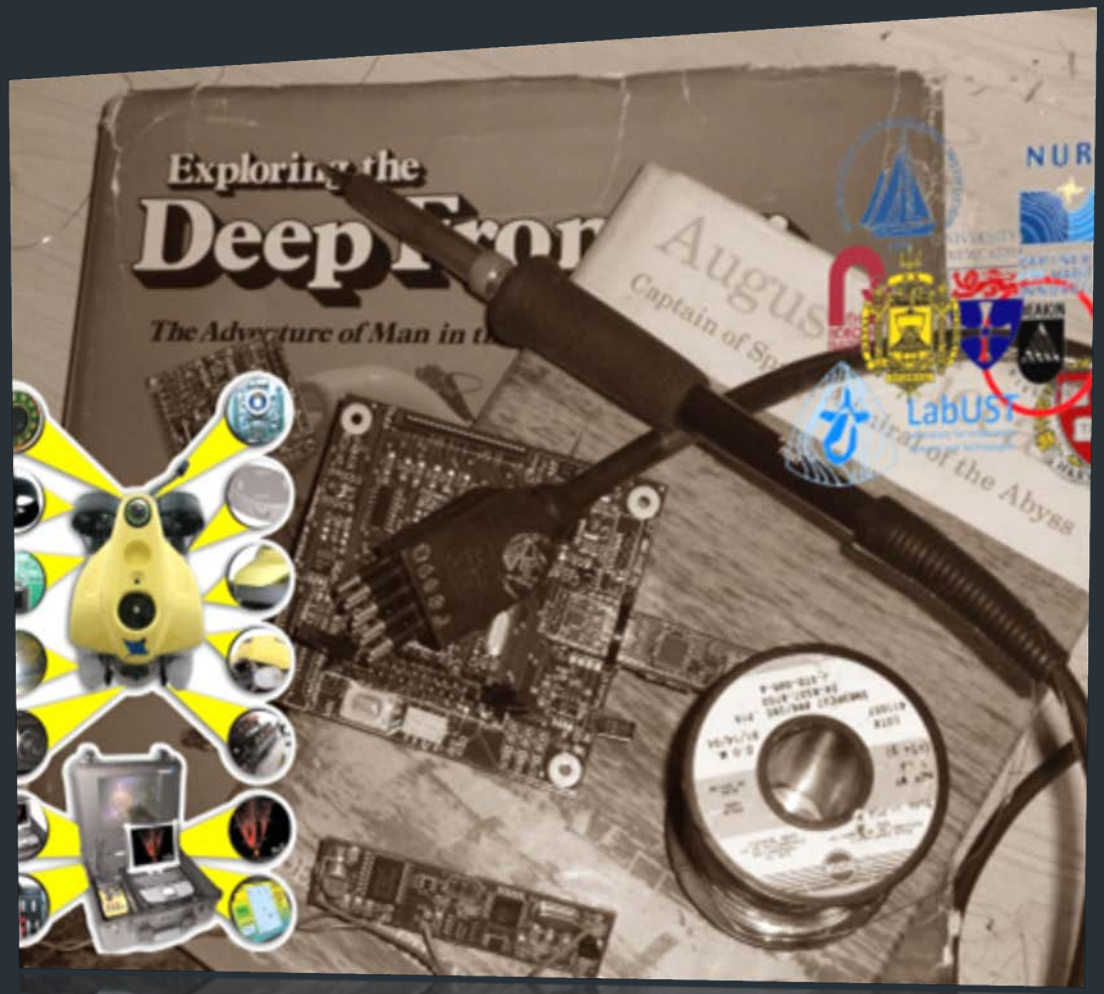
More Tools For MicroROV Navigation

Presented by
Andrew Goldstein

Director – Software Engineering
VideoRay LLC

My Perspective

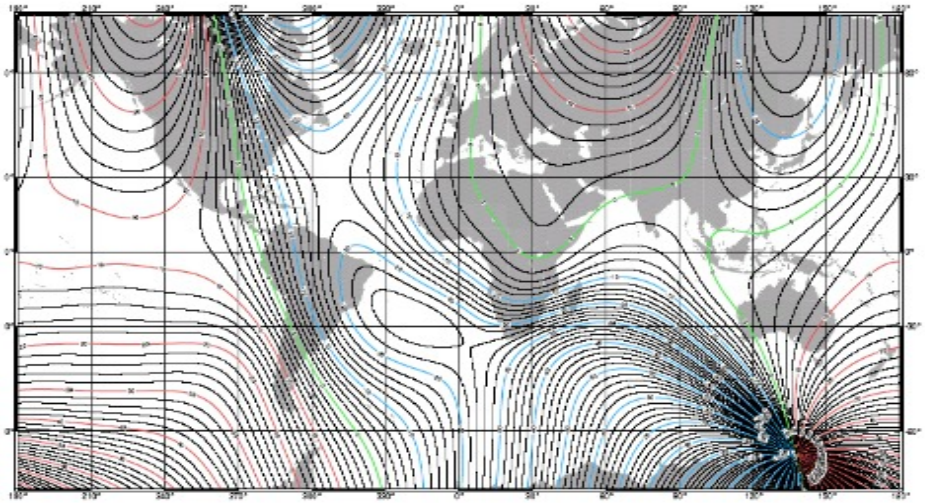


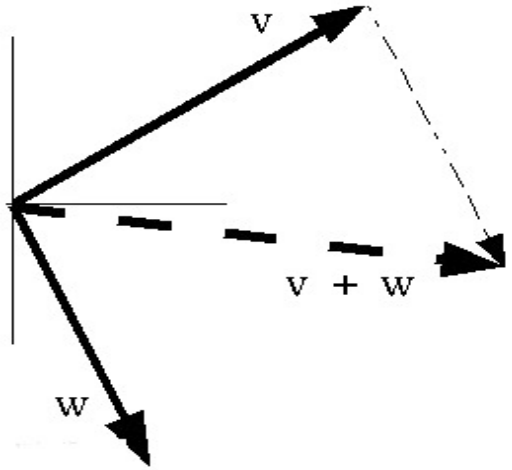
Director of Software Engineering at VideoRay

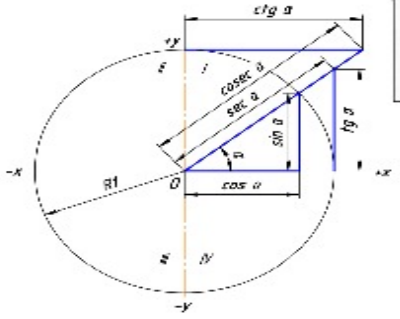
Contact for Academic Development programs

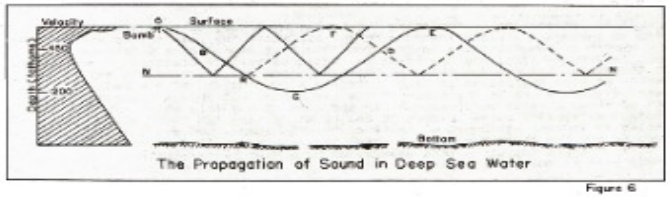
VideoRay
The Global Leader in Micro-ROV Technology

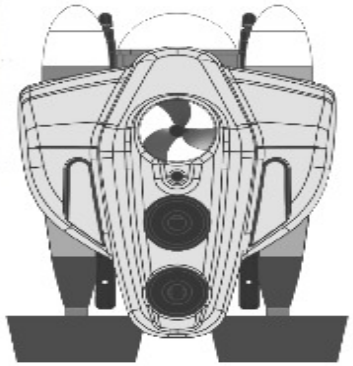
Themes




v
v + w
w


ctg α
cosec α
sec α
sin α
tg α
cos α
α
α1
O
+y
-y
-x
+x


Velocity
Surface
Bottom
The Propagation of Sound in Deep Sea Water
Figure 6



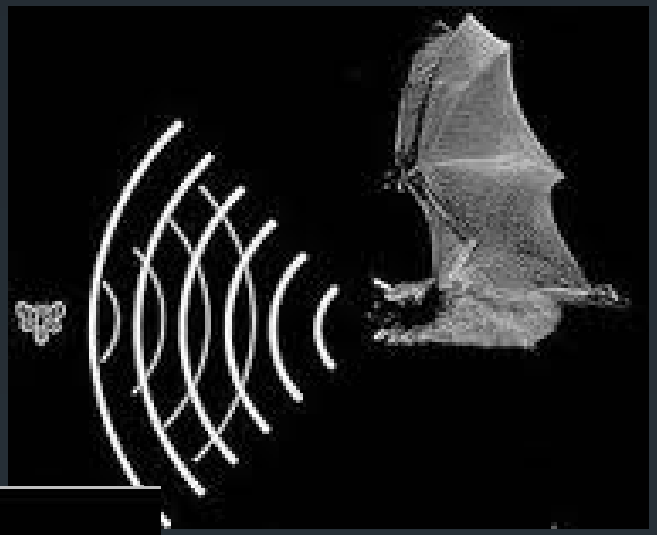
Micro-ROV

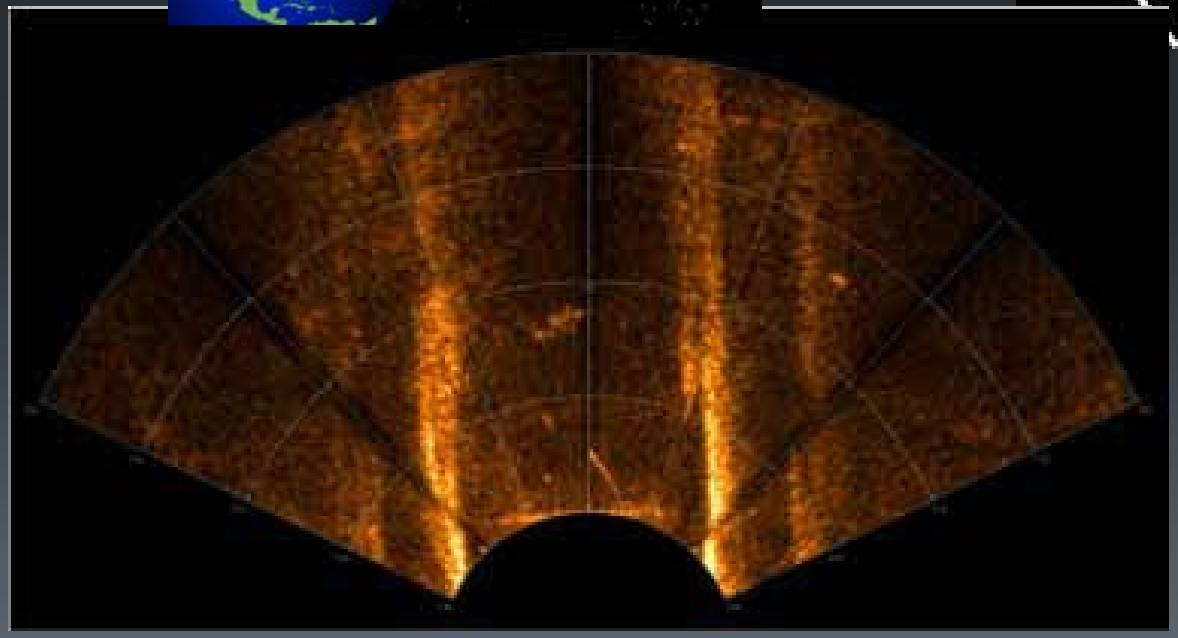
Where Am I???


