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)

	Z+F		Leica		Riegl	
Scanner	5006	5010	Scanstation2	C10	VZ-400	VZ-1000
Range	80m	180m	300m	300m	500m	1400m
Rate	up to 500.000 p/sec	up to 1.000.000 p/sec	up to 50.000 p/sec		up to 125.000 p/sec	up to 122.000 p/sec
Field	310 x 360	320 x 360	270 x 360		100 x 360	
Security	3R	1	3R	3R	1	1

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 sofw. packeges for a single project – in average

Laserscanning

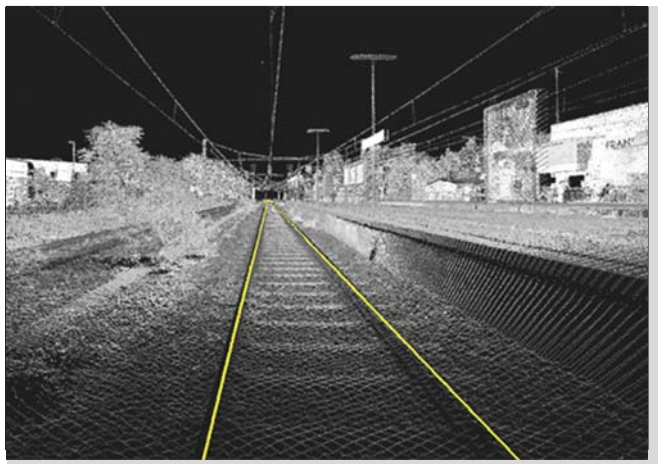
Measuring methods

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



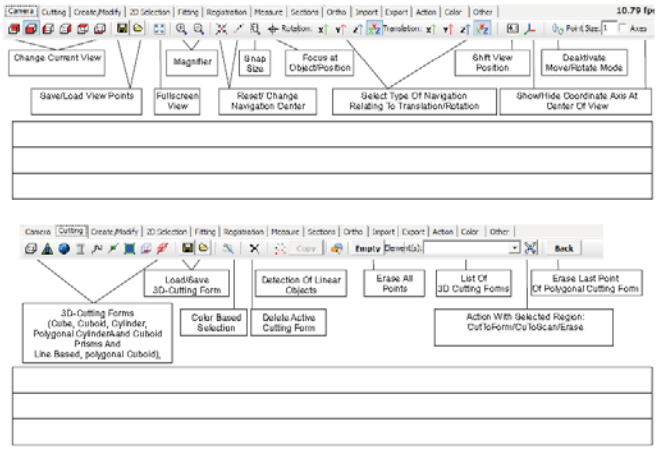
Laserscanning

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!

