Sensors II

True Dual Redundant Acoustic Dynamic Positioning Sensors

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True Dual Redundant Acoustic DP Sensors

Presented by

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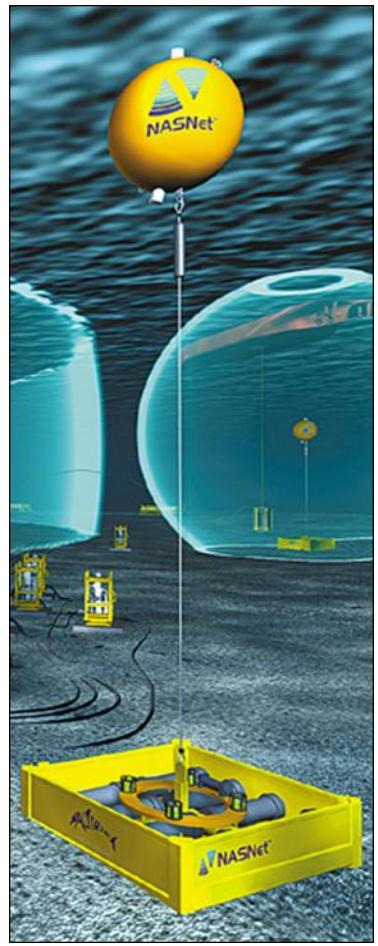
Our vision is to be..

'Global Leaders in Through Water Communication and Positioning Technology'

We provide:

Marine Technology Solutions

Nautronix Technology is proven in the Defence, Offshore and Ocean Science markets, where we offer our customers an unrivalled performance capability to give them a leading edge advantage in the marine environment.



Worldwide locations

Aberdeen

Santa Barbara

San Diego

Houston

Fremantle

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- Requirements
- What is Redundancy
- Technologies
- Some Solutions
- Conclusions

Background

- The offshore industry is moving into deeper and deeper water further offshore.
- Deep water operations are more demanding.
- As a result larger and more sophisticated vessels are being utilised. Moored operations are generally not an option except for some drilling.
- DP operations are therefore now the norm.
- To achieve the required performance reliable and redundant sensors feeding the DP are a must.

Requirements

DP Sensors should be:

- Reliable
- Stable
- Accurate
- Easily Operated
- Low Maintenance
- For DP 2 and 3 - Redundant

What is Redundancy

Dictionary Definition : serving no useful purpose?

Alternate Definition : using more than necessary for completeness

For DP Operations replace ‘completeness’ with ‘Safety’

More Than Necessary

- **Redundancy in all aspects of the System:**
  - **Processors (topside equipment)**
  - **Transmitters (satellites / beacons)**
  - **Receivers (antennae / hydrophones)**
  - **Methodology (GPS / Glonas or USBL / SBL / LBL)**
  - **Signal Environment (DGPS correction method / acoustic wave path)**

Achieving Redundancy (Surface)

- Redundancy of surface positioning is relatively easy to achieve.
- There is a choice of Satellite positioning systems, namely GPS and Glonass.
- Dual receivers are now common.
- There are a number of suppliers of differential signals who can now provide worldwide corrections.
- There are also options on the method of delivery of the corrections.
- The correct choice of the 3 variables above is important to ensure true surface sensor redundancy, perhaps a topic for a future paper?

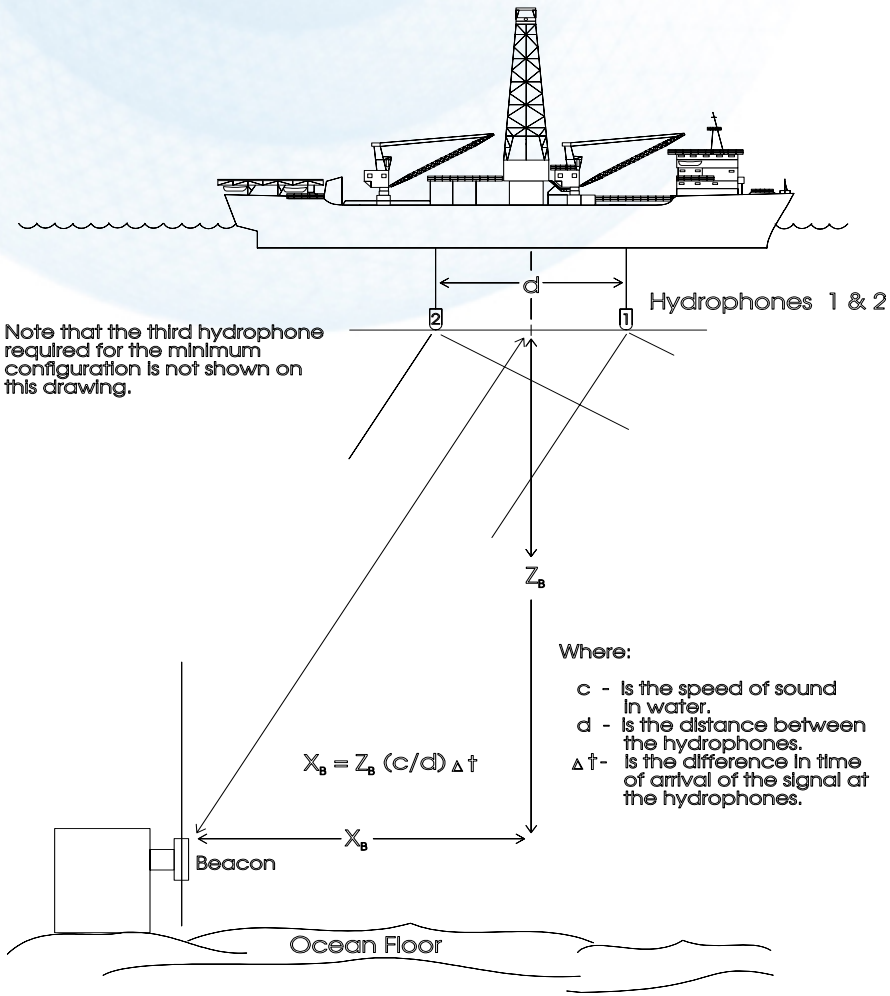
Achieving Redundancy (Subsea)

