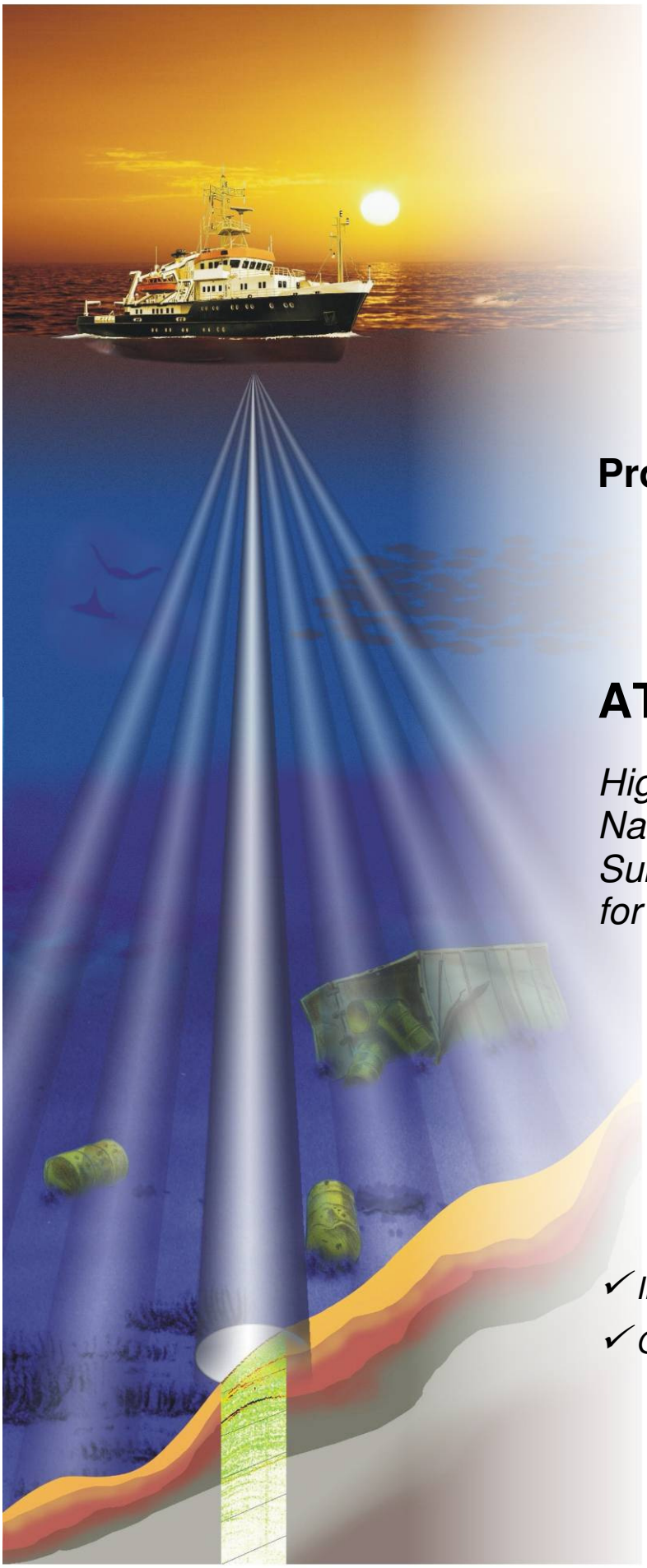
ATLAS HYDROGRAPHIC

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Product Description

ATLAS PARASOUND

Highest Level
Narrow-Beam Parametric
Sub-Bottom Profilers
for Deep-Sea Applications

- ✓ *Innovative Electronic Design*
- ✓ *Outstanding Survey Performance*

Doc No.: BL 6029 G 002 (Order No. **520000xxx**)

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1 Overview

With the ongoing rapid globalisation of economies, the World Oceans have become a prime target not only for an increasing national exploitation of natural resources but also for international communication, transport and trade. The worldwide constitution of National Exclusive Economic Zones (EEZ) focused the nations attention on both the enormous resource potential as well as the strategic importance of their offshore and oceanic regimes. The utilisation of these vast areas from inshore to the High-Seas offers a broad spectrum of technological challenges. The future management of these marine resources highly depends on the availability of appropriate technologies for surveying, monitoring and exploitation.

The ATLAS PARASOUND is a unique surveying tool for the acquisition of highly demanded seafloor sediment data. International Marine Research Institutions, National Hydrographic Services, Offshore Surveyors and Engineers as well as Environmental Agencies utilise the instrument's outstanding accuracy, resolution and the unbeaten sediment penetration in a demanding environment.

The ATLAS PARASOUND sub-bottom sediment profiler system presents the state-of-the-art multifunctional echosounder combining a:

- Narrow-beam deep-sea echosounder for full ocean depth.
- Parametric sediment survey echosounder with extreme sub-bottom profiling capabilities.
- Conventional sediment survey echosounder for the operation in areas where high transmission source levels are forbidden in order to protect marine mammals.

Highly integrated electronic modules and modern software-driven control and display structures provide the outstanding system performance:

- Full ocean depth capability > 11,000 meters.
- Sediments layer penetration of more than 200 meters (depending on the sediment characteristics).
- High angular and vertical resolution providing optimal stratigraphic layer identification and morphological information.
- Operability for ship's speeds up to 15 knots
- Integrated seismic data online and processing package with SEG-Y and PS3 data exchange format.
- "Incidence Angle Control (IAC)" for autonomous ("watch-free") operation for a wide range of bottom slopes.
- Different selectable pulse characteristics for improving the signal quality via a better S/N ratio.
- Complete sounding profiles, including the entire water column and the bottom sediment.
- Powerful sonar target detector, identifying not only the bottom but also objects in the water column.
- Compatibility to all existing ATLAS PARASOUND transducers.

- Upward compatibility to the functionality of all existing ATLAS PARASOUND systems.
- Significantly reduced efforts for setting-to-work and maintenance.

2 Description of the ATLAS PARASOUND

2.1 Introduction

Knowledge of the marine sediment structure and composition is a necessary prerequisite for any kind of geotechnical and/or sedimentological investigation.

Precise knowledge of sediment layers is essential in offshore technology and in hydraulic engineering, e.g. in order to investigate the load-bearing capacity of the bottom for the foundations of structures, to identify the nature of the upper layers of the bottom for pipeline laying, or to determine what type of material will be encountered during dredging works especially for the detection of buried rocks in the bottom. Most applications require ground truth verification by means of direct bottom samples. This is a time consuming job. It becomes even more difficult and expensive with increasing depth of water. Sampling *cannot* be replaced entirely by remote measurement methods, however, the number of the drilling or sampling locations can be reduced significantly if the stratigraphy of the sediments can be traced properly between drill sides.

The acoustic echo sounding principle is an obvious and for deep-sea applications the only choice for remote sediment assessments. Accordingly, highly suitable measuring devices have come into operation in the last ten years; these sub-bottom profilers feature low ultrasonic frequencies. 3 – 5 kHz has become the standard frequency range for these kinds of application.

Depending on the nature of the seabed and the depth of the water, hydro-acoustic methods achieve penetration depths of more than 200 meters.

The less dense and more water permeated the sediment layers are, the more easily they can be penetrated by acoustic signals. There are particular regions which contain hydro-acoustically quite “ideal” sediment layers, for example in the Baltic Sea off Bornholm, where good recordings can be achieved even with conventional echosounders. However, such sediments are very rare in the continental shelf areas (down to 2,000 m depth of water). Sediment layers with similar good hydro-acoustic penetration are encountered more frequently at water depths of 4,000 to 5,000 meters and beyond.

Because of the low frequencies required for any kind of significant sediment penetration, *conventional* sub-bottom profilers require massive transmitters and transducers with linear dimensions of 5 to 12 meters to achieve the necessary performance. Nevertheless, receiver side-lobes and side-echoes which arrive later than the vertical signal can severely blur the sediment recording and may ruin its horizontal and/or vertical resolution. To avoid this effect, some systems are installed in underwater towed bodies/fishes to take a closer look at the seabed. Economic and operational disadvantages are the penalty to be paid (see section 2.4.2).

With the launch of the original ATLAS PARASOUND system, the first parametric sub-bottom profiler had been introduced. The original ATLAS PARASOUND as well as the newest member of the series utilise the so-called parametric effect to generate a very low frequency secondary signal by emitting two primary signals of higher frequencies. The parametric secondary signal combines the high spatial resolution of the primary source signals for

maximum data quality with the unbeatable acoustic performance of the low frequency for maximum range and maximum bottom penetration. Due to these facts, the ATLAS PARASOUND can be installed hull-mounted, even though surpassing towed systems in bottom penetration and accuracy of measurement.

Due to the fact that the ATLAS PARASOUND is a hull-mounted system, all survey operations and maintenance activities are easy to handle and can be accomplished very rapidly.

2.2 Fields of Application

The ATLAS PARASOUND sub-bottom profilers are dedicated to the following main fields of application:

- Scientific research (geology, geophysics, biology and others)
- Investigation of sediment properties and sediment flow
- Identification of deposits to be exploited (e.g. hydrocarbons)
- Hydrographic surveying
- Investigations of the sea bottom as a basis for cable laying or the installation of offshore wind farms and oil platforms
- Detection of underwater objects (e.g. pipelines, marine mammals)
- Scientific investigations of the water column
- Pre-investigations for drilling activities and ROV/AUV missions.

2.3 Main Functions

The ATLAS PARASOUND sub-bottom profilers provide the following main functions:

- Parametric single-beam or multi-beam sub-bottom profiling
- Conventional single-beam sub-bottom profiling
- Imaging of the water column
- Feature/object detection
- Side-scan visualisation
- Bottom backscatter visualisation
- Single-beam or multi-beam echosounder operation
- Transmission of whale-warning signals.

2.4 Key Characteristics

2.4.1 The Acoustic Principle

Conventional echosounders generate pulse-modulated harmonic signals and transmit these via rectangular or circular acoustic transducer arrays into the water column. The harmonic or so-called carrier frequency together with the linear dimensions of the chosen transducer determine the physical aperture and thus the angular resolution of the system.

Deep-sea sediment investigations typically require opening angles of 4 to 8 degrees to provide sufficient resolution also for smaller bottom structures. Due to the extremely high acoustic absorption rates of sound in sediments, only lower frequencies in the range from 0.5 kHz to 6.0 kHz can be utilised efficiently for deeper bottom penetrations. Unfortunately low frequencies combined with high angular resolutions are difficult to achieve in conventional echosounder design, e.g. a conventional 3.5 kHz sediment profiler with a physical aperture of 4 degrees would unavoidably lead to an array of 7.0 by 7.0 meters, a size with major constructional difficulties.

The ATLAS PARASOUND sub-bottom profiler leaves the beaten tracks and follows a completely different working principle:

The parametric or non-linear propagation effect of sound in seawater

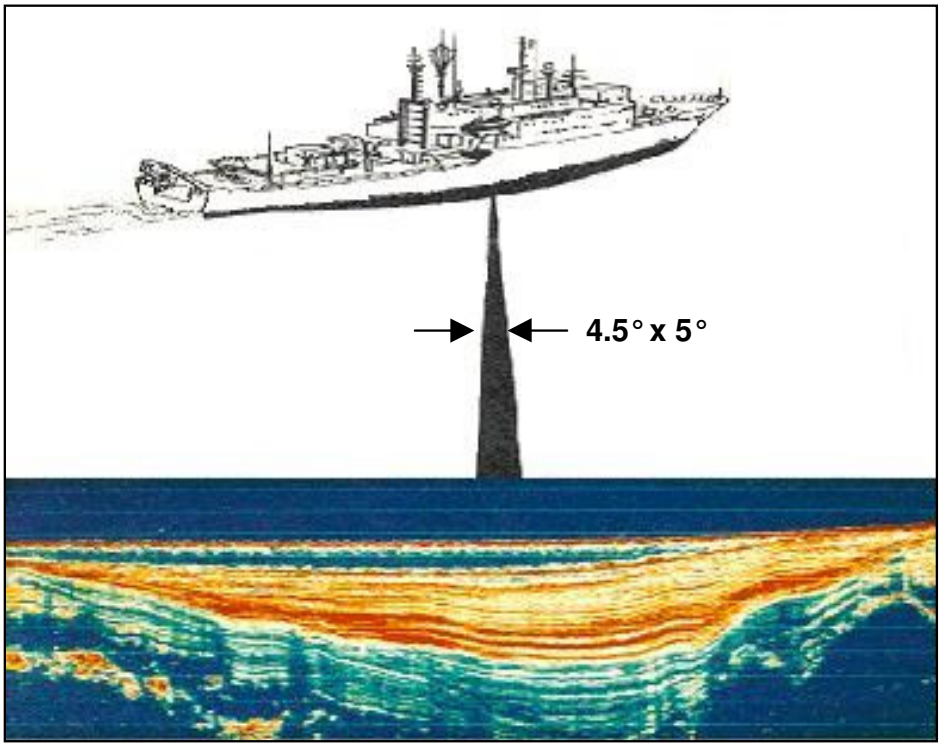


Figure 2-1: The ATLAS PARASOUND sub-bottom profiler

A parametric sub-bottom profiler simultaneously transmits two independent pulse-modulated harmonic signals via the same transducer array. To generate and utilise the parametric effect, these signals must be generated with extremely high amplitudes. At such signal levels

which are typically very close to cavitation – the physical break-up of water molecules due to the enormous acting forces in high-power sound fields – the seawater does not only serve as a propagation medium for the original signals, but also generates additional new signal components at different frequencies. The seawater in this case works as an additional transmitter / transducer. The effect, in non-technical terms, could possibly best compared to ringing effects in distorted loudspeakers.

This parametric effect offers a by far superior performance over a conventional design in various aspects, e.g.:

- High angular resolutions can be achieved with drastically reduced array sizes (see Figure 2-3, Figure 2-4 and Figure 2-5).
- Normal transducer side lobes in the beam pattern are cancelled out, providing significantly better and undistorted sediment records.
- Even in deep-sea environment, high-resolution sediment records can be achieved without the necessity for a operationally demanding and risky deep-towed sonar.

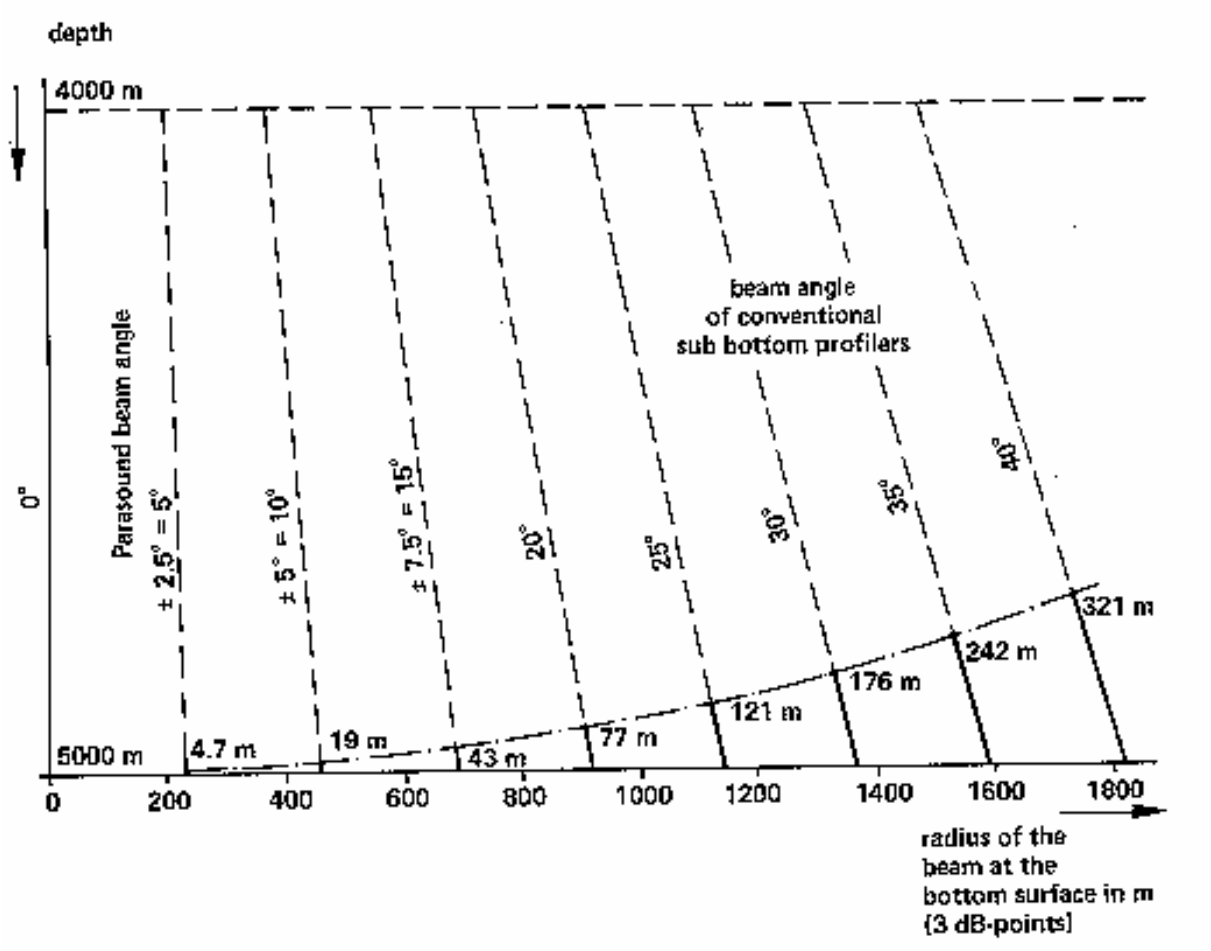


Figure 2-2: Radius of the acoustic beam projected to an assumed water depth of 5,000 meters. The difference between a conventional sub-bottom profiler with 18 degrees angular resolution (~ 1,600 meters footprint) and the ATLAS PARASOUND with 4 degrees resolution (~ 350 meters footprint) is significant. The vertical uncertainty is stretched from 4.7 m only up to more than 150 m in the worst case.

To utilise this effect efficiently in sediment investigations, the two primary frequencies of the ATLAS PARASOUND have been chosen with particular considerations to:

- Provide an optimum frequency for sediment analysis for varying environmental conditions.
- Utilise one or both of the two original frequencies for additional applications.

As primary signals, the ATLAS PARASOUND uses one adjustable signal with a frequency between 18.0 kHz and 33 kHz and a second one, adjustable between 18.5 kHz and 39 kHz. The first primary signal is simultaneously utilised to trigger the parametric effect and additionally to work as a conventional narrow-beam deep-sea echosounder to provide high-resolution bottom profiles achieving a maximum range of 11,000 meters.

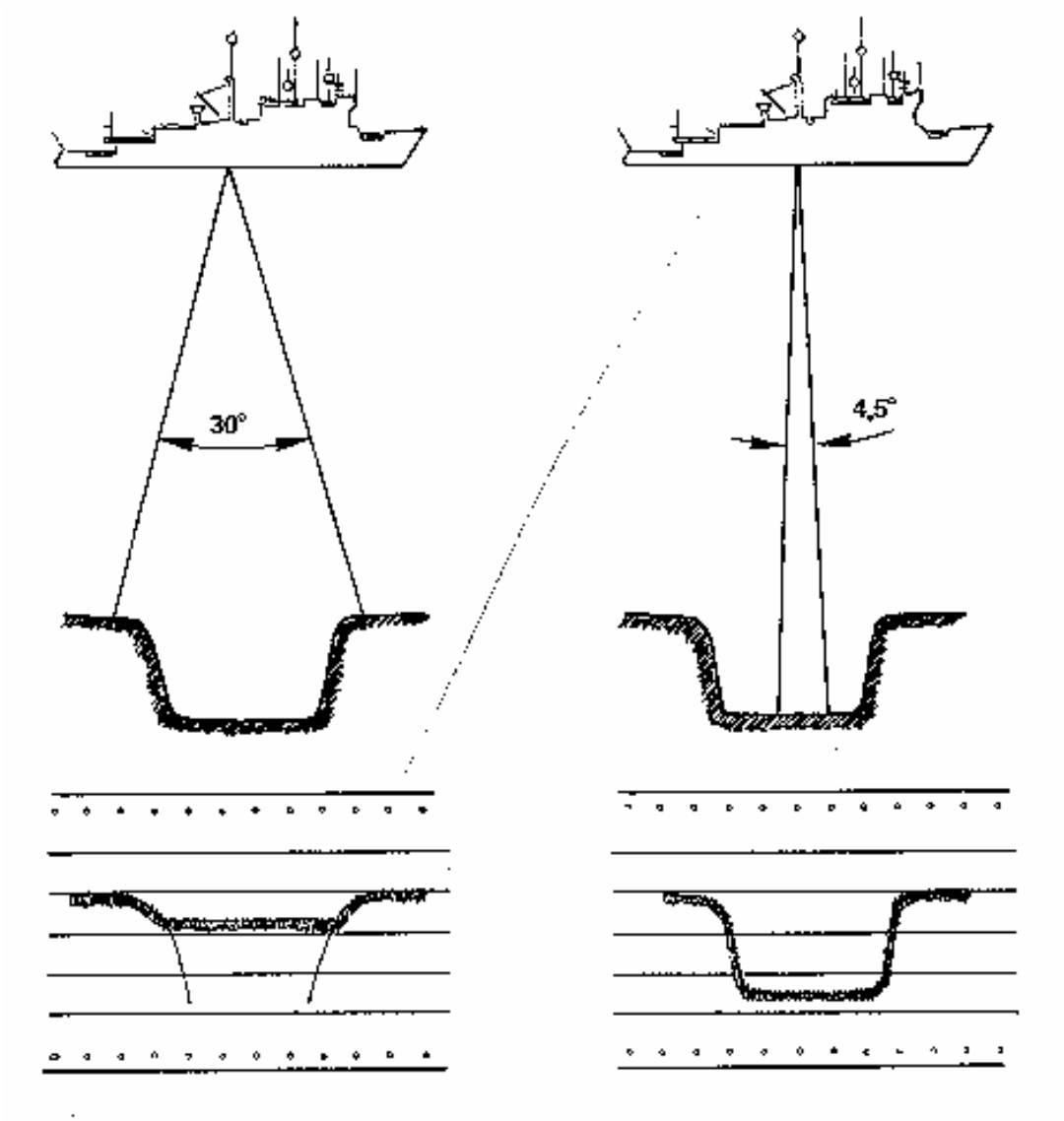


Figure 2-3: The extremely narrow-focussed beam of the ATLAS PARASOUND resolves even small-scale bottom structures. Still enough acoustic energy is available to penetrate the seafloor even at steeper slopes.