Laserscanning

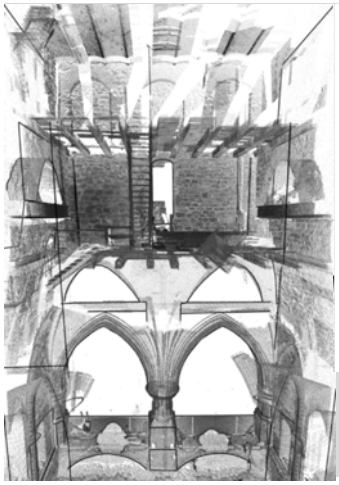
Laser scan data – software structure

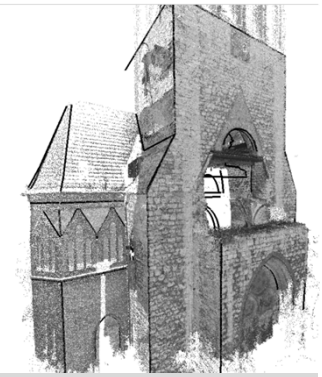


Products based on the customer requirements

Building & Architecture

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





Building & Architecture

- Documentation as build
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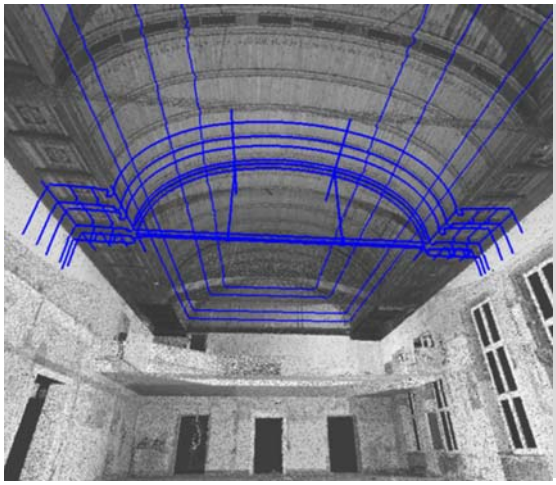

Building & Architecture

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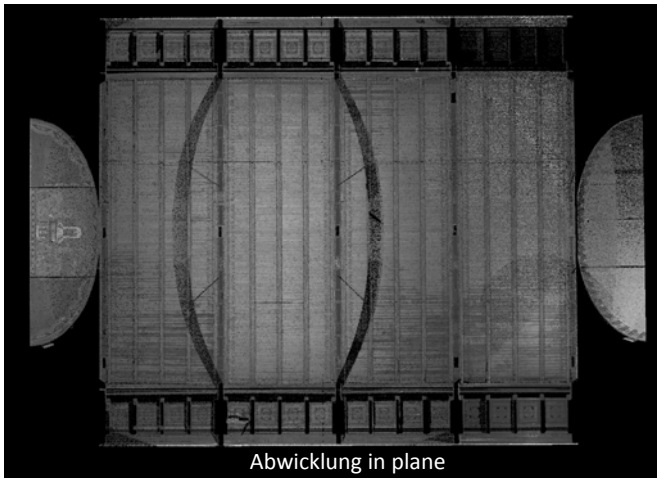


