FEDERAL INTERAGENCY SEDIMENTATION PROJECT

IDEA FORM

Idea Title: Orientation Sensor for Bedload Sampler

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Additional Investigators: None

PI Location: Wayne State University, Department of Civil and Environmental Engineer, Detroit, MI

Introduction:
Accurate bedload sediment transport measurements are important to many aspects of waterway management. The US BL-84 bed-load sampler has been a standard sampling tool since the mid 1980's; however, there are operation limitations that affect data quality during high flow events, which is when bedload measurements are most important (Edwards and Glysson, 1999; FISP, 2000; Gray, 2012; Gray and Landers, 2015). As such, their most critical deployment is typically during highly turbulent and turbid conditions. The samplers are typically attached to a cable and are lowered into the water from the surface until settling on the bottom. In low flow, the sampler orientation can typically be viewed from above; however, high turbidity makes it impossible to see the sampler once it breaks the surface, adding uncertainty to its flight and orientation. Moreover, the turbulent nature of high flows and hydraulic-altering bridge constrictions create conditions that alter the stable descent and landing of a bedload sampler. This proposal seeks to develop an orientation sensor that can tell the BL-84 user the location and orientation of the sampler once settling on the bottom of a riverbed, which can lead to more efficient and reliable bedload data collection.

Background:
The BL-84 is a 32 lb sampler constructed of stainless steel and aluminum designed to collect bedload samples from streams of any depth (FISP, 2000 – Figure 1). The design has been carefully developed and rigorously tested to ensure both isokinetic sampling and a stable descent through the water column.

Figure 1. Image of US BL-84 bed-load sampler (Source: FISP, 2000).

Despite this testing, the sampler is occasionally subjected to hydraulics that cause the sampler to land on the bed in an orientation that is not parallel to the flow. In extreme instances, the sampler has flipped upside down or turned 180° to the flow. Various camera systems have been attached to the sampler to observe the orientation and landing; however, these have significantly altered the stable flight of the sampler and are not very useful in turbid flows. Additionally, others have designed a barrier/door for the opening of the BL-84 to prevent scooping if the sampler lands on the bed with its nose sloped down.

Purpose and Scope:
We propose to develop a waterproof, low-drag sensor that will fit on to the BL-84 and record the 3-dimensional orientation of the sampler at touchdown. This information will be stored internally and displayed on the sensor. Internal tilt-meters will be used to measure the orientation and an accelerometer will sense touchdown on the bed. Based on the main-axis orientation at touchdown, the user will be able to assess the extent to which the nozzle scooped the bed. Moreover, the departure angle from flow-parallel will be displayed, thus allowing the user to determine if the sampler was properly oriented with respect to flow. This sensor will eliminate the greatest sources of uncertainty with the use of a bedload sampler: (1) orientation and (2) extent of scooping.

Technical Requirements:
While the design of the sensor package is still in the concept design phase, it is anticipated that an Arduino Nano will serve as the microcontroller that will be interfaced with off-the-shelf tilt-sensors and accelerometers. The sensor will be enclosed in a 3D printed body that will be sealed with marine epoxy. In addition, a waterproof battery compartment will be designed into the housing with an accessible button for zeroing the orientation of the sampler in the upstream direction before deployment. In future work, we hope to miniaturize an acoustic modem to allow viewing of this data from a bridge or boat.

Deliverables:

(1) All aspects of the sensor will be open source and made publicly available on Github.
(2) Written and video instructions will be created and published.
(3) Ten sensors will be constructed and delivered to FISP for use and distribution.

Timeline:
This project will be complete in 12 months following the below timeline:

Months 1-2 - Design of sensor electronics

Months 3-5 - Design of waterproof, ruggedized, low-drag housing

Months 6-9 - Construct/test prototypes

Months 9-11 - Document/publish methods

Month 12 - Present results at conference.

Budget:
Labor (Salaries, wages, and fringe benefits): $17,575
Sensors, hardware, and materials: $6,000
Travel: $2,000
Indirect Costs: $13,810
Total: $39,385

Unique Qualifications:
The Civil and Environmental Engineering Department has a long history of sensor development and deployment in urban environmental waters and also has a long-standing relationship with the USACE Sediment and Hydraulics Lab in Detroit. The USACE Sediment and Hydraulics Lab will be supplying WSU with a BL-84 and will act in an advisory capacity during this work. The Dittrich lab also has experience developing and testing various types of sensors and 3D printed housing, and will make use of the 3D printer in the Wayne State University College of Engineering for the BL-84 orientation sensor development.

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