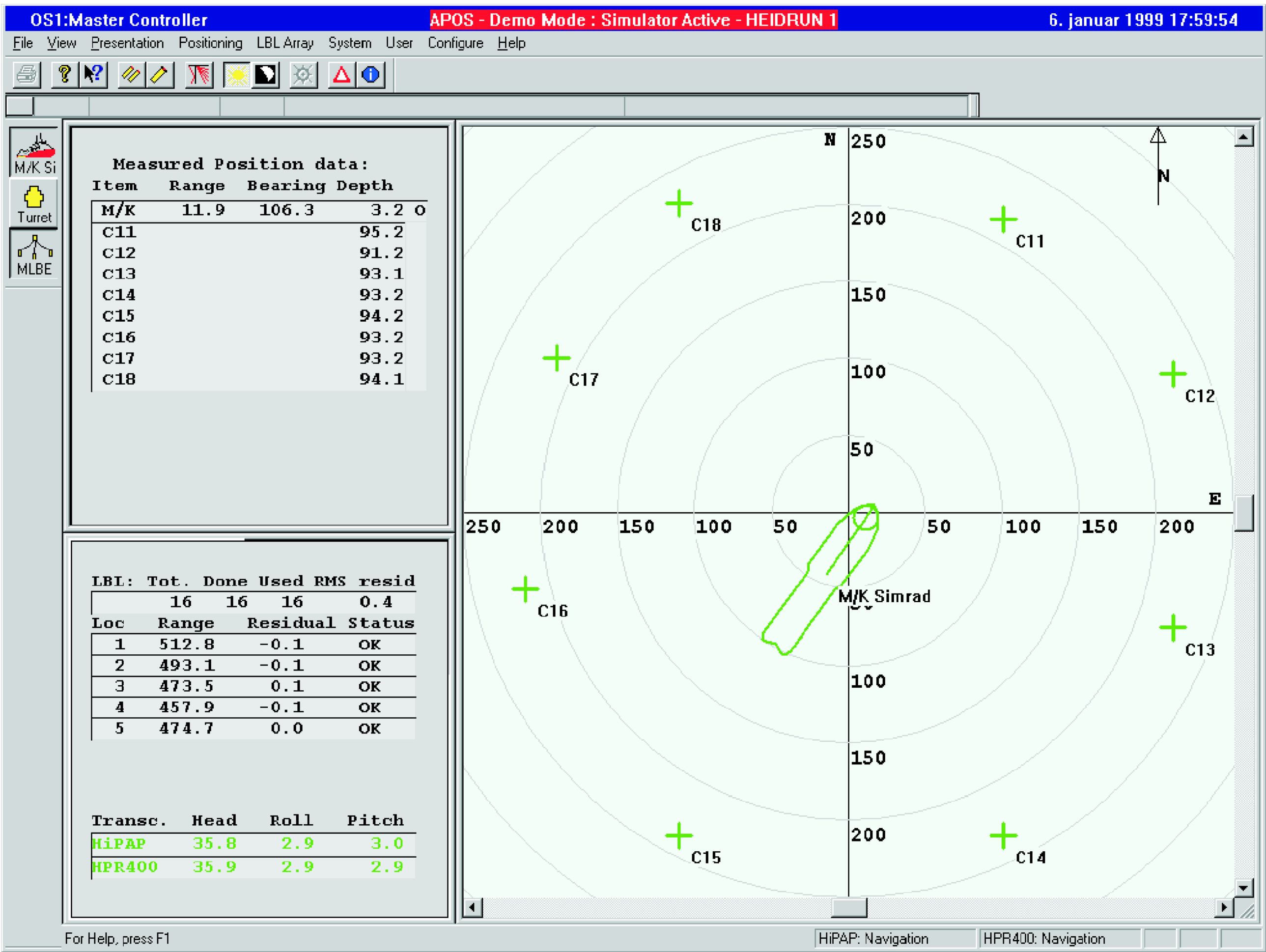
Course Training Guide

Kongsberg Simrad APOS –
SSBL & LBL Operation

Operator Course



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Kongsberg Simrad APOS – SSBL & LBL Operation

Course Training Guide – Operator Course

160940 / / AB 035/–***

Note

Kongsberg Simrad AS makes every effort to ensure that the information contained within this document is correct. However, our equipment is continuously being improved and updated, so we cannot assume liability for any errors which may occur.

Warning

The equipment to which this manual applies must only be used for the purpose for which it was designed. Improper use or maintenance may cause damage to the equipment or injury to personnel. The user must be familiar with the contents of the appropriate manuals before attempting to install, operate or maintain the equipment.

Kongsberg Simrad AS disclaims any responsibility for damage or injury caused by improper installation, use or maintenance of the equipment.

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Kongsberg Simrad AS, P.O.Box 111, N-3191 Horten, Norway
Telephone:+47 33 03 40 00, Telefax:+47 33 04 44 24
www.kongsberg-simrad.com / E-mail: ui@kongsberg.simrad.no

Sections

Remarks

References

Further information about Kongsberg Simrad APOS may be found in the following manuals:

- APOS Operator manual
- HiPAP/HPR400 Product description

The reader

This manual is intended to be used by participants at APOS operator courses held by Kongsberg Simrad.

Note

This manual will not be updated.

Document revisions

Rev	Date	Written by	Checked by	Approved by
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(The original signatures are recorded in the company's logistic database)

To assist us in making improvements to the product and to this manual, we would welcome comments and constructive criticism. Please send all such – in writing or by Email – to:

Kongsberg Simrad AS
Documentation Department
P.O.Box 111
N–3191 Horten
Norway

or Email:

dokavd@simrad.no

References

(The information on this page is intended for internal use)

Documents

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1 HPR DEVELOPMENT

1.1 What is HPR?

HPR stands for Hydro Acoustic Position and Referense System. It is a system for underwater navigation. The main purpose for such a system is to find a underwater position relative a vessel, rig, array or any other object.

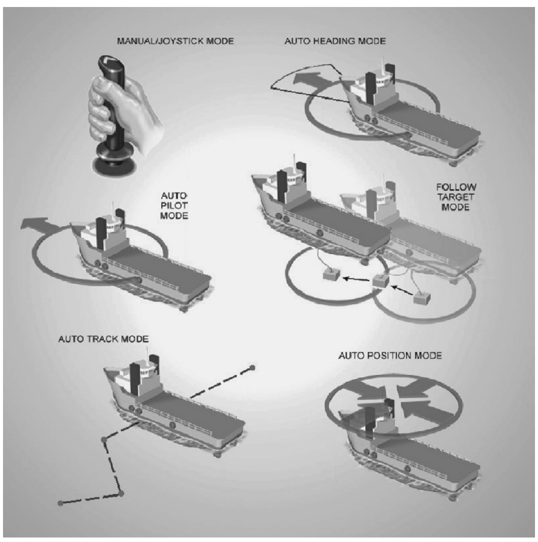
1.2 Applications for HPR products

1.2.1 Interfaces to HiPAP/HPR 400 system

The HiPAP®/HPR 400 can be interfaced to other computers allowing them to process the position data for various applications. Several binary and ASCII formats are available on serial line and ethernet using UDP protocol. A dual ethernet is available for secure DP operations. An accurate time–tagged position output is available if the system is interfaced to a DGPS and synchronised to 1PPS.

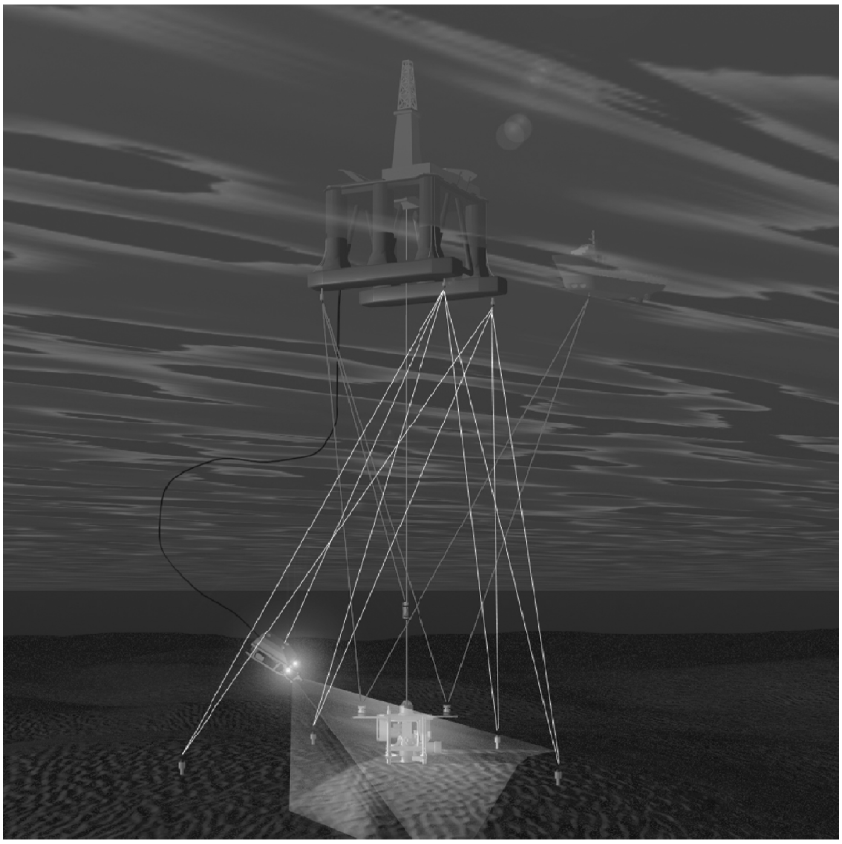
1.2.2 DP reference

The position data can be used by a Dynamic Positioning system as the reference signals for keeping the vessel in the desired position. High position accuracy and reliability ensure a secure and stable reference input to the Dynamic Positioning systems. SSBL, LBL and SSLBL systems may be used.



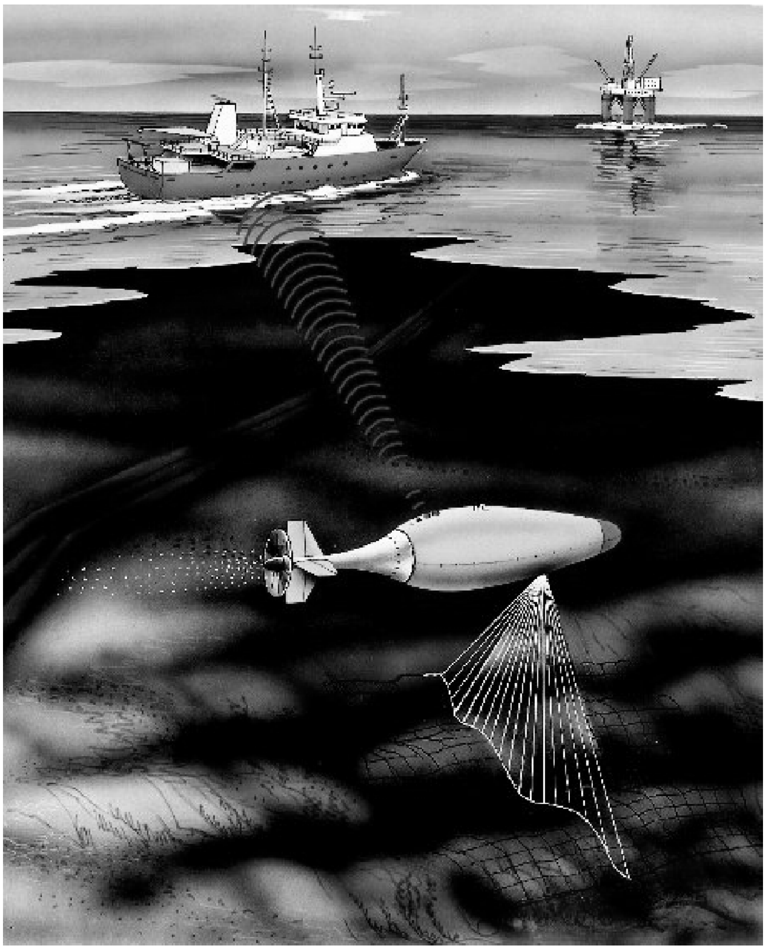
1.2.3 Rig and drilling monitoring

The HiPAP®/HPR 400 systems can be used to monitor the drill rig position relative to the well/BOP. It makes re-entries on template easier. The system can also be used with inclinometer transponders to monitor the BOP and riser inclination. Interface to electrical riser angle measurement is also available. Used with the ACS 400 it can be used for acoustic BOP control.



1.2.4 Sub–sea survey and inspection

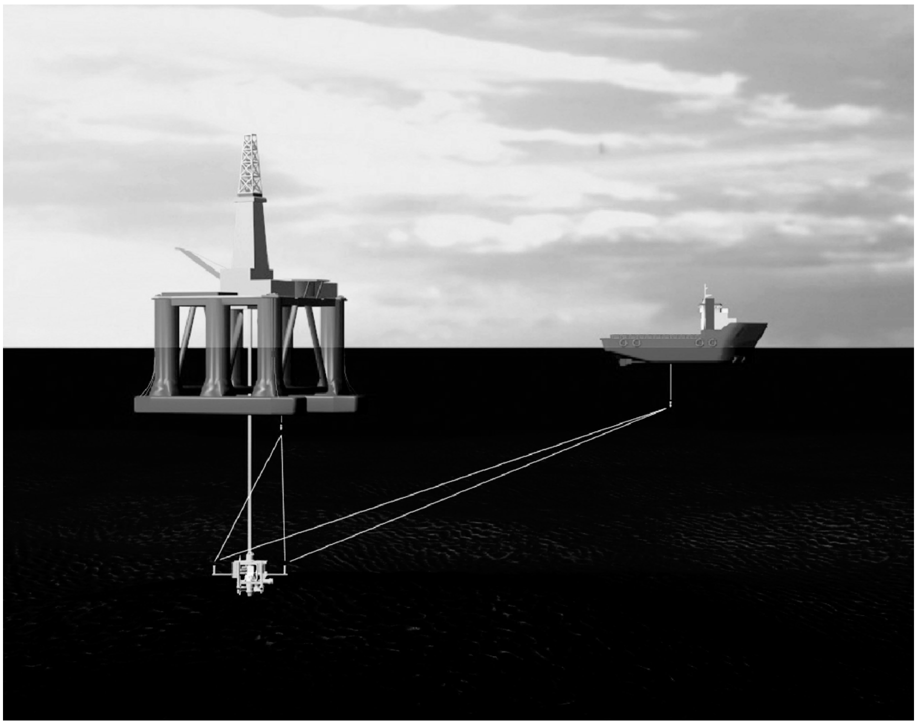
Positioning of ROVs carrying instruments for survey and inspection is another important application for the HiPAP® / HPR systems. The ROV position relative to the vessel is integrated with the position from surface navigation to provide a geographical position of the ROV. In this application a responder is suitable. The ROV can perform video inspection, bathymetric surveys, pipeline or cable tracking e.g.



Tracking towed bodies for similar applications may also be done. In survey applications, a best possible geographic position is wanted. To obtain this, sound velocity and pressure sensor input to the HiPAP® / HPR may be used.

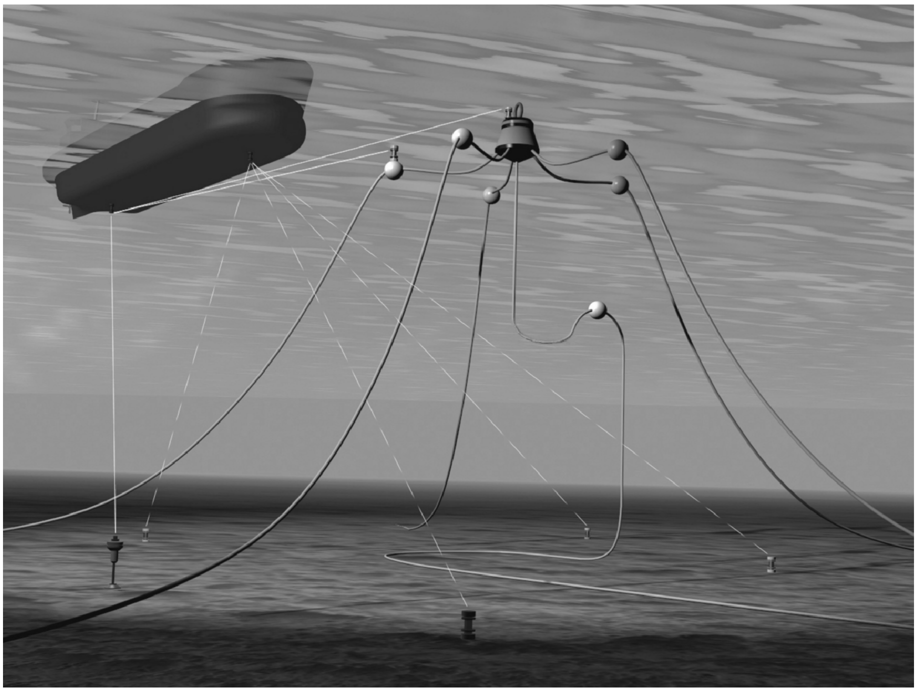
1.2.5 Acoustic BOP Control

The HiPAP®/HPR system is also used for transmitting and receiving acoustic telemetry command with high security. This is used for acoustic BOP control and the opening and closing of a valve governing the flow of crude oil to a tanker as on OLS. Further, the system can monitor critical functions by reading sub–sea status information and sending this information to the operator onboard the vessel. A separate system, ACS, is required on the BOP stack. A small portable unit is also available in case of emergencies. The unit can be brought onboard a lifeboat or a helicopter in case the rig has to be abandoned. The well can be closed using the portable system. The HiPAP® system can only be used with the new ACS 400 system.



1.2.6 Offshore loading

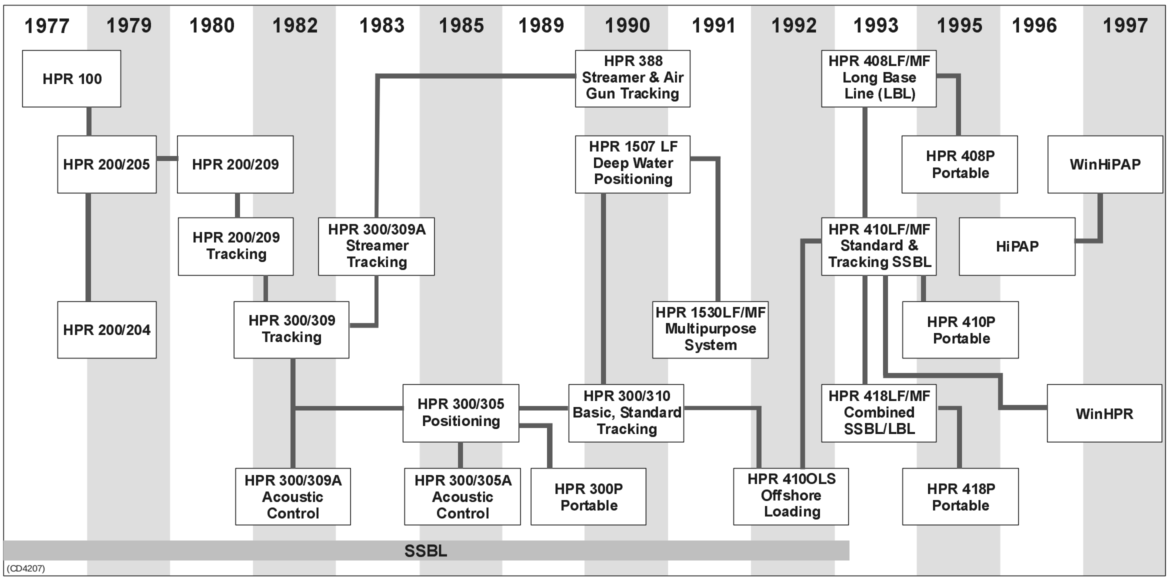
The HiPAP®/HPR system is also used for offshore loading from a submurged turret buoy.



1.3 HPR Development

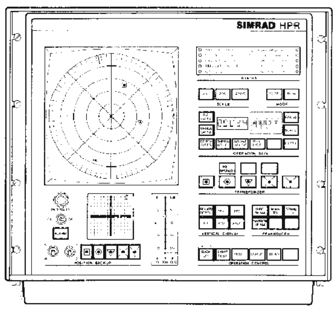
1.3.1 Introduction

The HPR systems have changed since they were first introduced in the 70's. They were first used as a reference in a dynamic positioned vessel. Since then the physical size and number of circuit boards have been reduced, and the number of available channels has been increased.



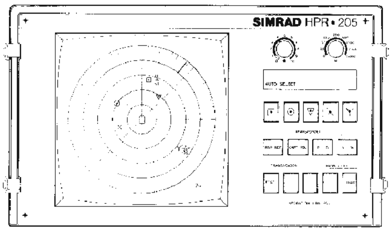
1.3.2 HPR 100

The HPR 100 systems from 1977 came with five transponder channels (symbol channels □, O, ∇, X, Y). The system was operated using dedicated push buttons on the front. It was also used for simple telemetry of inclination and depth.



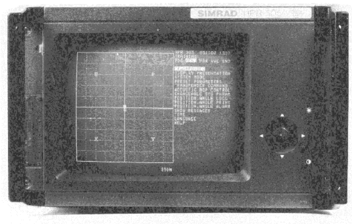
1.3.3 HPR 200

The HPR 200 systems could also handle five transponder channels. The number of push buttons was reduced, and menu selection introduced.



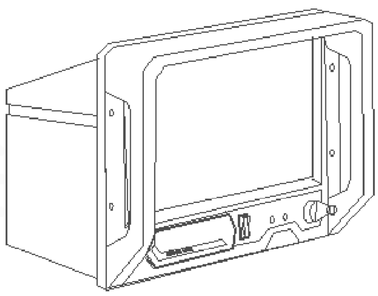
1.3.4 HPR 300

The HPR 300 system from 1985 came with the five symbol channels (□, O, Δ, X, Y) and the channels B1–B9 (a total of 14 channels). The systems are joystick operated, with menus on the display.



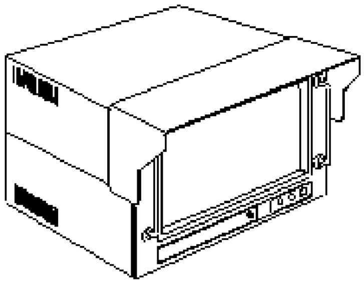
1.3.5 HPR 400

The HPR 400 series were introduced in 1992 and came with more built–in functions than its predecessor HPR 3xx. The number of transponder channels is increased to 70 (14 ″old″ and 56 new channels). The telemetry capabilities were improved.



1.3.6 HiPAP

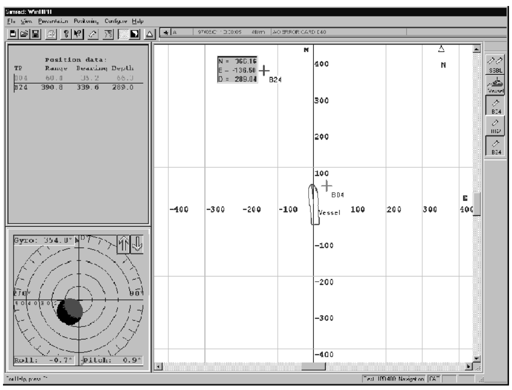
The HiPAP® system from 1996 looks like an HPR 400 system to the user operationwise, but the transceiver hardware is quite different. HiPAP® uses only the channels B12–B87.



1.3.7 APOS

There is also a very new windows based operator station.

The display monitor can stand alone or be mounted in an operator console.



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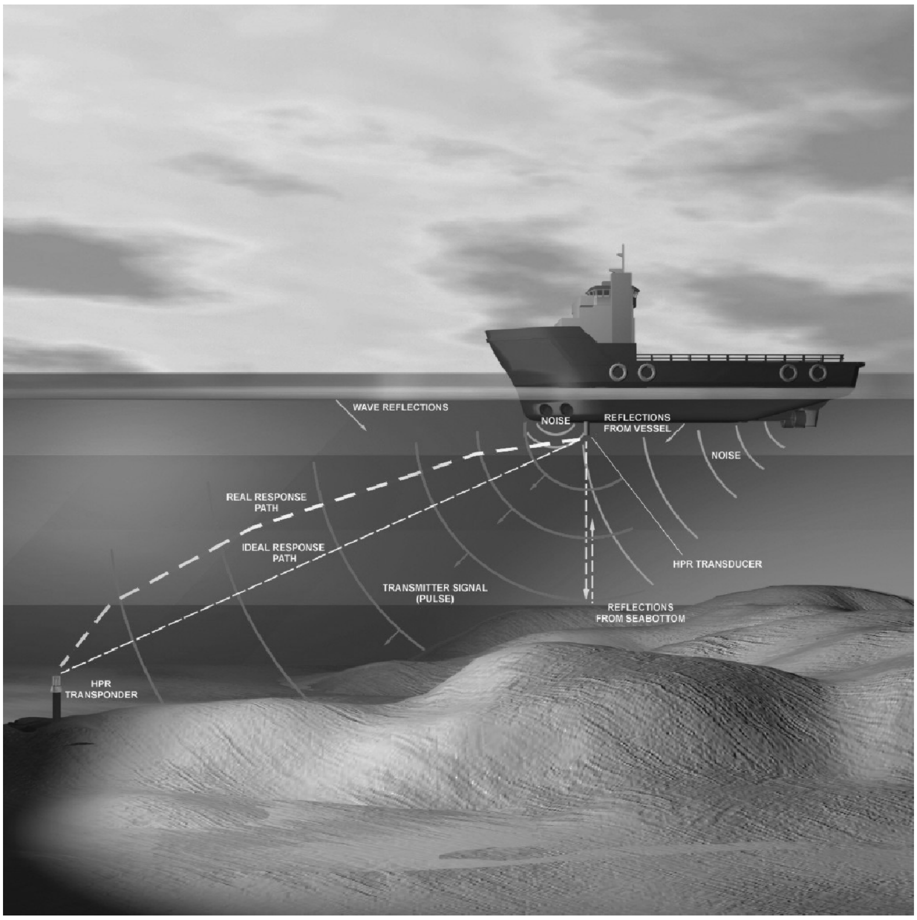
2 HYDRO ACOUSTICS – SOUND IN WATER

2.1 Introduction

Sound waves are alternating high pressure waves and low pressure waves. Sound is transmitted through water in the form of pressure waves. Water is a complex medium for the propagation of sound and many physical factors influence the sound signals in several ways.

Typical factors that influence in hydro acoustics:

- Transmission loss caused by Spreading and Absorption
- Reflection
- Noise
- Ray bending coused by variation in sound velocity

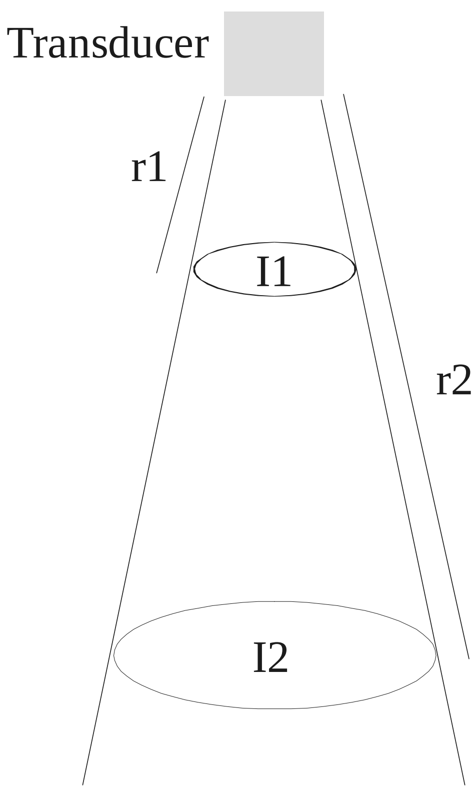


2.2 Transmission losses

The transducer output signal strength is reduced as a function of distance and frequency. Acoustic low frequency signals may travel long distances without too much transmission loss. Light, radar and radiosignals are very much attenuated in water.

2.2.1 Geometrical Spreading

The sound energy is radiated spherically by the signal source. The wave front covers a larger and larger area and the sound energy will therfore decrease as the wave moves away from the transducer. In a distance r away from the signal source the radiated sound energy will be reduced by the factor $1/r^2$. If we double the distance the sound intensity is reduced four times. Notice that geometrical spreading is independent of frequency.



The transmission loss caused by spreading is expressed by:

- TLs=10log(I2/I1)=10log$(r2/r1)^2$=20 log(r2/r1) where

I1 and I2 is the sound intensities at distance r1 and r2.

r1 is the reference distance and r2 is the distance to the object.

when we set r1 to reference distance of 1 metre we have:

- TLs=20 logr2

Examples of TLs–values for different ranges:

r (m)	TLs (dB)
5	14
10	20
50	34
100	40
500	54
1000	60
2000	66
3000	70
5000	74

2.2.2 Absorption

The sound is also to some extent exposed to absorption when passing through the water. This absorption is caused by losses due to heating of the water molecules by friction as the sound pulses cause them to move against each other. Absorption is mostly caused by the saltmolecules when they are pressed together.

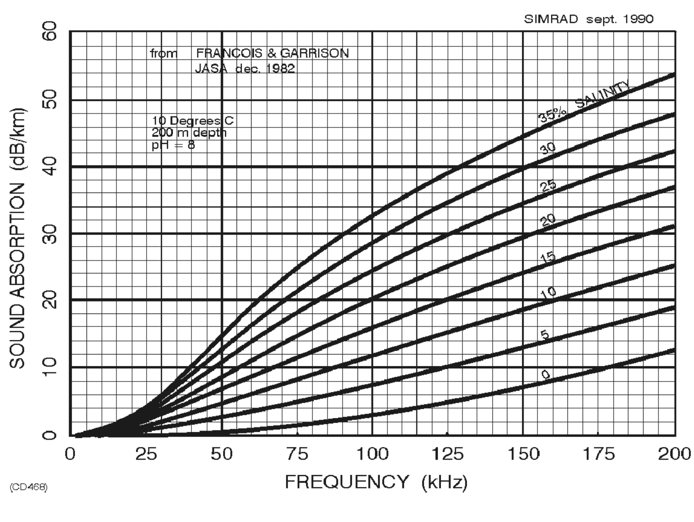
The absorption loss is expressed by:

- TLa=10 log(I2/I1)=α (r2–r1)=α r2 (if r2>>r1)

α is named absorption coeffisient

The value α increases strongly with frequency. Low frequencies have less loss than higher, and should work at longer range. There is a trade–off between range and accuracy. Lower frequencies give longer wave lengths and less resolution.

A typical value used in the North Sea is 7 dB/km for 30kHz signals.



2.2.3 Total Transmission loss

The total transmission loss is expressed by the sum of the spreading and the absorption loss.

- TL=TLs + TLa

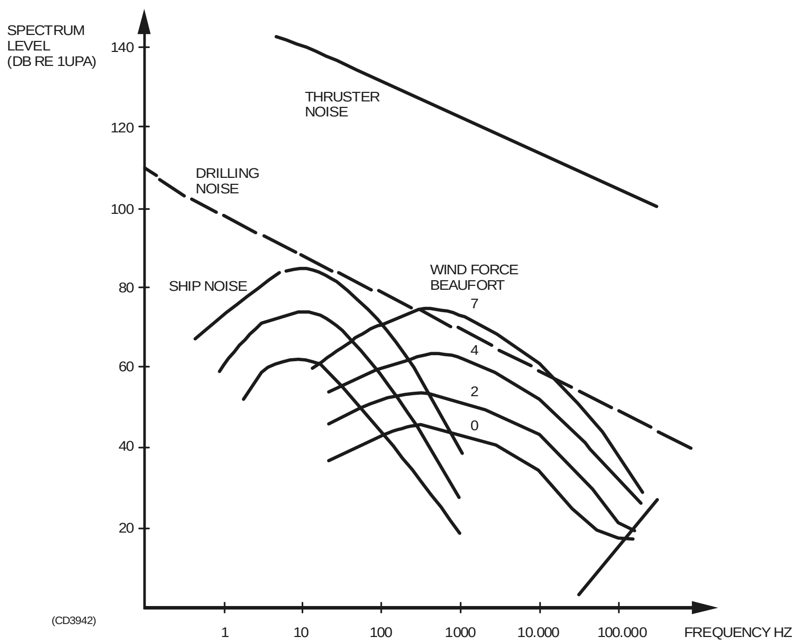
2.3 Reflections

Reflections of the sound waves by the surface, the seabed and underwater structures also create distortions. The systems have therefore been designed with regard to influences from such distortion sources, both through hardware and software signal detection and by the use of signal filtering techniques.

2.4 Noise

One of the factors which causes problems in hydro acoustics is acoustic noise. Noise can be generated from the vessel or rig itself (equipment, motors, thrusters etc.), from neighbouring installations or vessels, ROVs or from the waves.

From the diagram you can see the contribution from different sources with respect to frequency.



ENVIRONMENTAL ACOUSTIC NOISE LEVEL

As you can see from the curves, the thruster noise is far stronger than other types of noise in connection with HPR frequencies, typical 9500–30000 Hz. Azimuth thrusters generally generate more noise than tunnel thrusters.

Thrusters generate noise, but they might also make air bubbles in the water. If the bubbles are in between the transducer and the transponder, the signal can be blocked. This is like using a search light in fog; increasing transmitting power will not help.

Also going astern with the vessel using the main propellers normally pulls a lot of air under the hull and might cause signal blockage similar to that caused by the thrusters.

Going astern or having the weather/waves from astern might give difficult acoustic conditions.

Having the thruster wash between the transducer and transponder might cause blockage.

2.5 Ray bending effect

Ray bending effect is dependent on the acoustic transmission direction. The sound waves will follow a path from the surface to the seabed depending on salinity and temperature layers.

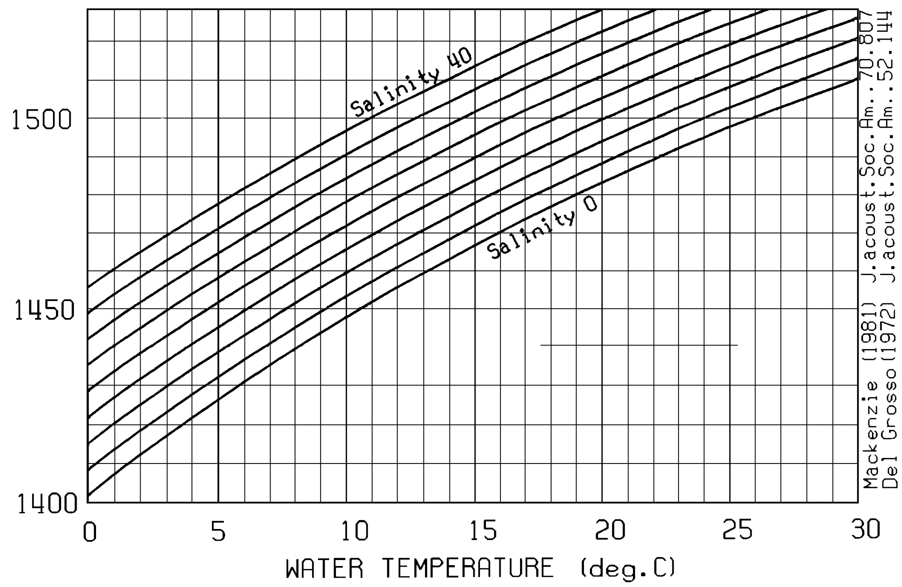
There might be several different layers with different characteristics from the surface to the seabed. When the sound waves pass through layers of different temperature and/or salinity, the rays will be bent, and the changes reflected in the sound velocity. It is the different temperature layers that cause ray bending, not the temperature itself.

When the velocity increases from the surface to the bottom (higher salinity and/or temperature), the signal path will be bent up. When the velocity decreases from the surface to the bottom (lower salinity and/or temperature), the signal path will be bent down.

A sound velocity probe can be lowered to calculate the speed of sound through these layers. If it is required, this information can be applied to the HPR system and used to compensate for this error.

2.6 Sound velocity

The speed of sound in water is depending on salinity and temperature. The speed increases with warmer water temperature and decreases with cooler water.



Typical value for the salinity in the North Sea is 35/1000. With a temperatrure of 9°C the sound velocity is about 1485 m/s. In warmer areas, with a water temperature of 19°C and the same salinity, the sound velocity might be 1520 m/s.

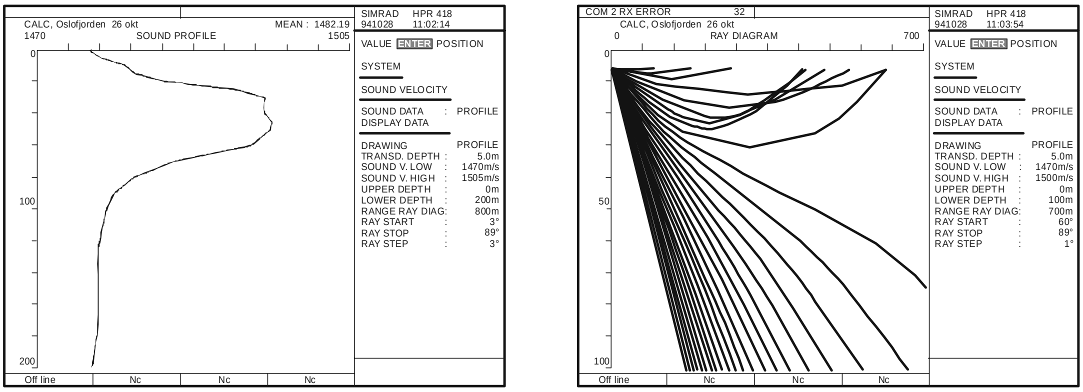
The speed of sound in air is 330m/s, in steel 5000m/s and for light the speed is 300.000.000m/s (300.000 km/s).

2.7 Sound velocity profile

The mean sound velocity is used to calculate the range, while the transducer sound velocity is used to calculate the direction angles to the transponders. Using the transponder's depth function, if available, will give a more accurate position calculation to the transponder. If the ray bending effects is significant.

The figure shows an example of a profile. On the picture to the left you can see the sound profile. The velocity at the surface is the same as at the seabed but you can see a sudden increase in the velocity down to 50m followed by a decrease from 50m. The changes are caused by the different temperature and salinity layers.

The sudden change in the sound profile is also found on the ray trace picture to the right.



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The ray trace tells us it is difficult to have any direct contact with a transponder in the area at 600–700 m range and 30–40 m depth, since all the rays are bent down to the seabed or up to the surface. This area is in the theory called "The shaddow zone".

2.8 Bandwidth

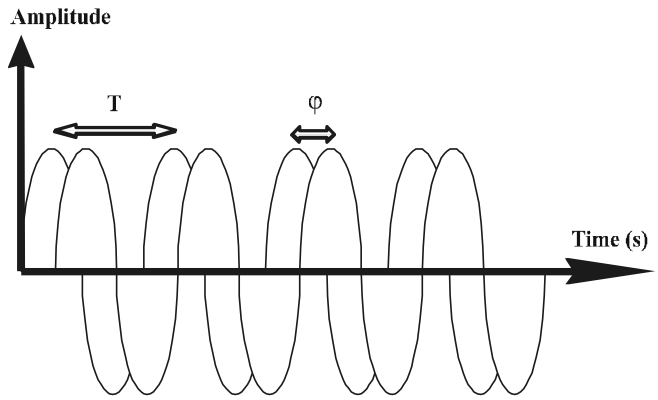
We operate with different bandwidths for different transducers and for different filters used in the hardware.

A transducer may have a bandwidth of approx. 20000Hz but inside the transceiver there are filters operating with smaller bandwidths.

Outside this frequency band the sensitivity drops. If we increase and decrease the frequency until the sensitivity has dropped 3dB, the difference between the two frequencies is called the bandwidth. A typical detection bandwidth for the HiPAP system is 500 Hz and for the HPR400 system 300Hz.

In order to establish a more accurate detection of pulse time arrival, parallel detection with i.e. 6000Hz is used.

2.9 Fundamental parameters



- λ = wavelength (meter)
  - distance between two maxima on the wave
- f = frequency (hertz)
  - the number of maxima which pass per second
- φ = phase difference (°)
  - the distance between two maximas from two different signals
- c = sound velocity (m/s)
  - the distance one maxima travels in one second
- T = period (s)
  - the time between two maxima
- τ = pulselength (s)
  - the time duration of one pulse
- n = number
  - the number of periods
- I = intensity (W/m^2)
  - the energy passing through a unit area per second
- p = pressure (N/m^2)
  - the pressure at an area per square meter
  - 1 pascal (Pa)=1 Newton/m^2
  - 1 μPa =0,000001 Pa=10–6 Pa

We have these equations between some of the parameters:

c=λ * f

T=1/f

Example:

Two pulses are transmitted into the water with a time delay of 30ms (0,03s).

The first pulse has the frequency 21000Hz.

The second pulse has the frequency 24000Hz.

What is the wavelength with these frequencies?

λ=c/f=1485/21000=0,0707m (7,1cm)

λ=c/f=1485/24000=0,0619m (6,2cm)

How long are the different periods?

T=1/f=1/21000=0,000048s (0,048ms)

T=1/f=1/24000=0,000042s (0,042ms)

How far away is the first pulse when the second is transmitted?

Δr=c*Δt=1485*0,03=44m

2.10 What is dB?

The desibel (dB) is a dimensionless unit for representing the ratio of two values.

In the case of electrical power we have: n=10 log(p2/p1)

Examples:

p1=1W	p2=0.1W	n=–10dB re 1W
p1=1W	p2=1W	n=0dB re 1W
p1=1W	p2=2W:	n=3dB re 1W

If we double the power we increase the ratio with 3dB.

2.11 The sonar equation

One of the critical factors in the HPR systems are the Signal to Noise ratio, S/N. The Sonar Equation below states the Signal to Noise ratio. As long as the noise is coming from outside the main lobe of the receiving transducer, the ”Directivity Index, DI” factor of the transducer reduces the noise in the system.

S/N=So–N

where: So=SL–TL

N=No+BW–DI

- S/N is the signal to noise ratio
- So is the source level at the receiver transducer
- N is the total noise energy at the transducer
- SL is the transponder source level in the actual direction
- TL is the total transmission loss from transponder to vessel
- No is the ambient noise spectrum level at the transducer
- BW is the systems bandwidth
- DI is the transducers directivity

From previous chapters we know these equations:

- $TL=TLs+TLa=20\log R+0{,}007R$

where R is the distance between the transponder and the HPR transducer.

- $N=No_{thruster}-TL_{thruster-transducer}=No_{thruster}-(20\log r+0{,}007r)$

where $No_{thruster}$ is actual thruster noise and r is the distance between the thruster and the HPR transducer.

- $BW=10\log B$

where B is bandwidth in Hz

From the sonar equation, it is possible to establish the maximum range to a transponder, or the maximum allowed noise from thrusters etc.

Example:

Vessel with main thrusters

Medium beam transducer

SPT339 transponder

R=1000 metre (distance from transducer to transponder)

r=30 metre (distance from main thruster to transducer)

S/N=So–N

where: So=SL–TL

N=No+BW–DI

- SL taken from product description: 195dB
- TL=TLs+TLa=20logR+0,007R=
  20log1000+0,007*1000=20*3+7=67dB
- $No=No_{thruster}-TL_{thruster-transducer}=No_{thruster}-(20\log r+0{,}007r)=$
  125–(20 log30+0.007*30)=125–(20*1.3+0.14)=125–26.14=98dB
- BW=10 logB=10 log300=10*2.5=25dB
- DI from table at next page=9dB

So=SL–TL=195–67=128dB

N=No+BW–DI=98+25–9=114dB

S/N=So–N=128–114=14dB

The signal noise ratio is smaller than 20dB and we might have som problems when we use this system.

To improve the S/N we can:

- Increase source level from the transponder
- Use another transponder type with higher source level
- Use another transducer with better directivity
  (such as the narrow beam transducer or the HiPAP)
- Decrease the thruster noise
- Mount the transducer somewhere else at the vessel

As you see there are severel factors to have in mind when configurating and using the different systems.

The following table shows some of the different system parameters for using in the Sonar Equation:

System unit	DI	BW	SL
SSBL NB	15dB	23dB(300Hz)	
SSBL MB	9dB		
SSBL WB	4dB		
HiPAP	17–25dB	26dB(500Hz)	
LBL NB	15dB	23dB(250Hz)(Narrow array)	
LBL Wide beam	4dB	23dB(250Hz)(Wide array)	
Transponder SPT331			202 dB
Transponder SPT339			195 dB
Transponder MPT331–S (LBL)			202 dB
Transponder MPT339–S (LBL)			195 dB

$NO_{thruster}$ = 125 dB rel 1 μPa / sq Hz at 1 meter distance in the 30 kHz band.

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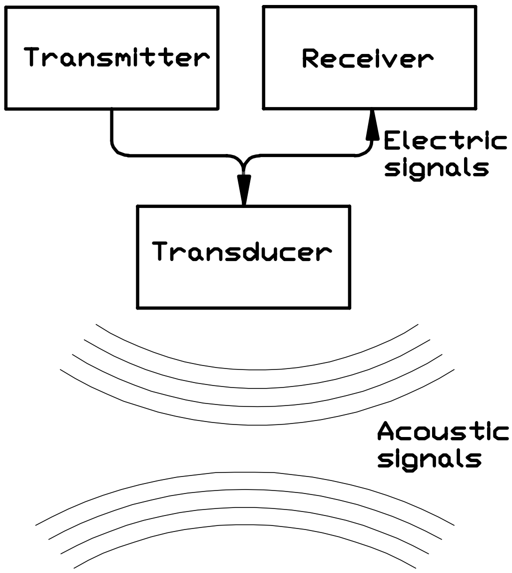
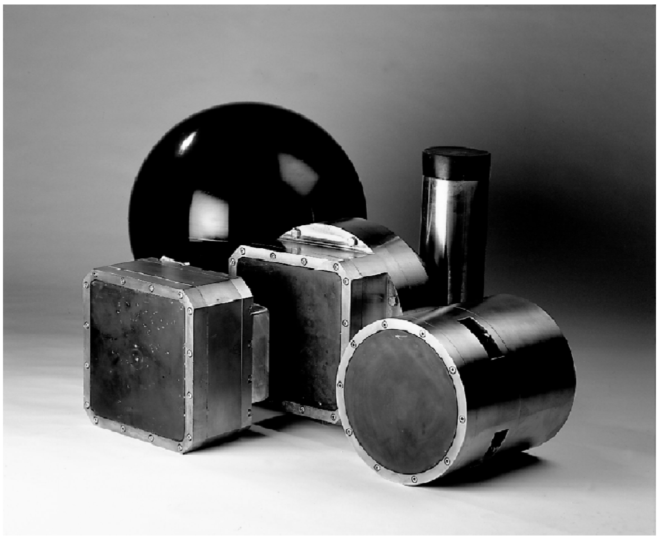
3 TRANSDUCERS

3.1 What is a transducer?

A transducer is an antenna, loudspeaker and microphone in one. It converts electrical energy to acoustic energy and vice versa. A transducer is in other words an acoustic transmitter and receiver.



A transducer might look like one of these:



The transducers in the figure are:

Tracking, HiPAP®, Narrow Beam, Portable and Standard.

3.2 Single element transducers

3.2.1 Introduction

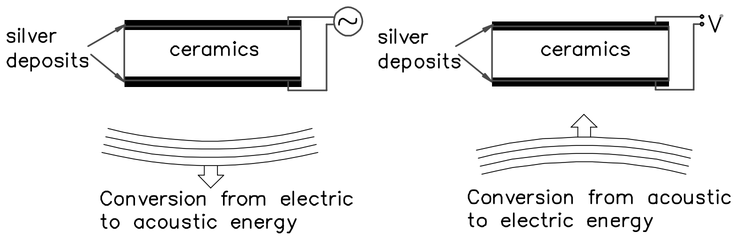
A typical design of a transducer element has a circular or square aluminium head, a piezoceramic ring in the middle, a circular bronze or steel tail and a centre bolt to keep the parts together. The dimensions and the materials are chosen to to give the element the required resonance frequency. The lower the frequency, the larger the element must be. Soldering ears are included for electrical connection.

3.2.2 Piezoelectric ceramic ring

There are a number of materials having the ability to convert electric energy to acoustic, and vice versa. Today, piezoelectric ceramics is the most widely used material. It is often referred to as piezoceramics. An alternating voltage, applied to electrodes on two opposite sides of a piezoelectric disc, causes the disc to vibrate and thus radiate sound waves.

Vice versa, if the piezoelectric disc is placed in a sound field and set into vibrations, it generates an electric voltage across the disc. Piezoelectric ceramics is manufactured in a variety of sizes and shapes (discs, rings, tubes, spheres) for application in various transducer types.

We try to find a ceramic with a resonance frequency similar, or very close to, the frequency we want to transmit in the water. In that way it takes smaller energy to maintain the vibration.



3.2.3 Center bolt

The center bolt keeps the parts together.

3.2.4 Insulation

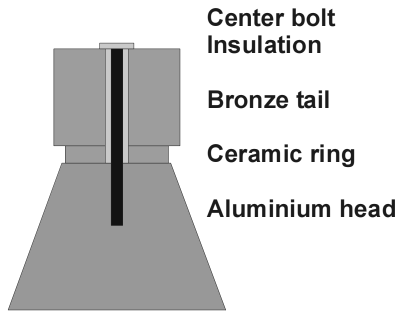
An insulation is applied to keep an electrical separation.

3.2.5 Tail

The tail is rather heavy and made of bronze or steel. The vibrations from the ceramics find it very hard to go through the heavy tail. Instead the vibrations go the easier way through the aluminum head.

3.2.6 Aluminium head

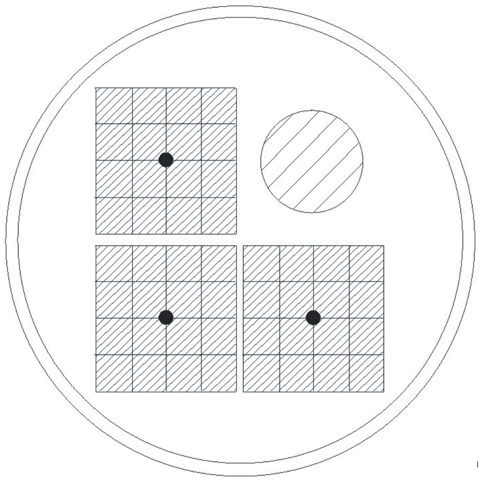
The aluminium head is the part that creates the low/high pressure waves in the water, via a rubber coating. The head is very light and transmits the vibrations very easily.



3.3 Multi element transducers

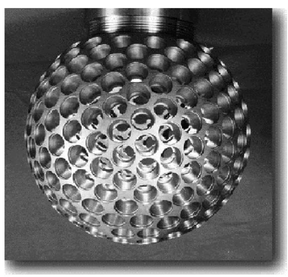
3.3.1 Introduction

Inside a multi element transducer there are several elements. They will start vibrating when voltage is applied and transmit sound waves with correct frequency, and when the pulses from the transponder are received, the elements start generating voltage.



We can use one element or groups of elements. It gives us the option to produce different beam shapes using the same transducer.

An example of a multi element transducer is the HiPAP. It contains more than 200 elements.



3.3.2 Applications for multi element transducerers

- Single beam transducers such as in transponders
- Split beam transducers such as in standard transducers
- Phased arrays used in fishery transducers
- Sonars

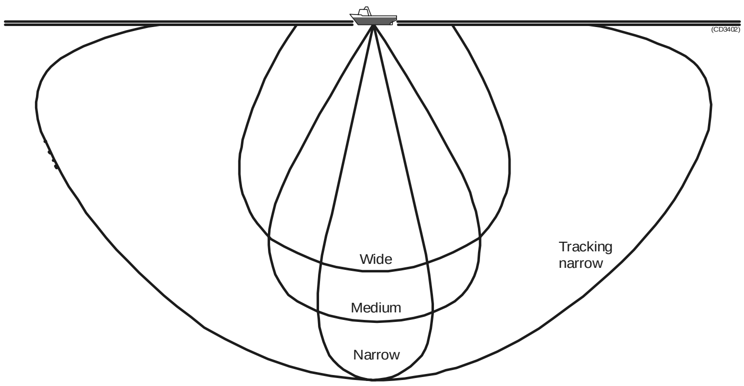
3.3.3 Why multi element?

- High efficiency
- High reliability
- Mechanically strong
- Low impedance unrelated to cable length (75 Ohm)
- Low side lobes
- Low back radiation

3.4 Different beam shapes

We operate with several beam shapes. The beam angle might variate some within the different beam shapes:

- Wide beam
- Medium beam
- Narrow beam
- Tracking beam



Operation area for the wide, medium, narrow and tracking narrow transducer

Also notice that the narrower beam the longer range.

3.4.1 How to transmit and receive different beam shapes

The beam angle is determined by the size of the transducer head relative to the wavelength. A small transducer will produce a wide beam and a large transducer will produce a narrow beam.

To transmit a wide beam from a standard transducer we can use one element. For narrow beams with the same transducer we can let 4 elements transmit or receive at the same time.

In the narrow beam transducer we let 16 elements transmit / receive at the same time.

The HiPAP uses 7 elememt for a wide beam. For narrow beams the HiPAP uses 18 groups of 7 elements.

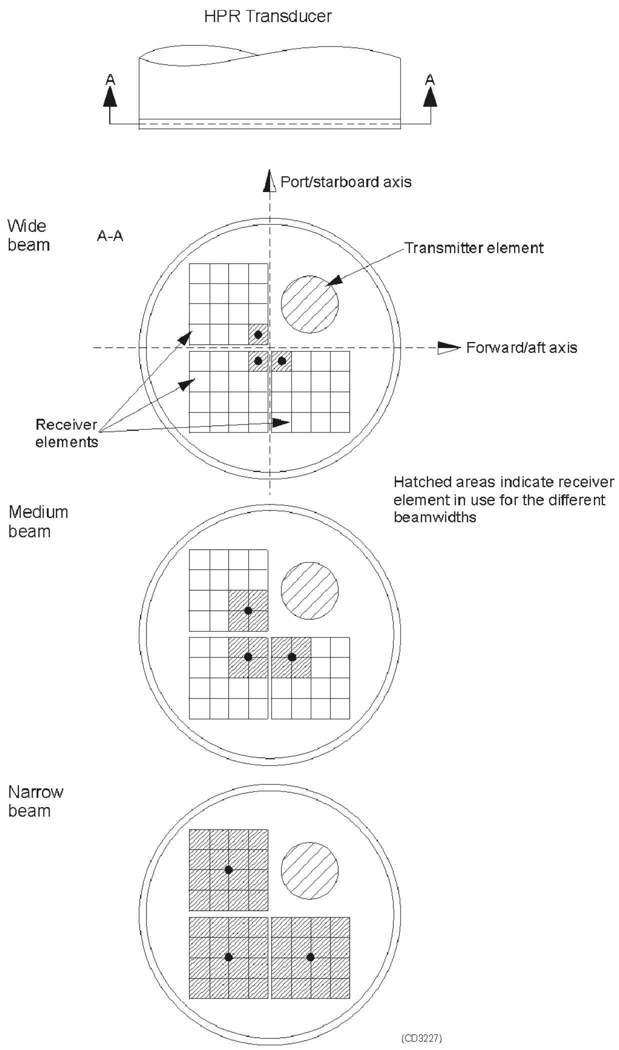
We can also adjust the source level to create different beamwidths. Source level is the sound pressure transmitted into the water. The higher source level the narrower beam.

Another example of a multielement transducer is the tracking transducer with more than 30 elements inside.

In the transducers the internal distances between the elements are fixed and split into three groups, called X, Y and Ref. X is for the athwartship axis, Y is for the alongship axis and Ref. is used as a reference element for the time delay measurement (explained later).

The standard transducer uses the same type of elements in the transmitter section as in the reciever section of the transducer. The elements are square.

The narrow beam transducer uses square receiver elements and a circle shaped transmitter element such as in the figure.



3.5 Different transducer types

Note ! *All the values below are for information only and may be changed without further notice.*

3.5.1 Narrow beam transducer

Transmitter: wide= ±80°

Receiver: wide= ±80°, narrow = ±15°

Accuracy: <=5% of slant range in wide beam.

<=1% of slant range in narrow beam.

3.5.2 Standard transducer

Transmitter: wide= ±80°

Receiver: wide= ±80°, medium= ± 55°

Accuracy: <=5% of slant range in wide beam.

<=2% of slant range in narrow beam.

3.5.3 Hipap transducer

Transmitter: wide= ±90°

Receiver: wide= ±15°, narrow= ±5°

Accuracy: <=0.3°

<=0.2 m

3.5.4 Portable transducer

Transmitter: wide= ±80°

Receiver: wide= ±80°

Accuracy: <=3% of slant range in narrow beam.

3.5.5 Duncking transducer (Telemetry only)

Transmitter: wide= ±90°, narrow= ±30°

Receiver: wide= ±90°, narrow= ±30°

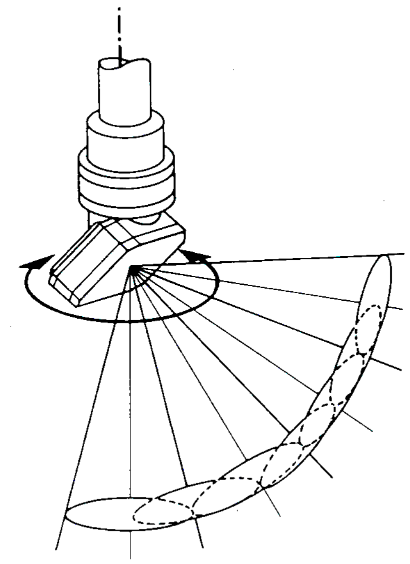
3.5.6 Tracking transducer

Transmitter: horizontal= ±80°

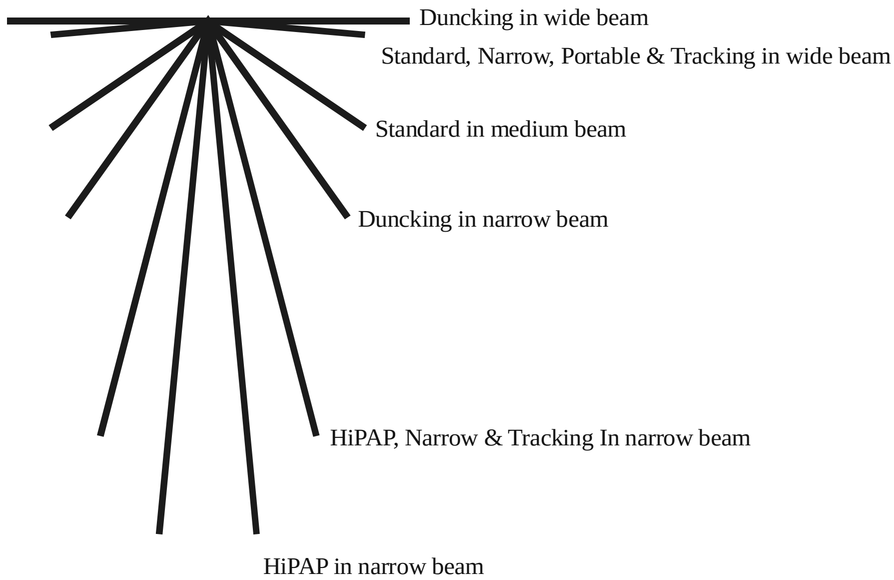
Receiver: wide= ±80°, narrow= ±15°

Accuracy: <=1% of slant range in narrow beam.

7 electronically steered narrow beams cover the area from horizontal to vertical. A mechanical system turns the transducer head 180° horizontaly within 2 seconds .



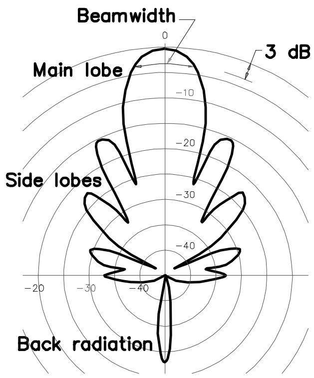
3.5.7 Receiver beamwidth for some transducers



3.6 Beamwidth and beam pattern

The beam pattern of a transducer, in the transmit mode, describes how the sound energy is radiated into different directions. The beam pattern is most often drawn as a polar plot, representing the radiation 360 degrees around in one plane through the beam axis. A complete presentation of the beam pattern demands a three-dimensional plot. For rectangular transducers it is common practice to present two polar plots, one along the longer side and one along the shorter side. For circular transducers one polar plot gives all necessary information, because also the beam pattern is circular.

Important features in the beam pattern is the main lobe, the side lobes and the back radiation. The transducer beamwidth is defined as the angle between the two points where the radiation is 3 dB down from the maximum level.



Piezo-ceramic transducers have the same beam pattern in the transmit mode and the receive mode. When the transducer is used as a receiver, the beam pattern presents the transducer sensitivity for sound coming from the different directions.

In most applications the side lobes are unwanted. Transducer tapering is a technique for reducing the side lobe level. In a multi-element transducer this is done by giving more power to the centre elements than to the elements on the periphery. The tapering is performed by utilising a transformer with a number of taps, connected to the different elements.

One of the unwanted effects of the side lobes is ghost echoes. That is echoes which do not originate from targets within the main lobe. They may show up in a situation with a nearby rising slope on the bottom, hit by a side lobe.

Bottom discrimination is one of the few applications which benefit from large side lobes. The main lobe hit the bottom with approximately 90 degrees incident angle, and gives a strong and short echo. The side lobes hit the bottom at smaller angles, which produces delayed and longer echoes. The level of these side lobe echoes depends upon the type of the bottom. A flat and smooth bottom shows weak side lobe echoes, whereas an irregular, stony bottom shows strong side lobe echoes.

The back–radiation from a hull mounted transducer is directed upwards, into the vessel. At some point it meets a steel to air interface, where it is reflected downwards and received by the transducer through the back lobe.

3.7 Transducers directivity

Directivity is a measurement on beamwidth and measured in ”dB”. We can also look at is as a factor which desribes how well the transducer neglect noise from outside the beam.

With reference to transmission, the directivity factor of a transducer is defined by:

D = Io / Im

DI=10logD (to get the factor in desibel)

Io is the radiated intensity at the beam axis.

Im is the mean intensity for all directions (including back–radiation). Both intensities are measured at the same distance from the transducer.

The mean intensity, Im, is equal to the intensity from an omnidirectional source, given the same power, and having the same efficiency as the transducer. The directivity factor could therefore also be defined as the ratio between the radiated intensity at the beam axis and the intensity of an omnidirectional source.

Typical values for some transducers are:

360°	beam	DI=0dB	(spherical beam)
180°	beam	DI=3 dB	(half spherical beam)
120°	beam	DI=4dB	(wide beam)
90°	beam	DI=6 dB	(medium beam)
60°	beam	DI=9dB	(medium beam)
30°	beam	DI=15dB	(narrow beam)

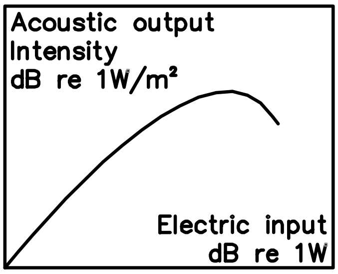
The narrower the beam, the higher the directivity factor.

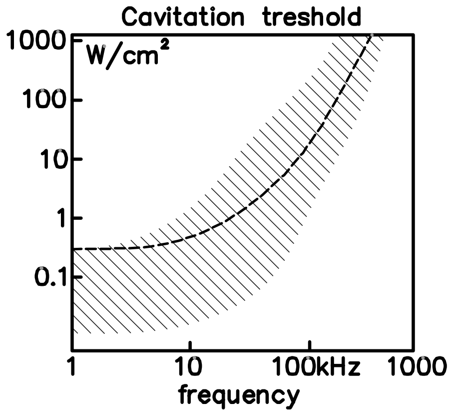
The narrower beam, the more transmitted energy = higher Source Level.

3.8 Cavitation

Cavitation is when the transducer face starts ”boiling”. Some of the water becomes gass, and bubbles are created on the transducer face and intermittent echo presentation.

Cavitation treshold is the transducers upper limit to convert electrical power to acoustic power (Source Level).





3.9 Transmitting frequencies

The HPR transducers transmit with frequencies in these bands:

Medium frequency band (MF) 30 kHz

Low frequency band (LF) 12kHz

3.10 Source Level

The source level (SL) of a transducer is the sound pressure in the transmitter pulse at the beam axis 1 metre from the transducer head.

For our transduceres the SL are from 180dB to 206dB

3.11 Where is the transducer mounted?

For HPR systems it is normally placed onboard a vessel approx. 3 m below the keel. It is mounted on a pole, which is remotely operated from the bridge and/or control room.

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4 TRANSPONDERS

All the Simrad transponders and responders are designed for use with the Simrad HPR and HiPAP® systems.

4.1 What is a transponder?

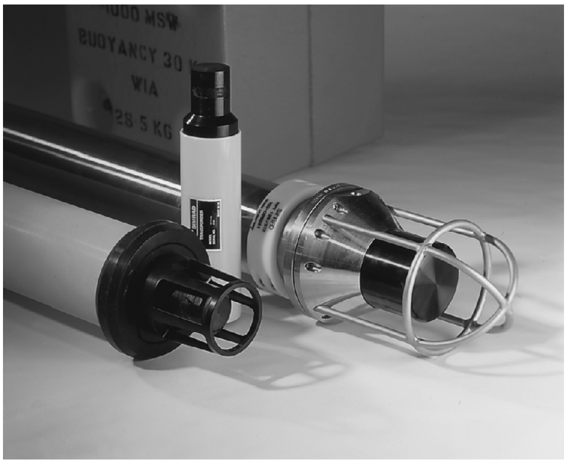
A transponder is an acoustic receiver/transmitter placed on the seabed, or onboard an ROV or any other structure to be positioned.

The transponder is triggered from the vessel using acoustic signals, and will in normal operation only answer if you interrogate it from the vessel.

The transponders are supplied with different transducer heads receiving/transmitting in different beamwidths.

The power source in an ROV transponder will normally use rechargeable batteries or external power, while other fixed transponder locations will use Lithium batteries to increase the lifetime and save recovery cost.

A transponder might look like one of these:



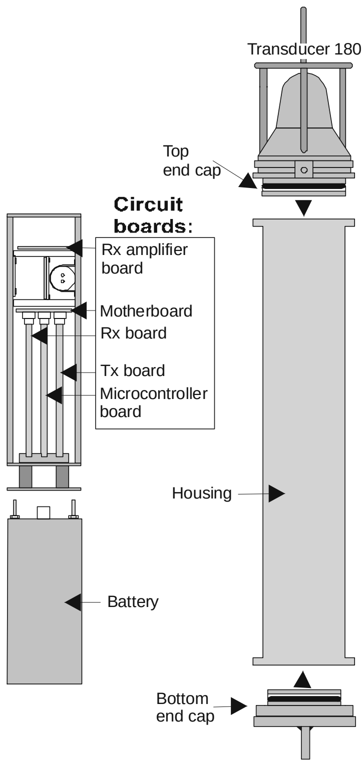
4.2 What is a responder

A responder is an acoustic transmitter, but it is triggered by an electric pulse through the ROV umbilical. By using responders we can be sure that interference of acoustic triggering is avoided. (Example rock dumping vessels).

The responders are often used on ROVs , on the towed fishes on seismic vessels. The responders are usually powered by the ROV, but can also run on batteries.

4.3 Main parts for MPT and SPT transponders

- Circuit boards:
  - Transmitter board (Tx)
  - Receiver board (Rx)
  - Receiver amplifier board
  - Microcontroller board
  - Motherboard
- Battery pack
- Transducer
- Housing
- Bottom end cap



4.4 Transponder models

4.4.1 Main groups

We have three main groups of transponders:

- **MPT** Multifunction Positioning Transponder.
- **SPT** SSBL Positioning Transponder.
- **RPT** ROV Positioning Transponder.

MPT Transponder are used in:

- LBL positioning
- Array calibration
- SSBL positioning
- General telemetry commands *)

SPT Transponders are used in:

- SSBL positioning
- General telemetry commands *)

RPT Transponders are used in:

- ROV positioning
- Tow–fish positioning

(the RPT does not have the telemetry option)

*) Generally telemetry commands:

Read sensor data (depth, temperature, inclination), acoustic release, change tp–channel, source level (4 steps of 3 dB), receiver sensitivity (2 steps, 106/100 dB)

4.4.2 Model name

The transponder model name give the user information about operating frequency, depth rating, transducer beamwidth and any option.

The transponder name is put together like this:

Transponder name = Model name + Model number + Options

Model names

MPT Multifunction Positioning Transponder

SPT SSBL Positioning Transponder (Super Short Base Line)

RPT ROV Positioning Transponder (Remote Operated Vehicle)

Model numbers

1. digit: 1=15 kHz (low frequency)
3=30 kHz (medium frequency)

2. digit: 1=1000 metre depth rating
2=2000 metre depth rating
3=3000 metre depth rating

3. digit: 1= ±15° beamwidth
3= ±30° beamwidth
4= ±45° beamwidth
6= ±60° beamwidth
9= ±90° beamwidth

Options

C	=	Commandable transponder
D	=	Depth sensor
H	=	Heading magnetic compass
E	=	External power
I	=	Inclinometer
II	=	Internal and external inclinometers, (diff. inclo. TP)
N	=	Rechargeable NiCAD or seal lead battery pack w/external connector
R	=	Release mechanism
S	=	Split, separate transducer and housing
T	=	Temperature sensor
L	=	Long tube
Sx	=	Short tube
Rsp	=	Responder
U	=	Unlisted special version, see product description
DuB	=	Dual Beam
Ail	=	Analogue interface logger
St	=	Stainless Steel housing

4.4.3 Transponder series

DEPTH	MPT	SPT	RPT
1000m	MPT 319 series MPT 316 series	SPT 319 series SPT 314 series	RPT 319 RPT 316
2000m			RPT 324
3000m	MPT 339 series MPT 331 series MPT 139 series	SPT 331 series SPT 133 series	

4.4.4 Example of a transponder name

MPT 319/DTR

Model name: MPT=Multifunction Positioning Transponder

Model number: 3=30 kHz

1=1000 metre depth rating

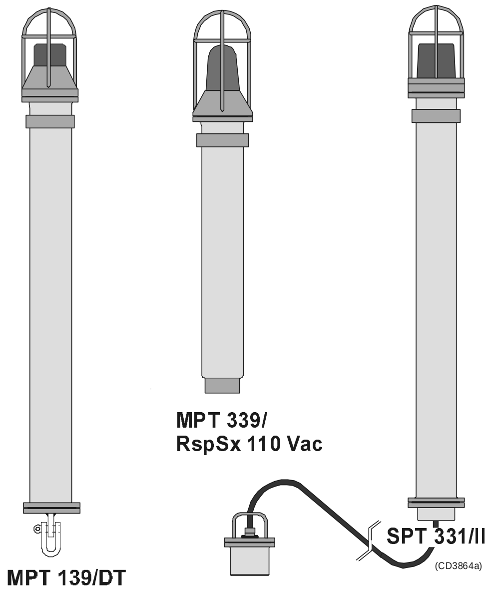
9=±90° beamwidth

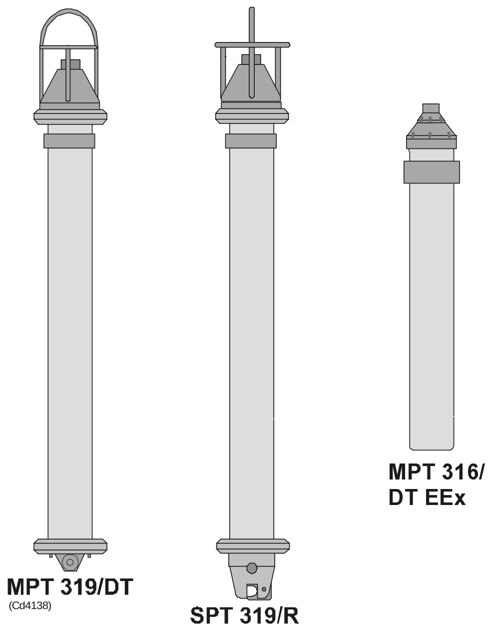
Options: D=Depth sensor

T=Temp. sensor

R=Release mechanism

4.4.5 Examples of some transponders





4.5 How does a transponder work?

4.5.1 Interrogation

When positioning a transponder is triggered with one or two acoustic pulses from the transducer onboard the vessel or rig. The HPR 300 series transponders are interrogated with one pulse. The HPR 400 transponders are interrogated with two pulses.

Each transponder channel has its own frequency code. This means that the transponder requires the exact frequency/frequencies to be received and detected before it replies, and the HPR system onboard is listening for this transponder's reply frequency.

The turn–around delay is the internal delay in the transponder.

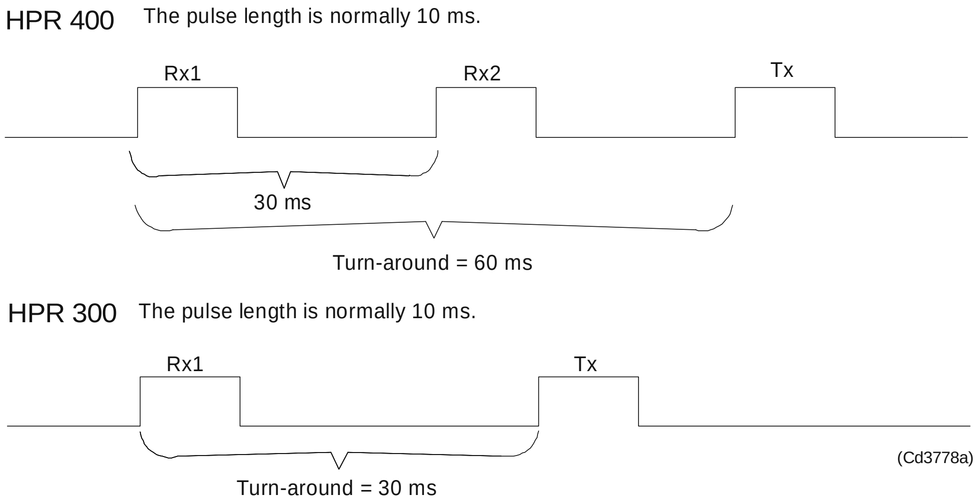


Figure: Transponder reception and transmission signal timing diagram.

4.5.2 HPR 300 Channels & Positioning Frequencies

HPR 300 transponders use the medium frequency band (MF) 30kHz

The channels are :

B01, B02, B03, B04, B05, B06, B07, B08, B09

and B11 □, B22 O , B33 ∇ , B44 X , B55 Y.

When positioning these transponders are all interrogated with one pulse from the transducer, the so called interrogation frequency, and reply with one pulse.

Transponder	**Operating frequencies (Hz)**	
Channel	**Interrogation**	**Reply**
Number	**(TP Rx)**	**(TP Tx)**
B01	20492	29762
B02	21552	30488
B03	22124	31250
B04	22727	31847
B05	23364	32468
B06	24038	27173
B07	24510	27777
B08	25000	28409
B09	26042	29070
B11	21552	27173
B22	22727	28409
B33	23923	29762
B44	25126	31250
B55	26455	32467

Example:

- Channel number B33

Frequency for interrogation pulse: 23923Hz

Frequency for reply pulse: 29762Hz.

4.5.3 HPR 400 and HiPAP Channels & Positioning Frequencies

HPR 400 transponders use the medium frequency band (MF) 30kHz

The channels are: B12, B13 ...... B87, except the HPR 300 channels.

The HPR 400 system interrogates the transponders by transmitting two pulses with frequencies according to the protocol. The transponder reply is determined by the second interrogation pulse. When the first interrogation pulse is an odd number (o) the reply is 250Hz higher than it is when the pulse is an even number (e).

Transponder Channel Number	*Operating frequencies (Hz) Interrogation (TP Rx)*	*Reply (TP Tx)*
Be1	21000	28500
Bo1	21000	28750
Be2	21500	29000
Bo2	21500	29250
Be3	22000	29500
Bo3	22000	29750
Be4	22500	30000
Bo4	22500	30250
Be5	23000	30500
Bo5	23000	30750
Be6	23500	27000
Bo6	23500	27250
Be7	24000	27500
Bo7	24000	27750
Be8	24500	28000
Bo8	24500	28250

Examples:

- Channel number B25

Frequency for first interrogation pulse (2): 21500Hz

Frequency for second interrogation pulse (5): 23000Hz.

Frequency for reply pulse (even/5): 30500Hz.

- Channel number B35

Frequency for first interrogation pulse (3): 22000Hz

Frequency for second interrogation pulse (5): 23000Hz.

Frequency for reply pulse (odd/5): 30750Hz.

Note ! *In the second example the reply pulse frequency is 250Hz higher than in the first example beacuse the first digit in the channel number is now odd and the second digit is similar in the two examples.*

4.5.4 Low frequency channels and frequencies

Low frequency transponders use the low frequency band (LF) 12kHz

Transponder	Operating frequencies (Hz)	
channel	Interrogation	Reply
number	(TP Rx)	(TP Tx)
Ae1	10000	13000
Ao1	10000	13250
Ae2	10500	13500
Ao2	10500	13750
Ae3	11000	14000
Ao3	11000	14250
Ae4	11500	14500
Ao4	11500	14750
Ae5	12000	15000
Ao5	12000	15250
Ae6	12500	15500
Ao6	12500	15750

Example:

- Channel number A12

Frequency for first interrogation pulse (1): 10000Hz

Frequency for second interrogation pulse (2): 10500Hz

Frequency for reply pulse (odd/1): 13750Hz.

4.5.5 Pulse positioning with sensor information

When positioning the HPR 300 and HPR 400 transponders reply with one pulse. When pulse positioning are used the transponders reply with two or three pulses. The time delay between the first and second and between the second and third reply pulse, contains coded information.

Inclination transponders are equipped with two inclinometers (X and Y directions), and will transmit the angle to the HPR system.

Inclination coding:

X–angle as time delay between first and second pulse.

Y–angle as time delay between second and third pulse.

4ms per degree(°):	–15°	=	180ms
	0°	=	240ms
	+15°	=	300ms

Depth transponders are equipped with a depth pressure sensor, and will transmit the depth information to the HPR system. The depth is used by the HPR system to increase the accuracy of the vertical angle measurement.

Depth coding:

Depth is measured as time delay between first and second pulse.

For HPR400:	1m per 1ms;	0m depth=125ms
For HPR300:	2m per 1ms;	0m depth=125ms

Compass transponders are equipped with an internal compass, and will transmit the true heading of the transponder.

Compass coding:

Compass angle is measured as time delay between first and second pulse.

1ms per degree (°);   125ms = 0°

(i.e. 125ms – 485ms full scale 360°)

4.5.6 HPR400 acoustic coding principle

The coding principle is called “Factoring coding”, and has a total of 5040 combinations. 4096 of these are used for defining a 12–bit message, while the remainder, 4097–5040, are spare. The spare combinations may be used for other messages such as ASCII transmissions and special single messages.

The telemtry link uses bursts of seven pulses, all with different frequencies, transmitted in a sequence to make up a message. Every burst is 310ms long and the delay between them are 1 second.

First a wake up call is sent on the Bxx/Axx channel. One second later the telegram is sent. The telegram contains an address and a command. The serial number is unik for every transponder and it is therefore used as the address.

If the telegram is received OK in the transponder it will answer with a data telegram containing an “OK aknowledge” message. The telegram might also contain the information/values you commanded the transponder to measure and send to topside.

If the telegram was not received in the transponder a timeout message will appeare on topside and you have to send the message again.

You can by telemetry commands change channels, source level, turnaround delay, receive gain, read depth, temperature, inclination values, battery status from the transponder, release the transponder etc.

4.5.7 HPR300 pulse command function

In a HPR300 system the command system uses a combination of "Frequency shift keying" and "Pulse position coding".

The commands are transmitted as a series of tone bursts. Two frequencies are required to transmit the range of commands to each transponder.

These frequencies are:

- A Common Command Frequency (CCF) – common to all transponders.
  - CCF=9005Hz for LF transponders
  - CCF=20000Hz for MF transponders
- An Individual Interrogation Frequency (IIF) – specific to the particular transponder.

The CFF pulse is sent first followed by the IIF pulse is sent. The delay between the two pulses contain the command address and decides which transponder(s) to be commanded. Every reachable transponder with this channel number is then awakened. After a delay the two pulses are sent again. The command function is coded in the size of this time delay.

The two pulses are transmitted a number of times to be sure that the transponder receives the command. To provide the required security and to prevent spurios operations, the command signal must be decoded correctly several times before the command is acted upon.

4.5.8 Ping count

Transponders with the pulse command option have the ping count function implemented. This function enables the operator to read battery status from the transponder. It is presented as number of pings transmitted from the transponder. The operator can then compare it to the battery specifications, and calculate the remaining battery capacity.

In HPR400 mode the telemetry link is used. The operator executes the command "Read battery status" from the menu. The command orders the transponder to send battery status back to the HPR system and the ping count value can then be presented in the display.

In HPR300 mode ping count coding is used. When we use the command "Enable SSBL TP" from the system the transponder automatically sends the ping count back to the HPR system. The ping count is measured between first and second reply pulse. After the enable command has been excepted the ping count will be transmitted on the next 8 interrogations and then presented in the display.

Code for HPR300 transponders:

125ms=0ping, +1ms=+20000 ping

Examples:

- 175ms=1M ping
- 180ms=1.1M ping

4.6 Which transponder to use

We cant use any kind of transponder. We have to take in consideration what we are going to use it for, communication range, how deep and how far away it will operate, which beamwidth we want and how much noise there is in the area we operate. Konsberg Simrad has over 30 different models.

4.6.1 Application

Typical use for different transponders:

- MPT LBL/SSBL/Telemetry/Array calibration
- SPT SSBL/Telemetry
- RPT ROV/Tow-fish (no Telemetry)

4.6.2 Depth rating

At what depth will the transponder operate?

- 1000 metre
- 2000 metre
- 3000 metre

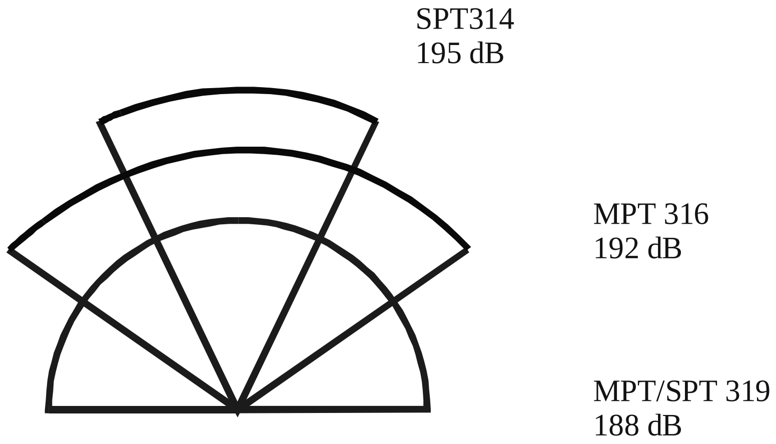
4.6.3 Beamwidth, Communication range, Source level and Noise

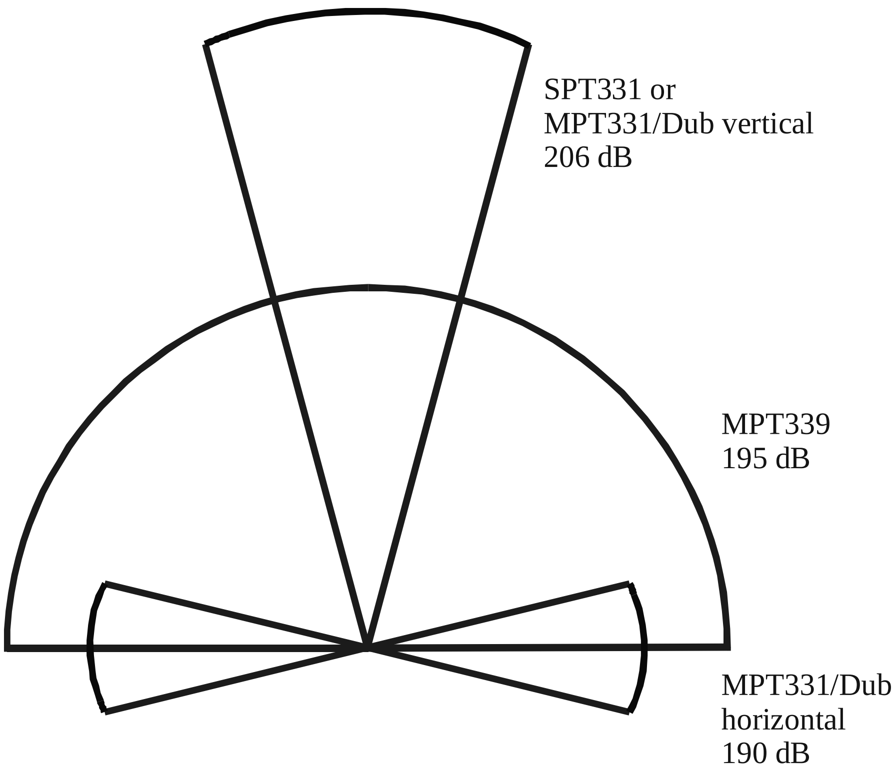
These are all factors we must have in mind to choose the right transponder. We have to compromise between beamwidth and source level to find the best solution for the parameteres. The Signal/Noise ratio has to be higher than 20dB.

Examples of Source Levels for some transponders:

- RPT 316 192dB
- RPT 324 195dB
- MPT/SPT 331 max 206dB vertical 190dB horizontal
- MPT/SPT 339 max 195dB
- MPT/SPT 314 max 192dB
- MPT/SPT/RPT 319 max 188dB

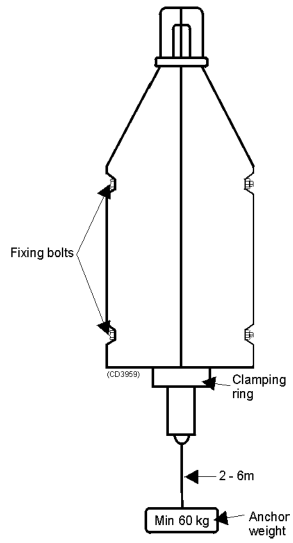
4.6.4 Examples of beampattern for some transponders





4.7 Transponders with floating collars

The transponders might be deployed with a rope or a wire going to a buoy or the vessel on the surface, or they might be ”thrown” over the side of the vessel if they have an acoustic release mechanism.



The length of the rope between the transponder base and the weight can be 2–6 m. The recommended weight of the sinker is different for 1000 m and 3000 m transponders. For 1000m transponders we recommend a weight of approx. 60 kg. For 3000m transponders we recommend 100 kg.

Keep in mind the current when transponders are deployed. The weight might be increased if the current is strong, it is most important to get the transponder in the exact predetermined position.

Make sure the weight of the transponder and the sinker is brought up in the sinker and not in the protective cage on the transponder whenever the transponder is handled.

The cage is for protection of the transducer, and is certified for lifting the transponder with flotation collar only.

When we release a transponder remember to have the interrogation on while it floats to the surface. Also notice that there might be current drifting the transponder som distance away from the vessel/rig. The time from 100 metre depth to surface might be a minute.

4.8 Battery lifetime

4.8.1 Lifetime dependent factors

A transponder uses power every time it receives and transmits a pulse (ping). If the transponder has not received a ping for some time it automatically goes to sleep mode (the transponder uses some power in sleep mode as well).

The lifetime of the battery depends on the following factors:

- Activity

One ping is used to send only a reply pulse. Two pings are required to transmit the depth information and three pings to transmit the inclinometer information. When the transponder is set to HPR 400, and used for full telemetry, seven pings are required for each message. The battery lifetime could therefore be much reduced from that stated. However each reply is counted up and can be available to the operator.

- Source level

The higer source level the more battery power is used. The source level can be set in 4 different steps.

- Pulse length (Tx)

The longer pulse the more battery power is used. The pulse length can be set in steps from 5 to 10 ms.

4.8.2 The ammount of pings

Battery lifetime can be presented as the number of reply pulses.

Battery lifetime at operation. *Batterytype L10/36*						
Transponder type	*Low SL*	*Max SL*	*Low SL*	*Max SL*	*Low SL*	*Max SL*
SPT 319 series	19.6	4.9	N/A	N/A	N/A	N/A
SPT 314 series	19.6	4.9	N/A	N/A	N/A	N/A
MPT 319 series	19.6	4.9	N/A	N/A	N/A	N/A
MPT 319 / DT–St	19.6	4.9	N/A	N/A	N/A	N/A
MPT 316 / DT EEx	N/A	N/A	10.8	2.7	N/A	N/A
MPT 316 / EEx 90	N/A	N/A	10.8	2.7	N/A	N/A
MPT 319 / L–St	N/A	N/A	N/A	N/A	48	12

4.8.3 Quiescent lifetime

This is the total time the transponder can listen for interrogation pulses. After this time the transponder will not be able to reply.

4.8.4 Max continuous on time

This is the maximum time the transponder can be continuously in operation, receiving and transmitting. If a low interrogation rate is used, this time may be required.

Battery lifetime at quiescent state. *Battery type L10/36*			* if 1 ping pr 5 sec.			
Transponder type	*Max. count on time*	*Quies-cent time*	*Max. count on time*	*Quies-cent time*	*Max. count on time*	*Quies-cent time*
SPT 319 series	185	1045	N/A	N/A	N/A	N/A
SPT 314 series	185	1045	N/A	N/A	N/A	N/A
MPT 319 series	185	1045	N/A	N/A	N/A	N/A
MPT 319 / DT–St	N/A	N/A	150 *	1045	N/A	N/A
MPT 316 / DT EEx	N/A	N/A	150 *	1045	N/A	N/A
MPT 316 / EEx 90	N/A	N/A	150	1045	N/A	N/A
MPT 319 / L–St	N/A	N/A	N/A	N/A	375	1150

Look in the Transponder Instruction Manuals for details about battery lifetimes for other transponders.

4.9 Instruction manuals

There is only three different instruction manuals:

- SPT and MPT x3x series
- SPT and MPT 31x series
- RPT series

They contain technical specifications, operating instructions, maintenance procedures and listing of spare parts for all of our transponders.

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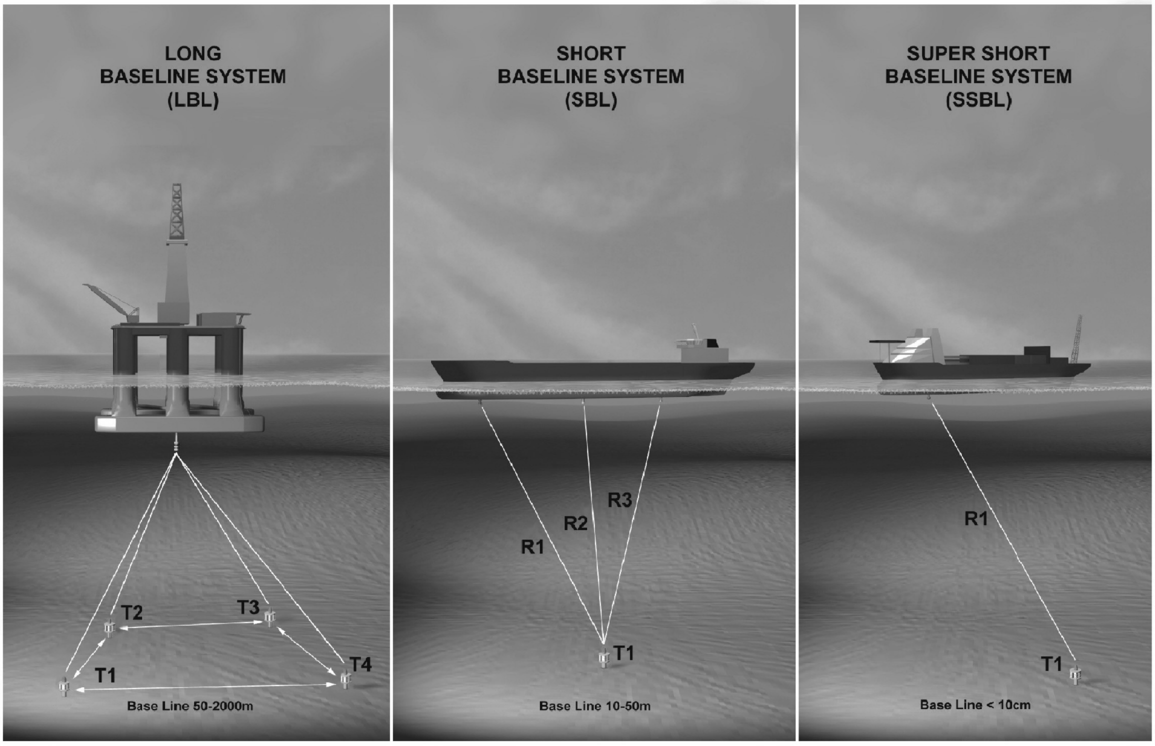
5 POSITIONING PRINCIPLES

5.1 Introduction

Accurate positioning of vessels, remotely operated vehicles (ROV), subsea structures and towed bodies sets new requirements in deeper waters. The position accuracy of the existing Super Short Base Line systems, SSBL, is not sufficient when extra long ranges or high resolution maps are essential. The alternative to the SSBL systems is to deploy and calibrate a seabed Long Base Line, LBL, transponder array. These systems can provide a good accuracy within the range of the transponder array. The LBL method is complex, time consuming and expensive, especially when it comes to pipeline route surveys, or when a large area is to be covered

5.1.1 HPR 400 Systems

The HPR 400 Series of acoustic positioning systems integrates SSBL, LBL and combined SSBL / LBL positioning principles on the same hardware and software platform. The systems can be configured to be one or a combination of the principles as follows.



5.1.2 HPR 408 LBL system

Uses LBL type of transducer(s). Position surface vessel or ROV relative to local seabed transponder array. Provides data both in local and UTM co-ordinates. Can be used with a selection of LBL transponders. Uses acoustic telemetry for array calibration.

5.1.3 HPR 410 SSBL system

Uses SSBL type of transducer(s). Positions target(s) relative to vessel. Can be used with a selection of transponders. Acoustic telemetry is available.

5.1.4 HPR 418 SSLBL system

Uses SSBL type of transducers. Combines features from both SSBL and LBL. Position surface vessel or ROV relative to local seabed transponder array and/or target relative vessel. Provides data both in local and UTM co-ordinates. Combined algorithm uses both ranges and directional measurements to compute the position. Can be used with a selection of transponders. Uses acoustic telemetry for array calibration.

5.1.5 HPR 400P Portable system

The HPR 400 series also consists of a portable system, which has the same functionality as the above systems. The portable system has some limitations and is not for use with a DP system. The portable system is not described here.

5.1.6 HiPAP System

The High Precision Acoustic Positioning (HiPAP) system is designed to provide accurate positions of subsea targets such as ROVs, towed bodies or fixed transponders. To achieve the accuracy, the HiPAP system uses a new, spherical transducer design and a new signal processing technique. This new technique enables narrow beams to be generated in all directions within the lower half of the transducer using only electronic beam control. The HiPAP system operates as a SSBL system, but has a unique processing technique that provides very high accuracy.

The system calculates a three-dimensional subsea position of a transponder relative to a vessel-mounted transducer. The position calculation is based on range and direction measurements to one transponder. The onboard transducer transmits an interrogation pulse to a subsea transponder, which then answers with a reply pulse. The onboard transducer will then measure the range and direction to the transponder from this reply pulse, and present the result on the colour video display unit.

The system uses acoustic telemetry for communication to transponders and BOP control units

The HiPAP system used for SSLBL positioning may be used to position the surface vessel or ROV relative to local seabed transponder array. It can in addition position a target relative to the vessel.

The system provides data both in local and UTM co–ordinates. The combined algorithm uses both ranges and directional measurements to compute the position. It can be used with a selection of transponders. Acoustic telemetry is used for array calibration.

5.2 SSBL Positioning Principle

The SSBL principle has the obvious advantage that it requires no installation of transponders on the seabed. Only the targets that are to be positioned must be equipped with a transponder. A SSBL system is measuring the horizontal and vertical angles together with the range to the transponders. An error in the angle measurement causes the position error to be a function of the range to the transponder. To obtain better position accuracy in deep water with an SSBL system it is necessary to increase the angle measurement accuracy.

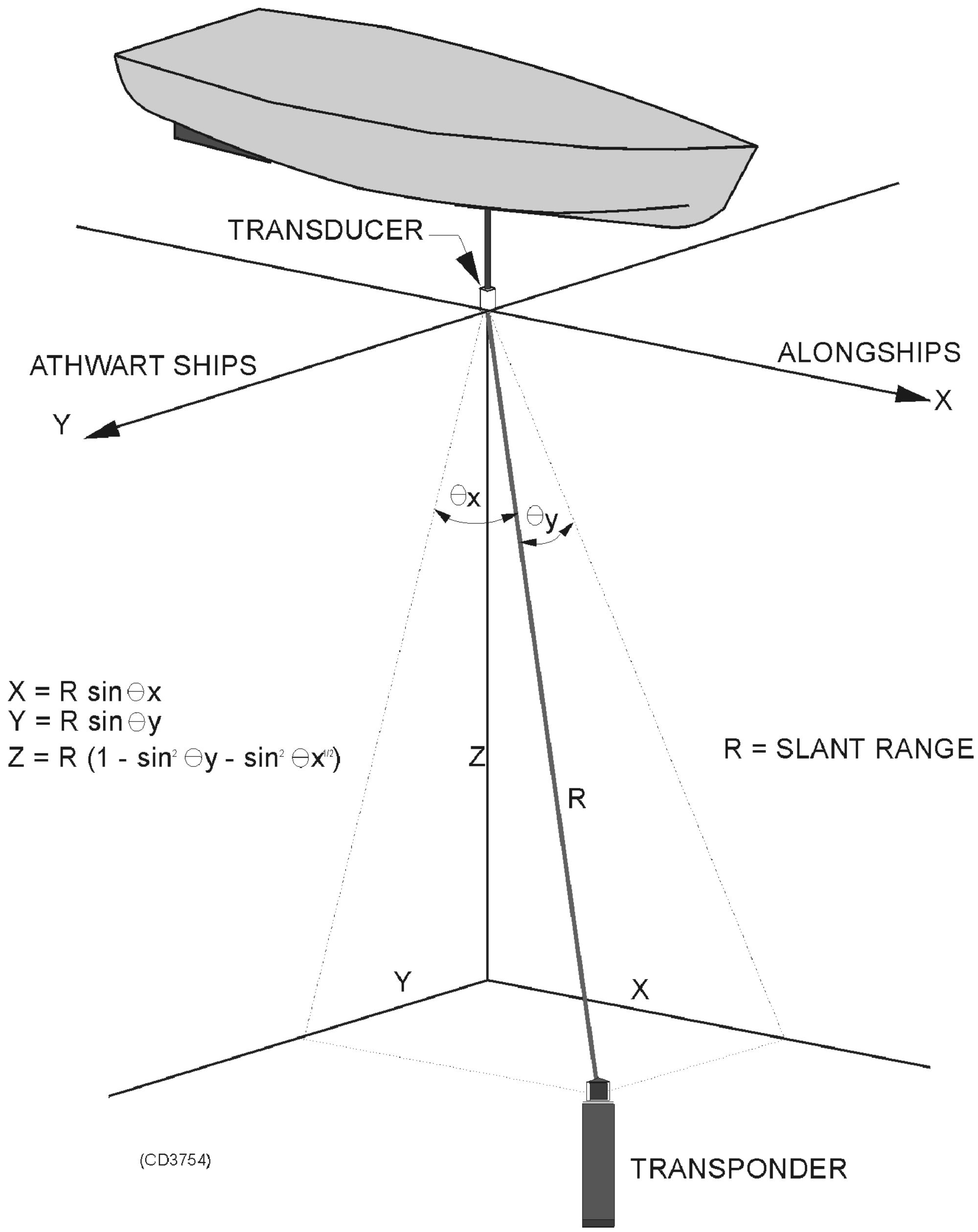
In SSBL the HiPAP® and HPR 410 system calculates a three-dimensional sub-sea position of a transponder relative to a vessel-mounted transducer. The position calculation is based on range and direction measurements to one transponder.

The onboard transducer transmits an interrogation pulse to a sub-sea transponder, which then answers with a reply pulse.

