN

Notes:
Depth rating 6000m
Minimum bending radius Dynamic 105mm (static 65mm)
Cable to be marked with:
Teledyne RESON ITEM No.: XXXXXXX and rev. no.
(Provided by purchase order)

Prepared	TELEDYNE RESON Everywhereyoulook™	Title: Cable Assy, MHDG-12-CPP, 12c AWG#20, Pigtail, 5m
Designed: 03-11-2015/MBO	Teledyne RESON A/S Fabriksvangen 13 3550 Slangerup Denmark Tel: +45 4738 0022	Dwg. No.-Rev. No.: PARTD17002-1
Peer Expert Approval		Status: Released

Figure 56: Cable Assembly, AUX Pigtail

F.2.8 Cable Assembly, SSP to SVP 70 (optional)

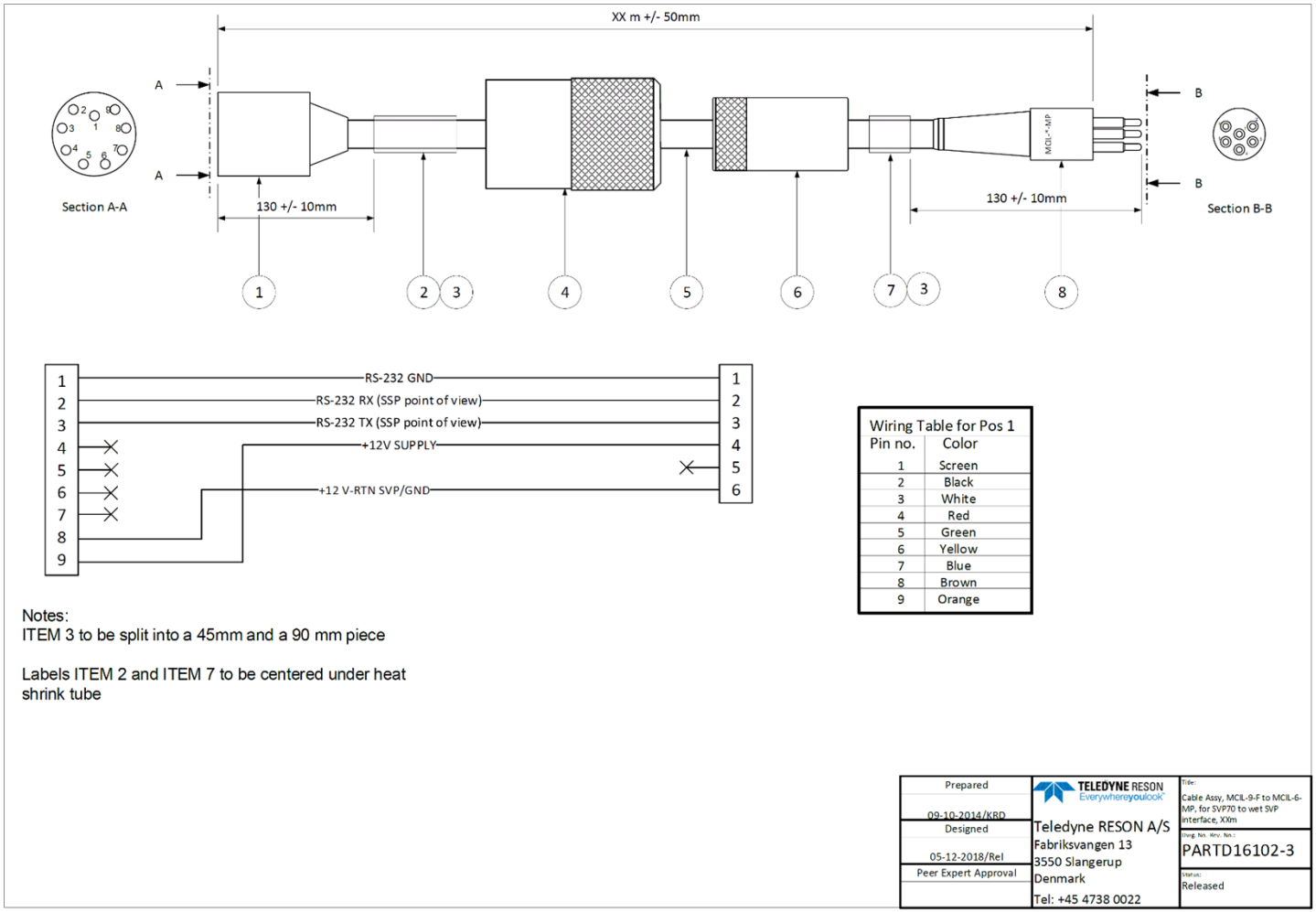


Figure 57: Cable Assembly, SSP to SVP 70 (optional)

