Representation of Mobile LiDAR and clearances provided by Adam Pike of Quantum Spatial.

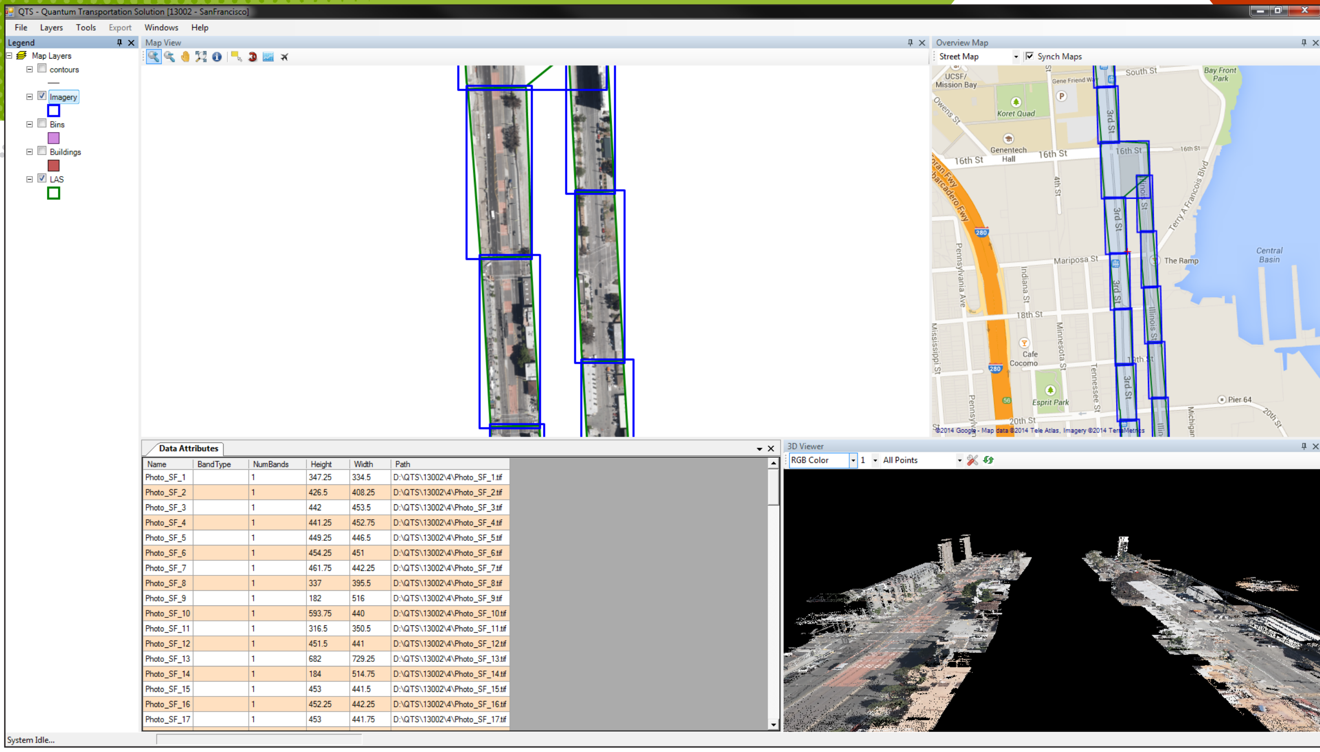
TRANSPORTATION MAPPING

When to Use a Helicopter, Mobile or Both

LiDAR technology is widely used in transportation mapping. For this case transportation would be defined as all transportation including roads, rails, light rail, subways and airports. Helicopter-based platforms have been used for a number of years for many Department of Transportation (DOT) projects and is a very useful technology for this application. The introduction of mobile LiDAR technology has provided additional advantages to transportation mapping. The combination of both technologies can also provide additional benefits to the transportation community.

