Acoustic Positioning Systems
A Practical Overview of Current Systems

Keith Vickery

Sonardyne, Inc.

Overview

- What acoustic positioning tools are available for the DP community?
- Who makes them?
- Limitations associated with acoustic positioning systems.
- What we can do to make the basic systems work as designed or specified

Session Agenda

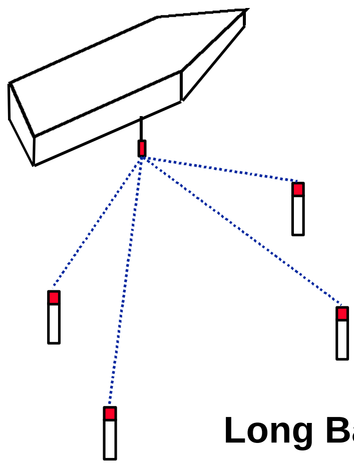
• Types of Acoustic Positioning Systems	5 min.
• Frequency Bands	4 min.
• Components of Acoustic Positioning Systems	5 min.
• Manufacturers	2 min.
• Positioning accuracy available from these systems	5 min
• Problems or limitations with these systems	15 min.
• Questions/Answers and general discussion	

Baseline Lengths

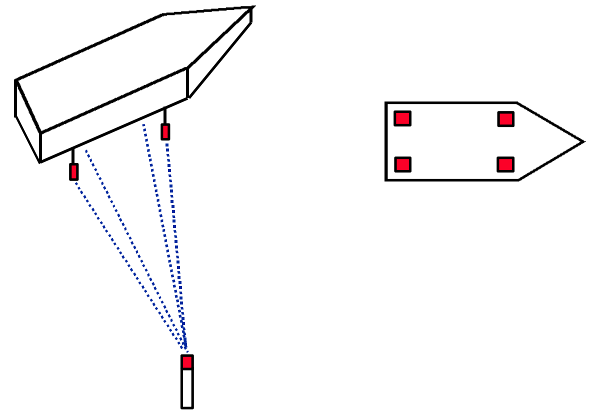
The distance between acoustic baselines is generally used to define the type of system:

Type of system	Baseline Length
Ultrashort Baseline	<10cm
Short Baseline	20m to 50m
Long Baseline	100m to 6,000m+