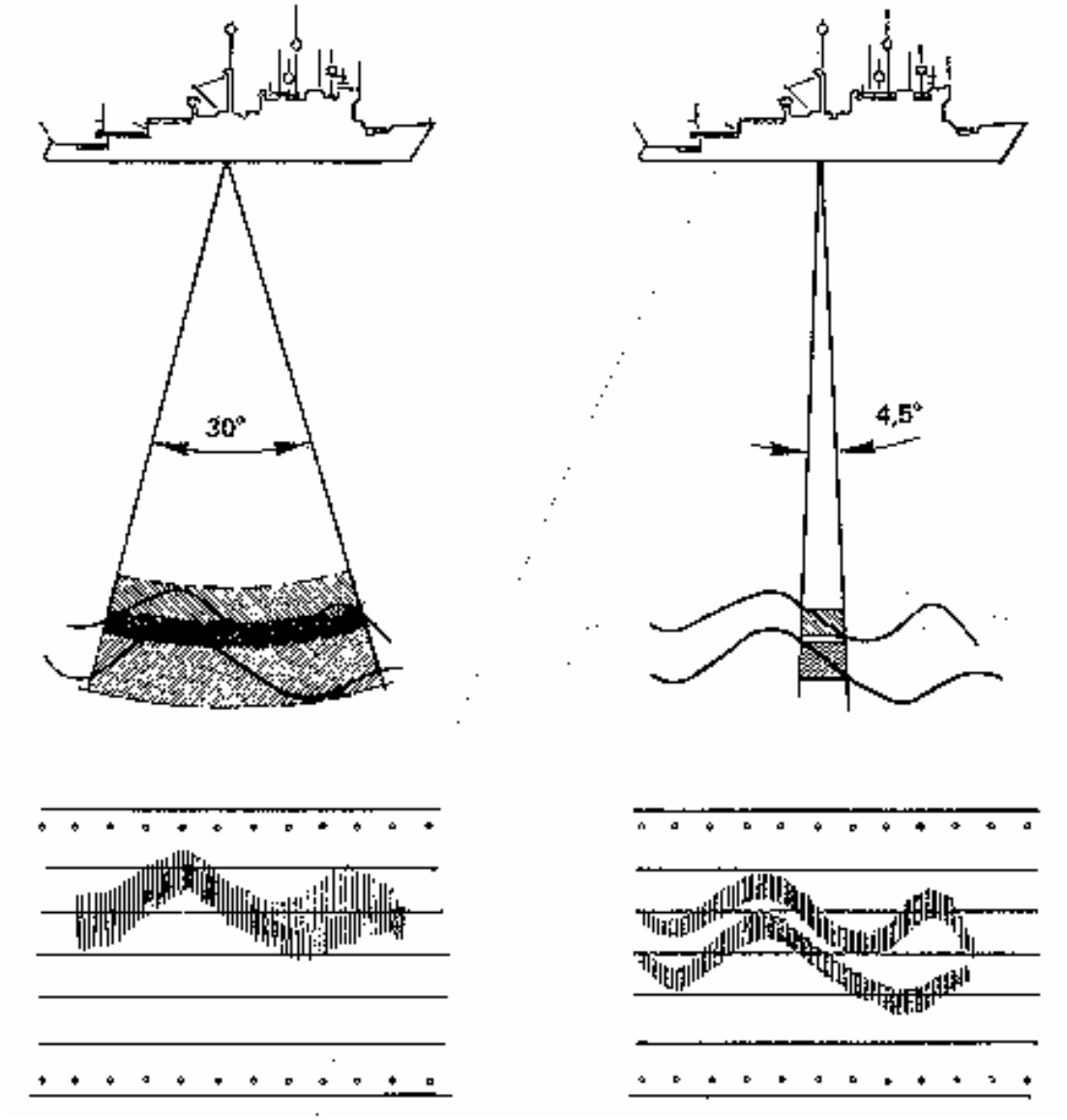


Figure 2-4: Short acoustic pulses provide the conventional means to improve the vertical resolution. However, the system beam width can significantly dominate the vertical resolution by varying the vertical uncertainty (see also Figure 2-2).

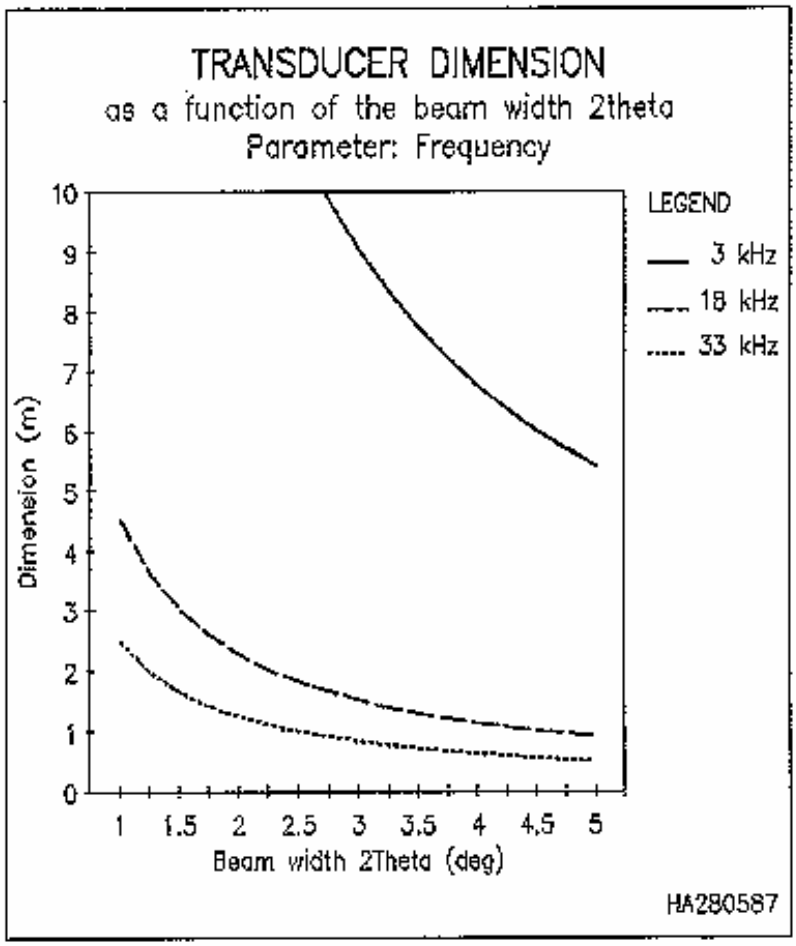


Figure 2-5: Benefit of using the parametric effect in order to generate the low frequency sediment signal. For a 4° beam width, a 18 kHz parametric sub-bottom profiler only needs a transducer size of 1.2 m as compared to 6.8 m for a conventional 3 kHz sub-bottom profiler.

With the ATLAS PARASOUND, the efficiency of the parametric method can easily be demonstrated by activating and deactivating the second primary transmit frequency. In the later case the system works as a conventional echosounder only (see Figure 4-11).

Still pending remains the question of whether the instrument reflects true sediment boundaries or merely uncorrelated acoustic interference patterns. Impressive results of a geological study by the University of Kiel / Germany however gave full evidence of a strong correlation between sediment boundaries and profiler traces received by the ATLAS PARASOUND.

2.4.2 Advantages Compared to Sub-Bottom Profilers on Towed Fishes

Compared to sub-bottom profilers installed on towed fishes, the hull-mounted ATLAS PARASOUND has the following main advantages:

1. The transmission beam angle of the ATLAS PARASOUND is much more narrow (approx. 4.5 degrees) compared to profilers installed on towed fishes (e.g. 40 degrees). This leads to measuring data of the ATLAS PARASOUND which have a significantly higher spatial resolution.

2. The ATLAS PARASOUND provides higher bottom penetration (more than 200 meters) than sub-bottom profilers installed on towed fishes.
3. The ATLAS PARASOUND can be operated at vessel speeds up to 15 knots, whereas towed fishes can be typically operated at speeds not higher than 4 – 6 knots. Due to this fact, survey missions can be accomplished much faster with the ATLAS PARASOUND – significantly reducing ship's operation costs.
4. The ATLAS PARASOUND is full ocean depth capable, i.e. applicable for water depths up to 11,000 meters. Compared to this, the operation of towed fishes is limited to much lower water depths due to the pressure-resistance of the towed fish (including the transducers) and the length of the winch cable.
5. The ATLAS PARASOUND can be operated in water areas with sheets of ice and in Polar Regions. In such regions, the application of towed fishes is considerably restricted or impossible.
6. The position accuracy of an ATLAS PARASOUND is usually higher than the position accuracy of sub-bottom profilers installed on towed fishes.
7. Compared to the reliable operation of the ATLAS PARASOUND, it happens quite often that towed fishes get damaged or get lost due to unexpected events or maloperations.
8. The ATLAS PARASOUND does not require a winch infrastructure on the vessel.
9. In order to achieve an acceptable quality of the measuring data, towed fishes have to be located near to the sea bed. This, however, requires a high-sophisticated logistics, which is not necessary for the ATLAS PARASOUND.

Due to these reasons, the hull-mounted ATLAS PARASOUND is usually the better choice compared to sub-bottom profilers installed on towed fishes.

2.4.3 Product Variants

The ATLAS PARASOUND parametric sub-bottom profilers are dedicated to deep-sea applications with very high bottom sediment penetration. They include two *main product variants*:

1. *ATLAS PARASOUND P70*
2. *ATLAS PARASOUND P35*

The ATLAS PARASOUND P70 has 70 kW maximum pulse transmission power and 128 stave channels, whereas the ATLAS PARASOUND P35 includes 35 kW maximum pulse transmission power and 64 stave channels. For the ATLAS PARASOUND P35, the lower number of channels significantly saves costs on the electronic side (reduced number of electronic channels) and on the transducer array side.

The basic performance characteristics of the ATLAS PARASOUND P35 are equivalent or better compared to 18 kHz parametric echosounder systems from competitors. Compared to this, basic performance characteristics of the ATLAS PARASOUND P70 (e.g. the sediment penetration) significantly exceed the performance of the systems currently available on the market.

The ATLAS PARASOUND P70 and the ATLAS PARASOUND P35 use different types of transducer modules (see section 2.6.1). From the electronic side, however, exactly the same components are applied within the ATLAS PARASOUND P70 and the ATLAS PARASOUND P35. Both product variants only differ in the degree of population with the standard components.

The ATLAS PARASOUND P70 includes 4 transducer modules. Beside this main product variant, also sub-variants with only 3 or 2 transducer modules are possible. These product sub-variants, however, have increased transmission beam angles and reduced depth ranges.

2.4.4 Utilised Operation Frequencies

The ATLAS PARASOUND parametric sub-bottom profiler utilises the following different operation frequencies:

Table 2-1: Operation frequencies of the ATLAS PARASOUND

Frequency Band	Value(s)	Benefits of the Frequency Band
Primary High Frequency PHF1	ATLAS PARASOUND P70: - 18 kHz … 33 kHz (adjustable) ATLAS PARASOUND P35: - 18 kHz … 21 kHz (adjustable)	• Basis for the creation of the parametric signal • Acquisition of bathymetric data
Primary High Frequency PHF2	PHF2 = PHF1 + SLF	• Basis for the creation of the parametric signal
Secondary (Parametric) Low Frequency (SLF)	500 Hz … 6 kHz (adjustable)	• Deep sediment penetration • Additional bathymetric data channel
Secondary (Parametric) High Frequency (SHF)	36.5 kHz … approx. 40 kHz	• High-resolution water column analysis
Primary Low Frequency (PLF)	Approx. 6 kHz … 10 kHz (adjustable)	• Conventional (non-parametric) sub-bottom profiling

2.4.5 Full Motion Compensation

In order to achieve best data accuracy and best sediment layer resolution, the transmission and reception beams are fully motion-compensated with respect to the roll, pitch and yaw movement of the vessel. That means:

1. The *transmission beams* (PHF and PLF) are fully *motion-stabilised* with respect to the roll, pitch and yaw movement of the vessel.

2. The *reception beams* of all different frequency bands (PHF, SLF/PLF and SHF) are fully *motion-corrected* with respect to the roll, pitch, yaw and heave movement of the vessel.

As a basis for the motion compensation, a state-of-the-art motion sensor and a heading sensor have to be connected to the ATLAS PARASOUND. Supported are motion sensors which transmit their data in the so-called ATLAS format or the Simrad EM3000 format and heading sensors which transmit their data in the NMEA format.

2.4.6 Sonar Target Detection

The ATLAS PARASOUND includes a powerful sonar target detector analysing the entire amplitude time functions of the PHF and SLF reception beams.

The ATLAS PARASOUND does *not only determine the water bottom, but also identifies sonar targets (objects) in the water column.* Adaptive bottom tracking windows are applied in order to identify which sonar targets belong to the bottom. For every identified sonar target, the target type ‘bottom’ or ‘not bottom’ is automatically provided.

Depending on the signal-to-noise ratio, a quality classifier is assigned to each sonar target. The sonar targets are transferred to the operator stations including their quality classifiers. No sonar target data are rejected.

In order to provide superior measuring quality of the bottom data, the ATLAS PARASOUND determines the water bottom not beam-wise, but instead by a simultaneous processing of several pings and, if available, multiple beam directions within each of these pings. Compared to a classical beam-wise bottom detection, the influence of noise is significantly reduced.

2.4.7 Marine Mammal Protection

In the recent past, various reports of whale strandings presumably caused by high energy seismological surveys and very high energy military sonar activities have been published.

Due to the fact that high transmission source levels may hurt whales and other marine animals, the German Environmental Agency has significantly restricted the use of hydro-acoustic equipment in the Antarctic region for German vessels. Also the environmental agencies of other countries start to discuss restrictions of hydro-acoustic equipment in certain areas.

ATLAS Hydrographic is dedicated to nature conservation and in particular marine mammal protection. We responsibly develop instruments in such a way that any possibility of compromising nature or even injuring animals is avoided in the first place.

Therefore, the ATLAS PARASOUND provides the following features dedicated to marine life protection:

1. *Automatic Transmission Source Level Control (ASLC):*

   In order to minimise the acoustic impact on the marine environment, ASLC automatically adjusts the transmission source level to the minimum level which is necessary for fulfilling the specific surveying task. This is done on the basis of user-defined settings of a desired bottom penetration or a desired signal-to-noise ratio, a user-defined maximum transmission source level and the most recently measured data (see section 2.11.2.4).

2. *Whale Warning Mode (WWM):*

   In the Whale Warning Mode, the ATLAS PARASOUND emits a user-defined sequence of acoustic signals to scare away marine mammals before normal survey operation is started (see section 2.8.6).

3. *Reduced Transmission Source Levels Due to Chirped and Barker Coded Pulses:*

   For frequency-modulated (chirped) pulses and Barker-coded pulses, the transmission source level and by this the acoustical impact on the marine environment can be reduced, compared to continuous wave (CW) pulses (see section 0).

4. *Automatic Transmission Termination (ATT):*

   The ATLAS PARASOUND has a selectable functionality for an instantaneous automatic termination of the transmission in order to protect marine mammals (see section 2.12.8).

5. *Conventional Sub-Bottom Profiling:*

   To generate the parametric effect, a certain acoustic source level is required. In source level restricted areas, the user has the option of reverting to conventional sub-bottom profiling to meet the restriction and still be able to continue survey operations (see section 2.8.3).

2.4.8 Data Telegrams

The bathymetric data measured by the ATLAS PARASOUND are transmitted to the operator PCs via network telegrams.

2.4.9 ATLAS Sounding Data Files (ASD Files)

Sounding profiles of the sediment layers and the water column as well as side-scan data acquired by the ATLAS PARASOUND usually include big data volumes. Therefore, these data are not transmitted to the operator PCs via network telegrams, but are stored instead on a hard disk within the transceiver electronics of the ATLAS PARASOUND in the so-called ASD raw data file format (ASD = ATLAS Sounding Data):

- ASD is a hybrid file format for the storage of complete sounding profiles. It contains an XML-formatted ASCII header and an XDR-formatted binary section containing the sounding data. ASD raw data files are recognisable by the file extension ".asd". The ASD format specification (see ref. /1/) is public and can be used by third-party software suppliers for interfacing purposes.

Via the ATLAS software component ASD File Service which works on ftp basis and runs on the operator PC, the ASD Files are copied from the hard disk of the ATLAS PARASOUND transceiver electronics to the operator PC for online data visualisation, processing and archiving.

There exist two types of ASD Files, i.e. *"Profile ASD Files" and "Side-Scan ASD Files".* Both types of ASD Files are compliant with the general ASD format specification and contain, among other things, the following ancillary information:

- All relevant operation parameters and system parameters of the ATLAS PARASOUND.
- Motion data, heading data, position data, C-mean data, C-keel data and center depths, if available (complete C-profiles are not stored within the ASD Files).

- All identified sonar targets, i.e. bottom targets (bathymetric data) and targets in the water column.
- Bottom backscatter amplitudes (one amplitude value for each bottom target).

When the user has selected the data recording option “no profile” (see section 2.9.2), then the Profile ASD Files contain only the above-mentioned ancillary information which, among other things, includes the bathymetric data.

Both types of ASD Files comprise all measuring data and all ancillary information which is necessary for data visualisation, online data processing and offline data processing.

For easy data handling, the measuring data are put into ASD Files with an adjustable size, each of which contains a set of complete soundings, i.e. the data of one sounding are not divided into different ASD Files. One ASD File includes as a minimum 2 seconds of data; for profiles longer than 2 seconds, one ASD File includes exactly one complete profile. The file names are generated automatically and contain – among other things – the date and time of file creation.

In order to reduce the number of ASD Files stored on the operator PCs, after the ftp transfer to an operator PC several ASD Files are packed together into so-called *“ASD Cabinet Files”.* These files have the extension “.acf”.

2.4.10 Frequency-Modulated (Chirped) Pulses and Barker Coded Pulses

The ATLAS PARASOUND provides the possibility to transmit not only continuous wave (CW) pulses, but also frequency-modulated (“chirped”) pulses and Barker coded pulses. Compared to CW pulses of the same pulse length, chirped pulses and Barker coded pulses have broader signal spectra which look similar to a so-called white noise signal spectrum. Due to this feature, chirped pulses and Barker coded pulses can be “compressed” during the reception signal processing leading to virtually shorter pulses and an improved accuracy of measurement. This leads to the following advantages:

1. For a fixed source level and a fixed pulse length, chirped pulses and Barker coded pulses lead to a higher accuracy of measurement.
2. For a fixed source level and a fixed accuracy of measurement, chirped pulses and Barker coded pulses lead to a higher depth range and an improved bottom penetration.
3. For a fixed accuracy of measurement and a fixed depth range or fixed bottom penetration, chirped pulses and Barker coded pulses require less transmission source level. This is an essential contribution to the protection of marine mammals.

2.4.11 Double Digitising of the PHF Reception Signals

For special scientific investigations it can be of interest to identify gas bubbles nearly above the sea bottom. The dynamic range of the reception signals created by such air bubbles and the bottom, however, is very high. This dynamic range cannot be compensated by a time variable gain (TVG). Even 24 bit A/D converters are not able to handle these dynamic range requirements.

Therefore, in order to increase the dynamic range of the A/D conversion, the ATLAS PARASOUND includes a complex technology called “Double Digitising”:

- On the analog signal reception circuitry, i.e. on the preamplifiers, each PHF reception channel is split into a lowly amplified PHF reception signal path (“PHF low path”) and a highly amplified PHF signal reception path (“PHF high path”). Both paths differ by an amplification of more than 40 dB, depending on the selected receiver gains. The PHF low paths and the PHF high paths are digitised independently via 24 bit A/D converters. On the digital side, for each PHF reception channel the corresponding PHF low signals and the PHF high signals are merged together. The merging is based upon a decision mechanism which chooses at each time instance the PHF high signal or the PHF low signal, depending on the relative magnitude of these signals. The resulting digital PHF signal has a resolution of 32 bits.

Due to the Double Digitising feature, for 128 PHF reception channels the remarkably high number of 256 A/D converters with a resolution of 24 bit is utilised.

2.4.12 Baseband Shift and Decimation of the Reception Signals

The ATLAS PARASOUND converts the analog reception data of all frequency bands (PHF, SLF/PLF and SHF) with a sample rate of approx. 98 kHz into digital data. Afterwards, these real-valued data are shifted to baseband. The result are complex measuring data which do not contain the carrier frequency any more. That means: In the frequency domain, the spectrum of these data is grouped around zero and not around the carrier frequency any more. The spectral characteristics of the transformed data are only influenced by the characteristics of the pulse, but not any more by the carrier frequency. The shift to baseband does not result in any loss of signal information. The phase information of the original carrier signal is contained in the complex data. The phase can be calculated in principle by the aid of the function arc tangent, applied to the ratio of the real part and the imaginary part.

The initial sample rate of approx. 98 kHz refers to the original measuring data. Therefore, this sample rate takes into account the carrier frequency and the pulse characteristics. After the baseband shift, i.e. after the elimination of the carrier frequency, however, this original sample rate results in an oversampling of the measuring data with respect to the pulse characteristics. Therefore, the baseband shifted measuring data is decimated in several stages and adapted to the bandwidth of the pulse. Each decimation stage includes a zero-phase low-pass filtering in order to avoid aliasing and a reduction of the sample rate by the factor 1/2. The resulting sample rate of the decimated baseband shifted measuring data is called *output sample rate*.

The number of decimation stages is user selectable from 3 to 7 stages, independently for the different frequency bands PHF, SHF and SLF/PLF. By varying the number of decimation stages, the output sample rate can be set to 12.2 kHz, 6.1 kHz, 3.0 kHz, 1.5 kHz or 750 Hz.

In order to further suppress noise, within the ATLAS PARASOUND sensor a digital low-pass filter is applied on the decimated measuring data prior to beamforming. The cut-off frequency of this low-pass filter defines the resulting bandwidth of the reception signals. The receiver bandwidth is specified as a percentage of the output sample rate. The user-selectable settings are 66%, 33% or 16% of the output sample rate (see section 2.12.3).

Table 2-2: Output sample rates, decimation stages and receiver bandwidths

Output Sample Rate:	12.2 kHz	6.1 kHz	3.0 kHz	1.5 kHz	750 Hz
Decimation Stages:	3	4	5	6	7
Cut-Off Frequency of the Low-Pass Filter	**Receiver Bandwidth**				
66 % of Output Sample Rate	8.1 kHz	4.0 kHz	2.0 kHz	1.0 kHz	500 Hz
33 % of Output Sample Rate	4.0 kHz	2.0 kHz	1.0 kHz	500 Hz	250 Hz
16 % of Output Sample Rate	2.0 kHz	1.0 kHz	500 Hz	250 Hz	120 Hz

The appropriate receiver bandwidth and thus an appropriate output sample rate depend upon the selected pulse characteristics (see section 2.11.4). Frequency-modulated and Barker coded pulses require more bandwidth compared to continuous wave (CW) pulses of the same pulse length. An appropriately selected receiver bandwidth is essential in order not to have an irreversible loss of signal information. The ATLAS PARASOUND provides an automatic mode in which the output sample rate and the receiver bandwidth are determined automatically. This is the standard mode in order to avoid that the user corrupts the measuring data by incorrect settings.