Abwicklung in plane

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

base $g : I \to \Re$

$$\partial^{\#j} L_k(u_j) = \delta_{jk}, \qquad j = 1 : m \qquad (3)$$

$$|L_k(t)| \le \alpha \exp(-\beta |t - u_k|), \qquad (1)$$

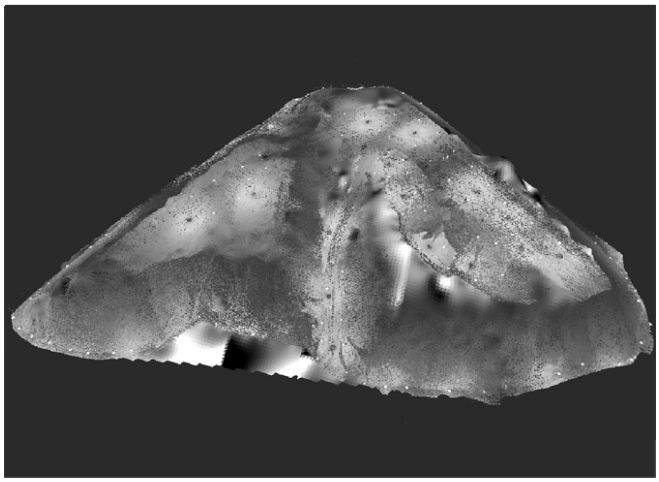
$$f = \sum_j L_j g_j \qquad (2)$$

Spline

- Data reduction
- Increasing surface accuracy

Spline/TIN models

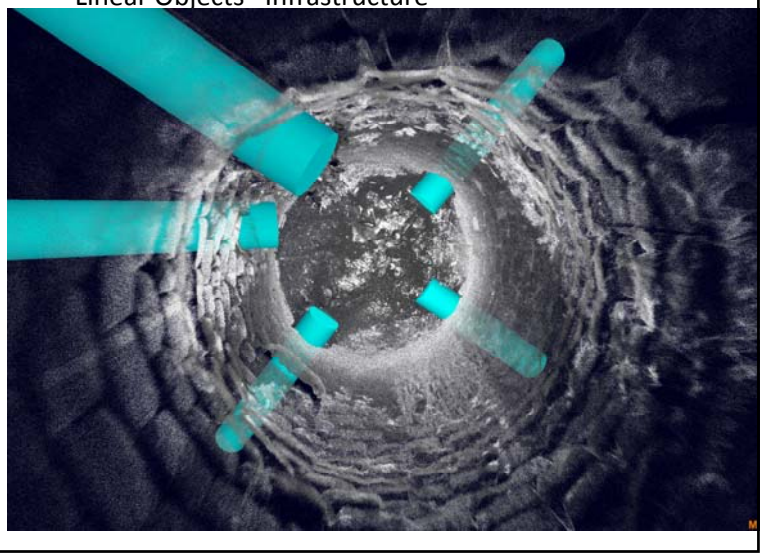
- Volume calculation



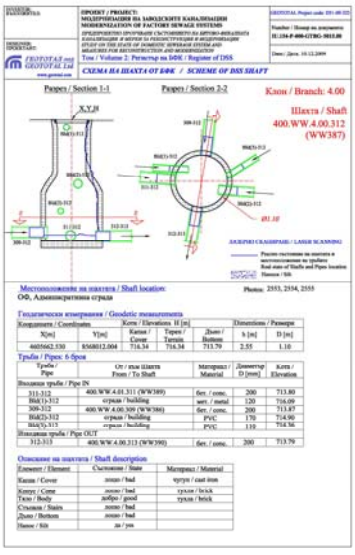
Linear Objects - Infrastructure

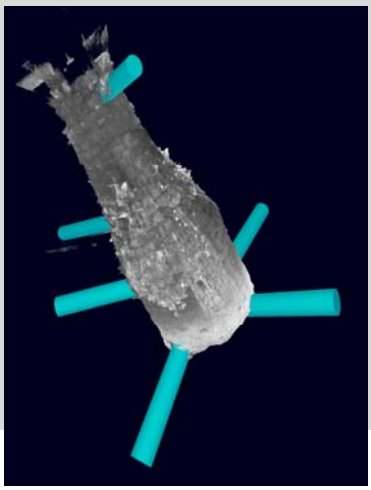
Linear Objects Infrastructure

Parameter calculation



Linear Objects Infrastructure

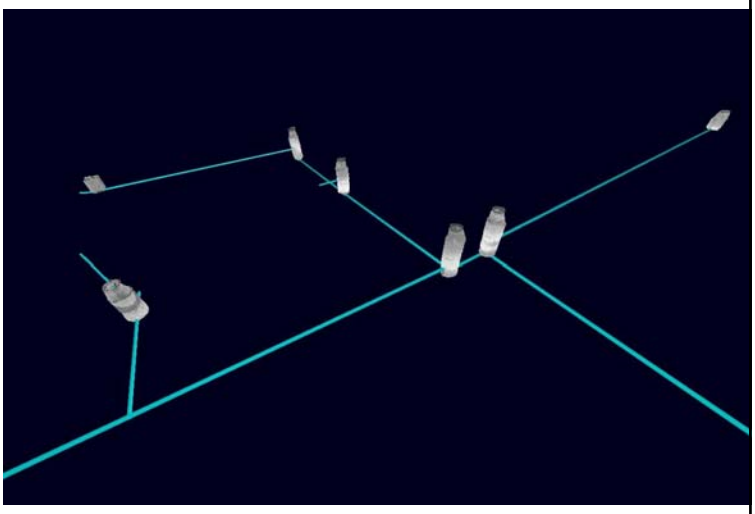




Linear Objects Infrastructure

Parameter calculation

