MOBILE MAPPING SYSTEMS FOR RAIL AND ROAD AS 3D TUNNEL INSPECTION TOOL

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Abstract

Rail and road constructions, especially tunnels, will be examined and documented in 3 dimensional models during the complete life circle. The execution of such measurements is economical and highly precise feasible with kinematic laser scanners. Based on two international projects the activities will be described and the solutions shown. First, a tunnel as- built survey including a tunnel inspection, for German Railway DB, and second a dynamic clearance analysis in Glasgow, for Stadler Rail. Both are extraordinary projects and were executed with Amberg Technologies AG equipment. The IMS 5000 and the MISS are perfectly suitable for this kind of work. Common, but terrestrial technologies have been used in local environment and will be presented in combination with ground penetrating radar measurements as tunnel lining condition and voids detecting in railway tunnel as well.

Based on those applied solutions the possibilities of such systems will be explained. A view in the digital world of Building Information Modeling and the new standards IFC 4 and IFC 5 will finalize this technical essay.

Povzetek

V članku bo obravnavano 3D kartiranje ter raba zajetih podatkov skozi celoten življenjski cikel objektov prometne infrastrukture.

Aktivnosti in končne rešitve bodo prikazane na osnovi dveh internacionalnih projektov, tj. kontrola geometrije dejanskega stanja predora za nemško železnico DB ter kot drugi primer izvedba kinematičnega skeniranja in analiza svetlega profila za "Stadler Rail" v Glasgow. Oba primera sta specifična in sta bila zajeta z opremo proizvajalca Amberg Technoilogies AG. Merilni sistemi IMS 5000 ter MISS so se izkazali kot aplikativni in ekonomično upravičeni za reševanje opisane problematike. Raba sorodnih tehnologij se je v lokalnem okolju že uporabljala ter bo prikazana s kombinacijo georadarskih meritev plašča železniškega predora.

Članek bo usmerjen prikazu integracije natančnih in ekonomičnih merskih metod ter produktov v dobo informacijskega modeliranja objektov, z upoštevanjem novih IFC 4 ter IFC 5 standardov.

Keywords
As built survey, rail, road, tunnel, mobile mapping, 3D scanning

AS BUILT SURVEY AND TUNNELINSPECTION OF A RAILWAY TUNNEL IN GERMANY

The German standard DIN 1076 advice to check structures with kinematic laser scanners if they are tunnels over 500m long or if tunnel chains. This is generally for the tunnel structure main inspection and valid for road and rail.
Also the guideline RIL 853 of German Railway DB explains the use of tunnel scans inside a railway tunnel for and combines tunnel several tunnel analytics. According to that document the primary goal is to perform:

- As built check and comparison to design values
- Check of horizontal displacement of tunnel segments in TBM tunnels
- Detection of flat deformations like spalling of concrete
- Clearance control

In case of the new build Zierenberg tunnel, Amberg technologies has to measure with a kinematic laser scanner. Because this was during hand over from construction company to rail laying it was no track installed and all measurements has to be performed on a concrete surface invert.

Figure 1: Tunnel portal with concrete surface and escape walkways.

All measurements were executed with the Amberg Mobile Infrastructure Scanning System MISS. Main parts of the system are:

- Amberg profiler scanner
- Leica total station to follow the vehicle
- "IMU" to control vehicle inclination
- Computer with special software

Figure 2: Amberg Mobile Infrastructure Scanning System MISS

Continuously recording of the scan and his 3D position allows a "helix" point cloud with high precision and a enormous dense of point. One, easy to calculate, result is the comparison to the design data as profile calculation, if necessary with relation to the clearance profile.

