NAUTRONIX

MARINE TECHNOLOGY SOLUTIONS

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Acoustic INS Integration – The Options, Challenges and Benefits

Positioning Options

Satellites
- GPS, GLONASS, COMPASS

Acoustics
- LBL, SBL, USBL

Relative sensors
- Laser systems
- Radio Systems
- Inertial Navigation Systems

Overview

- Inertial Navigation Overview
- General Integration Considerations
- Specific NASNet® INS Aiding Challenges
- Review of trials data
- Summing up

Inertial Navigation Overview

Inertial Navigation Concept

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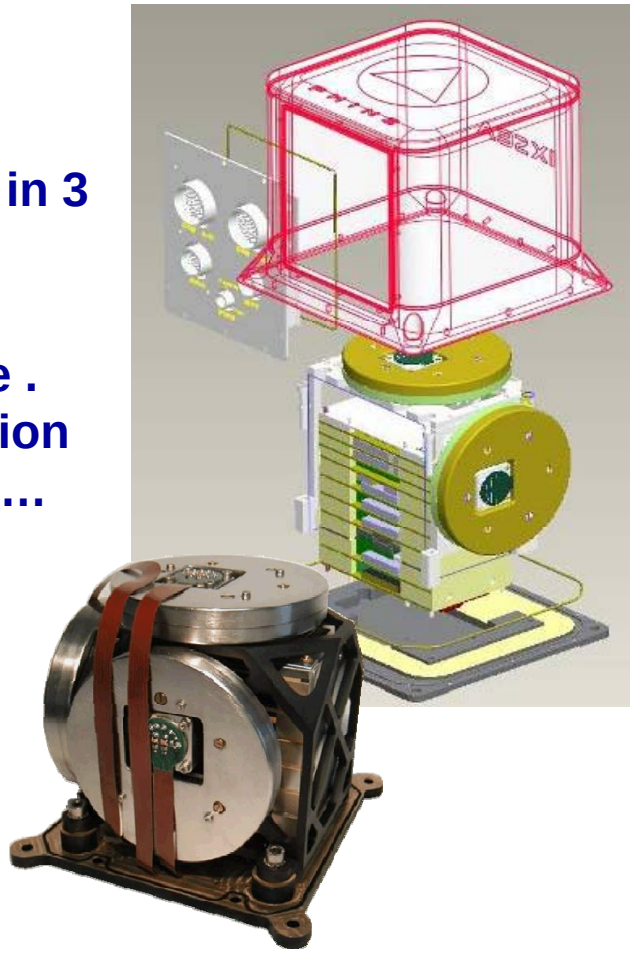
- **3 “FOG” gyrometers**
  monitor rotation and speed in X, Y & Z axis
- **3 accelerometers**
  measure acceleration (>> speed >> motion) in 3 axis
- **Powerful electronic / firmware package**
  INS “knows” in real time its motion in space .
  Firmware (Kalman filter) calculates its position in real time + heading, pitch, roll, heave, etc…



Inertial Navigation History

Basic 'INS' developed in 1940's for WWII rocket guidance

Military developments during 1950's & 1960's

First commercial use 1970's

Extensive use in

- **Aircraft**
- **Guided missiles**
- **Submarines**
- **Spacecraft**

First INS presentation at MTS DP conference – 1999

Inertial Navigation Benefits

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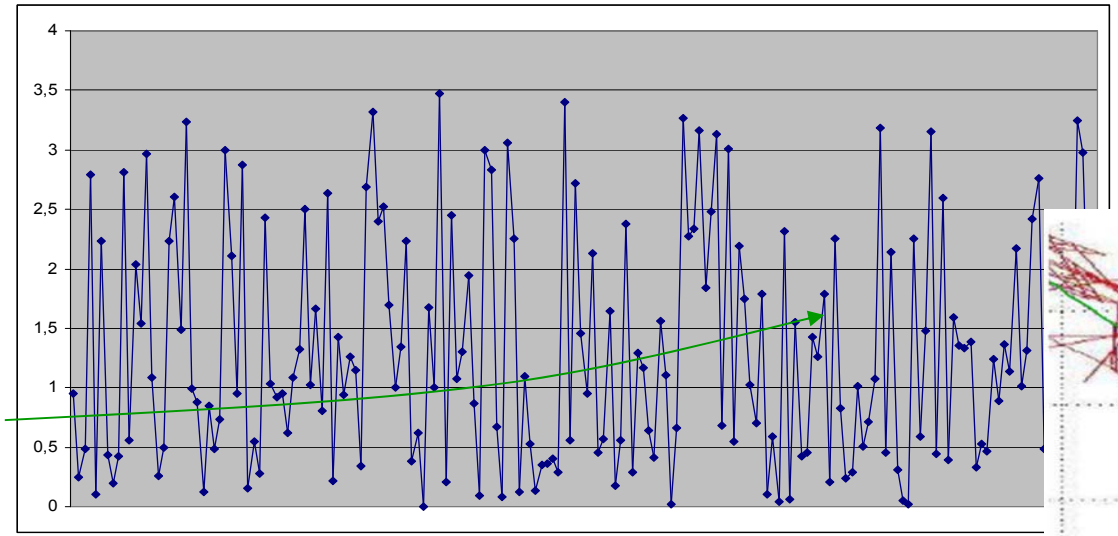
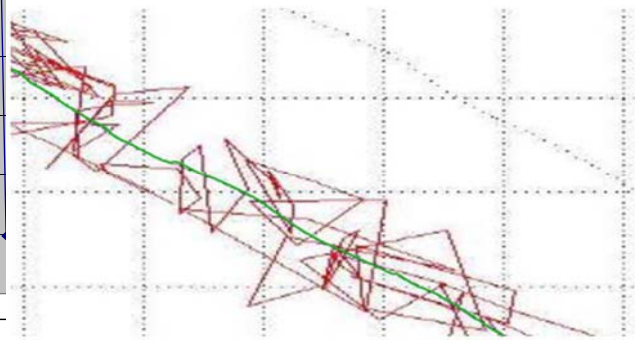
Various generic benefits to vessel positioning:

- **Improved position stability**
- **Faster position update**
- **Protection against drop-out of other position sensors**





General Integration Considerations

The Basics

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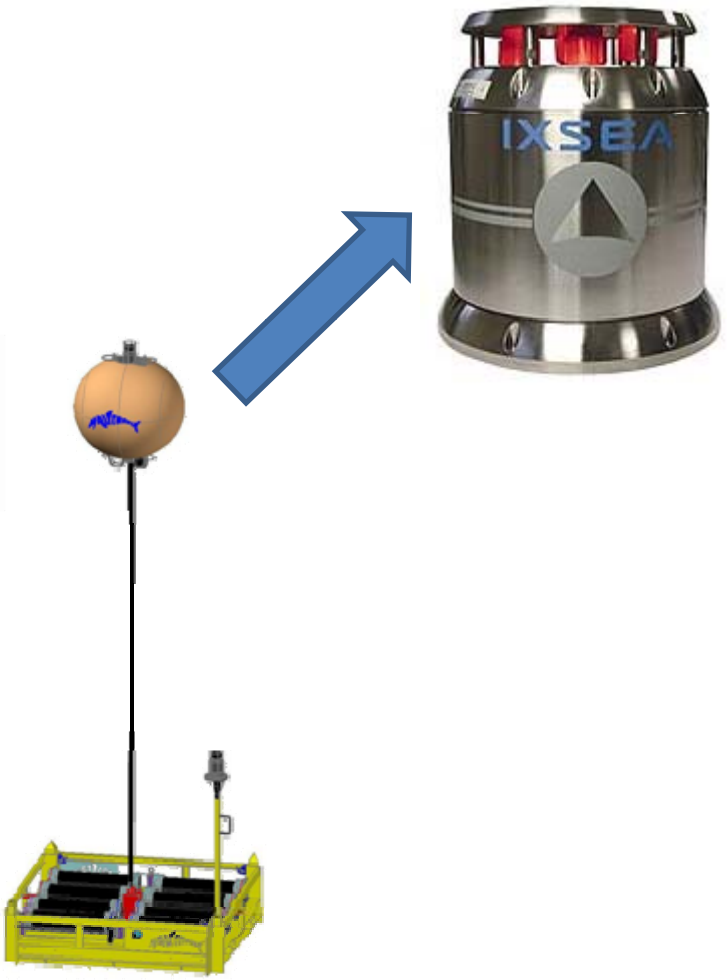
Requirements

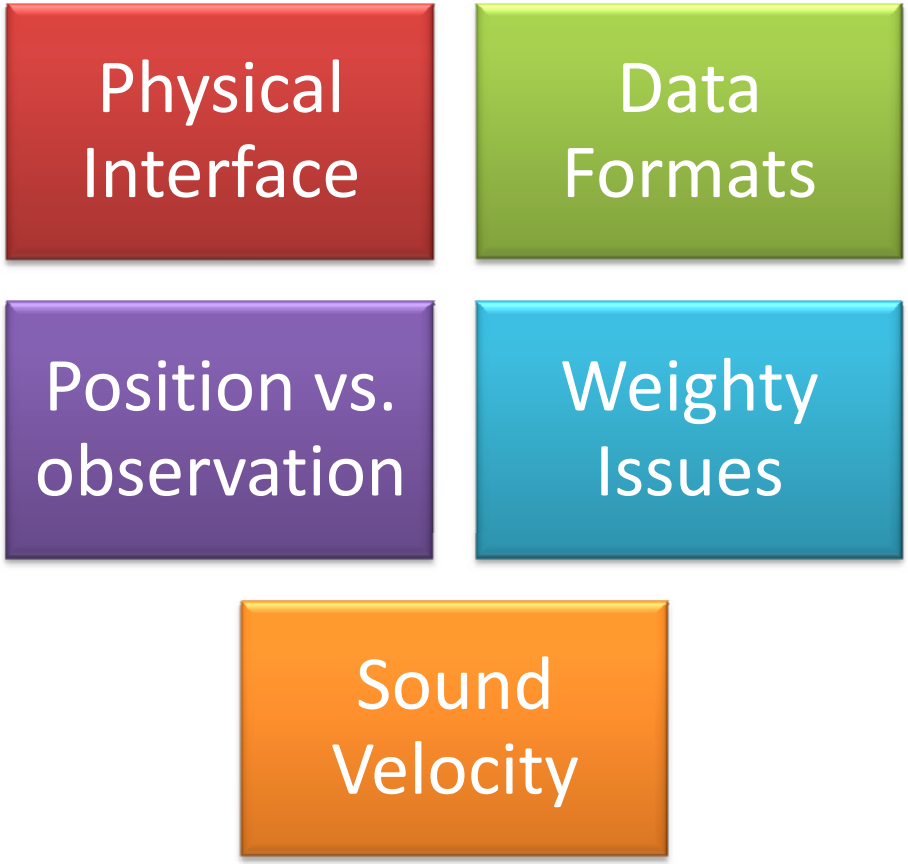
1. **Inertial Navigation System**
2. **Aiding System (acoustic positioning)**
3. **Ability to provide data from ‘2’ to ‘1’**

