



DYNAMIC POSITIONING CONFERENCE
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SENSORS

**Extended Use of Acoustic Positioning
Systems**

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Extended Use of Acoustic Positioning Systems

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Topics

- Positioning and communication
 - Limiting factors
 - Solutions
- Applications
 - Fatigue measurements
 - Survey
 - Multi-LBL
- Multi SSBL INS solution
 - Loose or Tight coupling
 - Benefits

Positioning and communication

The underwater communication channel

Limiting factors:

- Bandwidth
- Propagation delay
- Overlapping signals
- Multipath
- Noise

Positioning and communication

Bandwidth

- Bandwidth is a function of the center frequency of the transducers
- High frequency => High Bandwidth
- Low frequency => Low Bandwidth

- Bandwidth is typically 30% of the center frequency, typical 8kHz

- Bandwidth of 8kHz can give 16Kbit/s (BPSK)

Positioning and communication

Propagation delay

- Speed of sound is approximately 1500m/s
- Speed of light is 299792458m/s
 - Or 200000 times faster

Two way transmission over 3000m causes a delay of 4 seconds

Positioning and communication

Overlapping Signals

- Occurs when signals from 2 or more transmitters appears at the receiver at the same time
- The dynamic range of the signals can be very large

Example

Transmission loss at 200m range is 49.2dB

Transmission loss at 2500m range is 80.5dB

If these two signals appears in the receiver at the same time the signal from 200m will be 31.3dB stronger, or 1000 times.

The weaker signal will be suppressed.

Positioning and communication

Multipath

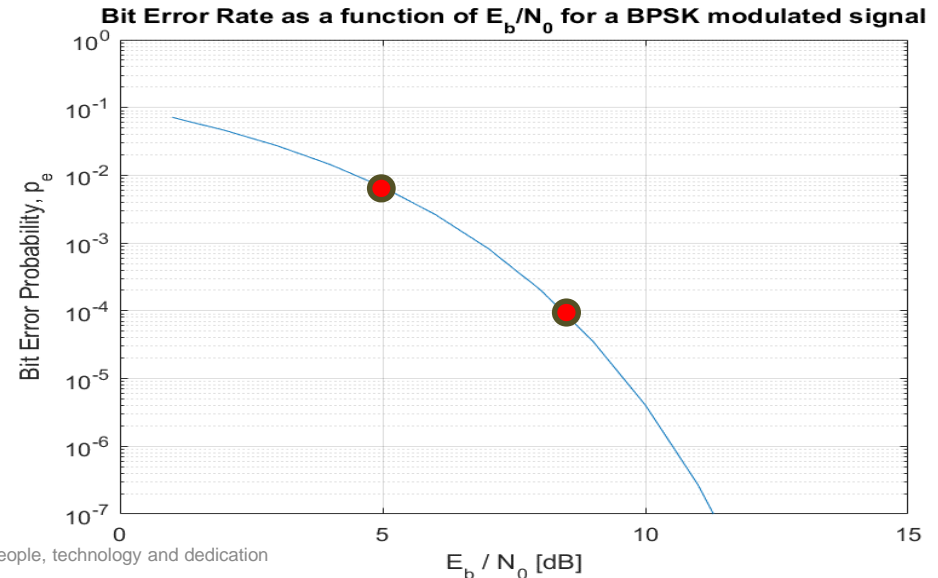
- Multipath occurs when there is more than one signal path from the transmitter to the receiver
- Caused by reflections from surface, seabed and vessels hull
- High data speed needs more or less continuous transmission
 - Creates a lot of multipath
 - Breakdown of communication

Positioning and communication

Noise

- In DP application the dominating noise is from thrusters
- High data speed needs high signal to noise ratio

Reduction in SNR of 3dB equals
100 times increase in bit error rate



Positioning and communication

Communication Profiles

- Handles various operation scenarios
- Uses various signal processing algorithms

