Kongsberg HIPAP Transducer Alignment on R/V Sally Ride

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Kongsberg "HiPAP" System

- High Precision Acoustic Positioning System
  - Uses both Super Short Baseline (SSBL) and Long Baseline (LBL) positioning techniques.
    - LBL- navigates using deployed seafloor transponders.
    - SSBL- navigates using many integrated transducer elements to measure target distance via signal run time, and direction by measuring the phase shift of the reply signal as seen by the individual elements of the transducer array

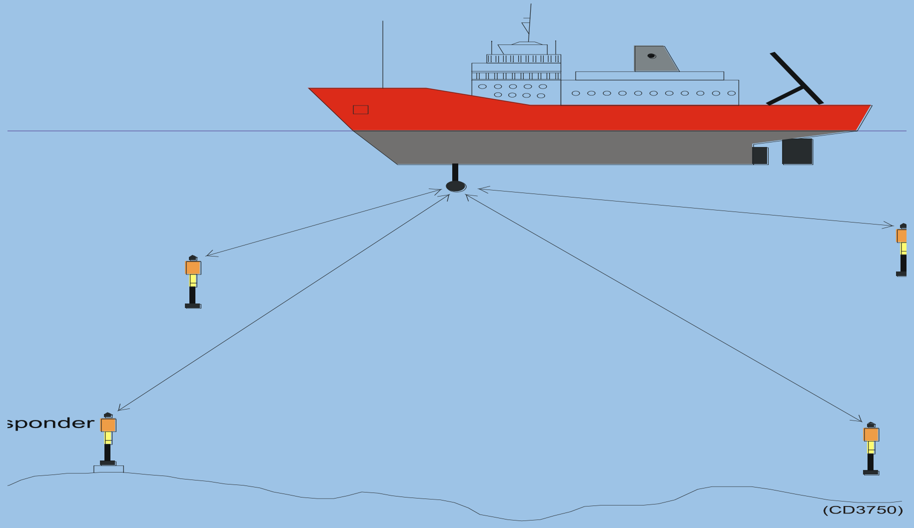

Figure 3 LBL principle

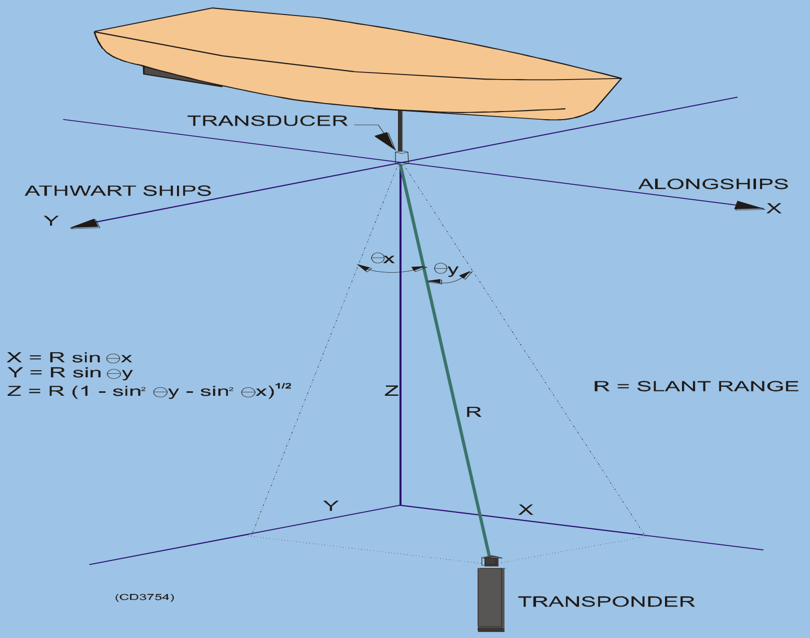

Figure 2 SSBL principle

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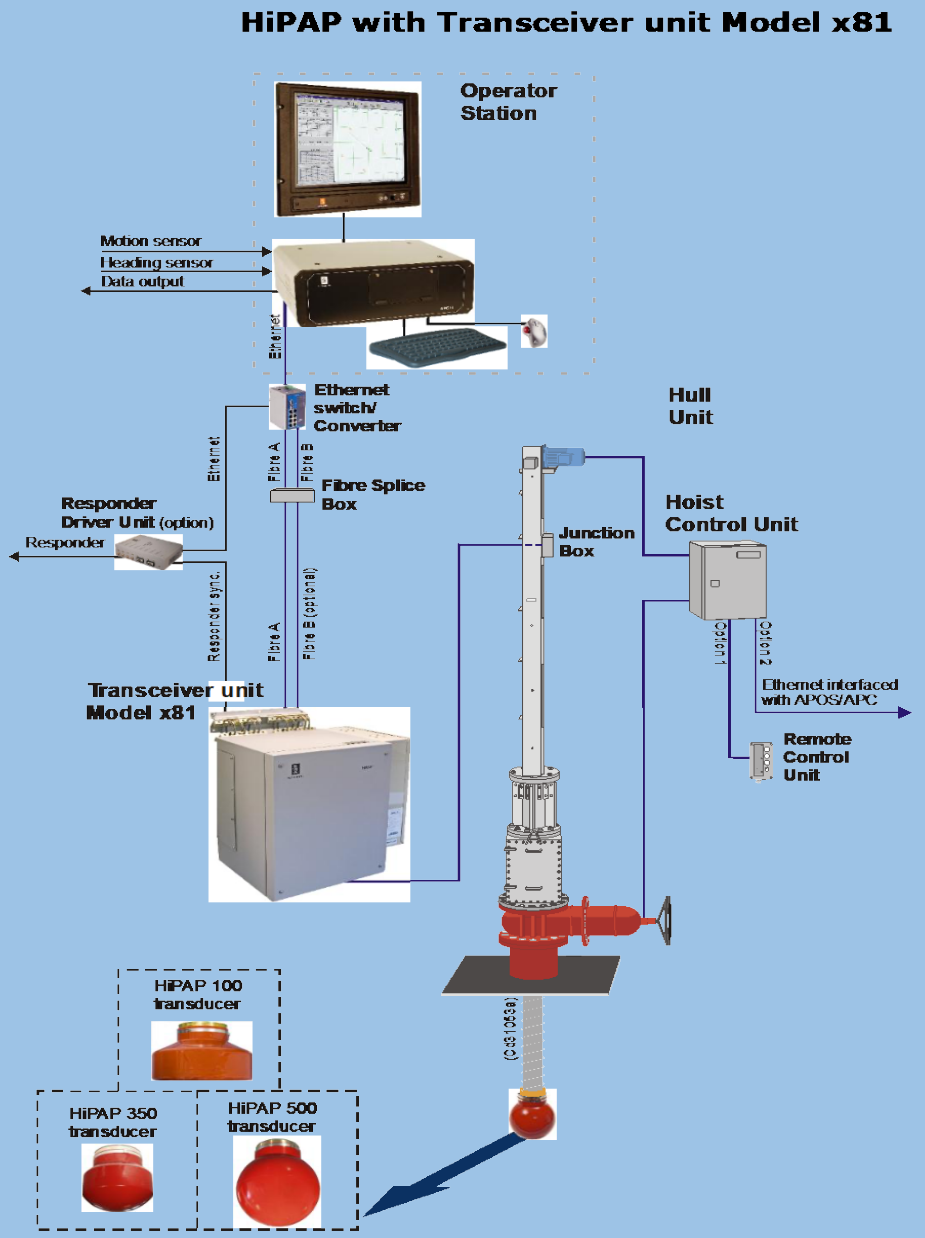
R/V Sally Ride HiPAP Specifics

The HiPAP system includes a Hull Unit with hydraulically actuated gate valve to allow raising and lowering of the HiPAP transducer.

- Ride has two different transducer units (HiPAP 501 and 101).
- Non-trivial to swap between the two.



