BEDS Preliminary Design Review

June 20, 2012

Project Team:

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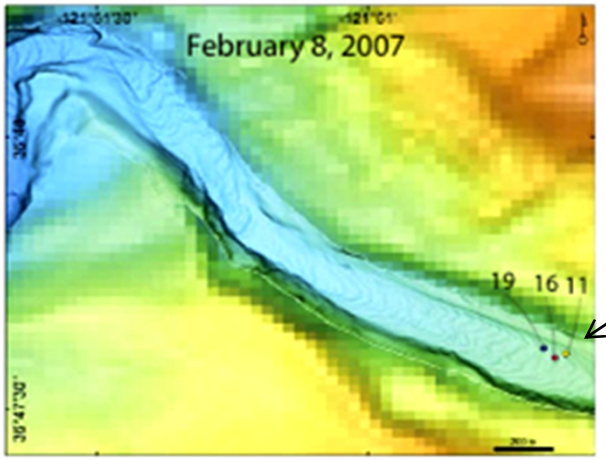
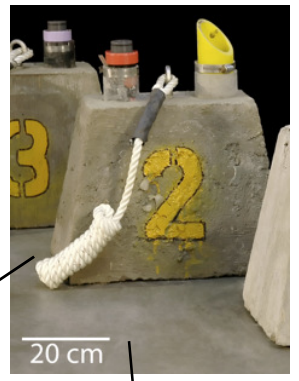
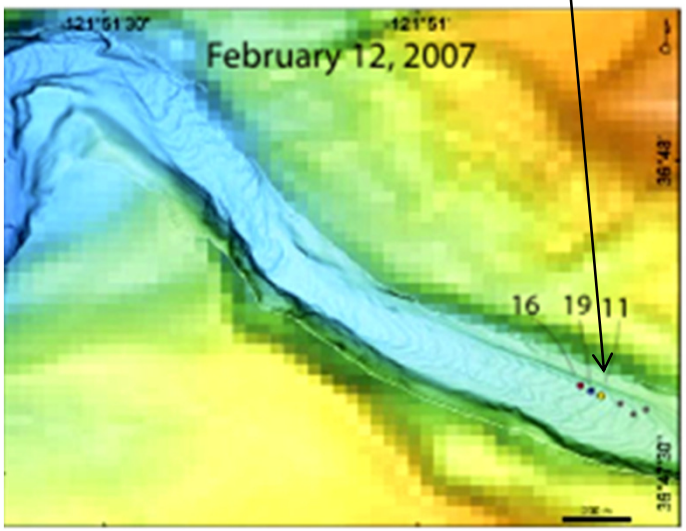
What is a Benthic Event Detector?

- Characterizes motion and frequency of submarine canyon sediment debris flows
- Allows for data recovery without instrument recovery
- May not necessarily be recovered
- Doesn't explicitly require MBARI ships for operation





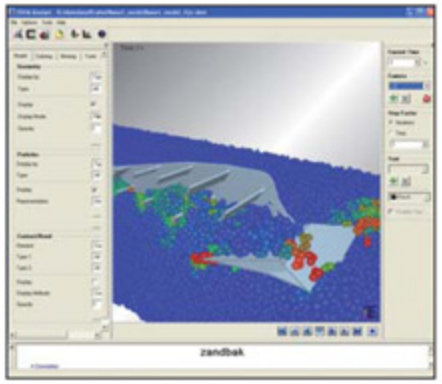


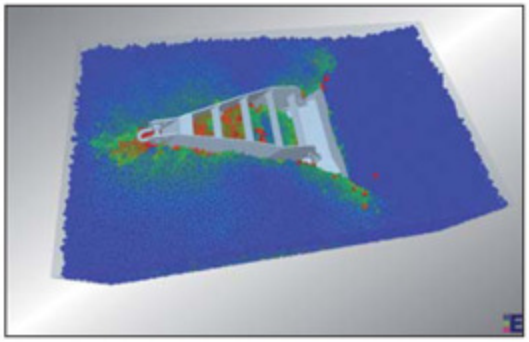
BEDs Considerations from Concept Review

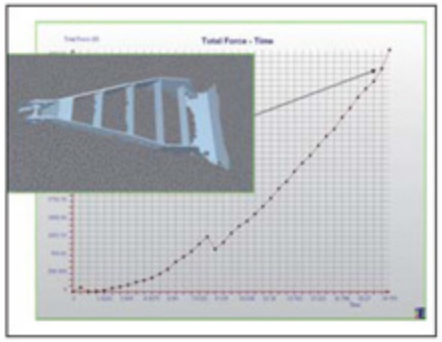
- Can data be retrieved from device?
- Can motion be resolved in a way useful to science?

BEDs Data Retrieval

- Acoustic modem
  - Burial test .7m @1200 bps – 2560 bps
  - Vryhof Anchors: 13m in 300m water @ 300 bps
  - Frequency hopping scheme for modem if needed