Speed [bit/sec]	Cymbal (PHY)			Application
	Bandwidth [Hz]	Telegram Duration [sec]	Environment	Typical Application
170	4000	2,0	Vertical and some horizontal	Control
450	4000	2,0	Vertical and some horizontal	Control and data
1100	2000	1,0	Vertical	Control and data
1800	4000	2,0	Vertical and some horizontal	Control and data
2400	4000	0,6	Vertical	Data
2500	4000	2,0	Vertical and some horizontal	Control and data
4500	4000	1,9	Vertical	Data
6000	4000	1,9	Vertical	Data
9000	8000	1,9	Vertical	Data
12000	8000	1,9	Vertical	Data

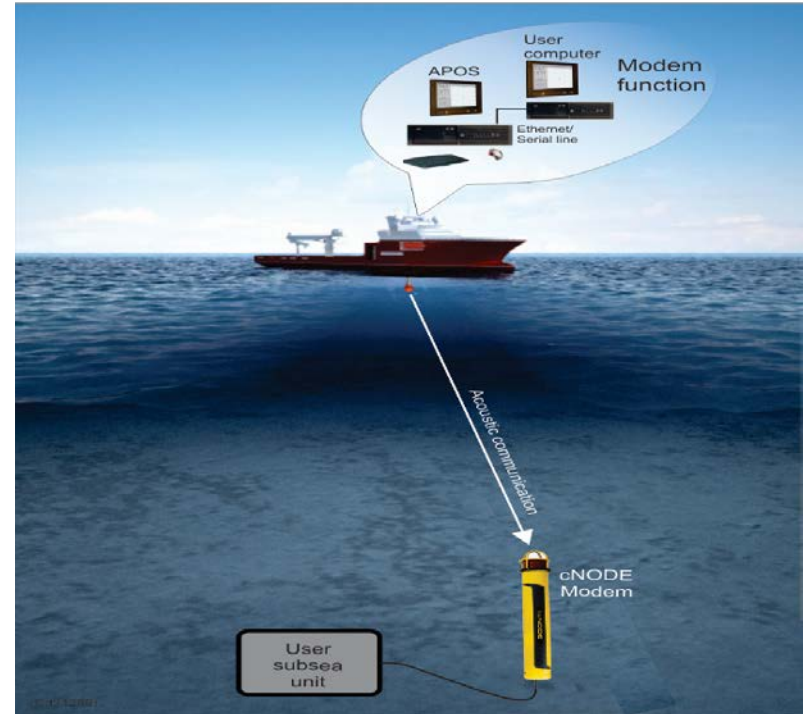
Positioning and communication

HiPAP Transparent Modem

- Interleaving positioning and telemetry
- Continuously transmission
- Configurable time period for positioning
- Electronic Beamforming receiver

HAIN

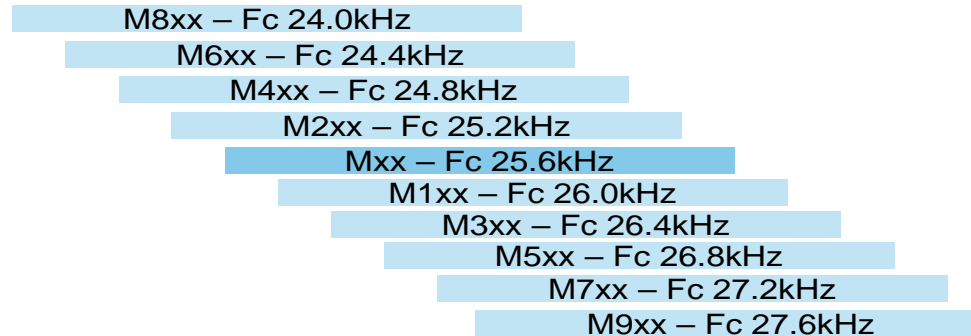
- Provides 1Hz position update



Positioning and communication

Multi Sub-Band

Channel number and carrier frequency (Fc):



