Working with Mobile Laser Scanning Providers to Optimise Value

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ABSTRACT

Mobile Laser Scanning (MLS) is a technology that has rapidly developed since its introduction to Australia in 2009. The technology provides the surveying industry enormous benefits in terms of safety, speed of data capture and richness of collected datasets. In the last few years, MLS technology has proven its capability with a large range of road and rail corridor surveys that have provided engineering-accurate surveying results. There is a growing interest in the market to understand how traditional survey companies can best take advantage of MLS technology and how they can work with MLS providers to achieve cost-effective solutions for corridor surveys. This paper addresses the issue of working with MLS data suppliers by discussing the capabilities of MLS technology (what accuracy can be achieved and what deliverables are available), the requirements of a successful MLS survey (what is required to ensure the MLS survey meets its goals), the limitations of the technology (so that they can plan to capture data using alternative approaches) and the role of data processing, data extraction and survey deliverables. The aim of the paper is to provide surveyors with some basic information about MLS surveys in order to understand the survey principles, processes and deliverables available. Understanding this information will help surveyors assess whether MLS should be considered for any corridor survey task, enable them to discuss the job requirements with their MLS supplier and better understand the role they can play in any future MLS survey.

KEYWORDS: *Mobile Laser Scanning, MLS, MLS control surveys, ground feature models, MLS data extraction.*

1 INTRODUCTION

Mobile Laser Scanning (MLS) technology emerged in the Australian survey market in 2009 and has proven to be an ideal tool for high-accuracy, corridor surveys that provide a 'data-rich' deliverable ideal for data mining. MLS is a Light Detection and Ranging (LiDAR) technology combining the principles to airborne LiDAR with the accuracies closer to Terrestrial Laser Scanning (TLS). The benefits that MLS offers include the increased safety for road/rail workers, more detailed and comprehensive measurement of all features on the corridor, high speed of data acquisition and the accuracy of the final result.

Since 2010, MLS has been used by most Roads Departments around Australia. Corridor surveys vary from rural and suburban roads to highways and freeways. They have also been used for railway surveys, and for other linear features such as powerline corridors and canals. The MLS surveys have been independently validated and have proven to achieve engineering accuracies.

From a technology point of view, these are still early days. A range of different systems are available in small numbers around the world. Some have been designed for ‘asset capture’ surveys, while others are developed to provide ‘survey-accurate’ MLS data. Many of these systems have been developed by the scanner suppliers, some adapted from airborne LiDAR equipment, and others by third party vendors who have assembled systems from ‘of-the-shelf’ components (i.e. scanners, IMUs, GNSS and cameras). Major surveying suppliers and software providers are working hard to develop ‘user friendly’ MLS systems for the wider market.

Over the last few years a number of MLS service providers have emerged on the market. Each of them has made a major investment in technology, software and hardware development and training of personnel. They are living in a world of steep learning curves, and constantly strive to optimise the output of their systems in a cost-effective manner.

This business model is not appealing to many traditional survey companies. However, many of them are involved in corridor survey work and are looking to the MLS suppliers in the same way as they look to suppliers of aerial photogrammetry or hydrographic data. There is a growing awareness of MLS in the market, and a desire to understand what data a MLS supplier can provide and the role that they can play in facilitating and supporting MLS surveys.

This paper aims to address these issues by:

- Providing an overview of the steps within a MLS survey.
- Demonstrating the dynamic nature of the technology by briefly describing some recent developments that have occurred to meet customers’ needs.
- Discussing the strengths of MLS surveys, and where they provide outstanding survey results.
- Explaining some of the limitations of MLS technology, and the role that traditional surveys play to address these limitations.
- Providing an overview of the functions that traditional surveys play to support and facilitate a MLS survey, and how survey companies can become involved in the MLS survey process and data deliverables.

2 MLS SURVEY OVERVIEW

Mobile Laser Scanning is another survey tool in the surveyor’s arsenal that needs to be treated with the same principles that apply to any other survey measurement. Surveys needs to be connected to local control and independently verified. For high-accuracy MLS surveys, the survey vehicle is positioned with a dual-frequency GNSS receiver (1 Hz), augmented with an Inertial Measurement Unit (IMU) that provides positions and attitude at 200 Hz. Data is processed in the WGS84 datum and transformed into the local reference frame, by measuring some local targeted control points.

