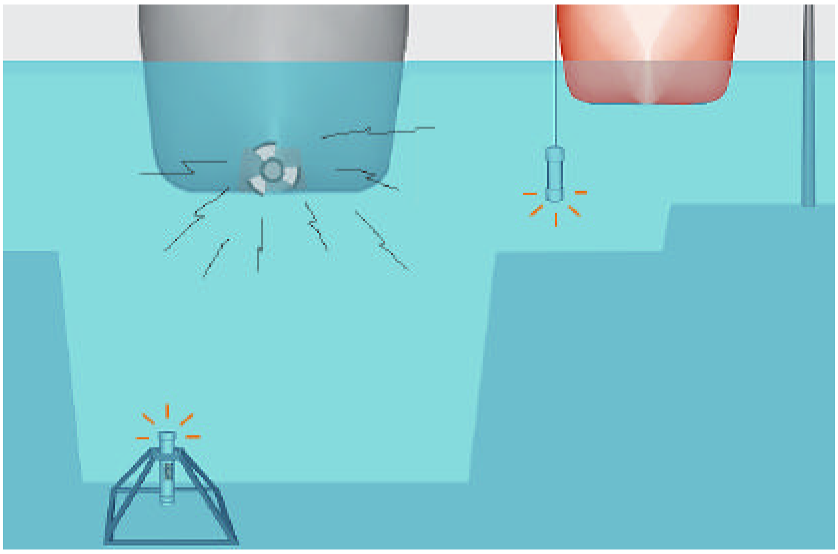
# Measurement plan for the first ACME trial

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# 1 Introduction

## *1.1 The project ACME*

**Title of project :** Acoustic Communication network for Monitoring of underwater Environment in coastal areas (ACME)

**The consortium.** ACME is a collaboration between the following partners: Thomson Marconi Sonar (TMS SAS), Orca Instrumentation, University of Newcastle (UNEW), Rijkswaterstaat (RWS), The Netherlands Organization for Applied Scientific Research (TNO).

**Problems to be solved :** The main challenge of ACME is to enable the continuous monitoring of the coastal underwater environment in areas (shipping lanes, fishing areas, estuaries…) where means of communication other than acoustic are prohibited, e.g. because of the high shipping intensity and/or strong current. These areas pose specifically high demands to the robustness of acoustic communication links, since (a) high intensity close shipping generates a high level of noise and rapidly changing propagation conditions and (b) coastal areas generally involve shallow water multipath propagation channels with high temporal (phase) and spatial variability. In addition, owing to the restricted bandwidth and the condition that an acoustic unit cannot in practice transmit and receive at the same time, particular attention must be paid to the protocol algorithms.

At the end of the project it is expected to verify the value of a robust acoustic communication network by integrating a prototype network within the existing measurement infrastructure in the Westerschelde shipping lane, and to actually monitor the current during a time span of weeks.

**The global objective** of the project ACME is to design robust communication and protocol algorithms, which will be implemented and tested in a prototype of a shallow water acoustic communication network that can be deployed in shipping lanes or other coastal areas where data have to be conveyed acoustically.

The ACME concept will be implemented in a prototype network. During the third and final ACME sea trial that will be conducted in the Westerschelde shipping lane, this prototype network will be integrated within the existing measurement and monitoring infrastructure to demonstrate that it is capable of conveying real-time ADCP current profiles. Monitoring of the current profiles is of paramount importance to safely guide ships towards Antwerp Harbour (Belgium).

**Quantified objectives** related to the above benchmark problem were formulated a priori:

- *Minimum number of modems in the network: 3.*
- *Water depth: 10-60 m.*
- *Typical ranges between modems: 200 m to 2 km.*
- *Bitrates up to 1 kbit/s.*

### *1.2 Goals of the first trial*

The first trial is performed in an early phase of the project. Its main purpose is the acquisition of a data set suitable for an analysis and understanding of the acoustic characteristics of the Westerschelde shipping lane, to provide guidance in the development of reception algorithms in the following stage of the project. To this end, in parallel to the acoustic data, an environmental data set will be collected which allows for the use of propagation simulation programs. The acoustic modems that are used in the first trial are basically off-the-shelf ORCA modems that have been extended with new waveforms for transmission during the trial. No receiver is implemented in the modems for these newly defined waveforms; demodulation will be performed in the laboratory. The performance of the existing transmitter/receiver, based on either FSK or chirp modulation, will also be evaluated during the trial. Since a network layer is absent in this stage of the project, the experiments will be performed in a point-to-point configuration employing only two modems.

The specific objectives of the first trial in the Westerschelde shipping lane are:

1. To determine characteristics of the environment in the Westerschelde shipping lane that influence the performance of an Underwater Acoustic Communication link (noise spectra, frequency shifts and spreading, time spreading).
2. To collect environmental data (sound speed profiles, bathymetry, sediment types) for sound propagation modelling in the laboratory.
3. To determine the usability and limitations of the existing modems in the Westerschelde.
4. To transmit and record a set of newly defined communication signals for laboratory analysis after the trial.

### *1.3 Outline of the measurement plan.*

The outline of the measurement plan is as follows:

- Section 2 briefly describes the existing Rijkswaterstaat measurement infrastructure at the trial location and specifies the measurements which are made on a continuous basis.
- Section 3 gives the global set-up of the configuration and describes the mobile platform and underwater frame that will be used.
- Section 4 gives the global overview of the trial period.
- Section 5 specifies the tracks, moorings and deployments of the underwater frame.
- Section 6 describes the equipment that will be used for the acoustic experiments
- Section 7 gives possible methods to deploy the frame and modems
- Section 8 describes the acoustic experiments that four of the ACME partners, ORCA, TNO, TMS and UNEW have defined.
- Section 9 specifies the environmental measurements (not already routinely done by either the measurement network or the measurement ship).
- Section 10 gives a detailed time-schedule for the experiments during the day.
- Section 11 outlines the data management and dissemination procedures that will be followed, both ACME-internal use and for dissemination to IFREMER.
- Section 12 overviews requests for permission to the responsible authorities and the precautions taken to minimize disturbance to the environment.
- Section 13 lists the main relevant risks and the envisaged backup procedures.
- Section 14 gives operational rules and procedures.
- Section 15 lists the participants involved in the trial, their role, addresses, telephone numbers, etc.

### 1.4 List of abbreviations

| | | |
|---|---|---|
| - | ACME | Acoustic Communication network for Monitoring of underwater Environment in coastal areas |
| - | ADCP | Acoustic Doppler Current Profiler |
| - | AGC | Automatic Gain Control |
| - | AIT | Advanced Intelligent Tape |
| - | CDMA | Code Division Multiple Access |
| - | CTD | Conductivity, Temperature, Depth |
| - | CW | Continuous Wave |
| - | DLT | Digital Linear Tape |
| - | DSP | Digital Signal Processor |
| - | DSSS | Direct Sequence Spread Spectrum |
| - | FSK | Frequency Shift Keying |
| - | GPS | Global Positioning System |
| - | HANS | Measurement pole Hansweert |
| - | IFREMER | Institut francais de recherche pour l'exploitation de la mer |
| - | LFM | Linear Frequency Modulation (chirp) |
| - | LRK | Long Range Kinematic |
| - | MATS | Multimodulation Acoustic Telemetry System |
| - | MET | Middle European Time |
| - | ML | Maximum Length |
| - | MS | Measurement Ship |
| - | NAP | Normaal Amsterdams Peil (average water level) |
| - | NETCDF | NETwork Common Data Form |
| - | PPT | Parts Per Thousand |
| - | PSK | Phase Shift keying |
| - | RAP | Programmable Acoustic Receiver |
| - | RWS | Rijkswaterstaat |
| - | SSP | Sound Speed Profile |
| - | TMS SAS | Thomson Marconi Sonar |
| - | TNO | The Netherlands Organisation for Applied Scientific Research |
| - | UNEW | University of Newcastle |
| - | UTC | Coordinated Universal Time |
| - | ZeGe | Zeeuwse Getijde wateren |

# 2 Measurement Network ZEGE and Measurement pole Hansweert

## *2.1 Measurement Network ZeGe*

The southwestern part of The Netherlands, the province of Zeeland, is shaped by the estuaries of the rivers Rhine, Meuse and Schelde. The area forms the entrance to the ports of Rotterdam, Antwerp and a number of smaller ports. To monitor and manage the water lanes in this area an extensive measurement network has been built. This network is called ZeGe (Zeeuwse Getijde wateren).

The Network ZeGe is property of and maintained by the Directie Zeeland of Rijkswaterstaat. It comprises a number of measurement poles that monitor a range of meteorological and hydrographical parameters. Parameters that are continuously monitored by the Measurement Network ZeGe include:

- Water level
- Wind speed
- Wind direction
- Wave height
- Wave direction
- Salinity

These parameters are obtained every minute and are made available every ten minutes for users of the Network (for special users they are available every minute). The data are archived and historical data are delivered on request. Figure 2.1 gives an overview of the monitoring network.

## *2.2 Measurement Pole Hansweert*

The second and final trial in the Westerschelde shipping lane is foreseen to take place near the Measurement Pole Hansweert (HANS). The ultimate goal of the final trial is to show that by using acoustic communication the functionality of the measurement pole can be extended to ADCP current profile measurements inside the shipping lane. The first trial will be conducted in the same area as the final trial. During this initial trial no equipment will be mounted on the measurement pole. The standard measurements made by HANS (and other relevant data from the measurement network) will be included in the data set for analysis after the trial.

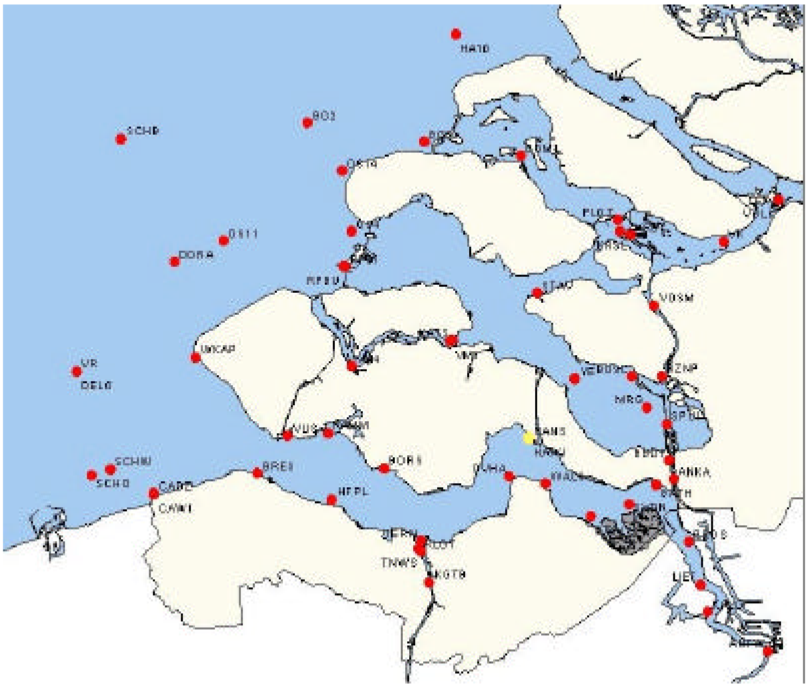

**Figure 2.1. Measurement network ZeGe. Measurement poles are indicated in red, the measurement pole Hansweert (HANS/HWRT) is indicated in yellow.**

The exact location of Measurement Pole Hansweert, indicated in yellow in Figure 2.1, is 51° 26’ 47.509 N, 3° 59’ 55.488 E (58390, 384990 ($x$, $y$) RD). The water depth in the area is 15-18 m re NAP (Normaal Amsterdam Peil, average water level). The depth at the pole is approximately 5 m re NAP, in the main shipping lane ⊃ 25 m re NAP. Tidal variations (from mean) range from -2 m (spring tide low) to 2.5 m (spring tide high). The current measures up to 1.5 m/s outside the main channel and up to 2 m/s inside the main channel. The salinity amounts to 20 ppt on average.