Slopes of the pipes

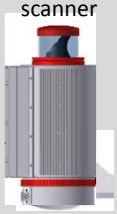


Kinematic system

- Low cost
- Scanner + GNSS + MEM'S
- ~ 100 0000 EUR

Kinematic system MLS VMX-450

- High end



laser scanner

mounting platform

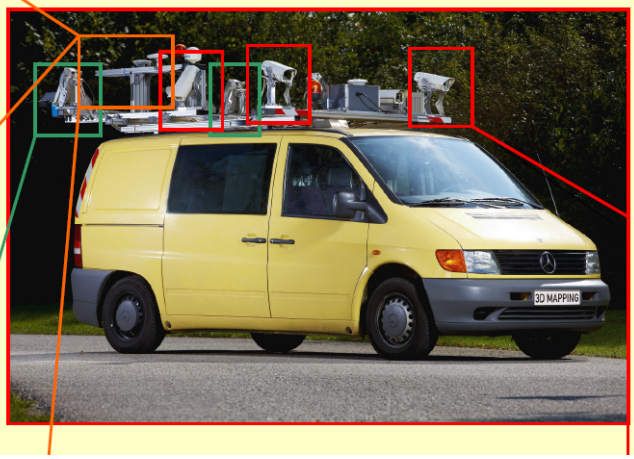
IMU

GNSS receiver

Kinematic system MLS

- High end
- ~ 400 000 EUR

First Prototype of an Mobile Street Aquisition System (MoSES)



Lynx Mobile Mapper system MLS

- High end

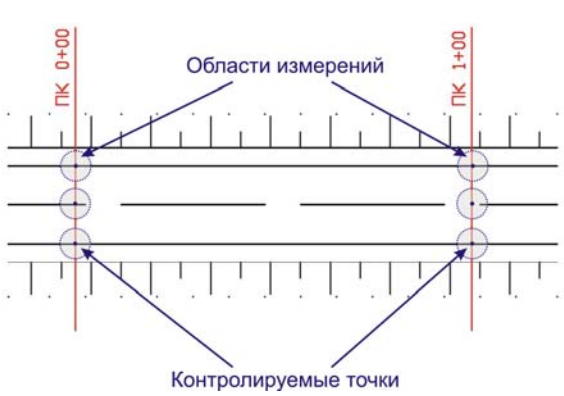
Application for the data syncronization - road

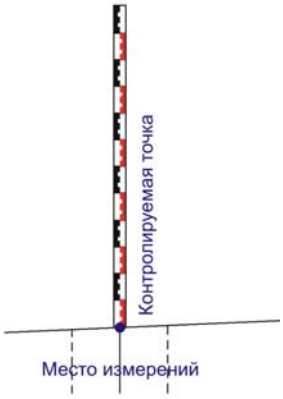
Kinematic system

- Roads

Clasic methods

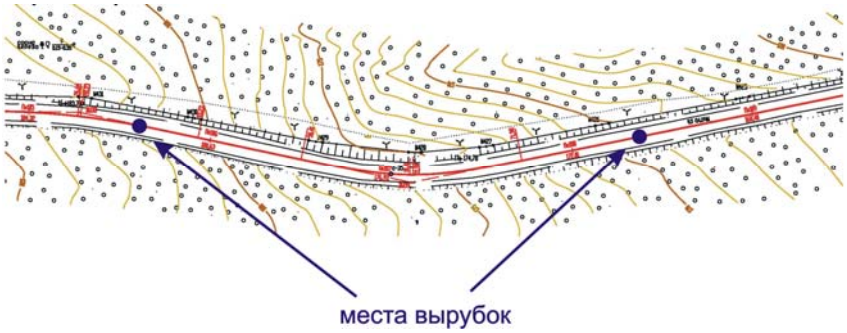
Repeat the measurements on the selected points is in fact not repeateble there are not fixed