The reception signal processing implemented within the ATLAS PARASOUND is different from the signal processing applied in the previous ATLAS PARASOUND system version. In the previous version, the analog beamformed reception data are digitised with a sample rate of 50 kHz. Afterwards, these digital data are not processed within the transceiver electronics, i.e. these data still contain the carrier frequency and are therefore oversampled with respect to the pulse characteristics. The current ATLAS PARASOUND avoids this oversampling, reduces the influence of noise and better extracts the received pulse characteristics and the phase information.

2.4.13 Creation of Side-Scan Data

The side-scan data of the ATLAS PARASOUND are created out of the beamformed complex time functions within all individual hard beams. The sample rate of the side-scan data is the output sample rate of the decimated data. At each time instance, the side-scan value is taken out of that hard beam, in which the bottom is mainly visible.

The side-scan data are stored in the Side-Scan ASD Files (see section 2.4.9). In these files, for all side-scan data it is indicated out of which hard beam they have been taken. This information is of interest for seabed classification software packages which are based upon the side-scan data.

2.5 Configuration of an ATLAS PARASOUND System

2.5.1 ATLAS Integrated Survey Sensor System (ATLAS IS^3)

The ATLAS Integrated Survey Sensor System (ATLAS IS^3) is a modular "from-sonar-to-chart" system, designed for customer-specific survey requirements. ATLAS IS^3 includes a defined set of echosounders and sensors as well as matched software and service components. ATLAS IS^3 is scalable from very small system configurations up to large system configurations consisting of several echosounders.

The ATLAS PARASOUND P70 and P35 parametric sub-bottom profilers are parts of the ATLAS IS^3.

An ATLAS IS^3 including an ATLAS PARASOUND consists of the following main segments:

1. ATLAS PARASOUND transducer array (see section 2.6):
2. ATLAS PARASOUND transceiver electronics (see section 2.7)
3. One or two Master Control PC(s) including an appropriate combination of the following software applications:
   - ATLAS HYDROMAP CONTROL for the control of the ATLAS PARASOUND.
   - ATLAS PARASTORE for the acquisition, visualisation, processing, storage, conversion, quality control, replay and printing of data from the ATLAS PARASOUND.
   - ATLAS HPS (Hydrographic Processing Suite) for the control of the ATLAS PARASOUND and the acquisition, visualisation and processing of ATLAS PARASOUND data.
4. One or more optional Data Acquisition PCs.
5. One or more optional Post-Processing PCs with customer specific software.
6. Several external sensors like a motion sensor, heading sensor, position sensor, C-keel sensor and SVP sensor.
7. Interfacing components like the ATLAS DIP and the ATLAS SENSOR MANAGER.

For scientific users (".edu users") with their specific needs for very flexible data visualisation and analysis, it is recommended to operate the ATLAS PARASOUND via a combination of ATLAS HYDROMAP CONTROL and ATLAS PARASTORE. Users out of the commercial surveying business (".com users") will normally operate the ATLAS PARASOUND solely with the ATLAS HPS. For governmental organisations (".gov users"), the appropriate software configuration depends on their specific tasks and needs.

Figure 2-6 shows a possible configuration of an ATLAS IS^3 including an ATLAS PARASOUND, operated with ATLAS PARASTORE and the echosounder control software ATLAS HYDROMAP CONTROL. The configuration of an ATLAS PARASOUND system, operated with ATLAS PARASTORE and/or the ATLAS HPS looks similar.

The different segments and components of an ATLAS IS^3 including an ATLAS PARASOUND are described in the following sections.

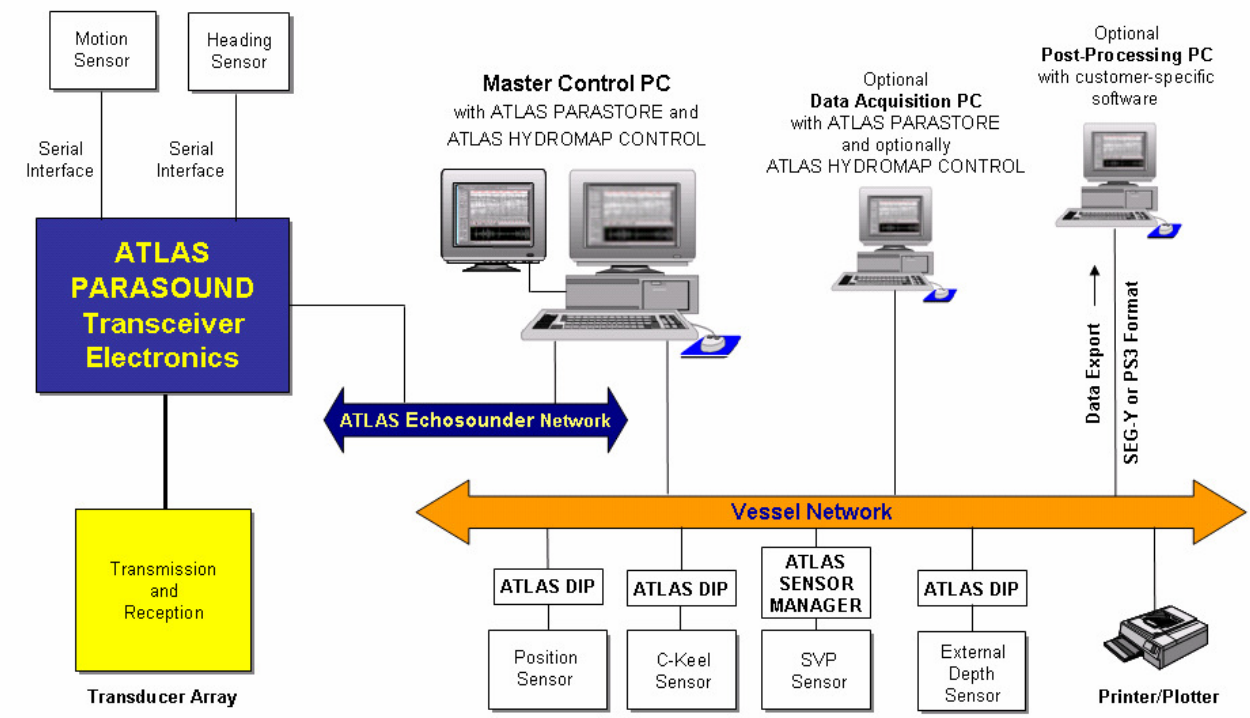


Figure 2-6: Possible ATLAS IS[3] configuration including an ATLAS PARASOUND

2.5.2 ATLAS HYDROMAP CONTROL

ATLAS HYDROMAP CONTROL (see ref. /2/) is a software product for the operational control of echosounders. It includes a SQL database and is capable of multi-user operation: It is possible to run several instances of ATLAS HYDROMAP CONTROL on separate PCs with respect to the same echosounder to be controlled. This feature is helpful for echosounder remote control or when it shall be possible to control an echosounder from different places on a ship.

Superior quality control of measuring data acquisition is of fundamental importance due to high ship's operation costs and consequential costs caused by incorrect data. Therefore, ATLAS HYDROMAP CONTROL comprises, among others, the following quality control functionality:

- Storage of complete parameter sets for echosounder control.
- Logging of all user transactions and system messages.
- Configurable automatic alarm generation.
- User administration for protection against unauthorised access.

2.5.3 ATLAS HPS – Hydrographic Processing Suite

The ATLAS HPS (see ref. /3/) is a most modern and very powerful software product for the acquisition, storage, visualisation, processing and export of data from multi-beam echosounders and single-beam echosounders. It includes navigation planning, 3-D visualisation and storage of the measuring data in a database.

2.5.4 ATLAS PARASTORE

ATLAS PARASTORE (see ref. /4/) is a highly sophisticated data acquisition software for sediment profiles and water column profiles, measured by ATLAS PARASOUND and ATLAS HYDROSWEEP echosounders. ATLAS PARASTORE includes the acquisition, visualisation, processing, storage, conversion, quality control, replay and print of profile data. It has been developed in close partnership with the University of Bremen for demanding scientific analyses. The software allows differentiated investigations on sub-bottom and water column details with its multi-window graphical user interface.

ATLAS PARASTORE can be run several times in parallel on different operator PCs. Thus, redundant data recording for independent applications can be made available very easily upon request.

2.5.5 Master Control PCs

The ATLAS PARASOUND is controlled by so-called Master Control PCs which are connected to the ATLAS PARASOUND via a “private” Gigabit ATLAS echosounder network. “Private” means that this network connection is exclusively dedicated to the control of the ATLAS PARASOUND by the Master Control PCs.

The Master Control PCs are also linked to the public vessel network. Thus, it is on the one hand possible to access measuring data from the ATLAS PARASOUND on optional Data Acquisition PCs and Post-Processing PCs which are connected anyplace to the vessel network. Via this link, on the other hand the ATLAS PARASOUND receives the data from external sensors.

The separation of the ATLAS echosounder network from the vessel network has the following advantages:

- The performance of the ATLAS PARASOUND is independent from the data traffic on the vessel network.
- The performance of the ATLAS PARASOUND is independent from the number of operator PCs which access the ASD files created by the ATLAS PARASOUND.
- The ATLAS PARASOUND is protected against viruses which may occur on the vessel network.

2.5.6 Optional Data Acquisition PCs

Optional data acquisition PCs can be connected anywhere to the vessel network. On these PCs, specific online information like water column data can be visualised. These PCs can also be used for remote control of the ATLAS PARASOUND.

2.5.7 Optional Post-Processing PCs

Optional post-processing PCs can also be connected anywhere to the vessel network. On these PCs, customer-specific post-processing software can be installed.

2.5.8 ATLAS DIP

The position sensor, the C-keel sensor (C = water sound velocity) and an optional external depth sensor are connected via so-called ATLAS DIP nodes to the vessel network. DIP stands for “Distributed Interface Processor”. A DIP node is an interface converter which transforms the serial interface of an external sensor into an appropriate data structure which can be accessed via the vessel network.

2.5.9 ATLAS SENSOR MANAGER

The SVP sensor (SVP = sound velocity profile) is connected to the vessel network via the so-called ATLAS SENSOR MANAGER. From the view of the vessel network, the ATLAS SENSOR MANAGER behaves like an ATLAS DIP. However, unlike the ATLAS DIP, the ATLAS SENSOR MANAGER is not connected to a serial sensor interface of the SVP sensor, but accesses ASCII files with sound velocity profiles which have been measured and generated by the SVP sensor.

Usually, a SVP sensor is delivered together with an associated SVP data acquisition software which generates the ASCII files containing the sound velocity profiles. Typically, the SVP data acquisition software and the ATLAS SENSOR MANAGER are installed on the same PC which is dedicated to SVP data acquisition.

2.5.10 Connection of the Motion Sensor and the Heading Sensor

The motion sensor and the heading sensor are connected directly to the transceiver electronics because the motion and heading data have to be available in real-time for the data processing inside the sonar. The transceiver electronics transfers these data to the ATLAS echosounder network via telegrams.

2.5.11 Time Synchronisation

The different components of an ATLAS PARASOUND system are time-synchronised via the well-proven Network Time Protocol (NTP). The following components are included in the NTP time synchronisation:

- ATLAS PARASOUND transceiver electronics.
- The different ATLAS DIP nodes.
- The ATLAS SENSOR MANAGER
- The Master Control PCs.
- The optional Data Acquisition PCs.
- The optional Post-Processing PCs.

2.6 Transducer Array

2.6.1 Transducer Array of the ATLAS PARASOUND P70

The ATLAS PARASOUND P70 applies high-performance transducer modules which are extremely reliable and well-proven over 20 years.

The hydro-acoustic transducer array of the ATLAS PARASOUND P70 is flat, has a rectangular shape with a size of approx. 1 meter x 1.2 meter and consists of four identical transducer modules (type “classic”). The transducer modules are precisely joined to one another by means of a “saw-tooth joint”.

The major reason for the sub-division of the transducer array into four modules (sub-arrays) is to provide a modular installation scheme for optimised customer installations. This takes into account the desired operation range and sediment penetration and the size of the vessel. Furthermore, individual array modules can be replaced in case of mechanical damages, e.g. vessel groundings.

Each transducer module of the ATLAS PARASOUND P70 has a size of approx. 0.3 meter x 1 meter and includes 96 hydro-acoustic elements wired together in triples, i.e. each transducer module has 32 stave channels, resulting in 128 stave channels for the full transducer array.

The 128 staves are organised in a matrix with 8 rows in the along-ship direction and 16 columns in the across-ship direction. Due to this matrix structure, the transmission and reception beams can be steered arbitrarily within the specified beam steering range (see chapter 3).

2.6.2 Transducer Array of the ATLAS PARASOUND P35

The hydro-acoustic transducer array of the ATLAS PARASOUND P35 is flat, has an octagonal shape with a size of approx. 1.2 meter x 1.2 meter and consists of two identical transducer modules (type “basic”).

Each transducer module of the ATLAS PARASOUND P35 includes 96 hydro-acoustic elements wired together in triples, i.e. each transducer module has 32 stave channels, resulting in 64 stave channels for the full transducer array.

The 64 staves of a full transducer array are organised in a kind of “stochastic” structure by which narrow beam widths and low side lobes are achieved.

The full transducer array of the ATLAS PARASOUND P35 has half the number of hydro-acoustic elements compared to the full transducer array of the ATLAS PARASOUND P70. Therefore, the maximum output power of the ATLAS PARASOUND P35 is 35 kW, compared to 70 kW of the ATLAS PARASOUND P70.

2.7 Transceiver Electronics

2.7.1 Overview

As shown in Figure 2-7, the ATLAS PARASOUND transceiver electronics consists of three hardware segments:

- Analog Electronic Unit (AEU)
- Digital Electronic Unit (DEU)
- Interconnection Unit (ICU).

The Analog Electronic Unit (AEU) and the Digital Electronic Unit (DEU) are connected via optical data links which are located in the Interconnection Unit (ICU). The transducer cables are fed into the ICU from above. The external data cables and the power cable are connected to the ICU from the bottom side.

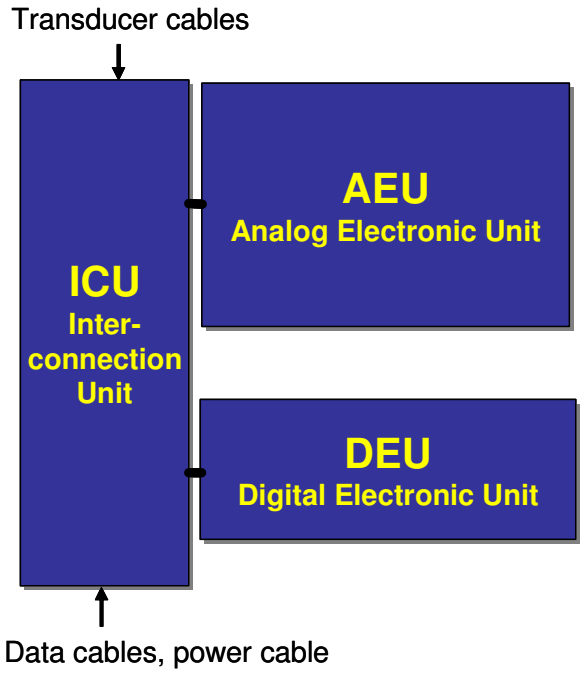


Figure 2-7: Hardware segments of the ATLAS PARASOUND transceiver electronics



Figure 2-8: Opened ATLAS PARASOUND P70 transceiver electronics

2.7.2 Analog Electronic Unit (AEU)

A fully populated Analog Electronic Unit (AEU) contains *two identical module racks* each of which includes the following components:

- 4 Transmitter Blocks each of which comprises two Transmitter Boards and one Transmission Beamformer Board.
- 4 Preamplifier Boards.
- 2 Digitiser Modules for the A/D conversion of the preamplified reception signals; each Digitiser Module includes eighty 24 bit Analog/Digital Converters.
- 2 Transceiver Backplanes, each of which is responsible for the interconnection of 2 Transmitter Blocks, 2 Preamplifier Boards, 1 Digitiser Module, 1 Capacitor Module and 1 ATLAS PARASOUND transducer module.
- 2 Capacitor Modules for the stabilisation of the power supply voltage of the Transmitter Boards.



Figure 2-9: Opened front side of an ATLAS PARASOUND P70 AEU with 8 Transmitter Blocks and 4 Digitiser Modules

Additionally to the module racks, a fully populated Analog Electronic Unit includes two Low-Voltage Power Supply Boards (LVPS) converting 48 VDC into the target voltages 12 VDC, 5 VDC, 3.3 VDC etc. via DC/DC converters.

The ATLAS PARASOUND P70 requires a fully populated AEU with two module racks, whereas the ATLAS PARASOUND P35 requires only one module rack. Figure 2-9 shows the opened front side of an ATLAS PARASOUND P70 AEU.



Figure 2-10: Component structure of the front side of an ATLAS PARASOUND P70 AEU

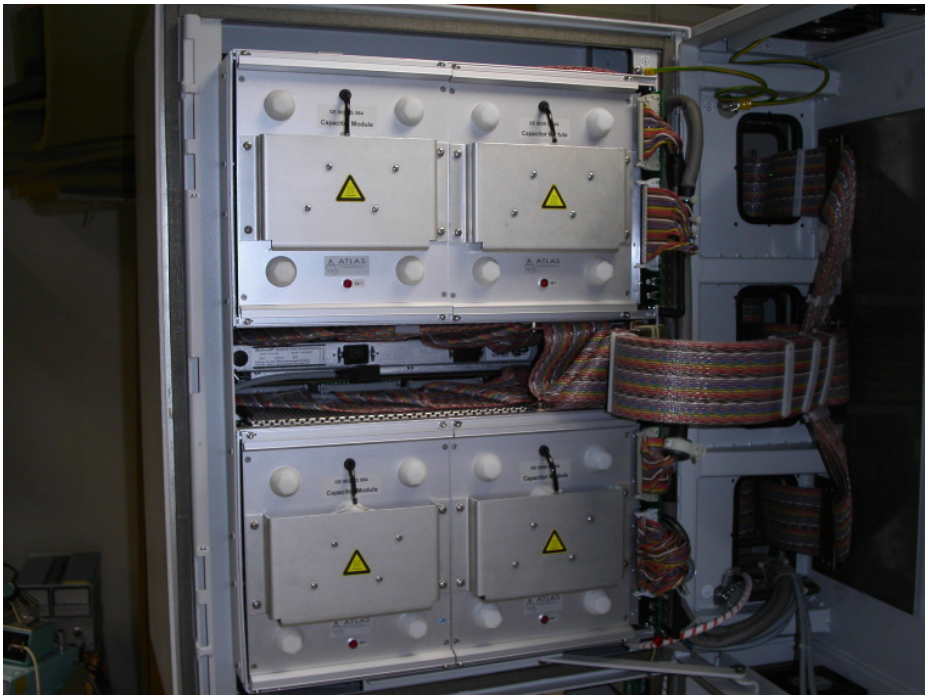


Figure 2-11: Opened back side of an ATLAS PARASOUND P70 AEU with 4 Capacitor Modules

2.7.3 Digital Electronic Unit (DEU)

The Digital Electronic Unit (DEU) includes the following components:

- Control Module (CM) for the internal control of the entire echosounder and the intermediate storage of the ASD files.
- Signal Processing Module (SPM) for the processing of the digital (A/D converted) reception signals.
- High-Voltage Power Module (HVPM) for the Transmitter Boards inside the AEU.
- Low-Voltage Power Supply Module converting 230 VAC into 48 VDC.
- Digital Power Supplies for the Control Module and the Signal Processing Module.
- AC Module (ACM) including fuses, two varistors, a relay, switches and control lamps.
- Mains Filter Module (MFM).

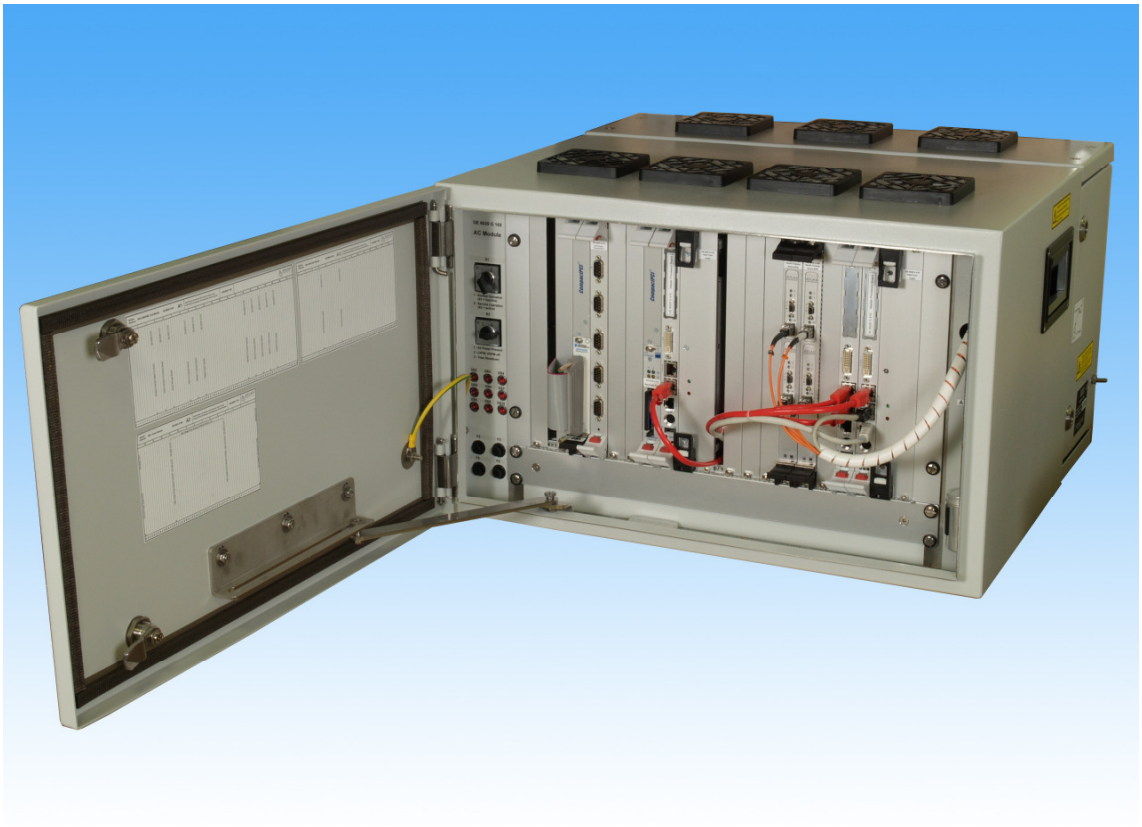


Figure 2-12: Opened front side of the Digital Electronic Unit (DEU)

2.7.4 Interconnection Unit (ICU)

The Interconnection Unit (ICU) fulfils the following purposes:

- Mechanical connection and matching of the cables from the transducer modules.
- General cable routing (serial interfaces, mains, optical data link, LAN interface).

