Surveying and 3D Modeling of a High-voltage Substation

Laser Scanning in the Tver Region

A large-scale survey of a high-voltage substation in the Tver region of Russia, was to be produced at a scale of 1:500, to include high accuracy determination of power line portals and associated features. Using the results of a laser scanning survey, a detailed 3D model of each portal and bearing was also generated. Together with reflectionless tachymeters, utilizing laser scanning technology can greatly improve the performance of a field survey, particularly in such a difficult object-oriented location as the high-voltage substation.

By Sergey Gorbunov

Figure 1: Laser Scanner RIEGL LMS-Z420i is on the high-voltage substation project.

A large-scale survey of a high-voltage substation in the Tver region of Russia, was to be produced at a scale of 1:500, to include high accuracy determination of power line portals and associated features. Using the results of a laser scanning survey, a detailed 3D model of each portal and bearing was also generated.The classical approach for undertaking a topographic survey was used, which required the use of tachymeters, plus the additional utilization of experts for portal and bearing measurements. Undertaking a topographical survey such as this would take several weeks, so the main part of job was done with a laser scanning system.

Equipment

The equipment used was a RIEGL LMS-Z420i, equipped with a Nikon D100 digital camera. Using the RIEGL LMS-Z420i scanner, we produced a 3D point cloud model in a very short time, and with high accuracy, ~ 10mm. The particular scanner used is a highly-accurate and reliable instrument, which can be utilized for a wide range of applications, such as industrial surveying, mining, civil engineering, and highway and railroad surveys. The increased use of this technology is a direct result of the considerable progress in scanner development and manufacture, particularly for terrestrial scanning applications. The advantage of using a laser scanning system, with reference to substation surveying, is its ability to produce an extraordinary amount of information, which is indispensable for detailed 3D modeling of the structural features associated with a high-voltage substation.

Work Technique

The high-voltage substation is a large and lengthy area with numerous installations, such as portals, shielding unit, generators, and cables. Furthermore, the building, maintenance and assembly of portals was being performed in the same area as the survey during the scanning sessions. The survey equipment and crews were put to the test by the high-voltage electromagnetic waves, but the scanner demonstrated proper functionality in these adverse conditions. The total number of scan positions was 104, with a 50m average distance between them. Two reflectors were placed between neighboring scan positions, for the best measurement accuracy, with another four reflectors relocated at the next scan position. Scanner surveys propose using at least six reflectors for point cloud transformations from the scanner's own coordinate system into the project coordinate system. Usually these reflectors coordinate with the reflectionless tachymeter with final results saved in a plain text file. For the best transformation results, most of the reflectors have to be distributed around the scanner at different distances and at different elevations. The work technique includes the development of a survey basis with five reference points, which are used for the execution of the tachometric survey of reflectors. The global coordinates of the reference points was derived by DGPS. Using these points, the survey traverses were built across the complete survey area. A cross check of scanner measurements was also made by neighboring scanner stations. The angular step width of scanning was 0.060, which meant the average time for one scanning session was approximately 16 minutes. The digital camera took photos in semi-automatic mode, after each scanning session. To get the necessary image coverage of each scanning field, 10 photos were needed each with a 10% overlap. This information was later used for point cloud coloring.

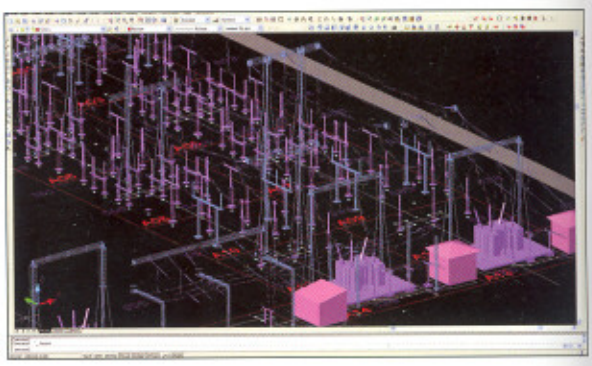

Figure 2: Color 3D model of substation, loaded in AutoCAD by Kubit PointCloud software.

# of Russia

Figure 3: Final 3D model of the high-voltage substation.

Post Processing and Modeling

Registration of scans in a global coordinate system usually executes using RiSCAN PRO software, which provides a lot of post processing features in addition to the scanner control functions. To produce an accurate definition of each registered scan position we used a Multi Station Adjustment procedure, which has an operating principle based on common point comparison allowing 10-12 scan positions to be the adjusted simultaneously. The final absolute accuracy of adjusted measurements locates within ~3 – 4 mm limits of error. With reference to our project we used the 2.5D raster filters of RiSCAN PRO for topographic surface detaching. We also drew polylines for boundaries and outline creation. Each registered point cloud was exported into AutoCAD, after coloring and resampling. For quick point cloud regenerating and ease of modeling in an AutoCAD environment, we used Kubit PointCloud software, which is compatible with AutoCAD. Using PointCloud, we can load several RiSCAN PRO projects simultaneously, without any serious rate reduction during regeneration. Using PointCloud, we applied color information using the digital camera imagery, to decipher the point data and facilitate 3D modeling. PointCloud installs as a plug-in module in AutoCAD, allowing you to use any of the AutoCAD functions, such as polylines, drawing, solids and surfaces creation, or snap-to-points. All of the loaded points transform in a so-called "proxy – graphic", which allows a greatly accelerated regeneration process. Together with PointCloud we used software suite "Geokosmos AutoCAD Tools", which has been specially developed for efficiently working with scan data, and data derived using traditional geodetic instruments, such as GPS, tachymeters and levels. By using Geokosmos AutoCAD Tools options, we created a digital elevation model (DEM) and used it for contour line creation. The 3D model of the substation was created using standard AutoCAD methods, such as meshes, solids, polylines, primitives; and using Geokosmos AutoCAD libraries for the creation of constructional elements for the portals, wires, cables and insulators.

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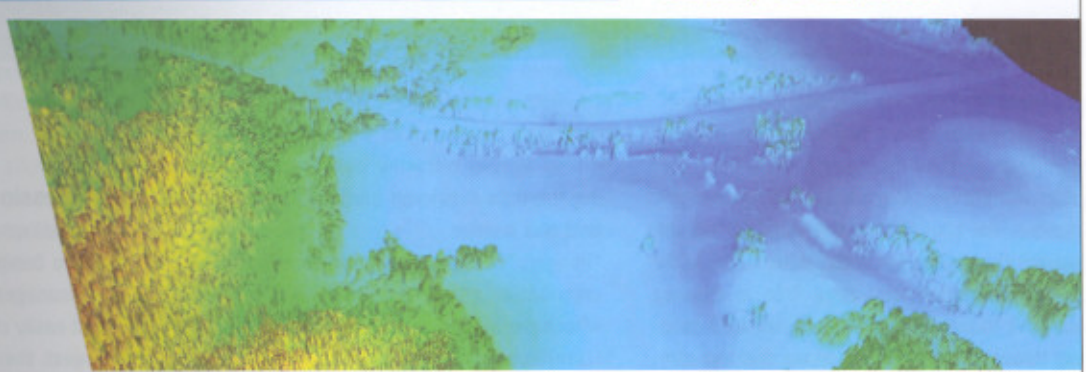

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