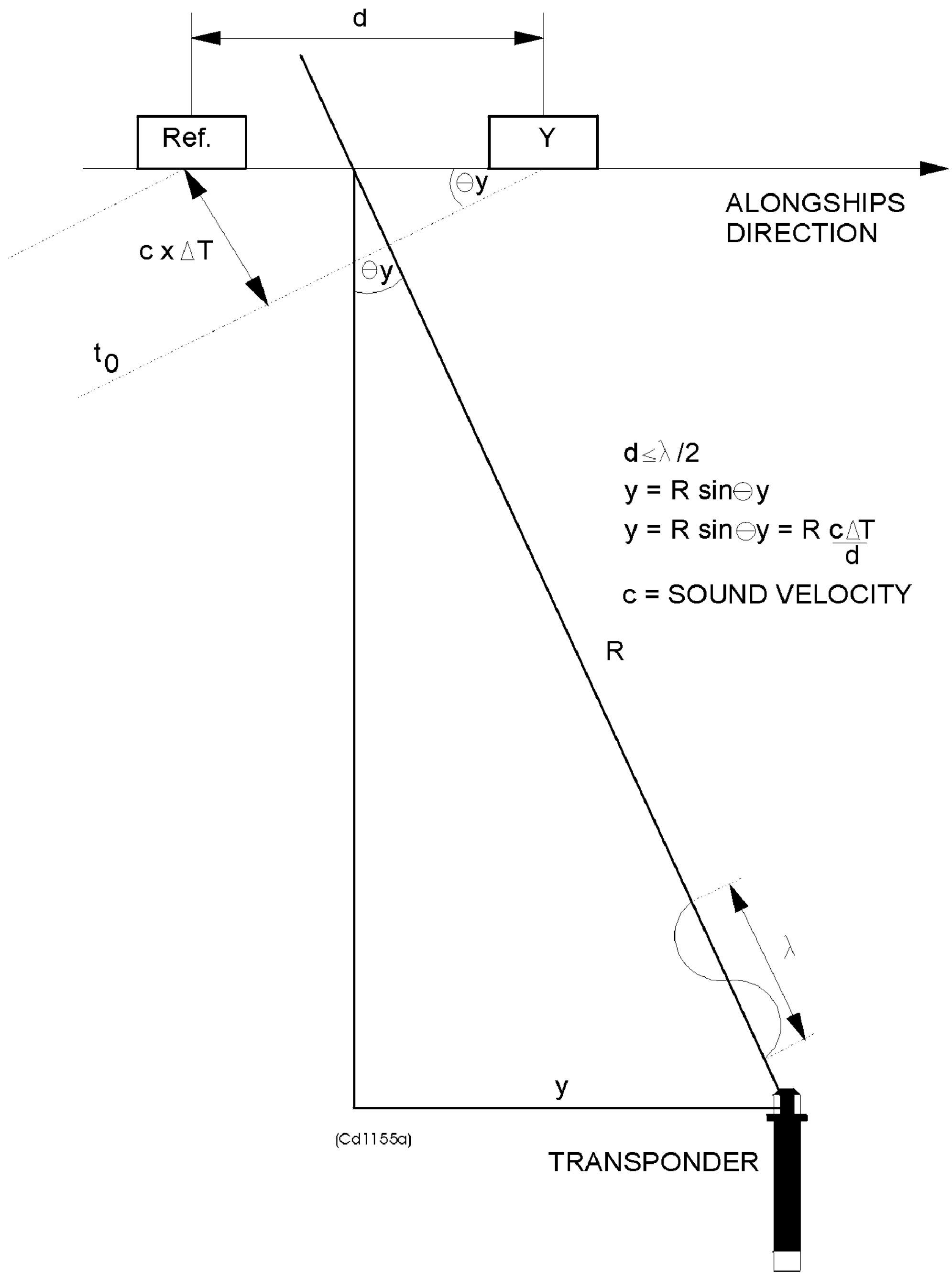
The onboard system will measure the time from interrogation to the reply pulse is detected and use the sound velocity to compute the range. The SSBL transducer consists of several element groups. In the HPR 400 system the direction to the transponder is computed from a phase measurement between the SSBL transducer elements. The transponder position is presented on the colour video display unit.

Using a pressure sensor in the sub-sea transponder can increase position and depth accuracy. The water pressure is measured and transmitted to the surface HiPAP® / HPR system using telemetry. The depth is then used in the algorithms for establishing the 3D position. The system can also read the depth via a serial line input from a pressure sensor. Simultaneous use of many transponders is made possible by utilising individual interrogation and reply frequencies.

The SSBL principle



The SSBL principle



5.3 HiPAP Positioning Principle

5.3.1 Introduction

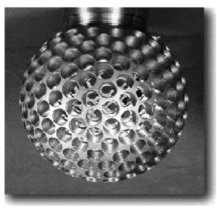
The High Precision Acoustic Positioning (HiPAP®) system is designed to provide a significant increase of the angle measurement accuracy compared to existing positioning systems. To obtain this the HiPAP® system uses a new transducer design along with new signal processing technique. This new technique allows us to form narrow beams in all directions within the lower half sphere using only electronic beam control. The narrow beams provide improved Signal to Noise (S/N) ratio, improved angle measurement accuracy and suppress the effect of reflections.

HiPAP® was originally designed to operate with two transducers in order to meet the demanding accuracy requirements. However, practical offshore performance achieved when utilizing a single transducer system has exceeded expectations and removed the need for a dual transducer installation.

On the other hand, if the requirement for even better accuracy, or for redundancy (both electrical and acoustical) is relevant, a dual transducer system is available. This allows redundant measurements, position estimation based on two measurements, and a quality check of the measurements.

5.3.2 Transducer

The HiPAP® has a spherical transducer with more than 200 elements covering the whole sphere except for a 45 degree cone around the ″north pole″. A large number of elements allows the system to form narrow beams of 10 degree for reception of signals from the transponder. This will minimize the influence of vessel noise to a level which is unique. For the interrogation of the transponder a wide beam is used.

5.3.3 Operational principles

The HiPAP® system determines the position of a subsea target (transponder or responder) by controlling a narrow reception beam towards its location. The system uses a digital beam–former, which takes its input from all the transducer elements. The system uses a number of wide fixed beams to generate an approximate position for the target. Once this is achieved, it uses data from all the elements on the hemisphere facing the target to compute the narrow reception beam and optimise the directional measurement. The range is measured by noting the time delay between interrogation and reception. The system will control the beam dynamically so it is always pointing towards the target. The target may be moving, and the vessel itself is affected by pitch, roll and yaw. Data from a roll/pitch sensor is used to stabilise the beam for roll and pitch, while directional data from a compass is input to the tracking algorithm to direct the beam in the correct horizontal direction.The HiPAP® transceiver can operate with up to 56 transponders simultaneously and uses the HPR 400 transponders channels.

5.3.4 Beam control

The system will control the beam dynamically so it is always pointing towards the target. The target may be moving, and the vessel itself will be affected by pitch, roll and yaw. Data from a roll/pitch sensor is used to stabilize the beam for roll and pitch, while directional data from a compass is input to the tracking algorithm to direct the beam in the correct horizontal direction.

5.3.5 Sound velocity compensation

The positions calculated from the measured angles and the measured range are influenced by raybending due to different sound velocity in the water column. The system can correct for these errors. The sound velocity values may be measured by a probe and transferred to the system or they may be entered manually. If the depth of the target (transponder) is known either by depth sensor in the transponder or by an ROV's depth sensor, these data can be transferred to the system. The range calculation is compensated for the error caused by different sound velocities in the water column, and for the extra travel path caused by the raybending. The transducer is equipped with a temperature sensor in order to continuously calculate the sound velocity at the transducer. The sound velocity may then be observed during the survey.

5.3.6 Dual system

The Simrad HiPAP® system is designed to operate with one or two transducers. Use of two transducers will increase the electrical and acoustic redundancy, and also increase the accuracy, as it opens for redundant measurement with position estimation based on two independent measurements and a quality control. The dual system uses both transducers to measure the position of one single target (transponder) by separately controlling the beamforming and phase measurement for each system in parallel. This means that for the same reply pulse from the transponder both systems will measure and calculate a position.

If the signal is lost on one of the transducers it is still possible to receive it on the other one. A position estimator will use the position information from both systems to estimate one optimal transponder position. Each system calculates a variance for its measurements. It is determined by the known system accuracy and the standard deviation of the measurements. The position estimator receives both the position and the variance from the two systems. It calculates a weighted mean of the two positions. The weight is the variances.

The quality control function will use variance data, standard deviation and position difference to perform a quality control of the positioning. If the variance and the position difference are outside a preset limit, a warning to the operator will be shown. This shows the benefits of a dual system:

5.3.7 Accuracy improvement

The improvement factor from 1 to 2 transducers is $1/\sqrt{2}$. This is based on the statistical improvements when using two independent systems. One transducer will give a horizontal bearing accuracy of 0.3°, while two transducers will give 0.2°

5.3.8 Redundancy improvement

The two transducers will typically be installed at different locations onboard. One transducer may then have a better location with respect to noise environments and reflections than the other. The computed position will be a weighted position of these two measurements. If one of the systems fail to receive a reply, the other system may receive it and the position will still be computed.

5.3.9 Quality improvement

When using two transducers, the system will check and report if the positions from the two systems will differ more than a preset value. Information about the position quality will also be available based on Kalman filtering.

5.3.10 Operator interface

Simrad HiPAP uses the same Operator Unit as the well known HPR 400 series. The Operator Unit controls both a single and a dual HiPAP® system. The Operator Unit consist of a color display, a computer, a keyboard and a joystick. The Operator Unit performs all user interface and controls the transceiver(s). The operation of the system is basically done by a joystick operated, self explanatory menu. The Operator Unit transmits position data to other equipment on a serial line or on an Ethernet using standard TCP/IP protocol. Data may also be stored for later processing.

5.3.11 HiPAP Telemetry processing

The unit transmits acoustic telemetry messages, and receives and decodes the acoustic telemetry message from the transponder. The data is sent to the APC 10.

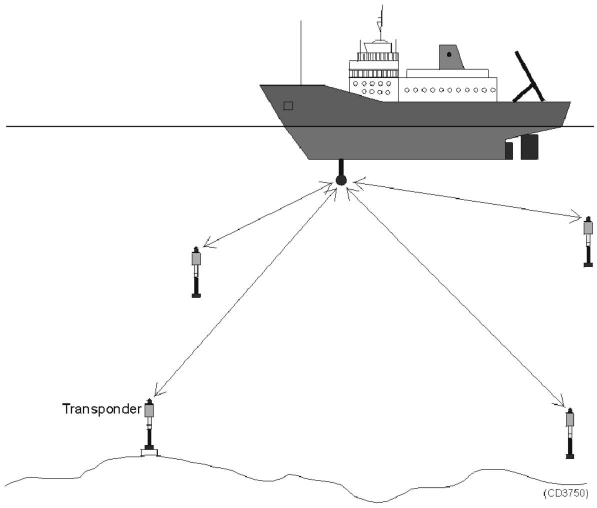
5.3.12 Summary

The Simrad HiPAP® system is a new generation of a SSBL system. It's main advantage is significantly increased accuracy. Other new features are:

- The system has no mechanical transducer steering.
- Narrow pointing receiver beams
- Corrections of errors caused by raybending
- Double position measurement, redundancy, quality control
- May be integrated with Simrad LBL system
- Better noise suppression

5.4 LBL Positioning Principle

The Long Base Line (LBL) principle is based on an onboard transducer, and normally 4 – 6 transponders on the seabed. This seabed transponder array needs to be calibrated before any positioning operations can begin, requiring the base lengths between the transponders to be known. There are automatic calibration functions in the surface HiPAP / HPR system, allowing all the ranges to be measured and made available by acoustic telemetry communication between the transponders and the vessel's system. The calibration is performed only once prior to positioning operation since the transponders will remain at the same location for the duration of the operation.



When the calibration data is known, positioning of the surface vessel can begin. All the seabed transponders will be interrogated simultaneously, and each will respond with its specific reply signal. The transponders do not reply at the same time. The LBL system will then calculate the ranges from the individual transponders. By using the calibration data together with the calculated ranges in software algorithms, the vessel or an ROV can be positioned.

The system can take the depth from an ROV–mounted pressure sensor via a serial line. By using this depth in the computation, it will increase the position accuracy of the ROV.

The range capabilities of a medium frequency LBL system will be approximately the same as those of an SSBL system.

LBL positioning is more complex to operate, needs more transponders than SSBL, but it will give better position accuracy at greater distances.

5.5 Combined SSBL and LBL positioning

The combined SSBL / LBL system uses an onboard multi–element transducer. The system may operate as an SSBL system and as an LBL system simultaneously.

As an example, the vessel may be positioned relative to the seabed using LBL when an SSBL transponder is positioned relative to the vessel, and the positions are displayed relative to the LBL transponder array on the seabed.

The combined system will also use the measured angles together with the measured ranges in the LBL positioning. The combined measurenemt gives a robust system with increased accuracy. An LBL solution is achievable when only two transponder replies are detected.

5.6 SBL Positioning Principle

SBL Positioning is delivered in engineering projects.

It is a LBL system “up-side-down”.

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6 SYSTEM UNITS AND CONFIGURATION

6.1 Introduction

The HiPAP® / HPR 400 system consists of 3 different main units:

- Operator station
- The transceiver
- The Hull Unit with transducer.

A system may be configured with one or several of these units. A gyrocompass and a vertical reference sensor will normally also be included in an HiPAP® / HPR 400 system.

The operator station is common for both HPR 400 Series and the HiPAP. The tranceiver, transducers and hull units are dedicated to each system.

The HPR 400 Series may be supplied with several alternatives for tranceivers, transducer and hull units. An overview of the available modules is shown in the figure "Simrad HPR 400 Series".

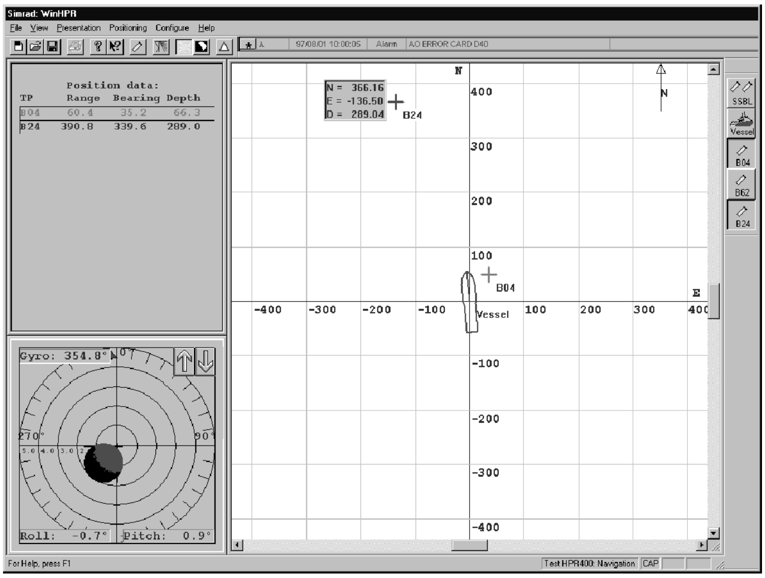
The HiPAP® System uses the same operator station alternatives as the HPR 400 Series, but has only one alternative for tranceiver, transducer and hull unit. The units are shown in system diagrams and in the "Outline dimensions" chapter.

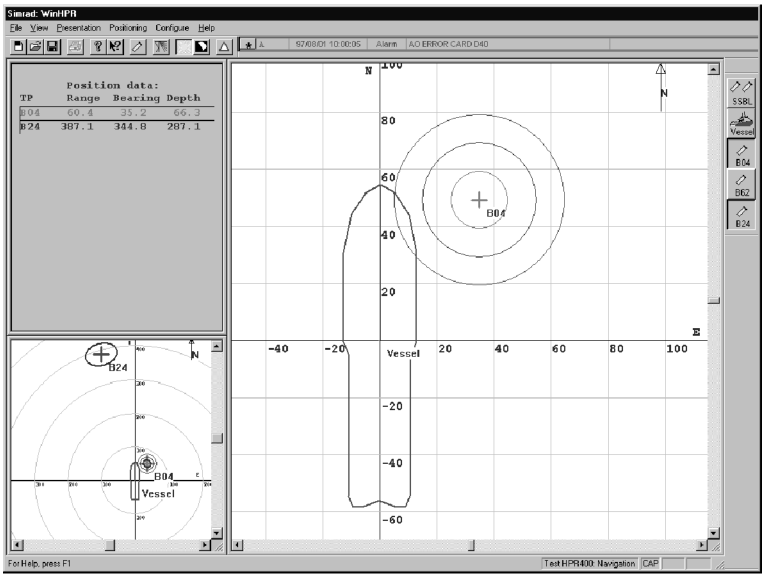
6.2 Operator Station

6.2.1 Introduction

The operator station consists of a computer, the APC 10, monitor and the WinKeyboard. The computer runs on the Microsoft Windows NT operating system. For ease of use, the user interface is a fully graphical user interface, designed as a standard Windows NT application. A keyboard with numerical keys and a roller ball controls the operation. The colour display screen is divided into 3 windows in which the operator can select several different views. Typical views are graphical position plot, numerical data inclination and roll, pitch and heading. The Operator Station is common for the HPR 400 Series and the HiPAP® system.

Examples of the display presentations are shown below.





One system may have one or several operator stations, which communicates on an ethernet. One of the units will be the master, which is selected by the operator(s).

The HiPAP® / HPR system may be configured with the Operator station in tree ways:

- Stand alone APC 10, the WinKeyboard and a monitor
- Operating Console
- Integrated application on the same operator console as the Simrad SDP 70X series DP

6.2.2 Integrated operation with SDP XX

The integrated HiPAP®/HPR and DP operation is available as two different solutions.

6.2.2.1 HiPAP/HPR and DP – one Operator Station.

The operator must select whether the HiPAP®/HPR or DP shall be viewed and operated. This is eligible from the menu. When the DP window is active, the HiPAP®/HPR can be accessed from the menu selecting the HiPAP®/HPR view or accessing a dialogue box for transponder operation. When the HiPAP®/HPR window is active, the DP can be accessed from the menu selecting DP view.

6.2.2.2 HiPAP®/HPR and DP – multiple Operator Stations.

When several operator stations are available, the operator can view/operate the DP on one/several screen(s) and the HiPAP®/HPR on another screen. The operation is the same as for a single operator console.

6.2.3 APC 10 – Acoustic Positioning Computer

The Simrad APC 10 is the computer in the HiPAP®/HPR's operator station. It holds all the operational software, and interfaces to display, keyboard, printers, network and other peripheral devices as required. The unit is normally fitted with a 3.5″ floppy drive. The APC 10 may be mounted attached to the colour monitor, in a 19″ rack or on a ″desk top″.

6.2.4 CF 1515, 1517 Colour monitor

The Simrad CF 1515 is a 15″ RGB colour monitor. The Simrad CF1517 is a 17″ RGB colour monitor. The CF 1515/1517 may be installed in several ways: desktop, 19″ rack, roof or panel.

6.2.5 Console monitors

The HiPAP®/HPR system may be integrated in a console. The monitor will normally then be supplied by the console manufacturer. It should be a 17″ monitor or larger, able to operate with 1240x1024 resolution at 60Hz refresh rate.

6.2.6 Keyboard

The keyboard is designed for easy use. It includes numerical keys, function keys and a roller ball with three buttons. The keyboard can be mounted on the APC 10 or be put on a desktop.

6.2.7 Operator console

The operator console integrates a 21″ monitor, system controller and a keyboard. The console is identical to consoles used with the Simrad DP systems. The console is to be mounted on the deck.

6.3 HiPAP units

6.3.1 HiPAP Transceiver

The HiPAP Transceiver Unit is interfaced to the spherical transducer array. The transceiver contains transmission amplifiers, A/D conversion circuits and a signal processing computer. It is interfaced to attitude sensors, and controls the triggering of up to 4 responders. The transceiver can operate with one HiPAP® transducer. The unit outputs the transponder position to the APC 10.

6.3.1.1 HiPAP Processing

The HiPAP® system determines the position of a subsea target (transponder or responder) by controlling a narrow reception beam towards its location. The system uses a digital beam-former, which takes its input from all the transducer elements. The system uses a number of wide fixed beams to generate an approximate position for the target. Once this is achieved, it uses data from all the elements on the hemisphere facing the target to compute the narrow reception beam and optimise the directional measurement. The range is measured by noting the time delay between interrogation and reception. The system will control the beam dynamically so it is always pointing towards the target. The target may be moving, and the vessel itself is affected by pitch, roll and yaw. Data from a roll/pitch sensor is used to stabilise the beam for roll and pitch, while directional data from a compass is input to the tracking algorithm to direct the beam in the correct horizontal direction.

The HiPAP® transceiver can operate with up to 56 transponders simultaneously, is uses the HPR 400 transponders channels.

6.3.1.2 HiPAP LBL processing

This mode is similar to the HiPAP® processing, but the transceiver positions up to 8 LBL transponders for each interrogation. Both ranges and directions to the transponders are measured. The data is sent to the APC 10.

6.3.1.3 HiPAP Telemetry processing

The unit transmits acoustic telemetry messages, and receives and decodes the acoustic telemetry message from the transponder. The data is sent to the APC 10.

6.3.2 HiPAP Transducer

The HiPAP® system uses a spherical transducer, with elements covering its entire surface area except for a small cone around the ”north-pole”. The large number of elements enables narrow receiver beams to be generated. The transducer is mounted on the hull unit.

6.3.3 HiPAP Hull unit

The hull unit enables the transducer to be lowered, under either local or remote control, through the vessel's hull to a depth sufficient to minimize the effects of noise and air layers below the vessel. The hull unit is installed on top of a gate valve, which can be closed during maintenance of the transducer. The hull unit also holds the guide–rail arrangement for keeping the transducer exactly aligned with the vessel.

The HiPAP® hull unit is the standard hull unit available for the Simrad HiPAP® systems. It is equipped with the following sub units:

- Relay UnitThis unit holds the power supplies and control logic for the hoist and lower operation. It also has a local control panel for local control of the hoist/lower operation
- Remote Control unitThis unit is normally mounted close to the display unit in the operation room. It allows remote control of the hoist and lower operation.

6.4 Attitude sensors

6.4.1 Introduction

Attitude sensors are a common definition for roll, pitch, heave and heading sensors. The HiPAP®/HPR 400 system has a wide range of interfaces to sensors from different manufacturers.

6.4.2 Vertical Reference Unit (VRU)

The Vertical Reference Unit (VRU) is interfaced to the HiPAP®/HPR 400 Transceiver Unit. The system can thereby automatically compensate for the vessel's roll and pitch movements. The HiPAP®/HPR system can use the same VRU as the Dynamic Positioning (DP) system (if one is fitted).

The Vertical Reference Unit may or may not be a part of the Simrad delivery. In any case, the unit is documented separately by the applicable manufacturer.

6.4.3 Gyro compass

The gyro compass supplies the HiPAP®/HPR with the vessel's heading relative to north. The HiPAP®/HPR may then provide transponder co-ordinates relative to north. It is also used to update the position filter as the vessel changes heading.

6.4.4 Integrated attitude sensors

These sensors integrate rate gyros, accelerometer and GPS to provide an accurate roll, pitch, heave and heading output. These sensors are superior to traditional gyros and VRUs. The HiPAP®/HPR may be interfaced to such sensors.

6.4.5 Interface specification

The HiPAP®/HPR has several interface formats available. These are described in "Attitude formats description".

6.5 Technical Specifications

6.5.1 APC 10

Power supply, voltage	180–264 VAC/ 90–132 VAC
Power supply, frequency	50–60 Hz
Power supply, current max	220 V–4 A/ 110V–6 A
Temperature, storage	–40 to +70 °C
Temperature, operating	+10 to +55 °C
Humidity, storage	95% relative
Humidity, operating	85% relative
Vibration:	
Range	5–100 Hz
Excitation level	5–13.2Hz 1.5mm, 13.2–100 Hz 1 g
Humidity, operating	85% relative
Colour graphics resolution	eligible max. 1600x1200
Video output	15 pin, analogue VGA
Floppy drive	3.5″
Printer interface	Parallel
Electrical interfaces	RS 422, RS 232, ethernet

Telegram formats serial lines:

- Binary HPR 209/309
- Binary HPR 400
- BCD code
- Proprietary NMEA

Telegram formats ethernet:

- Binary HPR 400
- Proprietary NMEA

6.5.2 CF 1517 Colour monitor

Power supply, voltage	220–240 VAC/ 100–120 VAC
Power supply, frequency	50–60 Hz
Power supply, current max.	1.3 A
Temperature, storage	–20 to +60 °C
Temperature, operating	+0 to +35 °C
Humidity, storage	10 – 90% relative
Humidity, operating	20 – 80% relative

6.5.3 CF 1515 Colour monitor

Power supply, voltage (JH 1504 MXV)	220–240 VAC
Power supply, voltage (JH 1504 110)	100–120 VAC
Power supply, frequency	50–60 Hz
Power supply, current max.	1.1 A
Temperature, storage	–20 to +60 °C
Temperature, operating	+0 to +35 °C
Humidity, storage	10 – 90% relative
Humidity, operating	20 – 80% relative

6.5.4 HPR 400 Transceiver Unit

Power supply, voltage	185 – 264 VAC
Power supply, frequency	50–60 Hz
Power supply, consumption max.	55 W
Temperature, storage	–20 to +60 °C
Temperature, operating	0 to +55 °C
Degree of protection, in 6u cabinet	IP 54
Humidity, storage	90% relative
Humidity, operating	80% relative

Heading reference:

- Synchronous
- Serial RS 422 SKR format
- Serial RS 422 STL format
- Serial RS 422 NMEA format
- Serial RS 422 Seatex MRU or Seapath
- Serial RS 422 DGR format (Tokimec DGR 11)

Roll and pitch reference:

- Analogue Sine +–90° +–10V
- Analogue Sine +–15° +–10V
- Analogue linear +–60° +–10V
- Analogue Seatex MRU +–20° +–10V
- Serial RS 422 Seatex MRU or Seapath

Transducer frequency combinations:

- 2 SSBL MF and 2 LBL/Telemetry MF
- 2 SSBL LF and 2 LBL/Telemetry LF
- 1 SSBL & 1 LBL/Telemetry MF and 1 SSBL & 1 LBL/Telemetry LF

Responder drives	max. 4
Transponders in use max.	56
Transponder channels	HPR 300 and HPR 400

6.5.5 HiPAP Transceiver Unit

Power supply, voltage	230 VAC +/–10%
Power supply, frequency	50–60 Hz
Power supply, consumption	max. 700 W
Temperature, storage	–20 to +65 °C
Temperature, operating	0 to +35 °C
Degree of protection, in 6u cabinet	IP 22
Humidity, storage	90% relative
Humidity, operating	80% relative
Weight	Approx. 55kg

Heading reference:

- Serial RS 422 SKR format
- Serial RS 422 STL format
- Serial RS 422 NMEA format
- Serial RS 422 Seatex MRU or Seapath
- Serial RS 422 DGR format (Tokimec DGR 11)
- Serial RS 422 NMEA HDT, VHW

Roll and pitch reference:

- Serial RS 422 Seatex MRU or Seapath

Transducer frequency combinations:

- 1 HiPAP MF

Responder drives	max. 4
Transponders in use	max. 56
Transponder channels	HPR 400

6.5.6 Hoist Control:

Power supply, voltage	230/440 VAC 3 Phase
Power supply, frequency	50–60 Hz
Power supply, consumption max.	1100 W
Temperature, storage	–20 to +60 °C
Temperature, operating	0 to +55 °C
Degree of protection	IP 54
Humidity, storage	90% relative
Humidity, operating	80% relative

6.5.7 Hull Unit

Power supply, voltage	230/440 VAC 3 Phase
Power supply, frequency	50–60 Hz
Power supply, consumption	max. 1100 W
Temperature, storage	–20 to +60 °C
Temperature, operating	0 to +55 °C
Degree of protection	IP 54
Humidity, storage	90% relative
Humidity, operating	80% relative
Weight, HL3880	1225 Kg
Weight, HL3100	1261 Kg
Weight, HL2300	1161 Kg
Weight, HL1530	1061 Kg
Weight, HL 3380 Ex–1	1336 Kg

6.6 Accuracy

6.6.1 HPR 400 Standard transducer 20–32 kHz:

Wide beam	± 80 °	<=5 % of slant range
Medium beam	± 55 °	<=2 % of slant range

6.6.2 HPR 400 Narrow beam transducer 20–32 kHz:

Wide beam	± 80 °	<=5 % of slant range
Narrow beam	± 22.5 °	<=1 % of slant range

6.6.3 HPR 400 Standard transducer 10–15 kHz:

Wide beam	± 80 °	<=5 % of slant range
Medium beam	± 55 °	<=2 % of slant range

6.6.4 HiPAP system 20–32 kHz:

Receiver beam, coverage	<=10º, 180º hemispherical
Single system, horizontal bearing	<=0.3º
Single system, vertical	<=0.3º at 0º elevation
Single system, vertical	<=0.6º at 90º elevation
Dual system, horizontal bearing	<=0.2º
Dual system, vertical	<=0.2º at 0º elevation
Dual system, vertical	<=0.4º at 90º elevation
Range	<=0.2m

The specification is based on:

- Line of sight from transducer to transponder
- No influence from ray bending
- Signal to Noise ratio >= 20 dB. rel. 1 μPa
- No error from heading and roll/pitch sensors.

6.7 Range capabilities

The range capabilities are very dependant of the vessels noise level and reduction in transponder signal level due to ray bending. The HiPAP® system will in most cases have longer range capabilities that specified below due to it's narrow receiving beam. The figures are approximate values for guidance.

6.7.1 Standard transponder

w/ 188 dB rel.1 μPa ref.1m Typical max. 1500m

6.7.2 High power transponder

w/ 195 dB rel.1 μPa ref.1m Typical max. 2000m

6.7.3 High power transponder

w/ 206 dB rel.1 μPa ref.1m Typical max. 3000m

The specification is based on:

- Line of sight from transducer to transponder,
- No influence from ray bending,
- Signal to Noise ratio >= 20 dB. rel. 1 μPa,
- No error from heading and roll/pitch sensors

6.8 System configuration

6.8.1 Introduction

The HiPAP®/HPR 400 system may be configured in several different ways, from a single system to a redundant system with several operator stations. Some configurations are described below.

6.8.2 Single HPR 400 system

The single system includes the minimum units for a fully operational system. The communication from Operator Station and HPR 400 transceiver is a serial line. The data output from the system is also serial line. A system like this can be a HPR 410 or a HPR 418. See following system diagram.

6.8.3 Redundant HPR 400 system

The redundant system has two of each unit to secure continuous operation even with a single failure. This system has communication between HPR 400 transceiver and Operator Station on a dual ethernet, which secures control of both transducers if one Operator Station breaks down. The communication to other computers may be via ethernet or via serial lines. See following system diagram.

6.8.4 Combined HiPAP and HPR 400 system

A combined configuration uses the common operator station or consoles to operate both HiPAP® and HPR 400 systems. Existing HPR 400 system may be upgraded to a combined system by adding the HiPAP® Hull Unit and transceiver. The operator can control both systems by using one operator station/console.

6.8.5 Dual HiPAP system

HiPAP® is designed to operate with one or two sets of transceivers/transducers, both operated from the same operator station(s). The use of two sets is recommended, and enables redundant measurements with position estimation based on two independent measurements and a quality control. The dual system uses both transducers to measure the position of one single target (transponder) by controlling beam forming and phase measurement separately for each system in parallel. This means that both systems will measure and calculate a position for the same reply pulse from the transponder. If the signal is lost on one of the transducers it may still possible to receive it on the other one.

A position estimator will use the position information from both systems to estimate one optimal transponder position. Each system calculates a variance for its measurements, determined from the known system accuracy and the standard deviation of the measurements. The position estimator receives the position and the variance from the two systems, and calculates the weighted mean of the two positions. The variances are used as the weights. The quality control function uses variance data, standard deviation and position difference to perform a quality control of the position. If the variance and the position difference are outside a preset limit, a warning will be displayed for the operator. For the dual configuration a synchronisation line between the transceiver are required.

The following paragraphs indicate the benefits of a dual system:

6.8.5.1 Accuracy improvement

The improvement factor from 1 to 2 transducers is $1/\sqrt{2}$. This is based on the statistical improvements when using two independent systems. One transducer will give a horizontal bearing accuracy of 0.3°, while two transducers will give 0.2°.

6.8.5.2 Redundancy improvement

The two transducers will normally be installed at different locations onboard. One transducer may then have a better location with respect to noise environments and reflections than the other. The computed position will be a weighted mean of these two measurements, if one of the systems fails to receive a reply, the other system may still receive it and the position will still be computed.

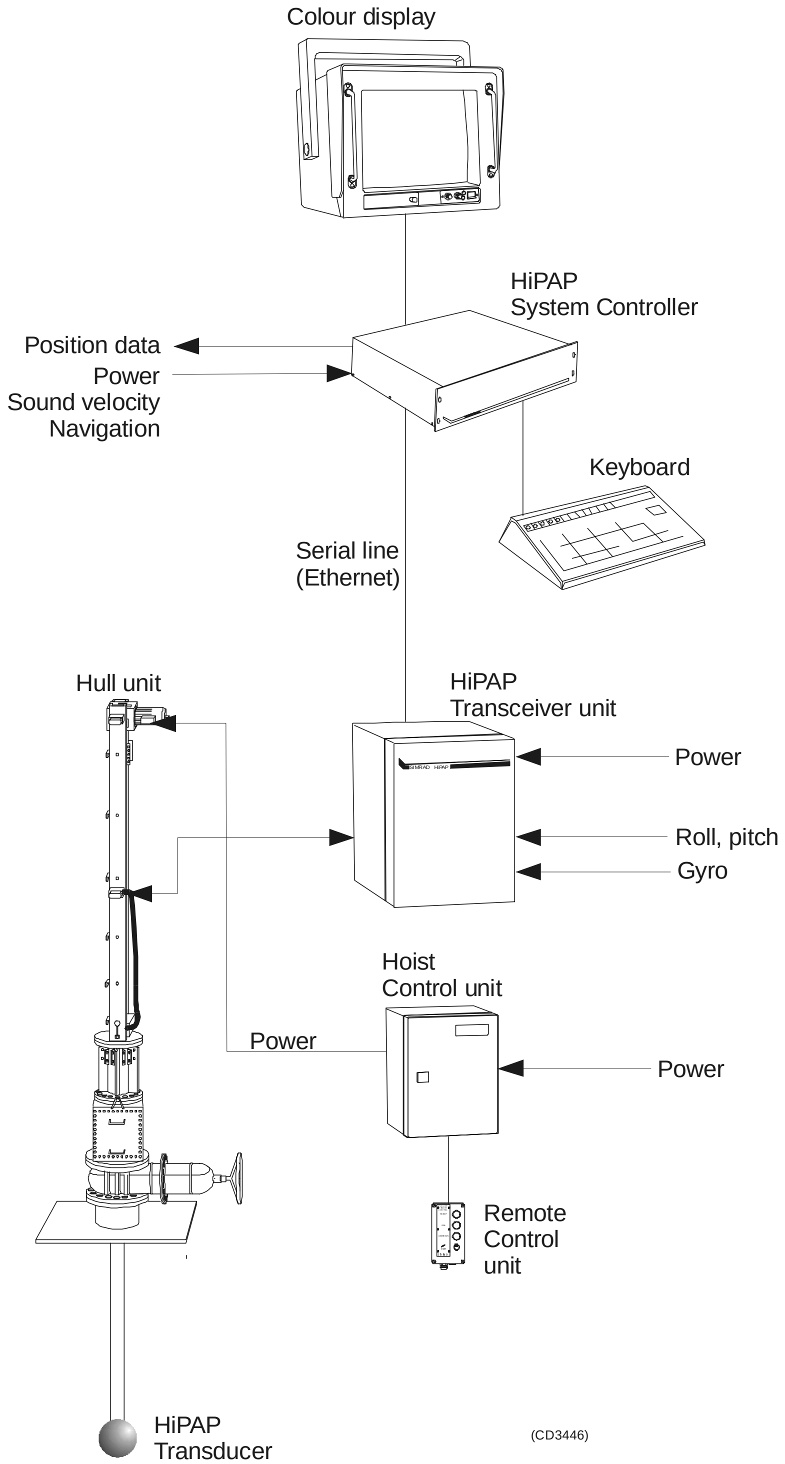
6.8.5.3 Quality improvement

When using two transducers, the system will check and report if the positions from the two systems differ by more than a pre set value. Information about the position quality will also be available based on error ellipses.

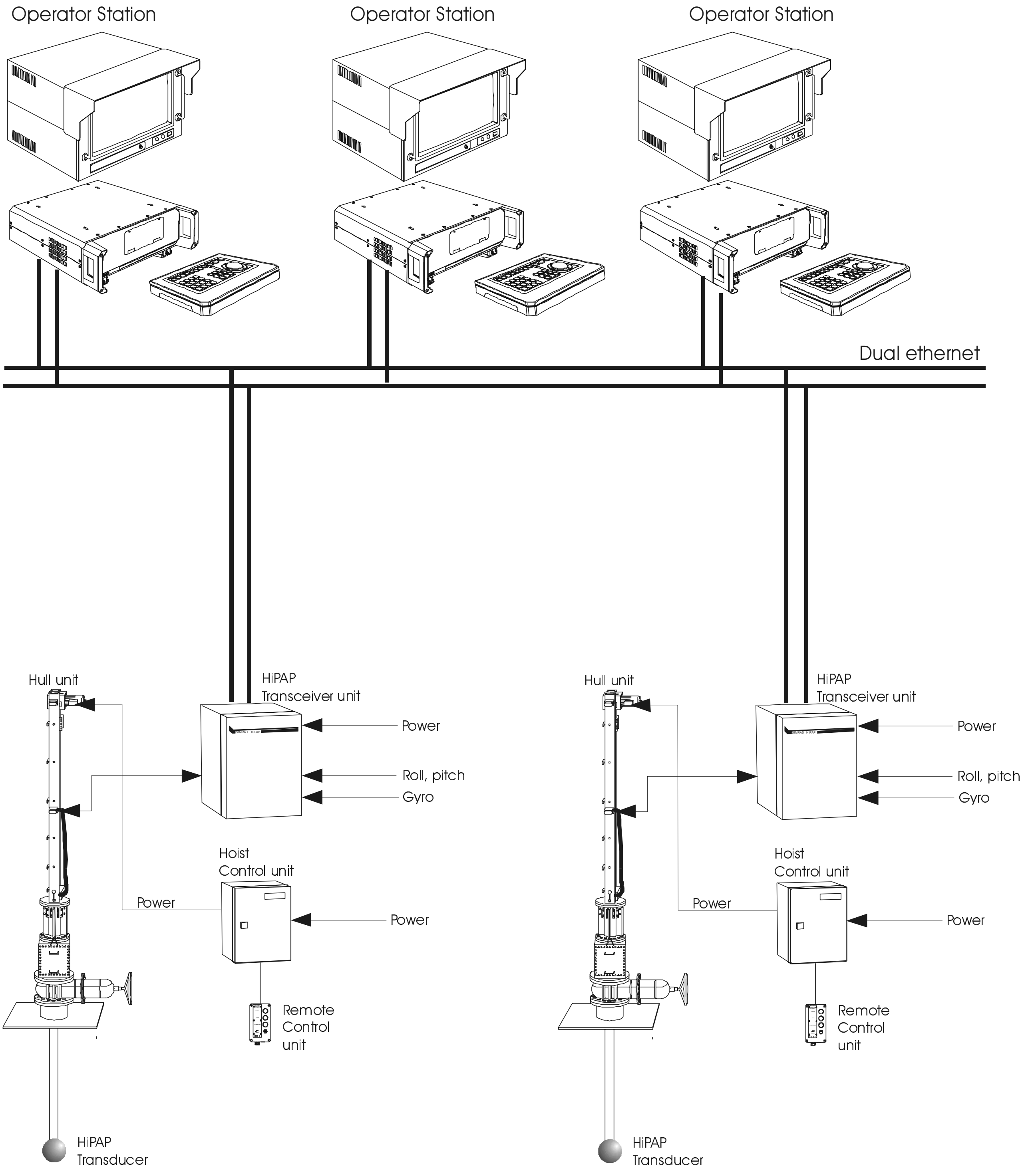
6.8.6 Redundant HiPAP system

The redundant HiPAP® system is similar the dual system, but does not combine the position from both systems to a weighted mean position. The redundant system will operate with 2 transponders, one on each transducer. The dual system can also operate with two transponders, one on each transducer.For the redundant configuration the synchronisation line between the transceiver is not needed.

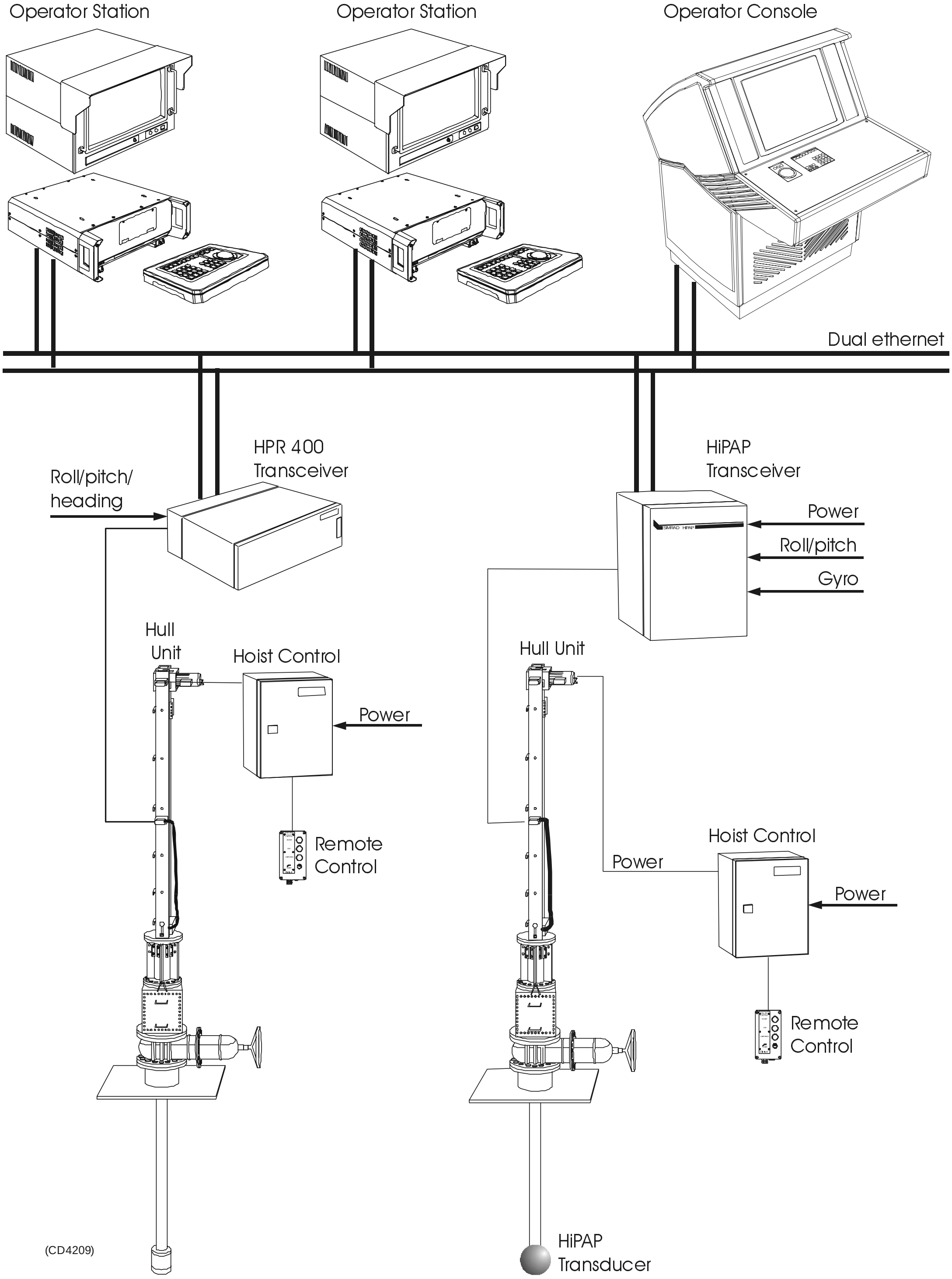
Single HiPAP® System Diagram



Redundant HiPAP® System Diagram



Combined HPR 400 and HiPAP® System Diagram



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7 LBL PRINCIPLES OF OPERATION

7.1 Introduction

This module describes the theory of operation behind the LBL section of the HiPAP/HPR system. The terms used in LBL positioning are defined, and the mathematical principles are described.

7.2 Definitions

7.2.1 Mathematical terms

Standard deviation tells how much a variable varies around its mean value. It is often written as s. If the variable is normally distributed, 68% of its values are expected to be between (Mean_value – σ) and (mean_value + σ).

Variance is the square of the standard deviation, i.e. σ^2.

Root Mean Square (RMS) of a set of values is a mean of the values in which the greater values contribute more than the smaller values. It is often used instead of the mean value.

Iteration is a repetitive mathematical process. Some algorithms need starting values for some of the variables before they may be executed. The result of the calculation is a new set of values for those variables that are closer to the answer than the old ones. By repeating the algorithm starting at the new values, the result becomes more accurate each time. Each execution is called an iteration, and the algorithm is termed iterative.

Cartesian coordinates are measured in a coordinate system with three mutually perpendicular axes. In this text, the axes are named EAST, NORTH and DEPTH. NORTH is normally the geographical north direction, and EAST the geographical East direction. You are allowed to select other directions, but you must be consistent. The origin of the coordinate system has the coordinates (0,0,0).

Polar coordinates. The polar coordinates of a point are:

- Range The horizontal distance from the origin to the point.
- Bearing The horizontal direction from the origin to the point.

  0 is the north direction.

  The bearing increases clockwise to 360º.
- Depth The vertical distance from the origin to the point.

7.3 LBL terms

TP Array. LBL positioning is based on range measurements to the transponders on the seabed. These transponders are called a ″transponder array″.

Local calibration. The LBL positioning algorithms must know the coordinates of the transponders in the transponder array relative to a local origin. The process to decide these coordinates is called the local calibration of the transponder array. It is performed by first measuring the ranges between the transponders in the array and then calculating their coordinates based on the ranges.

Global calibration. Decides the location of the local origin in latitude and longitude, and the rotation of the local north axis relative to geographical north.

Range residual. HiPAP/HPR measures ranges to decide the position of a transponder or a transducer. Normally, more ranges than necessary are measured. Then the position is calculated based on a best fit of the measured ranges. The residual of a range is the measured range minus the range calculated by using Pythagoras' theorem on the calculated positions.

Local coordinates. The origin of the local coordinate system is in the area covered by the transponder array. The axes are called EAST, NORTH and DEPTH. The NORTH axis is not necessarily pointing in the geographical north direction. The names of the axes in the coordinate system are written in upper case letters (EAST, NORTH), and the geographical directions are written in lower case letters.

Global coordinates. When a global calibration is performed, positions may be presented in global coordinates; either in latitude and longitude or in UTM coordinates.

Initial positions. The positions of the transponders in the transponder array inserted before the local calibration is performed. The positions are given in local or global coordinates. The only requirement to the accuracy of these positions is that they roughly indicate the transponder positions relative to each other.

Calibrated positions. The positions of the transponders in the transponder array calculated in the local calibration. The positions are given in local coordinates.

Error ellipse. There is an uncertainty associated with all positions, both initial and calibrated. This uncertainty is expressed as a 1–sigma error ellipse both in the input to and the output from the HiPAP/HPR system. The error ellipse has a major and a minor semi–axis, and the direction of the major semi–axis relative to north is specified. Assuming that the uncertainty of the position is normally distributed, the probability that the position really is within the error ellipse is 0.67 x 0.67 = 45%.

7.4 HiPAP/HPR terms

The **APOS** is the HiPAP/HPR System Controller. It consists of a Pentium based PC. It can also contain a keyboard and circuit boards for serial lines, Ethernet etc. as options.

HPR 400 is a transceiver. It consists of single Europe circuit boards normally mounted in a 19″ rack. The PCBs may be mounted in a cylinder for subsea use. The transceiver measures ranges and SSBL directions and handles telemetry.

HiPAP is a transceiver with one spherical transducer.

A **Transducer** consists of elements (vibrators) and some electronics. It converts the electrical transmission signals generated by the transceiver into hydroacoustic pulses. It also converts the hydroacoustic pulses received into electrical signals for the transceiver.

The transducer may be of the ordinary LBL type or of the SSBL type. Both are capable of measuring ranges. The SSBL transducer can also measure directions.

The HPR 4xx consists of an Operator unit, transceiver(s) and transducer(s). There may be up to four transceivers connected to the Operator Unit, and there may be two LBL transducers plus two SSBL or LBL transducers connected to each transceiver.

HPR 410 is an SSBL system, HPR 408 is an LBL system while HPR 418 is a combined LBL and SSBL system.

A **Transponder** consists of a LBL type transducer, electronics and batteries. It is placed on the seabed or on an ROV. The transponders may be commanded by telemetry to execute functions.

Most LBL transponders contain a pressure and a temperature sensor. These are used to decide the transponder depth.

When enabled for positioning, the transponder may be interrogated by two pulses on different frequencies and will then reply with a pulse on a third frequency. The HiPAP/HPR system may command it to switch frequencies.

Each transponder is uniquely identified by a serial number.

7.5 LBL Measurement principles

LBL positioning is based on range measurements, both for the calibration and for the positioning. The principle is basically the same for positioning and for calibration, but the explanation is split into separate chapters in this text.

7.5.1 Positioning

The HiPAP/HPR system measures ranges from a transducer to the transponders on the seabed. A common interrogation channel is used for all the transponders in the transponder array. The HiPAP/HPR system knows the transponder positions. Each range measurement indicates that the transducer is on a sphere with its centre at the transponder and with its radius equal to the range. If more than one range measurement is made, the transducer's position must be on the lines where the spheres intersect.

When the measurements are done on a SSBL type of transducer, the directions may be used together with the range in the calculations. In shallow water, and when an accurate HiPAP transducer is used, the measured directions contribute to a more accurate position.

The depth of the transducer is often known. In these cases, each range measurement indicates that the transducer is on the circle where the sphere around the transponder intersects with the horizontal plane at the transducer. This is illustrated in Figure 3. Here three circles are drawn where the transducer's depth plane crosses the three spheres.

Normally there will be noise on each measurement. That is illustrated on the figure by not letting the three circles intersect exactly in one point. There are three intersections close to each other, and the position can be assumed to be somewhere in the triangle formed by the intersections.

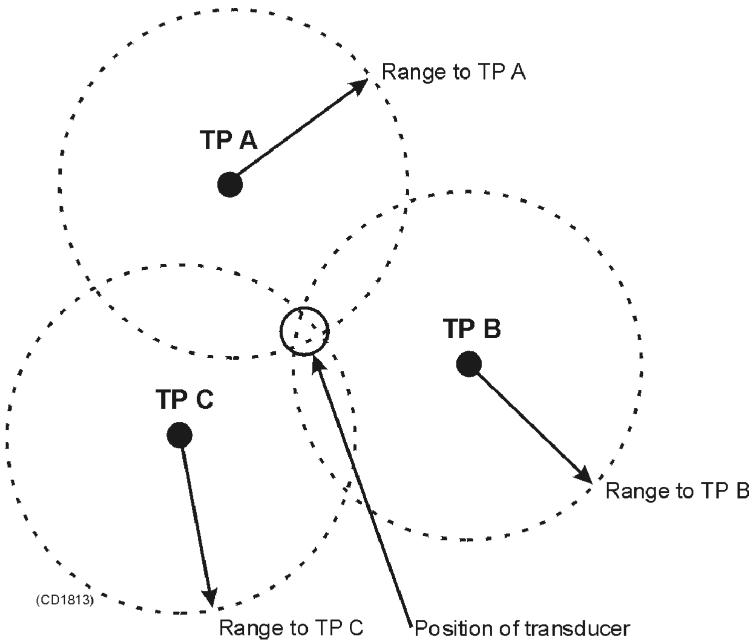

Figure 3 LBL positioning

Normally, more ranges than necessary are measured, and the number of intersections close to each other increases. Still the best guess of the position is somewhere in the space between these intersections. The program uses a weighted least square error algorithm to decide the position. The algorithm is iterative, and the errors are the differences between the measured ranges and the corresponding ranges calculated by using Pythagoras' theorem on the vessel position. These errors are called range residuals.

The iterations start at the vessel's previous known position, and continue until the increment from the previous iteration is less than a preset number of centimetres. The accuracy of the old position does not influence the accuracy of the new position.

Situations may arise when too few ranges are measured. Then there are two possible solutions for the new position. The programs will iterate towards the position closest to the old one.

7.5.2 Calibration

The ″position″ used during the calibration consists of the position of each array transponder. Consequently, it contains many coordinate values.

The programs must know something about the transponder positions before the calibration calculations can start. These positions are called ″Initial positions″. That information must be inserted by you, or it may be read from an ASCII file. SSBL measurements may be used to identify the initial transponder positions.

You must inform the system of the accuracy of the initial positions. This is achieved by specifying a 1–sigma error ellipse for the horizontal position and a standard deviation for the depth. The transponders are often at approximately the same depth, and the range measurements then contain no information about their relative depths. In this case, the depth standard deviation should be set to 0.00 m for all the transponders.

The next step of the calibration is to measure the subsea ranges between the transponders. The range from one transponder to another is normally measured many times. The mean value and the standard deviation of these ranges are then calculated and used later in the calculations.

The programs use a weighted least square error algorithm to decide the positions of the transponders. The algorithm is iterative, starting at the initial positions of the transponders. There are two types of errors as seen from the algorithm.

The range errors are the differences between the measured ranges and the corresponding ranges calculated by using the Pythagoras formula on the transponder positions. These errors are called range residuals. In the algorithm the squares of the range residuals are weighted with the inverse of the variance calculated during the range measurements. In this way the ranges measured with a small standard deviation have a greater impact on the resulting transponder positions than the ranges measured with a large standard deviation.

The position errors are the differences between the calculated transponder positions and the starting values of those positions. In the algorithm, the squares of these errors are weighted with the inverse of the squares of their uncertainties. The uncertainty of a transponder position starts at the error ellipse for the initial position. The uncertainty reduces in size during the calculation, and the result is the uncertainty of the calibrated transponder position.

7.5.3 Combined use of LBL and SSBL

When a transponder array is active on an SSBL transducer, the HiPAP/HPR system may perform SSBL measurements when receiving the replies. The direction information is then used together with the range information to make the system more accurate and robust. The transponders in the transponder array are still classified as LBL transponders.

Transponders may be interrogated as SSBL transponders. They are interrogated using their individual frequencies, and the SSBL measurements are performed as on a pure SSBL system.

The same transponder may not be interrogated as an SSBL transponder and an LBL transponder simultaneously.

When both a transponder array and one or more SSBL transponders are active, the system will alternate between LBL interrogations and SSBL interrogations. The sequence is controlled by the interrogation rate parameters for the LBL and SSBL interrogations.

The transponders used as SSBL transponders are of the same physical type as the LBL transponders. They are, however, commanded to be interrogated on their individual channels and not on the LBL common interrogation channel.

7.5.4 Global calibration

Many LBL applications do not perform global calibrations. For those applications, you may ignore this chapter.

The relative positions of seabed transponders in TP arrays are calculated based on range measurements between the transponders. When finished, the transponder positions relative to an origin are calculated. This process is called the local calibration.

Normally the position of the origin, and the rotation of the local North axis relative to the geographical north axis, remain unknown after the local calibration. These unknowns are decided in the global calibration.

The APOS uses positions of the vessel, simultaneously received from a DGPS system and calculated by the LBL system, as basis for the global calibration. DGPS and LBL position pairs are logged at many positions in the area before the calculation is performed. The calculation decides the origin latitude and longitude, and the rotation of the local north axis relative to geographical north axis, using a least square error algorithm.

When the latitude, longitude and rotation of the local origin are calculated, the LBL positions logged are converted to global coordinates. There is normally a difference between the LBL global position and the DGPS position logged in the same place. This is called the distance residual of the position pair. The residual is the statistical sum of the DGPS error and the LBL error. When these systems work correctly, the sound velocity profile used is accurate, and the local calibration was performed accurately, these residuals are normally in the 1 m order of magnitude.

The most accurate results for the origin position calculations are given if the position pairs are logged evenly distributed around the area. If for example the sound velocity profile is inaccurate, the distance residuals of the position pairs logged in the outer parts of the array may be much larger than the error in the origin calculated. If, on the other hand, position pairs are logged in only one part of the array, the situation could be the opposite – with small residuals but an inaccurate calculation of the origin. It must always be remembered that the objective of the calibration is to establish accurate positions, not to obtain small residuals.

The three parameters calculated in the global calibration are the latitude, longitude and rotation. When performing LBL positioning in the area later, errors in latitude and longitude will always contribute to errors in the LBL global position. The error in the rotation contributes an error proportional to the distance from the centre of the area in which the position pairs were logged.

The origin calculated is valid for the locations in the transponder arrays used in the LBL positioning during the global calibration. It may also be valid for some of the other transponder arrays. After an origin is calculated, you can select in which of the transponder arrays the origin is to be used.

7.6 Super array and Tp array

A limit of eight transponders can be in use simultaneously when performing LBL positioning or range measurements for local calibration. The limit is due to the use of frequencies within the frequency band available. The transponders in use simultaneously are named a TP array. The APOS can handle many TP arrays, but only one can be active at any one time.

In many applications, as for example pipe laying and inspection, there is a need to use more than 8 transponders. The places on the seabed where the transponders are placed are called locations.

When all the locations are grouped together, the resulting array is often called the ″superarray″.

Each location is a physical transponder. The same physical transponder may be used in more than one TP array, meaning that the TP arrays can overlap.

Example: Location 8 and 9 are used in both TP array 1 and TP array 2 because the arrays overlap, as shown in below.

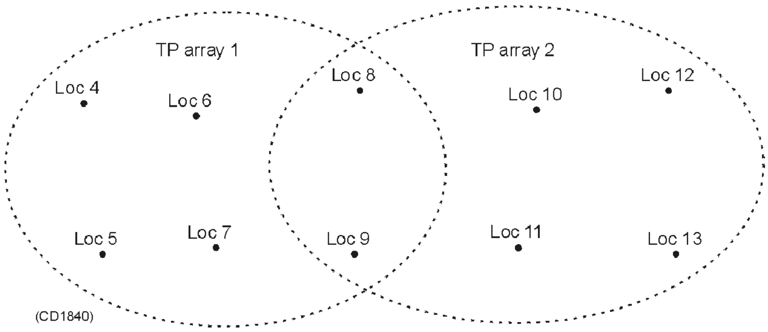

Figure 4 Two TP arrays with overlapping locations

All range measurements for the local calibration are performed within the TP arrays. When finished with the measurements in one TP array, a calculation using only those measurements should be performed to check the measurements. Then, only the locations specified as being part of the actual TP array receive new calibrated positions. The positions of the other locations will remain at their initial values. Normally, some of the locations receiving new calibrated positions will also be used in other TP arrays. The new positions will then also be valid for those arrays, i.e. one location has one and only one position, even when used in more than one TP array.

When the ranges are measured in all the TP arrays with overlapping locations, a local calibration calculation for the super array should be performed. The range measurements performed in all the TP arrays are then used, and all locations receive new calibrated positions.

7.7 Global coordinates

Many LBL applications do not use global coordinates. Then you may then ignore this chapter.

The APOS may receive global positions from a DGPS receiver, and it may present the calculated LBL positions in global coordinates.

Global coordinates are always referred to a datum defining the ellipsoid model of the earth. The APOS may work with three datum simultaneously. They are:

1. A reference datum. This datum is used by the HiPAP/HPR system in the internal calculations. It is by default WGS 84, and you should not change it.

2. A GPS datum. This datum is the one used by the DGPS receiver. After having received a global position from the DGPS receiver, the HiPAP/HPR system converts the position to the reference datum before starting any calculations. You may select the GPS datum from a list of datum in a menu.

3. An APOS datum. This datum is used by the HiPAP/HPR system when presenting LBL positions in global coordinates, both on the screen, in printouts and in binary telegrams. You may select the APOS datum from a list of datum in a menu.

The system always performs the LBL calculations in local coordinates. If the LBL positions are to be presented in global coordinates, the transformation from local to global is performed just before the presentation. The APOS must know the global coordinates of the local origin and the rotation of the local north axis to perform this conversion.

When the initial coordinates for the locations are entered in UTM coordinates, the APOS must convert the position to local coordinates before performing any calculations. To perform this conversion, it must know the global coordinates of the local origin to be used. That is inserted by you as a UTM centre. The rotation parameter of this origin is calculated automatically to the angle between the geographical north and the UTM north. You should not change the UTM centre when it is in use for the locations.

The use of the UTM centre as an origin is similar to the use of the origin calculated in a global calibration.

The UTM centre or the origin calculated in the global calibration may be transferred to the origin(s) of the TP array(s). When transferred to a TP array, the origin is used when:

· Positioning in the TP array. The LBL position calculated may be presented in UTM or in geographical coordinates.

· Printing the calibrated positions of the locations. The calibrated positions are always printed in local coordinates. Those locations used in a TP array with an origin are also printed in UTM coordinates.

7.8 Quality control of the data

The quality control of the data is performed on many levels. The HiPAP/HPR system measures more than is strictly necessary, and thereby gains the possibility to check the quality of the results.

7.8.1 Local calibration

The calibration is primarily based on range measurementsbetween the transponders. Each range is measured many times, and the program calculates a standard deviation on each range. You may examine the measurements, and the ranges may be measured anew. You may exclude ranges from the calibration calculations if no acceptable standard deviation is obtained.

The inverse of the standard deviations are used by the algorithms as weights when calculating the optimum transponder array positions.

After having calculated optimum positions for the array transponders, the APOS checks how the measured ranges fit with the calculated positions. Ranges that do not fit well have large range residuals, and these ranges may be measured anew or excluded before the calibration calculations are performed again.

The APOS calculates the uncertainties of the calibrated positions, and presents them as error ellipses around the positions.

7.8.2 Global calibration

The APOS uses positions of the vessel, simultaneously received from a DGPS system and calculated by the LBL system, as the basis for the global calibration. Only two DGPS / LBL position pairs are necessary to calculate the origin latitude, longitude and rotation, but up to many hundreds position pairs may be logged and used in the weighted least square error calculation. The calculation is over determined, and distance residuals are calculated for each position pair. The RMS value of these residuals indicate how well the position pairs match.

Each position pair has associated statistical information indicating its uncertainty. This information is used in the calculations, and it contributes to the statistical data giving the uncertainty of the origin calculated.

7.8.3 Positioning

During positioning the HiPAP/HPR system normally measures more ranges and SSBL directions than is necessary. After having calculated the position, it checks how well the measured ranges and directions fit with the position. Measurements obviously wrong may be automatically excluded when the position is calculated again.

The APOS calculates residuals of all measurements, and the uncertainty of the LBL position

The uncertainty of the local LBL position calculated, depends on several factors:

- The number of ranges and SSBL angles measured, and the geometrical crossings of the vectors from the transponders to the transducer.
- The accuracy with which the ranges and the angles are measured.
- The uncertainty of the sound velocity profile used. You insert this uncertainty in a menu.
- The uncertainty of the calibrated positions of the transponders in the array.

The local LBL positions calculated may be presented in global coordinates. In that case, the uncertainty of the origin is statistically added to the uncertainty of the local position before being presented. (The graphical presentation on the screen is always in local coordinates. The printouts however may be in global coordinates.)

7.9 Transponder Modes

Each transponder may be in one of the following modes.

- SSBL mode. The transponder enters this mode after power on and after reset. It must be in this mode when being interrogated as an SSBL transponder.
- LBL calibration mode. The transponder must be in this mode when performing the subsea range measurements during the Local calibration.
- LBL positioning mode. The transponders must be in this mode when measuring ranges from a transducer to the transponders. In this mode, the transponder is interrogated on an LBL interrogation channel, which is usually different from the transponder s channel. The transponder s reply frequency is decided by its channel number. This mode enables all the transponders in an array to be interrogated on the same interrogation channel, while replying on their individual frequencies.

In the LBL positioning mode, the turnaround delay is set individually for each transponder. This possibility is used to prevent the transponder replies being received at the transducer simultaneously.

7.10 Operation

The following paragraphs give an overview of the operations without going into details. For detailed description of the operation, refer to the APOS online help system.

7.10.1 Measure ranges

The transponders in the transponder array must all be in the Calibration mode before the subsea ranges are measured.

The local calibration is primarily based on range measurements between the transponders. They send the results up to the HiPAP/HPR system by telemetry. You may choose to request one transponder at a time to measure the ranges to all the others, or you may request all the transponders, one at a time, to measure the ranges to all the others. This operation will last for some minutes, depending upon the ranges and the number of ranges to measure. The second option should only be selected when the vessel has good telemetry communication with all transponders from a single position. In both cases only one telemetry function is performed at any one time in the water.

7.10.2 Execute the local calibration

Once the subsea ranges have been measured, the positions of the transponders in the array can be calculated.

When the APOS has completed the calculations, it displays the maximum and the RMS values of the range residuals. These indicate how well the calibrated positions fit with the measured ranges. If you are not satisfied with the residuals, you should identify the ranges contributing the most to the RMS value of the residuals. Ranges with large residuals should be measured again and the calibration calculations repeated. This iteration may need to be performed many times before the resulting residuals are considered to be small enough.

The left part of the screen is normally used to present graphical information. In the LBL local calibration process, it is better to use it to display the ranges. Then the display gives an overview over the ranges, the standard deviations and the range residuals. The ranges and the standard deviations are updated after each range measurement. The range residuals are updated after each local calibration calculation.

7.10.3 Position a vessel or ROV

When satisfied with the result of the local calibration, you can start the positioning operation. First the turnaround delays of those transponders in the array must be decided, then the transponders must be commanded to the LBL positioning mode.

7.10.4 Position a transponder

The transponders are able to measure the ranges to other transponders, and send the result, on telemetry, to the HiPAP/HPR system. This capability is used in the transponder range positioning mode. The transponder to be positioned is called the master transponder, and it is not part of the TP array. The master transponder measures ranges to transponders in a TP array, these other transponders being called the slaves. Up to six slaves may be used simultaneously by one master. The transponders in the TP array must be in the calibration mode. The master is commanded to be in a special TP range positioning mode, in which it knows the channels of the slaves to which it is to measure the ranges. The positioning sequence is initiated by the HiPAP/HPR system transmitting a short message to the master on telemetry. The master measures the ranges to the slaves, just as in calibration mode. Only one range is measured towards each slave. When it has finished, the master transmits the ranges, on telemetry, up to the HiPAP/HPR system, then waits for the next request to measure ranges.

The transponder range positioning mode is a flexible and simple solution for many applications. The drawback is the speed. Both the ranges and the request to measure are sent on telemetry, and the master transponder measures only one range at a time. The time used for a sequence depends on the number of slave transponders used, and if there are timeouts on the replies from the slaves. The positions may be updated as fast as once every 12 seconds, though more time may well be required, resulting in a slower update rate.

7.10.5 Global calibration

The global calibration requires that you position the vessel in local LBL coordinates and that the APOS reads the vessel position from a DGPS receiver simultaneously. An LBL position and a DGPS position, logged simultaneously, are named a position pair.

When logging the position pair, the vessel should be drifting to avoid noise and air bubbles from the thrusters and propellers disturbing the LBL measurements. 8 to 10 position pairs should be logged while the vessel is drifting in one position, then the vessel should be moved to another position and a new 8 to 10 position pairs should be logged. This procedure should be repeated at many positions, evenly distributed, in the area covered by the transponder array. Do not log only while located in the centre of the area as that will give a high uncertainty for the rotation of the local north axis.

When logging position pairs, attention should be paid to the ranges measured and the range residuals calculated. The best results are achieved when the position pairs are logged when many ranges are measured correctly and their residuals are small.

When enough position pairs are logged, the global calibration calculation is performed. Some position pairs will often have larger distance residuals than the others. In that case, you may exclude some of the position pairs with the large distance residuals and repeat the calculation. When performing the exclusions, be aware that the position pairs used in the calculation should be evenly distributed in the area.

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8 EXERCISES

8.1 Theoretical exercises

- Name some applications for HPR systems.

- What kind of problems might appear in hydro acoustics?
- Name some noise sources that influence in hydro acoustics.
- What gives most noise in the HPR serroundings?
- Give some examples of circumstances that can cause signal blockage.
- Explain the two types of transmission loss.
- What is ray bending?
- What is a sound profile?
- What does a ray diagram tell us?

- What is a transducer?
- What is the purpose of the piezoelectic ring in the transducer element?
- Name the different beam shapes for our transducers.
- List some of our transducer types.

- What is the difference between a transponder and a responder?
- What information can you read from the transponder name?
- What does it mean that the transponder works in HPR 300 mode?
- What does it mean that the transponder works in HPR 400 mode?
- Which frequencies are sent through the water from the transducer/from the transponder if we use channel B08?
- Which frequencies are sent through the water from the transducer/from the transponder if we use channel B34?
- What is a "ping"?
- What is pulse positioning with sensor information?
- What is telemetry?
- Explain the difference in ping count function in HPR300 and HPR400 mode.

- List the three main positioning principles.
- Explain the SSBL principle.
- What is the advantage of a SSBL system.
- Explain the LBL principle.
- What is the advantage of a LBL system.
- What is the disadvantage of a LBL system.
- What is the main difference between the SSBL and HiPAP® principle?
- What is the main components of an HPR system?

8.2 Answers to theoretical exercises

- Name some applications for HPR systems.
  - Reference for Dynamic Positioning systems
  - Rig monitoring
  - Drilling monitoring
  - Subsea survey
  - Subsea inspection
  - Acoustic blow out preventer
  - Offshore loading

- What kind of problems might appear in hydro acoustics?
  - Transmission loss
  - Reflection
  - Noise
  - Ray bending

- Name some noise sources that influence in hydro acoustics.
  - Thrusters
  - Drilling
  - Own ship
  - Other ships
  - Other HPR systems
  - Wind and waves

- What gives most noise in the HPR serroundings?
  - Thruster noise

- Give some examples of circumstances that can cause signal blockage.

Air bobbles created from thrusters. When they come between the transducer and the transponder the signal can be blocked. The problem is largest when going astern with the vessel.

- Explain the two types of transmission loss.
  - Geometrical spreading = the sound energy is radiated speherically in the water. The intensity will decrease with increased distance with the factor $1/r^2$. Geometrial spreading is not dependent on frequency, only range.
  - Absorption = some of the transmitted energy is lossed caused by heating of the water molecules. The higher frequency the more absorption.

- What is ray bending?

The hydro acoustic wave does not travel in a straight line between the transducer and the transponder. The wave will be bent in different dircetions depending on different temperature, salinity and pressure layers in the water.

- What is a sound profile?

The sound profile shows us different sound velocities for different depths.

- What does a ray diagram tell us?

The ray diagram shows us the ray trace from the transducer when a certain sound profile is used.

- What is a transducer?

A transducer is an acoustic transmitter and receiver in one.

- What is the purpose of the piezoelectic ring in the transducer element?

It vibrates when voltage is applied. It also creates voltage if it is set into vibrations.

- Name the different beam shapes for our transducers.
  - Wide
  - Medium
  - Narrow
  - Tracking

- List some of our transducer types.
  - Narrow beam
  - Standard
  - HiPAP®
  - Portable
  - Duncking
  - Tracking

- What is the difference between a transponder and a responder?

A transponder is triggered by an acoustic pulse. The responder is triggered by an electric pulse through the ROV umbilical. The transponder is powered by a battery, but the responder is most frequently powered by the ROV.

- What information can you read from the transponder name?
  - Model name; gives the function and use for the transponder (SSBL/LBL/ROV/Telemetry)
  - Model number; gives infrmation about working frequencies, depth rating and beamwidth.
  - Option; indicates the different extra equipment the transponder have such as depth sensor, compass, release function or other.

- What does it mean that the transponder works in HPR 300 mode?

They use HPR 300 channels and frequencies (B01–B09, B11, B22, B33, B44, B55) and are interrogated with only one pulse.

- What does it mean that the transponder works in HPR 400 mode?

They use HPR 300 channels and frequencies (B01–B09, B11, B22, B33, B44, B55) and HPR 400 channels and frequencies (B12–B87). When positioning the transponders are interrogated with two pulses from the transducer.

- Which frequencies are sent through the water from the transducer/from the transponder if we use channel B08?

25000 Hz is sent from the transducer to the transponder.

The transponder answers with: 28409 in first reply pulse
(27777 in second reply pulse)
(27173 in third reply pulse)

- Which frequencies are sent through the water from the transducer/from the transponder if we use channel B34?

The transducer use 22000Hz in the first interrogation pulse
22500Hz in the second interrogation pulse

The transponder replies with: 30250 in first reply pulse
(28750 in second reply pulse)
(29250 in third reply pulse)

- What is a "ping"?

A ping is another word for the pulse transmitted in the water.

- What is pulse positioning with sensor information?

When pulse positioning are used the transponders reply with two or three pulses. The time delay between the first and second and between the second and third reply pulse, contains coded information such as inclination, depth and compass.

- What is telemetry?

The telemtry link uses bursts of seven pulses, all with different frequencies, transmitted in a sequence to make up a message. Every burst is 310ms long and the delay between them are 1 second. First a wake up call is sent on the Bxx/Axx channel. One second later the telegram is sent. The telegram contains an address and a command. The serial number is unik for every transponder and it is therefore used as the address. You can by telemetry commands change channels, source level, turnaround delay, receive gain, read depth, temperature, inclination values, battery status from the transponder, release the transponder etc.

- Explain the difference in ping count function in HPR300 and HPR400 mode.

In HPR300 mode ping count coding is used.

In HPR400 mode the telemetry link is used.

- List the three main positioning principles.

SSBL Super Short Base line

LBL Long Base line

SBL Short Base line

- Explain the SSBL principle.

The transducer sends interrogation pulse(s) to a transponder which answers with reply pulse(s). The system calculates the range to the transponder and the direction to where the reply came from.

- What is the advantage of a SSBL system.

Easy and fast to install and operate. It requires no installation of transponders on the seabed, only the targets that are to be positioned must be equipped with a transponder.

- Explain the LBL principle.

The system calculates only the ranges to the transponders and between the transponders.

- What is the advantage of a LBL system.

LBL positioning will give better position accuracy at greater distances.

- What is the disadvantage of a LBL system.

LBL positioning is more complex to operate, needs more transponders than SSBL and are more expensive

- What is the main difference between the SSBL and HiPAP® principle?

The HiPAP uses the SSBL principle for range and angel measurments, but the system controls the beam electroncially so it is always pointing towards the target. The SSBL transducer is fixed in one position and the beam is pointing in one direction relative the vessel.

- What is the main components of an HPR system?

Display, keyboard, system controller, transceiver, hoist control unit, remote control unit, hull unit, transducer.

(VRU, MRU, GYRO, GPS, dGPS)

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8.3 SSBL positioning – basic operation

8.3.1 Introduction

The exercises will lead you through most of the menus and buttons for the APOS operator station.

The exercises are used both for the HPR400 and HiPAP® system.

The exercises are written like this:

- Read this text before you start the exercises.

8.3.2 General terms used

Bearing

The horizontal direction of one terrestrial point from another, expressed as the angular distance from a reference direction, clockwise through 360°.

Cartesian coordinate system

A coordinate system (local system) where the axes are mutually–perpendicular straight lines.

Clump weight

An anchor line element connected at a fixed position on an anchor line, causing a concentrated vertical force downwards on the anchor line.

Course

The horizontal direction in which a vessel is steered or is intended to be steered, expressed as angular distance from north, usually from 000° at north, clockwise through 360°. Strictly, this term applies to direction through the water, not the direction intended to be made good over the ground. Differs from heading.

Datum

Mathematical description of the shape of the earth (represented by flattening and semi–major axis).

Geodetic coordinate system

A mathematical way of dealing with the shape, size and area of the earth or large portions of it. Normally UTM coordinates with reference to a datum.

Heading

The horizontal direction in which a vessel actually points or heads at any instant, expressed in angular units from a reference direction, usually from 000° at the reference direction clockwise through 360°. Differs from course.

8.3.3 Windows terminology

Windows are the basic objects of the Microsoft Windows operation system. They will always be displayed with the same layout and functionality, as long as the system programmer did not change the configuration. The following paragraphs present a short description of the most used general properties.

Check box

A small square box that appears in a dialogue box and that can be turned on and off. A check box contains a tick mark when it is selected and is blank when it is not selected.

Choose

To perform an action that carries out a command in a menu or dialogue box. See also Select.

Command

A word or phrase, usually found in a menu, that you choose in order to carry out an action.

Command button

A rectangle with a label inside that describes an action, such as OK, Apply or Cancel. When chosen, the command button carries out the action.

Cursor

The pointer symbol that is displayed on the screen and that can be moved with the trackball.

Dialogue/Dialog box

A box that appears when the system needs additional information before it can carry out a command or action. See also Check box, Command button, List box, Option button and Text box.

Greyed

Describes a command or option that is listed in a menu or dialogue box but that cannot be chosen or selected. The command or option appears in grey type.

List box

A box within a dialogue box containing a list of items. If the list of available items is longer than the displayed list box, the list box will have a vertical scroll bar that lets you scroll through the list. A list box may be closed when you first see it. Selecting the down arrow next to the first item in the list will display the rest of the list.

Menu

A group listing of commands. Menu names appear in the menu bar beneath the caption bar. You use a command from a menu by selecting the menu and then choosing the command.

Option button group

A group of related options in a dialogue box. Only one button in a group can be selected at any one time.

Point

To move the cursor on the screen so that it points to the item you want to select or choose.

Radio button

A small round button appearing in a dialogue box. You select a radio button to set the option, but within a group of related radio buttons, you can only select one. An option button contains a black dot when it is selected and is blank when it is not selected.

Select

To point and click at the item that the next command you choose will affect. See also Choose.

Slider

Used to setting parameter values between a minimum and a maximum value. Drag the slider in the required direction.

Status bar

Displays general useful information.

Text box

A box within a dialogue box in which you type information needed to carry out a command. The text box may be blank when the dialogue box appears, or it may contain text if there is a default option or if you have selected something applicable to that command. Some text boxes are attached to a list box, in which case you can either type in the information or select it from the list.

Title bar

Displays an application–defined line of text. The title bar also used to move/drag the window.

Toolbar

A collection of buttons to give a fast entry to the most used commands.

Click

To press and release a button, without moving the cursor. If no trackball button is specified, the left button is assumed.

Drag

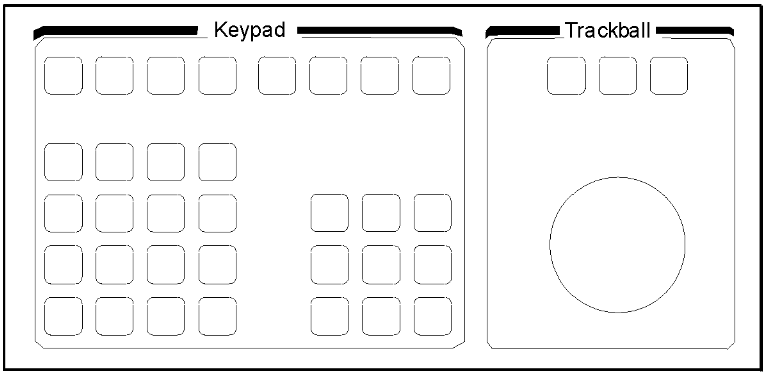
To press and hold down a button while moving the trackball. Used to move items. For example, you can move a dialogue box to another location on the screen by dragging its title bar.

Point

Move the cursor to the wanted screen location. Used to prepare for selection /operation.

8.3.4 WinKeyboard, trackball and buttons

The WinKeyboard is devided into a Keypad and a Trackball.



(CD4258)

Trackball

The trackball is used to position the cursor on the screen. Each movement of the trackball moves the cursor. The left button is used to click on buttons, operate menus and select displayed symbols. The right button is used to display menus and pop–up windows. The middle button is not used.

Keypad

The Keypad provides function, numeric and cursor keys. The numeric keys are used to entervalues into dialogue boxes, the function keys to select predefined view configurations, and the cursor to move the cursor.

Function keys:

- F1 is used for Help
- F2–F8 to be implemented later

Numeric keys:

- Standard keyboard operation

Cursor with following arrows:

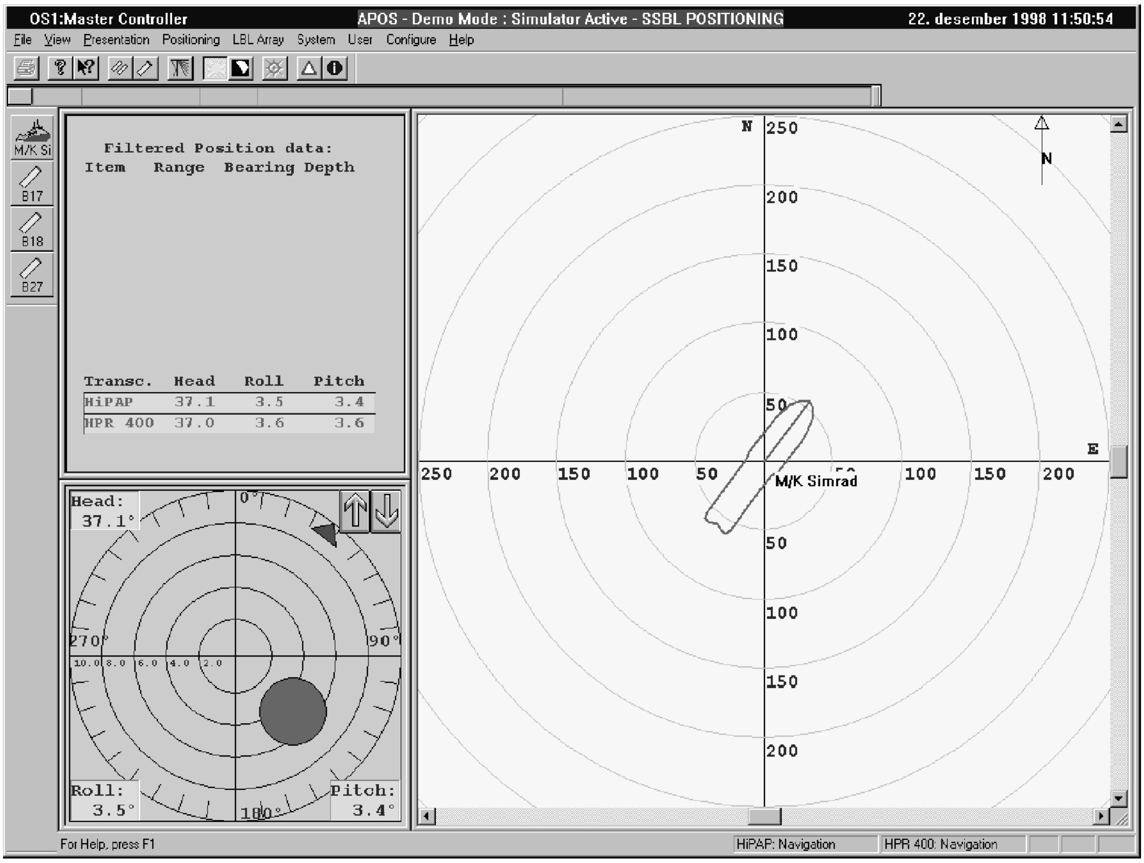
– UP/DOWN & LEFT/RIGHT	
– END	Go to end of line
– HOME	Go to start of line
– TAB	Tabulator
– PGUP/PGDWN	Go to start/end of page

8.3.5 Different views/areas in the display

- Let the instructor start the computer and configure the demo program.

In your display you have three different views; one large area to the right and two smaller to the left.

You also have a menu line and a toolbar at the top of the display, a column of transponder symbols to the left and a status bar at the bottom of the display.



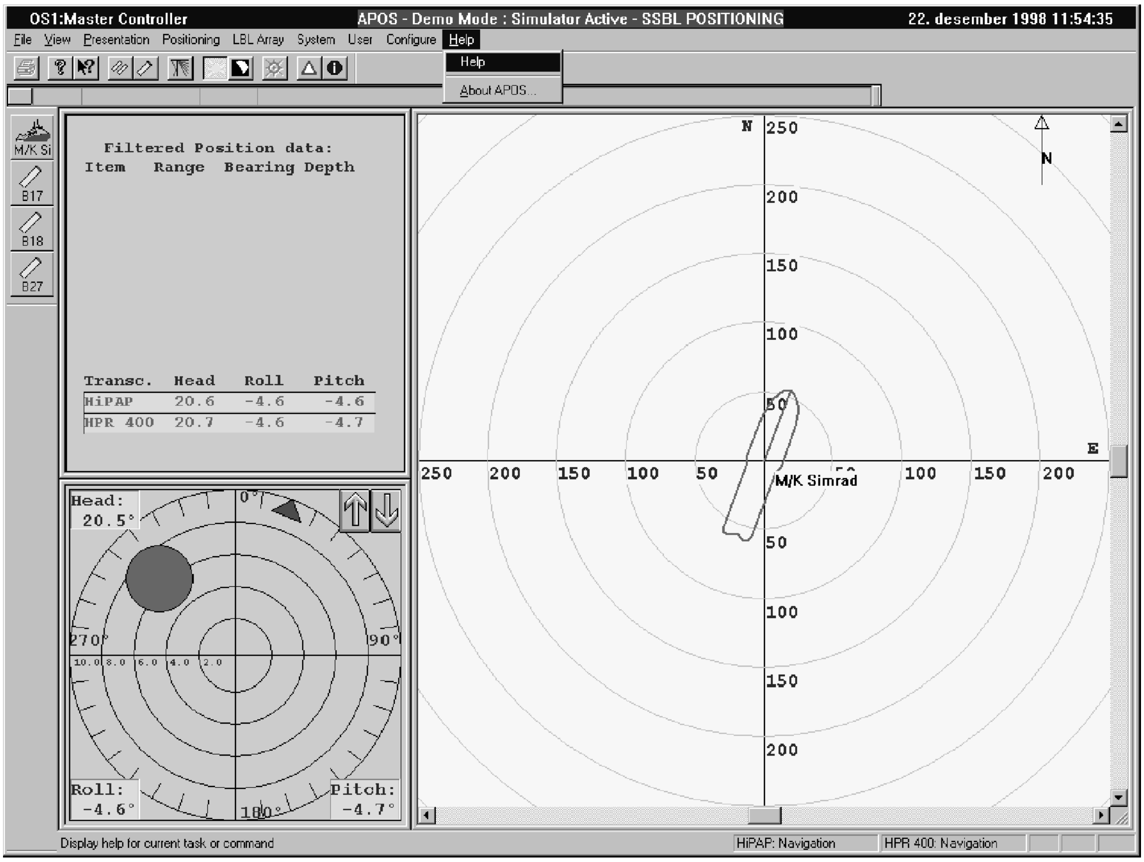
- Try to move the trackball and see how the cursor moves. Use the mouse if that is connected instead.

8.3.6 The APOS Online Help system

When operating the APOS, the **Online Help** is available by activating the APOS Help menu button, or the F1 button on the WinKeyboard. The online help may also be activated from a dialogue box, provided that the help button is available in that particular dialogue box.

- Try the Help function.

(Point at the **Help** menu and click once with the left button. Point at **Help** (it will turn blue) and click once again. During the exercises you might need to use this Help menu to find out how to operate the system.)

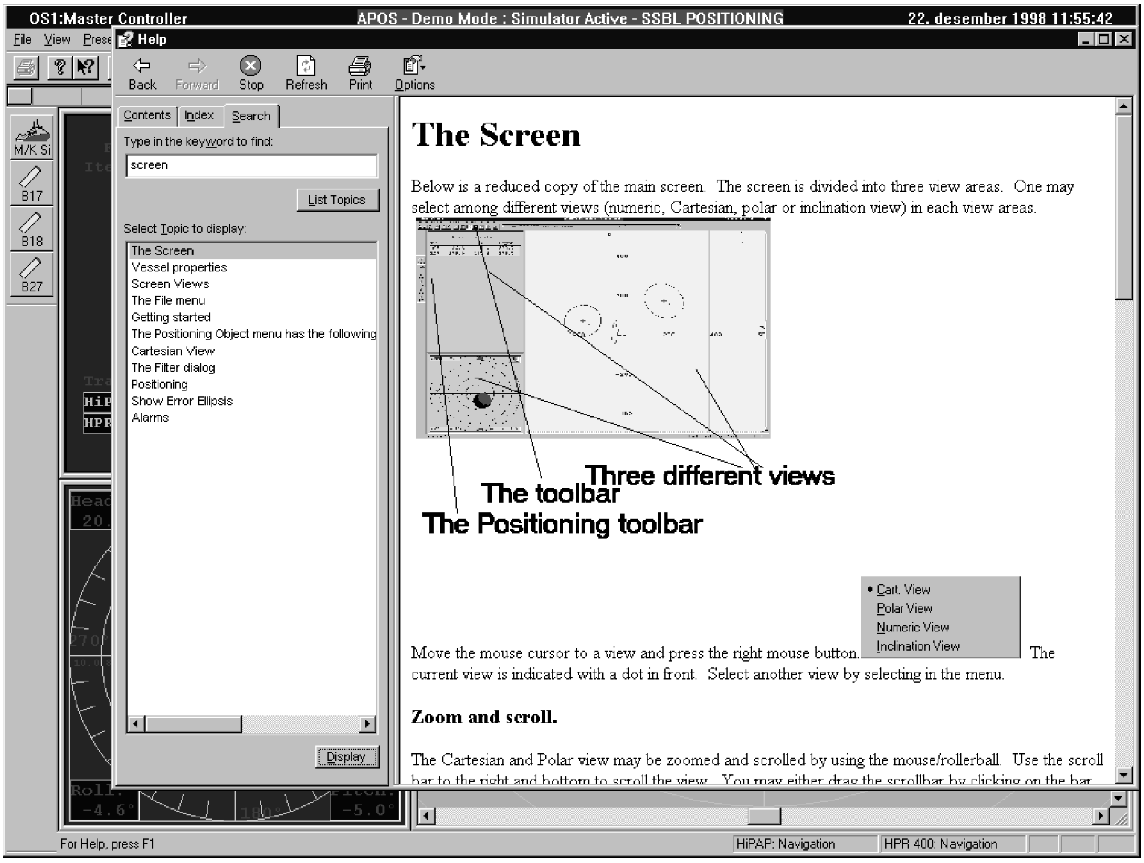


There are three options:

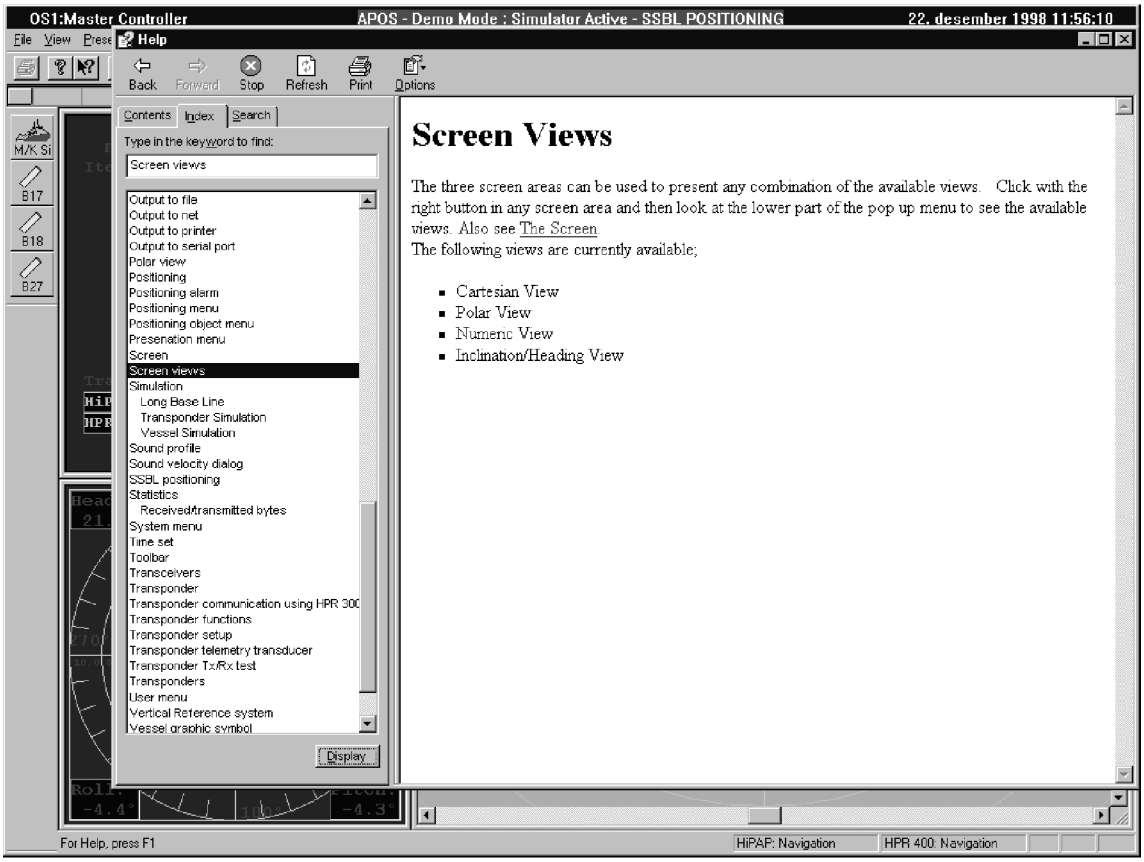
- **Contents** gives you the information listed in different topics. From Contens you only click once at the word.
- **Index** gives you the information in alphabetic order. From Index click once at the word and then click the Display button.
- **Search** gives you the option to search for any word you want to find out more about. From Search you can write the word then click the List options button. Double click at the word from the list.

• Click at the Search tab and enter the word "Screen" in the display and press the **List topics** button.

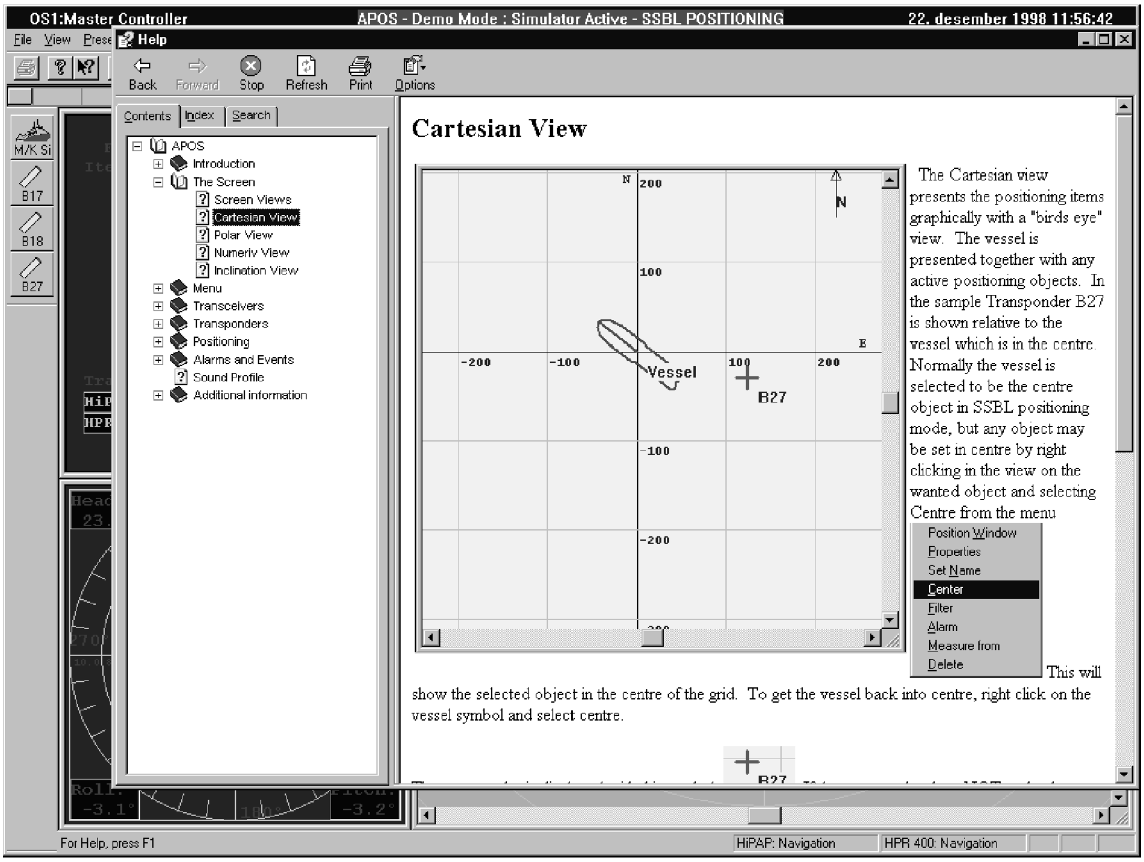
• Select one of the words from the search result menu and click then at the **Display** button to get more information.



- Try to find information about Screen Views by using the **Index** button and selecting a topic you want to know more about. Remember to click at the **Display** button.



- Use the **Contents** button and find information about Cartesian View.



- You close the window by clicking the X symbol in the upper right corner of the Help window.

8.3.7 Filter presentation

The filter is a toggle function that will toggle filtered positions on or off. When filter is On the positions and values displayed will be filtered and will not be as "jumpy" as they might be with filter function Off.

In the numeric view the heading describes the chosen presentation; **Filtered position data** or **Measured position data**.

- Check from the **Presentation** menu that there is a checkmark to the left of Filter. This means that the filter is ON.

8.3.8 Activating transponders

Prior to activating transponders, the system should be set up with the transponders available on the vessel/rig. This will simplify the operation of the system. The transponder setup is normally a one time operation and needs only to be changed whenever new transponders become available.

We assume the installation of the system has been carried out and the system configuration with correct transceivers and transducers etc. is correct.

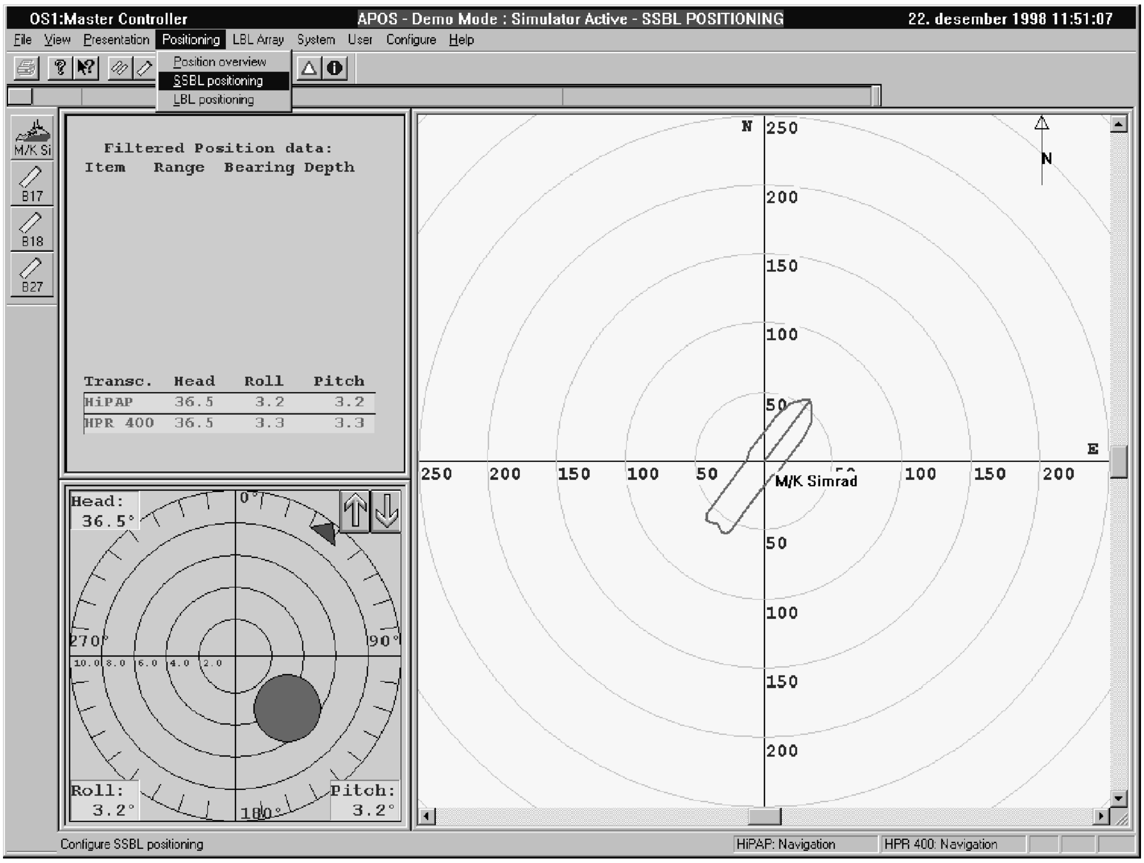
8.3.8.1 Activating transponders, method 1

- Start interrogation of transponder B17 with an interrogation interval of 4 seconds.

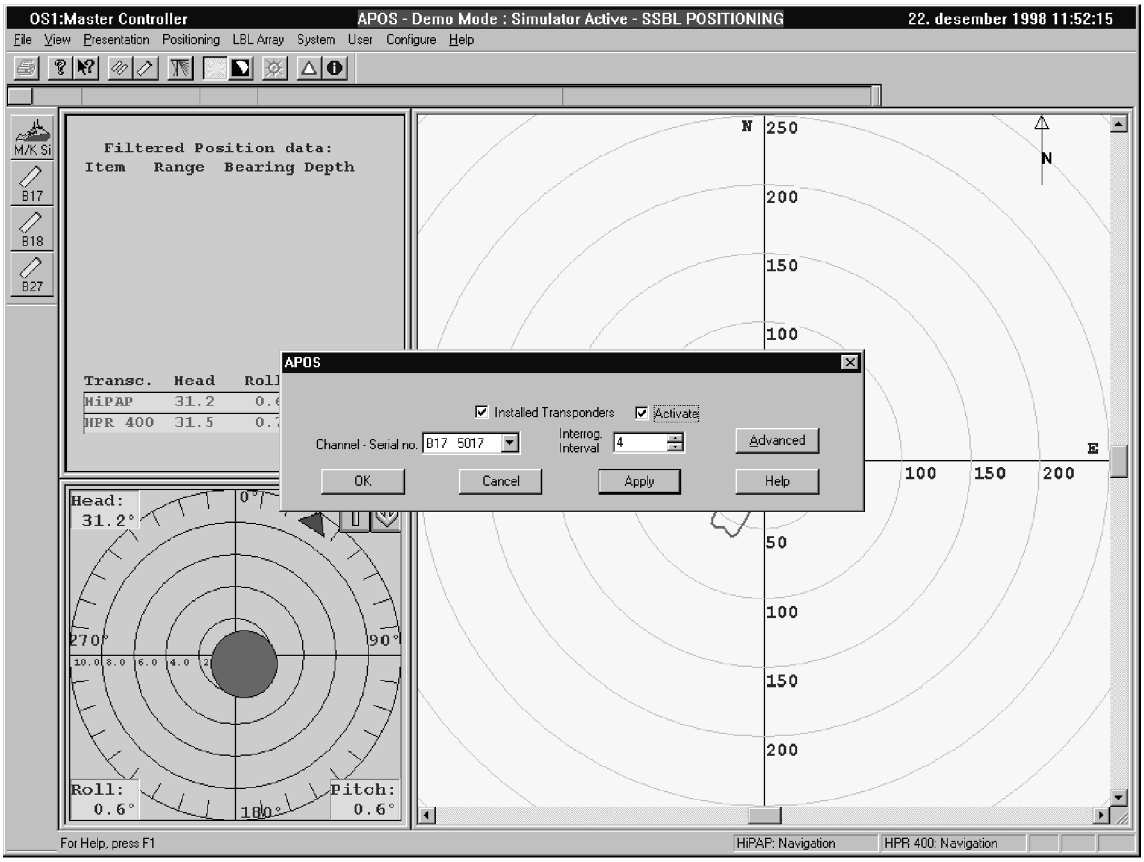
The **interrogation interval** decides how often you want to send an interrogation pulse to the transponder.