Optional

- **Understanding of relative data qualities**



Considerations



Physical Interface

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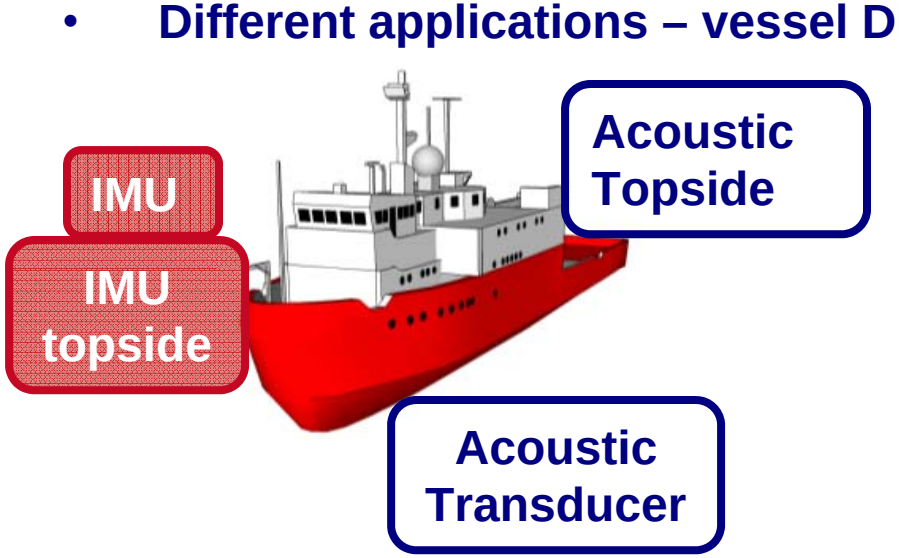
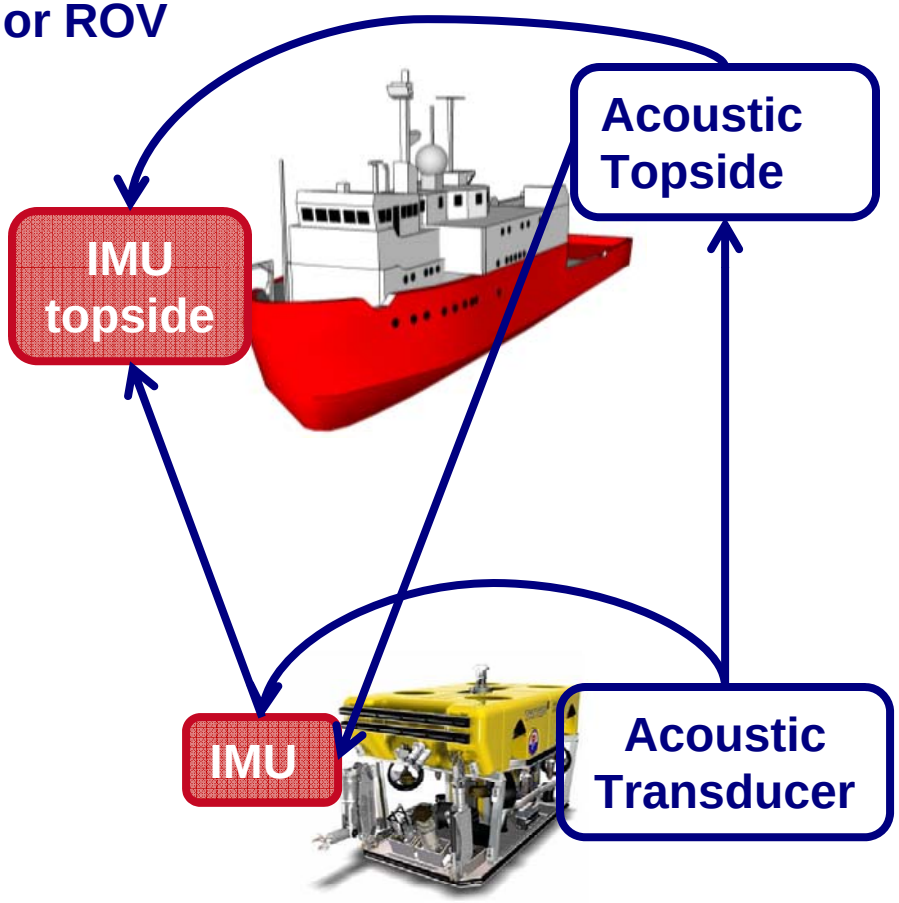
Where is the data generated, transferred and processed?

- **Different applications – vessel DP or ROV**





Data Formats

Generic String (GPS Position)

- **Quick and Easy – Plug and Play**
- **Optimal solution?**

$GPGGA,111828.00,0615.9594002,S,01043.3028162,E,2,09,1.0,53.75,M,0.00,M,23.7,0069*61

Quality related data:

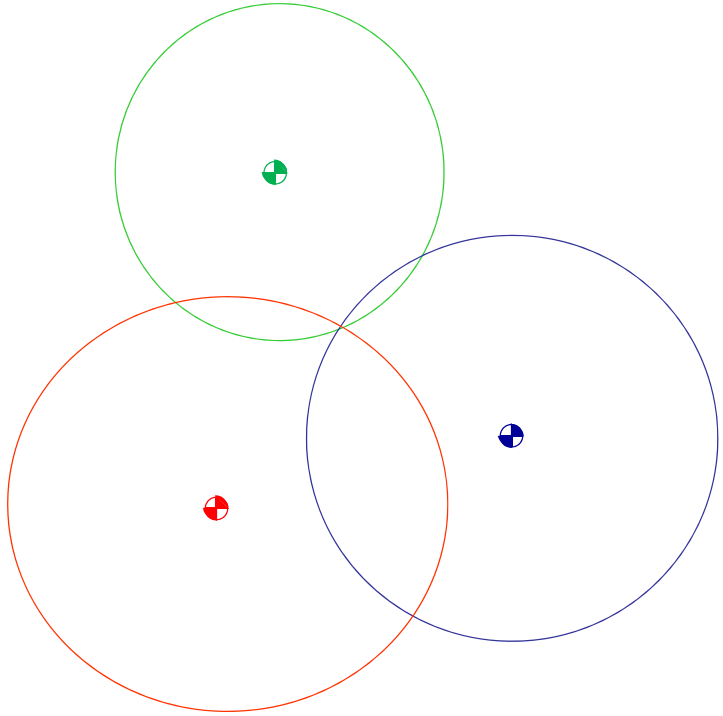
- **GPS quality indicator (0=invalid; 1=GPS fix; 2=Diff. GPS fix)**
- **Number of satellites in use**
- **Horizontal dilution of precision**