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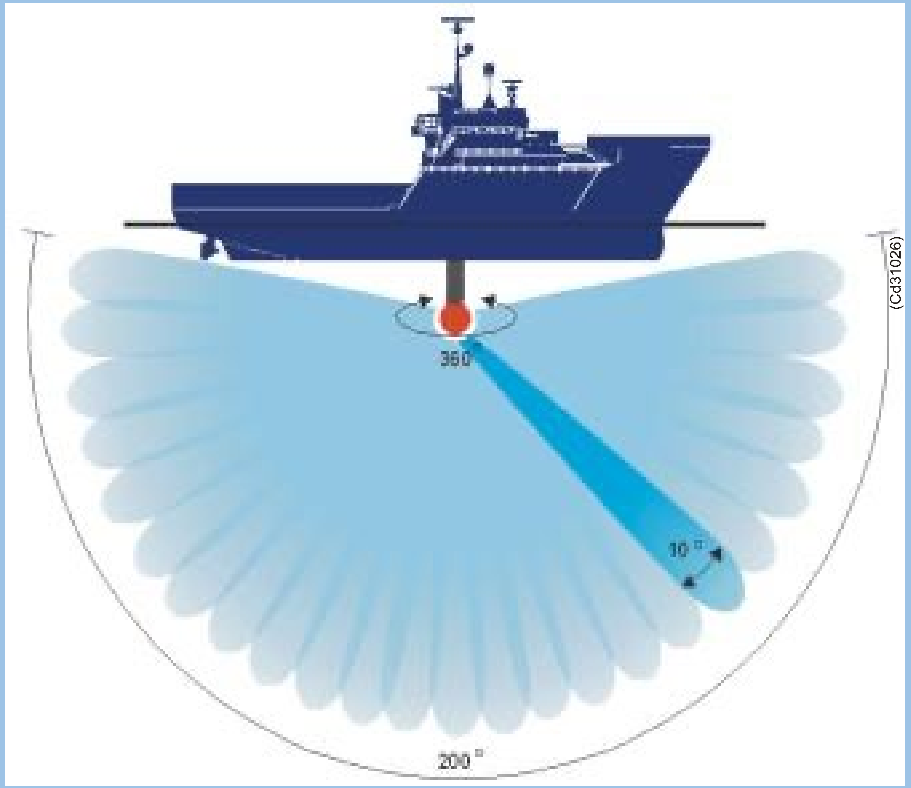
R/V Sally Ride HiPAP Specifics (continued)

The HiPAP 501 has a full spherical transducer body including 241 transducer elements. This model has close to full accuracy in the half sphere sector and is the preferred system where the best possible performance is required. The HiPAP 501 can also track targets above the half sphere sector. The HiPAP 501 is a medium frequency system operating from 21 kHz to 31 kHz.

The use of *very narrow beams* provides:

- High accuracy
- Long range capabilities
- Good noise reduction capabilities
- Good multipath suppression

The HiPAP 500 transducer has a diameter of 392 mm and will be installed with the 500 mm gate valve.



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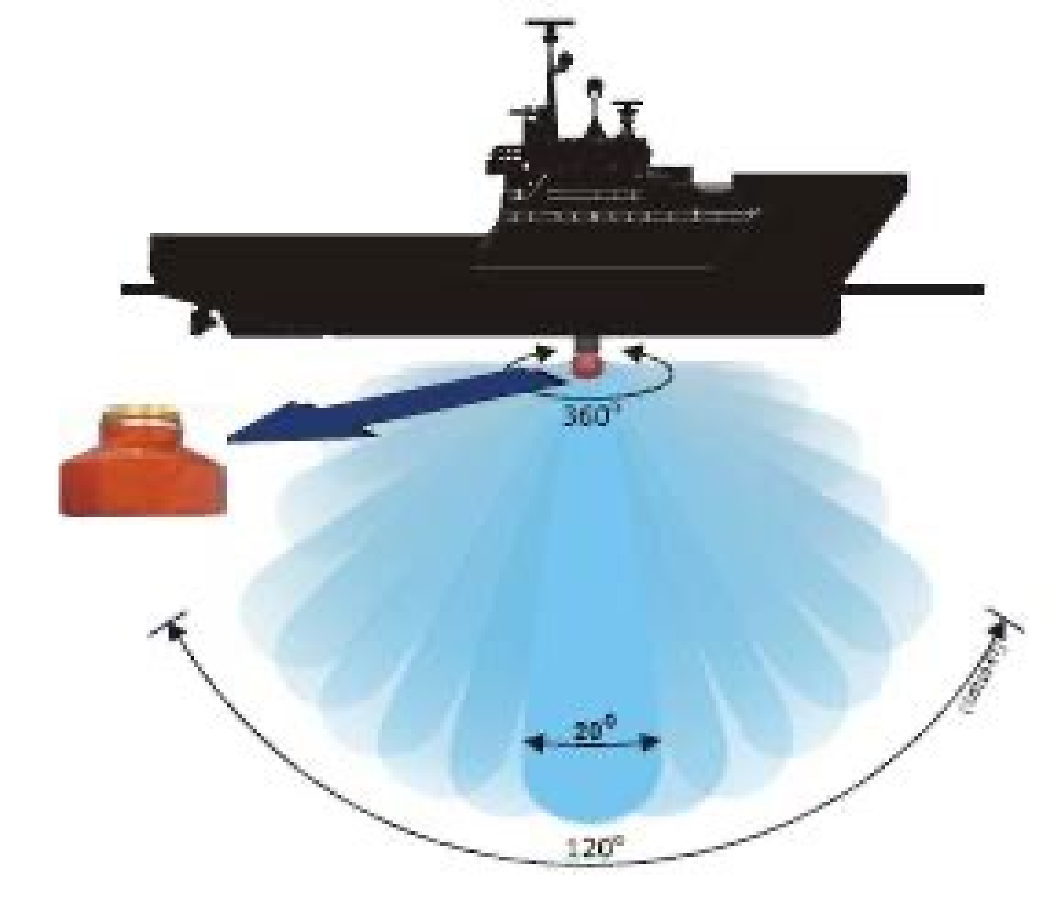
R/V Sally Ride HiPAP Specifics (continued)