- In this first exercise start positioning from the **Positioning** menu and the **SSBL Positioning** submenu.

(Click at the Positioning menu and then at SSBL Positioning from the pop–up menu)



- Select transponder number B17 if it is not already in the display, enter the interrogation interval, enter a tick mark in the Activate check box and click the Apply button.



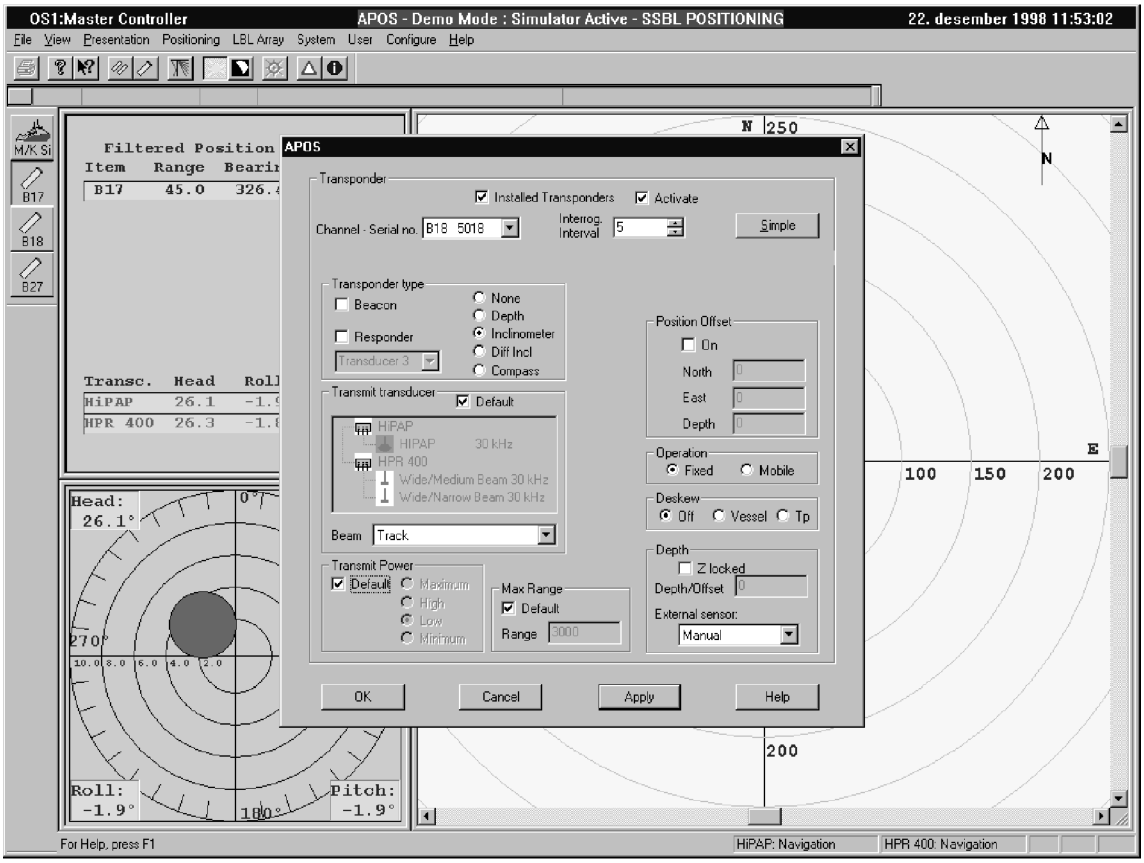
Check that the transponder symbol and the position values are presented in the display.

8.3.8.2 Activating transponders, method 2

- Select channel number B18 and click at the **Advanced** button to open another window with more details.

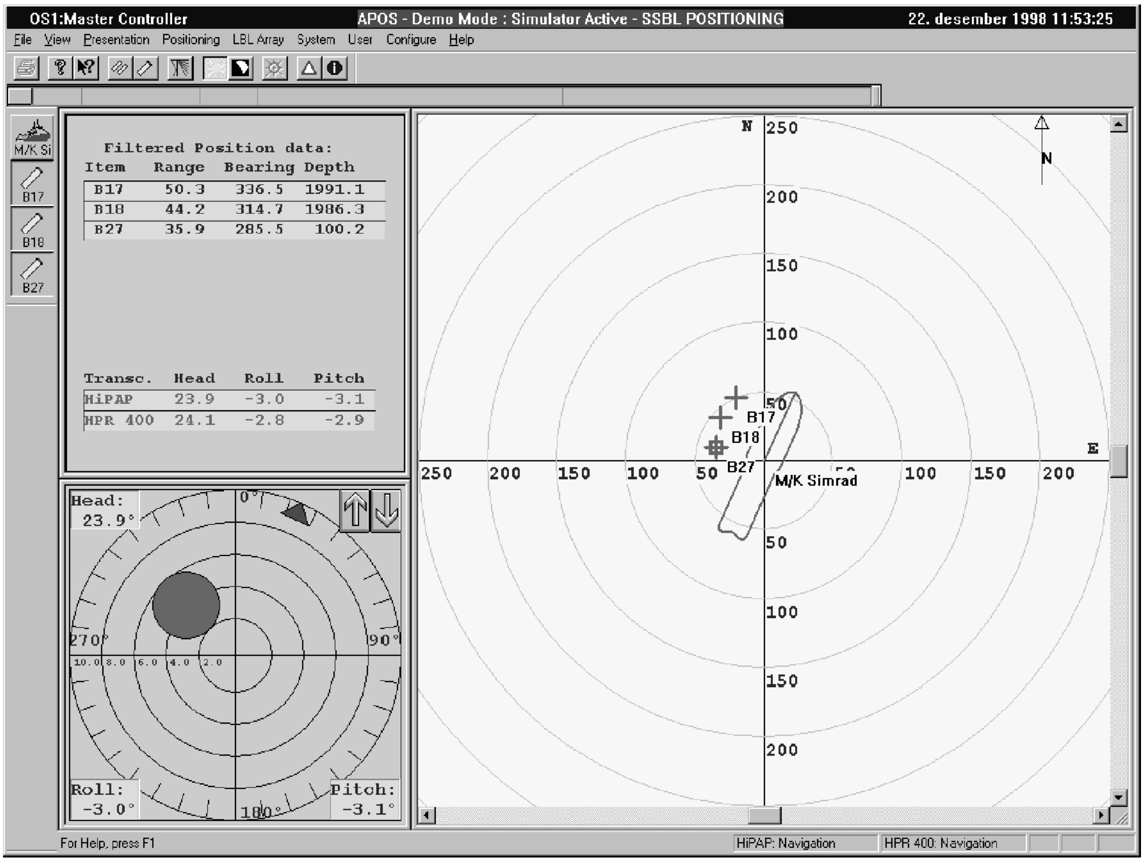
- Find out the purpose of the parameters in the new window:
  - Installed Transponders
  - Activate
  - Interrog. interval
  - Transponder type
  - Transmit transducer
  - Beam
  - Transmit Power
  - Max range
  - Position offset
  - Operation
  - Deskew
  - Depth

- Enter 5 seconds interrogation interval, enter a tick mark in the Activate check box and click at the OK button.



8.3.8.3 Activating transponders, method 3

- Move the cursor to the last transponder symbol in the Positioning toolbar and click left mouse button once.

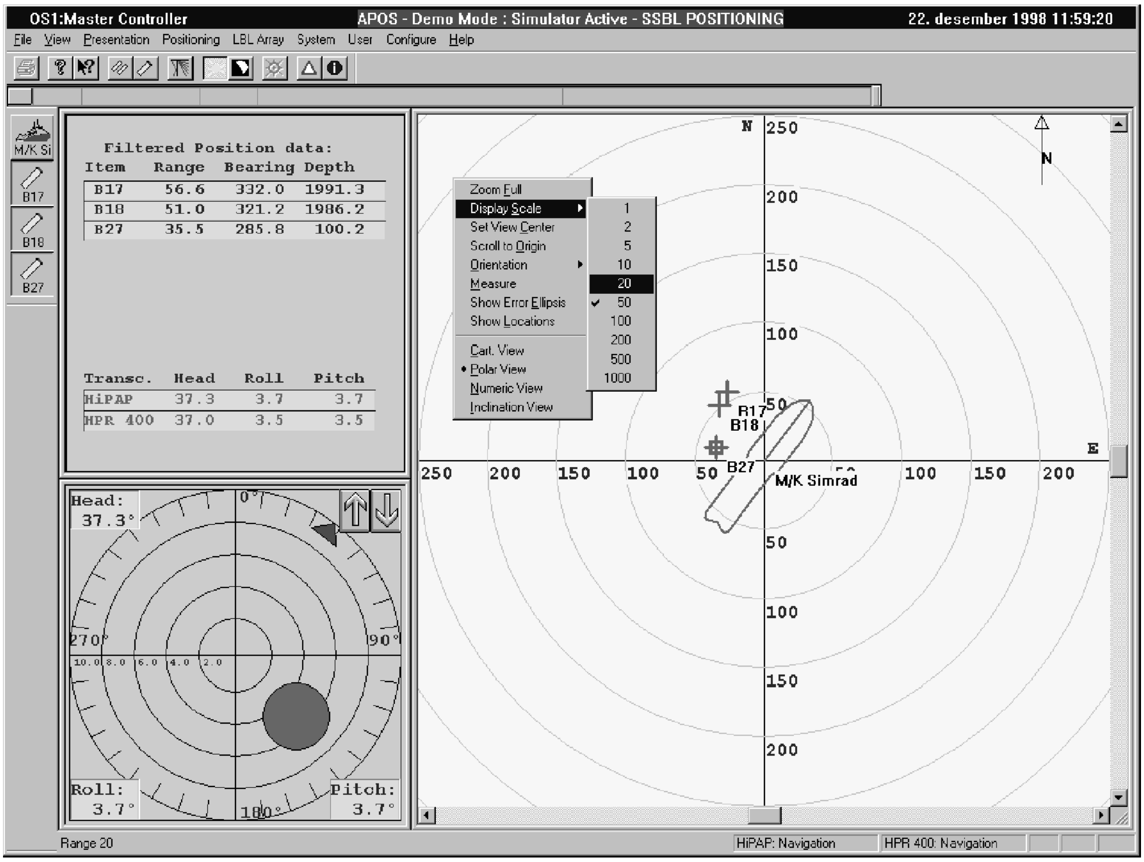


You have now activated the transponders and their symbols and positions will be displayed in the different views.

8.3.9 Scaling the view.

- Change view in the large window to a scale that fit the operation. Try 20m as scale.

(Move the cursor to the window and click right mouse button once. Move the cursor to **Display Scale** and a submenu appeares. Move the cursor to 20 and click once.)

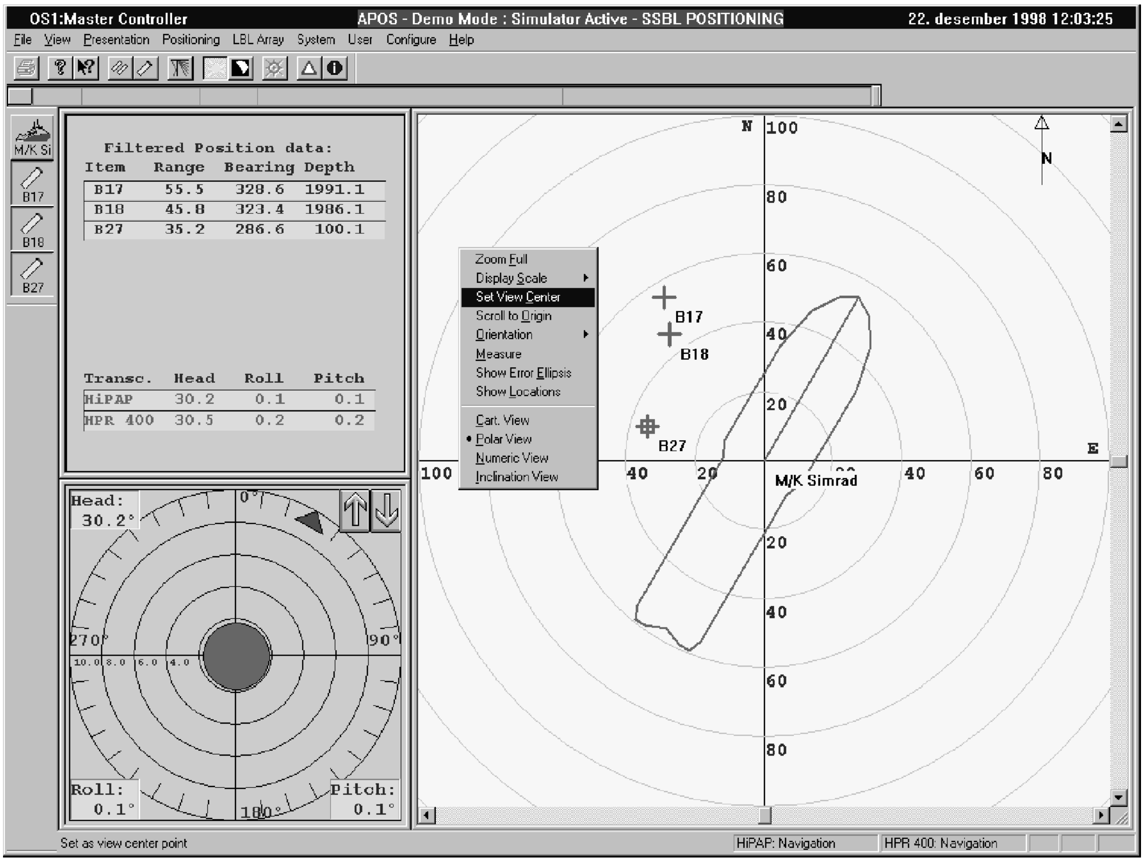


- Increase and decrease the scale without using any menus.

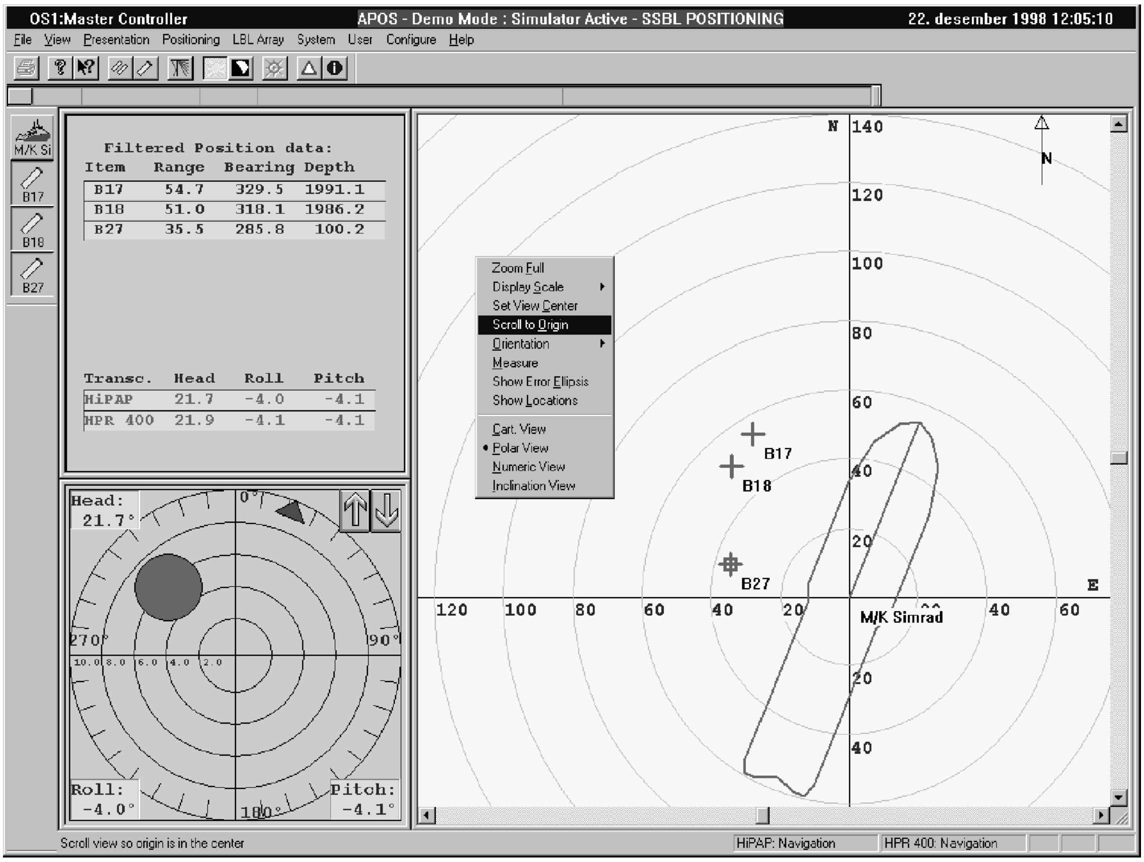
(Place the cursor somewhere in the window, hold the left mouse button down while you drag the mouse. A square will appear. Release the mouse button.)

- **Set View center** between two of the transponders.

(Move the cursor to the window and click right mouse button once. Move the cursor to **Set view center** and click once. A new cursor appeares. Place this cursor between two of the transponder symbols and click once.)



- To get the origin in the center of the window press right mouse button when the cursor is in the main display and click at **Scroll to Origin**.

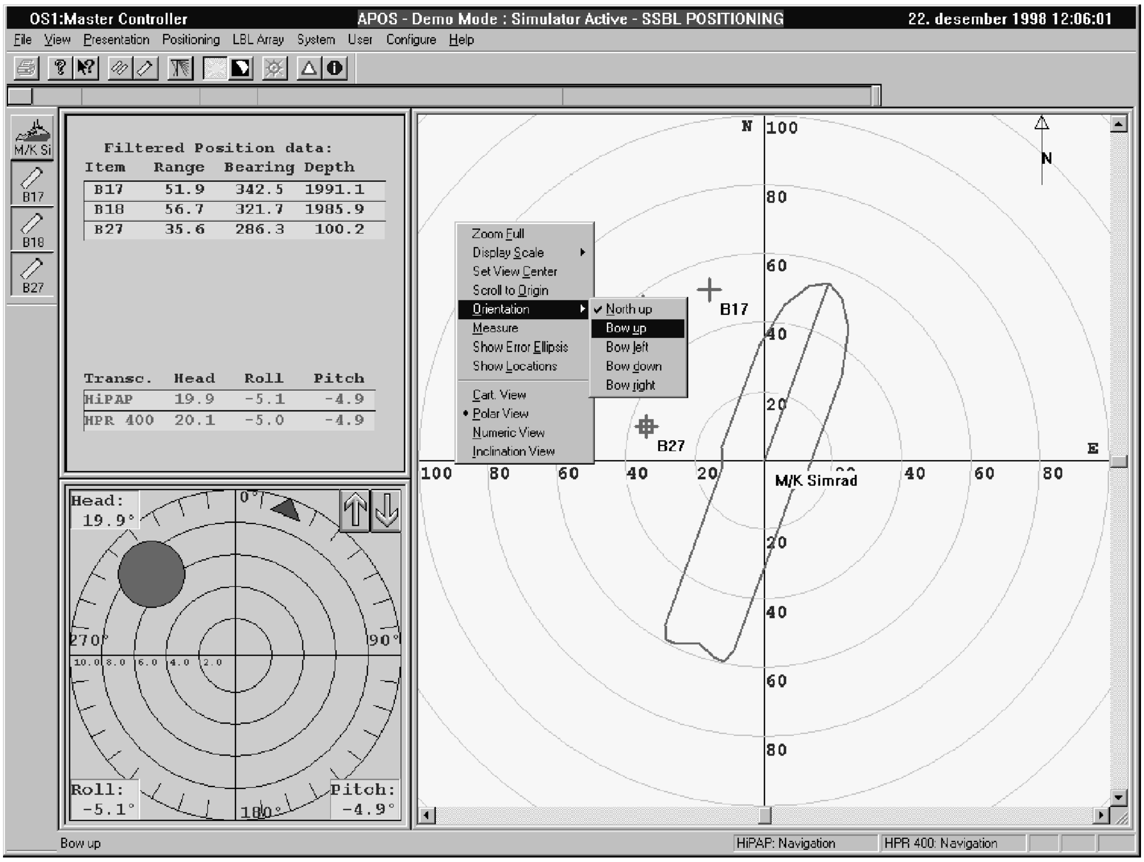


8.3.10 Vessel orientation

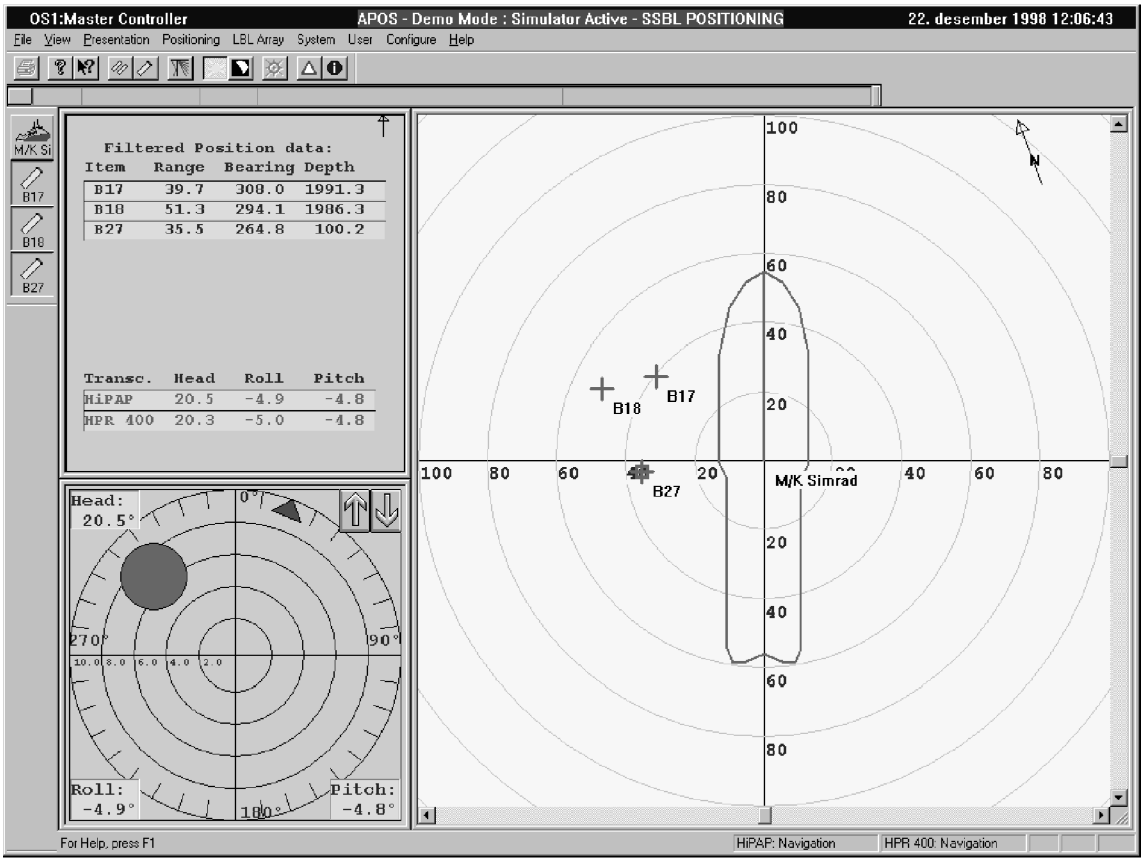
- Try different orientations for the vessel.

(Place the cursor in the main display, press right mouse button, move the cursor to **Orientation** to get a new submenu and press then left mouse button on the orientation you want to try)

Notice the North arrow and how the measured positions are presented in the different views.



- You will now be presented a question whether you want the Numeric view to have the same orientation or not.
- Click at Ja/Yes.



- Select the orientation you prefer.

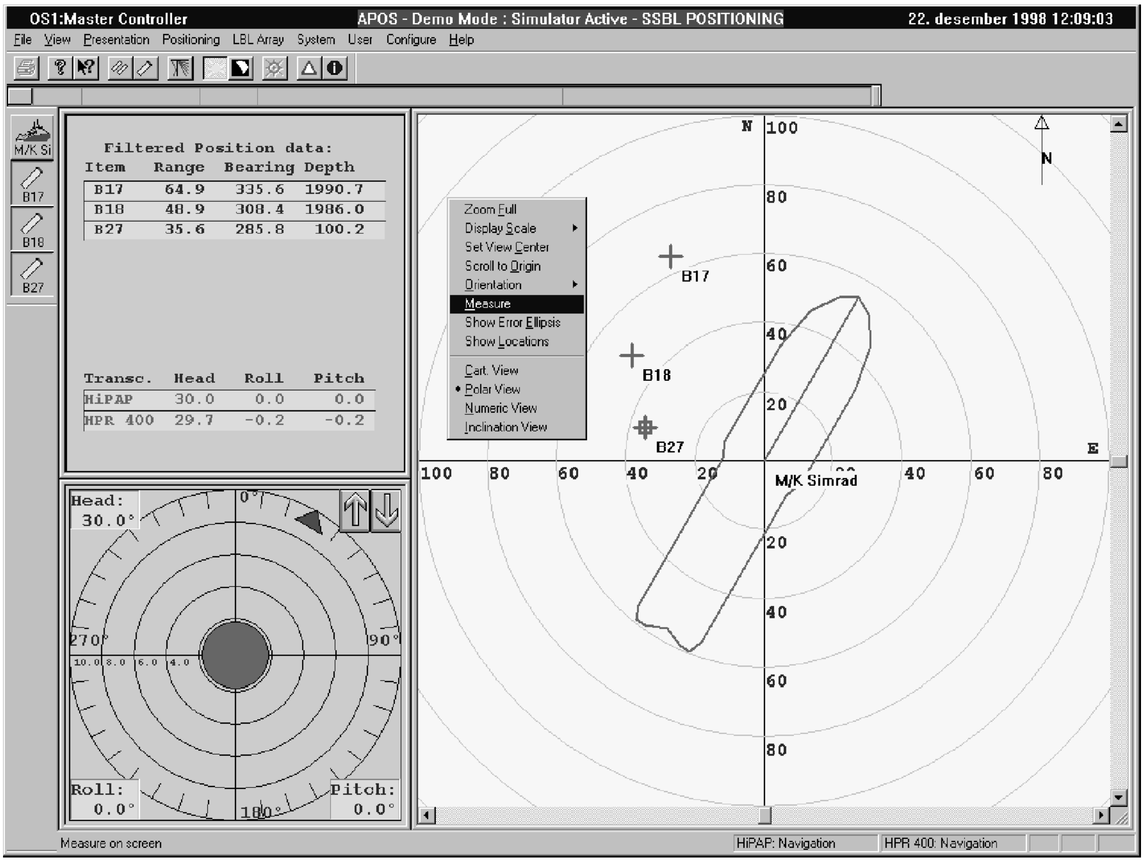
North up is used in the following screen dumps.

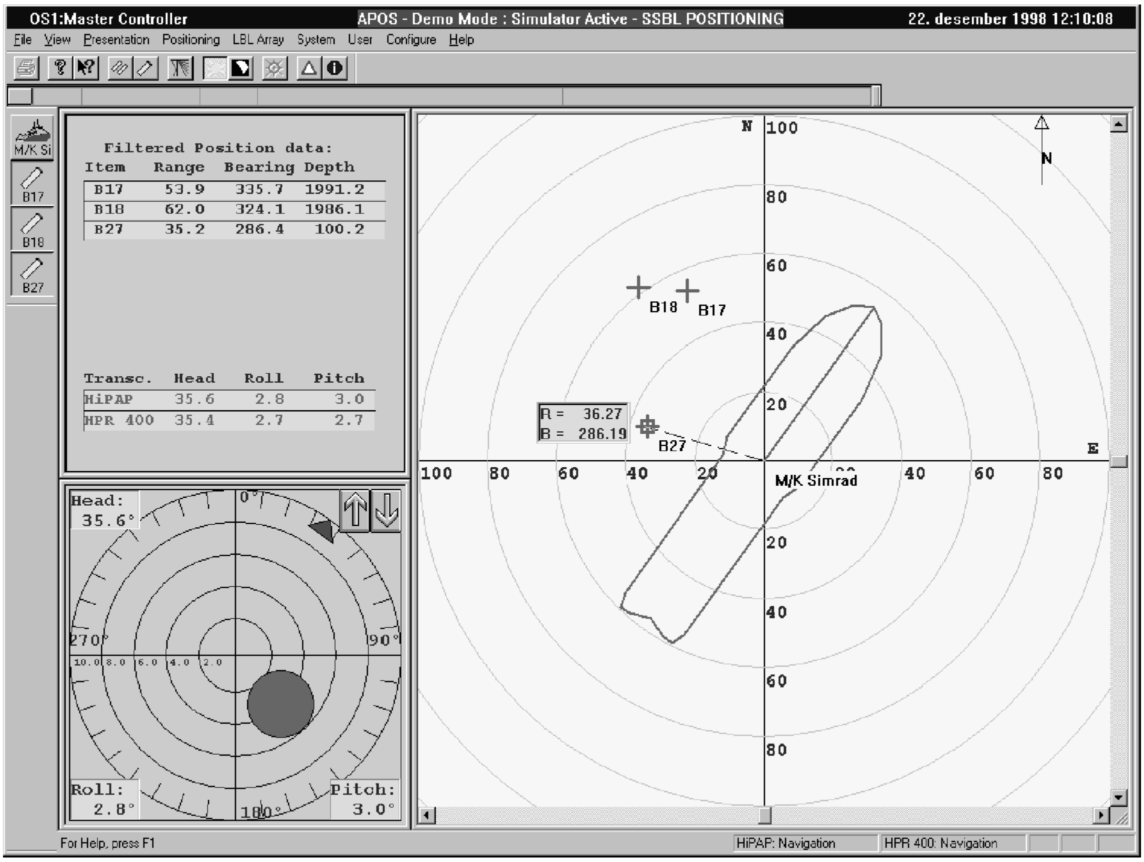
8.3.11 Simple measurement

There is a small measurement tool we can use in the numeric and polar view.

- Before you go further notice the range and bearing to one transponder.
- Use the measurement tool to control the values.

(Place the cursor in the large window and press right mouse button. Enable the **Measure** tool from the submenu. Place the cursor as close as possible to the transponder and press the left mouse button.)





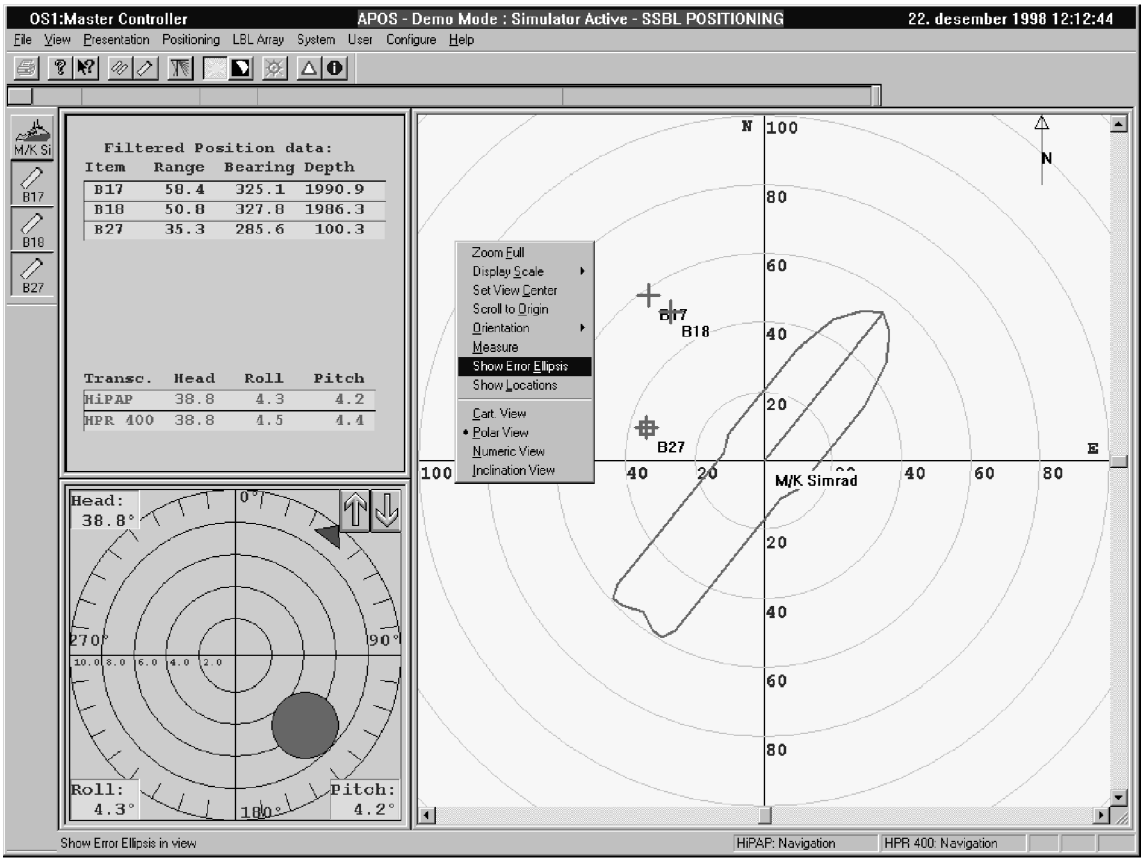
- Compare the values from the small window that appears.
- Disable the Measure tool

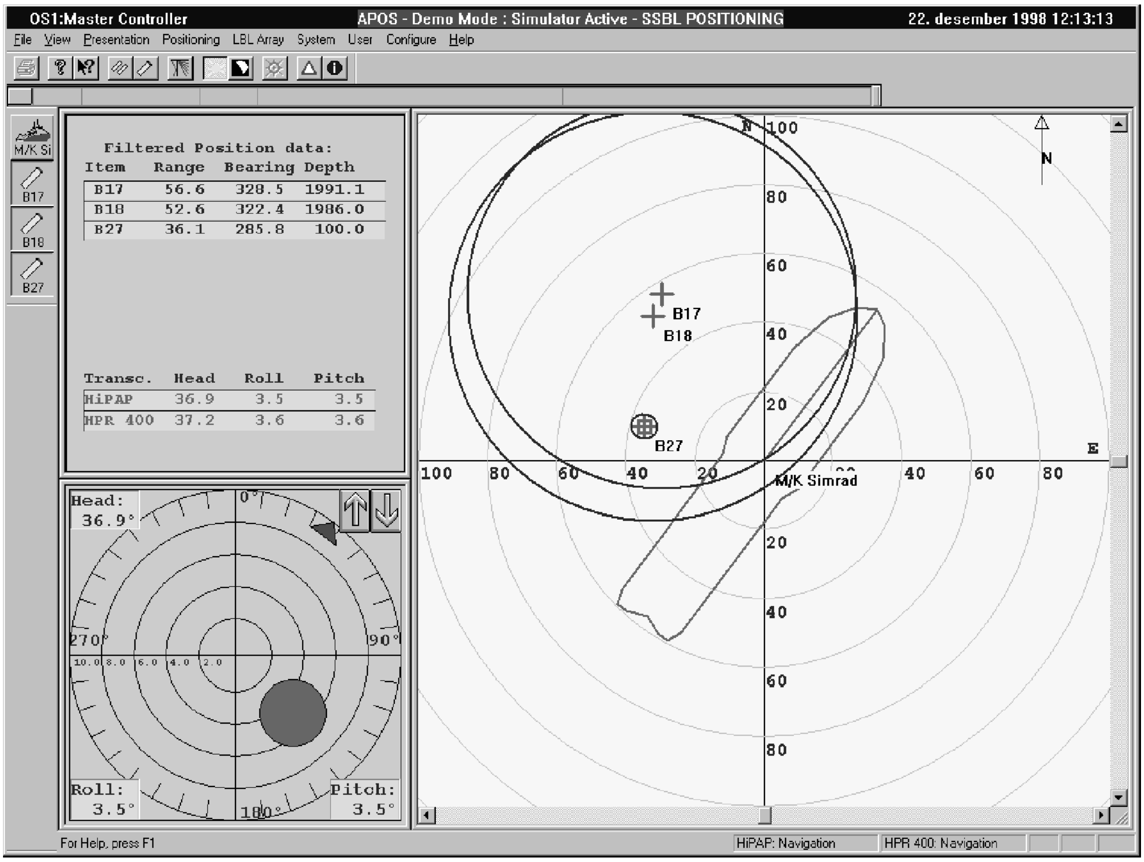
8.3.12 Error ellipsis

Error ellipsis indicates the quality of the measurements.

The distance from the center of the positioned object to the ellipsis represent one standard deviation.

- Show error ellipses around your transponders. Change scale/division to get the ellipsis inside the window.





- Turn off the error ellipses.

8.3.13 Polar view

When you start this course computer **Polar View** should be in the large right window, **Numeric View** in the upper left window and **Inclination View** in the lower left window.

You can have the same view in all the three areas or different views in each of them.

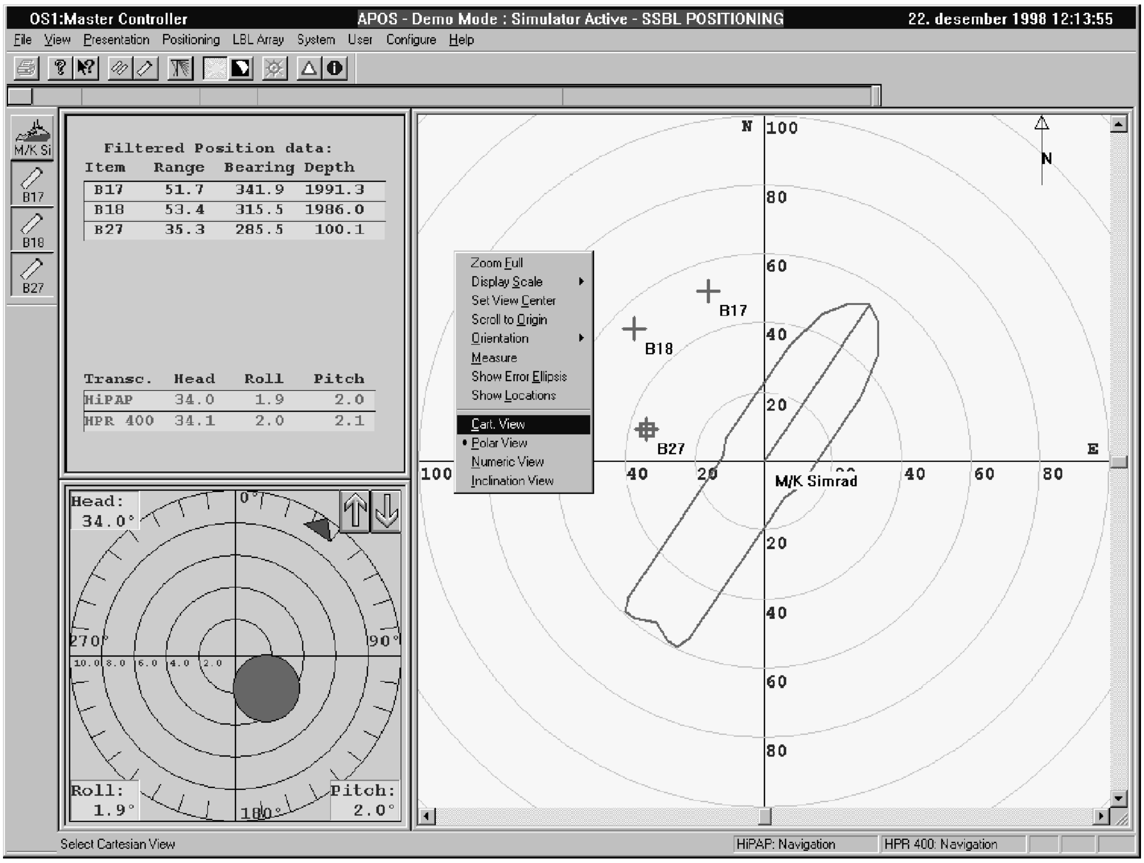
The options are

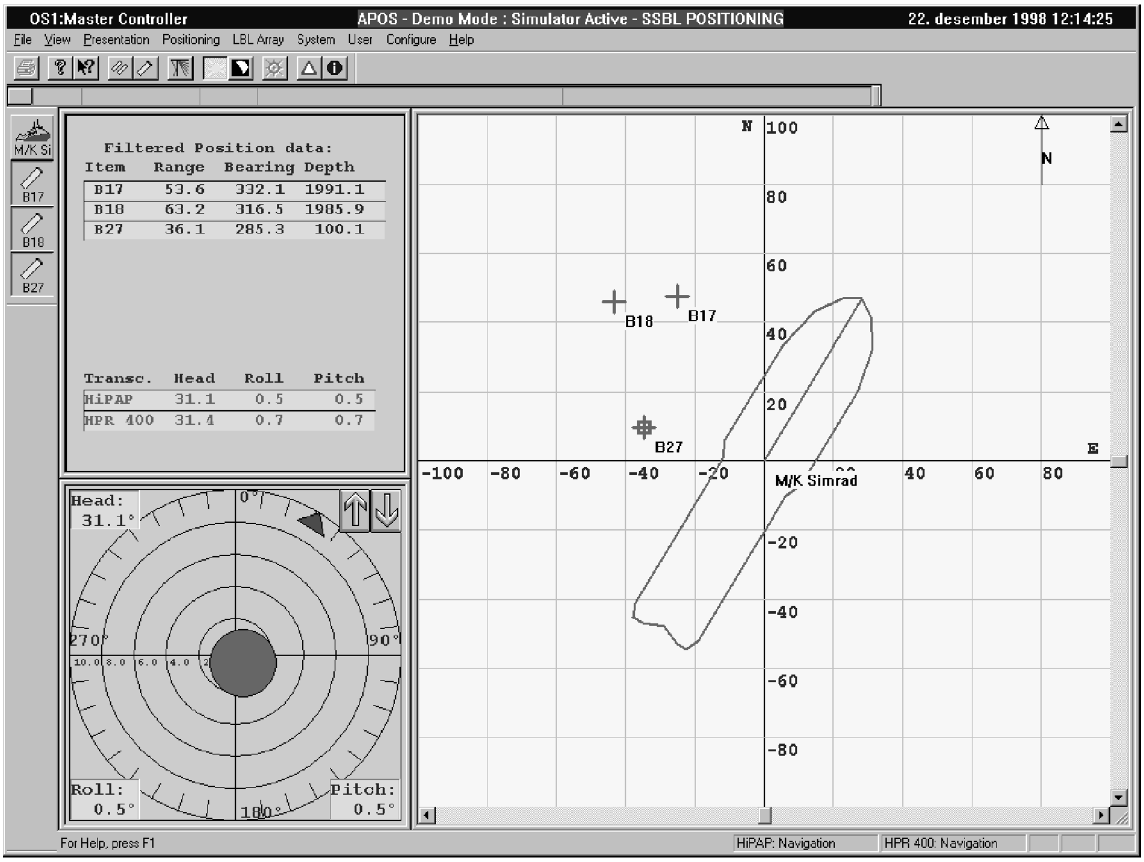
- Polar (Range–Bearing–Depth)
- Cartesian (North–East–Depth)
- Numeric (Item–Position)
- Incination (Roll–Pitch–Head / Tilt–Azimuth / X-tilt–Y-tilt)

8.3.14 Cartesian view

- Change the view to **Cartesian** in the main window.

(Place the cursor in the main window, but not above any of the symbols, and press right mouse button. Move the cursor to **Cart. View** in the pop up menu and press left mouse button.).





- Change the view back to **Polar view** in the main window if you prefer that presentation.

Cartesian is used in the following screen dumps.

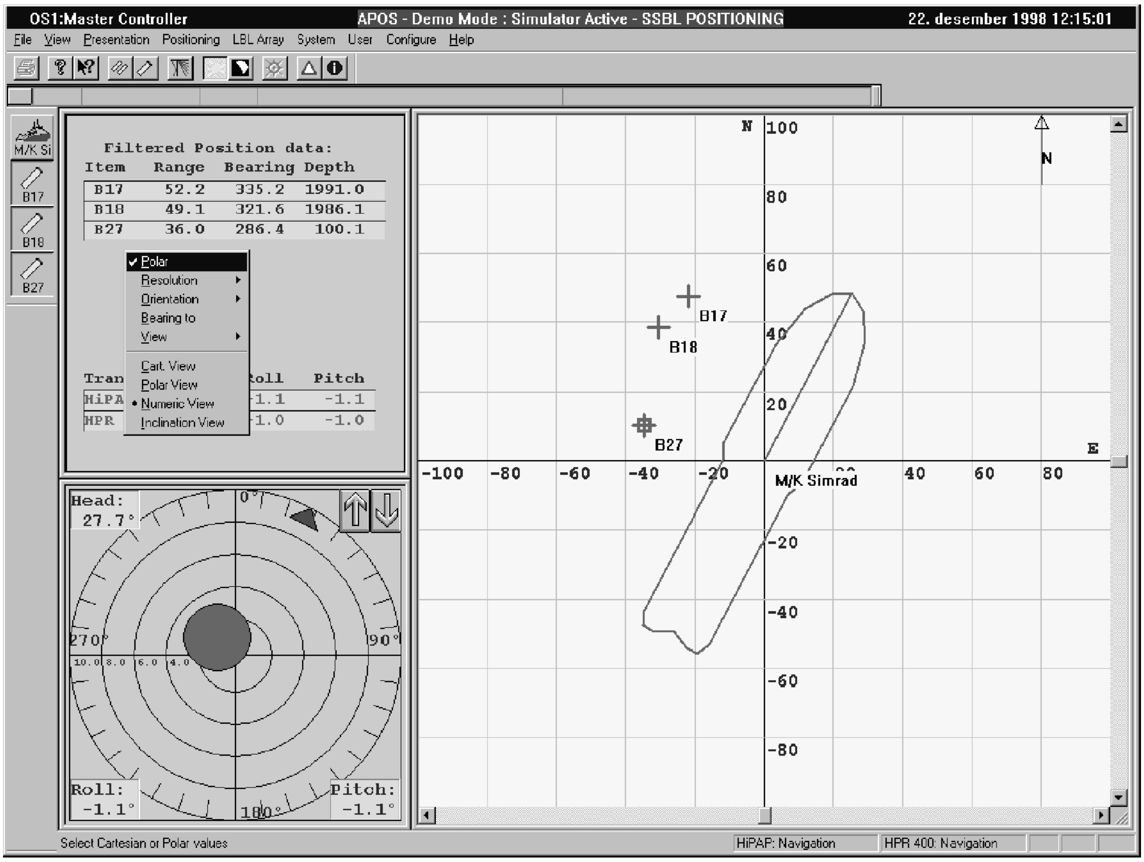
8.3.15 Numeric view

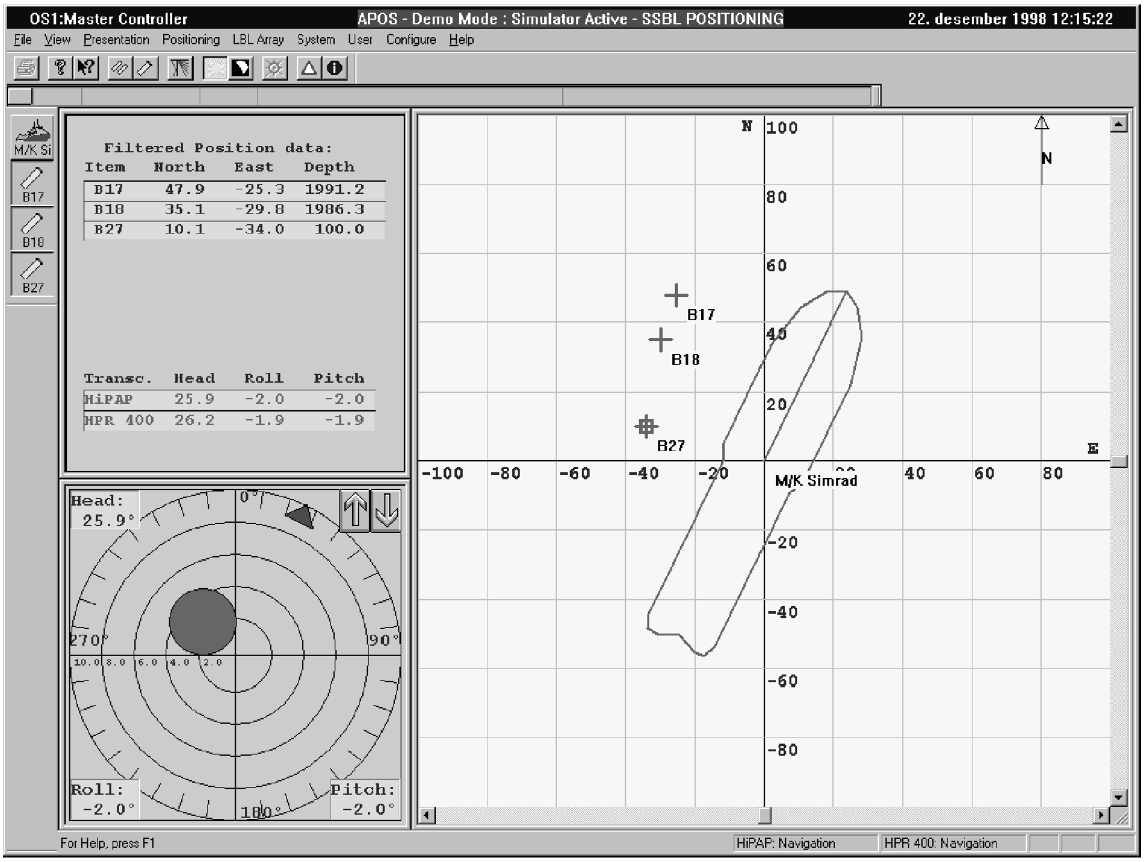
- Control that you have a numeric view in the upper left window.

In this numeric view we can choose if we want North–East–Depth presentation or Range–Bearing–Depth presentation.

- Disable Polar presentation to get North–East–Depth.

(Move the cursor to the Numeric View area and press right mouse button. Disable Polar so that there is no tick mark to the left of Polar.)

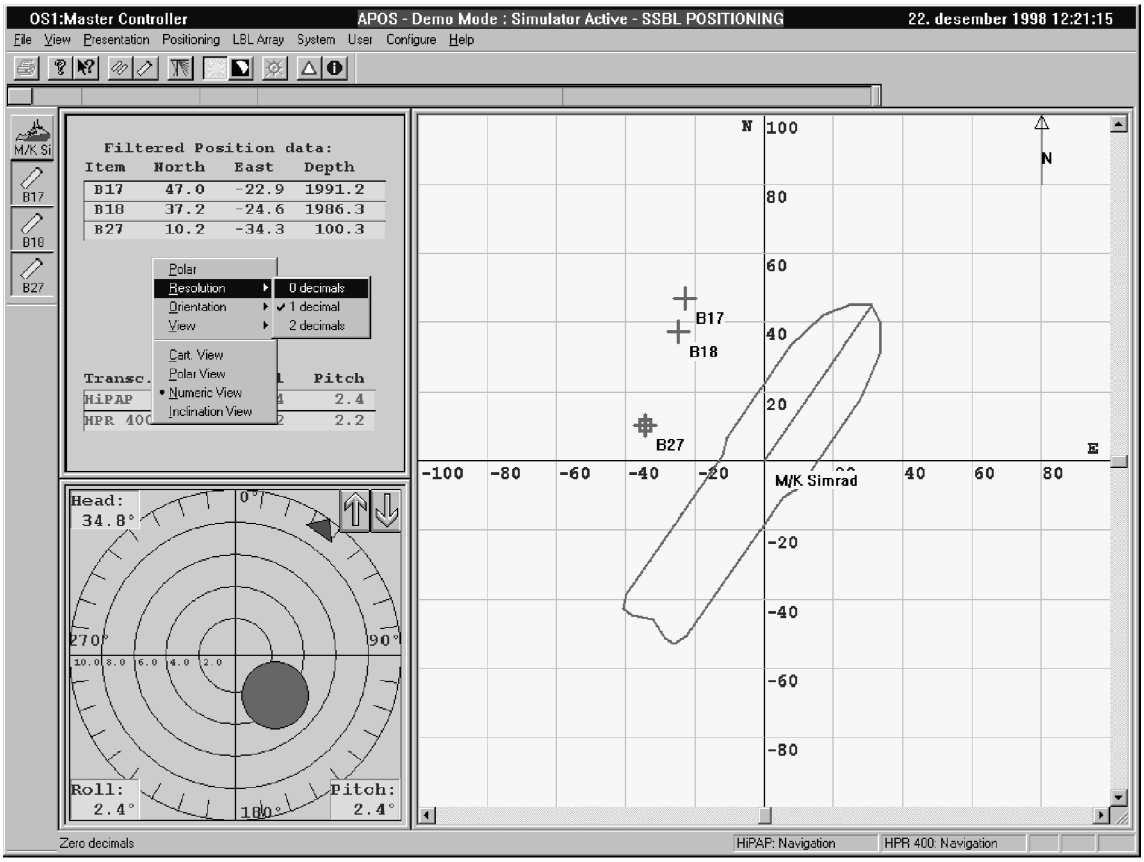


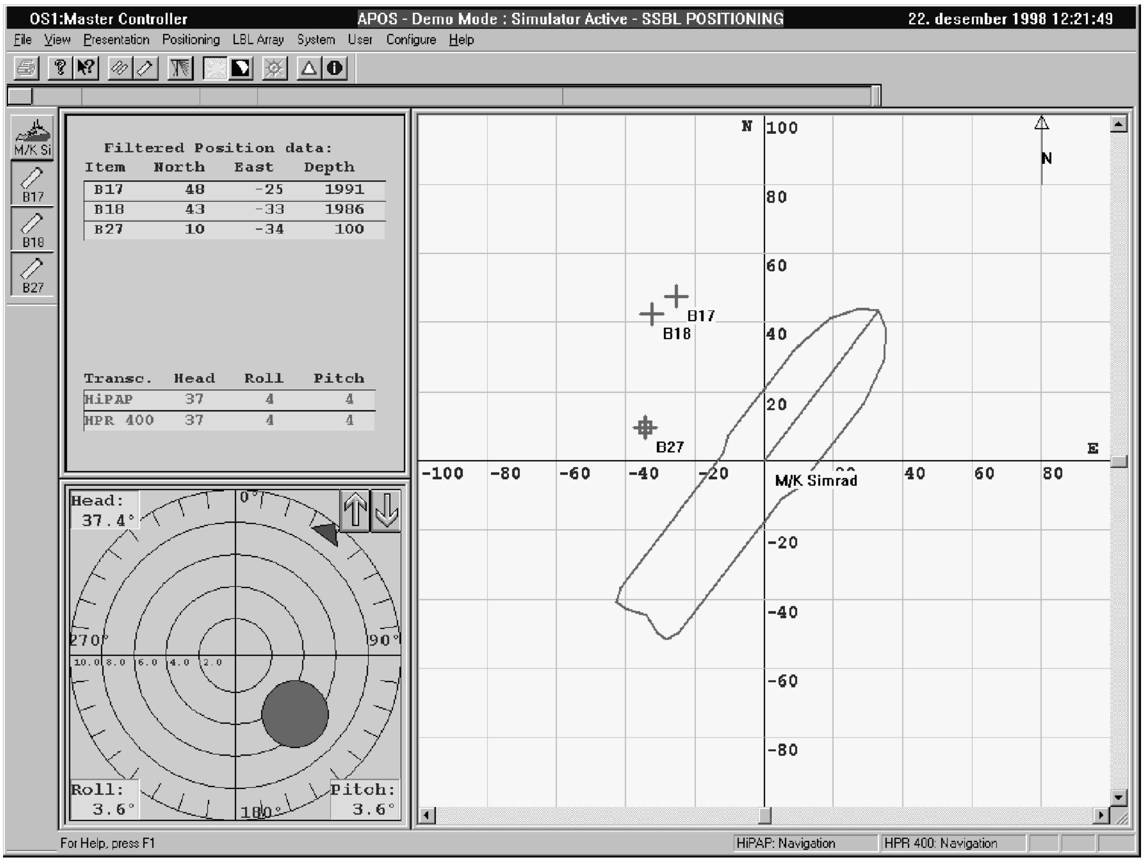

OS1:Master Controller
APOS - Demo Mode : Simulator Active - SSBL POSITIONING
22. desember 1998 12:15:22
File View Presentation Positioning LBL Array System User Configure Help
Filtered Position data:
Item North East Depth
B17 47.9 -25.3 1991.2
B18 35.1 -29.8 1986.3
B27 10.1 -34.0 100.0
Transc. Head Roll Pitch
HiPAP 25.9 -2.0 -2.0
HPR 400 26.2 -1.9 -1.9
Head: 25.9°
Roll: -2.0°
Pitch: -2.0°
M/K Simrad
For Help, press F1
HiPAP: Navigation
HPR 400: Navigation

8.3.16 Resolution

- Change resolution to 0 decimals in the Numeric View.

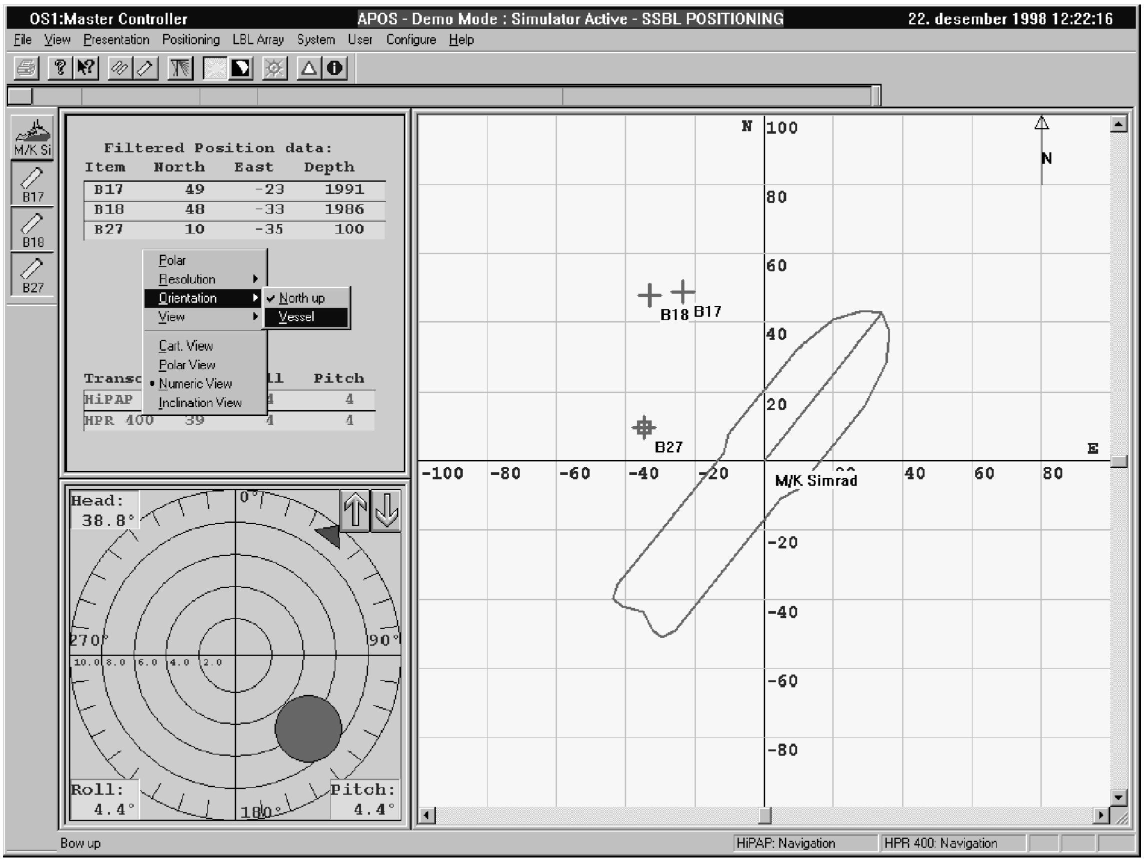
(Move the cursor to the Numeric View area and press right mouse buttom. From the **Resolution** submenu choose 0 decimal.)




OS1:Master Controller
APOS - Demo Mode : Simulator Active - SSBL POSITIONING
22. desember 1998 12:21:49
File View Presentation Positioning LBL Array System User Configure Help
Filtered Position data:
Item North East Depth
B17 48 -25 1991
B18 43 -33 1986
B27 10 -34 100
Transc. Head Roll Pitch
HiPAP 37 4 4
HPR 400 37 4 4
Head:
37.4°
Roll:
3.6°
Pitch:
3.6°
M/K Simrad
For Help, press F1
HiPAP: Navigation
HPR 400: Navigation

The orientation menu decides whether the position data is presented relative the vessel's heading of true north.

- Try this function.

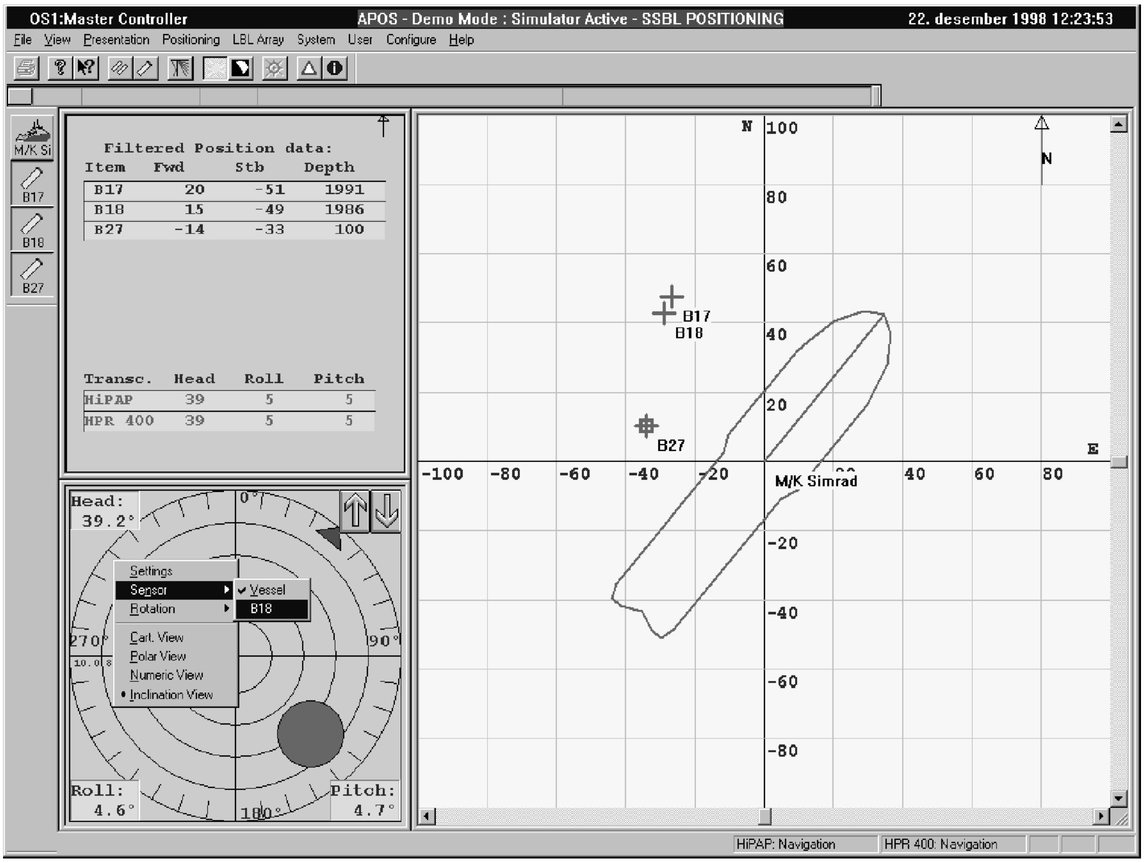


8.3.17 Inclination view

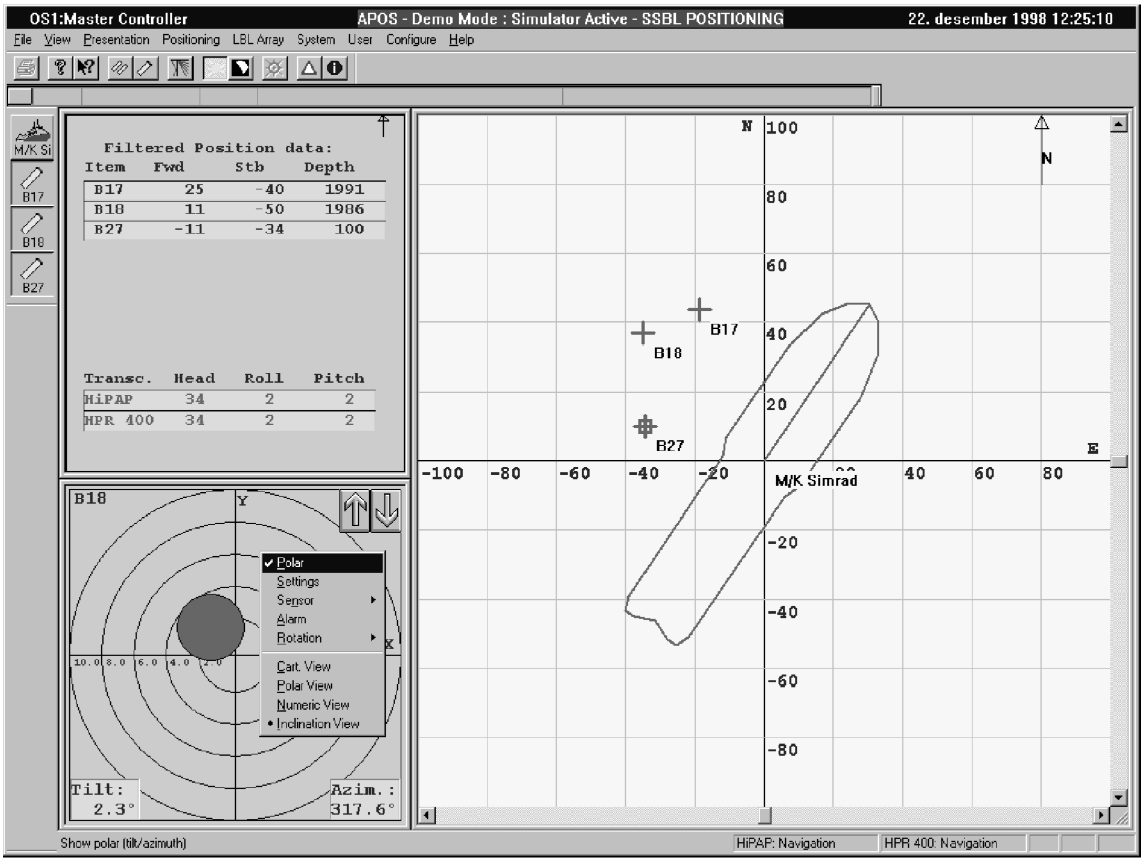
In the Inclination view you see roll, pitch and heading values for the vessel. You can also present information from an inclinometer transponder and in two ways; x and y tilt or tilt and azimuth.

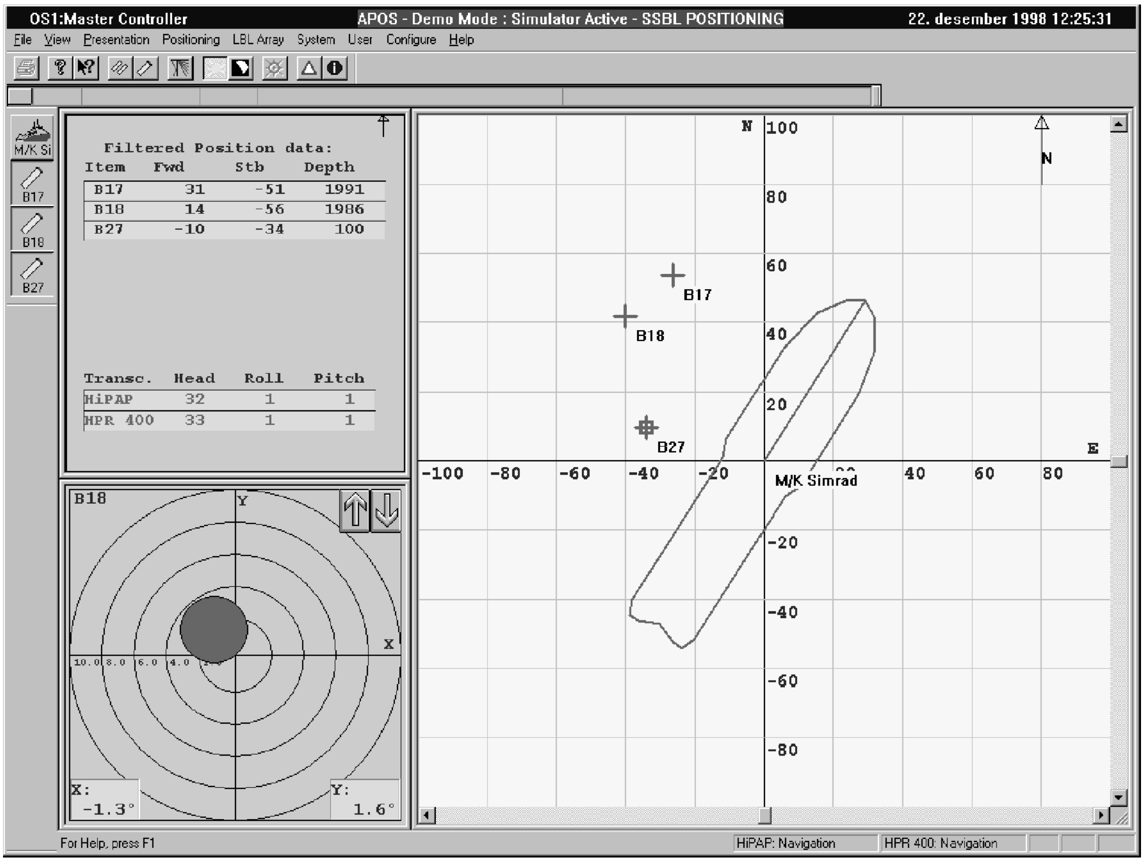
- Try different rotations for the vessel's roll, pitch and heading presentation by entering the **Rotation** submemu.

- Select an inclinometer transponder as **Sensor**.



- Use the arrow keys to change the scale in the Inclination View and select the scale you prefer.
- Notice that the valus are presented as Tilt and Azimuth
- Disable Polar to get x–tilt and y–tilt presentation in the inclination view.



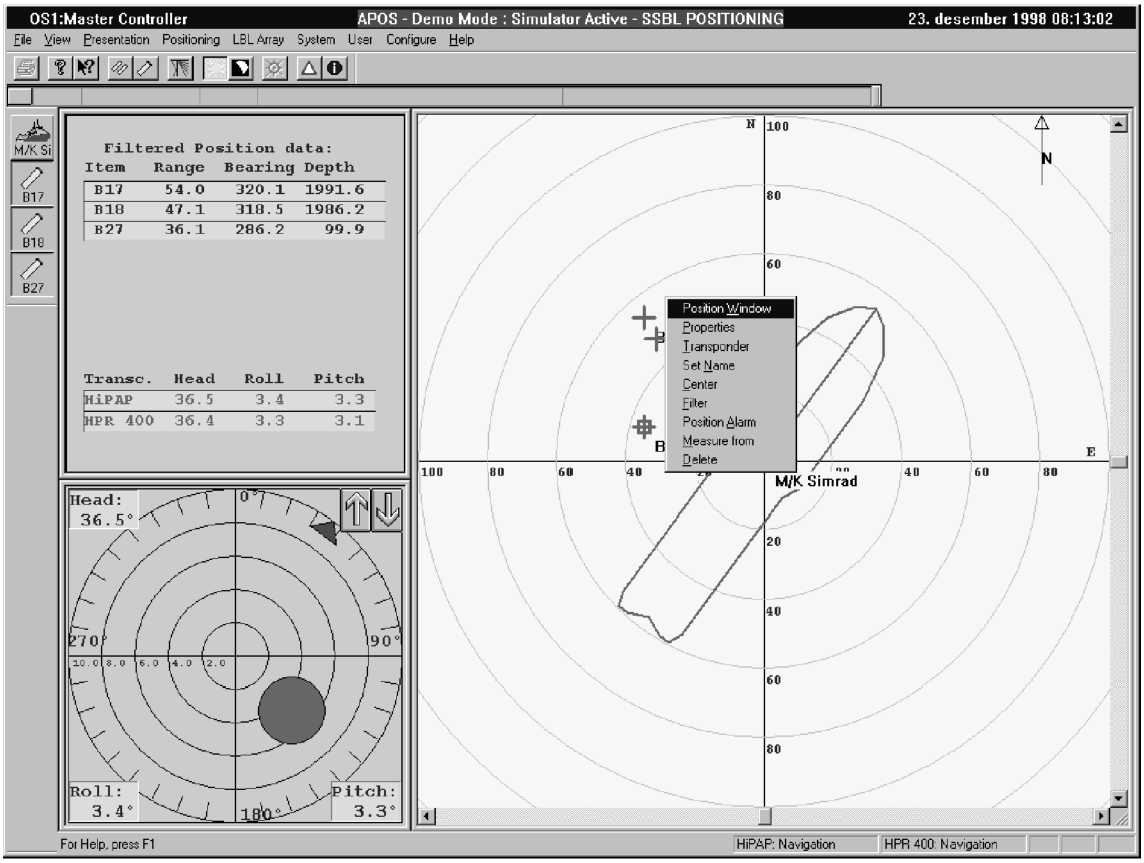


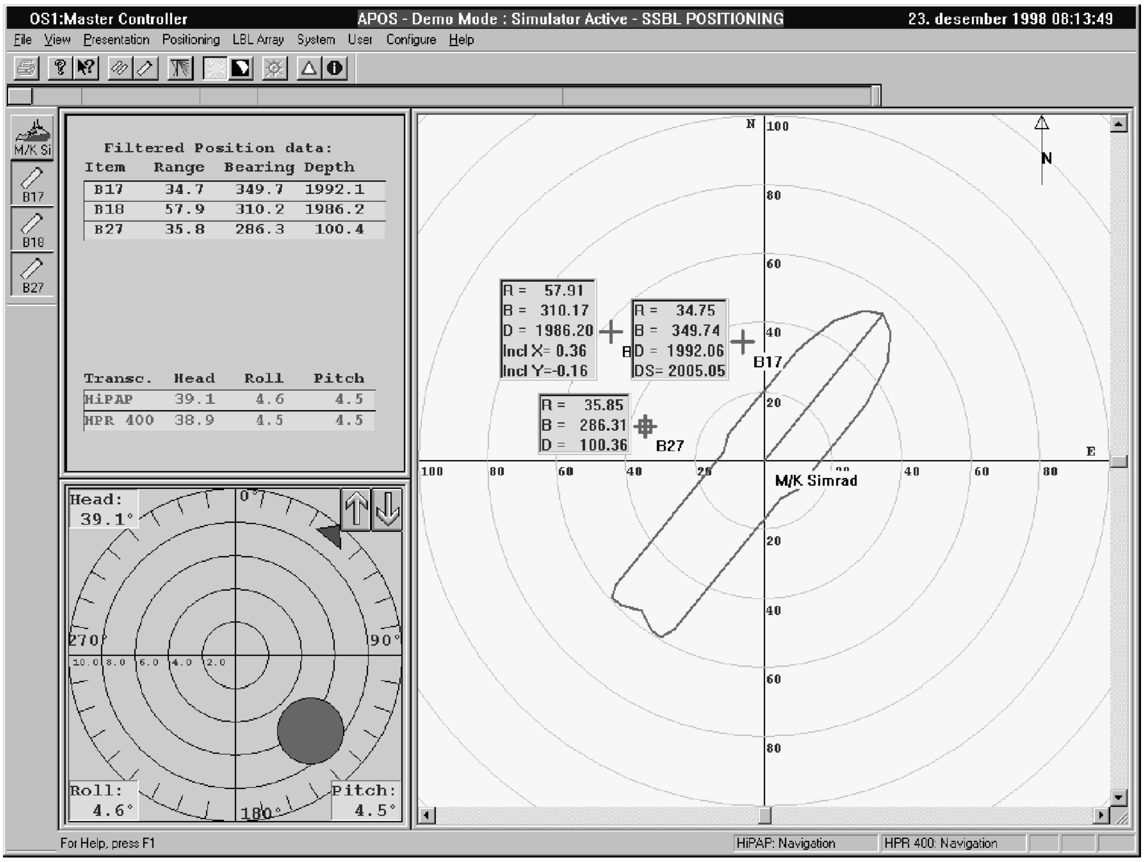
- Change back to Vessel as Sensor.

8.3.18 Position window

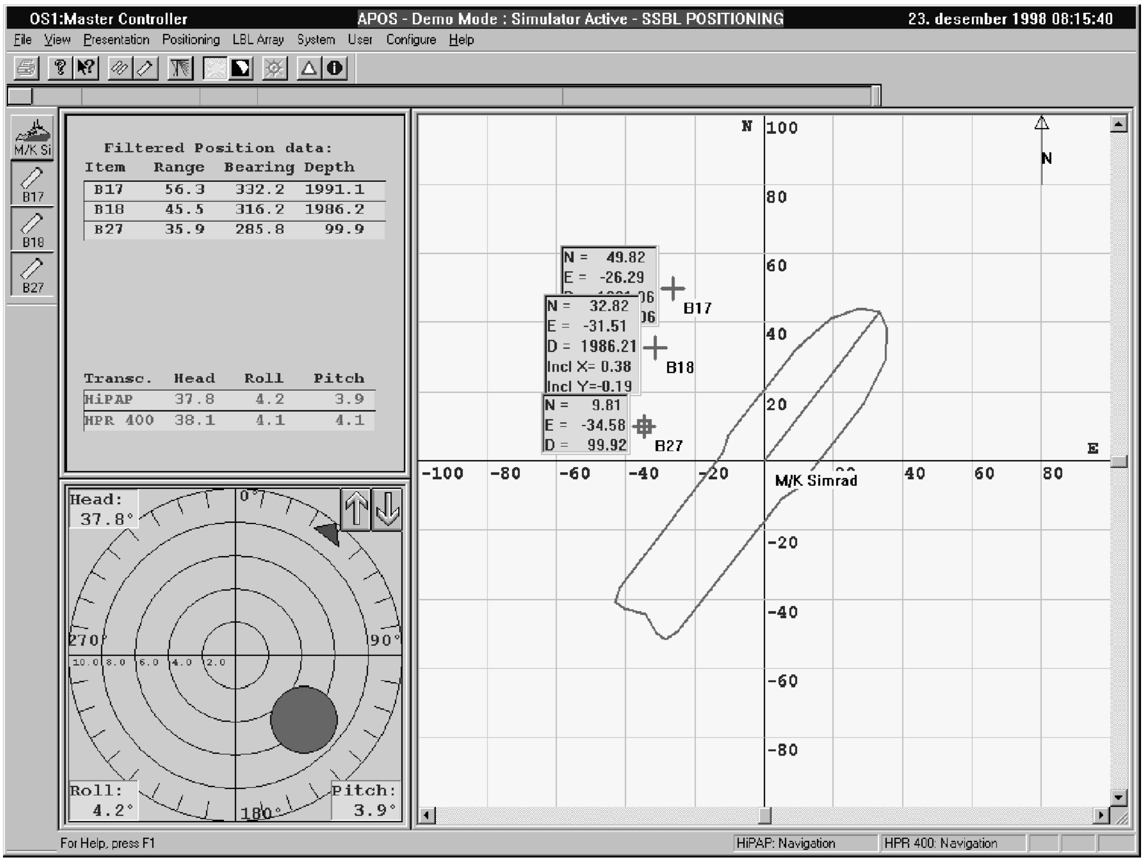
- Present one of the transponders position data in the large window with Cartesian View.

(Move the cursor above the Transponder in the view and press right mouse buttom. Select **Position Window**)




OS1:Master Controller
APOS - Demo Mode : Simulator Active - SSBL POSITIONING
23. desember 1998 08:13:49
File View Presentation Positioning LBL Array System User Configure Help
Filtered Position data:
Item Range Bearing Depth
B17 34.7 349.7 1992.1
B18 57.9 310.2 1986.2
B27 35.8 286.3 100.4
Transc. Head Roll Pitch
HiPAP 39.1 4.6 4.5
HPR 400 38.9 4.5 4.5
Head: 39.1°
Roll: 4.6°
Pitch: 4.5°
R = 57.91
B = 310.17
D = 1986.20
Incl X= 0.36
Incl Y=-0.16
R = 34.75
B = 349.74
D = 1992.06
DS= 2005.05
R = 35.85
B = 286.31
D = 100.36
B17
B27
M/K Simrad
For Help, press F1
HiPAP: Navigation
HPR 400: Navigation

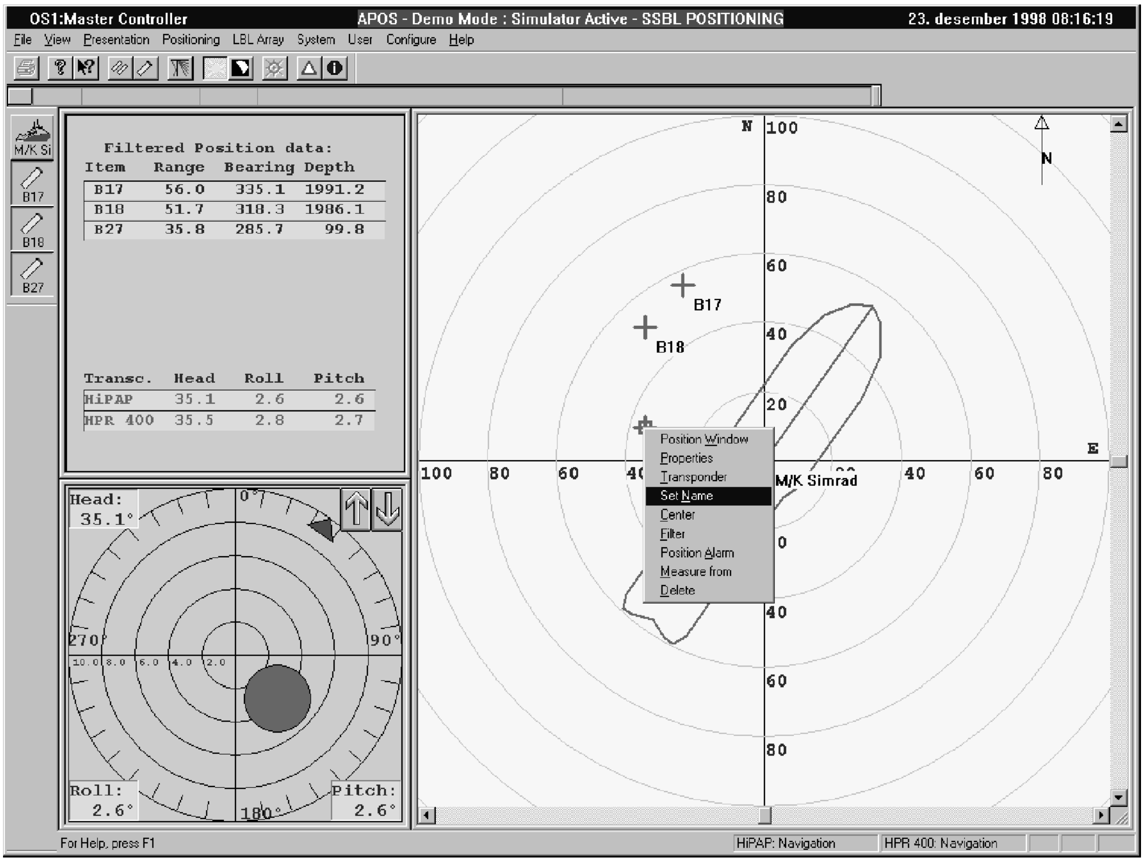
- Try this Position Window function both with Cartesian view and Polar view and notice the difference in presentation.



8.3.19 Changing name of a transponder.

- Rename transponder B27 to ROV B27.

(Place the cursor above the transponder symbol and click the right mouse button. Click at **Set Name**.)

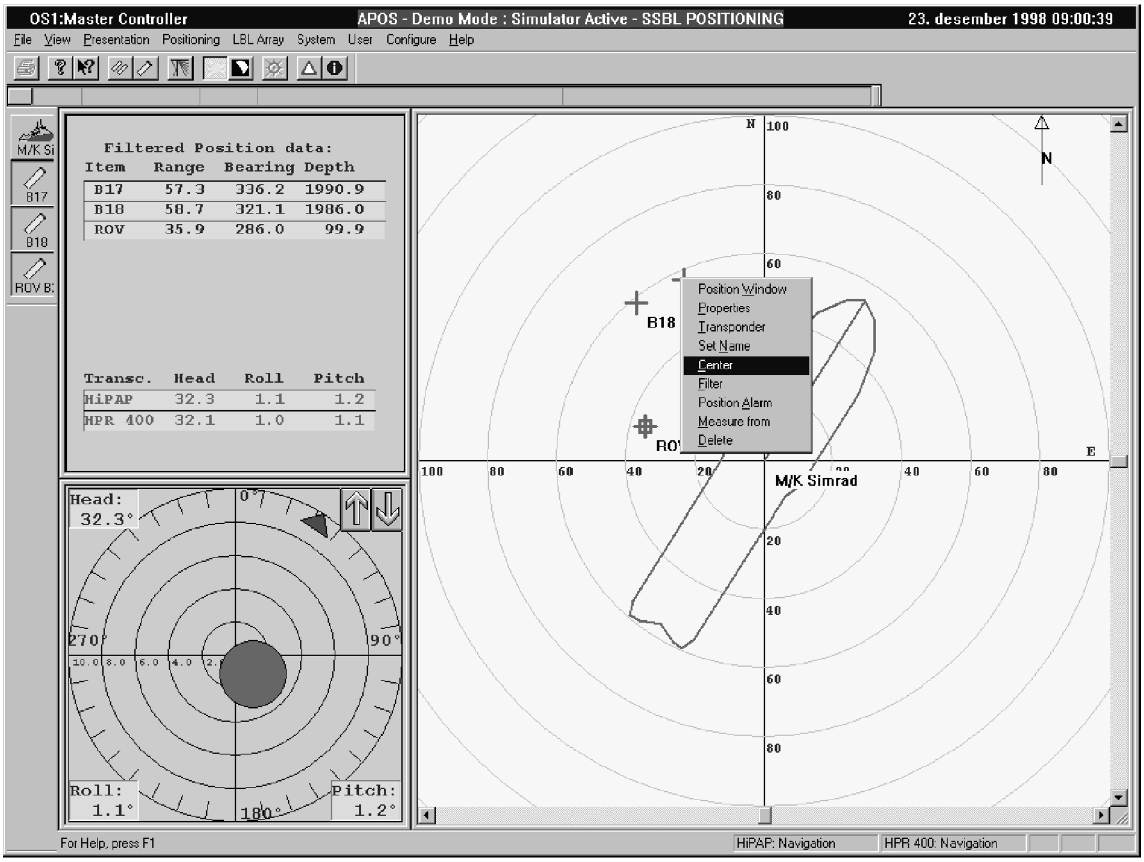


- Enter the new name in the new small window and click the OK button.

8.3.20 Center object

- Present one of the transponders in the center of the display window.

(Move the cursor above the transponder in the view and press right mouse buttom. Select **Center**)

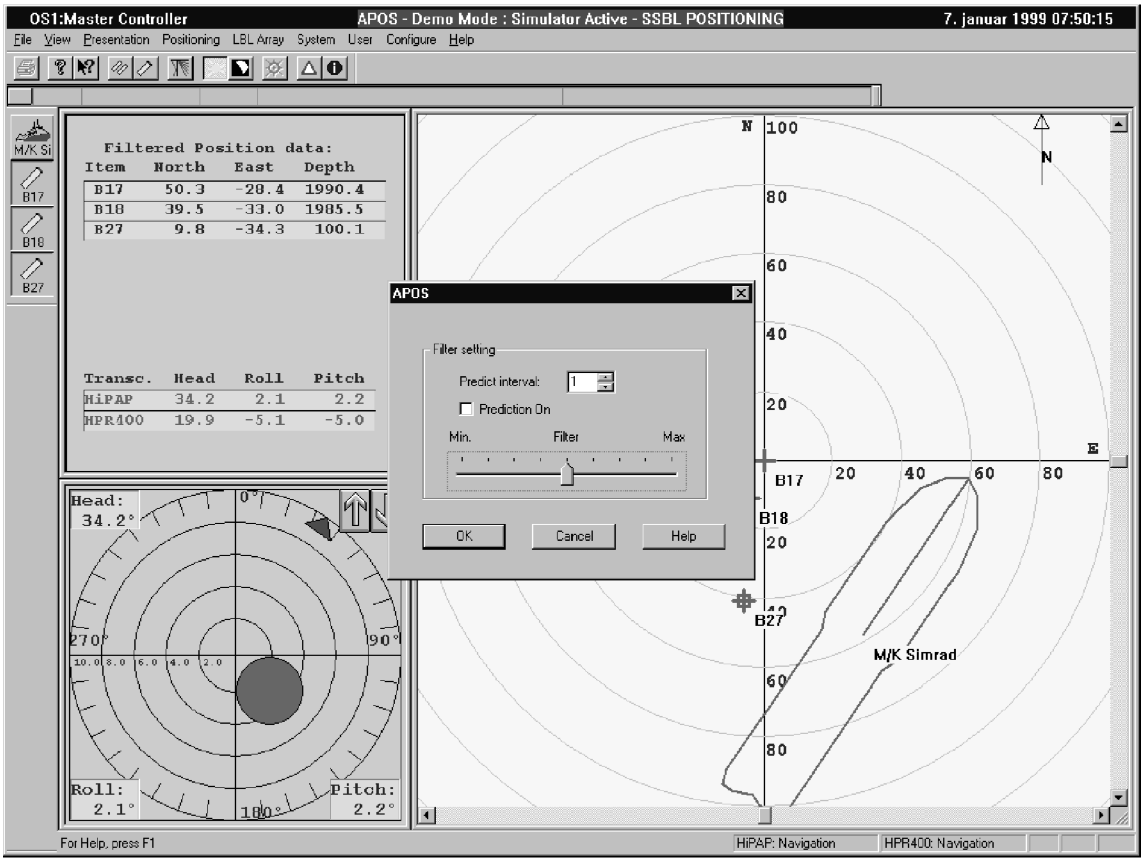


8.3.21 Filter

Each positioning object may have an individual set value for the Kalman filter used by the system.

- Enter the filter dialog.

(Move the cursor above the transponder in the view and press right mouse buttom. Select **Filter**)



The default value is filter factor 5 and no prediction.

For fast moving vessels or ROVs use a smaller filter value than default.

For slow moving vessels use a larger filter value than default.

If the update rate is slow, prediction will update the screen with predicted values in between each measured value.

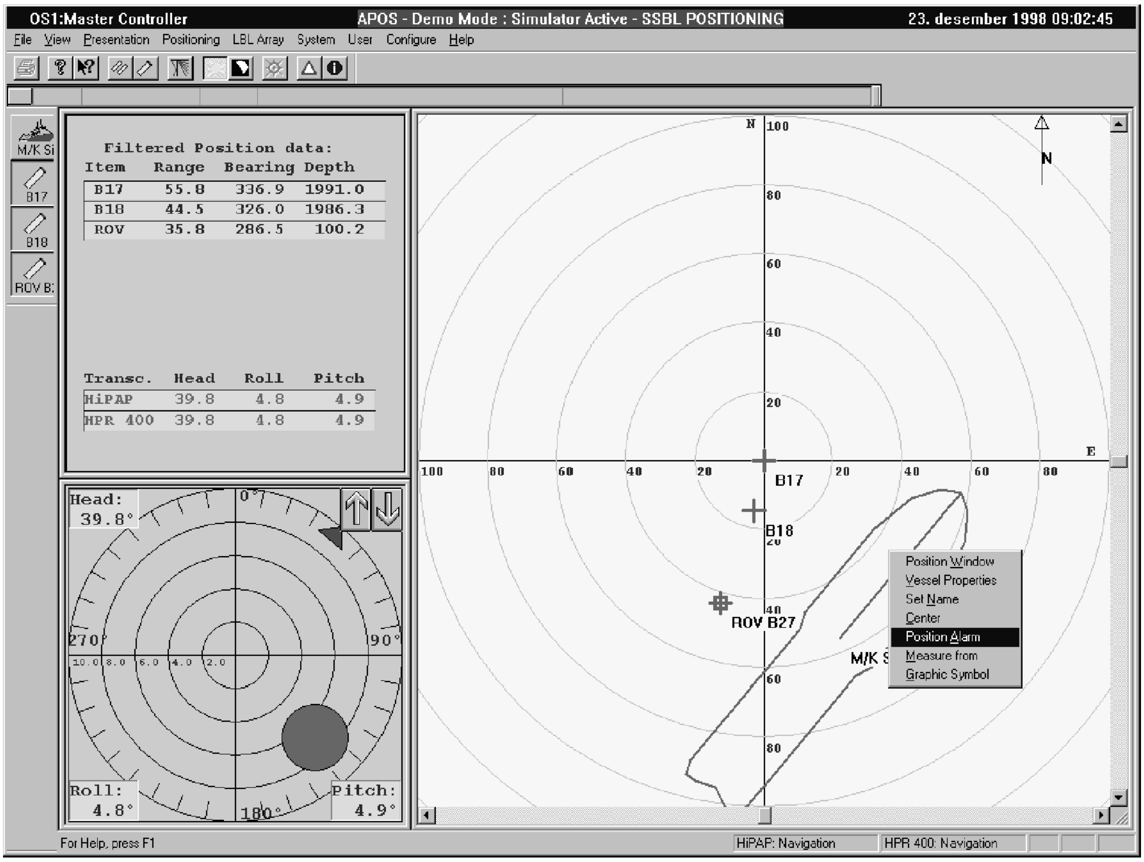
You se the Presentation menu to set filtering ON. This will display all positioned items with use filtered values.

8.3.22 Position alarms

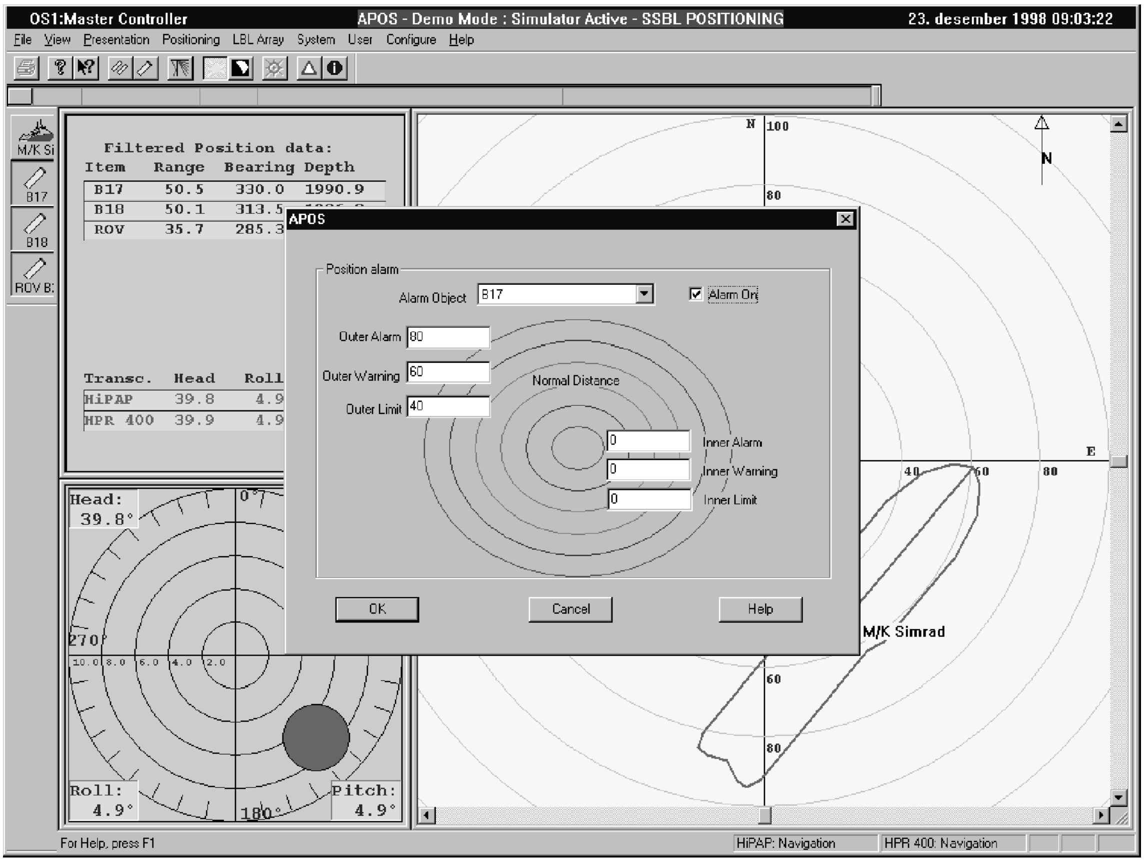
If transponder B17 is more than 40 metres away from the vessel we want an early warning. If the distance is more than 60m we want a warning. An alarm has to be presented if if the range is more than 80 metres.

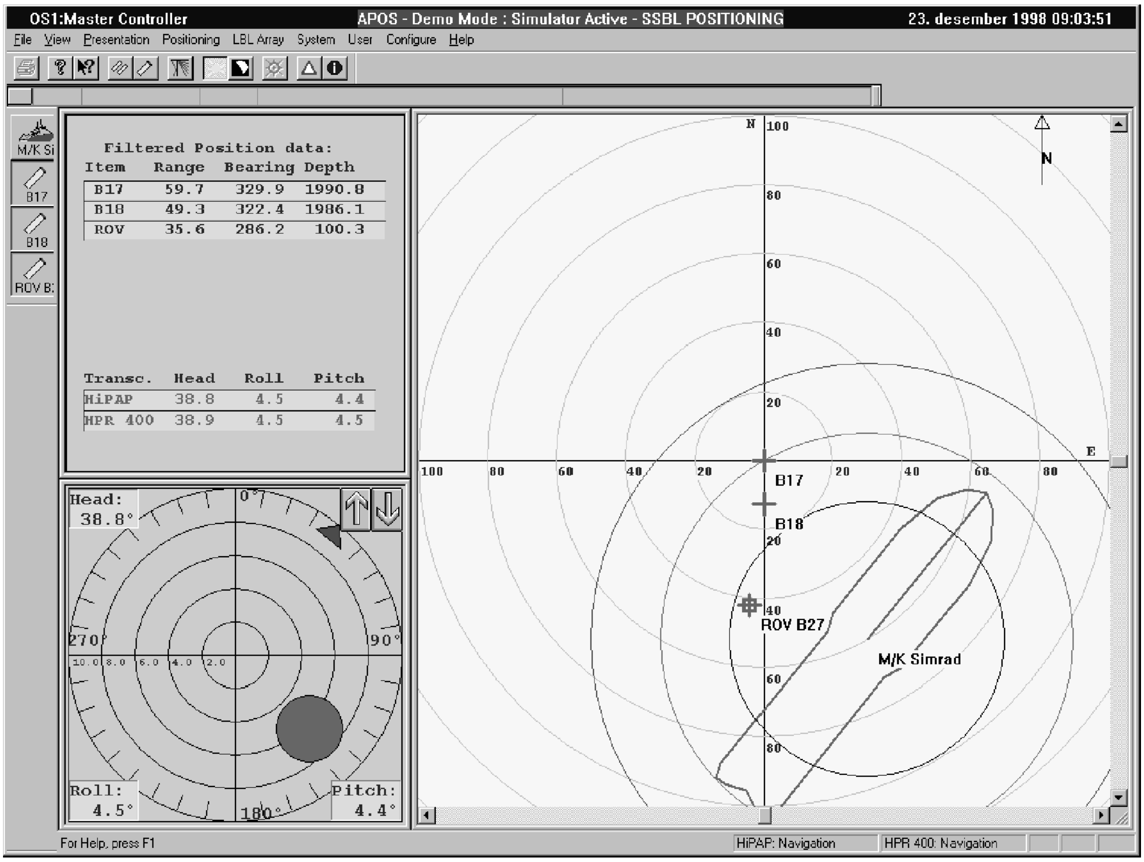
- Create alarm circles around your vessel.

The simulator is not configured to use this function but you will still be able to learn how to create the circles.



• Remember to enter a tick mark in the **Alarm On** check box.

