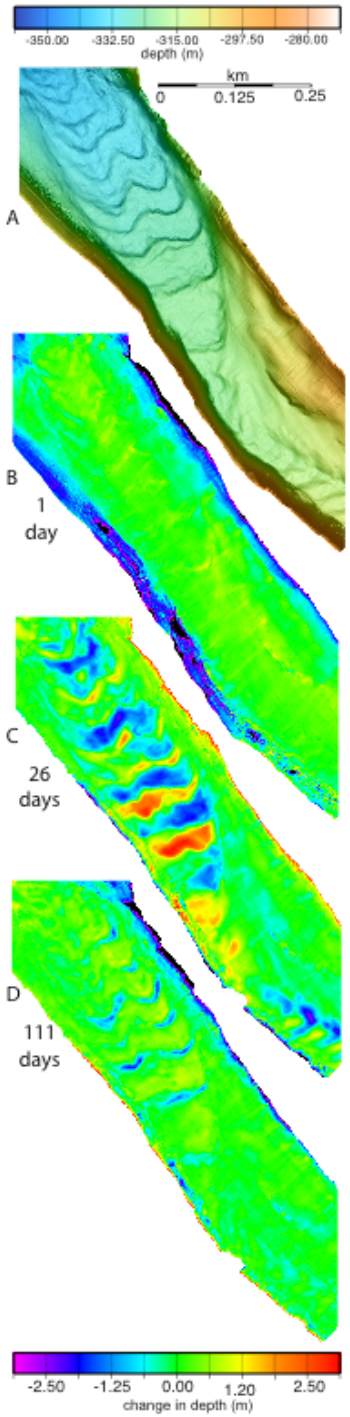
BEDS Concept Design Review

December 16, 2010

Agenda

- Statement of Science Problem and Goals
- Draft Functional Requirements
- Previous and relevant work
- Description of design concept being considered
- System block diagram
- High risk elements
- Power/Data budgets
- Future test and design plans
- Required resources

https://mww.mbari.org/pco/Project_Management/project_design_review_guidelines.pdf



Science Motivation

Monument experiments and Multi-beam data have shown that the Monterey Bay Canyon is very active.

The timing and mechanism of these sediment transport events is not well understood.

The ability to capture data during a sediment transport event would aid in understanding the nature of these events, and to test current models of sediment movement.

Debris Field Motion

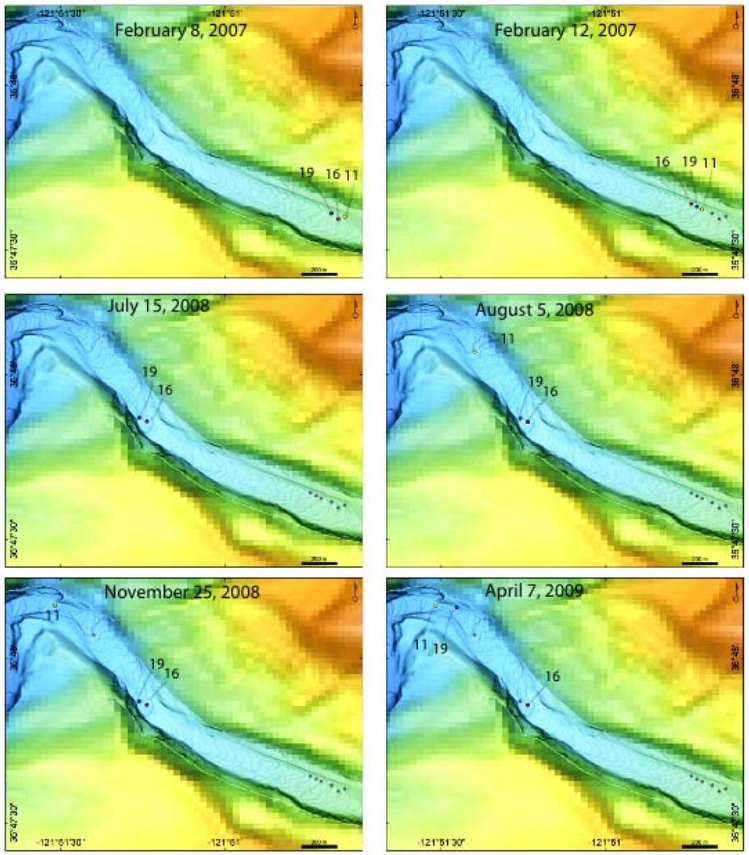
Debris Field

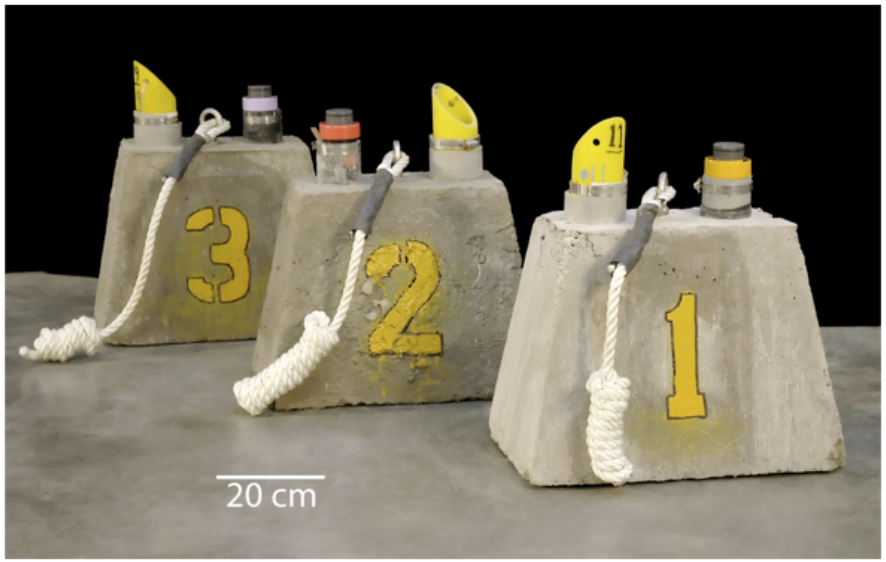
Science Questions

1. **Can we determine duration and frequency of these events?**
2. **Can we characterize the type of sediment motion (a slab flow or erosive/turbulent or composite flow)?**
3. Can we determine the physical scale of the event?
4. Can we determine the depth of no motion?

Previous and Concurrent Work

- Monuments
  - Concrete blocks carried hundreds of meters over a year
  - Provide evidence that events did occur but not motion or timing data