Immediate cost, schedule and safety benefits have been recognized from the use of LiDAR. There are advantages to both types of sensors, but there needs to be a thorough project understanding

BY JAMES **WILDER YOUNG**

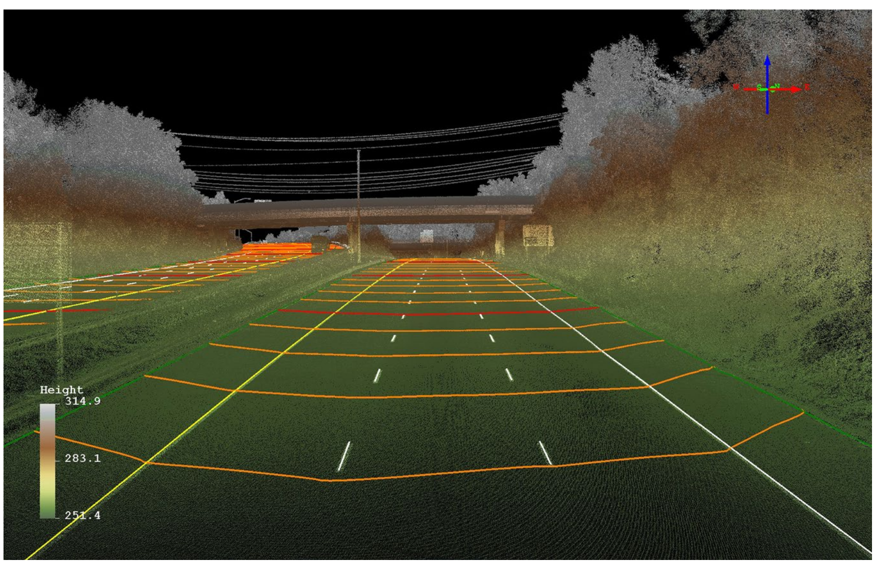


QTS—Transportation Dashboard Software for analytics and solutions using LiDAR data, Planimetric by-products, and imagery. Developed and Provided by Jason Mann.

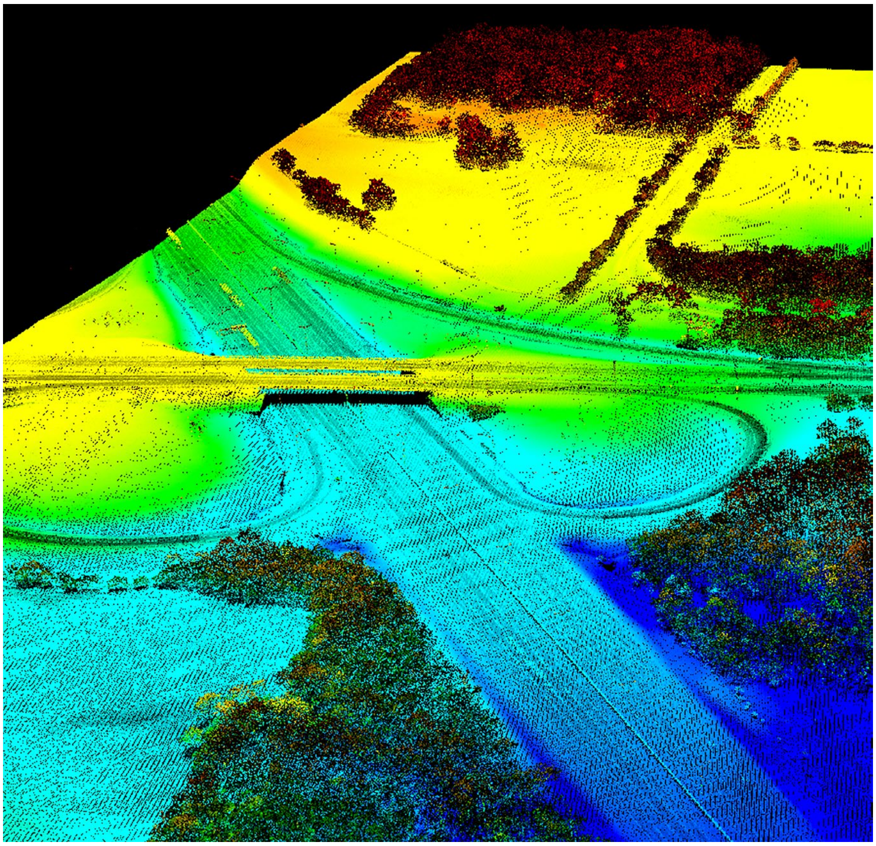
before selecting one type of LIDAR platform, or even both for a given project. There are several published DOT specifications for transportation mapping projects. Both sensor platforms meet a variation of some, or all of the specifications published from different DOTs. It is important to understand each specification in detail when selecting a type of LiDAR platform to perform a transportation mapping project.