# 3 Global set-up of the trial

## *3.1 Global set-up*

The aim of the *second* trial in the Westerschelde is to demonstrate the functionality of the newly developed acoustic network by conveying data from a bottom mounted ADCP situated inside the shipping lane to a measurement pole. The first trial is preparatory to this experiment. The experimental conditions should therefore resemble the circumstances of the final demonstration trial. Since the modems used for the first trial have no network capability implemented, only two nodes are used: a bottom, frame-mounted modem and a surface unit deployed from a ship.

The surface unit will function as the central command node in a network; it will issue commands to the remote node and record its response. The bottom mounted modem will act as a remote node. During the first trial it will not be connected to an ADCP, but it will transmit predefined signals at request.

## *3.2 Ms Lodycke*

The first trial in the Westerschelde shipping lane will be conducted with the Ms Lodycke. The Ms Lodycke is property of the Meetdienst Zeeland, Directoraat-Generaal Rijkswaterstaat, Directie Zeeland. The ship is used for a wide range of measurement services, and is especially well equipped for detection of wrecks. Among the facilities are a highly accurate positioning system, detection sonar and magnetometer.

**Figure 3.1. Measurement Ship Lodycke.**

During the ACME trial a 20-feet container will be placed on the afterdeck. The container contains working tables and a power supply. The container occupies about half of the afterdeck. The following power supply is available: 220/380 V, 50 Hz, UPS 5kVA stabilized.

Other features of the Lodycke.

Dimensions:
- Length: 25 m
- Width: 7.5 m
- Draught: 2.8 m

Ship data that can be logged via the RS232 port:
- horizontal position (accuracy ≈ 5 cm using LRK system),
- depth (accuracy ≈ 1 dm, frequency of echo sounder: 700 kHz).
- Aquamatic continuous real time sound speed sensor.

The detection sonar on board the Lodycke has a frequency band from 100-500 kHz. Transponders for measuring the position of underwater equipment are available.

### 3.3 Underwater frame

The underwater frame that will be used during the trial is supplied by RWS and has been used before to mount an ADCP, including its battery pack. It will be adapted for use during the first trial.

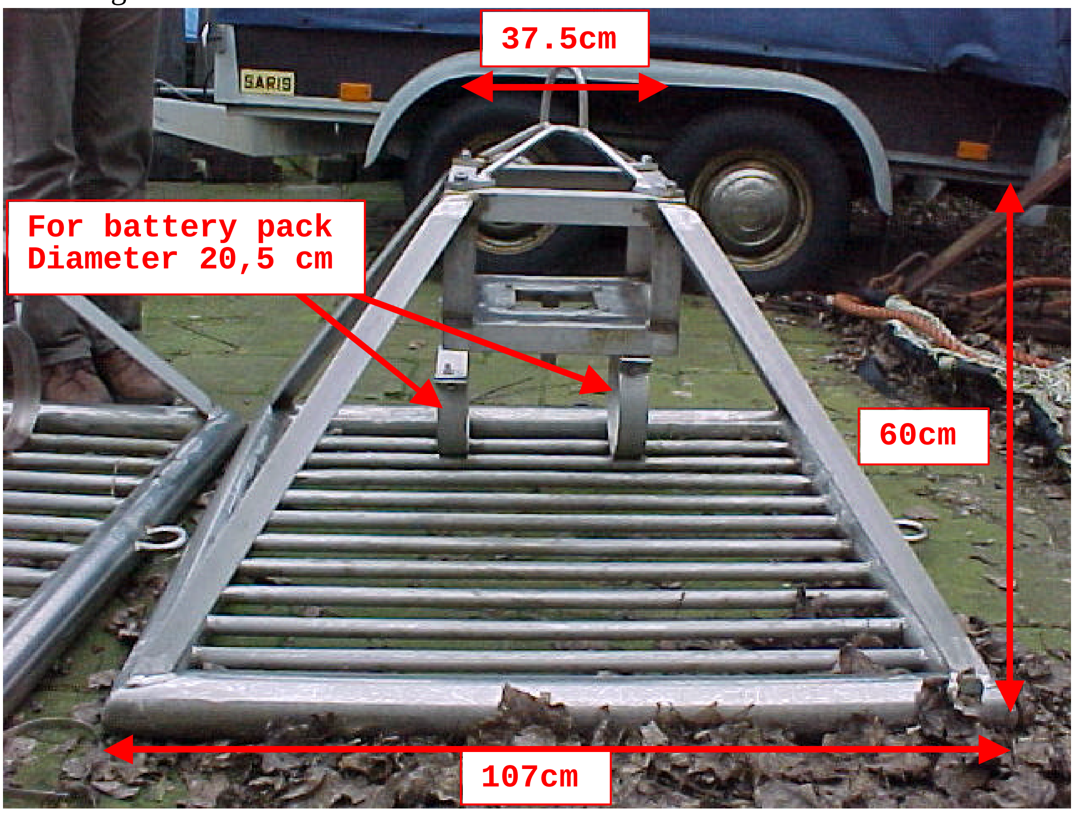


**Figure 3.2. Underwater frame, originally developed for mounting an ADCP.**

The frame will be modified as depicted in Figure 3.3.

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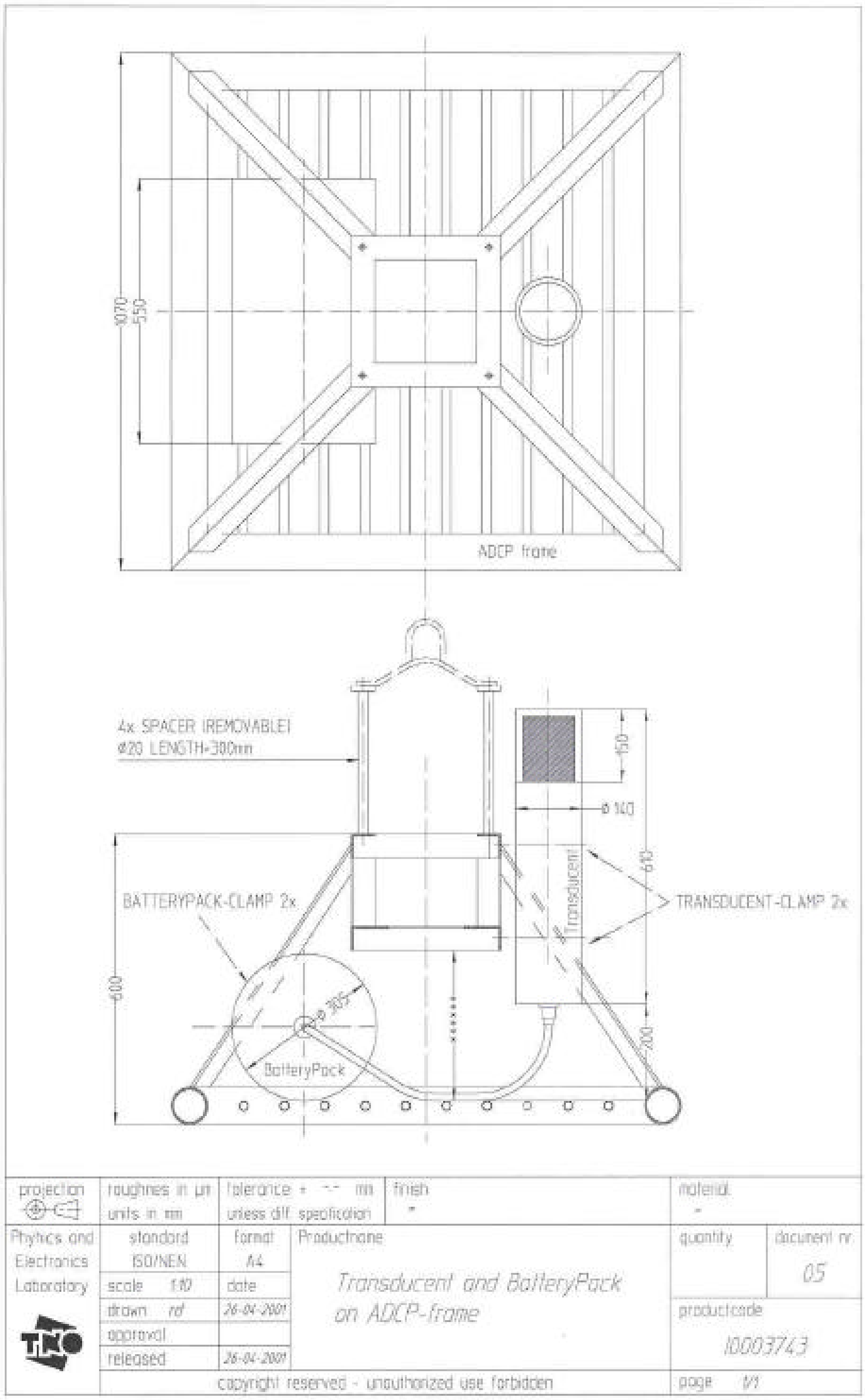


**Figure 3.3. Modifications to the frame to mount the transducer.**

The modem, particularly the transducer head, will be mounted as free from the frame as possible to minimize distortion of the radiation pattern. To better protect the transducer head spacers will be put between the frame and the eye. If these spacers cause too many reflections they can be removed. This will be tested during system integration, on June 12 (see Section 4).

# 4 Global time schedule of the trial

The total trial period, including installation and removal of equipment is from June 11 till June 22.

June 11 and 12 are reserved for installation, integration, and testing of the equipment. This will be done at the Rijkswaterstaat site in Vlissingen. Owing to the tight schedule for the preparation of the trial, it will not be possible to make the integration of the equipment earlier. On June 12, after installation and testing, the integration will be concluded by a short cruise during which

- The deployment of frame is tested,
- The deployment of the central node is tested,
- The noise on the hydrophones is measured,
- Simple communication tests are performed.

June 13 to 15 are devoted to experiments. The aim is to be at sea approximately 8-10 hours per day. The nights will be spent in a hotel. To this end, the Lodycke will return each day to the Rijkswaterstaat site at Hansweert.

June 16 and 17, Saturday and Sunday, are days off.

June 18 to 20 are again devoted to experiments. This brings the total of experimentation days to six.

June 21 can be used as an extra day of experiments in case of mishaps. If this is not necessary, June 21 will be used for removal of equipment.

June 22 is used to remove the equipment from the Lodycke.