I'M ON A BOAT
PARENTAL
ADVISORY
EXPLICIT CONTENT

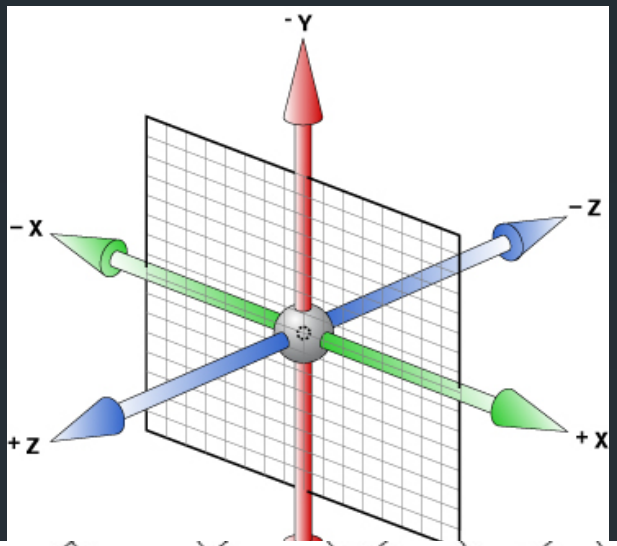

10/11/2012 11:54:23 AM
Judd Goldman Community Sailing Center, Chicago
H: 359.4 °
D: 0.00 ft
Temp: 52.0 °F

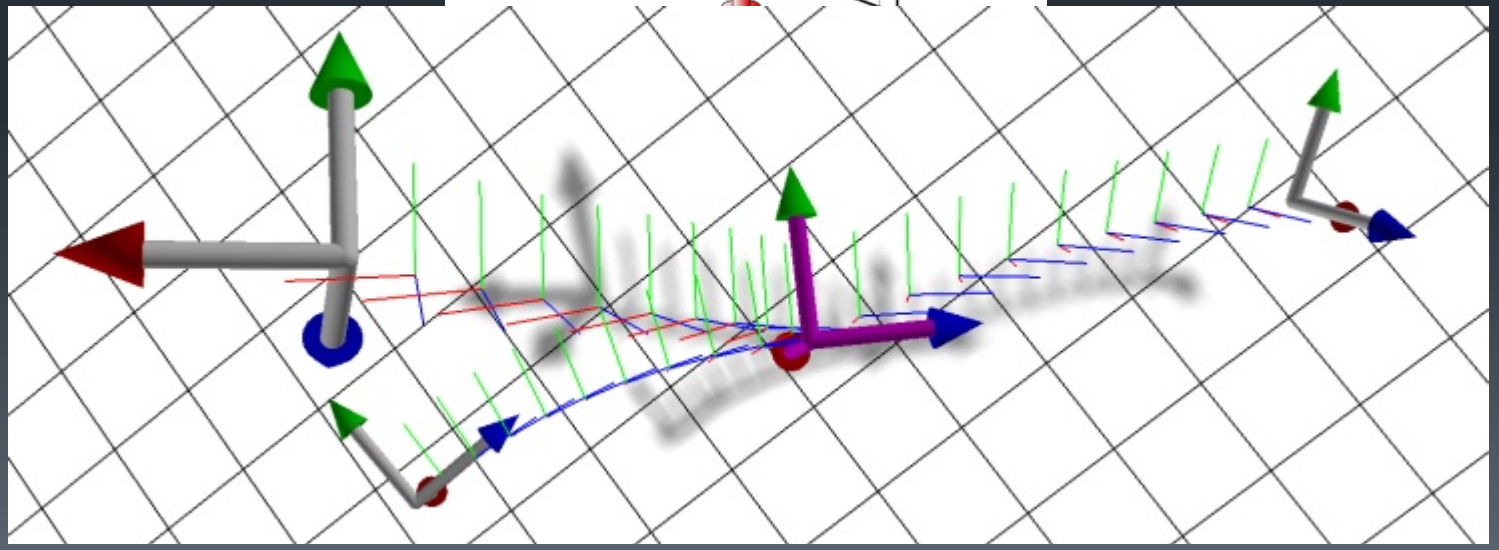
Where is It??