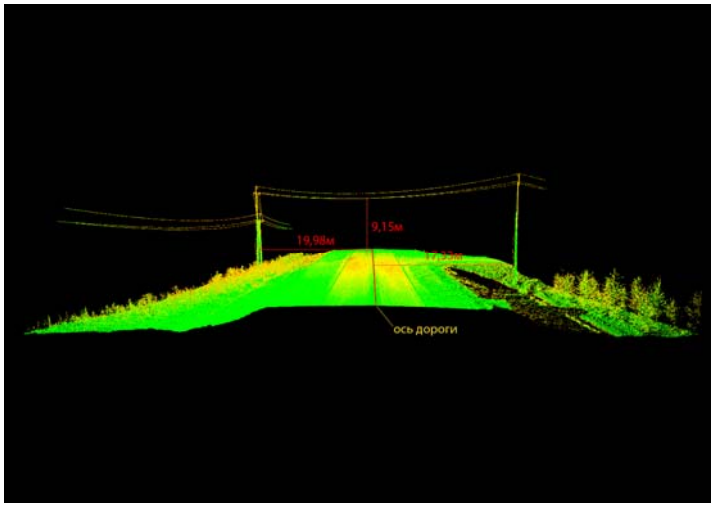
Clasic methods

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

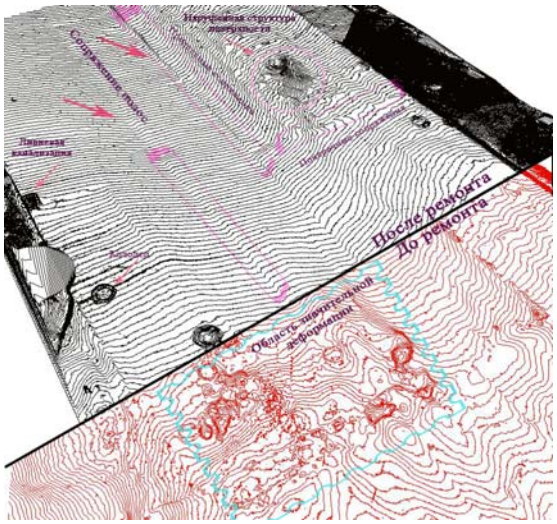


This causes that the process of geodetic works do nor alow to get an objective picture and information about the current state of the roadway as contineus engeneering object. Most important is the fact to not be able to controll the construction or rehabilitation work.
In this situation the contractor is not able to prove his construction results and the emloyer is permanent in right