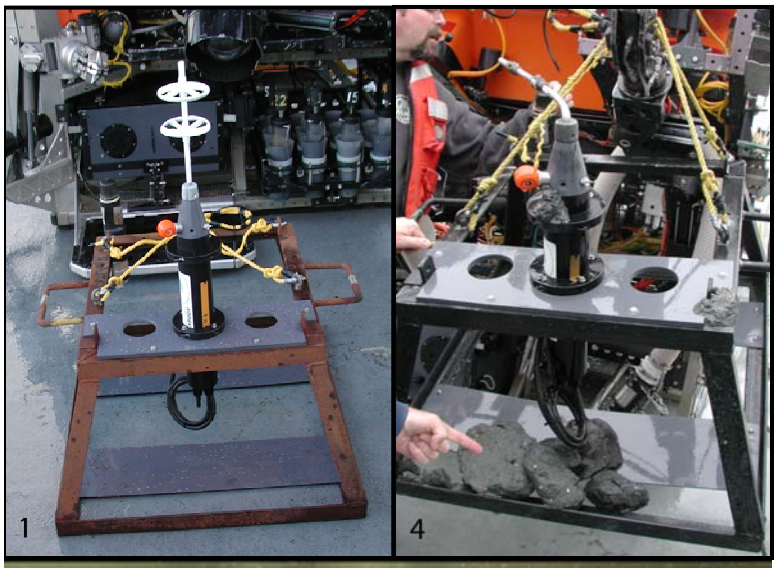


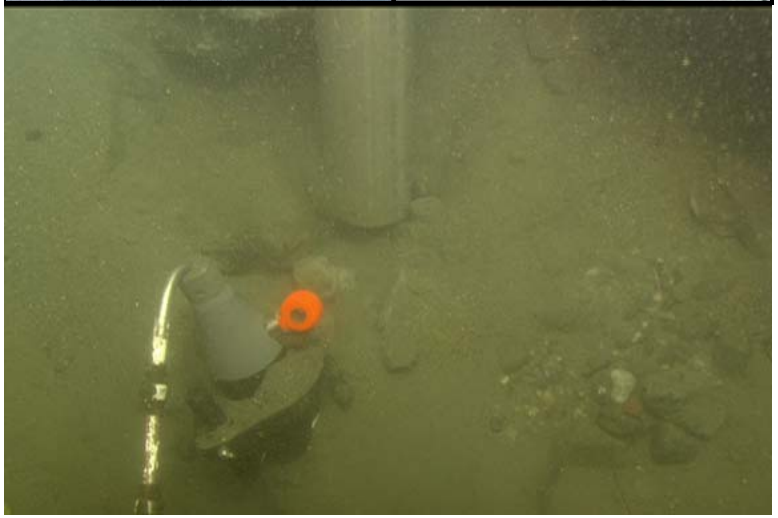
Previous and Concurrent Work

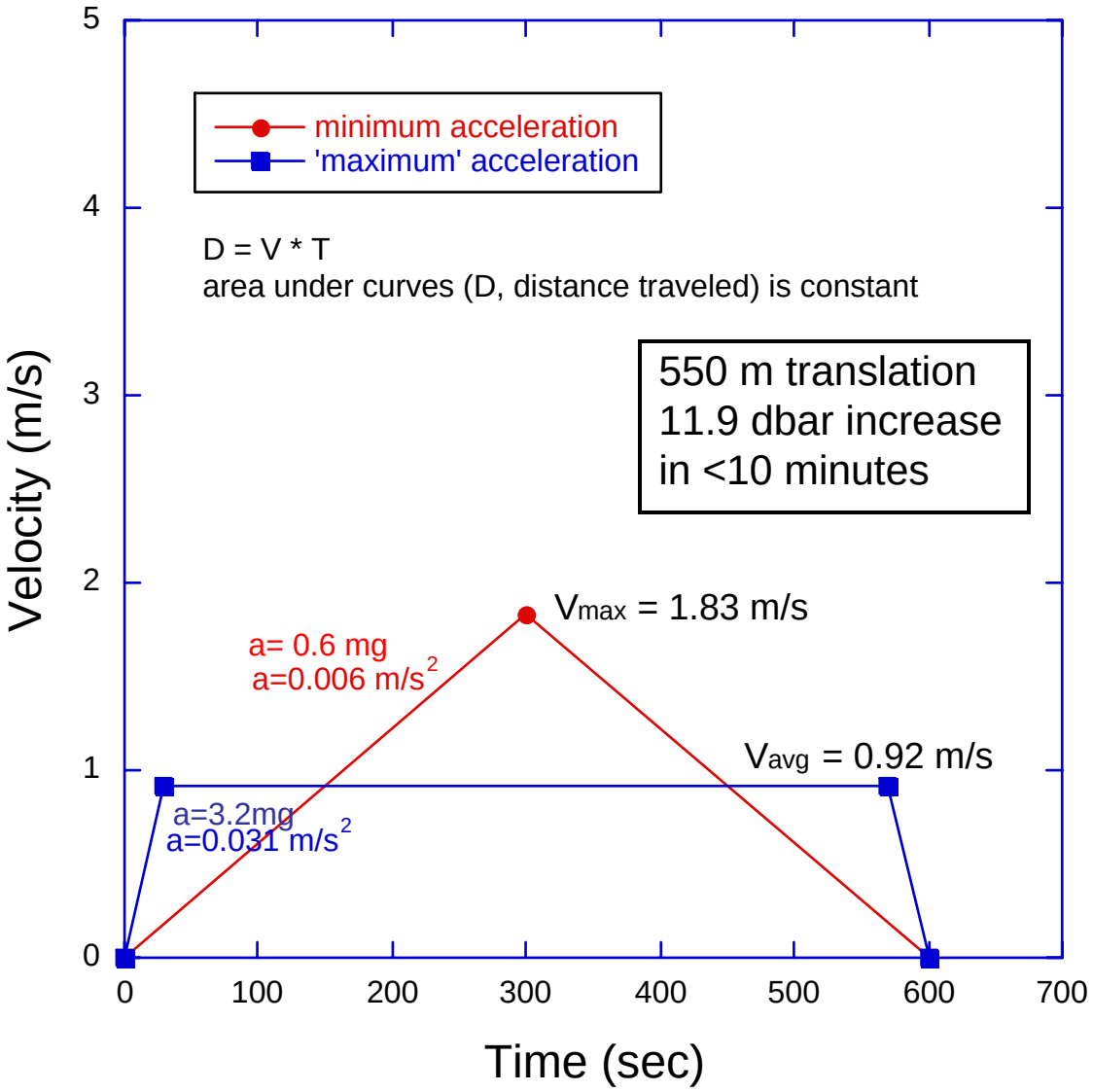
- STEDs
  - Measures water column events
- McStar
  - Records sounds associated with sediment transport events, may provide timing but no motion or scope data
- Multi-Beam
  - Repeat mapping documents change in seafloor texture

Only Transport Event Data

December 21, 2001 Event





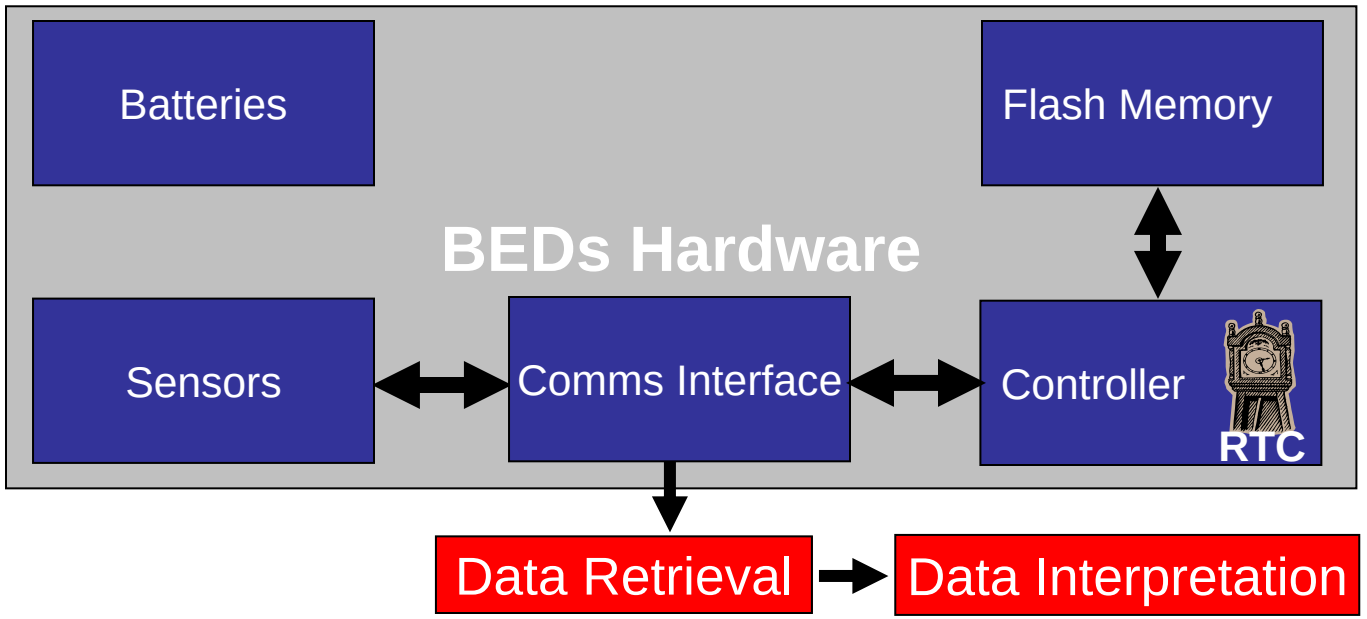


Draft Functional Requirements

BEDs FRS rev 0.2

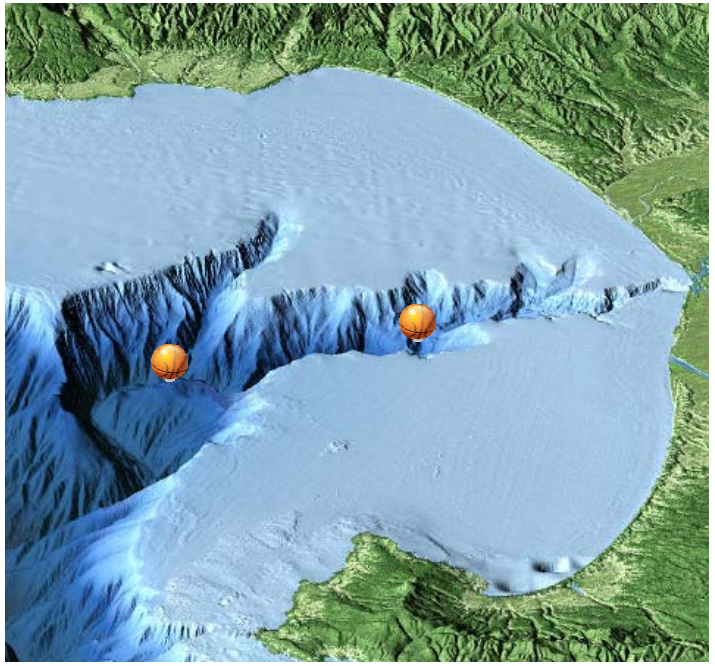
BEDs Concept

- The BED will be a stand-alone instrument package with a computer, sensors capable of resolving motion, and adequate memory to store data



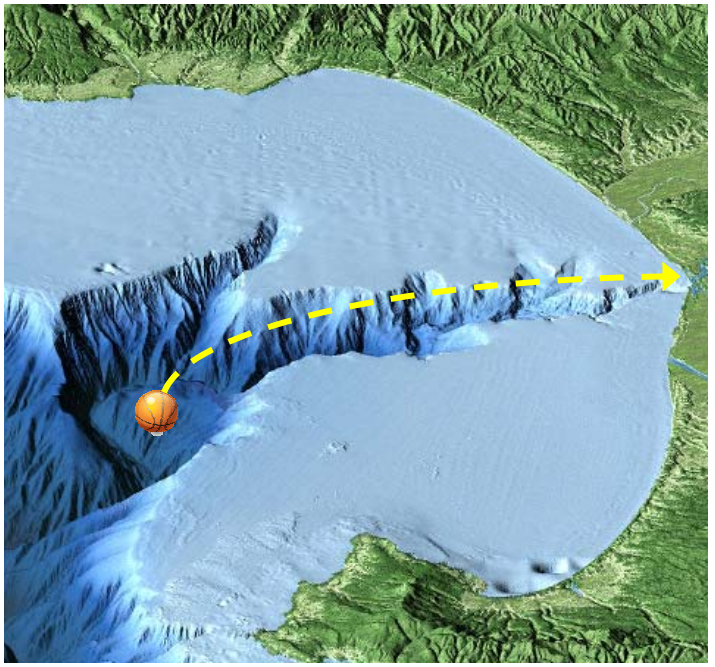
BEDs Concept

- The instrument shall be deployed in canyon, free to be carried down canyon by events



BEDs Concept

- Data stored on the instrument will be retrieved…somehow
- Analyze data and understand more about canyon events



BEDs Concept: High-risk Elements

- Can we retrieve data, possibly from buried instrument

⇩Yes ⇨ No, start over-new concept

- Can we find sensors to resolve the motion we are trying to detect?

⇩Yes ⇨ No, back to drawing board

- Can we detect an event?

⇩Yes ⇨ No, hmmm…

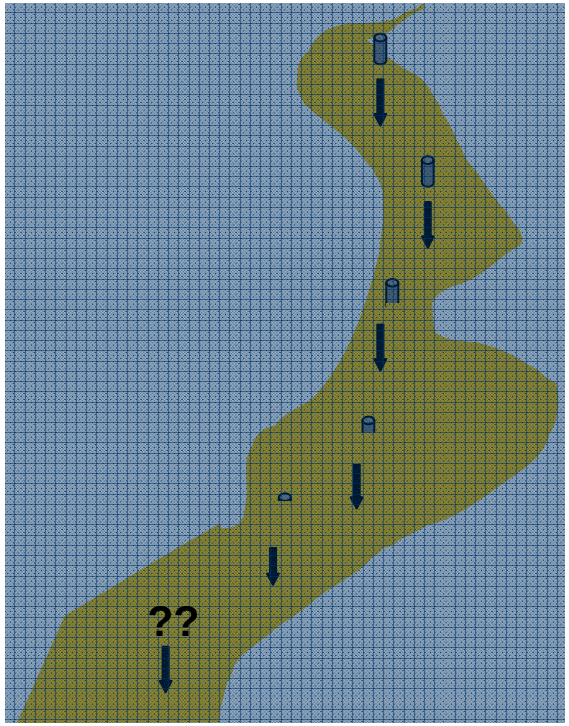
- Can we interpret the data?

⇨ No, @%@#$!%#

BEDs Concept: High-risk Elements

- Can we retrieve data, possibly from buried instrument
- Can we find sensors to resolve the motion we are trying to detect?
- Can we detect an event?
- Can we interpret the data?

High Risk:
Data Recovery



How could we recover the data?

Pop-up buoy

Avalanche cord

Electro-magnetic comms

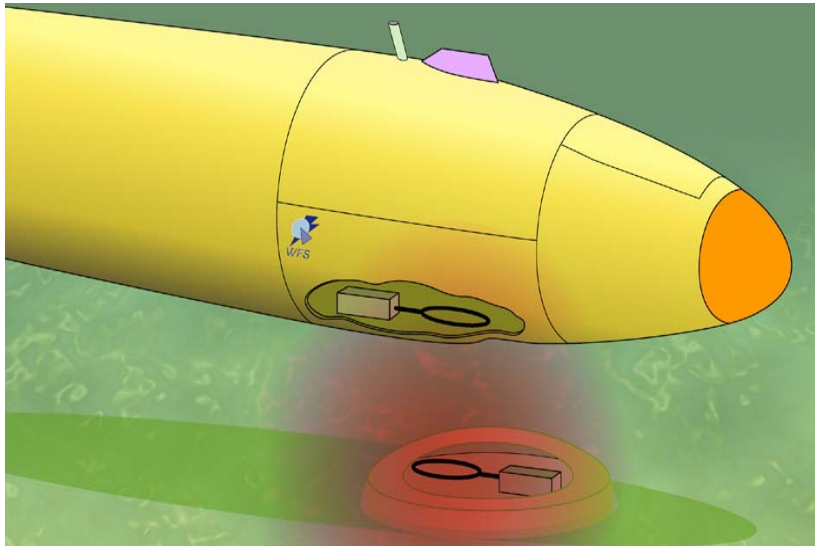
Acoustic

Data Recovery

Technical and Operational Challenges of each:

EM modem pair from WFS Defense tank tested –

- does work through concrete wall and seawater
- packaging issues
- Antennae are directional: would need two orthogonal hoops to be omnidirectional
- Modems must be within 10 m for fast bandwidth
- cost? (standard $25k)
- *Not ruled out as solution*



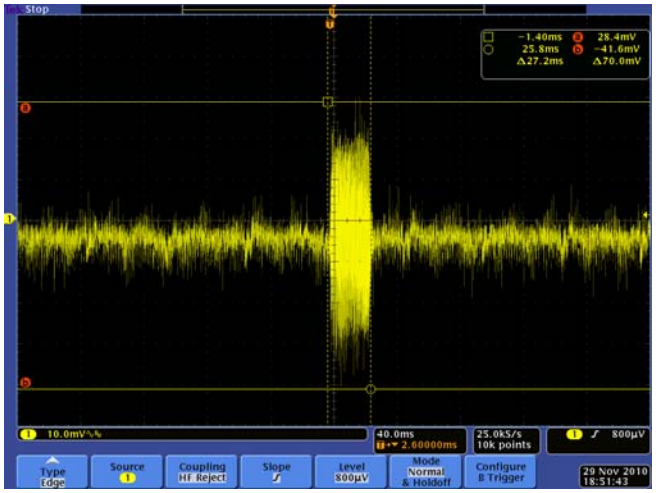
Data Recovery

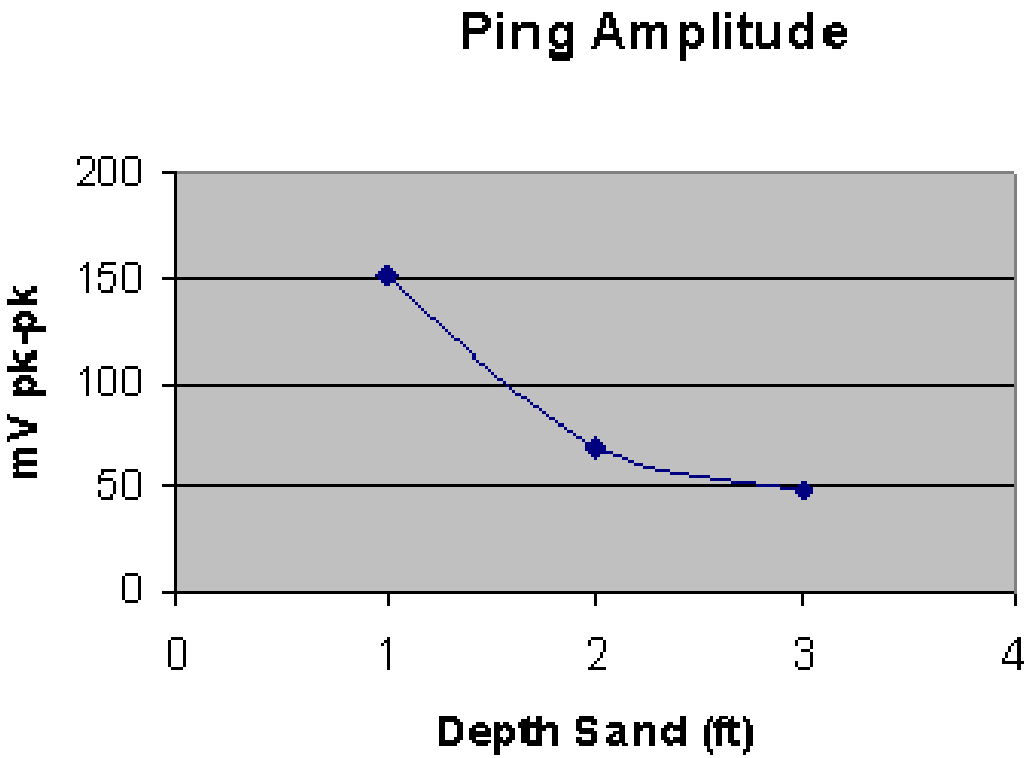
Technical and Operational Challenges of each:

- Acoustic
  - Will we be able to transmit through sediment?
  - Benthos says, “It should work…let us know.”
  - Developed tests for Benthos acoustic modem system