Position vs. Observation Aiding

Loosely Coupled vs. Tightly Coupled

INS Aiding using LBL acoustics can provide

- Calculated Acoustic Position
- Observed acoustic Time of Flight
- Distance (TOF x Speed of Sound)



Position and Range Aiding for LBL

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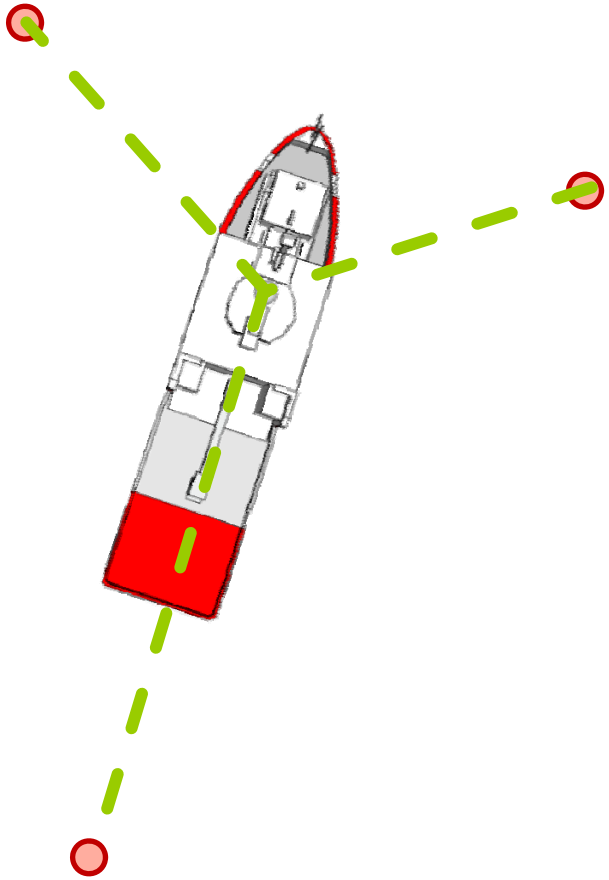

- **3 Ranges necessary for position to be generated**

Position and Range Aiding for LBL

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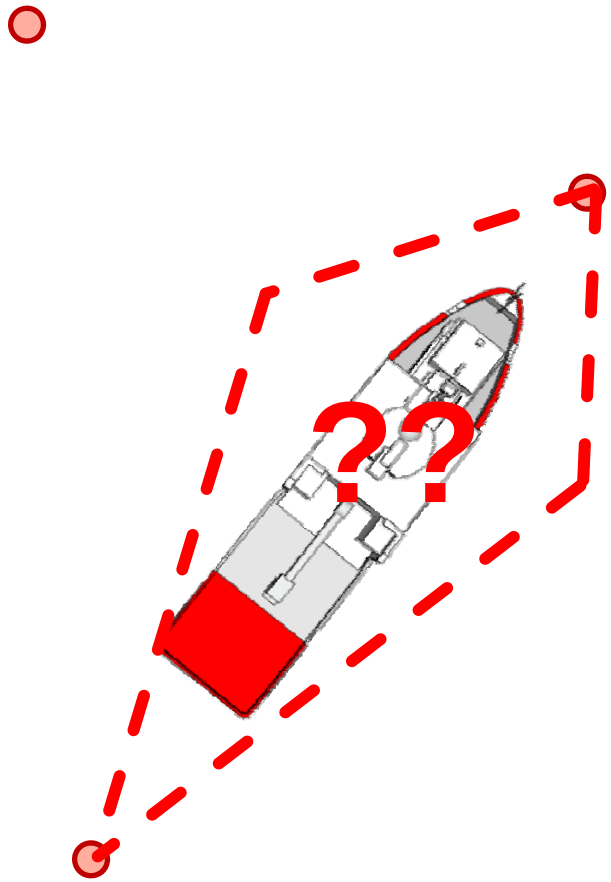

- **If less than 3 ranges available no acoustic position is available**

Position and Range Aiding for LBL

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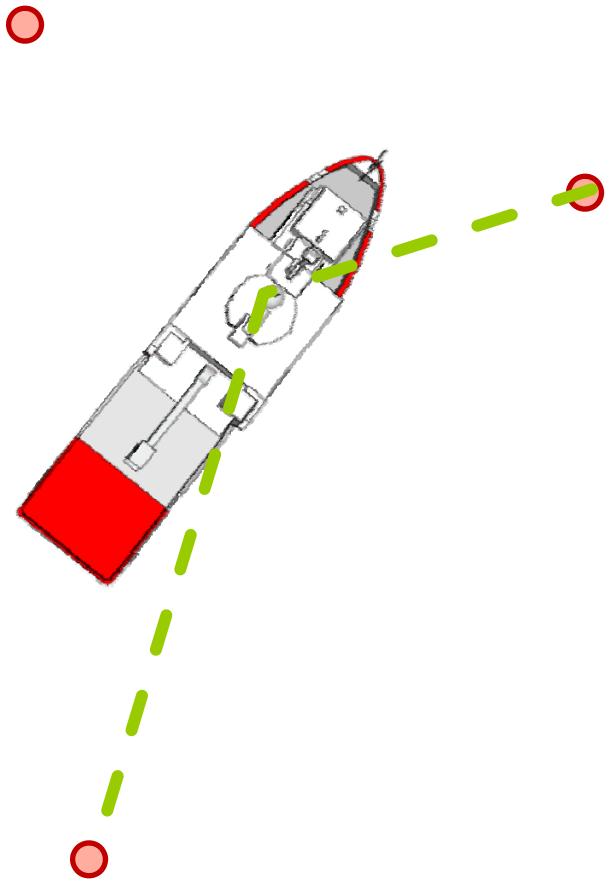

