LYNX SURVEY OF THE URBAN ENVIRONMENT AND HISTORICAL HERITAGE

Federica Zampa (*)

(*) Sineco S.p.A. – Federica.Zampa@sineco.co.it

1. INTRODUCTION

In 2008 Sineco received, after a fruitful collaboration with Optech lasted more than two years, the Lynx, that is the first mobile mapper ever built in the world. The Lynx Mobile Mapper is a fully integrated system with 360° laser sensors integrated with a very precise position and orientation system, that allows to survey large areas from a mobile platform at very high speeds (up to 100 km/hour), obtaining a 360° high-resolution (up to 1cm) point cloud.

This paper presents an accurate description of how mobile mapping technology works and which are the stunning results achievable, and this will be done explaining the working principles of the Lynx, along with the presentation of the survey of a city centre, from the pointcloud to the 3D model reconstruction.

Following it will be shown the application of a Lynx Survey to the historical sector, presenting on exclusive first release the results outcoming from the first laser survey ever carried on of a very important historical site: the Ancient Via Appia in Rome, with all the magnificent monuments that characterize this famous strip of road.

2. THE SYSTEM

The first prototype of mobile mapper was the result of the collaboration of Sineco S.p.A, engineering firm of ASTM Group, and Optech Incorporated, Canadian manufacturer of advanced laser-based imaging systems, and was developed in 2007.

It was based on a platform combining two static laser scanners, one scanning horizontal and the other vertical, and a position and orientation system (Applanix POS LV 420), which consisted of an inertial measurement unit (IMU), two dual-frequency GPS receivers and a DMI - distance measurement indicator.

Figure 1: Mobile Mapper Prototype

This system was the proof-of-concept that paved the way for the development of the new Lynx Mobile Mapper, a fully integrated system with 360° laser sensors that surveys large areas from a mobile platform at very high speeds (up to 100 km/hour), obtaining a 360° high-resolution (up to 1cm) point cloud.

The Lynx is designed for collecting grade lidar data over large areas that are impractical to survey with static lidar sensors yet require an accuracy and resolution that exceed airborne technologies. The mobile mapping solution, while accommodating two lidar sensor heads, fuses the lidar data with an on-board passive imaging system, the Trimble/Applanix POS LV system and an operational software platform to produce survey grade 3D data from the mobile vehicular rigid platform. A rigid design for the entire mounting structure ensures that alignment and accuracy between the sensors and the navigational equipment is maintained.

Figure 2: Lynx Mobile Mapper with all the system components

The system is characterized by an accuracy better than 5 cm, a measurement rate of 100.000 points per second per sensor, a 360° field-of-view and a resolution of up to 1 cm. In this way the Lynx Mobile Mapper has a feature set that allows for the generation of high resolution data at high vehicle speeds.

The dual-sensor configuration allows to minimize the shadowing caused by objects along the roadside while optimizing the field-of-view to full coverage.
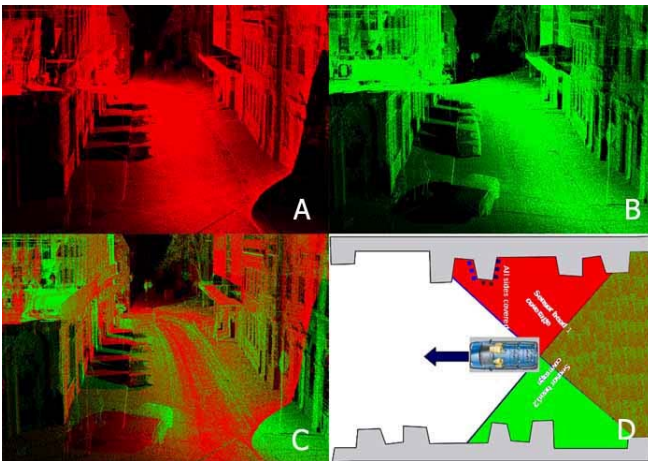

Figure 3. A - Left sensor head 1; B - Right sensor head 2; C - Data combination; D – Sensor coverage

wheel-mounted rotary shaft encoder that measures the precise linear distance traveled. These measurements give the POS LV a very accurate velocity measurement that helps constrain drift errors during GPS outages.