Tank Test Set Up

Tank Ping Test

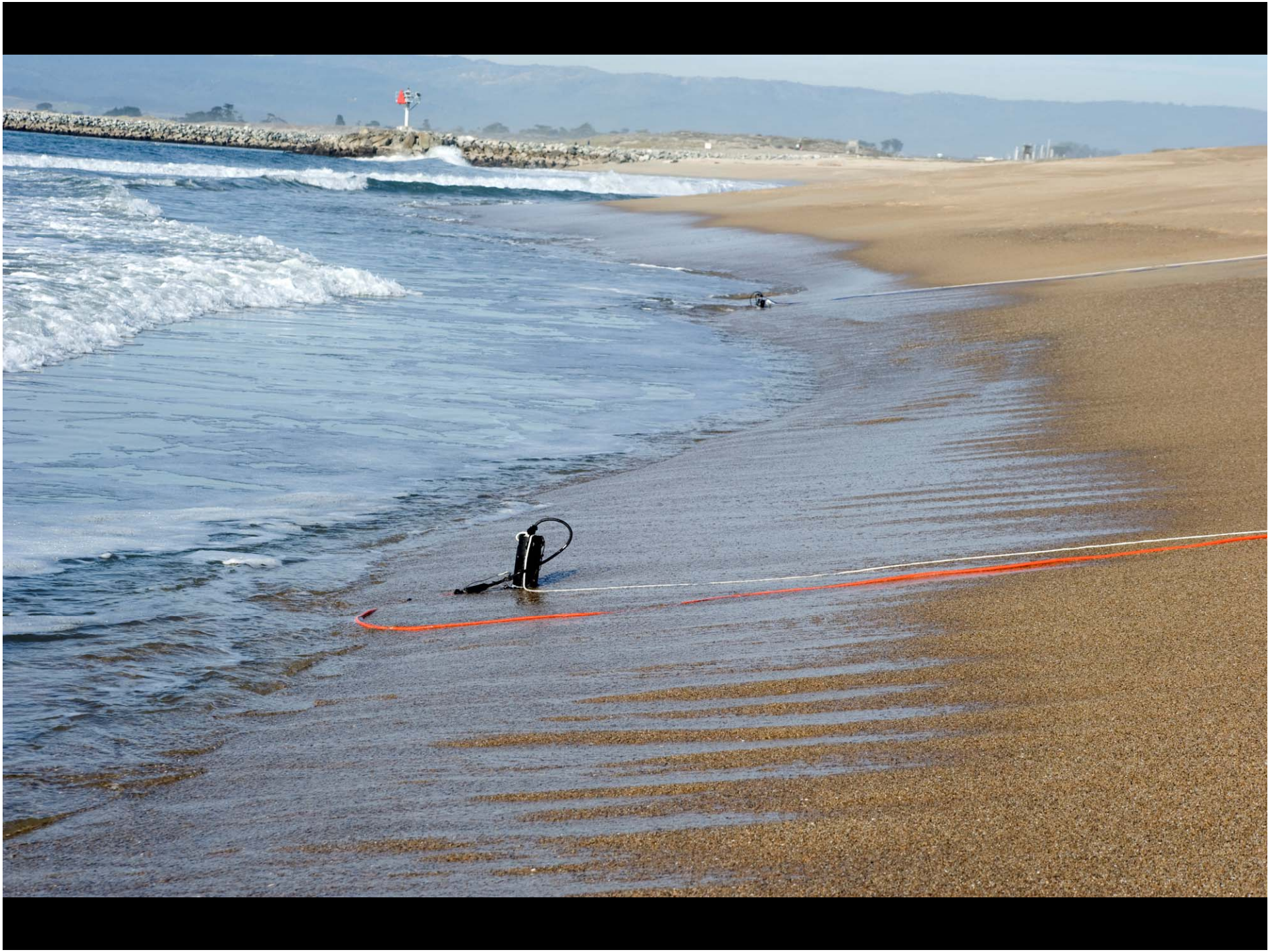




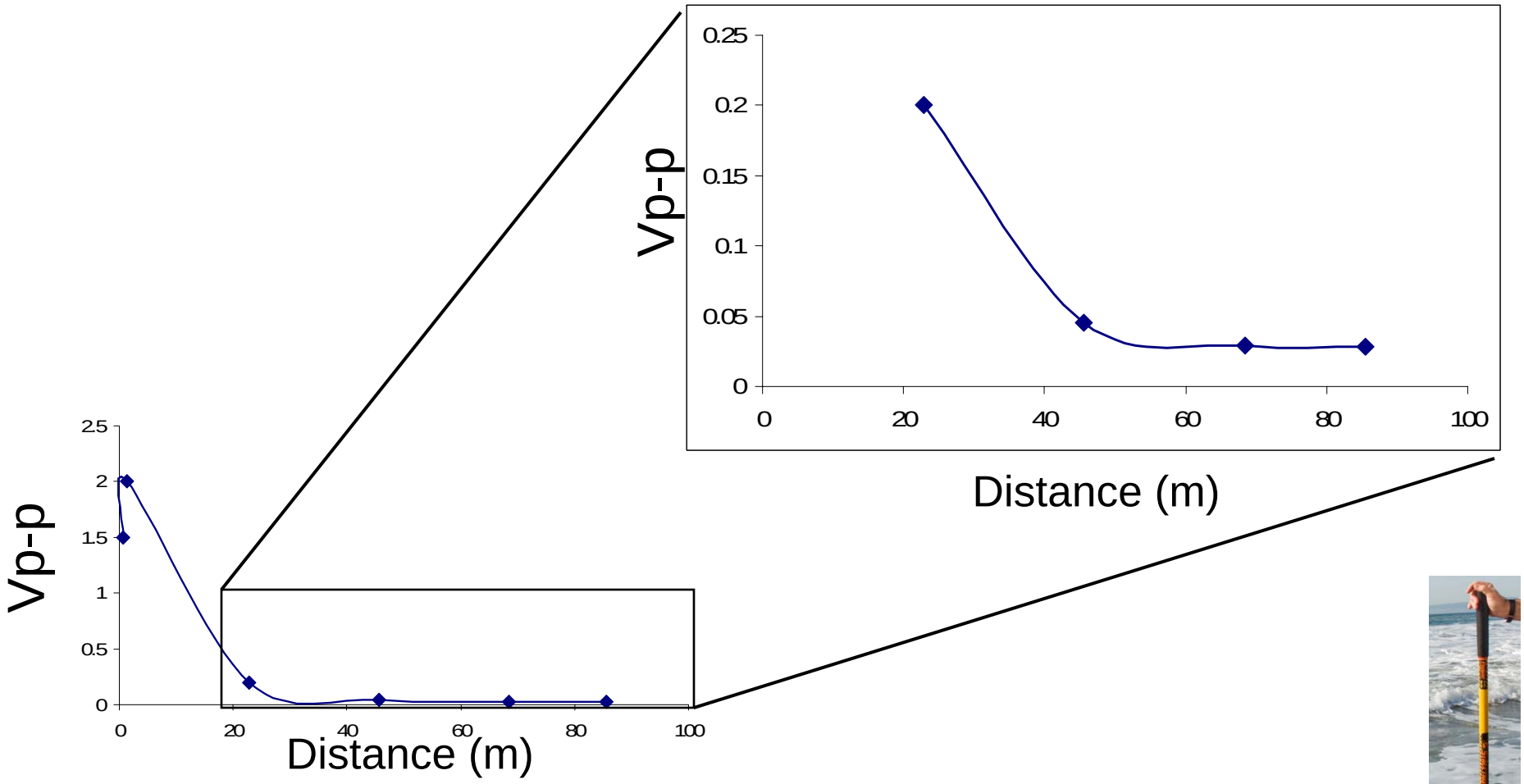
Tank File Transfer Test

Sand thickness	Maximum rate	File size
3 ft.	1200 bits/sec	642 bytes

How far does sound travel when both modems are buried??



Beach Ping Test

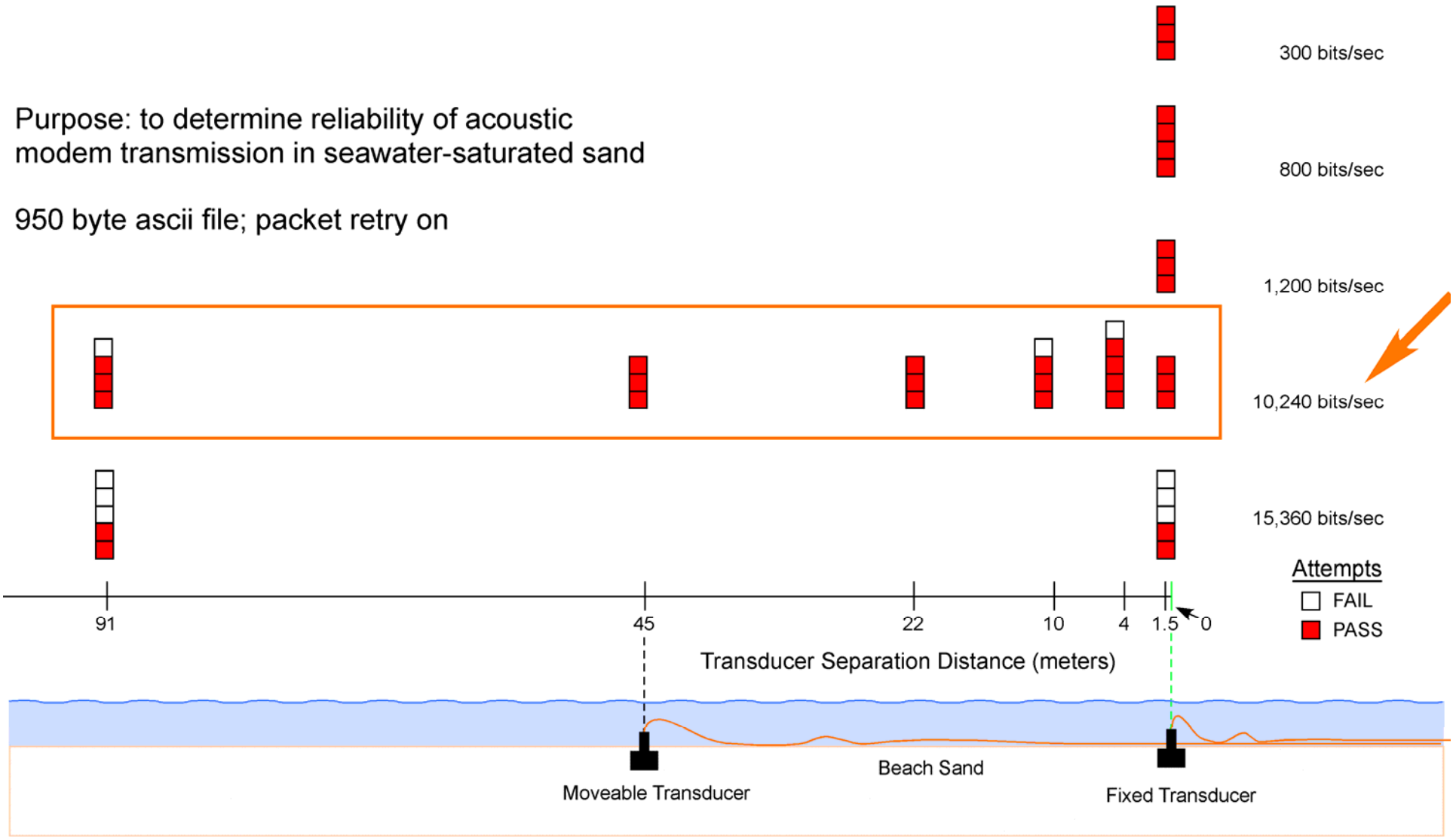


1 uS (Ussler) = 1.425m = 1 shovel length

Beach Face Acoustic Experiment

Purpose: to determine reliability of acoustic modem transmission in seawater-saturated sand

950 byte ascii file; packet retry on



Data Recovery Summary: Acoustics

- Bright colored shorts do not affect transmission quality
- Sand-sand transmission seemed promising (10kbits/sec at 91m apart)
- Water-sand interface further attenuates signal - possibly due to test tank set up (ping tests)
- Test results are encouraging further development

Data Recovery Summary

	Max baud	Range
Benthos Modem	10 kbps	sed-sed≥ 90 m
	1200 bps	H_2O-sed: 3 ft - ?
Seatooth EM modem	100 kbs	10 m
Seatext EM Modem	100 bps	350m

Will pursue acoustic solution first because of the range/throughput issues

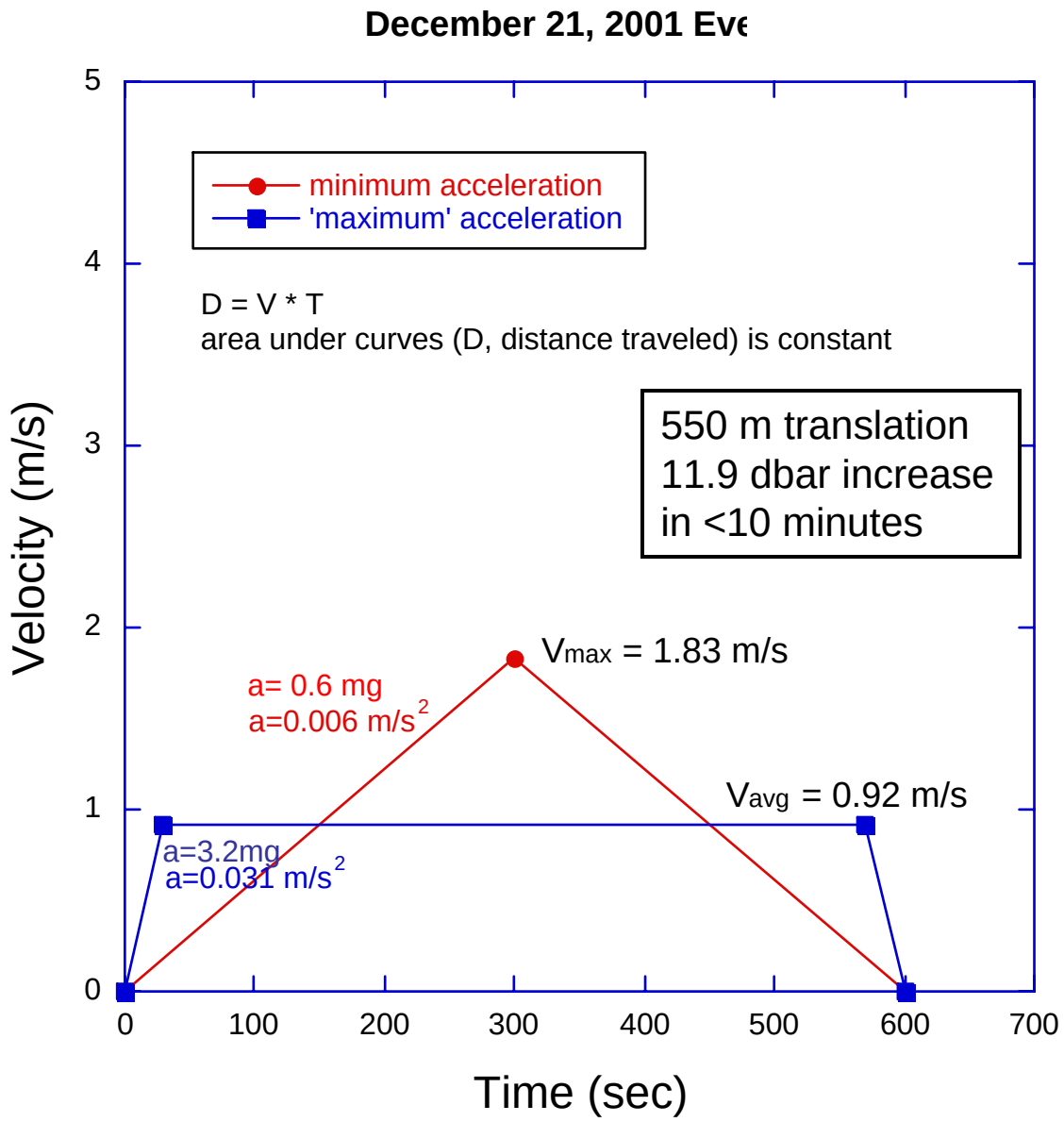
BEDs Concept: High-risk Elements

- Can we retrieve data, possibly from buried instrument
- Can we find sensors to resolve the motion we are trying to detect?
- Can we detect an event?
- Can we interpret the data?

What measurements could be used to resolve the motion of the bed?

- Acceleration
- Inclination
- Pressure
- Magnetic compass
- A combination of the above
- Sensor selection is part of test plan coming in a few slides

Only Transport Event Data



A Suite of Possible Sensors

Manufacturer	Type	Specs
Analog Devices	Accelerometer Inclinomter 6 DoF inertial	<1.25 mg accel sensitivity <.1°tilt sensitivity
Freescale	Accelerometer	3 axis ±2g/8g 0.9 mg/bit sensitivity
Microstrain	AHRS	360°about 3 axis .1°orientation resolution ±5g acceleration range 1Hz – 1kHz sampling freq
Various	Pressure	Resolution to <1cm

BEDs Concept: High-risk Elements

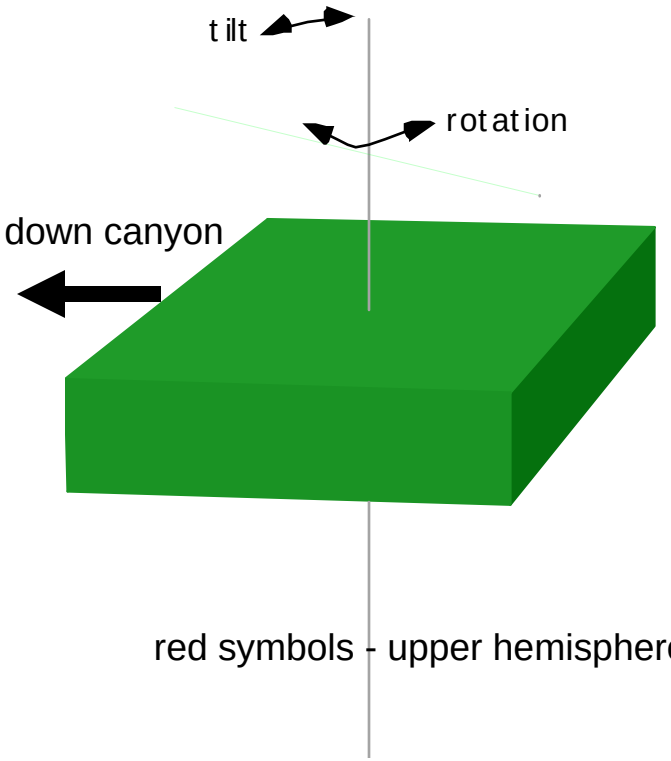
- Can we retrieve data, possibly from buried instrument
- Can we find sensors to resolve the motion we are trying to detect?
- Can we detect an event?
- Can we interpret the data?

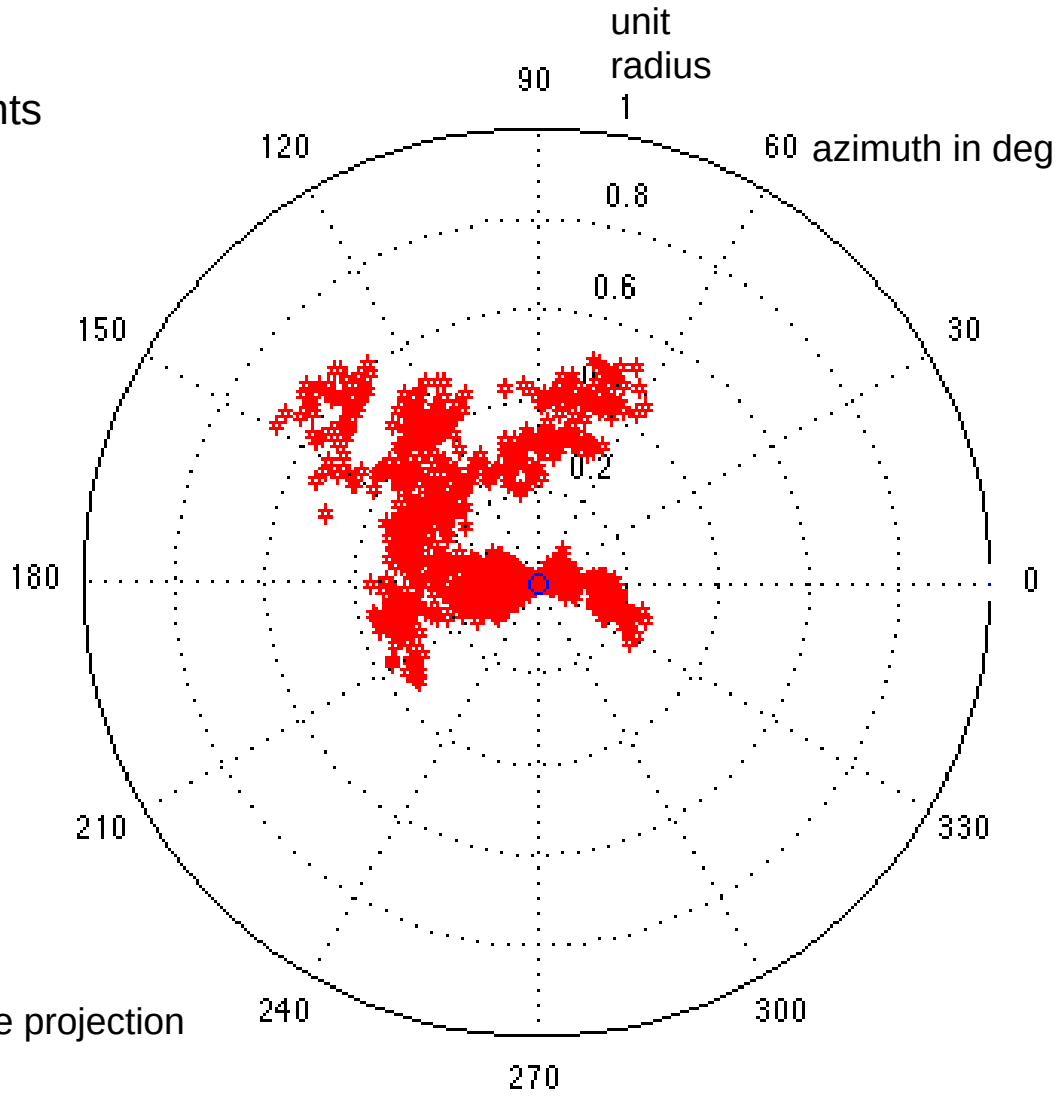
Simulation of rotation and tilt around a vertical axis

1000 samples

normally distributed random events
mean=0; sd = 1

tilt and rotation independent





red symbols - upper hemisphere projection

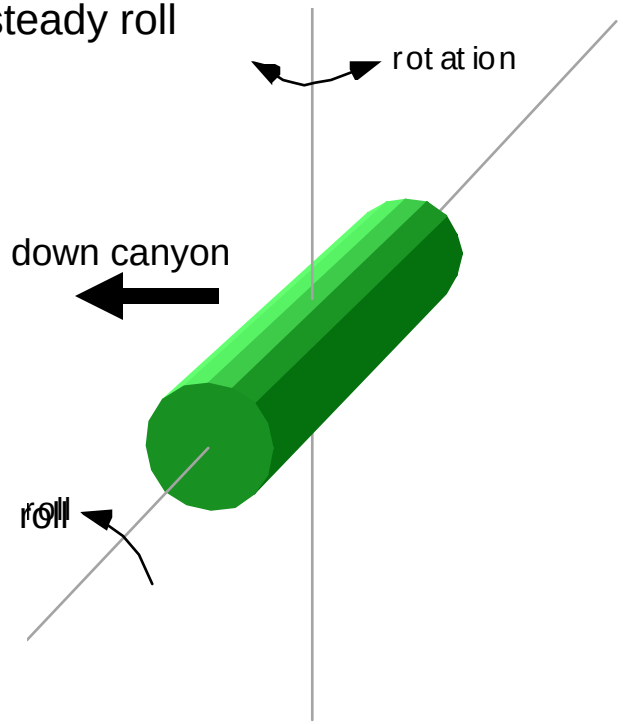
Simulation of rolling object

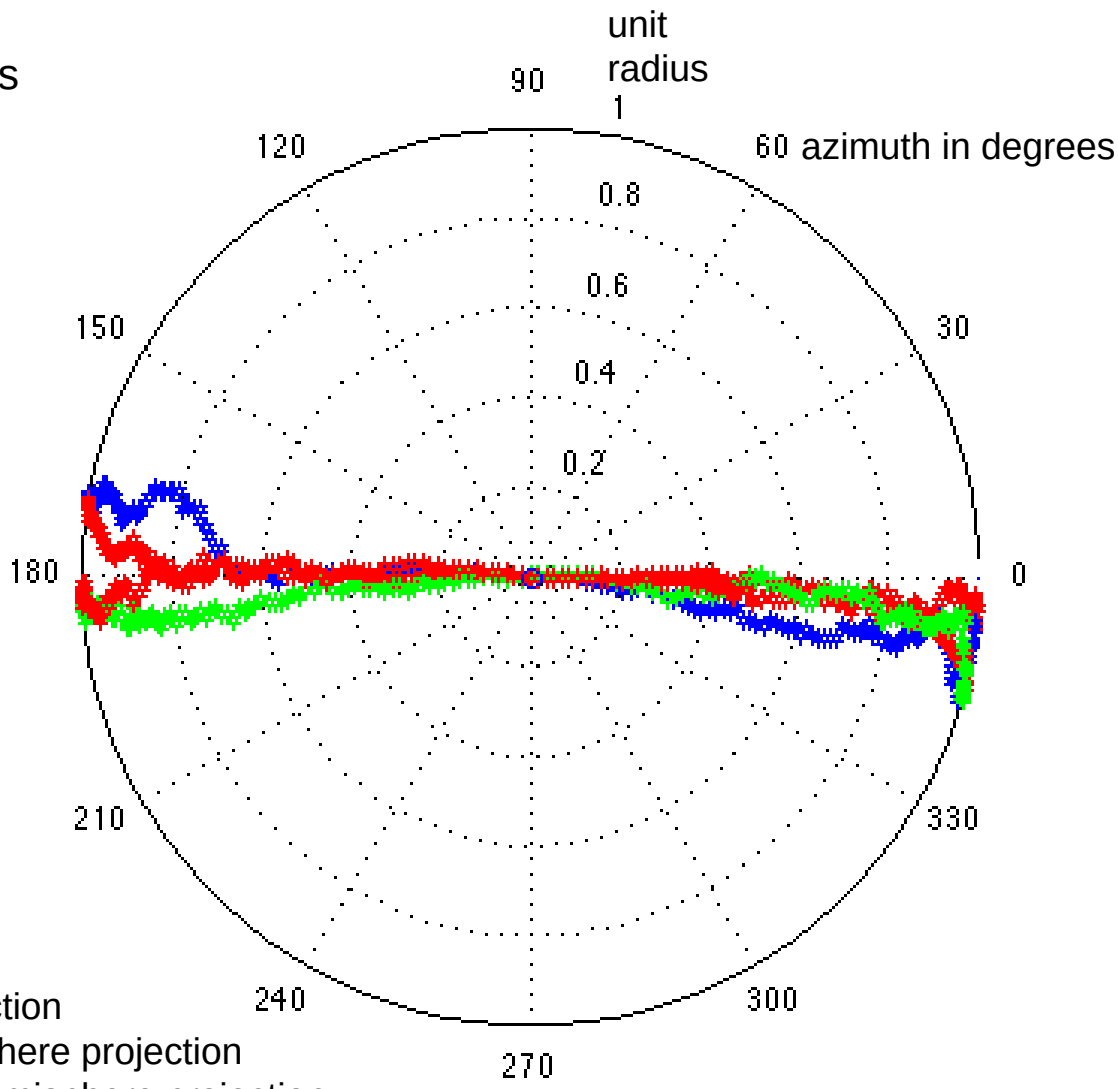
750 samples

normally distributed random events
mean=0; sd = 1

roll and azimuth independent

steady roll





red symbols - upper hemisphere projection
blue symbols - first roll in lower hemisphere projection
green symbols - second roll in lower hemisphere projection

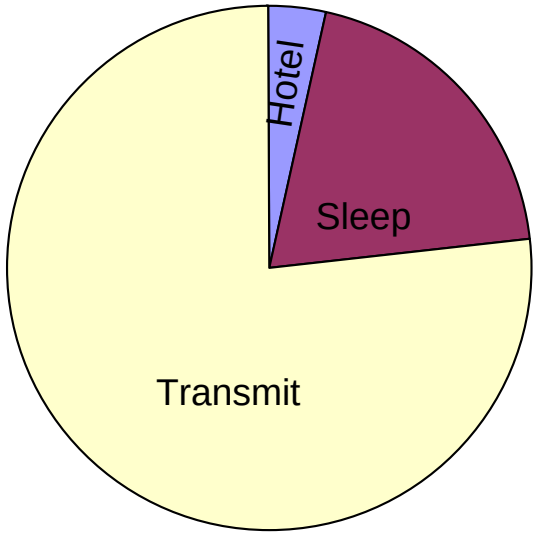
Now what: Other uncertainties

- Will we have the power and bandwidth to transmit the data?
- How to package BED – TBD

Data Budget

DATA		
Variable	**Value**	**Units**
Event Sampling Freq	10	Hz
Event Duration	960	sec
Individ. data record size	50	Bytes
Number of events	5	
Individ. Event data size	480	kBytes
Time to transmit one event at 600bps	6400	sec
	107	min
Time to transmit all events at 600 bps	533	Min
	9	Hr

ENERGY		
Variable	**Value**	**Units**
Deployment length	1	yr
ROV visits	3	times/yr
Bottom Time	3	hours
Ave Transmit Power	20	Watts
Ave Sleep Power	0.0105	Watts
Listening duty cycle	50	%
Transmit Baud Rate	600	bits/sec
Control Electronics Power	0.001	Watts
Calculated Values	**Value**	**Units**
Max data transmit per visit	810	kBytes
Transmit Energy per visit	60	WHr
Annual Control energy	8.76	WHr
Annual Sleep energy	45.99	WHr
Annual Transmit energy	180	WHr
Annual Energy budget	234.75	WHr
Number of Primary DD Cell Li Batts	2.934375	
min # of cells	6	



Now what: Future Tests

Modem sea trial

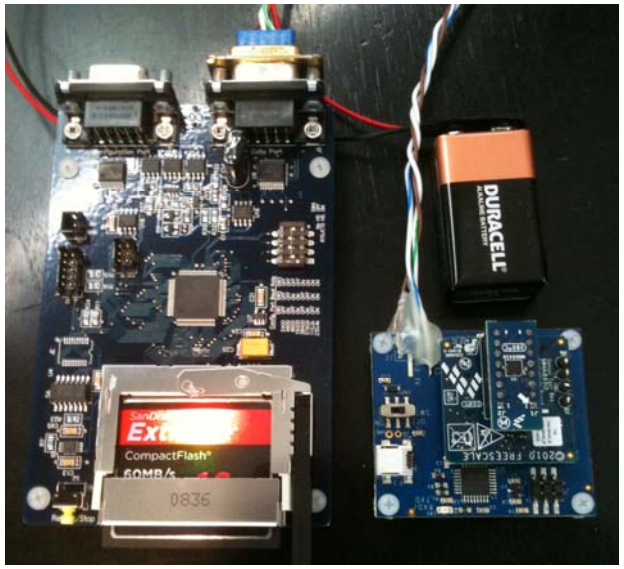
- Divers bury transducer ~1m in sediment
- Test will remove artifacts from tank testing
- Is sed-water worse than sed-sed?
- Can we avoid using an ROV for data recovery?

Pass if:

- Data throughput >= tank tests
- Determine additional attenuation from water/sand interface.

Now what: Future Tests

- Research and evaluate available sensors
- Build sensor test bed
  - Package for land based test
  - Accelerate across proposed range. Varied sampling rates
  - Video tests, interpret results



Pass if:

- Collected data shows translation of package
- Proposed sampling rates adequately capture motion

Now what: Future Tests

- Prototype BED
  - Deploy in canyon, near monument or STED
  - Limited sampling frequency
  - Limited deployment duration
  - Limited or no event detection
  - Recover full data set frequently

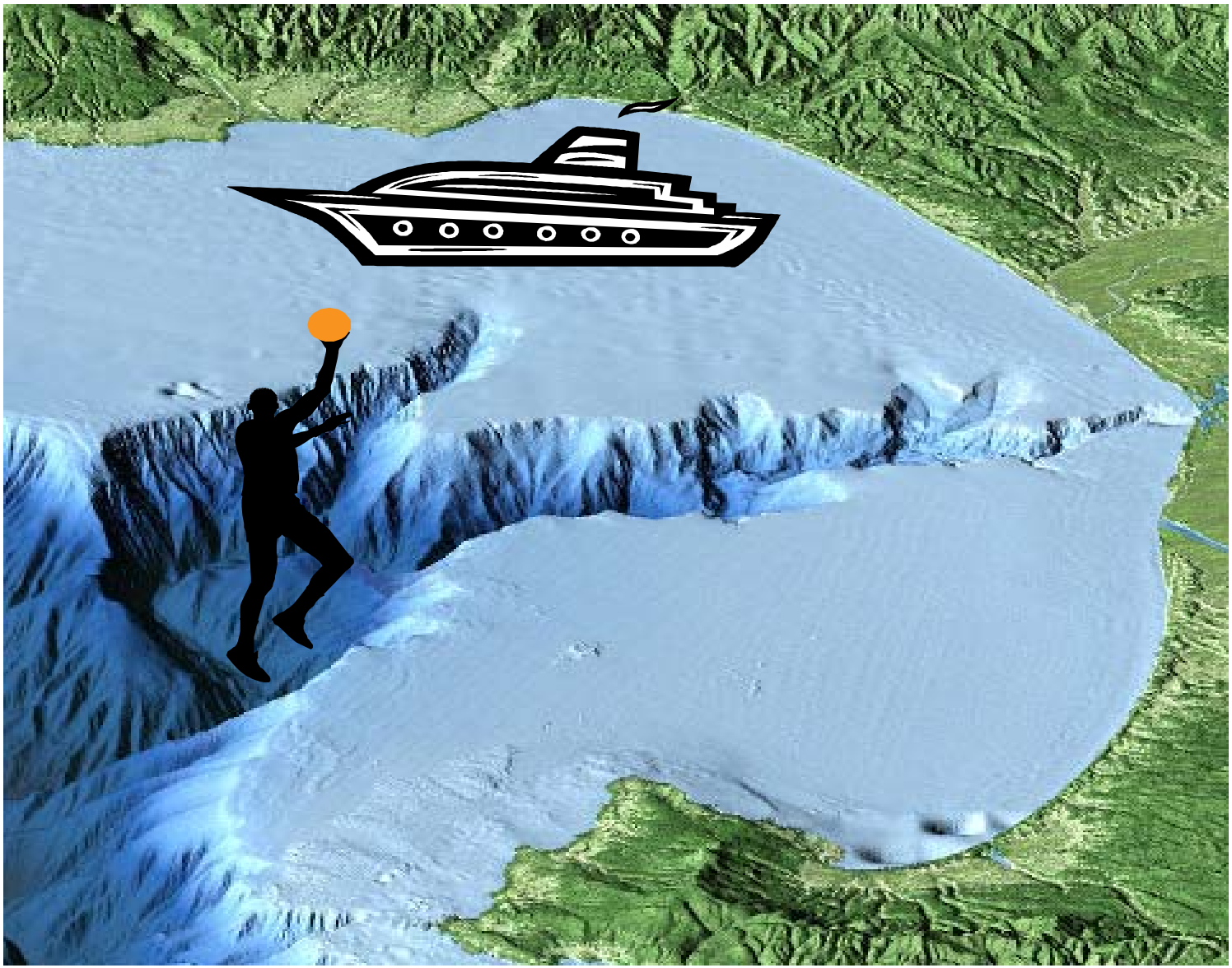
Pass if:

- Data is recovered
- Motion can be resolved from collected data

Labor Resources for 2011

	Position	**Hours for 2011**
Brian Kieft	Project Manager, SE	400 wanted 180 allocated
Bill Ussler	Project Scientist	400
Alana Sherman	EE	440
Dale Graves	ME	270
Larry Bird	ME	270
Bob Herlien	SE	300


Hows this thing work??@#$%?



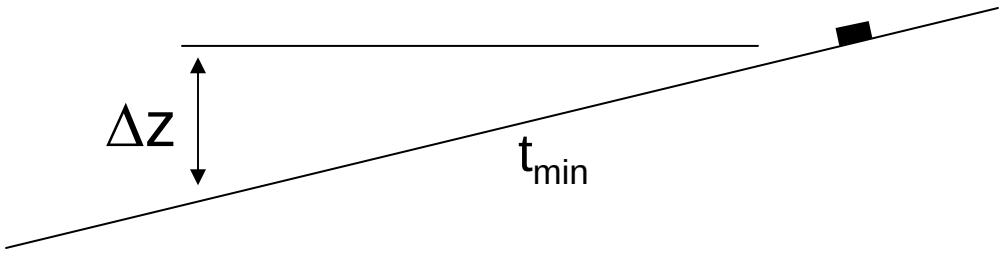
2011 Budget

CATEGORY	COST
Sensors	$15,000
Interface boards	$1,800
Microcomputer and ADC boards	$4,000
Acoustic or EM modem	$10,000 (acoustic) or $25,000 (EM)
Mechanical packaging	$15,000
Sonardyne Homer Pro	$8,000
Miscellaneous hardware and supplies	$3,000
Cables and connectors	$3,000

What criteria is needed to select a sensor?

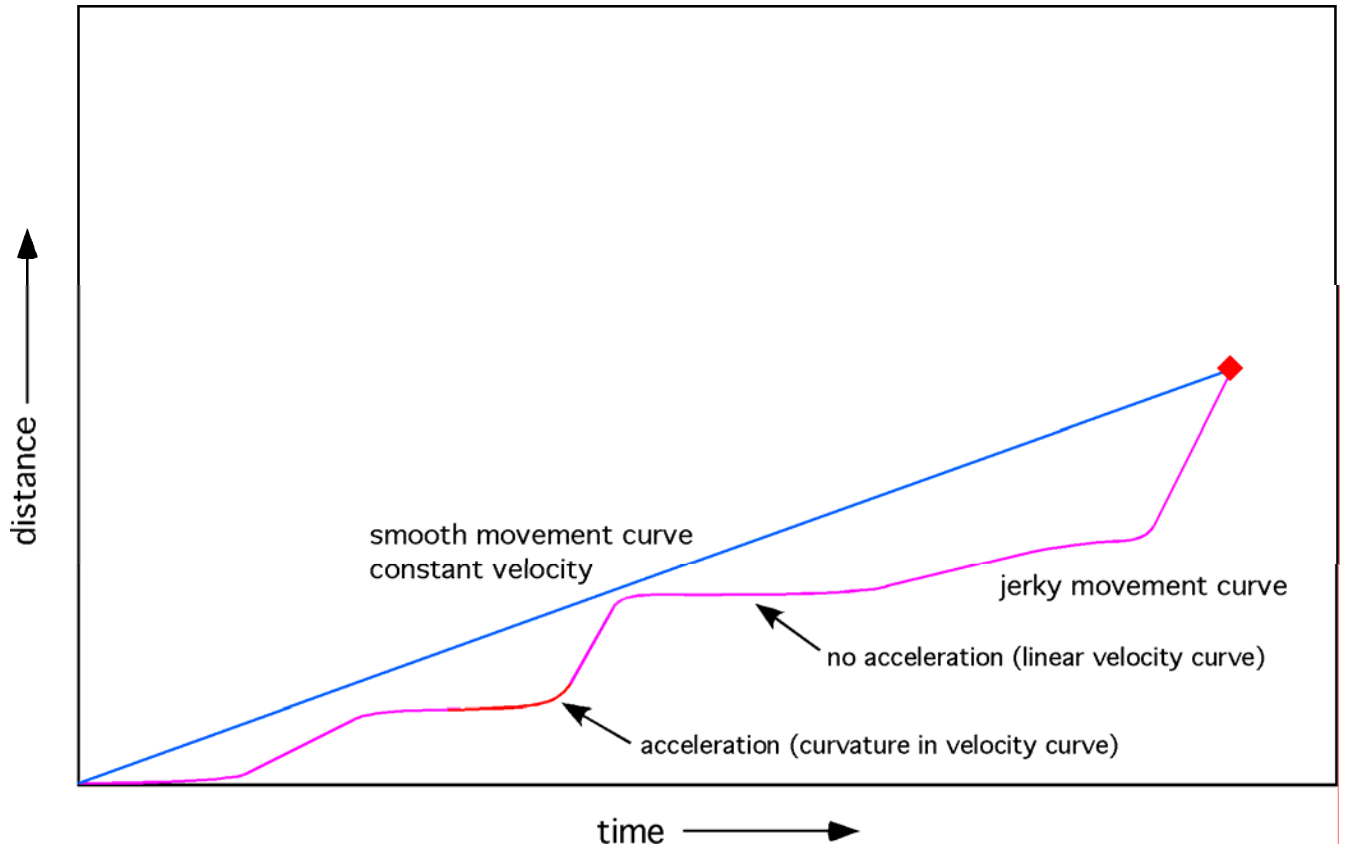
- Sensitivity
- Resolution
- Long-term stability
- Calibration
- Temperature compensation
- Signal conditioning - pre-amp, filters, shielded cables
- Range
- Power consumption

Pressure-resolved Translation for Event Detection



Sensor	Vertical resolution (Δz)	Minimum translation (t_{min}) resolved on 1.7° slope
Druck PTX600	15 cm	5 meters
SeaBird standard transducer	1.2 cm	40 cm

Hypothetical displacement curves

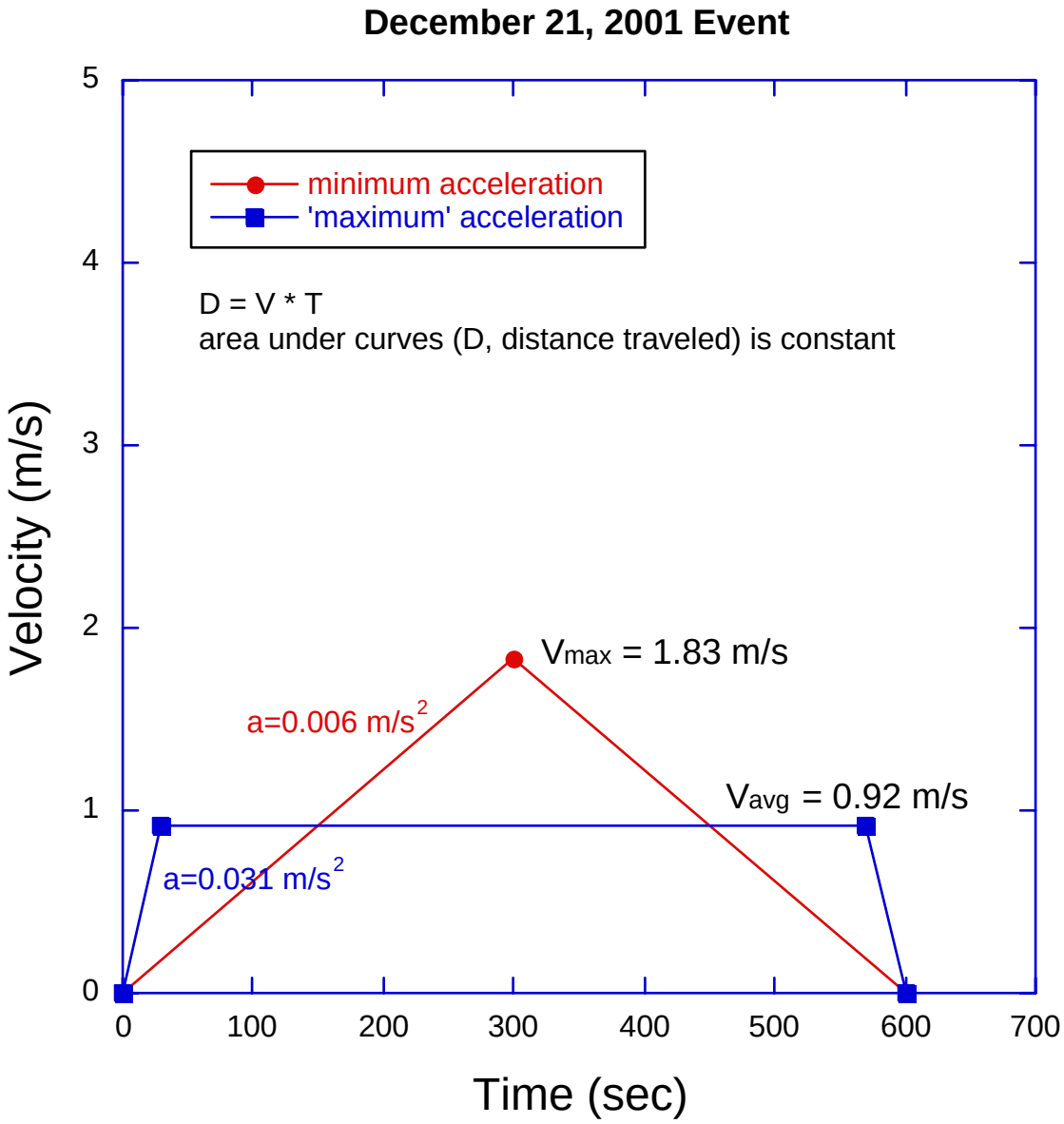


The Raybould Defense

“ Even after the Concept Design Review you may not know with a high degree of certainty whether the concept will meet all of your Functional Requirements.”

- MBARI Guidelines for Project Design Reviews

Range of Possible Accelerations



Are there off-the-shelf sensors that meet our requirements?

- Acceleration - Kistler Model xx (give specs)
- Tilt - AGI tiltmeter Model xx with preAmp (give specs)
- Pressure - SeaBird OEM pressure sensor with electronics (give specs)
- Timing - ?
- Orientation - ?
- Gyros - ?
- Magnetic compass - ?
- Vibration/acoustic - ?

Relevant work outside of MBARI and submarine studies

Landslide research - timing, acceleration, motion, acoustics

Glaciology - timing, creep, rheology, flow structure

Geotechnical industry - rheology, creep

Seismology - strainrate, wave propagation, acceleration, tilt

Geodesy - tilt, orientation,

Structural Engineering - vibration and acoustics, acceleration, tilt/sway

Gaming Industry - gyros and acceleration

iPhone and clones - gyros and acceleration

Data Recovery

Technical and Operational Challenges of each:

1. Pop-up buoy
   - Truncated data record
   - Other logistic issues

2. Avalanche cord
   - How do you anchor
   - Tether would probably break
   - Excavation is difficult/impossible

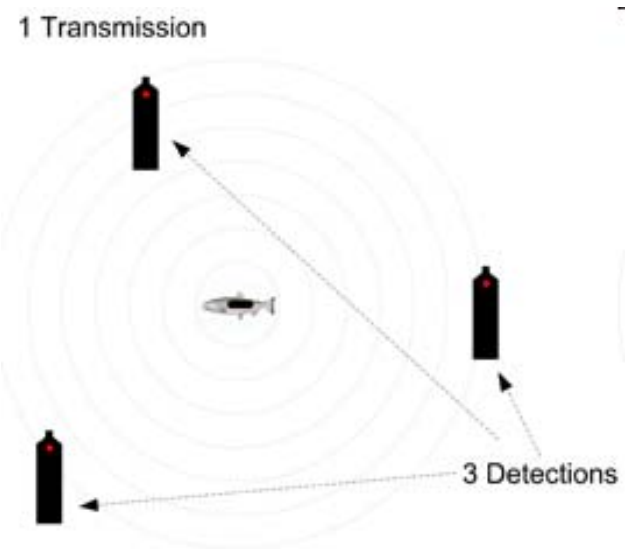
Data Recovery

Technical and Operational Challenges :

RF ID

- Commercial RF ID tags (TI) tested
  short range <1m

- Fish tags investigated (Vemco)
  range limited
  won’t go through sediment



Basic BEDs Concept