UTC Spotlight

University Transportation Centers Program

This month: May 2018

University of Washington with consortium members Boise State University, Gonzaga University, Oregon State University, University of Alaska-Fairbanks, University of Idaho, Washington State University

U.S. Department of Transportation

Office of the Assistant Secretary for Research and Technology

No. 122

PacTrans Researchers Develop New Techniques to Assess Rock Slopes Endangering Highways

Over the past six years, the Pacific Northwest Transportation Consortium (PacTrans) has funded a group of four researchers from three partner universities to explore innovative methods for rockfall and landslide risk assessment. The four phases of this work resulted in numerous real-world implementations. Assessing rockfall and landslide risk poses significant challenges to transportation departments (DOTs). Classical slope assessment methods are laborious, unsafe, and costly. Two key factors limiting slope assessment are inadequate data, and modern observation systems. Without baseline data and monitoring systems, analysis of changing factors affecting transportation infrastructure is not feasible.

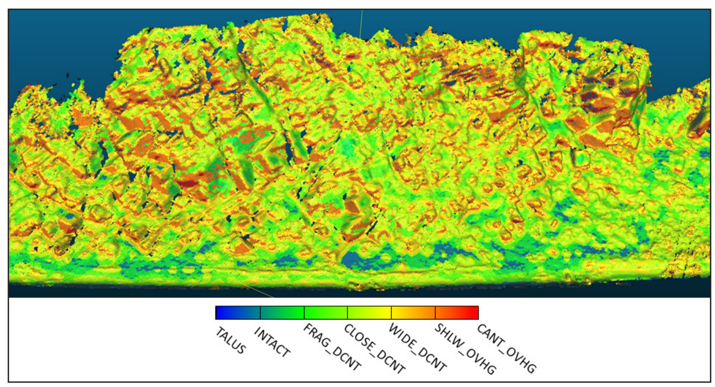
Claire Rault

Example field acquisition showing the team (Joseph Wartman (UW), Matt O'Banion (OSU), and Alireza Kashani (OSU)) deploying an unmanned aircraft system and a terrestrial laser scanner mounted to a mobile wagon platform for efficiency.

In 2012 PacTrans, matched by Alaska DOT, supported an interdisciplinary research project to collect baseline laser-scan surveys at two locations in Alaska with a long history of rockfall and landslide events. Light Detecting and Ranging (LIDAR) was used to evaluate the magnitude and frequency of rockfall activity. Scans were taken at each of the sites four times (once during each of the four phases) in a five-year period, producing a rich dataset that can be used to develop a more precise and quantifiable geohazard risk assessment.

Matt O'Banion, OSU

Structure from motion 3D reconstruction of a rock slope in Long Lake.



Michael Olsen, OSU

Example of the Rockfall Activity Index on a slope at Long Lake identifying the most precarious sections of the slope.

During the second phase of their work, the team developed a *rockfall activity index* (RAI) [Dunham et al. 2017]. The RAI is a point cloud-derived, high-resolution, morphology-based method for assessing rockfall hazards. This method has been implemented as a simple and computationally efficient algorithm, which makes it repeatable and easy to apply across rock slopes of virtually any size. The method provides an estimate of rockfall kinetic energy release along rock slope segments, as well as detailed mapping of rock slope morphology and kinetic energy release areas.

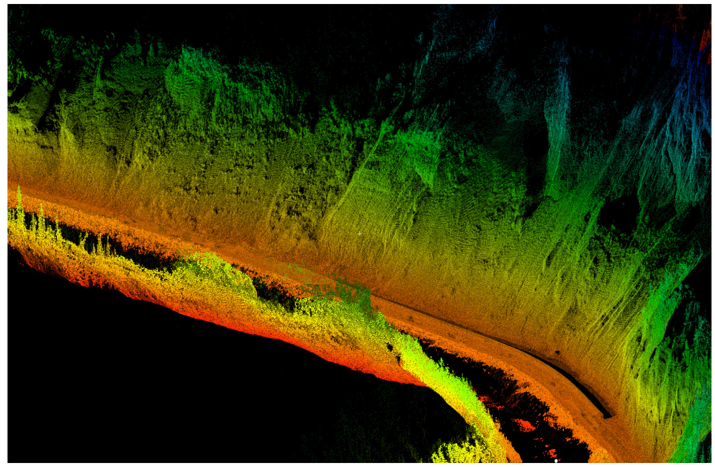
PacTrans later sponsored the team's Phase III research with a new project to evaluate the quality of additional photogrammetric data collected via UAV. The additional data helped the team develop a quantifiable rockfall and slope stability model utilizing change detection techniques to forecast future slope behavior. This research effort also provided an opportunity to test and refine the RAI system to support the point clouds acquired from drones.