- Achieving true redundancy subsea is a more difficult problem.
- Unlike surface positioning the user is generally responsible for his own ‘satellites’ i.e. transponders.
- Installation (and therefore choice) of antennas (hydrophones) is more difficult and expensive.
- There is a choice of methodologies each with pros and cons.

Acoustic Positioning - Methods

- **UltraShort Baseline (USBL)**
  - Determines beacon position by measuring the relative phases of the acoustic signal received by closely spaced elements in a single hydrophone.
- **Short Baseline (SBL)**
  - Determines beacon position by measuring the relative arrival times at three or more vessel mounted hydrophones.
- **Long Baseline (LBL)**
  - Determines beacon position by measuring the slant ranges from three or more widely spaced transponder.

Short Baseline - Theory of Operation



Short Baseline - Dominant Errors

- **Correction for Vessel Motion**
  - Minimized by using high accuracy VRU sensor.
- **Timing and Signal Detection**
  - Overcome by using DSP signal processing providing very accurate time resolution on peak detection.
- **Platform Alignment and Measurement Errors**
  - Once off calibration of the system to eliminate measurement and mounting errors.

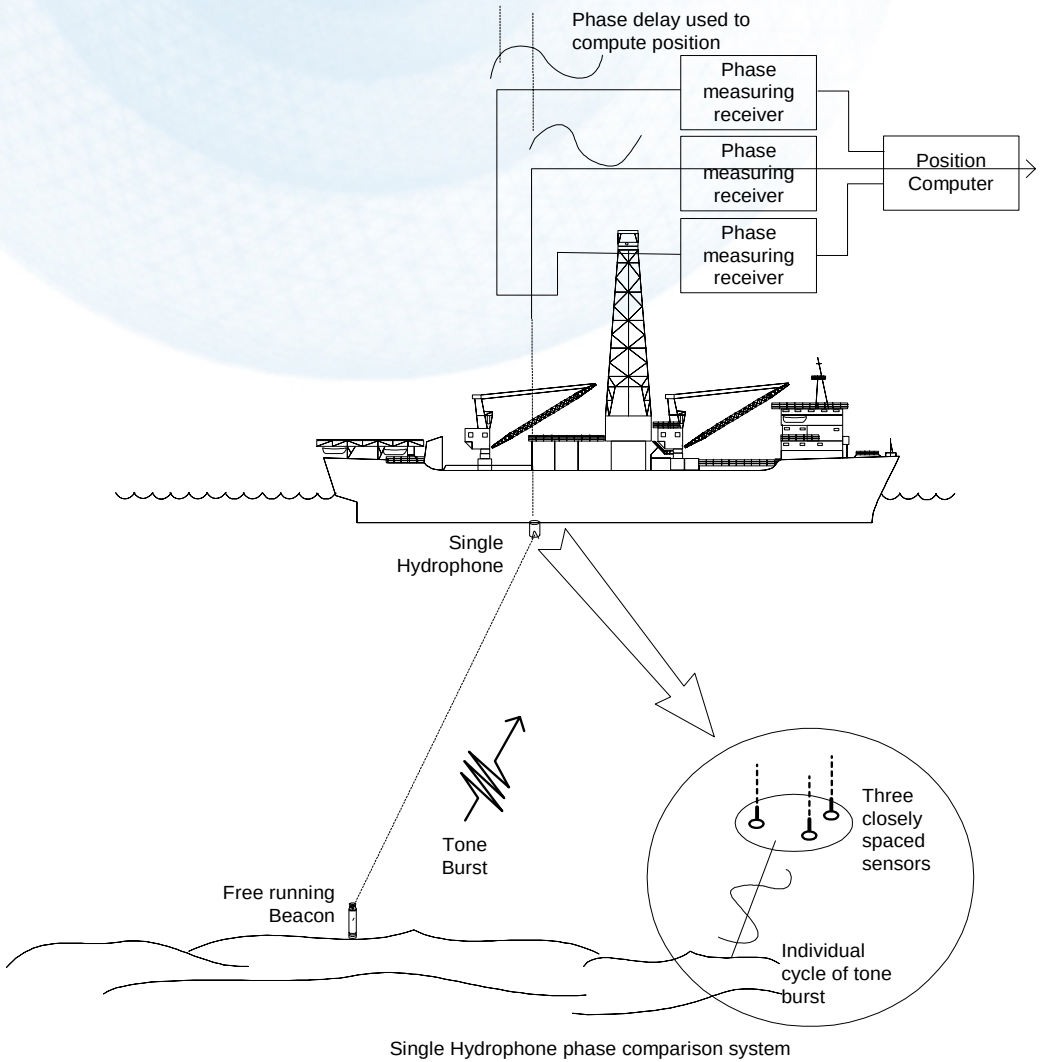
Short Baseline - Advantages

- High update rates to the Dynamic Positioning System.
- One time calibration at installation only.
- Improved accuracy over USBL. Typically 0.15% RMS of water depth.
- Pinger based system eliminates interrogating through the water column.
- Can operate with a single subsea beacon.
- Not adversely effected by acoustic ray bending as typically operating directly above the beacon.
- Lower installation and maintenance costs. Uses simple single element low cost hydrophones.

