



Applications of Remote Monitoring Technologies to Geotechnical Asset Management



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Portland, Maine

Remote Monitoring for Geotechnical Assets

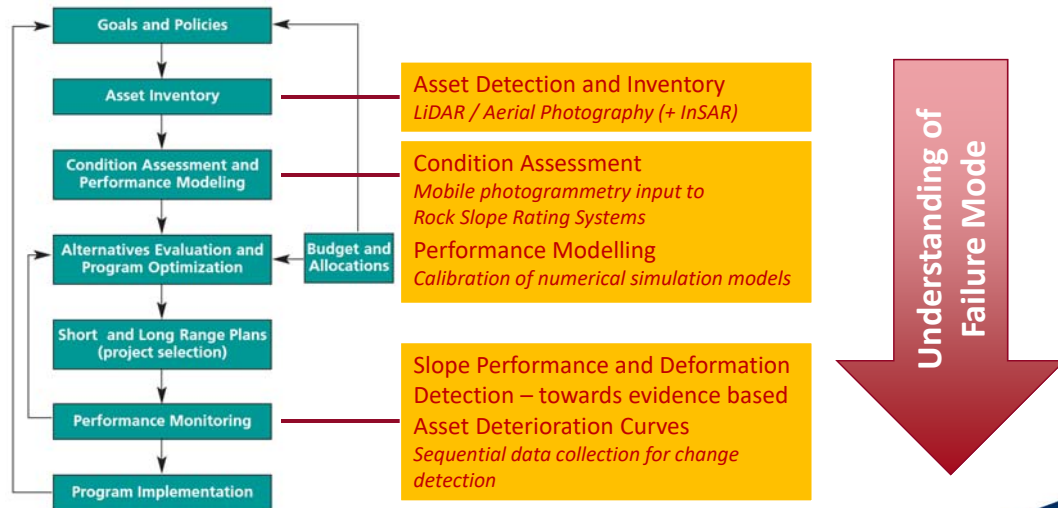


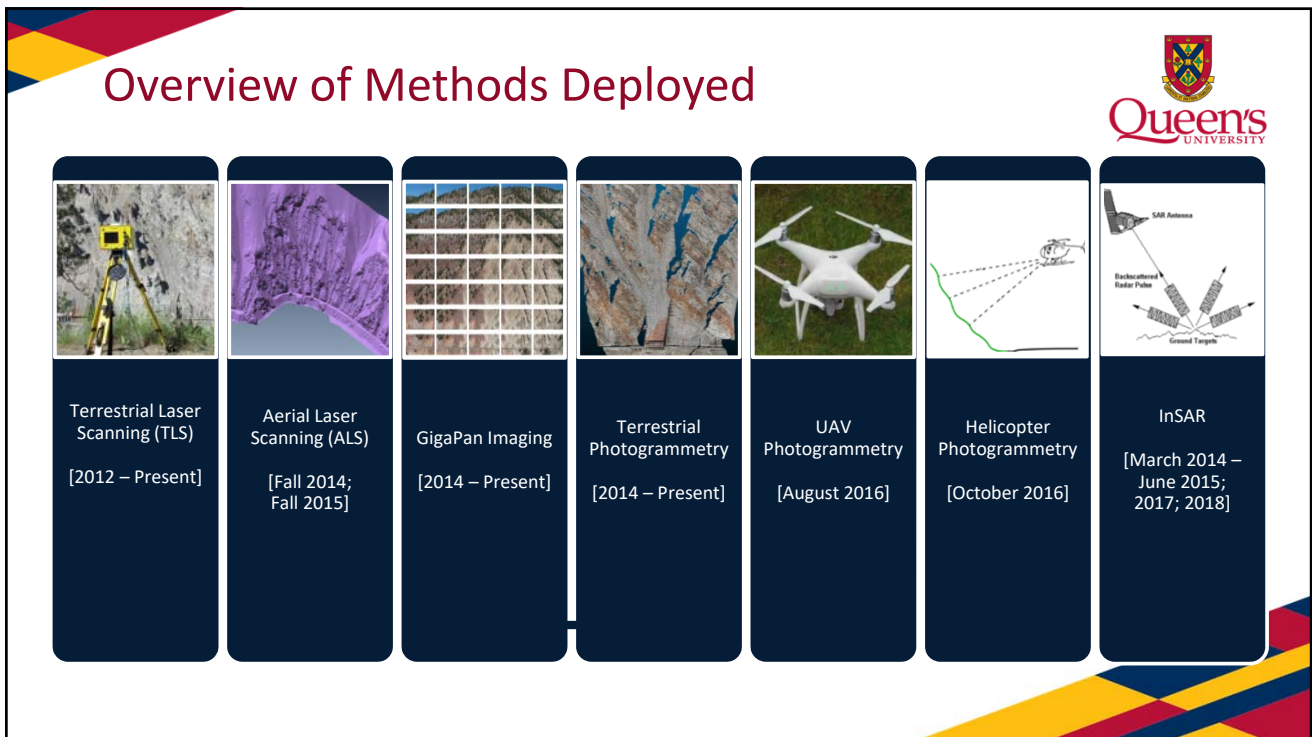
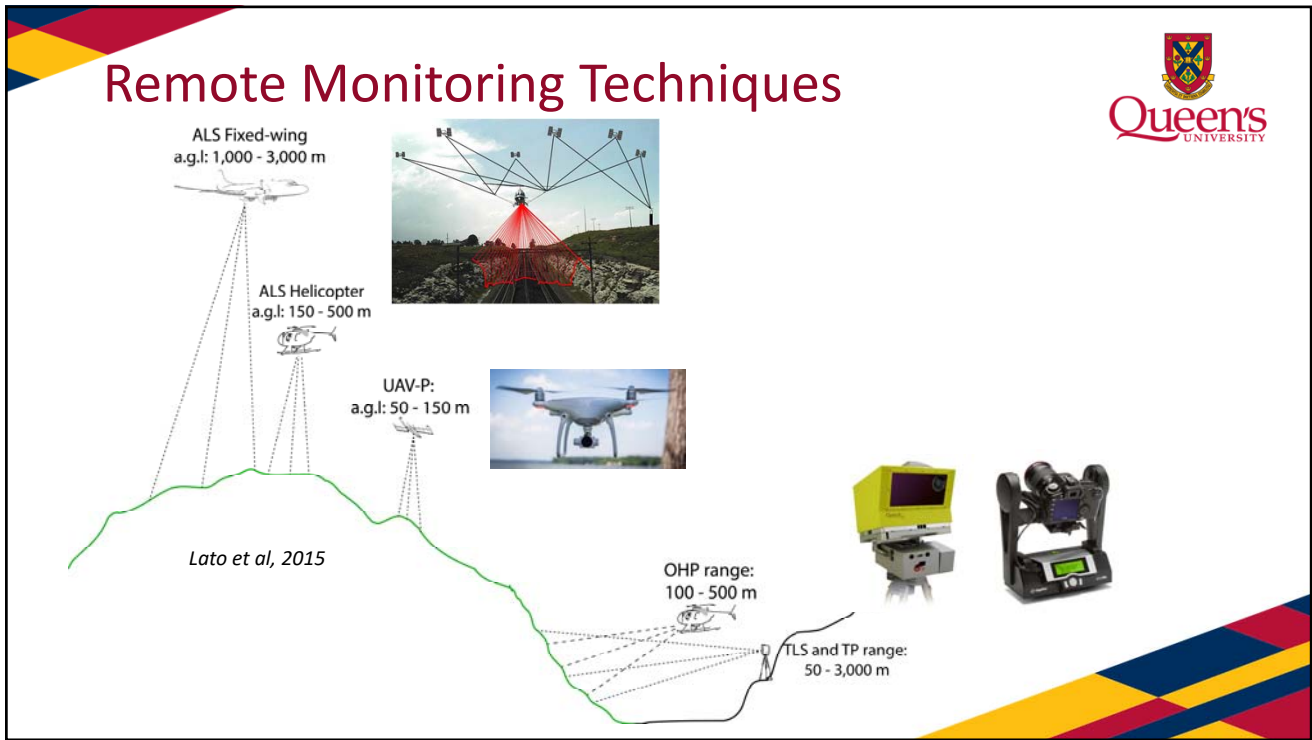
Image on left from: Stanley, D.A. 2011.
After: Transportation Asset Management Guide. American Association of State Highway and Transportation Officials, Washington, D.C., 2002.