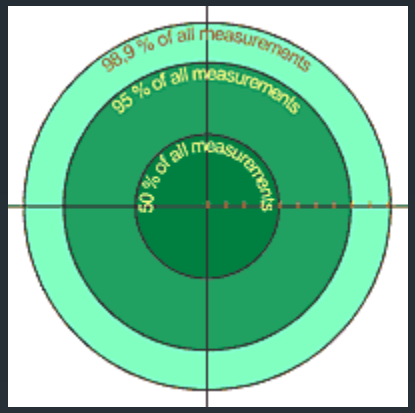


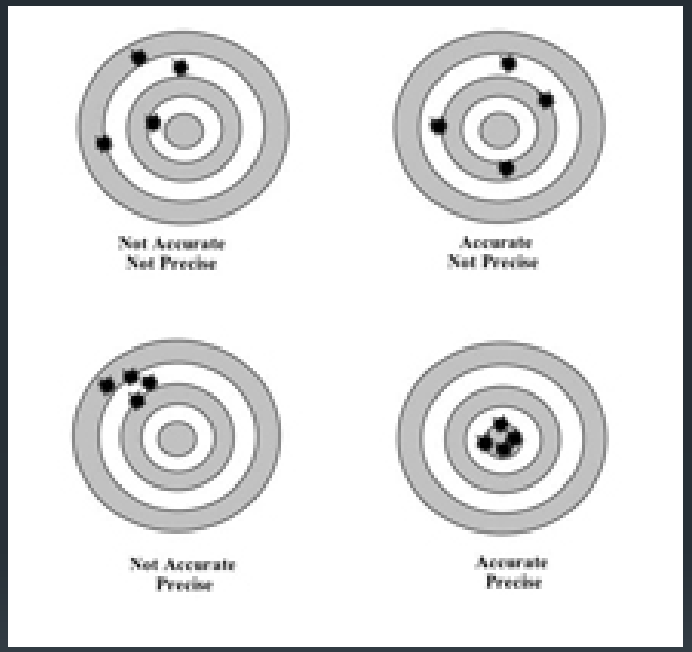
LOCALIZATION



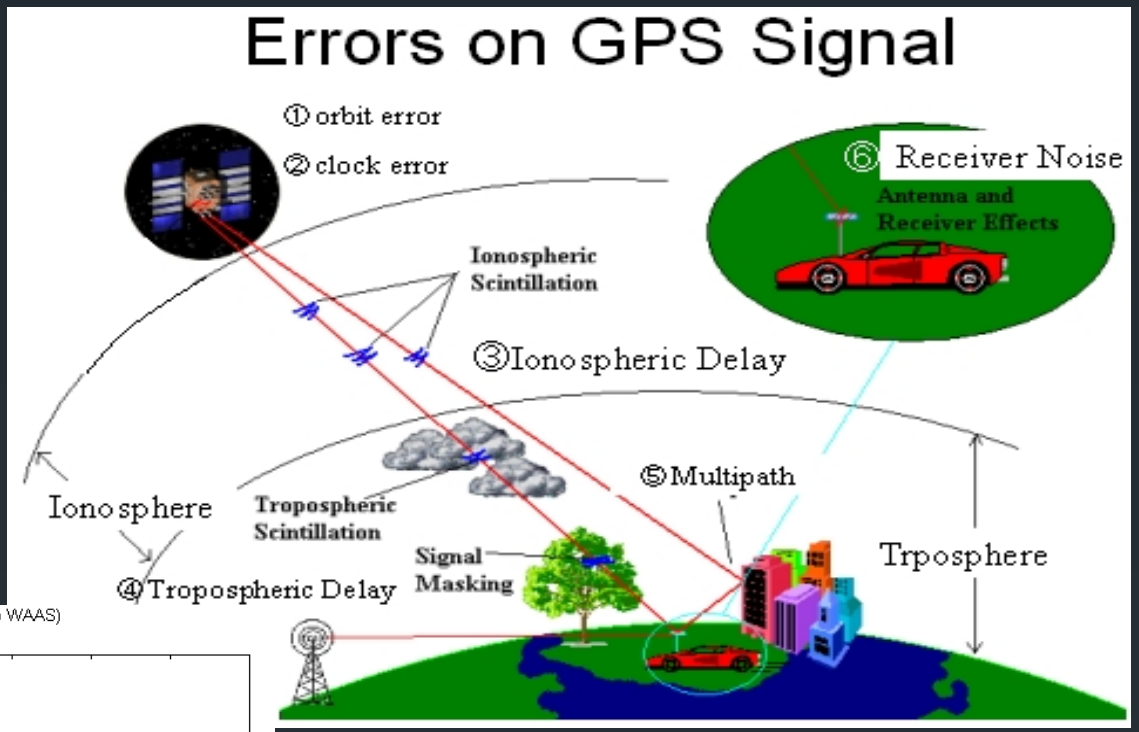


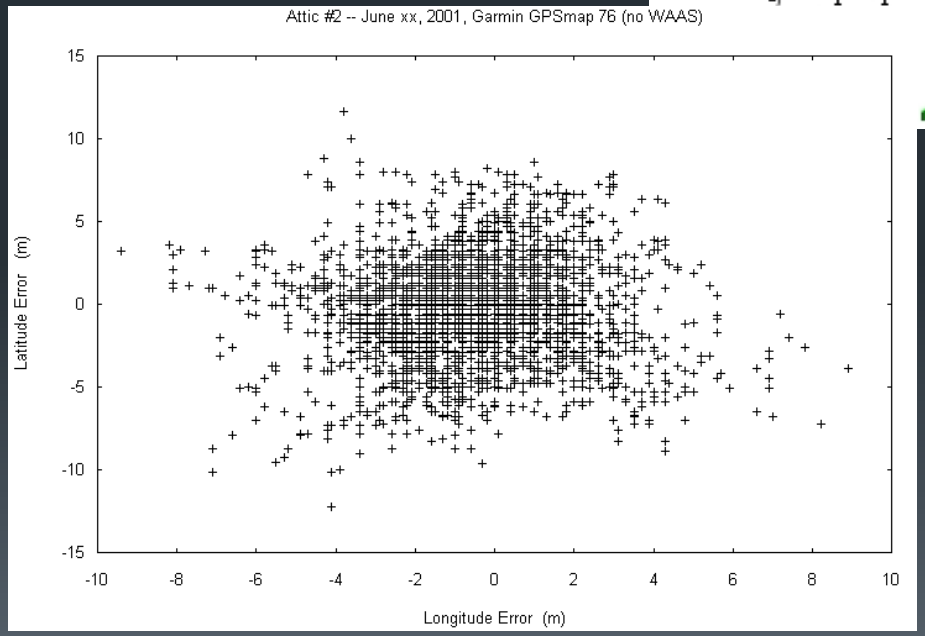
Accuracy / Precision





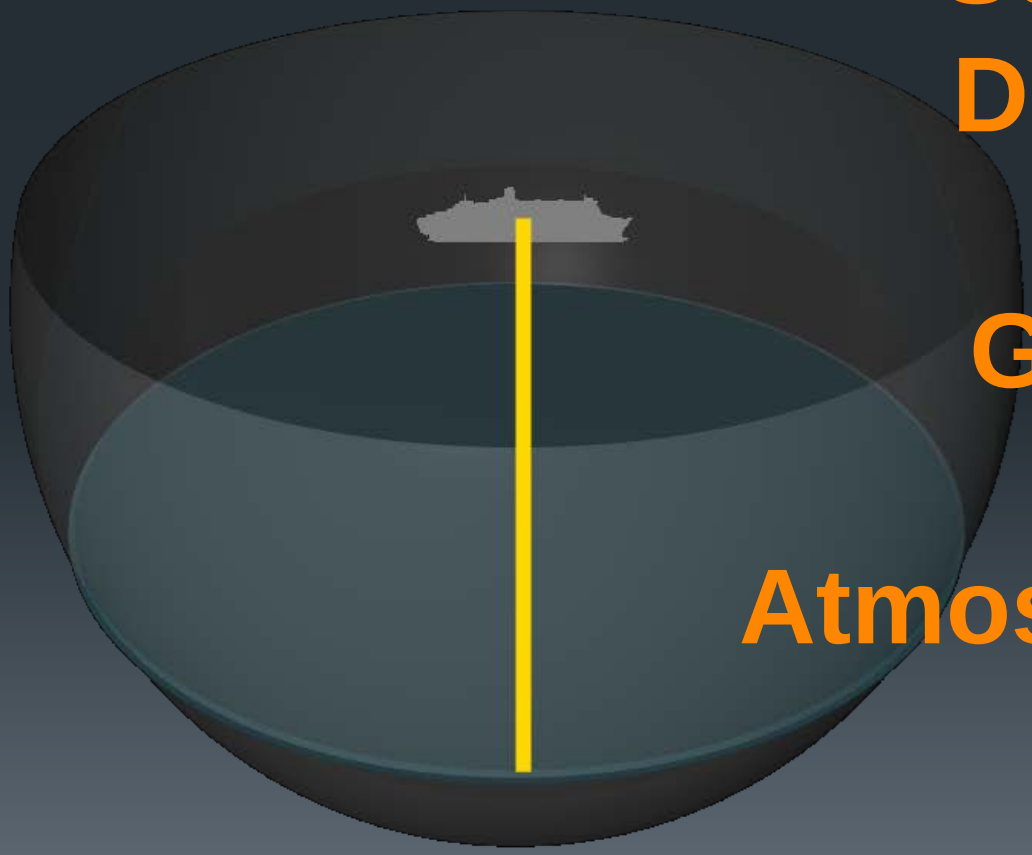
Minimize Errors (Bias/Noise)
Make use of all available information
Optimize operations





$2,500,000,000 / ~20 years
Atomic Clocks, Corrected for relativity
Still has augmented improvements (WAAS)

Depth Errors



Sensor Bias/Noise
Density Variations
Temperature
Gravity Variations
Tides
Atmospheric Pressure
Bernoulli effects

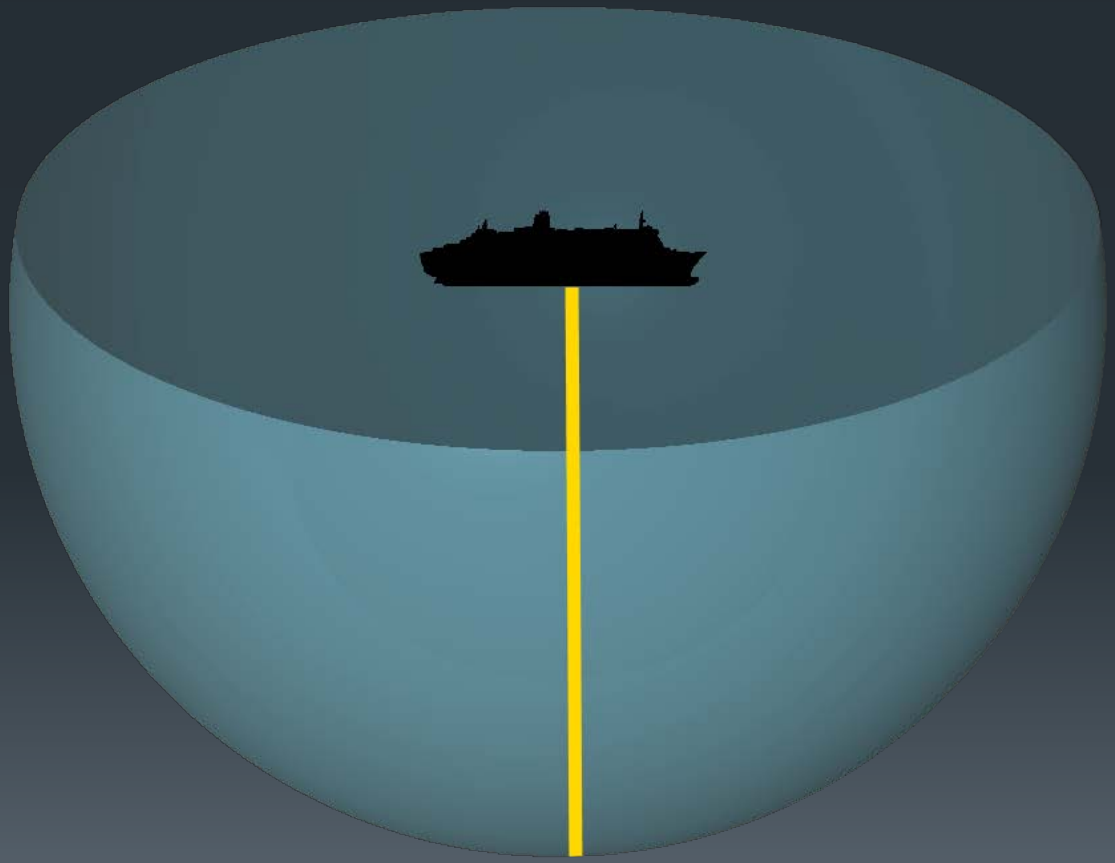
Where am I??????????

Errors everywhere
Errors are cumulative
Navigation models are simplistic
Time/Money/Effort constraints are real
Landmarks are scarce underwater

Relax !

Good enough +/- X
Usually can get better than you need
Scalable in cost and effort
Multiple solutions

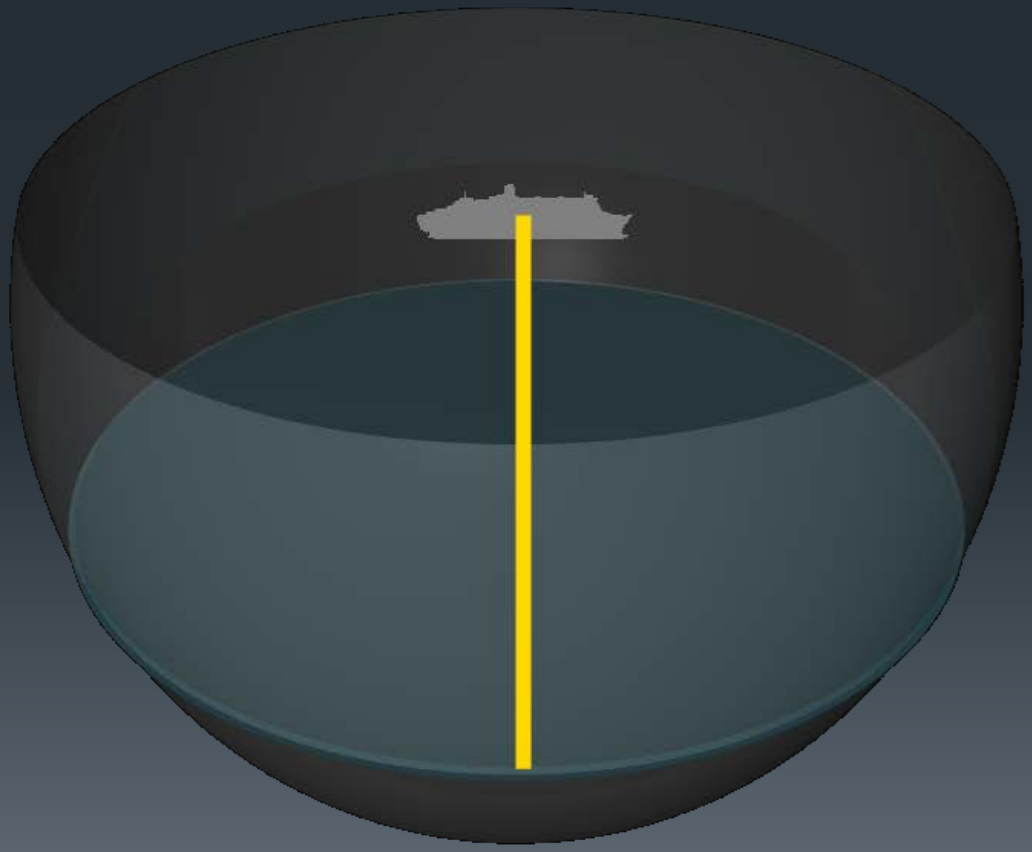
No Sensors



?