Short Baseline - Disadvantages

- Accuracy dependant on VRU and VRU calibration.
- Requires multiple hydrophone installations. A minimum of three must be installed.
- Requires manual entry of Water depth.
- Unintelligent pinger based beacons.

Ultra Short Baseline - Theory of Operation



Single Hydrophone phase comparison system

Ultra Short Baseline - Dominant Errors

- **Phase Errors**
  - Can be minimized by using DSP and beam forming techniques.
  - Significant improvements with Spread Spectrum Signaling
- **Range Errors**
  - Can be minimized by using DSP to accurately measure total travel time.
  - Improved by use of Spread Spectrum Signaling
- **Platform Alignment**
  - High accuracy VRU can help minimize this error.
- **Measurement Errors**
  - Once off calibration of the system to eliminate measurement and mounting errors.

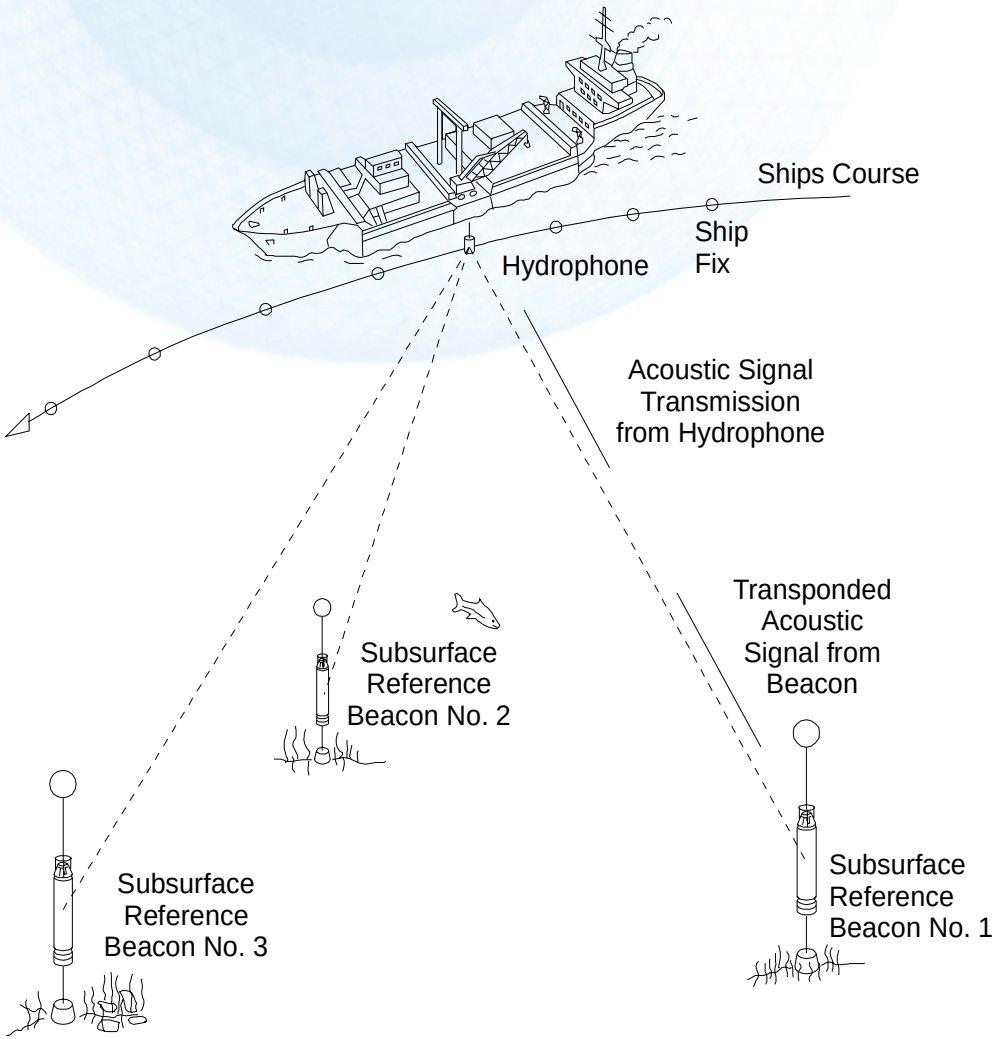
Ultra Short Baseline - Advantages

- One time calibration at installation only.
  - Accuracy is dependant of calibration and alignment.
- Single hydrophone deployment.
- Operates with pingers or transponders.
- Can operate with a single subsea beacon.

Ultra Short Baseline - Disadvantages

- Accuracy is limit to about 0.25 to 0.5% RMS of slant range.
- Less accurate and stable as water depth increases
- More susceptible to background acoustic vessel noise because of the lower array gain of the hydrophone.
- Update times per beacon vary as a function of range and number of beacons deployed.

Long Baseline - Theory of Operation



Long Baseline - Dominant Errors

- **Accuracy is dependant on the size of the beacon grid deployed.**
  - **Grid must be at least equal to the water depth.**
- **Range detection timing errors.**
  - **Can be minimized by using DSP processing techniques and apread spectrum signaling to accurately measure travel times.**
- **Field calibration errors of subsea acoustic grid.**
  - **Can be reduced via box in calibration methods.**
- **The large grid results in acoustic propagation errors from multi-path and ray bending in deep water.**
- **Master / Slave modes for redundancy only.**
  - **Only one hydrophone can interrogate.**

Long Baseline - Advantages

- **Highest potential accuracy independent of slant range and somewhat insensitive to depth.**
- **Only requires single vessel mounted hydrophone.**
- **Accuracy is largely independent of ship motion. Does not require high accuracy motion sensors.**

Long Baseline - Disadvantages

- Slow turn around time and subsequent update rates to the Dynamic Positioning System due to large ranges.
- Area of operation limited to location of subsea reference transponders.
- Adversely effected by acoustic ray bending in deep water.
- System complexity:
  - Requires the deployment and Calibration of at least three beacons.
  - Requires calibration each time reference transponders are re-deployed.
- Higher setup and maintenance cost.
  - Calibration and Initial setup costs are higher.

Options for Redundancy

- **Combine different technologies to achieve redundancy.**
- **Possibilities**
  - **USBL / SBL**
  - **USBL / LBL**
  - **SBL / LBL**

USBL / SBL

Eamples – Nautronix RS915 or Sonardyne:

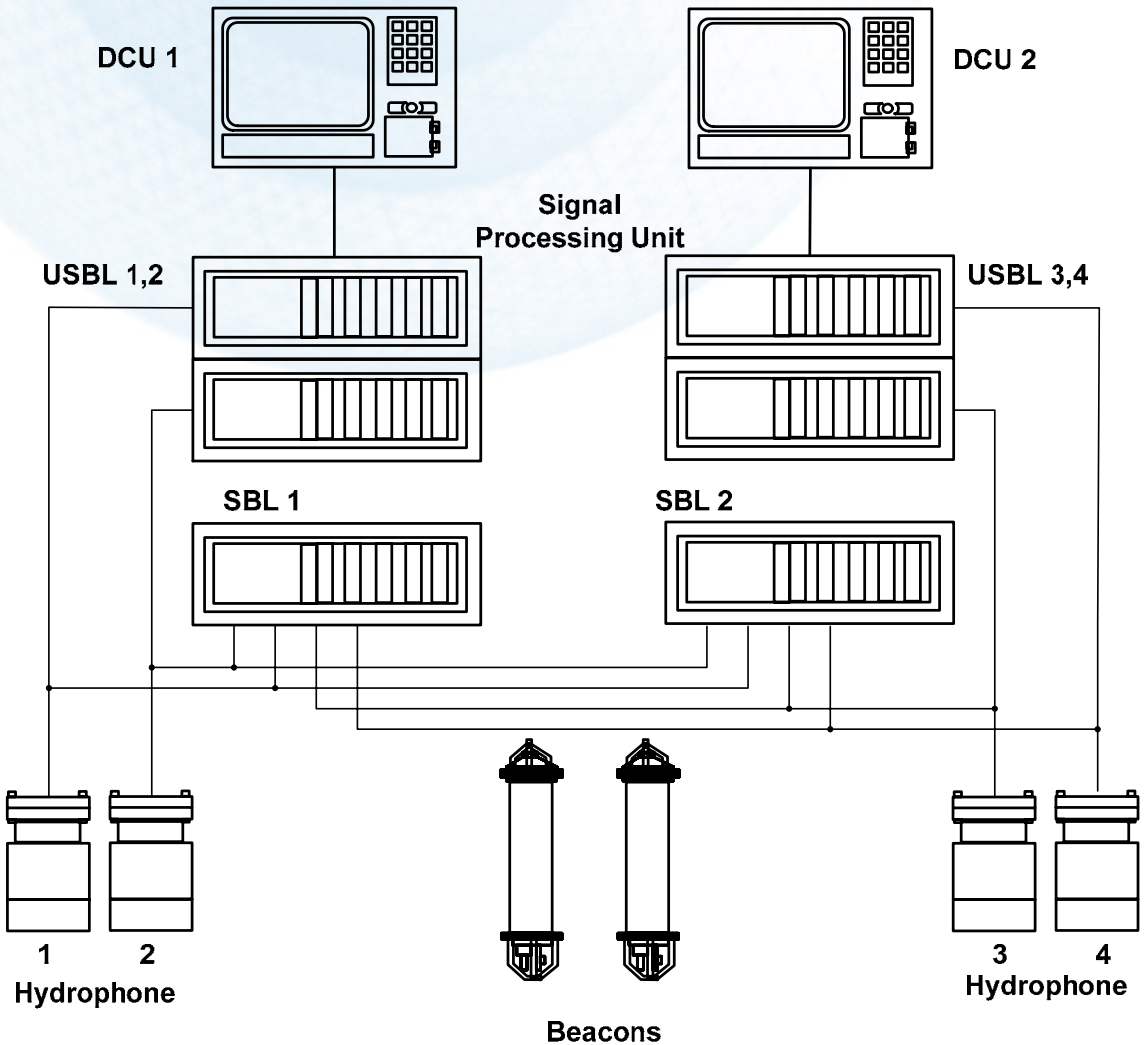
- Requires Minimum of 4 Hydrophones
- Each Hydrophone Multi Element
- Hydrophones are Expensive
- Minimum of 2 Seabed Beacons
- Calibration is Complicated
- Very Few in Existence

USBL / LBL

Eamples – HiPAP or Sonardyne USBL / LBL:

- **Only Requires 2 Hydrophones**
- **Complex Multi Element Hydrophones**
- **Can be prone to Thruster and Environmental Noise**
- **Requires Deployment and Calibration of Seabed Array (4 or 5 beacons)**
- **Acoustic Path Redundancy Limited**
- **Dual Redundant?**

USBL / SBL

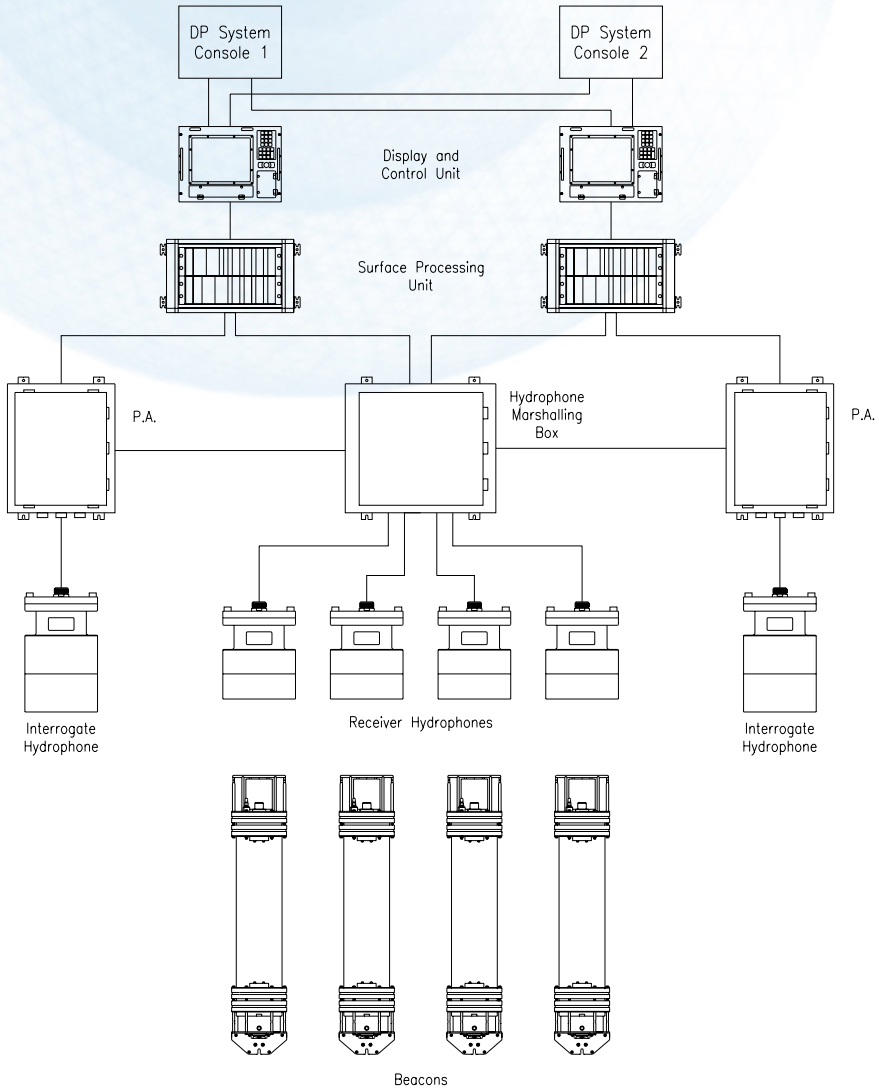

DCU 1
DCU 2
Signal
Processing Unit
USBL 1,2
USBL 3,4
SBL 1
SBL 2
1
2
Hydrophone
Beacons
3
4
Hydrophone

SBL / LBL

Eamples – Nautronix RS925:

- **Requires Minimum 4 Hydrophones (can be up to 8)**
- **Hydrophones are Single Element**
- **Requires Deployment and Calibration of Seabed Array (4 or 5 beacons)**
- **Simple Calibration**
- **Redundancy?**

RS925 Configuration



RS925 - Acoustic Modes

The RS925 can position the vessel using one of the following modes:

- **In combined SBL / LBL mode a transponder reply from at least three beacons must be received by at least three receiver hydrophones.**
- **In LBL only mode a transponder reply from at least three beacons must be received by at least one receiver hydrophone.**
- **In SBL only mode a pinger reply from at least one beacon must be received by at least three receiver hydrophones.**
- **Positioning accuracy 2.5m in 3500msw.**
  - **SBL only – better than 0.15% water depth**
  - **LBL only – 1m**

SBL Mode

- **A signal requires to be received from one beacon at a minimum of 3 hydrophones to achieve an SBL position fix. There is therefore redundancy in the hydrophones and beacons for SBL operation.**

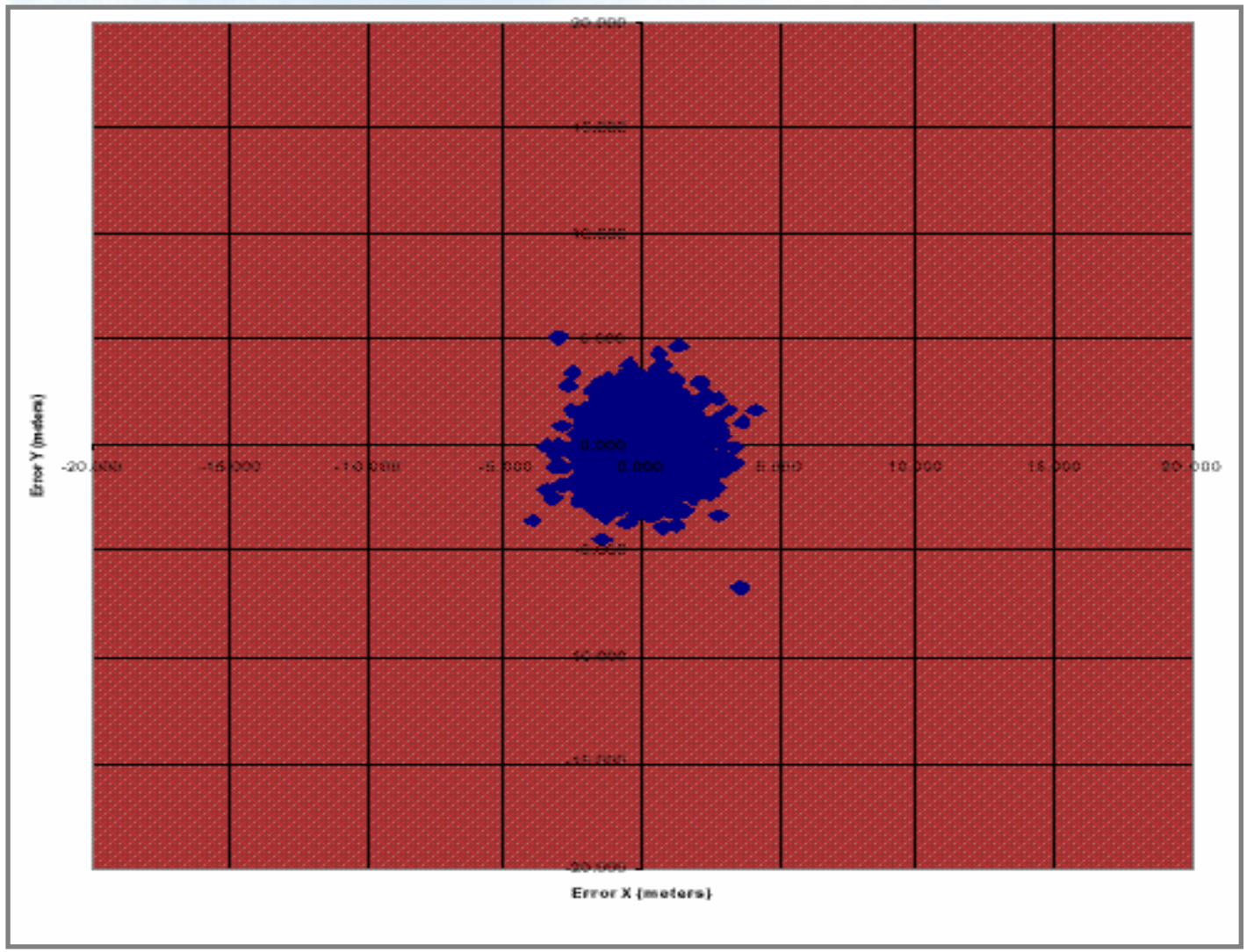
LBL Mode

- In LBL operation signals from 3 of the 4 seabed beacons need to be received at one of the vessel hydrophones. There is therefore redundancy in both hydrophones and beacons for LBL operation.
- For LBL operation an interrogation pulse is required. The system utilises 2 x Tx/Rx hydrophones each of which can be connected to and triggered by either DCU.

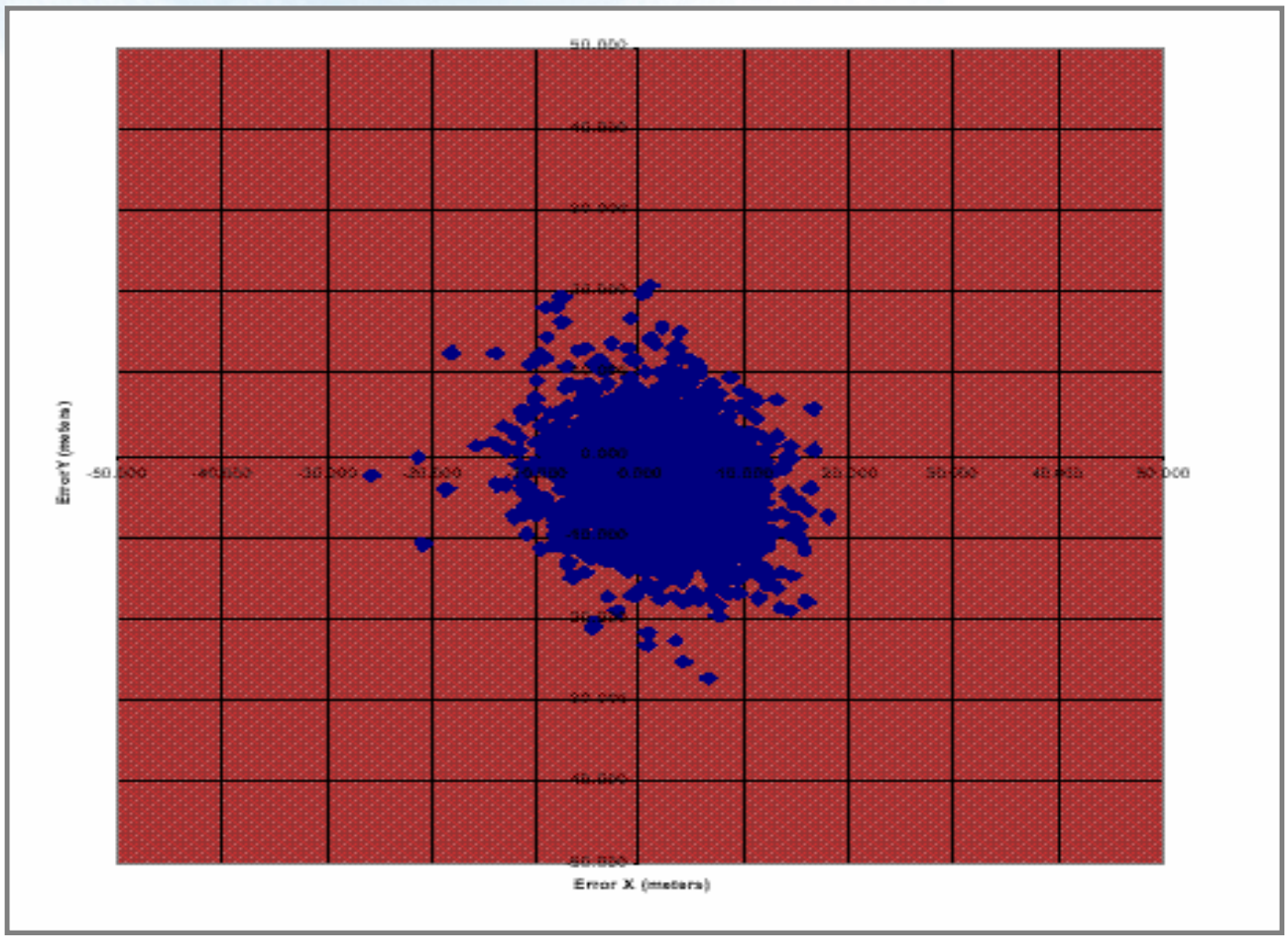
RS925 Redundancy Summary

- The system operates with 4 x seabed beacons calibrated in an array.
- In its normal implementation NASDrill RS925 operates with 6 hydrophones and can utilise up to 8. Each hydrophone is connected to both Display Control Units (DCU) in a dual configuration. Signals from all 4 seabed beacons are detected by all hydrophones, resulting in significant additional redundancy.
- If signals are received by only 4 hydrophones from all 4 beacons both DCUs will independently calculate:
  - 4 x LBL positions and
  - 4 x SBL positions (each the mean of 4 independent position solutions)
- There is therefore significant redundancy in beacons and hydrophones and topside hardware and acoustic path.

ADS² Results Deepwater Expedition (SBL/LBL)2870m 1.7M RMS



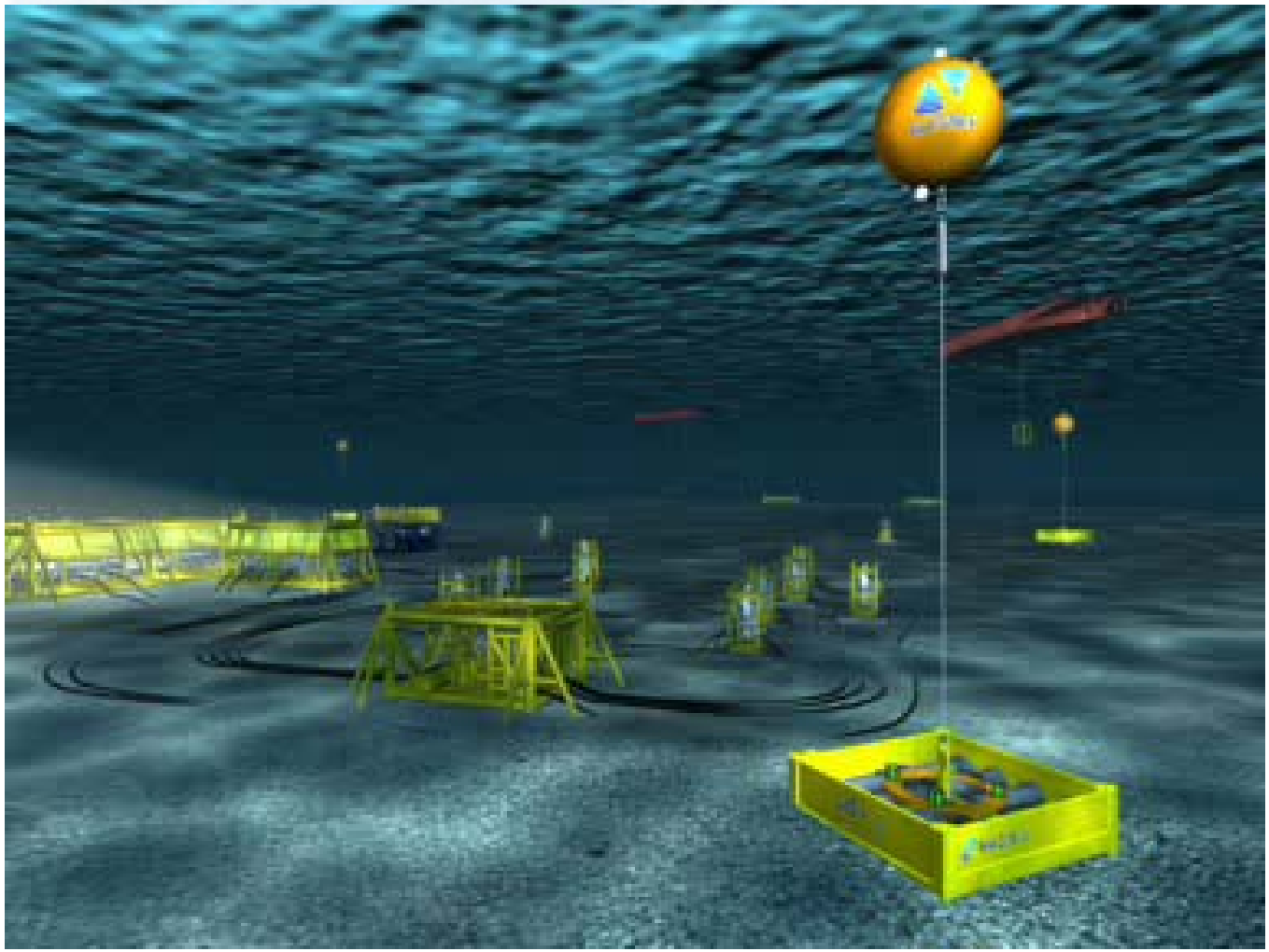
ADS^2 Results Joides Resolution (SBL) 5300m 8.5m RMS



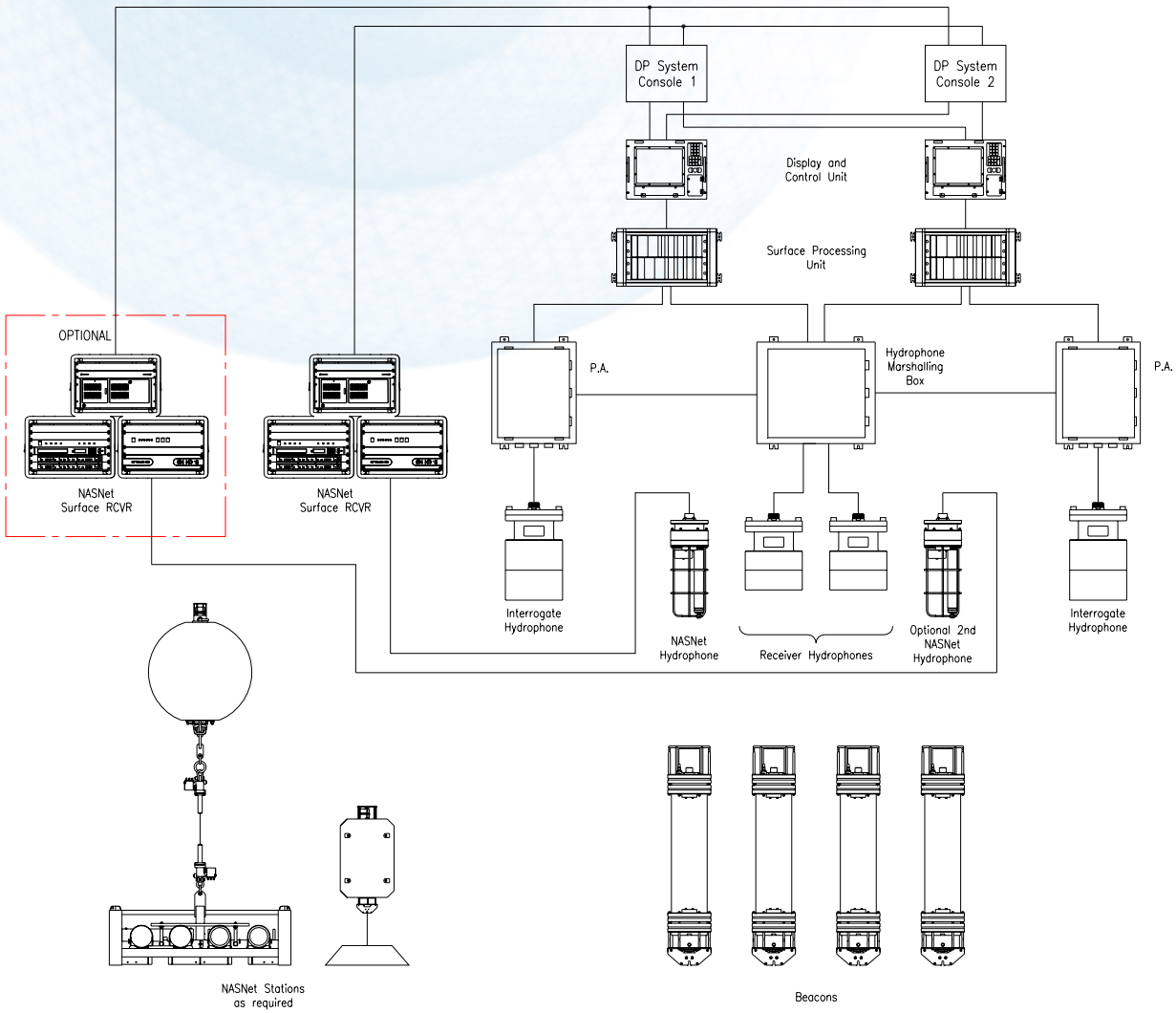
A New Option - NASNet®

- NASNet® is a new field wide multi user positioning system.
- The system is installed to cover a complete field or area.
- Station spacing is normally 2.5 to 4km.
- Signals are available to all users with a NASNet® receiver.
- Signals are available from at least 6 stations at all locations within the grid.

NASNet®



NASNet® Configuration



Conclusions

- Not all acoustic systems provide true dual redundant capability.
- It is important when considering which system to fit to your vessel to ensure it is redundant in all aspects, and that it fully meets both the regulatory and customer requirements.
- A poor choice will limit vessel up time, reduce revenue and decrease safety.
- Changing or retrofitting an acoustic system can be difficult and expensive.

Thank you for your attention.

Questions?

'Global Leaders in Through Water Communication and Positioning Technology'