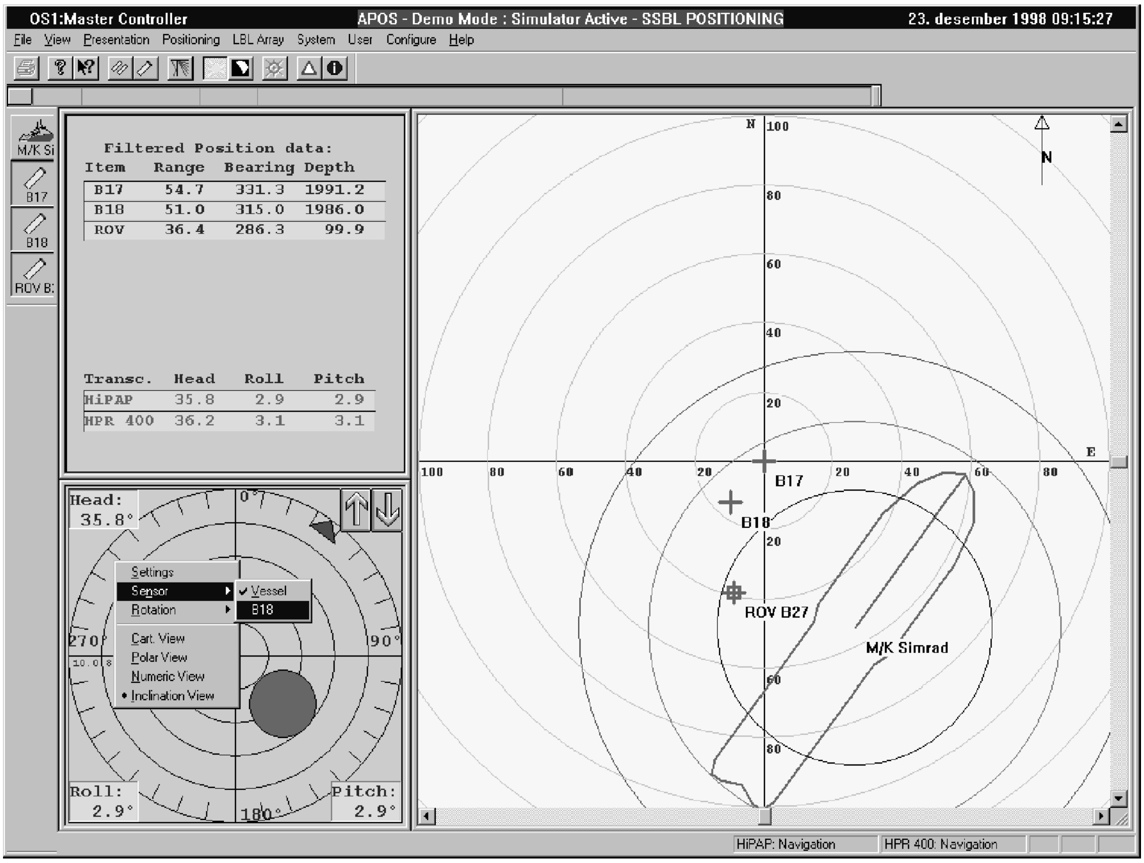




Try other limits if you want.

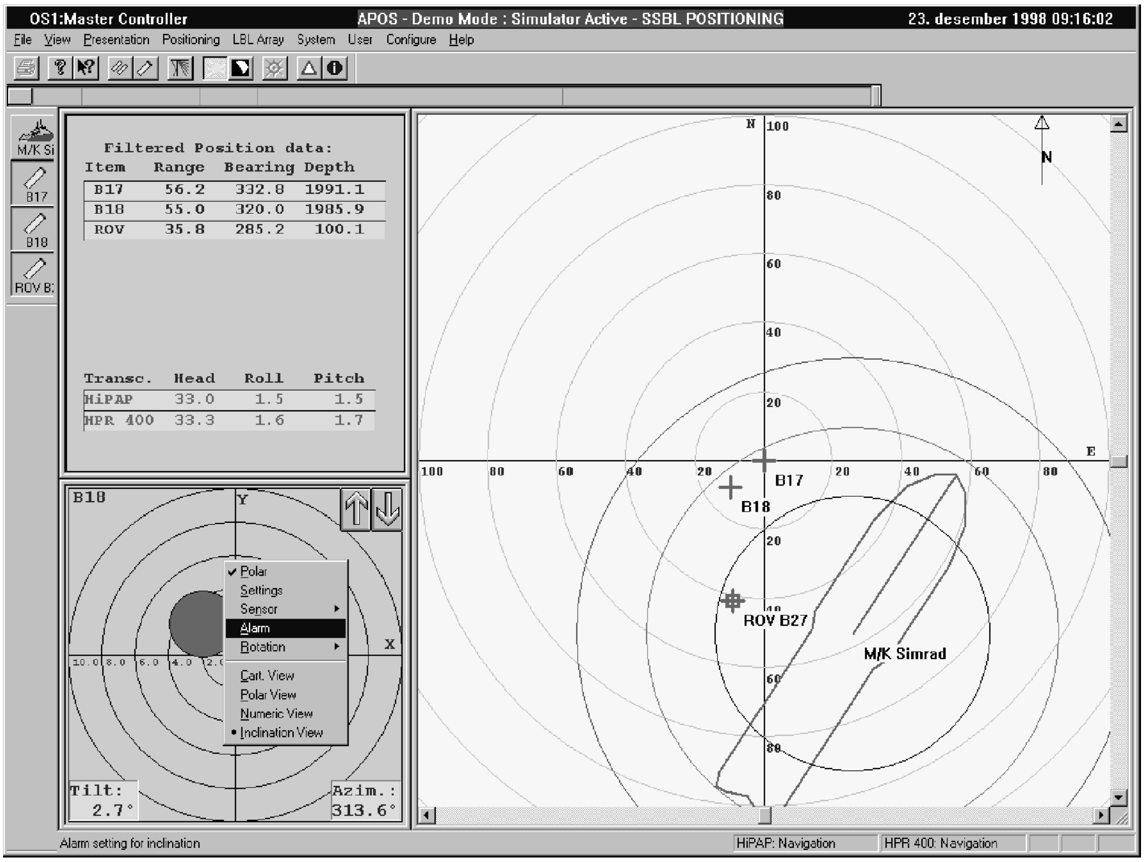
8.3.23 Inclination alarms.

- Let data from the inclo transponder be displayed in the Inclination View.

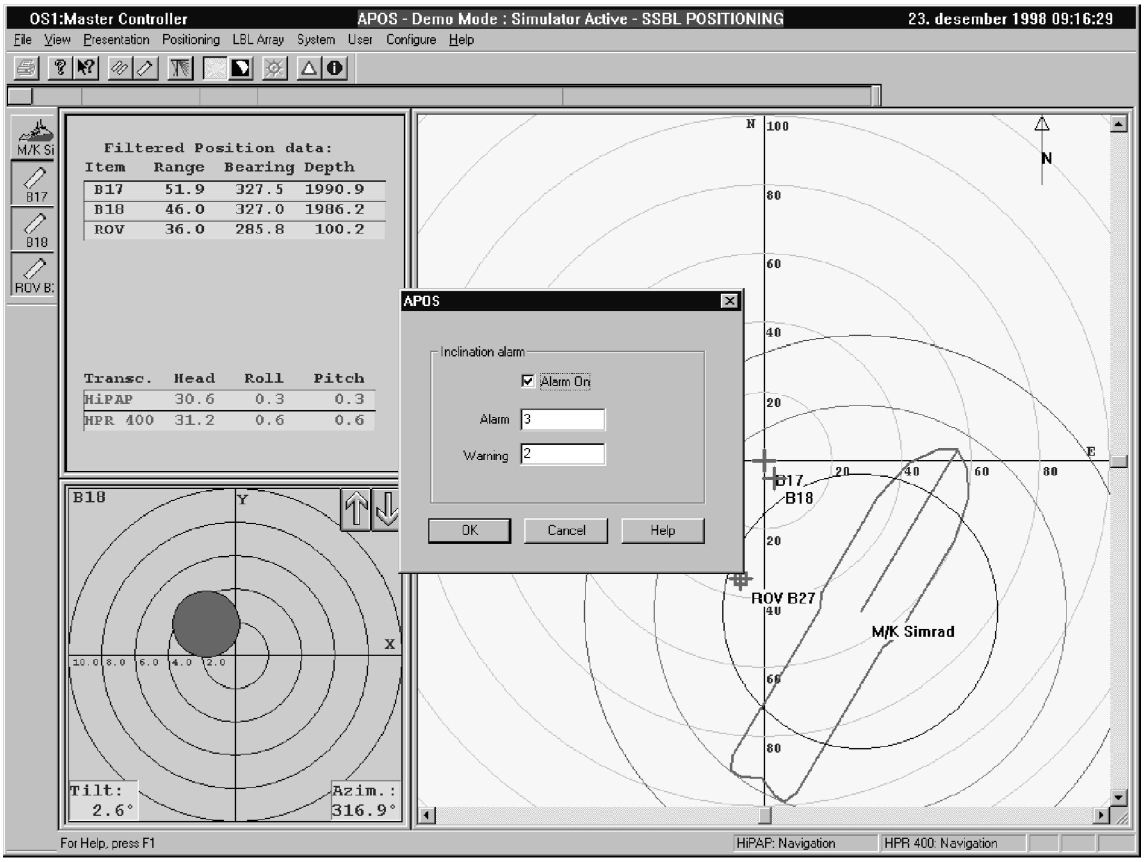


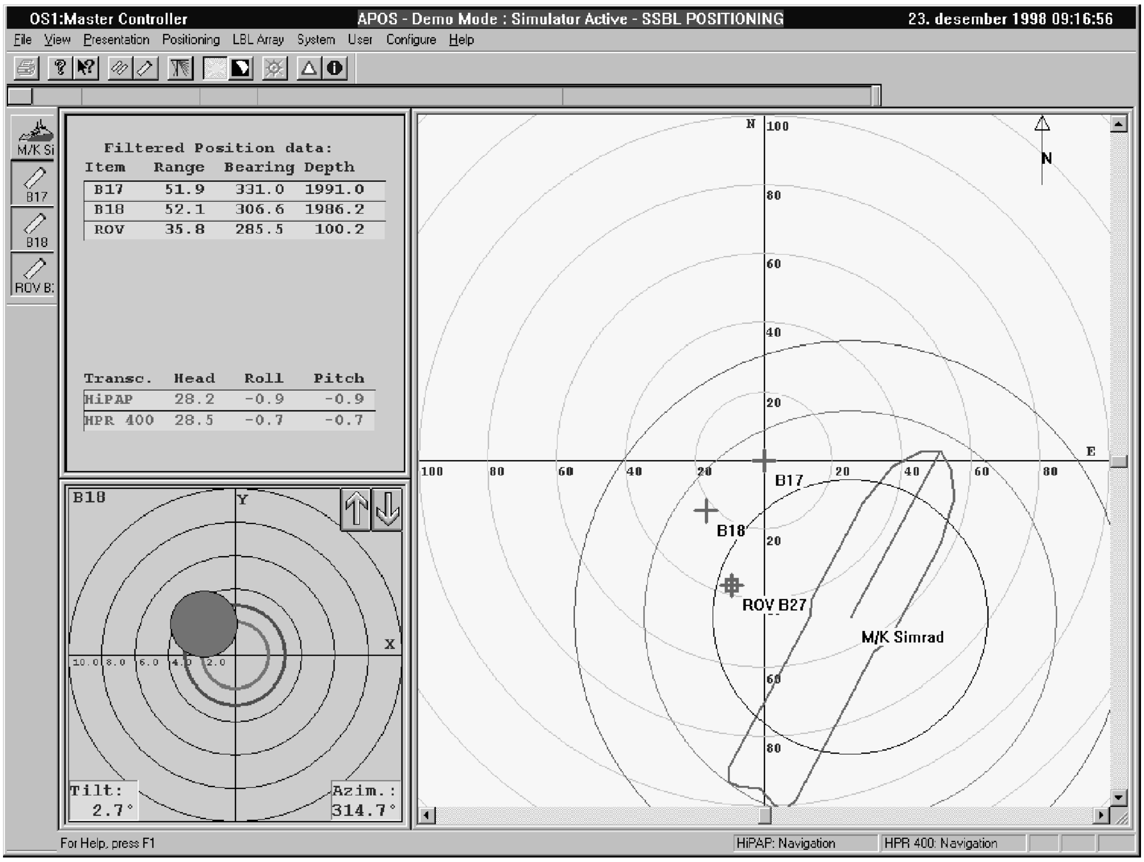
For the inclo transponder you want to have a warning if the tilt is more than 2° and an alarm if the tilt is more than 3°.

- Configure the alarm circle.



- Remember to enter the tick mark in the **Alarm On** check box.



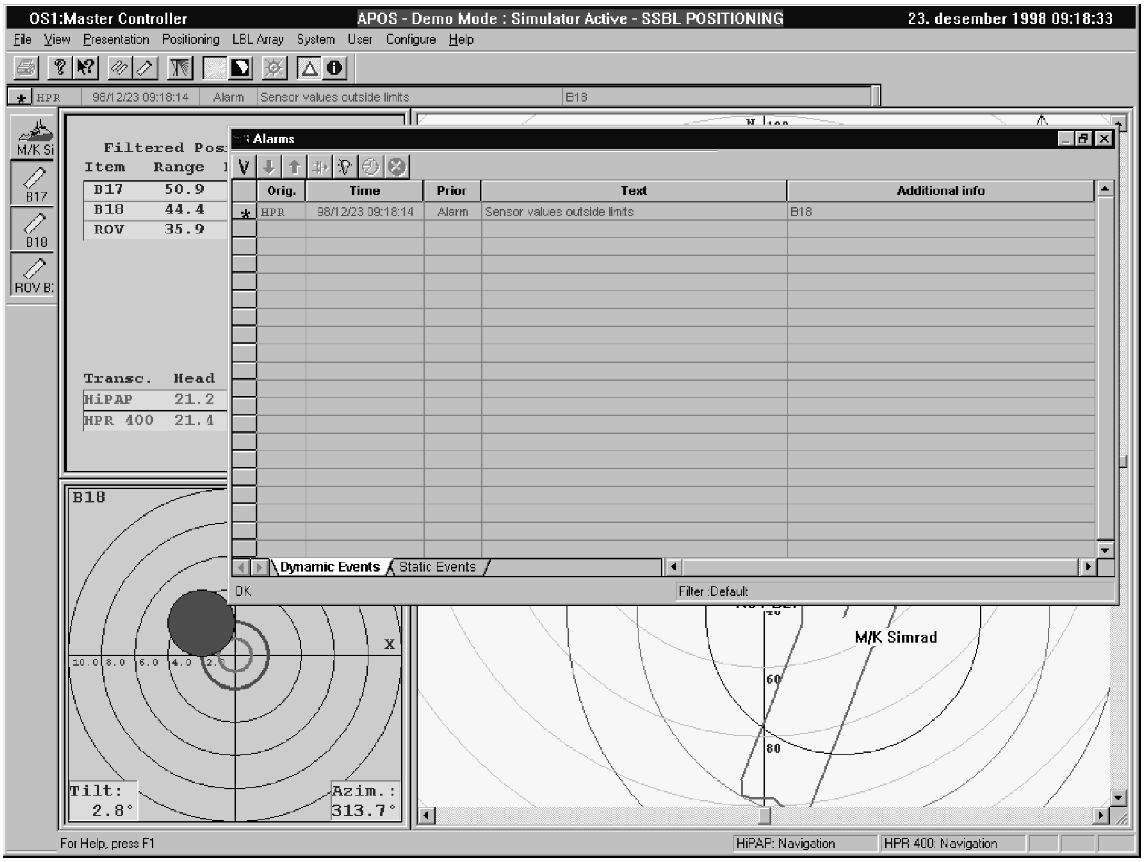


- If no warnings or alarms are presented, try to decrease the alarm circles.

8.3.24 Alarm view

- Let the Alarm view be displayed and see if you can find the alarms/warnings you caused.

(Click at the red triangle symbol in the toolbar)

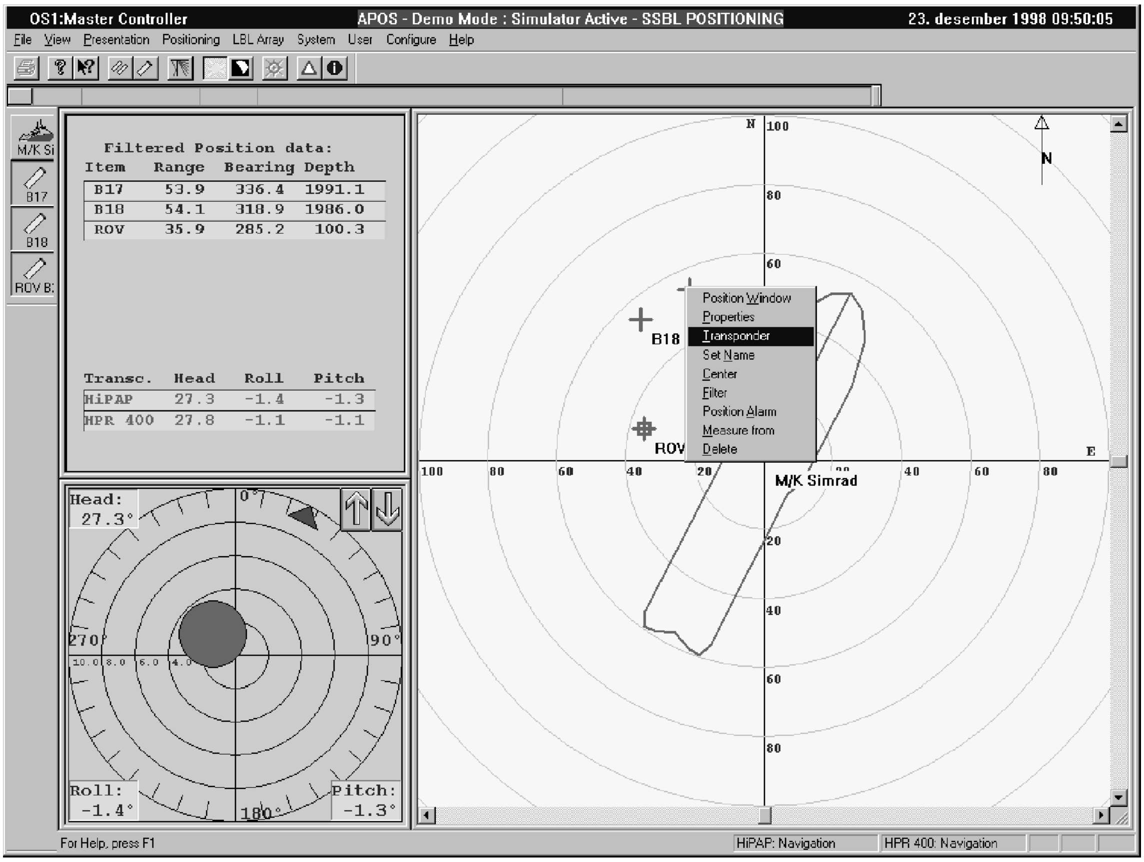


You acknowledge the warnings and alarms by clicking the ✓ button at the top of this window.

8.3.25 Transponder configure

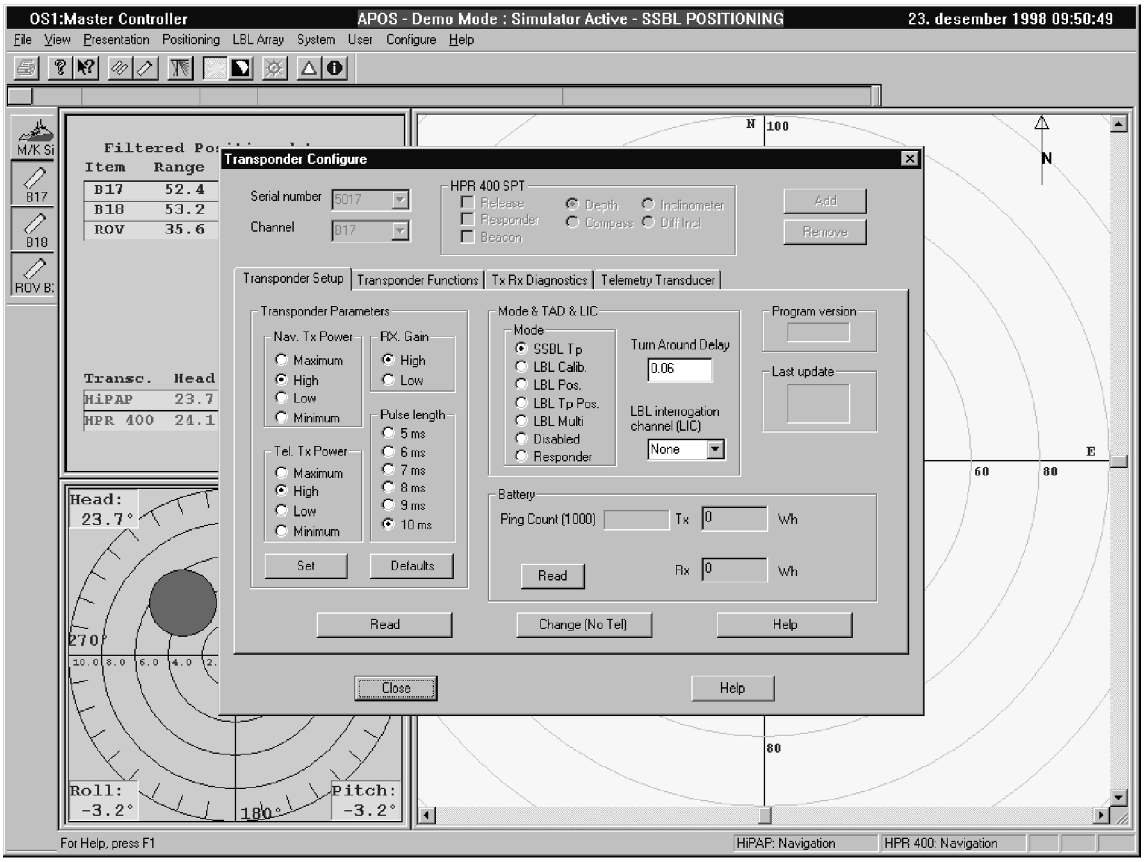
- Take a look at the Transponder configure for one of the transponders.

(Place the cursor above B17, click right mouse button and select **Transponder**. It is also possible to select **Transponder** from the **Configure** menu and then enter the wanted transponder.)



8.3.25.1 Transponder Setup

- Find out the purpose of these parameters in this new window:
  - Nav. Tx power
  - Tel. Tx power
  - RX Gain
  - Pulse length
  - Mode

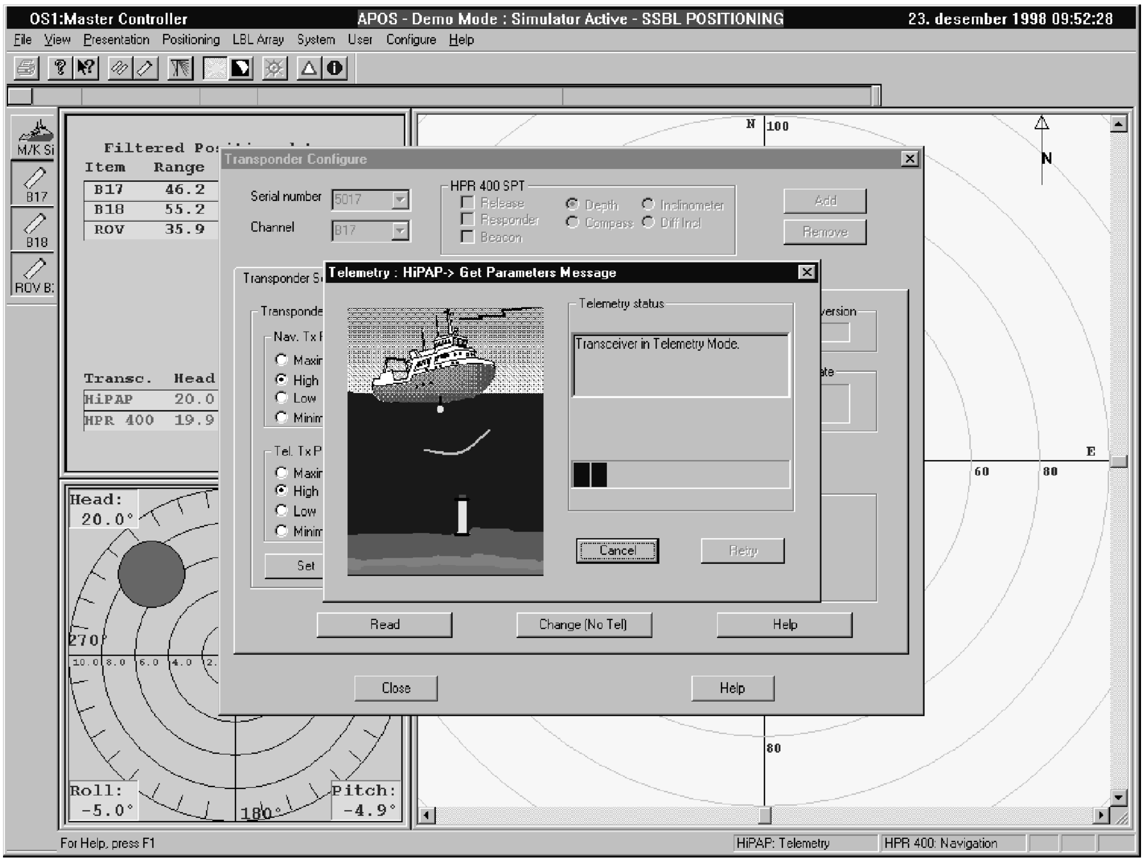


- Read transponder parameters from the selected transponder.

(Click at the Read button)

Telemetry is executed.

We have no transceiver connected and there is no simulator for the values we read. Click therfore the **Cancle** button.



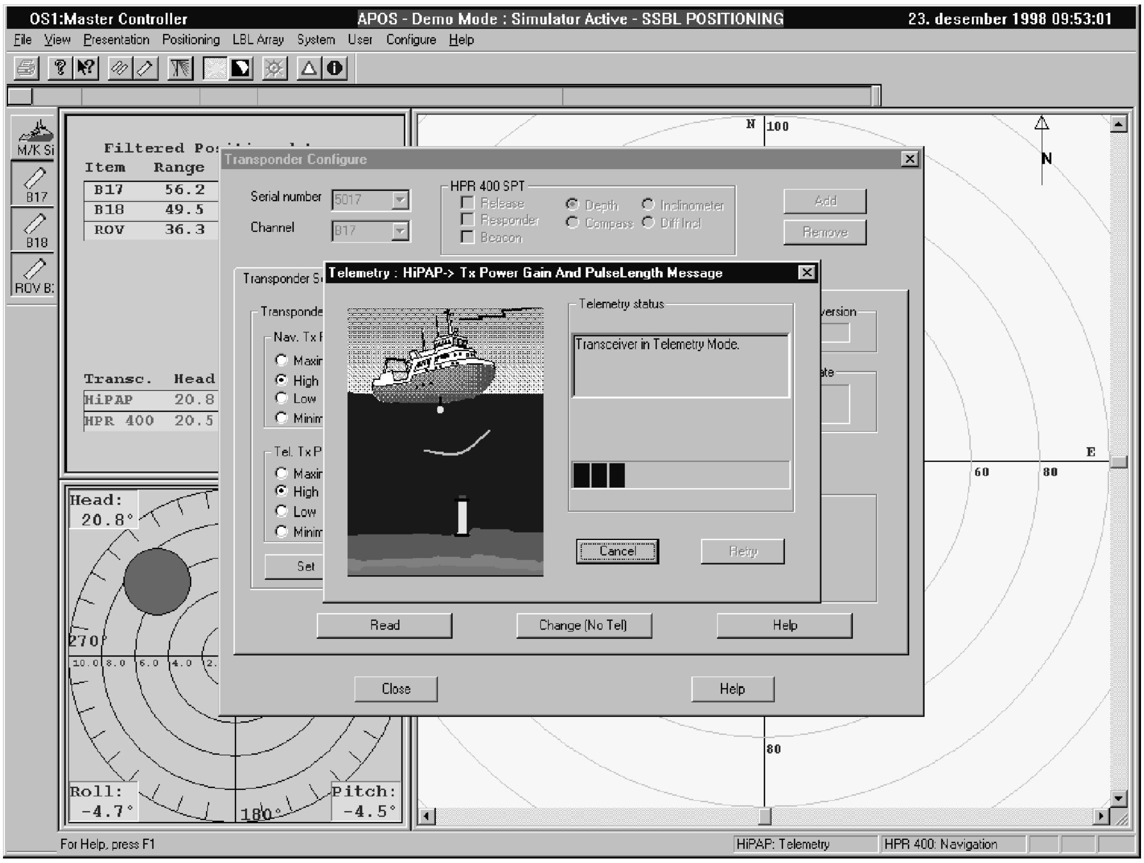
We want the transponder to use High power when navigating and when sending telemetry.

- Change power to High and send the command for changes to the selected transponder.

(Enter the values and click the **Set** button)

Telemetry is executed.

We have no transceiver connected and there is no simulator for the values we set. Click therfore the **Cancle** button.

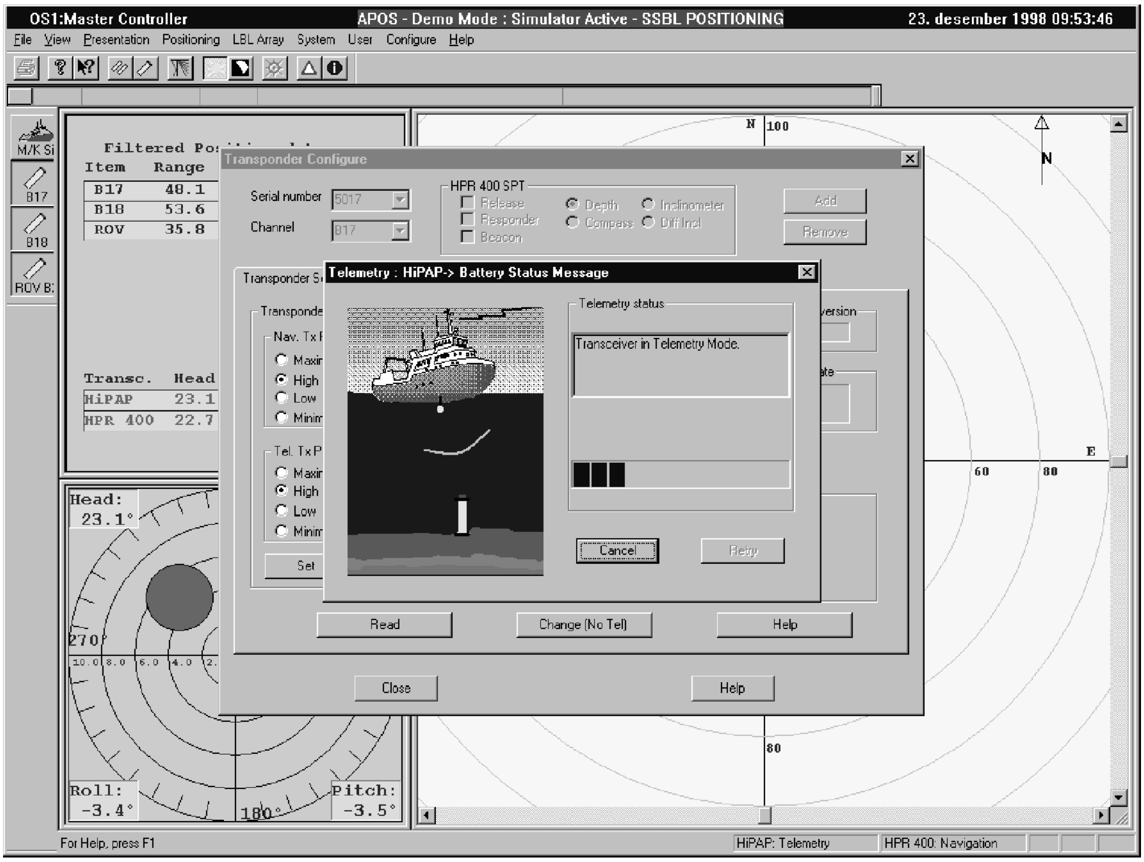


- Read battery status for the selected transponder.

(Click the Read button in the Read battery window)

Telemetry is executed.

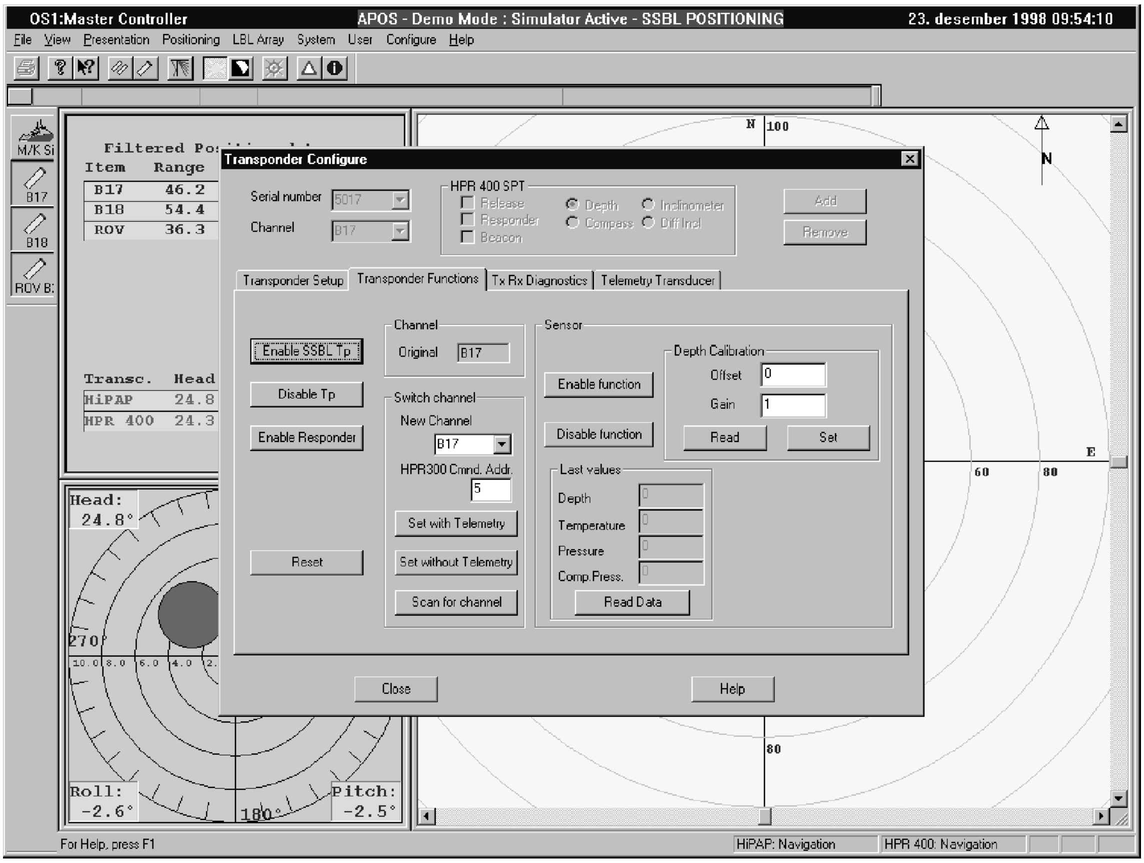
We have no transceiver connected and there is no simulator for the values we read. Click therfore the **Cancle** button.



8.3.25.2 Transponder Functions

- Click at the Transponder function tab to get this new window.

- Find out the purpose of these parameters and buttons in this new window:
  - Enable SSBL Tp
  - Disable Tp
  - Reset
  - Channel
  - Switch channel
  - New channel
  - Set with
  - Set without telemetry
  - Scan for channel
  - Sensor – Enable function
  - Sensor – Disable function
  - Sensor – Last values
  - Read data

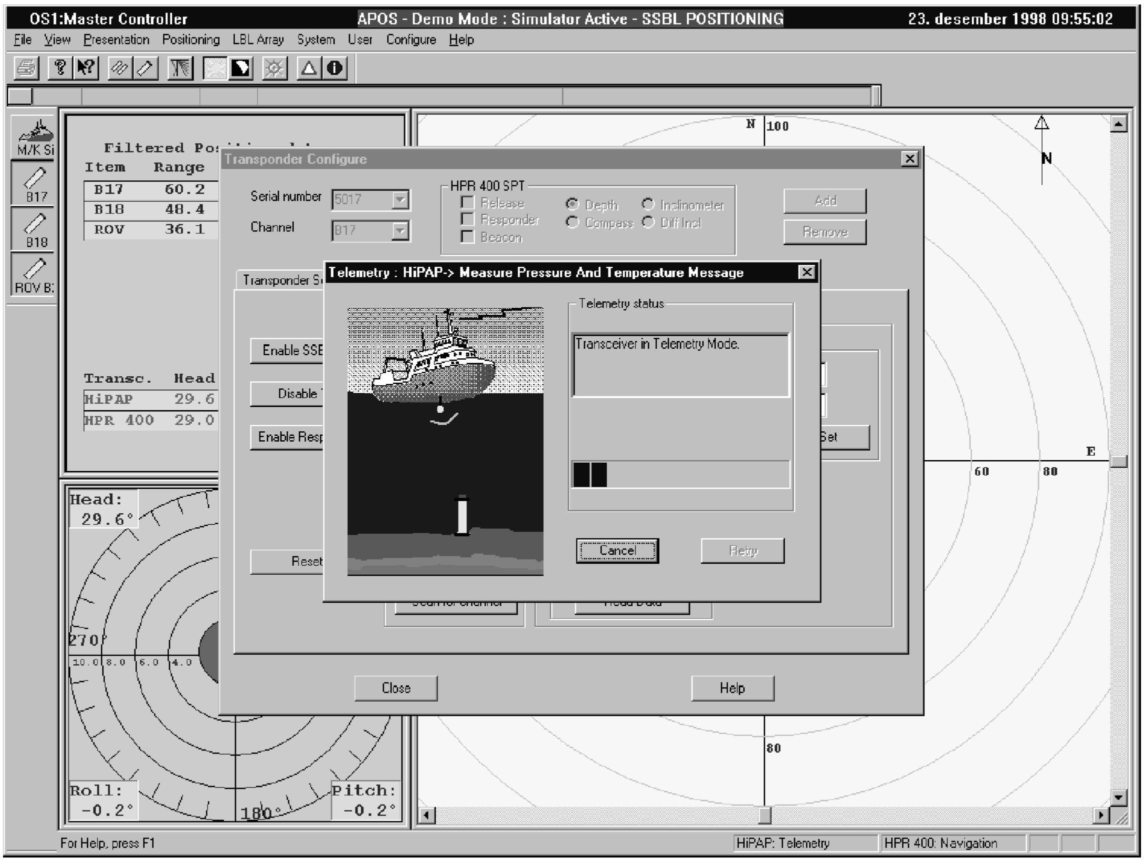


- Read data from the selected transponder to get latest values from it's sensors.

(Click at the Read Data button)

Telemetry is executed.

We have no transceiver connected and there is no simulator for the values we read. Click therfore the **Cancle** button.



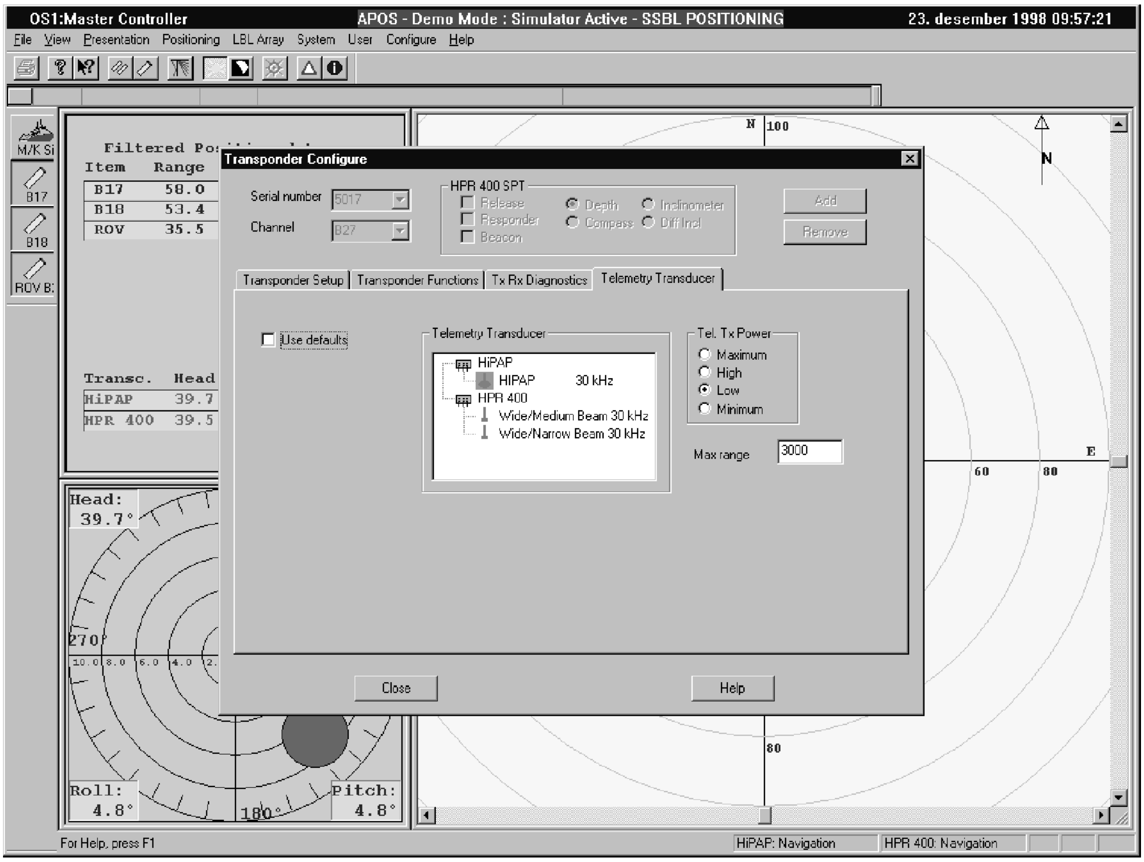
8.3.25.3 Telemetry Transducer

- Click at the Telemetry transducer tab to get this new window.

From this window you select which transducer you want to use when sending telemetry messages to the selected transponder.

You aslo select how much power to be used in telemetry and the max range for this transponder.

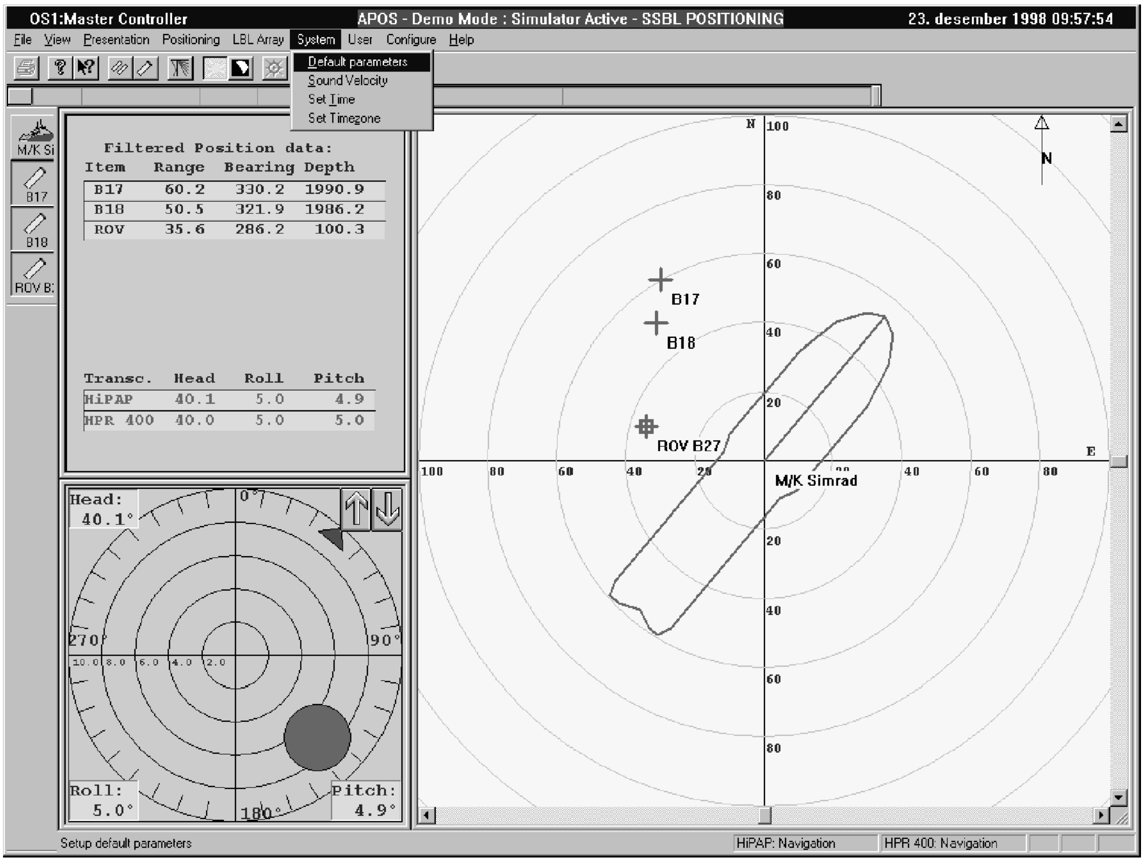
- Try to make a change.



8.3.26 Default parameters

The **Default parameters** submenu is used to adjust some of the default parameters for the system. The values specified in this submenu are used in operations started from other submenus when parameter value default is selected from those submenus.

- Enter the Default parameters submenu from the System menu.

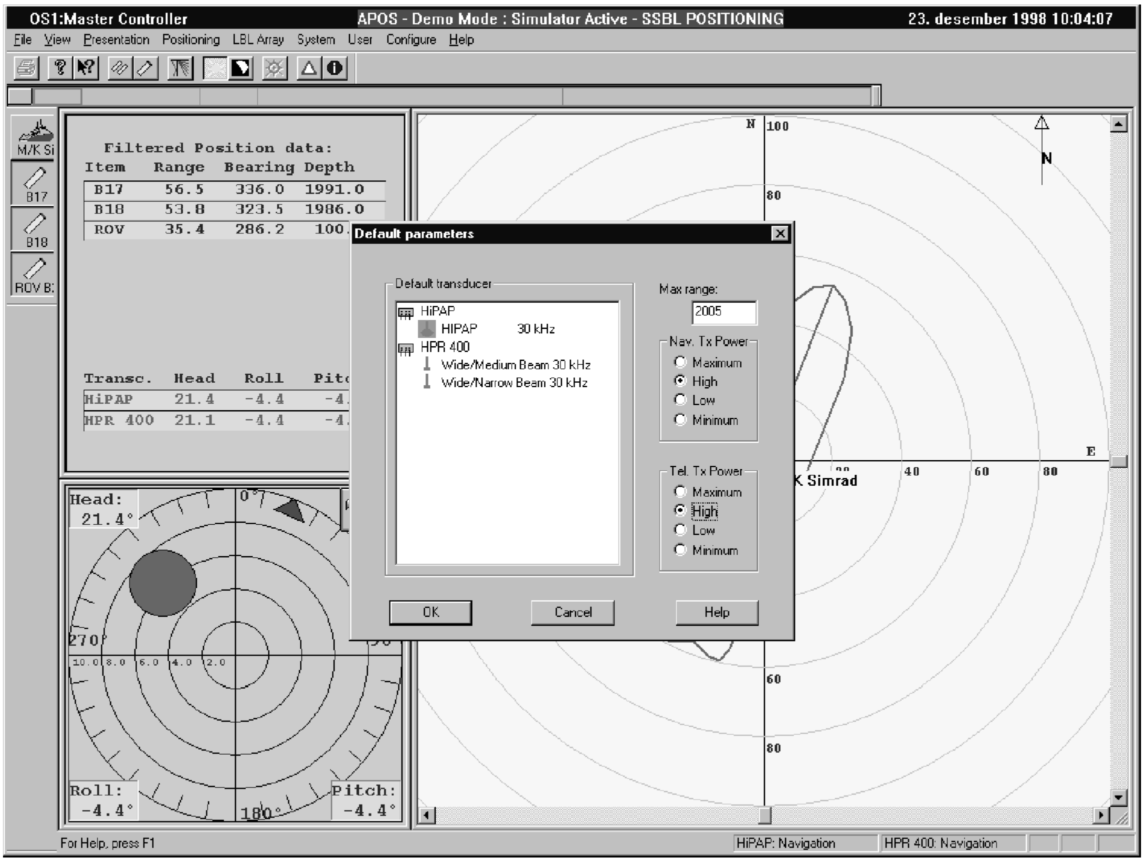


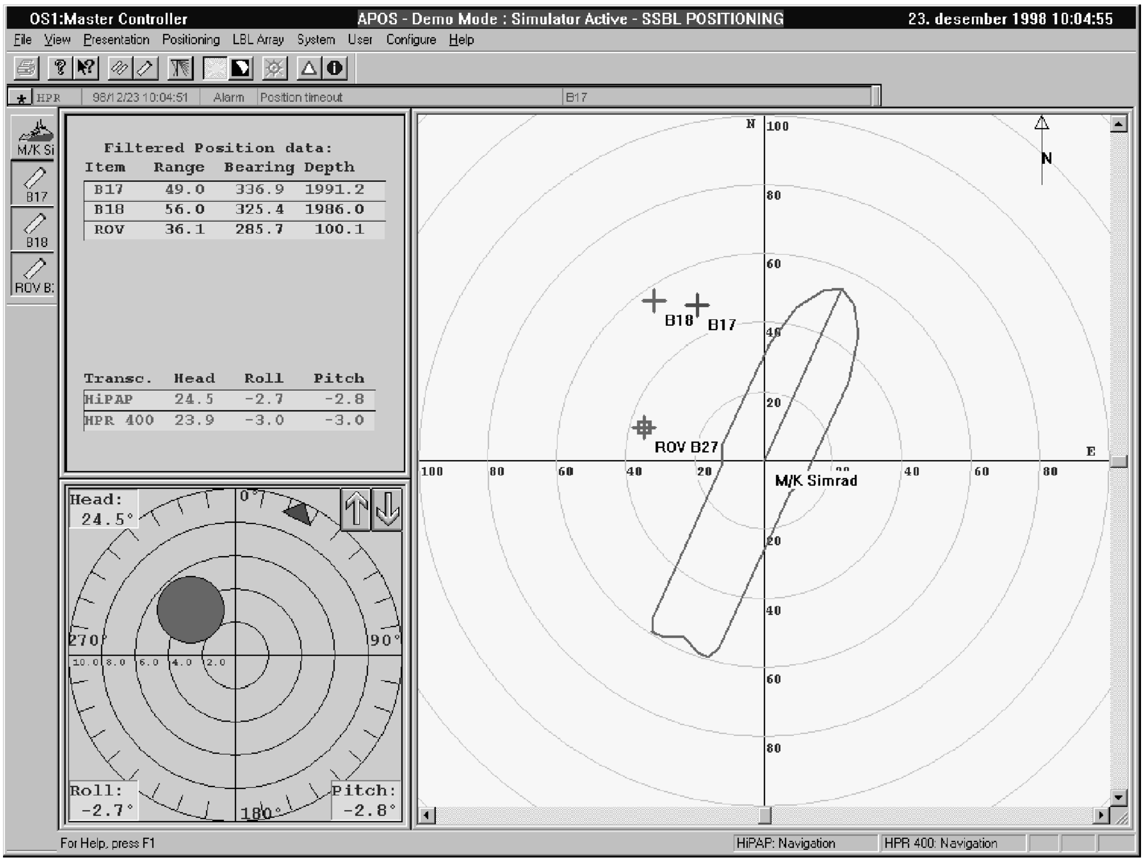
The **Max range** parameter sets the maximum search range of the system when waiting for a reply on the selected transponder channel.

Do not set this value too low as this will prevent the HPR/HiPAP® system from detecting the direct replies from the transponder. The system may detect a reflection of the previous reply signal, giving a wrong and unstable position.

In general as low power as possible should be used in navigation and telemetry to avoid retrigging of the transponder and interference with other HPR/HiPAP users.

- Change default parameters as follows:
  - Max range 2005
  - Nav. Tx power High
  - Tel Tx power High
  - Transducer If more than one listed, select one of them





- Explain why you loose contact with only some of the transponders.

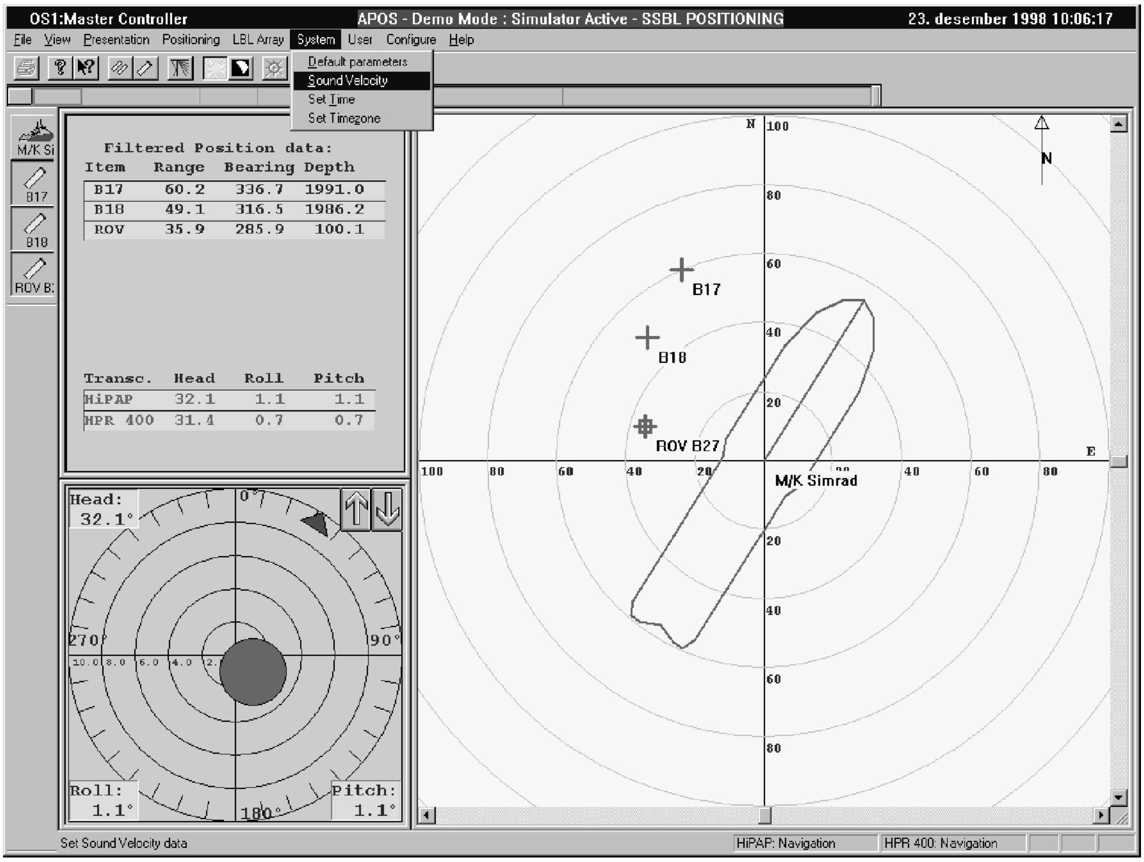
- Increase Max range until you get reply from all of the transponders.

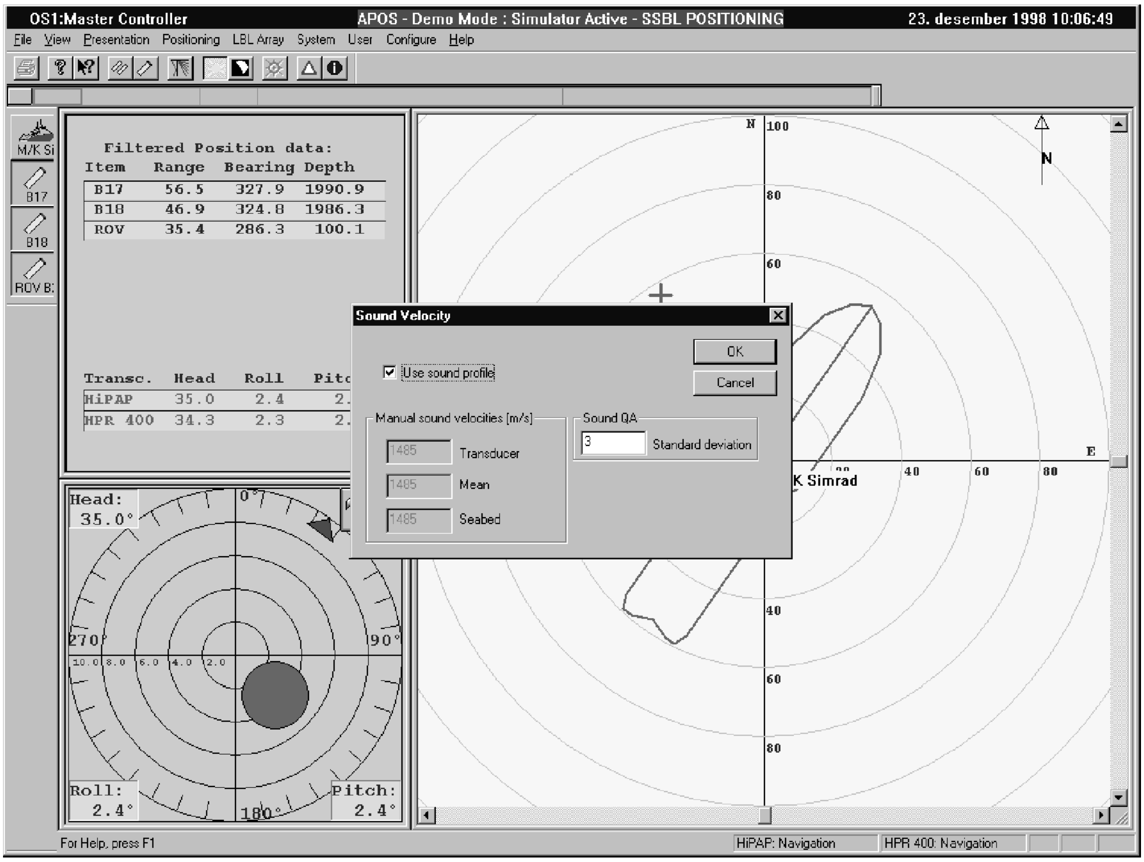
8.3.27 Manual sound velocity

As you know from the theoretical section the sound velocity is important for the accuracy. We can enter the sound velocity manually or use sound profiles.

- Find out the fixed values for the sound velocity.

(Choose Sound Velocity from the System menu.)





In this window you can enter the fixed values you might have collected and standard deviation for them.

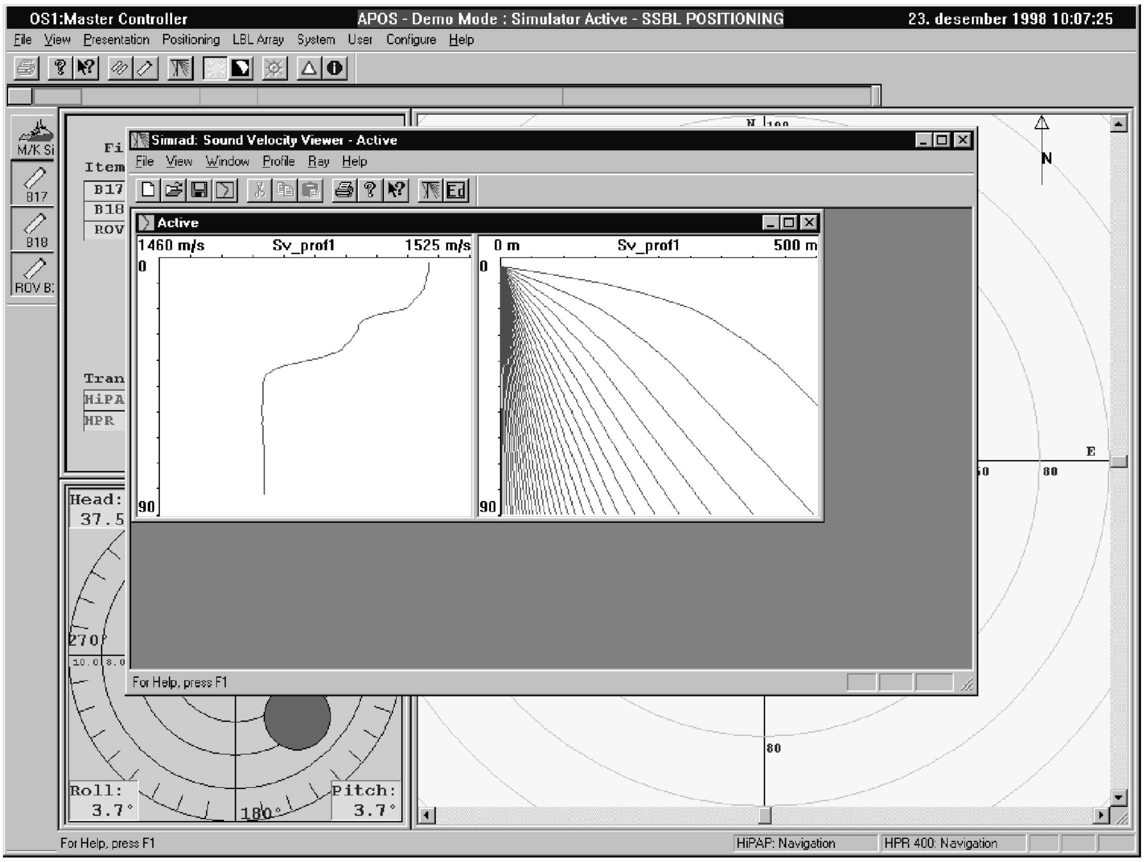
- Let the system use a sound profile as input.

(Enter a tick mark in the Use sound profile check box.)

8.3.28 Sound profiles

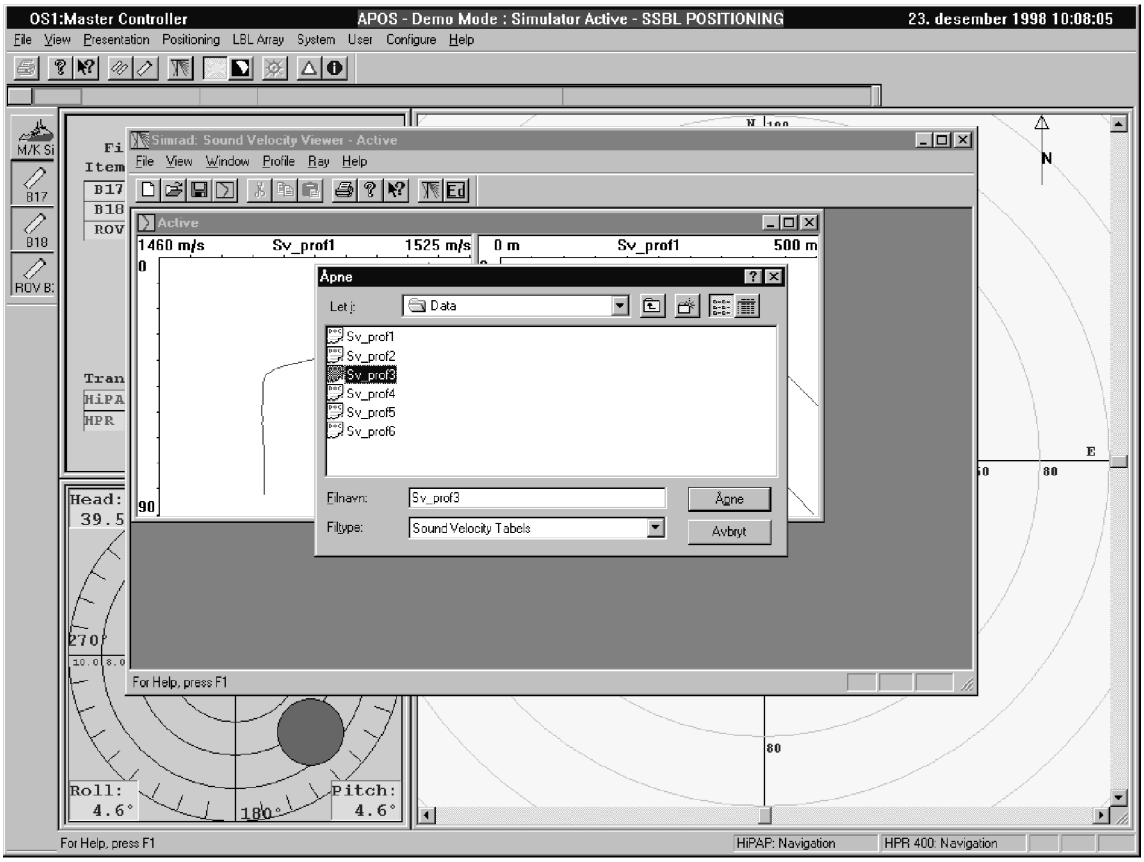
You might have got severel sound profiles on your computer hard drive or at a floppy disk. The profiles might be taken in different areas at sea and at different time of year.

- Display the sound profile currently used by clicking the Sound Profile button in the toolbar.



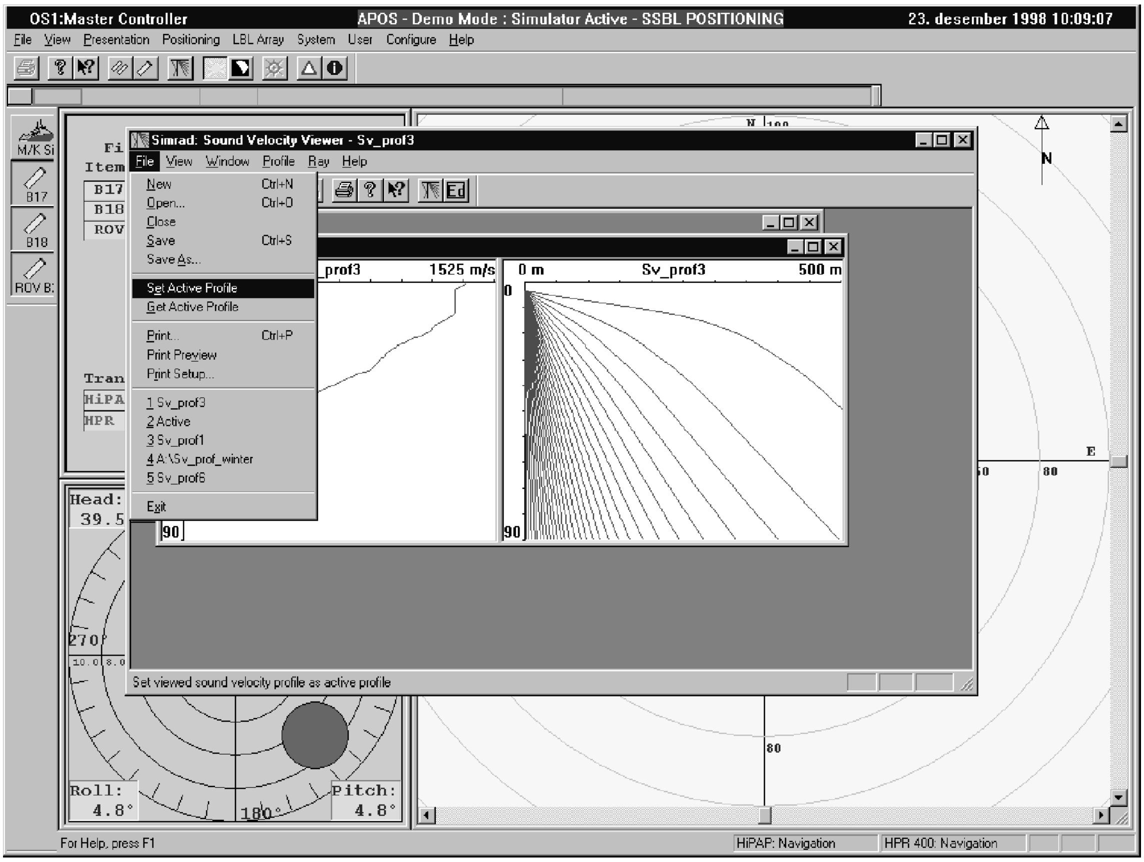
- Enter another sound profile from the hard drive and display it. Use this file: d:\WinHPR\Data\Sv_prof3.svt

(Choose Open from the File menu in the Sound Profile Viewer. Select then the file and click the Åpne/Open button.)



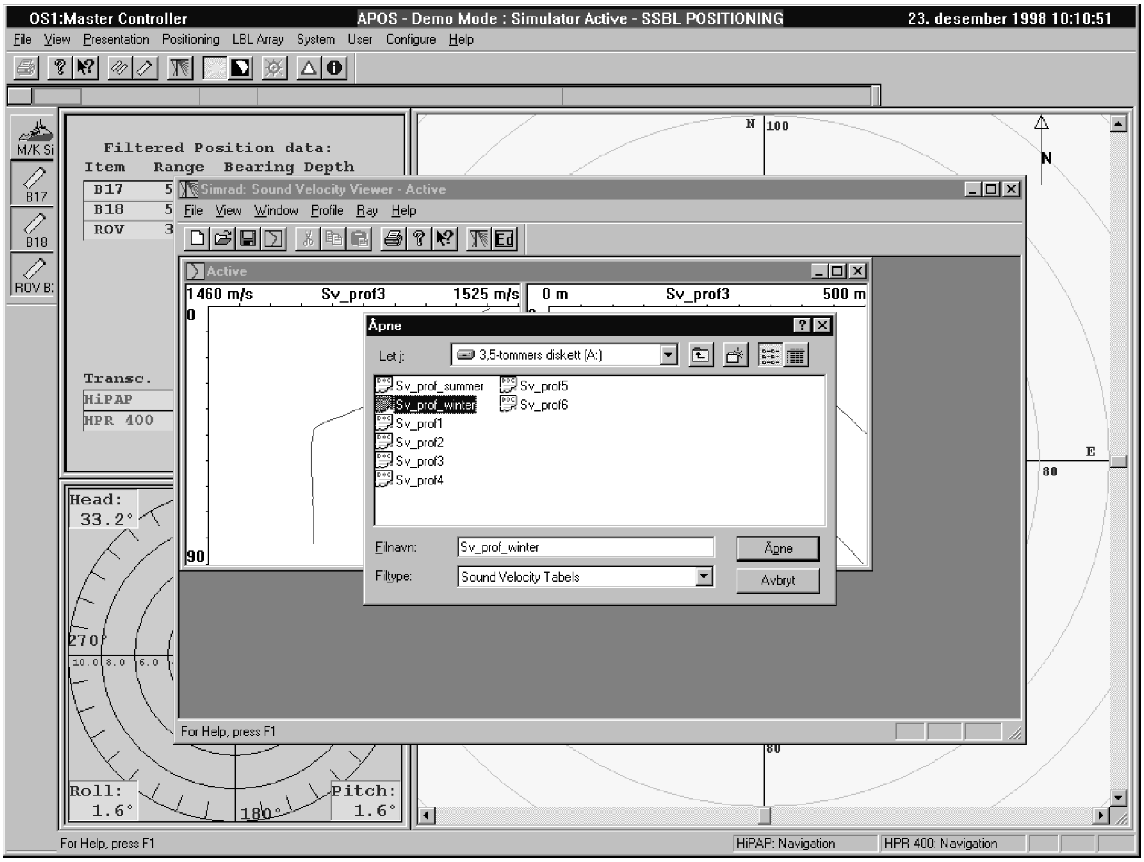
• Let this profile be the active profile used by the system.

(Select **Set Active Profile** from the File menu in this window.)



• Exit the Sound Profile Viewer and enter it again to control that the new profile has become the active one

- Enter a sound profile from the floppy disk if available.

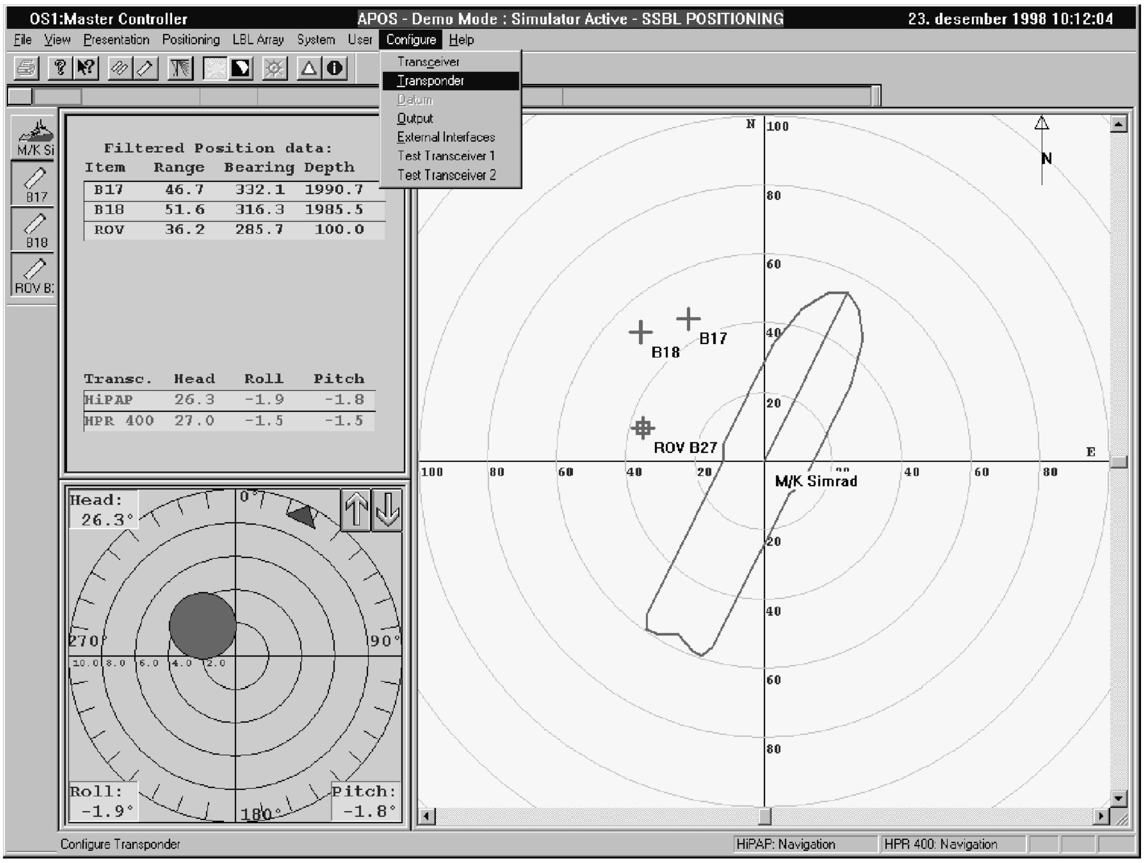


8.3.29 Installing transponders

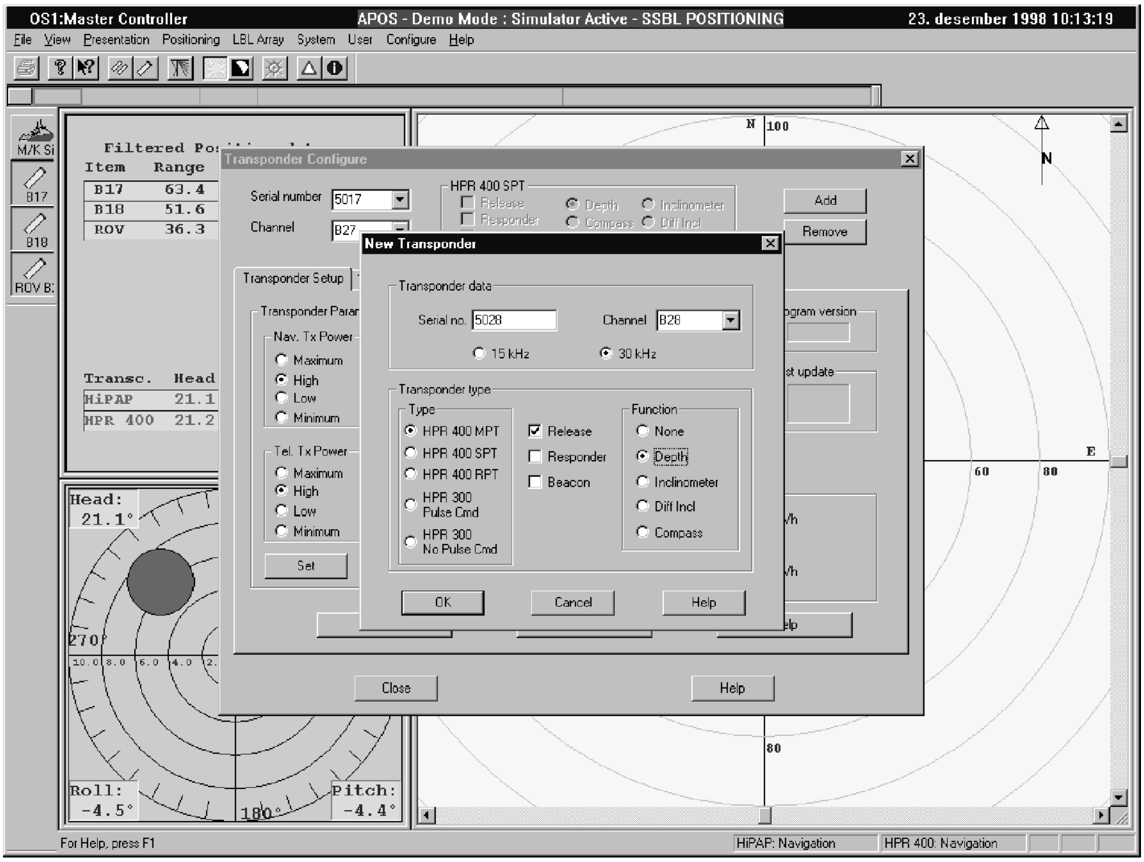
Assume you have bought a new SPT transponder with depth and release function.

- Configure the new transponder.

(Select Transponder from the Configure menu.)



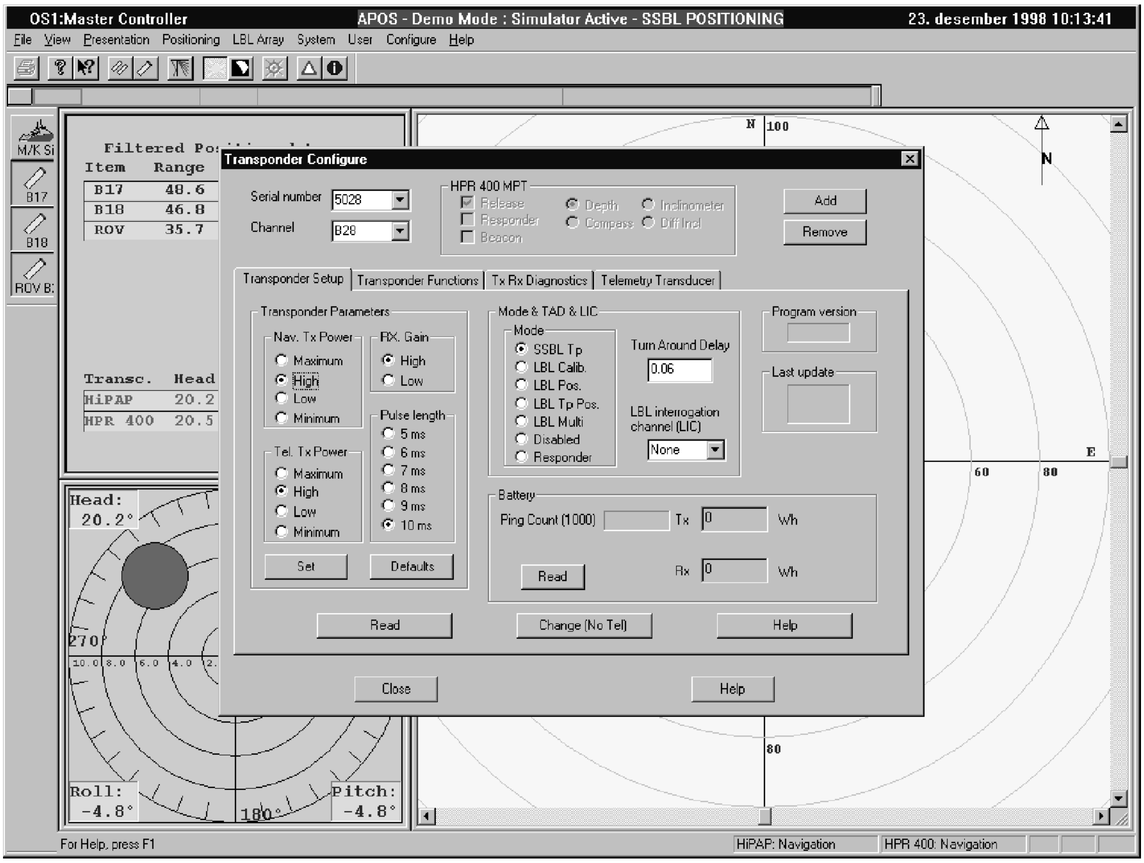
- Click the Add button to get this small new window, **New Transponder**.



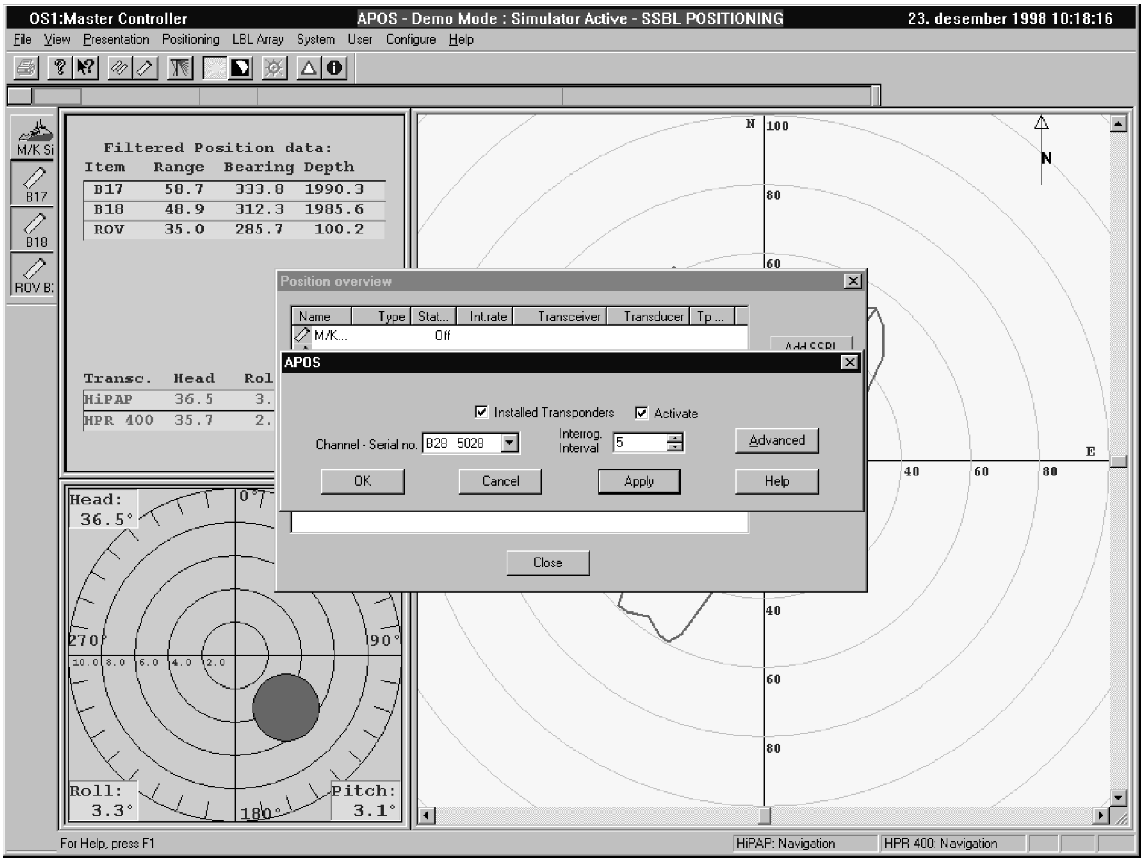
- Enter the serial no, channel no, transponder type and function.

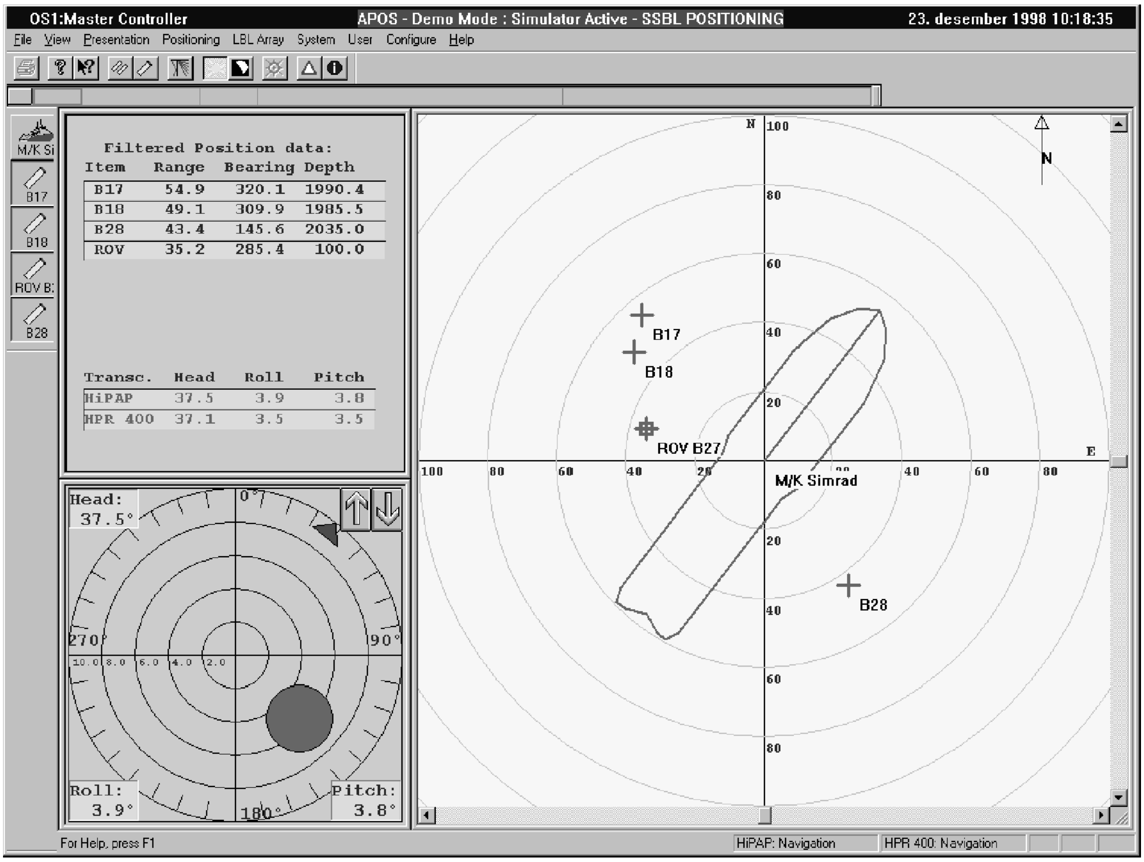
- Click at the OK button.

- Select values for the transponder parameters and click OK.



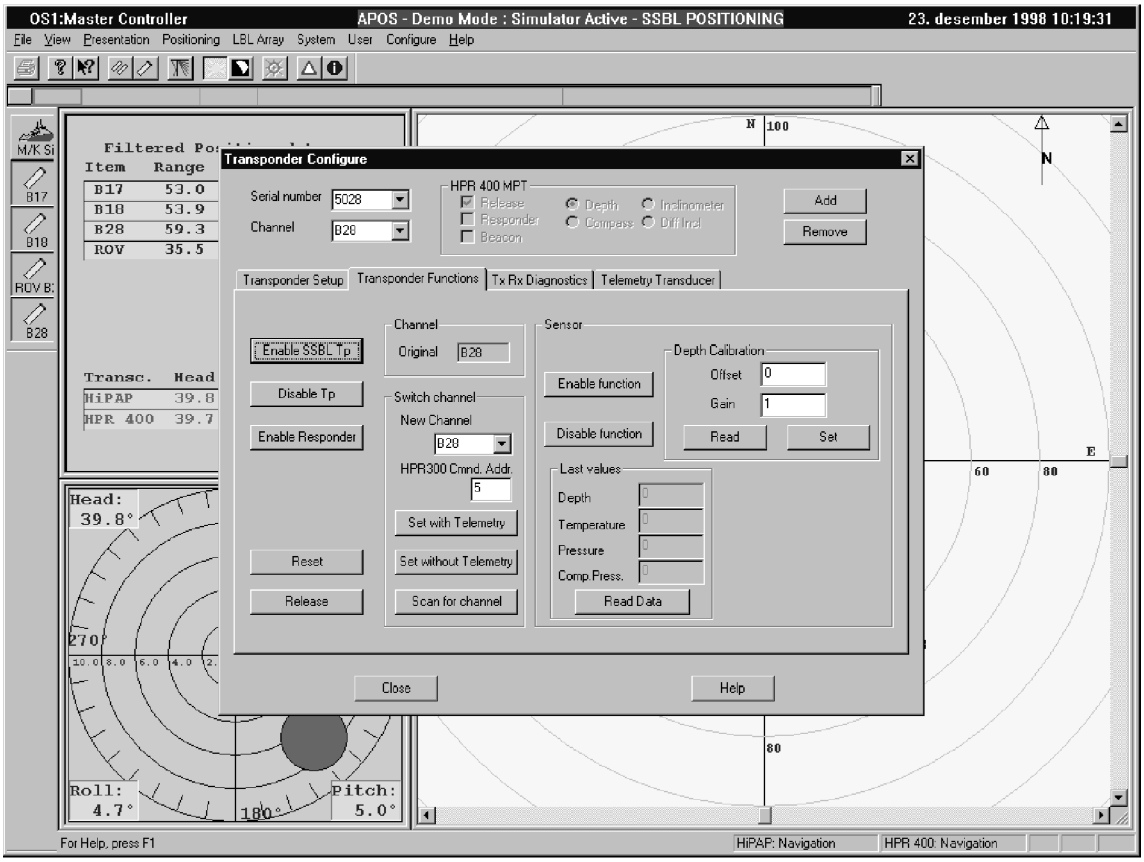
- Interrogate the transponder with an interrogation interval of 5s.



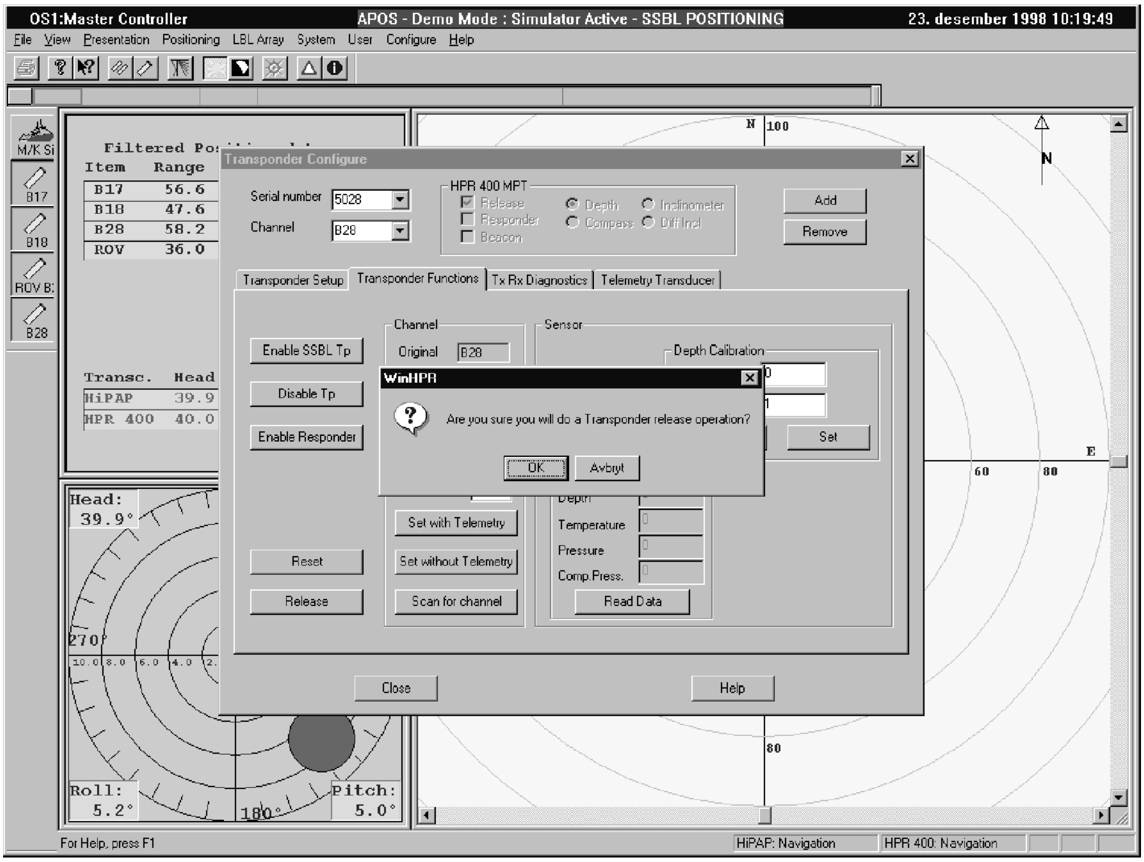

OS1:Master Controller
APOS - Demo Mode : Simulator Active - SSBL POSITIONING
23. desember 1998 10:18:35
File View Presentation Positioning LBL Array System User Configure Help
M/K Si
B17
B18
ROV B
B28
Filtered Position data:
Item Range Bearing Depth
B17 54.9 320.1 1990.4
B18 49.1 309.9 1985.5
B28 43.4 145.6 2035.0
ROV 35.2 285.4 100.0
Transc. Head Roll Pitch
HiPAP 37.5 3.9 3.8
HPR 400 37.1 3.5 3.5
Head:
37.5°
0°
270°
90°
180°
Roll:
3.9°
Pitch:
3.8°
N
E
B17
B18
ROV B27
M/K Simrad
B28
For Help, press F1
HiPAP: Navigation
HPR 400: Navigation

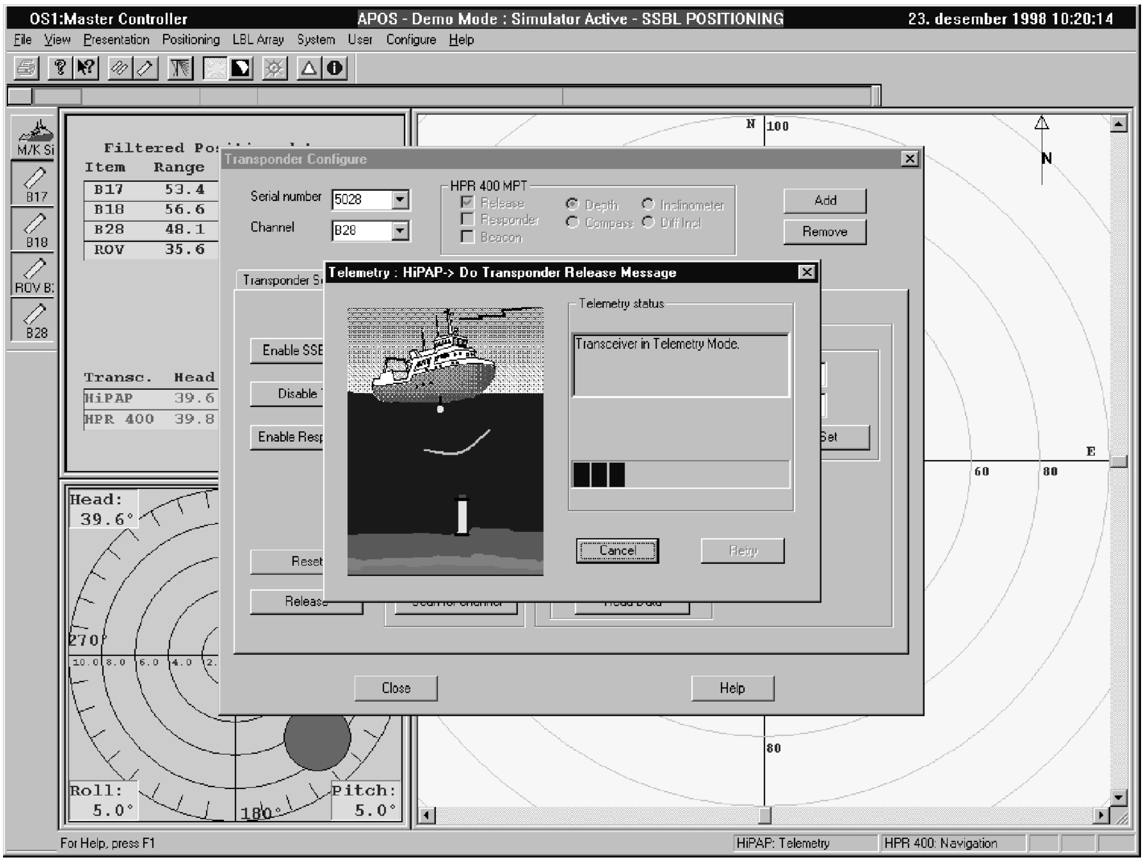
- Release the transponder.

(Enter Transponder from the Configure menu. Select the transponder and click **Transponder Functions** tab to get to the right window page. Press then the Release button.)



- Confirm that you want to do the function.





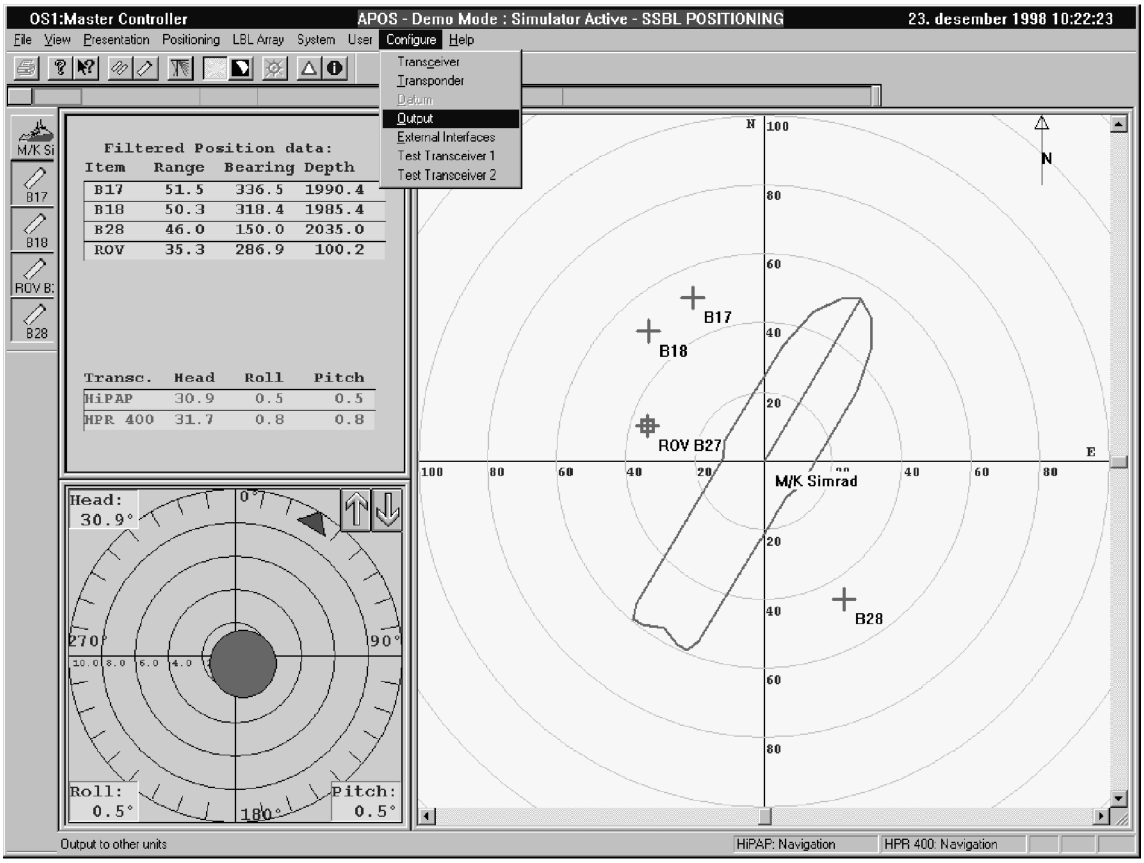
The demo program is now simulating telemetry to the transponder.

The decreasing depth value for the transponder is not simulated.

8.3.30 Output to other computers

When the system was installed outputs were configured.

- Enter the menu and take a look at the options and how the configuration is done.



8.3.30.1 Available outputs overview

The Outputs dialog is used to configure outputs to other systems.