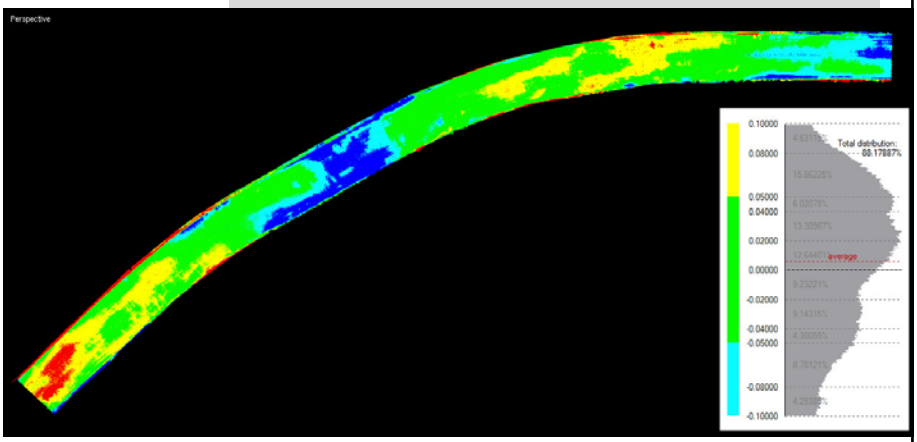
Clereance



Inconsistencies in the roadway deck



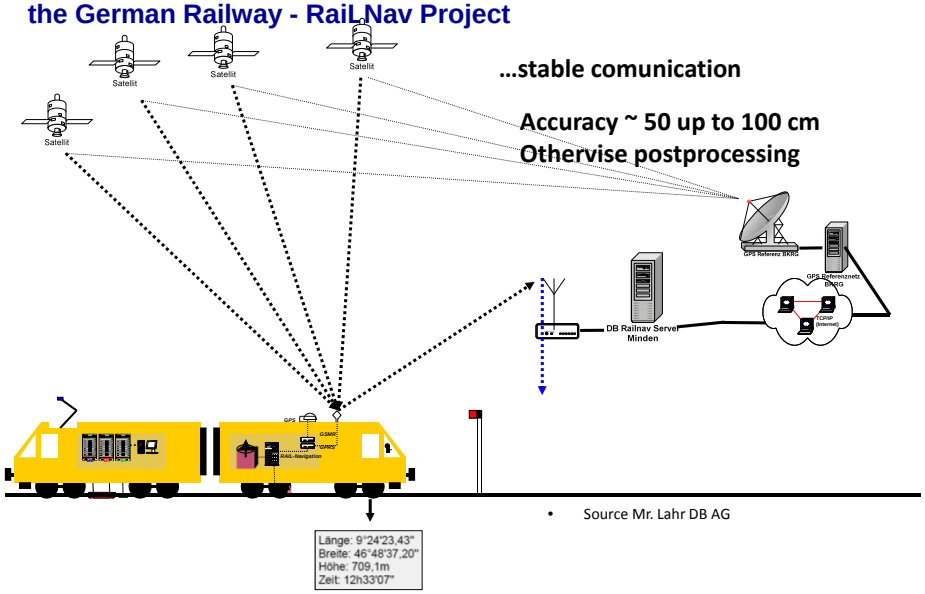
As build measured and colored against CAD



Kinematic system MLS - Rail

- Low cost

EUPOS/SA*POS*-based Vehicle Scheduling and Control System by the German Railway - Rail.Nav Project



- Source Mr. Lahr DB AG

Kinematic system MLS - Rail

Kinematic system MLS - Rail

Kinematic system MLS - Rail

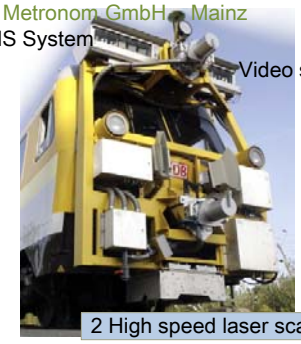
Kinematic systems

3D clearance measuring train

20 HZ GNSS receiver

- Metronom GmbH, Mainz
INS System

Video system



2 High speed laser scanner

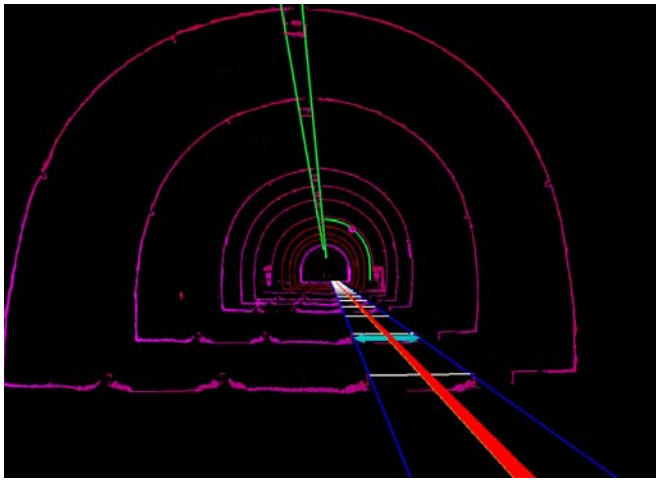
Highest data acquisition rates 300, 500, 1000Hz depends of the scanner type
Up to 80 km/h for the measurement ride