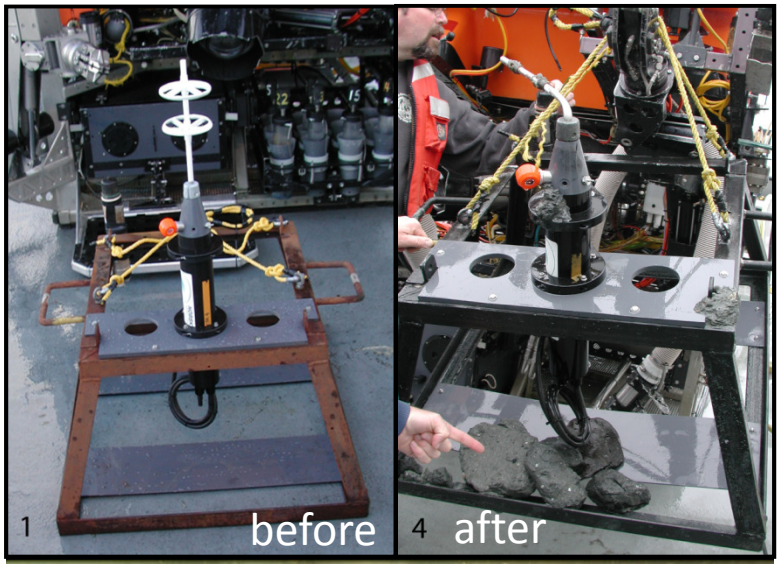


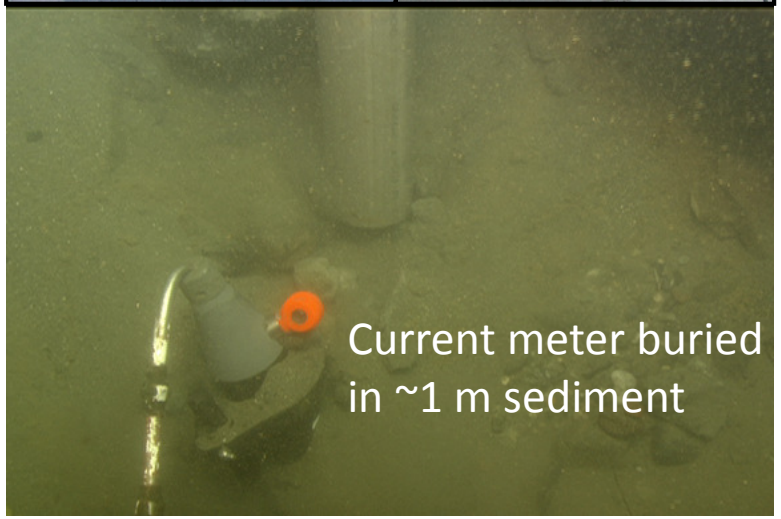
Sediment Debris Flows in Monterey Canyon

- *Only* transport data obtained in 12 years is from a single debris flow event - what we know is:
  - 550 m down canyon translation of current meter
  - 11.9 dbar pressure increase
  - ~10 minute duration
  - ~1 m/s average velocity

- **Would like to know more:**
  - Onset and duration of events
  - Continuous or episodic motion
  - Maximum acceleration
  - Insight into type of sediment grain motion:
    - Sliding
    - Rotation
  - Depth of no motion in sediment