The Interconnection Unit contains the following components:

- Transducer Adaption Boards (TABs).
- System Interface Modules.
- Power Supply for the System Interface Modules.
- LAN Switch.

There exist two variants of the ICU, i.e. an ICU with a width of 500 mm and an ICU with a width of 400 mm.

Normally, the 500 mm ICU is applied for all ATLAS PARASOUND systems. However, if there are space limitations on a vessel, the ATLAS PARASOUND P35 can alternatively be equipped with the 400 mm ICU.

2.7.5 Common Components

The ATLAS PARASOUND parametric sub-bottom profilers include several components which are common to the entire ATLAS HYDROSWEEP multi-beam echosounder product family (see references /5/, /6/ and /7/).

These common components *can be interchanged between the different ATLAS PARASOUND and ATLAS HYDROSWEEP products*. Among others, the common components include:

- Transmission Beamformer Board (TBF)
- Capacitor Module
- Digitiser Module
- All boards of the Control Module (CM)
- High-Voltage Power Module (HVPM)
- Low-Voltage Power Module (LVPM)
- Low-Voltage Power Supply Board (LVPS)
- Digital Power Supply for the Control Module and Signal Processing Module
- Remote Power Switch (RPS)
- AC Module (ACM)
- Mains Filter Module (MFM)
- Interconnection Board (ICB)
- Special Interface Pool (SIP) Board
- LAN Switch
- System Interface Modules
- Power Supply for the System Interface Modules.

2.8 Basic Operation Modes

The ATLAS PARASOUND provides six exclusive *Basic Operation Modes* which are selectable by loading an appropriate sensor control data set within the software application ATLAS HYDROMAP CONTROL (see ref /2/):

1. *P-SBP/SBES Operation Mode:* Parametric sub-bottom profiling and single-beam echosounder operation.
2. *P-SBP/MBES Operation Mode:* Across-ship parametric sub-bottom profiling and multi-beam echosounder operation.
3. *C-SBP/SBES Operation Mode:* Conventional sub-bottom profiling and single-beam echosounder operation.
4. *SBES Operation Mode:* Single-beam echosounder operation.
5. *Area MBES Operation Mode*: Area-related (i.e. along-ship and across-ship) multi-beam echosounder operation.

6. *Whale Warning Mode (WWM)*.

The functionality of these Basic Operation Modes is described in the following sections. The Basic Operation Modes 1 – 5 are configurable by the user with respect to different kinds of settings:

- Operation settings (see section 2.9)
- Sounder environment settings (see section 2.10)
- Basic settings (see section 2.11)
- Advanced settings (see section 2.12).

All these configuration possibilities can be combined in an arbitrary manner, as far as reasonable. They provide the user with a big variety of operating options for the ATLAS PARASOUND.

However, in spite of this variety of configuration potentials, the handling of the ATLAS PARASOUND is very easy due to the fact that all settings have reasonable default values and predefined parameter sets can be applied via ATLAS HYDROMAP CONTROL.

2.8.1 P-SBP/SBES Operation Mode

The parametric sub-bottom profiling and single-beam echosounder operation mode (P-SBP/SBES Operation Mode) provides the following main functionality:

- Single-beam sub-bottom profiling and water column profiling, based upon the following signals:
  - Secondary (Parametric) Low Frequency signal (SLF signal)
  - Primary High Frequency signal (PHF signal)
- Single-beam water column profiling, based upon the Secondary (Parametric) High Frequency signal (SHF signal).
- Single-beam bottom detection and sonar target detection in the water column, based upon the following signals:
  - Primary High Frequency (PHF) signal.
  - Secondary (Parametric) Low Frequency signal (SLF signal)
  - Secondary (Parametric) High Frequency signal (SHF signal).

2.8.2 P-SBP/MBES Operation Mode

The across-ship parametric sub-bottom profiling and multi-beam echosounder operation mode (P-SBP/MBES Operation Mode) alleviates the searching for objects on the bottom or in the water column; it provides the following main functionality:

- Across-ship multi-beam sub-bottom profiling and water column profiling, based upon the following signals:
  - Secondary (Parametric) Low Frequency signal (SLF signal)
  - Primary High Frequency signal (PHF signal)
- Across-ship multi-beam water column profiling, based upon the Secondary (Parametric) High Frequency signal (SHF signal).

- Across-ship multi-beam bottom detection and sonar target detection in the water column, based upon the following signals:
  - Primary High Frequency signal (PHF signal).
  - Secondary (Parametric) Low Frequency signal (SLF signal)
  - Secondary (Parametric) High Frequency signal (SHF signal).

2.8.3 C-SBP/SBES Operation Mode

The conventional sub-bottom profiling and single-beam echosounder operation mode (C-SBP/SBES Operation Mode) allows an operation of the ATLAS PARASOUND with significantly lower transmission source levels compared to the parametric operation. In cases when a parametric operation is forbidden in order to protect marine mammals, the ATLAS PARASOUND may be operated in the C-SBP/SBES Operation Mode. However, in this mode the spatial resolution and the bottom penetration are reduced compared to the P-SBP/SBES Operation Mode. The C-SBP/SBES Operation Mode provides the following main functionality:

- Single-beam sub-bottom profiling and water column profiling, based upon the following signals:
  - Primary Low Frequency signal (PLF signal).
  - Primary High Frequency signal (PHF signal).
- Single-beam bottom detection and sonar target detection in the water column, based upon the Primary High Frequency (PHF) signal.

2.8.4 SBES Operation Mode

The single-beam echosounder operation mode (SBES Operation Mode) provides the following main functionality:

- Single-beam sub-bottom profiling and water column profiling, based upon the Primary High Frequency (PHF) signal.
- Single-beam bottom detection and sonar target detection in the water column, based upon the Primary High Frequency (PHF) signal.

2.8.5 Area MBES Operation Mode

The area-related multi-beam echosounder operation mode (Area MBES Operation Mode) provides the bottom topography around the vessel's position in the along-ship direction and the across-ship direction. This is, for example, relevant as a basis for the automatic Incidence Angle Control (IAC). The Area MBES Operation Mode provides the following main functionality:

- Across-ship and along-ship multi-beam sub-bottom profiling and water column profiling, based upon the Primary High Frequency (PHF) signal.
- Across-ship and along-ship multi-beam bottom detection and sonar target detection in the water column, based upon the Primary High Frequency (PHF) signal.

2.8.6 Whale Warning Mode (WWM)

The protection of the marine environment and especially of marine mammals (whales, dolphins, seals etc.) is of great importance for ATLAS Hydrographic. Therefore, the ATLAS PARASOUND provides the so-called automatic 'Whale Warning Mode (WWM)'. This Basic Operation Mode has the objective to prevent marine mammals from being hurt by the high acoustic source levels of the ATLAS PARASOUND during normal operation.

In the Whale Warning Mode, a predefined sequence of consecutive pulses with different harmless transmission source levels and different pulse characteristics is sent out in order to scare away marine mammals which may be in the neighbourhood of the ATLAS PARASOUND.

The WWM pulse sequence can be configured by the user via an XML file with respect to the number of pulses and the following characteristics of each individual pulse:

- Transmission source level
- Pulse length
- Pulse shape
- Time delay to the previous pulse
- Carrier frequency of the pulse
- Carrier frequency shift of the pulse (for a chirped pulse)
- Transmission beam width.

The completely configured WWM pulse sequence is triggered by a single manual interaction on the operator PC. After having finished the entire WWM sequence, the ATLAS PARASOUND automatically sends a 'WWM Sequence Finished' message to the operator.

2.9 Operation Settings

The operation settings refer to triggering, data recording and the echosounder operation states.

2.9.1 Triggering

The ATLAS PARASOUND provides different possibilities for triggering its operation:

- Autonomous operation of the ATLAS PARASOUND.
- Manually triggered operation.
- Externally triggered operation.

Via the externally triggered operation, an interference-free operation of the ATLAS PARASOUND in an environment with other hydro-acoustic equipment can be enabled. The externally triggered operation is able to handle the trigger signals of two external echosounders, which can typically be a deep-sea multi-beam echosounder and/or a single-beam echosounder. The interfaces for the external trigger signals can be RS232 or RS422.

2.9.2 Data Recording

Individually for the different frequency bands PHF, SHF and PLF/SLF, the type of data recording can be configured. The following options are available:

- Full profile, including the water column plus bottom plus sediment layers.
- Bottom and sediment layers only.
- Water column only.
- Manually selected range for data recording, i.e. a range between a manually selected start depth and a manually selected stop depth.
- No profile.

2.9.3 Sounder Operation

The ATLAS PARASOUND has two selectable echosounder operation states:

- Standby.
- Sounding.

2.10 Sounder Environment Settings

The sounder environment settings refer to the system depth source, the blanking output, the water sound velocity and depth values to be specified by the user.

2.10.1 System Depth Source

The selected system depth source determines which bottom depth shall be applied for ATLAS PARASOUND internal calculations, e.g. for the Pulse Train Mode and the Quasi-Equidistant Transmission Mode (see section 2.11.1). The following exclusive data sources for the system depth can be selected:

- ATLAS PARASOUND PHF channel.
- ATLAS PARASOUND SLF channel.
- Manually entered system depth.
- Other sounding system (e.g. an ATLAS HYDROSWEEP system).
- ATLAS DESO 25/30 channel 1.
- ATLAS DESO 25/30 channel 2.

2.10.2 Blanking Output

The ATLAS PARASOUND provides two external blanking output signals which can be individually activated or deactivated. Via these signals, the reception function of other hydro-acoustic equipment on a vessel can be suppressed during the transmission pulses of the ATLAS PARASOUND.

For each individual external blanking output signal, a delay time and a prolongation time can be specified.

2.10.3 C-Mean Source

For the mean water sound velocity (C-mean), the ATLAS PARASOUND supports the following data source options:

- Manually entered C-mean value.
- System C-Profile: When this option has been selected, C-mean is calculated out of the C-profile provided by the ATLAS SENSOR MANAGER (see section 2.5.9).
- Manual C-Profile: For this option, C-mean is calculated out of a manually entered C-profile.

2.10.4 C-Keel Source

For the water sound velocity at the keel of the vessel (C-keel), the ATLAS PARASOUND supports the following data source options:

- Manually entered C-keel value.
- System C-Profile: When this option has been selected, C-keel is calculated out of the C-profile provided by the ATLAS SENSOR MANAGER (see section 2.5.9).
- System C-keel: When this option has been selected, C-keel is provided by an external C-keel sensor which is connected to an ATLAS DIP node.
- Manual C-Profile: For this option, C-keel is determined out of a manually entered C-profile.

2.10.5 Depth Window

For a correct bottom tracking of the ATLAS PARASOUND, the user has to specify the following “depth window” parameters:

- Minimum depth.
- Maximum depth
- Tracking window mode.

The tracking window mode defines how the above-mentioned minimum depth and the maximum depth are applied within the ATLAS PARASOUND. The following options are available:

- *Variable min/max depth limit:* In this mode, the specified values for the minimum depth and the maximum depth are valid only at the start of sounding. During sounding operation, the internal tracking windows are allowed to overstep the specified maximum depth and/or to fall below the specified minimum depth.
- *Fixed min/max depth limit:* In this mode, the specified values for the minimum depth and the maximum depth are valid during the entire sounding operation, i.e. the internal tracking windows are not allowed to leave the specified depth range.
- *Fixed min depth:* In this mode, the specified minimum depth is valid during the entire sounding operation. The specified maximum depth, however, is valid only at the start

of sounding. During sounding operation, the internal tracking windows are allowed to overstep the specified maximum depth.

- *Fixed max depth:* In this mode, the specified maximum depth is valid during the entire sounding operation. The specified minimum depth, however, is valid only at the start of sounding. During sounding operation, the internal tracking windows are allowed to fall below the specified minimum depth.

Additionally, a desired bottom penetration has to be specified: This parameter influences the internal time interval for the reception of data; the desired bottom penetration is also relevant for the Automatic Transmission Source Level Control (ASLC, see section 2.11.2.4).

2.11 Basic Settings

The basic settings include sensor control parameters which may be modified quite often during the normal operation of the ATLAS PARASOUND.

2.11.1 Transmission Sequence Modes

2.11.1.1 Overview

The ATLAS PARASOUND provides four exclusive transmission sequence modes which refer to the time behaviour of the transmitted pulses:

- Transmission on Request.
- Single Pulse Mode.
- Pulse Train Mode.
- Quasi-Equidistant Transmission Mode.

These different modes are described in the following sections.

2.11.1.2 Transmission on Request

The transmission on request is a manually triggered transmission including one single pulse (single shot operation).

2.11.1.3 Single Pulse Mode

In the Single Pulse Mode, at every point in time only one pulse is in the water column. A new pulse is transmitted automatically when the echo of the previous pulse has been completely received.

In the Single Pulse Mode, the ATLAS PARASOUND provides data on the sediment layers and the entire water column. In this mode, pulses are transmitted as fast as possible under the restriction that only one pulse is in the water column at every time instance.

2.11.1.4 Pulse Train Mode

In the Pulse Train Mode (in previous versions of the ATLAS PARASOUND called 'Pilot Mode'), a burst of several consecutive pulses is sent out. Up to 16 sound pulses can be sent "en route", vertically separated, so that a high echo return rate is achieved. The Pulse Train Mode is especially worthwhile in deep-sea areas, where the return trip of a single sound pulse lasts several seconds, as it enhances the horizontal resolution of the profile or sediment survey operation. The calculation of the maximum length of the transmitted pulse train is identical to the algorithm applied in the previous ATLAS PARASOUND version. The pulse trains are configurable by the user with respect to the following items:

- Time interval between the pulses, i.e. the time interval between the starting flanks of two consecutive pulses.
- Desired number of pulses; the actual number of pulses is calculated by the ATLAS PARASOUND automatically in dependency of the water depth, the reference depth (see below), the time interval between the pulses and the selected pulse length.
- Increment by which the SLF start carrier frequency is increased from pulse to pulse within every pulse train.

A setting of the Pulse Train Mode, in which the start carrier frequencies of the different pulses within each pulse train are incremented, is called Digital Chirp Mode (DCM).

For the calculation of the actual number of pulses, a so-called reference depth has to be specified which lies above the system depth (see section 2.10.1) and depends upon the following parameters:

- System depth.
- Reception Window Altitude, i.e. a distance above the system depth.
- Upper Hysteresis, i.e. a distance above the system depth (specified as a percentage of the Reception Window Altitude).
- Lower Hysteresis, i.e. a distance below the system depth (specified as a percentage of the Reception Window Altitude).

When the Pulse Train Mode is started, the Reference Depth is calculated by subtracting the Reception Window Altitude from the current system depth. Additionally, an upper hysteresis threshold is calculated by subtracting the Upper Hysteresis from the current system depth, and a lower hysteresis threshold is calculated by adding the Lower Hysteresis to the current system depth. As long as the measured system depth varies within the hysteresis range defined by the upper and lower hysteresis threshold, the Reference Depth is constant. Every time, when the system depth leaves this hysteresis range, the calculation of the Reference Depth, the upper hysteresis threshold and the lower hysteresis threshold is updated.

2.11.1.5 Quasi-Equidistant Transmission Mode

In the Quasi-Equidistant Transmission Mode, the user can define a desired time interval between the transmission pulses. Depending on the water depth, the ATLAS PARASOUND automatically calculates a resulting time interval between the pulses which is roughly equal to the desired time interval and secures that pulses are transmitted only at those times at which no sediment data is received.

For desired time intervals which are longer than the travel times of the entire echoes including water column and sediment layers, the resulting time interval is equal to the desired time interval. In this case, the transmission sequence is equidistant and not quasi-equidistant.

2.11.2 Transmission Source Level Modes

2.11.2.1 Overview

The ATLAS PARASOUND provides four exclusive modes for determining the transmission source level:

1. Operation with manually entered transmission power.
2. Operation with manually entered transmission source level reduction.
3. Operation with Automatic Transmission Source Level Control (ASLC).
4. Operation with manually entered transmission voltage.

The transmission source level depends on the transmission voltage, the duty cycle and the selected transmission beam width. In order to achieve a desired transmission source level for the modes 2 and 3, the ATLAS PARASOUND internally calculates the transmission voltage and the duty cycle as a function of the desired transmission source level and the selected transmission beam width.

2.11.2.2 Manually Entered Transmission Power

A manually entered transmission power refers to the primary acoustic signals. For non-rectangular pulse shapes, the manually entered transmission power is identical to the peak transmission power when the pulses have their maximum. Depending on the manually entered transmission power, the ATLAS PARASOUND internally determines appropriate transmission voltages and transmission duty cycles. The manually entered transmission power is specified as a percentage of the maximum transmission power which is achievable with the currently selected transmission beam width.

2.11.2.3 Manually Entered Transmission Source Level Reduction

A manually entered transmission source level reduction refers to the primary acoustic signals. All primary acoustic signals are transmitted with the manually entered source level reduction. The source level reduction refers to the maximum transmission source level which is achievable with the currently selected transmission beam width.

For non-rectangular pulse shapes, the reduced transmission source level is identical to the peak transmission source level when the pulses have their maximum.

2.11.2.4 Automatic Transmission Source Level Control (ASLC)

The Automatic Transmission Source Level Control (ASLC) secures that only the minimum source level is transmitted which is necessary for fulfilling the specific surveying task. The source level can be automatically adapted with respect to a desired bottom penetration or a desired S/N ratio of the measuring data – depending on what the user has selected. The desired target values for the bottom penetration or the S/N ratio can also be selected by the user. Additionally, the maximum primary transmission source level is limited to a user-definable threshold value. If, due to the limited transmission source level, the bottom signal is lost, an alarm is generated automatically.

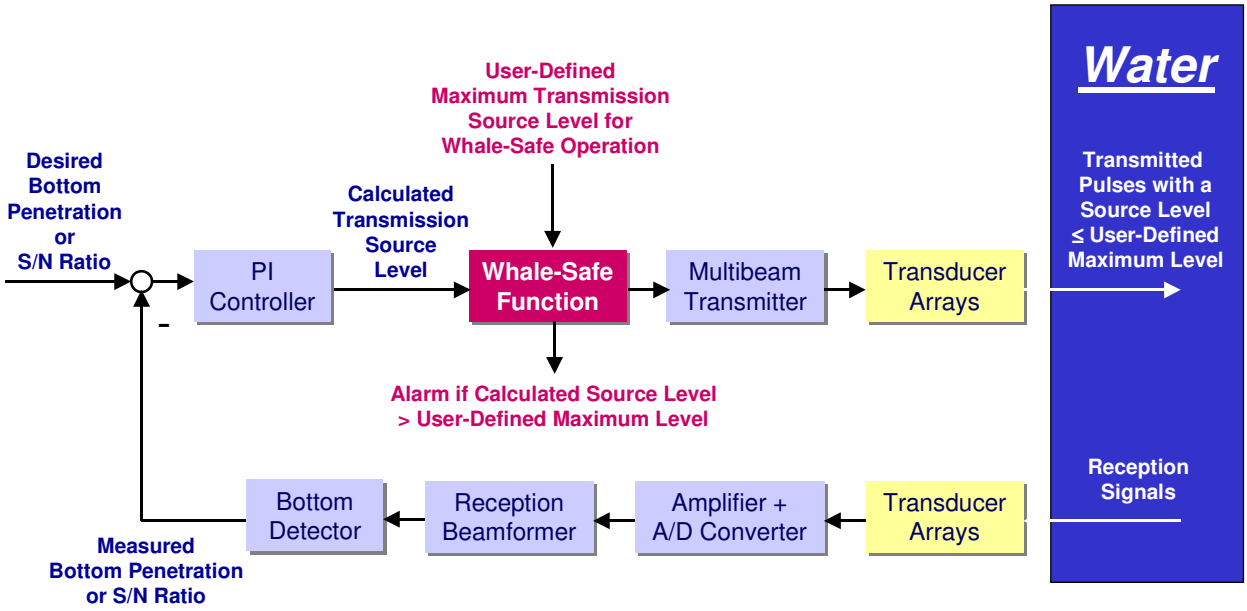


Figure 2-13: Block diagram of the Automatic Transmission Source Level Control (ASLC)

2.11.2.5 Manually Entered Transmission Voltage

The operation with manually entered transmission voltage is mainly relevant for maintenance purposes. When this setting has been selected, all primary acoustic signals are transmitted with the manually entered transmission voltage.

2.11.3 Beam Steering

2.11.3.1 Overview

For the steering of the transmission beams, the ATLAS PARASOUND provides on the one hand a so-called Incidence Angle Control (IAC) and on the other hand different beam steering settings with a manual steering reference. These settings are described in the following sections.

2.11.3.2 Incidence Angle Control (IAC)

If the SLF signal is transmitted vertically to the bottom and hits bottom areas with a slope of more than a few degrees, then the SLF signal reflected back to the vessel is so weak that sediments below the bottom cannot be identified any more. Therefore, in order not to loose the SLF reception signal, the previous ATLAS PARASOUND versions required a manual correction of the transmitted beams in such a manner that the beams hit the bottom perpendicularly. This procedure was often difficult and required operation personnel.

In order to ensure an autonomous ('watch-free') operation for a wide range of bottom slopes, the steering of the transmitted beams perpendicular to the bottom has been automated within the ATLAS PARASOUND. This feature is called "Incidence Angle Control (IAC)". It requires information on the current ship's position and the current ship's heading.

IAC includes the following functionality:

- Automatic change into the Area MBES Basic Operation Mode at certain configurable time or distance intervals in order to acquire the bottom topography data necessary for bottom slope determination.
- Automatic determination of the current bottom slope.
- Automatic adaptation of the transmission beam steering to the current bottom slope in order to secure uninterrupted reception signals.
- Automatic correction of the footprint positions with respect to the steered transmission beams.

2.11.3.3 Manual Steering References

The ATLAS PARASOUND provides three beam steering settings with a manual steering reference:

1. *Vertical Axis and Heading:* When this setting is selected, the ATLAS PARASOUND operates with motion-stabilised transmission and reception beams (roll and pitch), overlaid by manually entered offset values for the across-ship direction and the along-ship direction. These manually entered offset values refer to the vertical axis in space. For multi-beam operation, the swath is always transmitted perpendicular to the ship's heading, i.e. *no yaw compensation of the transmitted beams is applied*.
2. *Vertical Axis and Track:* When this setting is selected, the ATLAS PARASOUND operates with motion-stabilised transmission and reception beams (roll, pitch and yaw) overlaid by manually entered offset values for the across-ship direction and the along-ship direction. These manually entered offset values refer to the vertical axis in space. For multi-beam operation and a defined range of yaw angles (i.e. a defined range of deviations between the ship's heading and the track's heading), the swath is transmitted perpendicular to the track's heading (*yaw compensation*). This beam steering setting requires information on the track's heading and the current ship's heading. For single-beam operation, this beam steering setting is equivalent to the beam steering setting "Vertical Axis and Heading".
3. *Transducer Base:* When this setting is selected, the ATLAS PARASOUND operates with *fixed (not motion-stabilised)* beam steering offset values which are manually entered and which refer to the transducer basis. This beam steering setting is relevant for maintenance purposes.