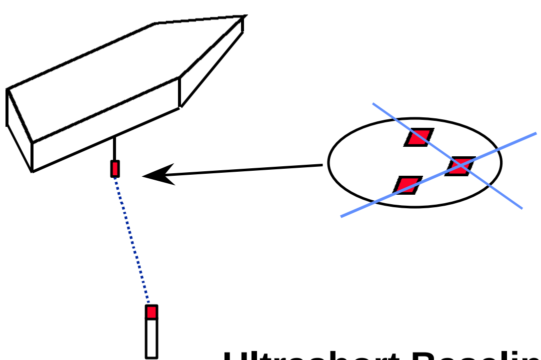
Types of Acoustic Positioning Systems



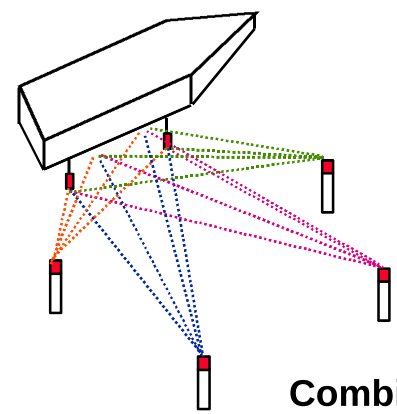
Long Baseline



Short Baseline

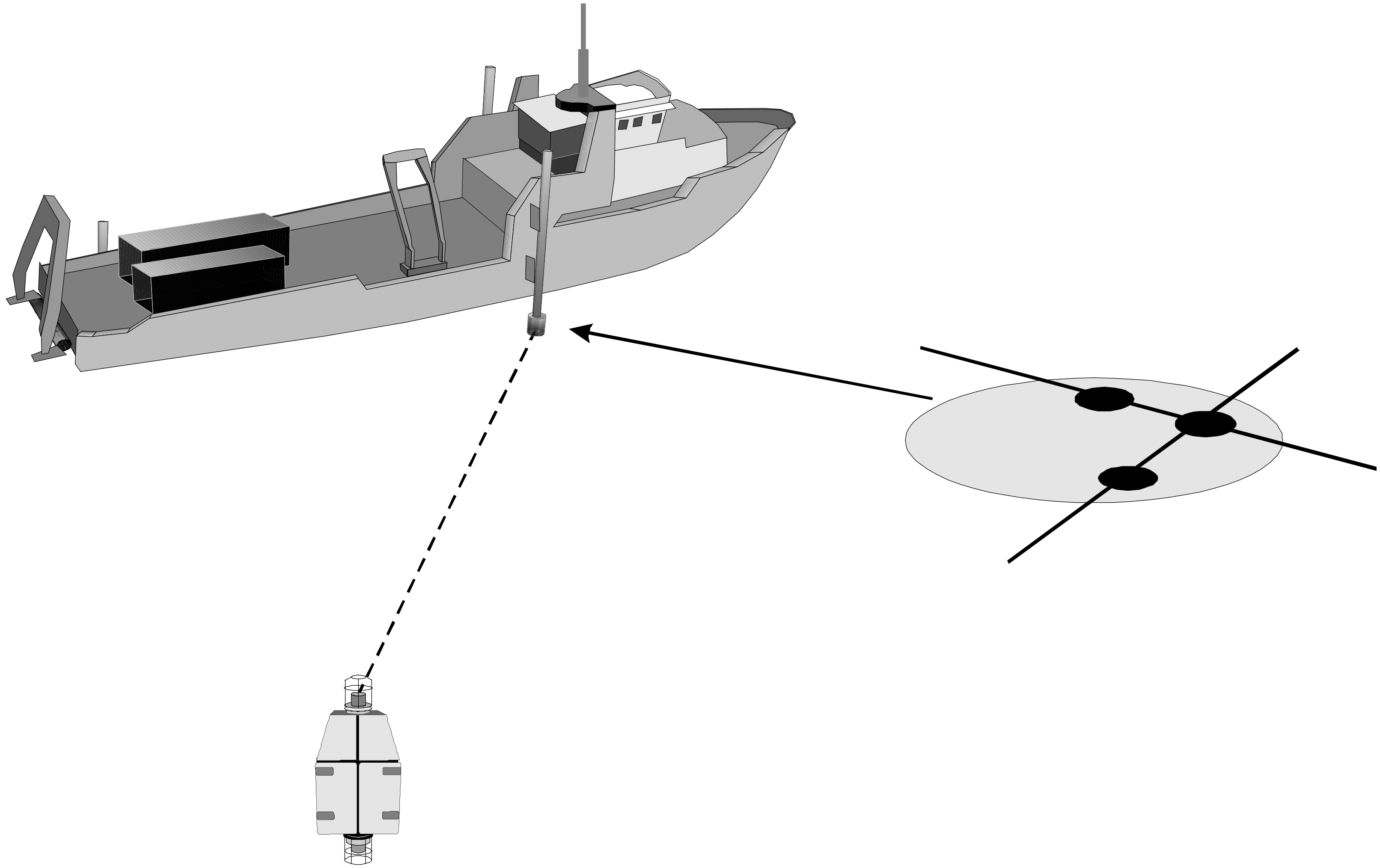


Ultrashort Baseline



Combined

Ultrashort Baseline or Super Short Baseline - USBL or SSBL



USBL or SSBL

- **Advantages**
- Low system complexity makes USBL an easy tool to use.
- Ship based system – no need to deploy transponders on the seafloor.
- Only a single transceiver at the surface – one pole/deployment machine.
- Good range accuracy with time of flight systems.

- **Disadvantages**
- Detailed calibration of system required - usually not rigorously completed.
- Absolute position accuracy depends on additional sensors - ship's gyro and vertical reference unit.
- Minimal redundancy – only a few commercial systems offer an over-determined solution.
- Large transceiver/transducer gate valve or pole required with a high degree of repeatability of alignment.

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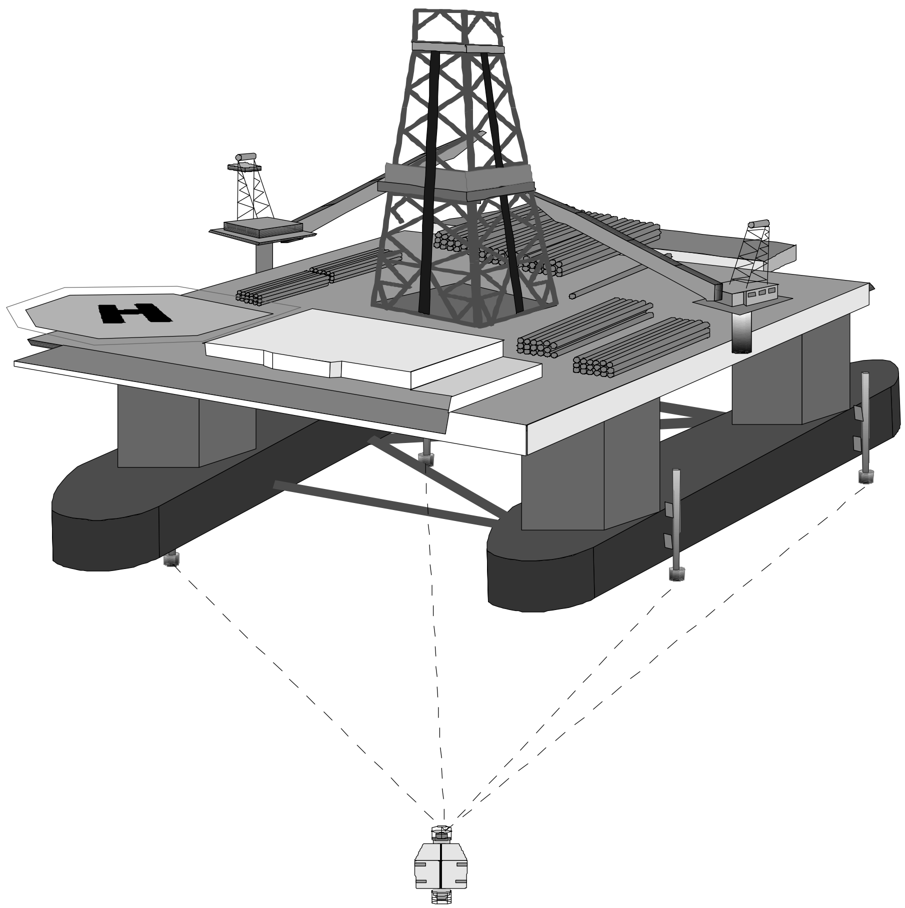
Short Baseline - SBL