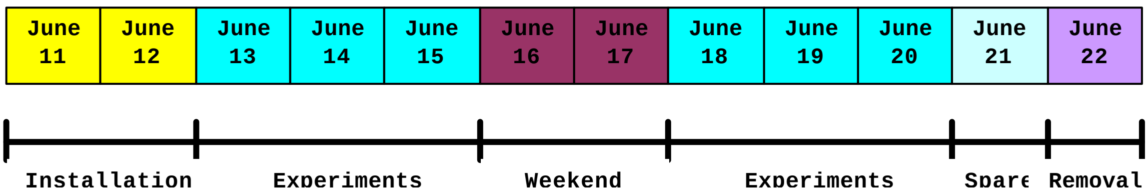


**Figure 4.1. Global time schedule.**

# 5 Tracks and moorings

During the trial, the communication and probe signals will be transmitted over five predefined tracks. Figure 5.1 shows the tracks as well as the foreseen modem positions and ship moorings.

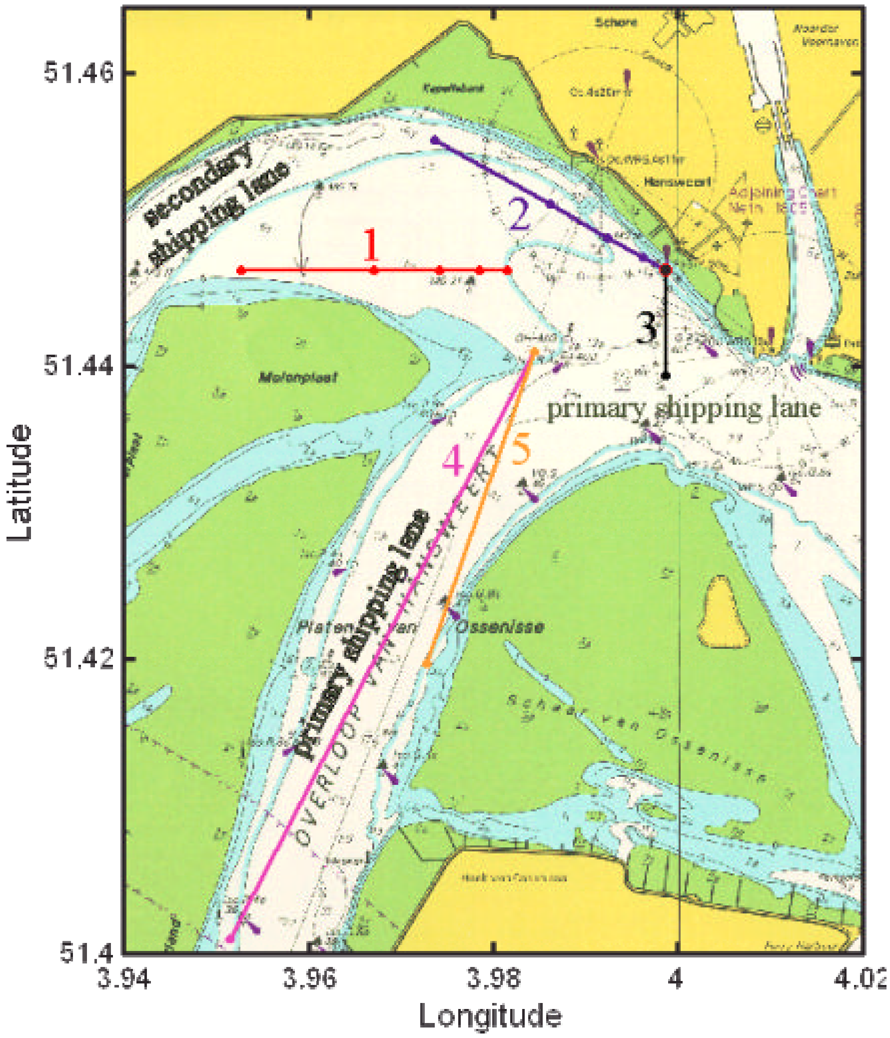


**Figure 5.1. Trial area, tracks and moorings (axes in decimal degrees).**

Track 1 (red) covers a shallow and relatively flat part of the Westerschelde alongside the secondary shipping lane. The purpose is to examine the performance over a flat bathymetry and over various ranges. Track 1 is well suited to test bottom to bottom communication. Since this track is located in a relatively calm area (with respect to shipping), it can be expected that deployment of the underwater frame and anchoring of the ship can be performed without interference.

<table>
<tr><td colspan="2">Modem (lat-long)</td><td colspan="2">Modem ((x, y) RD)</td></tr>
<tr><td colspan="2">51° 26’ 47.5 N  3° 58 53.364 E</td><td colspan="2">57190, 385013</td></tr>
<tr><td>Range ship-modem (m)</td><td colspan="2">Mooring (lat-long)</td><td>Mooring ((x, y) RD)</td></tr>
<tr><td>200</td><td colspan="2">51° 26’ 47.5 N  3° 58’ 43.0 E</td><td>56990, 385017</td></tr>
<tr><td>500</td><td colspan="2">51° 26’ 47.5 N  3° 58’ 27.5 E</td><td>56691, 385023</td></tr>
<tr><td>1000</td><td colspan="2">51° 26’ 47.5 N  3° 58’ 01.6 E</td><td>56191, 385032</td></tr>
<tr><td>2000</td><td colspan="2">51° 26’ 47.5 N  3° 57’ 09.8 E</td><td>55191, 385052</td></tr>
</table>

**Table 5-1. Track 1: Outside the shipping lanes, relatively flat bottom.**

Track 2 (blue) covers large changes in bathymetry. The bottom-mounted unit is deployed near HANS, while the surface unit is deployed from Ms Lodycke at several distances along the track. The goal is to examine the signalling characteristics over a strongly varying bathymetry. The secondary shipping lane is characterized by modest shipping (mainly fishing boats and smaller carriers).

<table>
<tr><td colspan="2">Modem (lat-long)</td><td colspan="2">Modem ((x, y) RD)</td></tr>
<tr><td colspan="2">51° 26’ 47.509 N 3° 59’ 55.488 E<br>Measurement pole Hansweert</td><td colspan="2">58390, 384990</td></tr>
<tr><td>Range ship-modem (m)</td><td colspan="2">Mooring (lat-long)</td><td>Mooring ((x, y) RD)</td></tr>
<tr><td>200</td><td colspan="2">51° 26’ 50.7 N  3° 59’ 46.5 E</td><td>58218, 385092</td></tr>
<tr><td>500</td><td colspan="2">51° 26’ 55.5 N  3° 59’ 33.0 E</td><td>57960, 385245</td></tr>
<tr><td>1000</td><td colspan="2">51° 27’ 03.5 N  3° 59’ 10.5 E</td><td>57530, 385500</td></tr>
<tr><td>2000</td><td colspan="2">51° 27’ 19.4 N  3° 58’ 25.4 E</td><td>56670, 386010</td></tr>
</table>

**Table 5-2. Track 2: Along and in the secondary shipping lane. Large variations in bathymetry.**

Track 3 (black) is a particularly important one. The bottom unit is placed in the centre of the primary shipping lane, while the receiver unit is deployed next to HANS. This track is a test to convey data from the shipping lane upwards to the shore. Since the bottom unit is deployed in the middle of the shipping lane, special attention must be paid to deployment depth (top of the bottom unit must be below 17 m). Track 3 is subject to heavy shipping.

<table>
<tr><td colspan="2">Modem (lat-long)</td><td colspan="2">Modem ((x, y) RD)</td></tr>
<tr><td colspan="2">51° 26’ 21.6 N  3° 59’ 55.5 E</td><td colspan="2">58375, 384190</td></tr>
<tr><td>Range ship-modem (m)</td><td colspan="2">Mooring (lat-long)</td><td>Mooring ((x, y) RD)</td></tr>
<tr><td>800</td><td colspan="2">51° 26’ 47.509 N 3° 59’ 55.488 E<br>Measurement pole Hansweert</td><td>58390, 384990</td></tr>
</table>

**Table 5-3. Track 3: From inside the principal shipping lane to the measurement pole.**

Track 4 (purple) and Track 5 (orange). These tracks allow for transmission in a noisy environment along the principal shipping lane and over long distances. Since the modem is deployed and the ship anchors outside the shipping lane the commercial shipping inside the lane will not be hampered.

| Modem (lat-long) | Modem ((*x*, *y*) RD) |
|---|---|
| 51° 26’ 27.5 N 3° 59’ 04.3 E | 57390, 384390 |

| Range ship-modem (m) | Mooring (lat-long) | Mooring ((*x*, *y*) RD) |
|---|---|---|
| 5000 | 51° 24’ 03.6 N 3° 57’ 05.9 E | 55015, 379990 |
| 2500 | 51° 25’ 10.9 N 3° 58’ 22.6 E | 56538, 382040 |

**Table 5-4. Track 4 and 5: Along and over the principal shipping lane over long(er) ranges.**

Table 5-5 gives the priority of the tracks, which is of importance in case the experiments along a certain track are cancelled owing to, for instance, bad weather.

| Track nr | Reason of priority |
|---|---|
| 1 | Smallest risk, best chance to get useful data |
| 3 | Most realistic |
| 2 | Challenging, but less realistic than Track 3 |
| 4 | Realistic configuration but range exceeds objectives |
| 5 | Realistic configuration but range exceeds objectives |

**Table 5-5. Priority of the tracks, from highest to lowest.**

This priority is tentative. Certainly the first experiments are performed along the first track and the last experiments along track 4 and 5. The order of experiments along tracks 2 and 3 will be decided in consultation with the captain of the Lodycke. Relevant factors are the tide (experiments along track 3 cover a complete tidal period) and the fact that the experimentation time along track 3 will amount to 12 hours.

# 6 Equipment for the acoustic experiments

## *6.1 Global set-up of the acoustic equipment*

The table below gives an overview of the acoustic equipment that will be used during the first trial and who is going to deliver what. Attention has been paid that sufficient backup arrangements have been made and that interdependence between the equipment of ORCA and TNO is minimized. In fact, both partners deliver a complete system capable of performing all (ORCA) or part of (TNO) the experiments. Furthermore, TMS delivers a backup recorder (see also Section 11.2).

| Equipment | Purpose | Supplied by |
|---|---|---|
| MATS modem, surface unit Adapted for experiments. The surface unit is composed of a control unit and a (submerged) transducer. The two parts are connected by a 50 m cable. | Transmission of control signals to bottom mounted unit, reception of requested signals from bottom mounted unit | ORCA |
| Cable (30 m) for connection between control unit and transducer | Spare | ORCA |
| MATS modem, bottom mounted unit, adapted for experiment | Transmission of signal requested by surface unit | ORCA |
| Processor board | Spare | ORCA |
| RAP receiver | Amplifier/filter including monitoring capability | ORCA |
| Reference hydrophone (including cable) | To be connected with RAP, will be mounted next to the transducer | ORCA |
| DAT recorder | Recording of monitoring signal (passed through RAP) and signal passed through receiver modem | ORCA |
| Laptop computer | Control of the MATS surface unit | ORCA |
| Container with battery pack | Power supply for bottom mounted modem | ORCA |
| Container for battery pack | Spare | ORCA |
| MATS modem | Spare surface unit, standard model | TNO |
| MATS modem | Spare, bottom unit, standard model | TNO |
| Spectral analyser | Monitoring (includes pre-amp) | TNO |
| Two hydrophones plus cables | To be connected with spectral analyser, mounted as short array below modem | TNO |
| Multi-channel data-acquisition system (ICS 121 Signal Conditioning board + ICS 130 A/D converter) + | Recording of signal via hydrophones + modem signal (four channels in total) | TNO |

| | | |
|---|---|---|
| PC for controlling and data-storage | | |
| GPS | Timing synchronisation | TNO |
| At least one extra PC with CD writer | Analysis, backup of nonacoustic data | TNO |
| SONY SIR1000 AIT tape-streamer | Backup of acoustic data | TNO |
| DAT recorder | Backup, recording of two hydrophone signals | TMS |
| Laptop computer | Analysis | TMS |

**Table 6-1. Overview of equipment for the acoustic experiments.**

The two TNO hydrophone will be mounted below the modem and thus form a miniature array. A third hydrophone, supplied by ORCA, will be used for monitoring and reference purposes. It will be mounted on the modem to ensure that the unprocessed raw signal is recorded (the signal received by the modem itself is passed through a variable-gain amplifier). The hydrophone signal will be passed through the RAP, which allows real time monitoring. All three hydrophone signals and the (unprocessed) output from the modem will be recorded. The output of the modem (processed data) will also be logged.