- If less than 3 ranges available no acoustic position is available
- But range aiding still provides useful information to INS

Sound Velocity

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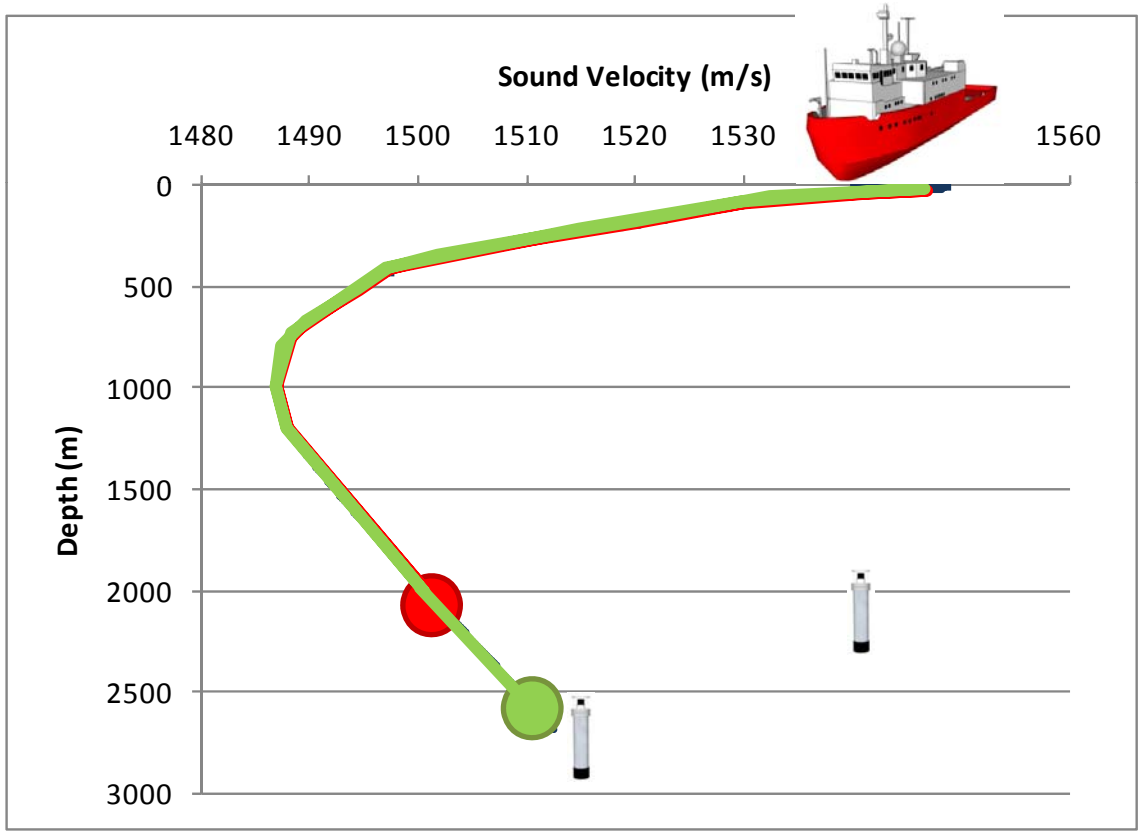
LBL Acoustic systems measure travel times
Distance = time x speed (velocity)



Weighting

Different data types combined within INS solution

- **Gyro and accelerometer data – from IMU**
- **Position/time/distance – from acoustic aiding source**

Optimal positioning requires appropriate weighting of observations – similar to that in the DP system

Weighting is primarily affected by accuracy and latency (age) of data

Weighting

Custom strings better suited to conveying quality information

GPGGA contains no quantative accuracy or age information

- **INS may assume GPGGA data has same parameters as GPS**

Position aiding relatively simple

- **Calculated accuracy (residuals, error ellipse etc)**
- **Uses position solution range rejection and adjustment**

Observation aiding more tricky

- **How do you QC a single observation?**
- **Can you determine the accuracy of one measurement?**

NASNet® - PHINS Integration

The components

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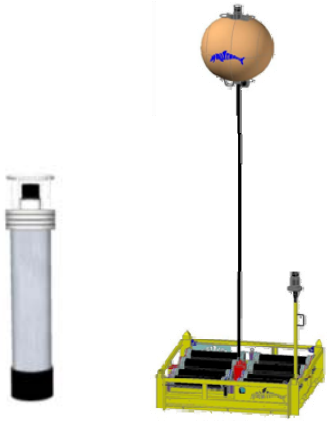
NASNet®

- Acoustic Long Baseline (LBL) subsea positioning system
- One-way broadcast transmissions
- High update, low latency positioning