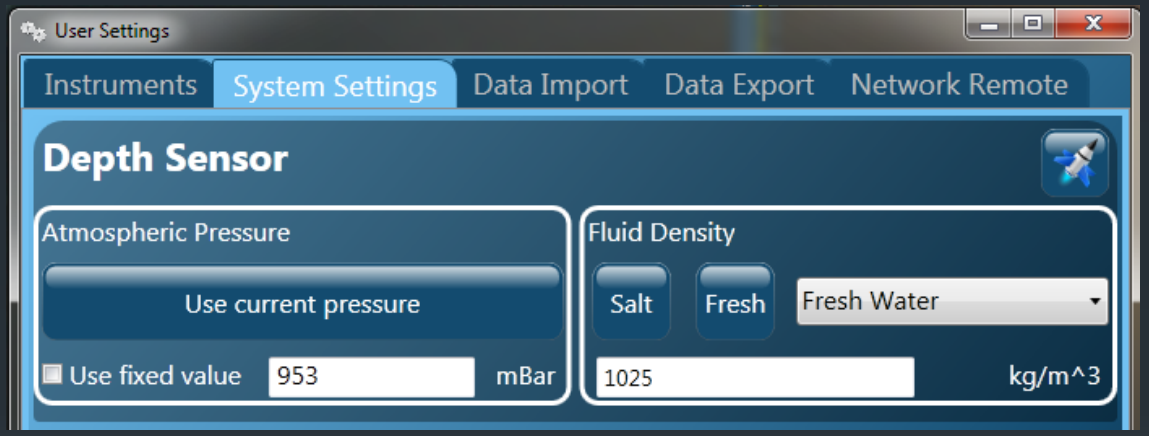
Depth

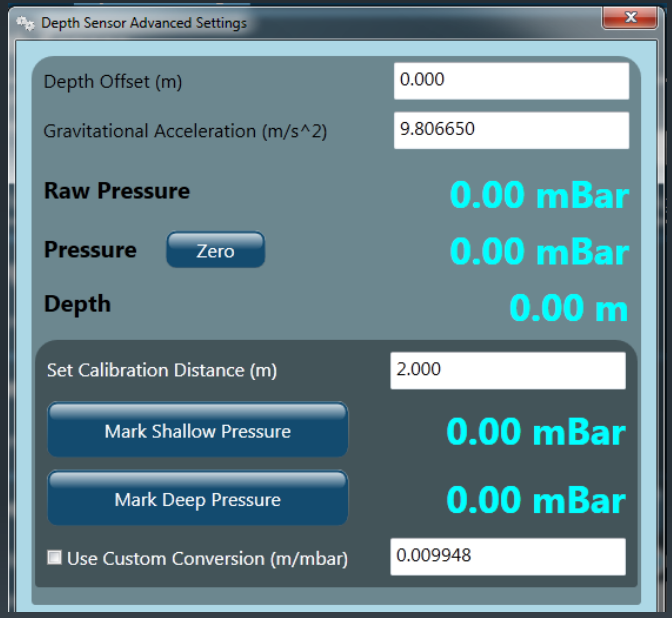
Pressure measurement
gives distance from surface



Typically 1% -> 0.01%

Depth


User Settings
Instruments
System Settings
Data Import
Data Export
Network Remote
Depth Sensor
Atmospheric Pressure
Use current pressure
Use fixed value
953
mBar
Fluid Density
Salt
Fresh
Fresh Water
1025
kg/m^3

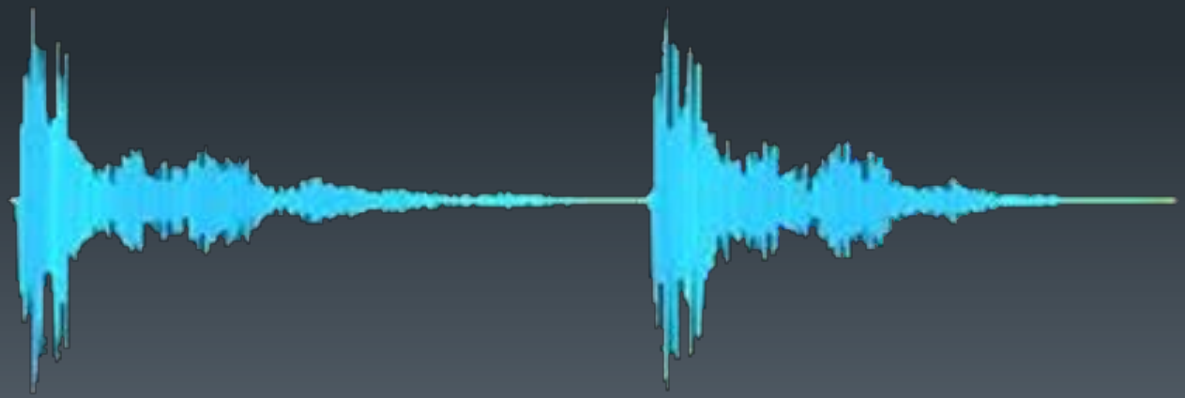

Depth Sensor Advanced Settings
Depth Offset (m)
0.000
Gravitational Acceleration (m/s^2)
9.806650
Raw Pressure
0.00 mBar
Pressure
Zero
0.00 mBar
Depth
0.00 m
Set Calibration Distance (m)
2.000
Mark Shallow Pressure
0.00 mBar
Mark Deep Pressure
0.00 mBar
Use Custom Conversion (m/mbar)
0.009948

~ 0.5 - 2

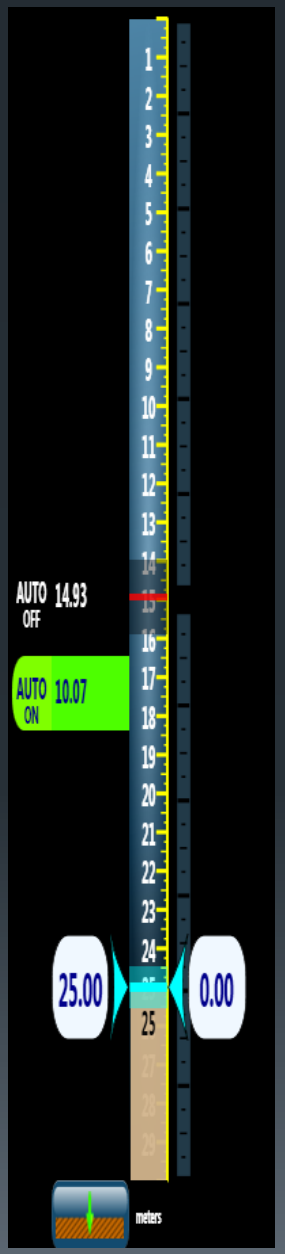
Altimeter / Echo Sounder

- Simplest acoustic measurement device
- Distance off seafloor OR other surface

~1mm resolution



Pseudo-Altimeter



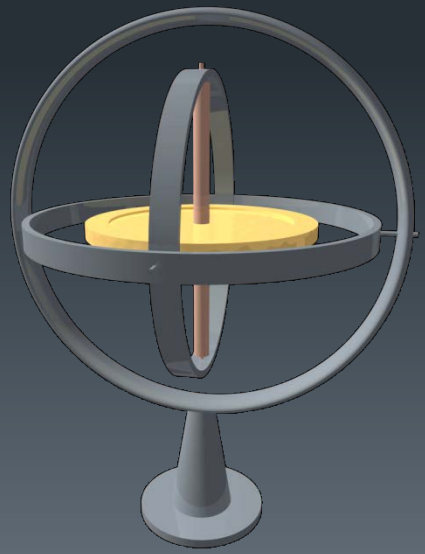
On Board

Compass

(heading, attitude reference, INS)

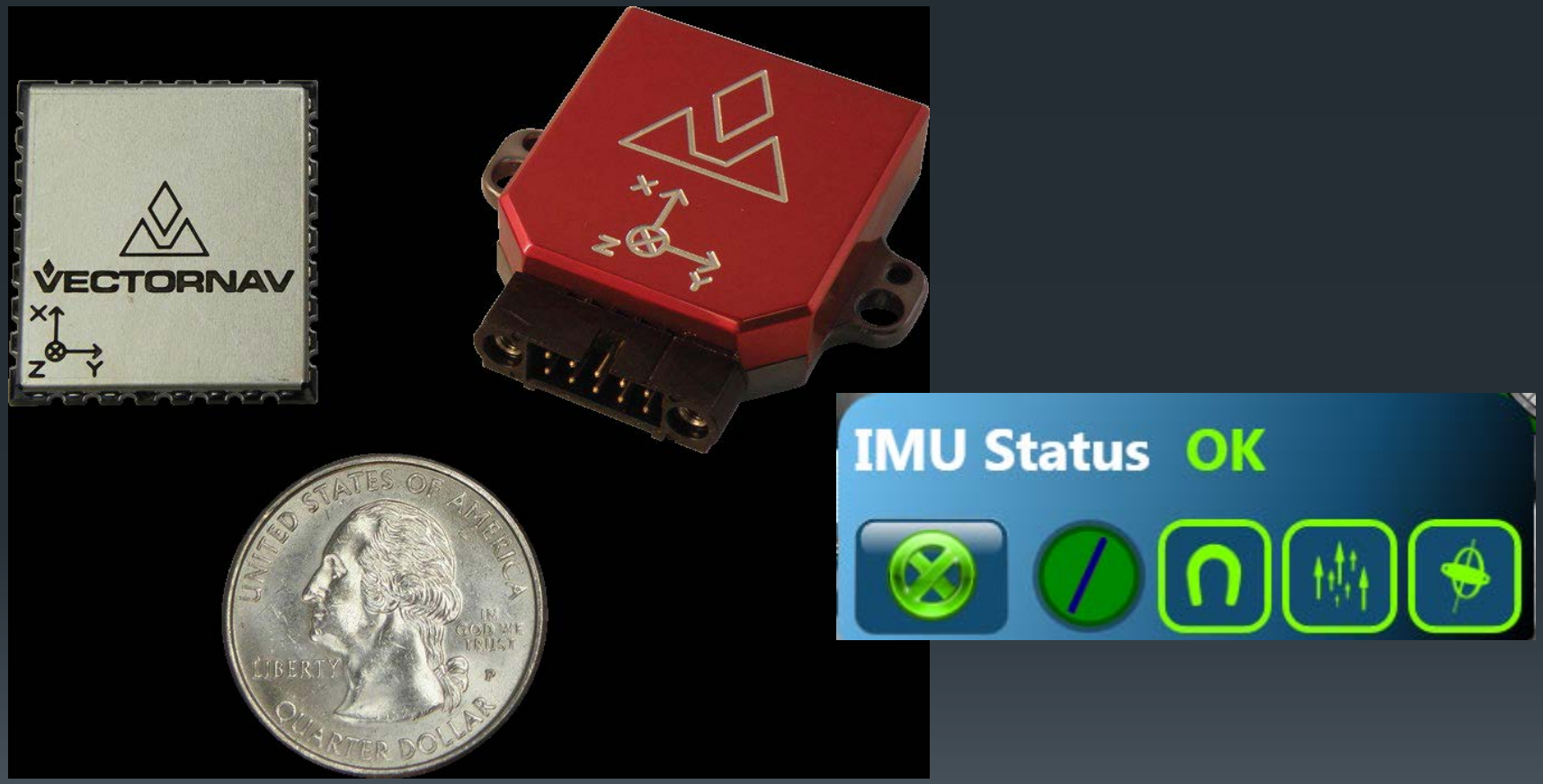
- Gives sensor “look direction”
- Required for DR, INS, DVL
- Magnetic variation and anomalies can be large