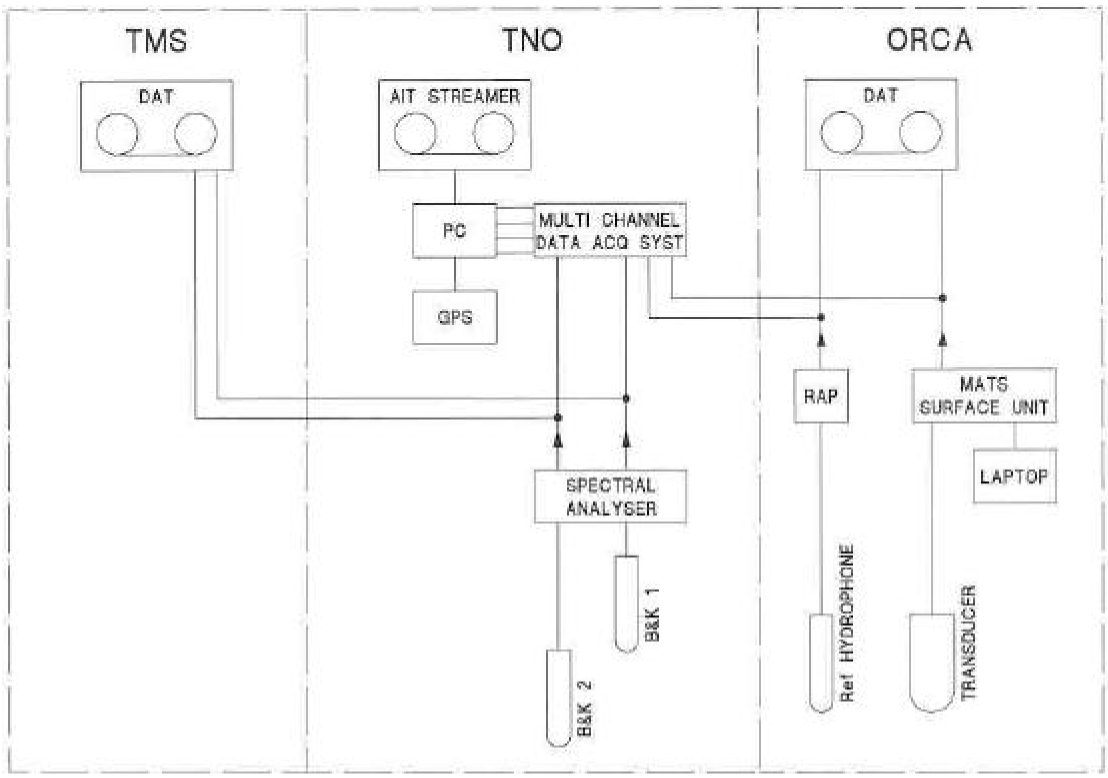


**Figure 6.1. Overview of equipment for the acoustic experiments**

## *6.2 Characteristics of the main pieces of equipment*

### 6.2.1 ORCA equipment

Figure 6.2 gives a detailed overview of the ORCA equipment.

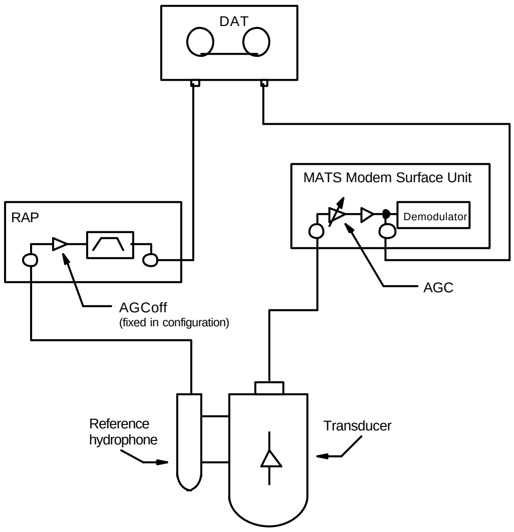


**Figure 6.2. Detailed overview of ORCA equipment.**

As can be seen, the signal passed through the modem will be captured after the AGC and before the demodulator. The figure also shows that the ORCA will be mounted on the modem.

#### 6.2.1.1 Acoustic modems

The two modems, one surface unit and one bottom unit form the heart of the acoustic equipment. The main difference between the two modems is that the transducer is physically separated from the signal processing unit (DSP). The signal processing unit is contained in a separate surface unit (see also Figure 6.2). Table 6-2 tabulates the most important modem features. Note that dedicated signals, defined by the ACME partners, are transmitted during the trial. These signals are not included in Table 6-2.

| | |
|---|---|
| Frequency band | 10 – 14 kHz |
| Implemented modulations | CHIRP – MFSK |
| Digital rate | CHIRP: 20 bit/s with coding<br>MFSK: from 100 to 200 bit/s with coding |
| Error correction | Included |
| Technology | Based on micro-controller and DSP.<br>Fixed point DSP TMS320C5416 (160 Mips) |
| On board memory | In Flash : 1MWords.<br>In RAM : 16 kWords. |
| Sample frequency | Programmable |
| Consumption | At emission: 3.5 A / 24 V at 185 dB re 1 µ Pa @ 1m.<br>At reception: 80 mA / 24 V.<br>1 mA / 24 V (idle mode) |
| Acoustic source level | 185 dB (see Figure 6.3), 179 dB, 173 dB |
| Transducer diagram | Omnidirectional |
| Dimensions (D*L) | 140x610 mm |
| Weight in air (water) | 9 kg (3.5 kg) |

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| | |
|---|---|
| Cable length | 50 m |
| I/O connectors | One plug for external power (24 V DC).<br>One plug for host equipment (serial interface type RS 232) |

**Table 6-2. Main characteristics of the acoustic modem**

The maximum (spectral) source level is given in Figure 6.3.

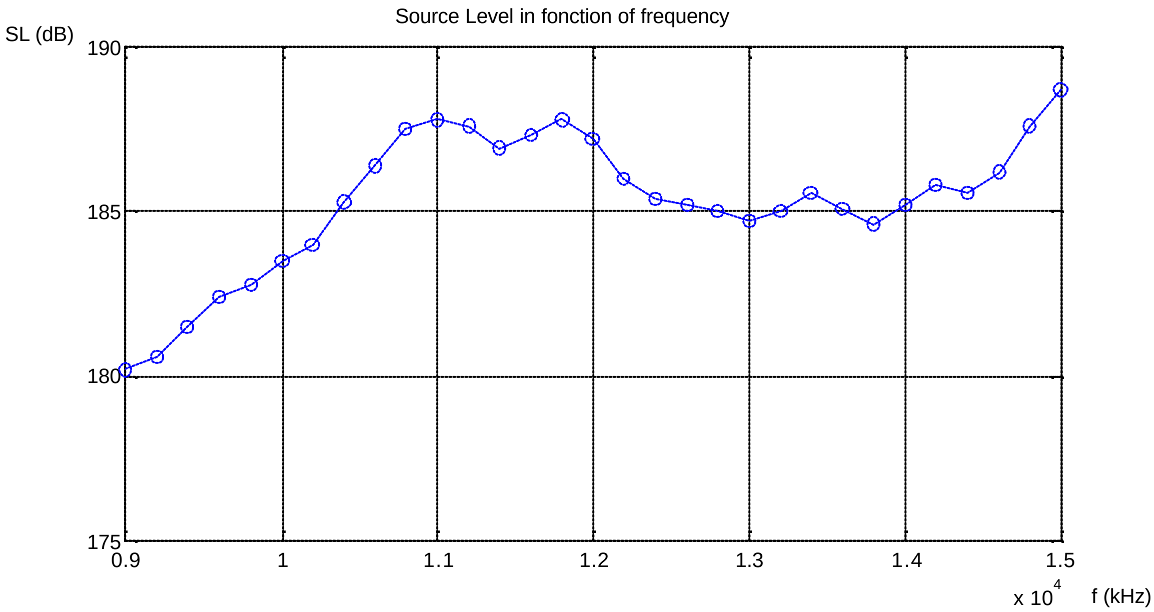


**Figure 6.3. Source level as function of frequency.**

### 6.2.1.2 Reference hydrophone and RAP receiver

The RAP receiver is a compact, integrated signal conditioning and monitoring tool. Signal conditioning includes preamplification and filtering. Monitoring can be done audibly.

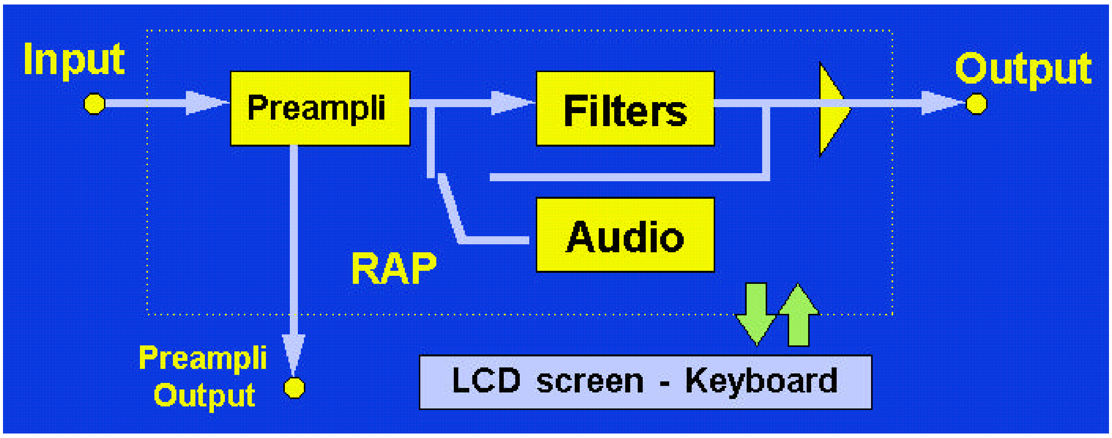


**Figure 6.4. RAP receiver**

The module PREAMPLI (100 kHz bandwidth) includes a preamplifier (0-60 dB programmable gain) and a selective AGC (Automatic Gain Control). The AGC will be turned off for the experiments. The AUDIO module allows the operator to listen to signals using the built-in loudspeaker.
Several types of filters are installed inside the FILTER module:

- Two 8th order high-pass filters in cascade
- Two 8th order low-pas filters in cascade
- One Notch filter with a 60 dB rejection rate
- Cut-off frequency of all filters is programmable with 100 Hz resolution.
- When all filters are "OFF", the RAP is used as a receiver-amplifier.