- The HiPAP® 101 has a planar transducer array with a cylindrical body including 31 transducer elements.
- This model
- Has good accuracy in the ± 60º coverage sector and is suited for operations where the major positioning targets are within this sector.
- Used for ”ultra deep water navigation.” Transponders rated up to 6500m.
- The HiPAP 101 is a low frequency system operating between 10 kHz to 15.5 kHz.
- The HiPAP® 100 transducer has a diameter of 452 mm and will be installed with the 500 mm gate valve.



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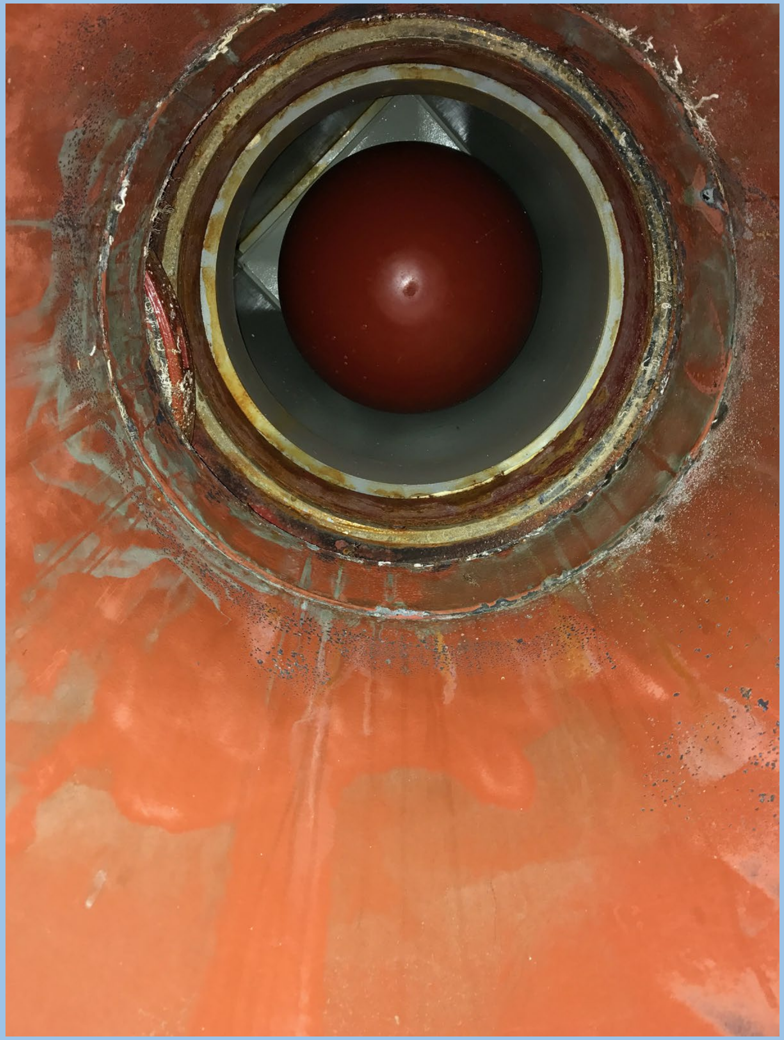
HiPAP 501 Transducer

Images showing HiPAP 501 installed on R/V Sally Ride. With gate valve open, x-ducer in "up" position, and deployed (not fully deployed due to space limitation in dry dock).



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HiPAP Compatible Transponders

The cNODE® series consist of three main models:
- **Maxi transponder** - a full size transponder with large battery capacity well suited for seabed deployment and long life operation.
- **Midi transponder -** a short transponder with good battery capacity well suited for installation on structures etc.
- **Mini transponder** - a small sized transponder suited for ROV mounting.
- The cNODE® transponders have a flexible design based on a standard housing which can have various transducers, release mechanism and sensor modules attached.