F.2.9 Sonar Reference Point Definition

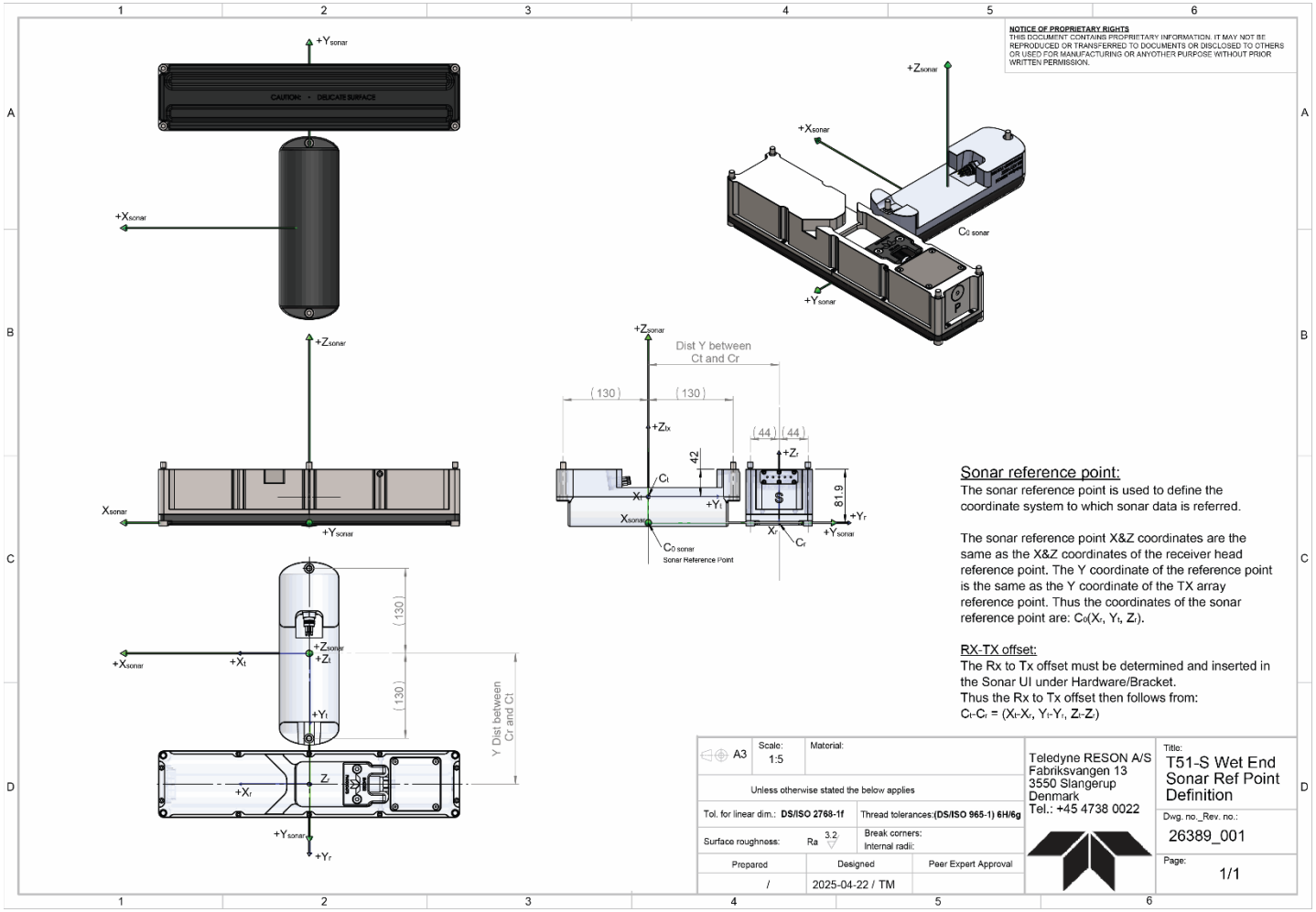


Figure 58: Sonar Reference Point Definition

F.3 7kCenter Licenses – Copyright Information

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APPENDIX G SEABAT T51-S/IDH T51-S SYSTEM OPTIONS

The following options are available with the SeaBat T51-S/IDH T51-S system. If you require more detailed information about any of these options, please contact Teledyne RESON Sales for assistance.