SBL

- **Advantages**
- Low system complexity makes SBL an easy tool to use.
- Good range accuracy with time of flight system.
- Spatial redundancy built in.
- Ship based system – no need to deploy transponders on the seafloor.
- Small transducers/gate values.

- **Disadvantages**
- System needs large baselines for accuracy in deep water (>40m).
- Very good dry dock/structure calibration required.
- Detailed offshore calibration of system required - usually not rigorously completed.
- Absolute position accuracy depends on additional sensors - ship's gyro and vertical reference unit.
- >3 transceiver deployment poles/machines needed.

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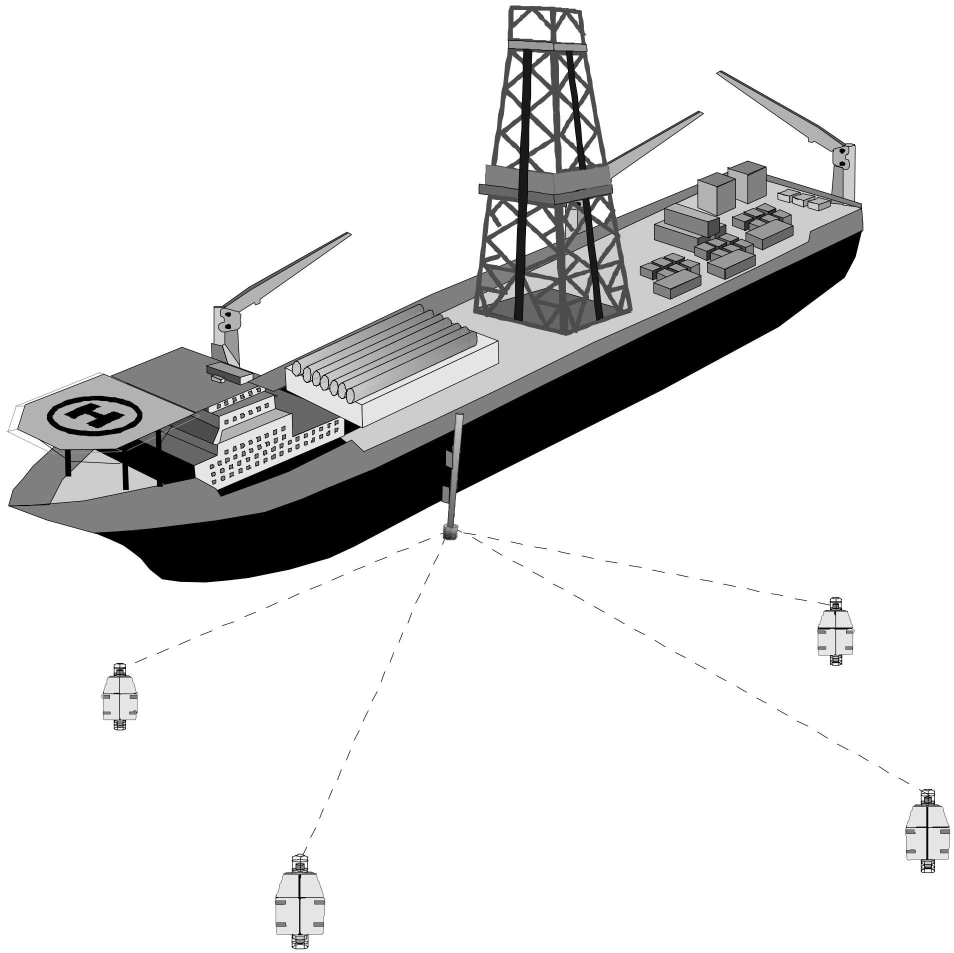
Long Baseline - LBL