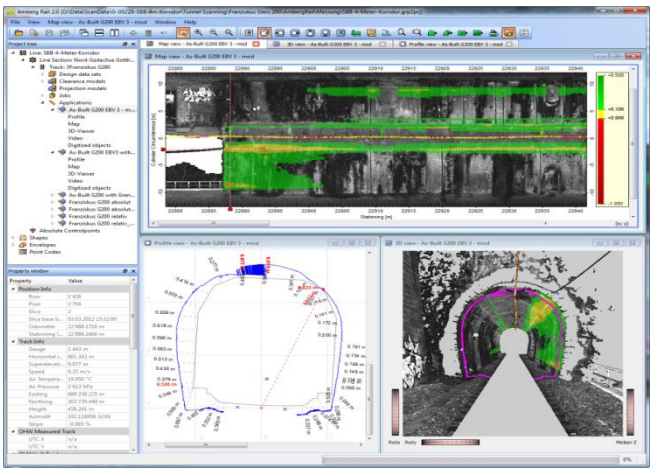

Figure 3: Typical results of profile measurements as 3D, 2D unwound plane and 2D profile view

The density of points allows creating a grey scale picture from the scan data. This will be transformed to a TIFF picture file and normally classified as section. Most relevant damages of the structure can be detected directly out of that pictures and stored in a database as objects.

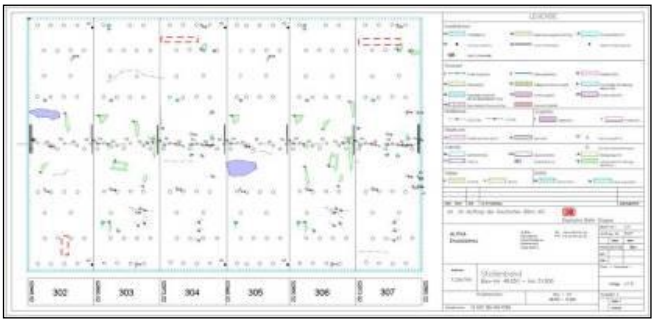

Figure 4: Tunnel inspection document according to a prior established phenomenon catalogue

The Amberg MISS is a system to fulfill all needs of modern tunnel investigation where no rails are installed. High precision geometry data in a 10mm to10mm grid and pictures, maid in absolute darkness if necessary, allow a complete data set, even concrete cracks in submillimeter range are detectable..

DYNAMIC CLEARANCE SURVEY OF METRO LINE IN SCOTLAND

Clearly, the development of a new train design for the subway would be dependent on understanding the precise characteristics of the infrastructure as well as the dimensions of the existing fleet. Because the current motor and trailer cars are not physically identical, nor there was no extensive data on the clearance envelope neither a comprehensive policy for handling data.

Because the costumer was required to provide proof that the new trains could operate on the existing infrastructure, it became necessary to source comprehensive geometric data on track and structures, Amberg Technologies was appointed to undertake the required surveying and carry out customer specific clearance testing to achieve full-coverage, capture and recording of an extremely precise geometric baseline.

Figure 5: Measurements at the tunnel in Glasgow

A total of 21 track-km had to be surveyed, covering the two concentric unidirectional running lines, depot access tracks and sidings, and other nonrevenue track. Because of the restrictive dimensions of the tunnel bores, the new vehicle design must make best use of space. As a result, calculation reserves had to be kept to a minimum, and very stringent requirements were issued for data accuracy and density.
The 3D geometry of both the track and the tunnel walls had to be determined very accurately. To ensure that every asset relevant to the clearance calculation could be surveyed, including wayside signs, structural supports and other fixed installations, a data density of 5 mm was specified. Precise recording of the track parameters has a direct influence on the resulting clearance envelope. Inconsistent track geometry, either horizontally or vertically, can affect the dynamic behavior of the rolling stock and the resulting clearance requirements. Track gauge and cant can also affect the clearance calculations.

Figure 6: Amberg IMS 5000 clearance

Key figures of Amberg IMS 5000:
Components:

- Amberg Profiler 6012 scanner: 200 profiles or 1 million points per second
- IMU AMU 1030: 3 gyros, 3 accelerometer
- Odometer
- Gauge sensor
- Inclinometers

Speed :

- < 5km/h

System accuracy:

- Track geometry 30 m chord: 0.7 mm (2 sigma)
- Track geometry 300 m chord: 3.0 mm (2 sigma)
- Gauge: 0.3 mm
- Super elevation: 0.5 mm
- Profile accuracy related to track: 3.0 mm

A basis for BIM the high-resolution 3D data obtained from the surveys can also be used to support wider objectives in the Subway upgrading program. Because known control points along the track were measured as well, the 3D point can be georeferenced and provided with absolute coordinates. This can be used to support construction activity taking place around or close to the metro, and as the basis for the network owner to use Building Information Modelling in the future.

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