The main characteristics of the hydrophone associated with the RAP are summarized below:

- Voltage sensitivity -200 dB re 1V/µPa (not recently calibrated)
- Omni-directional
- Flat frequency response between 2 Hz and 30 kHz

#### 6.2.1.3 ORCA DAT recorder[1]

The DAT recorder will mainly be used as a backup for the TNO digitization and storage equipment. The two-channel recorder will be used to record the signal from the MATS modem and the signal from the ORCA reference hydrophone.

### 6.2.2 TNO equipment

#### 6.2.2.1 Two hydrophones plus Spectral analyser

A second system is supplied by TNO and is composed of two B&K hydrophones and a spectral analyser. The two hydrophones will be mounted at 1.5 m and 3.0 m below the acoustic modem (See Section 7.1). The main specifications of the hydrophones are:

- Hydrophone 1: Type B&K 8101, Serial number 783889
- Voltage sensitivity –183.9 dB re 1V/µPa
- Calibration date March 15, 2000
- Omnidirectional
- Flat frequency response between 0 and 50 kHz

- Hydrophone 2: Type B&K 8101, Serial number 1290461
- Voltage sensitivity –184.3 dB re 1V/µPa
- Calibration date March 15, 2000
- Omnidirectional
- Flat frequency response between 0 and 50 kHz

The hydrophones are connected to a spectral analyser that allows for a variety of real time analyses:

- Type B&K 2035
- Frequency range 0-100 kHz
- Two input channels
- Wide range of analyses (e.g. power averaging, time signal, selective band filtering)
- Output range 3 Vpp
- Calibration date March 30, 2000

[1] A second DAT recorder will be supplied by TMS. This one will record the signals coming from the two B&K hydrophones. See also the section on data management.

#### 6.2.2.2 TNO multichannel digitization device

The multichannel digitisation device is a flexible programmable device that digitizes and stores directly on hard disk. The device is composed of three separate boards:

- A signal conditioning board (for amplification/attenuation of the incoming signal)
- An A/D converter for digitization
- An interface for communication with a PC

The number of input channels, the sample frequency and the number of samples per recording can be programmed. The maximum number of input channels is 32 and the maximum sample frequency is 1.2 MHz. At the highest sampling rate it is not possible to record and store continuously. Continuous recording will be possible for the sample frequency and number of input channels needed for the ACME trial.

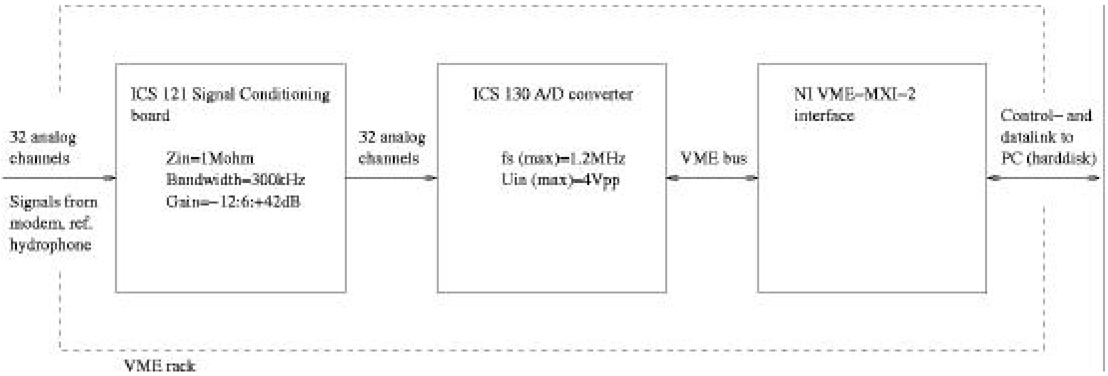


**Figure 6.5. TNO multichannel digitization device.**

During the trial the data acquisition system will be used with a sampling frequency of 48 kHz, which is sufficient for signals in the 10-14 kHz band. Four input channels will be recorded.

Specifications of the data acquisition system in the configuration that will be used during the trial are:

- Four input channels
- Input impedance signal conditioning board 1 Mohm
- Full Scale Input: 16 Vpp
- Programmable gain: -12 dB to + 42 dB in steps of 6 dB
- Sample frequency 48 kHz
- 16 bit A/D conversion
- Signal/(Noise+Distortion+Crosstalk) > 80 dB
- Flat response between 0-18.4 kHz
- -3dB point low-pass filter 22.9 kHz
- Continuous storage on hard disk in binary format
- MATLAB software to import data available

# 7 Deployment of the equipment

This Section outlines the deployment of the (central) modem from MS Lodycke. It also discusses the deployment of the frame on the bottom of a shipping lane.

## *7.1 Deployment of the surface modem*

The transducer of the surface modem will be deployed using a float (subsurface buoy) and a weight on the bottom. The weight will be lowered by a separate cable that can be led to the Lodycke via the bottom (best way to deploy the weight will be decided by the crew of the Lodycke). The float will be connected to the mounting frame of the modem. The signal cables will be led to the ship via the surface. The modem will be mounted at approximately 4 m above the bottom, together with the ORCA reference hydrophone. Below the transducer the two B&K hydrophones will be mounted at 1m, respectively 2.5 m above the bottom. Note that the deployment depth of the lowest hydrophone corresponds to the depth of a bottom-mounted modem. The deployment depth of the transducer corresponds to the depth of a modem mounted on measurement pole Hansweert (similar to the second ACME trial in the Westerschelde). The total construction should not exceed a length of approximately 6 m when deployed near measurement pole Hansweert. Upon deployment in deeper water the cable between the float and the mounting frame of the transducer will be extended, if necessary.

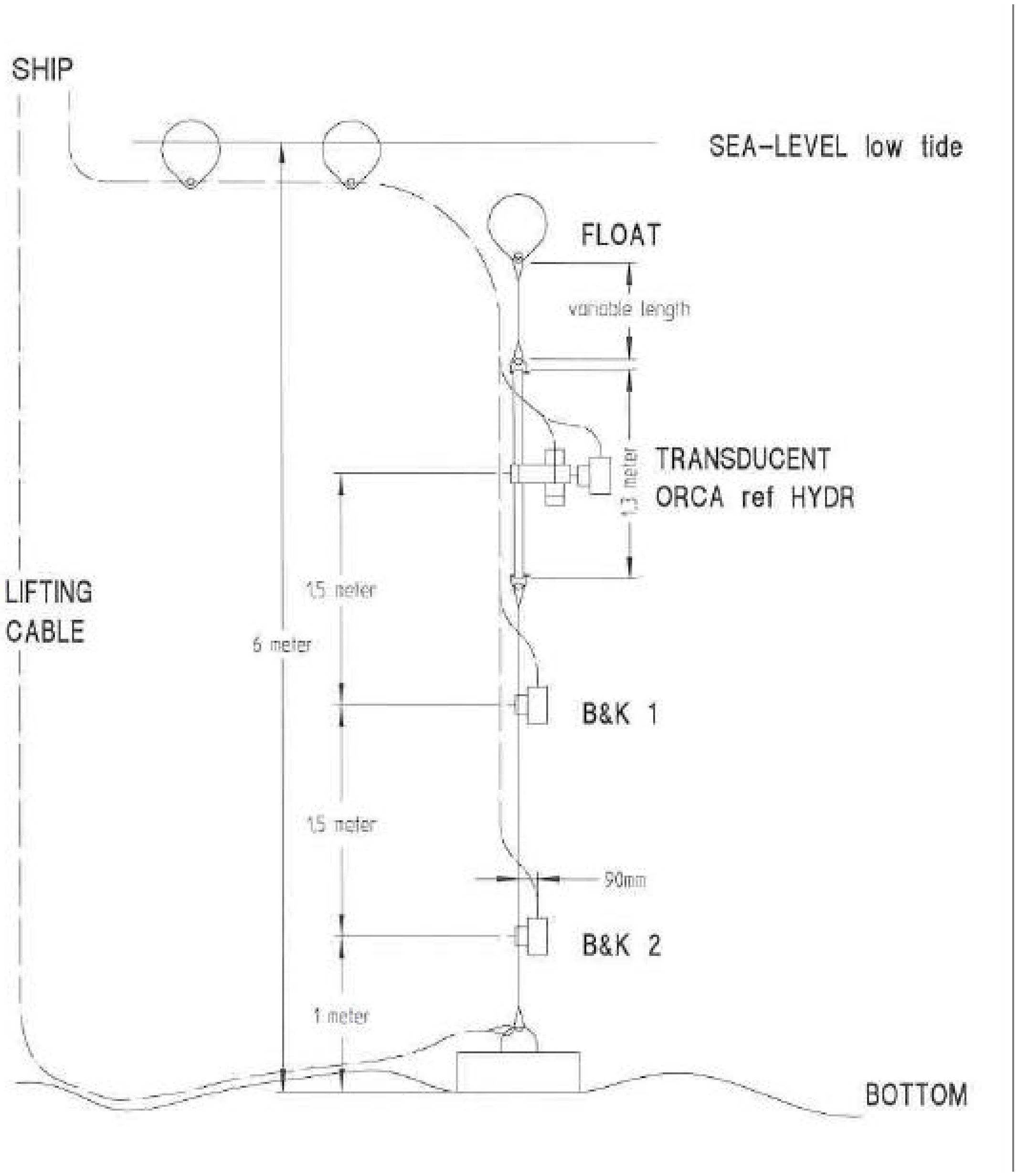


**Figure 7.1. Deployment of the wet part of the central node.**

| Equipment | Supplied by |
|---|---|
| Transducer connected to MATS surface unit | ORCA |
| Signal cable between surface unit and transducer (50 m) | ORCA |
| Mounting frame for transducer | ORCA |
| Reference hydrophone | ORCA |
| Signal cable for reference hydrophone (50 m) | ORCA |
| Connection to mount hydrophone near transducer | ORCA |
| Two B&K hydrophones | TNO |
| Signal cables for B&K hydrophones (50 m minimum) | TNO |
| Float and buoys | RWS |
| Weight | RWS |
| Cables | RWS |

**Table 7-1. Who supplies what for the wet part of the central node**

Figure 7.2 shows the mounting frame of the transducer. This frame will be supplied by ORCA.

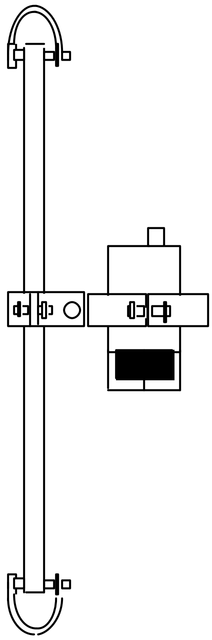

**Figure 7.2. Mounting frame for transducer.**

### *7.2 Deployment of the frame*

The best deployment method of the frame will be decided upon by the crew of MS Lodycke, which is very experienced with deployment of underwater frames. A problem that has to be overcome with the deployment and recovery of the frame inside the shipping lane is the fact that no buoys are allowed inside the lane. A possible solution is to place the buoy outside the shipping lane, and to attach it to the frame with a cable. This is depicted in Figure 7.3.