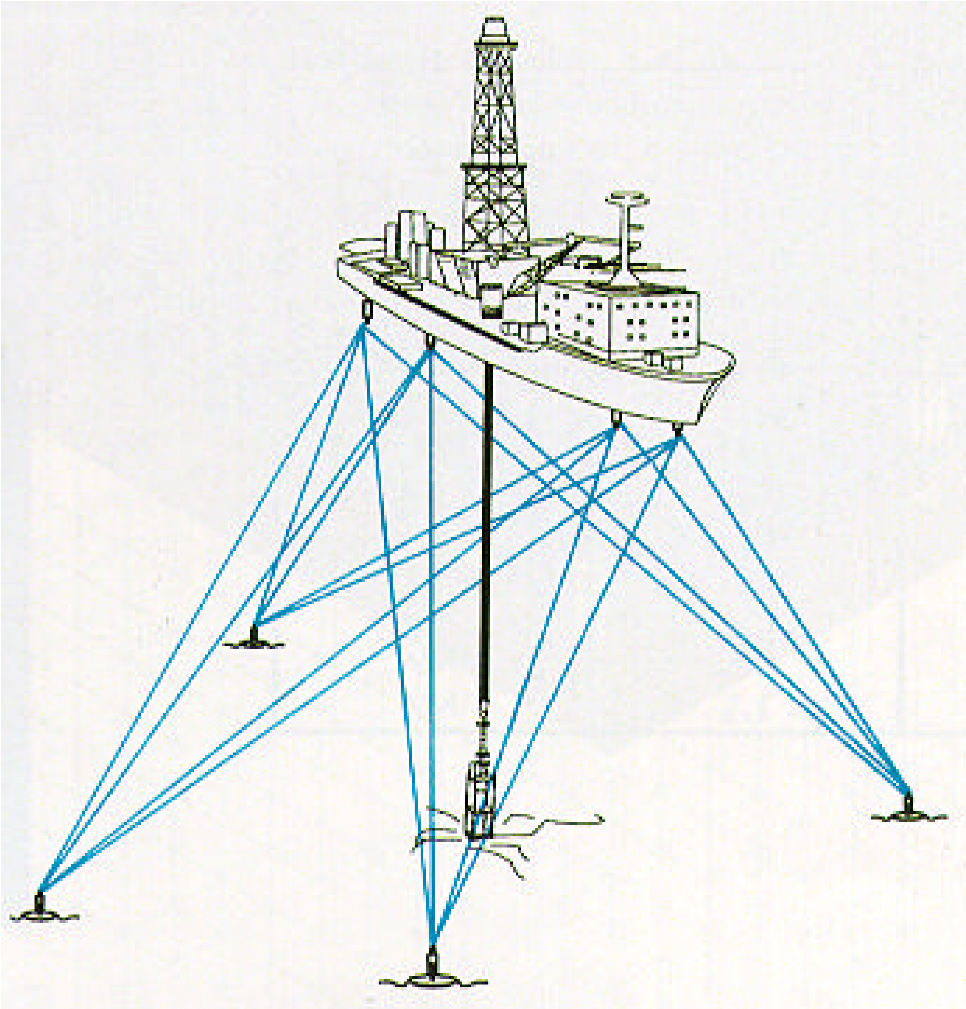


LBL

- **Advantages**
- Very good position accuracy independent of water depth.
- Observation redundancy.
- Can provide high relative accuracy positioning over large areas.
- Small transducer – only one deployment machine/pole.

- **Disadvantages**
- Complex system requiring expert operators.
- Large arrays of expensive equipment.
- Operational time consumed for deployment/recovery.
- Conventional systems require comprehensive calibration at each deployment.

Combined Systems



Combined Systems

- **These systems combine the benefits from all of the above systems and provide very reliable and redundant positions. With these benefits come more complex systems.**

- **Combined systems come in many varieties**:

- Long and Ultrashort Baseline (L/USBL)
- Long and Short Baseline (L/SBL)
- Short and Ultrashort Baseline (S/USBL)
- Long, Short, Ultrashort Baseline (L/S/USBL)

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Multi-User Systems or Acoustic pollution