Linear infrastructure adjacent to rock slopes

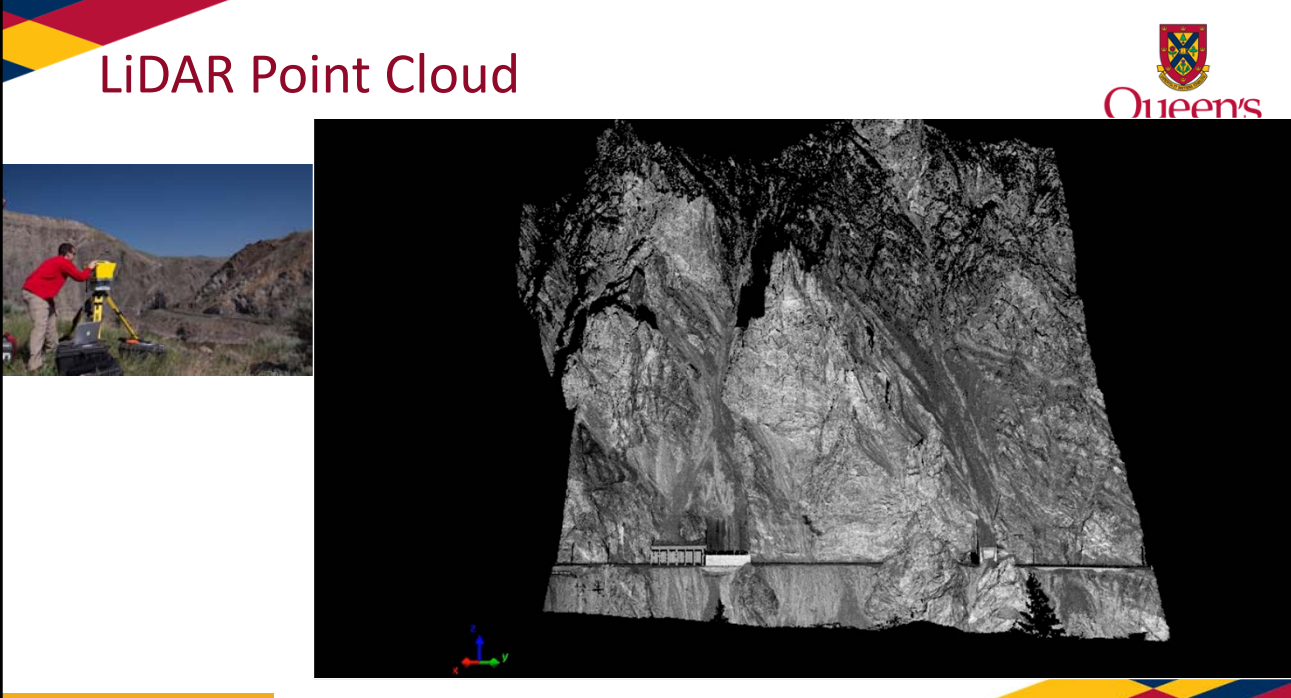


Linear infrastructure adjacent to rock slopes



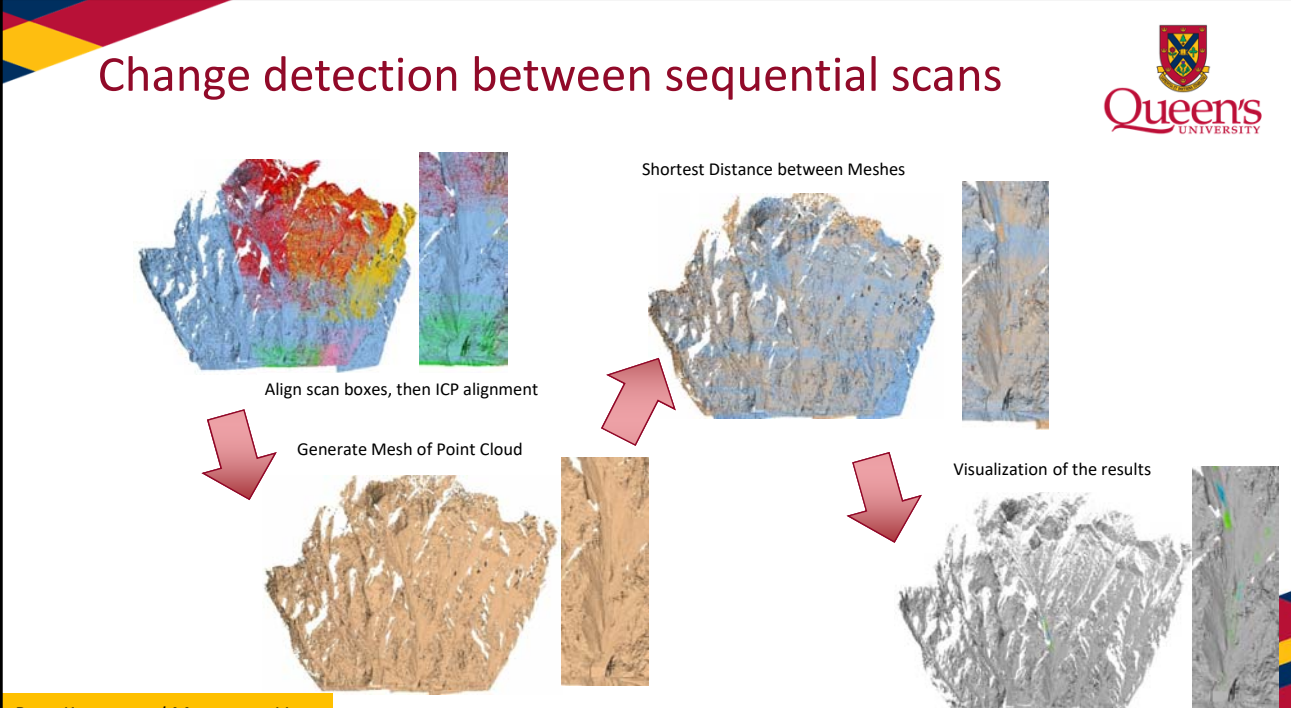


LiDAR Point Cloud



Matt Lato and Ryan Kromer

Change detection between sequential scans



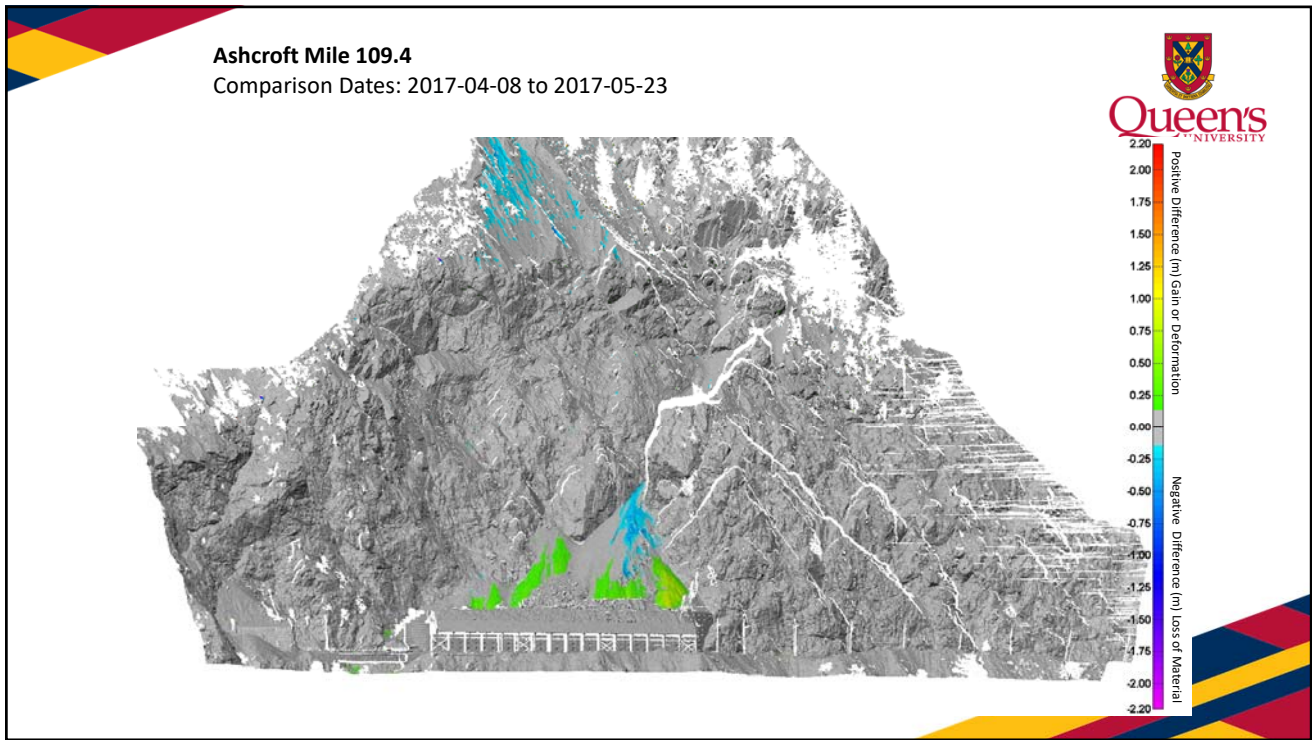
Align scan boxes, then ICP alignment

Generate Mesh of Point Cloud

Shortest Distance between Meshes

Visualization of the results

Ryan Kromer and Megan van Veen



GigaPan Imaging

Queen's UNIVERSITY

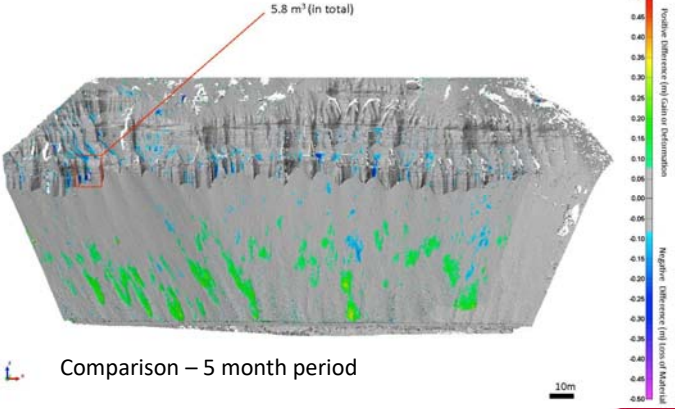



GigaPan

Gigapan example

van Veen et al, 2015, 2016 & 2017

Change detection from 3-D models

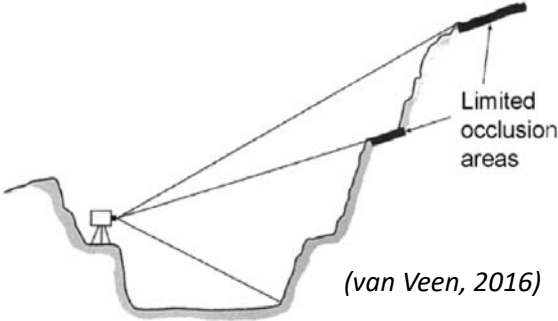

Feature observation from GigaPan



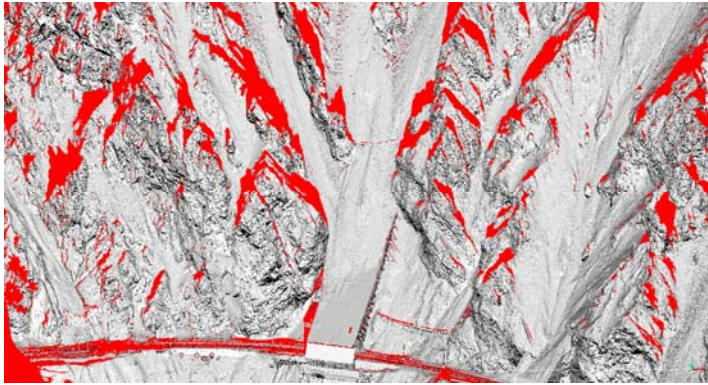
Comparison – 5 month period

<http://gigapan.com/galleries/11447/gigapans/183644>

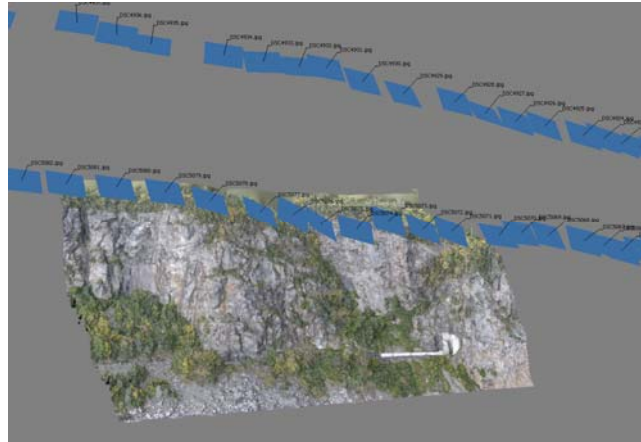
Occlusions in Terrestrial Remote Monitoring



(van Veen, 2016)



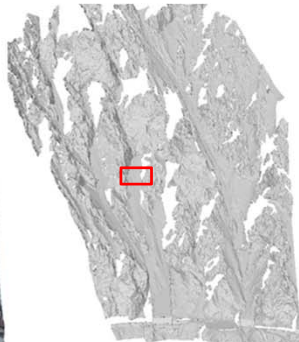
Solution = Aerial data collection



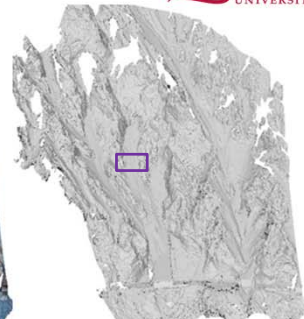
Photogrammetry revolutionized by Structure From Motion processing – Agisoft PhotoScan