~ 2° -> 0.2 °



VN-100

(heading, attitude reference, INS)



VN-100

(heading, attitude reference, INS)

Attitude & Heading

Range: Heading, Roll: ±180 °
Range: Pitch: ±90 °
Static Accuracy (heading): < 2.0 °
Static Accuracy (pitch/roll): < 0.5 °
Angular Resolution: < 0.05 °
Repeatability: < 0.2 °
Maximum Output Rate: 200 Hz
Output Modes (Combinations of):
- Euler Angles (Yaw, Pitch, Roll)
- Quaternion
- Rotation Matrix
- Acceleration, Angular Rate, Magnetic Field and Pressure

Filtering:
- Extended Kalman Filter (EKF)
- Adjustable tuning parameters for improved immunity to magnetic and dynamic disturbances
- Active Disturbance Rejection
- Automatic or User Selectable Tuning
- Adaptive Signal Processing

IMU - Angular Rate

Range - Standard: ±500 °/s
Range - Extended*: ±2000 °/s
Linearity: < 0.1 % FS
Noise Density: 0.005 °/s /√Hz
Bandwidth: 256 Hz
Alignment Error: ±0.05 °

IMU - Acceleration

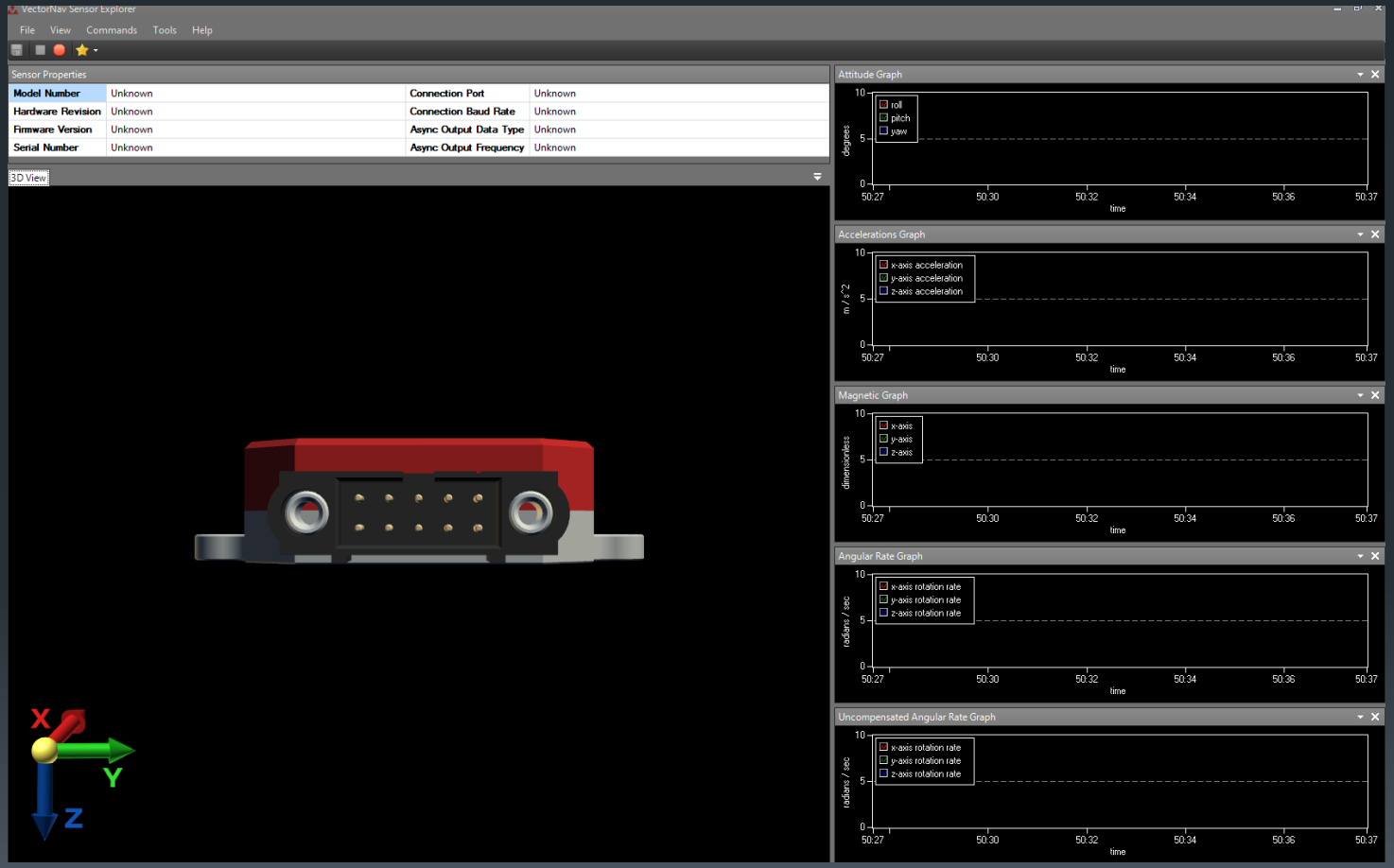
Range - Standard: ±8 g
Range - Extended*: ±16 g
Linearity: < 0.5 % FS
Noise Density: 0.4 mg/√Hz
Bandwidth: 260 Hz
Alignment Error: ±0.05 °

IMU - Magnetic

Range - Standard: ±2.5 Gauss
Range - Extended*: ±8 Gauss
Linearity: < 0.1 % FS
Noise Density: 140 µGauss/√Hz
Bandwidth: 200 Hz
Alignment Error: ±0.05 °

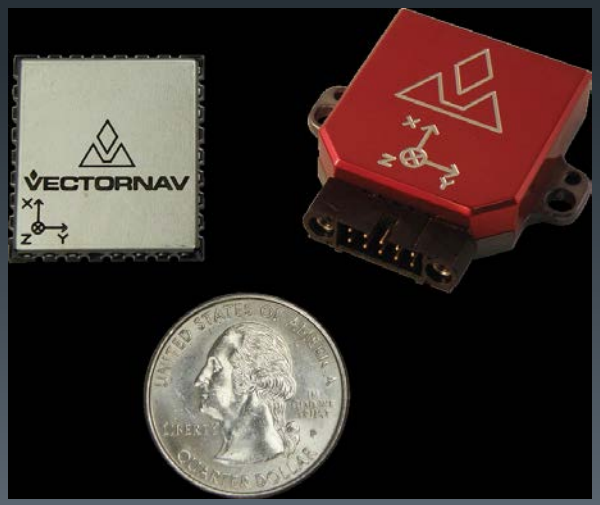
VN-100

(heading, attitude reference, INS)