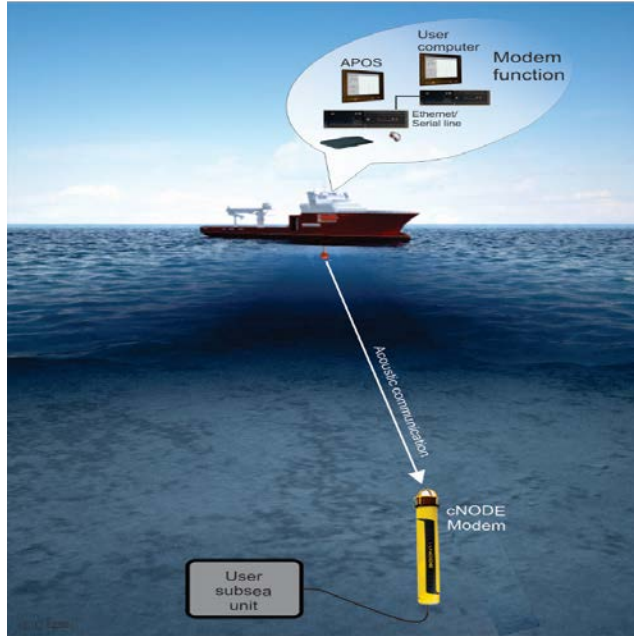
22.0kHz

Bandwidth of each band is 4kHz
Total number of unique channels is 560

29.6kHz

Positioning and communication

Fatigue Measurements

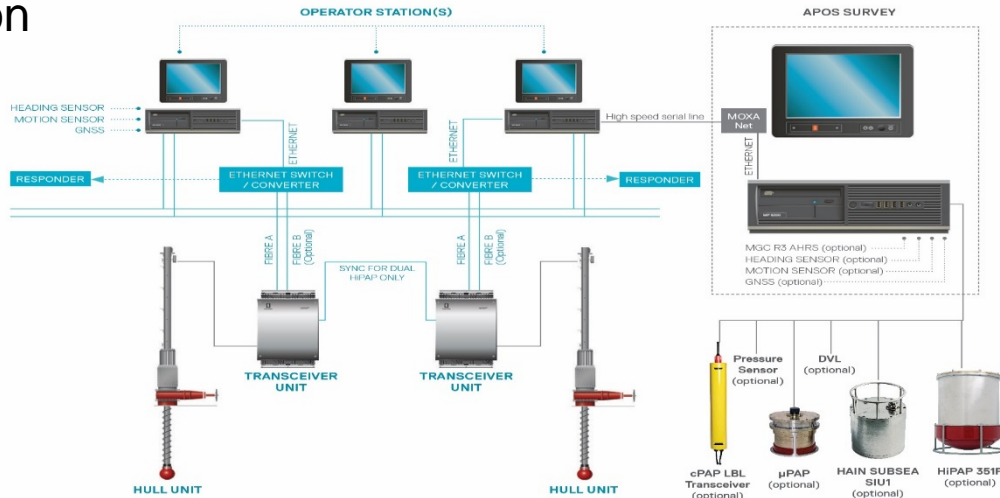


cNODE with integrated accelerometers and gyros
 Subsea processing
 Logging
 Transmittal of raw and processed data