Gauthier et al, 2015

Photogrammetry



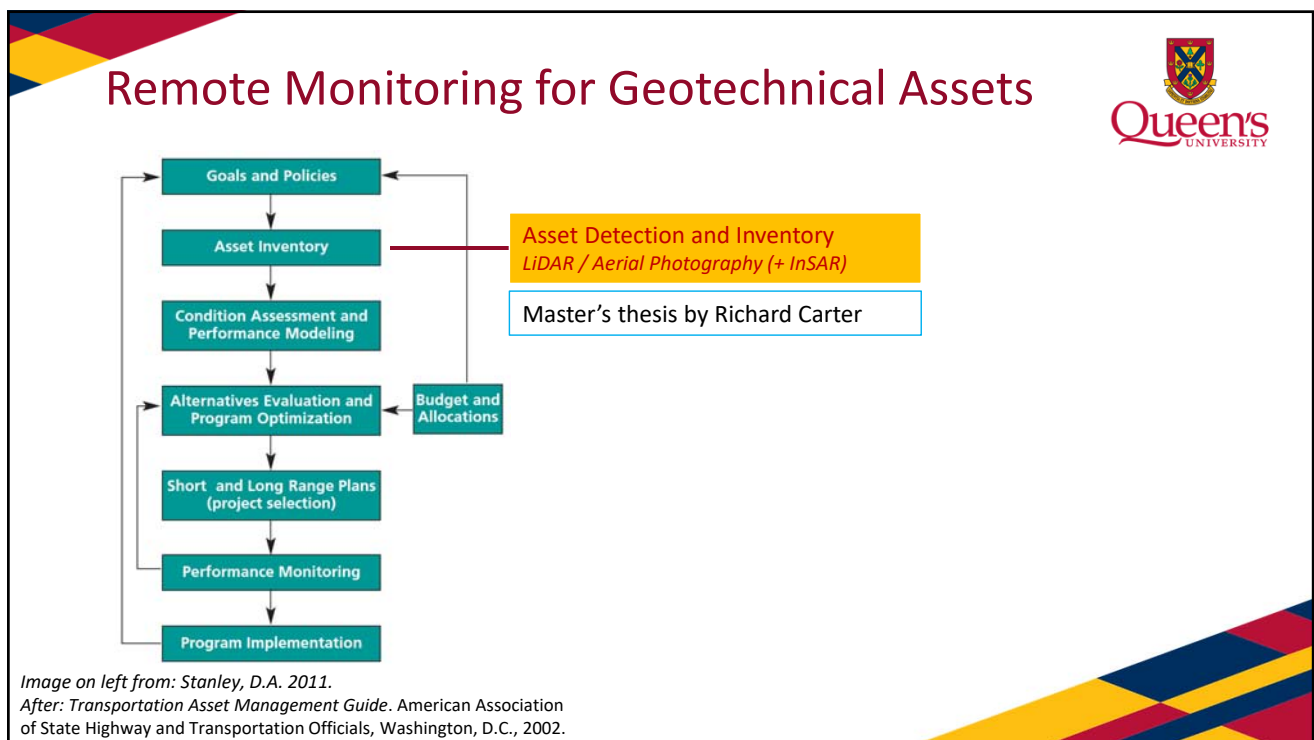
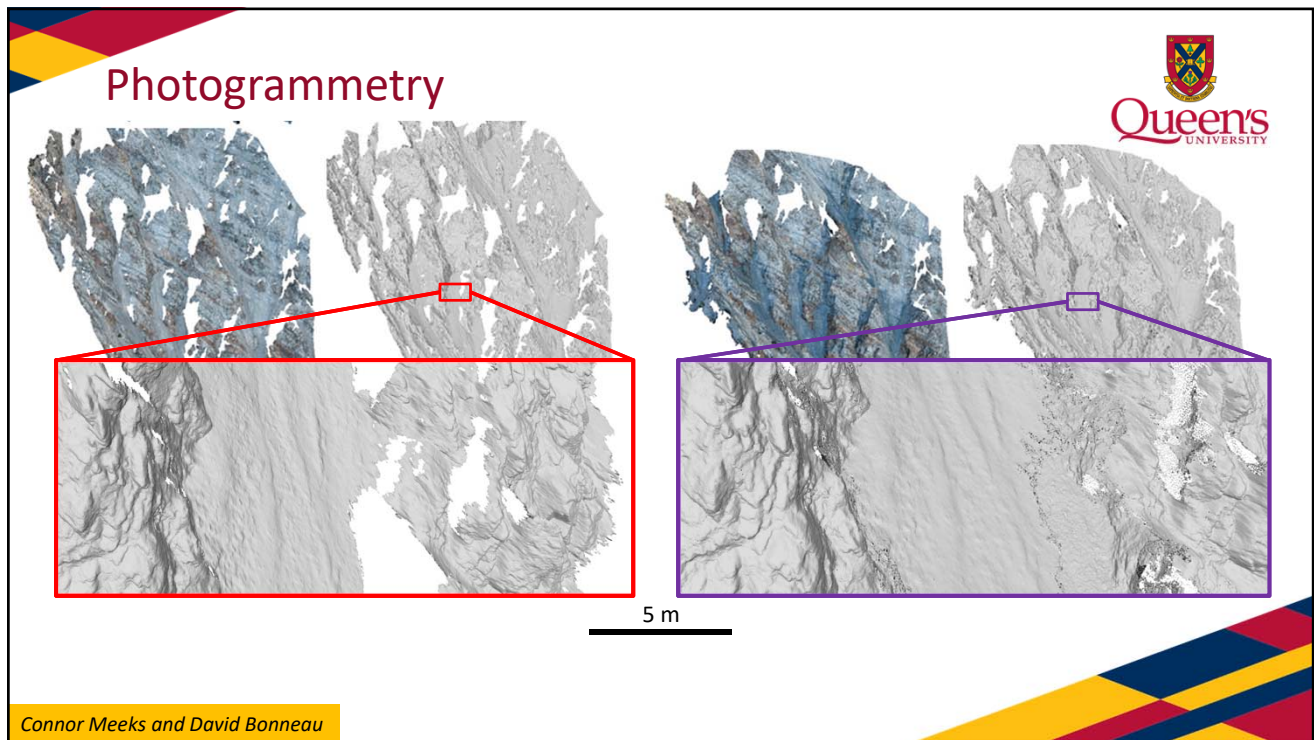
Terrestrial

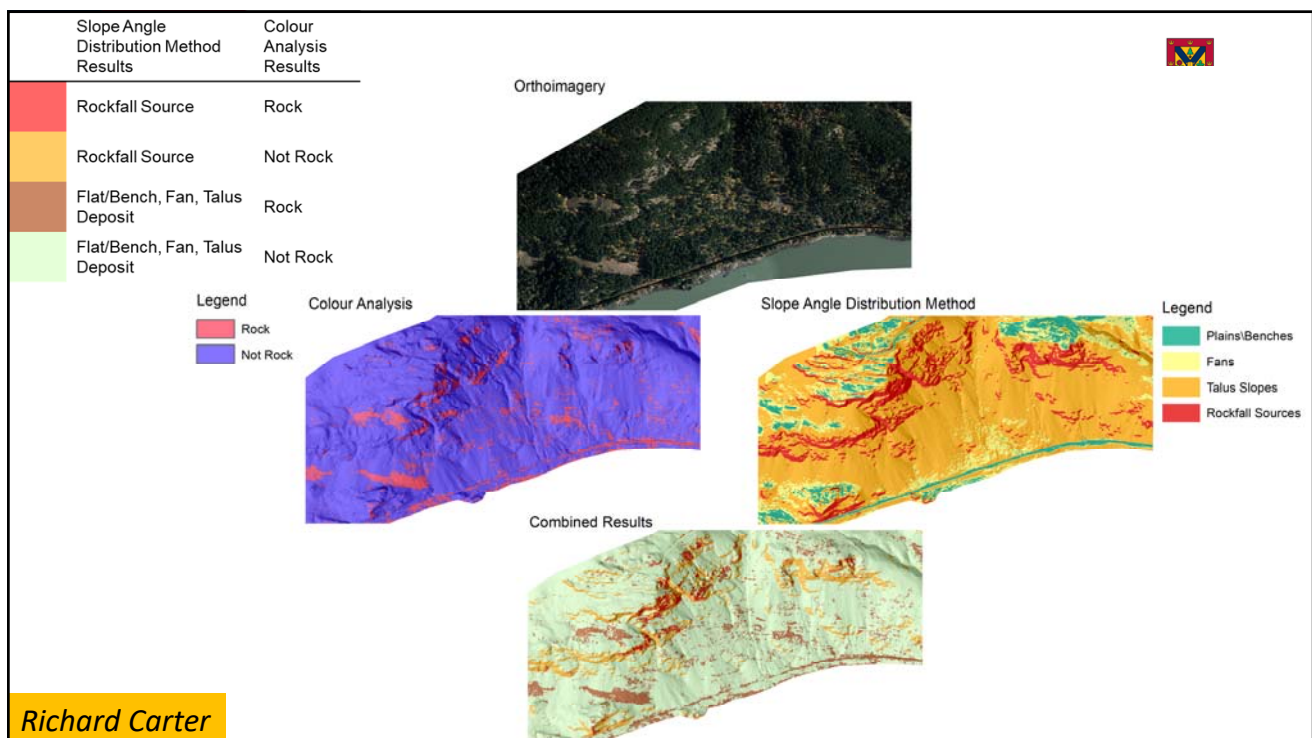
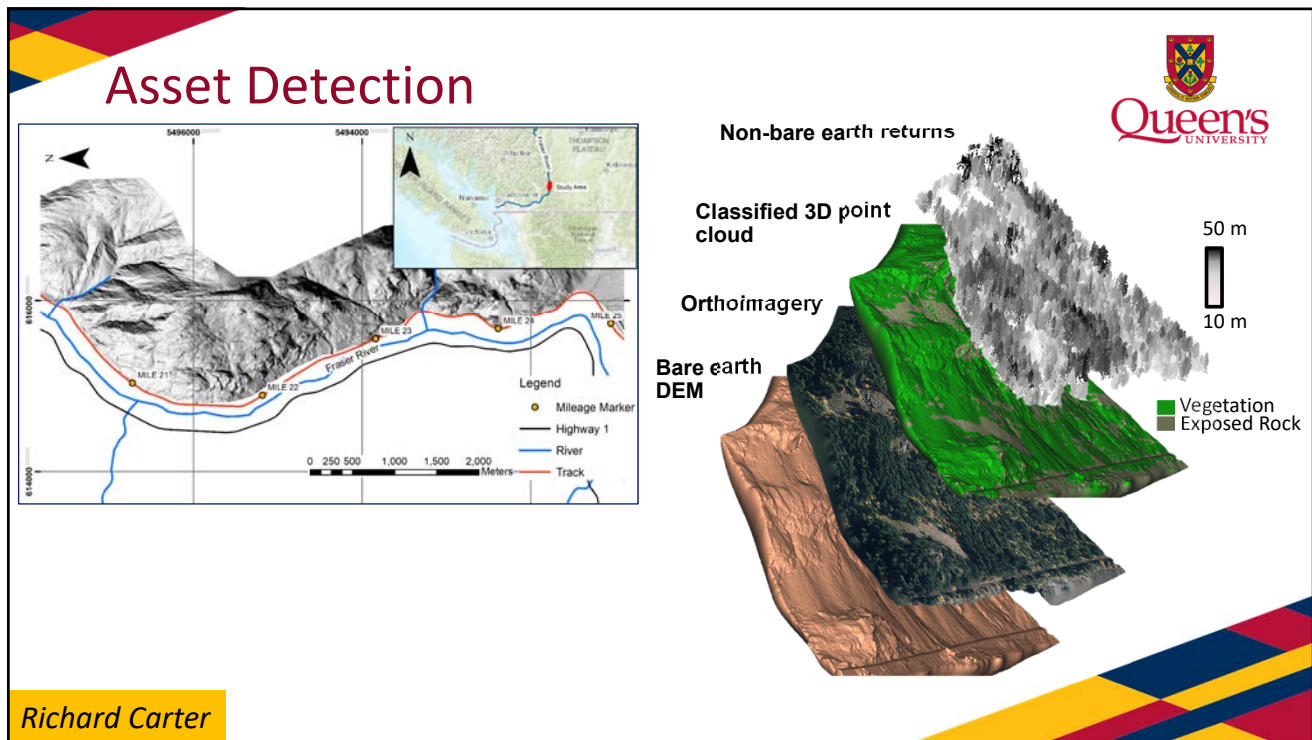