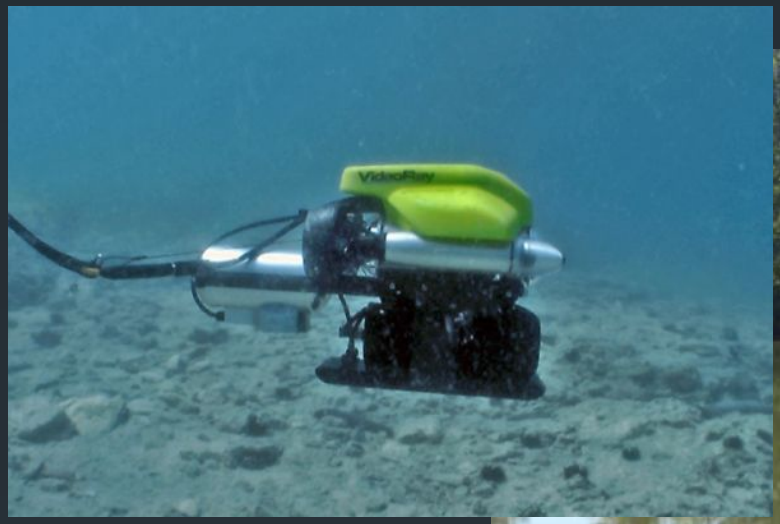
New CPU board

Flexible Daughter-board Interface



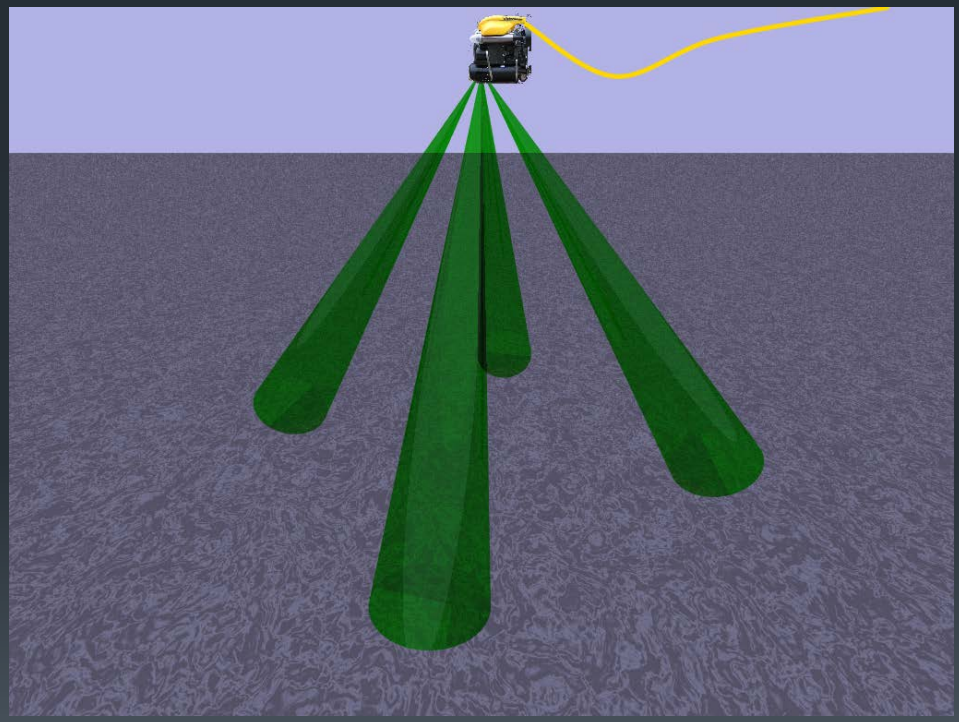
ROV GPS

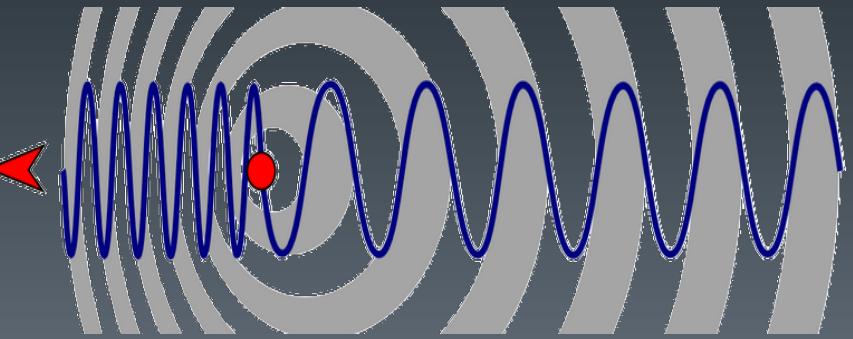
Doppler Velocity Log



Doppler Velocity Log

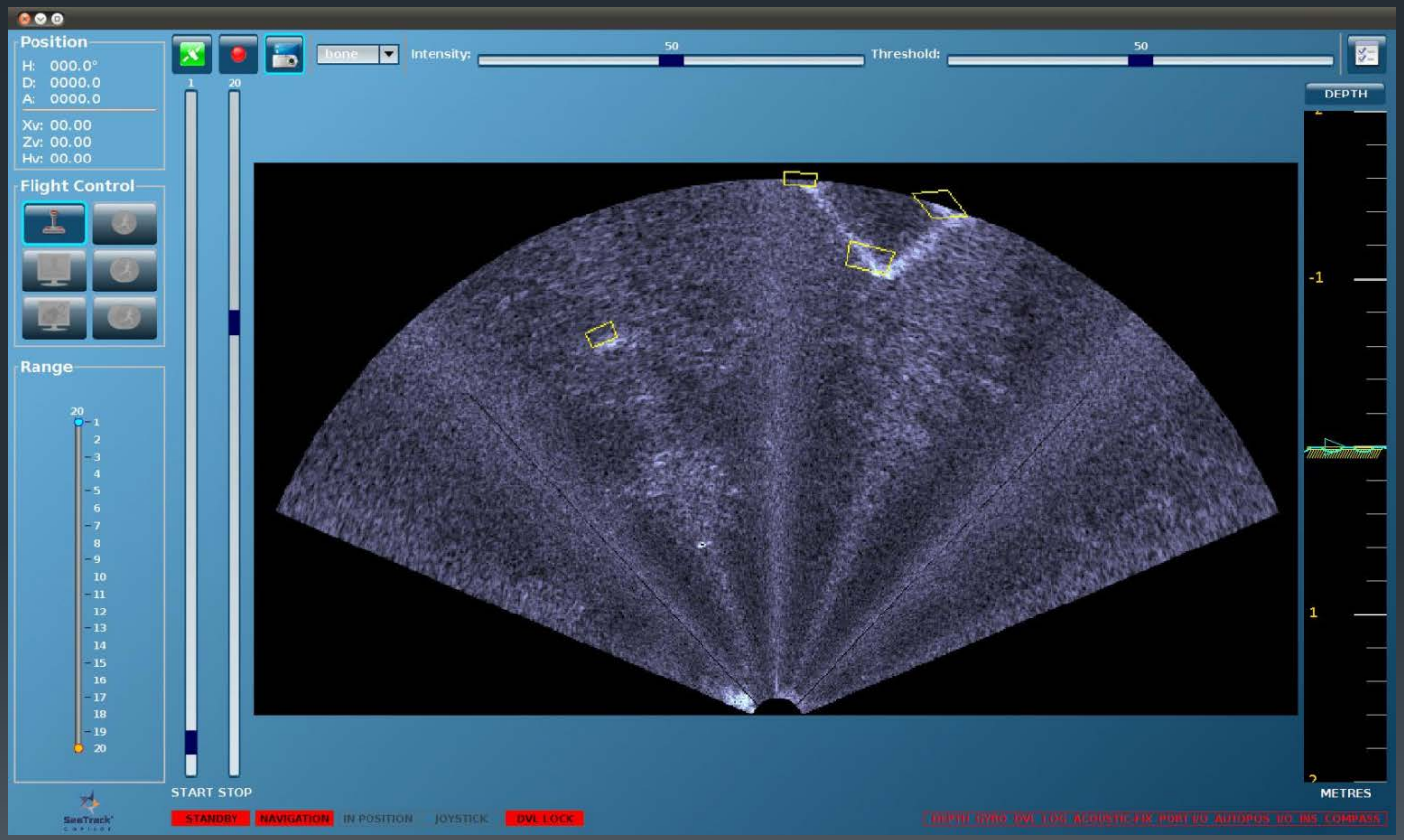
~0.5-1% and 2 mm/s



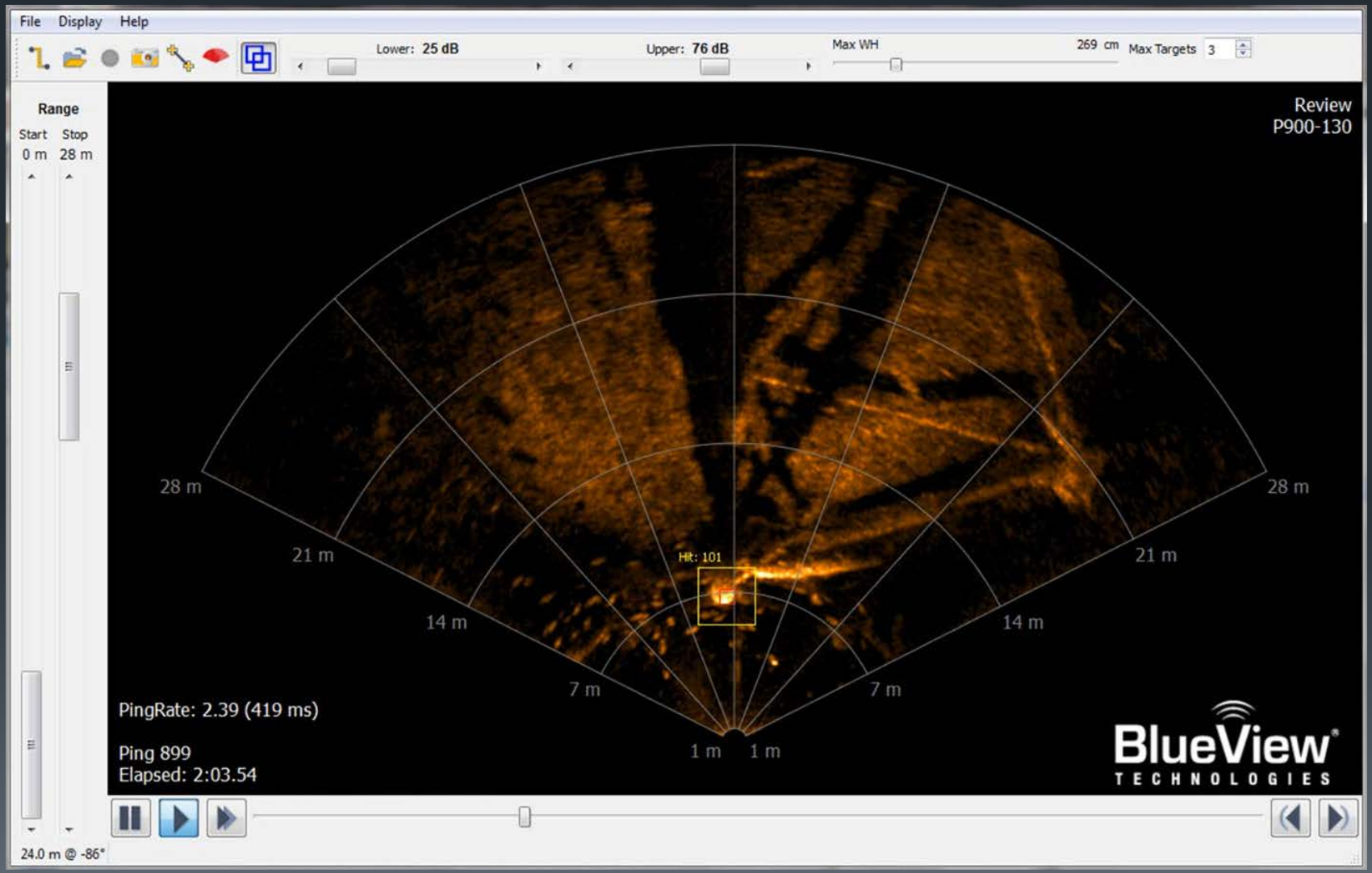


Survey CoPilot by SeeByte

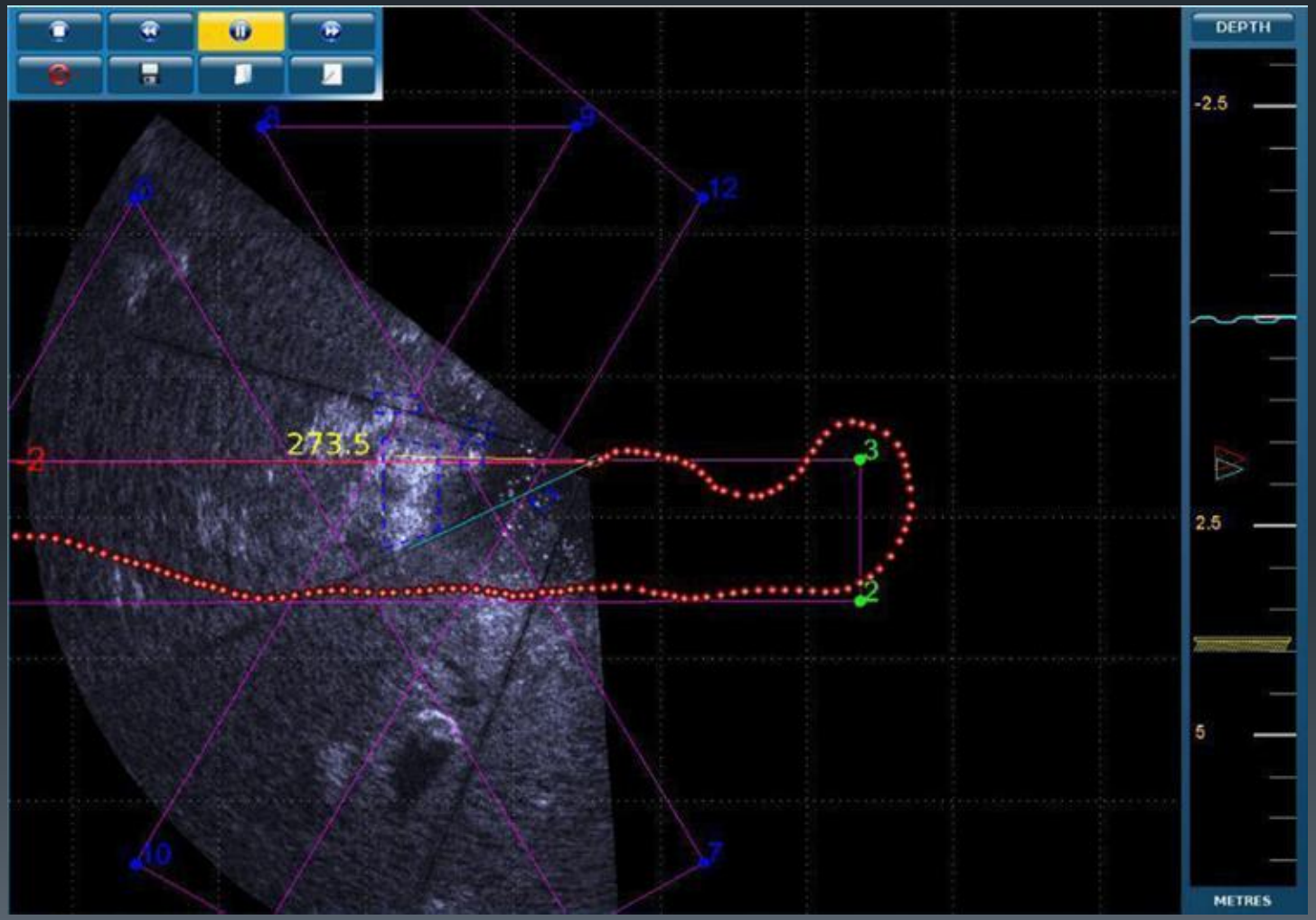
SONAR CoPilot by SeeByte



BlueView ProViewer Plus



RI CoPilot by SeeByte