The selection of a LIDAR platform will be based on several factors for a given project. The required accuracy will play a major role in selection and there is a fine line between the expected accuracies for helicopter and mobile platforms. Budget, size and mapping detail also play a role in selecting a platform. In many cases some of the project could be done with a helicopter where other locations like under bridge decks will need to be performed using a mobile sensor.

Mobile LiDAR collection can present additional challenges, for example, deep drainage at the edge of roadways, where the scanner can't "see" the terrain based on its position on the road. In general the complexity of the project determines the platform. Even so mobile and/or helicopter provide extensive advantages to transportation mapping as compared to conventional survey methods used prior to this technology. It should be noted that both LiDAR technologies depend strongly on the survey information obtained for reference in a transportation mapping exercise. The amount of conventional survey information required is greatly



Representation of Mobile LiDAR and Line work for transportation provided by Adam Pike of Quantum Spatial.



Helicopter LiDAR collected located close to an interchange. This project was collected at 50ppm

reduced, while providing safety, schedule and budget advantages.

Additionally, several groups of mapping professionals and software providers have developed innovative software to manipulate and use the data in order to better help engineers and transportation professionals answer questions and solve problems. This software continues to develop at an exciting rate. In some cases the problem solving solutions provide an array of data not just limited to the LiDAR data itself. The mobile and helicopter platforms are also not limited to just LiDAR technology. Three and four band cameras, pavement cameras, weather gathering instruments, video, thermal and hyper-spectral sensors can be integrated with the LiDAR sensors on the same platforms. It is common to have 4 to 6 cameras attached to a mobile LiDAR platform. Today's software packages have the ability to utilize the different forms of data, as well as online data services and can be tailored to the requirements of the end users. This is not just spatial data, tabular data can be presented spatially within the software as it relates to the area of interest, similar to most mapping software packages.

Typically, a mobile LIDAR platform's laser repetition rate can be about double that of a helicopter platform. Mobile LiDAR operate at between 500 and 1100 kHz were as the typical helicopter type sensor will operate at roughly 500 kHz, give or take. Although the altitude may vary for given projects based on specifications, helicopter LiDAR sensors will collect anywhere between 30 to 150 points per square meter (PPM) and depending on repetition rates the mobile sensors collect between 2,000 and 10,000 PPM. The mobile data is significantly denser. This creates very detailed surfaces, although in many cases 2000 PPM is much more information than needed and in many cases the helicopter system will provide the accuracy and detail needed for a given transportation project.

The accuracy of these system can be debated depending on who provides the information. The accuracy of the data whether helicopter or mobile is largely dependent on the control survey information provided for the project. The most accurate and strict specifications will require more extensive conventional survey to reference the LiDAR data. The surveys will vary from roughly parallel survey points at 500 feet apart along the corridor to 1500 feet along the corridor and in some cases more. It should be also noted that not all mobile LiDAR sensors or helicopter sensors are equal and a thorough analysis should be done when choosing a provider or system.