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HiPAP Compatible Transponders (continued)

The MST is an SSBL mini transponder suited for ROV operation and where the size of the transponder can be a limiting factor. The transponder models cover various water depths. The MST series consists of the following models:

- **MST 319** - rated for 1000 m water depth
- **MST 324** - rated for 2000 m water depth
- **MST 342** - rated for 4000 m water depth

All units have a rechargeable battery, can operate in responder mode and can also be externally powered.

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Alignment Procedure

Materials Needed:

- HiPAP system installed. R/V Sally Ride has HiPAP 501 installed.
- Transponder set up for stationary deployment on seafloor.
  - We had to build a mini-mooring with anchor, cNODE transponder in float collar, with RDF and Strobe attached, acoustic release, and additional floatation to float acoustic release and aid in recovery.
  - STS went on a scavenger hunt around SIO to gather lightweight/shallow water acoustic release, floatation, and anchor weights.
- Transponder testing unit. Unit works with cNODE and MST transponders, but must be configured for the correct transponder type.
  - Also, note that the HiPAP 101 transponders are different and not compatible with the HiPAP 501.

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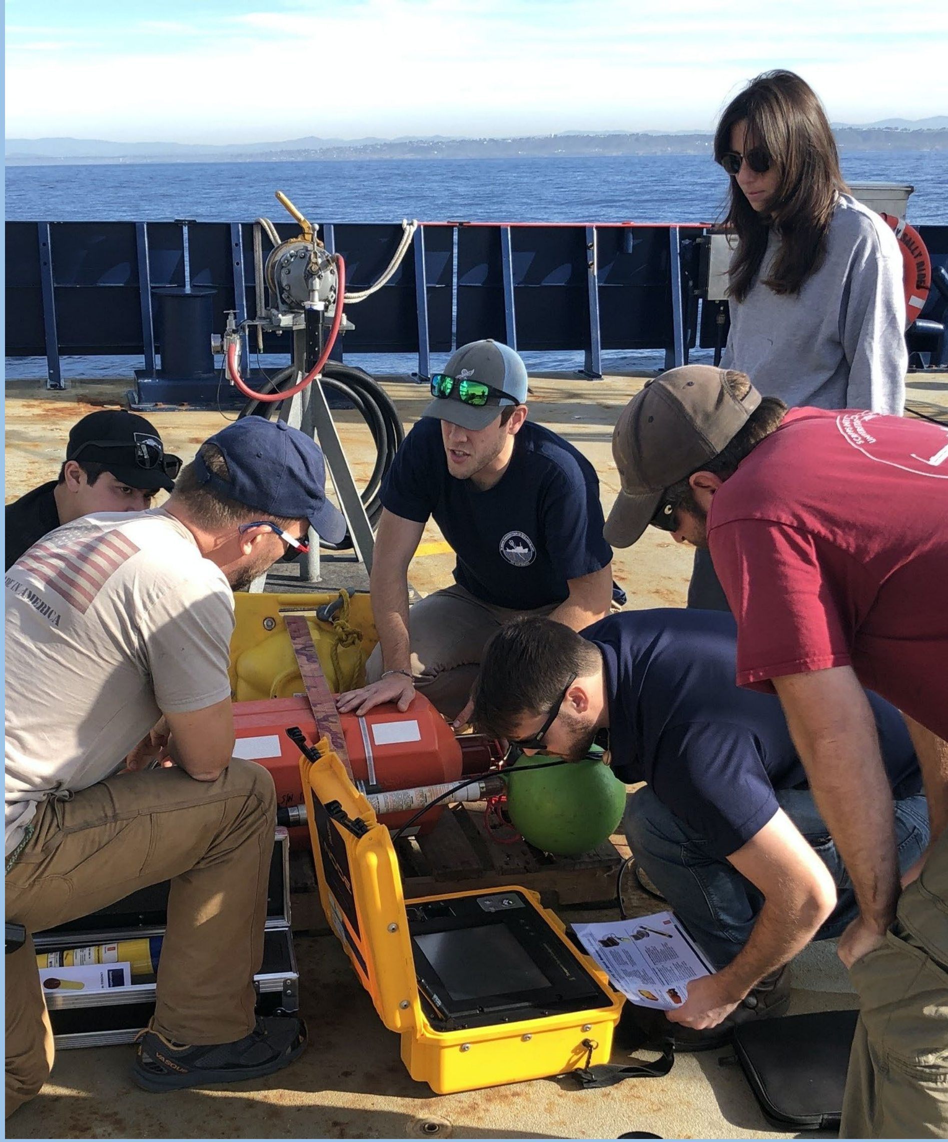
Alignment Procedure (continued)

Preparation:

- Coordinate with Bridge and Engineering to deploy the HiPAP transducer. Ship should be holding station for deployment.
  - Gate valve is opened, HiPAP Is lowered (either using local or remote control).
  - Ship speed not to exceed 6 knots while HiPAP is deployed.
- Once appropriate transponder is selected, verify battery charge and functionality using deck box.
- Good practice to lower transponder on hydro wire to establish/verify communication with HiPAP transducer. 20-50m depth is sufficient.