PHINS

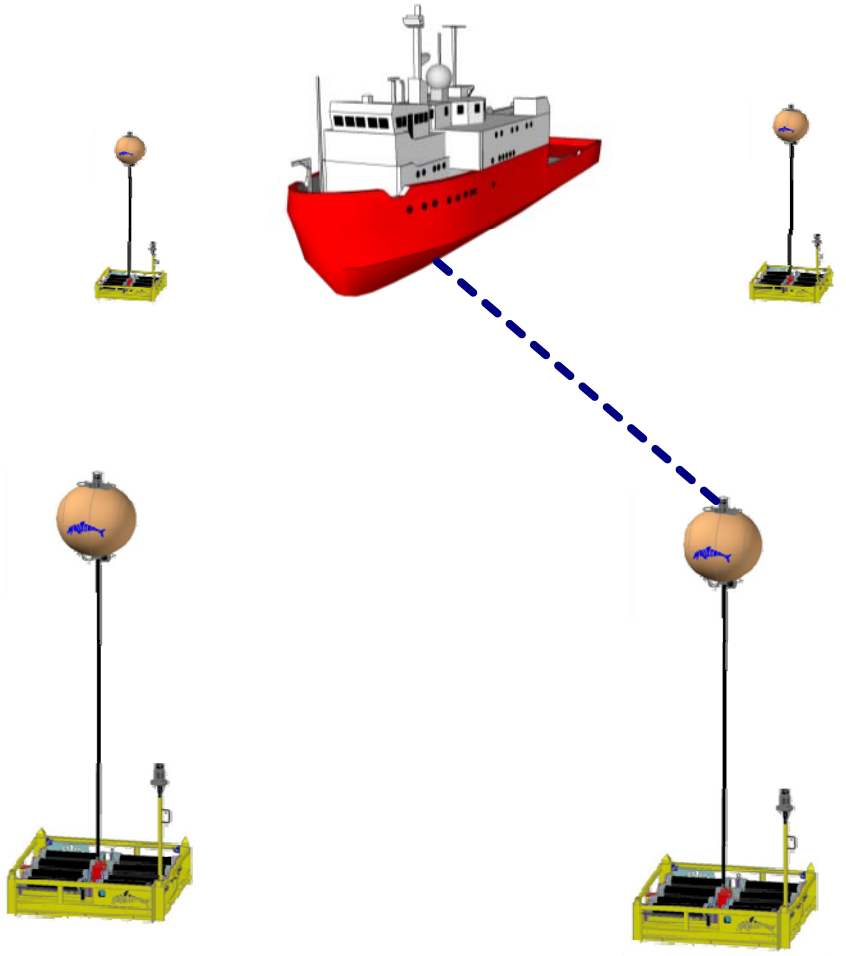
- PHotonic Inertial Navigation System
- FOG based strap-down INS
- Subsea and surface versions

NASNet® Features

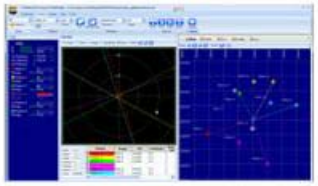
- **Moving range source**

NASNet® Features

- **Low Latency**
- **Simpler to deal with!**



Interface Path



Specific String (Acoustic Position)

$BFUSBLllmm.mm,a,LLLmm.mm,b,±dd.d,cc.c,cc.c,cc.c,cc.c,e.e*hh<CR><LF>

- **Vehicle Latitude, Longitude & Depth**
- **Latitude, longitude and depth Standard Deviations**
- **Age of Data**

Specific String (Acoustic Range)

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$BFLBL,llmm.mmmm,a,LLLmm.mmmm,b, dddd.d,xx,rrrr.r,ccc.c, e.e*hh<CR><LF>

String contains:

- **Acoustic source Latitude, Longitude and Depth**
- **Measured Range**
- **Range SD (estimation of accuracy)**
- **Age of Data**

Trials Vessels

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Loch Shiel

Talon

Interface Arrangement

NASNet® Beamforming Transducer (vessel)

NASNet® VTrx (ROV)

- **Bottle**
- **Transducer**

IXBLUE PHINS

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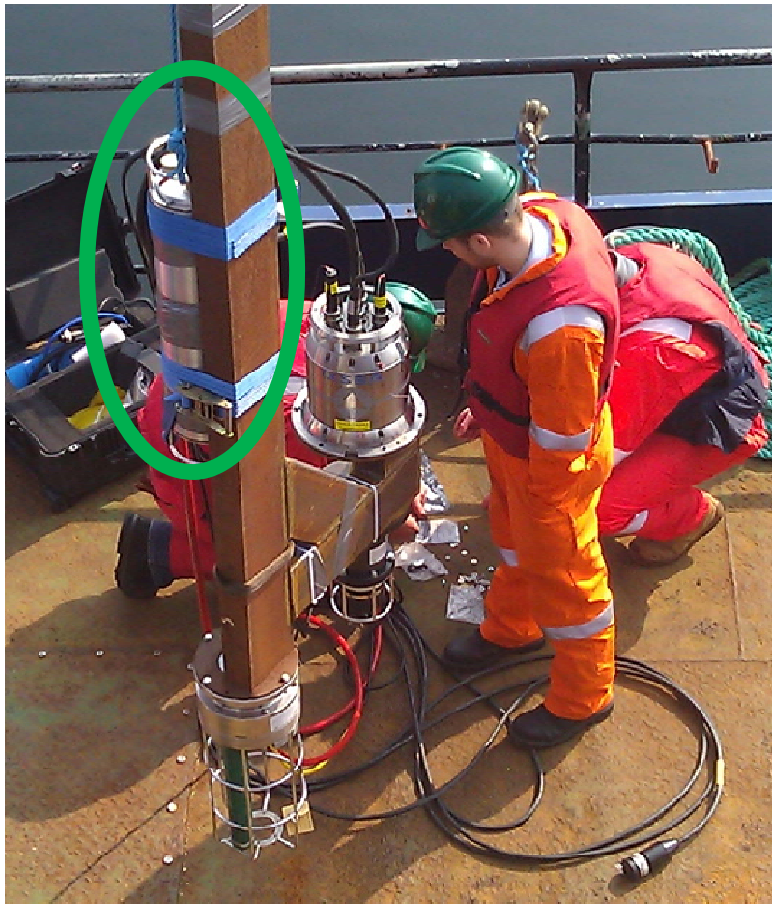

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NASNet® - PHINS
Initial Trials Data

