# Benthic Event Detection System

# 2011 Status Report

Program Number: 901006
Prepared By: B., Kieft
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In December of 2010 the BEDs team held a Concept Design Review[i] (CoDR) which outlined the high risk elements of the project. They are as follows:

1.) Can data be retrieved from a buried instrument?
2.) Can the motion be resolved and interpreted to provide adequate scientific data
3.) Can an event (i.e. motion versus non-motion) be detected

After encouraging tank tests and beach face test results, a test plan and procedure[ii] were drafted to test communications from a buried transducer to a top-side transducer. Divers buried the transducer 0.76m beneath the sediment off Santa Cruz wharf and the test was carried out over two days. Results were favorable with reliable data transfer rates between 1200 bps and 2560 bps at -21dB transmission power. We were further encouraged that a reliable data link would be possible after being put into contact with a company using the same modems buried 3m beneath the seafloor attached to very large anchors. The vendor (Benthos) is working to achieve data transmission to 10m beneath the seafloor and is employing a new frequency hopping signal scheme that is available to us via a firmware upgrade that was released this fall.

Satisfied for now with the results from our communication testing, the team moved on to select and begin evaluating a suite of potential sensors. Based on its accuracy, power consumption, and range of motion the sensor of choice is the ADIS16405[iii] from Analog Devices. This unit comprises a triaxial accelerometer, magnetometer, and angular rate sensors. Because the motion of sediment debris flows is thought to be complex, the BED sensor needs to accurately measure both changes in orientation and translation (i.e. linear displacement) in any direction relative to Earth coordinates. Attempting to do this for any length of time using sensors of this class will quickly result in large errors due to sensor drift and bias. However, two recent papers have provided insight for using relatively low-end IMUs derive linear displacement over short periods of time[iv] as well as the use of filter based algorithms to determine orientation[v]. We believe that due to the relatively short duration of the debris flow events we can depict the motion and intensity of these events in a way that has never been done before.

The team has moved from desktop simulation to implementing equation of motion algorithms on data obtained in the lab using the ADIS16405 sensor. One task yet to be completed though is motion event detection and sensor offset and bias calculations. Currently the team is working on both of these in post-processing to see how long we will be able to accurately depict debris flow motion. Because event detection is integral to our algorithm, we recognize that certain types of motion will go undetected – particularly slow creeping translation without changes in orientation. Based on limited data from previously studied debris flow events, this type of motion seems unlikely to be sustained during an event.

In parallel with the motion and sensor integration, initial electrical and mechanical designs were created, as well as interface descriptions for data

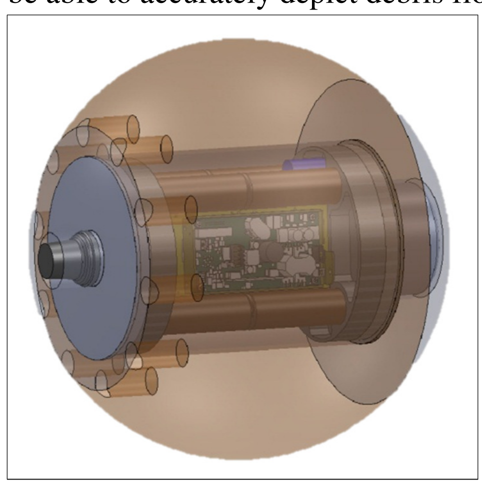

**Figure 1 – Initial Mechanical Design of BED**

transmission[vi]. Due mainly to the open-ended question on motion detection and interpretation, the team has elected to postpone the PDR until Q1 of 2012. This will allow for a more complete description of what our design can accomplish as well as its limitations. We are still planning to deploy prototype instruments on the schedule proposed for 2012 pending a favorable review at PDR. Data retrieval will ideally shed light on what type and magnitude of motion we might expect, allowing the team to adjust design prior to the CDR and the science experiment planned for 2013. While humans are currently required to retrieve data, future work could include autonomous survey and data collection from platforms such as Long Range AUV or Waveglider. This option may be explored in 2012 following the prototype deployment.

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[i] \\TORNADO\ProjectLibrary\901006.BEDS\BEDS.Documents\Project.Reviews\Project.Concept.Review\FinalSlides

[ii] \\TORNADO\ProjectLibrary\901006.BEDS\Testing\acoustic_modem_sea_test\acoustic_modem_burial_test_rev_2.0.pdf

[iii] http://www.analog.com/en/mems-sensors/imu/adis16405/products/product.html

[iv] Pfau, T., Witte, T.H. & Wilson, A.M. (2005) A method for deriving displacement data during cyclical movement using an inertial sensor.*Journal of Experimental Biology*, **208**, 2503–2514.

[v] Madgwick, S.O.H.; Harrison, A.J.L.; Vaidyanathan, R.; , "Estimation of IMU and MARG orientation using a gradient descent algorithm," *Rehabilitation Robotics (ICORR), 2011 IEEE International Conference on* , vol., no., pp.1-7, June 29 2011-July 1 2011
doi: 10.1109/ICORR.2011.5975346
URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5975346&isnumber=5975334

[vi] \\TORNADO\ProjectLibrary\901006.BEDS\BEDS.Documents\Interfaces