Kinematic systems

- Tunnel shape - clearance
- Distance to neighbour track

Kinematic systems

- Rail geometry
- Electricity wiers
- Batch Sections functionality

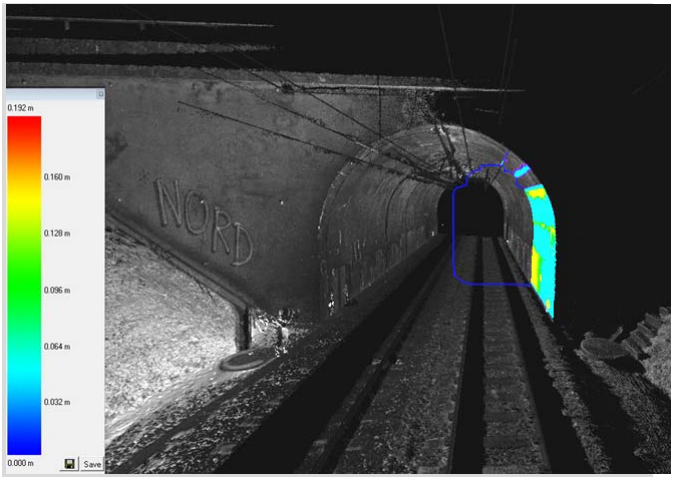


Kinematic systems

- Rail geometry
- Electricity
- Batch Sections

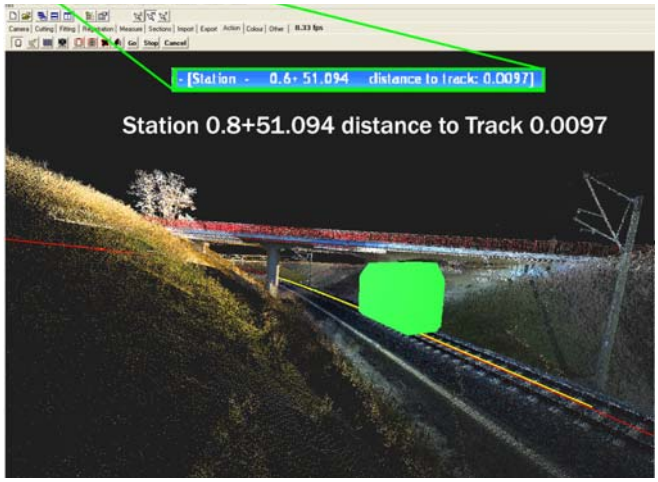
Kinematic systems

- Rail geometry
- Electricity
- Batch Sections
- Collision detection



Kinematic system

- Maintenance purposes



Kinematic system

- Variance comparision

```
16:01:23[Stats]: neubeern> Station  -     0.6+ 24.260     distance to track: 0.0140
16:01:24[Stats]: neubeern> Station  -     0.6+ 23.919     distance to track: 0.0136
16:01:24[Stats]: neubeern> Station  -     0.6+ 23.573     distance to track: 0.0130
16:01:24[Stats]: neubeern> Station  -     0.6+ 23.223     distance to track: 0.0121
16:01:25[Stats]: neubeern> Station  -     0.6+ 22.873     distance to track: 0.0111
16:01:25[Stats]: neubeern> Station  -     0.6+ 22.526     distance to track: 0.0099
16:01:25[Stats]: neubeern> Station  -     0.6+ 22.187     distance to track: 0.0089
16:01:26[Stats]: neubeern> Station  -     0.6+ 21.860     distance to track: 0.0079
16:01:26[Stats]: neubeern> Station  -     0.6+ 21.543     distance to track: 0.0073
16:01:26[Stats]: neubeern> Station  -     0.6+ 21.233     distance to track: 0.0068
16:01:27[Stats]: neubeern> Station  -     0.6+ 20.925     distance to track: 0.0066
16:01:27[Stats]: neubeern> Station  -     0.6+ 20.615     distance to track: 0.0066
16:01:27[Stats]: neubeern> Station  -     0.6+ 20.301     distance to track: 0.0068
16:01:28[Stats]: neubeern> Station  -     0.6+ 19.985     distance to track: 0.0073
16:01:28[Stats]: neubeern> Station  -     0.6+ 19.668     distance to track: 0.0077