- Extended Warranty Contract
- SeaBat Cables
- Service Level Agreement
- Sound Velocity Probe
- System Integration and Training
- Teledyne PDS Data Acquisition Software

G.1 Extended Warranty Contract

All SeaBat T51-S/IDH T51-S systems are provided with a standard 36-month warranty (see *Appendix H Standard Warranty Information*). This option provides the user with the possibility of purchasing additional annual support.

G.2 SeaBat Cables

Additional cables in various lengths are available for purchase.

G.3 Service Level Agreement

A Service Level Agreement (SLA) runs for annual terms of 12 months at a time, and covers 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 defect repair services
- Software and firmware updates
- Spare part allowance
- Telephone and email support

G.4 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 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 23: 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.

G.5 System Integration and Training

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

G.6 Teledyne PDS Data Acquisition Software

Teledyne PDS software provides a wealth of displays and data processing options. Configure the software on a separate computer and postprocess your data there.

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

APPENDIX H STANDARD WARRANTY INFORMATION[26]

H.1 Limited Warranty

Teledyne RESON warrants that our SeaBat™ T-Series systems shall be free from defects in materials and workmanship for a period of thirty-six (36) months from the date of Teledyne RESON's original shipment, and that all our other systems and/or auxiliary items shall be free from defects in materials and workmanship for a period of twelve (12) months from the date of Teledyne RESON's original shipment. These warranty periods apply, unless Teledyne RESON has specified a longer standard warranty period for a particular product and/or offered an extended warranty.

During the warranty period, Teledyne RESON will, at its sole option, either repair, replace, or issue a credit for the original price of the defective system. Such repair, replacement, or credit shall be the sole remedy for a defective system. For full information about the warranty provisions, please refer to the section "Limited Warranty" in our General Terms and Conditions of Sale.

Teledyne RESON systems must be serviced by Teledyne RESON or one of Teledyne RESON's authorized service providers. Any return of nonconforming or defective systems is subject to Teledyne RESON's current return authorization process and procedures *(see appendix I.2 Equipment Service Procedure)*.

H.2 Warranty Exclusions

The warranty on Teledyne RESON systems does not apply to defects arising from:

- Improper installation, operation, or maintenance.
- Improper handling, storage, or transportation.
- Unauthorized modifications, alterations, or repairs.
- Failure to comply with Teledyne RESON's safety precautions.
- Accidental damage.
- Normal wear and tear.

H.3 Warranty Disclaimer

No warranties of merchantability or fitness for a particular purpose is intended or given.

H.4 Servicing During Warranty Period

If your system should encounter technical issues during the warranty period, please contact Teledyne RESON Support (see *appendix I.1 Teledyne RESON Support*) to protect your warranty rights.

[26] Please refer to Teledyne RESON's General Terms and Conditions of Sale, available at http://www.teledynemarine.com/reson/ > Terms and Conditions.

APPENDIX I SUPPORT AND SERVICE

I.1 Teledyne RESON Support[27]

If you experience difficulties with your Teledyne RESON system, please contact Teledyne RESON Support for further instructions:

E-MAIL

reson-support@teledyne.com
pds-support@teledyne.com

PHONE Nos.

+45 4738 0022	Denmark
+31 1 0245 1500	The Netherlands
+44 1 2247 7234 5	United Kingdom
+1 805 233 3900	USA

24-Hour Support – Open Monday-Friday

+45 2099 9088

NOTE	Open 24/7/365 for customers with SLA agreements exclusively.

I.2 Equipment Service Procedure

I.2.1 Policy for Servicing Equipment

NOTE
Serviced items will be returned with the latest released firmware/software.

- Teledyne RESON continuously releases new firmware to mitigate any stability, functionality, or other issue, and to improve system performance.
- We ensure that firmware/software releases are backwards compatible with older hardware.
- We can't always support new hardware on older firmware/software releases; thus we can't guarantee that a repaired component is compatible with other than the latest released firmware/software.

[27] Refer also to http://www.teledynemarine.com/support.

I.2.2 Returning Equipment for Service

NOTE
Please do **not** return any equipment without prior authorization from Teledyne RESON, as evidenced by a Return Authorization (RMA) Number.

Before returning any equipment for service, you must follow the Teledyne RESON equipment return authorization procedure as outlined here:

1. Contact Teledyne RESON Support (see *section I.1 above*) 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, transportation and insurance prepaid, according to the instructions issued by Teledyne RESON.
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 which identifies the model or part number, and serial number (if applicable) along with a brief, but thorough, description of the problem.



SeaBat T51-S/IDH T51-S Operator's Manual

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