Maser Consulting P.A.'s mobile LiDAR vehicle

DATA FUSION

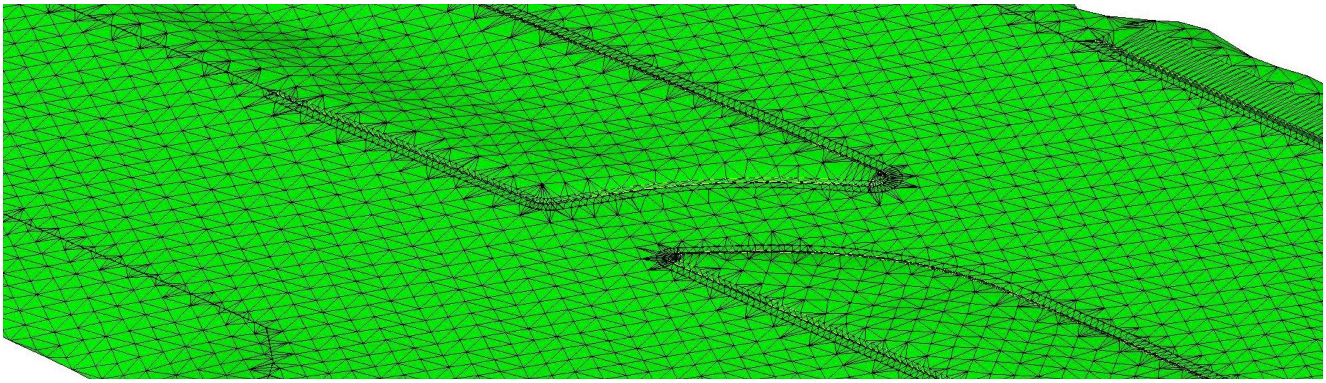
A Case Study for Design-Build Projects

The design-build industry demands efficient and effective management of various datasets in order to confidently understand and execute a project that has only been partially designed and conceptualized when the construction begins. An important factor in gaining this confidence is the quality and accuracy of the existing physical aspects of a project site.

Commonly these projects are surveyed and designed years before a design-build contract is advertised, meaning information can be vastly out of date and what is available can be insufficient or even incorrect. The survey community is typically relied upon to verify the quality of this information prior to the project award and under a schedule that can be extremely compressed compared to typical standards. This can cause ineffective or unconvincing results to the detriment of the surveyor and the design team as they develop a proposal and design.

With the advent of technology and the fusion of available datasets,

BY CHAD **BOGGS, PSM** AND **MICHAEL EHRHART, PSM**



Detailed Digital Terrain Model created from mobile LiDAR

these problems can now be addressed and overcome while expediting schedules and managing costs. This article describes such a project where technologies including mobile, aerial, and terrestrial LiDAR were fused with conventional survey and existing data in order to provide confidence and quality not typically available on design-builds.

Under the direction of Pepper Contracting Services Inc. and ICON Consultant Group, Inc., Maser Consulting, P.A. was chosen to verify and rectify all survey aspects of the State Route 54 design-build project in Pasco County, Florida. A project which consisted of approximately five miles of four lane divided highway that was slated for widening, resurfacing, and multiple traffic and pedestrian improvements.

District Seven of the Florida Department of Transportation advertised this project and provided numerous design files that where over 6 years old. The age of these files and local knowledge of the project corridor lead us to believe that major changes to the existing infrastructure had taken place and had not been considered in the design. In order to quantify these changes and provide the designers with updated information, we chose to employ mobile LiDAR in the short listing phase of the project.

Utilizing a vector based data set collected with a Riegl VMX 450, 3D planimetrics were developed along with a detailed 3D Digital Terrain Model (DTM) for the roadway surface and adjacent terrain surfaces. Identifying and mapping areas that had changed since the original survey had been completed would have severely impacted the project schedule without the use of mobile LiDAR. Traditional boots on the ground techniques would have resulted in weeks of field work and tens of thousands of dollars in survey costs. Mobile LiDAR data was collected in 2 hours and subsequently processed in 4 hours. The Digital Terrain Model (DTM) for the road surface was then created in 5 working days using TopoDOT. The cost and effort expended at this point in the process was significantly less than would have been required using conventional survey techniques.

As part of the design-build package, post selection survey services would be required. In order to accurately estimate those efforts, the mobile LiDAR data was overlaid on the existing FDOT provided CAD files. This allowed our technicians to identify areas that had changed since the original survey data was collected. Once these areas had been identified, the appropriate strategy was utilized to develop cost estimates employing various techniques, most of which involved the use of a controlled mobile LIDAR point cloud combined with conventional survey techniques.

Using this updated data, the design-build team was able to confidently estimate the construction costs for this project when developing quantities and pricing for the design-build package. While hard to quantify, knowing the design team had utilized current survey data as the basis for design and construction quantities, Pepper Contracting Inc. aggressively priced the construction costs. This ultimately led to the selection of the Pepper Contracting/ICON Consultant Group team based on the low bid scoring.