0.1m Range Weighting

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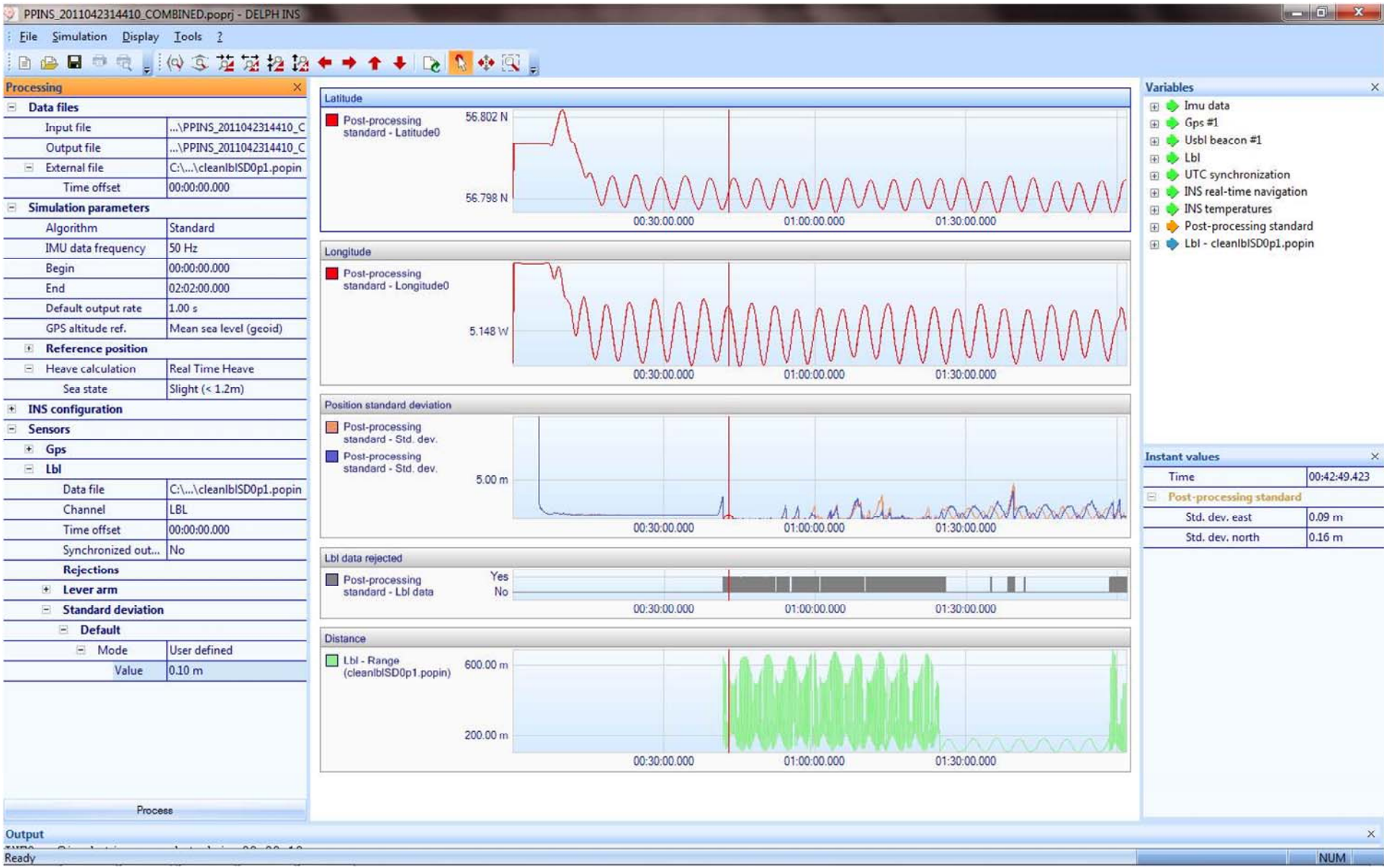

0.5m Range Weighting

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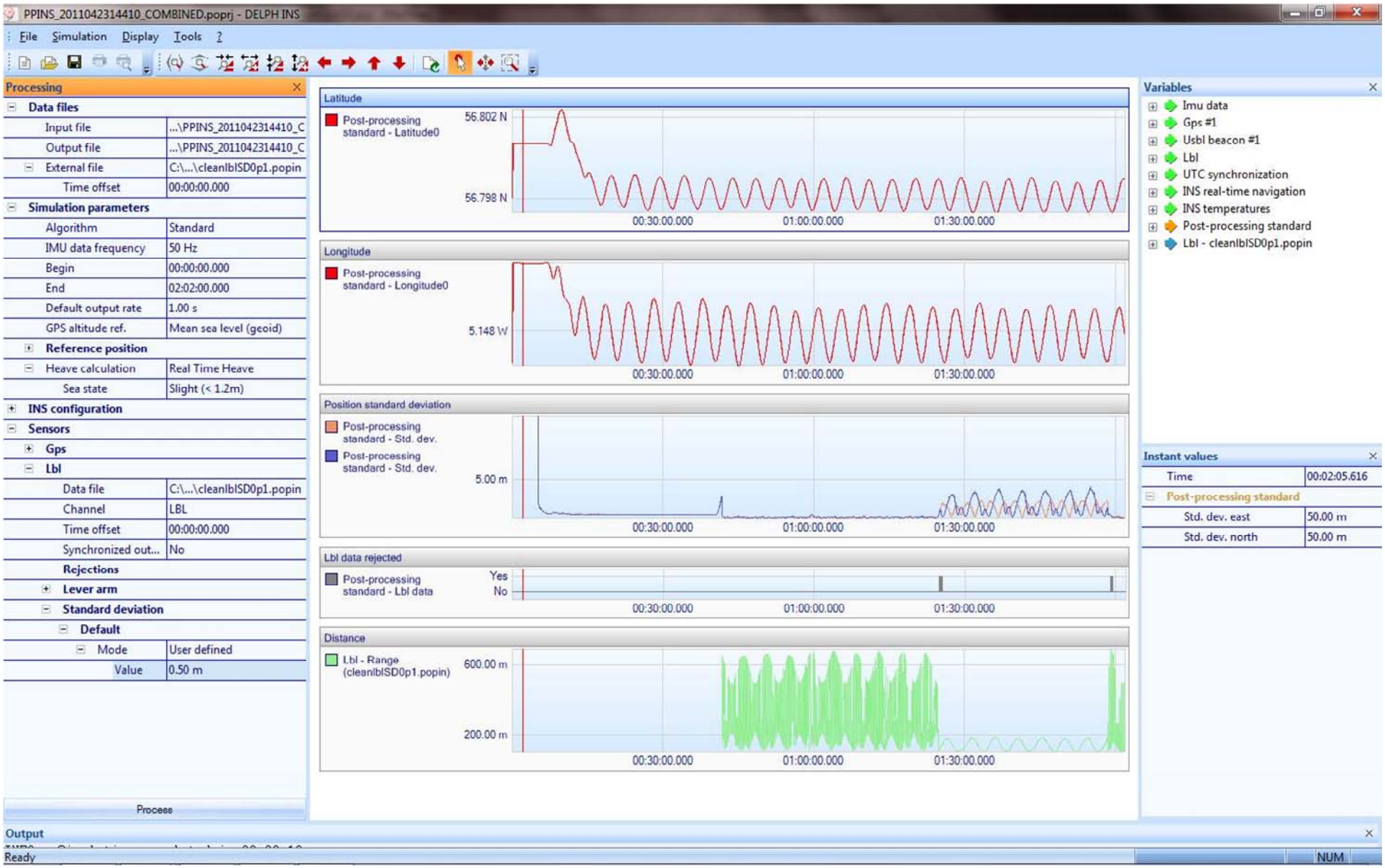