This is even more the case with mobile technology. There are mapping grade and engineering grade mobile sensors and for high accuracy mapping projects, such as a transportation project typically the engineering grade systems are required. The latest in engineering grade technology can provide results with an accuracy of 8mm and a precision of 5mm. The transportation professionals often do not require this type of accuracy and it is important to remember that these are the manufacturer's claimed accuracy specifications.

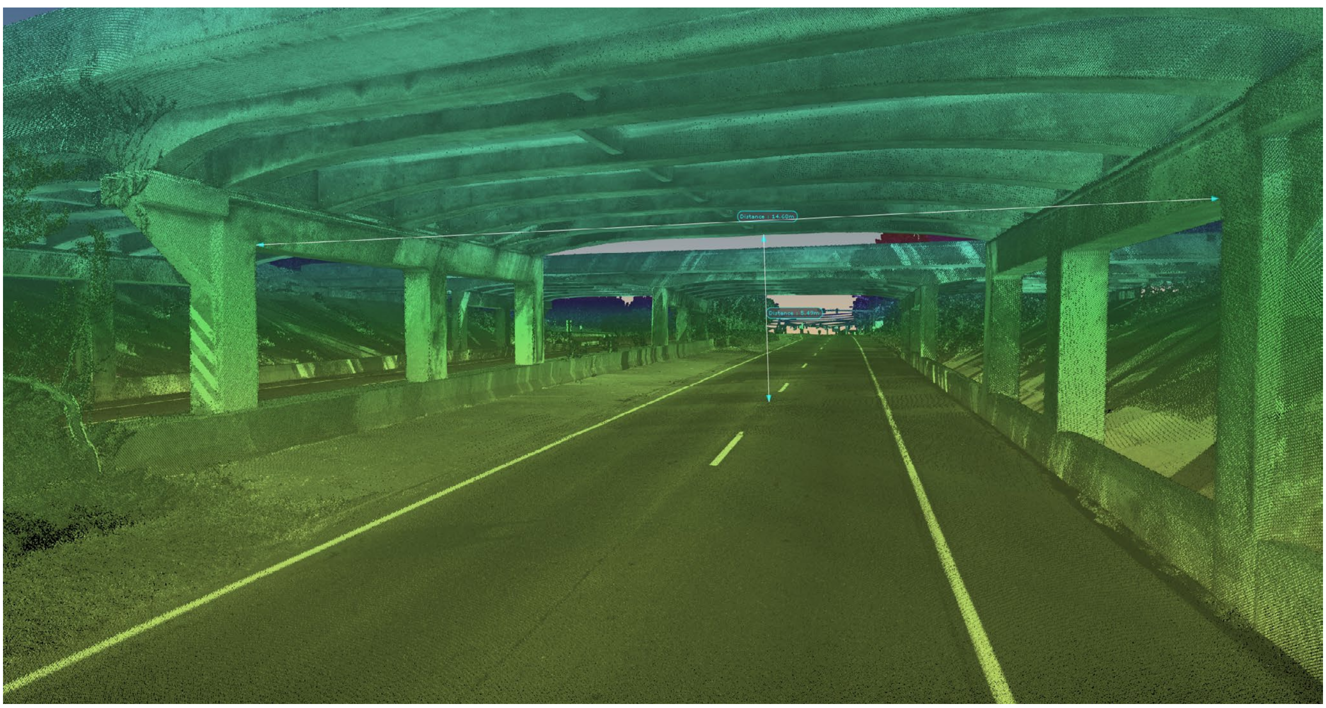
The mapping grade mobile systems are much less accurate than the high accuracy helicopter systems in most cases. Specifications of 5 to 10 centimeters have been documented for those manufacturer's systems. One should expect to get 2 to 3 centimeter accuracy from the helicopter systems with proper control. Typically, for most transportation projects the requirement for accuracy is 0.05 to 0.2 of a foot vertical. Most of the helicopter-based transportation projects are roughly 0.1 to 0.2 of a foot vertical. There are exceptions to these rules depending on the type of project. Construction and planning projects often require much less data and less accuracy.

