CHAPTER 6 – EXPECTED ADVANCES IN THE NEXT 5 YEARS

This section contains some discussion about expected future improvements to LiDAR hardware and software in the next few years. This is based on discussions and presentations that took place with hardware and software manufacturers at the following meetings and workshops:

- Workshop on Laser and Photogrammetric Methods for Rock Face Characterization, Golden, CO (June 17-18, 2006)
- 5th International Visualization in Transportation Symposium and Workshop, Denver, CO (October 23-26, 2006)
- LiDAR Spar Point Conference, Sugarland, TX (March 26-27, 2007)
- Workshop on LiDAR and Photogrammetry Methods for Rock Engineering, Vancouver, Canada (May 26-27, 2007).
- LiDAR Spar Point Conference, Houston, TX (March 3-5, 2008)

Overall, future improvements to LiDAR technologies fall into the following categories:

- Hardware improvements;
- Multi-sensor fusion;
- Mobile scanning;
- Improvements to point cloud processing software, including integration with CAD and GIS;
- 3D mashups; and
- Standards.

Each of these topics, as it relates to using LiDAR for highway rock slope stability, is discussed below.

HARDWARE IMPROVEMENTS

Recent improvements to LiDAR hardware include the following:

- Time-of-flight scanners with capture rates up to 50,000 pps
- Phase shift scanners with capture rates up to 1 million pps
- Increased range in time of flight scanners, up to 2 km
- Increased range in phase shift scanners, up to 50 meters
- Increased accuracies in time of flight and phase shift scanners

This trend is expected to continue in the future. The best information on recent hardware improvements is available from the scanner manufacturers web sites (see Chapter 2).

MULTI-SENSOR FUSION

LiDAR manufacturers are currently adding more and more useful features to the LiDAR units. These features include built in surveying capabilities, built in GPS, automated pan and tilt movement, built in tilt and compass bearing measurements, better onboard camera, built in motion compensators, etc. Already the fusion of ground-based LiDAR and high-resolution digital imaging has occurred, resulting in high-resolution, 3D, photo-quality digital terrain models. Also, the fusion of ground-based and airborne LiDAR is starting to take place. Future sensor fusion may include the integration of hyper-spectral imaging, radar and other sensor data.

MOBILE SCANNING

Mobile scanning (also referred to as dynamic scanning) includes the ability to scan from a moving ground-based vehicle or boat. Several of the scanner manufacturers are now involved with the production of mobile scanning units. From POB (2007):

> Several manufacturers, companies and agencies offer dynamic scanning solutions. Optech Inc. (Vaughan, Ontario, Canada) recently announced a dynamic scanner called the ILRIS-3Dmc. The Canadian manufacturer is promoting the use of its motion-compensated scanner for three common applications: stop-and-scan, mobile platform vertical scan (i.e., oil rig from a boat) and mobile platform horizontal scan (i.e., road surface survey from a vehicle). Riegl offers several scanners that can be deployed as dynamic scanners, and that have successfully been used on boats to inventory waterway assets and to geo-reference obstructions (such as semi-submerged rocks) that cannot be mapped directly from a boat. The Nottinghamshire, UK company 3D Laser Mapping has released a system called the StreetMapper Mobile LiDAR mapping system based on Riegl scanners. It offers a turnkey survey vehicle with all the necessary components mounted on it or as a combination of the sensor platform and the electronic rack. The overall weight of its system is about 150 kg (330 lb), which is small enough to operate from normal passenger cars.
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> The Federal Highway Administration's Turner-Fairbank Highway Research Center is also using dynamic LiDAR. The agency has developed a system called the Digital Highway Measurement vehicle. This multi-sensor system uses laser scanners and Macrotexture lasers (lasers with a submillimeter beam diameter) to profile the texture of highway surfaces. It is also being used to explore the use of new 3D ground penetrating radar for subsurface evaluations down to 6 to 9 m (19.7 to 29.5 ft) for locating utilities and pavement thickness. Data collection like this would represent complete roadway cross-section and would be very valuable to highway designers.
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> The accuracy of the final point cloud and subsequent drawings and models is dependent on many factors. One factor is the error from a single laser scanner measurement. This relative accuracy can be provided by the laser scanner manufacturer; for example, this can be as small as 10 mm for a Riegl scanner. The ability to accurately measure objects in the point cloud is also dependent on the point density, which is affected by vehicle and scanner speed. The slower the vehicle goes, the denser the point cloud will be. The absolute accuracy of the data in relation to a local coordinate system is dominated by the navigation system. This can be as low as 3 cm under favorable conditions and might be as high as 0.5 m under poor conditions.

3D MASHUPS

"Mashups" are new kinds of web-based applications that combine data from more than one source and provide an integrated tool for information searching, data retrieval and analysis (IBM, 2006). 3D mashups combine LiDAR or other 3D results with other types of information such as maps and 2D images. Google Maps, for example, could be combined with LiDAR scanning results and slope stability software to rapidly determine areas where slope problems are likely to occur. Repeated scans could be used to provide time-dependent maps of change and rockfall hazard. There are some technical challenges involved with mashups with integrating the different types of information.

IMPROVEMENTS IN POINT CLOUD PROCESSING SOFTWARE

Point cloud processing software has improved greatly in the past few years and is expected to continue to improve in the near future. More CADD tools are expected to be implemented into the point cloud processing software, and CADD software is now being developed that can integrate point clouds and CADD objects (Autodesk Navisworks, for example). Also, the ability to use smaller amounts of data in memory, either through compression or dynamic viewing windows, to allow large clouds to be viewed and processed on standard computers. Advanced filters is another area that needs to be developed, such as filters to automatically remove vegetation from rock slope point clouds.

STANDARDIZED DATA FORMATS

This is a major subject that needs to be tackled in the near future. The xyz ASCII format for point clouds as shown in Chapter 2 is widely used and accepted, but does not contain draped photo information, as well as other header information. Possible standard formats for ground-based LiDAR data include .LAS (used for airborne LiDAR), 3D TIFF, 3D JPEG, .AAF (advanced authoring format), .X3D, VRML and GeoVRML.

Other needs in terms of data standards include a highly compressed data format for efficient archiving, a standard terminology for ground-based LiDAR and the various kinds of output data, better integration between LiDAR point clouds and CADD software, better integration with mapping, geospatial applications (see Spar Point, 2007 for more details).