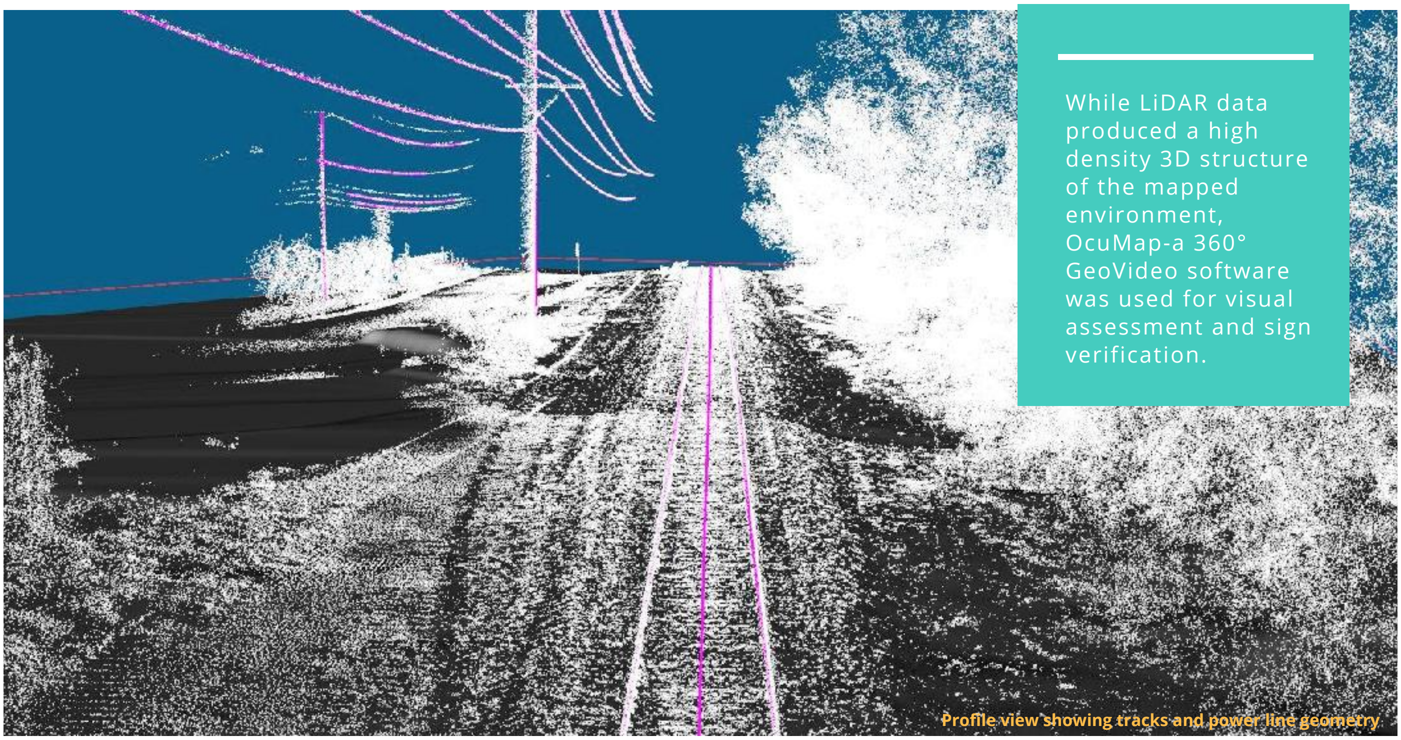
RAIL ROAD LIDAR MAPPING- A CASE STUDY

Commuter Rail As-built Survey Plan and Profile - Map, Image, and Identify Infrastructure Assets Within the Right of Way.

by Ala Hamdan



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Profile view showing tracks and power line geometry

Commuter rail was operational and our team had limited time on the tracks. Survey control points needed to be established and 40 mi needed to be mapped within a few hours. 23 mi were in a heavily densed urban area. Client had a deadline to comply with a request from the Federal Railroad Administration (FRA). Multiple stakeholders needed that data to perform different analysis however, no one had any experience with LiDAR surveys and expectations needed to be managed across the board.

The Process

1. Establish Geodetic Control

Survey Geodetic Parameters were done based on local coordinate system. Leica SmartNet (North America) VRS system was used as the primary source of Real-Time Kinematic (RTK) corrections for all survey operations. SmartNet provides high-precision, high-availability Network RTK corrections using both the GPS and GLONASS satellite constellations.

2. Establish Temporary Survey Benchmarks

Prior to data collection, temporary survey benchmarks were fixed to the railway line ties approximately every mile for the full length. The survey benchmarks were coordinated by the averaging of 1,800 stationary positions taken with a GNSS receiver in RTK Fixed mode using the corrections provided by the SmartNet network RTK service.

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Figure 1. Temporary Survey Benchmarks.

3. Mount 360° Geo Video Camera and Front Looking Video Camera

Two separate digital camera systems were used to collect geo-referenced videos including a 360° spherical video camera mounted on the roof, and a second wide-angle digital camera mounted in front of the truck to help view track features.

4. Mobile LiDAR System

InteLAS™ mobile LiDAR system by iLinks was used to collect the data. The system comprises a dual GNSS positioning and heading system tightly coupled to a Fiber Optic Gyroscope (FOG) based Inertial Navigation System (INS). A Velodyne HDL-32 LiDAR sensor delivers 700,000 survey grade measurements every second. The system was fitted to the rear of the rail vehicle enabling the collection of survey-grade LiDAR data in a 360° field of view at ranges of up to 300 feet.

Figure 2. Hi-Rail Vehicle with RTK GPS.

5. GNSS/INS Data Post Processing

To achieve the maximum accuracy possible, and to ensure that survey-grade tolerances were met, the mobile LiDAR data was post processed using Novatel's proprietary "Inertial Explorer" GNSS and INS post processing software. Inertial Explorer post-processing software is a powerful, highly configurable processing engine that allows for the best possible static or kinematic GNSS accuracy using all available GNSS data. The final LiDAR (.LAZ) files for the route contained over 800 Million survey-grade 3D data points.

6. LiDAR Data Processing

Once the pointcloud data is adjusted to local Datum and corrections are applied, the pointcloud is then classified based on the following parameters: Ground surface, buildings, low-medium or high vegetation, rail tracks surface, centerline, curb, water bodies, powerlines, and other irregular structures/masts, etc.

Features were then Isolated and an auto-detection is applied to locate similar shapes within the pointcloud. Human interference was necessary especially at road crossings and powerlines. Detected features are then traced to generate point features, line features and polygon features. Surface meshes were then

Project Details

Project Length: 40 Miles (64 km).

Technology: Vehicle Based LiDAR & 360 GeoVideo.

Project Requirements: Asset verification and Geometry as-built survey with the following list of requirements:

1. Geometry:

- Vertical and horizontal curves including spirals and super-elevation for simple & complex curves.
- Left/right of tracks including latitude, longitude and elevation
- Underpass, overpass, bridge and culverts
- Turnouts, switch points and diamonds
- Right of Way Limits

2. Asset features:

- - Insulated Joints, derail and bumping posts
- - Mile post monuments and markers
- - Speed signs, road/pedestrian crossing signs, and DOT crossings.
- - Method of operations signs.
- - Signal bungalows, cases, junction boxes and Switch machines
- - Wayside Signals (Mast, bridge, and cantilever)
- - Radio Towers, overhead AC power lines.

created to generate contour lines at 1 meter intervals. The final step in processing LiDAR data is to export the extracted features into a DXF for further analysis in Autodesk Civil 3D.

7. 360° GeoVideo and Front Looking Video

While LiDAR data produced a high density 3D structure of the mapped environment, OcuMap-a 360° GeoVideo software was used for visual assessment and sign verification. The front looking camera's video was used to geotag Insulated joints that were not visible from the LiDAR data. Geotagged features were then converted to local coordinate system and imported into CAD to be displayed on the plan and profile drawings.

8. Real-time Super-elevation Calculations

While the LiDAR survey was accurate up to 1/10th of a foot, Superelevation calculations needed to be accurate up to 1/50th of a foot (¼ inch) to meet design standards. Superelevation calculations were done based on the precise Roll angle of the hi-rail LiDAR vehicle as measured by the Inertial Navigation System (INS) which was logging angular data 20 times/sec. Roll measurements were extracted in real-time based on the geographical positions of the start and end curves stationing. The angular measurement accuracy of the INS is better than 100th degree, so theoretically it is much more accurate than the 1/4 inch requirement. This new method provided superelevation readings evert 10 feet as fast as the hi-rail car was travelling.

Conclusion

Mobile LiDAR survey can improve efficiency of rail surveys by a minimum of 40%. The amount of geospatial data collected during the survey far exceeds one collected by conventional methods. The Accuracy of data collected using LiDAR system meets or exceeds the rail industry requirements which is currently done with a Track Geometry Car and a Tamper. While it may take time for the industry to adapt this new way of generating as-builts and working with such data, industry leaders are starting to test this out as they are pressed for time and under pressure to reduce operational cost through the application of technology.

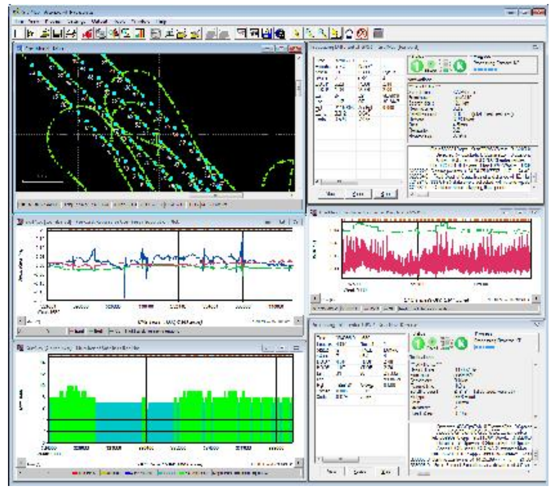

Figure 3. Inertial Explorer by Novatel.

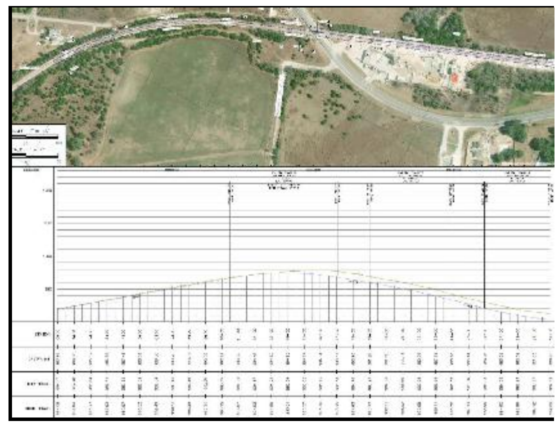

Figure 4. Profile view-Showing Center Line Elevation, Right &Left Track Elevation and Vertical Curve Geometry.

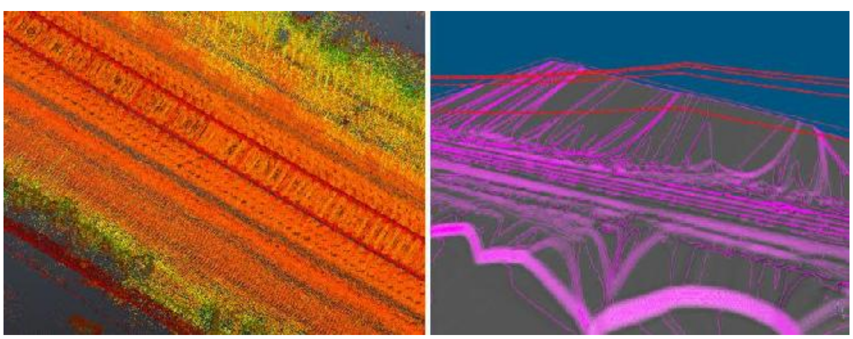

Figure 5. Classified pointcloud data shown by elevation (left). Surface mesh DEM-TIN (right).

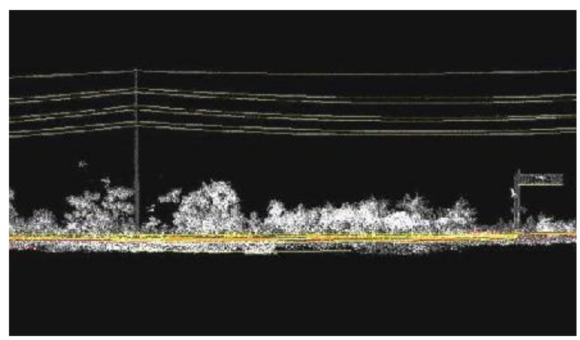

Figure 6. Civil3D-Profile view showing tracks and powerlines geometry.

Figure 7. OcuMap-360 Geovideo software- showing geotagged feature.

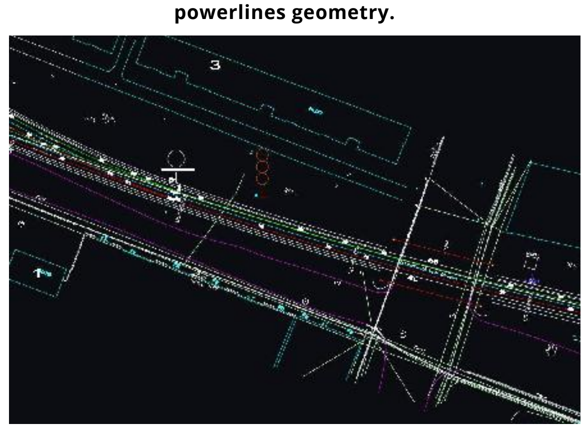

Figure 8. Civil3D-Plan view showing ROW features.