2.11.4 Pulse Characteristics

The characteristics of the transmitted pulses include the pulse length, the pulse type and the pulse shape. These three characteristics can be set individually.

2.11.4.1 Pulse Length

The ATLAS PARASOUND provides two exclusive pulse length settings:

- Manually entered pulse length which can be specified in milliseconds or via the number of frequency periods per pulse; the pulse length can vary in the range of 0.167 ms up to 25 ms.
- Automatically determined pulse lengths, depending on the water depth.

2.11.4.2 Pulse Type

The ATLAS PARASOUND provides three exclusive pulse type settings:

- Continuous wave (CW) pulse, i.e. a pulse with a constant carrier frequency.
- Carrier frequency-modulated (“chirped”) pulses with a selectable linear chirp frequency shift.
- 11 bit Barker coded pulses in which each bit corresponds to a defined number of frequency periods which depends on the selected pulse length. In Barker coded pulses, a “1” corresponds to frequency periods with a positive amplitude and a “0” corresponds to frequency periods with a negative amplitude. A change from “1” to “0” or from “0” to “1” results in a phase jump of 180°.

2.11.4.3 Pulse Shape

The ATLAS PARASOUND provides two exclusive pulse shape settings:

- Rectangular pulse shape.
- User-defined pulse shapes which are provided via appropriate files in an amplitude-normalised and a time-normalised manner.

Non-rectangular pulse shapes have the advantage that – compared to rectangular pulse shapes – the spectral side lobes are reduced. On the other hand, however, the main lobe is broader. The following pulse shapes are predefined for the ATLAS PARASOUND:

- Triangular
- Hann
- Hamming
- Gaussian
- Minimum phase

2.11.5 Operation Frequencies

The user can specify a desired PHF frequency and a desired SLF or PLF frequency. The operation frequencies can be specified in the ranges as indicated in section 2.4.4.

Due to restrictions of the transmission beamformer, the actually applied frequencies differ slightly from the desired frequency values.

2.12 Advanced Settings

Compared to the basic settings (see section 2.11), the advanced settings are normally not modified during system operation. Therefore, the “normal” user of the ATLAS PARASOUND should not change the predefined values of these sensor control parameters.

Only for specific scientific investigations, it can be useful to apply advanced settings which differ from the predefined values.

2.12.1 Transmission Beam Width

The ATLAS PARASOUND provides the possibility to modify the transmission beam width. The following options are available:

- Standard: When this option is selected, always the entire transducer basis is applied for transmission.
- Automatic: When this option is selected, the transmission beam width is automatically determined by the ATLAS PARASOUND in dependency of the water depth. Under most conditions, the ATLAS PARASOUND applies the most narrow beam width, i.e. the entire transducer basis is applied during transmission. Only in shallow-water areas, the ATLAS PARASOUND transmits with a reduced transducer basis, i.e. with a broader beam width.
- Manual Element Selection: When this option is selected, the user can manually choose a set of transducer elements to be applied during transmission. Via this option, the transmission beam width can be increased in several steps, independently for the across-ship and the along-ship direction.

2.12.2 Reception Shading

For the different frequency bands PHF, SHF and SLF / PLF, the type of reception shading can be selected. Available are 5 different predefined reception shading tables.

The user can choose between a manually selected shading table or an automatic determination of the shading table to be applied.

For the reception shading table No. 1, the entire transducer basis without any weighting factors is applied for the signal reception, i.e. no reception shading is applied.

2.12.3 Receiver Bandwidth

Combined for the PHF and SHF reception channels and for the SLF/PLF reception channel, the user can select whether the output sample rates and the receiver bandwidths are set automatically by the ATLAS PARASOUND sensor or manually by the user.

When the manual modes haven been chosen, then individually for the PHF, SHF and SLF/PLF reception channels, appropriate output sample rates and appropriate receiver bandwidths can be selected manually. These settings have to be adapted to the selected pulse characteristics in order to avoid aliasing effects.

The possible output sample rates are 750 Hz, 1.5 kHz, 3.0 kHz, 6.1 kHz or 12.2 kHz. The receiver bandwidth is specified as a percentage of the output sample rate. The user-selectable settings are 66%, 33% or 16% of the output sample rate (see section 2.4.12).

2.12.4 Receiver Amplification

Individually for the PHF channel and the SLF channel, the following amplification settings are provided:

PHF Channel:

- Automatic or manual mode.
- In the manual mode, the gains 0 dB or 15 dB can be selected.

SLF Channel:

- Automatic or manual mode.
- In the manual mode, the gains 0 dB or 10 dB can be selected.

Manually entered receiver amplification values are of interest if, for example, the ATLAS PARASOUND is applied for detailed investigations of the water column. In such cases, the amplification may be increased beyond the normal level, accepting overdriven bottom signals.

2.12.5 Multi-Beam Settings

The ATLAS PARASOUND provides the following multi-beam settings for the across-ship direction and the along-ship direction:

Across-ship direction:

- Beam spacing mode: ‘equal angle’ or ‘equal footprint’
- Number of beams
- Maximum angle starboard and maximum angle port

Along-ship direction:

- Beam spacing mode: ‘equal angle’ or ‘equal footprint’
- Number of beams
- Maximum angle ahead and maximum angle back

2.12.6 Sonar Target Settings

The ATLAS PARASOUND provides the following sonar target settings:

- If desired, the beam-oriented amplitude/time functions can be correlated with the function of the transmitted pulse before the sonar target detection algorithm is applied. This option, which is relevant for frequency-modulated (“chirped”) pulses and Barker-coded pulses, results in a so-called pulse compression, leading to a better accuracy of measurement.
- The detection of targets in the water column can be switched on or off. If the detection of targets in the water column is switched on, a signal-to-noise ratio (S/N ratio) of

these targets can be specified. Only those targets are considered in the target detection algorithm which are louder than the specified S/N ratio. The specified S/N ratio is normalised to a distance of 1 meter below the transducer array.

2.12.7 Side-Scan Data Settings

The ATLAS PARASOUND provides the following side-scan data settings:

- The across-ship resolution of the side-scan data can be specified by the number of samples or the sample distance.
- The along-ship resolution of the side-scan data can be specified by the number of samples or the sample distance.
- The acquisition of side-scan data for the entire water column can be switched on and off. If the data acquisition for the water column is switched off, a distance before the bottom contact can be specified at which the acquisition of side-scan data starts.

2.12.8 Automatic Transmission Termination

The ATLAS PARASOUND has a built-in functionality for an instantaneous automatic termination of the transmission in order to protect marine mammals. This automatic transmission termination is effective if it is activated and if within a specified depth range objects are identified, the reverberation level of which is higher than a level specified by the user.

2.12.9 Stave Data Recording

For maintenance and scientific purposes, it is possible to activate a recording of the stave data. This mode can be used, for example, for an offline analysis of acoustic noise sources and their spectral characteristics. Main features of the stave data recording mode are:

- Provides the original digitised stave data *before* baseband shift, low-pass filtering, decimation and beamforming.
- Interrupts normal data acquisition.
- No separate stave data recorder needed.
- 160 channels for the ATLAS PARASOUND P70
  (128 PHF channels + 32 SLF channels)
- 80 channels for the ATLAS PARASOUND P35
  (64 PHF channels + 16 SLF channels).
- 16 bit resolution.
- 98 kHz sample frequency.

2.13 Watch Keeping

For users which are not specifically skilled in the operation of the ATLAS PARASOUND, a subset of the most important settings is duplicated on a special window tab within the ATLAS HYDROMAP CONTROL software application. This window tab which is called “watch keeping” includes the following settings:

- SLF/PLF frequency.
- System depth source.
- Number of periods per pulse.
- Depth window settings.
- Pulse train reception window settings.

2.14 Setting-to-Work and Maintenance

Due to highly integrated electronics and several self-test facilities (BITE = Built-In Test Equipment), the efforts for setting-to-work and maintenance for the ATLAS PARASOUND are significantly reduced, compared to the previous ATLAS PARASOUND versions.

The ATLAS PARASOUND can be serviced via remote maintenance and provides the possibility to install software updates via remote access.

Hardware defects can be corrected by a simple removal of well-defined Lowest Replaceable Units (LRUs). This can be conducted by low-qualified on-board personnel. The main LRUs are:

- Transmitter Block
- Preamplifier Board
- Capacitor Module
- Digitiser Module
- Transducer Adaption Board (TAB)
- Each individual board of the Signal Processing Module (SPM)
- Each individual board of the Control Module (CM)
- High-Voltage Power Module (HVPM)
- Low-Voltage Power Module (LVPM)
- Low-Voltage Power Supply Board (LVPS)
- Digital Power Supply for the Control Module and Signal Processing Module
- AC Module (ACM)
- Mains Filter Module (MFM)
- Remote Power Switch (RPS)

- Interconnection Board (ICB)
- Special Interface Pool (SIP) Board
- LAN Switch
- System Interface Modules
- Power Supply for the System Interface Modules.

For integrated systems with an ATLAS PARASOUND and an ATLAS HYDROSWEEP DS multi-beam echosounder (see ref. /5/) or an ATLAS HYDROSWEEP MD multi-beam echosounder (see references /6/ and /7/), the spare part logistics and the maintenance training are significantly simplified due to the common components integrated in these sonars (see section 0).

3 Technical Specifications

In the following, technical specifications of the ATLAS PARASOUND are provided. If not explicitly distinguished, all specifications are valid for both product variants, i.e. for the ATLAS PARASOUND P70 and the ATLAS PARASOUND P35.

3.1 Key Technical Data of the ATLAS PARASOUND[1]

Technology:

- The ATLAS PARASOUND and the ATLAS HYDROSWEEP DS, ATLAS HYDROSWEEP MD/30 and ATLAS HYDROSWEEP MD/50 multi-beam echosounders are based upon the same most advanced hardware and software technology, including 24 bit ADCs, DSPs, FPGAs and optical data links.

Operation Frequencies:

- Primary High Frequency PHF1:
  - ATLAS PARASOUND P70: 18 kHz … 33 kHz (adjustable)
  - ATLAS PARASOUND P35: 18 kHz … 21 kHz (adjustable)
- Primary High Frequency PHF2:
  - PHF2 = PHF1 + SLF
- Secondary (Parametric) Low Frequency:
  - SLF: 500 Hz … 6 kHz (adjustable)
- Secondary (Parametric) High Frequency:
  - SHF: 36.5 kHz … approx. 40 kHz
- Primary Low Frequency:
  - PLF: approx. 6 kHz … 10 kHz (adjustable)

Basic Operation Modes:

- P-SBP/SBES:
  - Single-beam parametric sub-bottom profiling
  - Single-beam echo sounding
  - SLF, PHF1, PHF2 and SHF frequency bands

[1] ATLAS Hydrographic reserves the right to alter technical specifications of the ATLAS PARASOUND P70 and the ATLAS PARASOUND P35 without further notice.

- P-SBP/MBES:
  - Multi-beam across-ship parametric sub-bottom profiling
  - Multi-beam across-ship echosounding
  - SLF, PHF1, PHF2 and SHF frequency bands
- C-SBP/SBES:
  - Conventional (non-parametric) single-beam sub-bottom profiling
  - Single-beam echosounding
  - PLF and PHF1 frequency bands
- SBES:
  - Single-beam echosounding
  - PHF1 frequency band
- Area MBES:
  - Area-related (i.e. along-ship and across-ship) multi-beam bathymetric survey
  - PHF1 frequency band
- WWM
  - Whale Warning Mode
  - Flexible pulse sequence utilisation

Acquired Data:

- Sediment profile data
- Water column amplitude data for water column imaging (for PHF1, SLF/PLF and SHF frequency bands)
- Bathymetric depth data
- Side-scan data
- Bottom backscatter amplitudes for seabed classification

Depth Range:[1]

- PHF (for 18 kHz): 10 m (below the transducers) … 11,000 m
- SLF: 10 m (below the transducers) … > 10,000 m

Maximum Bottom Penetration:[1]

- ATLAS PARASOUND P70: > 200 m
- ATLAS PARASOUND P35: > 150 m

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[1] The achievable maximum depth depends upon the ambient noise level (sea state), the noise level of the vessel, the characteristics of the water column (especially bubbles in the water column or bio layers), the bottom reverberation and the bottom slope.

[1] The penetration depth in sediment layers depends on the nature of the bottom, the depth of the water, the secondary frequency, the noise level of the ship and the ambient noise level. The data are given for an example assuming low ship's noise and a 5,000 meters deep abyssal plane (sea state $\leq$ 2, ship speed 6 knots and a bottom absorption of < 0.2 dB/m).

Transducer Installation:

- Hull-mounted

Number of Transducer Modules:

- ATLAS PARASOUND P70: 4 transducer modules of the type “classic”
- ATLAS PARASOUND P35: 2 transducer modules of the type “basic”

Beam Widths:[2]

- PHF for ATLAS PARASOUND P70:
  - 4° x 4.5° for PHF1 = 18 kHz
  - 2.2° x 2.5° for PHF1 = 33 kHz
- PHF for ATLAS PARASOUND P35:
  - 4.5° x 4.5° for PHF1 = 18 kHz
- SLF for ATLAS PARASOUND P70:
  - 4.5° x 5° for PHF1 = 18 kHz
  - 2.5° x 2.8° for PHF1 = 33 kHz
- SLF for ATLAS PARASOUND P35:
  - 5° x 5° for PHF1 = 18 kHz
- SHF for ATLAS PARASOUND P70:
  - 2° x 2.3° for SHF = 36 kHz
- SHF for ATLAS PARASOUND P35:
  - 2.3° x 2.3° for SHF = 36 kHz
- PLF for ATLAS PARASOUND P70:
  - 7° x 8° for PLF = 9 kHz
  - 12° x 14° for PLF = 6 kHz
- PLF for ATLAS PARASOUND P35:
  - 8° x 8° for PLF = 9 kHz
  - 14° x 14° for PLF = 6 kHz

Reception Shading:

- Rectangular, triangular, Hann, Hamming, Gaussian (user selectable)

Pulse Characteristics:

- Pulse lengths:
  - 0.167 ms … 25 ms (selectable).

[2] The beam widths vary with the operating frequency, the transducer shading on the transmission and reception side as well as with the beam directions.

- Pulse types:
  - Continuous wave (CW) pulses
  - Chirped pulses with linear frequency shift (user selectable)
  - 11 bit Barker coded pulses
- Pulse shapes:
  - Rectangular, triangular, Hann, Hamming, Gaussian, minimum phase and user-defined pulse shapes (user selectable).

PHF Pulse Transmission Power:

- ATLAS PARASOUND P70: Up to 70 kW
- ATLAS PARASOUND P35: Up to 35 kW

Maximum Transmission Source Level:[1]

- PHF:
  - ATLAS PARASOUND P70: Approx. 245 dB
  - ATLAS PARASOUND P35: Approx. 242 dB
- SLF (for 3.5 kHz):
  - ATLAS PARASOUND P70: Approx. 206 dB
  - ATLAS PARASOUND P35: Approx. 200 dB

Motion Compensation:[2]

- Stabilisation of the PHF and PLF transmission beams with respect to roll and pitch.
- Stabilisation of the PHF and PLF transmission beams with respect to yaw during multi-beam operation.
- Correction of the PHF, SLF/PLF and SHF reception signals with respect to roll, pitch, yaw and heave.

Ranges for Beam Steering (Stabilisation and Correction) Relative to the Transducer Array:[3]

- Across-ship direction (for PHF1 = 18 kHz):
  - ATLAS PARASOUND P70: ± 25 degrees
  - ATLAS PARASOUND P35: ± 15 degrees

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1 The maximum transmission source levels stated above are approximate values; they are only applicable in the case of far field conditions and for transmission with the full transducer basis vertical to the transducer plane.

2 The roll, pitch and heave data of the vessel's motion have to be provided by an appropriate external motion sensor. The yaw angle of the vessel has to be provided by an appropriate external heading sensor.

3 The specified range for beam steering is an "overall budget" which is available for motion compensation, Incidence Angle Control and multi-beam operation. That means, for example, that the range of bottom slopes in the across-ship direction for Incidence Angle Control is reduced by the steering budget consumed by the vessel's rolling.

- Along-ship direction (for PHF1 = 18 kHz):
  - ATLAS PARASOUND P70: ± 15 degrees
  - ATLAS PARASOUND P35: ± 15 degrees

Technique for Ensonification of the Swath for Multi-Beam Operation:

- Sector scan technique with several consecutive transmission pings.

Resolution:

- Output sample rates (amplitude and phase):[1]
  - 12.2 kHz, 6.1 kHz, 3 kHz, 1.5 kHz or 750 Hz
- Range resolution (amplitude and phase):
  - 6.1 cm, 12.3 cm, 25 cm, 50 cm or 1.0 m
- Side-scan resolution:
  - 82 µs, 0.16 ms, 0.33 ms, 0.67 ms or 1.33 ms
- Sediment layer resolution:
  - Down to less than 15 cm

Accuracy:[2]

- Bottom depth accuracy: Better than ± max [0.2 m, 0.2% of water depth]

Maximum Ping Rate:[4]

- > 20 Hz

Multi-Ping Operation:[5]

- Up to 16 pings

Survey Speed:[6]

- Up to 15 knots

Raw Data Format:

- ASD format (ASD = ATLAS Sounding Data); the ASD format specification is public.

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1 The appropriate output sample rate and thereby the range resolution and the side scan resolution depend on the frequency characteristics of the selected transmission pulses.

2 The listed values are expected 1 sigma values in normal survey situations and in absence of adverse bottom, water sound velocity or environmental conditions. The accuracy value includes systematic and stochastic errors of the ATLAS PARASOUND sensor. It has to be mentioned that the accuracy of an entire surveying system including an ATLAS PARASOUND is not identical to the accuracy of the ATLAS PARASOUND sensor, because it includes additional error sources coming from the motion sensor, the applied sound velocity probe and other sensors.

4 The ping rate (sounding rate) depends on the water depth. The specified value constitutes the maximum possible ping rate of the ATLAS PARASOUND.

5 The maximum number of multiple pulses depends on the water depth.

6 The maximum admissible survey speed depends upon the ship's noise and the flow noise.

Quality Classifiers:

- For each identified sonar target

Motion Sensor Interface:

- Data formats:
  - ATLAS format
  - Simrad EM3000 format
  - Other data formats upon request
- Data rate: ≤ 40 Hz

Heading Sensor Interface:

- Data formats:
  - NMEA format
  - Other data formats upon request
- Data rate: ≤ 20 Hz

Transmission Sequence Modes:

- Transmission on Request (single shot operation)
- Single Pulse Mode
- Pulse Train Mode
- Quasi-Equidistant Transmission Mode

Automatic Transmission Source Level Control (ASLC):

- A selectable Transmission Source Level Mode, minimising the acoustic impact on the marine environment (for the protection of marine mammals)

Incidence Angle Control (IAC):

- Automatic beam angle stabilisation and correction depending on the bottom slope in order to achieve a nearly autonomous (‘watch-free’) system operation

Compatibility to Former Systems:

- Compatibility to all existing ATLAS PARASOUND transducers
- Upward compatibility to the functionality of existing ATLAS PARASOUND systems

Interface to the Scientific Community:

- Via the data export formats SEG-Y and PS3, provided by ATLAS PARASTORE
- Via the data export format SURF4, provided by ATLAS HPS

Maintenance:

- BITE facilities for different system components
- Remote maintenance

Configuration of sensor control and signal processing algorithms:

- Via XML configuration files

Automatic Operation Control Functionality (OCF):

- Operating hour meter

Power Supply:

- Operating voltage: 230 VAC ±10%, single phase
- Frequency: 47 – 63 Hz
- Externally fused by 16 A
- Other voltages upon request

Power Consumption:

- ATLAS PARASOUND P70: < 2.7 kW
- ATLAS PARASOUND P35: < 2.0 kW

Dimensions of the Transducers (Width x Length x Height):

- Single ATLAS PARASOUND P70 transducer module:
  - Normal P70 transducer module: Approx. 300 mm x 950 mm x 138 mm
  - Ice-protected P70transducer module: Approx. 300 mm x 950 mm x 163 mm
- Complete ATLAS PARASOUND P70 transducer array:
  - Normal P70 transducer array: Approx. 1,200 mm x 950 mm x 138 mm
  - Ice-protected P70 transducer array: Approx. 1,200 mm x 950 mm x 163 mm
- Single ATLAS PARASOUND P35 transducer module:
  - Normal P35 transducer module: Approx. 600 mm x 1,200 mm x 138 mm
  - Ice-protected P35 transducer module: Approx. 600 mm x 1,200 mm x 163 mm
- Complete ATLAS PARASOUND P35 transducer array:
  - Normal P35 transducer array: Approx. 1,200 mm x 1,200 mm x 138 mm
  - Ice-protected P35 transducer array: Approx. 1,200 mm x 1,200 mm x 163 mm

Dimensions of the Transceiver Electronics (Height x Width x Depth):

- Analog Electronic Unit (AEU): 766 mm x 600 mm x 578 mm
- Digital Electronic Unit (DEU): 366 mm x 600 mm x 578 mm
- 500 mm Interconnection Unit (500 mm ICU): 1366 mm x 500 mm x 155 mm
- 400 mm Interconnection Unit (400 mm ICU): 1366 mm x 400 mm x 155 mm

Weights of the Transducers:

- Single ATLAS PARASOUND P70 transducer module:
  - Normal P70 transducer module: Approx. 115 kg including transducer cable

  - Ice-protected P70 transducer module: Approx. 123 kg including transducer cable
- Complete ATLAS PARASOUND P70 transducer array:
  - Normal P70 transducer array: Approx. 4 x 115 kg including transducer cables
  - Ice-protected P70 transducer array: Approx. 4 x 123 kg including transducer cables
- Single ATLAS PARASOUND P35 transducer module:
  - Normal P35 transducer module: Approx. 175 kg including transducer cable
  - Ice-protected P35 transducer module: Approx. 190 kg including transducer cable
- Complete ATLAS PARASOUND P35 transducer array:
  - Normal P35 transducer array: Approx. 2 x 175 kg including transducer cables
  - Ice-protected P35 transducer array: Approx. 2 x 190 kg including transducer cables

Weights of the Transceiver Electronics:

- Analog Electronic Unit (AEU): Up to approx. 155 kg (depending on the product variant)
- Digital Electronic Unit (DEU): Approx. 60 kg
- 500 mm Interconnection Unit (500 mm ICU): Approx. 80 kg
- 400 mm Interconnection Unit (400 mm ICU): Approx. 70 kg

3.2 Operational Conditions

Isotropic Noise Level in Shallow Water:

- < 55 dB [rel.1 µPa, $Hz^{-1/2}$] in the range of 18 kHz
- < 65 dB [rel.1 µPa, $Hz^{-1/2}$] in the range of 3 kHz

Isotropic Noise Level in Deep Water:

- < 40 dB [rel.1 µPa, $Hz^{-1/2}$] in the range of 18 kHz
- < 50 dB [rel.1 µPa, $Hz^{-1/2}$] in the range of 3 kHz

Roll Angle:

- Less than ± 10°

Pitch Angle:

- Less than ± 5°

Heave:

- Less than ± 5 m

Roll Rate:

- < 10° per second

Pitch Rate:

- < 5° per second

Yaw Rate:

- < 10° per sounding

Ray Path:

- Continuously uninterrupted

Acoustic Contact between the Water and the Transducer Surface:

- Undisturbed, i.e. no air bubbles below and beside the transducers.