Application Survey

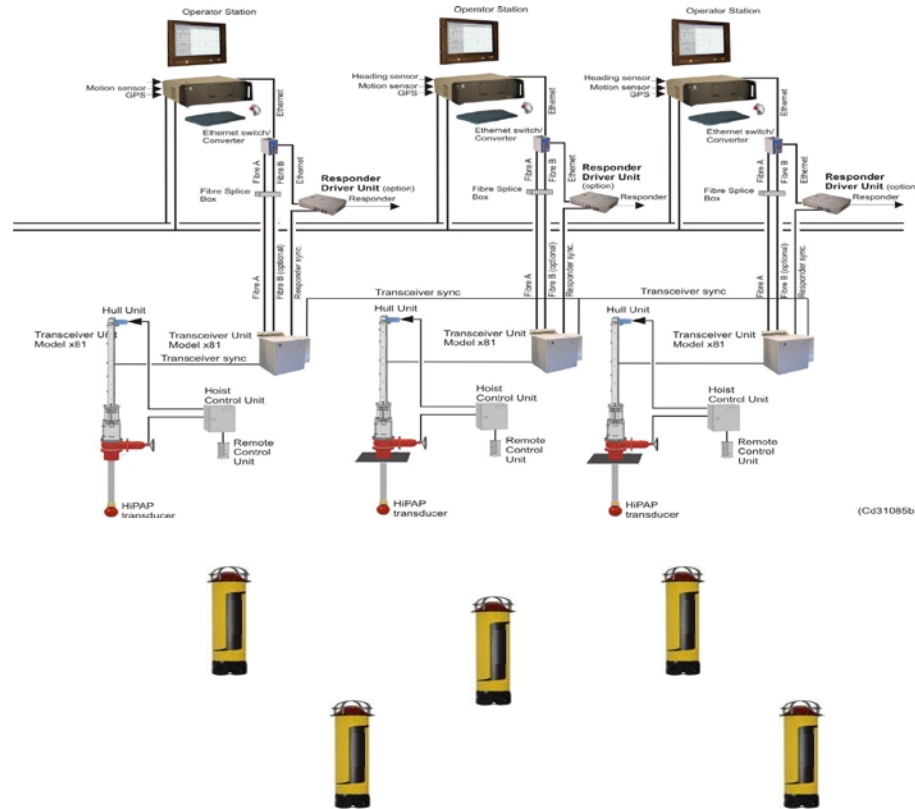
APOS Remote:

- Connected to vessels system
- No change to vessels system
- Work with own configuration



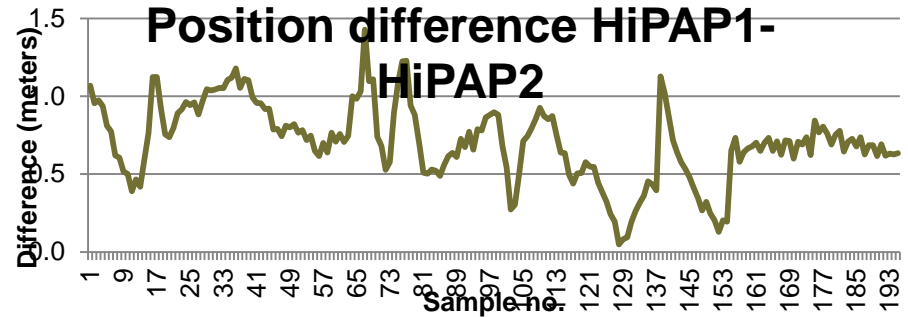
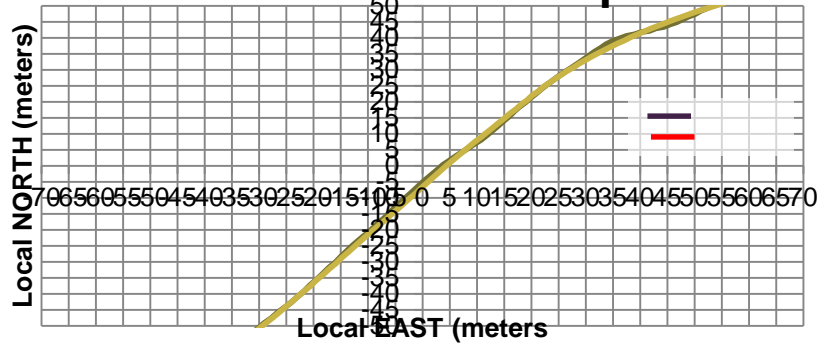
Multi LBL

- 1 interrogation gives 2 - 3 independent position to DP
- 5 transponders in LBL array (redundancy of 2)
- No dependency of GPS
- Less cost and battery consumption
- Less battery replacement
- No interference problem from several interrogations
- Reduced time on TP deployment
- Reduced time on LBL calibration