There are a range of error sources that affect the system. Many of them can be minimised by correct calibration of the equipment. Some major error sources that cannot be corrected through a calibration process include the GNSS positioning errors caused by multipath, changes in satellite configuration and heighting errors from incorrect geoid modelling. There are a couple of methods currently used to monitor and correct these errors. One commonly used method is the multi-target approach, which requires multiple targets to be placed along the road corridor to monitor the difference between GNSS-derived positions and target positions. An alternative approach is 'Multi-Pass' which uses multiple passes along the same corridor (under different satellite conditions) to monitor the deviation and magnitude of the GNSS trajectory between known target points. These methods have been described in Eckels and Nolan (2013).

Table 1 shows the basic steps involved in a MLS survey.

Table 1: The basic steps of a MLS survey.

	Action	Description
1	Check control – Horizontal and vertical	As the MLS survey needs to be connected to the local control, it is important to verify that local marks exist, that they have not been disturbed, and whether or not they can be used for GNSS base stations. Checking of the marks is carried out by GNSS surveys and traversing. Digital levelling is carried out where required.
2	Target placement	Targets are placed on the road shoulder, where they can be identified in the scan. For some surveys targets are required every 400 m. For other approaches, targets need to be placed each 5 km. It is important to note that placement of targets and validation points is one of the most labour-intensive and time-consuming processes of any MLS survey, and often requires applications of road occupancy licenses and traffic management.
3	Provide validation points	Many surveys require independent QQ string or validation points along the corridor. These points are used to take independent survey measurements across the road profile to check the cross section of the scanned model.
4	Scan and collect data – GNSS base stations	During the scanning process, a couple of GNSS base stations are established on local control. This enables high-accuracy phase differential GNSS positioning of the working vehicle. Scanning takes place from the scanning vehicle and all data is logged in an on-board computer.
5	Process the point cloud – including pinning to control	Collected data (can be many 100 Gb) is downloaded, and a point cloud is processed. The data is transformed into the local reference frame using the target information provided.
6	Extracting data from the point cloud	One of the most labour-intensive components of the survey is the extraction of data from the point cloud. This process highlights the differences between LiDAR surveys (which have lots of points without attributes) and standard surveys (which have few points with associated attributes).
7	Delivering the data in the correct format for customer	A key issue for all customers is to deliver the extracted data in their documented CAD format. This process is not always straightforward and takes experience and knowledge to ensure the final deliverable is acceptable.

3 FAST DEVELOPING TECHNOLOGY

The procedures used for MLS surveys are constantly changing and improving. As consumers and end-users review the MLS process, they seek to improve and automate as many procedures as possible. One example of these changes can be found in the approach to target design over the last four years. The first major improvement was to increase the size of the targets (0.6 m x 0.6 m) to accommodate the collection of scan data at any speed. Recent developments have enabled Terrestrial Laser Scanning to be used to create a 'target surface' on the road. These can be a good alternative, as they can be measured from outside the road corridor, without having to block a lane.

Significant amounts of research and development are being conducted to address the labour-intensive and cost-inefficient components of current MLS survey methodology. The two most time consuming components of common MLS methodology are (a) setting out the targets for monitoring the MLS point cloud (methods such as 'Multi-Pass' have been developed by McMullen Nolan Group (MNG) to address this issue – see Eckels and Nolan, 2013), and (b) extraction of point and line CAD data from the point cloud itself.

Many software companies are working hard to automate the extraction process, but this process will take some years to perfect. Our experience has shown that software can currently automate 80% of an extraction process, however, the time saved (and often more) is spent in manually sifting through the data to find where the 20% of errors actually are. Much of the extraction therefore is still a manual process.

In addition to optimising current processes to meet survey requirements, a range of applications are emerging for project visualisation. Coloured point clouds (Figure 1) are now available. As these point clouds have such a dense richness of data, they are being used as 3D imagery – offering 'photo-like representations' of the existing survey corridor. However, these are not photographs, but a dense cloud of measurable points. This process has been even further advanced with Euclideon's release of 'Solidscan', which manipulates the point cloud to appear exactly like a photograph. These sorts of technologies will continue to explore the 'visualisation' aspect of point clouds for planners, architects and project managers.

Another exciting development is the combination of all types of LiDAR data for a total corridor survey. Recently MNG has combined MLS corridor surveys with airborne LiDAR along road corridors in WA. MLS provides high-accuracy road surface and ground feature modelling information, while airborne LiDAR covers a wider swath of data over the entire corridor. The aerial data provides enhanced vertical measurements for Digital Terrain Model (DTM) determination and offers measurements of some features that have been obstructed from the road (e.g. behind noise walls). In the next five years, we should expect MLS survey processes and data extraction methodologies to improve, to become even more automated, productive and cost-effective.