December 21, 2001 Event

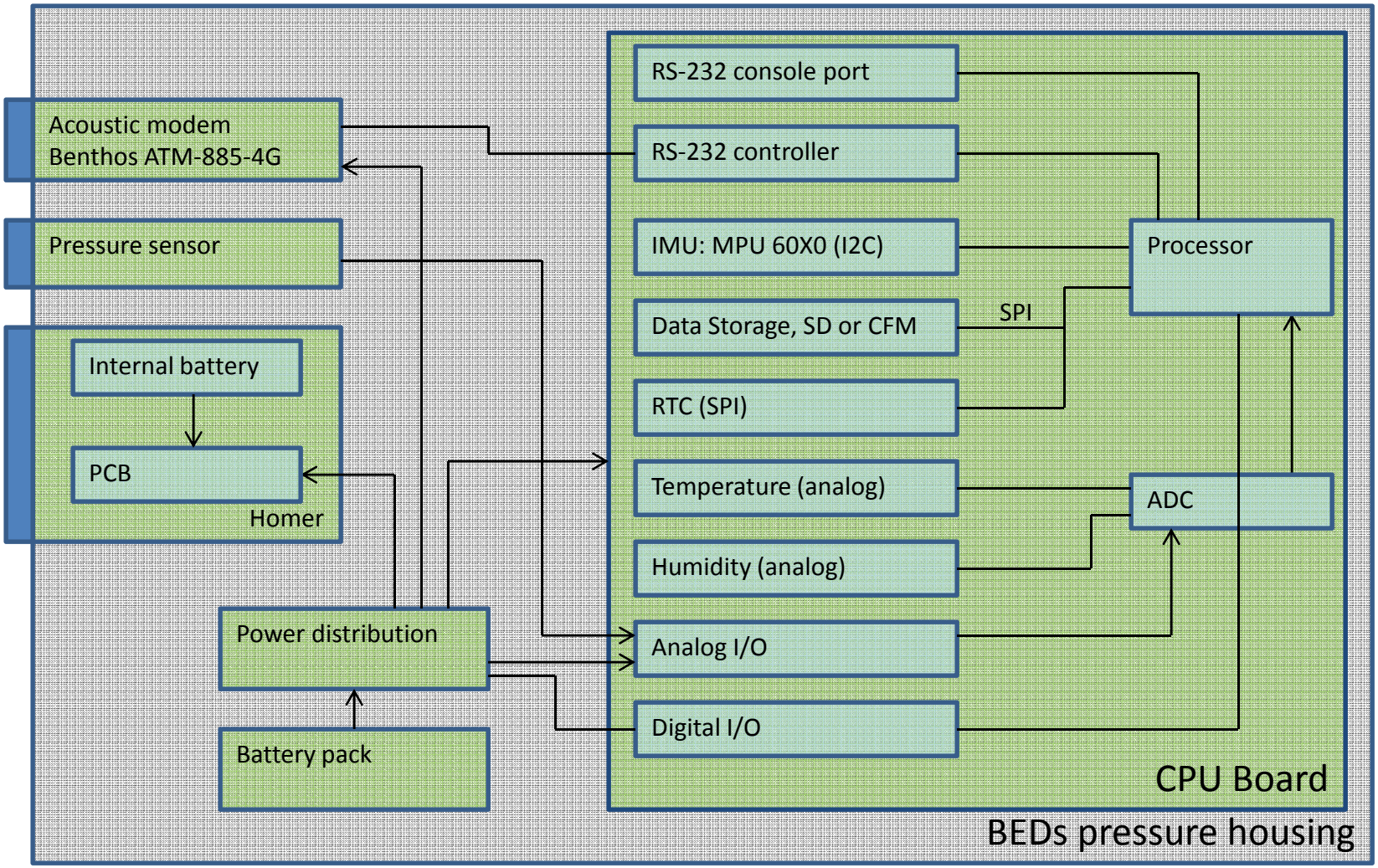




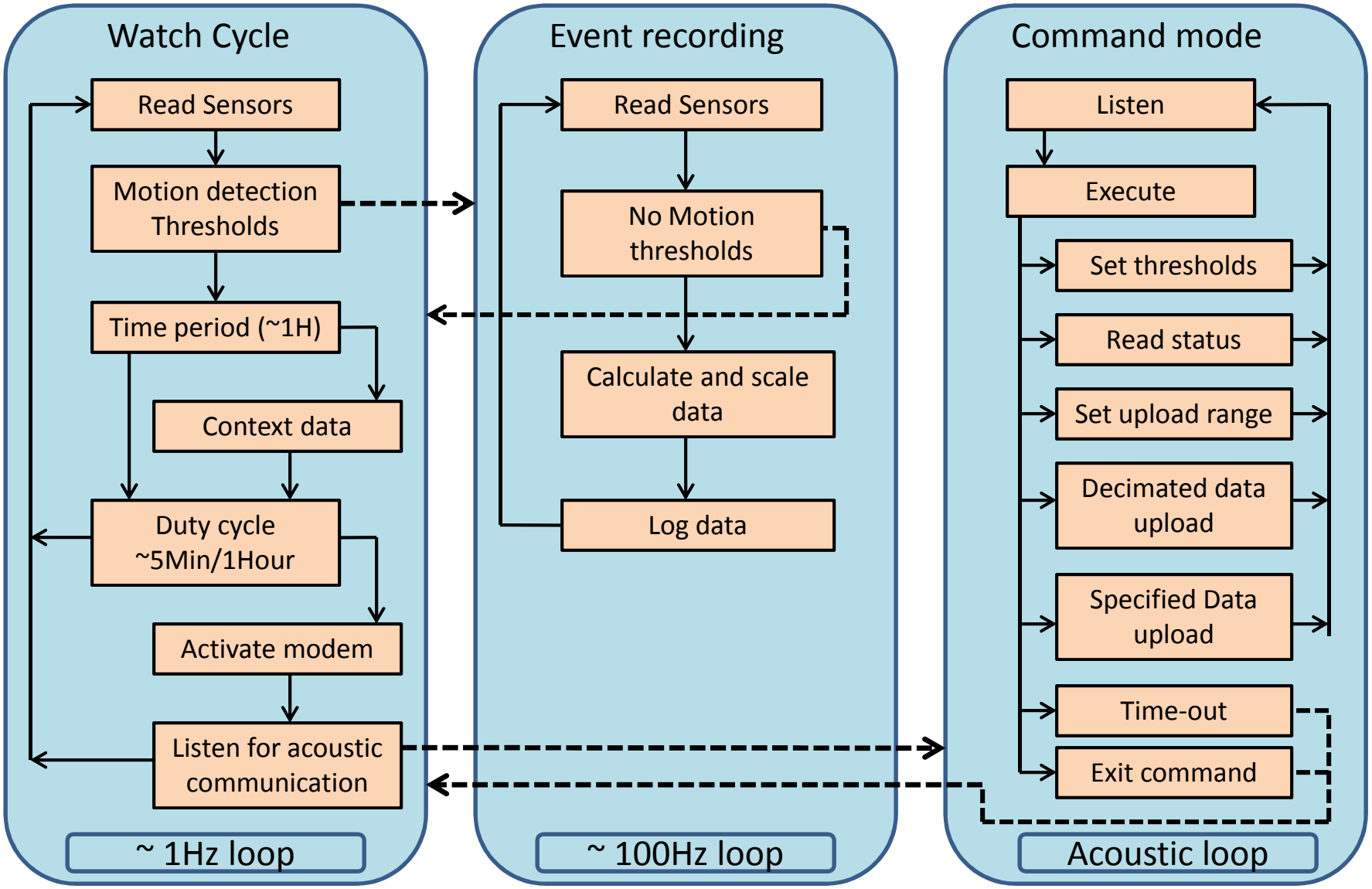
Method

- Benthic Event Detector → Compact autonomous motion detector and transmitter
- Deployment → Top or inside of sediment layer
- Sediment motion → Blending into sediment layer
- Data transmission → Acoustic

BEDs Architecture



BEDs Operation Flowchart



BEDs Electrical

Data and Power Budget: EnergyBudgetv2.3-Electrochem14cells.xls

- Operating modes: Watch Cycle; recording Cycle; Command mode
- Power of subsystems and duty cycles defined in each mode
- Data rates and number of bytes per point defined

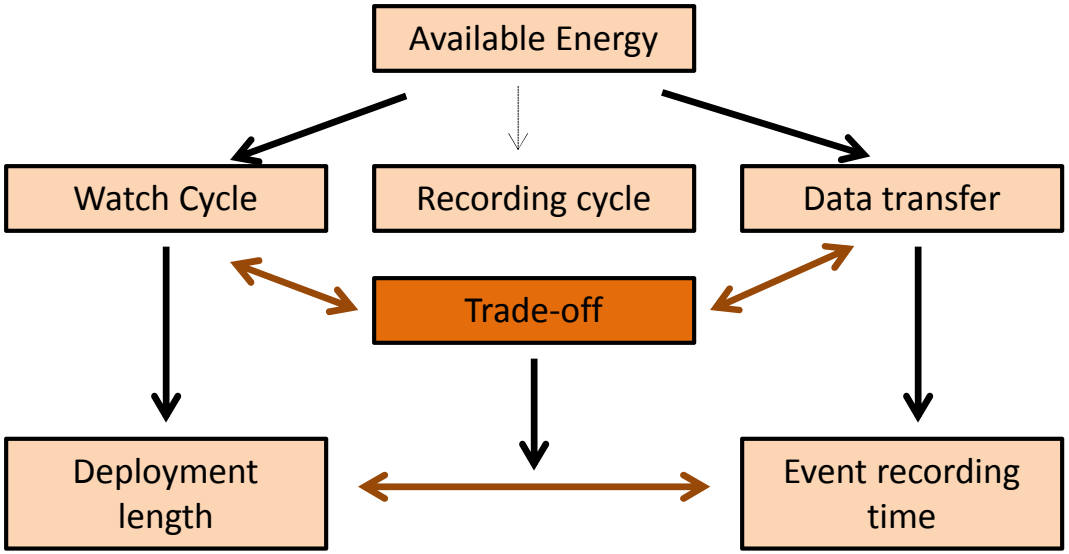
Parameter	Watch cycle	Recording cycle	Command mode (based on 800 bps)
Acoustic modem power, W	0.60	0.60	21.00
Acoustic modem duty cycle, %	10%	10%	100%
Inertial sensor & microcontroller power, W	0.16	0.40	0.40
Peripherals power, W	0.04	0.20	0.20
Peripherals and sensor duty cycle, %	20%	100%	100%
Cycle average power, W	0.10	0.66	21.60
Duration in mode, hrs	Depends on length of deployment	Depends on length of event(s)	Depends on data to be transmitted
Cycle energy, WHr			