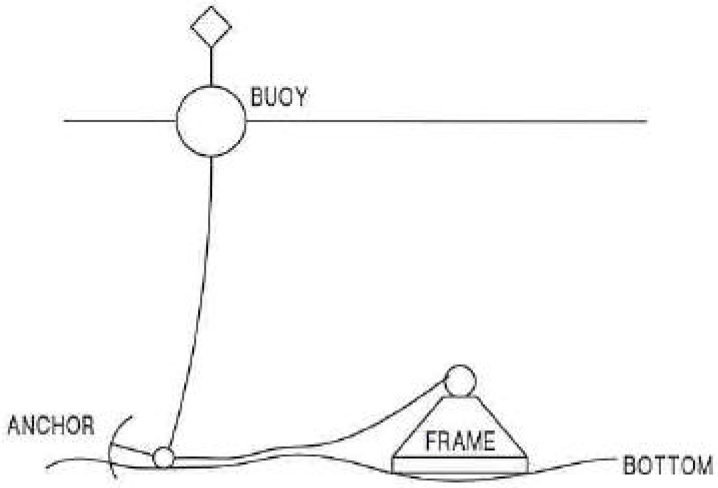


**Figure 7.3. Deployment of frame inside shipping lane.**

Another option is to mount an acoustic release on the frame. The crew of the Lodycke will decide upon the best solution.

| **Equipment** | **Supplied by** |
|---|---|
| Frame | RWS |
| Acoustic release | RWS |
| Anchor, cables, buoy | RWS |
| Modem + battery pack + connecting cable + spare cable | ORCA |

**Table 7-2. Who supplies what for the remote node**

# 8 Overview of the acoustic experiments

Four partners have defined acoustic experiments: ORCA, TNO, TMS and UNEW. An experiment consists of the transmission of a predefined sequence of signals by the bottom-mounted modem, which are recorded after reception on board the ship. Transmission of a sequence is commanded by the surface modems. All experiments have a unique name (for logging the experiments using the form given in Appendix B) and a unique tag known by the remote modem. The definitions of the acoustic experiments are described below.

## *8.1 Experiments defined by ORCA*

The ORCA modem has the capability to quickly assess the acoustic environment by means of standard tests. Moreover it can perform tests to make a first assessment of the performance of its standard waveforms and processing algorithms. These include chirp modulation with bit rate 20 bit/s, and MFSK modulations with bit rates of 100 bit/s and of 200 bit/s. The performance of the different communication methods can be assessed for different source levels. The SNR is automatically estimated upon performing standard communication test (i.e. when the modems operate in dedicated test mode).

| Experiment | Time duration [s] | Remark | Name (for logging form) |
|---|---|---|---|
| Measurement of time spread | 8 | | ORCA1 |
| Noise measurement | 2 (surface modem) | | ORCA2 |
| | 16 (seabed modem) | | ORCA3 |
| Chirp | 124 (seabed to surface) | Per test, multiply by three if tested at three different source levels. | ORCA4 |
| | 131 (surface to seabed) | | ORCA5 |
| MFSK (100 bit/s) | 32 (seabed to surface) | Same remark as for chirp | ORCA6 |
| | 39 (surface to seabed) | | ORCA7 |
| MFSK (200 bit/s) | 22 (seabed to surface) | Same remark as for chirp | ORCA8 |
| | 29 (surface to seabed) | | ORCA9 |

**Table 8-1. Overview of ORCA experiments.**

Remark 1: The above time durations include an estimate for the propagation time. For this purpose the modems are assumed ~ 1 km apart.
Remark 2: One more remote control (in chirp modulation: 20 bit/s) is needed to request the seabed modem to return the results of the measurements (SNR, number of bit errors).

The total time for the above experiments is about 20 minutes, on the assumption that the communication experiments are performed at three different source levels.

## *8.2 Experiments defined by TNO*

The experiments that are defined by TNO have the aim to be able to characterise and understand the acoustic properties of the trial area as encountered during the trial.

These properties will be determined after the trial by analysis of the acoustic and environmental data. Quantities to be determined are:

- Noise spectral levels
- Time spread
- Doppler shifts
- Doppler spread
- Variability, at time scales of hours, minutes, and seconds

Moreover, a set of communication signals will be transmitted. The signals and recordings are grouped into four experiments. Table 8-2 gives an overview. The total time for the four experiments is about 15 minutes. The first two experiments (noise measurement and transmission of LFM and CW) are repeated every 20 minutes.

| **Experiment** | **Total duration [s]** | **Purpose** | **Name (for logging form)** |
|---|---|---|---|
| Noise measurement (38 s) | 38 | Measurement of noise spectrum | TNO0 |
| LFM (2 s), silence (10 s), CW (10 s) | 22 | Determination of multipath, reverberation level, frequency spread, and variability (time scale quarter of an hour-hours) | TNO1 |
| LFM (2 s), silence (13 s) repeated 40 times | 600 | Determination of variability (time scale 15 sec – 10 min) | TNO2 |
| Communication signals:<br>3 s between signals<br>• Repeated ML seq. (25,5 s)<br>• BPSK signal (3,2 s)<br>• Five DSSS signals (different ML lengths) | 150<br>(a bit less) | Determination of variability (time scale (0.2 s – seconds))<br>Test high bit rate<br>Test performance of robust DSSS signals with different bit rates | TNO3 |

**Table 8-2. Definition of TNO experiments**

## *8.3 Experiments defined by TMS*

Two sets of experiments have been defined by TMS SAS:

**Block A: CDMA**

First experiment aims at assessing whether signalling scheme studied within previous MAST project ROBLINKS can be used within the context of ACME. This signalling scheme is based upon orthogonal sequences (Oppermann sequences) and has been extended to allow simultaneous transmission by several users (CDMA, 1 to 4 users).

A set of four different communication signals has been defined corresponding to different bitrates (from 150 to 300 bit/s per user) and number of simultaneous users. Transmission of this set of communication signals will be preceded by transmission of a header (CW + FM pulse), suited to probe the acoustic channel. Moreover transmission will be repeated two or four times for each transmitter location (in order to acquire signals from different users). Recorded received signals corresponding to different transmitting users will be added off-line before analysis in order to assess capability to retrieved data transmitted by different users.

| | **bitrate** | **Duration (sec)** | |
|---|---|---|---|
| Header (CW+FM pulses) | | 100 | |
| CDMA 1 | 298.5 x 2 | 70 (signal=60 + pause=10) | User 1 |
| CDMA 2 | 183.2 x 2 | 70 (signal=60 + pause=10) | User 1 |
| CDMA 3 | 305.3 x 2 | 70 (signal=60 + pause=10) | User 1 |
| CDMA 4 | 146.0 x 4 | 70 (signal=60 + pause=10) | User 1 |
| CDMA 4 | 146.0 x 4 | 70 (signal=60 + pause=10) | User 3 |
| CDMA 1 | 298.5 x 2 | 70 (signal=60 + pause=10) | User 2 |
| CDMA 2 | 183.2 x 2 | 70 (signal=60 + pause=10) | User 2 |
| CDMA 3 | 305.3 x 2 | 70 (signal=60 + pause=10) | User 2 |
| CDMA 4 | 146.0 x 4 | 70 (signal=60 + pause=10) | User 2 |
| CDMA 4 | 146.0 x 4 | 60 (signal=60, no pause) | User 4 |

**Table 8-3. Block A: CDMA signals**

Total duration block A: 790 seconds (=100 + 9x70 + 60)

**Block B: FSK**

Second experiment aims at assessing performance a simple FSK modulation, with frequency hopping.

| | **bitrate** | **Duration (sec)** |
|---|---|---|
| Header (CW+FM pulses) | | 100 |
| FSK 1 | 750 | 70 (signal=60 + pause=10) |
| FSK 2 | 562 | 70 (signal=60 + pause=10) |
| FSK 3 | 469 | 70 (signal=60 + pause=10) |
| FSK 4 | 375 | 70 (signal=60 + pause=10) |
| FSK 5 | 281 | 70 (signal=60 + pause=10) |
| FSK 6 | 234 | 60 (signal=60 ; no pause) |

**Table 8-4. Block B: FSK signals**

Total duration block B: 510 seconds

The Table below summarizes the TMS experiments.

| **Experiment** | **Total duration [s]** | **Purpose** | **Name (for logging form)** |
|---|---|---|---|
| Block A | 790 | CDMA signals | TMS1 |
| Block B | 510 | FSK signals | TMS2 |

**Table 8-5. Summary of TMS experiments**

### 8.4 Experiments defined by UNEW

The part of the experiment defined by UNEW is intended to investigate how well techniques developed in earlier projects, can transfer to the circumstances that exist in the ACME sea trials. Earlier work in this field, which has demonstrated the successful operation of sub-sea-communications, has used multi-element receivers, and has relied on diversity to a greater or lesser extent. The ACME receiver uses only a single element and thus diversity techniques cannot be applied. With a view to use in future networks, where several transmitters will be used, CDMA signals will be transmitted. The efficacy of different length spreading codes will be investigated, longer spreading codes than used in earlier experiments will be applied in an attempt to compensate for the reduction in receive element separation. For some single same length but different codes will be applied. These will be mixed off-line during post-experiment analysis in order to simulate a multi-user scenario.

Each signal set is of the form:

| | | |
|---|---|---|
| 100 Chirp cycles | 511-bit $PN_1$ | Data spread by n-chip sequence |

where a Chirp cycle is:

| | | | | |
|---|---|---|---|---|
| 10ms Chirp | 40ms silence | 10ms Chirp | 40ms silence | … 100 cycles |

There are two main signal groups:

Group A, QPSK:

| Coding | User Signal | Duration (s) |
|---|---|---|
| CDMA 15-chip spread | 1 | 16.64 |
| CDMA 15-chip spread | 2 | 16.64 |
| CDMA 31-chip spread | 1 | 33.02 |
| CDMA 31-chip spread | 2 | 33.02 |
| CDMA 63-chip spread | 1 | 65.78 |
| CDMA 63-chip spread | 2 | 65.78 |
| | | |
| | Total | 230.88 |

**Table 8-6. UNEW signals, group A**

Group B, BPSK:

| Coding | User Signal | Duration (s) |
|---|---|---|
| CDMA 15-chip spread | 1 | 16.64 |
| CDMA 15-chip spread | 2 | 16.64 |
| CDMA 31-chip spread | 1 | 33.02 |
| CDMA 31-chip spread | 2 | 33.02 |
| CDMA 63-chip spread | 1 | 65.78 |
| CDMA 63-chip spread | 2 | 65.78 |
| Gold Sequence 31-chip | 1 | 33.02 |
| Gold Sequence 31-chip | 2 | 33.02 |

| | | |
|---|---|---|
| Gold Sequence 63-chip | 1 | 65.78 |
| Gold Sequence 63-chip | 2 | 65.78 |
| | | |
| | Total | 428.48 |

**Table 8-7. UNEW signals, group B**

Complete signal suite will consist of

| Group | Duration | Name (for logging form) |
|---|---|---|
| A | 3m 50.88s | UNC1 |
| B | 7m 8.48s | UNC2 |
| A | 3m 50.88s | UNC1 |
| | | |
| Total | 14m 50.24s | |

**Table 8-8. UNEW experiments, duration of a complete cycle.**

# 9 Overview of nonacoustic experiments

The nonacoustic data are composed of two sets:

1. Measurements made by the Measurement Network ZeGe, these are described in Section 2.
2. Ship data and data that come from additional measurements. These are the topic of this Section.