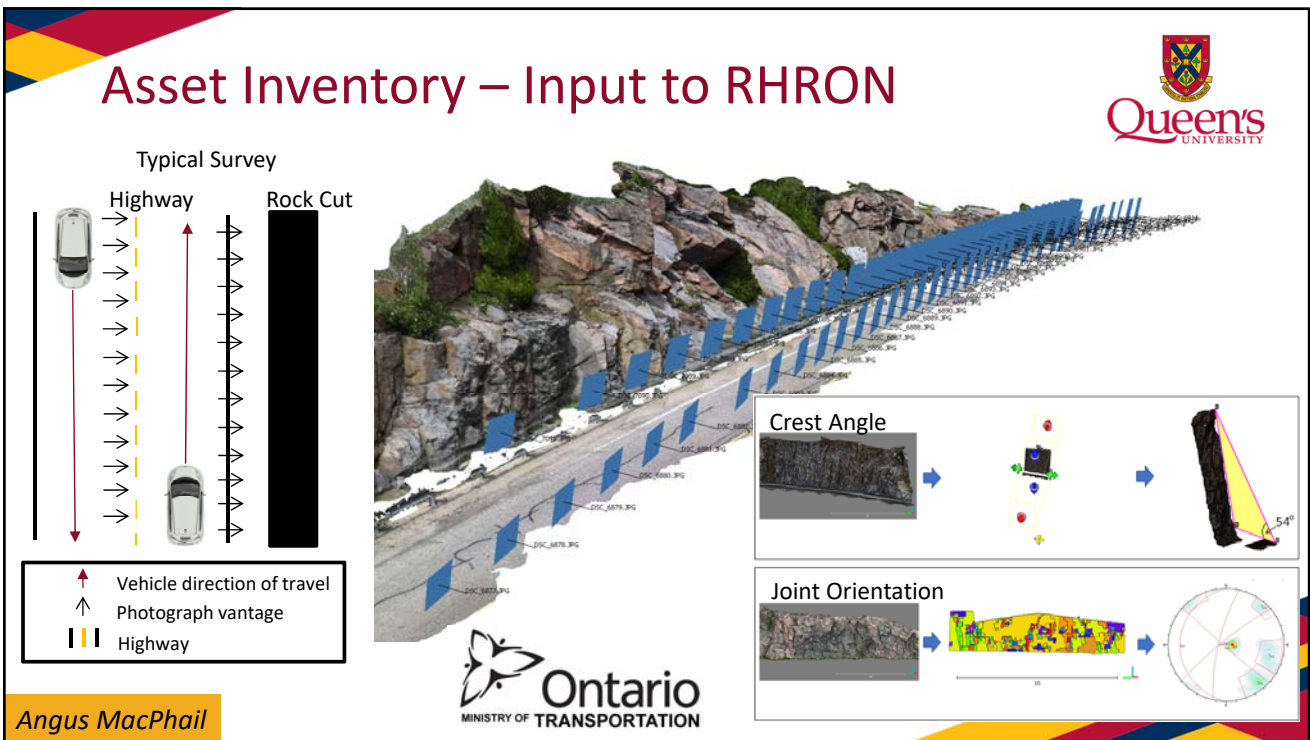
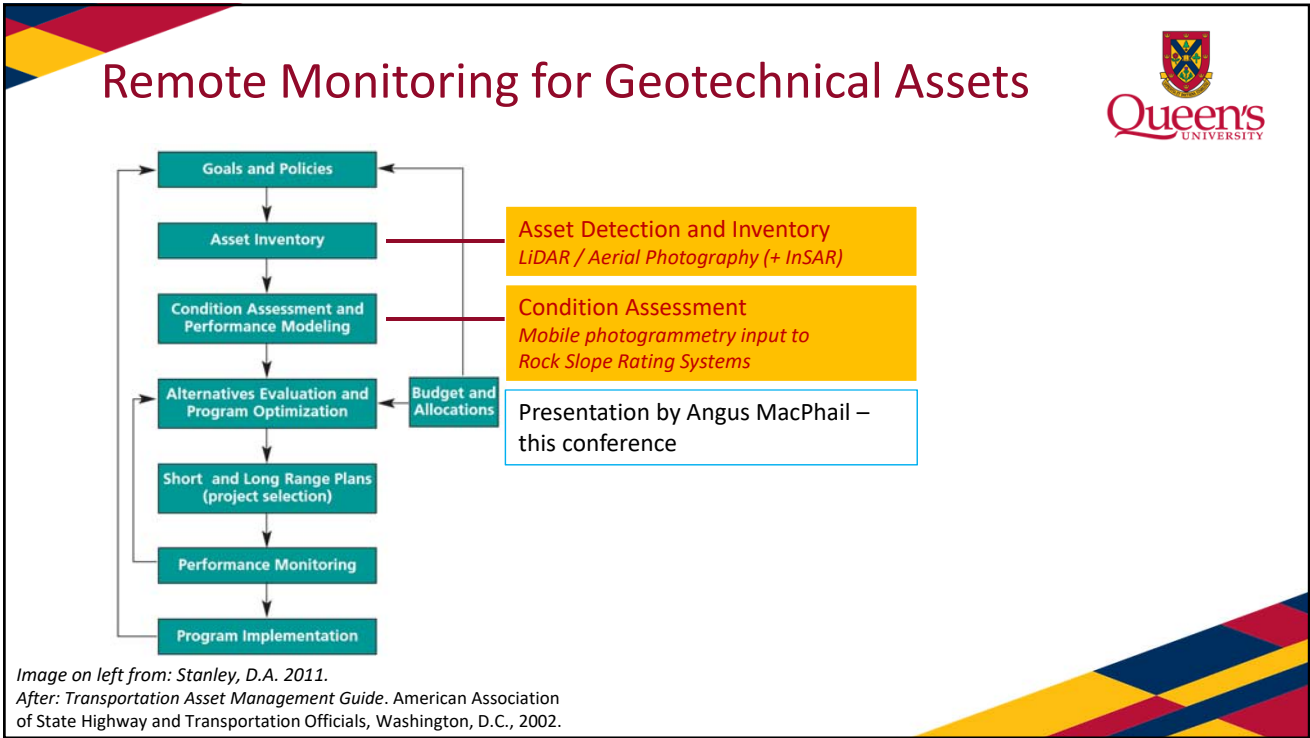
Terrestrial + UAV

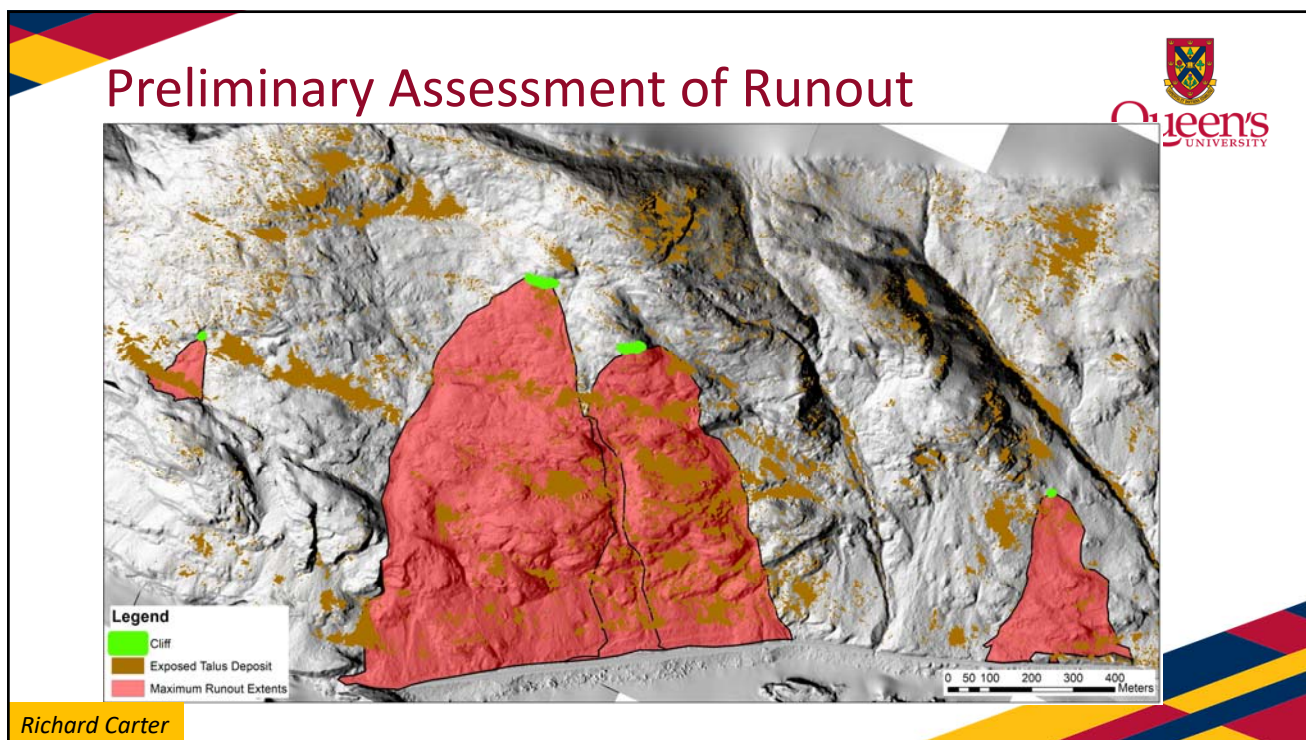
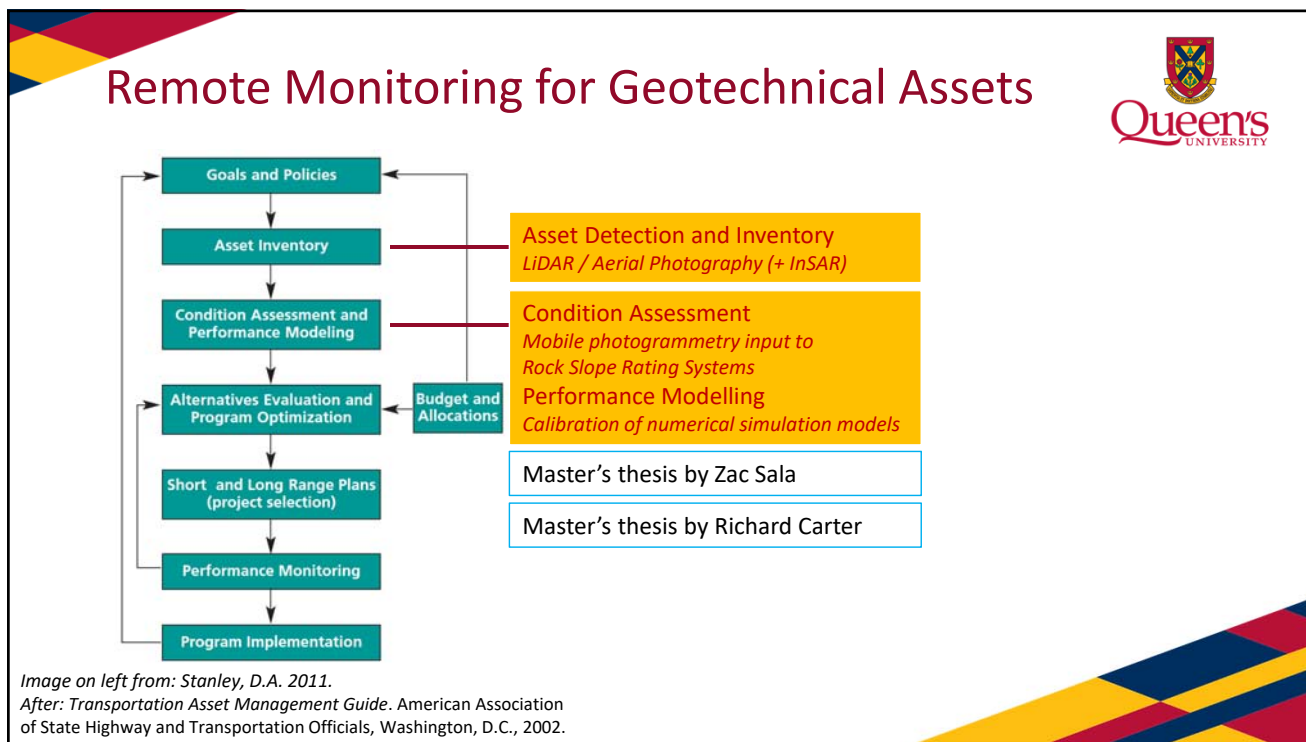
75 m

Connor Meeks and David Bonneau



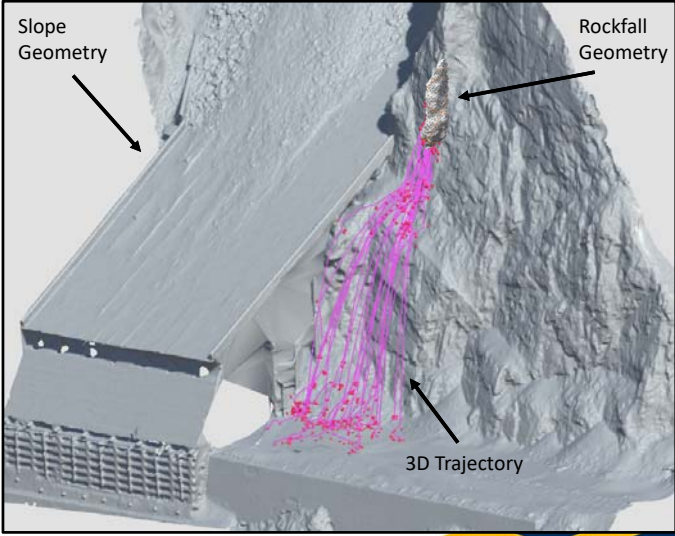







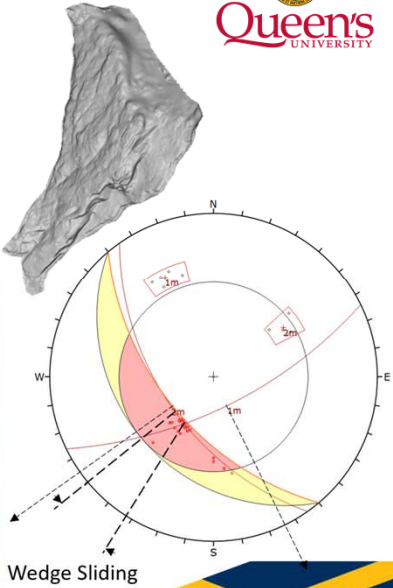
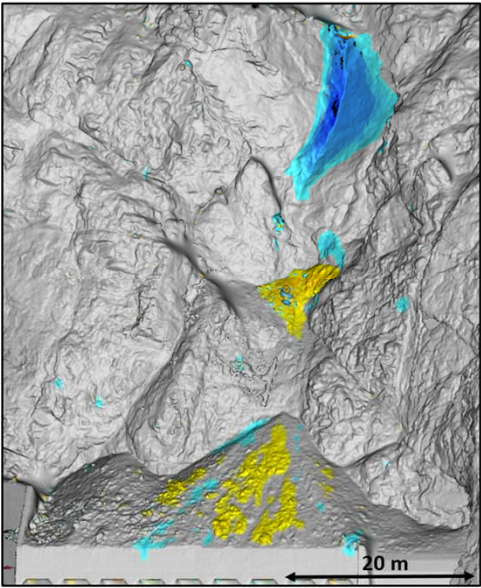