The POS is used to give position and orientation to the two lidar sensors, thus generating a complete geo-referenced point cloud automatically.
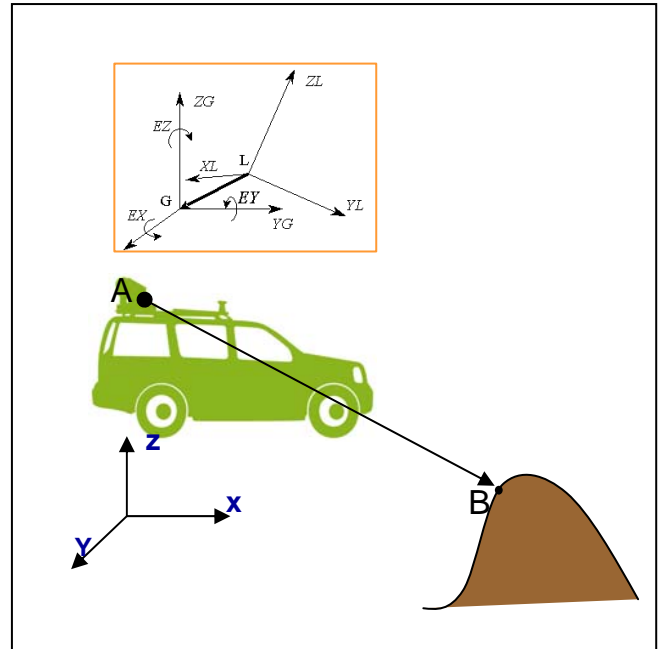

Figure 4. Integration of POS technology with laser sensors

The connectivity between the lidar sensors and POS is limited to synchronizing the clocks between the instruments. This operation is executed by setting up a GPS PPS connection that lets the laser timestamp events with its local clock. At the same time a GPS NMEA string is required to indicate the precise GPS time of the previous PPS event. The lidar sensors then use this time to establish the offset between their local clocks and GPS time.POS has its own orientation and position above the platform and it is important to know the exact orientation and location of both lidar sensors with regard to the POS. For this reason mobile lidar sensors must be calibration after they are mounted to the vehicle.

3. THE TECHNOLOGY

The navigation solution is a critical component for any mobile system. The position and orientation solution (POS) makes use of an IMU, of the GPS and DMI. The IMU contains three accelerometers and three gyroscopes which measure the acceleration and angular velocity necessary for computing all aspects of the vehicle motion: position, speed, acceleration, orientation and rotation. Two dual-frequency (L1/L2) GPS receivers track and record the vehicle path. Differential GPS processing is used to correct and refine the geo-referenced data. In case of GPS outrage the POS can correct the location by using the DMI (Distance Measurement Indicator): the DMI is a

4. SURVEY EXAMPLE : CITY MODELING

In the following example we can see the application of the Lynx in a Urban Environemnt.

The aim of the project was to obtain a faithful model reconstruction of a block in the city centre of Milan, for a complete digital archive.

Due to traffic congestion the entire area had to be scanned at an average speed of 30 km/h, while collecting data with spot spacing of about 4 cm. In 20 minutes the Lynx Mobile Mapper scanned a total of 156 million points. All the pre-processing was carried out using a single GPS base station placed around the area.

The raw data obtained with the survey are shown in the following picture: all the points are already georeferenced, and carry with them the information on the reflectivity of the different materials.

A pointcloud like this can be explored at any time, and a bunch of different information can be extracted by the user.