To better understand the propagation conditions and to provide input data for simulation programs the following additional measurement will be made:

**CTD and SSP measurements**

One CTD/SSP measurement will be made approximately every 90 minutes, one per cycle of acoustic experiments (see next Section). The measurements will be made by the Aquamatic sound speed probe of RWS.

**Bathymetry scan**

Bathymetry scans will be made with the echo sounder on board Lodycke. Scans will be made along the five tracks defined in Section 5. Specifically, a bathymetry scan will be made while sailing from the bottom-mounted modem (after deployment) to the location where the surface unit will be deployed. Before deployment of frame and surface unit an accurate scan will be made at the location of the intended deployment to make sure that deployment will be made at a flat location.

**Sediment cores or sediment grabs**

During the experiments a vibro core and Van Veen grab are available. In consultation between RWS and TNO a number of cores will be made. The exact locations of the cores will be decided upon during the trial. The choice of the core measurements will depend on the available time, on safety considerations and on interest for further analysis. Preferred locations are on the first and third track.

# 10 Detailed time schedule for a day

This section gives an example of a detailed time schedule for a day. The exact time schedule for each day will depend on various factors: progress of the experiments, tide, time needed for deployment etc. A general presumption is that the acoustic experiments defined by the ACME partners are clustered in a full cycle of experiments in the following way:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Noise, LFM, CW | ORCA experiments | Noise, LFM, CW | TNO experiments | Noise, LFM, CW | TMS experiments | Noise, LFM, CW | UNEW experiments |

**Figure 10.1. Clustering of acoustic experiments.**

The total length of this cycle is approximately 90 minutes. During each cycle a CTD measurement is made. There is sufficient time for up to four cycles per day. Since for most days two different moorings are defined, two cycles per mooring can be performed. During the second cycle all experiments can simply be repeated.

A typical day of can thus be as follows:

- 08.00 Departure from port
- 08.00 - 08.45 Voyage to location where modem will be deployed. Deployment of underwater frame.
- 09.00– 09.30 Voyage to place of first mooring. Bathymetry scan. Anchoring and deployment of surface modem.
- 09.30 First CTD
- 09.30 – 11.00 First cycle of acoustic experiments
- 11.00 Second CTD
- 11.00 – 12.30 Second cycle of acoustic experiments
- 12.30 – 13.00 Core grab, retrieval of surface modem
- 13.30 – 14.00 Voyage to place of second mooring. Bathymetry scan. Anchoring and deployment of surface modem.
- 14.00 Third CTD
- 14.00 – 15.30 Third cycle of acoustic experiments
- 15.30 Fourth CTD
- 15.30 – 17.00 Fourth cycle of acoustic experiments
- 17.00 – 17.30 Retrieval of surface modem
- 17.30 – 18.30 Retrieval of frame, return to port

# 11 Data management

The data management during and after the trial will be carried out in accordance with the data management plan [1].

## 11.1 Expected amount of data

The bulk of the data will be formed by the acoustic data. The amount of acoustic data is estimated on basis of the following presumptions:

- Four channels are recorded (modem + three hydrophones)
- 15 minutes per partner per cycle of experiments
- 3 partners whose signals need to be recorded (the ORCA experiments yield processed data, the raw signals can also be recorded though, if necessary)
- Sample frequency of the TNO A/D converter 48 kHz
- Two bytes per sample

This yields a total of $4\times15\times60\times3\times48000\times2=$ 1 Gbyte per complete cycle. There is a maximum of four cycles per day and six days of experiments are planned. Hence the maximum amount of data amounts to 24 Gbyte.

## 11.2 Storage during the trial

For initial storage a large hard disk will be used with 60 Gb capacity, more than enough to store all data. This hard disk will be connected to the TNO A/D converting device. Backup of all data recorded during a day of experiments will be made using a Sony SDV-300PK AIT Streamer (or, if more convenient, a DLT streamer). The capacity per AIT tape is 25 Gb, which should be enough to store all acoustic data. The data resulting from one day of experiments are put on tape as one or more tar files using the shareware package WINTAR.

As explained in the Section about the equipment, ORCA will provide a backup primary storage device in the form of a DAT recorder. This recorder records only two channels. Moreover, TMS will provide a second backup recorder. This recorder will be used to record the other two channels (corresponding to the TNO hydrophones).

The data of the nonacoustic sensors are read out and initially stored on hard disk. Each day, all nonacoustic data will be put on CD.

## 11.3 First quality checks performed during the trial

During the trial regular checks will be performed to ascertain that data is actually recorded and stored. To this end data, specifically corresponding to the 2-s LFM sweep or the 10-s CW, will be read out and checked. Note that the aim of this action is not to test processing algorithms but to verify the correct recording of the signals.

## 11.4 Dissemination to the partners

### 11.4.1 Acoustic data

Since both TMS and ORCA bring along their own recorders, these partners will be in the possession of a partial data set immediately after the trial.

TNO will provide UNEW and TMS a copy of the acoustic data on AIT-tape. The acoustic data will be stored as tar files.

#### 11.4.2 Nonacoustic data

All nonacoustic data, comprising CTD data, Sound Speed Profiles, analysis results of core measurements, ship data and relevant data from the Measurement Network ZeGe will be collected on a CD. This CD will include software or documentation to read and, where appropriate, visualize the data. All documentation available at that time (measurement plan, cruise report, data management plan, description of signals) is also be included.

### *11.5 Dissemination to IFREMER for banking*

The data and meta-data that will be disseminated to IFREMER for banking comprise the following:

- Documentation (Data management plan, cruise report, cruise summary report, measurement plan)
- Classical environmental data (CTD/sound speed profiles and batthymetry)
- Selected acoustic data

The echo soundings (vertical bathymetry) and the sound speed profiles will be quality checked and reformatted by IFREMER (CTD in MEDATLAS format and vertical bathymetry in the international MGD77).

Selected acoustic data will be reformatted by TNO into NETCDF format before dissemination to IFREMER. The ACME partners will decide which part of the acoustic data set will be disseminated to IFREMER.

# 12 Permission of authorities, precautions to limit impact on marine life

Two demands for information about regulations and (if appropriate) permission have been issued by RWS to the local authorities:

1. Request for permission to conduct experiments at the edges of and inside the main shipping lane.
2. Request for information on official regulations with respect to exposure of marine life to acoustic pressure.

Furthermore RWS has inquired about dredging activities.

## *12.1 Permission for experiments inside the main shipping lane*

As regards experiments in the chief shipping lane the following regulations apply:
No official message to the traffic (a 'Bericht Aan Scheepvaart') is necessary if:

- The Lodycke does not anchor inside the shipping lane,
- The radar post Hansweert is kept informed of all actions/anchorings.

Anchoring in between or outside the buoys is no problem.

Since the Lodycke can deploy the frame without anchoring, no special 'Bericht Aan Scheepvaart' will be necessary. The crew of the Lodycke will keep the radar post Hansweert informed.

## *12.2 Official environmental regulations for underwater acoustic experiments*

After consultation of the Province of Zeeland (responsible local authorities) by the legal department of Rijkswaterstaat (Directorate General Zeeland), it turned out that there are no official regulations concerning a maximum acoustic pressure level impinging on marine life.

## *12.3 Dredging activities*

Dredging activities *are* planned near the trial area. To avoid interference as much as possible the dredging activities and the ACME experiments will be geared with one another. To this end the captain of the Lodycke will inform the dredgers about the envisaged location of the experiments one day in advance. If necessary, a new dredging location will be determined or the order of the experiments will be changed.

## *12.4 Precautions to limit impact on marine life*

As part of the ACME project a research has been carried out to determine maximum sound exposure levels to marine mammals [2]. The only marine mammal that can be observed in the trial area is the seal. Observations are rare, however (according to the crew of the Lodycke), although populations of the seal can be found both upstream and downstream.

The minimum requirement proposed in [2] is to limit the maximum source level during the ACME trials to a level such that no permanent damage can be done to the hearing system of a seal that is in the immediate proximity of a modem on the moment it transmits. In [2] this level is estimated to be 190 dB re 1 μPa @ 1m. Taking a safety margin of 10 dB yields that the maximum received sound pressure level must be below 180 dB. Alternatively one can conclude that there is only a chance of damage to the hearing system if a seal is within two meters of the modem at the moment it starts transmitting at full power (185 dB). This chance is so small that one can conclude that no restrictions are necessary for the first trial.

However, to be completely safe, an observer will look out for seals during the acoustic experiments. He will keep a log of any observations made and he will advice to lower the source level in case a seal is observed near a modem.

# 13 Main relevant risks, backup procedures

## *13.1 Failure of equipment*

### 13.1.1 Failure of recording devices

If the TNO recording device fails, two remaining recording devices (the DAT recorders of ORCA and TMS) provide sufficient capacity to record all four channels. Moreover, there is the possibility to get a backup recorder from e.g. TNO-FEL (although with a delay).

### 13.1.2 Failure of hydrophones

One backup hydrophone is available.

### 13.1.3 Failure of acoustic modems

In case one of the modems fails beyond repair (ORCA provides a spare processor board) the experiments will be performed with the MATS modems of TNO. These modems, however, are capable of performing only the standard test and thus no data set of new communication signals can be recorded. Obviously, this would have an important adverse effect on the ACME project. But even experiments performed with the standard modems will yield valuable results and much experience can be gained like:

- Rough impression of propagation conditions, specifically of time spread and SNR
- Assessment of performance of standard modems
- Practical experience in construction and deployment of underwater frame

The standard modems can in fact perform the experiments that are described in the Description of Work of the ACME contract.

### 13.1.4 Further problems with equipment or frames

In case of other unforseen problems it is always possible to make use of the existing facilities at the RWS location at Vlissingen. Furthermore, both TNO-FEL and TNO-TPD only require a 1,5 hours drive from the trial site.

## *13.2 Bad weather*

The captain of the Lodycke will decide if it is save to deploy the equipment. If the weather is too poor a day of experiments will be lost. In this case the spare day (Thursday June 21) will be used. If more than one day is lost the least important signalling tracks will be skipped, beginning with tracks four and five.

## *13.3 Failure to contact the remote modem*

A minimum requirement for performing the acoustic experiments is the ability to issue commands to the remote modem by the central node modem. Owing to hostile propagation conditions this may not be possible. This is certainly a real risk for the long-range experiments. In the case no contact can be made with the remote modem the following procedure will be followed:

- Noise measurements will be made
- A CTD will be taken
- Signals will be transmitted by the central modem to try to contact the remote modem at a regular basis, say every 5 minutes.

If no contact has been made within an hour the central node will be recovered. The Lodycke will sail to the remote modem and will check the position of the frame by using its sonar. To check the correct functioning of the underwater modem the standard ORCA communication tests can be performed at short range. To this end, the transducer connected to the surface unit is deployed by lowering it from the rail.