3.3 Environmental Conditions

The following environmental conditions are required for the transducers and the transceiver electronics of the ATLAS PARASOUND:

Transducer Modules Including Cables:

- Water temperature: Between -4° C and +40° C
- Water pressure: < 20 meters water depth

Transceiver Electronics:

- Ambient temperature: Between 0°C and +40° C
- Ambient humidity: Max. 95%, without condensation

Maximum Vibrations for Transceiver Electronics and Transducer Modules:

- Horizontal and vertical vibrations of up to 1 mm for stimulations between 3 Hz and 12.5 Hz
- Horizontal and vertical vibrations of up to 0.5 g for stimulations between 12.5 Hz and 80 Hz

COTS components such as PCs, printers, plotters, magnetic and optical storage devices and storage media shall exposed to environmental conditions according to manufacturer's specifications. It is recommended to provide an "office type environment" for the computer hardware and associated peripherals.

4 Data Examples

Figure 4-1 up to Figure 4-6 and Figure 4-10 show ATLAS PARASOUND data acquired by the German research vessel “MARIA S. MERIAN” in 2005.

Figure 4-7 and Figure 4-8 show ATLAS PARASOUND records acquired by the German research vessel “SONNE” in 2002 in the Gulf of Bengal (Channel Levee System).

Figure 4-9 shows fine-grained sediment waves on the western flank of the Zapiola Drift, Argentine Basin. These data have been provided by the University of Bremen, Department of Marine Technology / Environmental Research.

Figure 4-11 shows the different bottom penetration properties of the primary frequency of 18 kHz and of the secondary (parametric) frequency of 3.5 kHz.

Figure 4-12 presents a data record of the “Giant sand ripples” in the English Channel off the Dutch coast. This example shows the excellent horizontal resolution by means of the narrow-beam transmission.

Figure 4-13 presents another data record acquired in the English Channel. It shows Mesozoic layers covered by sand.

Figure 4-14 presents a data record showing the excellent sub-bottom profiling capabilities of the ATLAS PARASOUND, reaching down to more than 100 m in the soft sediments off the Norwegian coast.

Figure 4-15 to Figure 4-18: In April/May 1993 the German research vessel “SONNE” carried out a pre-site survey for the Ocean Drilling Programme. The survey concentrated on the Congo basin at the African West Coast. At varying depths between 1,000 and 3,000 meters, bottom penetrations of more than 120 meters were achieved. Even at extreme slopes, the SLF pulse resolved sub-bottom layers down to 100 meters.

Figure 4-19 shows data with a bottom penetration of more than 200 meters; these data have been acquired by the German research vessel “POLARSTERN”.

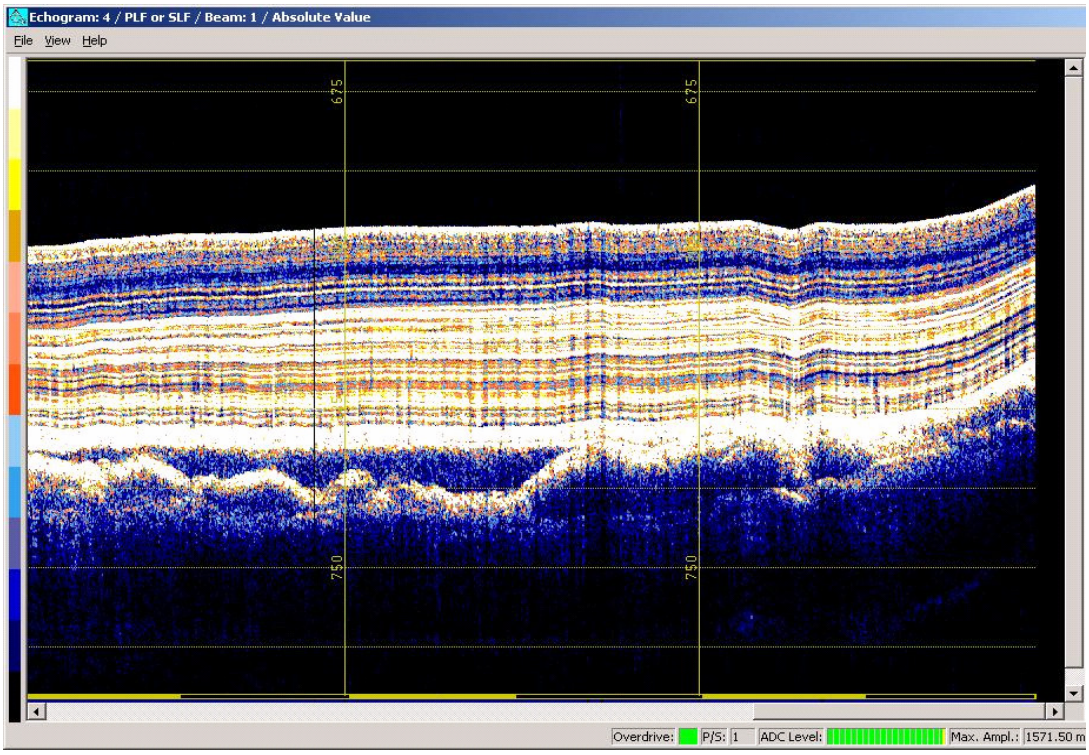


Figure 4-1: ATLAS PARASOUND record, acquired by the German research vessel MARIA S. MERIAN in November 2005 in the Skagerak at a water depth of approx. 700 meters

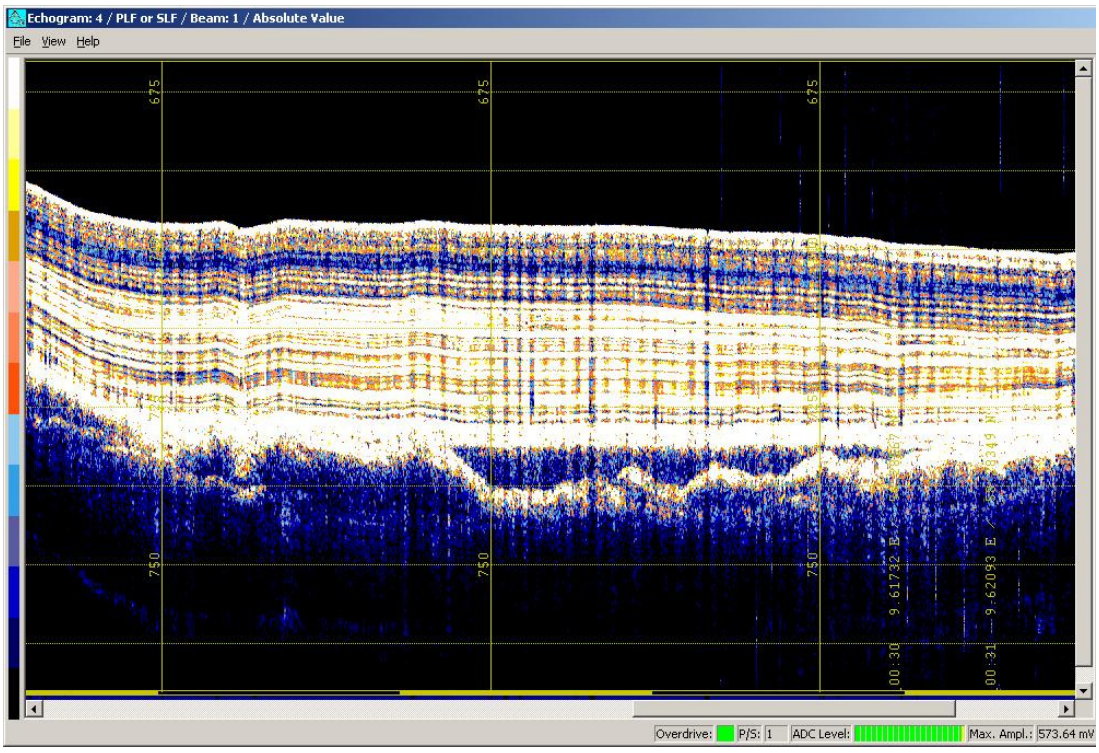


Figure 4-2: ATLAS PARASOUND record, acquired by the German research vessel MARIA S. MERIAN in November 2005 in the Skagerak at a water depth of approx. 700 meters (chirped pulses)

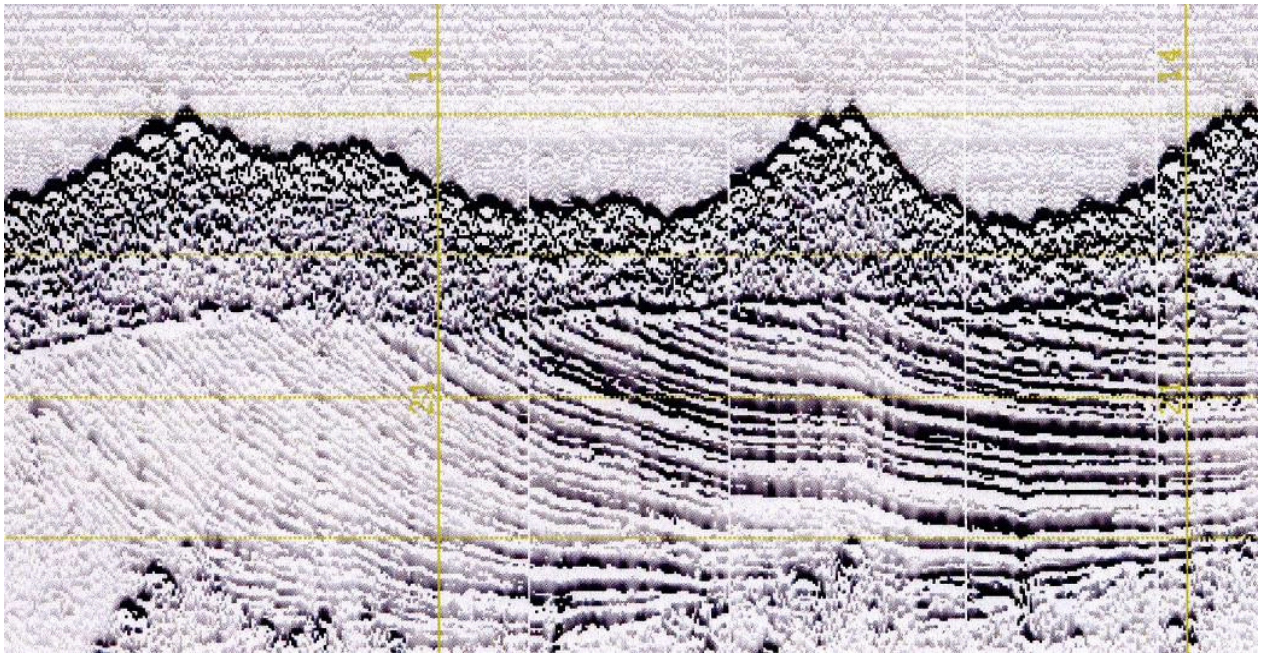


Figure 4-3: ATLAS PARASOUND record, acquired by the German research vessel MARIA S. MERIAN in the English Channel in October 2005

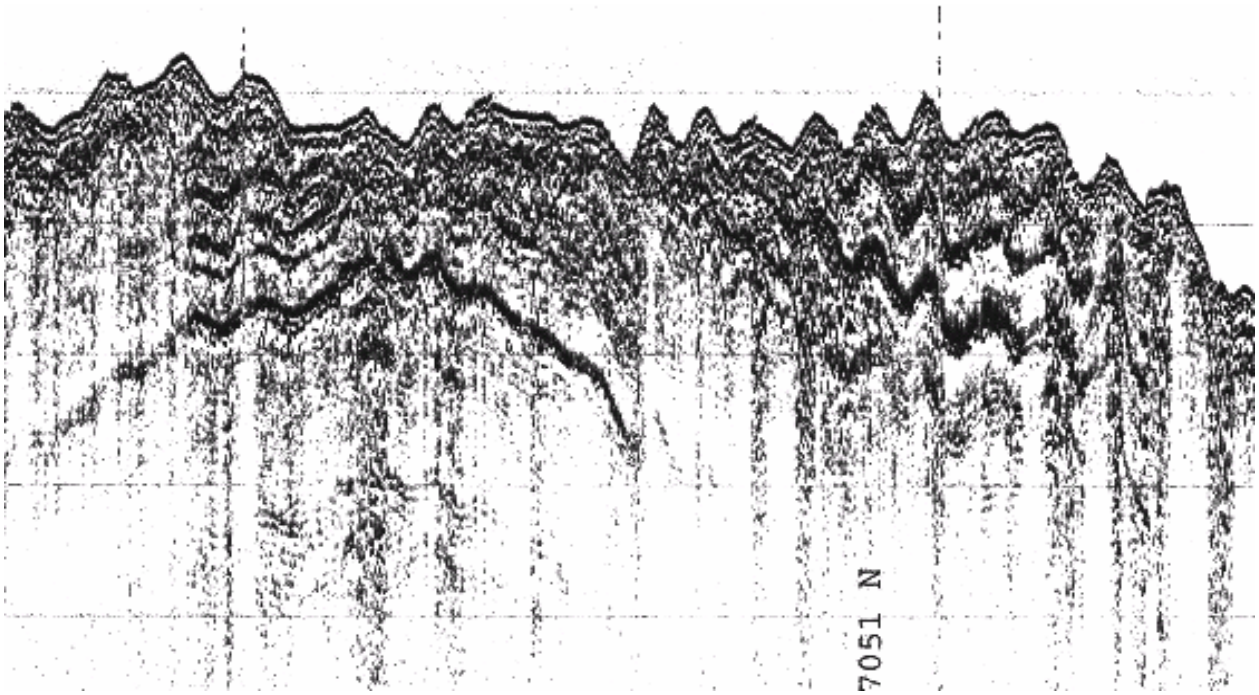


Figure 4-4: ATLAS PARASOUND record, acquired by the German research vessel MARIA S. MERIAN in the English Channel in October 2005

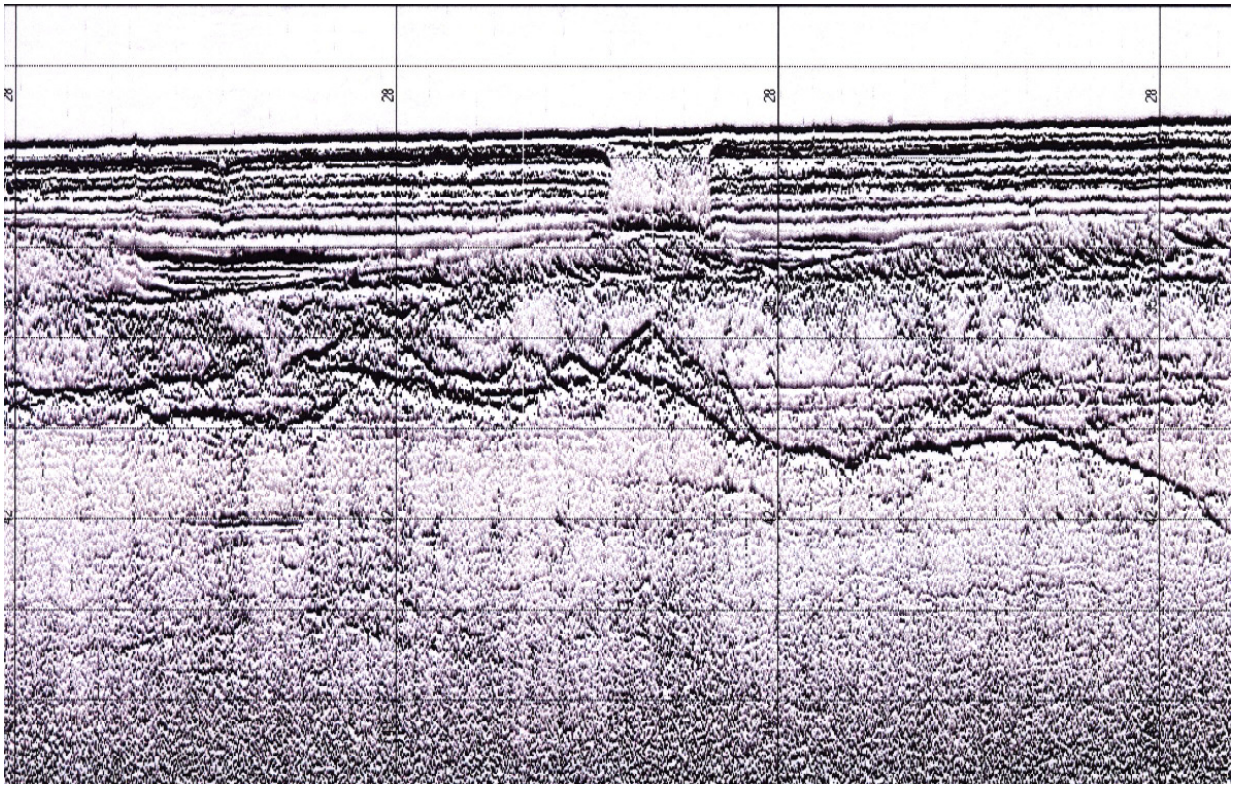


Figure 4-5: ATLAS PARASOUND record, acquired by the German research vessel MARIA S. MERIAN in October 2005 near the isle Helgoland in the German Bight (North Sea)

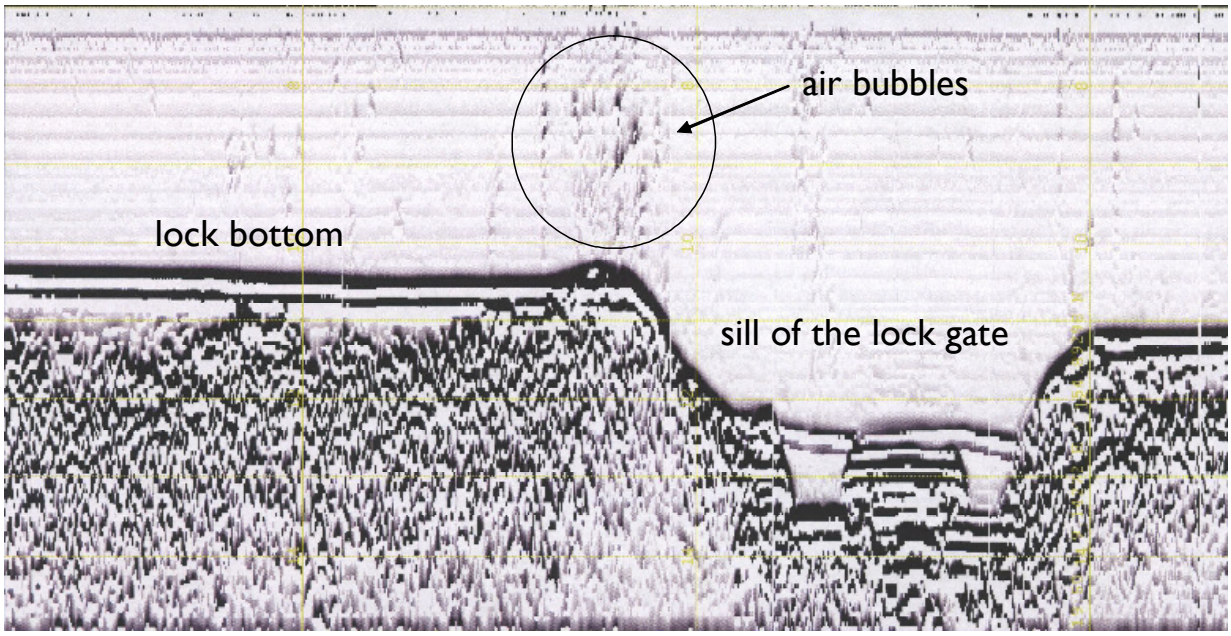


Figure 4-6: ATLAS PARASOUND record, acquired by the German research vessel MARIA S. MERIAN in September 2005, leaving a lock of the Kiel-Channel.