In it all kinds of measurement can be done, with a millimetric precision, and it has a high historic value, since it records the situation of an environment at a certain time.
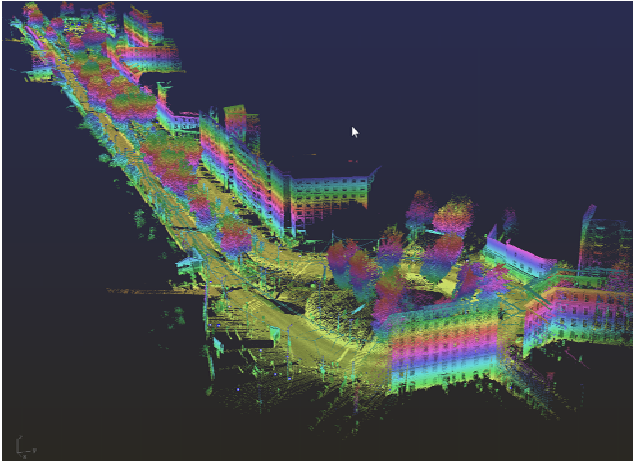

Figure 4: Lynx data of a block in Milan

In the following pictures there is the example of the steps for obtaining the modelling of the surveyed area, in this case of a Urban Environment, from Lynx data.
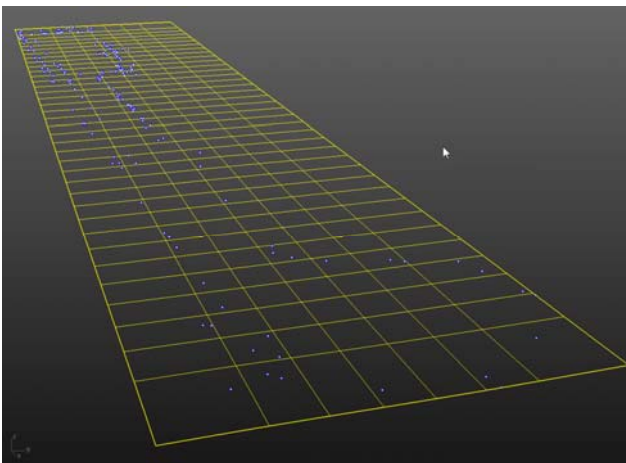

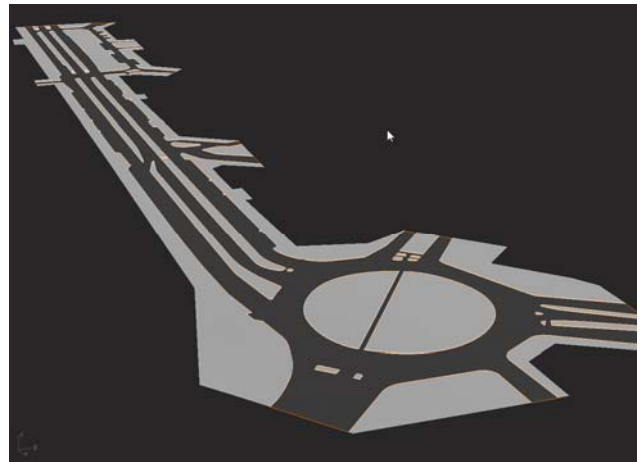**Figure 5: Modeling of the surface**
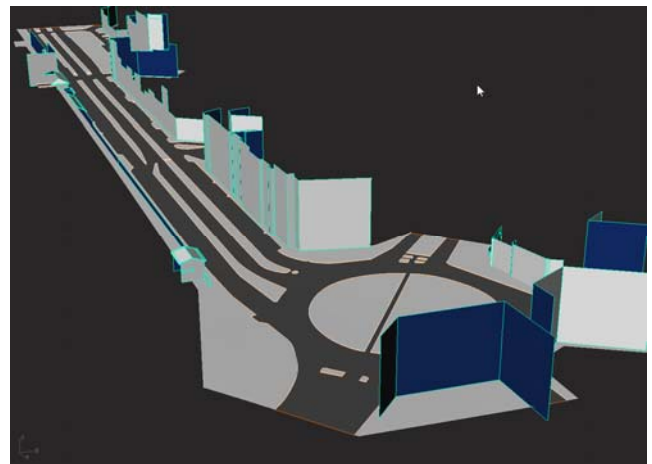