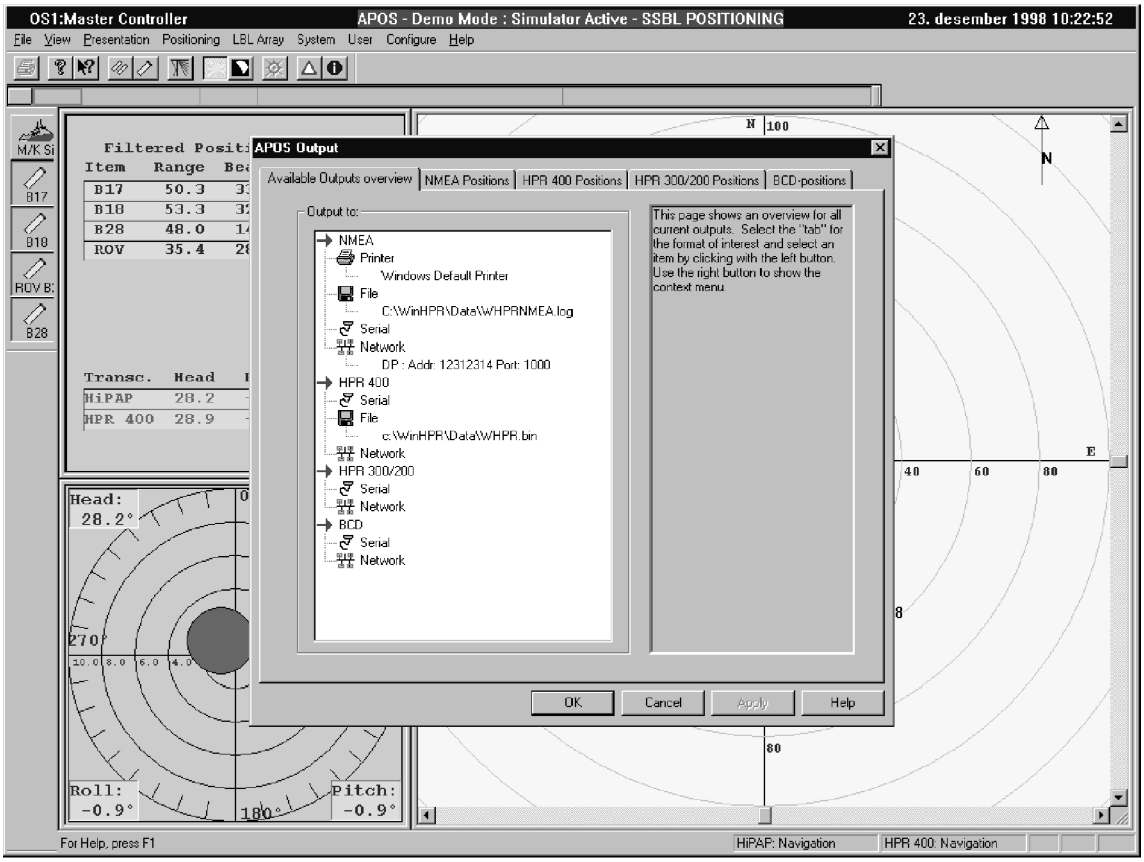
The APOS may output data on several different formats to either a disk file, the printer, the network or a serial port.

This first page is an overview that shows which outputs that are defined.

The other pages are used to enable the output and select what should be sent on each individual output.

A green check mark in front of the output name indicates that the output is active.

You click on the tab with the output format of interest to define and configure an output.



8.3.30.2 NMEA positions

The right side will show the settings for this output. For the SSBL format, the checkbox Activate Local Positions must be checked in order for the output to be active.

The Output Data radiobuttons may be used to select if either Measured, Filtered or both shall be sent to the output. One may select either Polar, Cartesian X/Y (vessel relative) or North/East, East/North relative data on the output.

The Global format may be either UTM N/E or E/N.

The Global checkbox must be checked in order to get global positions.

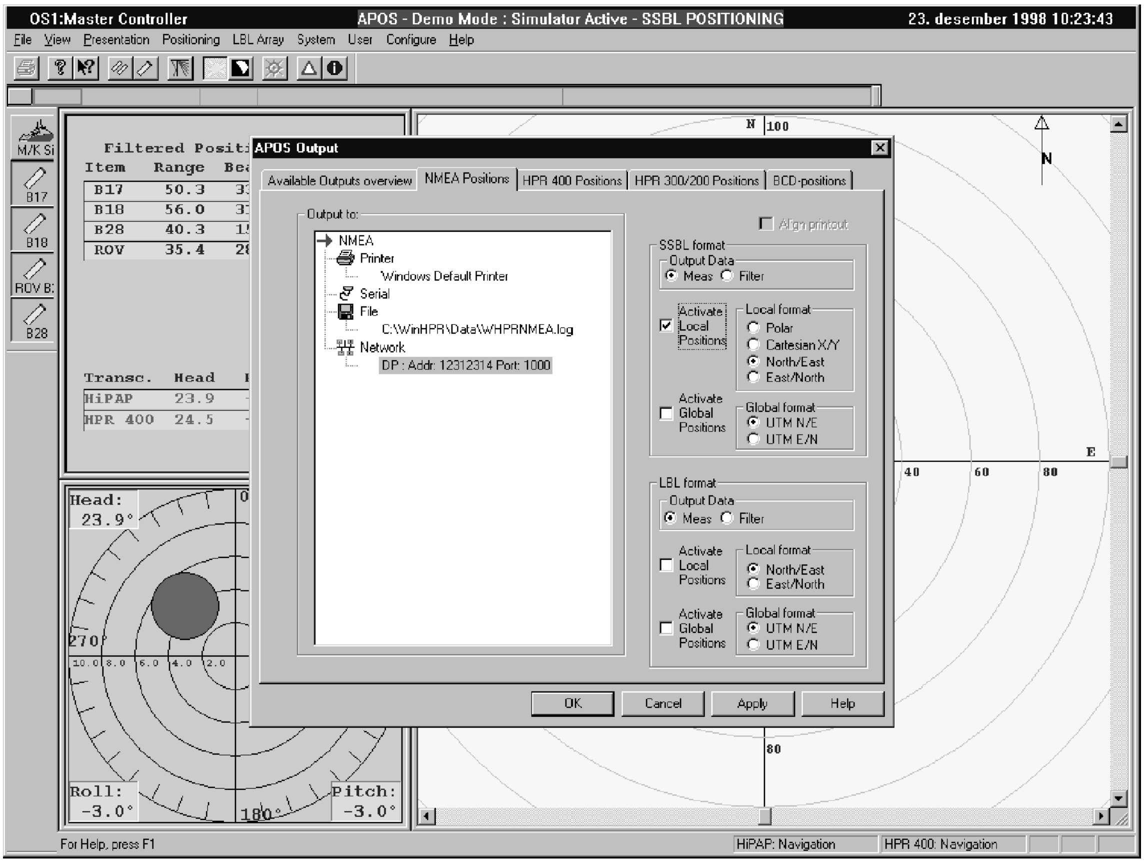
A GPS or similar position receiver will normally have to be connected in order to get Global positions from an SSBL system.

The LBL format section is similar.

Activate Local Positions must be checked in order to enable local LBL positions to be sent to the output.

One may chose between measured, filtered or both data by selecting one of the three radio buttons.

The Local format may be either North/East or East/North.



8.3.30.3 HPR 400 positions

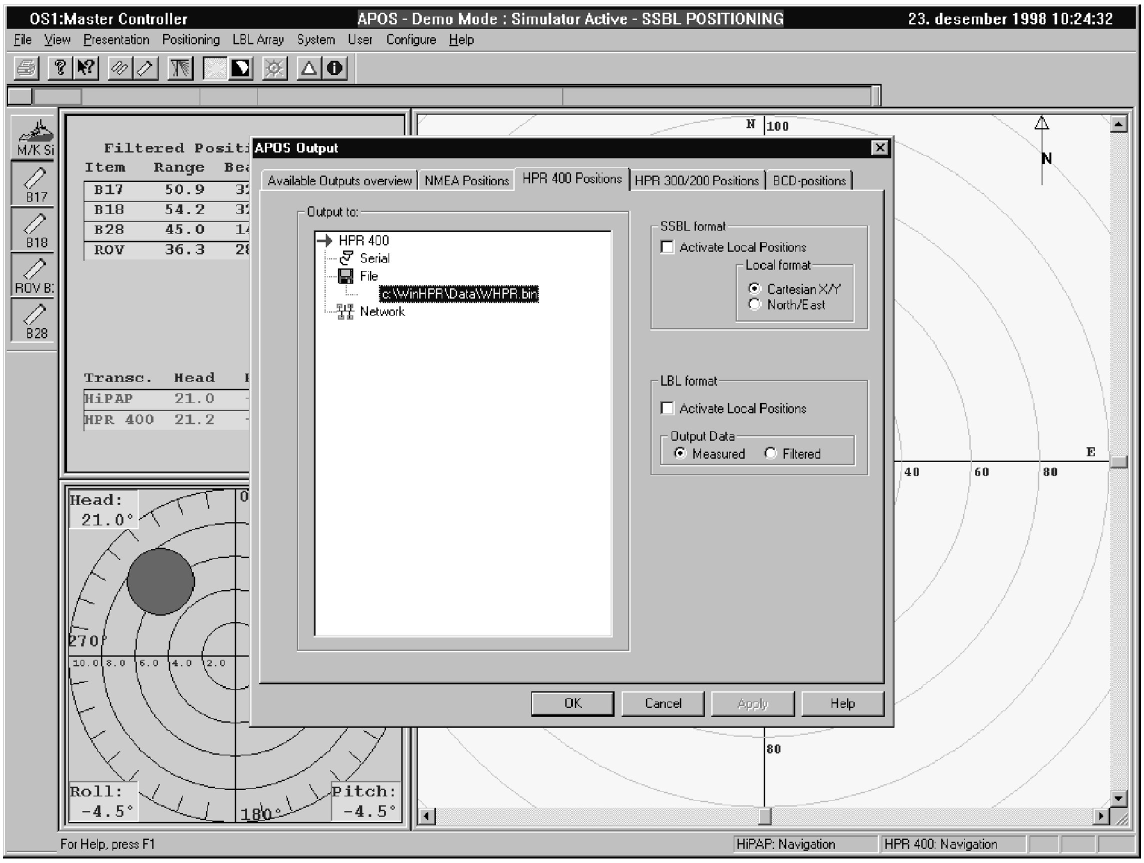
The right side will show the settings for this output. For the SSBL format, the checkbox Activate Local Positions must be checked in order for the output to be active.

One may select either Cartesian (vessel relative) or North/East relative data on the output.

The LBL format section is similar.

Activate Local Position must be checked in order to enable local LBL positions to be sent to the output.

One may chose between measured and filtered data by selecting one of the two radio buttons.



8.3.30.4 HPR 300/200 positions

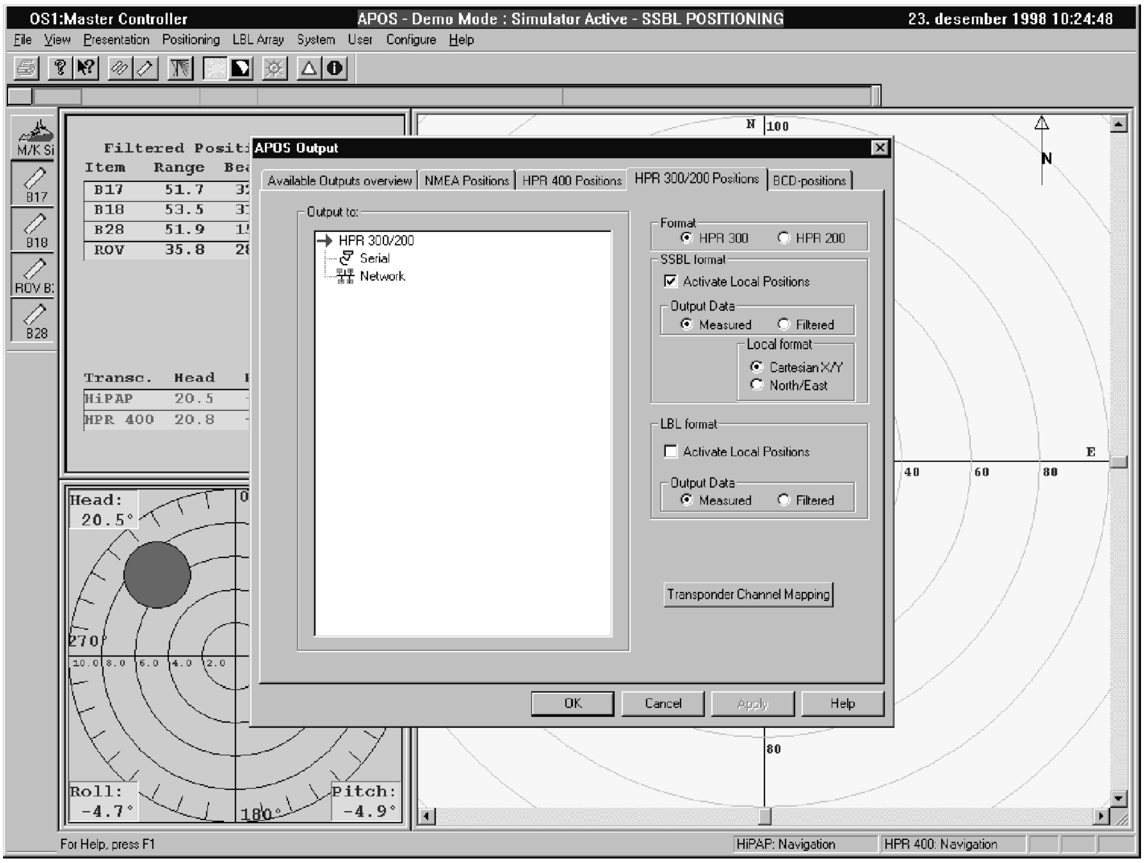
The right side will show the settings for this output. First select if the format shall be HPR 300 or HPR 200 compatible. For the SSBL format, the checkbox Activate Local Positions must be checked in order for the output to be active.

One may select either Measured or Filtered data on the output. The format may also be in either Cartesian X/Y (Vessel relative) or North/East.

The LBL format section is similar.

Activate Local Positions must be checked in order to enable local LBL positions to be sent to the output. One may chose between measured and filtered data by selecting one of the two radio buttons.

If the HPR200 format is selected, there will be no choice between measured and filtered.



8.3.30.5 Transponder mapping

The HPR 200 and 300 format can NOT handle all the HPR400/HiPAP transponder channels. Therefore it may be necessary to map a HPR 400/HiPAP channel to a channel that is compatible with HPR 300/200.

This dialog may be used to select which transponder code shall be used in the message sent out to external equipment from the APOS. The default mapping is as shown in the example. Select which transponder (the right combo box) shall be sent as the transponder codes on the left.

An example;

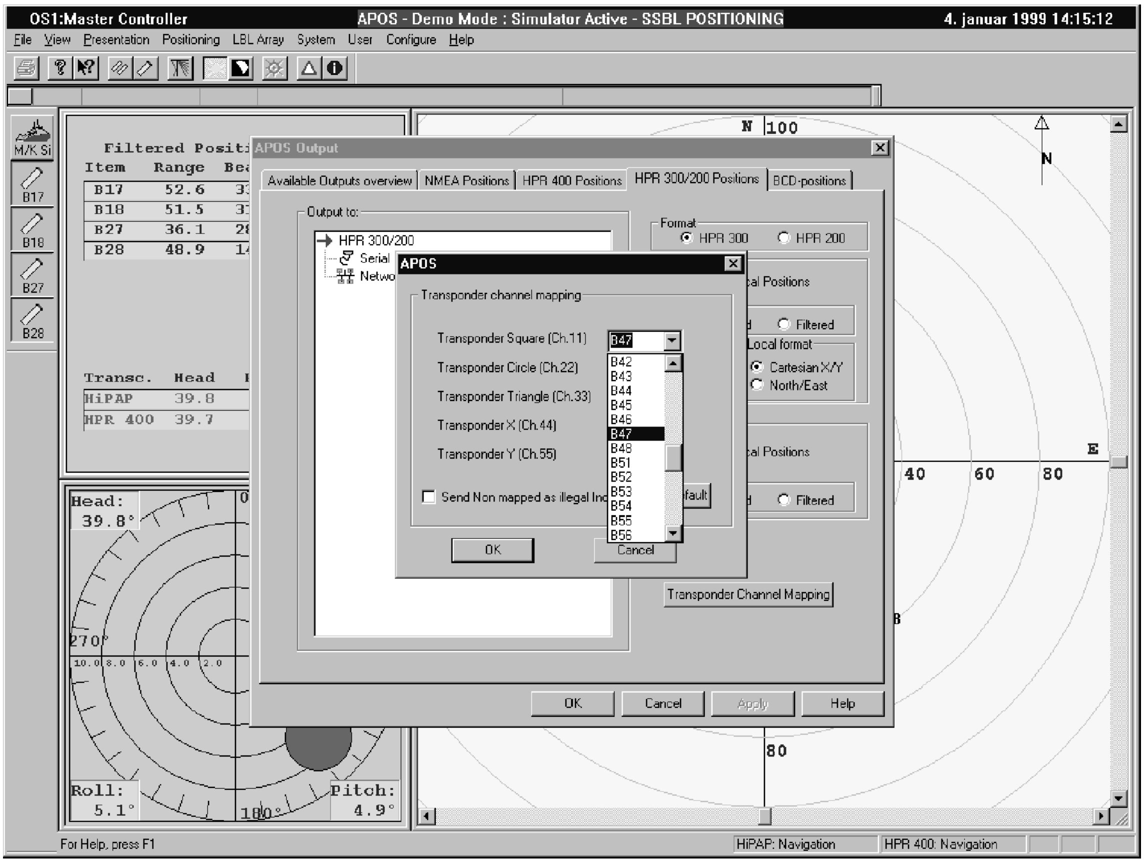
If transponder B47 is used for positioning and an external DP system uses the HPR 300 protocol, a mapping from B47 to one of the HPR 300 transponders are needed.

In this example we may choose to use B11 (transponder square) as the transponder code to the external DP system.

Select the combo box next to the Transponder Square (B11) and select channel B47.

Now channel B47 (the one in use) will be sent to the DP as code Transponder Square (B11).

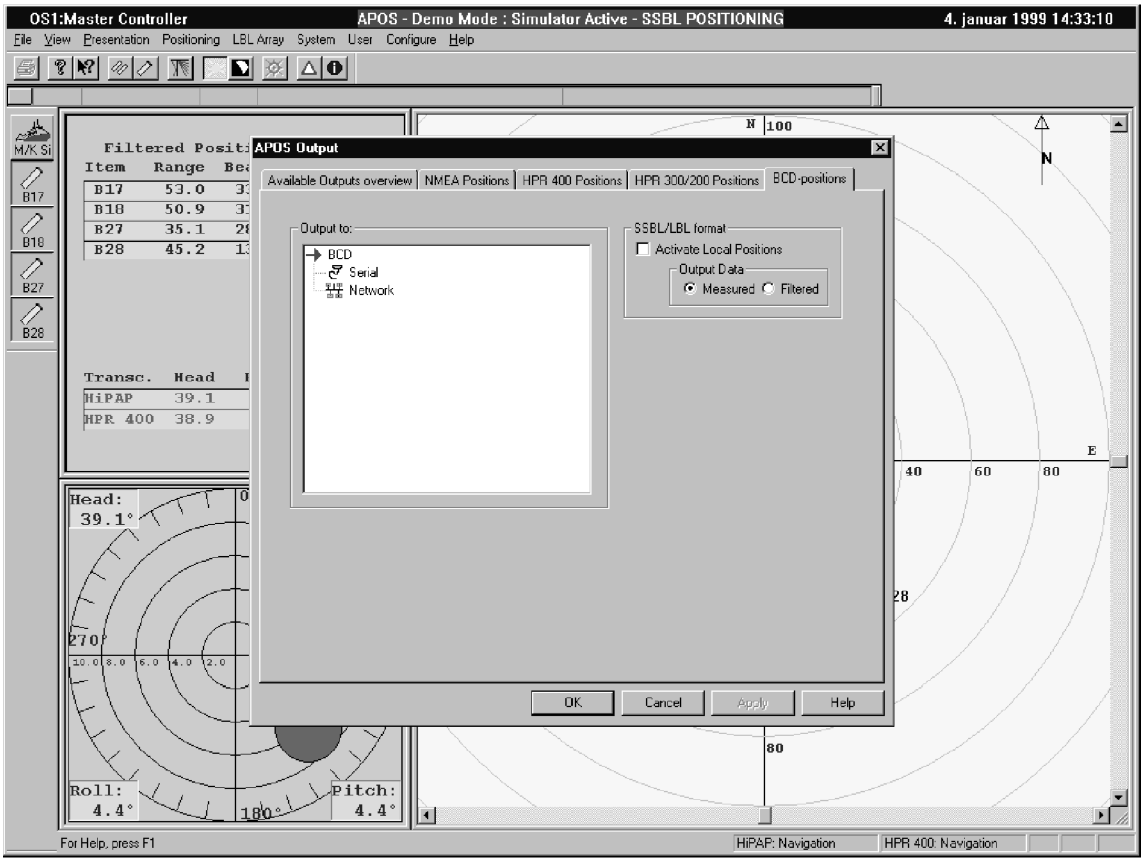
Press OK to activate the mapping.



8.3.30.6 BCD positions

The right side will show the settings for this output. For the SSBL and LBL format, the checkbox Activate Local Positions must be checked in order for the output to be active.

One may select either Measured or Filtered data on the output.



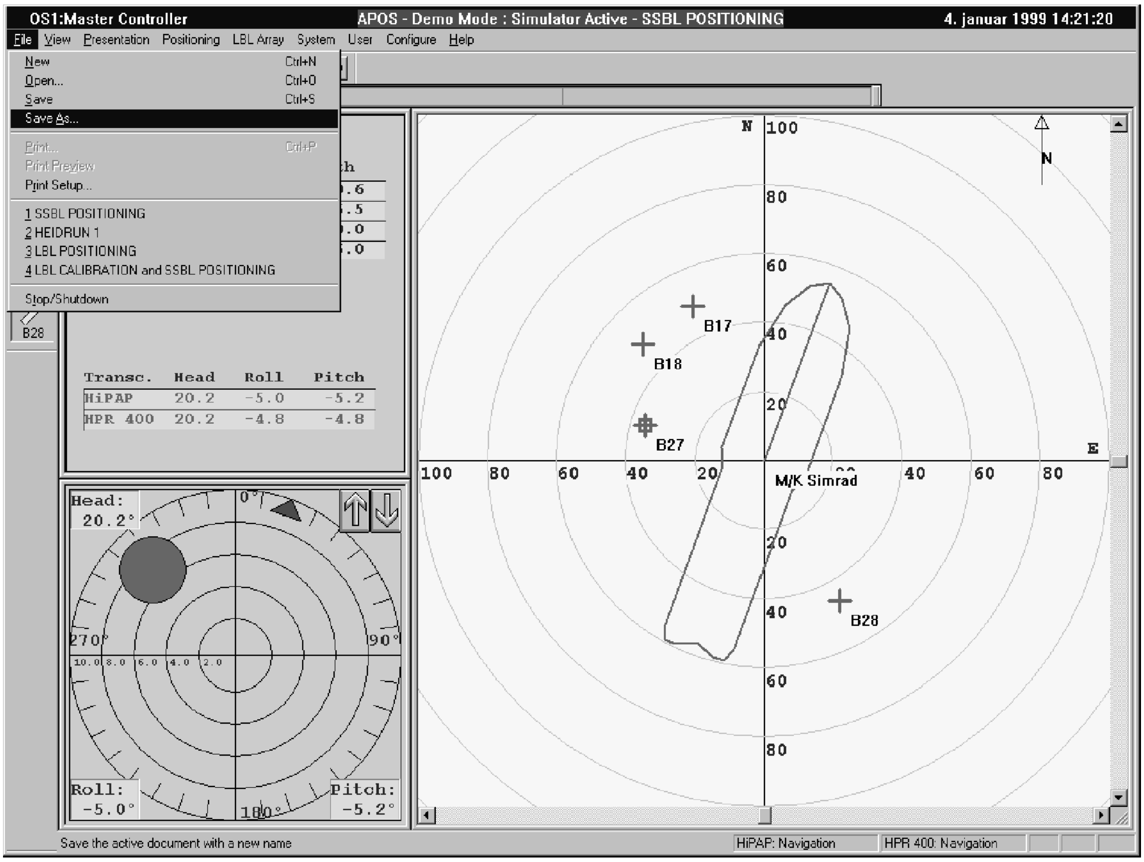
8.3.31 Save a setting to disk

- Save the settings you have done.

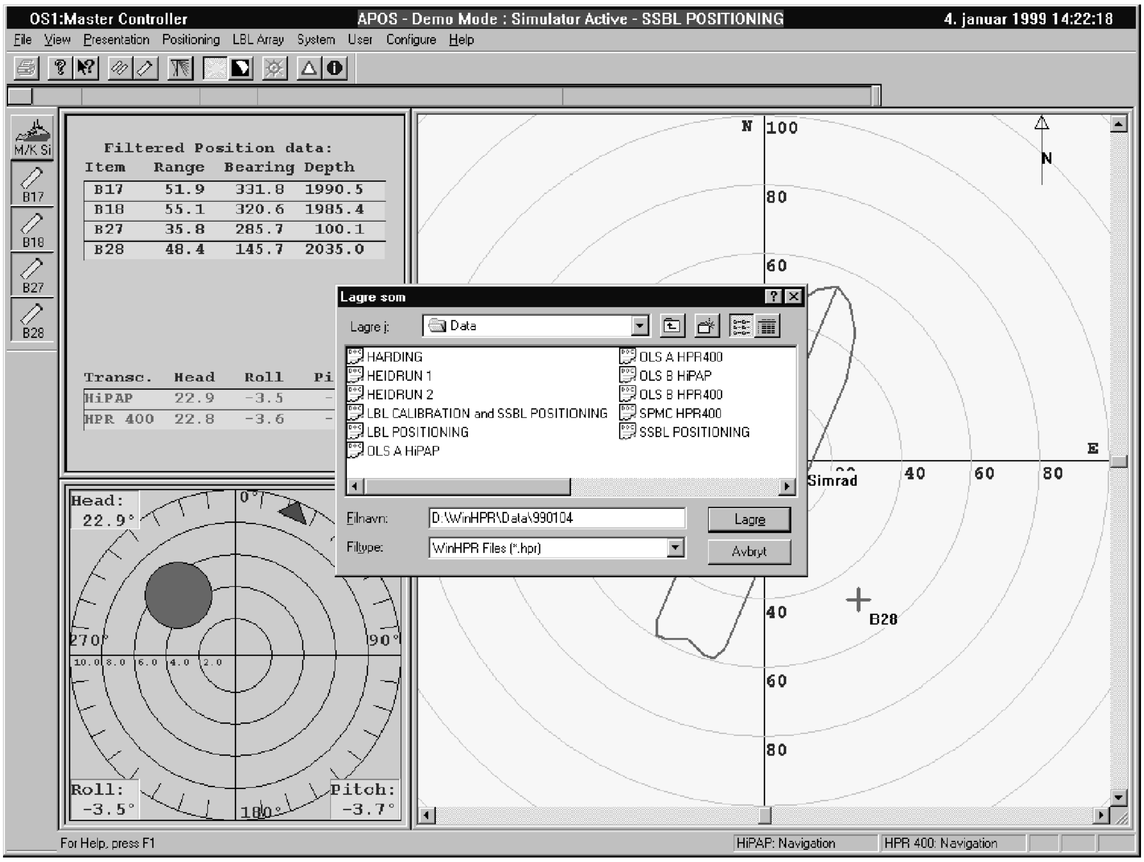
You can use names or numbers in the file name.

- Use the **date** as filename: D:\WINHPR\DATA\YYMMDD.HPR

Use the Help menu if you have any problems finding it out.



- Enter the filename and click Lagre/Save.



- Create a new file

(Select **New** from the **File** menu).

Notice that only the vessel is displayed and none of the transponder symbols.

- Open the settings you just saved.

Blank page

Blank page

8.4 SSBL positioning at OLS A, OLS B & SPMC

8.4.1 Introduction

These exercises will lead you through the HPR400/HiPAP positioning at:

- OLS A
- OLS B
- SPMC

8.4.2 Approaching the loading position

As the vessel nears the loading position power up the system and when the vessel has slowed down to a few knots, lower the HPR/HiPAP® hull unit.

When you power up your operator station, the display will have the same layout as when you turned the operator station off last time you used it.

- Start the demo computer, if it is not already been started, and let the instructor configure the demo program before you go on with the exercises.

8.4.3 Positioning at OLS A

The vessel will be positioned relative to two or four transponders moored at the seabed. When using HiPAP systems you can position two transponders. When using the HPR 400 system you can position four transponders.

The SSBL positioning should be started at the appropriate time according to the loading procedure. The SSBL position(s) will be used as reference input to the Dynamic Positioning system.

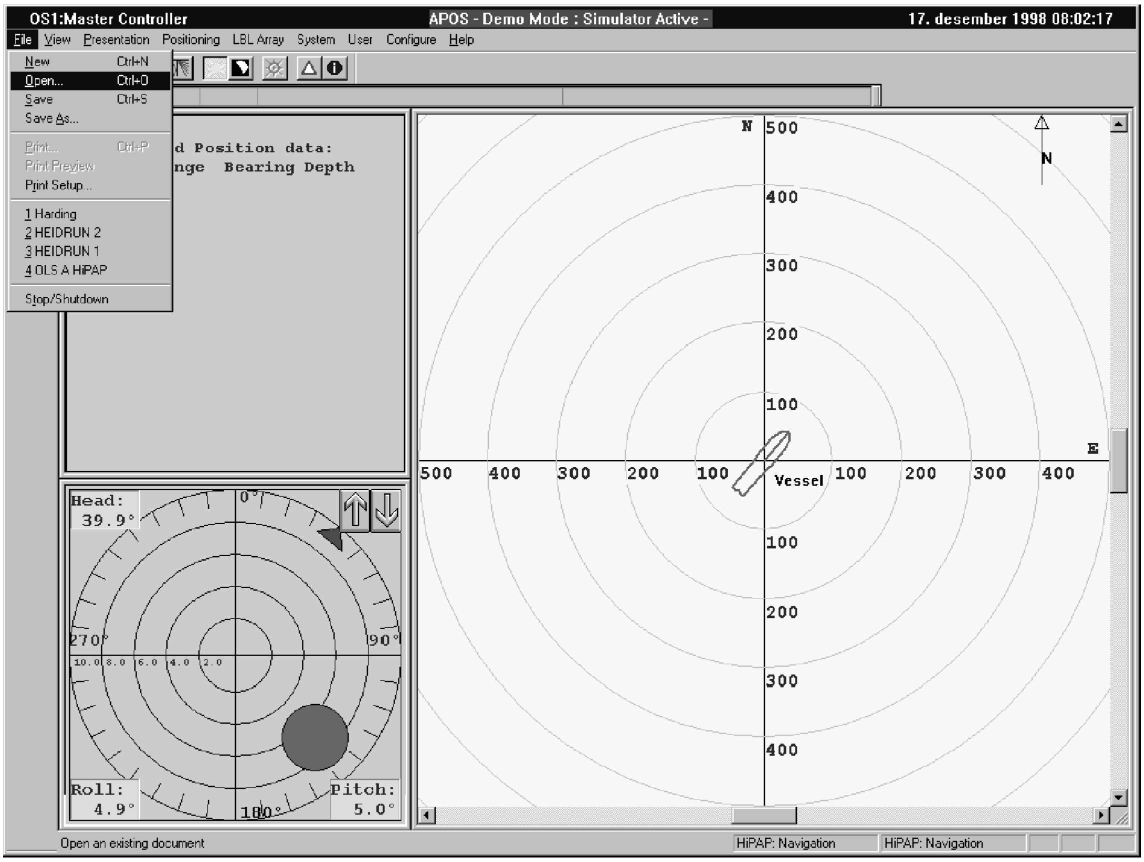
You can read already configured settings for the oil field you are at. Settings for OLS A, OLS B, SPMC, HEIDRUN 1, HEIDRUN 2 & HARDING might be available.

- Assume you are at the OLS A field.
- Open the file * from D:\WINHPR\DATA\

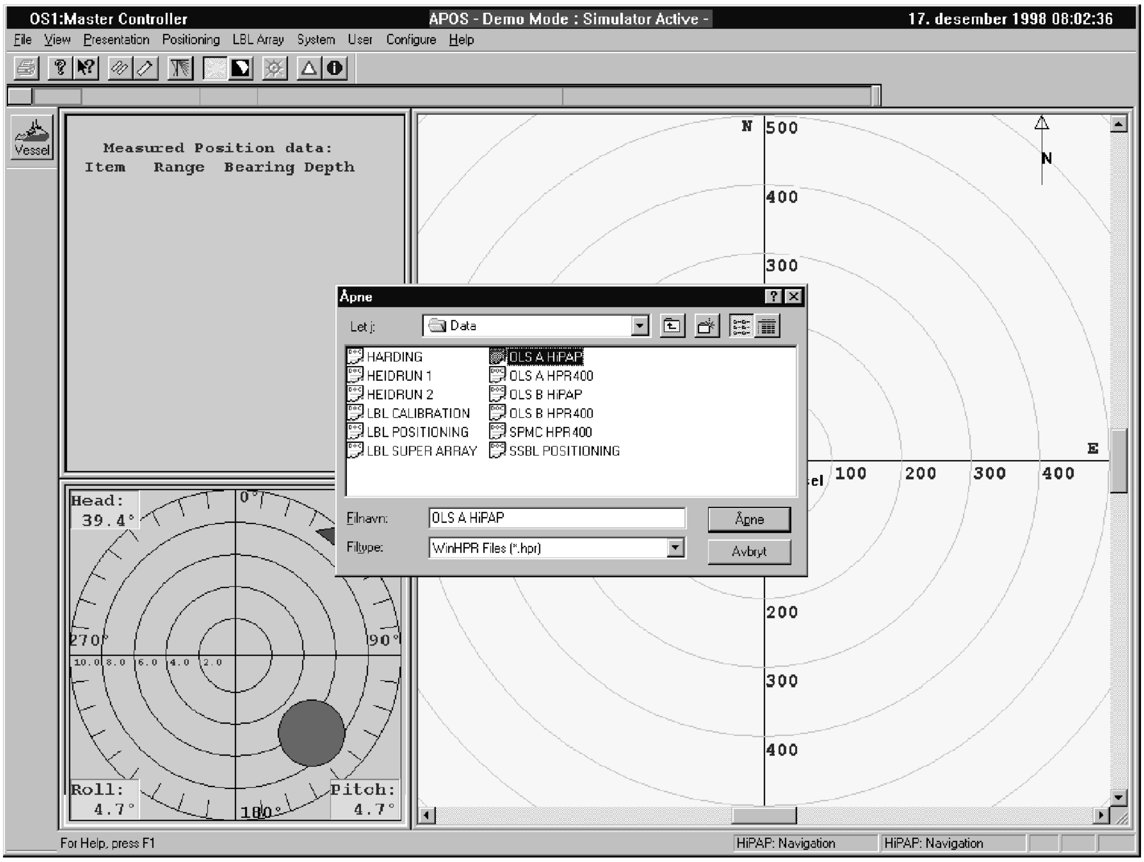
* If you are at a HiPAP course use the file **OLS A HiPAP**

* If you are at a HPR 400 course use the file **OLS A HPR400**

(Select **Open** from the **File** menu)



- Select the wanted **OLS A** file and click the **Åpne/Open** button.



The display will now show the SSBL transponders to be used.

OLS A, OLS B and SPMC have different transponder channels for not disturbing each other.

OLS A and OLS B have seabead transponders .

- Let the upper left window be in **Numeric View** and presenting **Position values** in **Polar** format.

- Let the lower left window be in **Inclination view** and presenting the vessel's roll, pitch and heading.

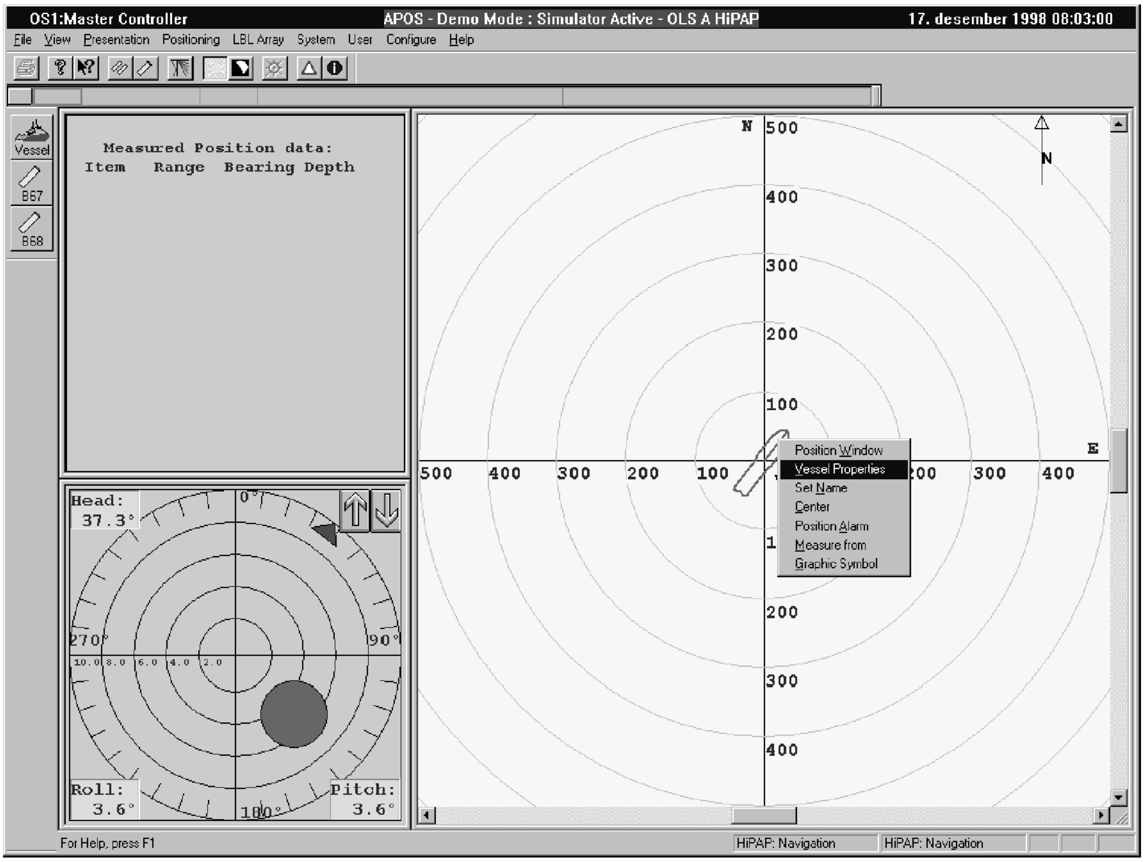
- Let the main window be in **Polar view** or **Cartesian view**.

8.4.4 Graphical display arrangement

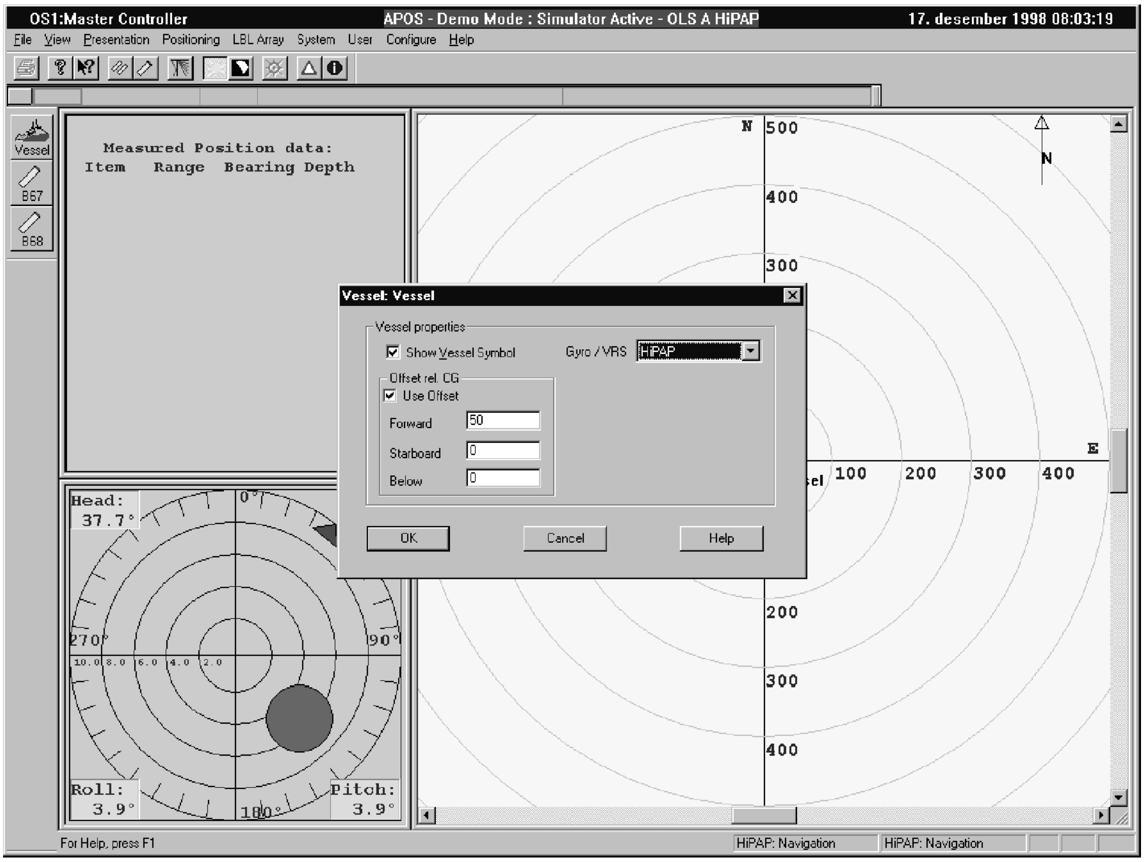
Prior to positioning you should arrange the display presentation to fit the operations.

- For this vessel insert 50 m as **Vessel offset relative CG** to get the **Bow** as a new reference point in the vessel symbol and in the position value in the Numeric View.

(Place the cursor above the vessel and click the right mouse button. Click at Vessel Properties.)

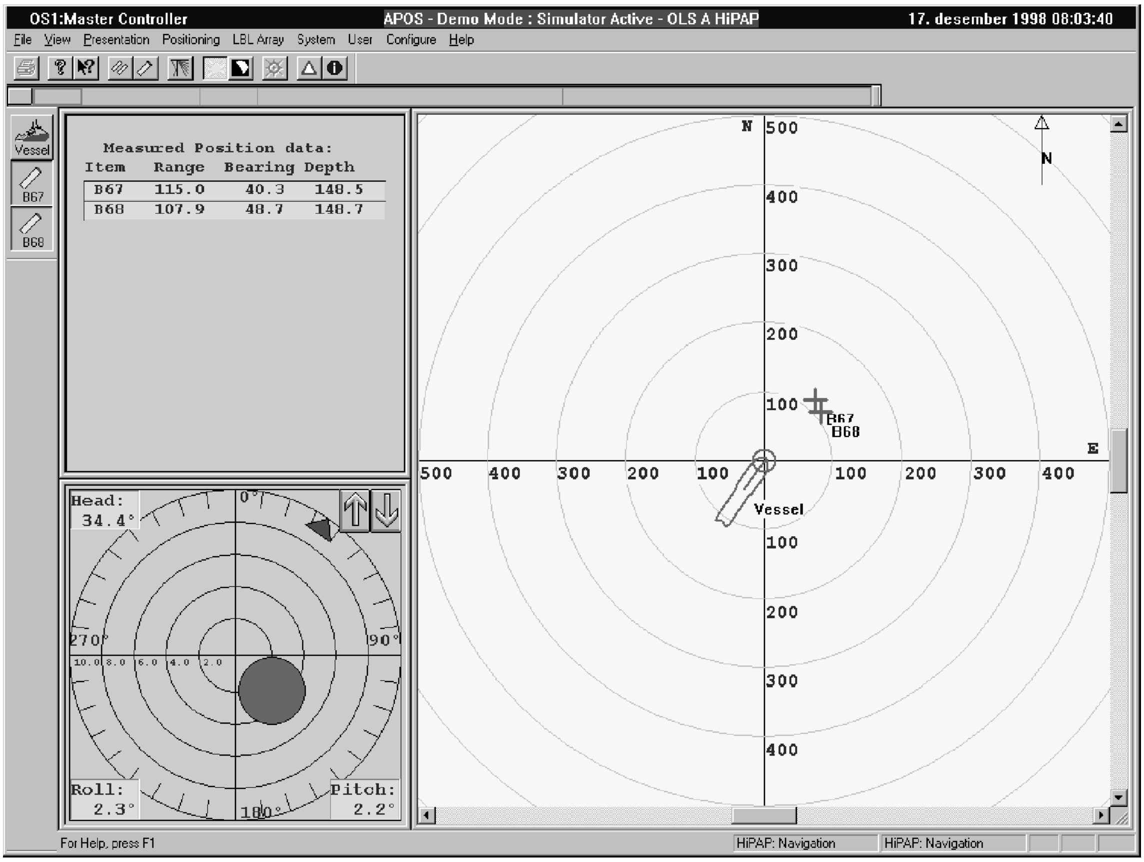


- Enter Forward offset and remember to enter the tick mark in the **Use Offset** check box before you clik the OK button.

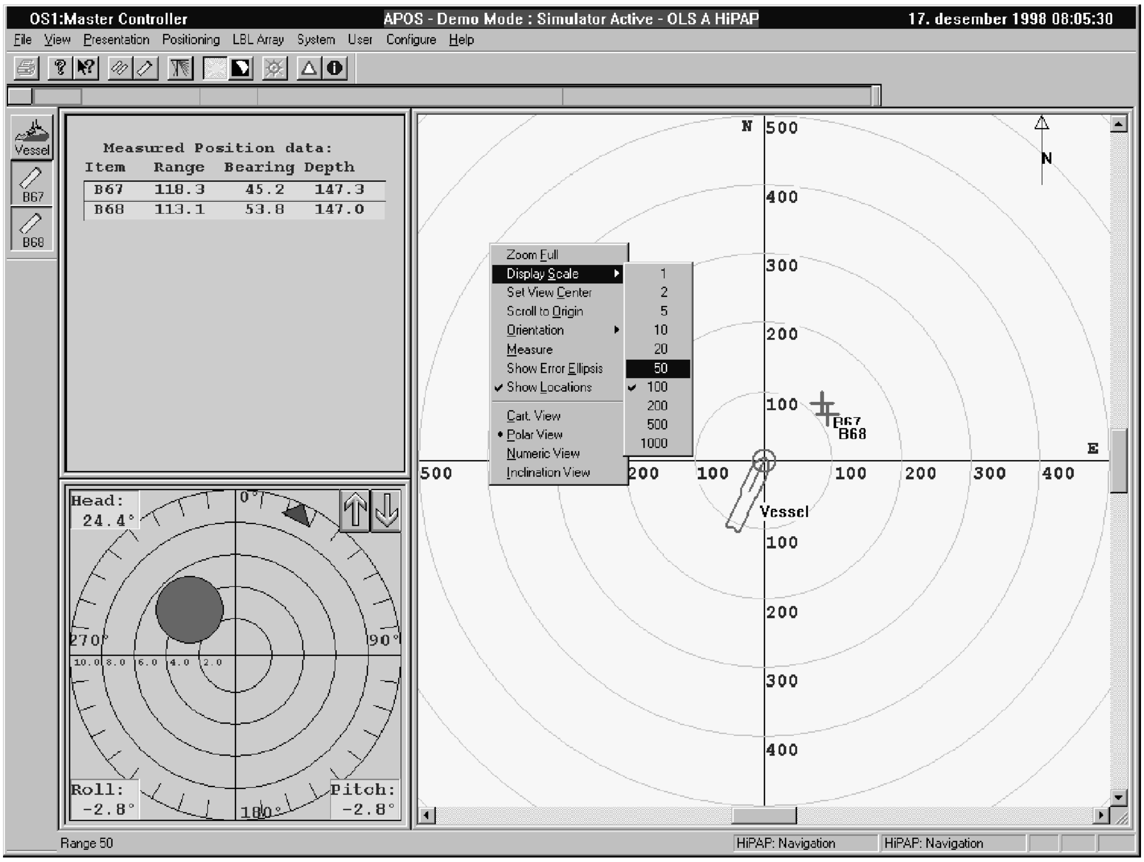


- Notice the change in vessel symbol presentation.

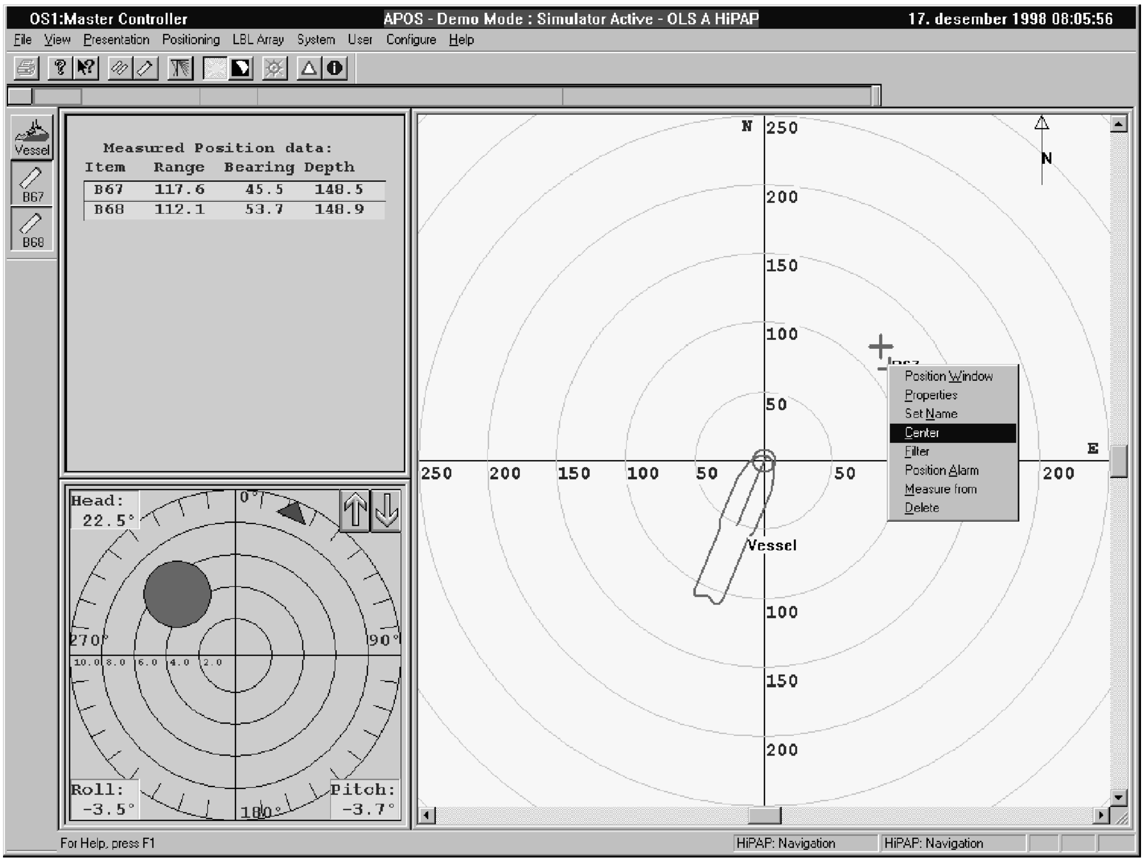
- Start **SSBL positioning** by clicking once at the transponder symbols.

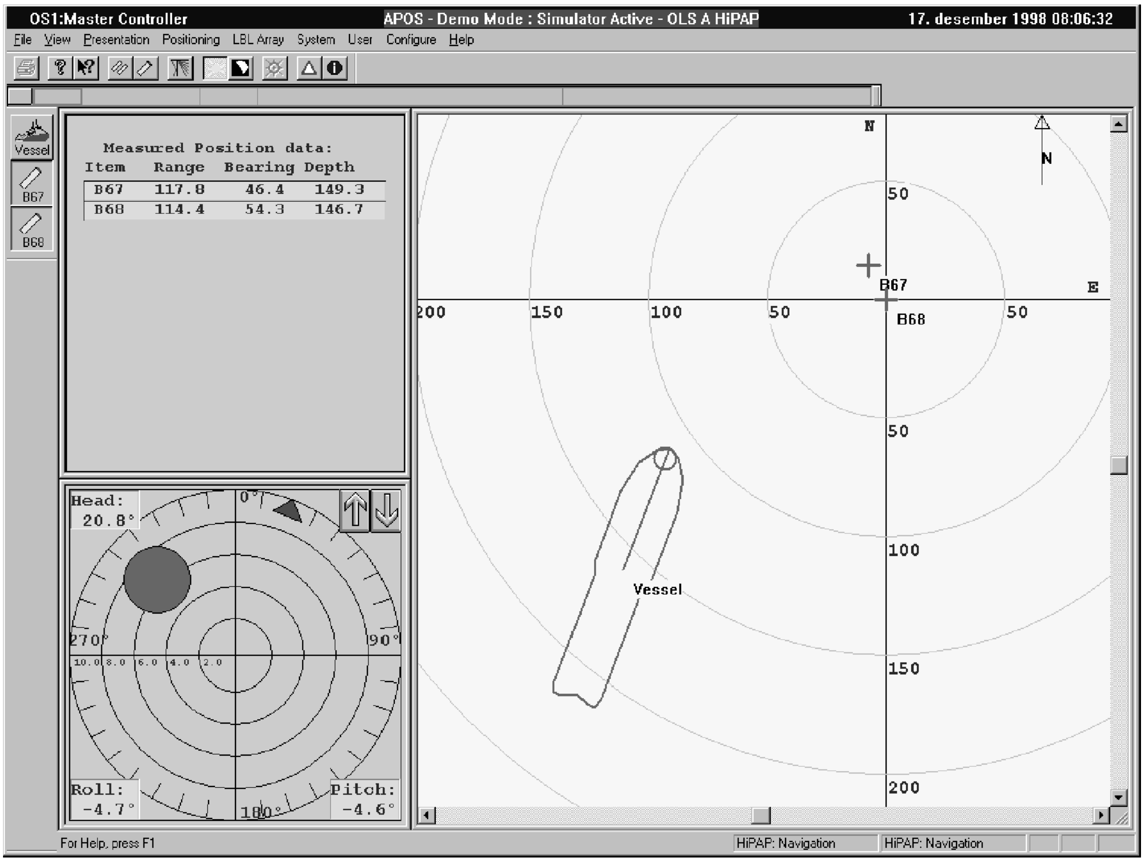


- To zoom in the graphical presentation of the **Vessel** and the **Transponders** select 50m as **Display scale**.



- You can also let a transponder be in **center** of the display if you prefer that presentation.



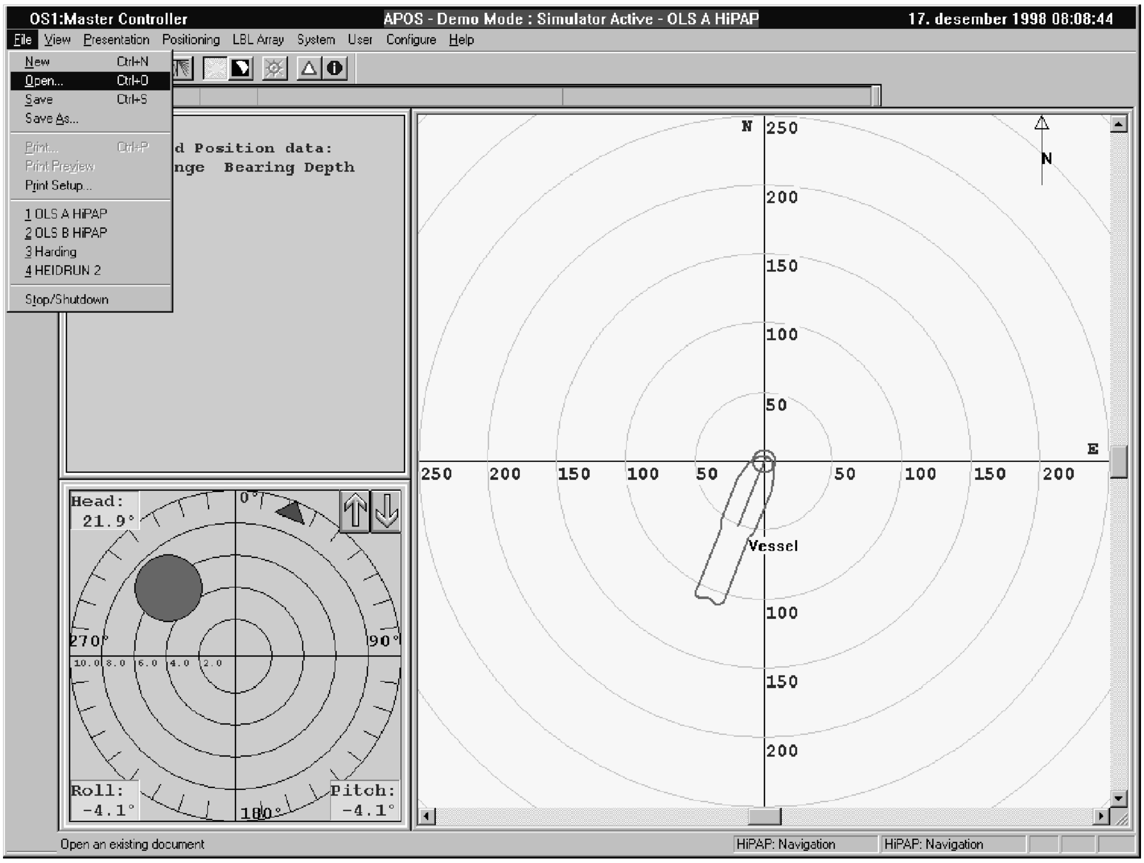


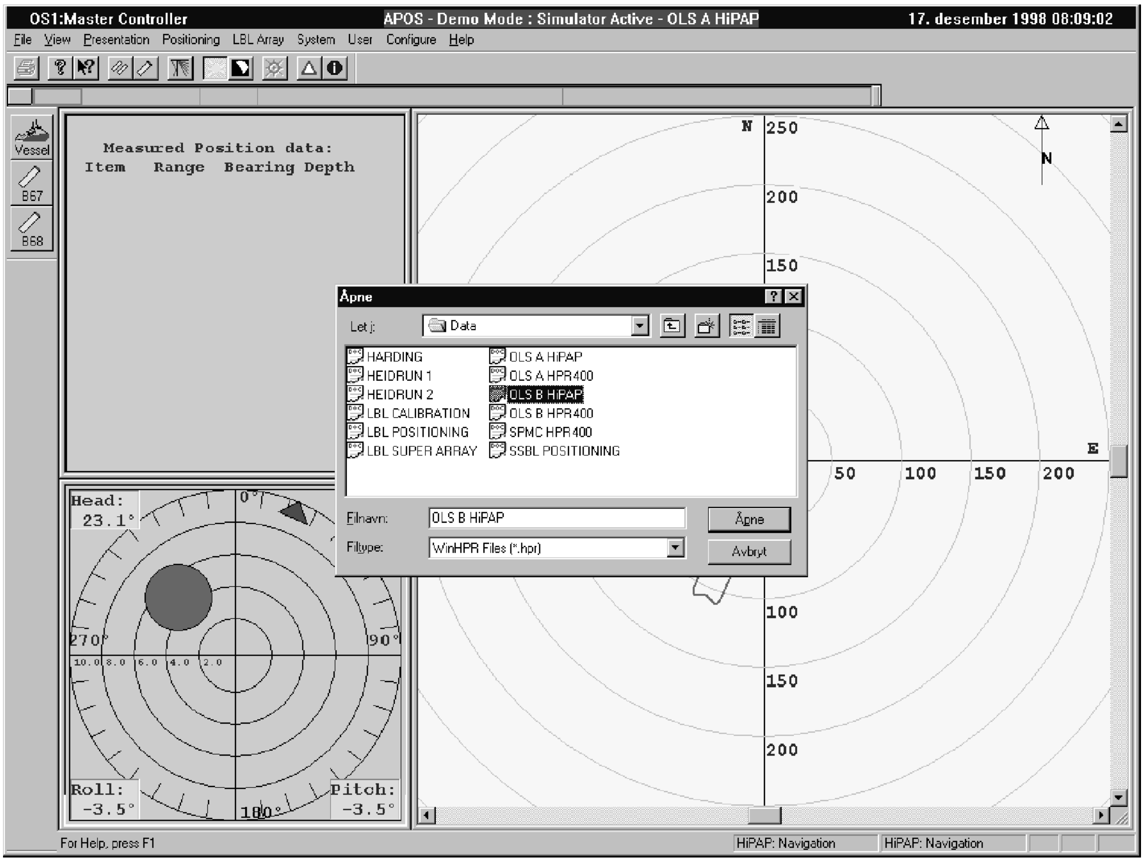
- Turn off the SSBL positioning.

- Rememeber to raise the HPR/HiPAP transducer before you leave the loading station.

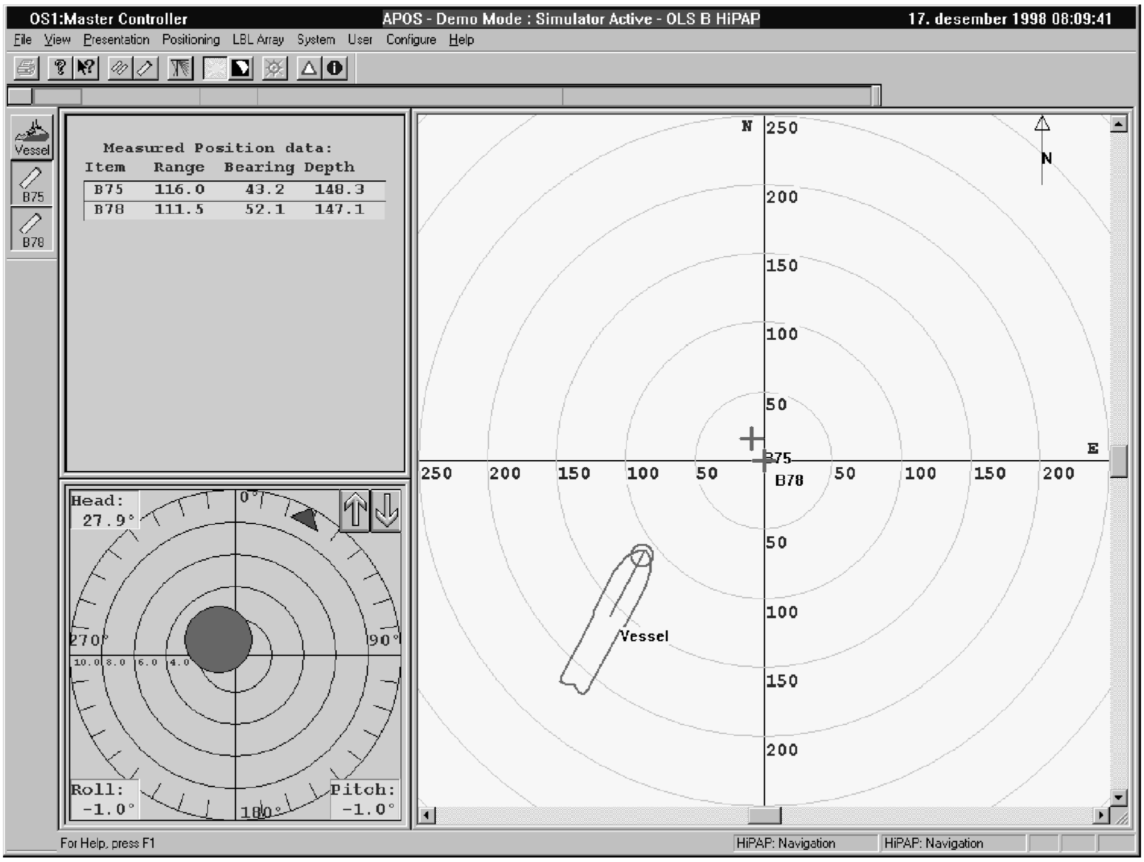
8.4.5 Positioning at OLS B

- Assume you are at the **OLS B** loading position.
- Open the file **OLS B** from D:\WINHPR\DATA\
- Do the same exercises as for OLS A.





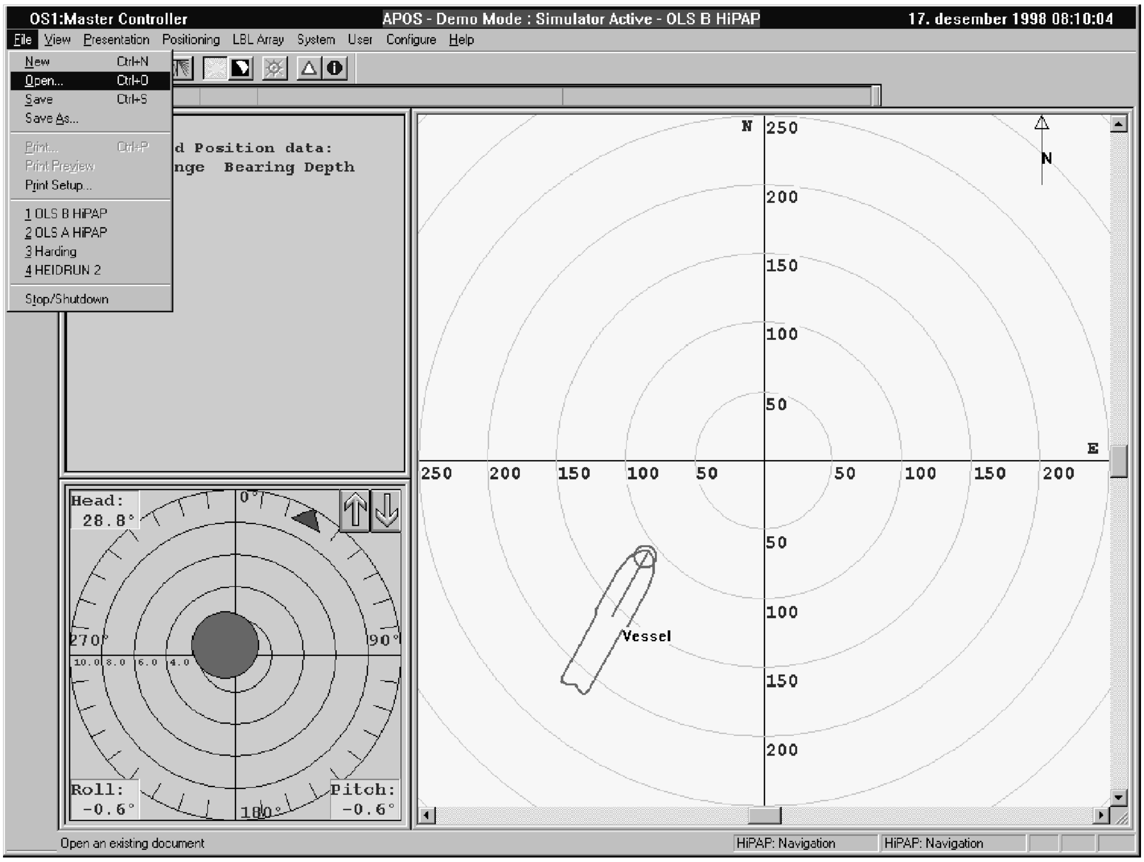
OS1:Master Controller
APOS - Demo Mode : Simulator Active - OLS A HiPAP
17. desember 1998 08:09:02
File View Presentation Positioning LBL Array System User Configure Help
Measured Position data:
Item Range Bearing Depth
Vessel
B67
B68
Åpne
Let i:
Data
HARDING
HEIDRUN 1
HEIDRUN 2
LBL CALIBRATION
LBL POSITIONING
LBL SUPER ARRAY
OLS A HiPAP
OLS A HPR400
OLS B HiPAP
OLS B HPR400
SPMC HPR400
SSBL POSITIONING
Filnavn:
OLS B HiPAP
Filtype:
WinHPR Files (*.hpr)
Åpne
Avbryt
Head:
23.1°
Roll:
-3.5°
Pitch:
-3.5°
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

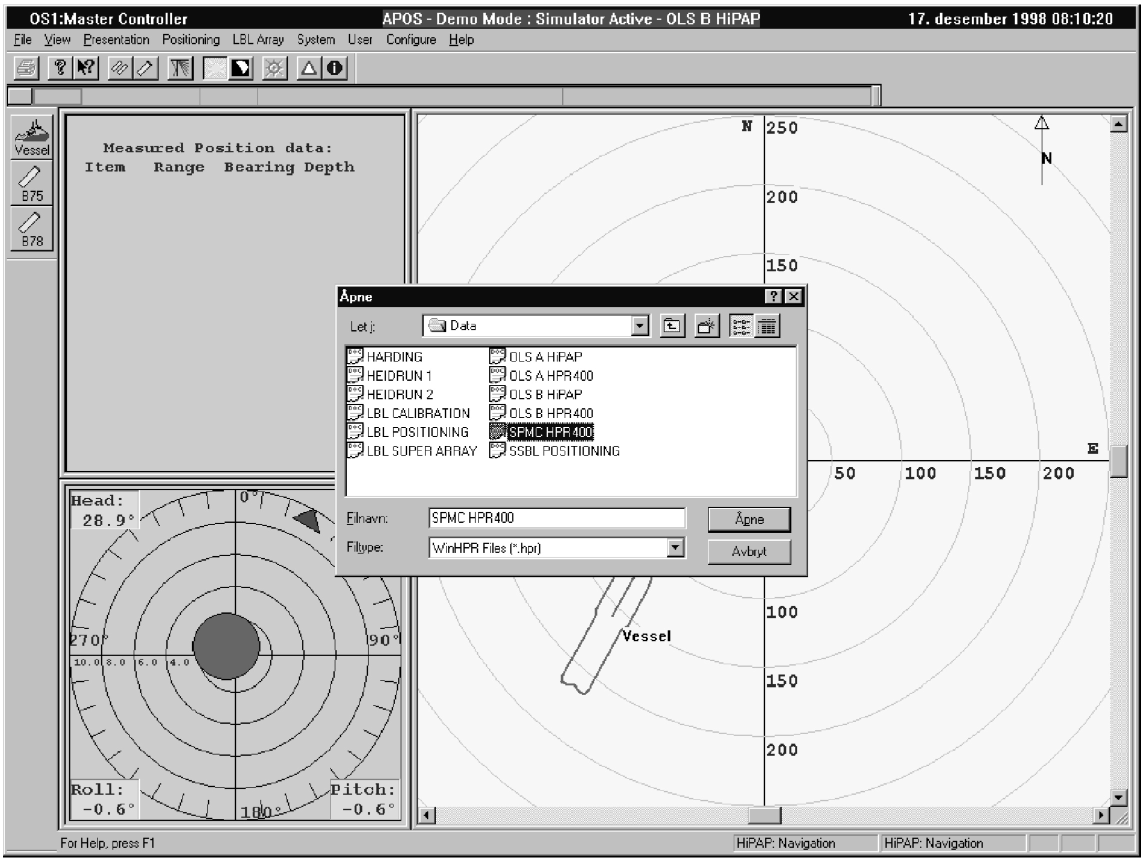

OS1:Master Controller
APOS - Demo Mode : Simulator Active - OLS B HiPAP
17. desember 1998 08:09:41
File View Presentation Positioning LBL Array System User Configure Help
Vessel
B75
B78
Measured Position data:
Item Range Bearing Depth
B75 116.0 43.2 148.3
B78 111.5 52.1 147.1
Head:
27.9°
0°
270°
90°
Roll:
-1.0°
180°
Pitch:
-1.0°
N
E
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

8.4.6 Positioning at SPMC

- Assume you are at the SPMC.
- Open the file **SPMC HPR400** from D:\WINHPR\DATA\
- Do the same exercises as for OLS A.

Note ! *At SPMC you can only use HPR 400 systems for positioning. The transponders can not be used with HiPAP ®.*

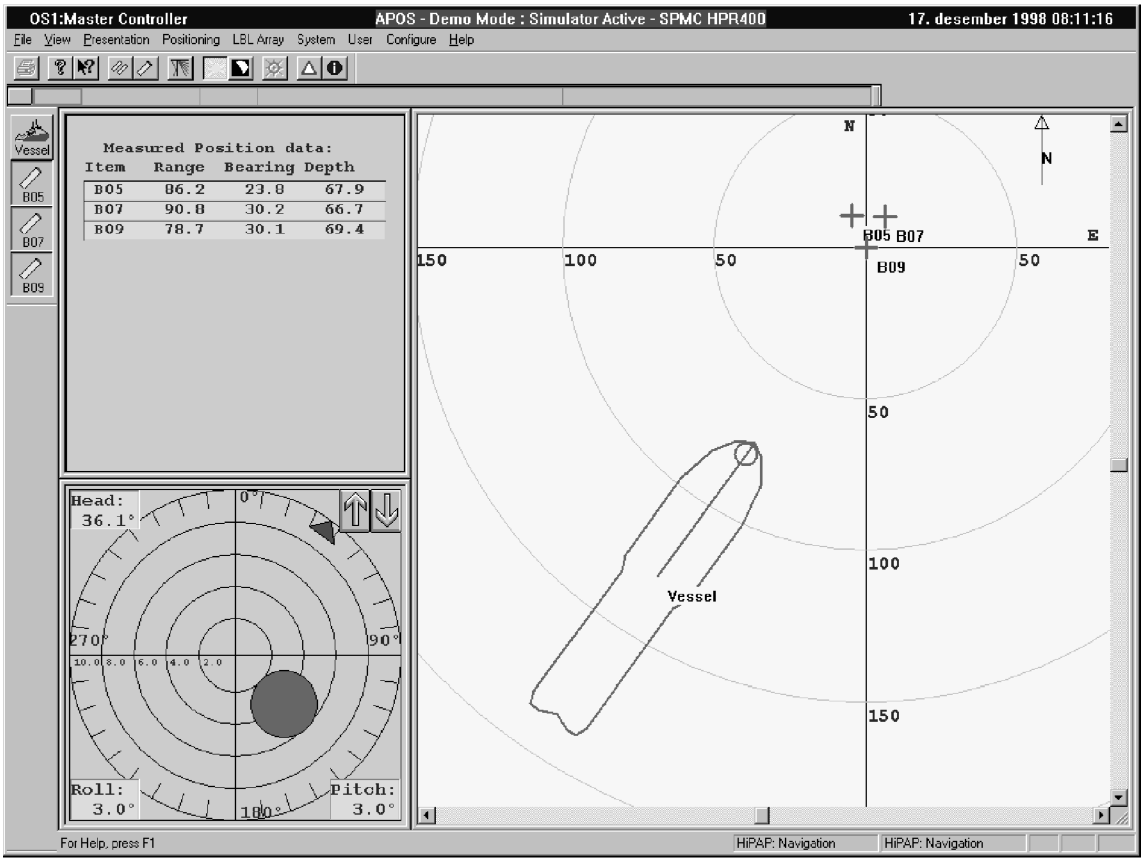



OS1:Master Controller
APOS - Demo Mode : Simulator Active - OLS B HiPAP
17. desember 1998 08:10:20
File View Presentation Positioning LBL Array System User Configure Help
Vessel
B75
B78
Measured Position data:
Item Range Bearing Depth
Åpne
Let i: Data
HARDING
HEIDRUN 1
HEIDRUN 2
LBL CALIBRATION
LBL POSITIONING
LBL SUPER ARRAY
OLS A HiPAP
OLS A HPR400
OLS B HiPAP
OLS B HPR400
SPMC HPR400
SSBL POSITIONING
Filnavn: SPMC HPR400
Filtype: WinHPR Files (*.hpr)
Åpne
Avbryt
Head: 28.9°
Roll: -0.6°
Pitch: -0.6°
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

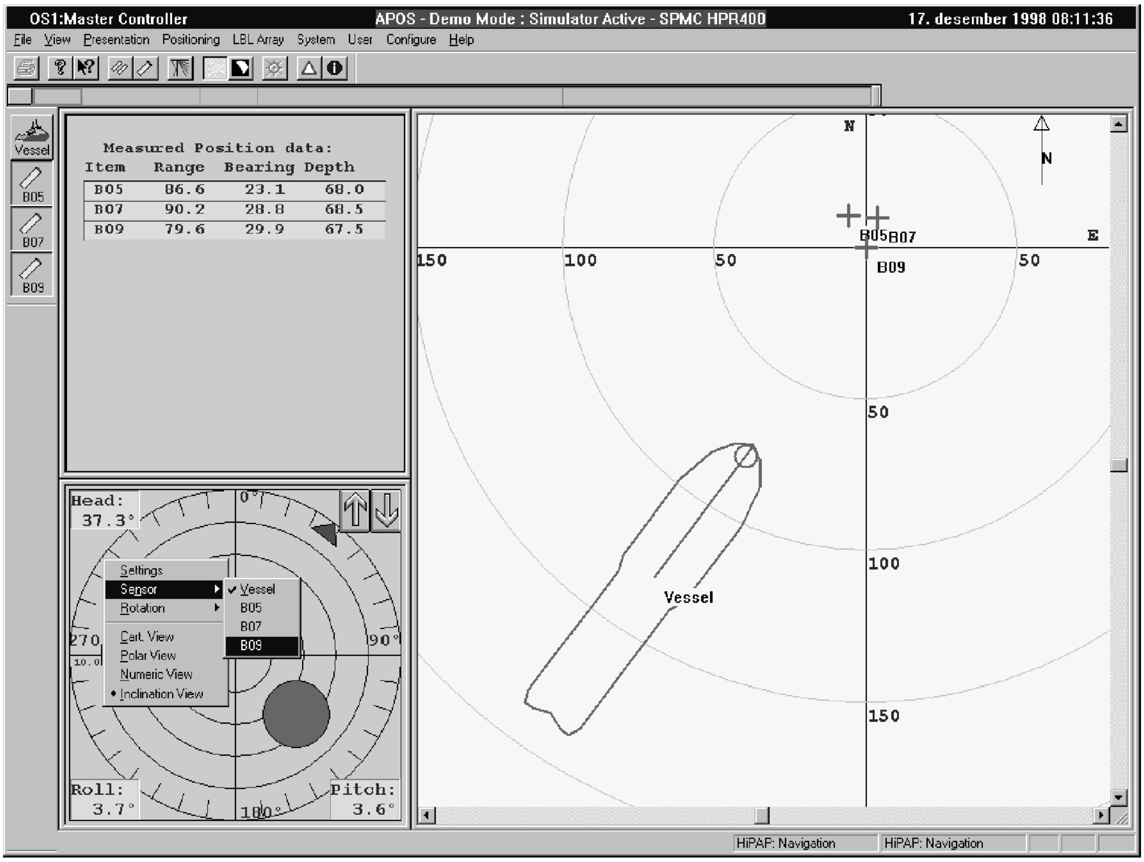
- Start **SSBL positioning** and change **Display scale** as you prefer.

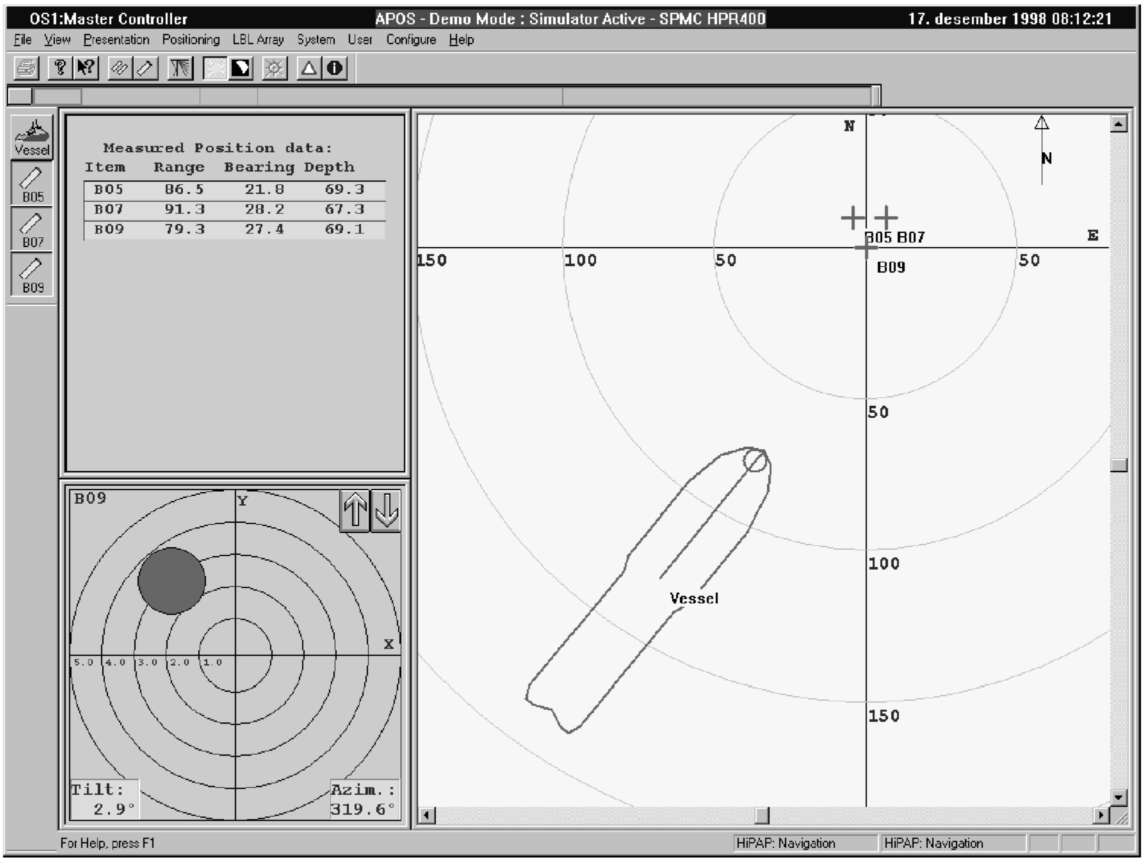
At SPMC there are no transponders at the seabed for positioning. Instead there are three inclination transponders connected to the buoy approxematly 67m below the sea surface. The SSBL position(s) will **NOT** be used as reference input to a Dynamic Positioning system.

You will have problems positioning all of the transponders since one or two of them always will be at the opposite side of the buoy.



- Let the **inclination value** from one of the transponders be presented in the **Inclination view**.




OS1:Master Controller
APOS - Demo Mode : Simulator Active - SPMC HPR400
17. desember 1998 08:12:21
File View Presentation Positioning LBL Array System User Configure Help
Vessel
B05
B07
B09
Measured Position data:
Item Range Bearing Depth
B05 86.5 21.8 69.3
B07 91.3 28.2 67.3
B09 79.3 27.4 69.1
B09
Y
X
5.0 4.0 3.0 2.0 1.0
Tilt: 2.9°
Azim.: 319.6°
N
E
150
100
50
50
B05 B07
B09
50
100
150
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

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8.5 STL positioning at Heidrun and Harding

8.5.1 Introduction

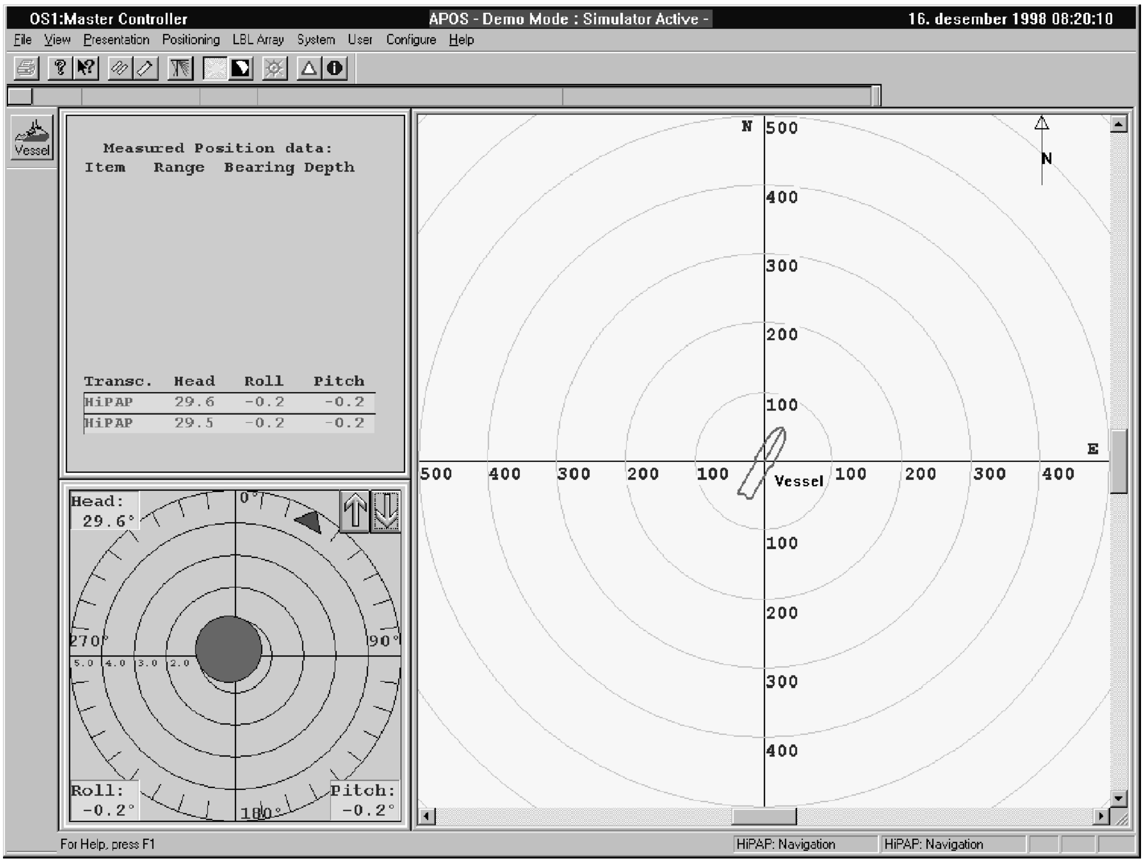
These exercises will lead you through the operation for the STL function in the HPR/HiPAP® system.

8.5.2 Approaching the loading position

As the vessel approaches the loading position power up the system, and when the vessel has slowed down to a few knots, lower the HPR/HiPAP® hull unit.

When you power up your operator station, the display will have the same layout as when you turned the operator station off last time you used it.

- Start the demo computer and let the instructor configure the demo program before you go on with the exercises.



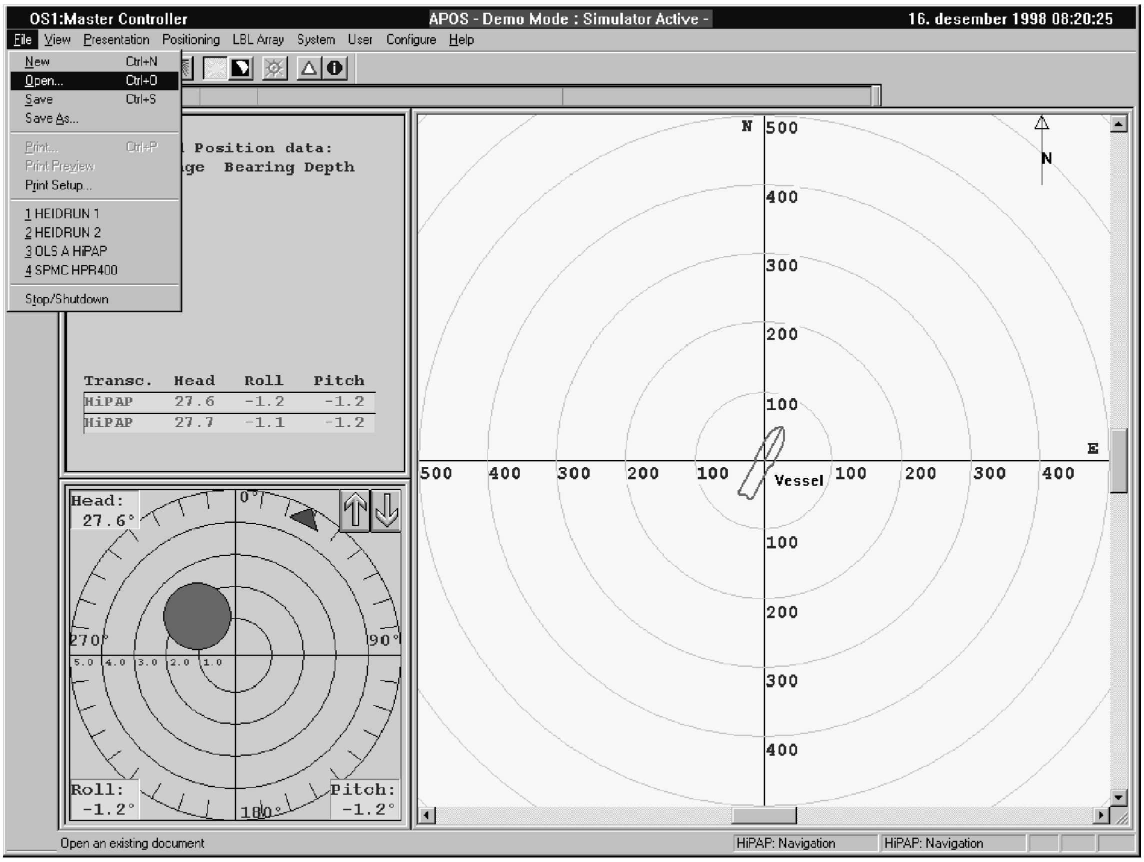
8.5.3 Open settings for a field

You can read already configured settings for the oil field you are approaching.

Settings for HEIDRUN 1, HEIDRUN 2 and HARDING might be available at this training course.

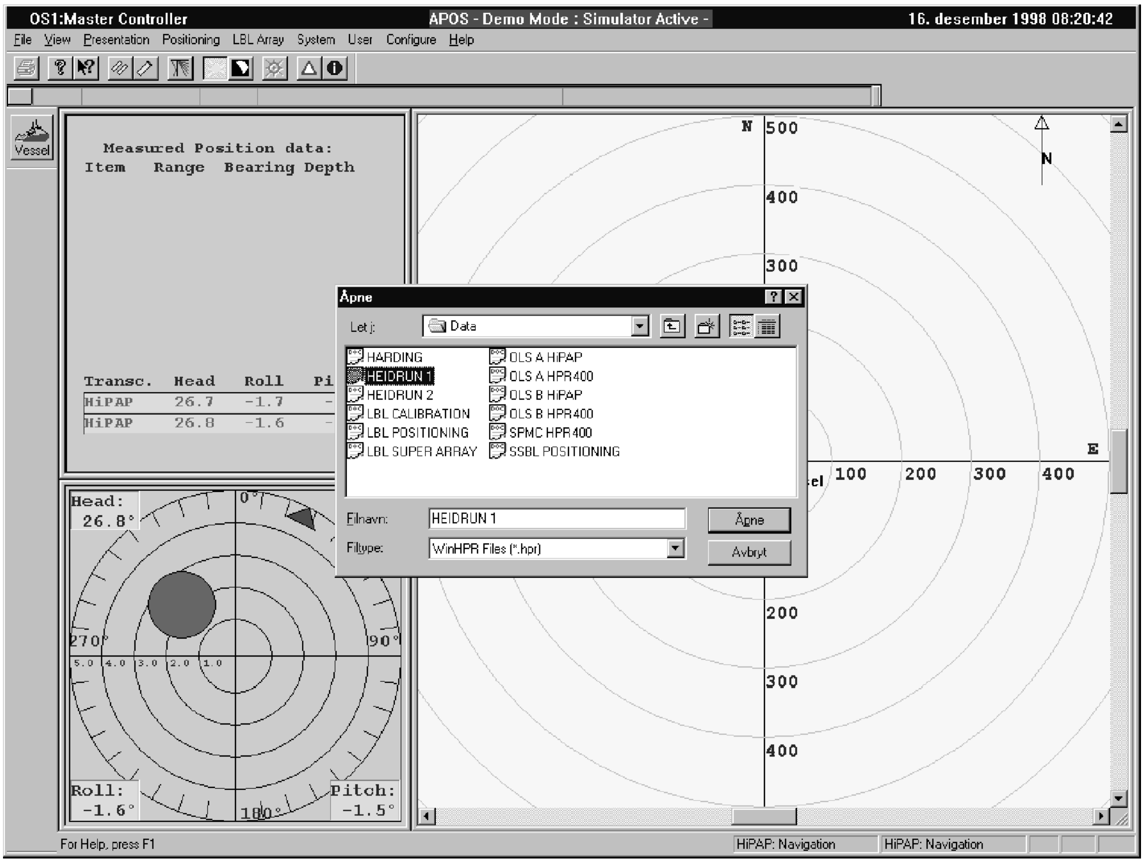
- Assume you are at the **HEIDRUN 1** field.

- Open the **HEIDRUN 1.HPR** file from the disk directory D:\WINHPR\DATA\



- Select **HEIDRUN 1** from the list and click at the **Åpne (Open)** button to read all the settings into the system.

It is also possible to read this file from a floppy disk. You can try this function after you have finished the other exercises.

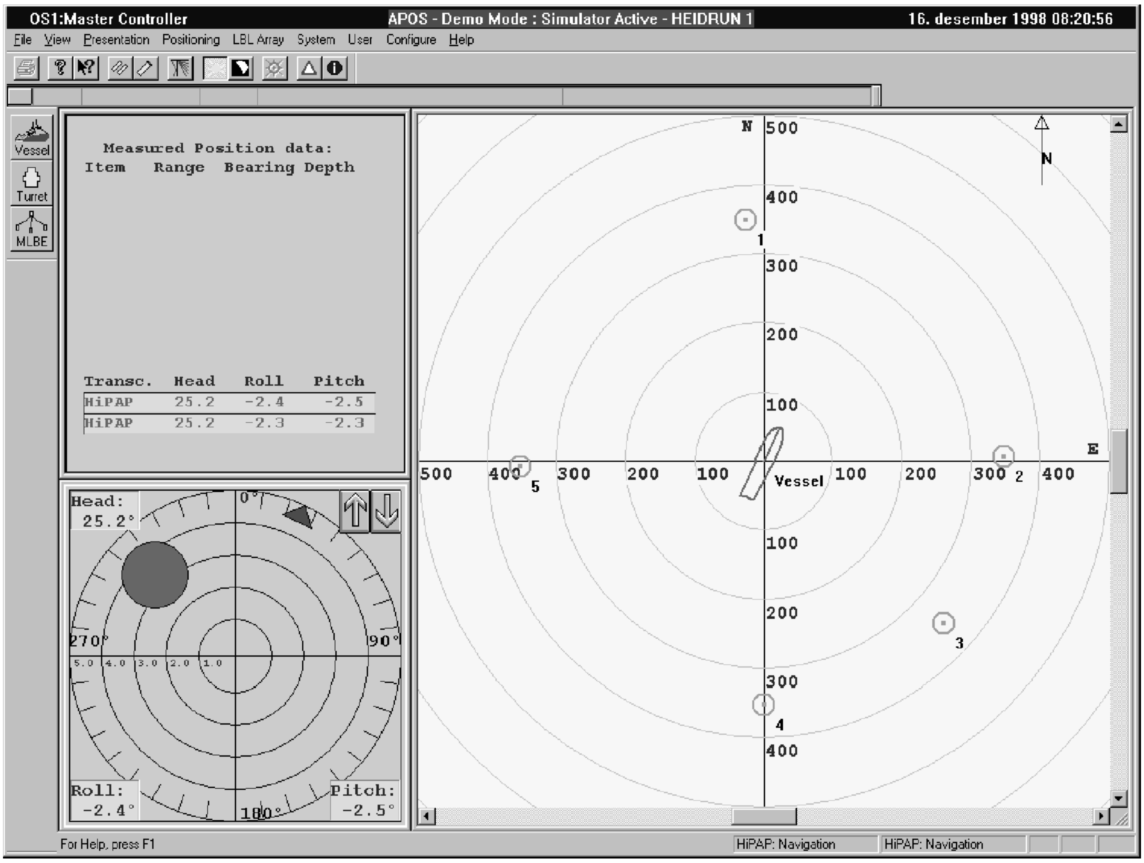


The display will now present the LBL seabed transponder locations (LOC) with circles and location number, corresponding to the selected field:

HEIDRUN 1 with LOCATIONS 1, 2, 3, 4 & 5 (in this exercise)

HEIDRUN 2 with LOCATIONS 6, 7, 8, 9 & 10

HARDING with LOCATIONS 1, 2, 3, 4 & 5



8.5.4 Graphical display arrangement

Prior to positioning you should arrange the display presentation to fit the operations.

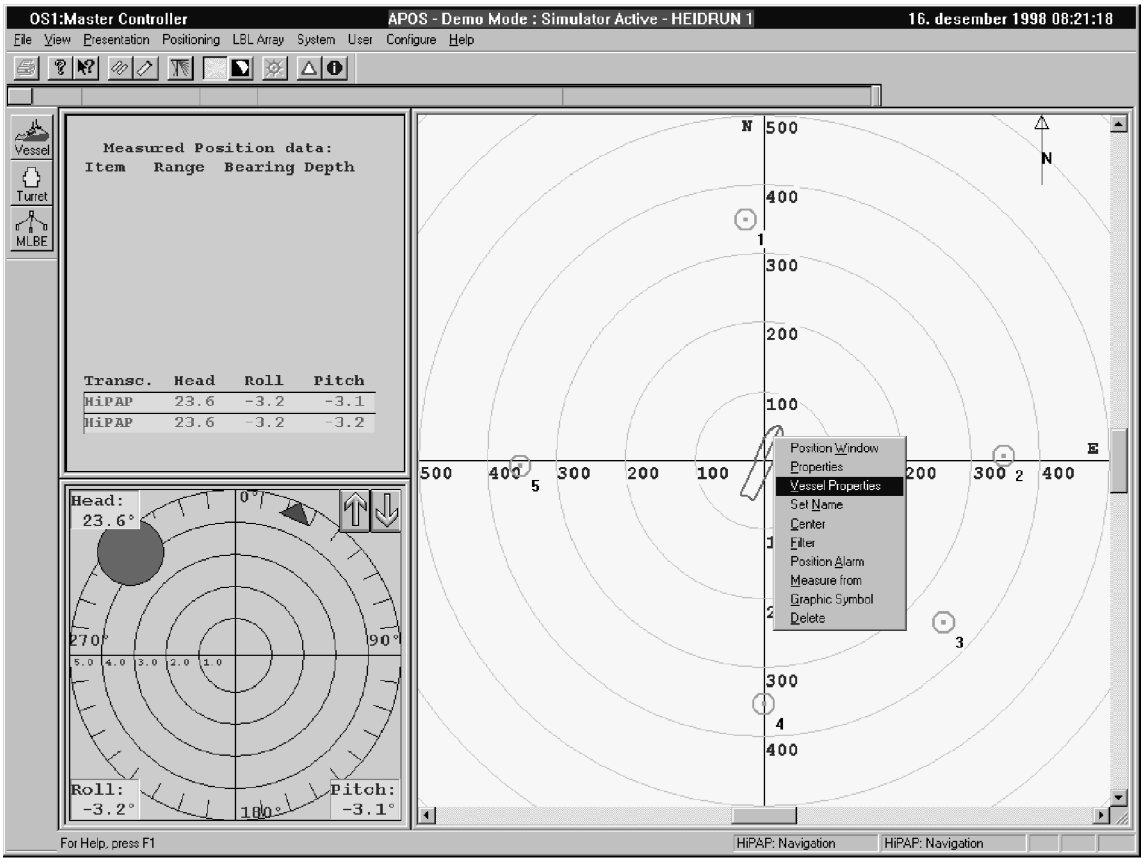
This training vessel is 100m long.

Center of gravity is 50m behind the bow point.

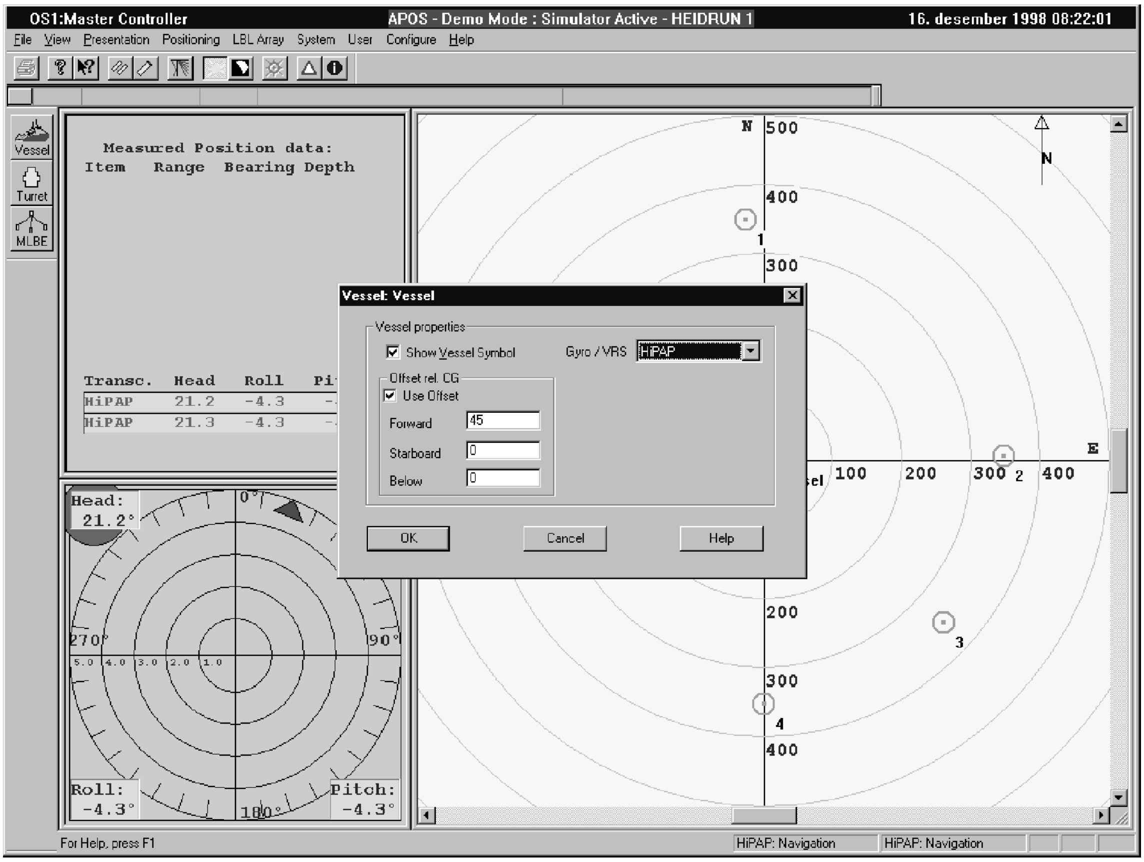
Assume the vessel has a mating cone 5m behind the bow point.