# 14 Various rules, procedures and responsibilities

## *14.1 Time stamping*

All data will be time stamped in MET, which is local time minus 1 hour and UTC plus 1 hour. MET will also be used on the logging forms.

## *14.2 Logging*

Three logs will be maintained:

1. Biological log: all sightings of marine mammals will be logged, together with the time, species, and possible reaction of the animal to the sound.
2. Bridge log: A log will be made of all important events that are not directly related to the acoustic experiments. These include: time and place of moorings and deployments, time and place of CTD's, sediment grabs and bathymetry scans, nearby ships, sea state (visual), rain etc.
3. Log of acoustic experiments: The start time of all acoustic experiments is logged, together with the name of the experiment and the equipment settings.

Sample logging forms are given in Appendix B. Naming conventions for the acoustic experiments are indicated in Section 8.

## *14.3 Responsibilities*

- The Chief Scientist is responsible for the proper coordination and execution of the experiments. He will make decisions about the experiments in consultation with the project coordinator and with representatives of ORCA, RWS and with the captain of the Lodycke. The exact location of the experiments, deployment of equipment, anchoring and time of departure from port will be decided upon and made known to the participants of the trial and to the authorities at least one day in advance.
- The crew of the Lodycke has the right and obligation to veto all decisions that can jeopardise ship, crew, equipment, or other vessels in any way.
- Methods of deployment will be decided upon by the technicians of TNO in consultation the representative of ORCA and with the crew of the Lodycke.
- Each partners is responsible for the proper functioning of the equipment he supplies.
- Each partners is responsible for insurance of his own equipment.

# 15 Persons involved in the trial, useful addresses

## 15.1 Persons involved in the trial

| Person | Institute | Task | Tel. number and E-mail address |
|---|---|---|---|
| Passerieux<br>Jean-Michel | TMS-SAS | Project Coordinator | 00 33 492964444<br>jean-michel.passerieux@tms.thomson-csf.com |
| Robert<br>Christophe | TMS-SAS | Technical support, operator of TMS equipment | christophe.robert@tms.thomson-csf.com |
| Coatelan<br>Stéphane | ORCA | Responsible for ORCA equipment and experiments | stephane.coatelan@orca-inst.com |
| Adams<br>Alan | UNEW | Definition of UNEW experiments, will not attend the trial | 00 44 1912227273<br>Alan.Adams@newcastle.ac.uk |
| Van Gijzen<br>Martin | TNO-FEL | Chief Scientist | 06 22458314<br>070 2740713<br>vanGijzen@fel.tno.nl |
| Van Walree<br>Paul | TNO-FEL | Environmental data<br>Photographer | 070 3740726<br>vanWalree@fel.tno.nl |
| Janmaat<br>Jeroen | TNO-FEL | Technician | 070 3740492<br>Janmaat@fel.tno.nl |
| Gerk<br>Adri | TNO-FEL | Technician, will attend 1st week | 070 3740480<br>Gerk@fel.tno.nl |
| Kromjongh<br>Joost | TNO-FEL | Technician, will attend 2nd week | 06 51262644<br>070 3740484<br>Kromjongh@fel.tno.nl |
| Wilmink<br>Engbert | TNO-TPD | Observer, environmental observations | 015 2692058<br>Wilmink@tpd.tno.nl |
| Fischer<br>Stefan | RWS MD | Observer | 06 1282152<br>015 2512586<br>s.fischer@mdi.rws.minvenw.nl |
| Goffau<br>Mart de | RWS DZL | Contact Lodycke and RWS-DZ, will partly attend the trial | 06 53404144<br>0118 686416<br>m.d.goffau@dzl.m |
| Cornelissen<br>Ed | RWS DZL | Technical maintenance measurement network | e.w.f.cornelissen@dzl.rws.minvenw.nl |
| Westende<br>Jan van 't | RWS DZL | Contact Lodycke,<br>Will partly attend the trial | 06 53547354<br>0118 422253<br>j.m.vtwestende@dzl.rws.minvenw.nl<br>MSLodycke@hetnet.nl |

**Table 15-1. Persons involved in the ACME trial**

Note that the MS Lodycke can be reached by e-mail: MSLodycke@hetnet.nl

## 15.2 Useful addresses

RWS location at Vlissingen (installation and integration of equipment):
RWS Meetinformatiedienst
Prins Hendrikweg 2
4382 NS Vlissingen
The Netherlands
Tel: 0118 422256

Martin van Gijzen
Paul van Walree

RWS-location at Hansweert (mooring place during the night):
Kanaalweg 8
4417 ER Hansweert
The Netherlands

Figure 15.1 shows a road map connecting the hotel in Goes to the Lodycke mooring place in Hansweert.

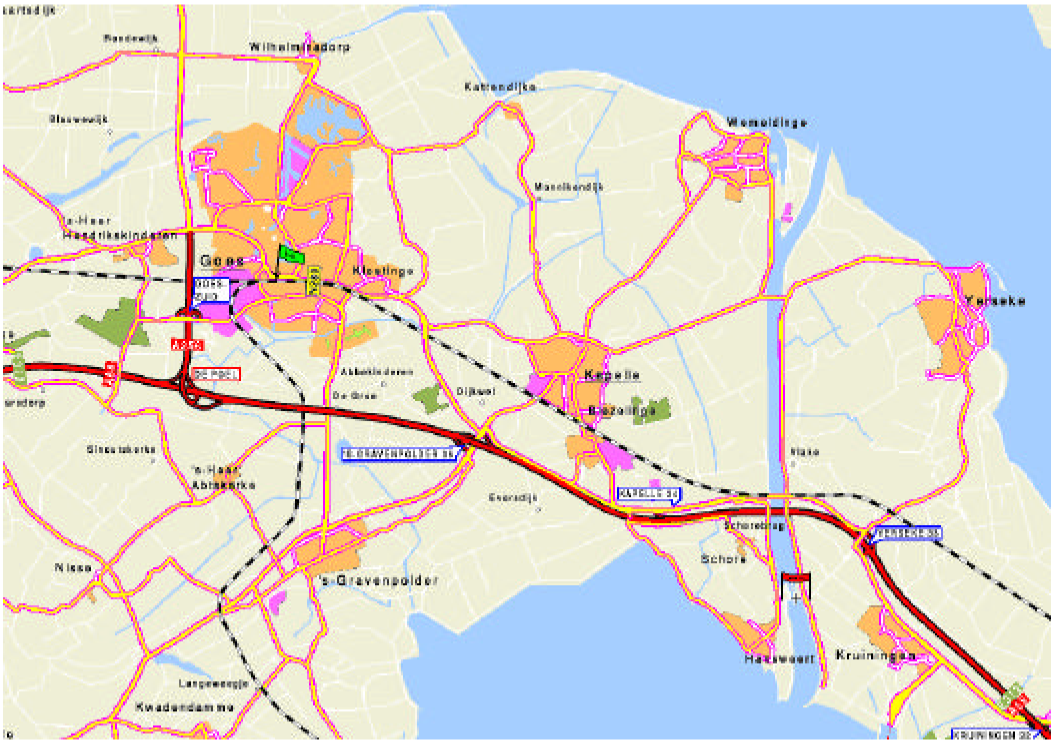


**Figure 15.1 Route connecting the hotel (green flag) to the Lodycke (red banner).**

Hotel for the trial participants:
Hotel Terminus
Stationsplein 1
4461 HP Goes
The Netherlands
E-mail: info@hotelterminusgoes.com
Telephone: 0113 23 00 85
Fax: 0113 23 25 79

| Guest name | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Martin van Gijzen | | X | X | X | | | X | X | X | X | |
| Paul van Walree | | X | X | X | | | X | X | X | X | |
| Adri Gerk | | X | X | X | | | | | | | |
| Jeroen Janmaat | X | X | X | X | | | X | X | X | X | X |
| Joost Kromjongh | | | | | | | | | | X | X |
| Stefan Fischer | | X | X | | | | | X | | | |
| Jean-Michel Passerieux | X | X | X | X | X | X | X | X | X | X | X |
| Christophe Robert | X | X | X | X | X | X | X | X | X | X | X |
| Stéphane Coatelan | X | X | X | X | X | | X | X | X | X | X |

**Table 15-2 Reservations at Hotel Terminus. (Dates are for June 2001.)**

## References

**[1]** A. E. Adams, **Data management plan,** May 15, *Draft*

**[2]** W.C. Verboom, **Marine mammal acoustic evaluation ACME signals,** TNO report TPD-HAG-RPT-01000, April 17 2001, *Draft*

# Appendix A: Tidal changes during the trial period

**Tidal difference at Hansweert, high tide and low tide relative to NAP.**

**Timezone: local time (UTC + 2 hours, MET + 1 hour)**

| Date | Time | Level re NAP (cm) |
|---|---|---|
| 11/06/2001 | 01:10 | -215 |
| | 07:05 | 231 |
| | 13:16 | -176 |
| | 19:21 | 217 |
| 12/06/2001 | 01:46 | -205 |
| | 07:48 | 214 |
| | 13:55 | -166 |
| | 20:05 | 202 |
| 13/06/2001 | 02:26 | -196 |
| | 08:36 | 197 |
| | 14:29 | -157 |
| | 20:52 | 187 |
| 14/06/2001 | 03:16 | -188 |
| | 09:26 | 184 |
| | 15:25 | -148 |
| | 21:45 | 174 |
| 15/06/2001 | 04:20 | -184 |
| | 10:26 | 179 |
| | 16:57 | -147 |
| | 22:56 | 171 |
| 18/06/2001 | 01:01 | 207 |
| | 07:26 | -209 |
| | 13:35 | 235 |
| | 19:45 | -191 |
| 19/06/2001 | 01:51 | 232 |
| | 08:12 | -221 |
| | 14:19 | 256 |
| | 20:39 | -206 |
| 20/06/2001 | 02:37 | 254 |
| | 09:02 | -229 |
| | 15:05 | 269 |
| | 21:26 | -217 |
| 21/06/2001 | 03:19 | 270 |
| | 09:48 | -233 |
| | 15:45 | 274 |
| | 22:13 | -228 |
| 22/06/2001 | 04:01 | 281 |
| | 10:33 | -233 |
| | 16:27 | 273 |
| | 23:01 | -237 |

# Appendix B

### *Biological logging form*

| **Date:** | | **Observer:** |
|---|---|---|
| **Track:** | | **Range:** |
| **Time of observation** | **Species** | **Remarks (response to signals, action taken)** |
| | | |

### *Bridge logging form*

| Date: | Observer: |
|---|---|
| **Track:** | **Range:** |
| **Time (MET)** | **Measurement/observation/remark** |
| | |

### *Logging form for acoustic experiments*

<table>
<tr><td>Date:</td><td colspan="3">Name:</td></tr>
<tr><td>Track:</td><td colspan="3">Range:</td></tr>
<tr><td colspan="4">SETTINGS OF EQUIPMENT</td></tr>
<tr><td>Gain<br>RAP:</td><td colspan="2">Gain Spectral Analyser<br>Gain channel 1:<br>Gain channel 2:</td><td>Gain Signal<br>Conditioning Board<br>Gain channel 1:<br>Gain channel 2:<br>Gain channel 3:<br>Gain channel 4:</td></tr>
<tr><td>Time (MET)</td><td>Name of experiment</td><td>File name</td><td>Remarks</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>