Figure 6: Surface and planes reconstruction

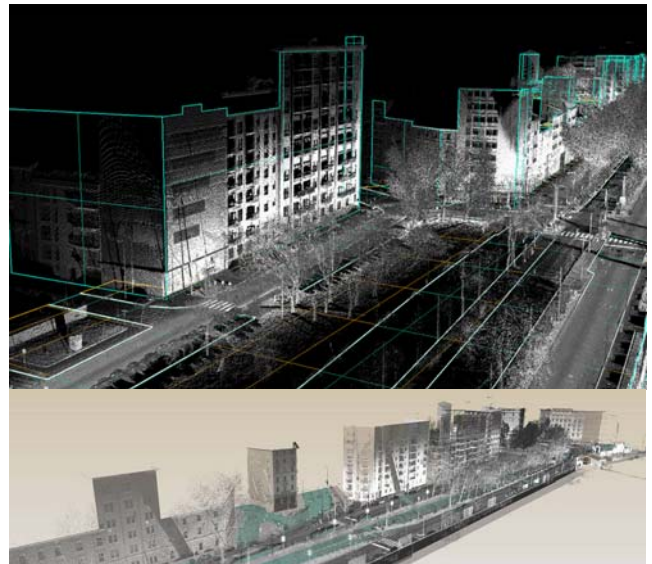

Figure 7: Building Modelling

Figure 8: Final CAD 3D reconstruction

The resulting point cloud was an efficient archiving of the "as built" structures for future reference.

5. SURVEY AREA : APPIAN WAY - ROME

Some historical hints
The Appian Way (Latin and Italian: Via Appia) was the most important ancient Roman road and was also called the "the queen road". It connected Rome to Brindisi, Apulia in southeast Italy. Its importance is indicated by its common name, recorded by Statius: Appia teritur regina longarum viarum ("the Appian way is commonly said to be the queen of the long roads")

The main part of the Appian Way was started and finished in 312 BC. The road began as a leveled dirt road upon which small stones and mortar were laid. Upon this gravel was laid, which was finally topped with tight fitting, and interlocking stones to provide a flat surface. Some of the stones were said to fit so well that you could not slide a knife into the cracks. The road was crested in the middle (for water runoff) and had ditches on either side of the road which were protected by retaining walls
As to Via appia, a great importance and attention is focused on this kind of subject, and this survey was carried on under the attention of the National "Ministero dei beni culturali italiani", that is the "National Ministry for Historical Heritage".

The IV miglio Via Appia survey was carried out in November 2008. The survey area consisted of 1 km stretch of historical road with the vehicle moving at a speed of 20 km/h, which is a very low speed fo the Lynx, due to the conditions of the road.

Figure 11: Picture of the particular famous pavement of the Appian Way

The main goal was to obtain an efficient archiving of the "as built" structures for future reference. The road was surveyed in only three minutes and the system acquired 52 million points. The point cloud was generated in WGS84/UTM32, with a final average spot spacing of 2 cm.
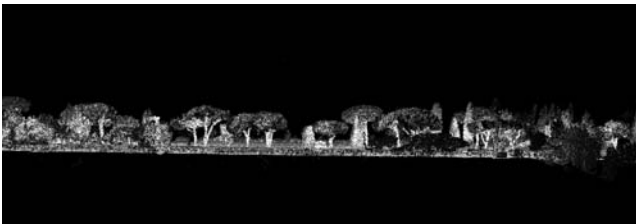In order to get all the results needed, different software was used for data processing.

Figure 9: Survey area lateral view

Figure 10: Appian Way Pavement Particular scanned with Lynx

Figure 12: View from the top of the Livio Fulco Funerary Monument scanned with the Lynx

Figure 13: Livio Fulco Funerary Monument pointcloud

Figure 14: Livio Fulco Funerary Monument Picture

It is really interesting looking at the perfect correspondence between the results obtained by known techniques, like photography, and the point cloud surveyed.

Figure 15: Appian Way Historical Building

Figure 16: Appian Way Historical Building Picture

Figure 17: Marmorean Alto-rilievo to the heroic nudity

Figure 18: Marmorean Alto – rilievo picture

6. CONCLUSION

The survey demonstrates how mobile lidar technology can be used to conduct different types of survey at an impressive speed, in a safe fashion.

The geo-referenced point clouds obtained have a very high-resolution and provide a complete database of information that anyone can examine anytime. The high-density point cloud allows for easy identification of objects such as structures, slopes, road signs, poles, buildings features, etc. Above all the resulting point cloud is an efficient archiving of the "as built" structures for future reference.