1m Range Weighting

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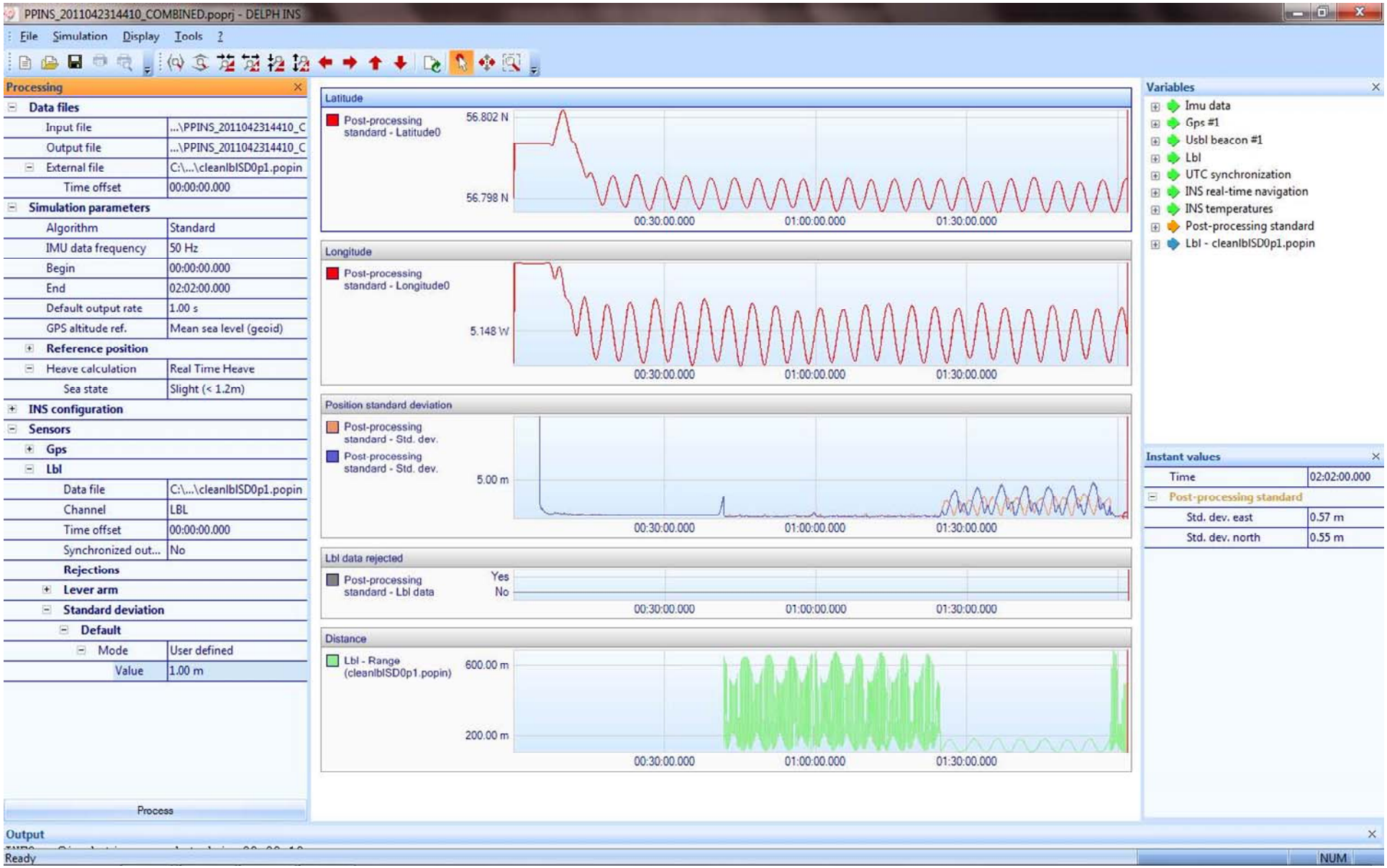

Summing up

In conclusion

Acoustic aided INS can provide operational performance and safety benefits

A basic interface is fairly straightforward and will provide some benefits to positioning quality and reliability

To achieve the maximum performance a custom interface should be created

Observation aiding (close coupled) is preferable to position aiding (loosely coupled)