Multi LBL

HiPAP1 and HiPAP2 positions

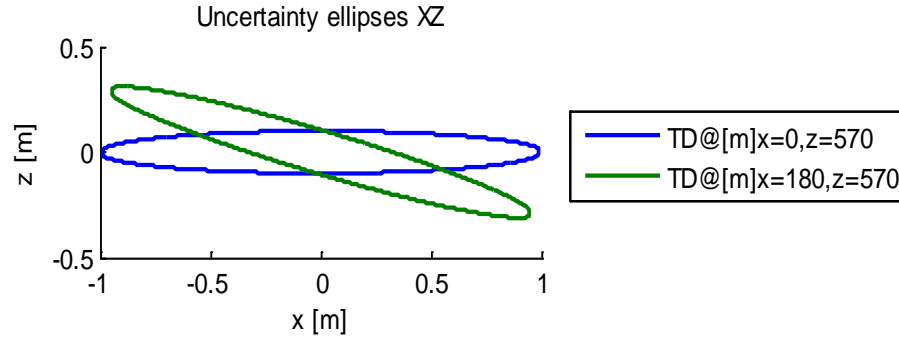


Acoustic positioning, Inertial & Integration

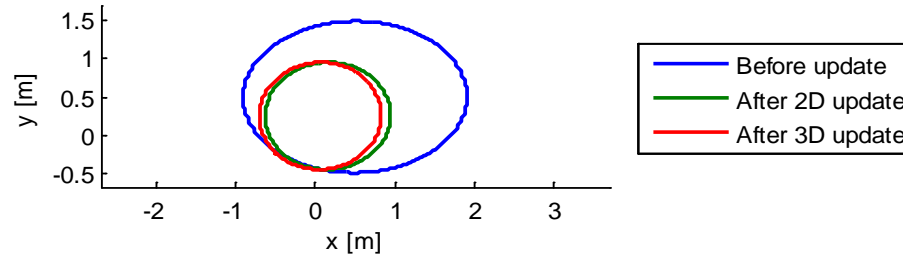
- Acoustic aided INS has given us benefits:
 - Increased battery lifetime
 - 1 Hz update always.
 - Improved accuracy
 - Improved integrity
 - Improved weighting
 - Less transponder deployment
- Tightness of coupling
 - Degree of transformation before used in the INS
 - XYZ or raw data from each single element
 - XYZ or Range and bearing – same amount of information

