

New LiDAR Technology Offers Faster, Less Expensive Field Data

Business Issue

Collecting data to design MoDOT projects can be time consuming and expensive. Furthermore, traditional field data collection can place employees dangerously close to traffic. However, Light Detection and Ranging (LiDAR) based mapping technology has emerged as a potential solution to field data collection problems.

Approach

MoDOT initiated a research project to evaluate the potential of LiDAR based mobile mapping technology and other static 3-D scanning technologies for use in mobile, static and photogrammetric operations within the department. The main goal of this research was to evaluate advantages (or disadvantages) of data collected from the LiDAR based mapping technology compared with traditional photogrammetric and surveying methods in the following areas:

- ❖ Cost,
- ❖ Delivery time including schedule flexibility,
- ❖ Safety, and
- ❖ Data quality for roadway design use.

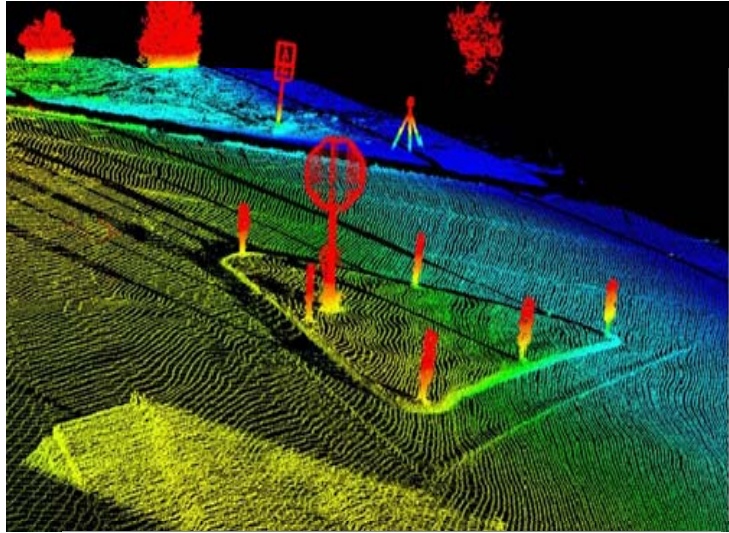
Sanborn Mapping Company was hired to collect data using three different LiDAR systems on an existing seven-mile MoDOT project on Route A, Franklin County between Union and Washington. The project had already had all the field control surveying and aerial photography collected using traditional survey methods. The project also had been designed using traditional photogrammetric methods.

Results

The research assessed three different types of data collection methods, and provided final recommendations for the most viable LiDAR based mapping methods. Some key observations for each type included:

Static Terrestrial LiDAR (3-D Scanning)

- Suitable for high detail local area surveys, such as tunnels, enhancement project or intersection (such as this project on Rt. A & Rt. YY)
- Reduces risk and potential schedule over traditional survey
- Requires additional specialized software and hardware



LiDAR Static Terrestrial Image Colored for Elevation

Results (cont'd)

Mobile Terrestrial LiDAR

- Limited due to ground perspective
- Lowest safety risk and rapid collection of data over conventional survey
- Limitations on the range of the sensor and occlusions or shadowing affecting potential information content

Airborne LiDAR

- Can “map” the same features as traditional photogrammetry” – look down perspective
- Cost effective for wide area projects
- Provides higher density “3-D point” measurements to improve surface modeling



Static LiDAR Unit



Class	Points
Default	39,871
Ground	30,815,366
Low Vegetation	57,778,875
Medium Vegetation	2,680,066
High Vegetation	18,064,128
Buildings	3,105,888
Low Points	5,266
Total	112,489,460

Aerial LiDAR Unit Data

Mobile LiDAR Unit

Class	Points
Default	12,930,697
Ground	88,843,333
Low Vegetation	429,024,011
Medium Vegetation	24,694,914
High Vegetation	101,940,979
Buildings	1,018,456
Low Points	14,308
Total	658,466,698

Mobile LiDAR Unit Data

Potential Benefits

Safety enhancements

LiDAR surveying techniques can provide a safer method of surveying. Surveyors, motorists, and designers will see an improvement in safety throughout the project corridor during surveying operations and through the reduced site visits and design field checks. Aerial and mobile LiDAR reduces the need for surveyors on or near the road.

Data quality for roadway design use

LiDAR surveys allow for more accurate development of project profiles and for generation of more precise earthwork quantities. LiDAR data can be filtered from a highly, detailed survey to a lower data density tailored to meet specific project needs.