- Insert 45 m as **Vessel offset relative CG** to get the **Mating cone** as a new reference point in the vessel symbol and in the position value in the Numeric View.

(Place the cursor above the vessel symbol in the display or in the toolbar and click right mouse button. Select Vessel properties.)

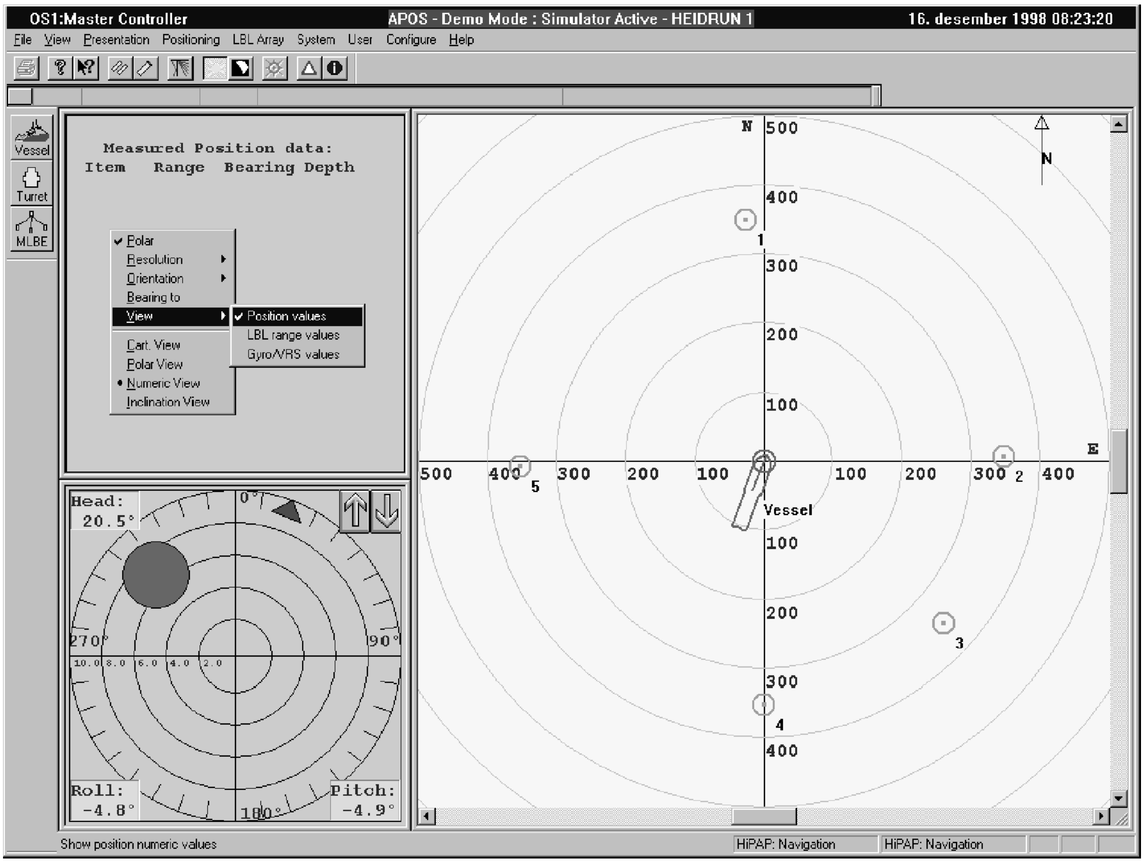


- Enter Forward 45m and remember to enter the tick mark in the **Use Offset** check box.

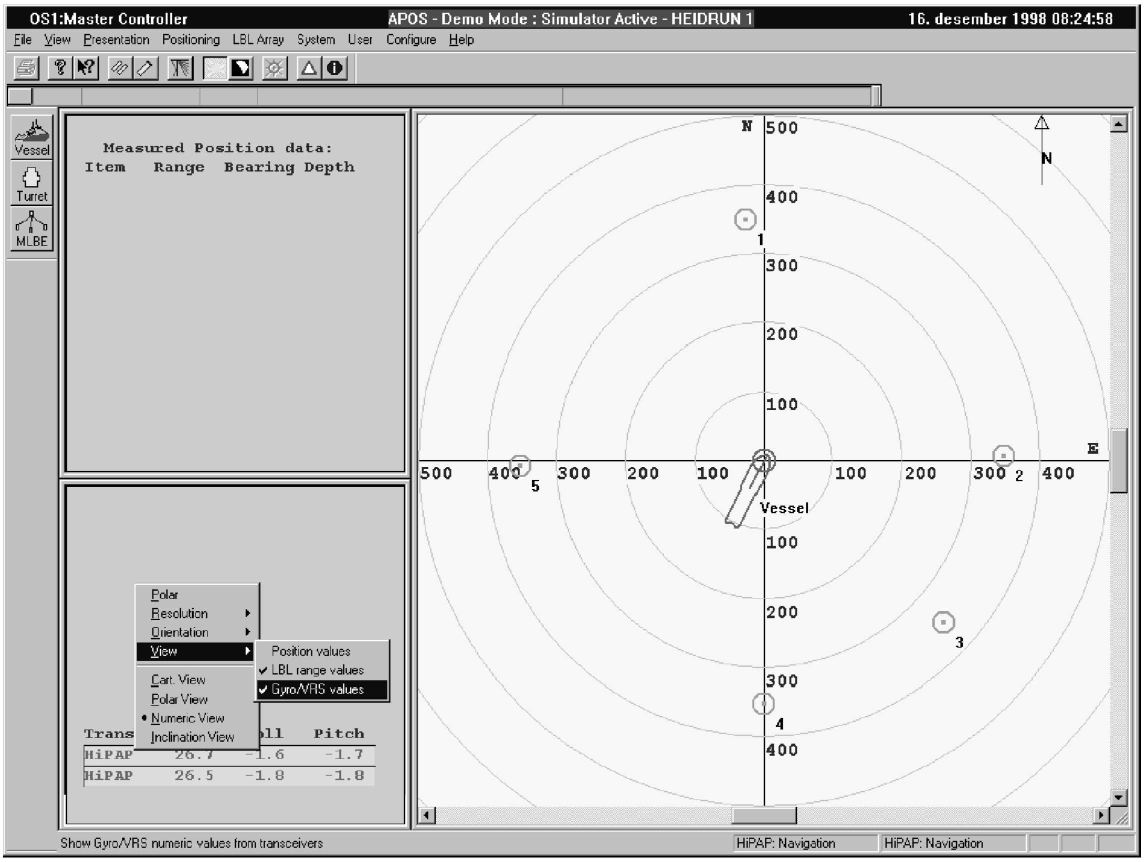


- Notice the change in **vessel symbol** presentation.

- Let the upper left window be in this configuration:
  - **Numeric View**
  - **Polar** presentation
  - **North** orientation
  - **Bearing from** (Bearaing to not checked)
  - **Position values**



- Let the lower left window be in **Numeric View** presenting **LBL range values** and **VRU/GYRO values**.



8.5.5 Vessel positioning

The vessel will be positioned relative to five calibrated LBL transponders located on the seabed.

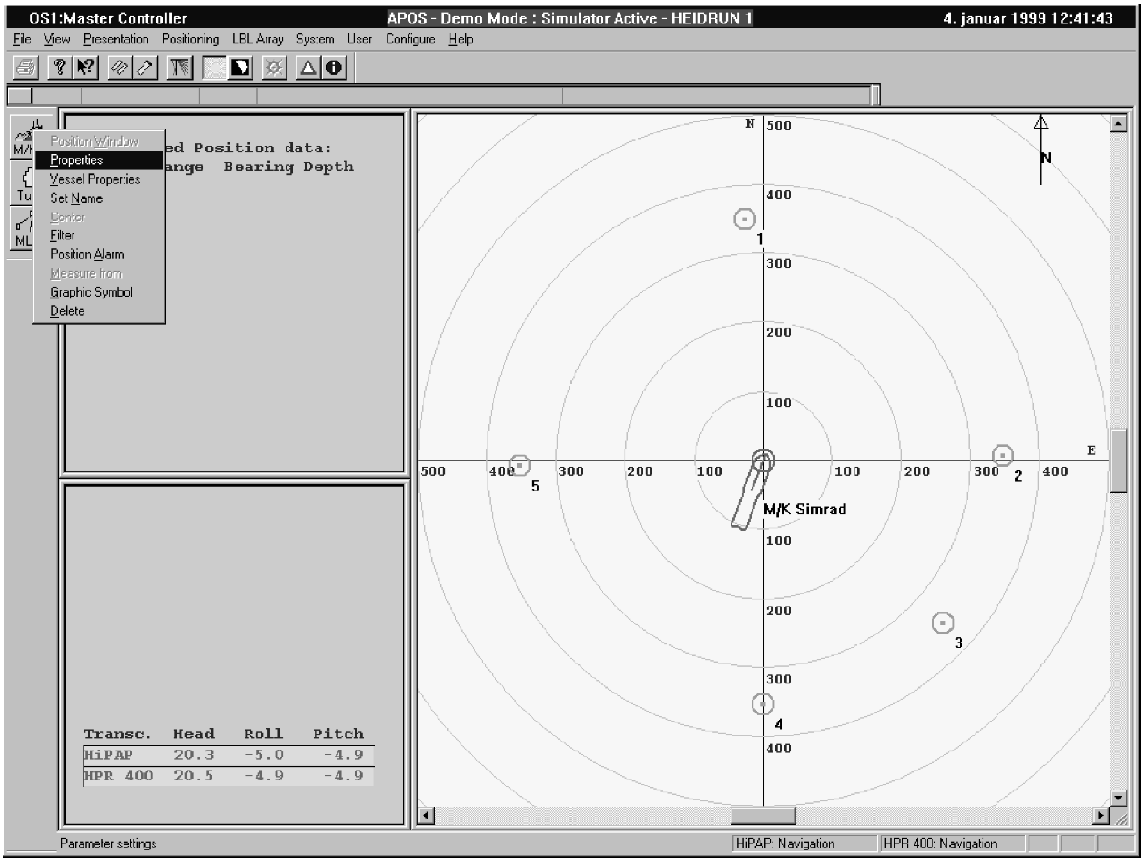
The LBL positioning should be started at the appropriate time according to the loading procedure.

- Start **LBL positioning**.

There are more than one way to start LBL positioning:

One way is to select **LBL positioning** from the **Positioning** menu.

The other way is to place the cursor at the Vessel symbol in the toolbar and click the right mouse button. Click then at **Properties** to get the correct new window.

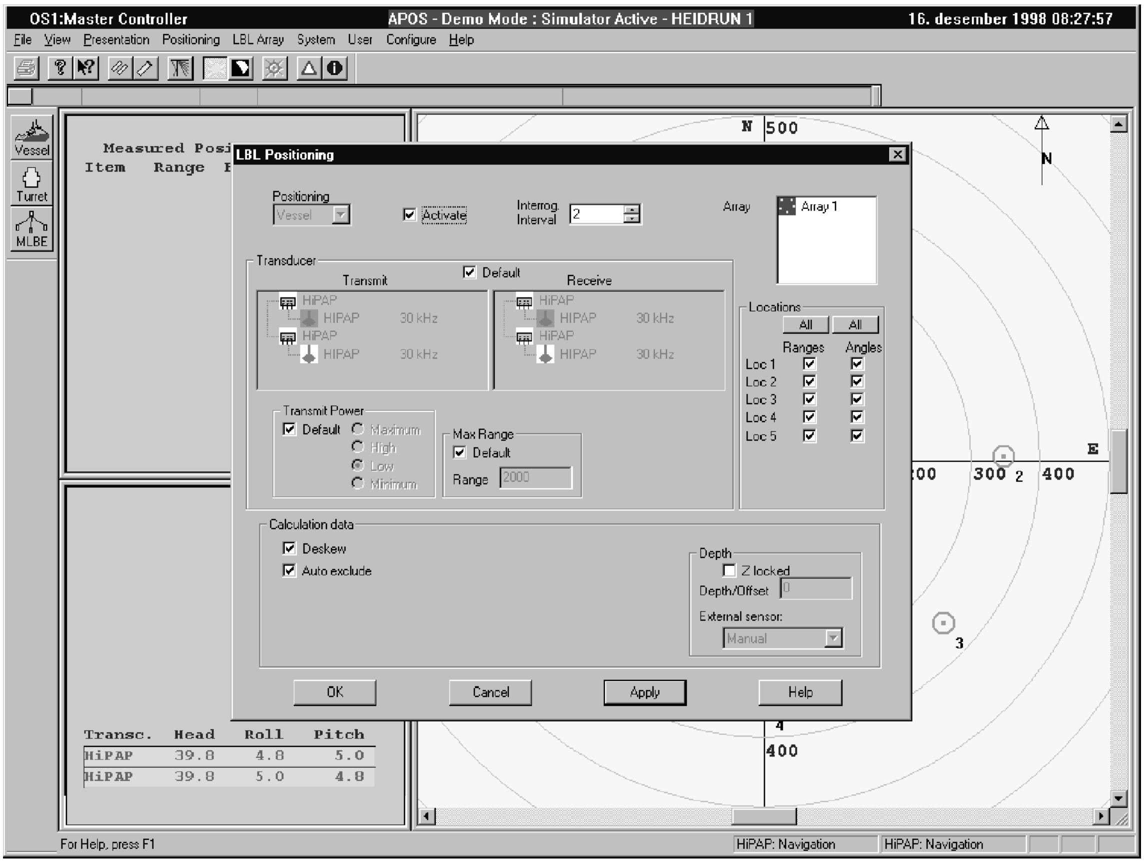


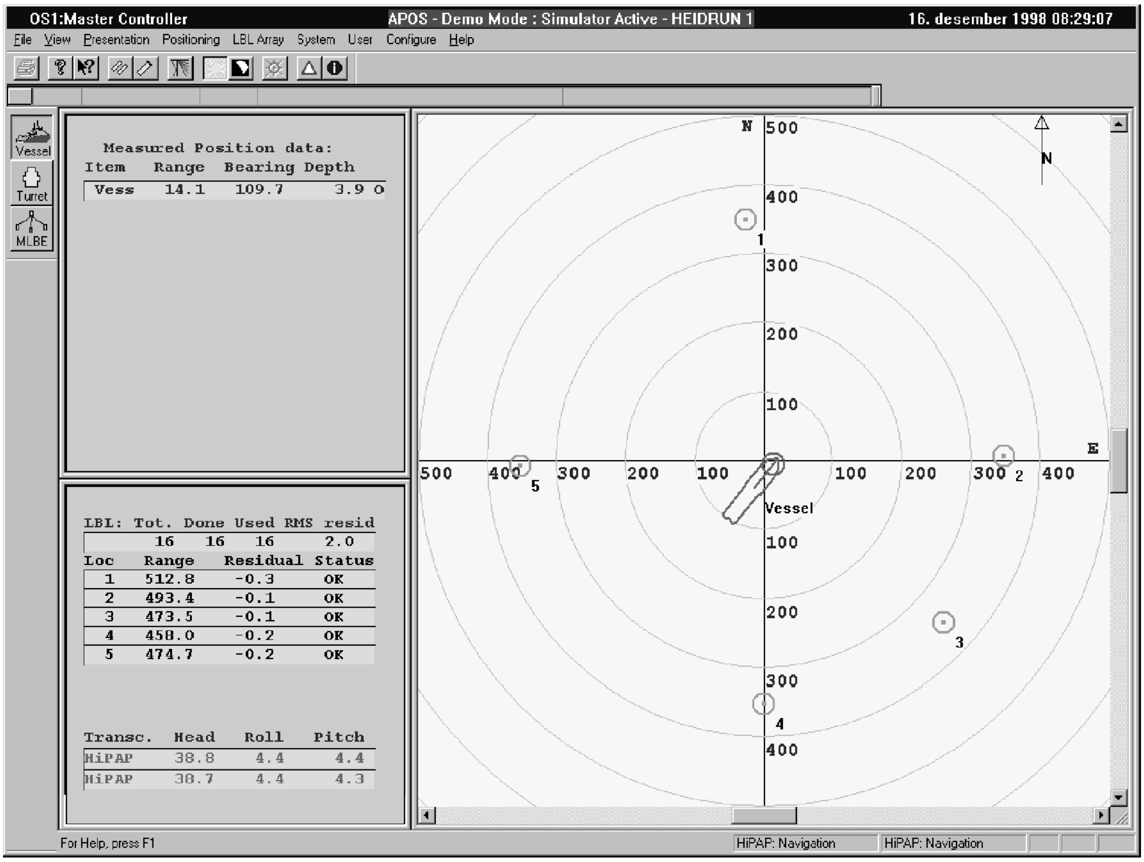
This new window contain many parameters.

- **Activate**; “On” / ”Off”
- **Interrogation interval**; tells the system how often you want to interrogate.
- **Transducer**; decides which transceiver and transducer to use to transmit and recieve (if more than one is fitted).
- **Transmit power**; decides how much power to be used when transmitting.
- **Max range**; sets max range for the system.
- **Locations**; decides which locations to be used in the LBL positioning and whether only ranges shall be used or both ranges and angles.
- **Auto exclude**; enables you to exclude inaccurate measurements from the position calculation.
- **Deskew**; lets the system compensate for the movements of the vessel during interrogation of the array.

• Use default settings.

• Remember to enter the tick mark in the **Activate** check box.





The upper left Numeric view displays:

- Vessel position relative the base point.
- Depth is the differenece between CG and the surface. Positive Depth values mean that CG is below the surface.

The lower left Numeric view displays:

- Number of measurements used to find the position
- RMS residual
- Location number
- Ranges to the transponders
- Residual for each range measurement
- Status of the measurement; OK, TM (timeout), EX (exclude)
- Heading, roll and pitch for the vessel

A faster way to start and stop LBL vessel positioning is to click at the vessel symbol.

- Try to stop and start LBL positiong by using the Vessel button.

8.5.6 MLBE positioning during approaching

Before mooring and loading you should check the depths of all the MLBE transponders at the appropriate time according to the loading procedure. The MLBE transponders have depth sensors. The depths are transmitted to the vessel every time the transponders are interrogated.

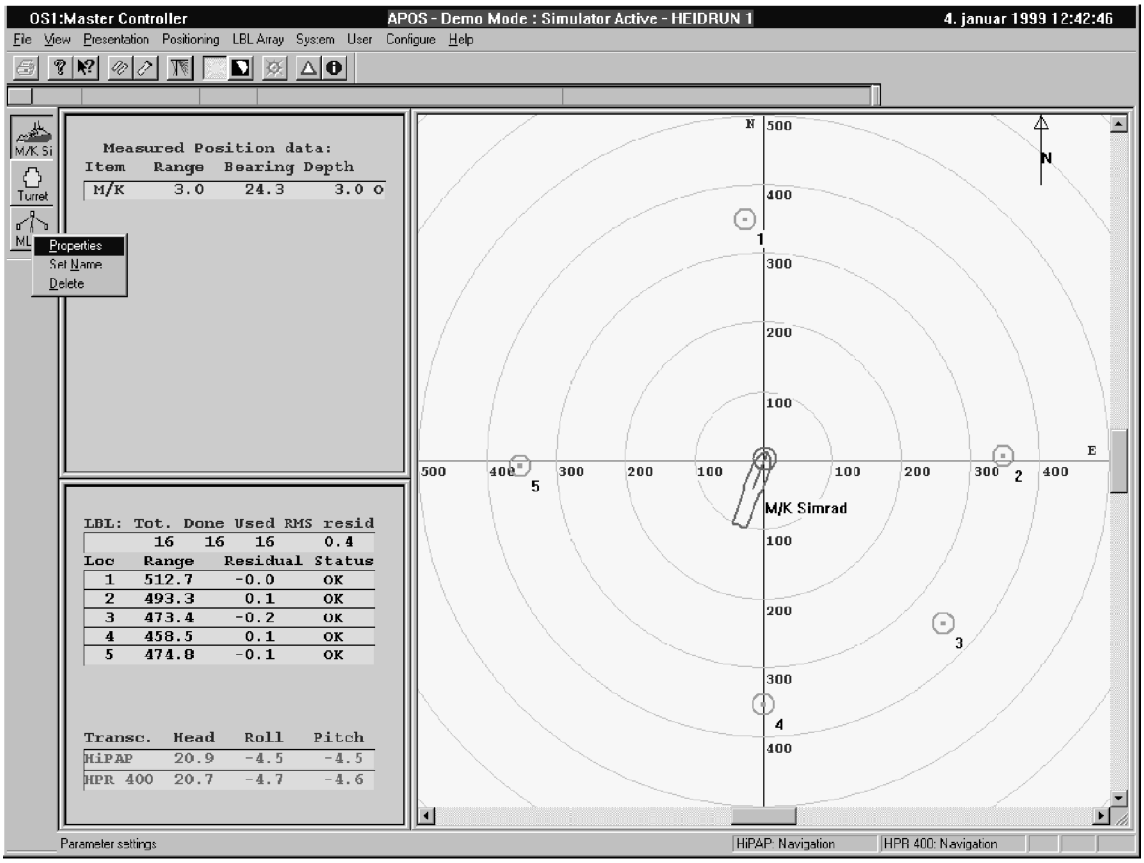
The positioning has to be done in the so called **Scan** mode. The **Scan** mode will start SSBL positioning of the eight MLBE transponders. The transponders will be positioned in sequence, with 10 measurements being taken for each transponder.

When five acceptable depth measurements are received from a transponder, the tag and depth information will be displayed in yellow. When ten acceptable depth measurements are received from a transponder, the tag and depth information will be displayed in normal colour (black).

Once the HPR/HiPAP® system has completed one scan of the transponders, the interrogation will stop.

- Turn on the **MLBE positioning** in **Scan** mode.

(Place the cursor at the MLBE symbol in the toolbar and click the right mouse button. Click then at **Properties** to get the correct new window.)



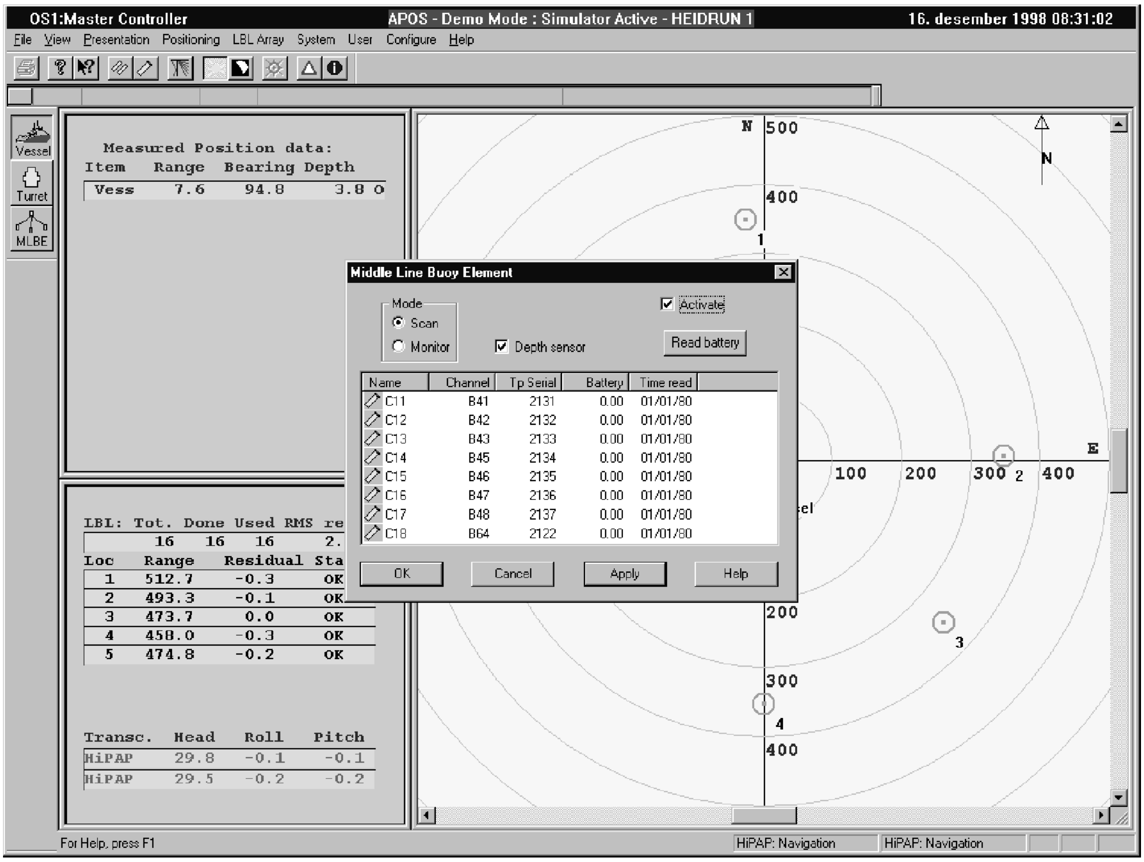
Another way is to select MLBE **positioning** from the **Positioning** menu.

From this new window you can see the transponder's name, channel, serial number and last battery status.

The **Depth sensor** check box decides if you want the depth sensor values from the transponders to be transmitted to the surface system or not. If this is not enabled the depths at the screen will only be the system' s calculated depths.

There is also a **Read battery** button. More about this later.

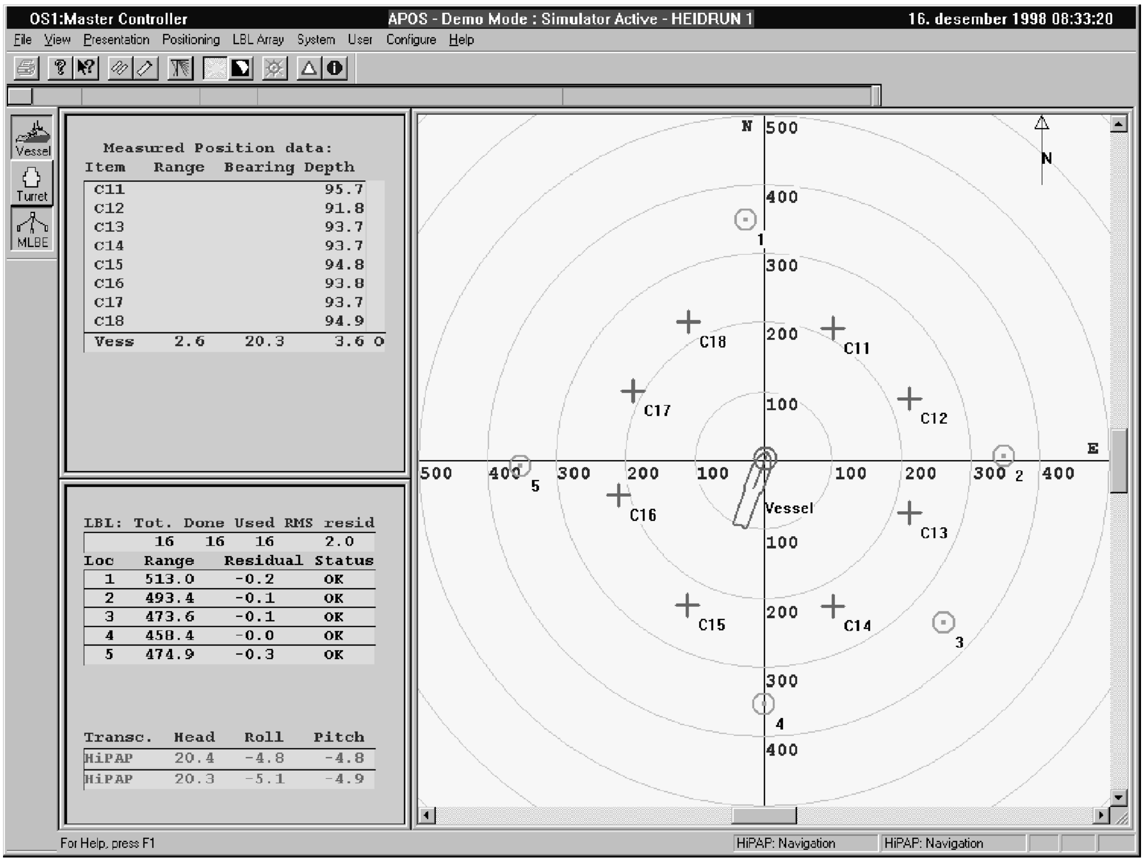
- Use **Depth sensor** and remember to select **Scan** mode and insert a tick mark in the **Activate** check box before you click OK.



In your display you should have the depth values written in the Numeric View.

The positions of the transponders are in addition displayed graphically in the main window.

- Wait until all of the transponders are in the display.

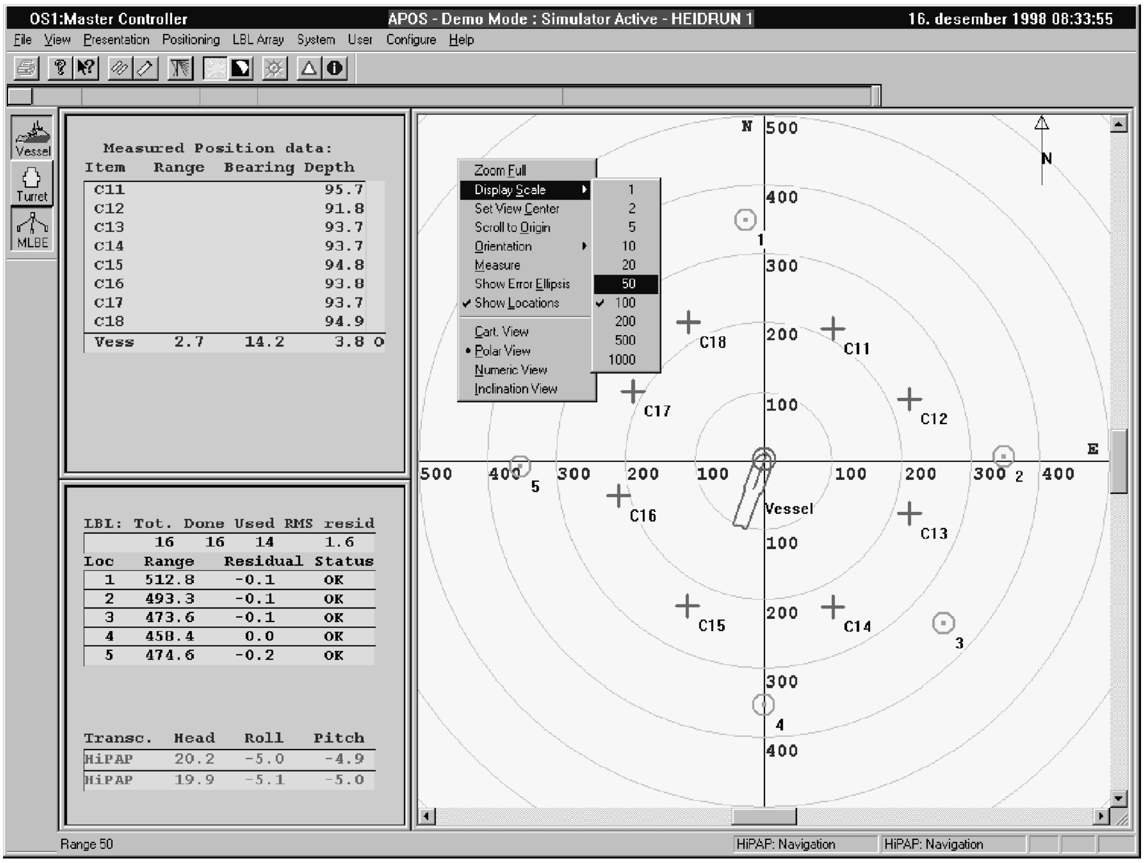


Another way to start and stop MLBE positioning is to click once at the MLBE button.

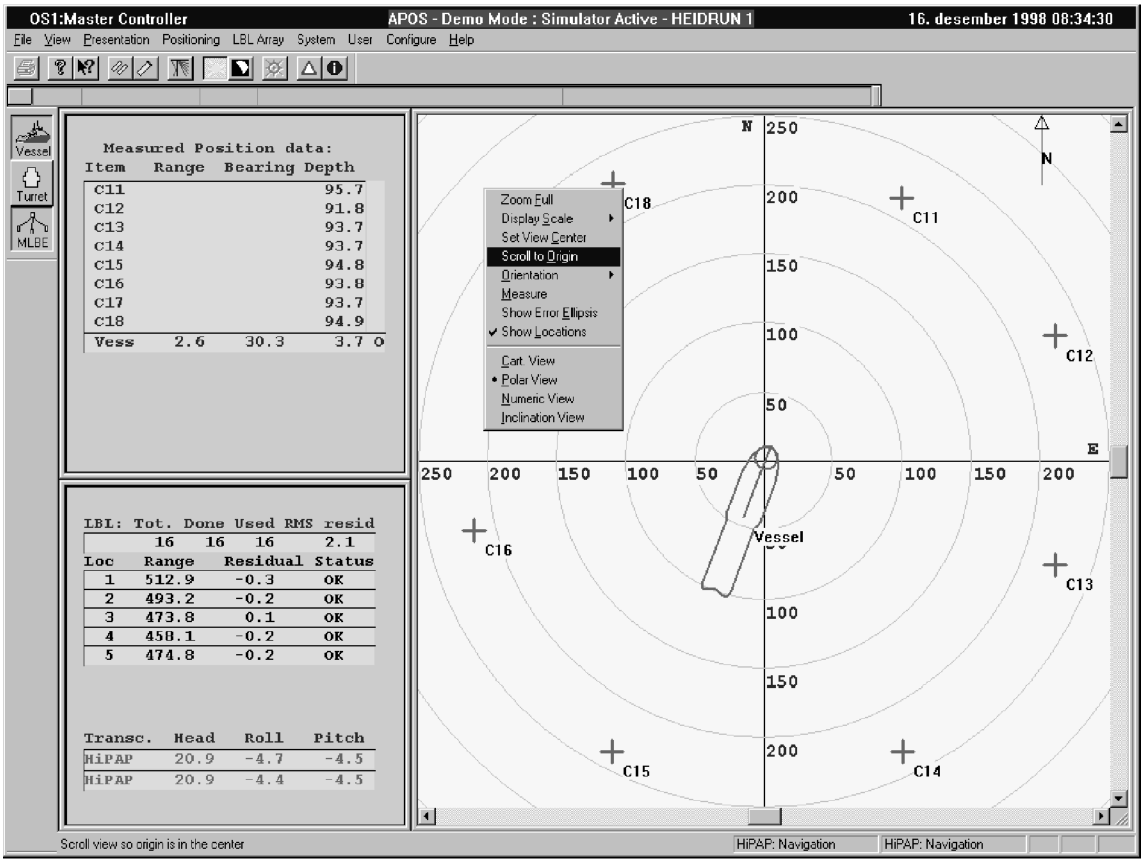
Notice that when you use the button, the system will select the mode you used last time you did this operation.

- Try to stop and start the MLBE positioning by using the MLBE button.

- Change **Display Scale** to 50m to fit the current operation.

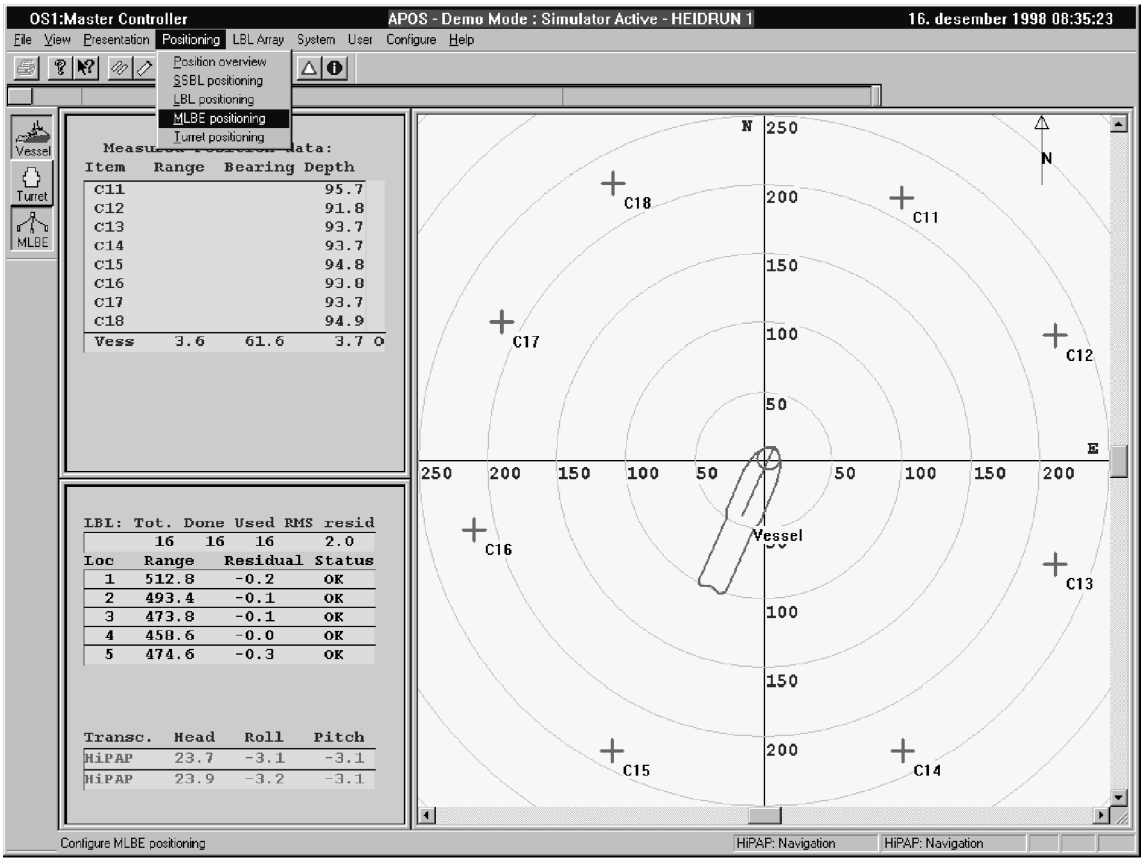


- **Scroll to origin** if the display is not in the center.

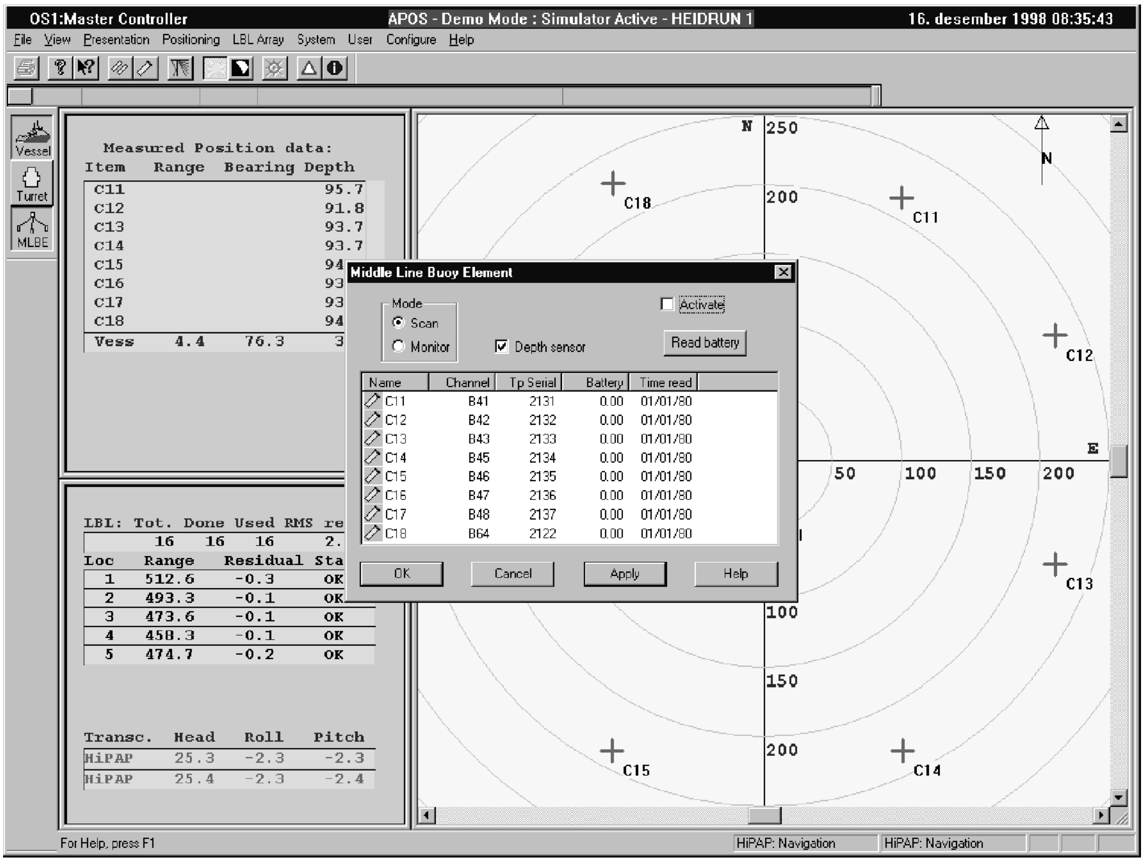


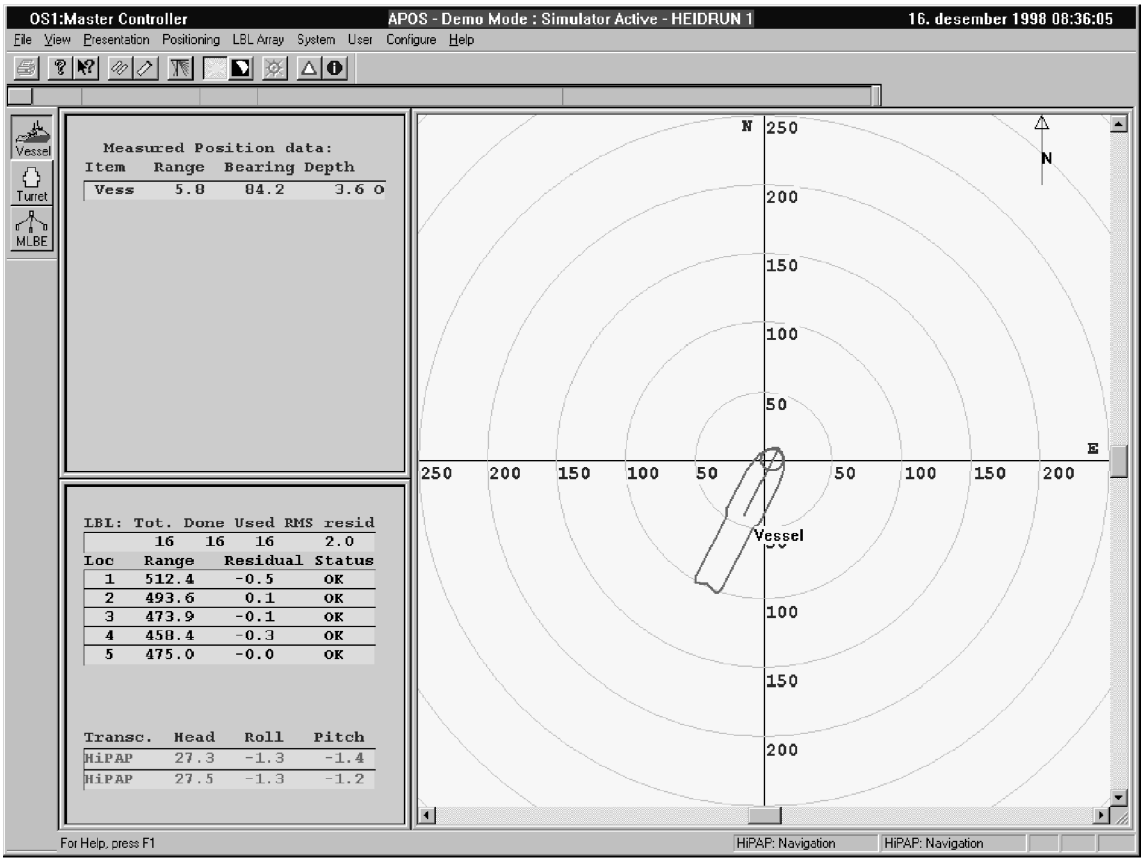
- Turn off the **MLBE positioning** when you have controlled that the depths are ok.

Remember that there is a more easy way to stop MLBE positioning than these screen dumps show you.



- Remember to take away the tick mark in the **Activate** check box before you click OK.




OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 08:36:05
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
Vess 5.8 84.2 3.6 O
LBL: Tot. Done Used RMS resid
16 16 16 2.0
Loc Range Residual Status
1 512.4 -0.5 OK
2 493.6 0.1 OK
3 473.9 -0.1 OK
4 458.4 -0.3 OK
5 475.0 -0.0 OK
Transc. Head Roll Pitch
HiPAP 27.3 -1.3 -1.4
HiPAP 27.5 -1.3 -1.2
N
E
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

8.5.7 Turret positioning during connection operation

The system is now ready to position the STL buoy.

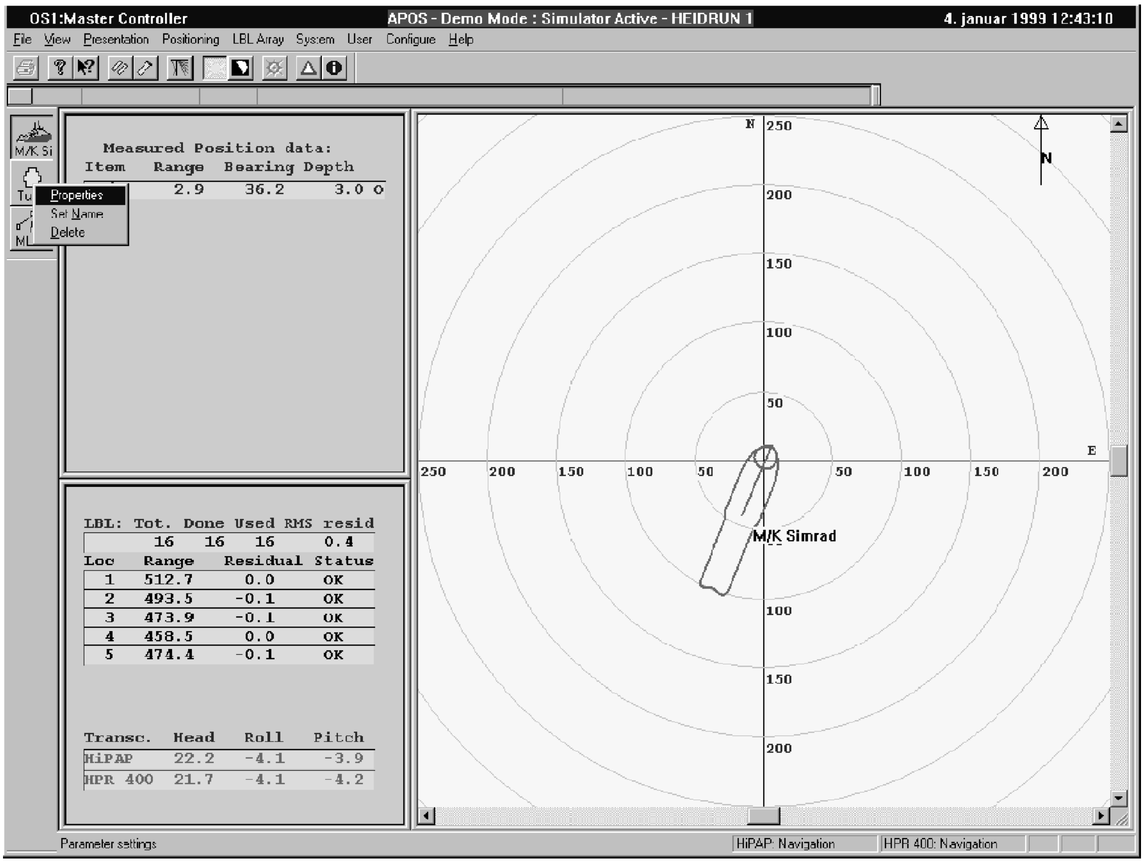
There are three transponders connected to the STL buoy. When the HPR/HiPAP system is set to the Search mode, it will automatically select the best STL buoy transponder to be interrogated during the connection operation. Only the position for this transponder will be displayed.

- Start **Turret positioning** in **Search** mode.

There are more than one way to start Turret positioning:

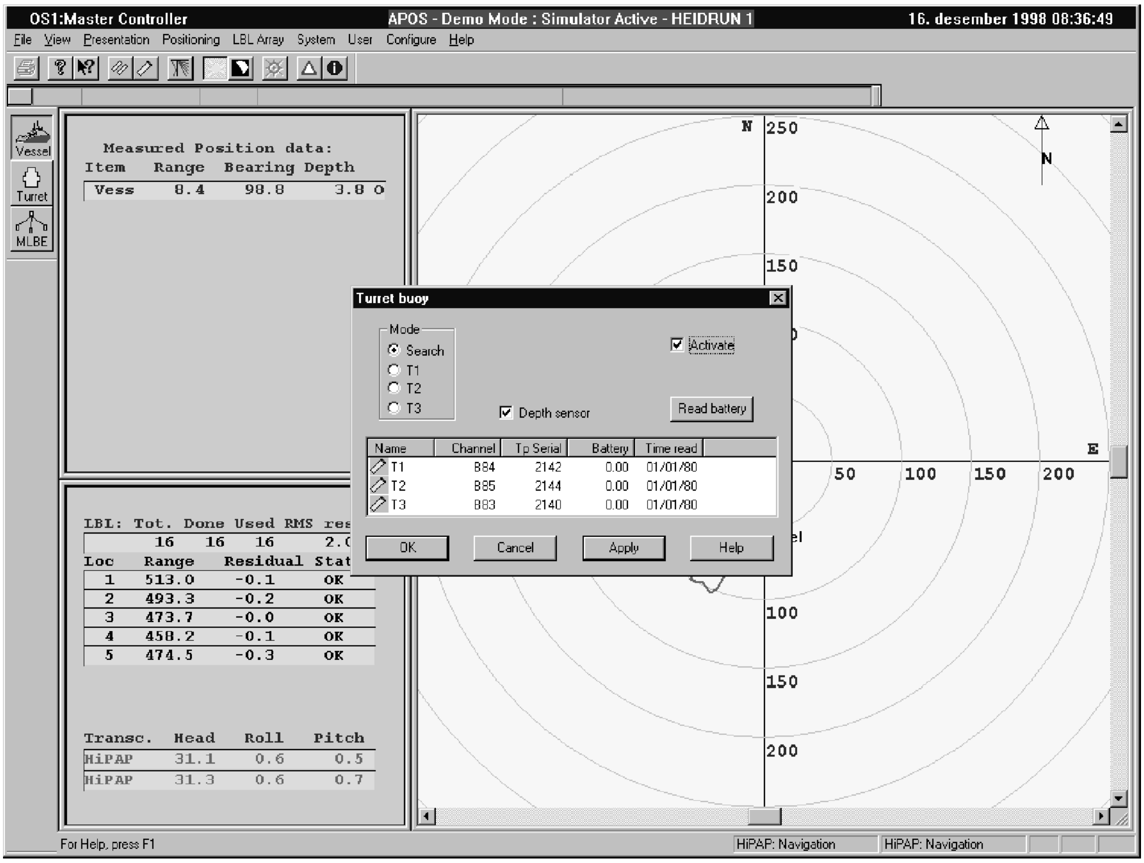
One way is to select **Turret positioning** from the **Positioning** menu.

The other way is to place the cursor at the Turret symbol in the toolbar and click the right mouse button. Click then at **Properties** to get the correct new window.



You have the same parameters and buttons as in the MLBE window; transponder's name, channel, serial number and last battery status. You also have the **Depth sensor** check box and the **Read battery** button. More about that later.

- Select **Depth sensor** and remember to select **Search** mode and insert a tick mark in the **Activate** check box before you click OK.

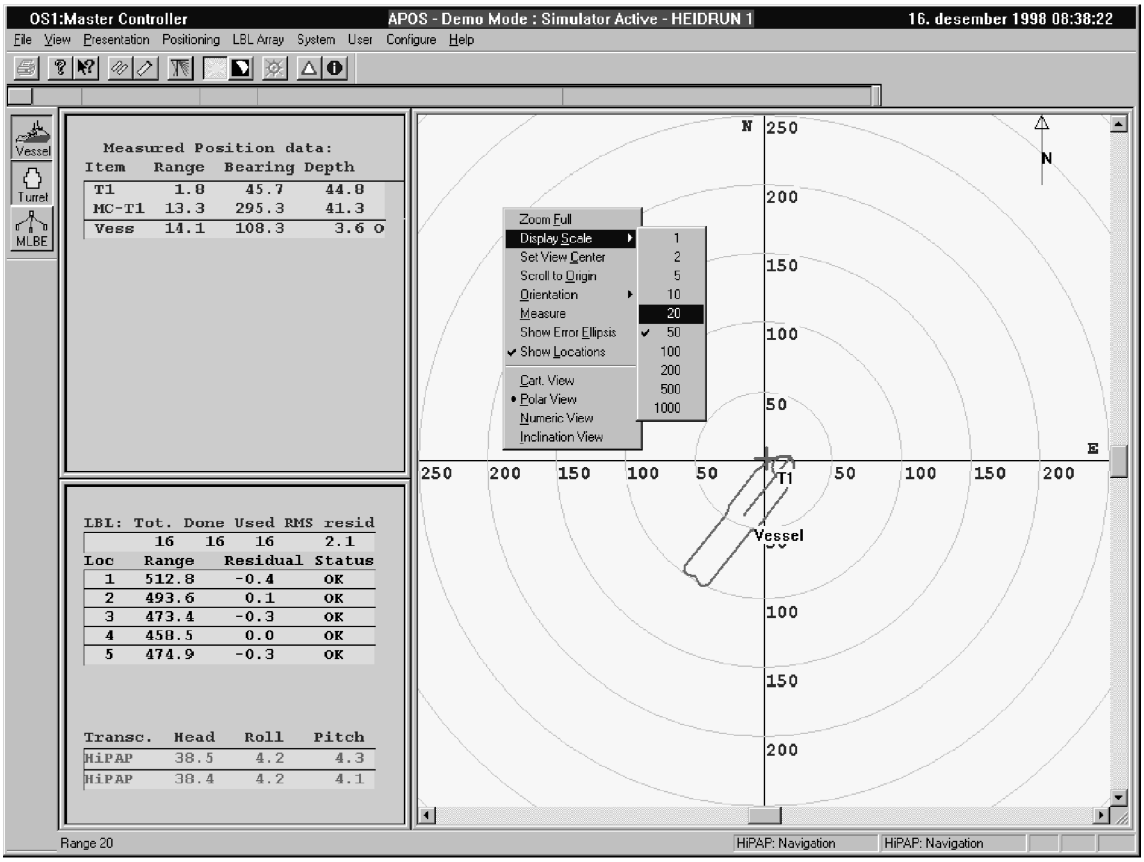


The STL buoy transponder position will be displayed in the numerical field with range and bearing, relative both to the field centre (Tn) and to the mating cone (MC–Tn). The bearing from the cone to the transponder is relative to the vessel s heading.

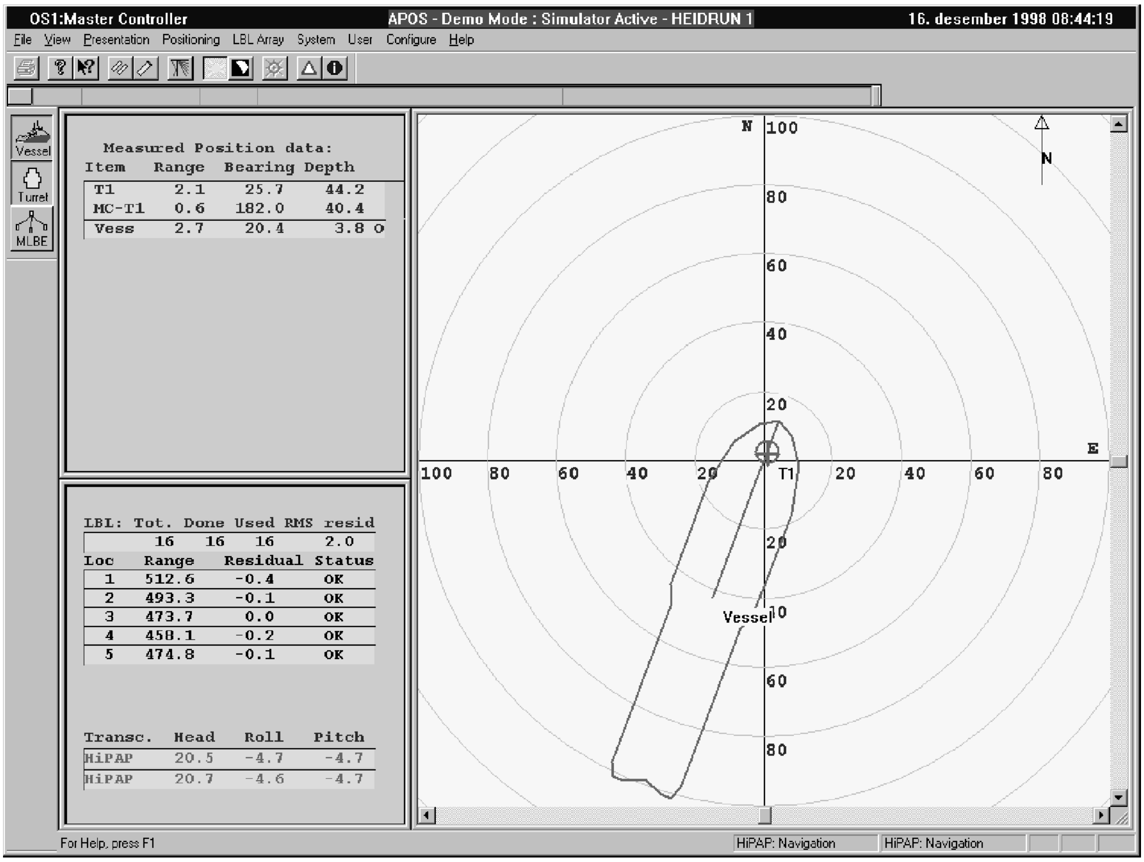
Another way to start and stop turret positiong is to click at the Turret button.

- Try to stop and start turret positioning using the **Turret button**.

- To zoom in the graphical presentation of the **STL buoy** and the **Mating cone** select 20m as **Display scale**.



If the turret and mating cone are some metres away from each other wait and see if the simulator rotates the vessel after some time.



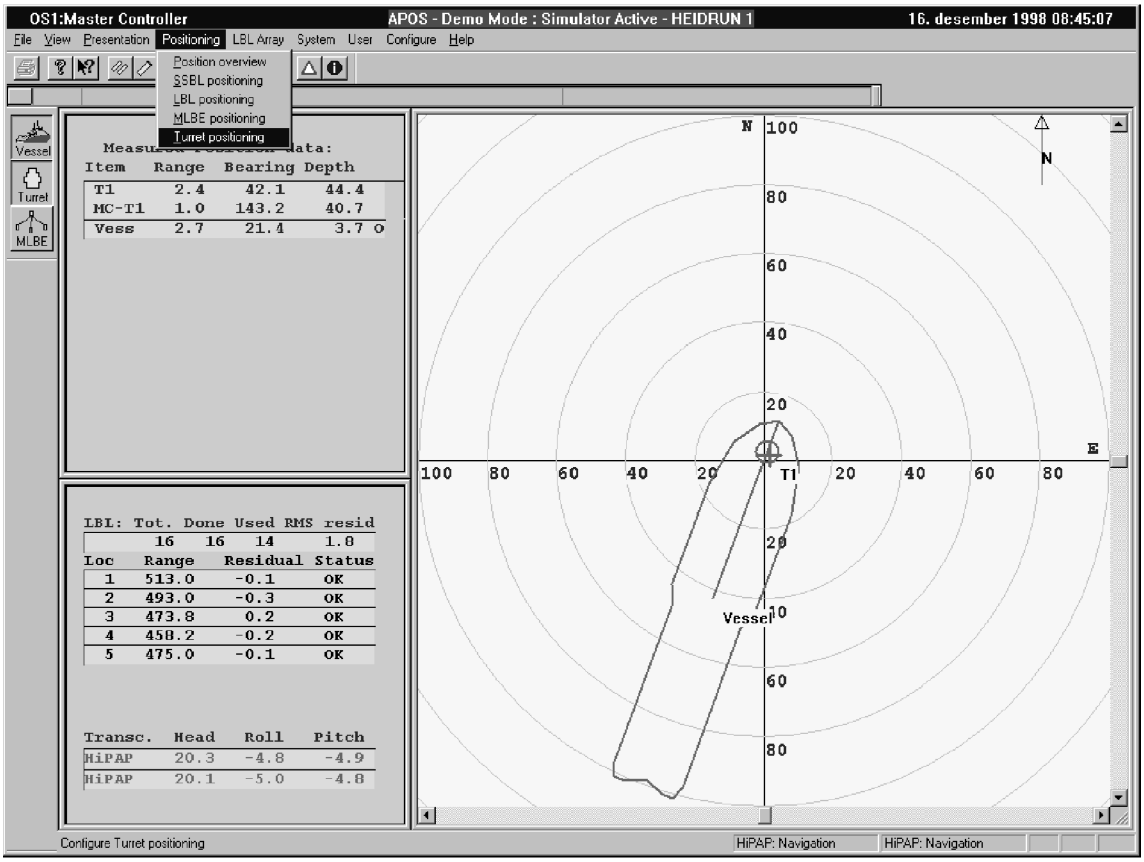
8.5.8 Approach to base point

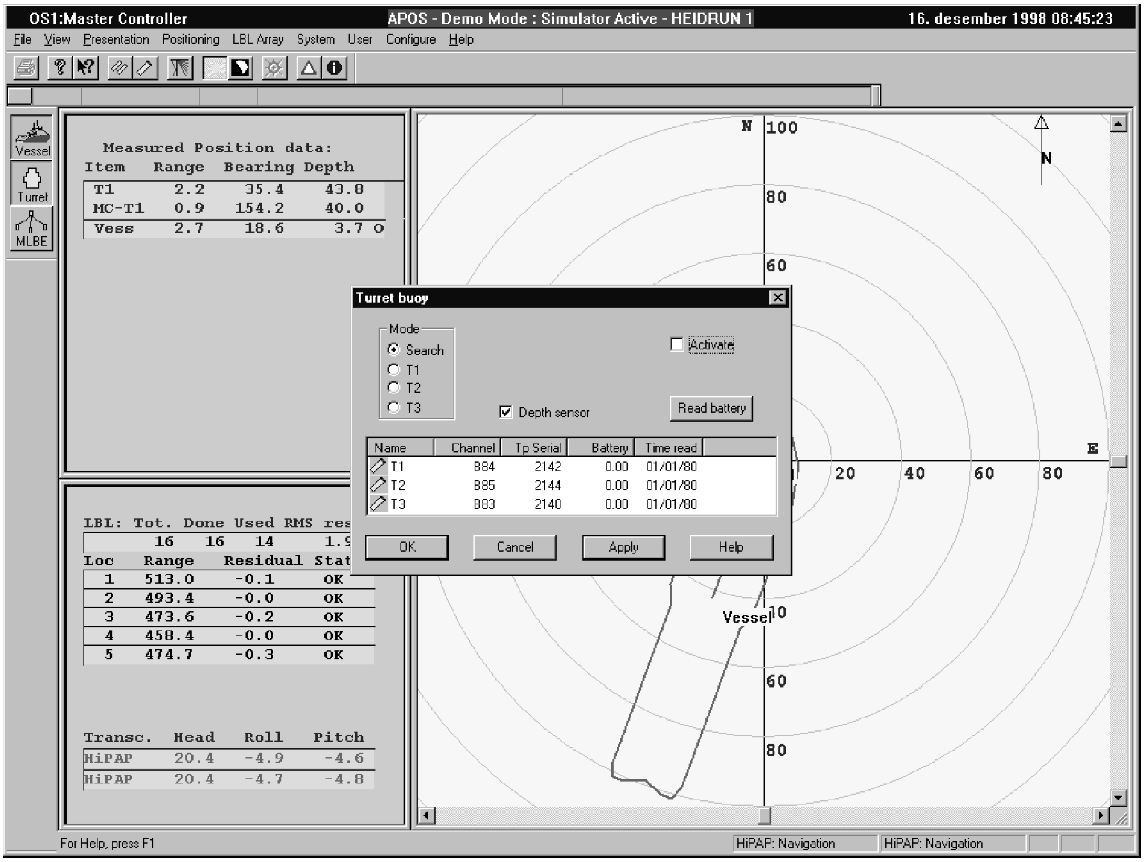
The HPR/HiPAP® system will alternate between vessel positioning and STL buoy positioning. This mode should continue until the STL buoy is five metres vertically below the keel of the vessel.

Switch off the STL interrogation when the turret transponder data is shown in red, or when the Turret is in position.

- Assume the STL buoy is just below the keel.
- Switch off the **Turret positioning**.

Remember that there is a more easy way to stop Turret positioning than these screen dumps show you.




OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 08:45:23
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
T1 2.2 35.4 43.8
MC-T1 0.9 154.2 40.0
Vess 2.7 18.6 3.7
Turret buoy
Mode
Search
T1
T2
T3
Activate
Depth sensor
Read battery
Name Channel Tp Serial Battery Time read
T1 B84 2142 0.00 01/01/80
T2 B85 2144 0.00 01/01/80
T3 B83 2140 0.00 01/01/80
OK
Cancel
Apply
Help
LBL: Tot. Done Used RMS
16 16 14
Loc Range Residual
1 513.0 -0.1 OK
2 493.4 -0.0 OK
3 473.6 -0.2 OK
4 458.4 -0.0 OK
5 474.7 -0.3 OK
Transc. Head Roll Pitch
HiPAP 20.4 -4.9 -4.6
HiPAP 20.4 -4.7 -4.8
N
100
80
60
E
20
40
60
80
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

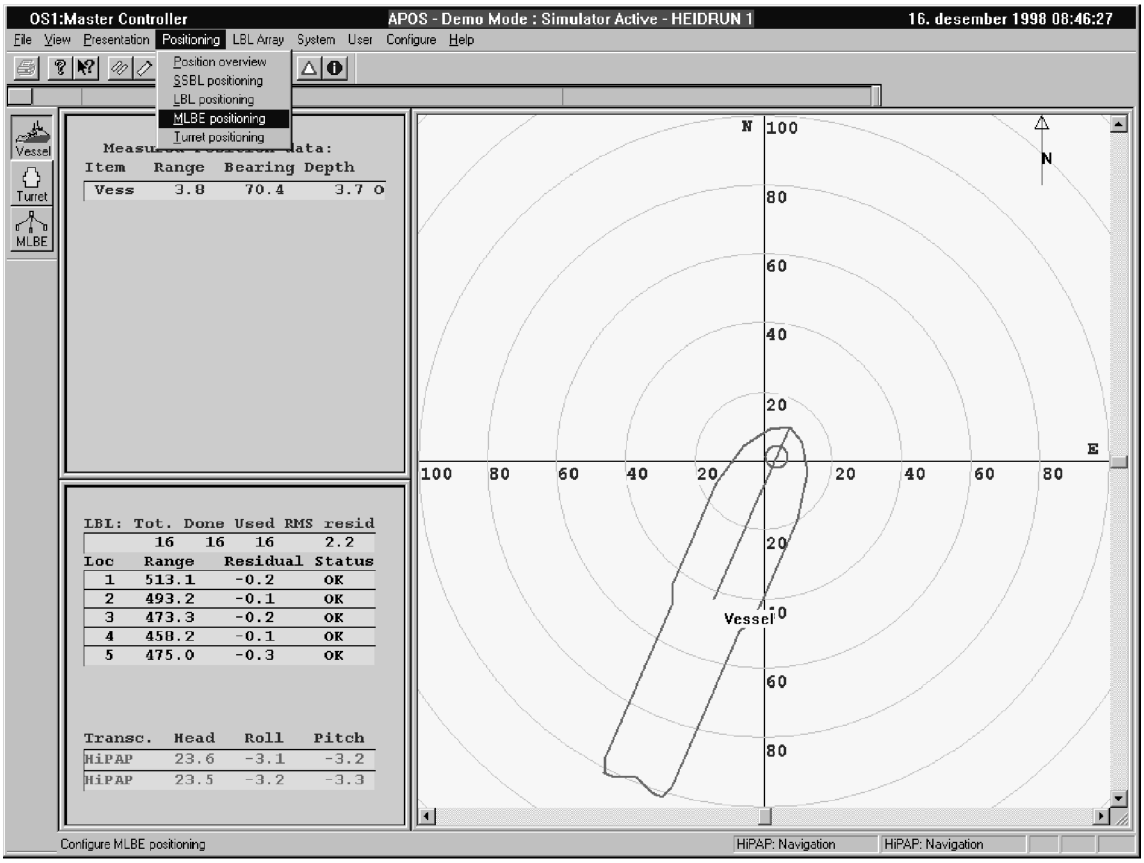
8.5.9 MLBE positioning during loading

Once the vessel is moored to the STL buoy, the slow **Monitor** MLBE buoy positioning mode should be used.

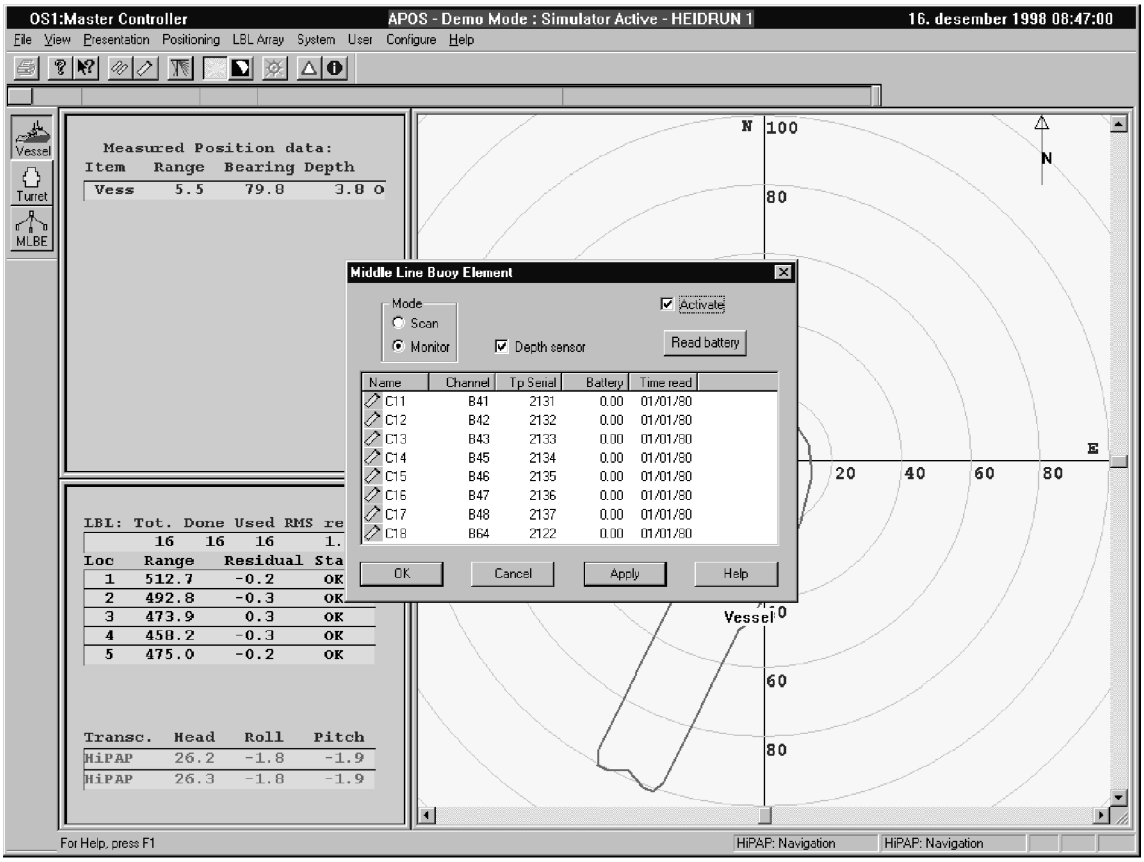
Once every ten minutes the system will position one of the MLBE transponders, positioning it ten times. The HPR/HiPAP system will follow this routine automatically, and will switch to the next MLBE transponder in the sequence after each ten minute interval. All the MLBE transponders will therefore be positioned over an 80–minute period, and the displayed MLBE information will be updated continuously.

- Turn on the **MLBE positioning** in **Monitor** mode.

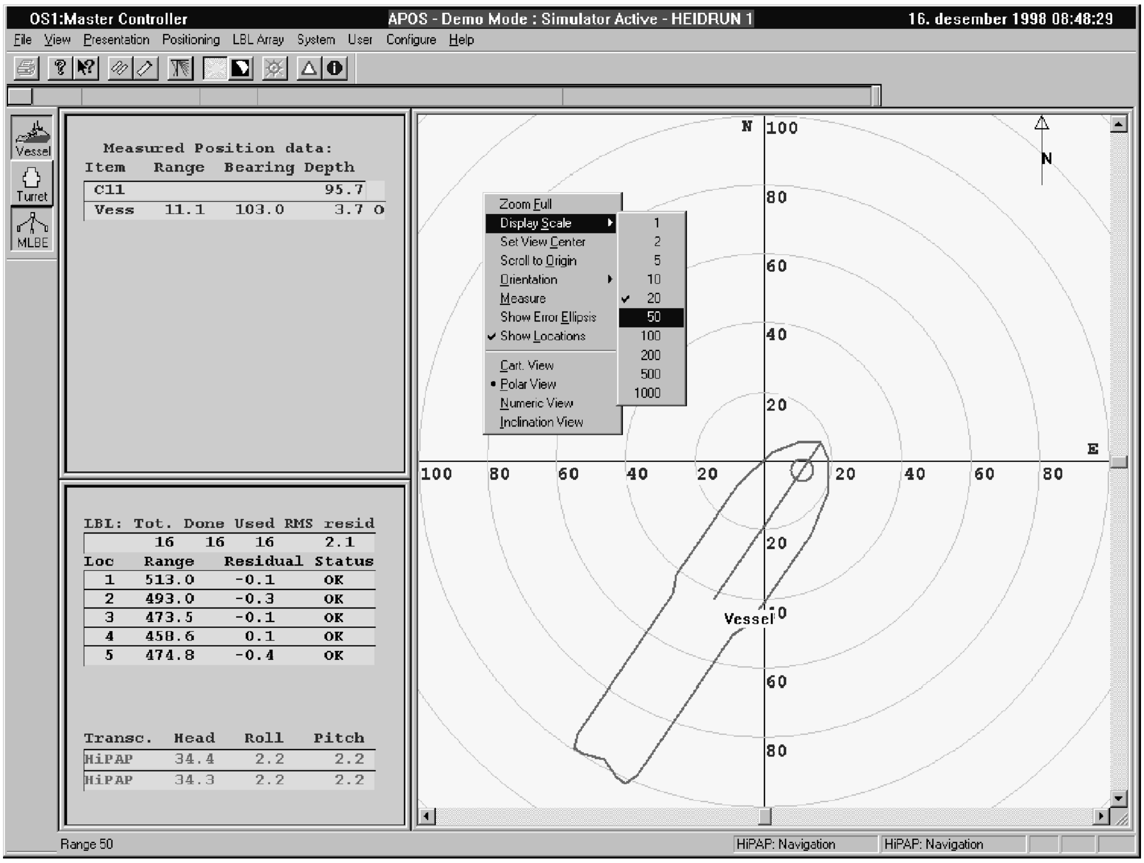
You can not use the MLBE button because this will start MLBE positioning in Scan mode, which was the mode you used last time you used this function.



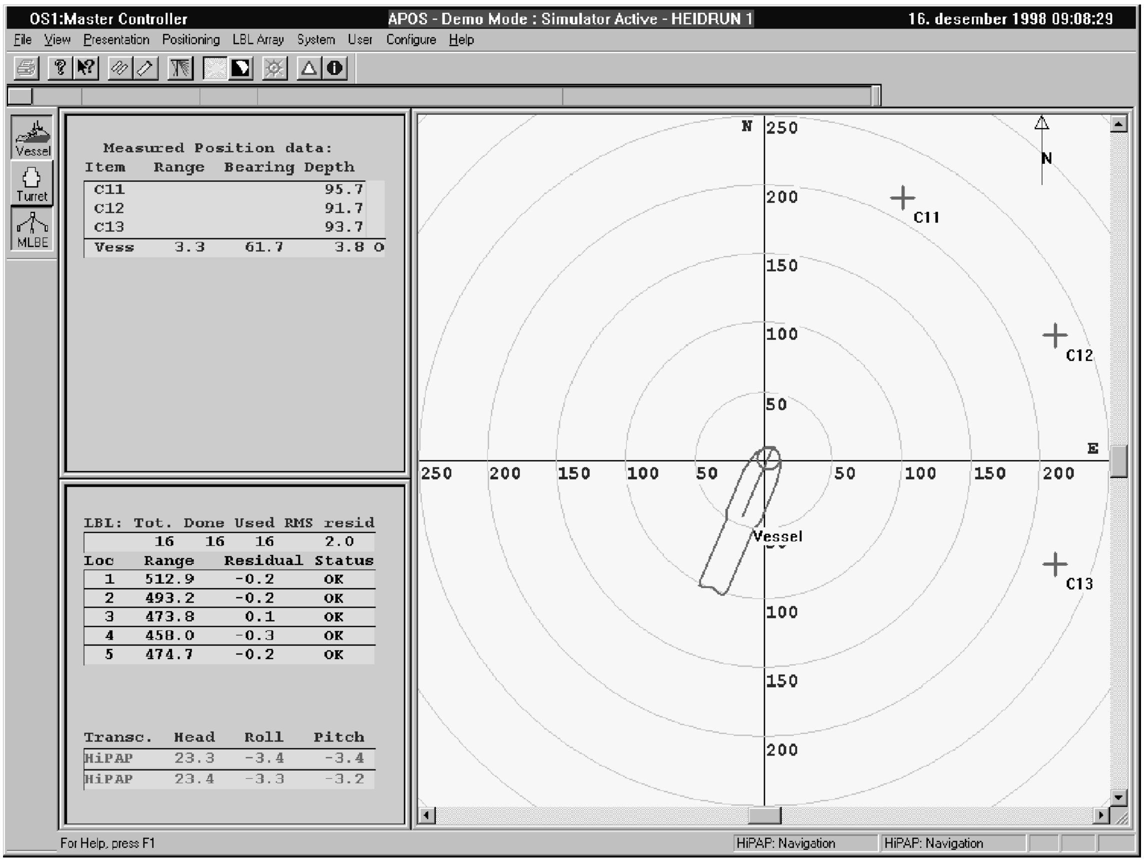
- Remember to select **Monitor** mode and insert a tick mark in the **Activate** check box before you click OK.



- Change **Display scale** to 50 m to better fit the operation.

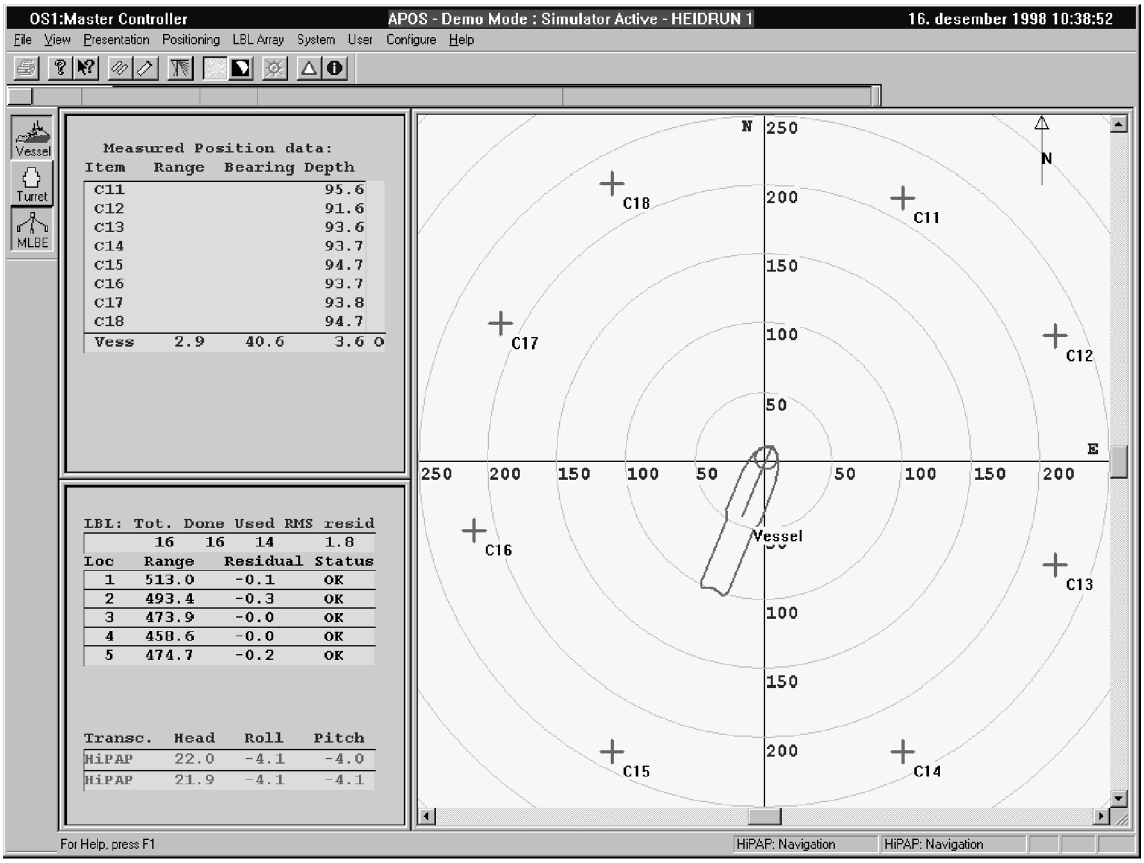


After some minutes you should have a display like this with only a few MLBE transponders displayed.



After one "round" the display might look like this.

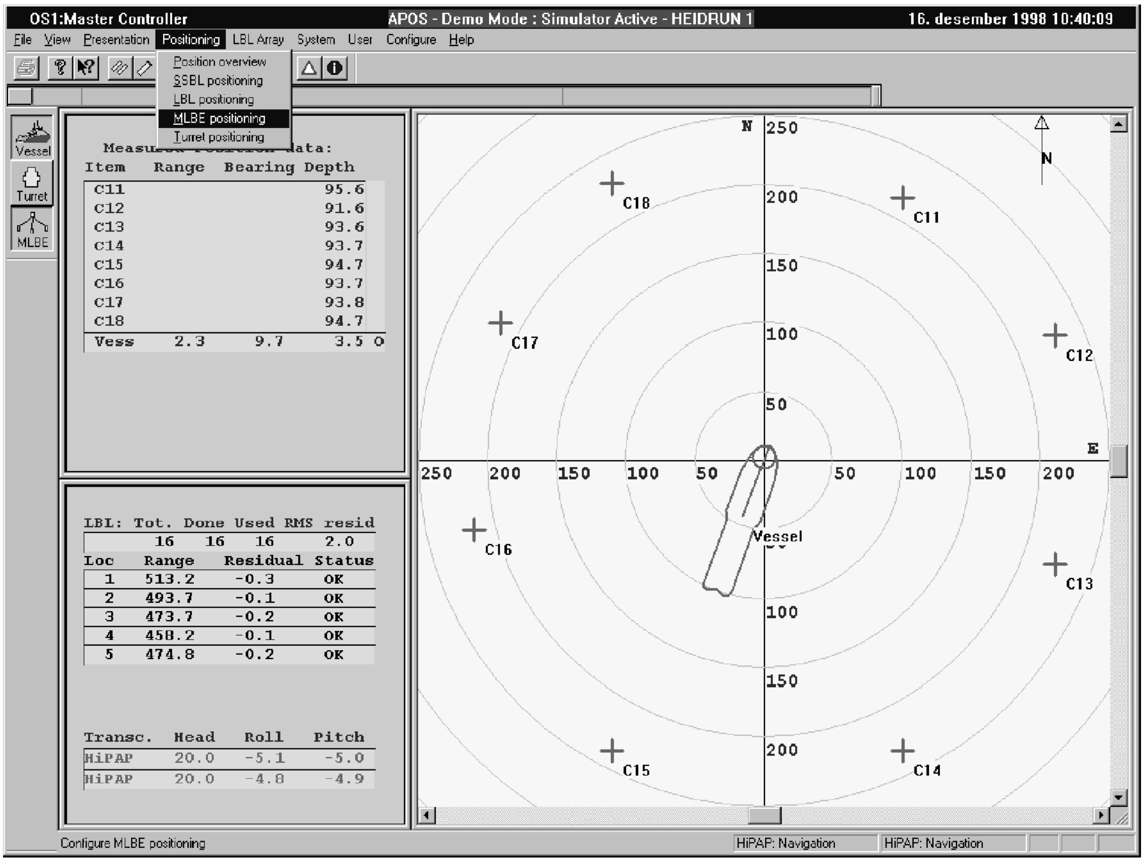
The system will continue to position the MLBE transponders during the loading period.

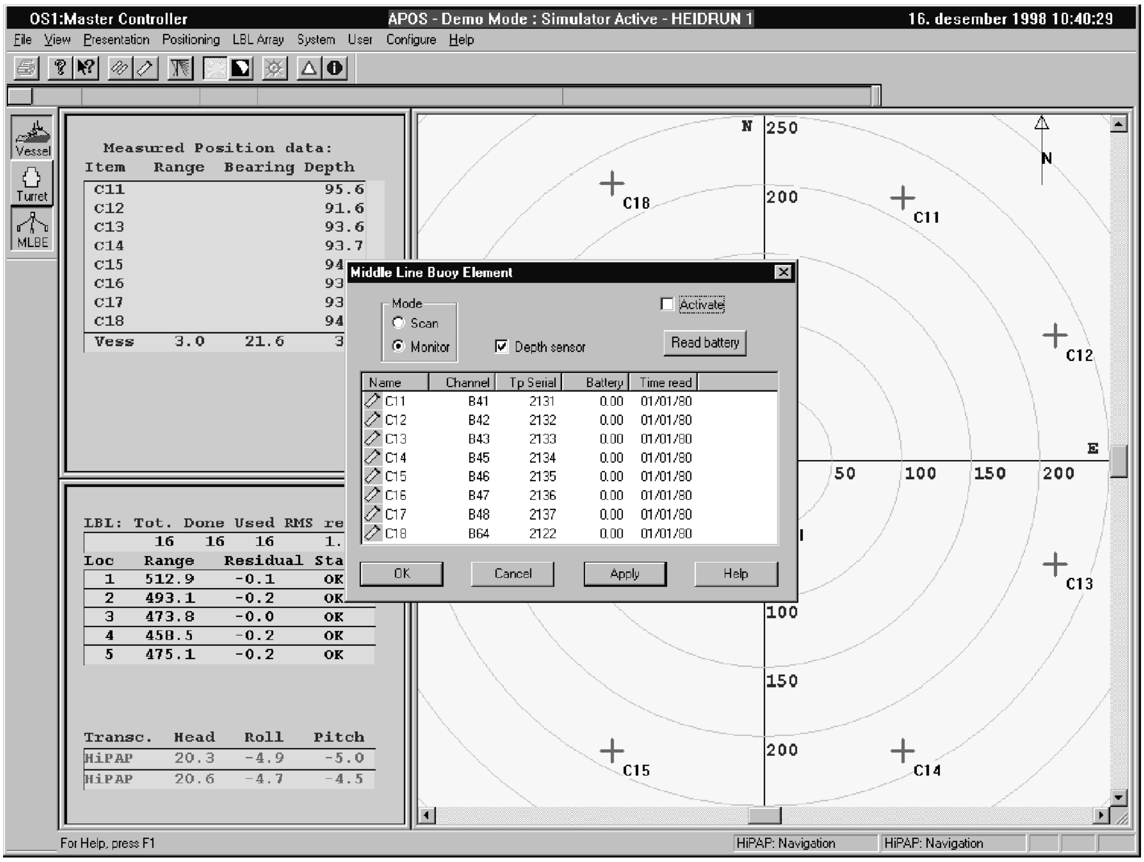


8.5.10 Disconnecting the STL buoy

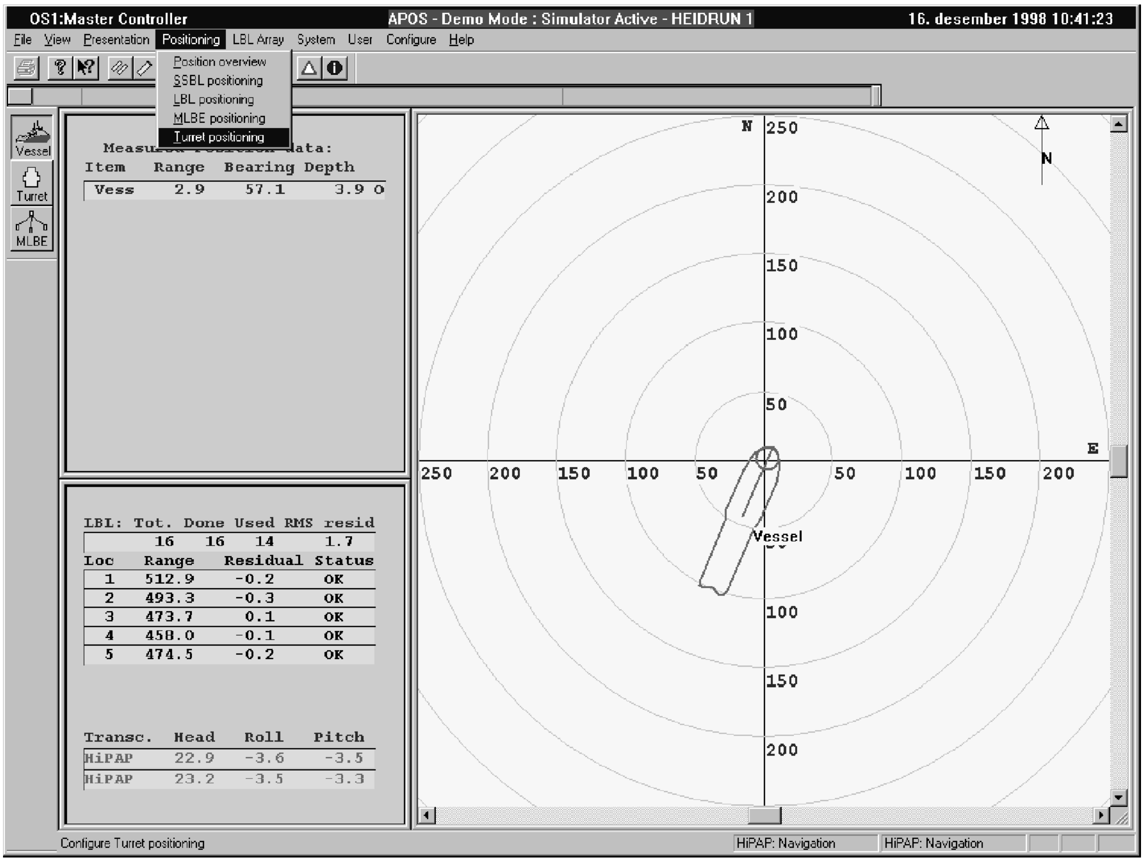
When you have finsihed loading and are ready to disconnect the STL buoy, you have to turn off the MLBE positioning function.

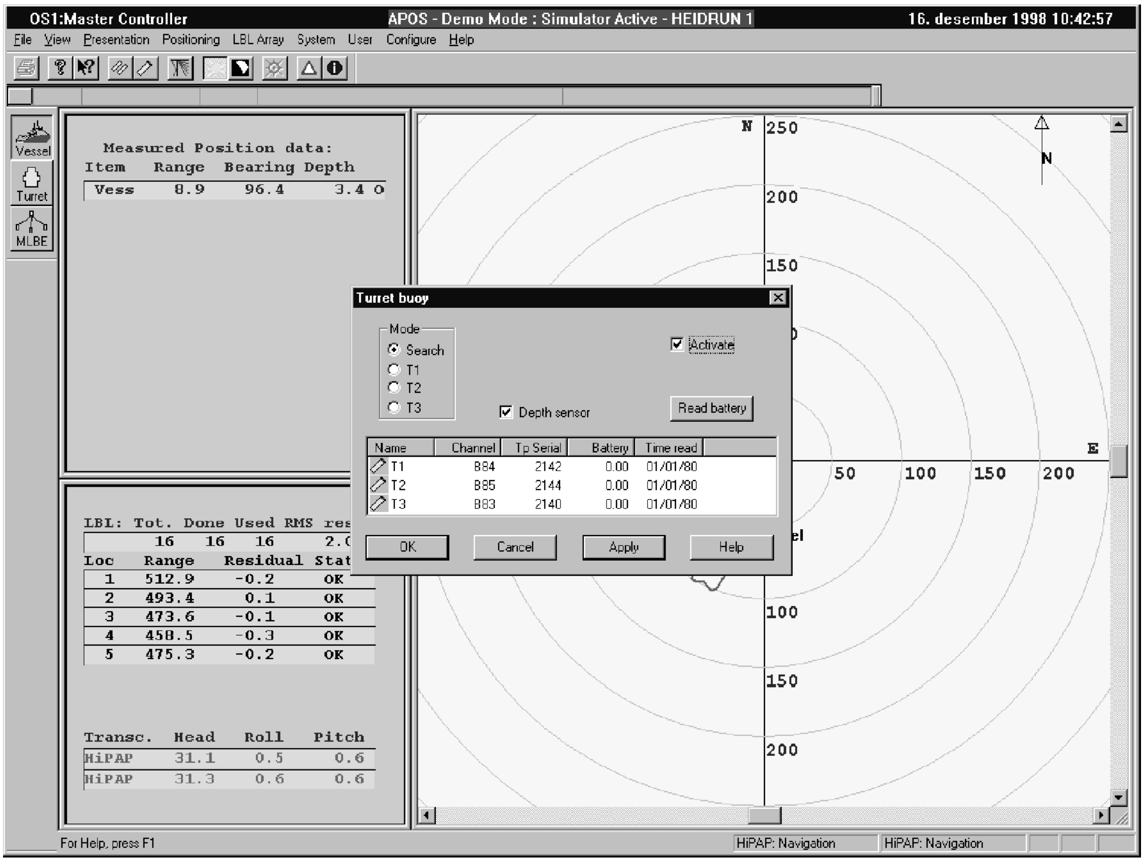
- Turn off the **MLBE positioning**.

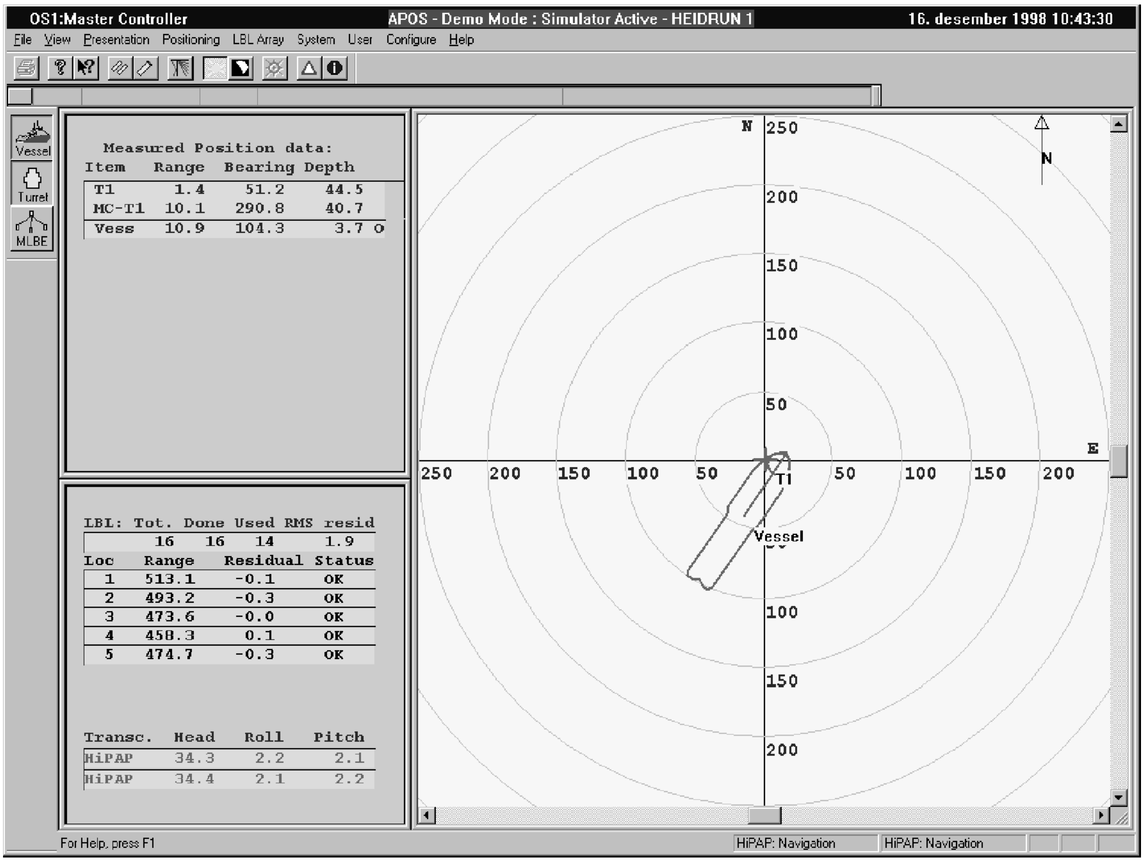



OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 10:40:29
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
C11 95.6
C12 91.6
C13 93.6
C14 93.7
C15 94
C16 93
C17 93
C18 94
Vess 3.0 21.6 3
LBL: Tot. Done Used RMS re
16 16 16 1.
Loc Range Residual Sta
1 512.9 -0.1 OK
2 493.1 -0.2 OK
3 473.8 -0.0 OK
4 458.5 -0.2 OK
5 475.1 -0.2 OK
Transc. Head Roll Pitch
HiPAP 20.3 -4.9 -5.0
HiPAP 20.6 -4.7 -4.5
Middle Line Buoy Element
Mode
Scan
Monitor
Depth sensor
Activate
Read battery
Name Channel Tp Serial Battery Time read
C11 B41 2131 0.00 01/01/80
C12 B42 2132 0.00 01/01/80
C13 B43 2133 0.00 01/01/80
C14 B45 2134 0.00 01/01/80
C15 B46 2135 0.00 01/01/80
C16 B47 2136 0.00 01/01/80
C17 B48 2137 0.00 01/01/80
C18 B64 2122 0.00 01/01/80
OK
Cancel
Apply
Help
N
250
200
100
150
200
50
100
150
200
E
C18
C11
C12
C13
C15
C14
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

- Start **Turret positioning** in **Search** mode.

