Some of the following material for the C19 webpages has been prepared by Engineering Geology students of Prof. Scott Burns at Portland State University (USA. This material has been screened and approved by the C19 Chair.

Best Practices in the Field

Scanning Procedures

A brief overview of the procedures for scanning a highway slope or natural rock outcrop is given below.

1. The scanner is placed at the outcrop of interest, at a safe distance from moving cars and steep cliffs. The scanner does not need to be levelled; however, levelling the scanner simplifies the scanner registration process.

2. The manufacturer's software is used to set the scanner field of view and the LiDAR point spacing, using either a laptop computer or a handheld device.

3. A method for survey control is established (scanner registration). Methods include placing surveyed targets in the scene, establishing the location and orientation of the scanner, back sighting to known points, and other methods.

4. Scanning is conducted. With a time-of-flight scanner this generally requires 5-25 minutes per scan to produce a point cloud with one to three million points. A phase-shift scanner would require less than 30 seconds for a point cloud with one to three million points.

5. Digital images are taken. High-resolution digital images accompany each LiDAR scan. Most scanners automatically capture the images using a built in camera. Some cameras are mounted on the inside of the scanner; some are mounted on the outside. By knowing the position of the camera relative to the laser and the camera characteristics, a color point cloud can be produced, and also the digital images can be draped onto the point cloud using texture-mapping techniques.

6. Point clouds are produced, as illustrated in Figures 1 and 3. Details on the point cloud file and software used for further processing are described in Chapter 3.

7. In general, 5-10 scans can be conducted in a day, depending on terrain, scan area, and the travel time to each site. A typical scan is taken from 20 to 100 meters from the rock outcrop, and a typical scan area can vary from 15x15 m2 to over 50x50 m2. The smaller areas require less than 10 minutes to scan, while a 50x50 m2 area takes about 45 minutes to scan with a time-of-flight scanner. More details are provided in Chapter 5.

Deciding on Scanner Placement and Number of Scans

One of the first and most important steps is to spend a few minutes at the field site to determine where the scanner will be placed and how many scans will be made. For scans of a slope adjacent to a highway, scans will most likely be made on the opposite side of the highway, along a turn-out or shoulder. In general, it is best if the distance from the scanner to the slope is at least as great as the height of the slope of interest.

Another parameter is the distance between scans taken along the highway. In general it is best if the scanner horizontal field of view is 50 degrees or less. Also, at least a 20% overlap between scans should be maintained. The overlap is used to assist with the stitching together of point clouds.

Deciding on the Method for Scanner Registration

The next important step is to decide how scanner registration will be conducted. All scanners are able to register a point cloud by having at least three targets of known position in the scene. The three or more targets should not be in the same plane and having targets across all areas of the scene produces the best results. Another procedure is to register some of the scans using targets, and register others by "stitching" them with those that have been registered (the stitching uses an
Iterative Closest Point algorithm and is available in several of the point cloud processing programs). Some scanners can be registered by backsighting to known benchmarks along with surveying in the location of the scanner. Backsighting uses a built in optical telescope to site to known points so that the orientation of the scan can be determined. Finally, the orientation can be registered by carefully measuring the orientation of the scanner (if the scanner is levelled this only involves the measurement of scanner bearing). This last method, along with an accurate GPS of the scanner origin (sighting over a known benchmark; for instance), will also give the full registration. It should be noted that none of the above methods involve putting targets on the rock slope itself. Putting targets on the slope is a safety hazard and should be avoided, particularly on unstable slopes. However, depending on specific site conditions, putting targets on the slope may have advantages if it improves the accuracy of the registration and can be conducted in a safe manner.

Taking Digital Images

High-resolution digital images should always accompany each point cloud. The digital images can be used stand-alone for rock mass characterization and rockfall applications, or registered with the point cloud using photo draping techniques.