LOUISIANA TRANSPORTATION RESEARCH CENTER

Technical Summary

LTRC Report 727

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LiDAR for Geotechnical Applications

Introduction

This research focused on the utilization of Light Detection and Ranging (LiDAR) technology within the Louisiana Department of Transportation and Development (DOTD) for various geotechnical applications. The study addresses key aspects, including site investigation and reconnaissance for drilling operations, Geotechnical Asset Management inventory data collection, change detection for forensic evaluations and monitoring, and cross-section data collection for stability analysis.

Objective

The objective of this research was to comprehensively evaluate the potential and effectiveness of Light Detection and Ranging (LiDAR) technology in enhancing geotechnical engineering practices within the Louisiana Department of Transportation and Development (DOTD). Specific objectives included:

- Utilizing available data within DOTD and Louisiana agencies (and others)
- Evaluating LiDAR's impact on site investigation and reconnaissance
- Examining LiDAR's contribution to Geotechnical Asset Management
- Exploring change detection for forensic evaluations and monitoring
- Investigating LiDAR for cross-section data collection
- Assessing synergy between LiDAR and drone technologies

Methodology

Task 1: Research existing local, state, and federal efforts regarding LiDAR. The research investigated the utilization of LiDAR within DOTD and other agencies. The DOTD Location and Survey section, under Administrator Stan Ard, was a valuable resource for this existing information. Several staff members provided assistance, including Steve LeBlanc, Jeremy Penton, and Dustin Smith, each of whom have expertise in geographic information systems (GIS) and data collection.

Task 2: Determine the applicability and implementation potential of LiDAR for geotechnical applications within Louisiana. After examining internal and external resources, LTRC examined these different applications and determined which have the most potential for geotechnical applications within DOTD.

Task 3: Conduct slope performance monitoring using remote sensing via drone and LiDAR. The Vicksburg Bridge is an ideal site to utilize drone and LiDAR technologies. The bridge and the surrounding slope are under other monitoring efforts at the site, which is still experiencing some movements. The site is vast and would benefit from multiple aerial collections. The active site is relatively steep in some locations and has over one hundred feet of difference from the river to the top of the slope. The slope and terrain reduce the speed/effectiveness of physical hand surveying readings.

Task 4: Connect information with the Geotechnical Database. LTRC has been working closely with the DOTD Geotechnical group to build a geotechnical database. The database has made remarkable progress over the years, especially with the addition of Bentley

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OpenGround. The researchers attempted to combine and connect efforts to build the database as an information source for designers. OpenGround has geographic information system (GIS) capabilities that will connect with other sources. Rather than developing new tools, efforts will focus on connecting with the existing structures as much as possible.

Task 5: Recommend and implement strategies. Researchers recommend steps to continue the research efforts to realize efficiencies (e.g., time, data, productivity, etc.) within the Department. Implementation strategies will be developed with the Project Review Committee (PRC) and guided by the researchers and stakeholders to the end users. Recommendations for best practices and those that meet Section 67 needs will be at the forefront. Drone utilization options, including DOTD services, consultant contracts, and LTRC Pavement and Geotechnical group ownership, were evaluated.

Conclusions

LTRC researched LiDAR resources within DOTD and beyond to compile a valuable resource for various sections within DOTD to use. Though collected for one purpose and by specific DOTD groups, the data may benefit other groups, such as Geotechnical, that did not initially request the scans. LiDAR scans and information contain information that can be used for many applications, such as:

- Visualizing terrain for site access prior to traveling to the site. This can save costs and time when planning and executing field excursions and testing events.
- Creating terrain maps that can be sliced into valuable cross-sectional data. This is important and can speed analysis when slope stability issues occur and remedial actions are necessary. This cross-sectional data can be extracted from LiDAR scans using software such as Global Mapper and sent directly to slope stability analysis software.
- Measuring and calculating stockpile volumes. This can also be done in Global Mapper to help with quantities used and needed to complete projects and their associated cost calculations.
- Quantifying changes and detecting slope movement. By comparing baseline scans with other scans, pixel location changes can be quantified to assess changes at a site over time. These comparisons can give engineers insight into the rate, direction, and magnitude of movements, helping them better adjust for immediate needs and future remedial efforts.

The Location and Survey Group, Section 30, of DOTD provides excellent service and insight using drones, LiDAR, and other geospatial tools. Especially given their busy schedule, their help is greatly appreciated. The addition of a LiDAR drone within LTRC or the Geotechnical group, Section 67, could provide faster turnaround for sites that are very active and require frequent, immediate visits to assess potential damage and the appropriate remedial response.

Recommendations

The following recommendations are provided based on the findings and conclusions of this report. It is recommended that:

- Scans conducted by Section 30 are logged and georeferenced in an internal GIS system, so that Section 30 and other DOTD sections can see each available scan's date, precision, and area covered.
- Section 67 communicates with Section 30 to coordinate and schedule LiDAR scans on important projects. Setting these baseline measurements could help document initial positions and locations.
- Subsequent scans are requested for comparison and analysis against baseline conditions.
- Section 67 staff install and become familiar with the functions and features of the Global Mapper software. This software is a powerful tool for visualizing information and performing calculations to support design decisions. Specifically, designers should use the software to determine:
    * Ground conditions, elevations, and contours for initial reconnaissance of project locations, without travel, to determine site access and surface conditions.
    * Stockpile volumes and areas of construction materials or slope cut and fill volumes.
    * Cross-sectional information for the use in slope stability analyses and remedial design decisions.
    * Changes within slopes and surfaces over time through the use of change detection processes.
    * Monitoring the long-term performance of geotechnical assets like retaining walls and embankment slopes.

The acquisition of an LTRC or Section 67 LiDAR drone is recommended for situations where Section 30 is unavailable due to prior commitments, and for sites with immediate geotechnical needs or requiring frequent visits.

Training on drone piloting and requirements is also recommended for staff to ensure a sufficient crew is available for drone missions. Additionally, a backpack, tethered, and /or land-based LiDAR options would also expedite field collections, since piloting, permitting, and crew sizes would be eliminated or reduced.

Further studies are also recommended to assist with streamlining LiDAR technologies into modeling software such as Bentley's Leapfrog, which links to the DOTD Geotechnical's OpenGround database.

The research recommends expanded use of existing available and DOTD LiDAR datasets and the LIDAR drone through Section 30 to support projects such as slope stability analysis, geotechnical borings access, and monitoring of geotechnical assets. By integrating new software tools and analysis methods, the datasets can improve efficiency, provide valuable cross-sectional information, and support proactive management of slopes, pavements, and other geotechnical assets across DOTD.