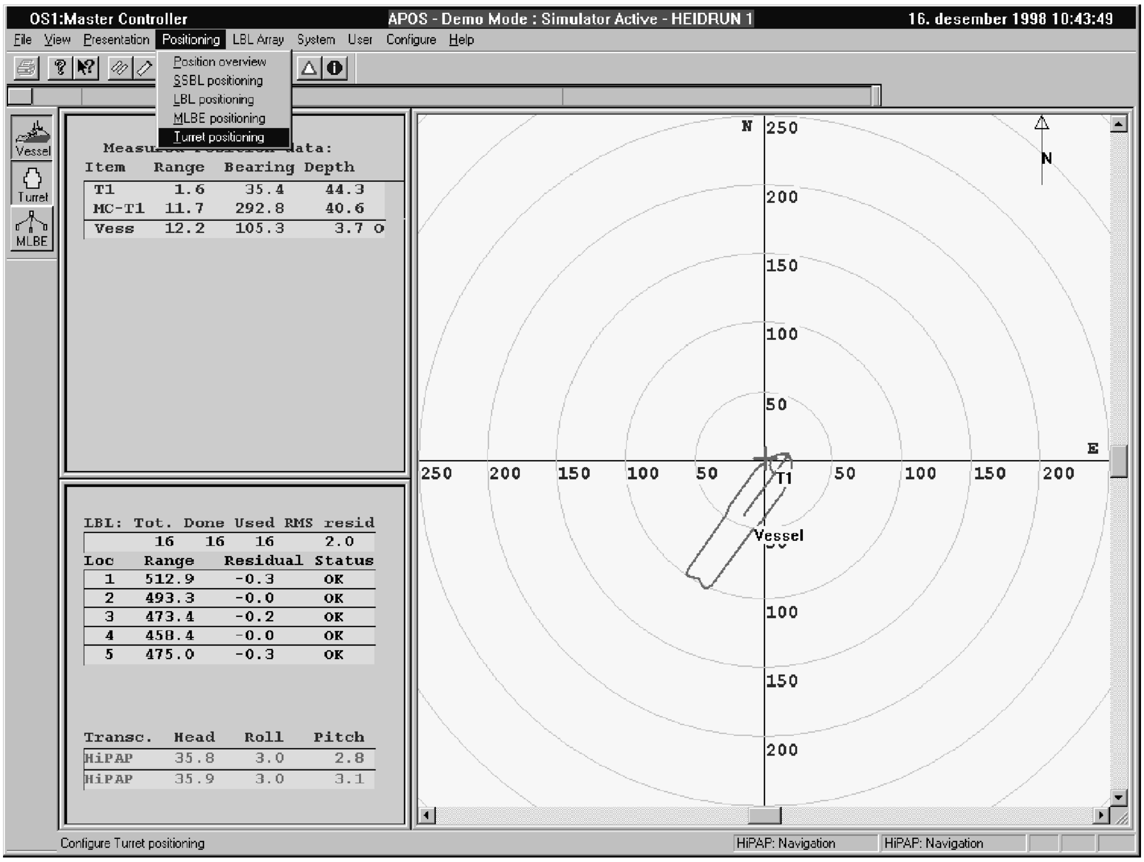


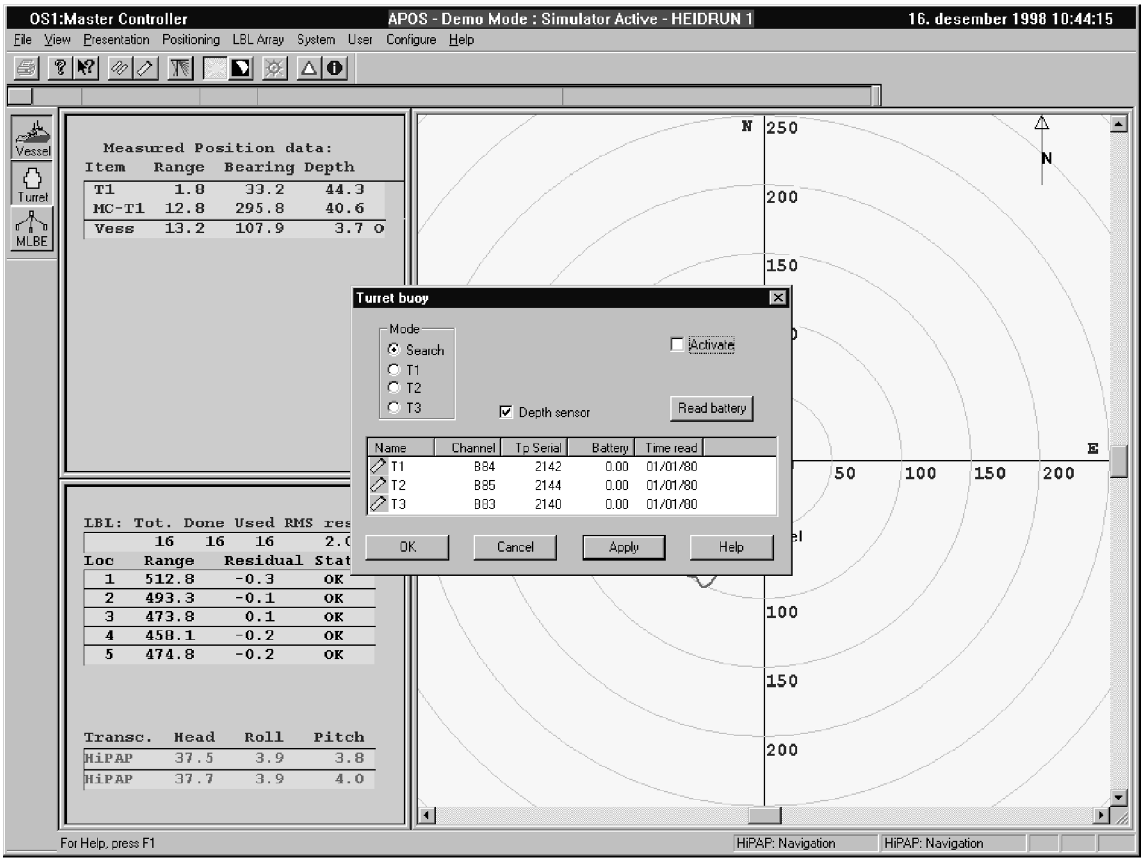

OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 10:42:57
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
Vess 8.9 96.4 3.4
LBL: Tot. Done Used RMS res
16 16 16
Loc Range Residual Stat
1 512.9 -0.2 OK
2 493.4 0.1 OK
3 473.6 -0.1 OK
4 458.5 -0.3 OK
5 475.3 -0.2 OK
Transc. Head Roll Pitch
HiPAP 31.1 0.5 0.6
HiPAP 31.3 0.6 0.6
Turret buoy
Mode
Search
T1
T2
T3
Activate
Depth sensor
Read battery
Name Channel Tp Serial Battery Time read
T1 B84 2142 0.00 01/01/80
T2 B85 2144 0.00 01/01/80
T3 B83 2140 0.00 01/01/80
OK
Cancel
Apply
Help
N
E
250
200
150
50
100
150
200
100
150
200
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation



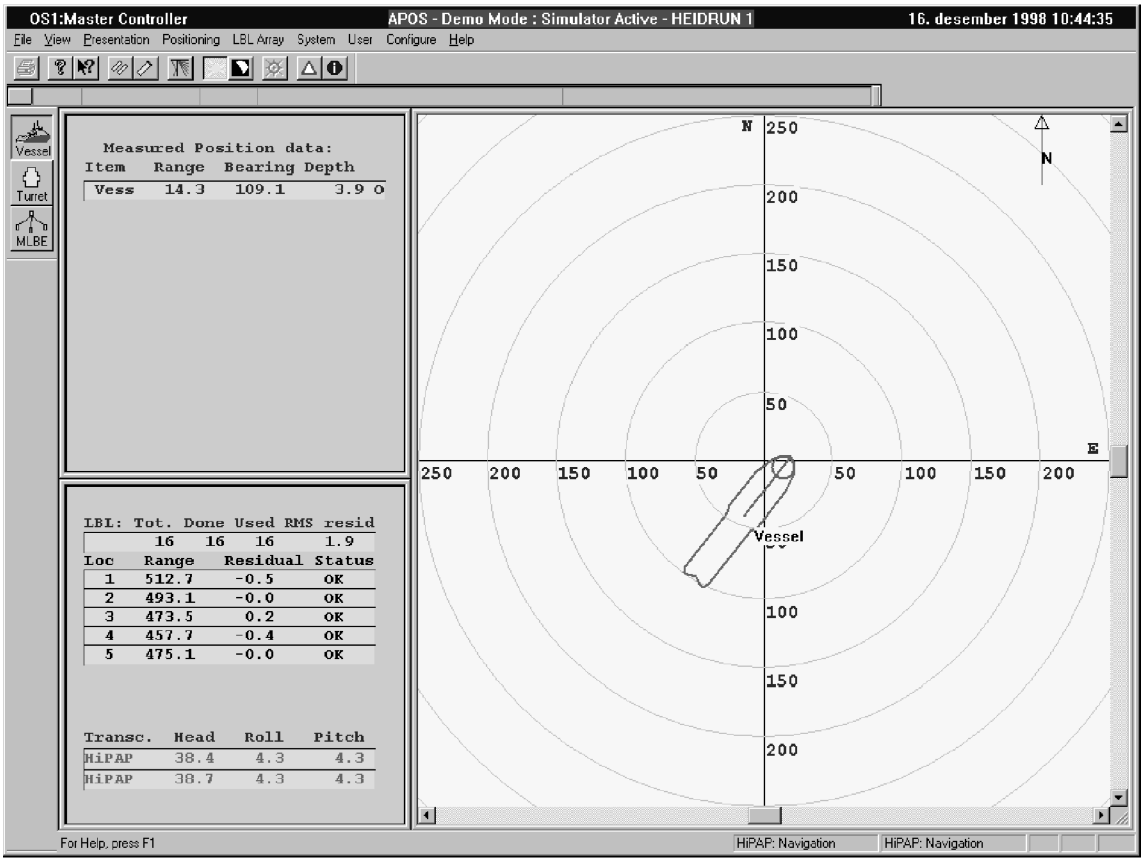
After five replies have not been accepted, the software should automatically attempt to interrogate one of the other transponders. When the STL buoy is being lowered, the system should lock on to one of the transponders, and the HPR system should now alternate between positioning the vessel and positioning the STL buoy.

- When the STL buoy has reached its neutral position, turn off the **Turret Positioning**.





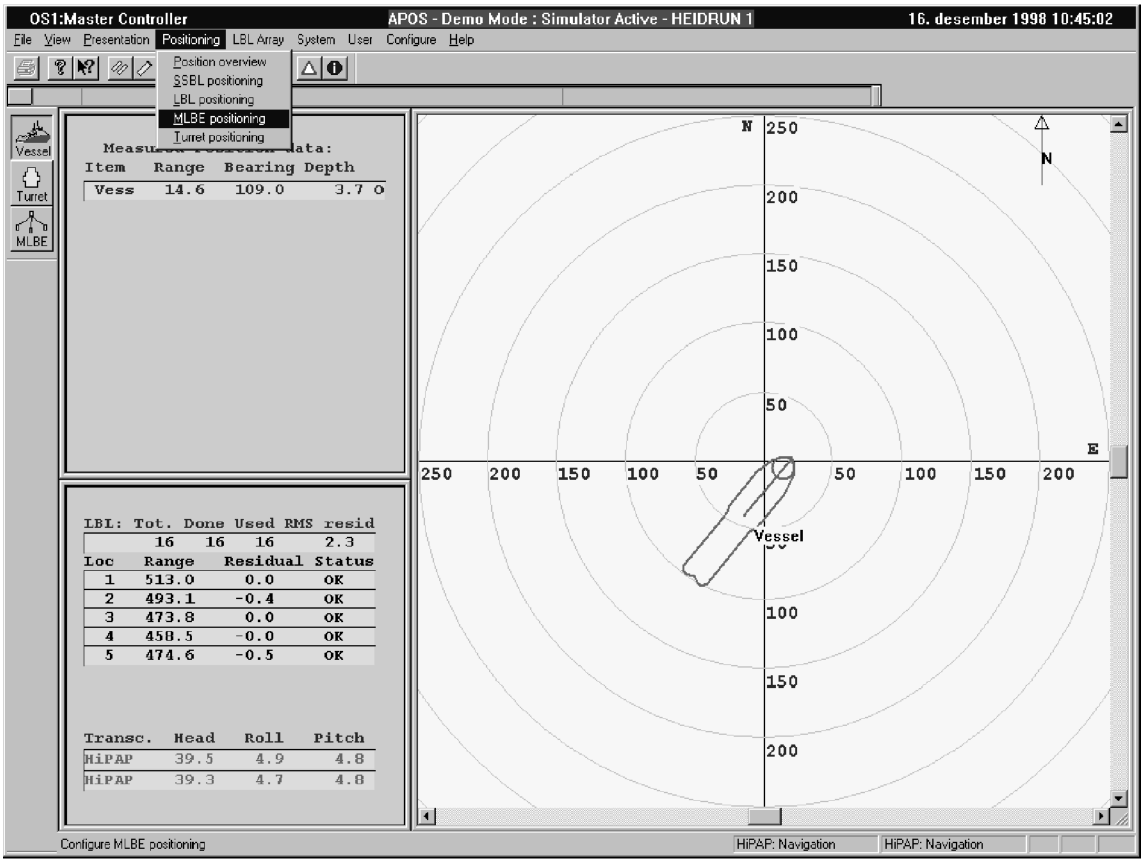
OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 10:44:15
File View Presentation Positioning LBL Array System User Configure Help
Measured Position data:
Item Range Bearing Depth
T1 1.8 33.2 44.3
MC-T1 12.8 295.8 40.6
Vess 13.2 107.9 3.7
LBL: Tot. Done Used RMS
Loc Range Residual
1 512.8 -0.3 OK
2 493.3 -0.1 OK
3 473.8 0.1 OK
4 458.1 -0.2 OK
5 474.8 -0.2 OK
Transc. Head Roll Pitch
HiPAP 37.5 3.9 3.8
HiPAP 37.7 3.9 4.0
Turret buoy
Mode
Search
T1
T2
T3
Activate
Depth sensor
Read battery
Name Channel Tp Serial Battery Time read
T1 B84 2142 0.00 01/01/80
T2 B85 2144 0.00 01/01/80
T3 B83 2140 0.00 01/01/80
OK
Cancel
Apply
Help
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

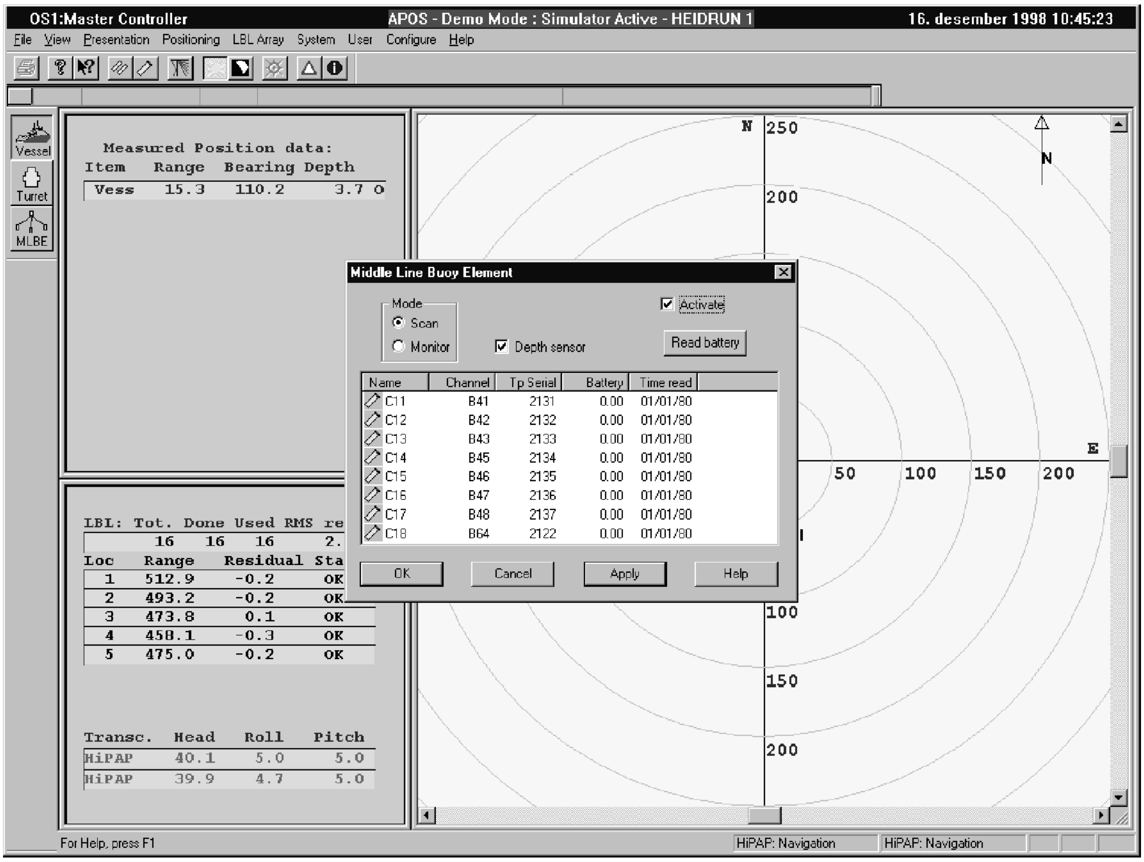

OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 10:44:35
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
Vess 14.3 109.1 3.9 O
LBL: Tot. Done Used RMS resid
16 16 16 1.9
Loc Range Residual Status
1 512.7 -0.5 OK
2 493.1 -0.0 OK
3 473.5 0.2 OK
4 457.7 -0.4 OK
5 475.1 -0.0 OK
Transc. Head Roll Pitch
HiPAP 38.4 4.3 4.3
HiPAP 38.7 4.3 4.3
N
E
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

8.5.11 MLBE positioning final check

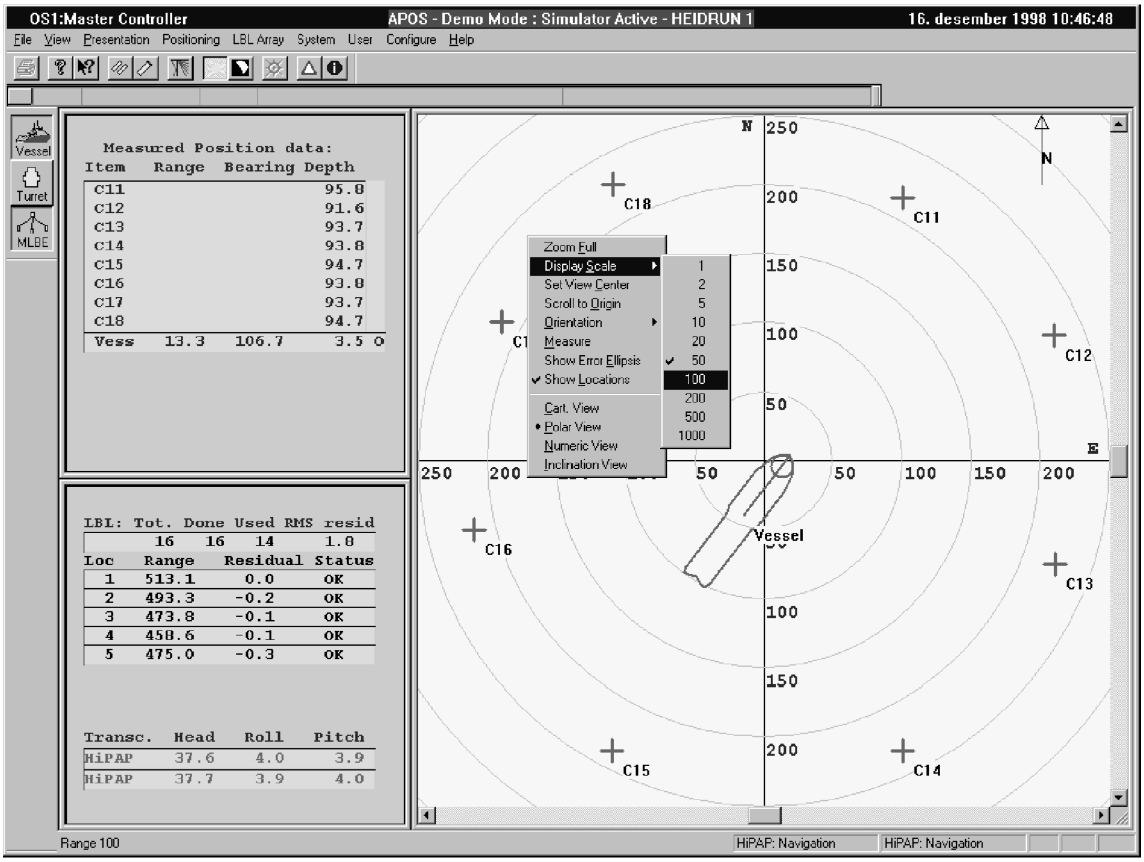
- As a final check before leaving the loading station, turn on **MLBE Positioning** in **Scan** mode.

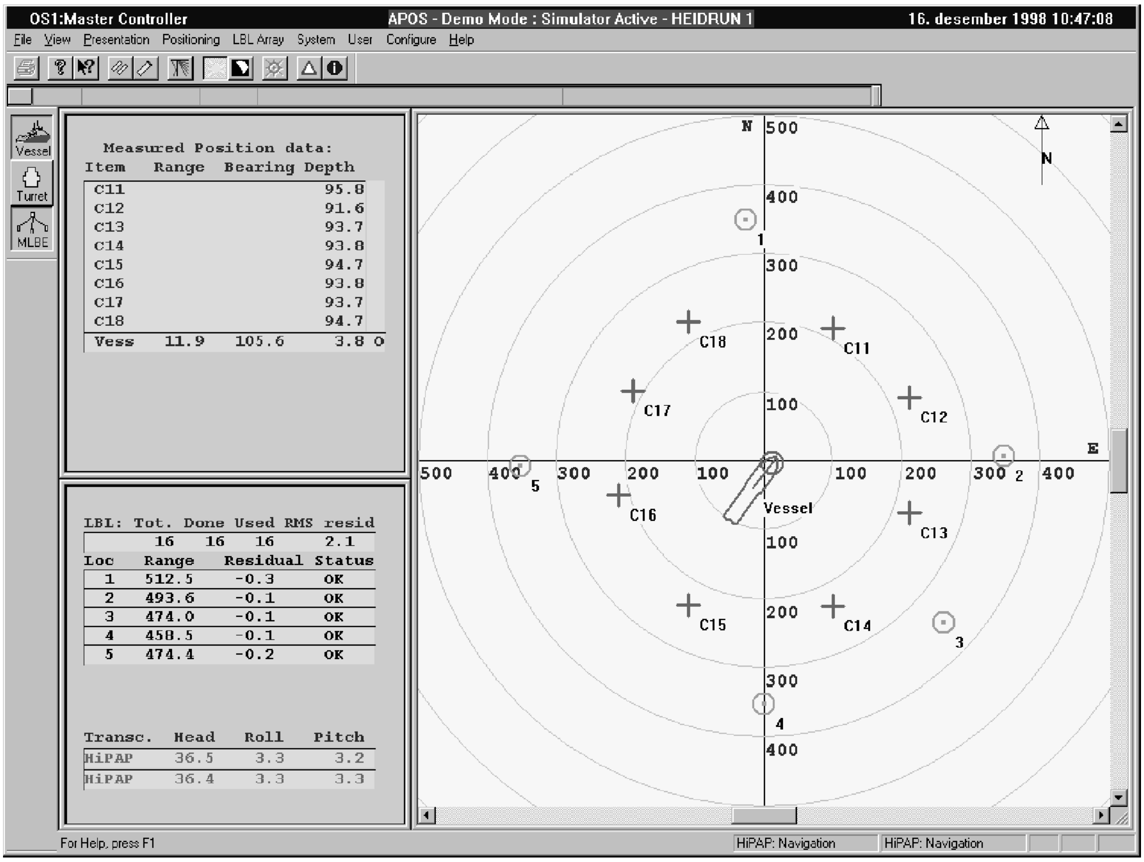
You can not use the MLBE button because this will start MLBE positioning in Monitor mode which you used last time.




OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 10:45:23
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
Vess 15.3 110.2 3.7 O
LBL: Tot. Done Used RMS re
16 16 16 2.
Loc Range Residual Sta
1 512.9 -0.2 OK
2 493.2 -0.2 OK
3 473.8 0.1 OK
4 458.1 -0.3 OK
5 475.0 -0.2 OK
Transc. Head Roll Pitch
HiPAP 40.1 5.0 5.0
HiPAP 39.9 4.7 5.0
Middle Line Buoy Element
Mode
Scan
Monitor
Depth sensor
Activate
Read battery
Name Channel Tp Serial Battery Time read
C11 B41 2131 0.00 01/01/80
C12 B42 2132 0.00 01/01/80
C13 B43 2133 0.00 01/01/80
C14 B45 2134 0.00 01/01/80
C15 B46 2135 0.00 01/01/80
C16 B47 2136 0.00 01/01/80
C17 B48 2137 0.00 01/01/80
C18 B64 2122 0.00 01/01/80
OK
Cancel
Apply
Help
N
250
200
100
150
200
50
100
150
200
E
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

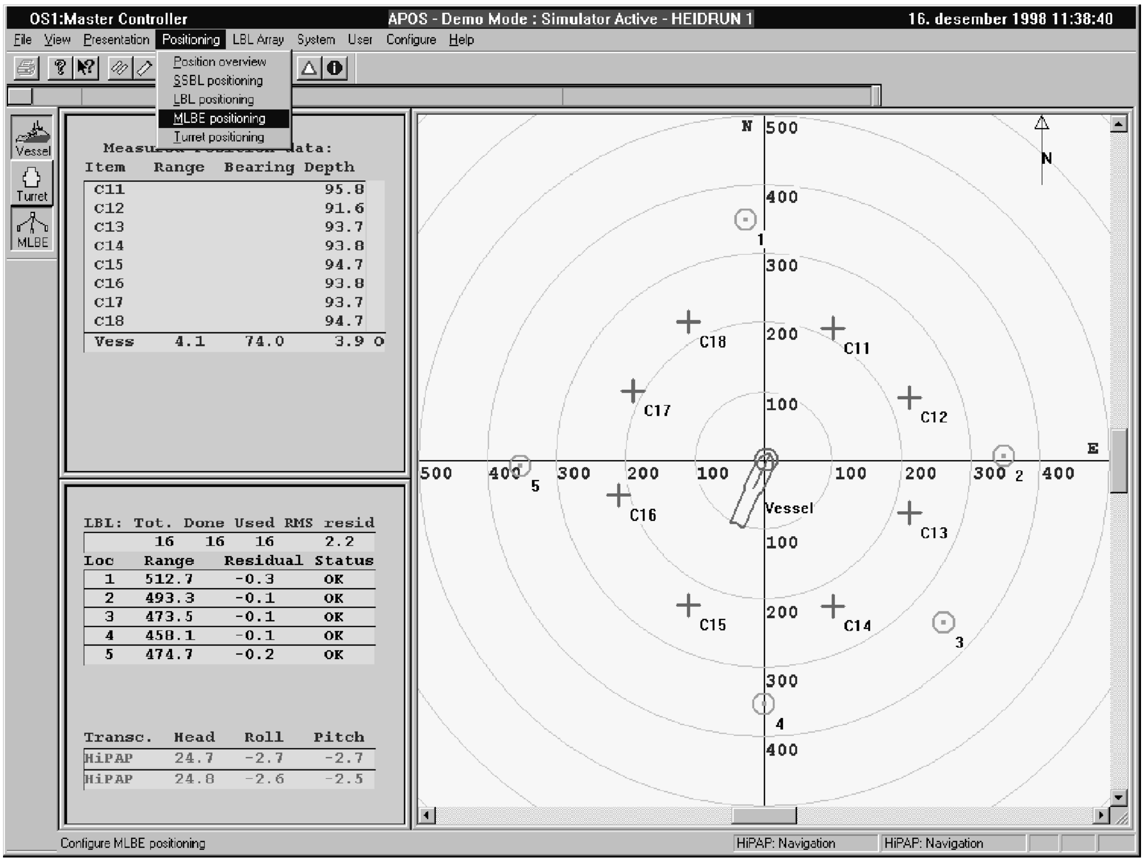
• Change **Display scale** to 50m to better fit the operation.

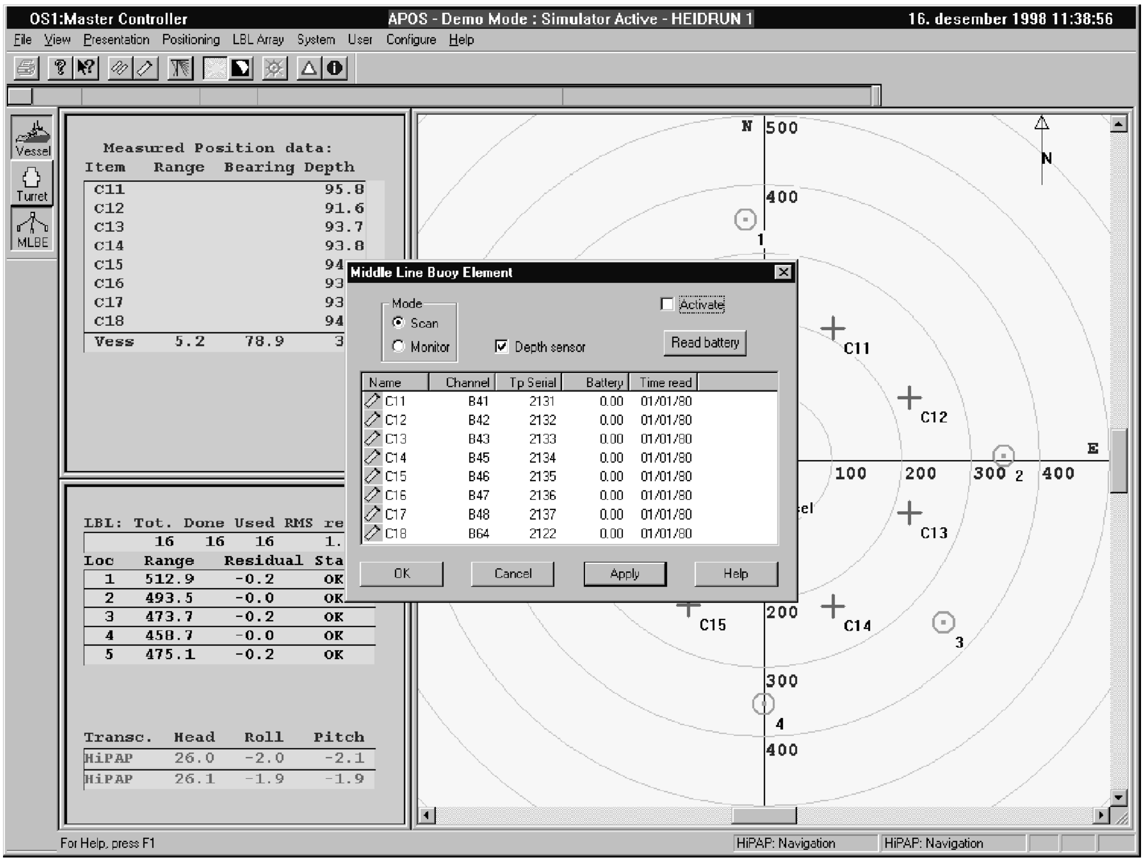



OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 10:47:08
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
C11 95.8
C12 91.6
C13 93.7
C14 93.8
C15 94.7
C16 93.8
C17 93.7
C18 94.7
Vess 11.9 105.6 3.8 O
LBL: Tot. Done Used RMS resid
16 16 16 2.1
Loc Range Residual Status
1 512.5 -0.3 OK
2 493.6 -0.1 OK
3 474.0 -0.1 OK
4 458.5 -0.1 OK
5 474.4 -0.2 OK
Transc. Head Roll Pitch
HiPAP 36.5 3.3 3.2
HiPAP 36.4 3.3 3.3
N
E
C11
C12
C13
C14
C15
C16
C17
C18
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

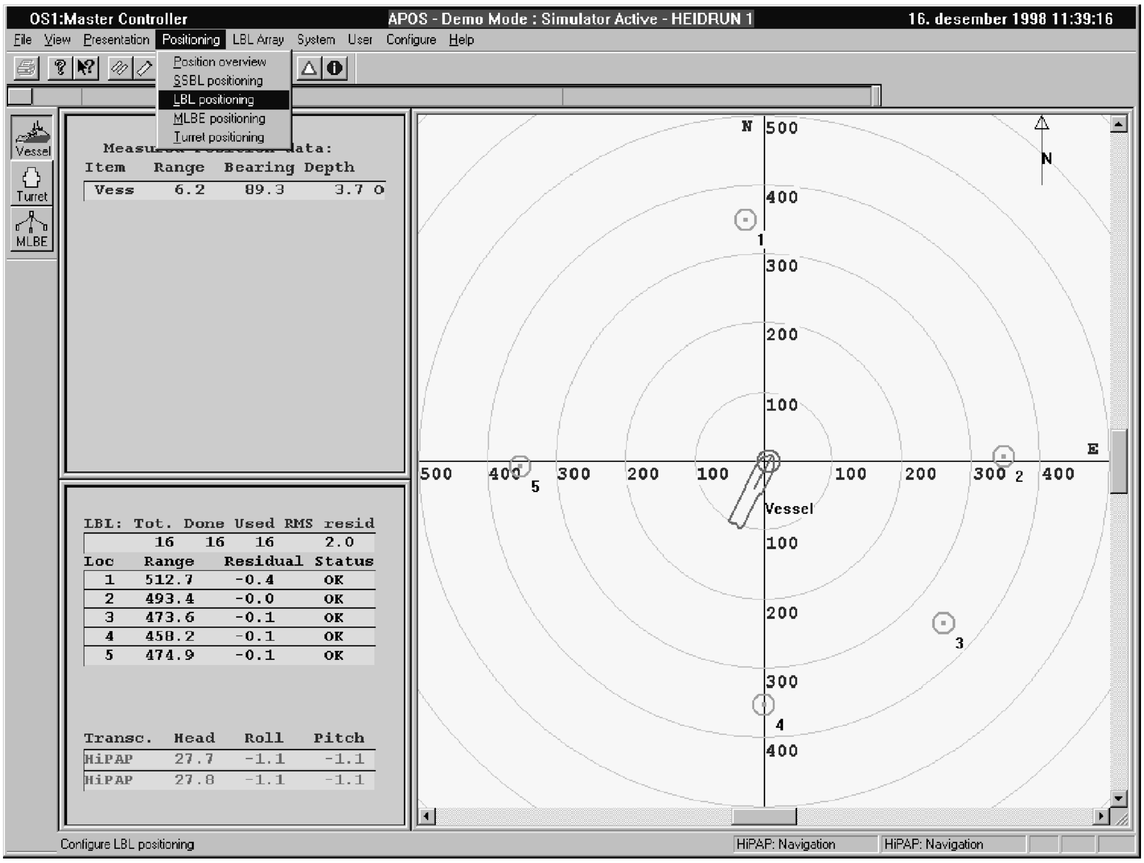
8.5.12 Ending the STL operation

- Turn off the **MLBE positioning**.

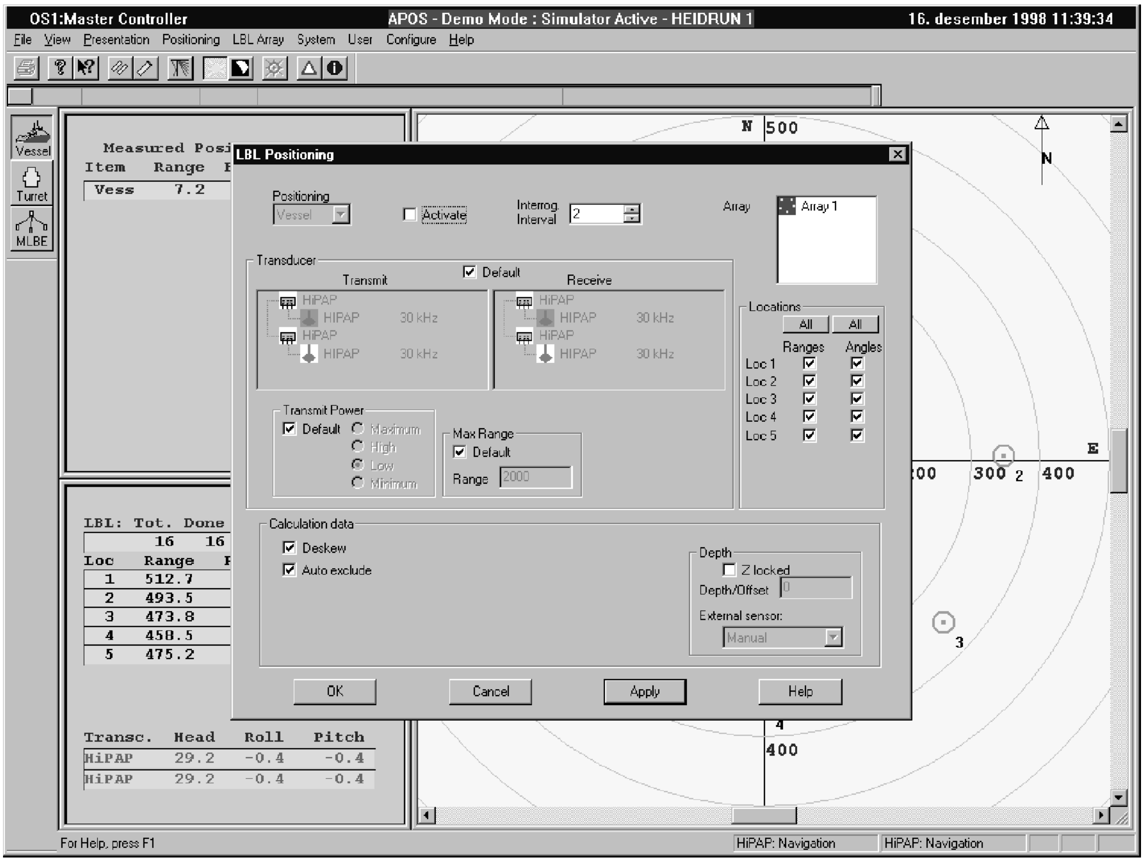



OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 1
16. desember 1998 11:38:56
File View Presentation Positioning LBL Array System User Configure Help
Measured Position data:
Item Range Bearing Depth
Middle Line Buoy Element
Mode
Scan
Monitor
Activate
Depth sensor
Read battery
Name Channel Tp Serial Battery Time read
OK Cancel Apply Help
For Help, press F1
HiPAP: Navigation

- Turn off the **LBL vessel positioning**.



- Remember to take away the tick mark in the **Activate** check box.



- Raise the HPR / HiPAP transducer before you leave the loading station.

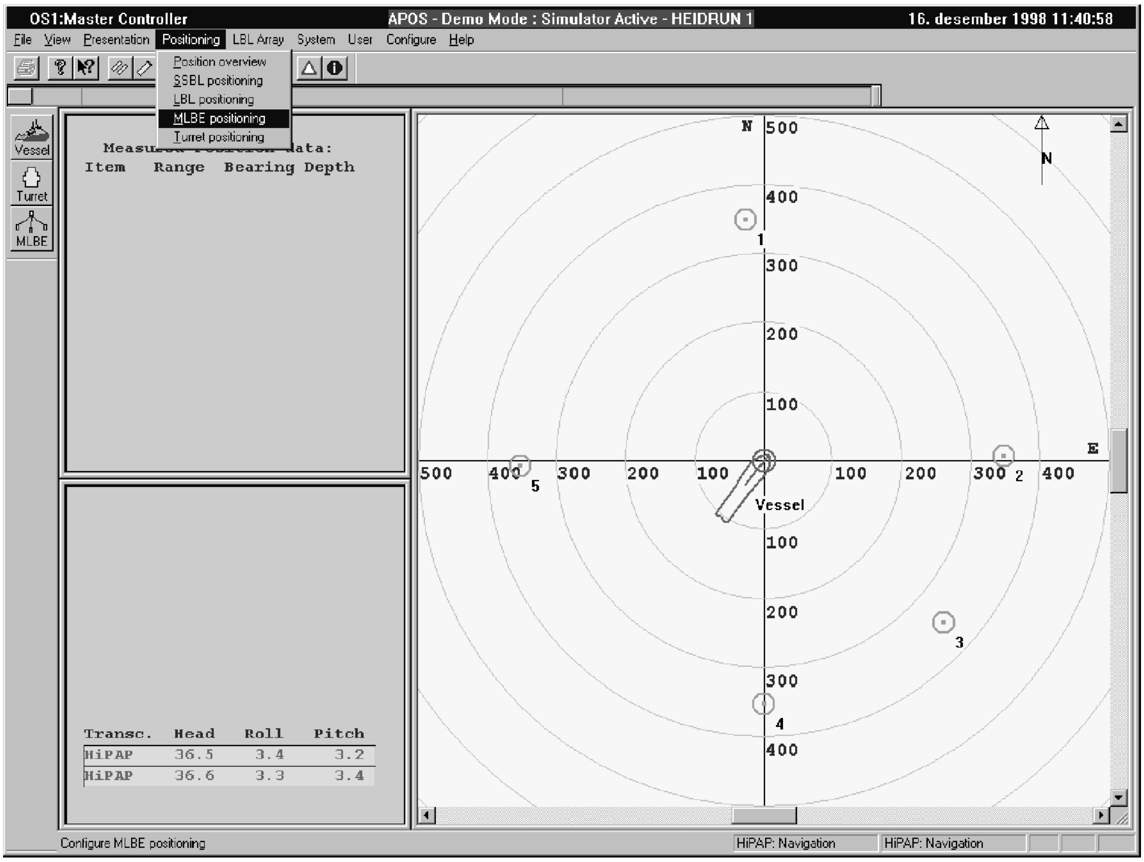
8.5.13 Battery status of MBLE and STL buoy transponders

WARNING ! **When reading battery status all positioning must be turned off.**

- Read **battery status** for the MLBE transponders.

(Select MLBE positioning from the Positioning menu.

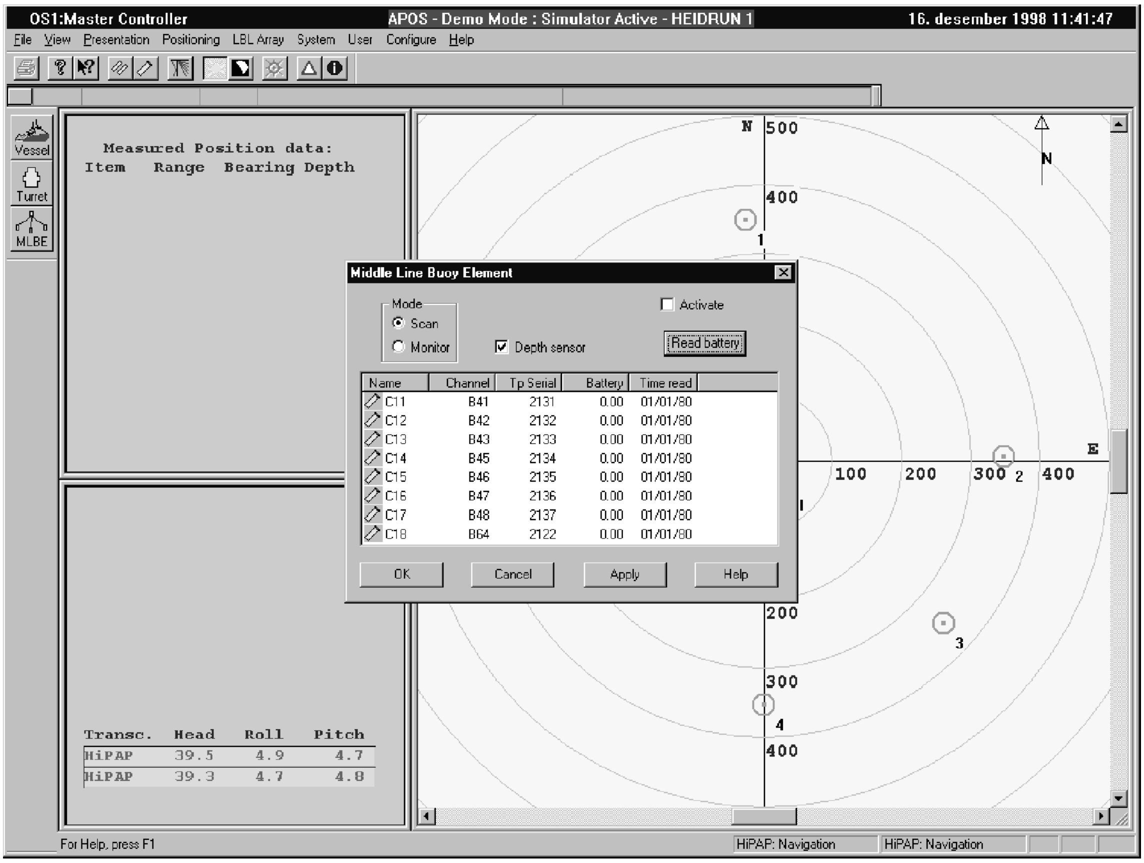
Another way is to click right mouse button when the cursor is above the MLBE symbol in the toolbar)



- Click at the **Read battery** button to start telemetry.

(Select Turret positioning from the Positioning menu.

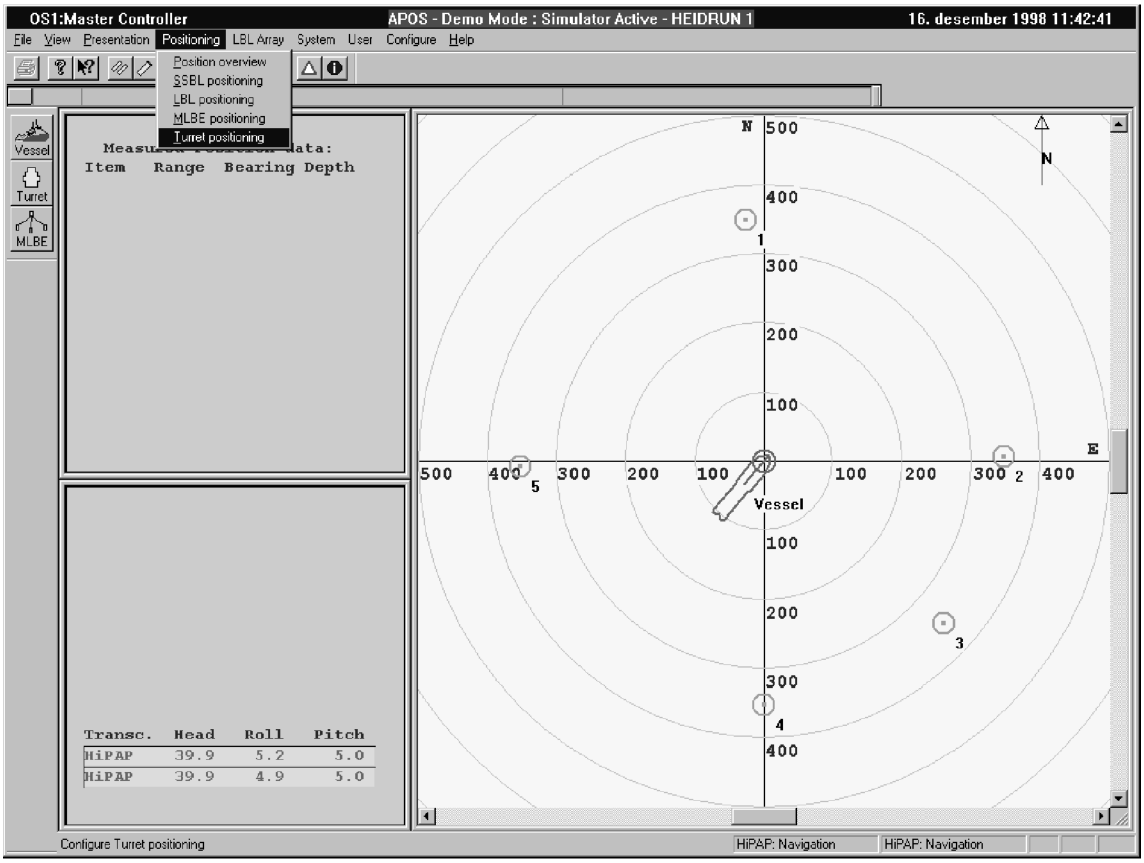
Another way is to click right mouse button when the cursor is above the Turret symbol in the toolbar)



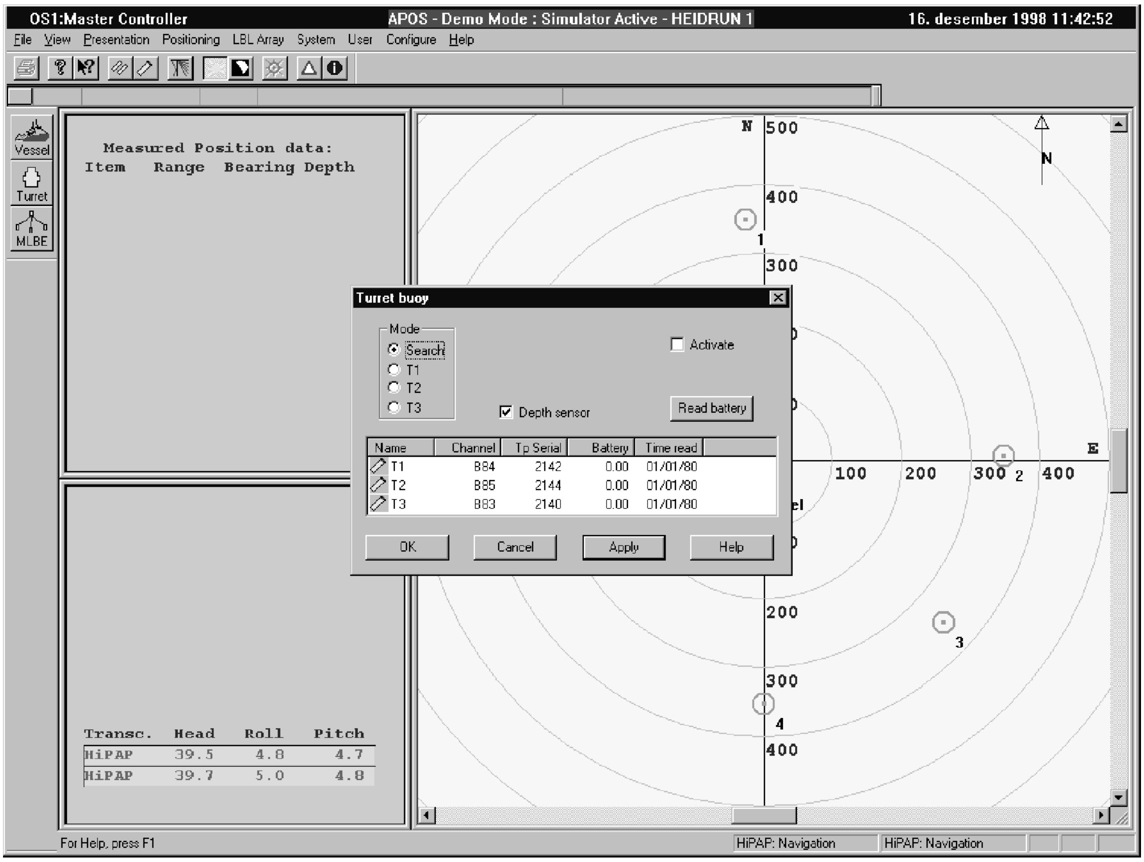
Telemetry is executed for some seconds and the battery status is then displayed as the amount of pings transmitted by the transponder.

There is no simulator for these values, only the telemetry symbol.

- Read **battery status** for the STL buoy transponders.



- Click at the **Read battery** button to start telemetry.

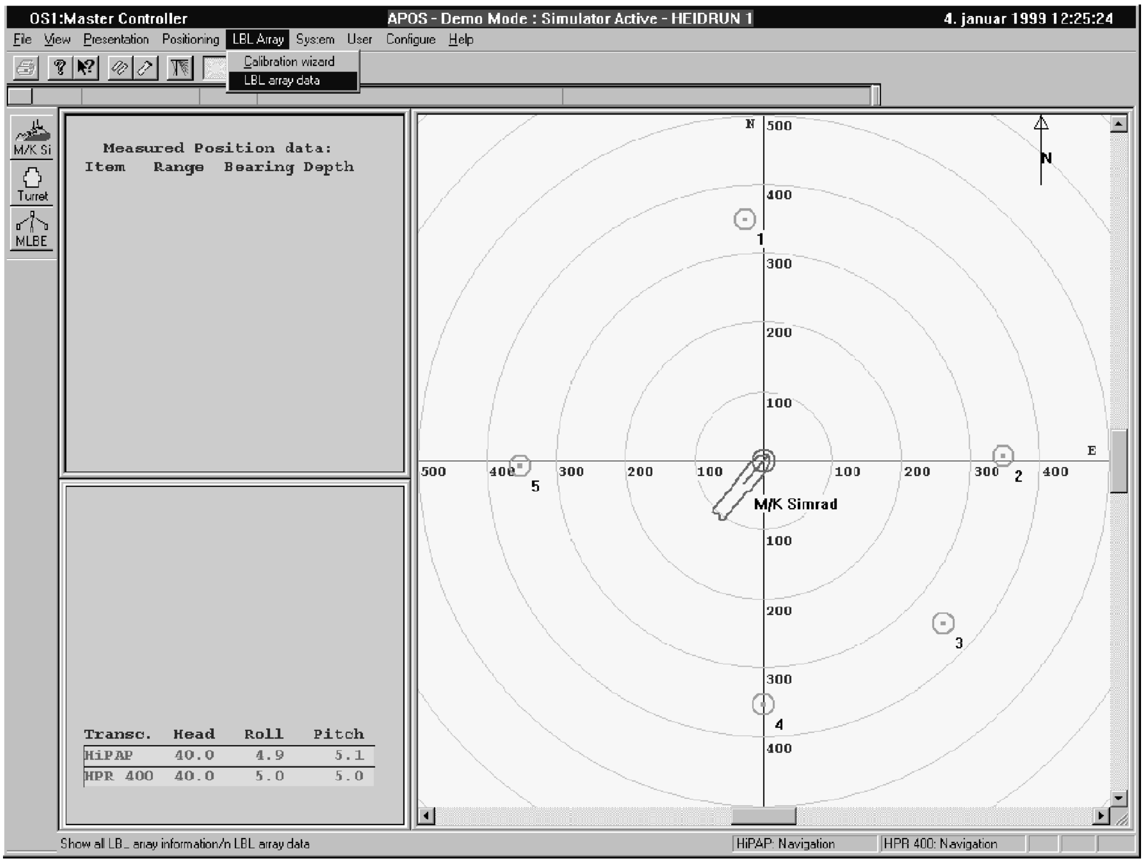


Telemetry is executed for some seconds and the battery status is then displayed as the amount of pings transmitted by the transponder.

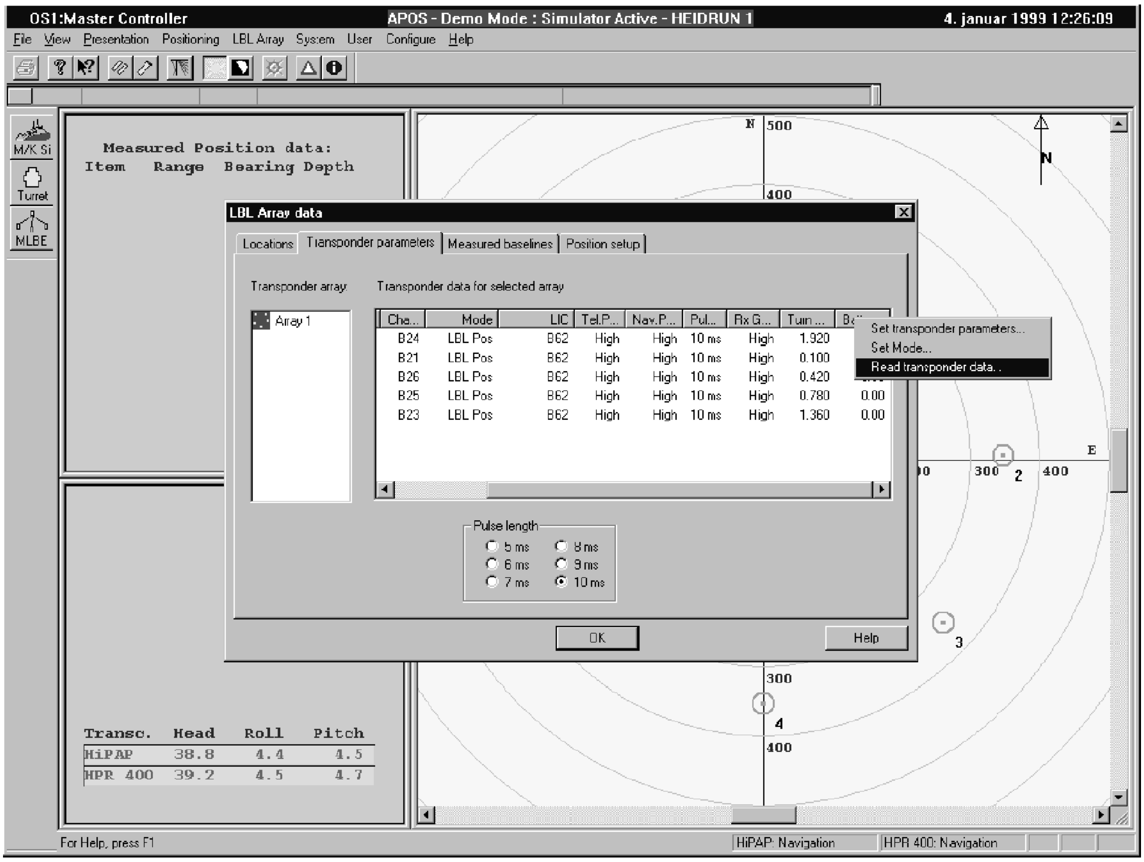
There is no simulator for these values, only the telemetry symbol.

- Read **battery status** for the LBL vessel positioning transponders at the seabed.

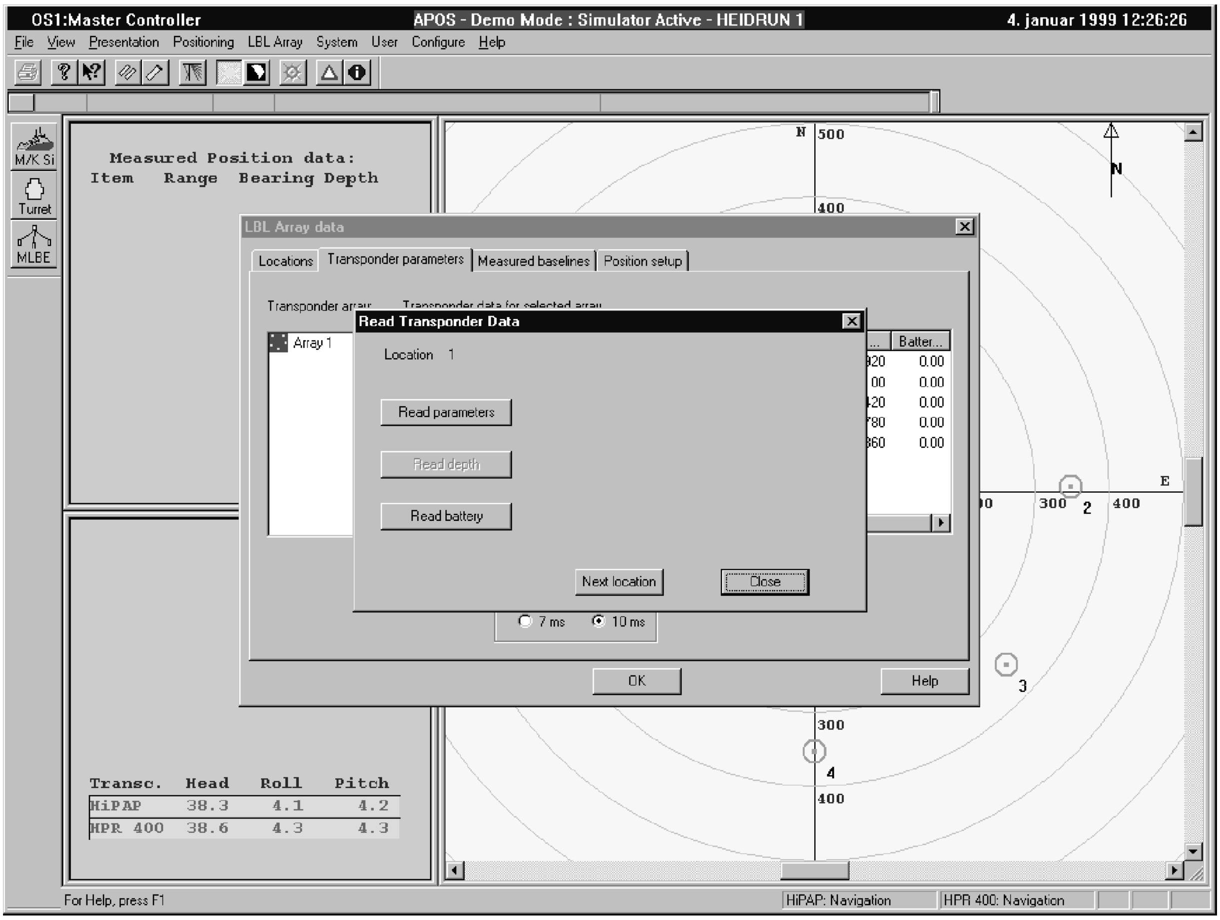
(For these transponders you can to go through the LBL array menu and select LBL Array data.)



- Select the **Transponder parameters** tab to get this new window.
- Place the cursor at above **Battery** and click right mouse button.
- Select **Read transponder data**.



- Click at the **Read battery** button for the locations



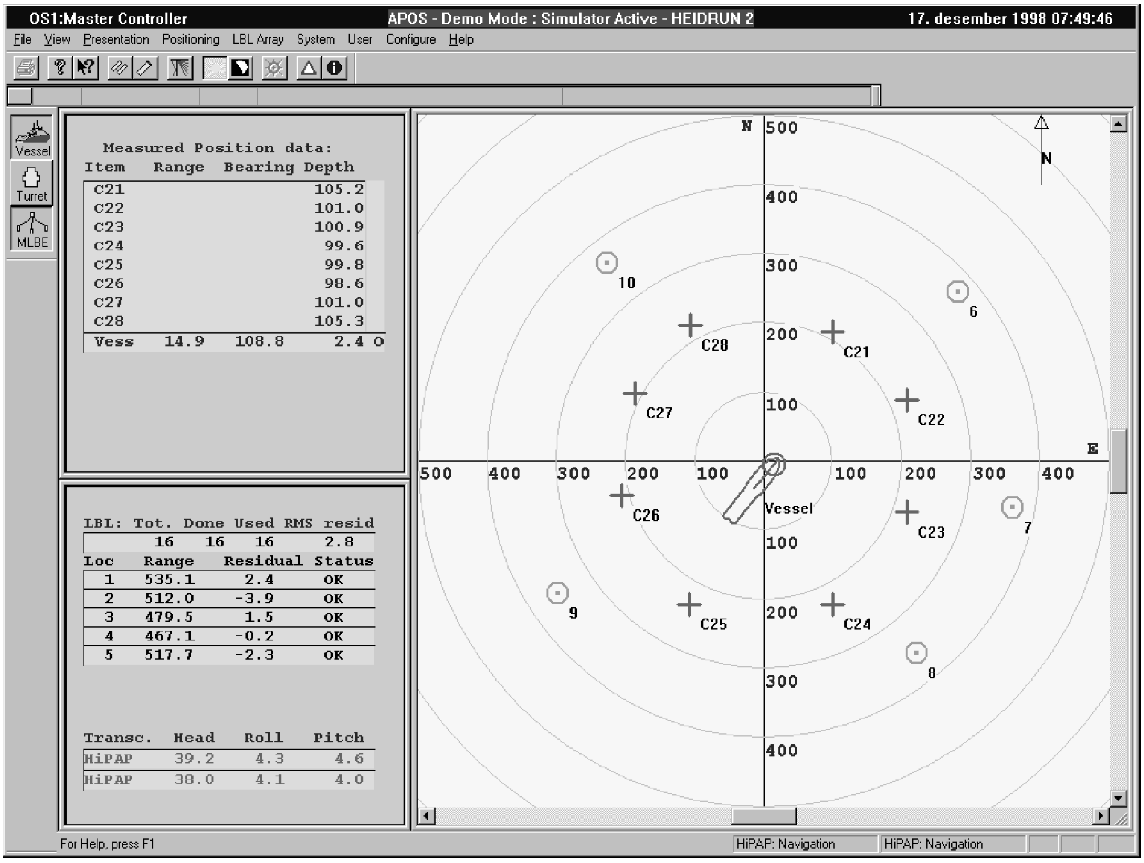
Telemetry is executed for some seconds and the battery status is then displayed as the amount of pings transmitted by the transponder.

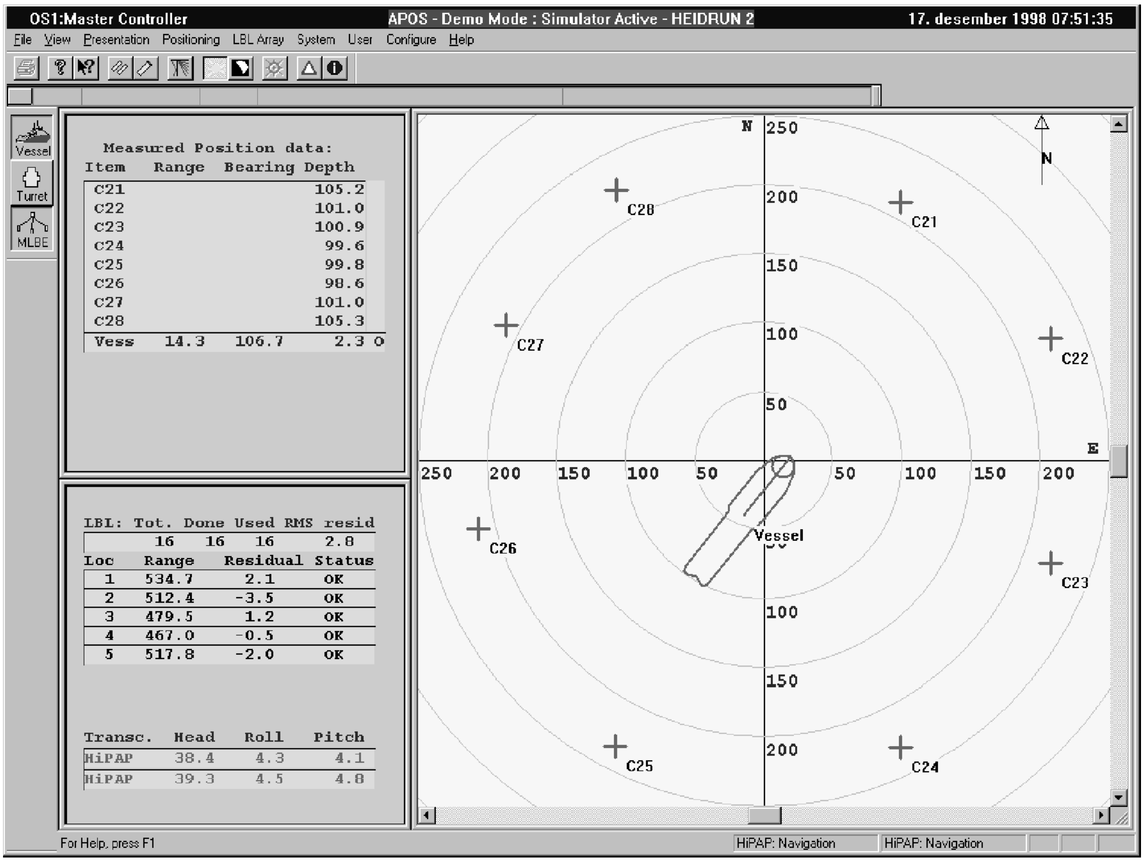
There is no simulator for these values, only the telemetry symbol.

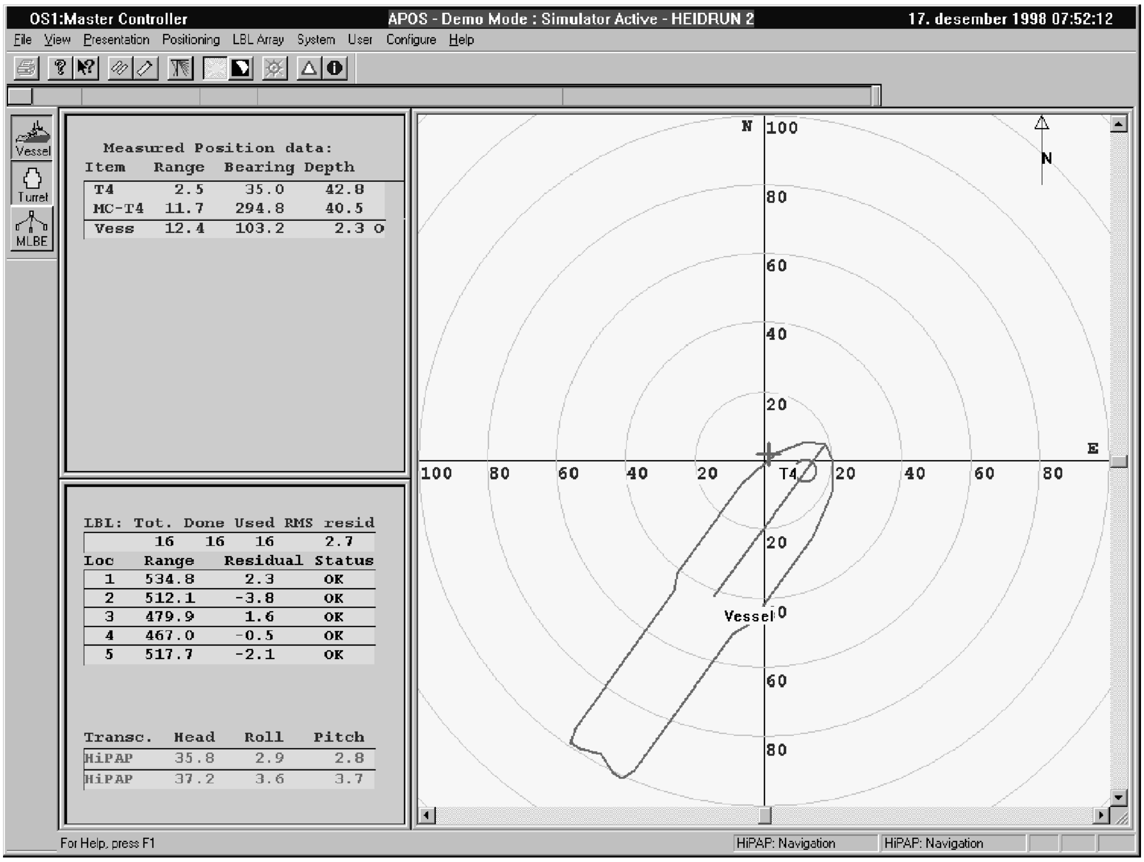
8.5.14 Approaching other fields

- Assume you are at the HEIDRUN 2.
- Let the instructor configure the demo program.
- Do the same exercises as for HEIDRUN 1.

Notice that the location number, MLBE transponder channels and turret transponder channels are different for this field.



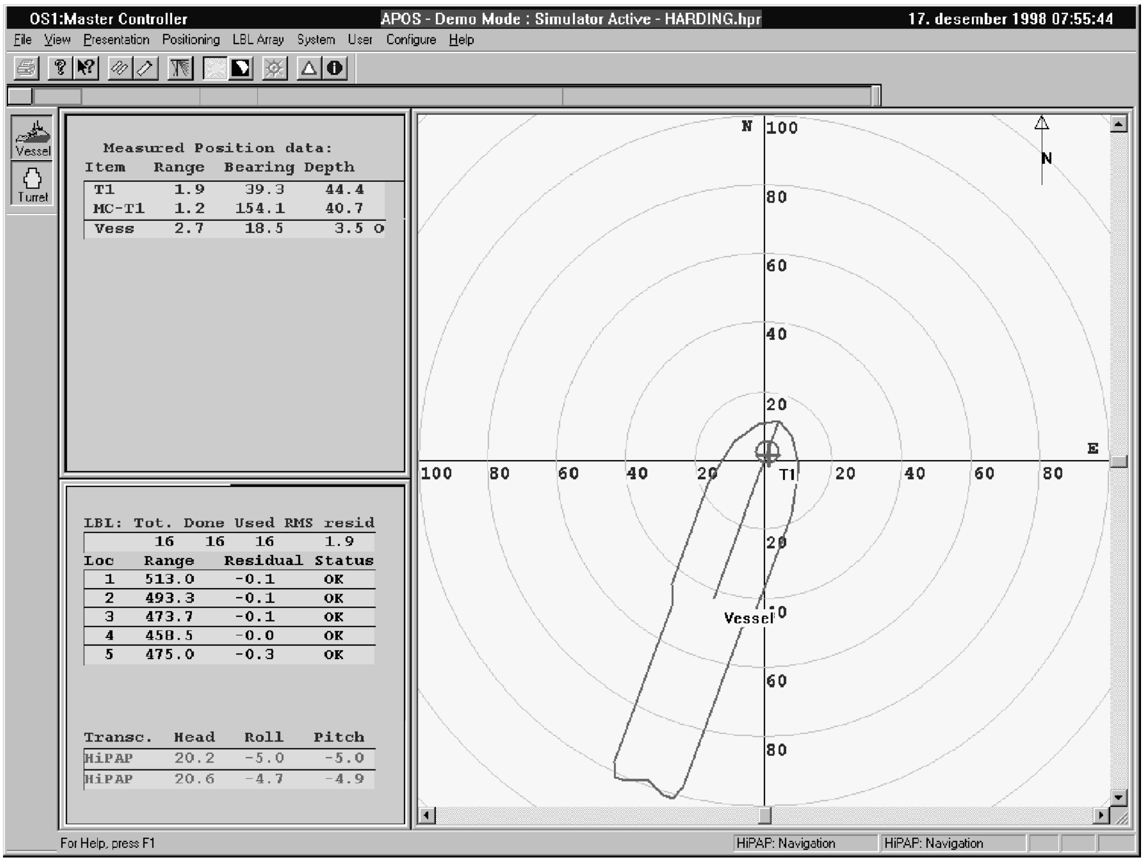

OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 2
17. desember 1998 07:51:35
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
C21 105.2
C22 101.0
C23 100.9
C24 99.6
C25 99.8
C26 98.6
C27 101.0
C28 105.3
Vess 14.3 106.7 2.3 O
LBL: Tot. Done Used RMS resid
16 16 16 2.8
Loc Range Residual Status
1 534.7 2.1 OK
2 512.4 -3.5 OK
3 479.5 1.2 OK
4 467.0 -0.5 OK
5 517.8 -2.0 OK
Transc. Head Roll Pitch
HiPAP 38.4 4.3 4.1
HiPAP 39.3 4.5 4.8
N
E
Vessel
C21
C22
C23
C24
C25
C26
C27
C28
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation



OS1:Master Controller
APOS - Demo Mode : Simulator Active - HEIDRUN 2
17. desember 1998 07:52:12
File View Presentation Positioning LBL Array System User Configure Help
Vessel
Turret
MLBE
Measured Position data:
Item Range Bearing Depth
T4 2.5 35.0 42.8
MC-T4 11.7 294.8 40.5
Vess 12.4 103.2 2.3
LBL: Tot. Done Used RMS resid
16 16 16 2.7
Loc Range Residual Status
1 534.8 2.3 OK
2 512.1 -3.8 OK
3 479.9 1.6 OK
4 467.0 -0.5 OK
5 517.7 -2.1 OK
Transc. Head Roll Pitch
HiPAP 35.8 2.9 2.8
HiPAP 37.2 3.6 3.7
N
E
T4
Vessel
For Help, press F1
HiPAP: Navigation
HiPAP: Navigation

- Assume you are at the HARDING.
- Let the instructor configure the demo program.
- Do the same exercises as for HEIDRUN 1.

Note ! *Notice that there are no MLBE positioning at the HARDING field.*



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8.6 LBL calibration – basic operation

8.6.1 Introduction

These exercises will leaad you through the basic operation of LBL calibration and positioning with the HPR/HiPAP system.

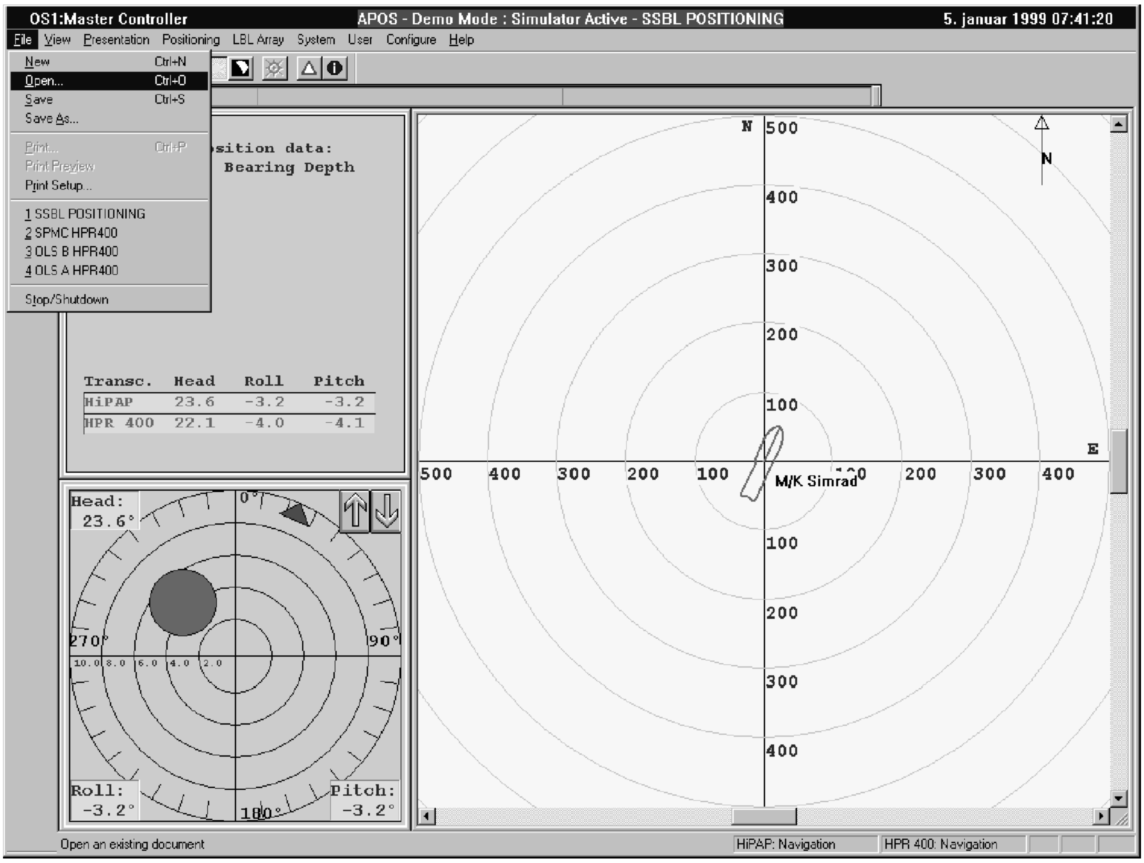
- Start the demo computer and let the instructor configure the demo program before you go on with the exercises.

8.6.2 Configure transponders

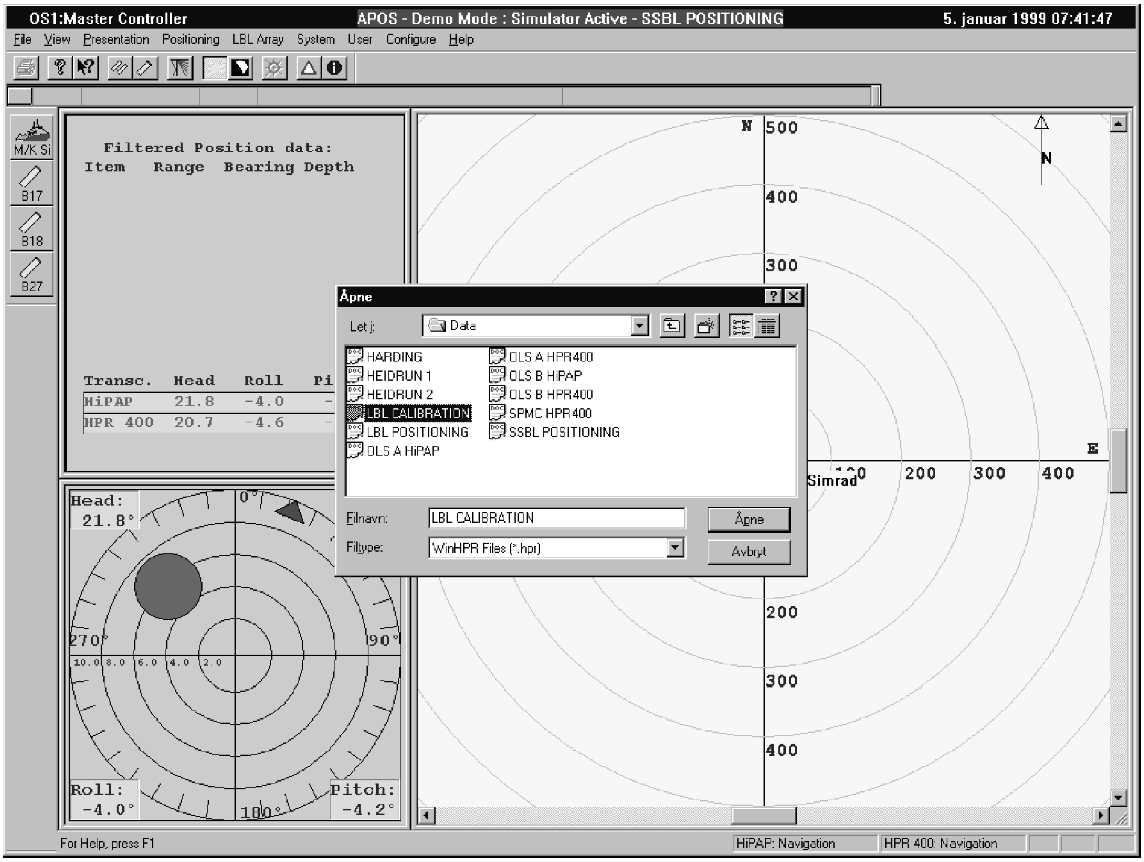
The transponders you are going to use in LBL positioning have to be configured in the HPR/HiPAP system with channels, serial number etc. This is done in the Transponder configure menu. You should have been through how this is done during the SSBL exercises.

To save time in this exercise you can open a file where all the transponders already are configured.

- Open the file D:\WINHPR\DATA\LBL CALIBRATION



- Select the file **LBL CALIBRATION** and click at the **Åpne/Open** button.



8.6.3 SSBL positioning

The system needs to know the initial positions for the transponders. If transponders are deployed for use in a new array, no information about the initial positions are available on file. Therfore the positions have to be entered.

The best initial positions you can get is from an SSBL interrogation of the transponders in the array. The system can enter these positions automatically or you can do it manually.

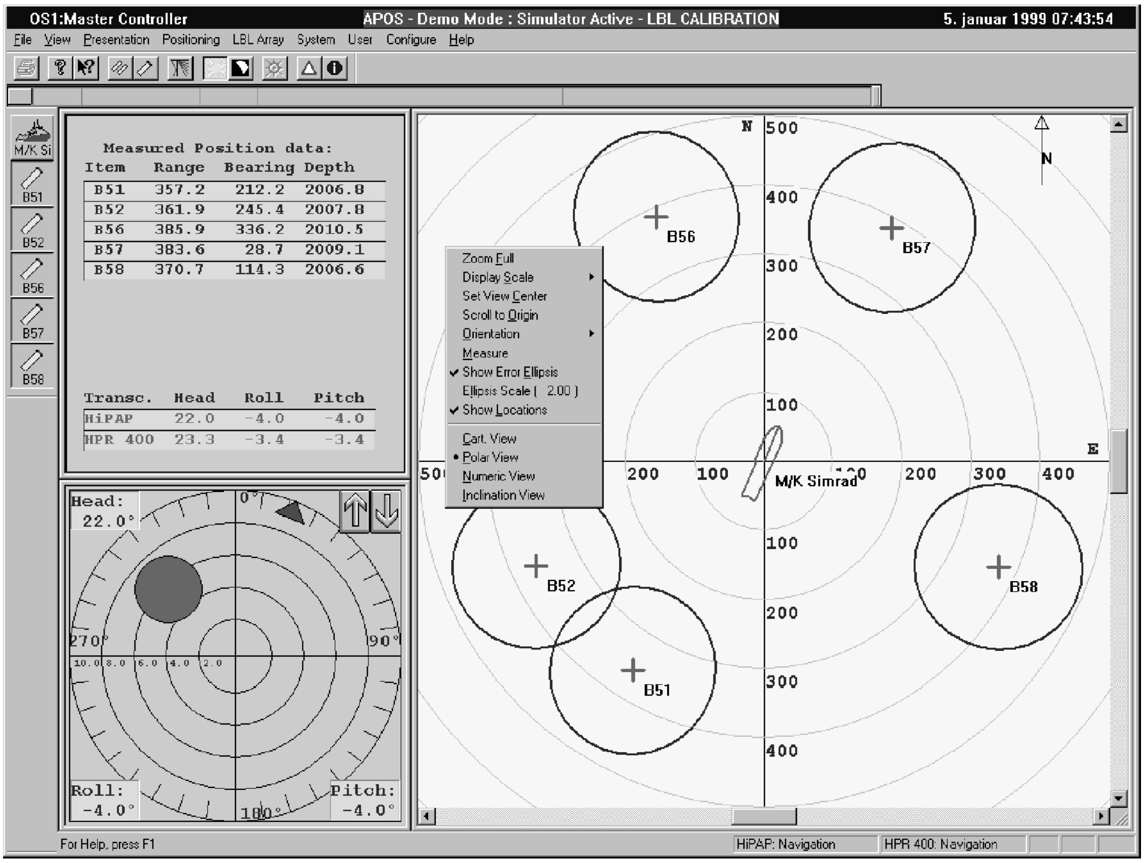
By selecting **North orientation** and **Cartesian view** the SSBL positions displayed can be used directly as initial coordinates when assigning locations manually. For each transponder you will then have North, East and Depth. Negative numbers indicate positions south/west of the origin.

The origin will then be the vessels position.

If the transponder has the depth and temp function, you can read this values by telemetry to get more accurate initial coordinates.

- Activate the transponders in SSBL mode.

If you use error ellipsis you can see the quality of the positions we are going to use as initial coordinates.

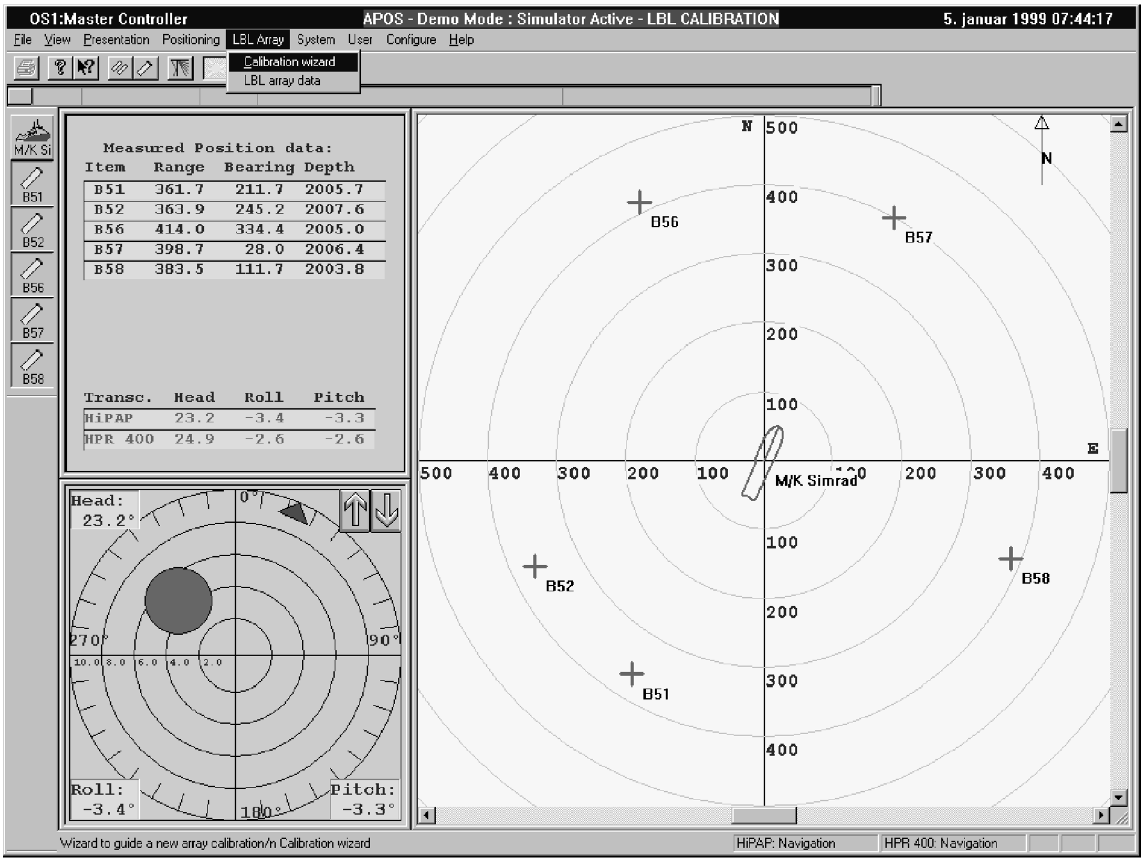


8.6.4 LBL calibration wizard

The APOS operator station has a wizard to help you through the LBL calibration.

- Start the LBL **Calibration wizard**.

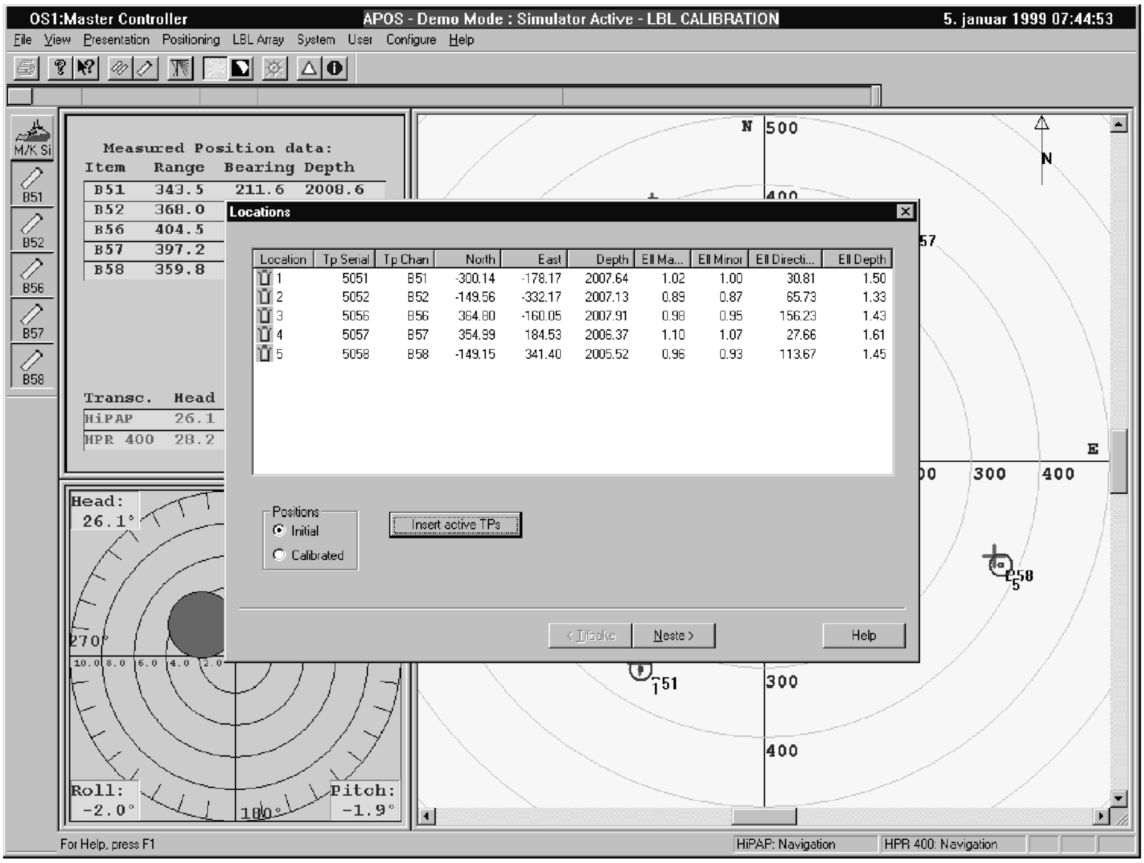
(Select **Calibration wizard** from the **LBL Array** menu)



The **Insert active TPs** button will automatically enter the current SSBL positions into the system.

These positions will be used as initial coordinates for the different locations. The system will also calculate and enter the accuracy of these positions.

- Click the **Insert active TPs** button to get initial coordinates.



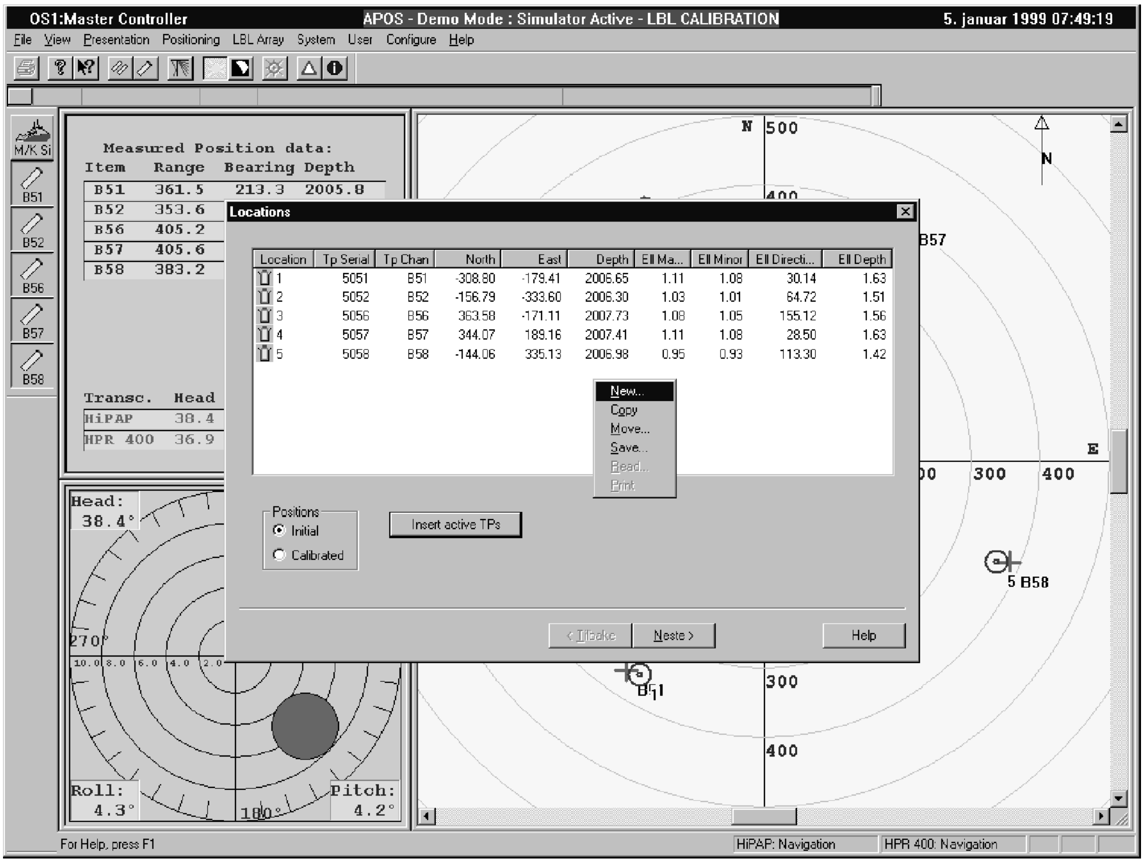
In the window you will now be presented these parameters and values:

- Location number
- Transponder serial number
- Transponder channel
- Transponder position in North, East and Depth
- Size of major error ellipse
- Size of minor error ellipse
- Direction of major error ellipse relative to north
- Standard deviation of the depth values

8.6.5 Enter new locations manually

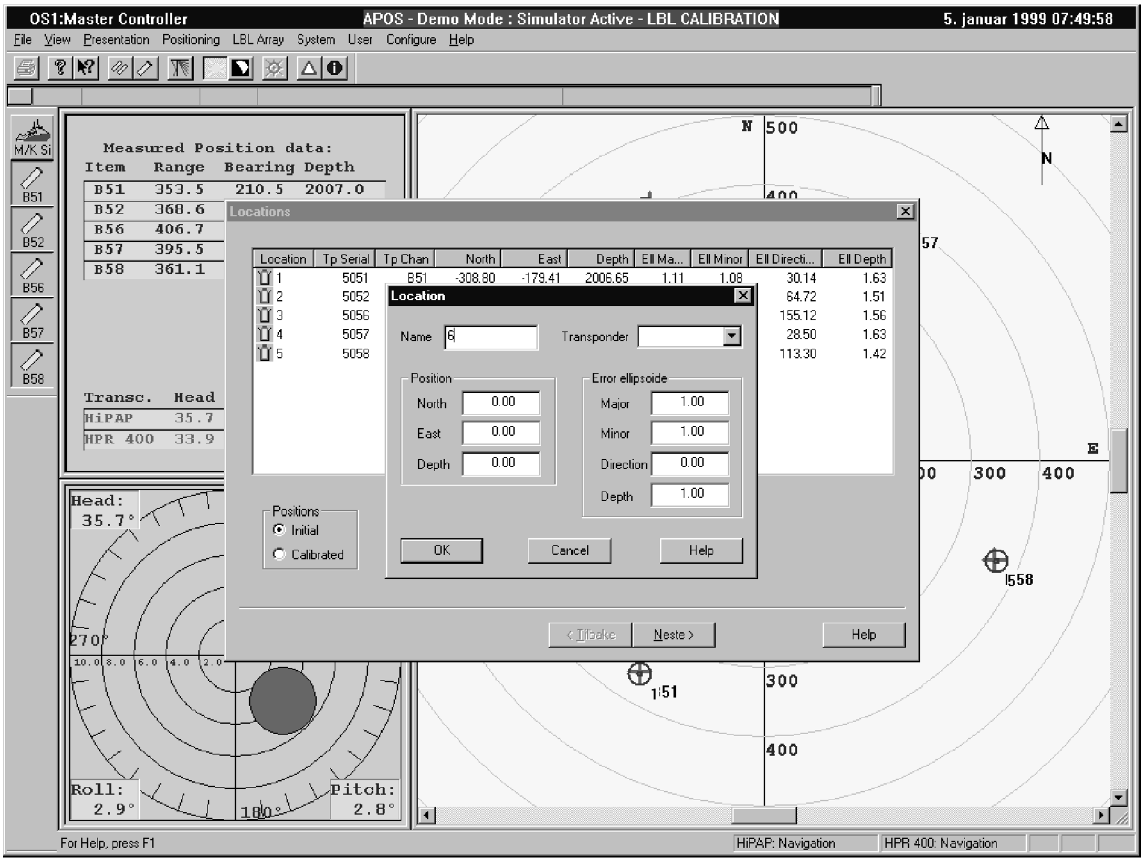
It is also possible to enter locations manually.

- Place the cursor inside the window, click right mouse button and select **New**.



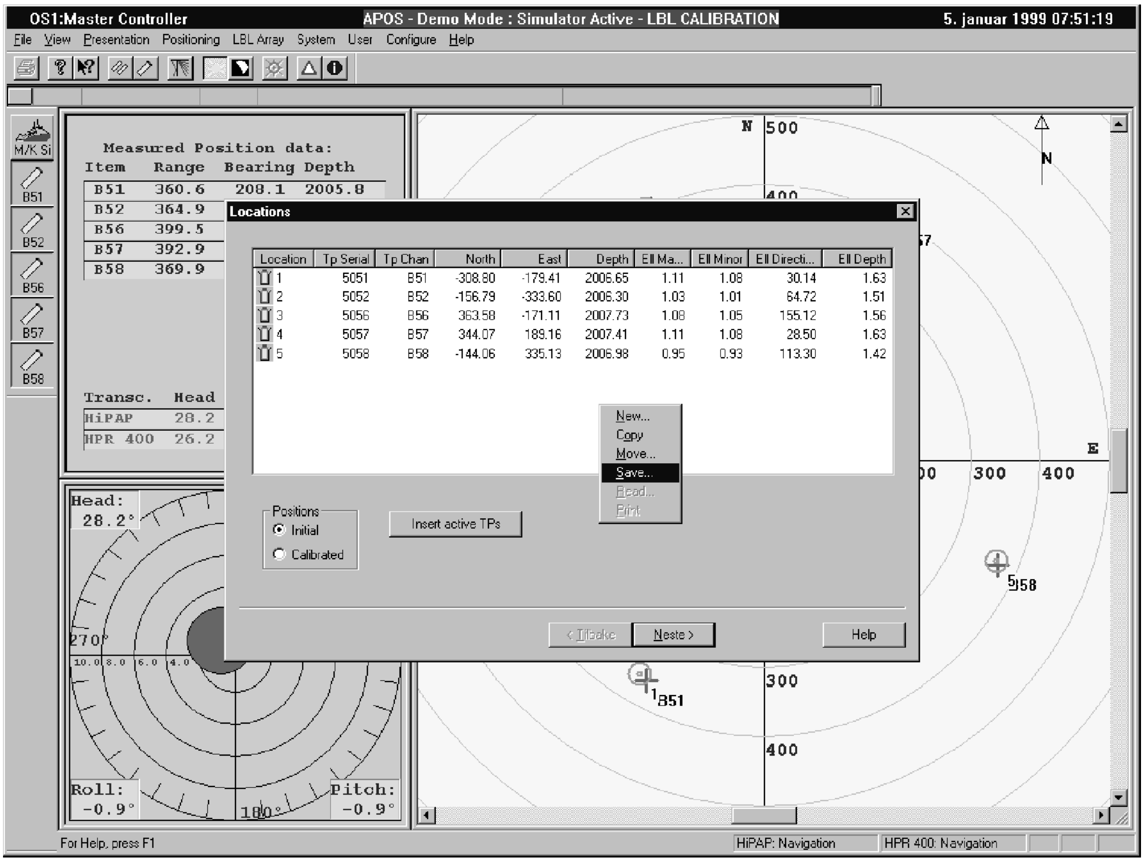
From this new window you can manually insert:

- Location name
- Transponder channel number (must already be configured)
- Positions:
  - √ North
  - √ East
  - √ Depth
- Error ellipsoide:
  - √ Major
  - √ Minor
  - √ Direction
  - √ Depth



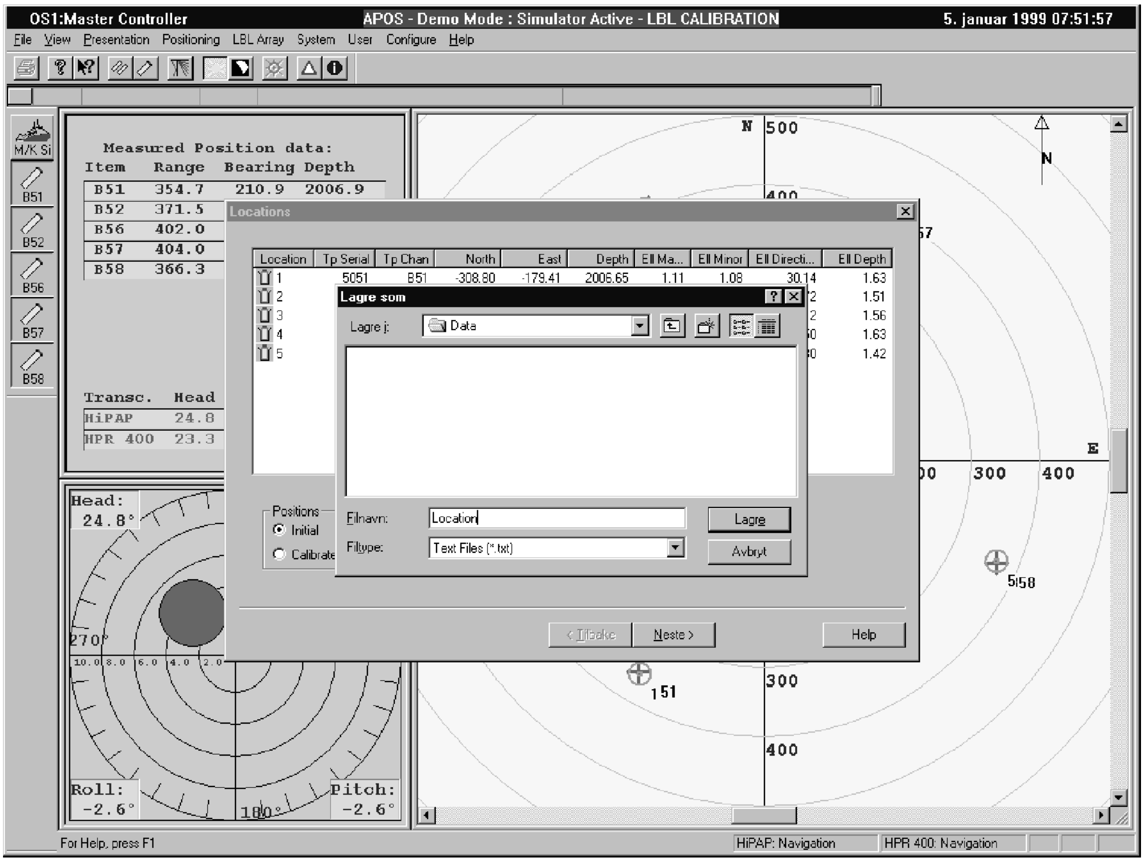
It is also possible to save a set of locations

- Place the cursor inside the window, click right mouse button and select **Save**.