Parameter	Watch cycle	Recording cycle
Bytes/data point	6	24
Data rate	1 / Hour	100 / sec
Event data, kB	Depends on length of deployment	Depends on length of event(s)

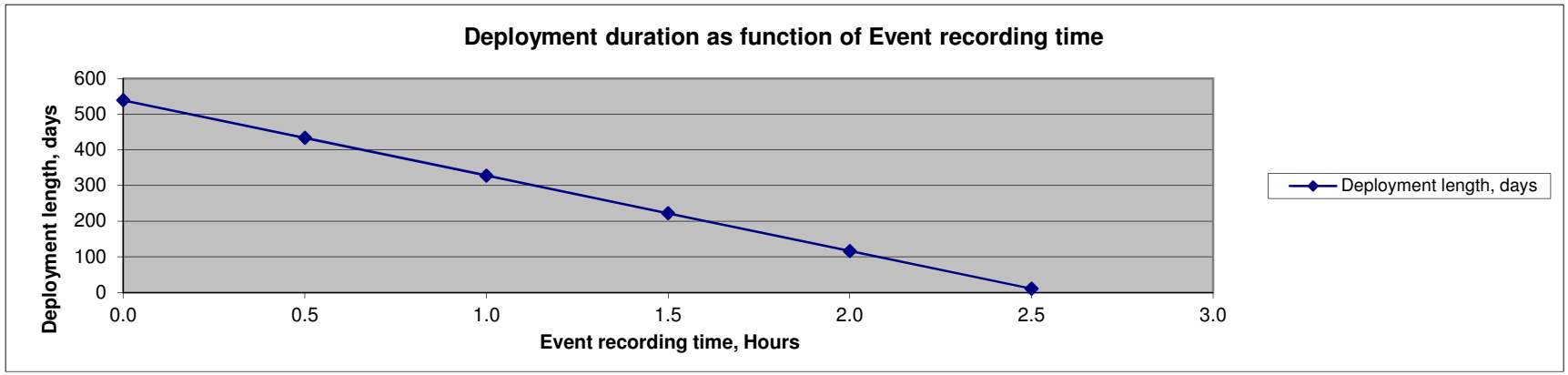
BEDs Electrical

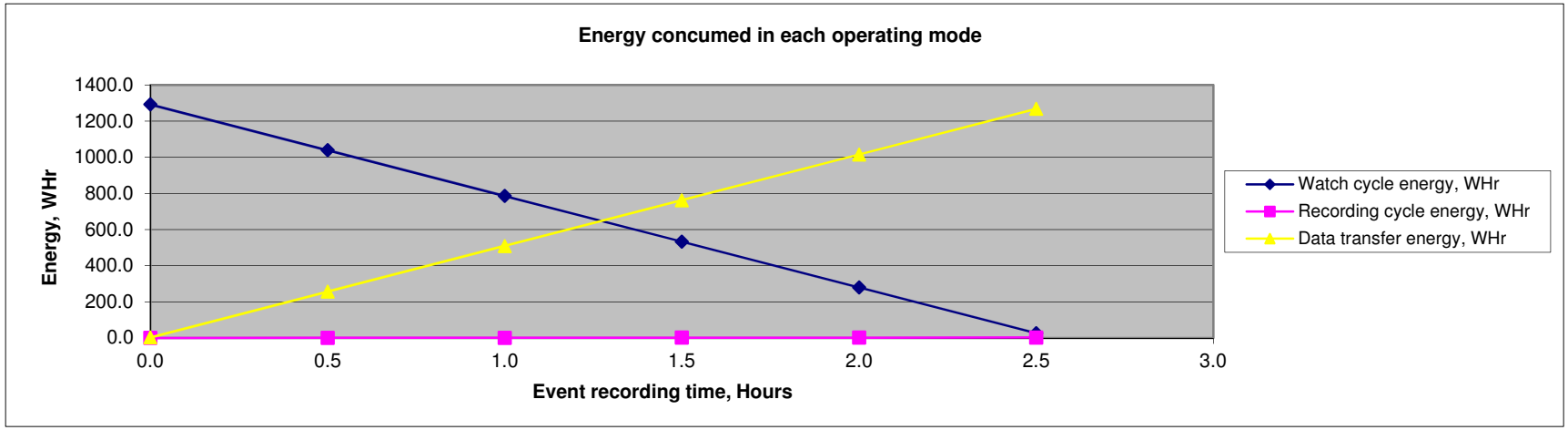
Data and Power Budget:

- Energy is limited and defines everything else
- Lithium DD cells 30AH, 90 W*H for deployable article
- Pack configuration 7s2p
- Alkaline D-cells for prototype



BEDs Electrical

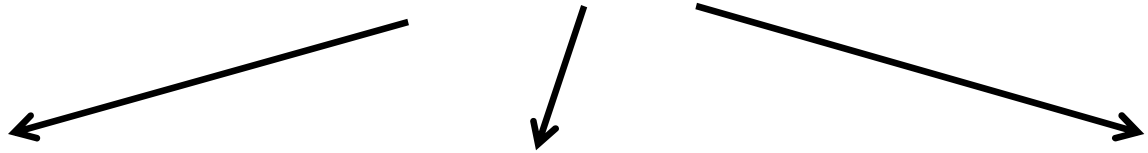




Why Invensense?