Post Selection Phase:

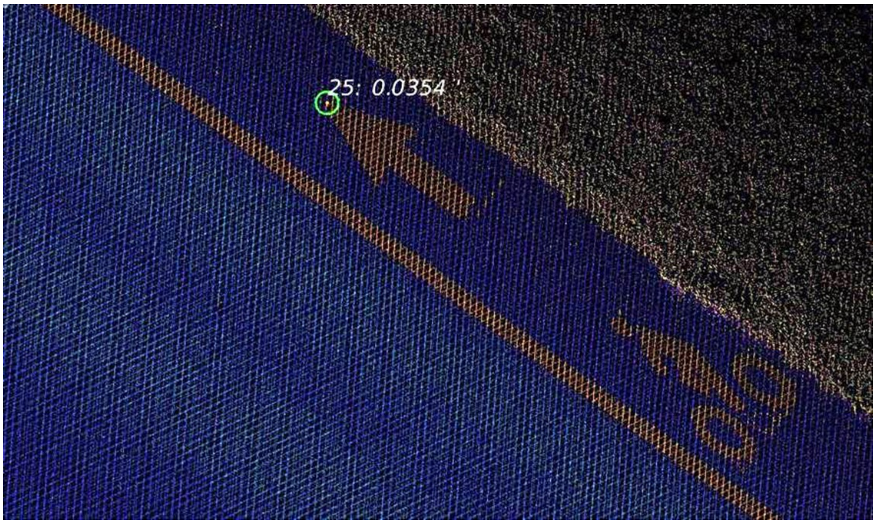
Upon successful selection of this design-build team, Maser Consulting set about the task of controlling the existing mobile LiDAR data set. Once controlled this data set would be used to replace the hard surface areas of the existing FDOT provided data, which would ultimately be merged with the remaining DTM information for the off-road areas. Areas that had changed since the original survey was performed seven years earlier would also be accounted for using the mobile LiDAR data and traditional boots on the ground survey techniques. Utilizing visible features in the point cloud, targets were identified and located using conventional survey techniques at regular intervals for use in transformation of the point cloud, in addition to validating the final point cloud data set.

Data merging involved the use of multiple data sources, starting with the controlled mobile LiDAR data. This data was primarily used to develop a very detailed surface DTM for the hard surface areas, mainly the roads and driveways. Where the existing FDOT provided DTM had not changed, this data was merged with the mobile LiDAR derived data. Any pond, ditch, or heavily vegetated areas relied upon the traditional surveying methods. Aerial LiDAR was also used for several ground areas that had changed. Once these data sets were combined, overlaps were examined and trimming of the datasets took place. In the case of the road shoulders, mobile LiDAR data was blended into either the FDOT provided DTM or the conventionally derived DTM.

> “Data fusion and Design/Build—a recipe for success.”

QA/QC and Final Deliverable: The initial plan for QC of the final deliverable involved field walks with plots. It quickly became apparent that this approach would not be very cost effective or accurate so another solution was warranted. Using the funds originally estimated for field QC, U.S. Imaging was employed for collection of aerial LiDAR and imagery for the corridor. Once the final deliverable was compiled, the aerial LiDAR was also used to inspect the final DTM at 100 foot cross sections which uncovered several areas that had changed slightly and were not evident in initial review of the FDOT information.

Once found, these issues were easily fixed using the aerial and mobile LiDAR data sets. The aerial imagery was then used to QC the final planimetrics, feature extraction, and in several cases helped identify drainage structures that had been slightly modified or omitted in the original design survey provided by the FDOT. These modifications would not have been readily apparent using a conventional field walk with paper plots, but were easily identified before the submittal and addressed using conventional surveying techniques in the field.



Retroreflective arrows used to control LiDAR datasets after collection

Lessons Learned:

The innovative methodology and reliance on multiple technologies led to an overall success in the survey aspect of this project. As with any new approach in this field it is important to reflect on the advantages and disadvantages discovered during the implementation process. This allows us to continue to improve and refine consistent procedures for proper utilization of advanced technology such as LiDAR. In this case study, the resulting benefits of data fusion far outweighed any drawbacks;

Comparison of existing storm drainage mapping from legacy data supplied by the owner to the current aerial imagery collected for the project.

yet reexamining the approach resulted in these lessons learned:

- The GPS vector-based mobile LiDAR dataset was extremely accurate horizontally. The adjustment to control only moved the data 0.02' in the horizontal plane which allowed us to utilize all planimetrics and breaklines extracted from the uncontrolled point cloud with only a vertical adjustment, vastly expediting the extraction schedule.
- Aerial LiDAR was not dense enough to allow for extraction of intricate features as initially hoped. Yet, it became an important tool for collection of natural ground areas void of vegetation and more importantly became an integral means for QC and validation of the 3D aspects of the design deliverables.
- The aerial Imagery collected with the aerial LiDAR dataset was well worth the cost and effort to obtain as it provided a current data source for the design team's effort not previously available and proved to be essential in verifying completeness of feature extraction that can become overwhelming with such a large LiDAR based dataset.

In conclusion, this implementation and subsequent analysis of data fusion with respect to LiDAR technology can be a powerful tool for the design-build industry. When properly managed and executed this methodology can result in safer means of survey data collection, expedited project schedules, extensive datasets for design inquiries, better quality survey deliverables, and extreme confidence in the reliability of information through the use of these multiple data sources.

Chad Boggs, PSM is the Regional Survey Manager for Maser Consulting based out of Tampa, FL. Mr. Boggs has over 23 years of land surveying experience with the last 5 years focused on the use of static and mobile LiDAR in the creation of standard survey deliverables.

Michael Ehrhart, PSM is a Project Manager for Maser Consulting based out of Tampa, FL. Mr. Ehrhart has over ten years of surveying experience and has spent the last 5 years focusing on the integration of modern survey technologies in order to deliver higher quality survey deliverables to clients.