- Insert a suitable name and click the **Lagre**/**Save** button.

The file is saved as a text file and can be pasted into other documents, reports etc.

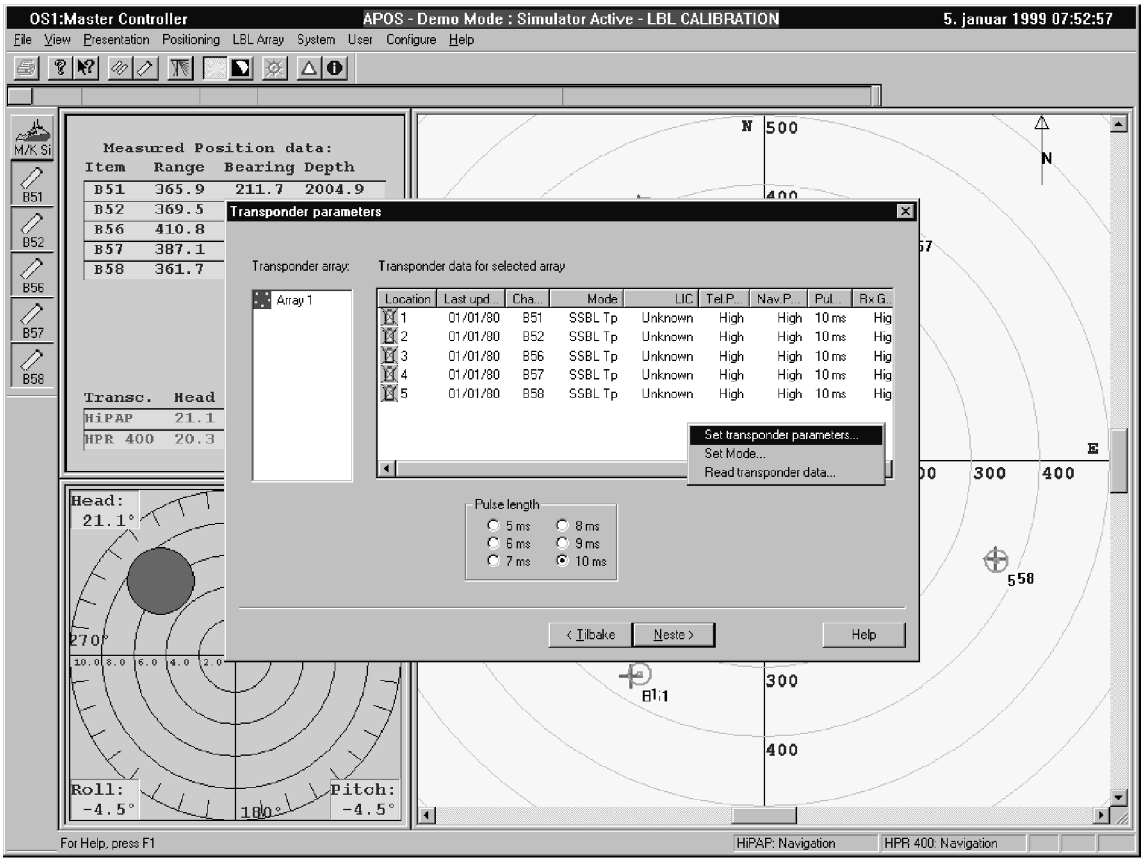


- Click at the **Neste**/**Next** button to go on with the wizard

8.6.6 Change transponder parameters

From this new window you can change parameter values for each of the transponders in the array.

- Place the cursor inside the window, click right mouse button and select **Set transponder parameters**.



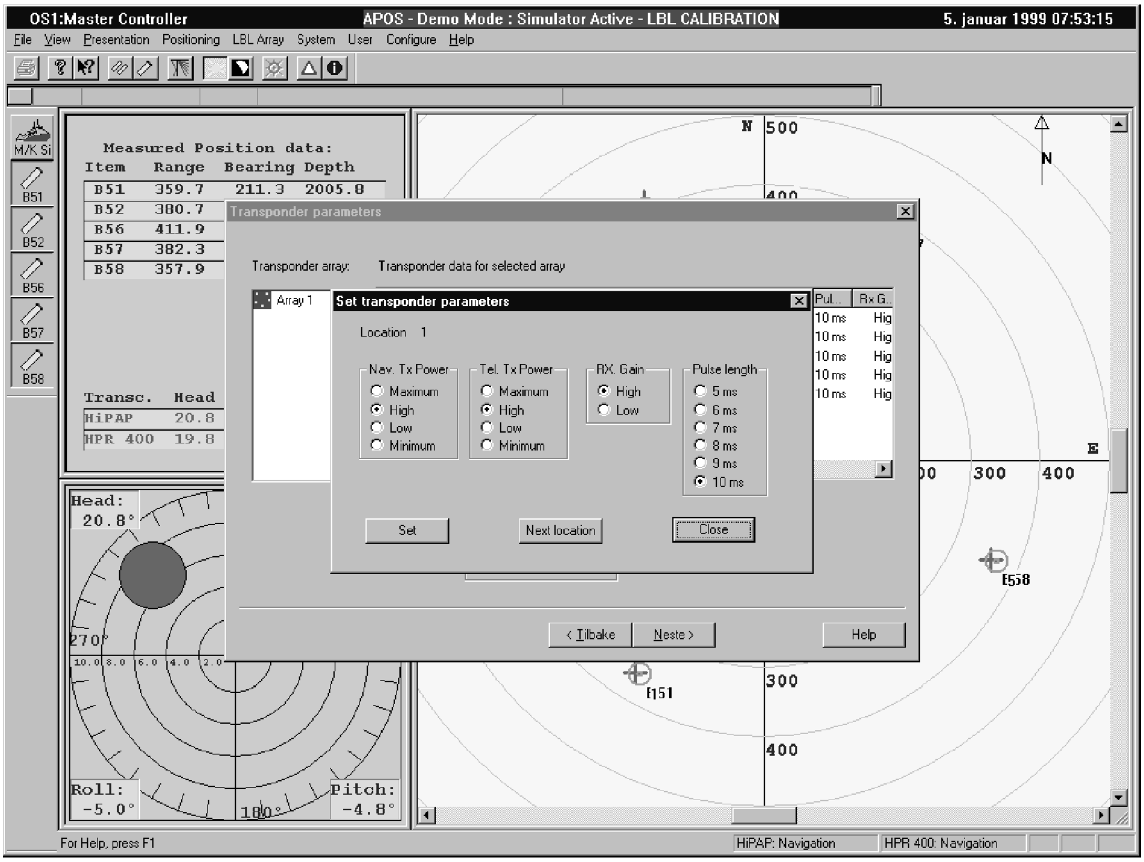
The **Nav. Tx power** parameter sets the power used by the transponder when transmitting replies for positioning. High should be selected for ranges between 500–800m. For longer baselines increase the power. For shorter baselines decrease the power. Lower power levels consume less battery power and causes fewer problems with reflections than higher power

The **Tel. Tx power** parameter sets the power used by the transponder when transmitting in telemetry. High should be selected for ranges between 500–800m. For longer baselines increase the power. For shorter baselines decrease the power.

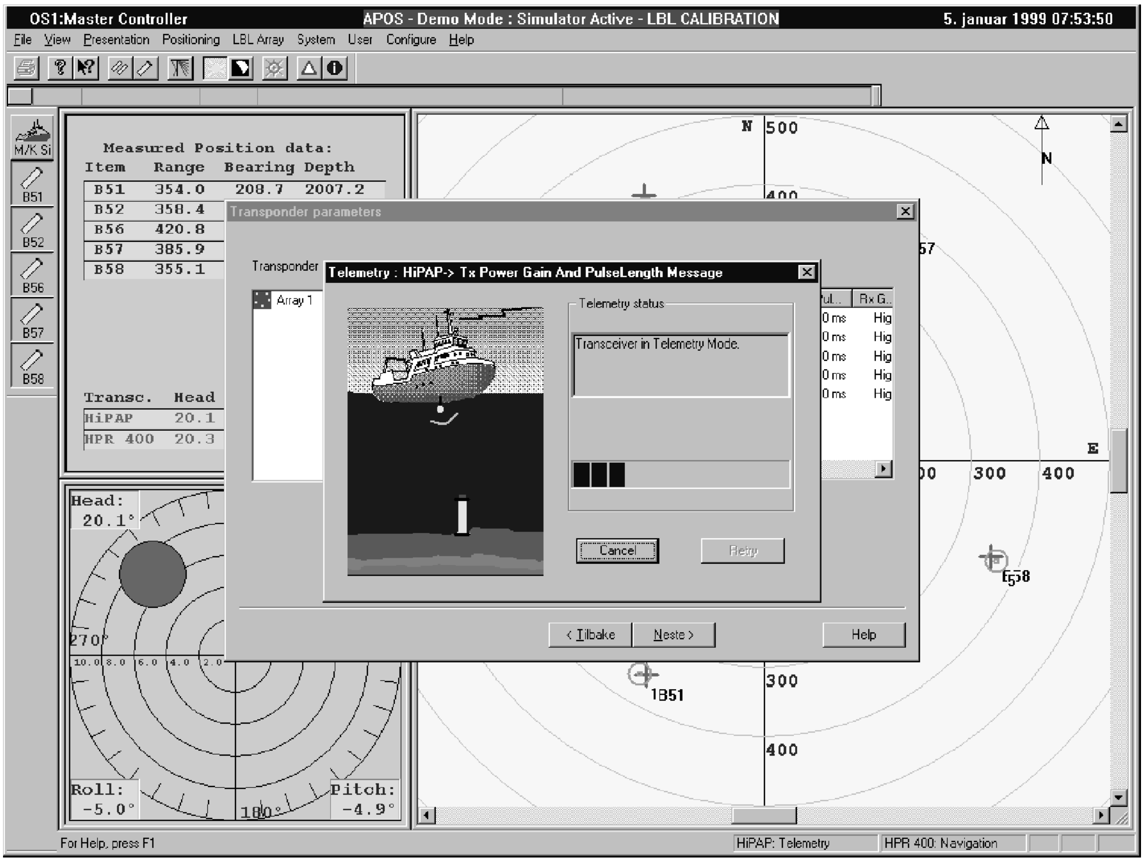
The **Rx gain** parameter is the receiver gain for the transponder. Use High if little noise around the transponders. In noisy environments use Low to prevent the transponder being disturbed by the noise.

The **Pulse length** parameter selects the pulse length for the transponder(s) and should be set to 10ms.

- Enter other values for one of the locations and click then at the **Set** button to start telemetry.



The changes are now sent to the location.



• Click the **Cancel** button to stop the telemetry.

• Click the **Neste/Next** button to go on with the wizard.

8.6.7 Measure baselines

The local calibration is based on range measurements between the transponders at seabed. The range between two transponders is often called a **baseline**. Normally each baseline is measured both ways, and they are treated as separate measurements.

A baseline is measured by the HPR/HiPAP system requesting one transponder via telemetry to measure the range to another one.

The **Master** parameter defines from which transponder the ranges are to be measured (defines the MASTER transponder).

The **Slave** parameter defines to which transponder the ranges are to be measured (defines the SLAVE transponder).

All locations can be selected as Master or Slave. Also individual measurements can be done by selecting specific locations.

The **No range meas.** parameter specify the number of measurements to be used when requesting a master transponder to measure the range to a slave. Default is 8.

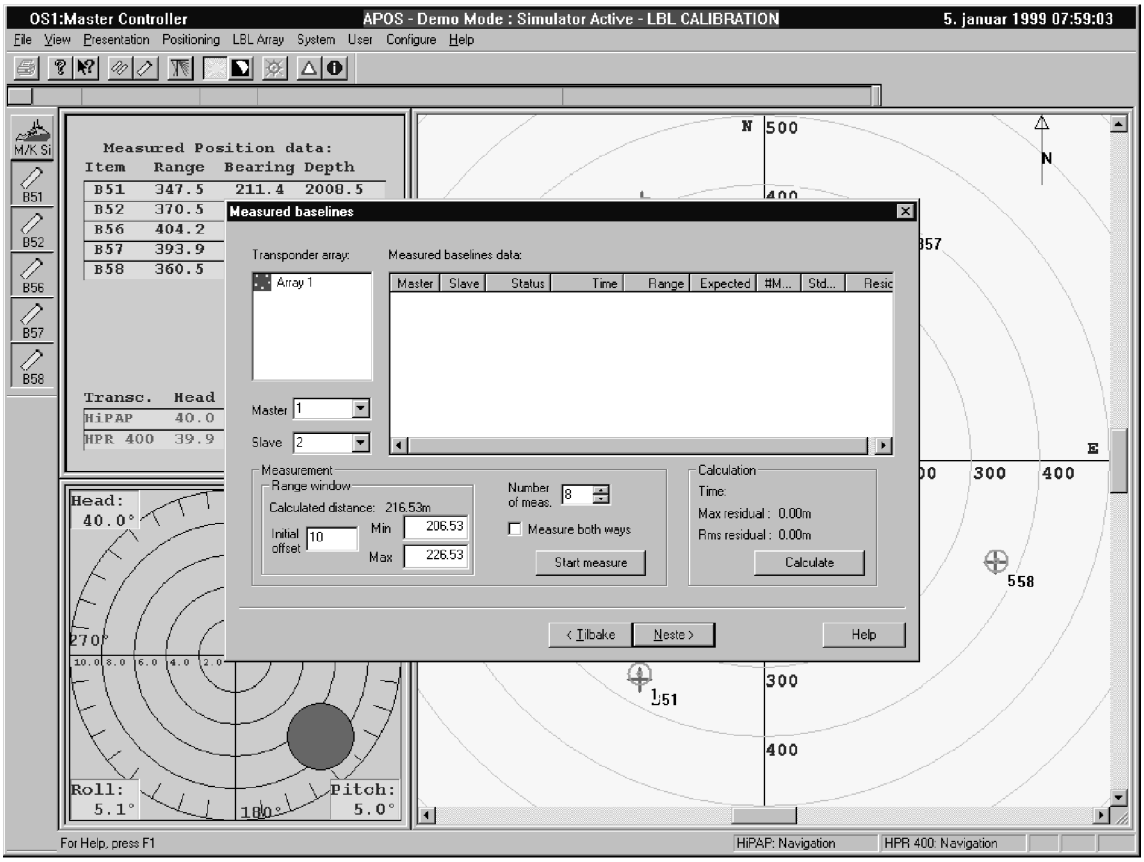
When measuring a subsea range, a master transponder interrogates a slave transponder and establishes a time window within which it listens for the reply from the slave. If this window is narrow the master is able to ignore reflections of the pulse sent from the slave.

The **Range window** parameters are set automatically by the system, but you can manually enter other values.

Min/Max sets the inner/outer limit of the detection.

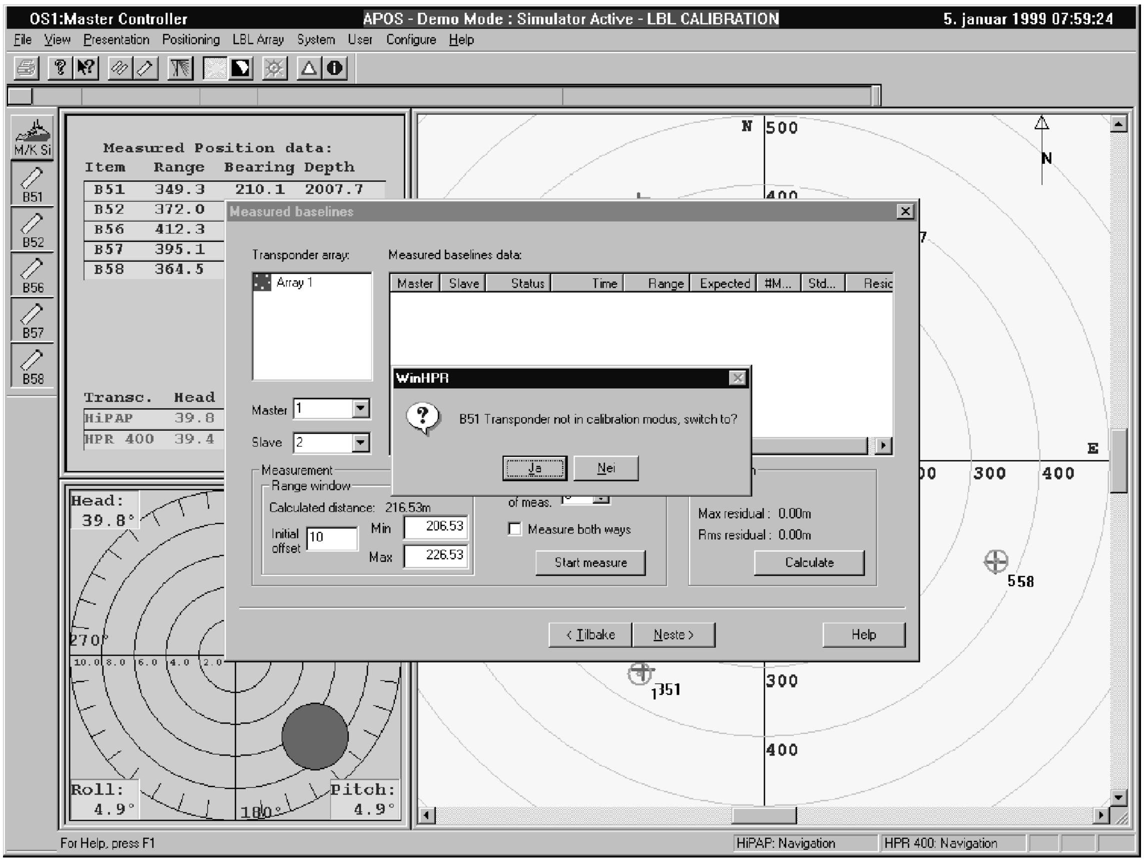
Initial offset can be used to set up a window around the range calculated from the initial coordinates.

- Use default values, select location 1 as Master, location 2 as Slave transponder and click the **Start measure** button.



The transponders are still in SSBL mode.

- Confirm that you want the transponder set to LBL **Calibration mode**.

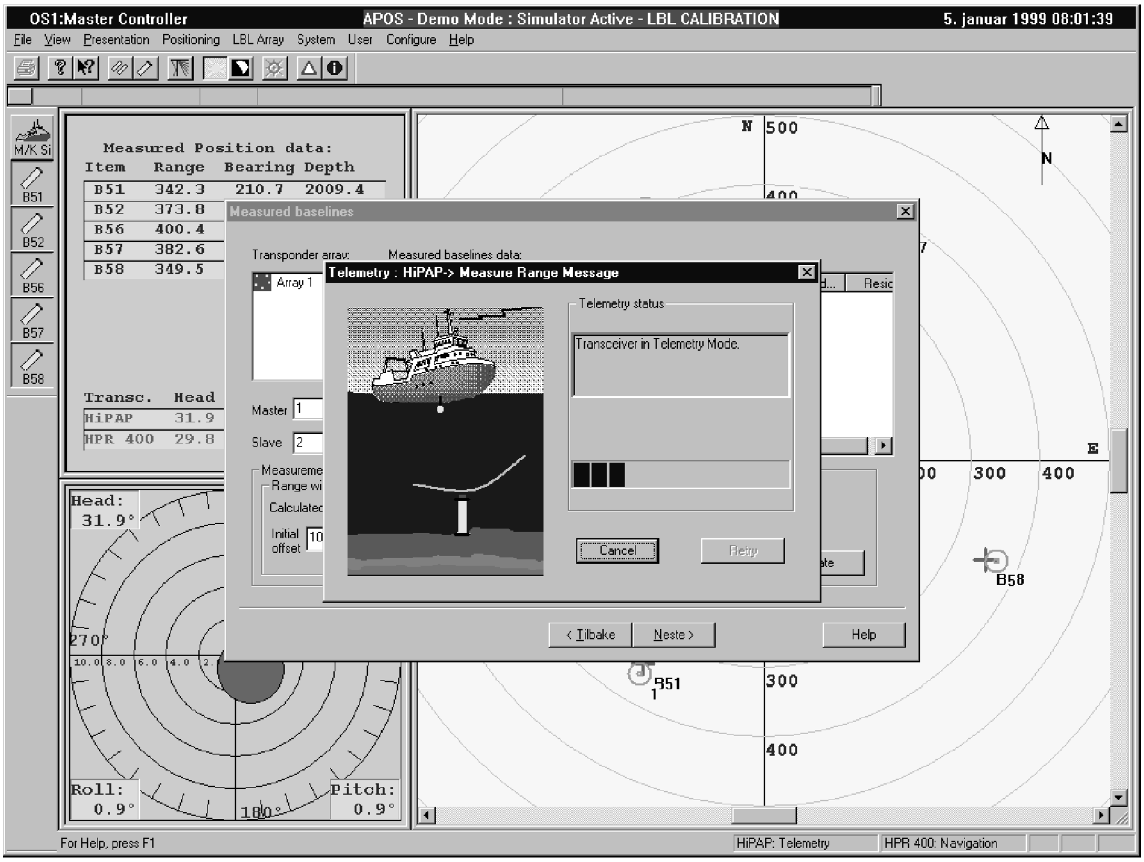


- When the telemetry picture is in the display, click the **Cancel** button.

The simulator has already set the transponder mode to LBL calibration.

You will have to confirm for the other transponders as you go on.

The system is no measuring ranges between the two transponders.



- Click the **Cancel** button.

The simulator has already done the measurment.

The result of the masurement will now be presented.

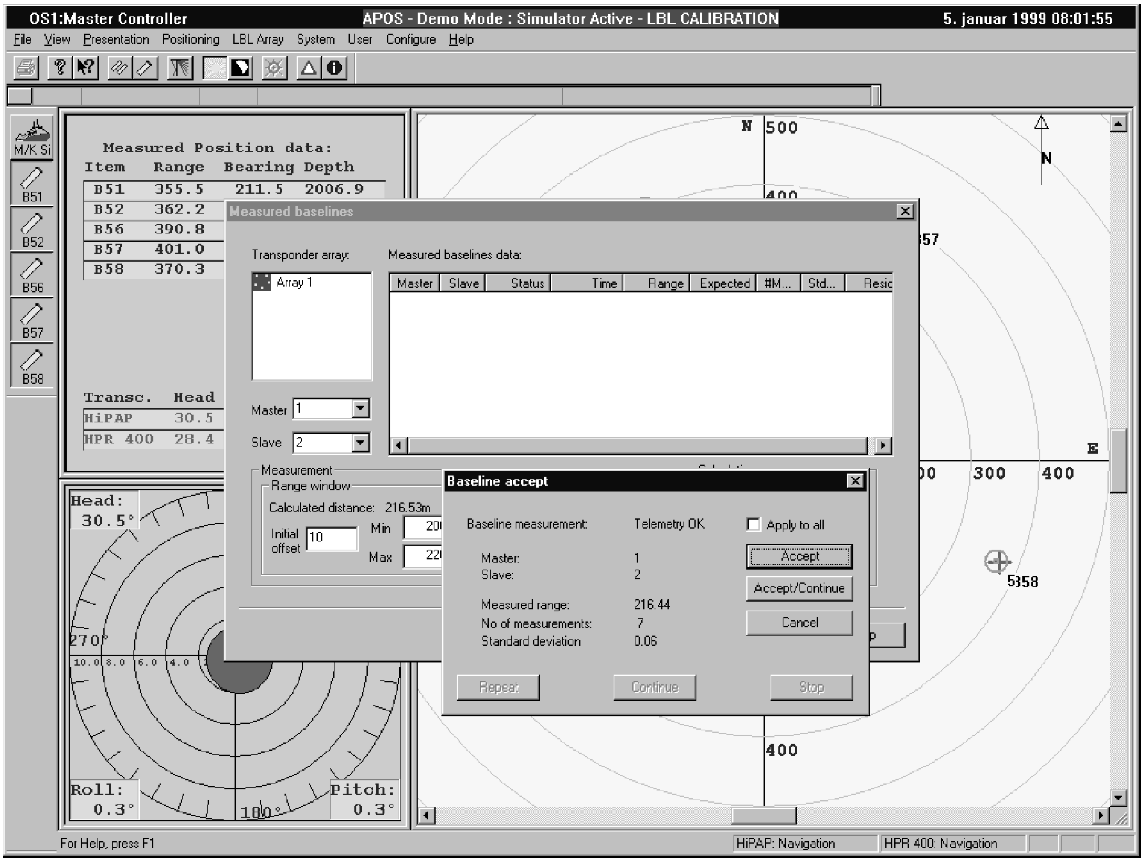
Each baseline can be measured many times by the Master transponder. It calculates the mean value and the standard deviation of the measurements, and transmits the values to the HPR/HiPAP system via telemetry.

The standard deviation is normally some centimeters and if it is more than a few decimetres the measuremensts should be repeated.

More about this later.

If no good standard deviation is achieved, you should exclude the measurement of the baseline.

More about this later.

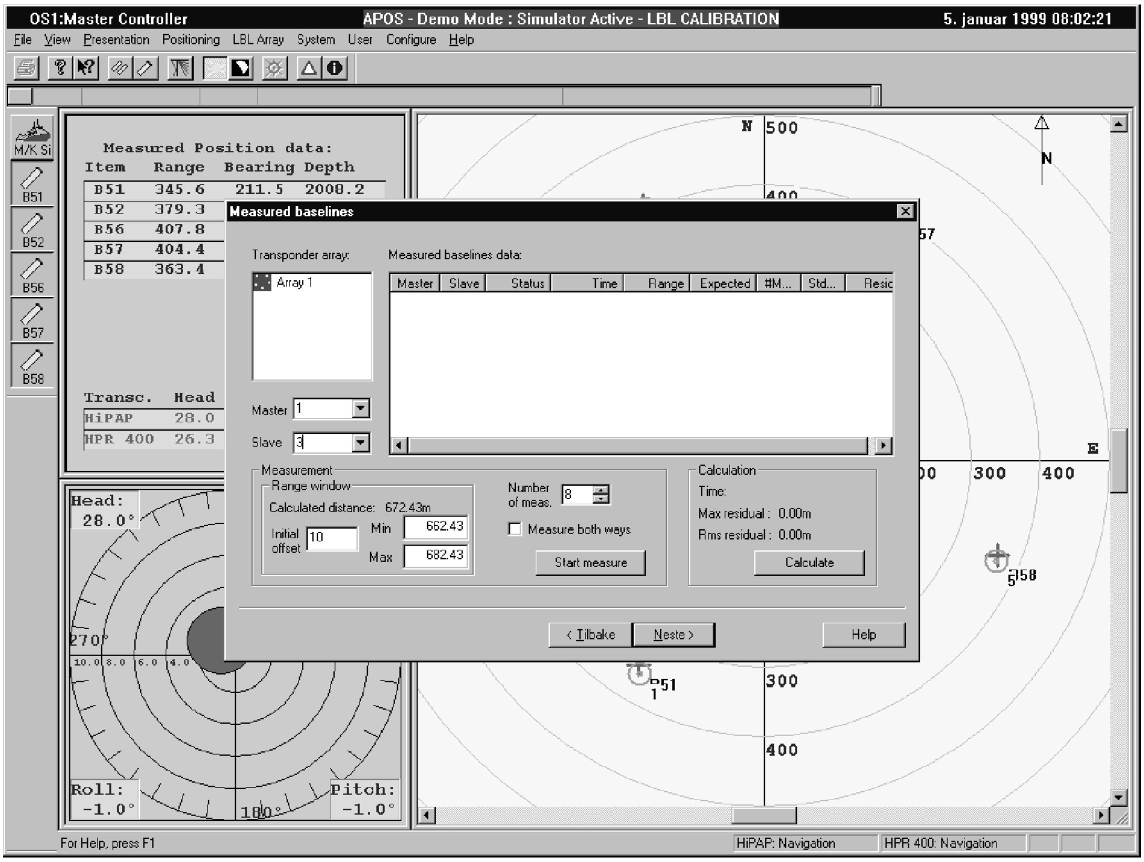


In this screen dump the standard deviation is only 6 centimeters. You might have got other and larger values, but us them so far.

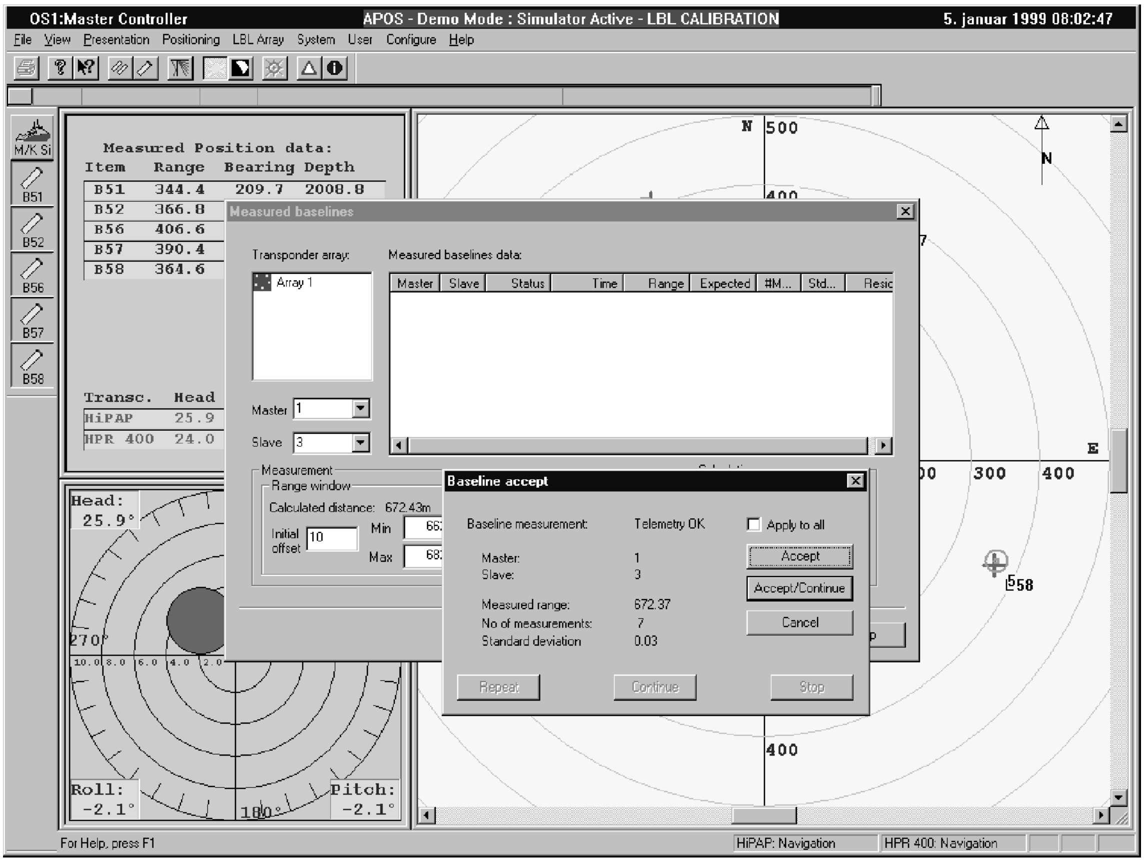
- Accept the measurement by clicking the **Accept/Continue** button.

Next baseline can now be measured.

- Keep location 1 as Master, select location 3 as Slave and click the **Start measure** button.



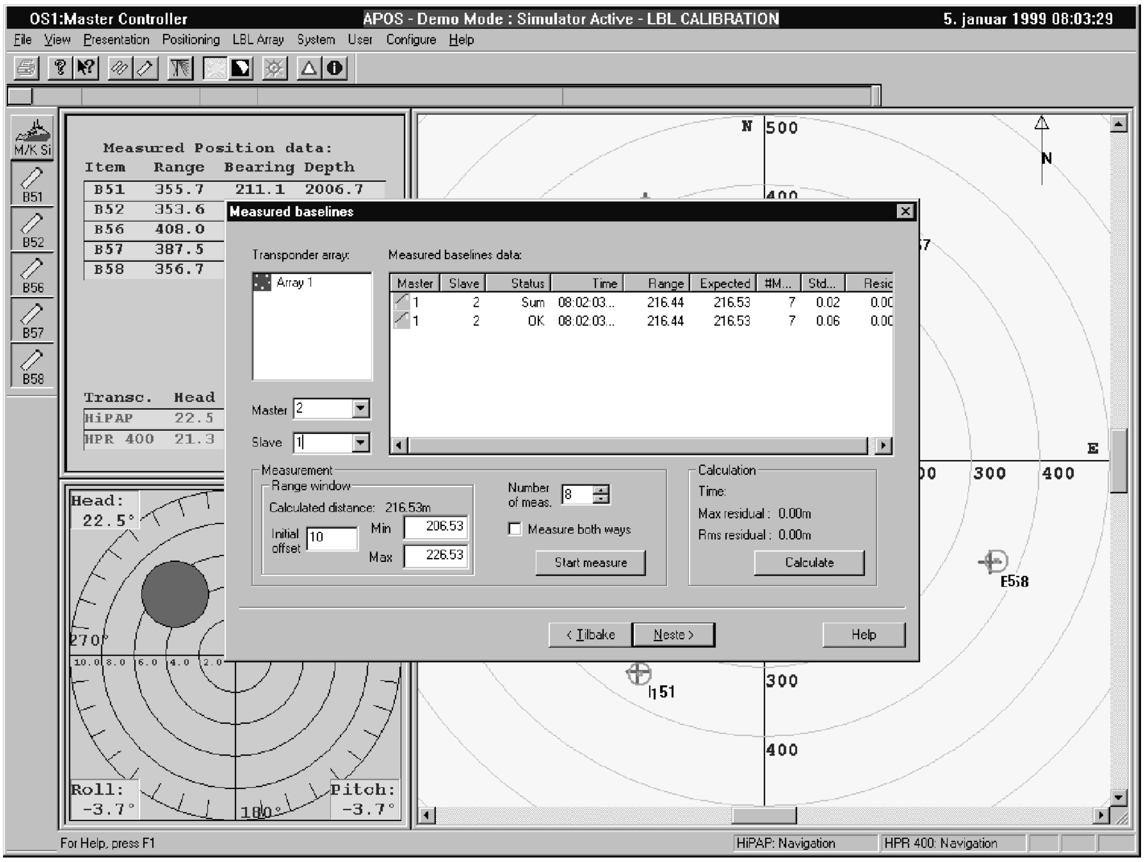
- Accept the measurement by clicking the **Accept/Continue** button.



- Do the same with location 4 and 5 as Slave and keep location 1 as Master..

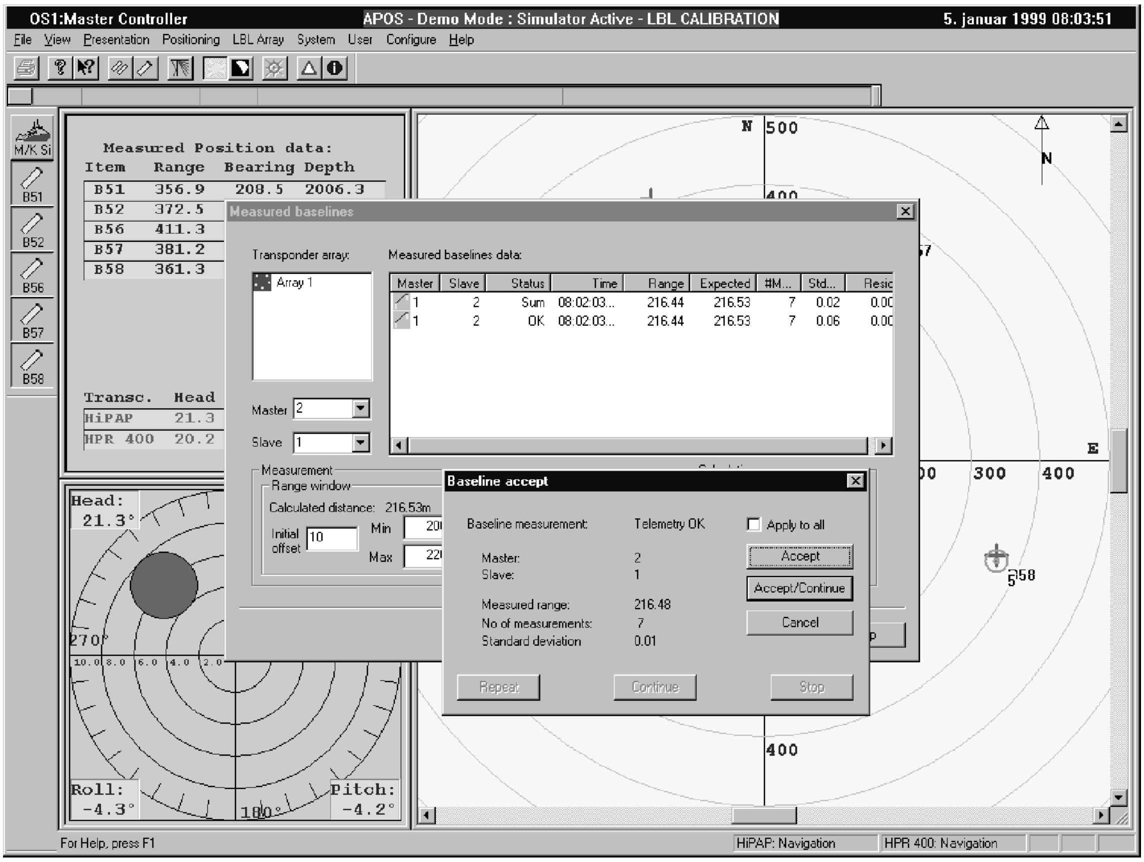
- Let location 2 be Master and location 1 be Slave.

You will now be presented the measurement you did few moments ago.



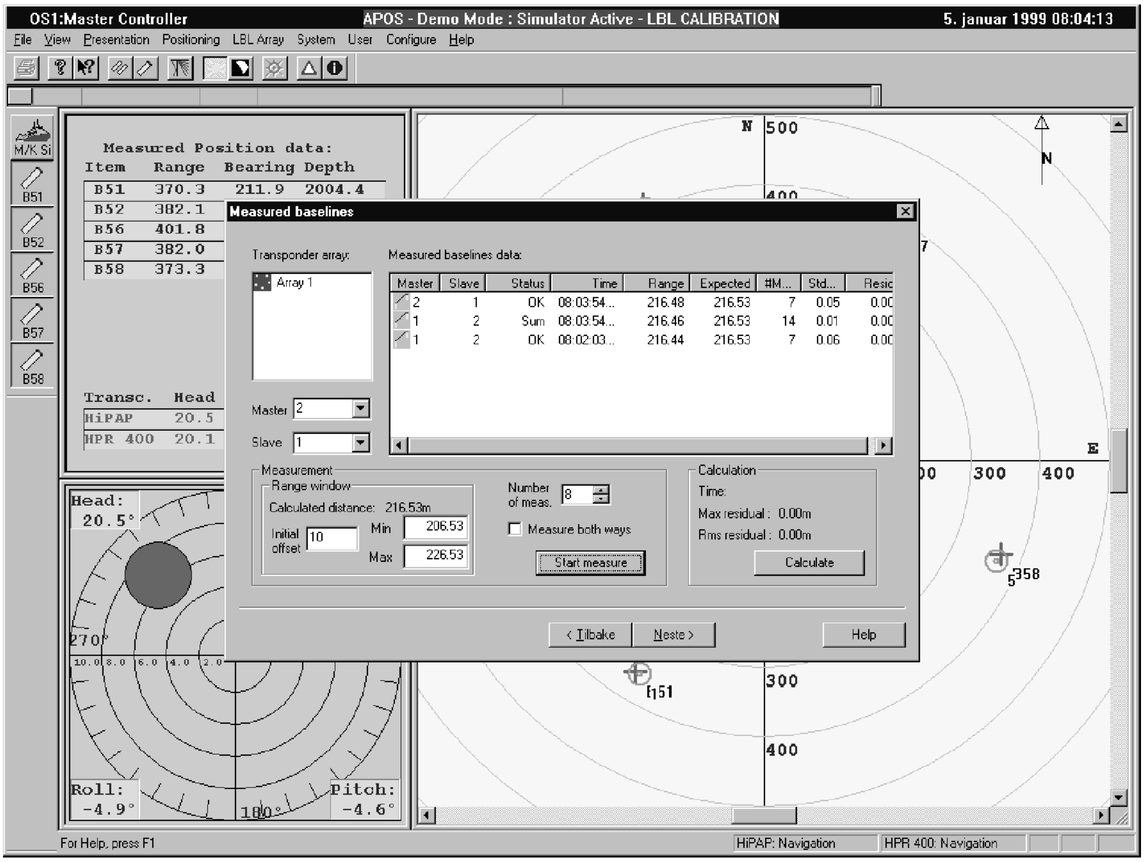
- Click the **Start measure** button.

- Accept the measurement by clicking the **Accept/Continue** button.



Measurements in both ways will now be presented in the same window.

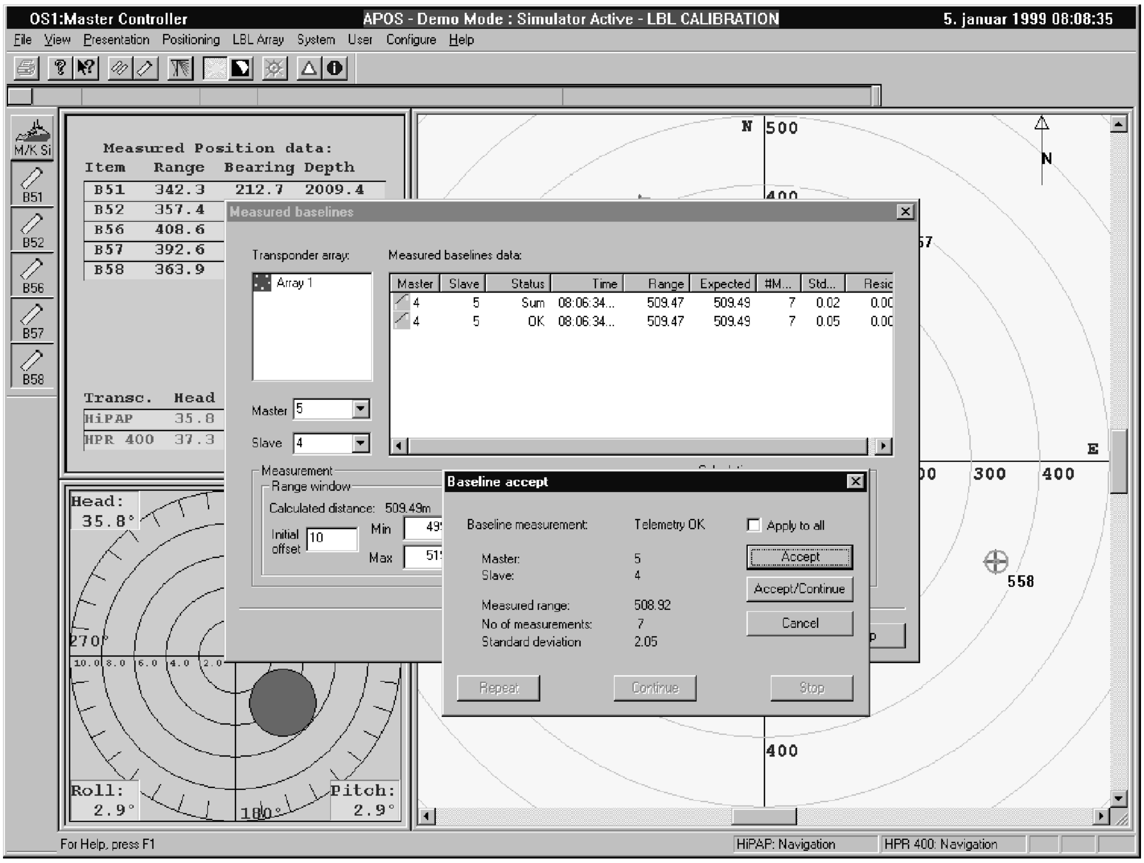
You have standard deviation for each measurement and standard deviation for the sum of the two measurements.



8.6.8 Cancel inaccurate measurements

You can also cancel a measurement that must be wrong.

- When you have the result of one of the measurements click the **Cancel** button.

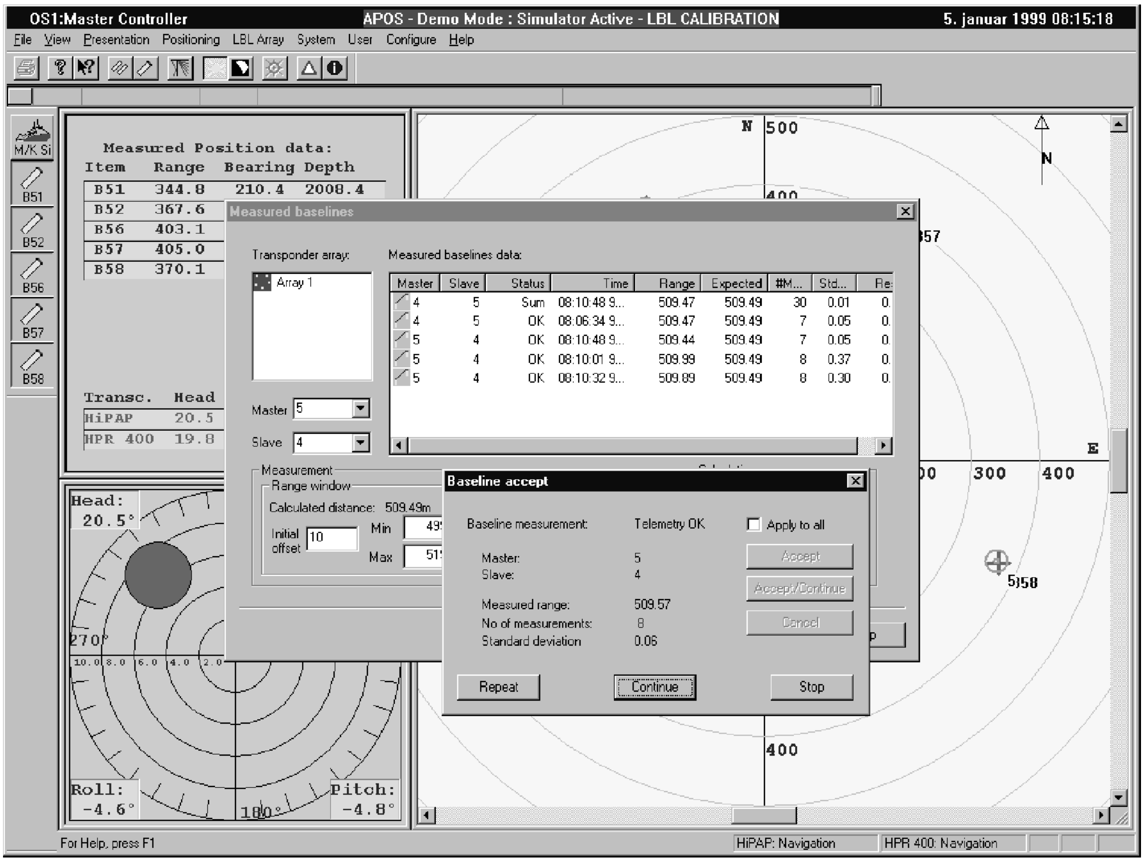


- Click the **Repeat** button to do the measurements over again.

8.6.9 Repeat measurements

If you are not satisfied with one or more measurements, you can repeat the measurement of this baseline.

- When you have the result of one of the measurements click the **Accept** button.



You will now be able to do the measurement of this particular baseline one more time.

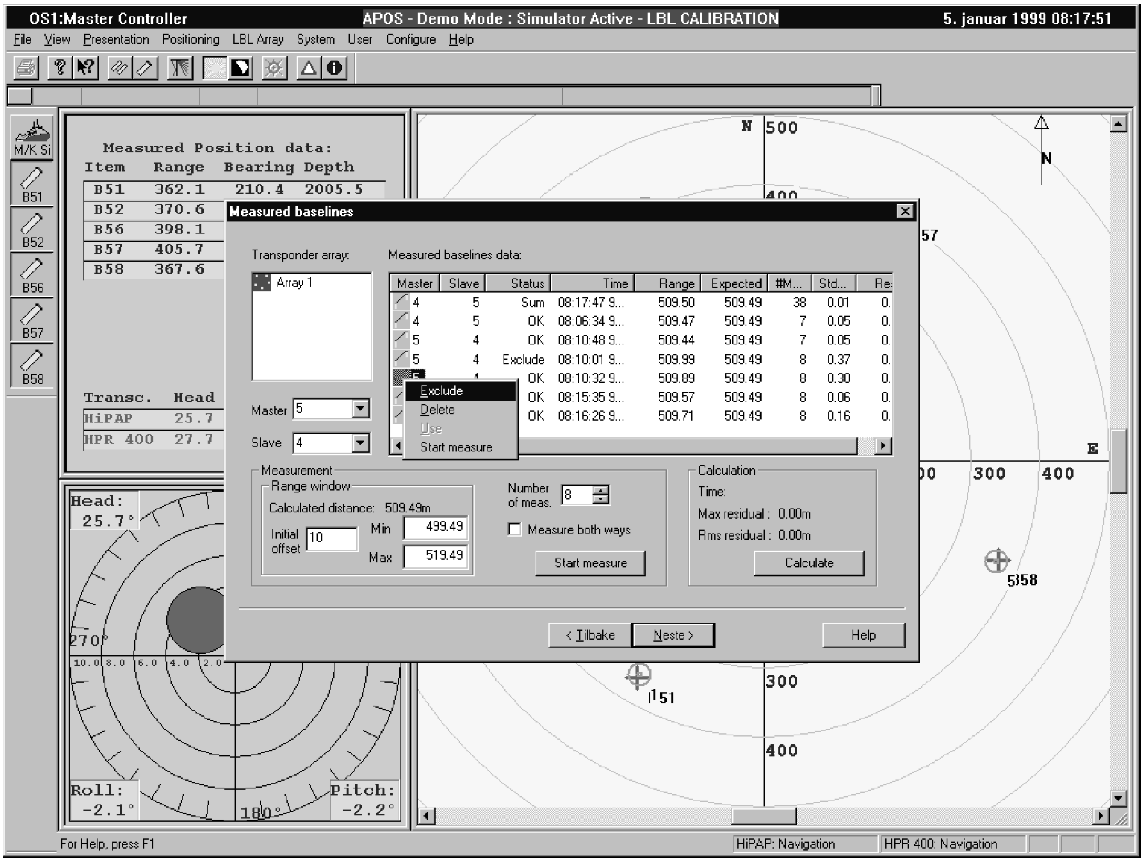
- You can now click the **Repeat** button to do the measuremet one more time.

- Do several measurements for one of the baselines.

8.6.10 Exclude measurements

You can also exclude some of the measurements you have done. The measuremenst will still be in the dsiaplay but will not be used when calculating positions later on.

- Exclude some of the measurements by placing the cursor above the measurement, click then right mouse button and select **Exclude** from the menu.

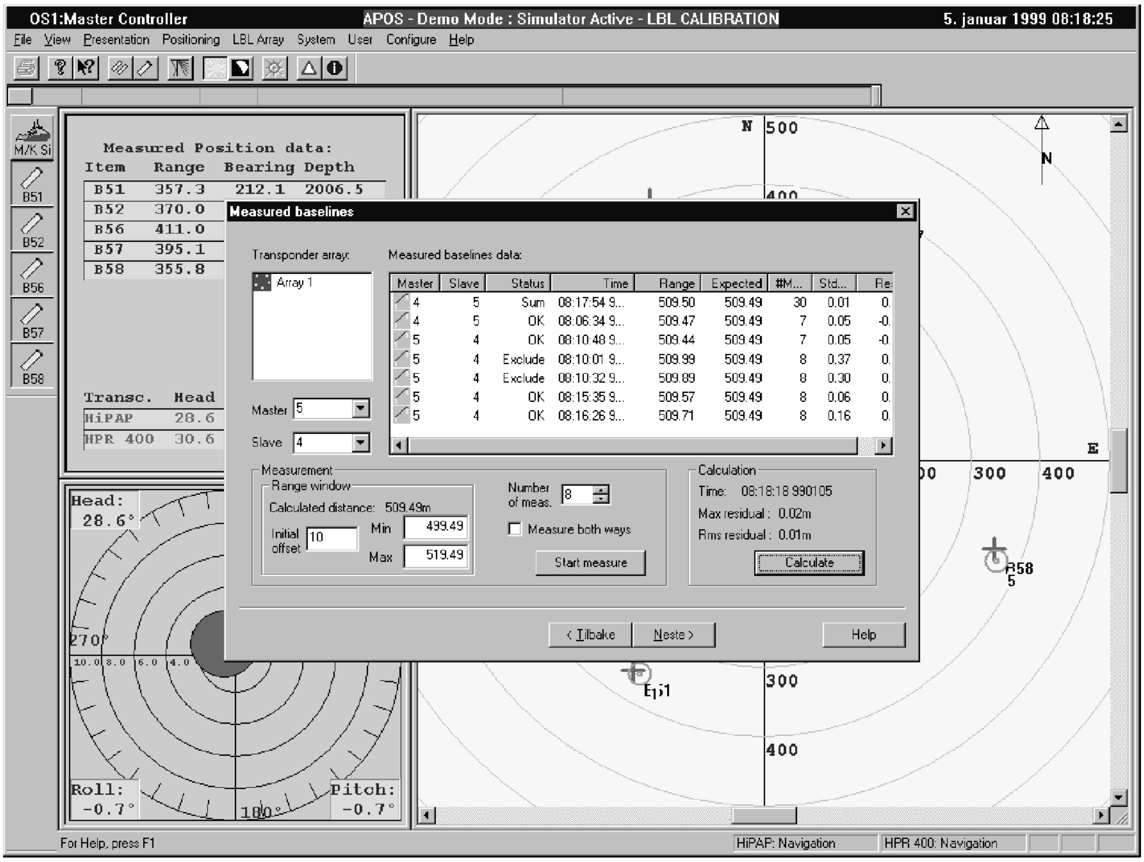


8.6.11 Calculate calibrated positions

It is now time to calculate the calibrated positions. The system uses the initial coordinates and the measured baselines and finds new and calculated positions for the locations.

The programs use a weighted least square error algorithm to decide the positions of the transponders. The algorithm is iterative, starting at the initial positions of the transponders.

- Click at the **Calculate** button



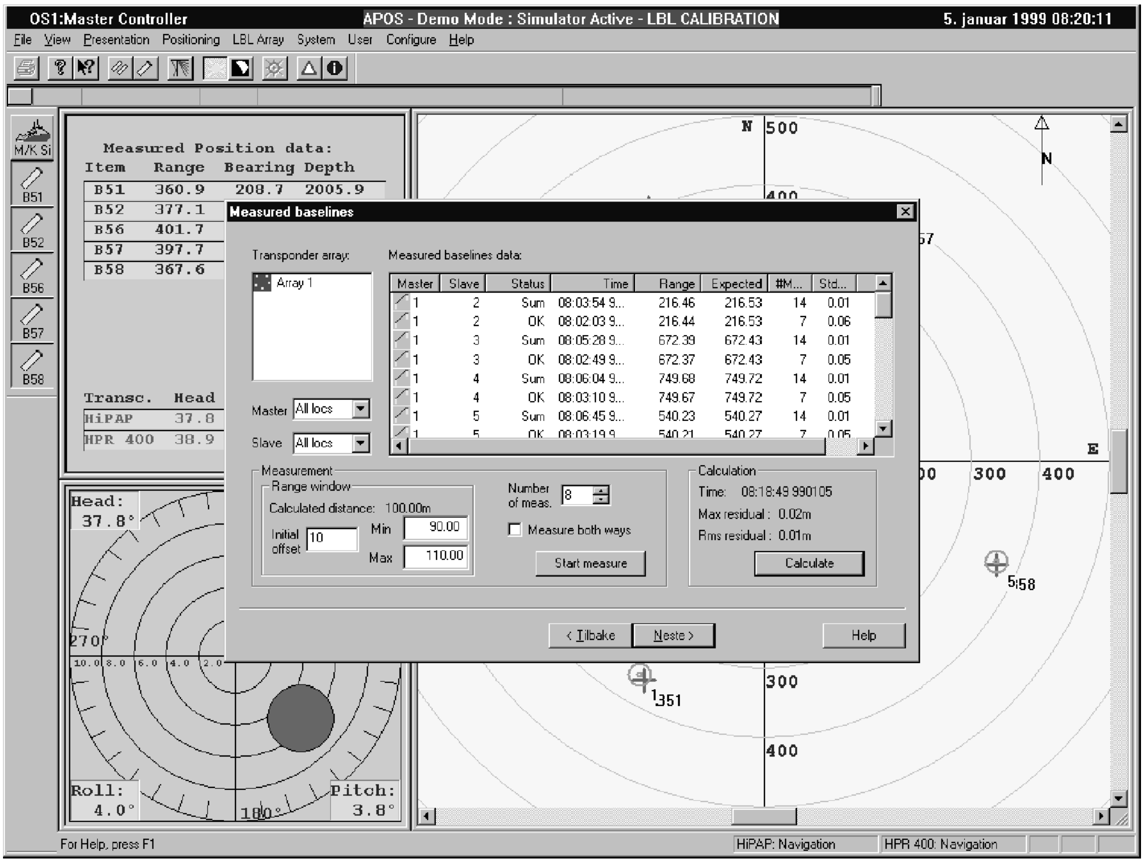
The range errors are the differences between the measured ranges and the corresponding ranges calculated by using the Pythagoras formula on the transponder positions. These errors are called range residuals.

The **Max residual** value tells us the max range residual of all locations.

The **Rms residual** value tells us the average range residual of all locations.

- Let both Master and Slave be **All locs**, click then once at the Master tab.

The system will now sort the measurements. All measurements with locations 1 as Master will be listed first, then measurements with locations 2 as Master so on.

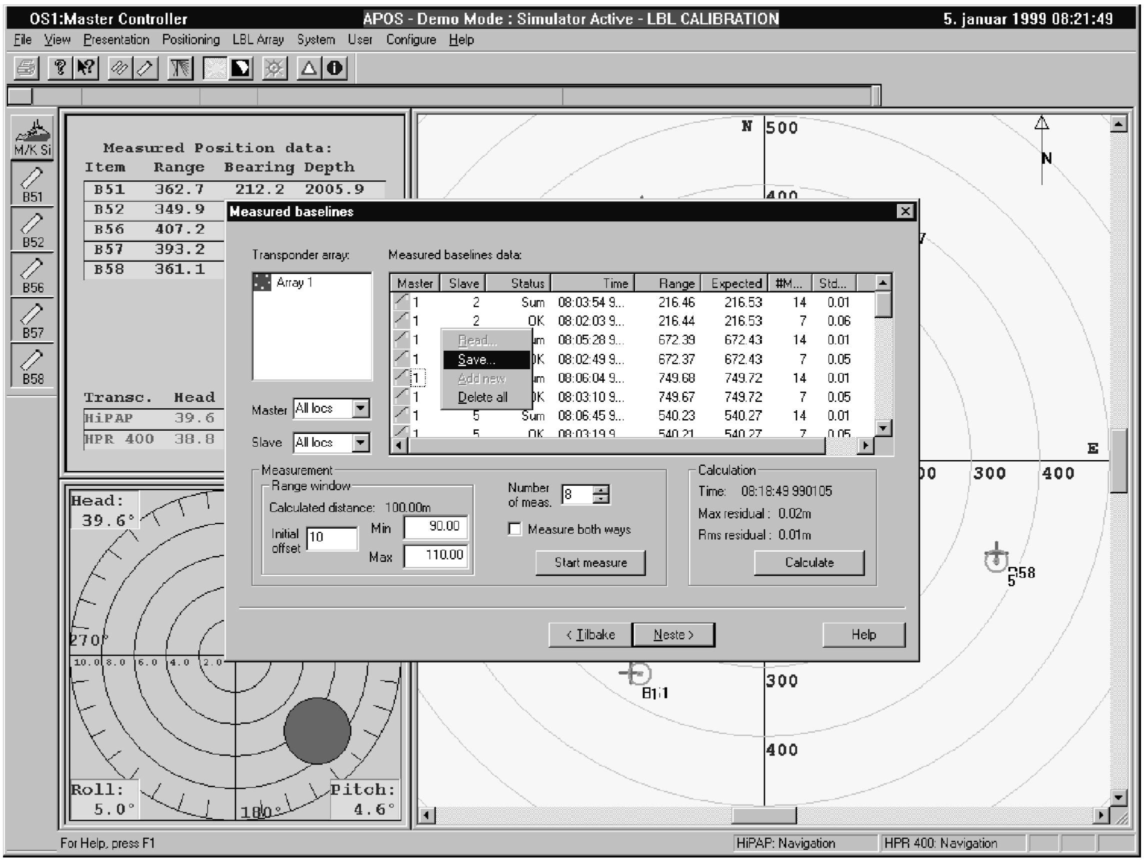


- Click one more time at the Master tab and the list will be displayed up–side–down.

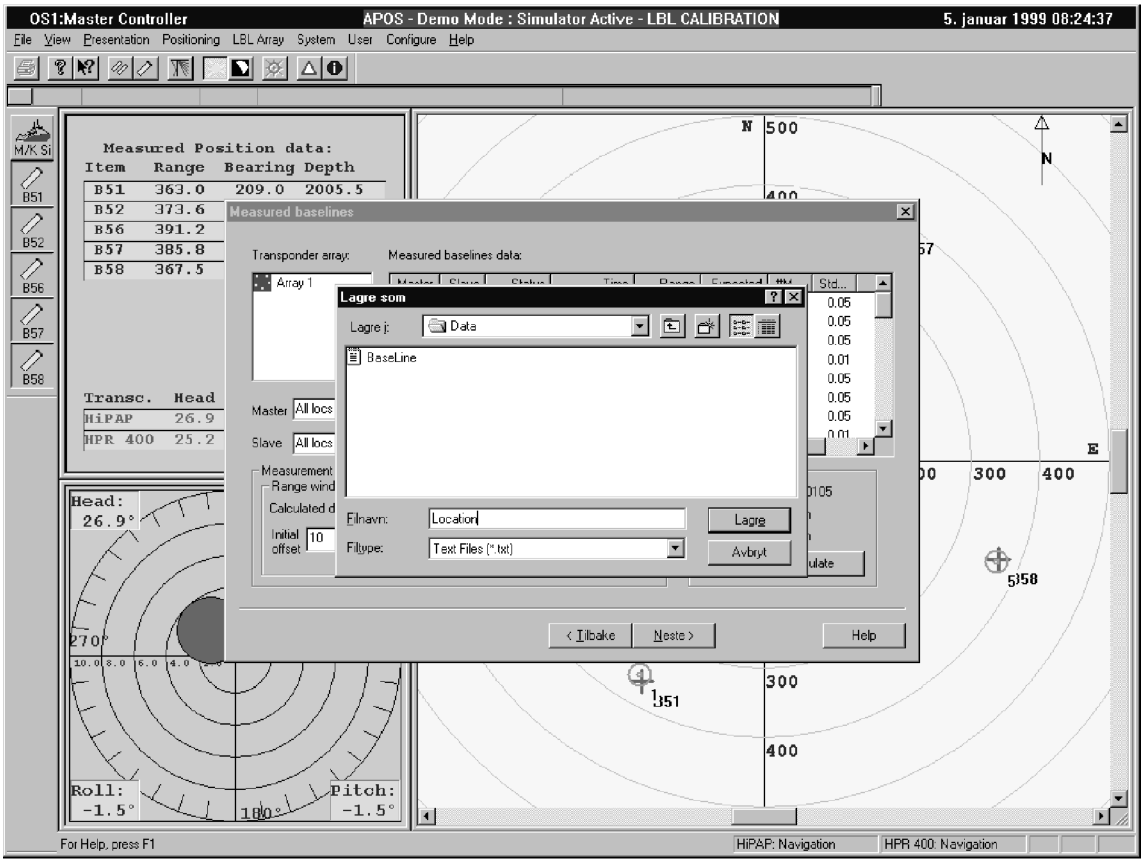
- Try to click one or two times at the other tabs such as Slave, Status, Time etc. and see how the data is presented.

- Save the baselines at a file by placing the cursor inside the window, click right mouse button and then select **Save**.

The text file can later on be pasted into documents, reports etc.

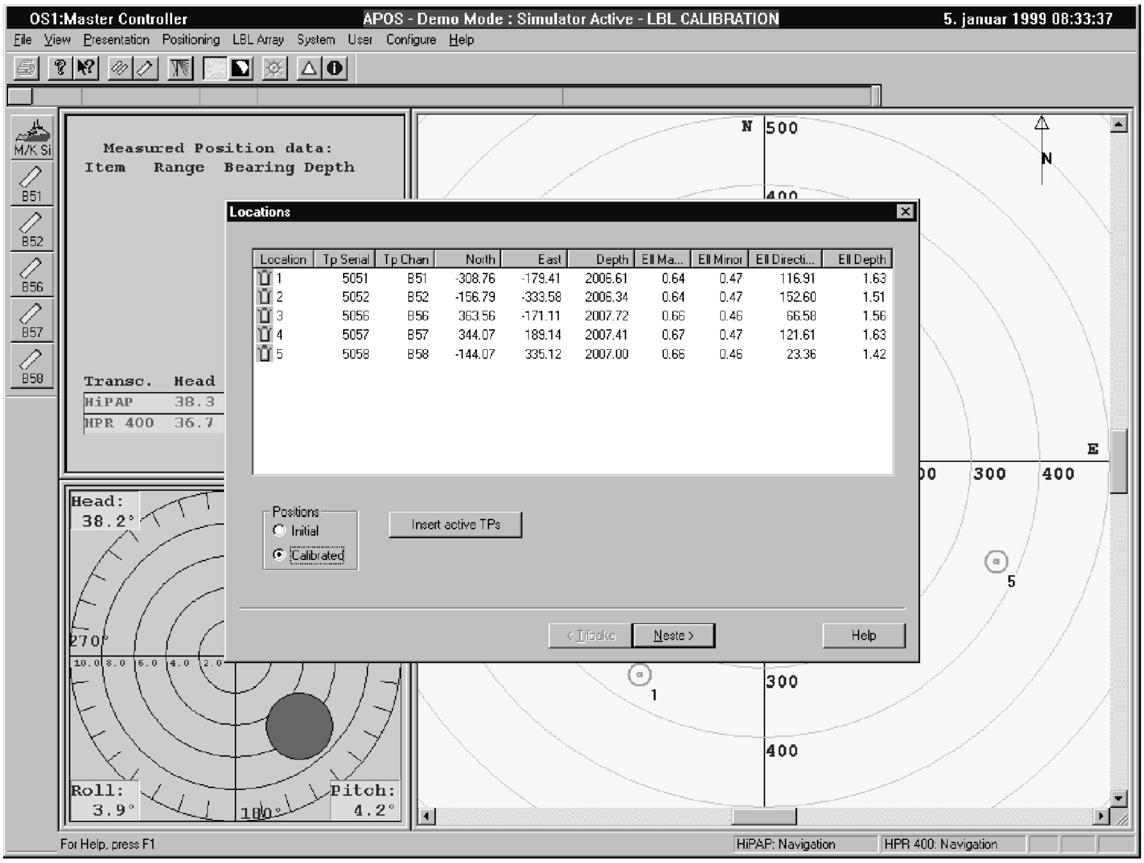


- Select a suitable name and click the **Lagre/Save** button.



- Go back to the first window in the wizard and display **Calibrated Positions** instead of **Initial Positions**.

- Compare the positions.



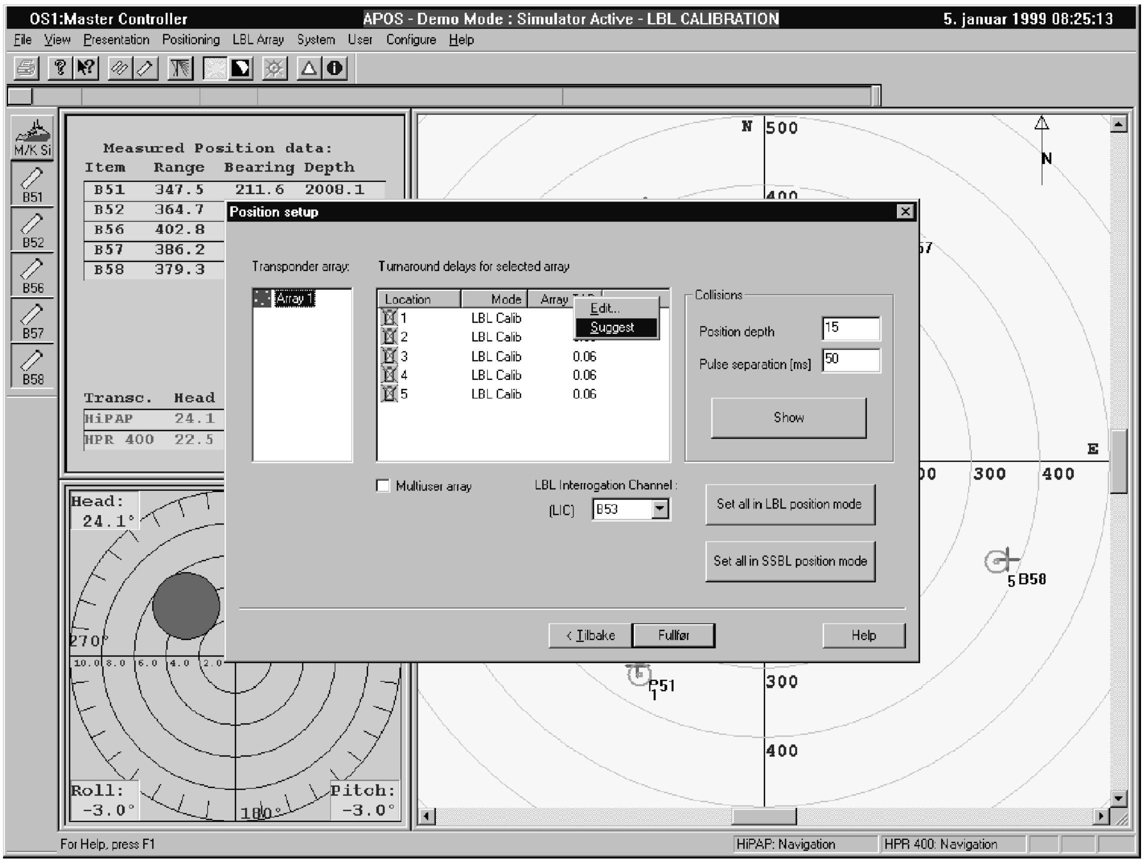
- Go to the final page in the wizard again by clicking the **Neste/Next** button three times.

8.6.12 LIC–channel and Turn araound delay

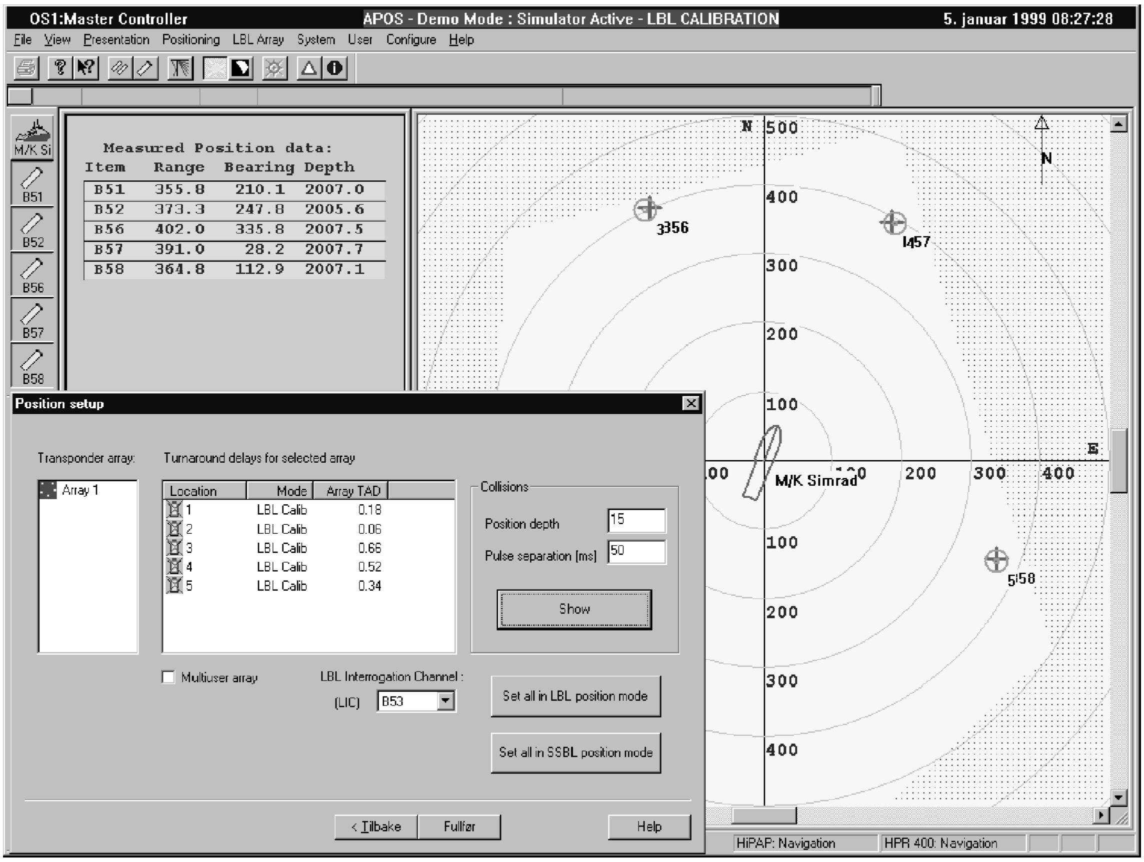
The LBL interrog channel parameter sets the channel number to be used to interrogate the transponder array during LBL positioning. All the transponders in the array will be interrogated simultaneously using this channel. Information about the channel is transfered to each transponder when set to the LBL positioning mode. The channel is abbreviated to LIC in some tables.

The LIC channel has either odd or even first digit in the two digit channel code, depending on the first digit of the transponders. E.g. if LOC#1–5 has channels B23–B27, the LIC channel can be B67 (EVEN). The second digit of the channel number does not matter.

- Enter B53 as **LIC**.
- In the **Position depth** parameter you enter the transducers depth.
- Place the cursor above the **Array TAD** tab, click right mouse button and click at **Suggest** to let the system find the best turnaround delays for this array.
- Click the **Show** button to get the graphical presentation of where we can expect collisions with these turnaround delays.



- Move the window to see the **collisions** in the display.

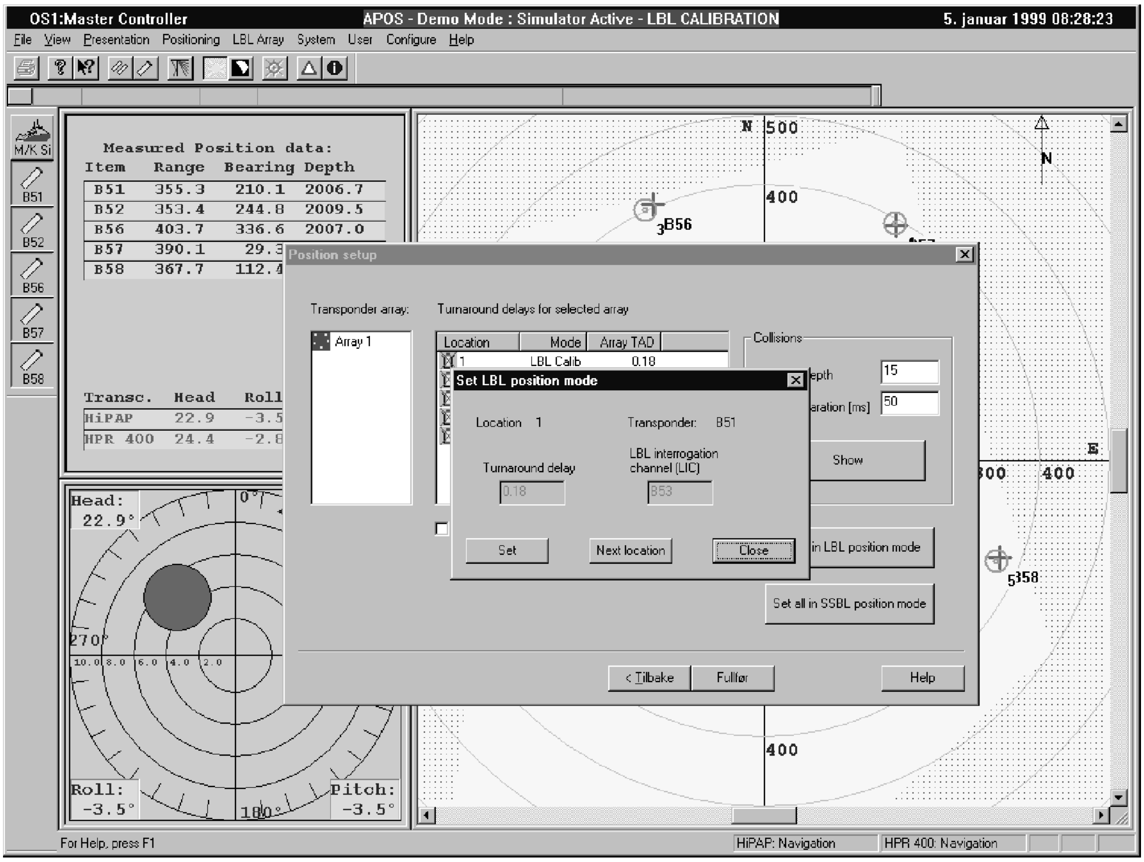


When positioning you will have no collisions as long as the vessel is inside the array.

8.6.13 Set to LBL Positioning mode

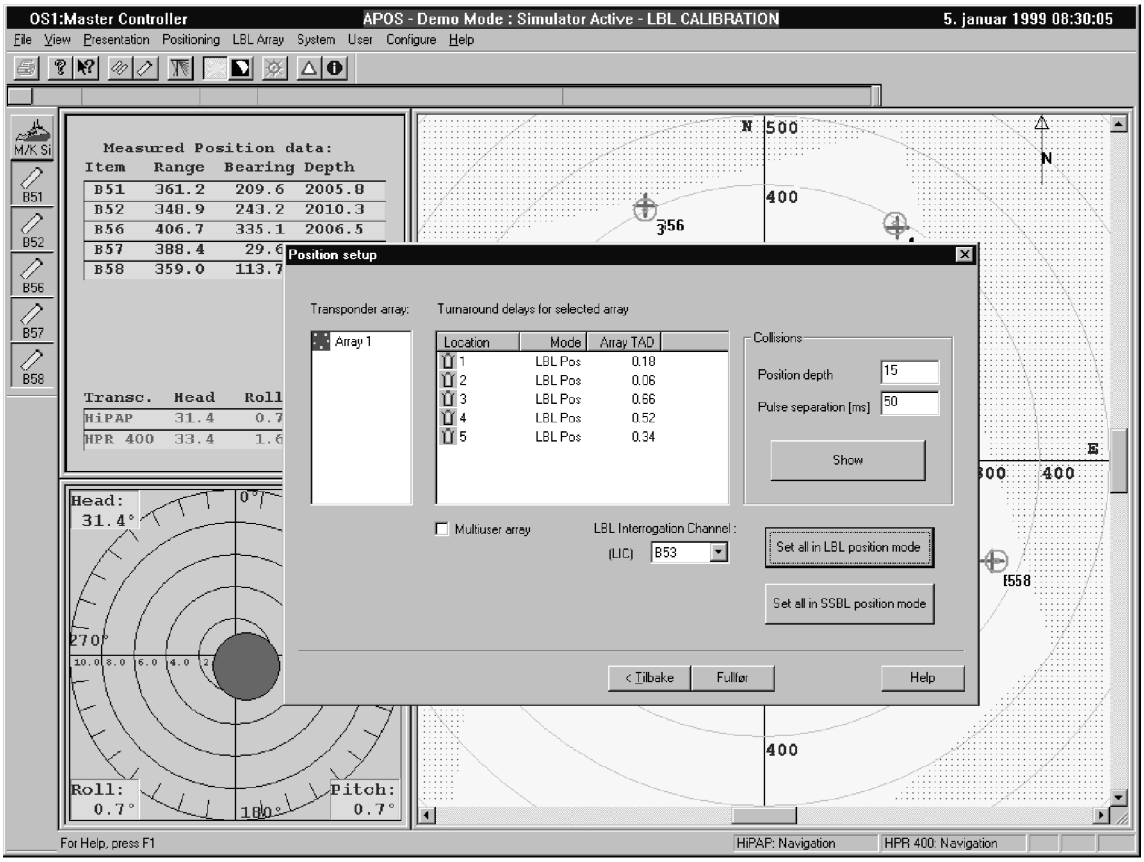
The transponders are now in LBL calibration mode. We have to set them to LBL position mode before before we can start the positioning.

- Set all transponders in LBL position mode by clicking the **Set all in LBL position mode** button.



- Repeat for all the locations.

- When you have done it for all of the transponders click the **Fullfør/Complete** button.

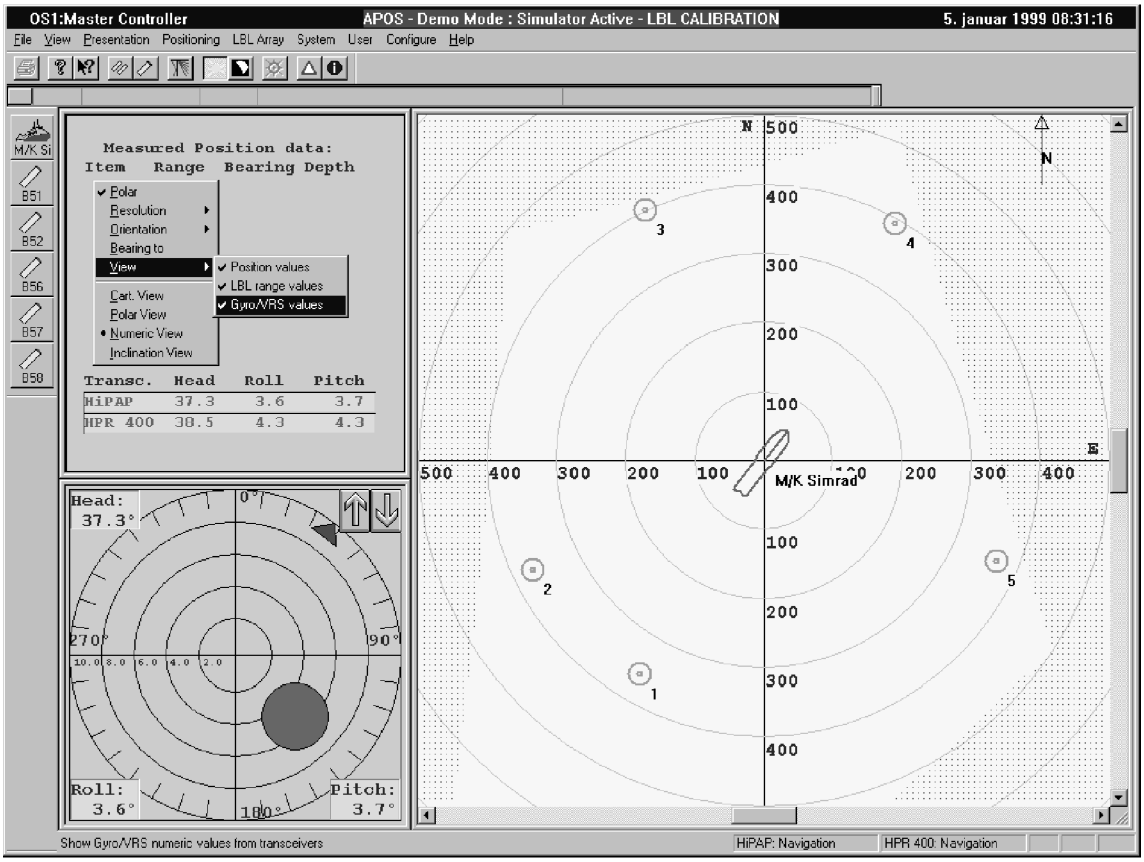


8.6.14 Start LBL positioning

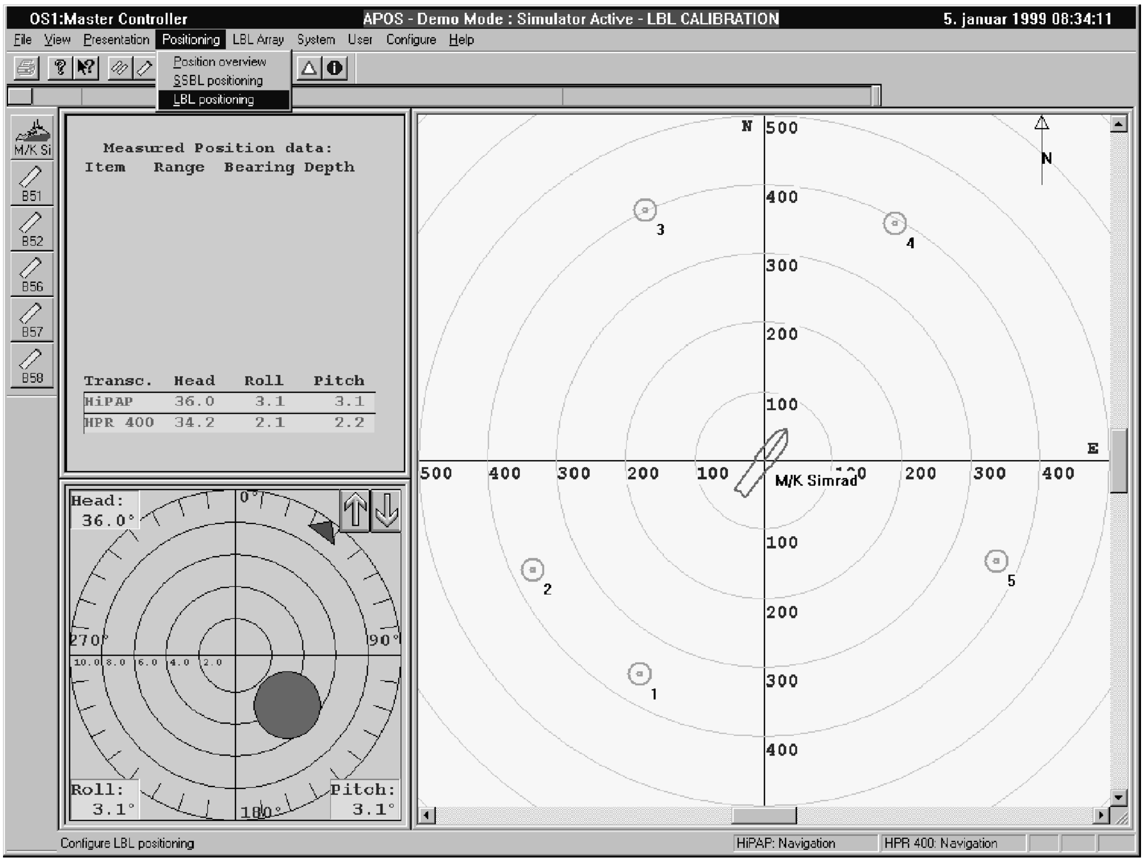
In this simulator we manually have to turn off the SSBL positioning for the transponders we are using. At your own vessel this will automatically be done by the system.

- Deactivate all of the transponders.

- Make sure that you in upper left window have **Polar** checked, that **North** orientation and **Bearing from** is selected and that **Position/LBL Range/ Gyro and VRU** values will be presented.



- Start LBL positioning by selecting **LBL positioning** from the **Positioning** menu.



A new window with some parameters and check boxes will appear.

From the **Interrog. Interval** parameter you set the interrogation rate which the transponder array is to be interrogated during LBL positioning. The fastest interrogation rate possible is the maximum turnaround delay plus the propagation time of the sound in the water. If the system is not receiving one or more replies, the update rate will be maximum TAD plus the time to reach max range set in the Default parameters submenu.

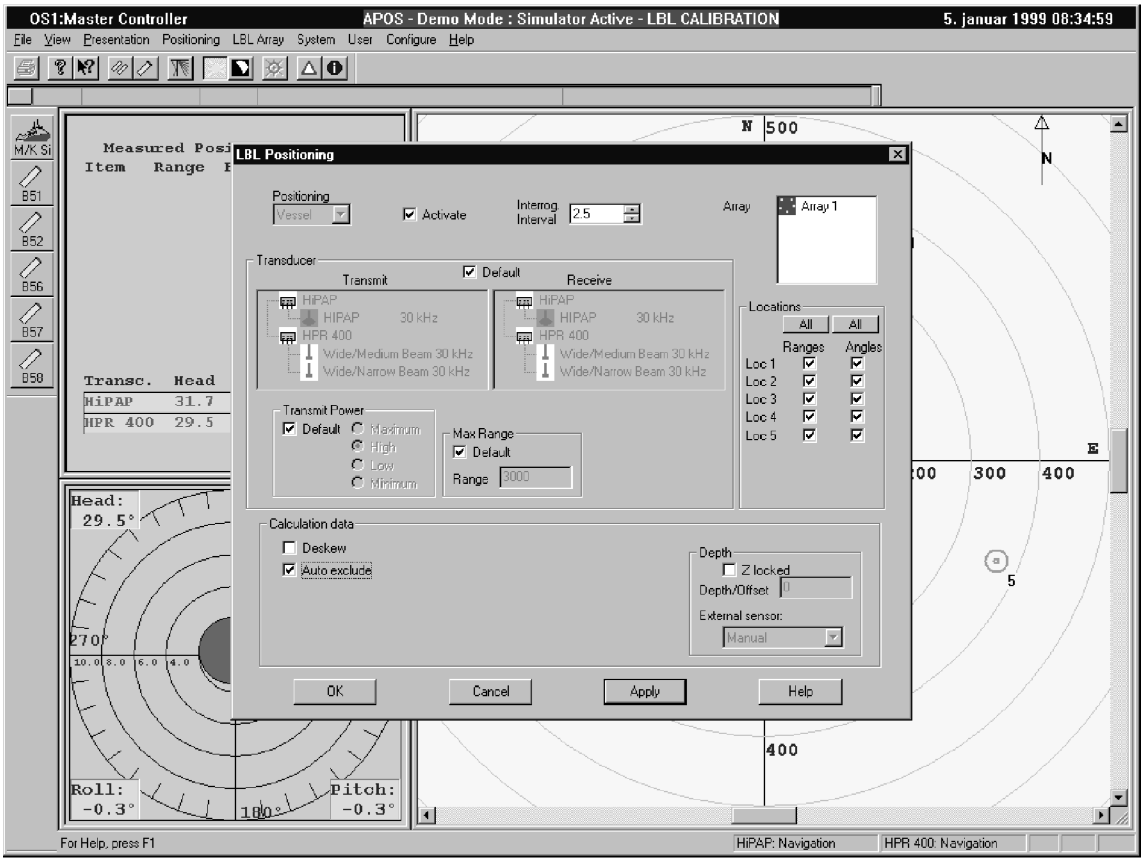
The **Transmit power** parameter sets the power to be used by the HPR/HiPAP system when interrogating the transponder array. The power level required will depend on the distance to the furthest transponder. High should be selected for ranges in the area 500–800m. Max can be used for longer and Low for shorter ranges.

The parameter **Auto exclude** enables you to exclude inaccurate measurements from the position calculation

The **Range deskew** parameter switches on and off the deskew function. When ON, the HPR system compensates for the movement of the vessel or ROV during the interrogation of the TP array. The ranges are modified to be as close as possible to the ranges that would have been measured if the vessel or ROV had not moved.

The **Transducer** parameter is used to specify the transducer to be used by the transceiver selected. The remaining parameters in the submenu apply to the transducer selected.

From the **Locations** parameter you select the transponder locations that are to be used for the current positioning operation. Locations not checked will not be used in position calculation. You also select if you will use only ranges or both ranges and angles when calculating the position. It is also possible to use only some of the ranges and angles.



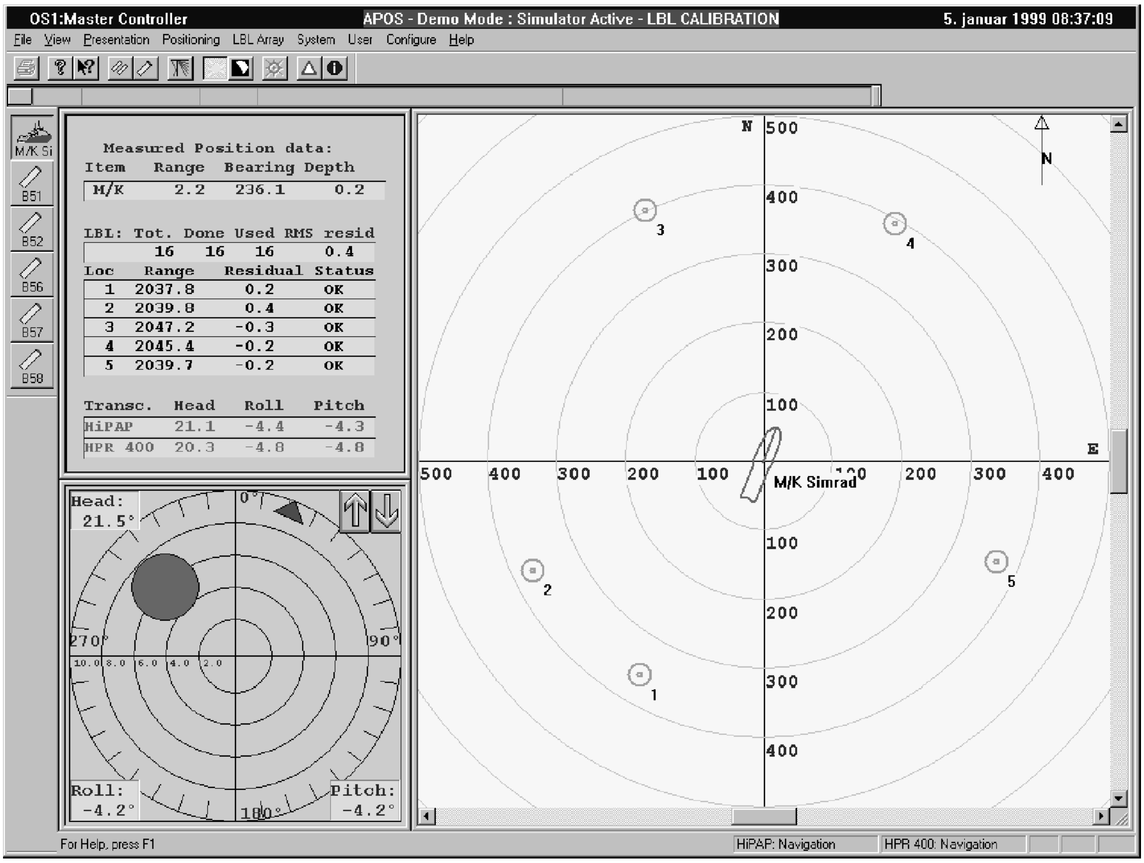
- Enter 3 seconds as Interrog. interval, use all ranges and angles, use default values and Auto exclude.
- Remember to enter a tick mark in the **Activate** check box before you click the **OK** button.

During positioning the HiPAP/HPR system normally measures more ranges and SSBL directions than necessary. After having calculated the position, it checks how well the measured ranges and directions fit with the position. Measurements obviously wrong may be automatically excluded when the position is calculated again.

The APOS calculates residuals of all measurements, and the uncertainty of the LBL position

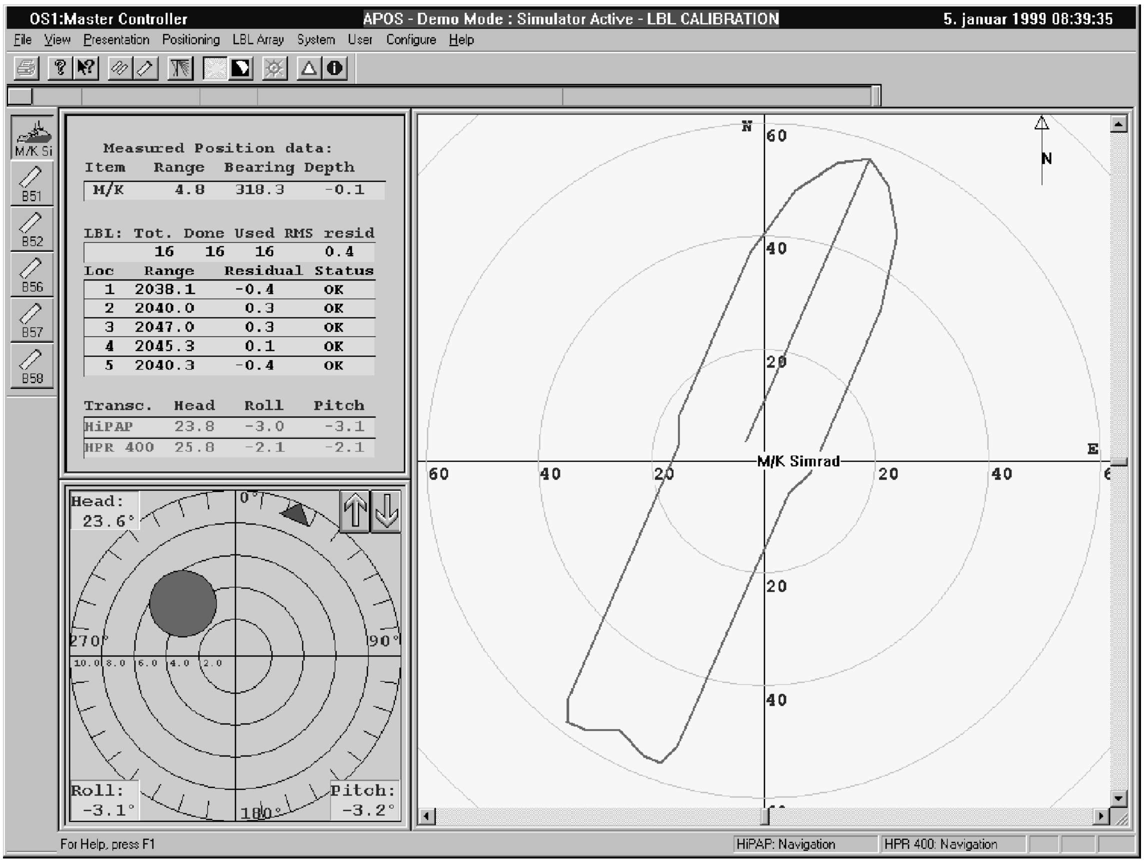
The uncertainty of the local LBL position calculated, depends on several factors:

- The number of ranges and SSBL angles measured, and the geometrical crossings of the vectors from the transponders to the transducer.
- The accuracy with which the ranges and the angles are measured.
- The uncertainty of the sound velocity profile used. You insert this uncertainty in a menu.
- The uncertainty of the calibrated positions of the transponders in the array.



The positions presented are:

- Vessel position relative the origin of the LBL array:
  - √ Range
  - √ Bearing
  - √ Depth (+ depth means that CG is below the surface)
- Number of measurements to get the position:
  - √ **Tot**. (tried to do as many measurements as this value)
  - √ **Done** (did as many measurementsas this value)
  - √ **Used** (used as many measurements as this value)
  - √ **RMS resid** (mean residual between measured and calculated ranges)
- For each locations:
  - √ Range (Slant range, not the horizontal range)
  - √ Residual (measured range minus calculated range)
  - √ Status (Ok, Timeout, Excluded)



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9 OTHER NOTES

In this chapter you might find other notes of interest.

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