

Abstract

A terrestrial, or ground-based, LIDAR (Light Detection and Ranging) scanner was used to map channel complexity and results were compared to traditional total station surveying techniques. Our evaluation included two separate end applications: streambank retreat (SBR) monitoring and 2-dimensional hydraulic modeling for fish habitat quantification. Most stream morphology research and monitoring employ traditional surveying (using electronic total stations or laser levels); however, traditional surveying has its limitations, including difficulty in surveying physical structures such as undercut banks and around large bed substrate. Traditional surveying can also be time consuming and has limitations representing highly-complex systems. Surveys were conducted using both techniques for two very different applications on different streams to analyze their respective abilities to replicate 3-dimensional channel geometry. The first is 11 m of streambank on Stroubles Creek in Blacksburg, VA being studied for SBR rates. The bank is mostly bare soil and is undercut, and the creek is located in an active cow pasture. The second is 80 m of the Staunton River in Shenandoah National Park near Wolfstown, VA being studied for hydraulic and habitat modeling. The total station and LIDAR surveys are being contrasted and compared based on accuracy, time and effort (in the field and during post-processing), as well as cost. The data points from both methods will be compared on their ability to produce 3-dimensional models of channel topography based on resolution and spatial alignment.

Objectives

The primary objective is to investigate the use of LIDAR technology in mapping stream geometry compared with traditional total station methods.

- Compare the relative difference between the points generated using both surveying tools.
- Compare the volumetric difference between the surfaces generated from triangulation between the points.

Introduction



Figure 1. The Optech ILRIS-3D LIDAR scanner.

The LIDAR scanner used is an Optech ILRIS-3D. LIDAR is an active remote sensor that emits a light pulse towards a target surface and then records the relative distance to objects from the scanner. This generates a 3-dimensional point cloud of the area that also includes light intensities and RGB color values from a digital camera. The software being used to analyze the data is Polyworks from InnovMetric (Supplied by Direct Dimensions, Inc.). LIDAR has the potential to offer quick, objective data collection, but is currently limited by the need for post-processing algorithms (Hopkinson et al., 2004). LIDAR file sizes are also typically very large (up to multiple GB), hindering data analysis (Bellian et al., 2005). Recent research comparing LIDAR to total station surveys for fluvial geomorphology has been favorable (Heritage and Hetherington, 2006).

Study Sites

Site 1 is an 11 m long bank on Stroubles Creek, which is a highly impaired stream with both urban and agricultural impacts. It is located on a dairy farm and cattle have complete access to the stream. The bank face is bare with little vegetation.

Site 2 is an 80 m long reach of the Staunton River, which is located in Shenandoah National Park (SNP). The reach is located in a forested area and the stream bed consists of many large rocks and boulders.

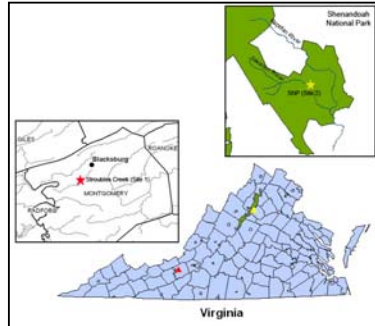


Figure 2. Location of study sites in VA.

Methods

Stream geometry data will be collected using two methods: an electronic total station and a terrestrial LIDAR scanner.

Total Station Surveying:

- At Site 1, five cross sections were taken along the stream width. The survey focused on measuring points representing the target stream bank.
- At Site 2, approximately 2800 survey points were taken along the 80 m reach with a density of at least one point every square meter. Important features such as rocks were surveyed by taking points at the top and around the bottom to define the shape of each feature.



Figure 3. Surveying with the total station.



Figure 4. Site 1 at Stroubles Creek.



Figure 5. Site 2 at Shenandoah National Park.

LIDAR:

- An average point cloud resolution of 1 cm was used for all scans.
- At Site 1, three scans were taken at different angles towards the target stream bank. To aid with alignment, three square reference targets were fixed in space.
- At Site 2, ninety-two scans were taken from twenty-six locations. Square targets along with site features such as rocks and trees were used to align the scans.

Results

Table 1. Number of points taken and approximate times for both methods at both sites.

	Site 1 (Stroubles)		Site 2 (SNP)	
	Survey	LIDAR	Survey	LIDAR
Total # of Points	87	~ 1 million	2755	~ 40 million
Field Time	3 Hours	1.5 Hours	4 Days	2 Days
Post-Processing	1 Hour	7 Hours	5 Hours	2 Weeks

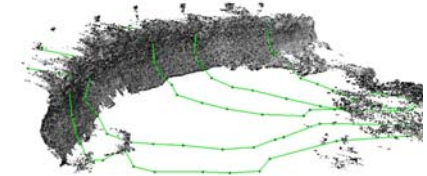


Figure 6. Surveyed cross sections (green) and LIDAR point cloud (grey) for the target bank from Site 1.

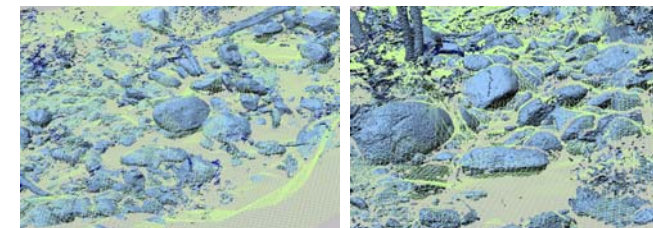


Figure 7. Two images of the total station (yellow) and LIDAR (blue) points for Site 2.

Table 2. Statistics for the point differences between survey and LIDAR datasets.

	Site 1 (Stroubles)	Site 2 (SNP)
# of Points	23	935
Mean (m)	0.0160	0.0132
St. Dev. (m)	0.0143	0.0419

Future Work

- Align the rest of the LIDAR data scans for the Shenandoah National Park site and compare in full to the total station data.
- Use the Polygonal Modeling module of Polyworks to generate watertight surfaces of both datasets and compare volumes.

Acknowledgements: B. Bezak, K. Bronnenkant, L. Clark, Dr. J. Dove, Dr. M. Gutierrez, A. Ludwig, S. Morris, S. Ranganath, S. Rosenquist, F. Smith.

References:
Bellian, J. A., C. Kerans, and D. C. Jennette. (2005). "Digital Outcrop Models: Applications of Terrestrial Scanning LIDAR Technology in Stratigraphic Modeling." *Journal of Sedimentary Research*. 75(2): 166-176.
Heritage G. and D. Hetherington. (2006). "Towards a protocol for laser scanning in fluvial geomorphology." *Earth Surface Processes and Landforms*. 32(1): 66-74.
Hopkinson, C., L. Chasmer, C. Young-Pow, and P. Treitz. (2004). "Assessing Forest Metrics with a Ground-based Scanning LIDAR." *Canadian Journal of Forest Restoration*. 34: 573-583.