Game Engine based simulation

- Built-in physics (NVIDIA PhysX)
 - Iterative rigid body solver
 - Bouncing, rolling, sliding
 - Multi-body interaction
 - Supports 3D Meshes
- Intuitive development environment
 - Modular and object-oriented
 - Fully scriptable (C# or JavaScript)
 - Freely available
 - Supported by large community of developers

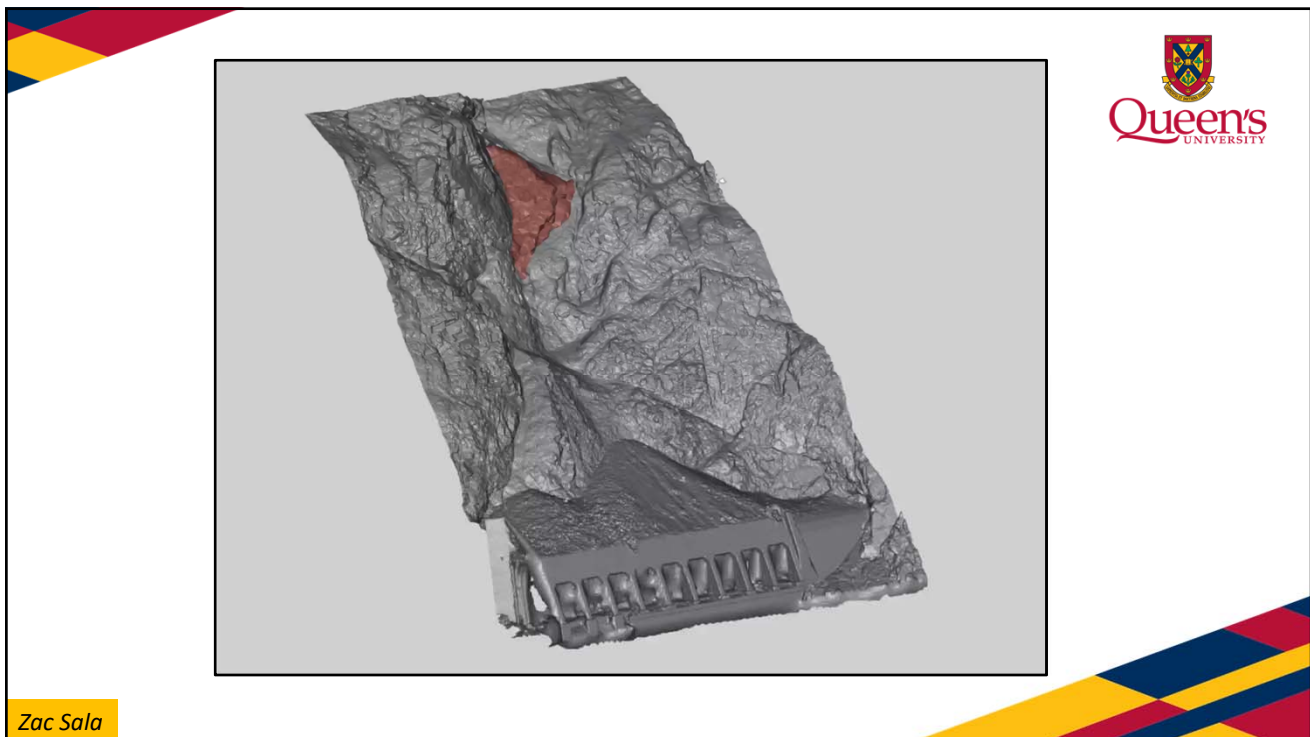
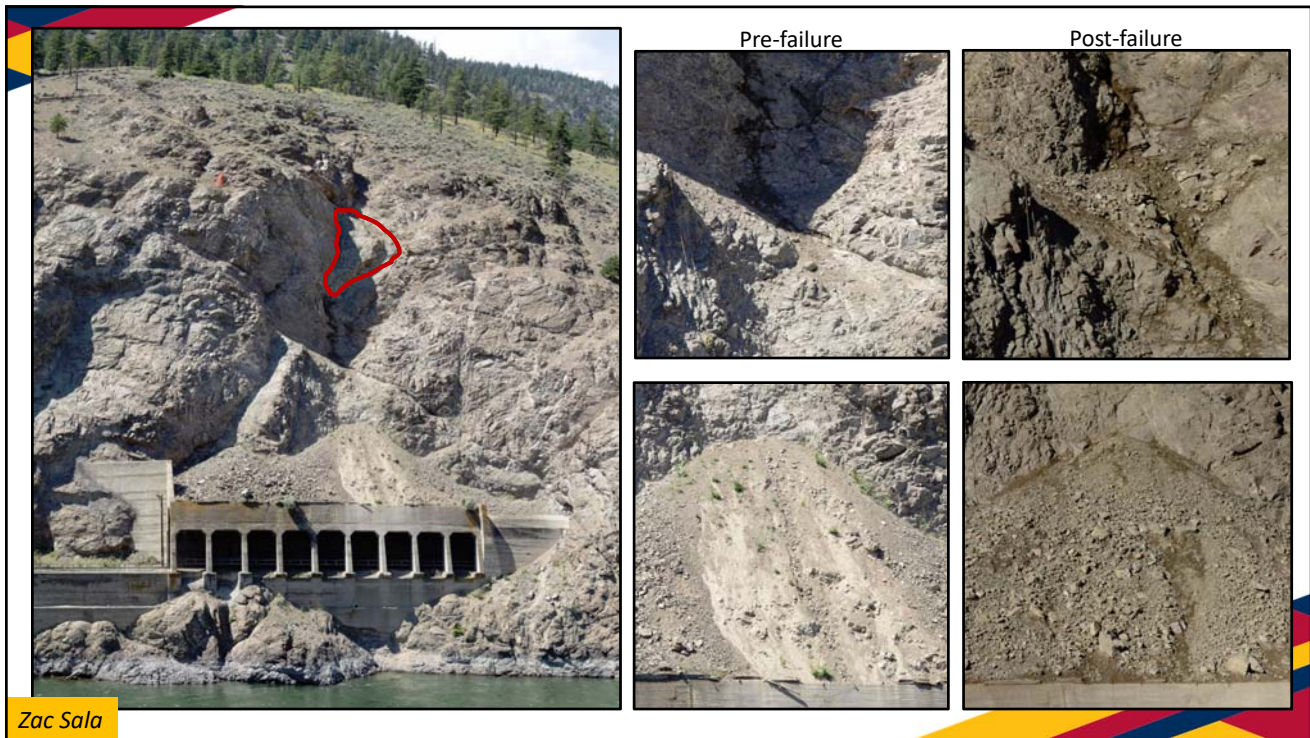


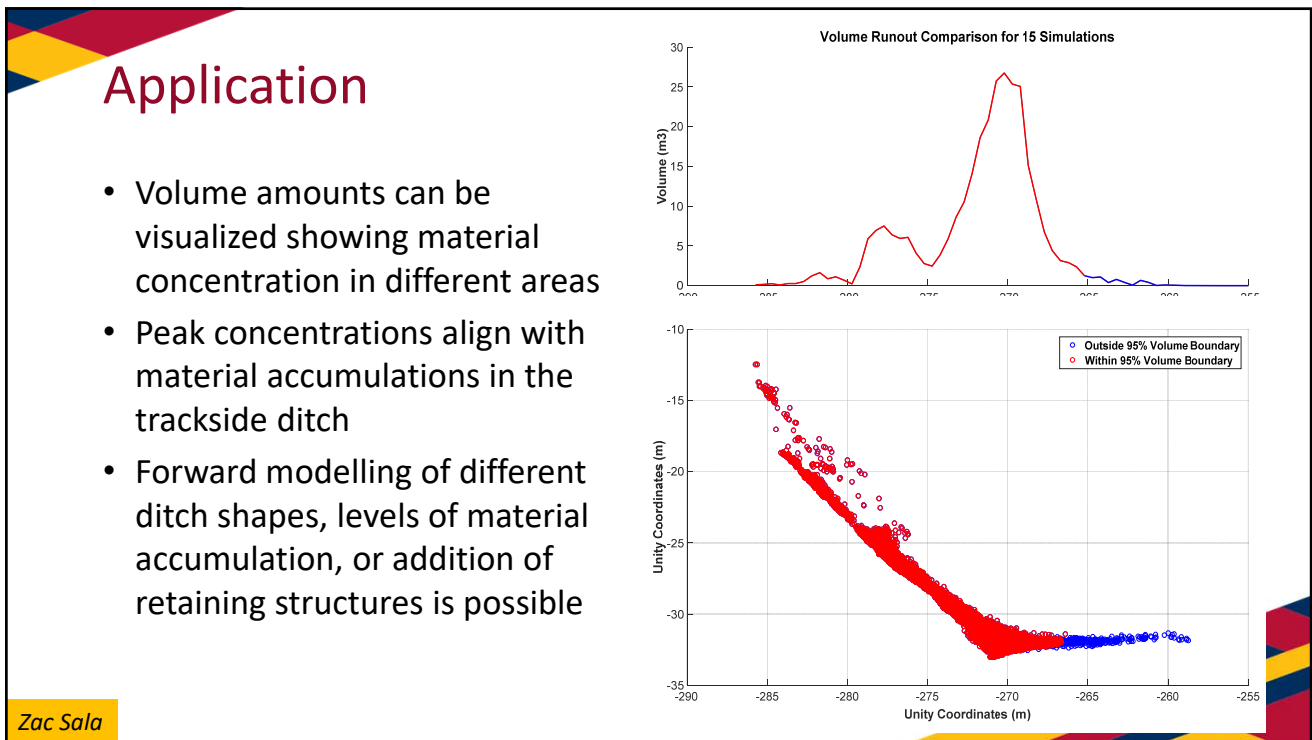
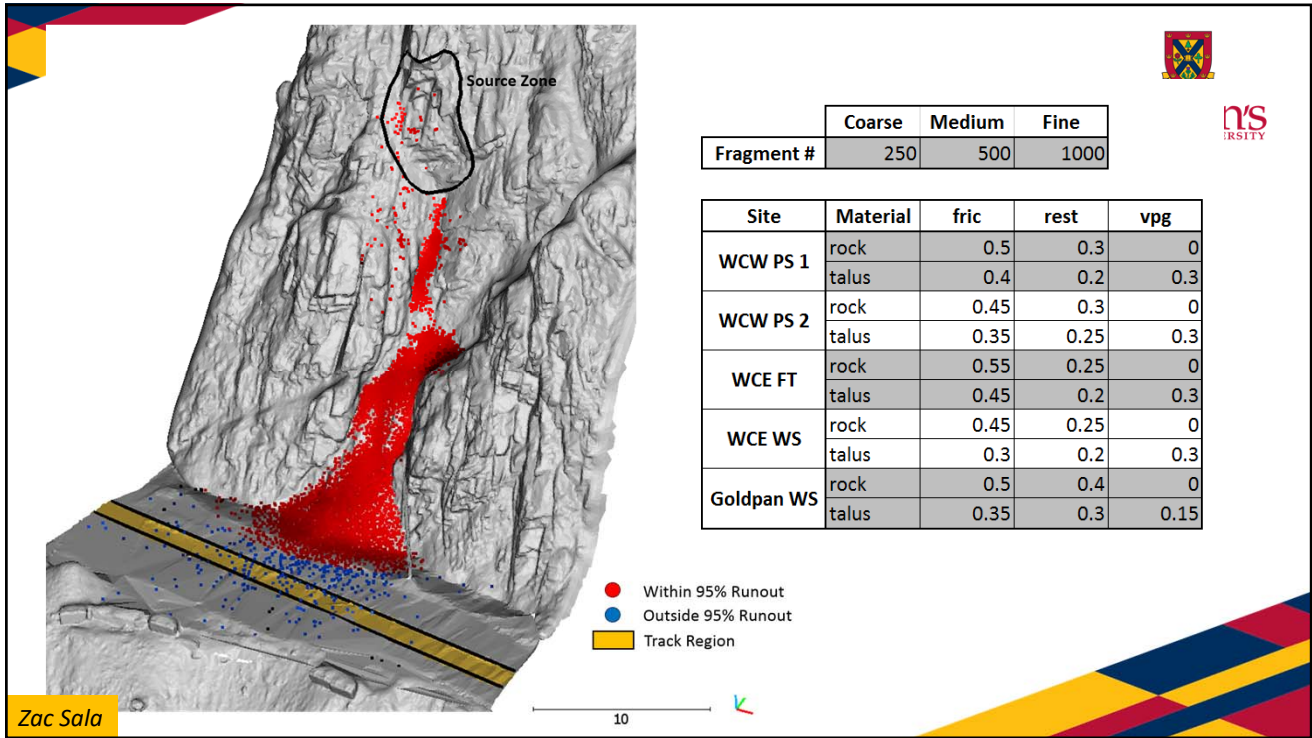
Zac Sala

