Geodesy, Mine Survey and Aerial Topography. At the turn of the centuries.

Moscow 14 – 15 February 2013

Mobile LiDAR in Road Surface Quality Control and Renovation

- *Latest Development of Terrasolid Software*

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Terrasolid

Road Condition from Mobile LiDAR

Surface

- Water flow on road surface
- Ruts
- Pot holes
- Cracks
- Paint markings
- Longer depressions
- Superelevation
- Road alignment geometry

Visibility

- Traffic signs
- Light poles
- Clearance to bridges & wires
- Danger objects next to road
- Room for snow

Example Mobile Road Workflow

- Collect signal markers from laser data and apply fluctuating xyz correction to laser and images
- Collect tie points in signal marker area and solve camera misalignment angles
- Compute depth maps using laser data close in time
- Collect **Depth** tie points on paint markings seen by multiple drive passes (about 25 m spacing)
- Solve and apply fluctuating xyz correction matching drive passes to each other
- Search flat ground tie lines (about 2 m spacing)
- Solve and apply fluctuating z correction matching drive passes to each other

=>TO GET VERY ACCURATE DATA TO MAKE QUALITY DELIVERIES

Need of Control Measurement

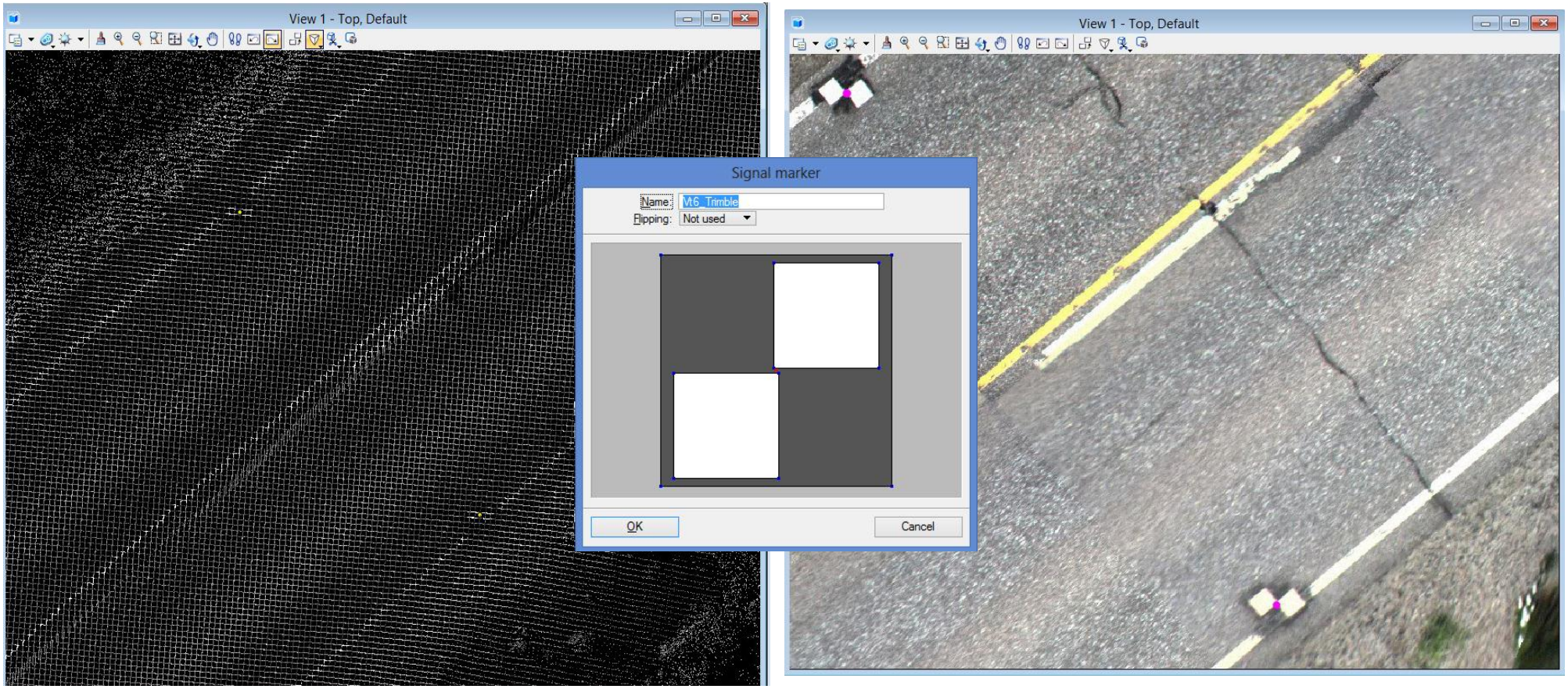
Test Results

Control spacing	100 m	200 m	500 m
Z average magnitude	0.003 m	0.005 m	0.025 m
Z standard deviation	0.005 m	0.007 m	0.019 m
XY average magnitude	0.013 m	0.018 m	0.024 m