Figure 1: Colour point cloud from Sorrento, WA.

4 SURVEYS SUITED TO MLS

MLS can be used for a range of surveys. For some types of surveys MLS offers exceptional value as it provides data that is extremely difficult to collect using traditional surveying technology. Some examples of these types of surveys are outlined in this section.

4.1 Road Surface – Kerb to Kerb

MLS is ideal for collecting high-density, high-accuracy data on any road surface kerb to kerb. This data can be collected without a surveyor having to work on the street. It does not require traffic management, night work or closed lanes. The accuracy of the survey and point density is high, as the distance from the scanner to the road surface is minimised.

Outputs from such surveys include the DTM of the road surface, e.g. to identify road rutting, surface camber, subsidence and slumping (Figure 2), and road utilities such as road furniture and drainage pits in order to determine status, dimensions, location and condition of assets (Figure 3). The only impediments to these surveys are obstructions on the roads caused by other traffic. However, these issues can be overcome by adopting techniques such as 'Multi-Pass'.

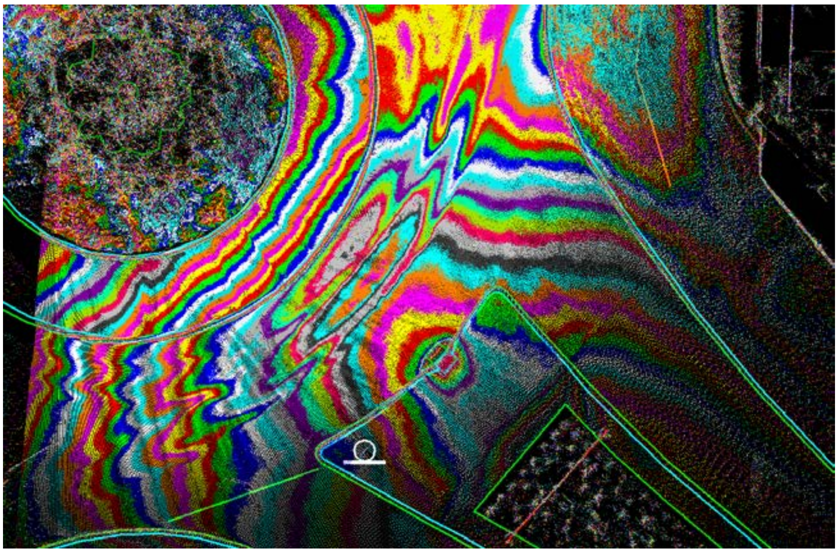

Figure 2: 1 cm contour of a roundabout.

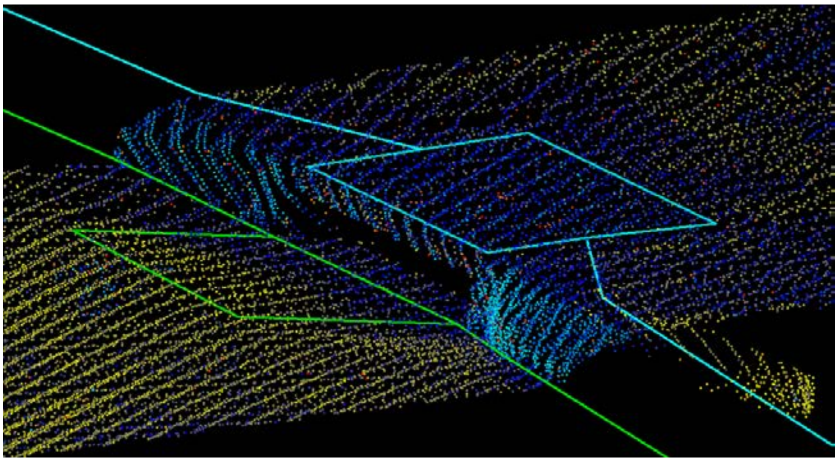

Figure 3: MLS measures a gully pit.

4.2 Hard-to-Access Structures

MLS surveys can accurately measure areas of difficult access quickly and productively. They can be used to accurately measure thousands of assets such as power poles, street signs and the clearance for overhead bridges at driving speed (Figure 4). They provide a comprehensive picture of assets that are difficult to reach with any other traditional survey technology.