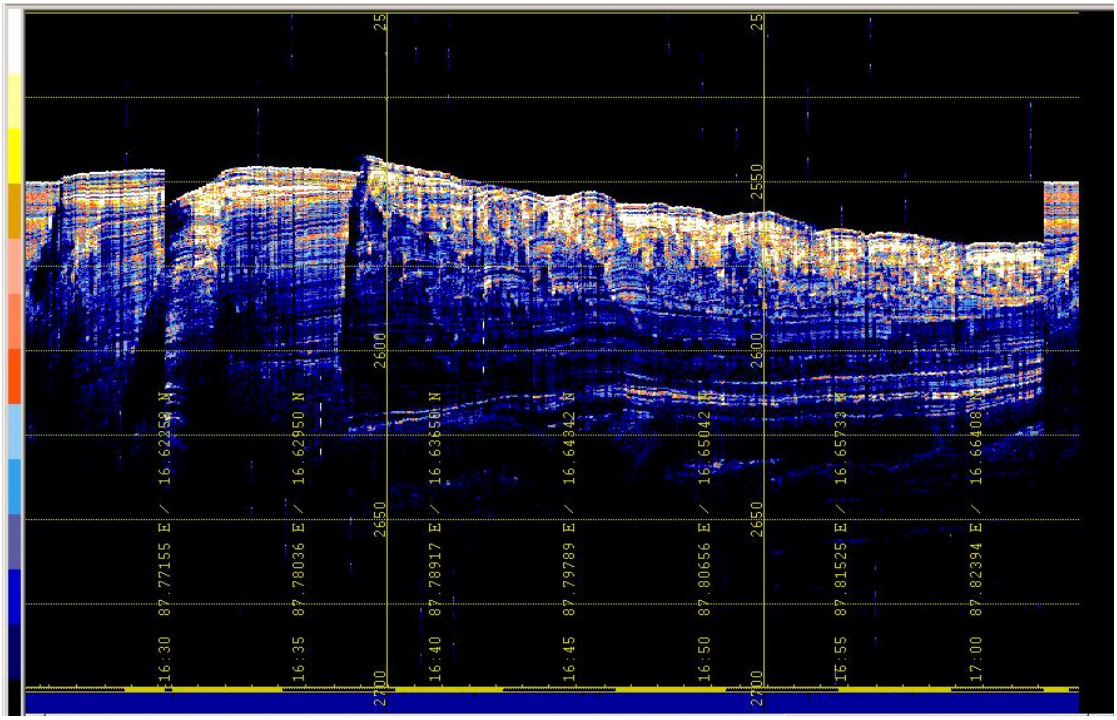


Figure 4-7: ATLAS PARASOUND record, acquired by the German research vessel SONNE in 2002 in the Gulf of Bengal (Channel Levee System)

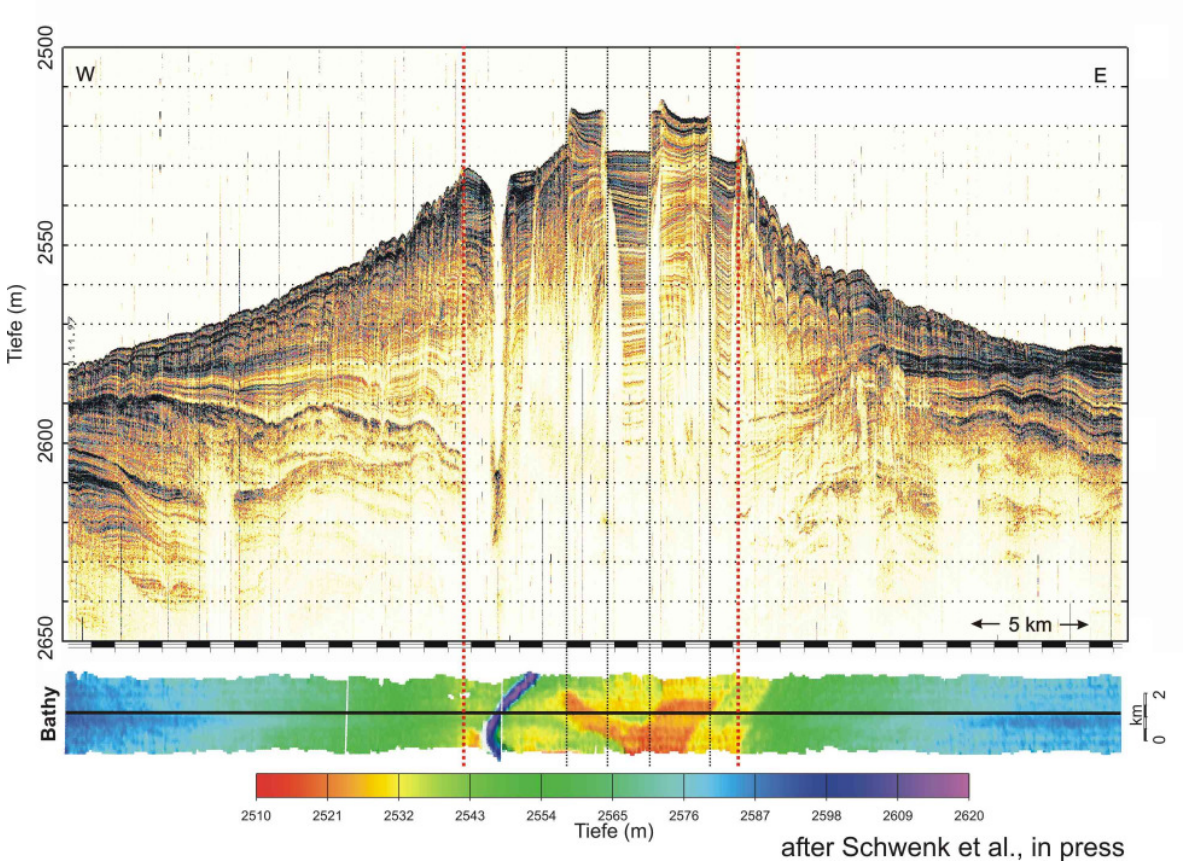


Figure 4-8: ATLAS PARASOUND record, acquired by German research vessel SONNE in 2002 in the Gulf of Bengal (Channel Levee System)

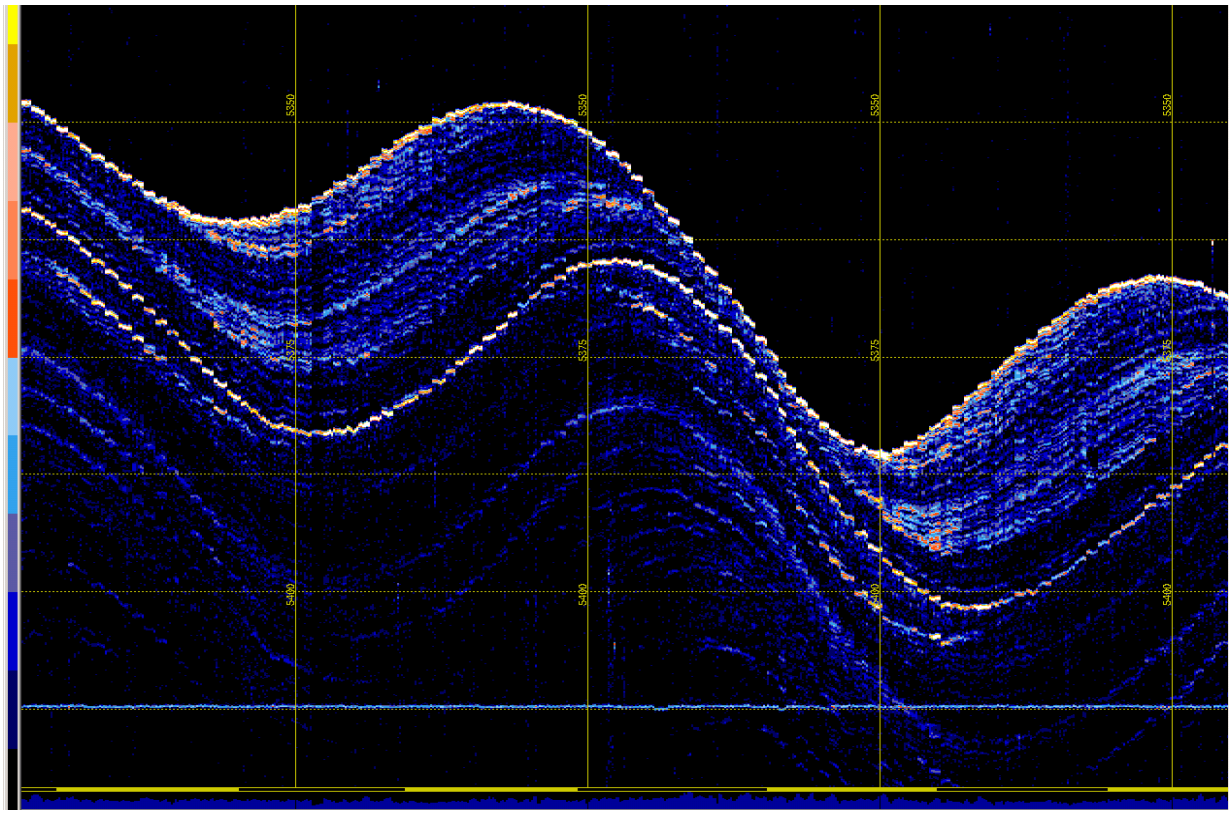


Figure 4-9: Fine-grained sediment waves on the western flank of the Zapiola Drift, Argentine Basin (data provided by the University of Bremen, Department of Marine Technology / Environmental Research) [1]

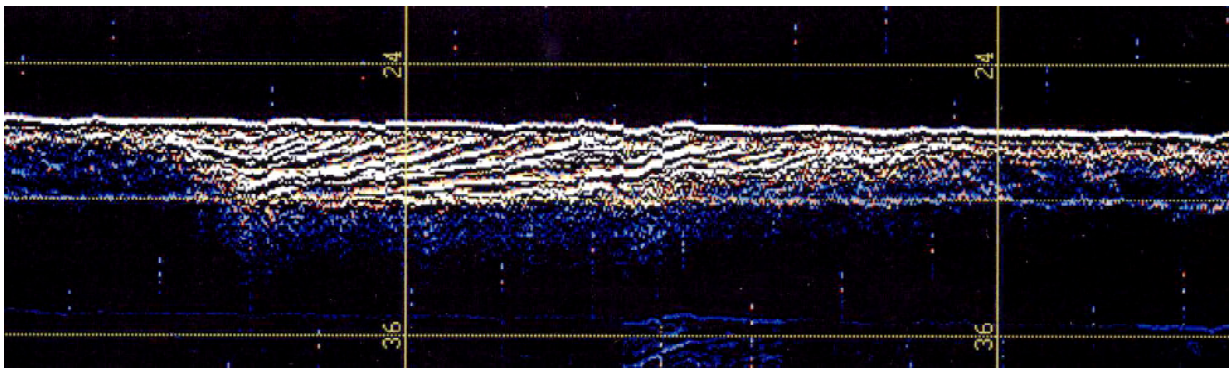


Figure 4-10: ATLAS PARASOUND record, acquired by German research vessel MARIA S. MERIAN in September 2005 at water depths of 27 m, using conventional sub-bottom profiling mode (C-SBP)

[1] H. von Lom-Keil, V. Spieß, V. Hopfauf (2002). Fine-grained sediment waves on the western flank of the Zapiola Drift, Argentine Basin: evidence for variations in Late Quaternary bottom flow activity. Marine Geology 192, pp 239 - 258.

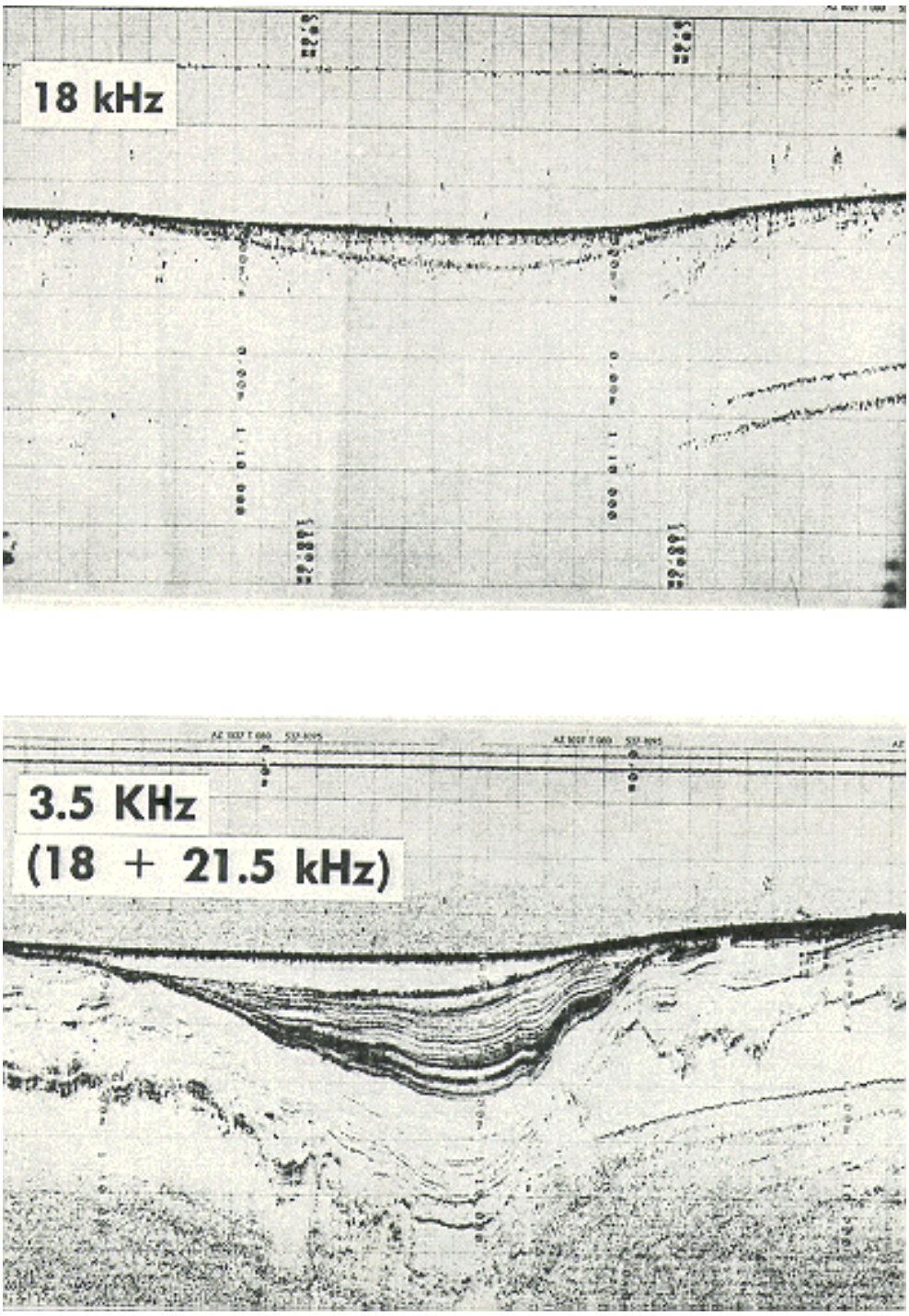


Figure 4-11: Different bottom penetration properties of the primary frequency of 18 kHz and of the secondary frequency of 3.5 kHz.

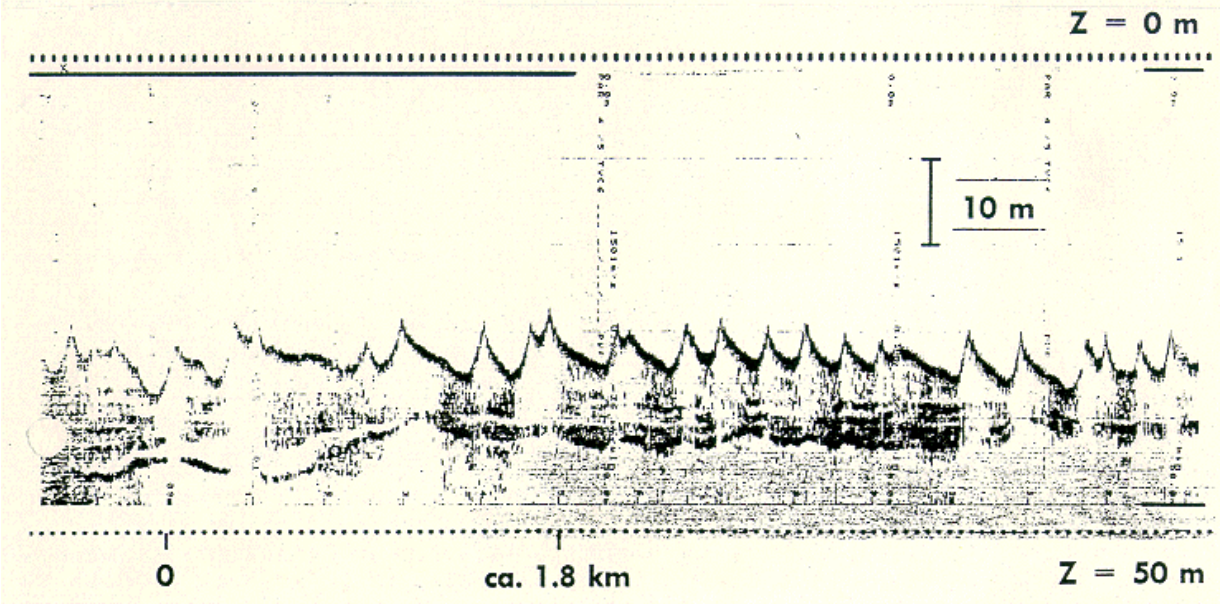


Figure 4-12: Recording of the "Giant sand ripples" in the English Channel off the Dutch coast. This example shows the excellent horizontal resolution by means of the narrow-beam transmission.

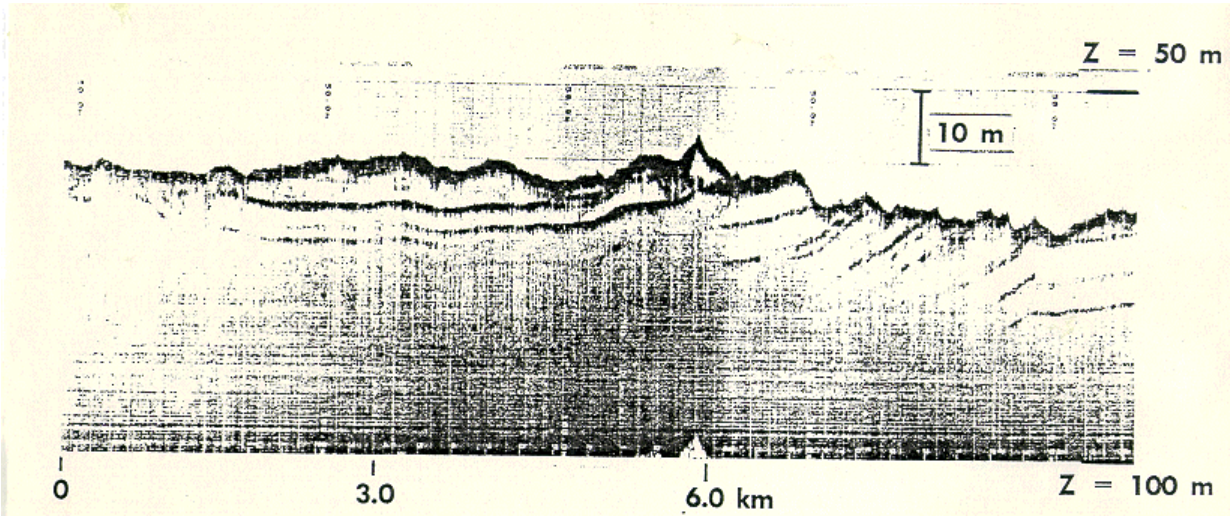


Figure 4-13: Another recording made in the English Channel. It shows Mesozoic layers covered by sand.

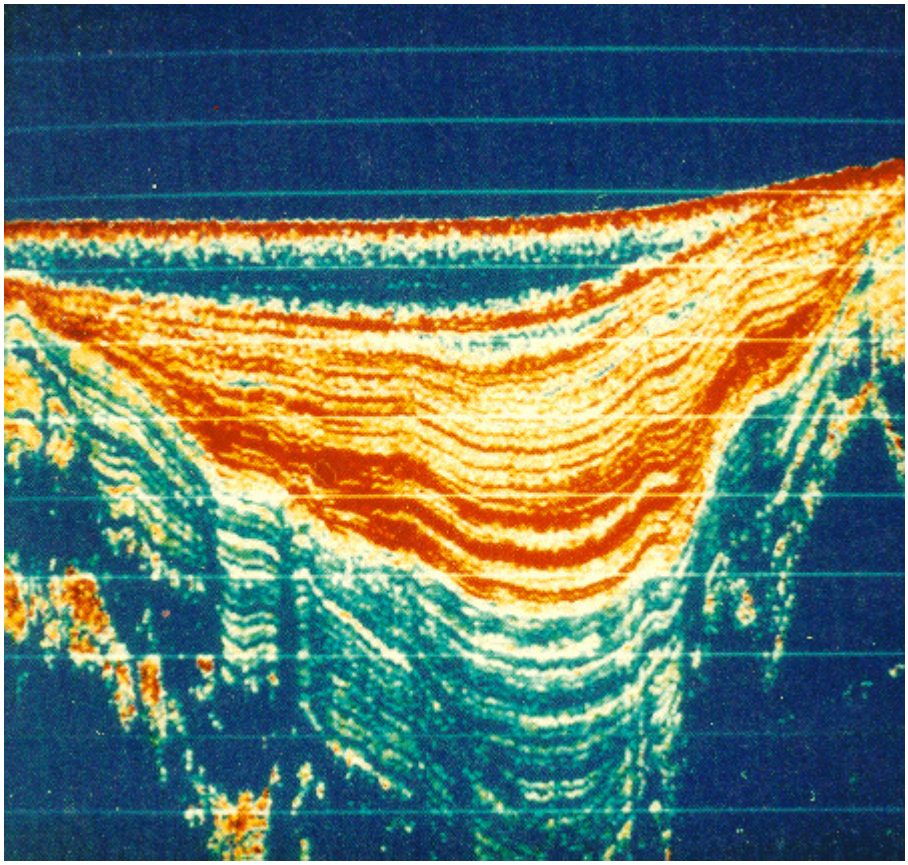


Figure 4-14: Data record showing the excellent sub-bottom profiling capabilities of the ATLAS PARASOUND, reaching down to more than 100 m in the soft sediments off the Norwegian coast.