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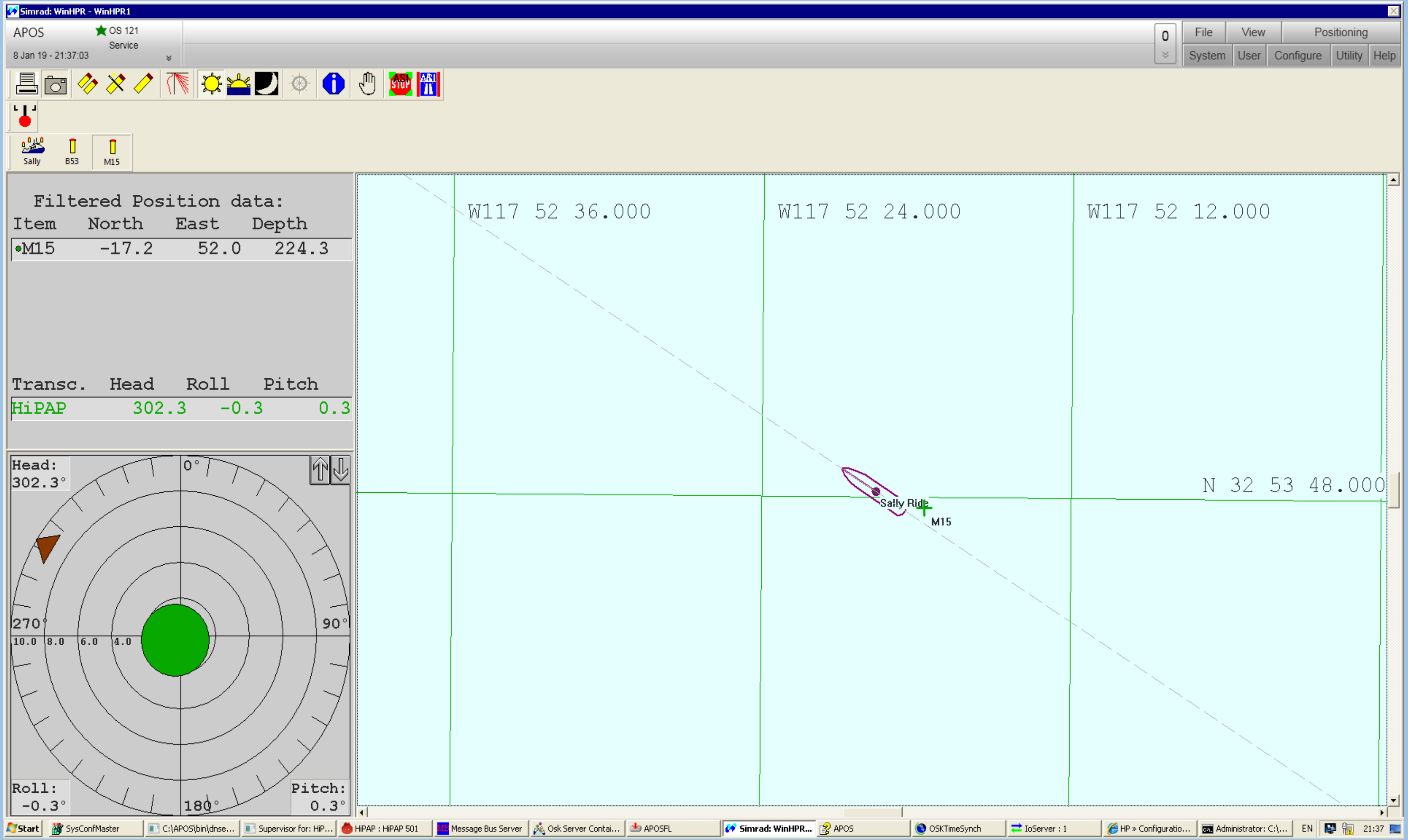
Alignment Procedure (continued)