Potential Benefits (cont'd)

	MOBILE DATA		Aerial Data	
	US Feet	cm	US Feet	cm
Average dz	-0.002	+0.06	-0.019	-0.57
Minimum dz	-0.196	-5.97	-0.472	-14.39
Maximum dz	+0.338	+10.3	+0.318	+9.69
Average magnitude	+0.104	+3.17	+0.135	+4.11
Root mean square	+0.0126	+3.84	+0.173	+5.27
Std deviation	+0.128	+3.90	+0.173	+5.27

LiDAR Data Accuracy

Speed

Conventional aerial or LiDAR Mapping provides for the shortest potential schedule for mapping data, based on available staff and resources. The speed of collection, especially mobile LiDAR, cannot be matched via traditional methods. This time savings allows surveying tasks to be completed within project constraints and scheduling.

Summary	Person Hrs	Schedule
Traditional Survey Design	1281	48.2
Aerial Lidar	444	40.5
Mobile Lidar	726	57.1
Static Lidar	1700	94.0
Conventional Aerial Mapping	548	42.9

LiDAR Scheduling Speed

Reducing the enormous amounts of data from the point clouds and processing it proved to be the biggest challenge on the project. In fact, although Sanborn had an ambitious schedule, which was four months ahead of the contract end date, the company ended up taking all that time to finish the processing and deliver the data in MicroStation and GEOPAK format as required.

Cost

Conventional aerial mapping is still the most cost effective method to collect mapping features, but LiDAR can provide potential cost savings by providing additional information content that may reduce field visits.

LiDAR surveys can help reduce construction change orders in earthwork quantities by providing a more accurate existing ground model. They can help limit costs associated with design tasks by allowing existing sign surveys to be conducted from the office and assist in utility coordination by providing overhead clearances without having to conduct a separate field visit. The reduction of field work also saves user costs associated with traffic control and lane drops required to safely conduct field operations.

Summary	Hrs	Labor Cost	Person Days	\$/Mile
Traditional Survey Design	1281	\$131,585	160.1	\$18,798
Aerial Lidar	444	\$58,250	55.5	\$8,321
Mobile Lidar	726	\$81,688	90.8	\$9,933
Static Lidar	1700	\$204,805	212.5	\$29,258
Conventional Aerial Mapping	548	\$55,234	68.5	\$7,891

Cost Comparisons

Project Conclusions

All three LiDAR technologies collect enormous amounts of point cloud data that proved extremely difficult to process and manage. Current software is limited in dealing with the mobile dataset in particular, requiring additional file creation and data management challenges.

The mobile technology significantly reduces field collection time but increases back office processing, requiring potentially additional hardware and software to effectively manage the datasets.

One important issue in selecting a LiDAR technique is to evaluate the future multiple potential uses of the data. While not the best solution for all surveying needs, LiDAR surveys do provide benefits to the end user in terms of data and to the public in terms of reduction in traffic disruption during field work.

Project Recommendations

MoDOT should consider the following:

- Develop leaders in the area of LiDAR collection techniques through specialized training and workshops including using the Power Point presentation supplied by Sanborn.
- Develop procedures and deliverable standards for working with LiDAR survey data sets.
- Upgrade and maintain currency with software and hardware requirements.
- Seek out additional opportunities to implement LiDAR surveying techniques on projects, while understanding that LiDAR may not be best suited for all surveying needs.
- MoDOT also has a member on a TRB Committee on Geospatial Data Acquisition Technologies in Design and Construction, AFB80. This group evaluates data acquisition technologies, such as LiDAR, and makes recommendations for methods and procedures in these areas.
- MoDOT is evaluating design software that can make better use of LIDAR point clouds and large LIDAR models. This includes the use of 64-bit computing to provide adequate memory to manipulate large datasets produced from LIDAR methods.

Project Implementation

MoDOT's Design Division has been heavily involved in evaluating the potential uses of LiDAR technologies for the past few years. As a result of that research along with the recommendations of this research report, the following steps have been taken to implement this technology at MoDOT:

- MoDOT has purchased two static LIDAR scanners for evaluation in real-world project use. One scanner is located in the Springfield Area District and one is located in the Kansas City Area District. These units are from different vendors and will be evaluated for cost effectiveness.
- MoDOT Photogrammetry has put out a request for proposals for aerial LiDAR surveys in the 2011 flight program for four projects consisting of 85.2 miles for new or realigned roadways. These projects are a mix of both urban and rural terrain and are ones that would have been done by traditional photogrammetric methods. Aerial photography is also being obtained on these projects as a means of quality control.
- MoDOT is participating in, and has a member on the panel for NCHRP Project 15-44, Guidelines for the Use of Mobile LiDAR in Transportation Applications. This project is setting nationwide standards for the procurement, accuracy levels, and delivery methods of mobile LIDAR.