Goldpan 170 m³ Failure



Zac Sala







Remote Monitoring for Geotechnical Assets

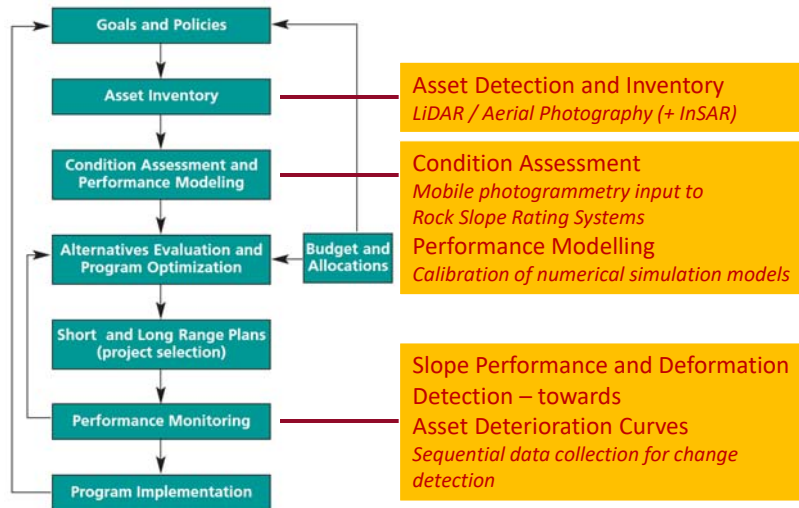
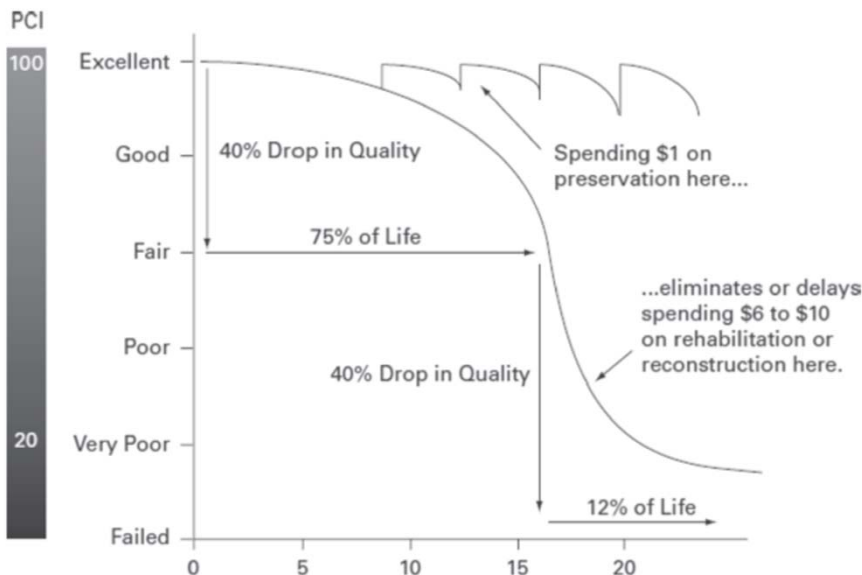


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Asset Deterioration – e.g. Pavement



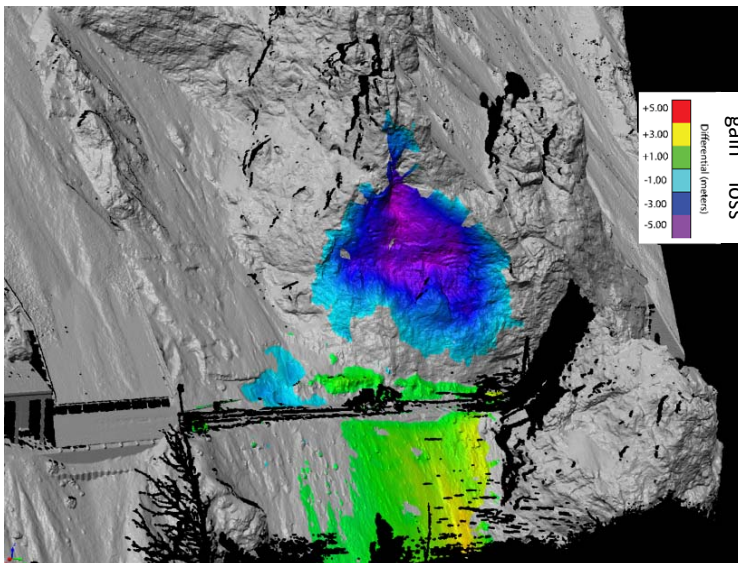
From: Anderson and Rivers, 2013

Asset Deterioration Curves – Rock Slopes



- Are pre-cursor movements / failures detectable?
 - Frequency of data collection vs rate and style of movement of slope
- Is the failure mode understood?
 - Expected behaviour? Detected behaviour? Failure thresholds defined / definable?
- Are effects of maintenance / improvement understood?
 - How much 'reset' occurs? Failures do not 'recur' – what can we learn from case histories?
- Added dimension of in-slope monitoring / effect and deterioration of support systems should also be considered.

Pre-cursor detection? Back analysis

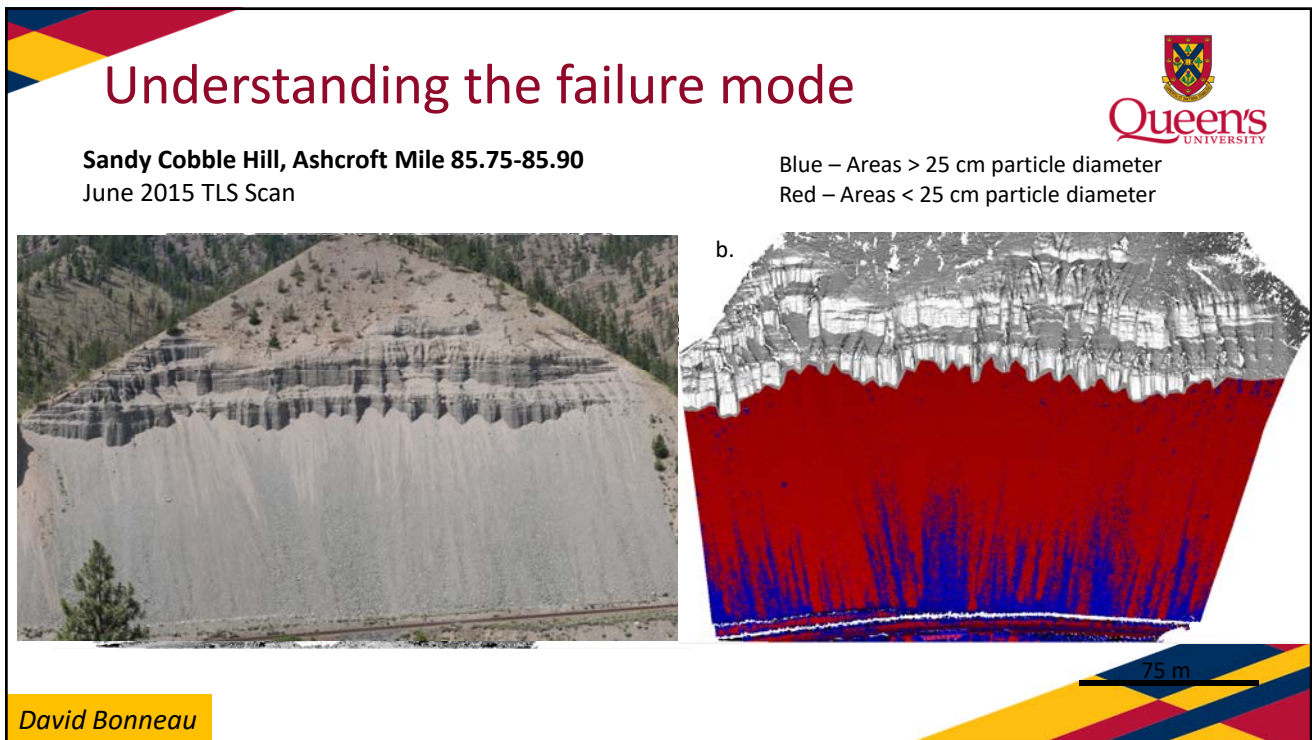
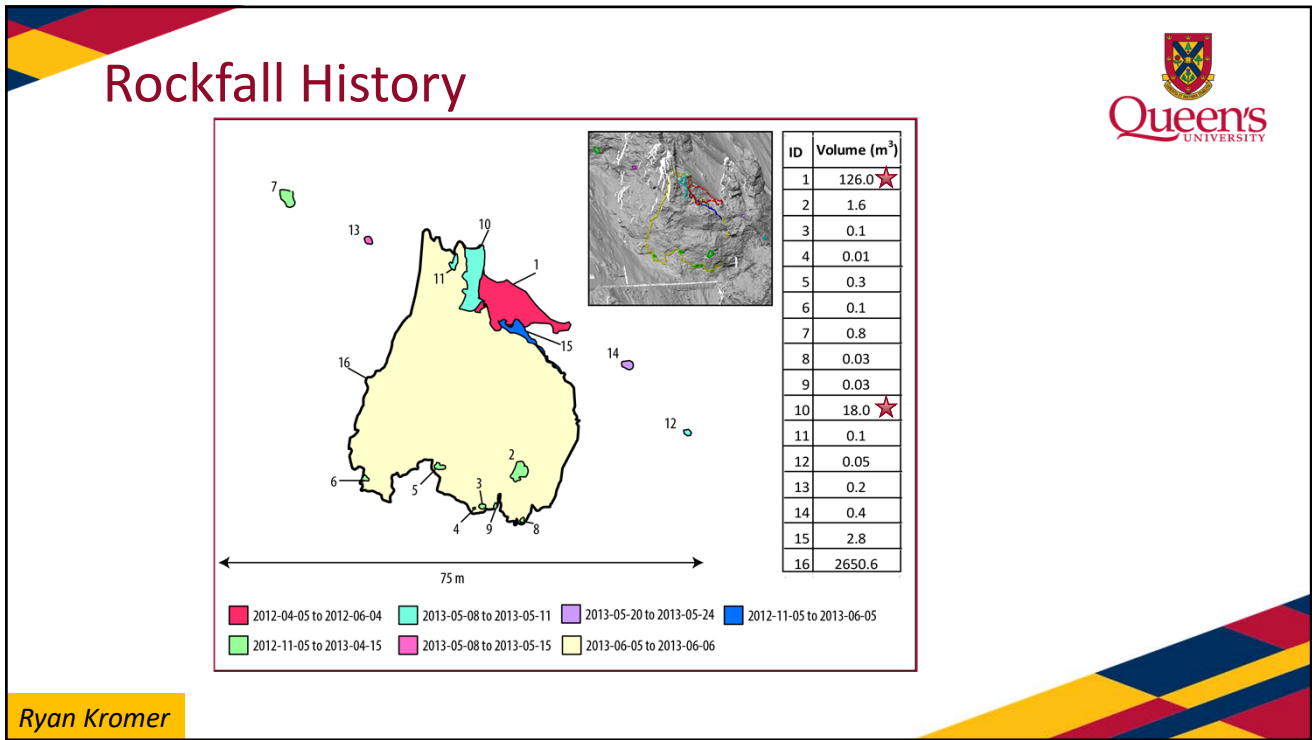