The photogrammetry process, called structure-from-motion (SfM), uses motion parallax of the drone's changing position to generate detailed three-dimensional models of the slope surfaces. The drone DEM was then fused with the LIDAR DEM, effectively filling occlusions in the lidar data, while the LIDAR data helped to "control" the draping of the drone DSM point cloud.

The most recently completed phase (Phase IV) of the project compared the quantitative slope changes the team measured since 2012. Based on the repeat laser scans and the RAI approach, a framework for assessing projected rockslope activity based on changes in time-dependent classification and DTM evolution was developed, entitled the *Rockslope Evolution Framework* (REF). This prototype was used to project the potential impacts of a changing climate, in this case using temperature increase as a proxy to increasing rockfall activity. The results show the yearly RAI for a given site may increase significantly more than the observed activity rate. That is, the slow and gradual increase of activity due to climate change may result in a more significant increase in rockfall impacts.

While the prior phases of these projects were primarily focused on the PacTrans theme of safety, the research team will soon embark on the next phase of the research: exploring mobility impacts. Sustaining mobility is a significant challenge in a dynamic and mountainous setting like the Pacific Northwest, but is essential for economic activity and community well-being. Besides closure of important transportation systems, the consequences of landslide events routinely include injuries, property losses, and infrastructure damage. In this effort, the research team will utilize data-mining techniques to create a new database to relate rockfall volumes with traffic delays and road closures. This database will help DOTs better understand the impacts of rockfall on their highway networks and can be utilized to help them prioritize slopes for mitigation for effective use of limited funds.

The insights and tools developed through this research have led to additional opportunities. The research team is working with Oregon DOT to implement the RAI methodology in their workflows for monitoring unstable slopes. Oregon DOT was the first DOT to purchase a mobile LIDAR unit, and routinely scans their highways for asset management and many other purposes. This research project is also exploring ways in which the RAI can be utilized to improve the efficiency of slope assessments, minimizing the need for dangerous and expensive fieldwork.



Michael Olsen, OSU

A mobile lidar point cloud colored by increasing elevation of the slopes along the Parks Highway in Glitter Gulch.

The research team is also working with collaborators at GNS Science in New Zealand to analyze a similar dataset of repeat laser scans of rockfall activity after the Canterbury Earthquake Sequence, to yield insights on rockfall activity trends during and after major seismic events.

Finally, as a direct result of their experiences working together and investigating new technologies, Co-PI's Joseph Wartman (UW) and Michael Olsen (OSU) joined together to compete for, and win the grant to build the National Science Foundation (NSF) Natural Hazards Engineering Research Infrastructure (NHERI) Natural Hazards Reconnaissance facility (known as the *RAPID*), which provides equipment, software, and training to support other researchers collecting perishable data following natural disasters. This center greatly assists the engineering community to better understand the nature of these hazards and the associated impacts on infrastructure. The headquarters for this facility is next door to the Pactrans research office.

About This Project

These projects have been interdisciplinary and collaborative endeavors that have drawn on the respective strengths of the investigators from the University of Alaska Fairbanks (Keith Cunningham), Oregon State University (Michael Olsen and Ben Leshchinsky), and the University of Washington (Joseph Wartman). Different investigators from these institutions have been involved in the various phases of the project, bringing new and exciting ideas to expand the research possibilities. The research has also provided opportunities for students from the different institutions work together and learn from each other including PacTrans Fellow Matt O'Banion and International Exchange Student Claire Rault.