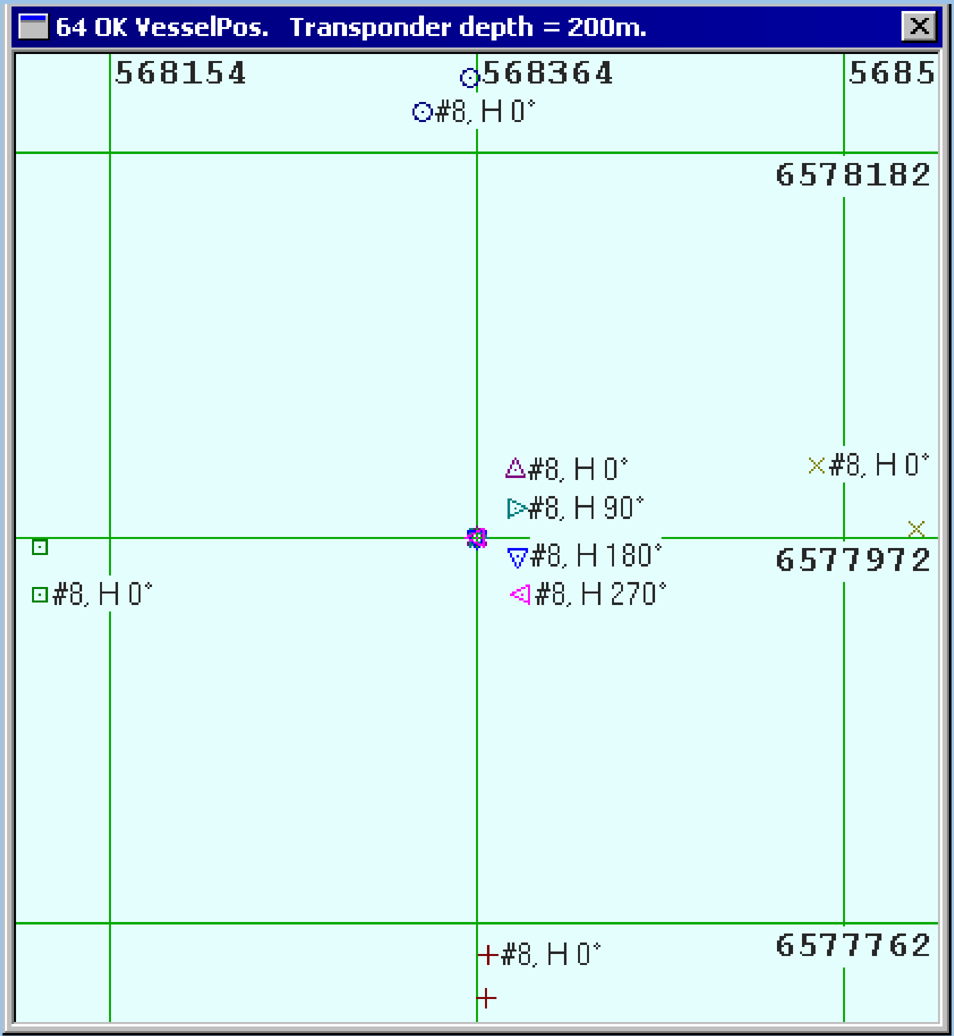
Deploy and Calibrate-

- Once everything is set up and communication between transducer and transponder is confirmed, deploy transponder mooring with a quick release (verifying correct anchor ballast and floatation is a good idea also).
- Track transponder to sea floor from APOS (Acoustic Positioning Operator Station).
- Once transponder is on seafloor, begin Alignment Procedure (Calibration)



Alignment Procedure (continued)

- The Transducer Alignment function calculation is based on simultaneous measurements of the position of a transponder on the seabed relative to the vessel, and the geographical position of the vessel as measured by a dGPS system. The transponder position and the dGPS position are valid at the same time. They are named a position pair. The alignment function calculates the parameters of the transducer on which the acoustic measurements are done.
- The recommended ship positions for the Alignment procedure is to maintain a northerly heading (can be adjusted based on conditions, but should remain constant) and occupy the 4 cardinal points around a circle of 50%-200% the water depth.
- Then position the vessel above the transponder, and rotate the heading holding at 0deg, 90deg, 180deg, and 270deg.