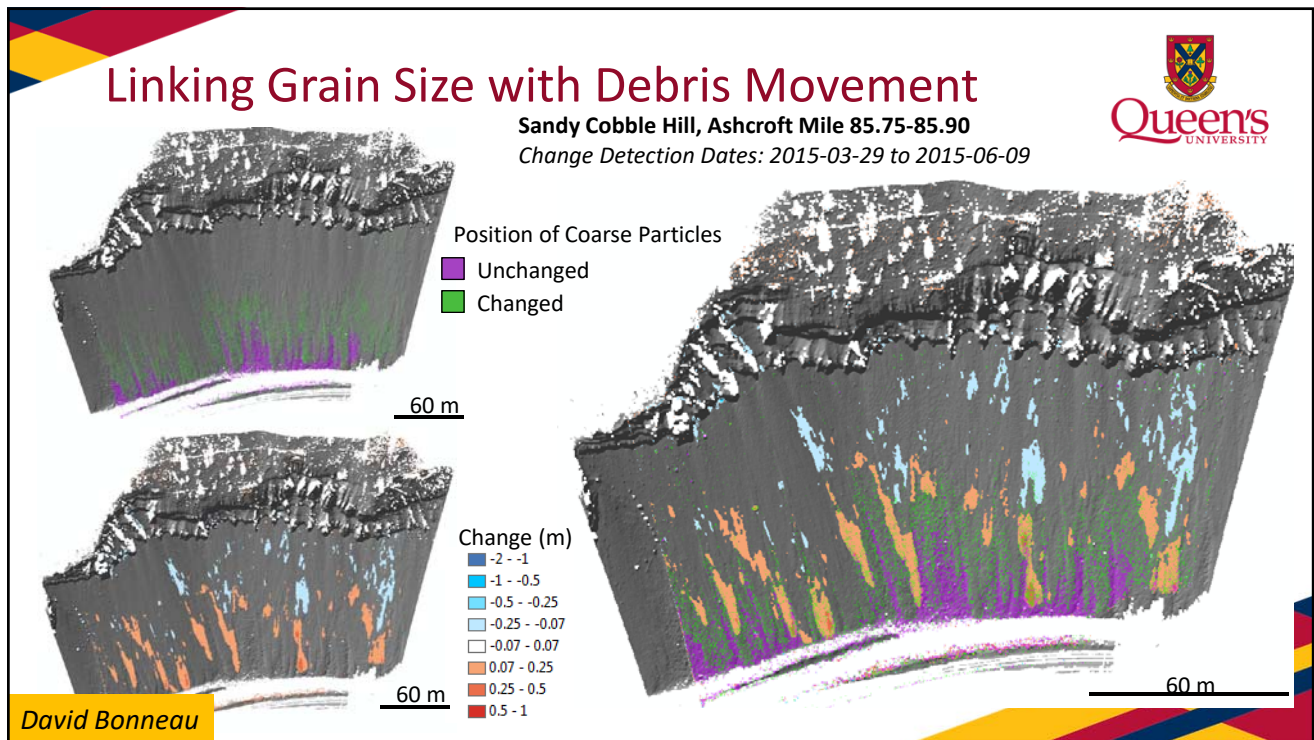
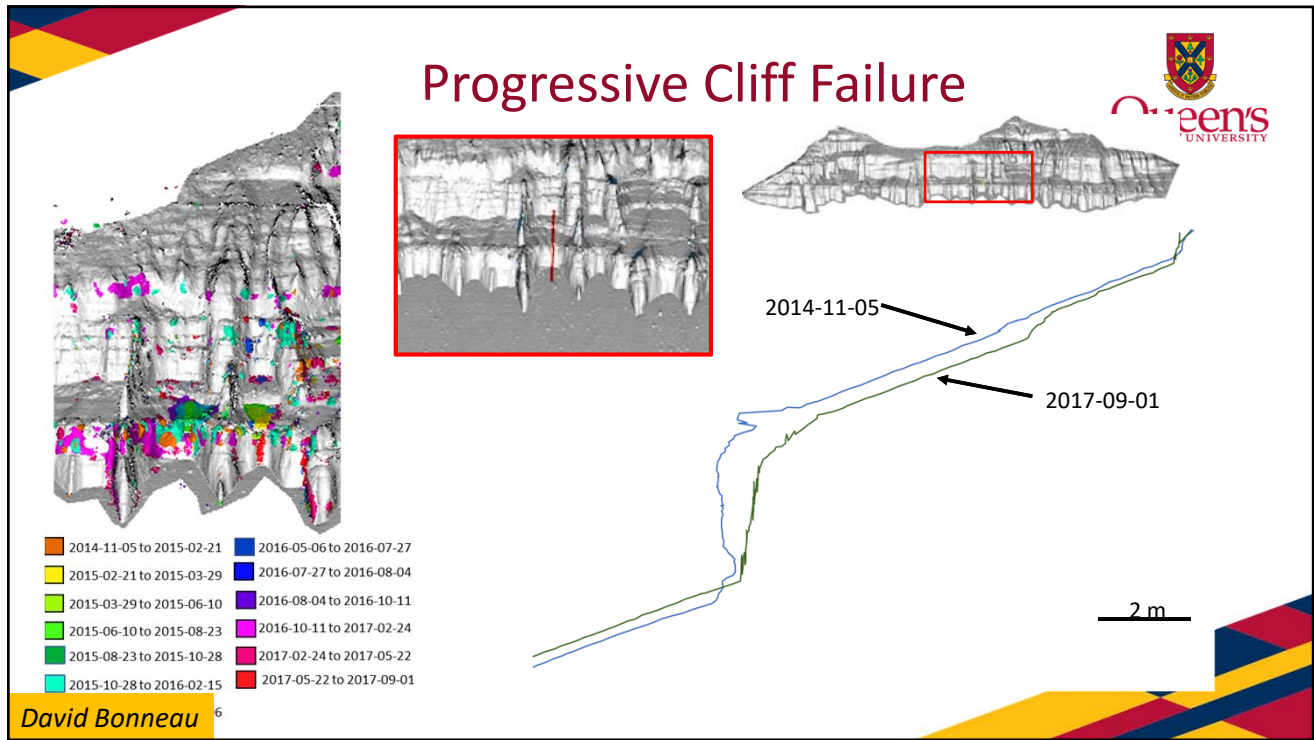
Dave Gauthier



Photo by Tom Edwards

2600 m³ failure, night, June 2014





Rockfall Database Development

Data Collection

→

Processing

→

Analysis

5m

3.9 m³ Rockfall

32.6 m³ Rockfall

From LIDAR

From Photos

Rockfall Database

- Scan Interval (time)
- Rockfall location
- Rockfall magnitude
- Expected/observed structure and failure mechanism
- Source zone lithology
- Rock quality estimate (GSI)

Megan van Veen

Extracting rockfall data

Data Set A

Change from A to B

Change from B to A

Two datasets, A and B aligned and cleaned

Filter out change: Less than -0.05 m for A to B
Greater than +0.05 m for B to A

Merge two datasets to form complete rockfall shapes

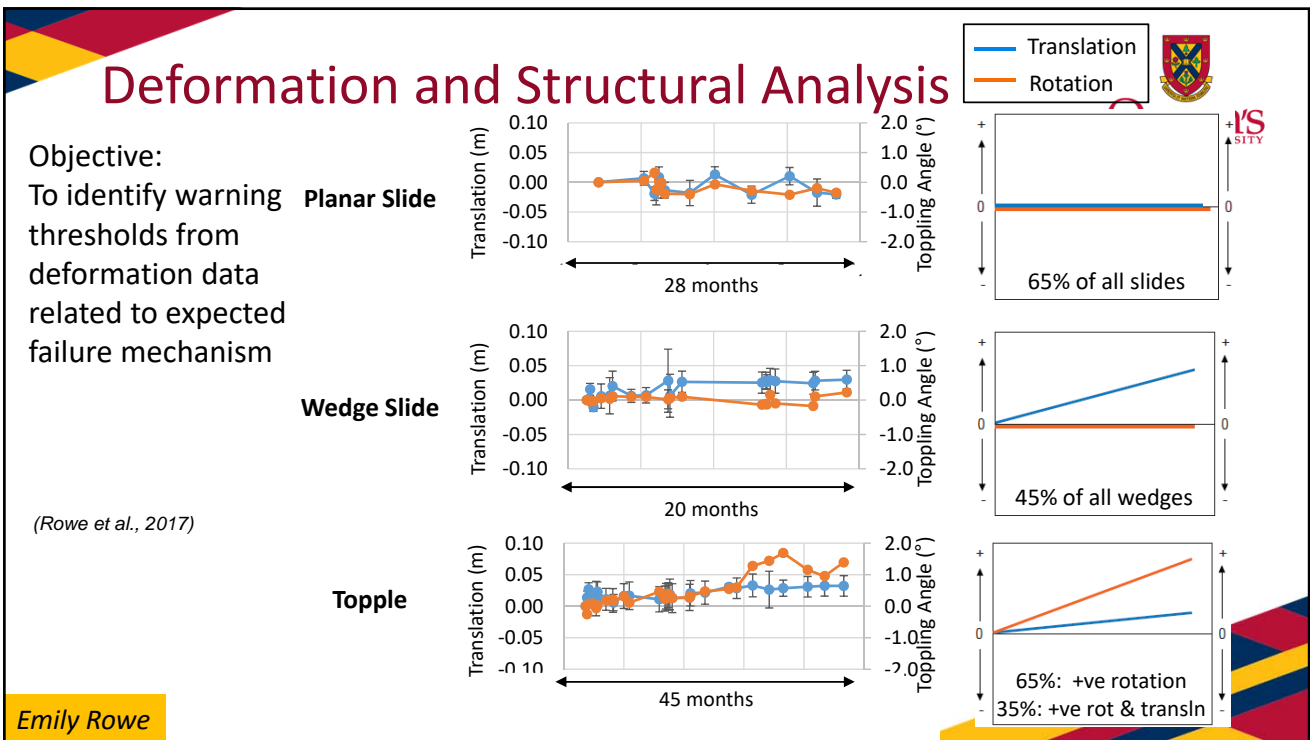
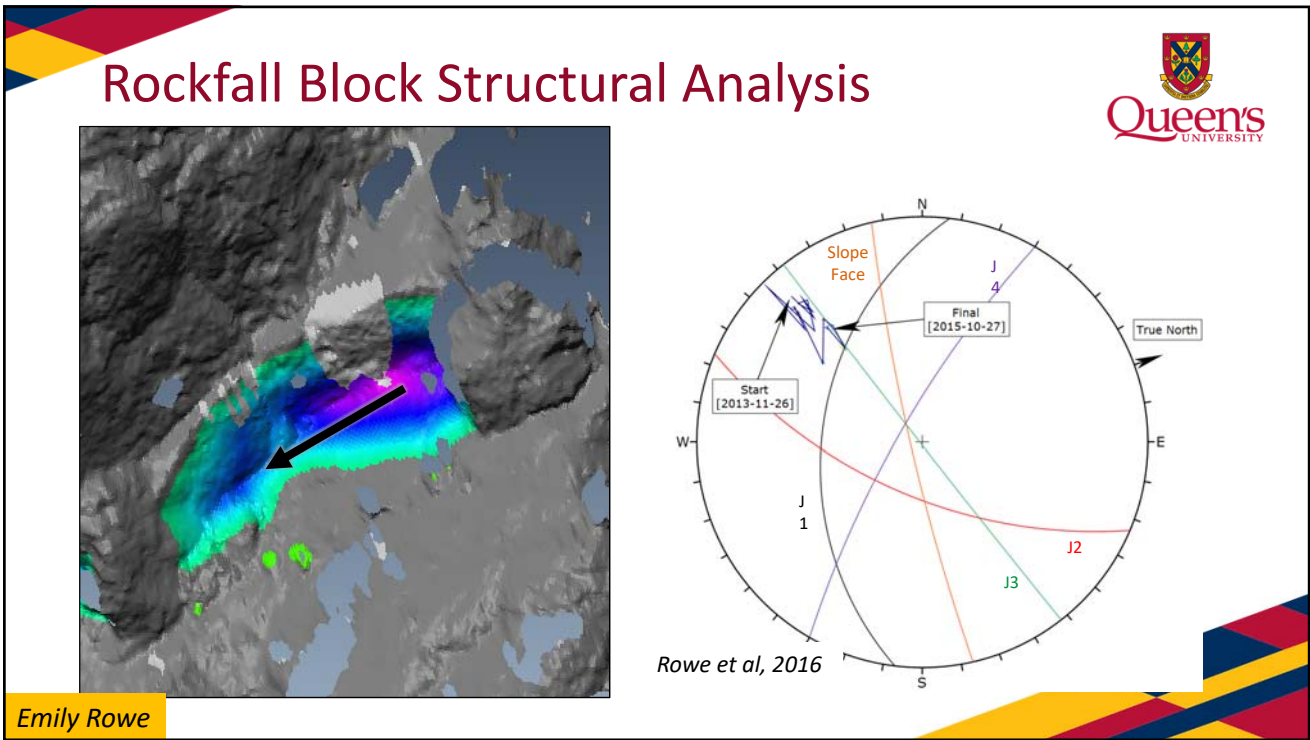
Location Axis Lengths