16:01:28[Stats]: neubeern> Station  -     0.6+ 19.351     distance to track: 0.0083
16:01:29[Stats]: neubeern> Station  -     0.6+ 19.034     distance to track: 0.0088
16:01:29[Stats]: neubeern> Station  -     0.6+ 18.717     distance to track: 0.0094
16:01:29[Stats]: neubeern> Station  -     0.6+ 18.399     distance to track: 0.0099
16:01:30[Stats]: neubeern> Station  -     0.6+ 18.082     distance to track: 0.0104
16:01:30[Stats]: neubeern> Station  -     0.6+ 17.766     distance to track: 0.0110
16:01:30[Stats]: neubeern> Station  -     0.6+ 17.452     distance to track: 0.0116
16:01:31[Stats]: neubeern> Station  -     0.6+ 17.138     distance to track: 0.0122
16:01:31[Stats]: neubeern> Station  -     0.6+ 16.822     distance to track: 0.0126
16:01:31[Stats]: neubeern> Station  -     0.6+ 16.503     distance to track: 0.0127
16:01:32[Stats]: neubeern> Station  -     0.6+ 16.180     distance to track: 0.0125
16:01:32[Stats]: neubeern> Station  -     0.6+ 15.849     distance to track: 0.0118
```

```
16:01:24[Stats]: neubeern> Station  -     0.6+ 23.573     distance to track: 0.0130
16:01:24[Stats]: neubeern> Station  -     0.6+ 23.223     distance to track: 0.0121
16:01:25[Stats]: neubeern> Station  -     0.6+ 22.873     distance to track: 0.0111
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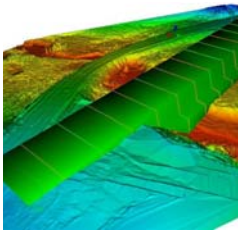
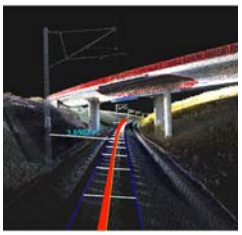




Rail and Road

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

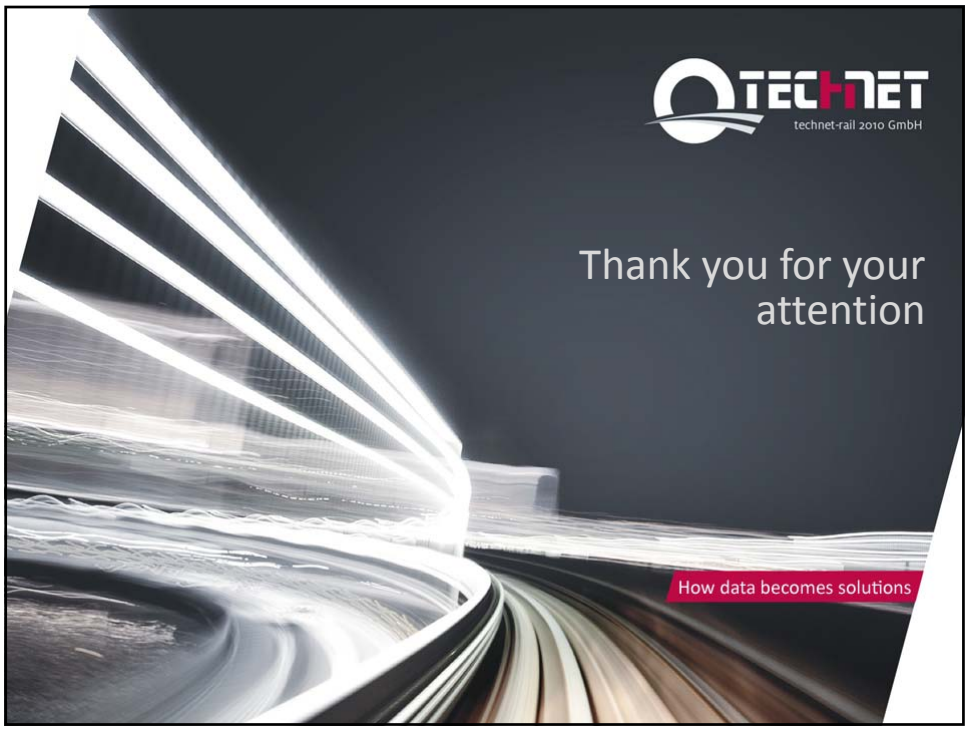
- The hardware is working stable, reliable and accurate
- Increasing the scanning speed

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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Thank you for your attention
How data becomes solutions


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