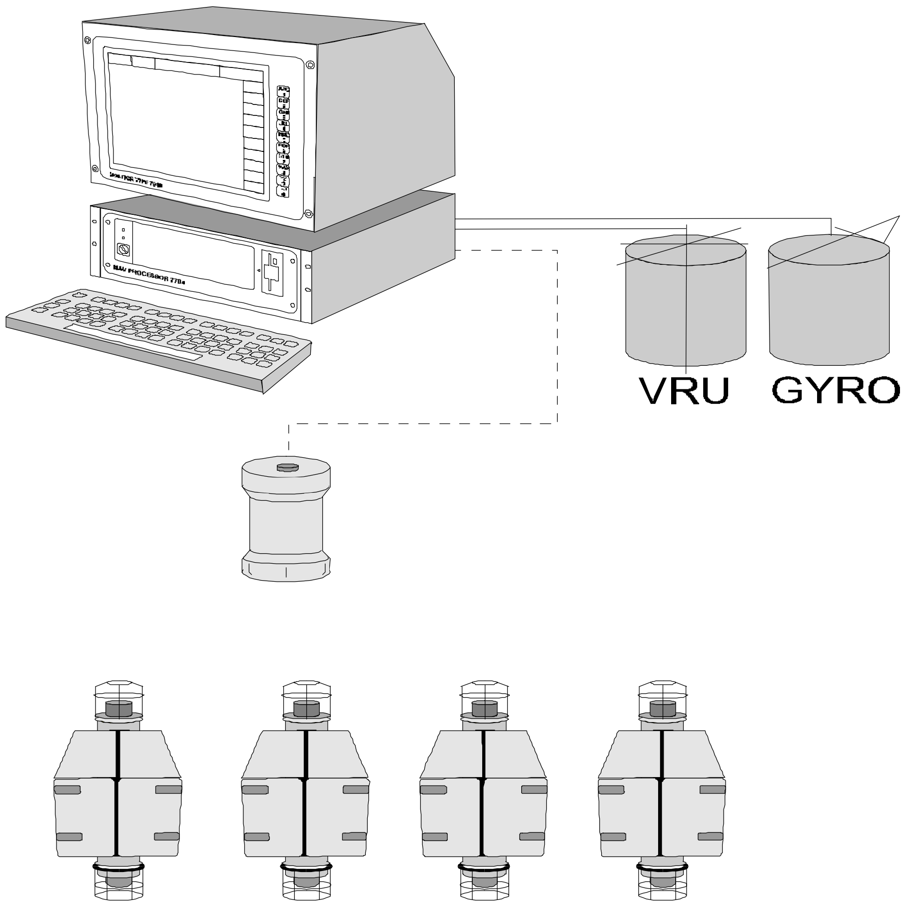
- **Multi-User system are required when more than a single vessel is working in close proximity.**
- **A field development example would be a Drilling vessel, Construction barge, Pipelay barge and ROV support vessel all on the same location holding station on DP.**
- **Several solutions to this are operational or under development:**
  - Single “Master” seafloor beacon interrogation systems
  - Master surface vessel with radio telemetry synchronization to other vessels
  - More channels within the same band through signal processing techniques
  - Use different frequency bands for construction and DP operations.
- **This is already a significant issue West of Shetland, Brazil and is becoming an issue in the Gulf of Mexico.**

Frequency Bands and Maximum Range

	Frequency	Max Range
Low Frequency (LF)	8 - 16kHz	>10Km
Medium Freq. (MF)	18 - 36kHz	2 - 3.5Km
High Frequency (HF)	30 - 64kHz	1,500m
Extra High Freq. (EHF)	50 - 110kHz	<1,000m
Very High Frequency (VHF)	200 - 300 kHz	<100m

Components of an Acoustic Positioning System

- A basic Acoustic Positioning System



Display and Processor

- **Monitor, Visual Display Unit**

- The system display of menus and positioning information providing an interface to the acoustic positioning system for the user or DPO

- **CPU or Computer**

- The central processor processes raw range data and sends graphical commands to the display. The processor also probably handles the scheduling of the interrogations into the water and the scheduling of the interfaces with other sensors and equipment. It is the processor that collects data from the Vertical Reference Unit and the Gyro for the acoustic positioning system. It is the processor that provides data out to the DP desk.

Transceiver

- Transceiver, transducer and with older SBL systems Hydrophone.

- A transceiver takes serial data and power from the processor and transmits and receives acoustic range and telemetry data through the water column. The transceiver is on the end of a deployment stem. Be it a deployment machine or an over the side pole, or a minim moon pool. Transceivers can be range range devices (LBL transceivers – RovNav). Multiple range range transceivers at the surface is a Short Baseline system. Transceivers can be range and bearing devices (USBL). Modern processors can have various different transceivers connected and operational at the same time.

Beacons

- A “Pinger” is a free running device that constantly transmits at a known repetition rate, on a known frequency for a predetermined pulse length.

- “Transponder” responds to an acoustic interrogation with an acoustic reply. “Intelligent Transponders” are units that have intelligence within them from a microprocessor. These units have telemetry links to the surface and allow many of their parameters to be modified or monitored acoustically through this link.

- A “Responder” is an acoustic device that is electrically triggered to reply acoustically. Small combined Transponder//Responder units are often used on ROV’s or Towfish with USBL systems. The primary advantage is the ability to electrically trigger a response from a noisy ROV rather than acoustically interrogate a transponder on the ROV.