The accuracy of a given project is a function of the LiDAR technology used, the way the data is collected, as well as the previously stated survey requirements. The quality of LiDAR technology is a function of the components used for a given system. The inertial measurement unit (IMU) plays an important role in accuracy of a given sensor. The better the IMU the better result. The GPS components and configuration can additionally play a role in the accuracy. Having a system with two GPS antennas can yield a much better result than just having one antenna. These antennas will typically be spaced parallel in the direction of movement as far apart as possible in order to provide a vector between the antennae which helps in determining the solution.

Given the almost certain potential for elevation masking of the GPS during collection of mobile data, it is important to initialize the system much like a helicopter LiDAR system would be initialized. This procedure would consist of performing a static initialization of the system for about 5 to 10 minutes at the beginning and end of the collection. Additionally, with the mobile sensor there should be a one to two minute, or maybe even longer static session, before and after going into areas of elevation masking. These could be locations of very tall vegetation, urban canyons and short tunnels or areas where there is extended overhead obstructions.

The main issue with helicopter sensors would be the location of the GPS antenna on the helicopter. Typically, the tail is the best place to locate the antenna because the main rotor could potentially effect the GPS signal.

There are obvious advantages in using mobile and helicopter



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Imagery collected concurrently with LiDAR using a phase One 80mp camera co-registered with a Riegl high accuracy LiDAR sensor. Imagery was captured at 1 in. pixel resolution while the LiDAR was collected at 32 ppm at the same altitude. **Inset:** showing the image resolution and detail of the gazebo at the center left of the larger image.

technology, or a combination. Typically the mobile sensors operate from the back, top of a vehicle. The potential to experience blind spots from this vantage point are common. Operational consideration is always given based on the presence of deep road ditches, culverts, beams and other obscured features. Additionally, the system can't "see" behind anything obscured or on roof tops. Some systems will be equipped with booms to help reduce the frequency of "blinding".

When using helicopter systems there will be no issues with the above stated blind spots but there will be voids as a result of bridges and overpasses. Overhead structure is often a critical part of transportation mapping. Additionally, sign inventory or location may be critical. In some cases depending on point density the helicopter systems will pick up the signs required for the project, but again it needs to be understood what the requirement is.

When assets such as columns, bents, beams, low chord, rip rap and clearance information are required under bridge decks mobile sensors will be required. In many cases a combination of mobile and helicopter could be used. Typically, the helicopter can collected everything except overhead structures with a point density of 30 to 150 ppm and the mobile would be used to collect under structures such as bridges and overpasses. It depends on the detail required for the collection but a cost savings can be realized from using both.

Curb detail which is required on many transportation project typically can be extracted from both mobile and helicopter systems. In some cases things such as catch basins would have to be surveyed in using conventional survey methods depending on the density of the surrounding grass and vegetation. It should be noted that both technologies can be affected by extreme vegetation. The presence of broad leaf plants in road ditches can yield very unfavorable results. Vegetation conditions on any project should be considered just in case there are extreme conditions regardless of season of collection. Even mowed grass can affect the results. Typically, the mobile sensors will get returns from the grass and the ground, so the data would need to be analyzed in order to make sure the proper information is represented.

There are many things to consider when selecting the correct sensor platform for transportation mapping projects. The planning of the project is the key to understanding the project requirements. It is important to select a system that can achieve the desired accuracy and meet the specifications, but it is not always necessary to pick the most accurate and expensive technology for a project. LiDAR technology provides a viable, cost effective solution for most transportation mapping projects regardless of the platform and as the technology improves so will the solutions provided to the transportation sector.

James Wilder Young is Vice President of Technology for Quantum Spatial. He has been working in all phases of LiDAR including sensor development, data acquisition, data processing and applications development since 1996.