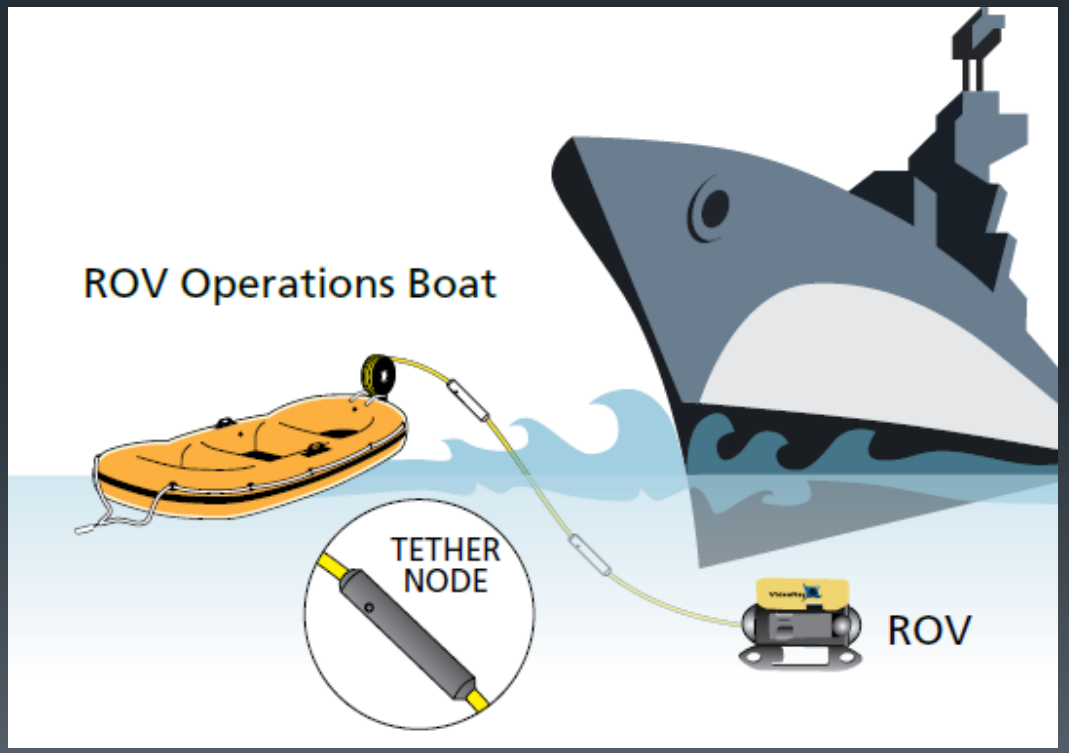


~ 0

KCF SmartTether

Orientation + Depth + Tether Model = **Position**

- Quick to deploy
- Fast update rate
- Errors are bounded



Smart Tether

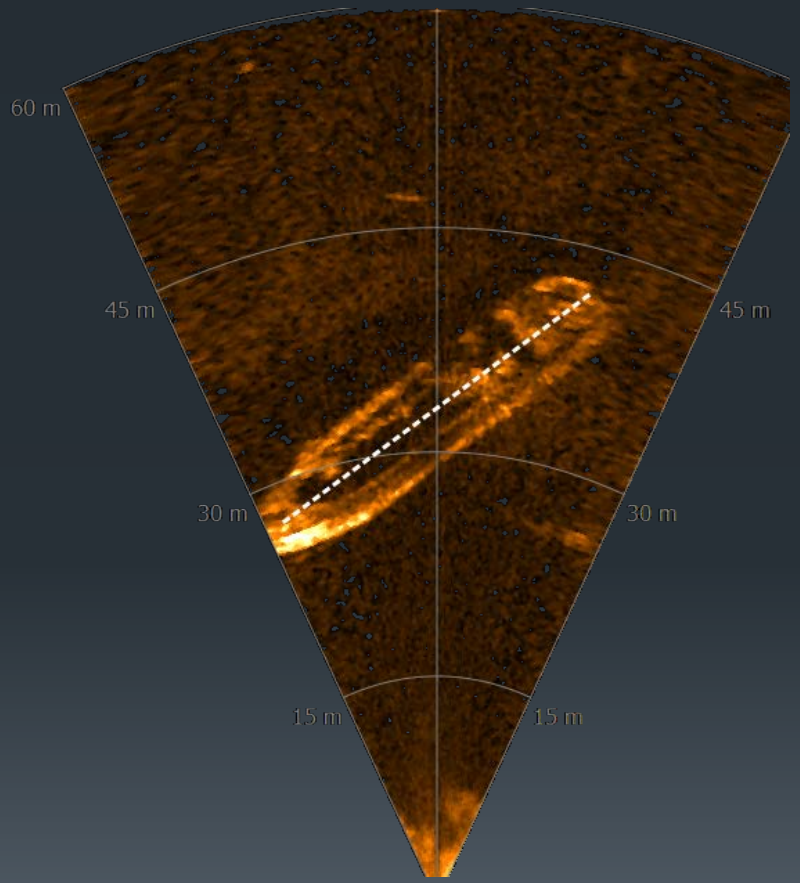
~ 0.5 - 2

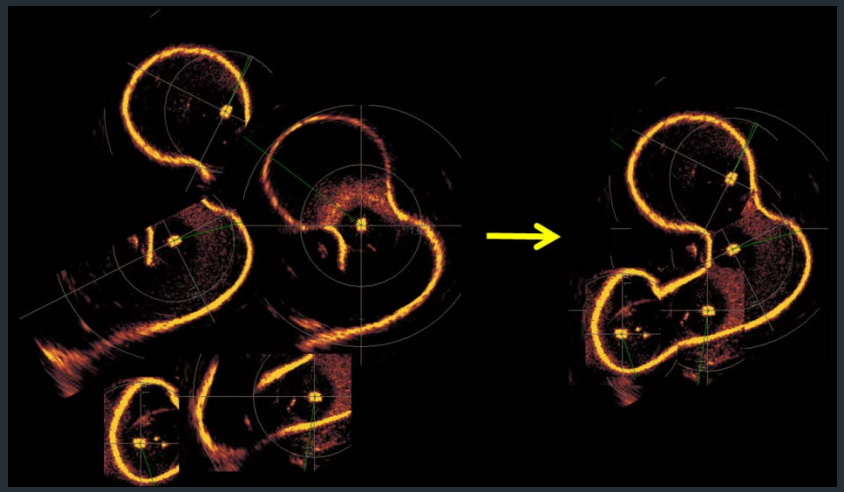
Transponder

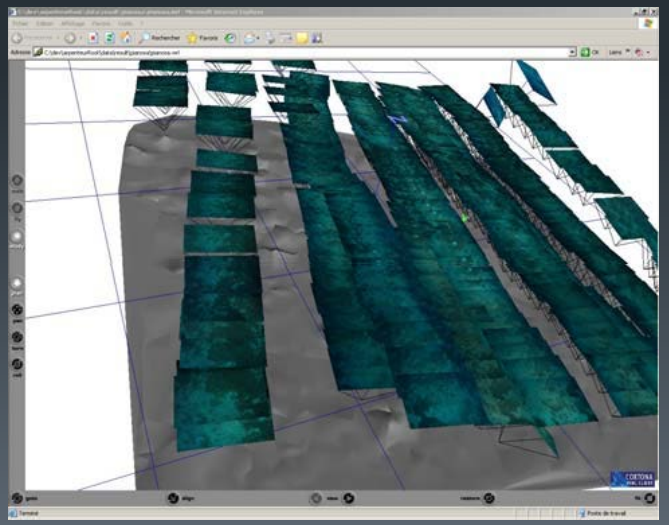
- USBL, LBL, etc.
- Does not drift
- Setup can be complex
- Range limited by sound propagation
- Can allow measurement of actual error