Positioning Accuracy

- **When quoting an accuracy one should always ensure the "type" of accuracy is defined:**

  Absolute

  Repeatable

  Relative

  Precision

  Resolution

LBL Positioning Accuracy V's Frequency

	Frequency Range	Typical relative, static accuracy*
Low Frequency	**8 kHz to 16 kHz**	**2m to 5m**
Medium Frequency	**18 kHz to 36 kHz**	**0.25m to 1m**
High Frequency	**30 kHz o 60 kHz**	**0.15m to 0.25m**
Extra High Frequency	**50 kHz to 110 kHz**	**<0.05m**
Very High Frequency	**200 kHz to 300 kHz**	**<0.01m**

* This definition requires clarification as often a static sampled (multiple acoustic observations in the same place) accuracy is quoted as being achievable for a dynamic moving objects (single position update per location with up to 3 or 4 second epochs) This is rarely the case

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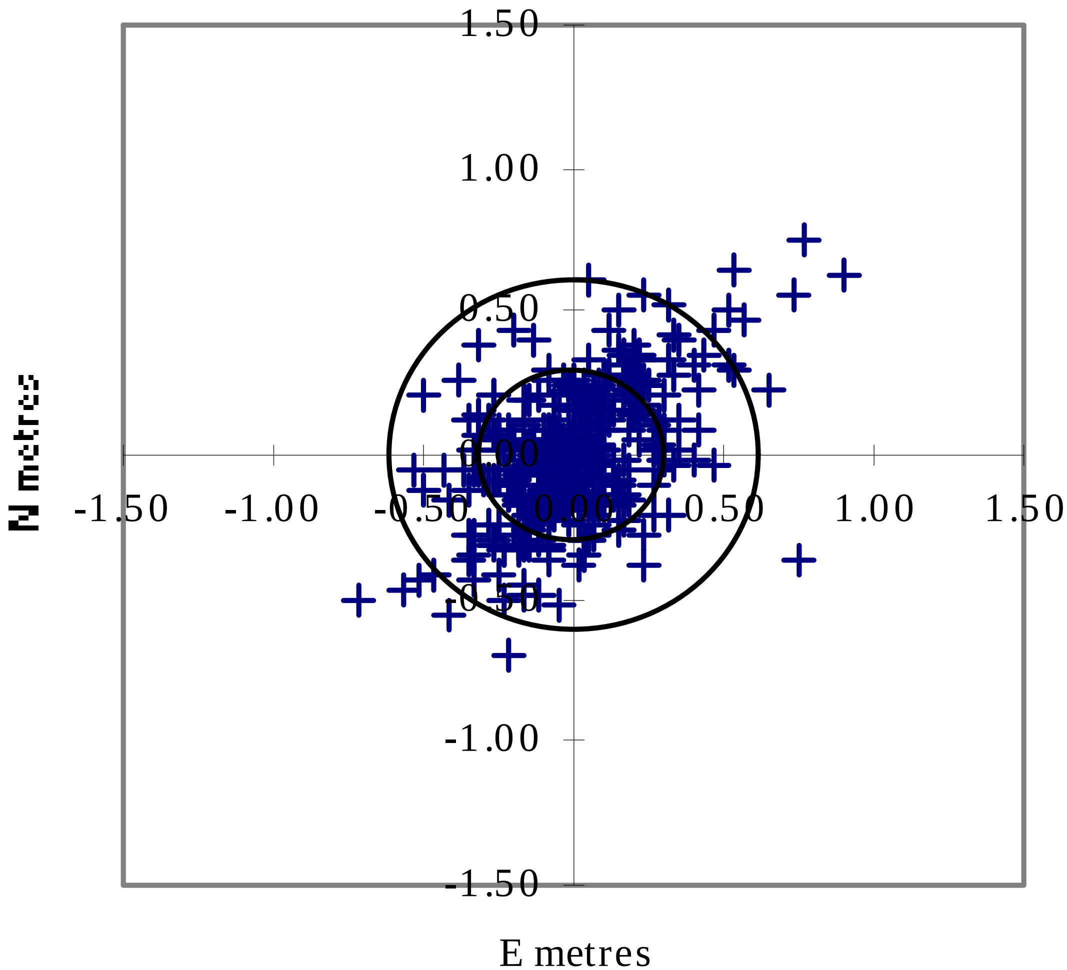
Actual L/USBL data from 5400 fsw