- Low power
- Sensor Fusion Algorithms onboard
- Gyro drift and accel bias compensated
- Event detection logic
- Cheap
- Open source community and COTs devel boards
  - Paparazzi code base includes peripherals like magnetometer, pressure
  - Integrated 9 DOF solutions available for MSP430

BEDs Software



Onboard

- Single-threaded state machine
- Three operating loops with defined transitions
- C++

Post processing

- Software runs on shore
- Algorithm to reconstruct linear motion (displacement)
- C, Java; or MatLab

Visualization

- Low-resolution (contextual) data panel
- Event data panel to represent high resolution data
- VRML can provide 3D modeling

Mechanical Requirements

- Operational Depth = 500 meters
- Deployment duration = up to 12 months
- Temperature range = -3 to 50 degrees C.
- “Ruggedized” to withstand acceleration shocks associated with transport
- Package density = 1.5 to 1.8 G/CC

Mechanical Requirements

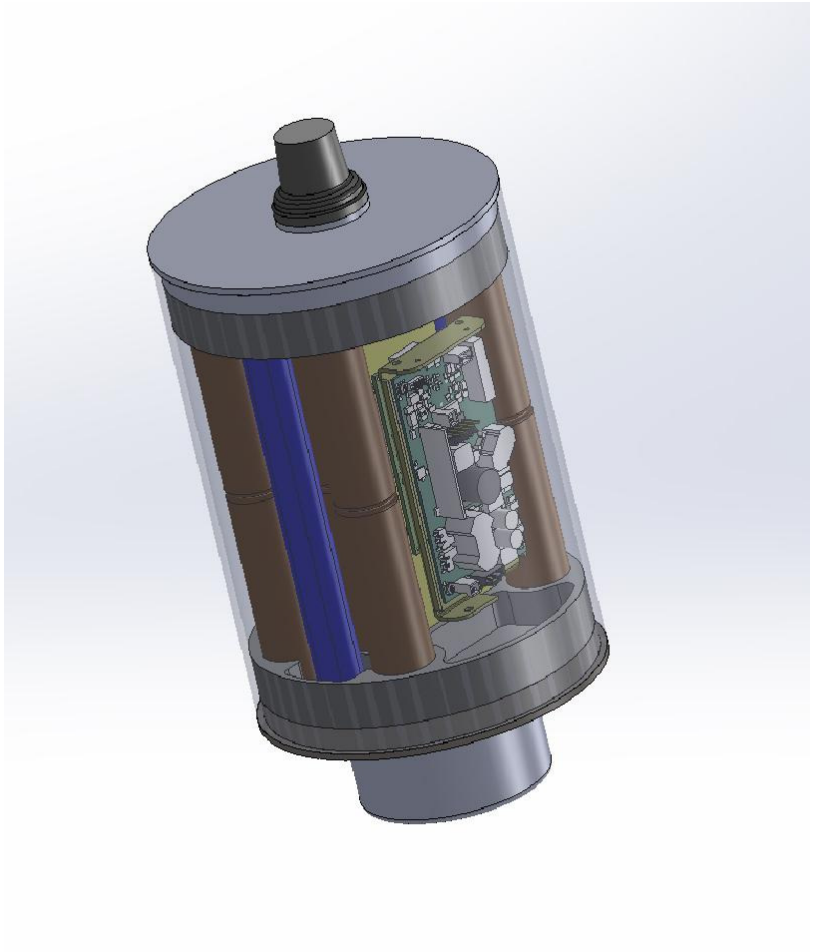
- The system shall be packaged such that its density could be increased to 3 times the default package density so that self-burial can occur (i.e., it can be made more dense).
- The system shall be designed as small as possible to approximate the natural motion of sediment within the canyon floor
- Be deployable and recoverable from an MBARI ROV
- The system shall communicate at any package orientation

Main Components

- Instrument housing
  - 7”ID X 10.5” cylinder w/modem & homer transducers
- Trim/ballast/system
  - 15” Flotation sphere - collar w/ballast weights
- Transducer guards
  - UHMW “windows”

Instrument Housing (internal components)

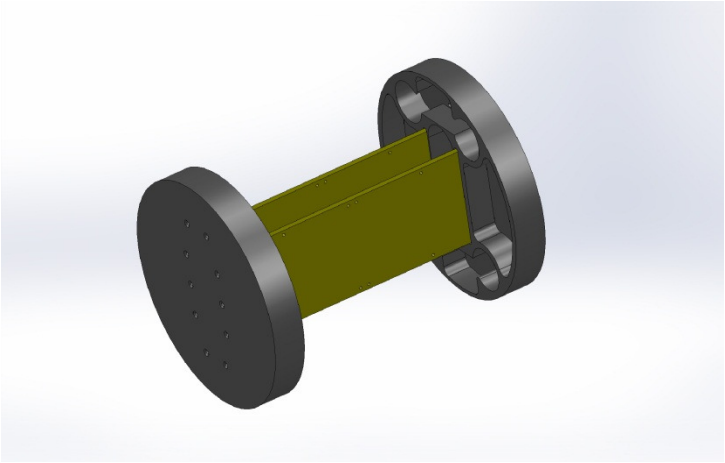
- Homer transducer
- Homer PCB
- Homer battery pack
- Inertial sensor board
- Pressure transducer
- Benthos G4 modem PCB assembly
- Benthos modem transducer
- Modem battery pack
- Instrument battery pack