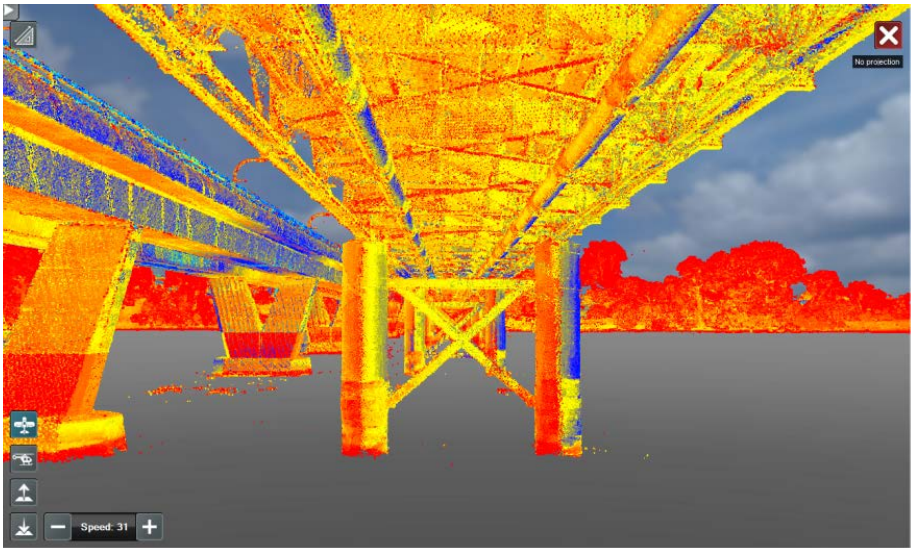

Figure 4: Measurement under the deck of Shoalhaven Bridge.

4.3 Sensitive Areas

MLS has also been employed in 'sensitive' areas, where high-accuracy survey work is required without alerting the neighbourhood to the presence of surveyors. A significant amount of survey data can be collected quickly and accurately just by driving past. As MLS surveys are limited to 'line of sight', features obstructed by fences and walls cannot be measured with MLS.

4.4 Clash Detection Surveys

MLS is an ideal tool for 'clash detection' surveys along a road or rail corridor (Figure 5). In a track maintenance program, the tracks are monitored to ensure that they have not moved from their design alignment. The vertical profile of the track can be significantly changed over the years as new ballast is placed under the tracks. When new rolling stock is introduced to the rail system, track managers are always concerned that clashes between fixed structures on the current track alignment and the rolling stock may occur.

On the road network, overhead clearance surveys are constantly undertaken. Clearances change as new layers of asphalt are applied to the road surface, and as the structures themselves settle. The clearance information is important to help route 'oversize' vehicles from one location to another, without risking a collision with the structure or damaging the load on the truck.

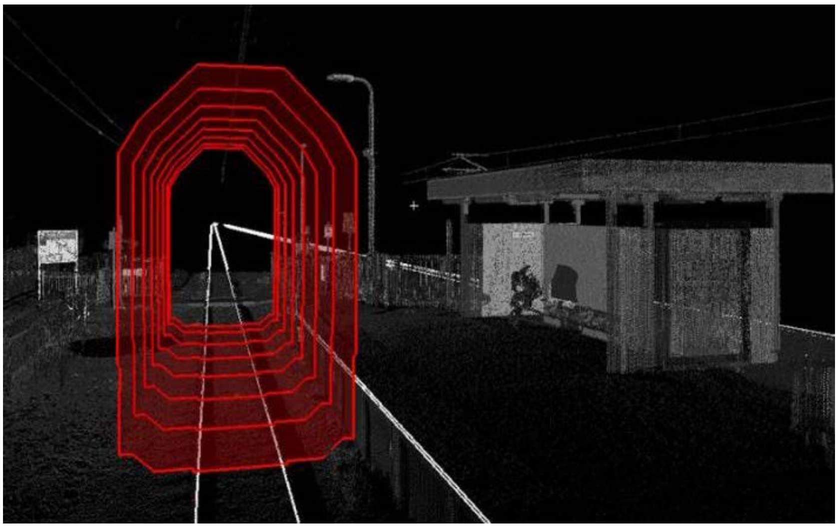

Figure 5: Clash detection survey.

5 PROJECTS REQUIRING BOTH MLS AND TRADITIONAL SURVEY

The majority of corridor surveys require a combination of both MLS and traditional survey methodology. As mentioned in section 2, traditional surveys are required to check the survey control and place targets and independent model validation control points (for QQ strings). However, many corridor surveys require survey information that is difficult to collect with MLS.

Ground features that are difficult to measure with MLS include:

- Utility manholes and access points. These can be hard to identify in the scan, especially if they are surrounded by grass, or partially covered by dirt. In many cases, our experience tells us that they are more easily identified by field personnel on the ground, and picked up using Real Time Kinematic (RTK) GNSS or other survey techniques.
- Drainage infrastructure, including pipes and culverts (Figure 6). Although MLS can identify the location, size and orientation of gully pits and headwalls, it is impossible to measure the pipe inverts or the direction of drainage. All of this work needs to be completed through a field survey.
- Natural surfaces in areas of thick vegetation. In areas of light vegetation, some parts of the laser signal will penetrate to ground level. By selecting the ‘lowest’ points on the natural surface, an accurate DTM can be generated. In areas of thick and dense vegetation or grassland, however, it may be impossible to measure any natural surface points using MLS. These areas can be identified and a field survey required measuring the appropriate number of ground shots in order to determine the shape of the topography. Often Airborne Laser Scanning (ALS), where points are measured down through the grass or canopy from the air, is more effective in determining the ground surface.
- A field survey is required in any areas that are obstructed from the scanner (Figure 7). These include areas behind noise walls, areas above embankments, areas obstructed by jersey kerbs or large billboard signs. In some inner city areas, these may also include features that are hidden behind parked cars.
- Features that need accurate positioning and are located more than 20-30 m from the scan vehicle. The errors in positioning gathered from scanning increase with distance from the scanner itself. The absolute position of any feature within should be able to be determined

to approximately ±15 mm accuracy. Once features lie more than 30 m from the scanner, their absolute accuracy will start to decrease. At about 80 m range, we would only expect positioning accuracy at the decimetre level. If the corridor survey requires features that may be located more than 30 m from the road (e.g. fence lines or utilities), a field survey will be required to collect them accurately.

Figure 6: Drainage pipe in imagery and laser scan.

Figure 7: Pit location behind a bus shelter – requires field survey.

As can be seen from these examples, traditional surveying plays an important role in supporting and supplementing the MLS data for corridor surveys.

6 PARTICIPATING IN A MLS SURVEY

Working with MLS suppliers can be of benefit to both parties. The MLS supplier can concentrate their efforts on the MLS survey, without having to ship equipment and survey crews around the country to carry out standard survey procedures. Local surveying companies and organisations can provide high-accuracy corridor surveys to their clients using MLS data. They can become involved in the MLS survey at many levels to ensure the survey is completed to the client's required accuracy. Local knowledge of the area and the survey marks can greatly assist the control survey. Participation in placing targets, extracting data and formatting extracted data to the client's specifications can speed up the survey and ensure a cost-effective result.

Table 2 summarises how survey firms and organisations can participate and become involved in MLS surveys.

Table 2: Possible actions to become involved in MLS surveys.

	Action	Description
1	Check control – horizontal and vertical	Complete the control survey – find marks, digital level. This major task includes working with traffic management.
2	Target placement	Place appropriate targets along the corridor – whether with physical markings or with TLS.
3	Provide validation points	Conduct an independent QQ string survey at identified cross sections across the road. This will satisfy you and the end user customer that the work has met accuracy specifications.
4	Scan and collect data – GNSS base stations	Assist the scanning process. Provide base stations on control marks. Assist the scanning crew.
5	Extracting data from the point cloud	Participate in extracting the data from the point cloud – this requires software and trained personnel. Those familiar with current TLS systems are well placed to do this.
6	Delivering the data in the correct format for customer	If you are familiar with the correct client formats and data protocols, you are able to finalise the datasets before delivery – to ensure the customer receives data in the correct format.

CONCLUDING REMARKS

Mobile Laser Scanning has made an impact on corridor surveys for road and rail. The technology continues to develop and improve, and there will be an increasing market demand for high-accuracy MLS data. New applications are being developed so that point clouds can be used for a range of applications other than survey (e.g. visualisation, planning and design).

There is a high barrier to entry to join in this market as significant investment is required in hardware and software. Also vendors eager to sell equipment often do not mention the high cost in training and maintenance required to run equipment. All MLS surveys, however, include a significant amount of traditional survey measurement. These tasks are outlined above and include control surveys, placing targets, feature pick-up, data extraction and data formatting.

It is worth for survey companies and organisations to consider the use of MLS for future corridor surveys. In order to be involved, they should contact their MLS supplier to discuss the job requirements (accuracies and deliverables), the costs involved and the level of participation of their own organisation. Working together with your MLS data supplier will provide the best opportunity to deliver high-accuracy corridor surveys to your client, within their specifications quickly and cost-effectively.

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