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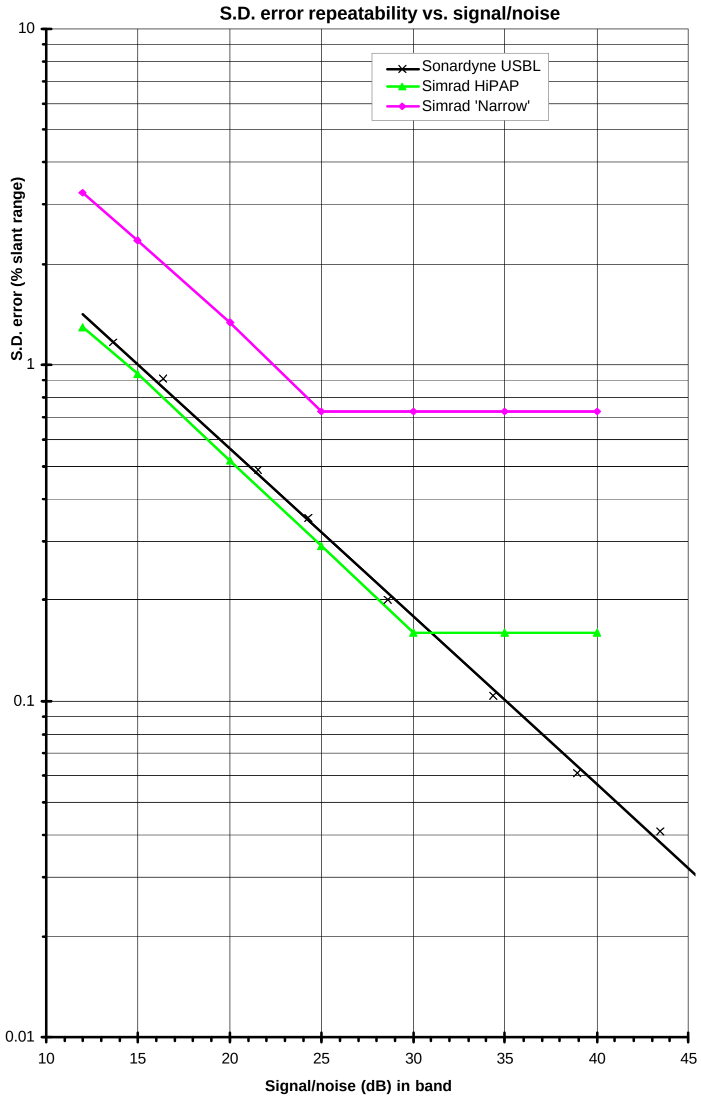
USBL Positioning Accuracy



The accuracy or repeatability of an USBL or SBL acoustic positioning systems is quoted as a percentage of slant range. The greater the depth - the greater the slant range - the less repeatable the position.

Equipment Manufacturers

USBL Manufacturers

Kongsberg Simrad	HPR300, HPR410, HiPAP
Nautronix	ATSII, Honeywell systems
ORE	LXT, Trackpoint II Plus
Sonardyne	USBL

SBL Manufacturers

MORS(Oceano)	
Nautronix(Honeywell)	RS5D
Sonardyne	SBL

Equipment Manufacturers - cont'd.

LBL Manufacturers

Benthos	
Desert Star	
Edgetech (EG&G)	
Imetrix	
Kongsberg Simrad	408
MORS(Oceano)	
Nautronix(Honeywell)	906, 916
ORCA	GIB
Sonardyne	PAN, Compatt etc.
Sonatech	

Integrated System Manufacturers

Kongsberg Simrad
Nautronix (Honeywell)
Sonardyne

Problems !!!!!

Some of the concerns commonly stated and problems encountered while, using acoustic positioning systems are:

Cost
Noise
Line of Sight
System Complexity
Positioning Accuracy

Cost

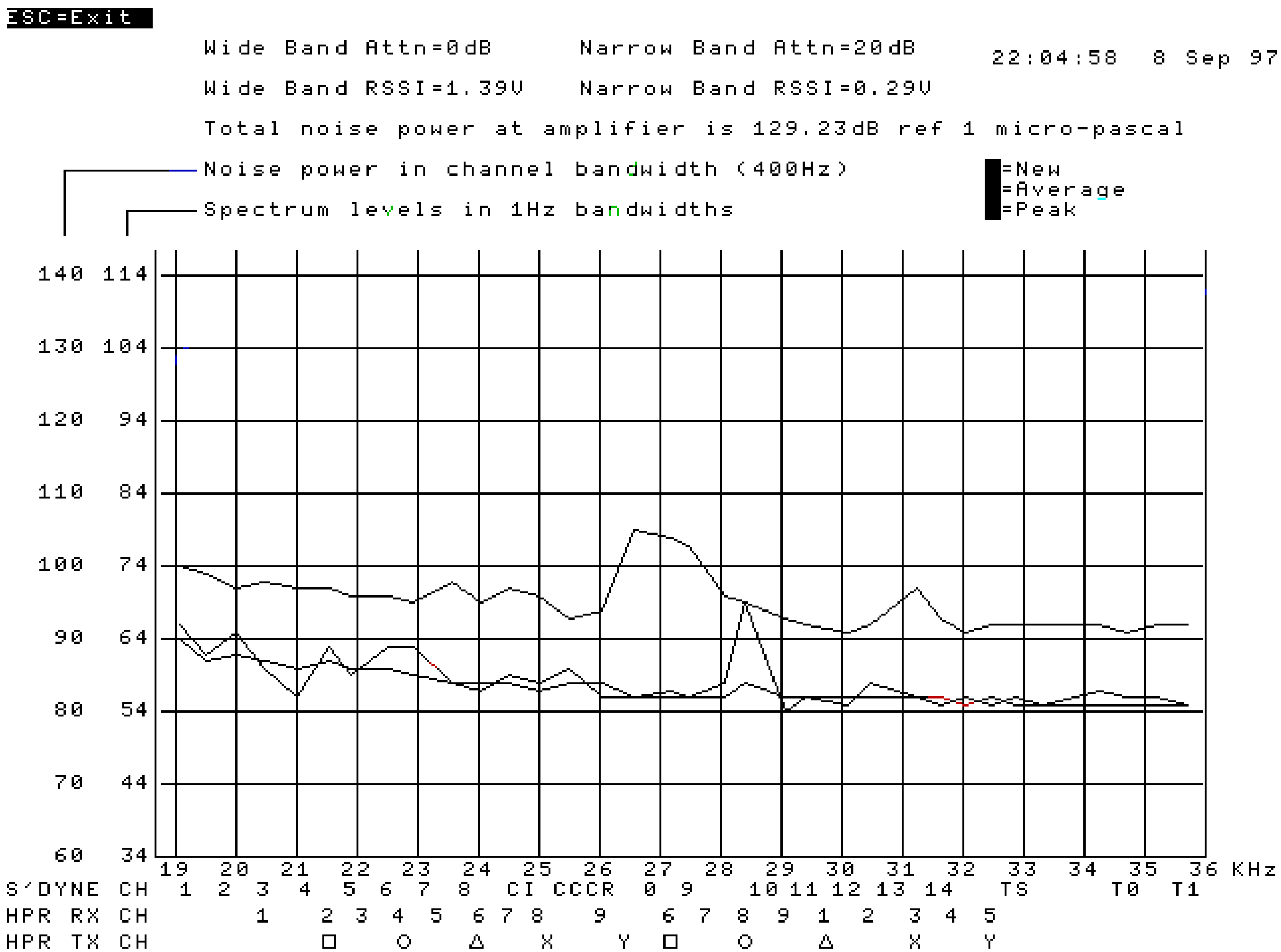
Think "Lifetime" cost, not component cost

A capital purchase saving of $200,000 can be lost with one day of down time for a deep water DP drilling vessel due to malfunction of an acoustic position reference system.

The design life of these systems are 15 to 20 years.

The difference between a "low" and "high" bid could be the the same as being **taken off day rate for a single day**.

Noise


ESC=Exit
Wide Band Attn=0dB
Narrow Band Attn=20dB
22:04:58 8 Sep 97
Wide Band RSSI=1.39V
Narrow Band RSSI=0.29V
Total noise power at amplifier is 129.23dB ref 1 micro-pascal
Noise power in channel bandwidth (400Hz)
Spectrum levels in 1Hz bandwidths
=New
=Average
=Peak
140 114
130 104
120 94
110 84
100 74
90 64
80 54
70 44
60 34
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 KHz
S'DYNE CH 1 2 3 4 5 6 7 8 CI CCCR 0 9 10 11 12 13 14 TS T0 T1
HPR RX CH 1 2 3 4 5 6 7 8 9 6 7 8 9 1 2 3 4 5
HPR TX CH X Y X Y

Noise

- **Ambient Noise (NA)**
  - Waves, wind rain etc.
- **Self Noise (NS) - from us being out there!**
  - Propulsion, Machinery, Flow
- **Reverberation Noise (NR)**
  - Volume reverberation, sea surface, sea bottom, structure (Aghh!)

Signal to Noise ratio (SNR) = $E – N$

Where $E = SL - TL$

$N = 20\ Log_{10}\ NT$

And $NT = Ö(NA^2 + NS^2 + NR^2)$

Line of Sight

- Placing beacons onto a Riser or BOP stack such that when deployed they are hidden from the surface transducer, due to the rotation of the stack, is a common example of a “line of sight” problem.

- Another example that causes problems for construction users of long baseline systems is the topography of the seabed. LBL array deployments have to be well planned in areas that have significant variations in seabed topography. Using longer deployment strops will help, as will bringing transponders closer into the work area. Longer strops reduces the accuracy of the system. Bringing the array closer in requires more beacons, more calibration, recovery and deployment time if not well planned.

System Complexity

- Train, Train and more Training, develop procedures.
- Many operations are jeopardized due to novice users trying to make complex systems work when under significant pressure.
- Good procedures and planning prior to any change in operations will always remove some pressure during say a rig move or complex offshore operation requiring detail use of an acoustic positioning system.
- Remember not to cut corners on pre-deployment check out, deployment and calibration time at the front end of the operation. A well calibrated system will be easier for all to use.

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Conclusion

- **System and component advances are needed and are presently under development to provide better solutions for multiple users and deeper water operations from more powerful, noisier vessels.**

- **Very capable acoustic positioning systems are presently available for DP operations to deep water depths today.**

- **A clear understanding during the procurement, engineering and operational stage is required by all involved to ensure that these systems are implemented correctly and provide the required results.**