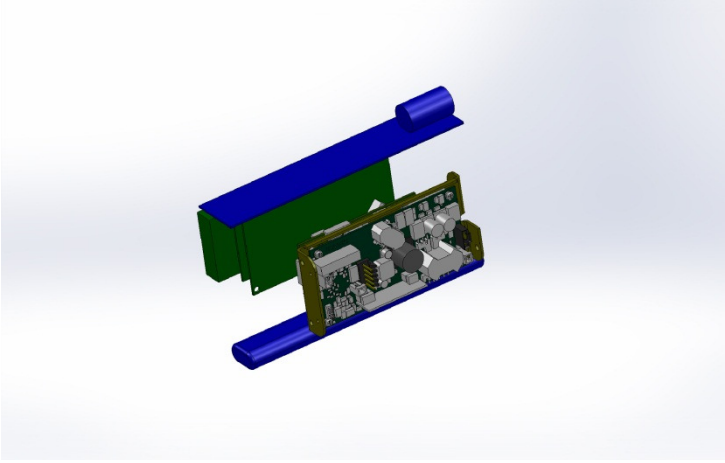


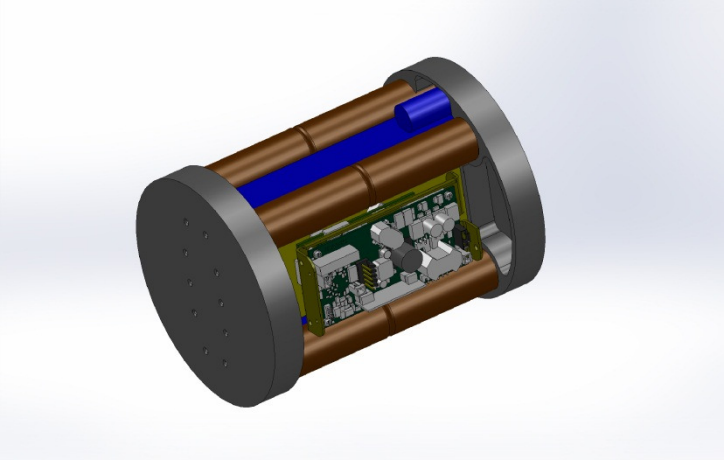
Instrument Housing (materials)

- Options
  - Ti
    - Pros – last for ever
    - Cons – high cost
  - Composite tube/Ti end caps
    - Pros – Very long life
    - Cons – higher costs than mild steel
  - Aluminum
    - Cons – very limited life due to corrosion and not predictable
  - Mild steel w/coating and or anodes
    - Pros – no crevice corrosion problems
      - Corrosion is predictable and design can accommodate for this
      - Inexpensive
    - Cons – limited life time (2-3 years)
      - Heavy compared to the Ti and Composite/Ti options
      - Magnetometer integration issues

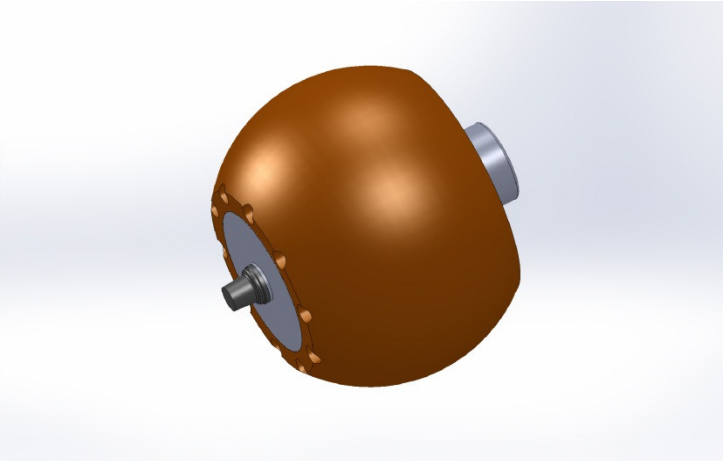
Instrument Housing
(internal packaging)

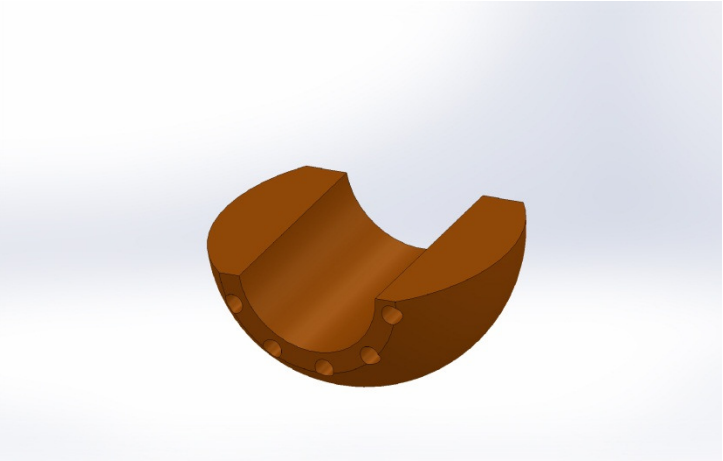






Trim & Ballast System

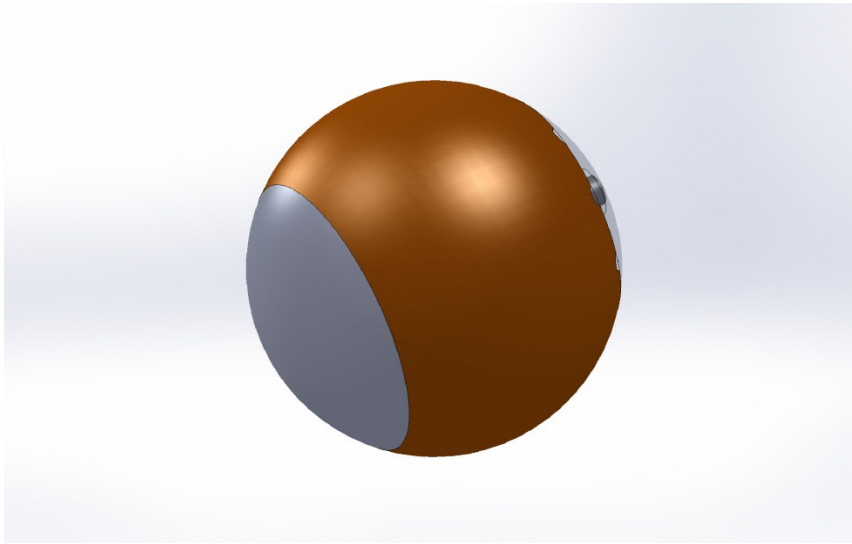




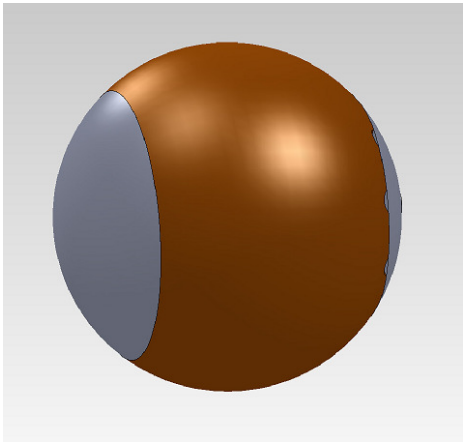
- Collar provides a hydrodynamic shape to the instrument housing that can be modified as needed.
  - In addition, the collar provides flotation, ballast & trim adjustments

Transducer Guards

- Protects transducers
- Provides hydrodynamic profile
- UHMW properties provide good acoustic path.