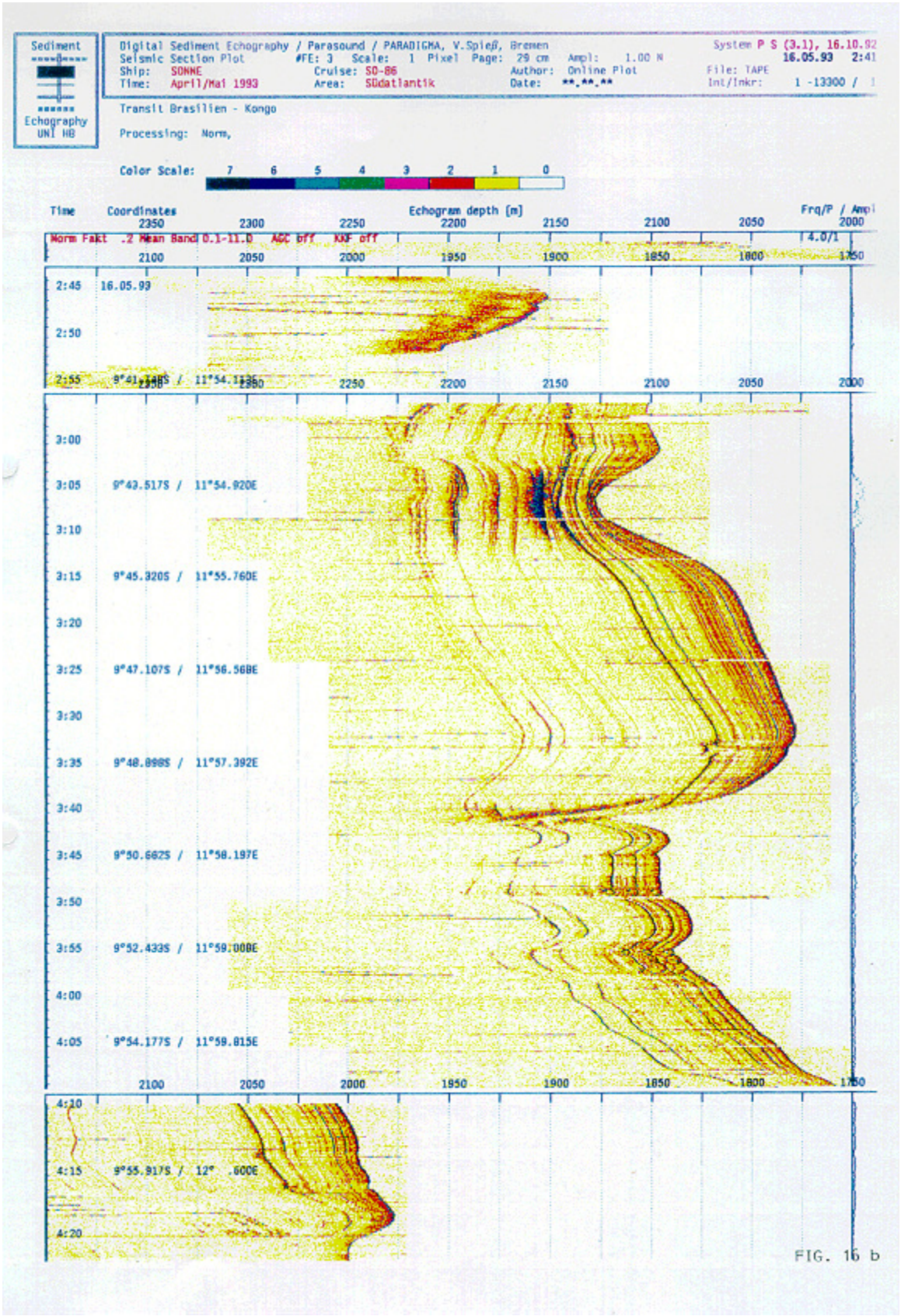


Figure 4-15: Data sample acquired in April/May 1993 by the German research vessel SONNE

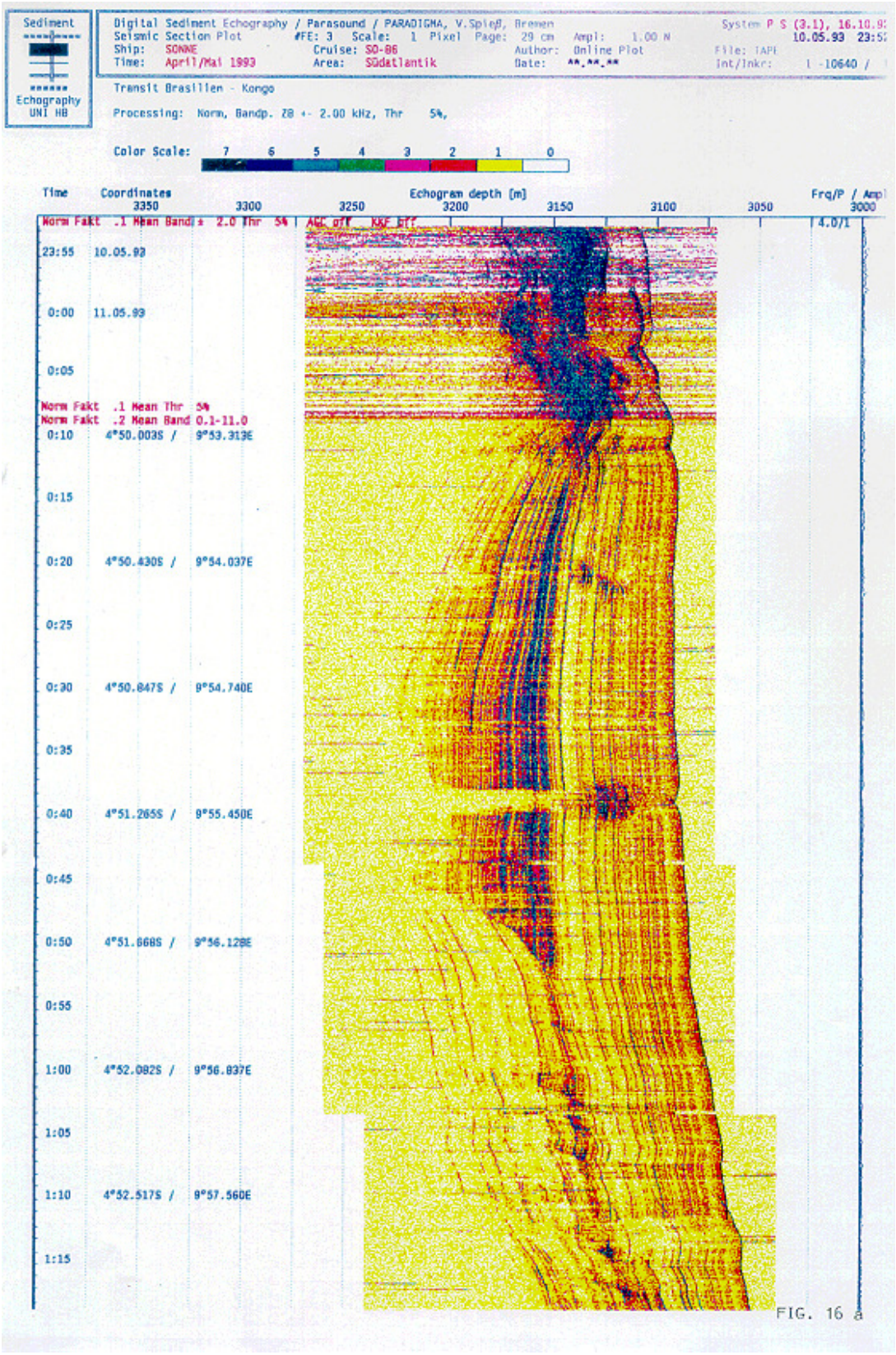


Figure 4-16: Data sample acquired in April/May 1993 by the German research vessel SONNE

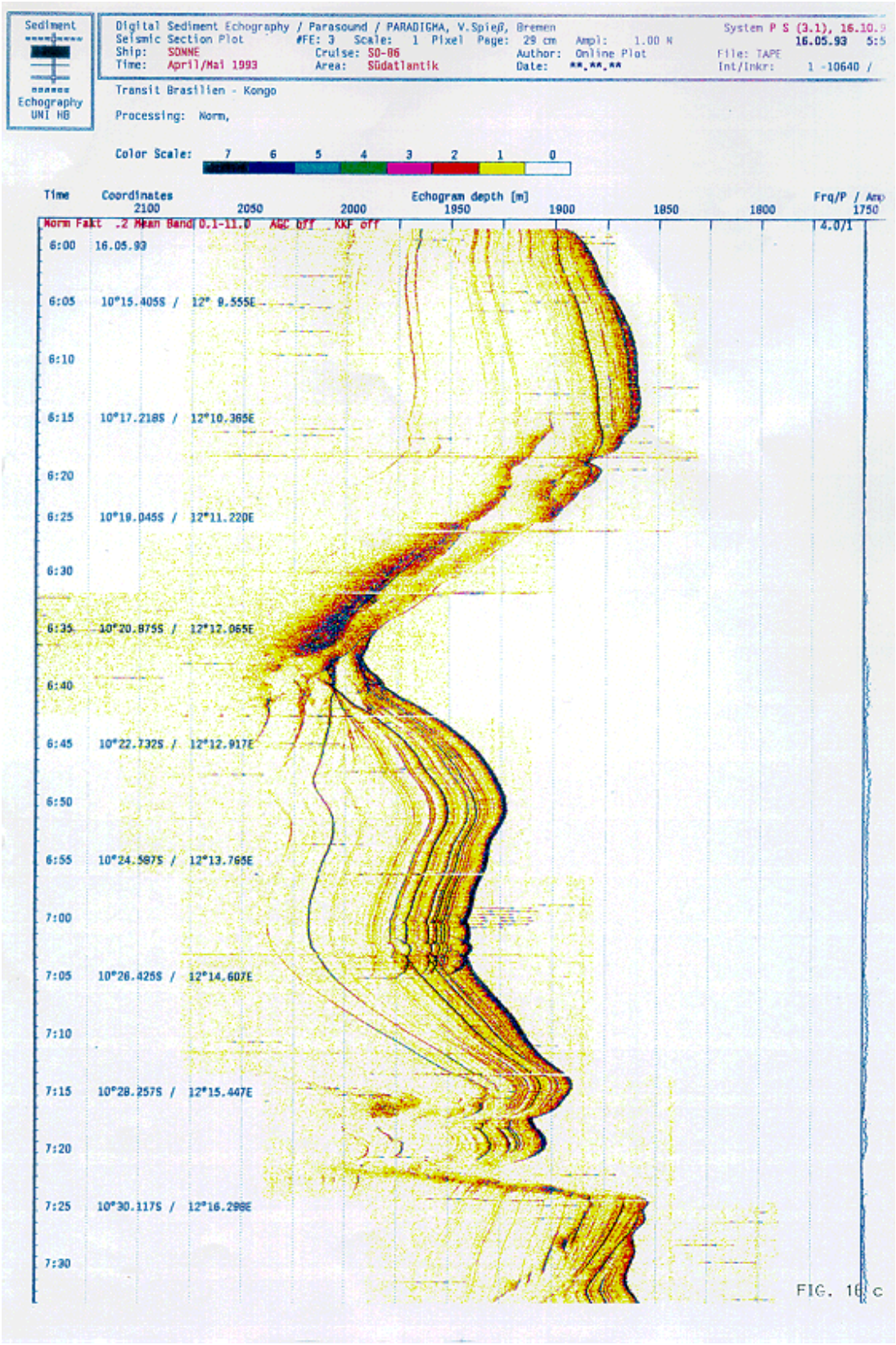


Figure 4-17: Data sample acquired in April/May 1993 by the German research vessel SONNE

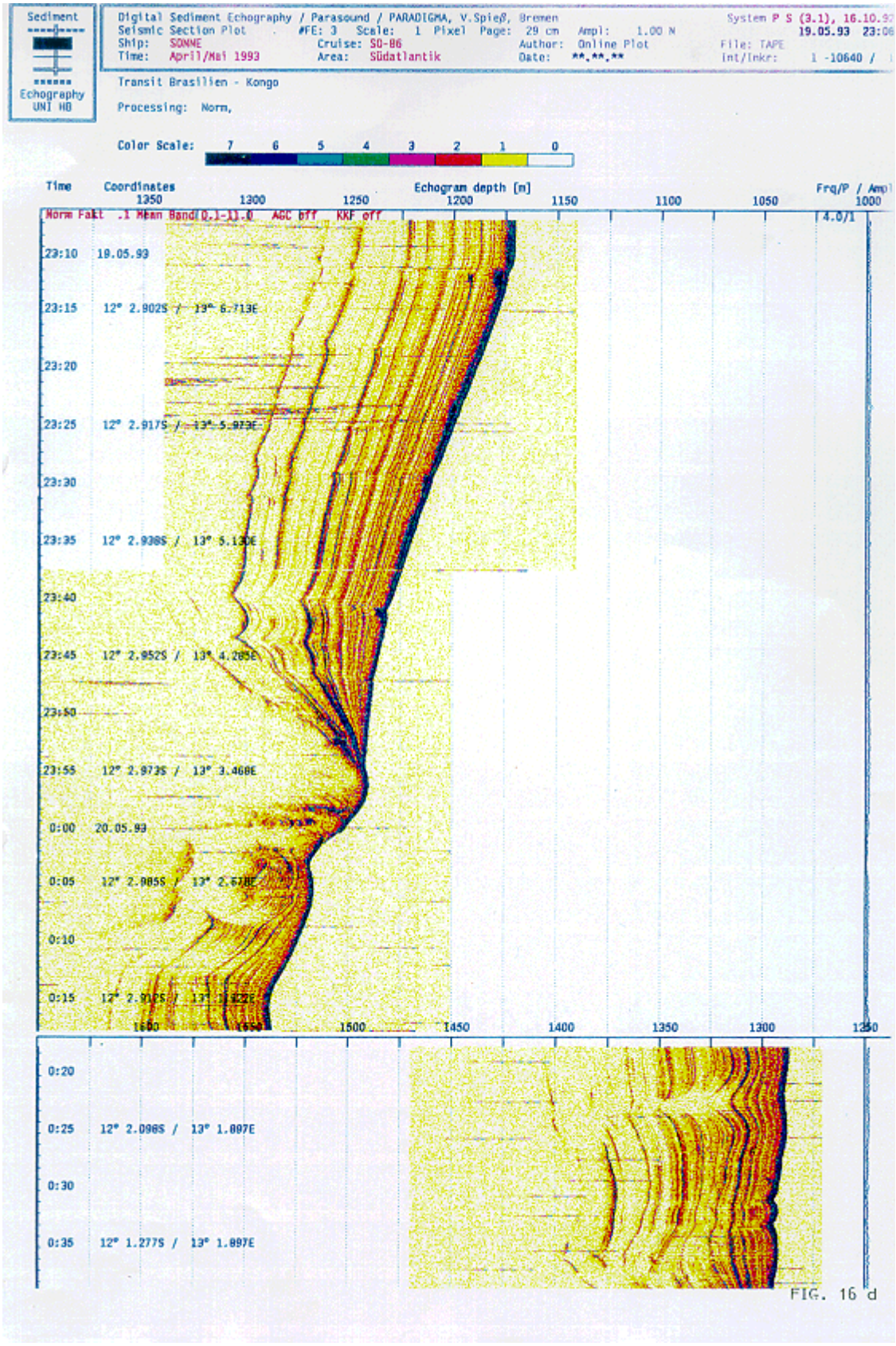


Figure 4-18: Data sample acquired in April/May 1993 by the German research vessel SONNE

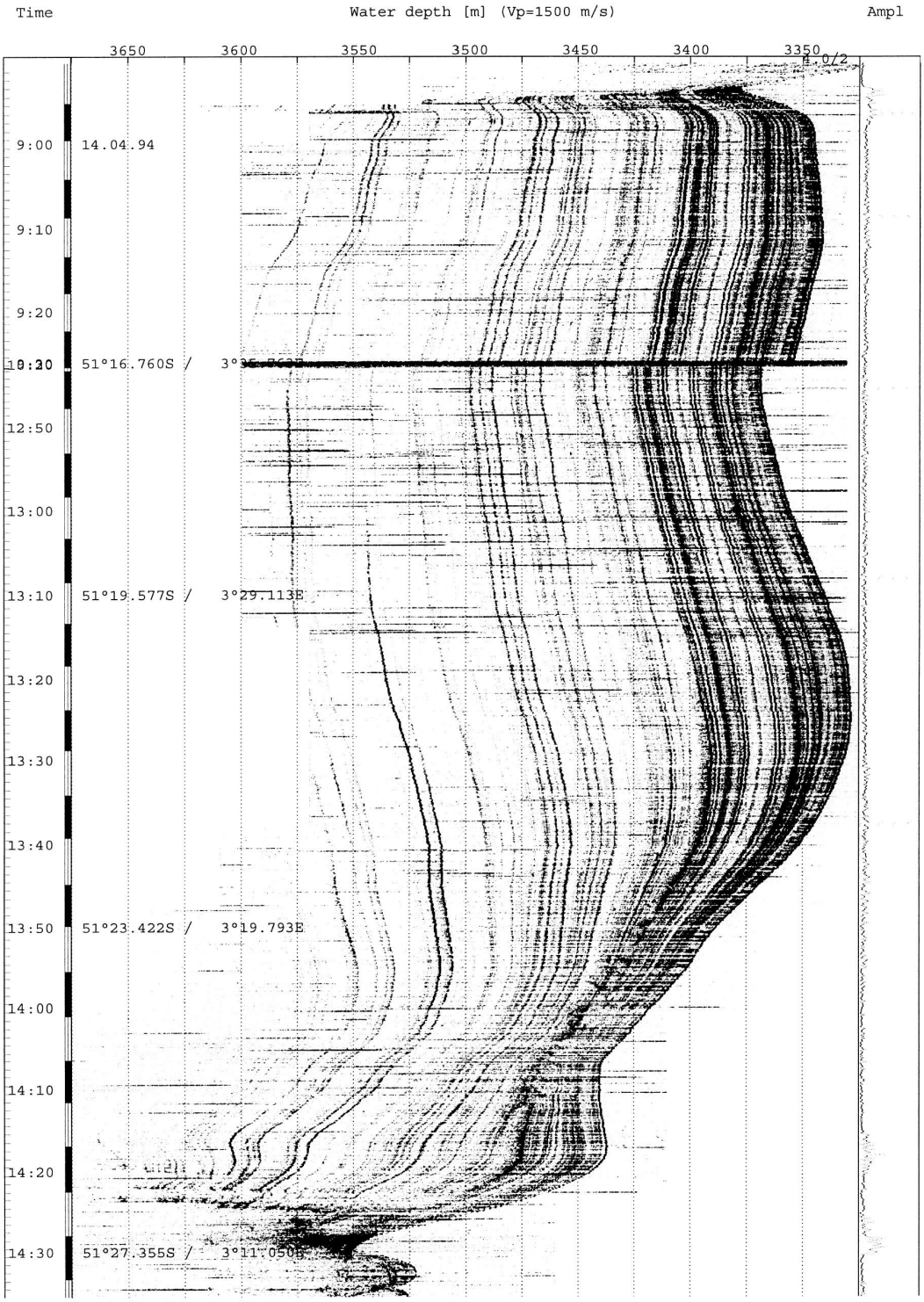


Figure 4-19: ATLAS PARASOUND record, acquired by the German research vessel POLARSTERN

5 Abbreviations

AC	Alternating Current
ACM	AC Module
AEU	Analog Electronic Unit
ASCII	American Standard Code for Information Interchange
ASD	ATLAS Sounding Data
ASLC	Automatic Transmission Source Level Control
ATLAS	ATLAS Hydrographic
ATT	Automatic Transmission Termination
AUV	Autonomous Underwater Vehicle
BITE	Built-in Test Equipment
C	Water sound velocity
CFCM	Cross-Fan Calibration Method
CM	Control Module
CORBA	Common Object Request Broker Architecture
CW	Continuous Wave
C-SBP	Conventional Sub-Bottom Profiling
DCM	Digital Chirp Mode
DEU	Digital Electronic Unit
DIP	Distributed Interface Processor
DSP	Digital Signal Processor
EEZ	Exclusive Economic Zone
FFT	Fast Fourier Transformation
FPGA	Field Programmable Gate Array
GSF	Generic Sensor Format
HOB	High Order Beamforming
HPS	Hydrographic Processing Suite
HVPM	High-Voltage Power Module (converts 230 VAC to 10 …160 VDC)
IAC	Incidence Angle Control
ICU	Interconnection Unit
IHO	International Hydrographic Organisation
ILS	Integrated Logistics and Support

kHz	Kilo Hertz
LAN	Local Area Network
LRU	Lowest Replaceable Unit
LVPM	Low Voltage Power Module (converts 230 VAC to 48 VDC)
LVPS	Low Voltage Power Supply Board
MBES	Multi-beam Echosounder
MFM	Mains Filter Module
NBS	Narrow Beam Sounder
NMEA	National Marine Electronics Association
NTP	Network Time Protocol
OCF	Operation Control Functionality
P35	Product version of the ATLAS PARASOUND with 35 kW pulse transmission power
P70	Product version of the ATLAS PARASOUND with 70 kW pulse transmission power
PHF	Primary High Frequency
PLF	Primary Low Frequency
PS3	Standard data format in the scientific community
P-SBP	Parametric Sub-Bottom Profiling
RCF	Resource Control Functionality
ROV	Remotely Operated Vehicle
RPS	Remote Power Switch
RV	Research Vessel
S/N Ratio	Signal-to-noise ratio
SBES	Single-Beam Echosounder
SBP	Sub-Bottom Profiling
SEG	Society of Exploration Physicists
SEG-Y	Standard Format for Seismic Data
SHF	Secondary High Frequency
SIP	Special Interface Pool Board
SLF	Secondary Low Frequency
SP	Special Publication
SPM	Signal Processing Module
SQL	Structured Query Language
SURF	Sensor-Unified Raw Data Format
SV	Survey Vessel
TBF	Transmission Beamformer

TVG	Time Variable Gain
UPS	Uninterruptible Power Supply
WWM	Whale Warning Mode
XDR	External Data Representation
XML	Extensible Markup Language

6 Delivered ATLAS PARASOUND Systems

Table 6-1: Delivered ATLAS PARASOUND Systems

Vessel	Customer	Country	Delivery Date	System Type
RV SARMIENTO DE GAMBOA	Centro Mediterraneo de Investigaciones Marinas y Ambientales (CMIMA), Vigo	Spain	2006	P35
RV POLARSTERN	Alfred Wegener Institute for Polar Research (AWI), Bremerhaven	Germany	2006	P70
RV METEOR	Federal Ministry for Education and Research	Germany	2006	P70
RV MARIA S MERIAN	Institute for Baltic Sea Research (IOW), Rostock-Warnemünde	Germany	2005	P70
RV POLARSTERN	Alfred Wegener Institute for Polar Research (AWI), Bremerhaven	Germany	2004	DS
AKADEMIK BORIS PETROV	Russian Academy of Sciences (RAS), Moscow	Russia	2002	DS
WFES PLANET	German Navy, Kiel	Germany	2002	DS
HAKUREI MARU II	Metal Mining Agency of Japan, Tokyo	Japan	1994	DS
RV SONNE	Federal Institute for Geosciences and Natural Resources (BGR), Hannover	Germany	1991	DS
RV POLARSTERN	Alfred Wegener Institute for Polar Research (AWI), Bremerhaven	Germany	1989	DS
AKADEMIK JOFFE	Russian Academy of Sciences (RAS), Moscow	Russia	1988	DS

Vessel	Customer	Country	Delivery Date	System Type
AKADEMIK SERGEI VAVILOV	Russian Academy of Sciences (RAS), Moscow	Russia	1987	DS
SV GAUSS	Federal Agency for Maritime Shipping and Hydrography (BSH), Hamburg	Germany	1986	MD
RV METEOR	University of Hamburg	Germany	1986	DS

7 References

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Product Description
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/**3**/ ATLAS Hydrographic GmbH:
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Data Acquisition System
Product Description
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/**4**/ ATLAS Hydrographic GmbH:
ATLAS PARASTORE
Data Acquisition Software for Sediment Profiles and Water Column Profiles
Product Description
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High-Performance Deep-Sea Multi-Beam Echosounder
Product Description
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High-Performance Medium-Depth Multi-Beam Echosounder
Product Description
Bremen (Germany), Doc. No. BL 1050 G 002

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ATLAS HYDROSWEEP MD/50
High-Performance Medium-Depth Multi-Beam Echosounder
Product Description
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8 Issue Notes

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