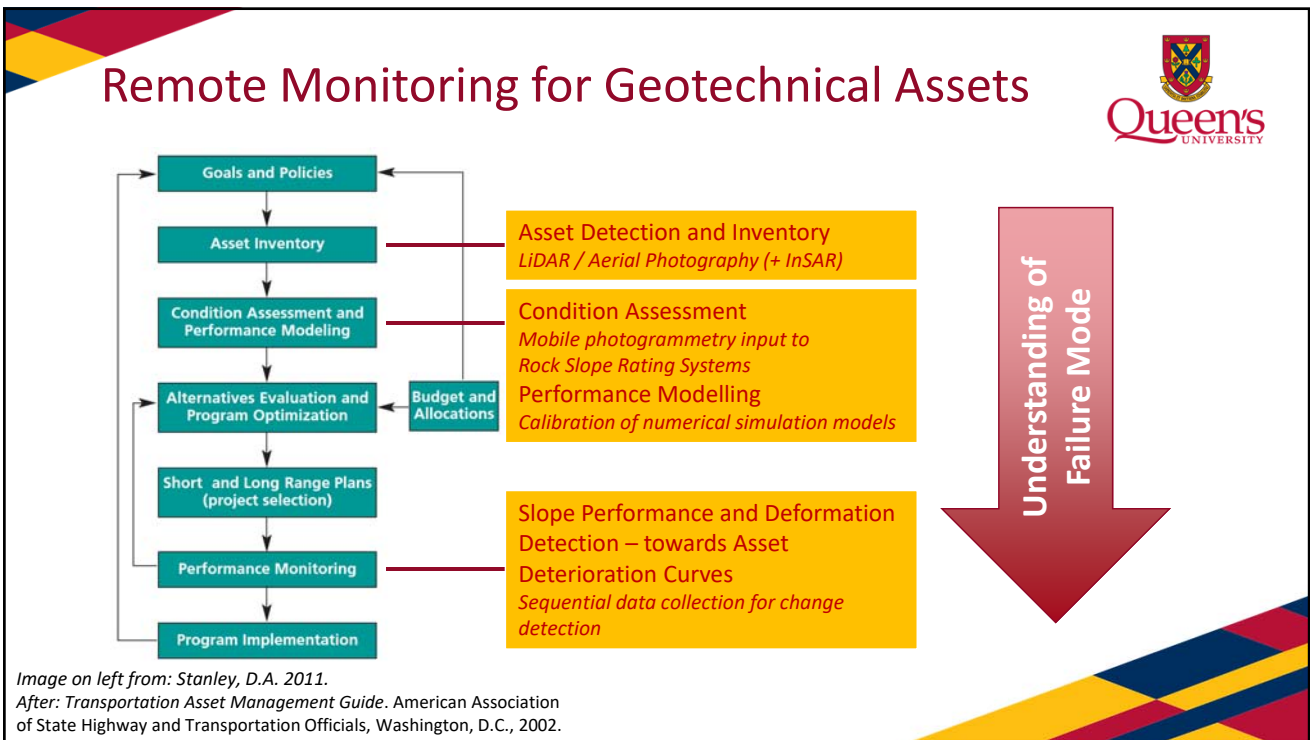
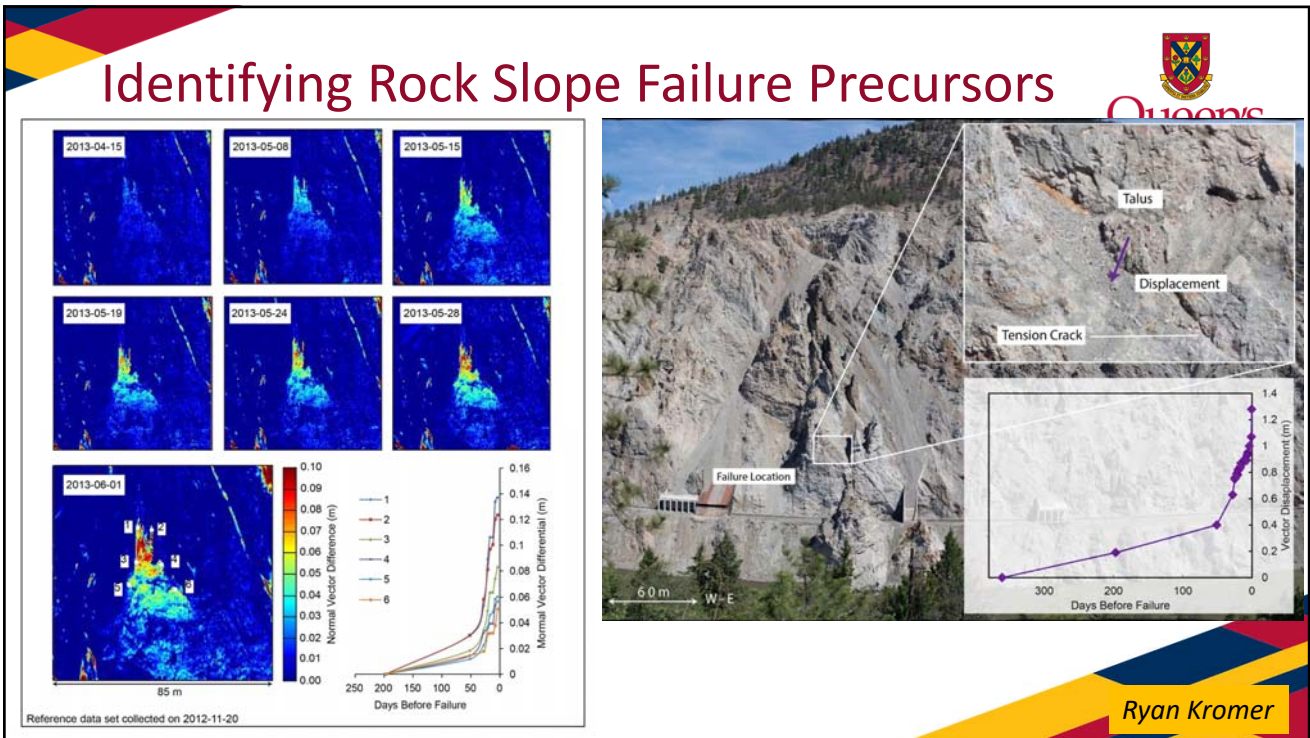
x y z m³ a b c

Cluster rockfalls and determine centroids, volume, and shape

Based on methods from Carrea et al. (2014), Tonini & Abellán (2014) and Janeras et al. (2015)

Megan van Veen

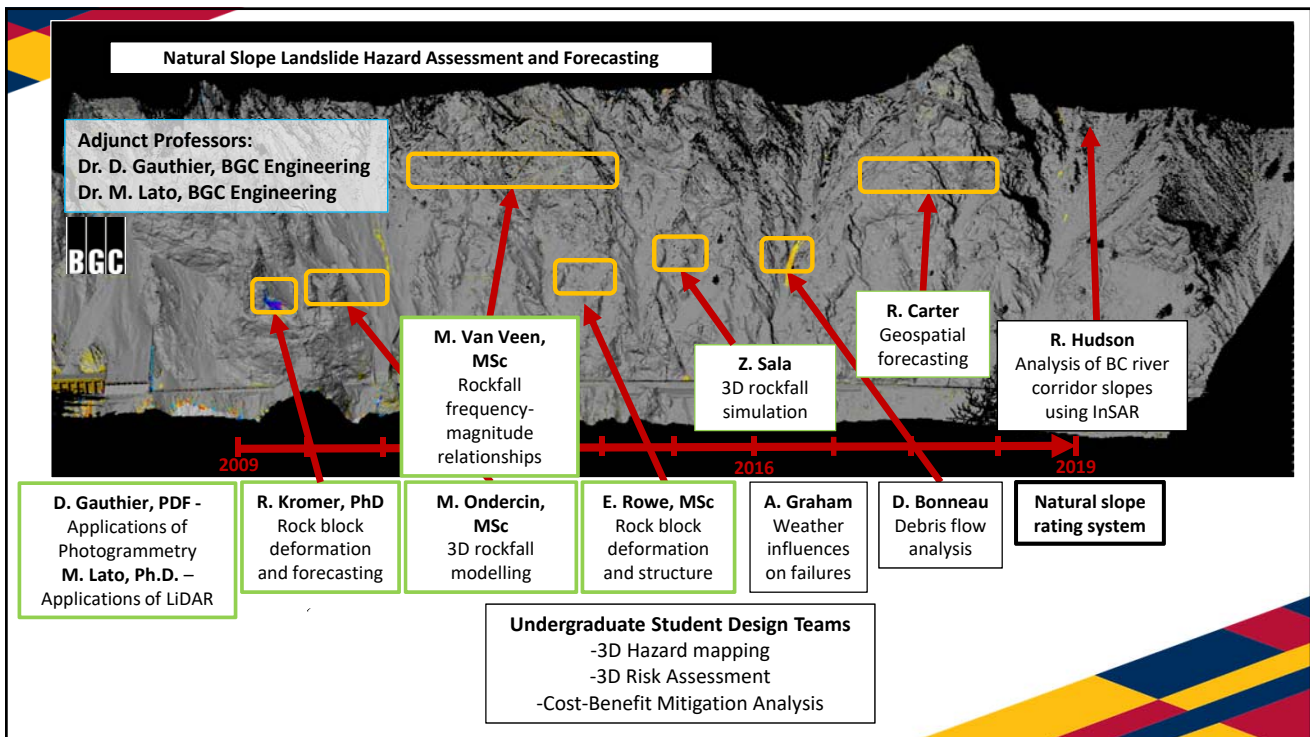




Towards Asset Deterioration Curves



- Asset deterioration curves are presently available based on expert knowledge and judgement
- Evidence based ADC become possible based on Remote Monitoring data, as long as:
 - Failure mode is understood and can be detected,
 - Data is collected over life-time of Geotechnical Assets, and
 - Data is made available in a database for collective analysis
- In-slope information must be integrated where warranted by risk / failure mode / type of maintenance



Project Funding and Technical Contributions



The slide features a central group photograph of project team members in a field setting. To the right, several logos are displayed, including the University of Alberta, Queen's University, NSERC CRSNG, CN CP, and Transport Canada. The slide is framed by a decorative border with a geometric pattern of red, yellow, and blue triangles in the corners.