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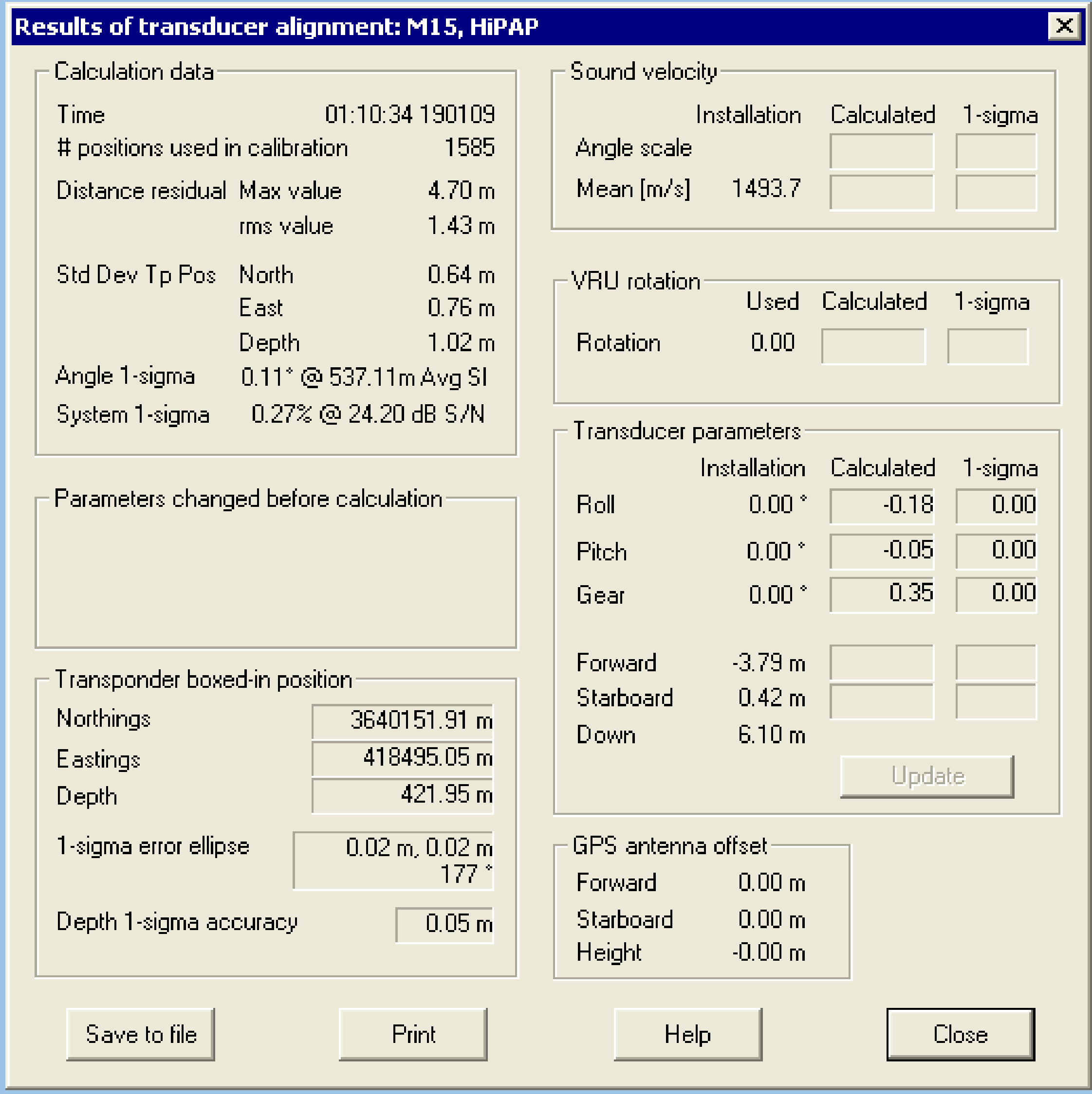
Alignment Procedure (continued)

The Transducer Alignment Function is a calculation performed in APOS to determine the horizontal offset and/or the inclination values of the HiPAP/SSBL transducers. It can also calculate the misalignment between the VRU and Gyro forward axes.



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Alignment Procedure (continued)

- The APOS online help is a useful resource to follow when setting up and executing the Alignment Procedure.
- A minimum of 100 position pairs logged is recommended (we set the criteria to 200 for our calibration) at each cardinal position, and heading when above the transponder.
- As a rule of thumb, it is far more important to have good signals than to have a good geometry between the transponder and the transducer.

Completing the Alignment Procedure

- Once satisfied with alignment function results, trigger the acoustic release on the transponder and track it's ascent to the surface. (refer to Kongsberg manual to determine quality control guidelines, and how to exclude erroneous data points).
- Recover the transponder.
- The HiPAP hull unit can then be retracted, and the vessel is free to maneuver as needed.

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References and Acknowledgements

Referenced Kongsberg manuals:

- 331070ac_HiPAP_system_check_and_alignment
- 215350ab_Alignment_Patterns

Thanks to: