Introduction

Application Groups - focus engineering surveying
- Linear Objects
  - Roads
  - Railways
  - Pipelines
  - Power lines
  - Harbor and river engineering objects scanned from the water side
- Construction work - buildings
- Industry

Other
- Forensic
- Cultural heritage
- Mining
Terrestrial Laserscanning / MLS

Wide range of use – leak of standardization for the methodology and the final products

- Depending of demand for projects
- Several manufacturers of Laser Scanner are on the market
- Different ranges and measuring rates
  - High speed low range
  - Low speed high range

Hardware - Laserscanner technical data (old/new)

<table>
<thead>
<tr>
<th></th>
<th>Z+F</th>
<th>Leica</th>
<th>Riegl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>5006</td>
<td>Scanstation2</td>
<td>C10</td>
</tr>
<tr>
<td>Range</td>
<td>80m</td>
<td>180m</td>
<td>300m</td>
</tr>
<tr>
<td>Rate</td>
<td>up to 500,000 p/sec</td>
<td>up to 1,000,000 p/sec</td>
<td>up to 50,000 p/sec</td>
</tr>
<tr>
<td>Field</td>
<td>310 x 360</td>
<td>310 x 360</td>
<td>270 x 360</td>
</tr>
<tr>
<td>Security</td>
<td>3R</td>
<td>1</td>
<td>3R</td>
</tr>
</tbody>
</table>
The Applications defines the main functionality, requirements for the results and also the processing steps in the software:

- Criteria for measuring method like static, stop & go or kinematic
- Planning a project
- Completeness vs. Accuracy
- Measuring
- Registration of Scans or Synchronization of the scan lines
- Analyzing and evaluating the Scans patches
- Presentation of the results
  - Different applications – leads to different software, cost intensive
  - At least 2 sofware packages for a single project – in average

Measuring methods

360° scans - profile scans

- Static
  - Scans from different station points 360° mode
- Stop and go
  - Scans from moveable platforms with total station support 360° mode
- Kinematic
  - Profile scans from a platform in motion, with DGPS and real time or post processing step for georeferencing profile mode
Measuring method

• Static
• Stop & go
• Kinematic

Laserscanning

Laserscan data – software needs and modules

• Analyzing software /pre process - provided by the manufacturers
• Project management - external providers
• Database
• Special graphics engine – the CAD plug in’s are not efficient enough
• Detect geometry objects / extracting features – just primitives if special requirements - third party specialized software
• Standard output formats (dxf, dgn, 3ds, geotiff, ecw, bmp, avi)
• The market is still creative regarding creation of new formats!
Laser scan data – software structure

Building & Architecture

- Documentation as build - actual state
- Getting plans
- Sections
- Orthophotos
- Mapping „hand photos“
Building & Architecture

- Documentation as build
- Getting plans
- Sections
- Orthophotos
- Mapping „hand photos“
Building & Architecture

- Documentation as build
- Getting plans
- Sections
- Orthophotos
- Mapping „hand photos“

Abwicklung in plane

Building & Architecture

- Documentation of actual state
- Getting plans
- Sections
- Orthophotos
- Mapping „hand photos“
Detailed modeling

Interpolation Functions

• Spline Definition
  • for surfaces & volume calculation
  • gives the parameter of the surface
• TIN models
  • increases the data volume

\[
g : I \rightarrow \mathbb{R}
\]
\[\delta^{u_j} L_k(n_j) = \delta_{k, j}, \quad j = 1, m \quad (3)\]
\[|y_k(x)| \leq \alpha \exp(-\beta|f - n_k|), \quad (1)\]
\[f \approx \sum_j L_j g_j \quad (2)\]

Spline

• Data reduction
• Increasing surface accuracy
Spline/TIN models

• Volume calculation

Linear Objects - Infrastructure
Linear Objects  Infrastructure

Parameter calculation
Linear Objects  Infrastructure

Parameter calculation

Slopes of the pipes

Kinematic system

- Low cost
- Scanner + GNSS + MEM’S
- ~ 100 000 EUR
Kinematic system MLS VMX-450

- High end

First Prototype of a Mobile Street Acquisition System (MoSES)

- High end
- ~400 000 EUR
Lynx Mobile Mapper system MLS

- High end

Kinematic system

- Roads

Application for the data synchronization - road
Repeat the measurements on the selected points is in fact not repeatable there are not fixed.

Clasic methods

Using this profile type for control and also the selected areas (area 3000m/2 each) do not give any representative information about the thickness and the homogeneous distribution of the asphalt thickness.
This causes that the process of geodetic works do nor allow to get an objective picture and information about the current state of the roadway as continuous engineering object. Most important is the fact to not be able to control the construction or rehabilitation work.
In this situation the contractor is not able to prove his construction results and the employer is permanent in right.
Inconsistencies in the roadway deck

As build measured and colored against CAD
Low cost

EUPOS/SAPOS-based Vehicle Scheduling and Control System by the German Railway - RailNav Project

...stable communication
Accuracy ~ 50 up to 100 cm
Otherwise postprocessing

Source Mr. Lahr DB AG
Kinematic system MLS - Rail

Kinematic system MLS - Rail
Kinematic systems

Kinematic system MLS - Rail

3D clearance measuring train

2 High speed laser scanner

20 HZ GNSS receiver

Frauenhofer Institute Freiburg

Metronom GmbH, Mainz

INS System

Video system

Highest data acquisition rates 300, 500, 1000Hz depends on the scanner type

Up to 80 km/h for the measurement ride
Kinematic systems

- Tunnel shape - clearance
- Distance to neighbour track

Kinematic systems

- Rail geometry
- Electricity wires
- Batch Sections functionality
Kinematic systems

- Rail geometry
- Electricity
- Batch Sections
- Collision detection
Kinematic system

• Maintenance purposes

Variance comparison

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Station</th>
<th>Distance to Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:00:29</td>
<td>20.254</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>20.667</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>21.080</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>21.493</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>21.906</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>22.319</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>22.732</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>23.145</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>23.558</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>24.071</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>24.484</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>24.897</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>25.310</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>25.723</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>26.136</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>26.549</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>26.962</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>27.375</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>27.788</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>28.201</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>28.614</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>29.027</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>29.440</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>29.853</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>30.266</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>30.679</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>31.092</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>31.505</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>31.918</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>32.331</td>
<td>Station</td>
<td>0.0089</td>
</tr>
<tr>
<td>14:00:29</td>
<td>32.744</td>
<td>Station</td>
<td>0.0089</td>
</tr>
</tbody>
</table>

Station 0.8+51.094 distance to Track 0.0097
Rail and Road

Getting all the information you need

- Documentation „As-Built“
- Quality control
- Useful calculation base for driving dynamics
- Maintenance purposes and helps make future decision

Conclusions

Hardware
- The hardware is working stable, reliable and accurate
- Increasing the scanning speed

Software
- Increase the degree of automatization for feature extraction
- Automated registration
- Change the proportion between the data acquisition and office processing

Technology
- Automatization of the data processing
- Future development of scanning complexes
- Integration of additional sensors – MEM’s; low cost IMU; ...
- We have to calculate engineering parameters
- Modeling and coloring is not the main target in the engineering surveying
- If you try to sell this as final product you will fail
Thank you for your attention