Acoustic positioning, Inertial & Integration

Dimension

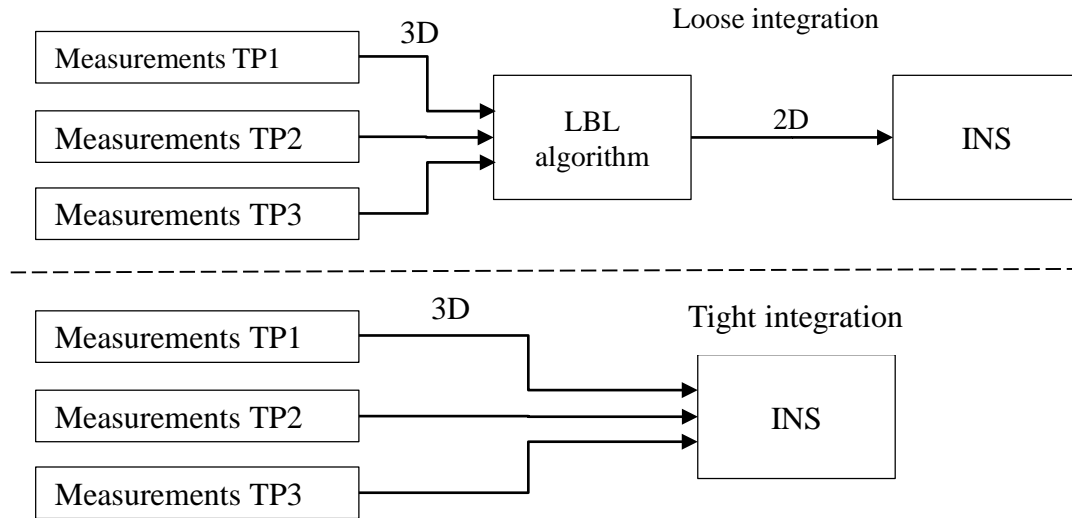


Uncertainty ellipses 2D and 3D updates TP@[m]x=180,z=570



Acoustic positioning, Inertial & Integration

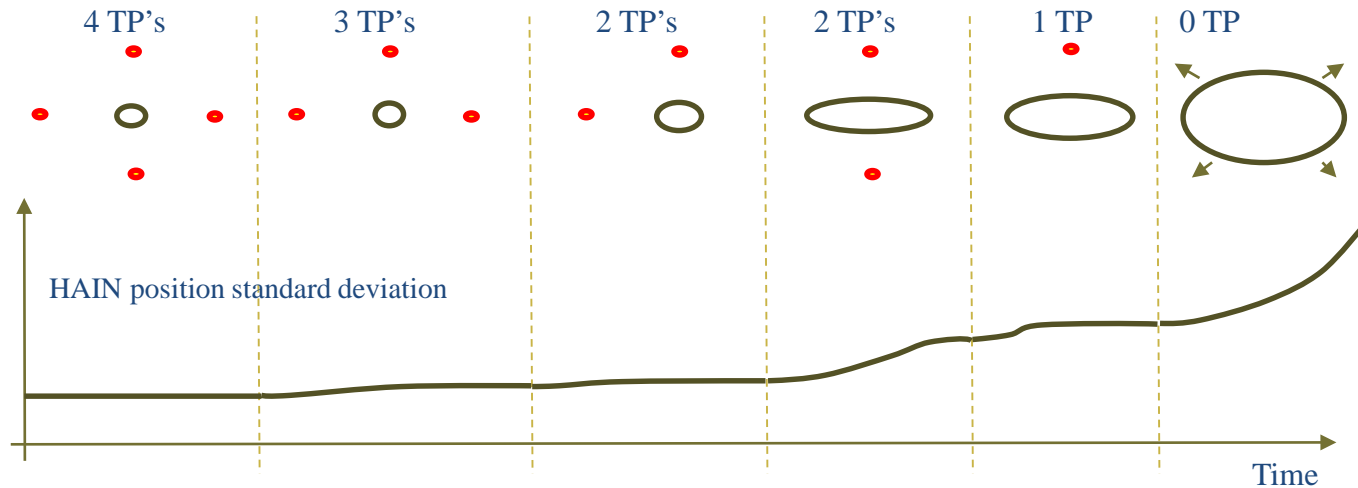
Multiple Transponders



Acoustic positioning, Inertial & Integration

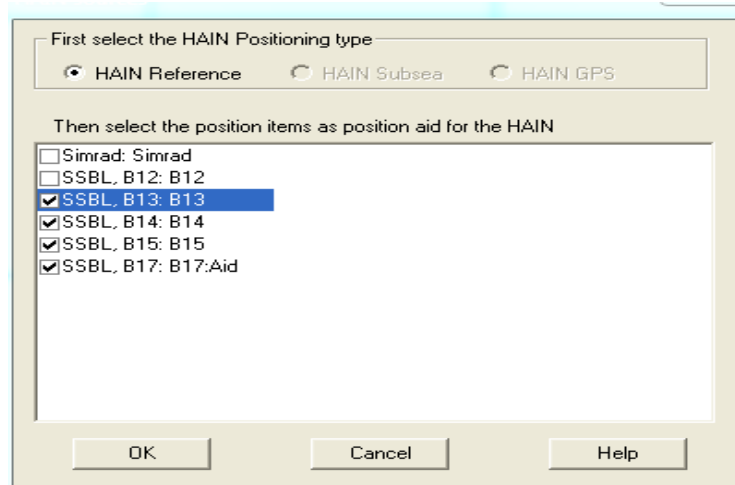
Error ellipse with different reply situations

Location of transponders with valid reply, and resulting HAIN uncertainty ellipse



Acoustic positioning, Inertial & Integration

Multi SSBL



	<i>Robustness</i>	<i>Accuracy</i>	<i>Ease of use</i>
<i>Improvements by tight integration (Multiple SSBL)</i>	Marginal	None	Yes

Improvements by tight integration (Multiple SSBL)

Extended Use of Acoustic Positioning Systems

Thank You!

Questions?

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