BEDs Specifications

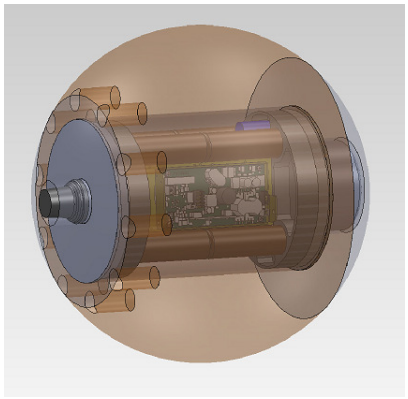


General Specifications

- Weight: 50lb (23 kg)
- Dimensions: 15” (0.38m) sphere
- Displacement: 0.58 cu.ft (16L)
- Operating temperature: -10 to +50C
- Transportation temperature: -20 to 80C
- Max operation depth: 500m

Motion detection performance

- Gyro resolution: 0.062 deg/sec
- Gyro full range: +/- 2000 deg/sec (5.5 turns/sec)
- Linear acceleration resolution: 0.5 mg (0.005 m/s^2)
- Linear acceleration full range: +/-16 g (+/-157 m/s^2)
- Depth resolution: 0.03m (at 14bit ADC)
- Depth accuracy: ~ 0.2%span or 1m
- Depth full range: 500m



Battery and electrical:

- Pack configuration: Electrochem CSC93, 7s2p
- DC load discharge range: 27.5 to 17.5 VDC
- Pulse load discharge range: 17.5 to 13.5V at 4A peak

Acoustic link performance:

- Max range: 2-3km (horizontal range in water)
- Operating range when buried: TBD
- Frequency bands: 9–14 kHz (LF)
- Baud rate: 300-10240 bps

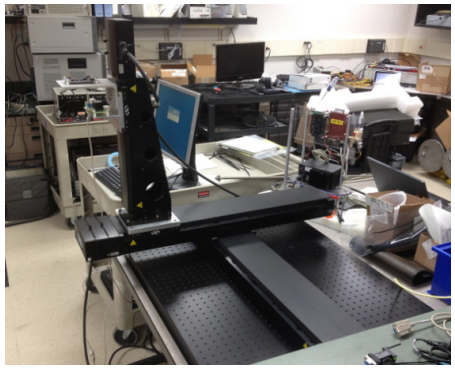
Deployment performance:

- Max length of deployment at Event Duration Transmitted:
    - 500 days at 0 hours
    - 400 days at 0.5 hours
    - 300 days at 1.0 hours
    - 200 days at 1.5 hours
    - 100 days at 2.0 hours

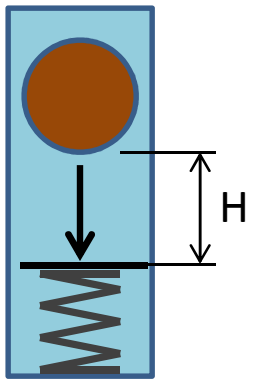
BEDs Testing

Motion thresholds and event detection

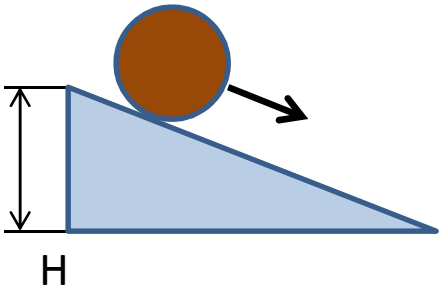
Whole assembly on X-Y stage,
Or IMU on X-Y-Z