<1 m to a few cm

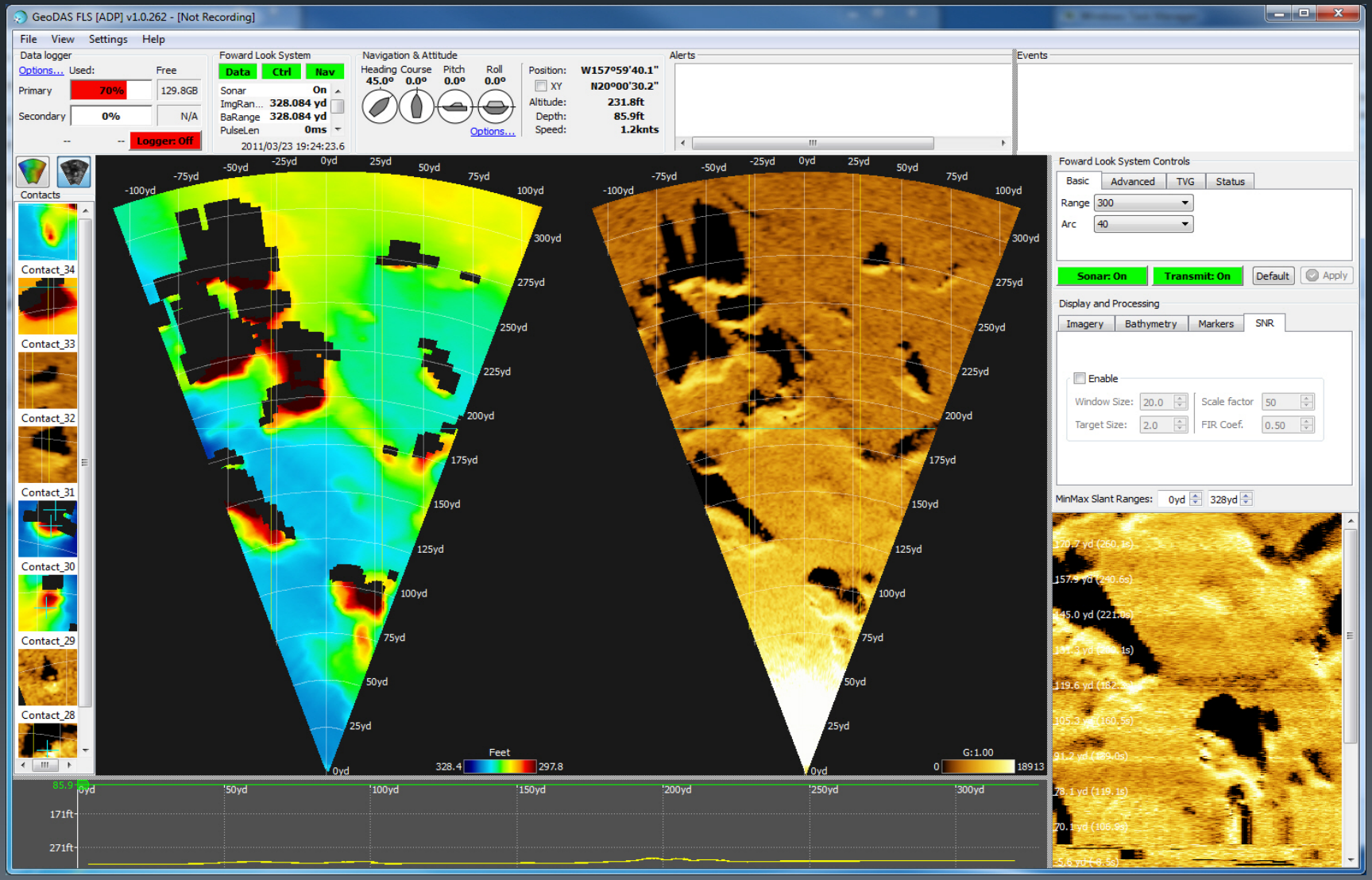
Data Mensuration



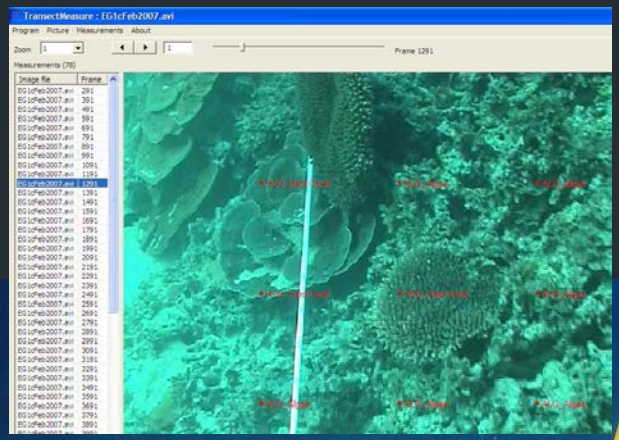


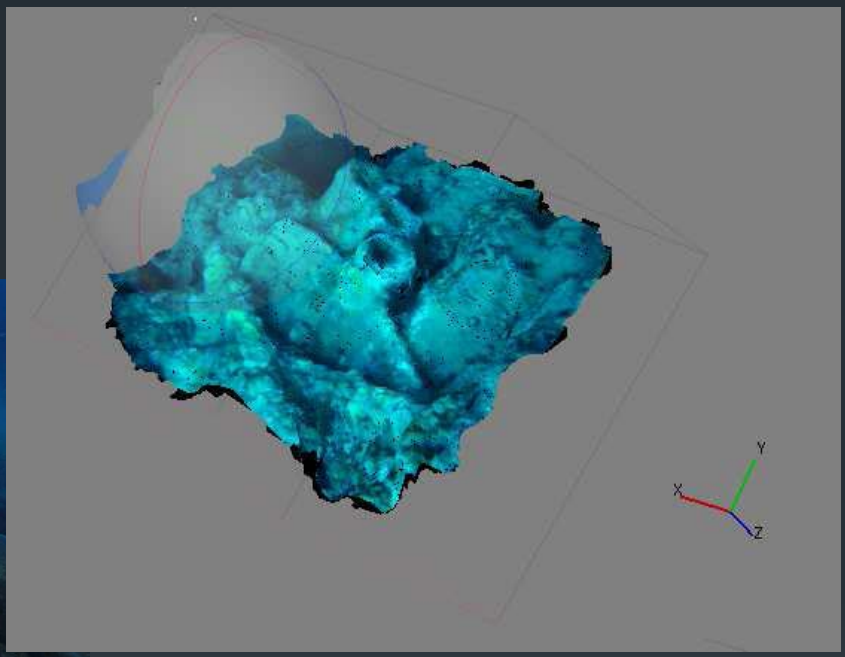


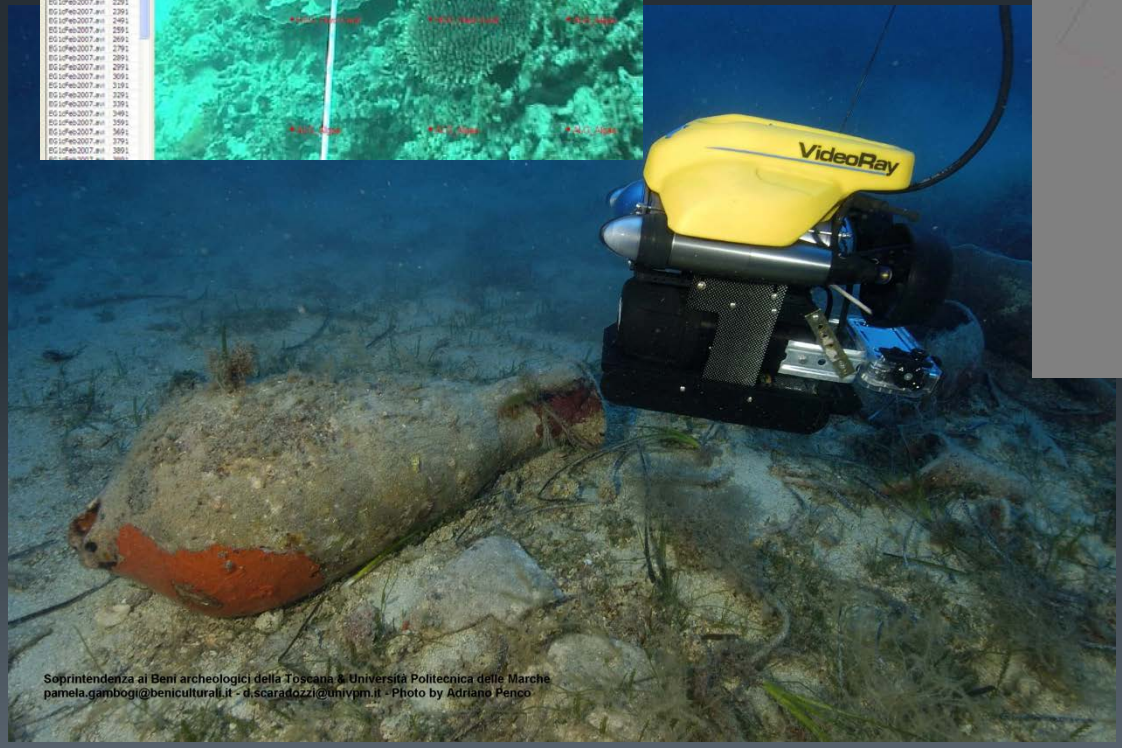
Forward Look Sonar Mosaics



Optical Imagery







The Best Navigation Tool

Japanese Tourists Follow GPS Directions, Wind Up in Bay

Woman Follows GPS, Drives Straight Into Swamp

Woman Sues Google Maps After Getting Hit By a Car (walked into traffic)

New Jersey Driver Follows GPS, Causes Four-Car Pileup

UK Woman Follows GPS, Drives Mercedes Into River

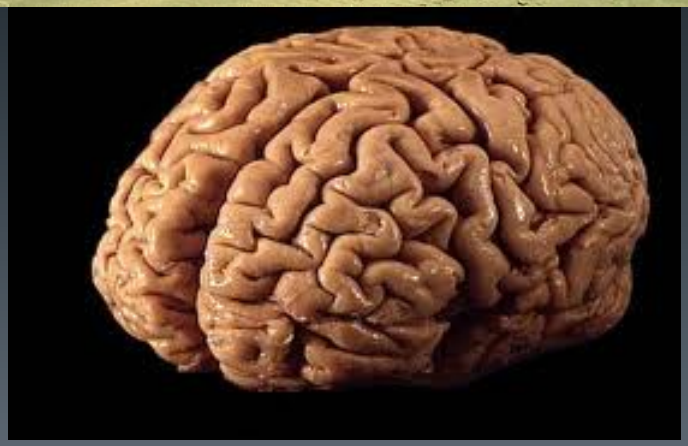
Bus Driver Follows GPS, Gets Wedged Under Bridge

Trucker Follows GPS Directions, Winds Up in Tree

UK Motorists Follow GPS, Get Stuck on Narrow Roads

German Driver Obeys GPS, Drives Into Sand Pile

The Best Navigation Tool



Questions?????