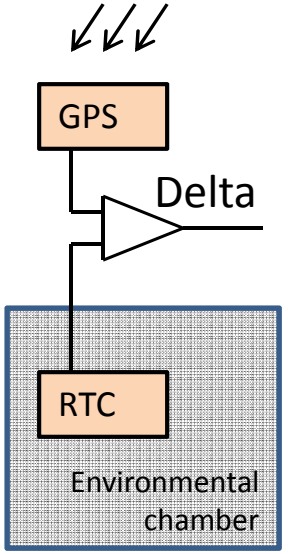
Acceleration, full range



Rotation

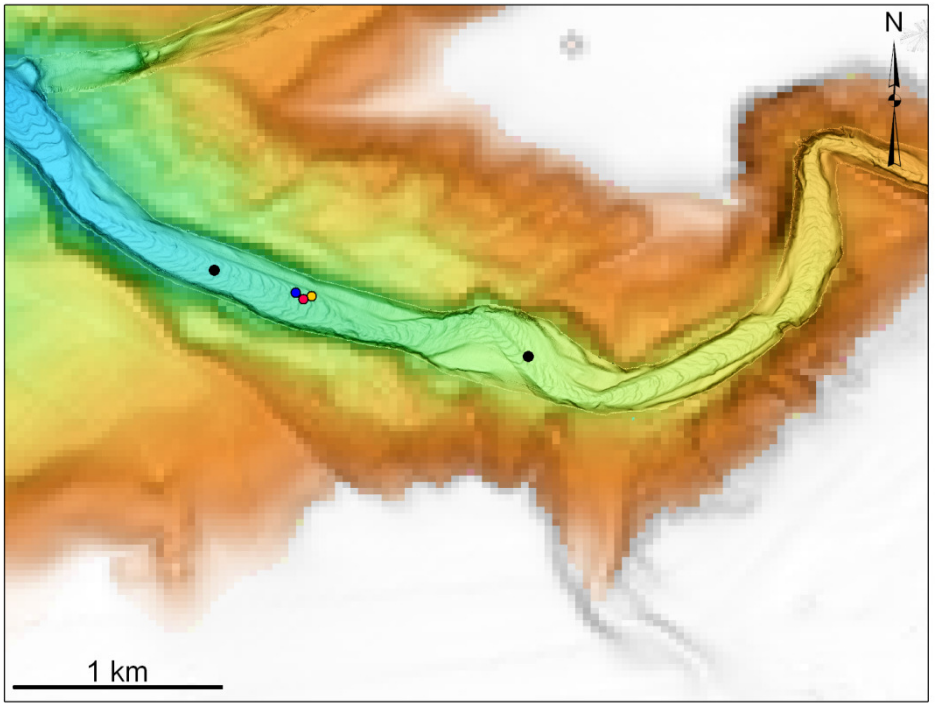


Calibration of RTC



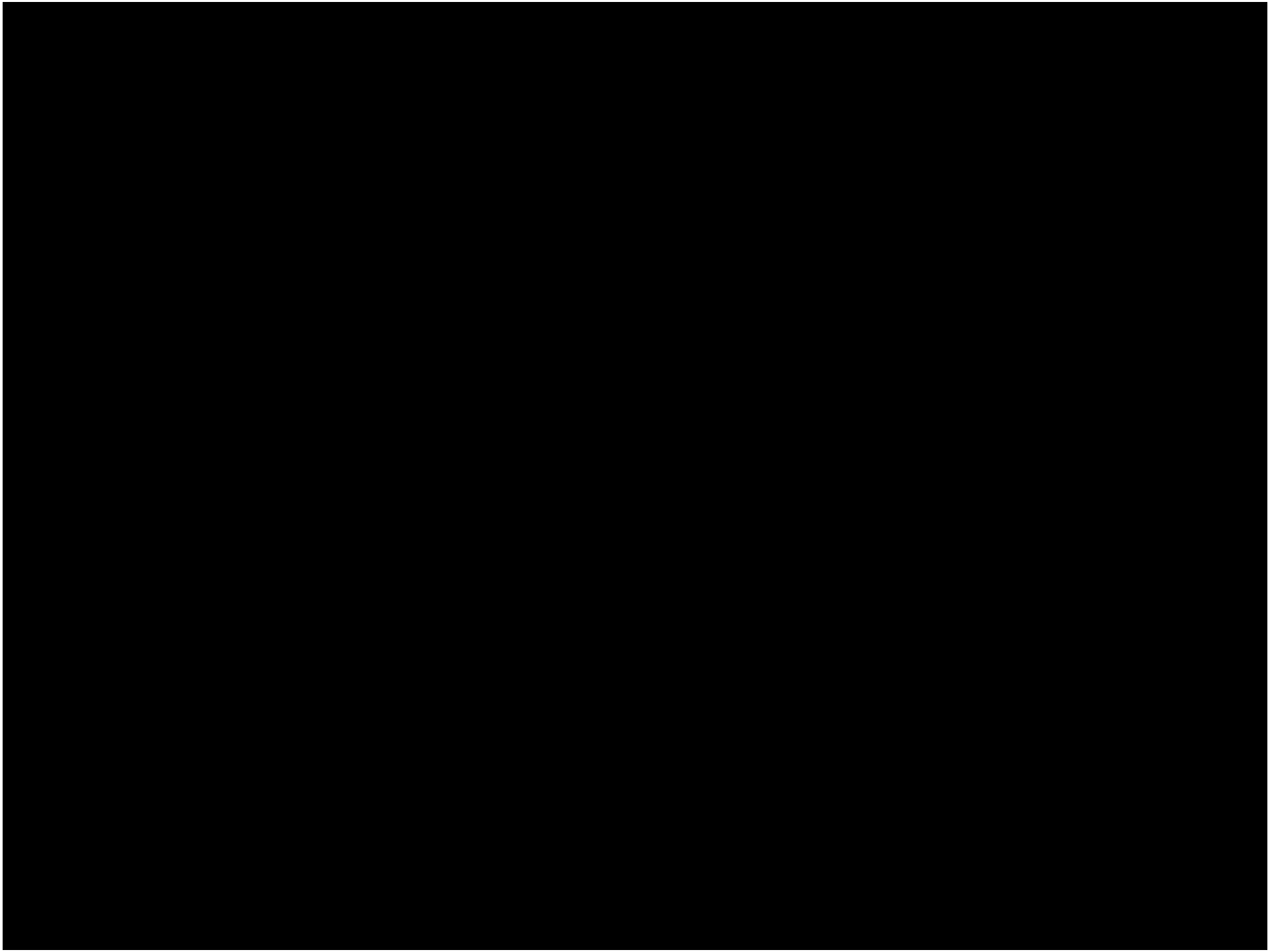
BEDs Prototype Deployment

- 250 m and 300 m test sites
- Close proximity for survey (4 km from ML harbor)
- High probability of sediment debris flows



BEDs Future Improvements

- Onboard linear displacement calculation?
- Adaptive TX power reduction?
- Adaptive baud rate?
- Acoustic frequency hopping?
- Clock drift reporting?
- Adaptive Decimation (zip?)
- Drop weight system?
- Depth in sediment layer?
- Measure viscosity/ density of sediment by vibration?
- Atomic clock



BEDs Resources & Budget

	Total Resources Assigned for each resource category	Labor YTD
EE	500	186
SE	640	376
ME	460	53
EE Tech	200	
SE Tech		
ME Tech	280	
Machine Shop	200	
Divers		
Bill	*160*	*27*
PM/SE		80
Total	**2440**	**722**

Project Number	Project Name	Budget Amount	Paid Amount	Total Commitment	Available	Percent Available
901006.00	Benthic Event Detectors	343,072	74,662	7,327	261,084	76%
901006.04	Acoustic Modem & Transduc	22,091			22,091	100%
901006 Benthic Event Detectors		**$365,163**	**$74,662**	**$7,327**	**$283,175**	**78%**