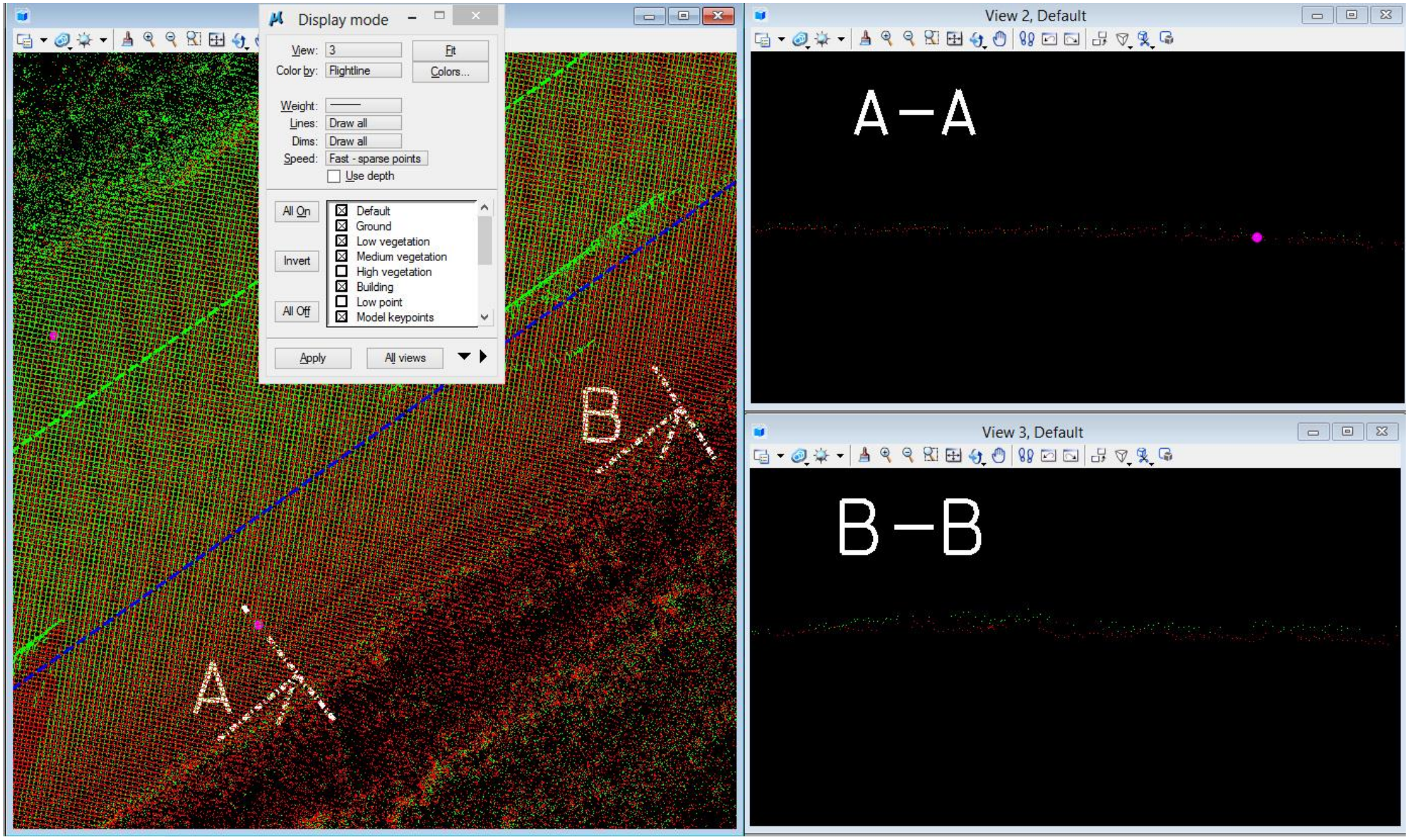
Recommendation for high accuracy work:

- Elevation control at 50m spacing and xy control at 250 m spacing
- Measure elevation control points at 50m spacing on both sides of the road using leveling instrument for elevation and GPS/total station for xy
- Place every 5th on a paint marking corner or paint your own signal

Calibration by Control Points



Control Point versus LiDAR



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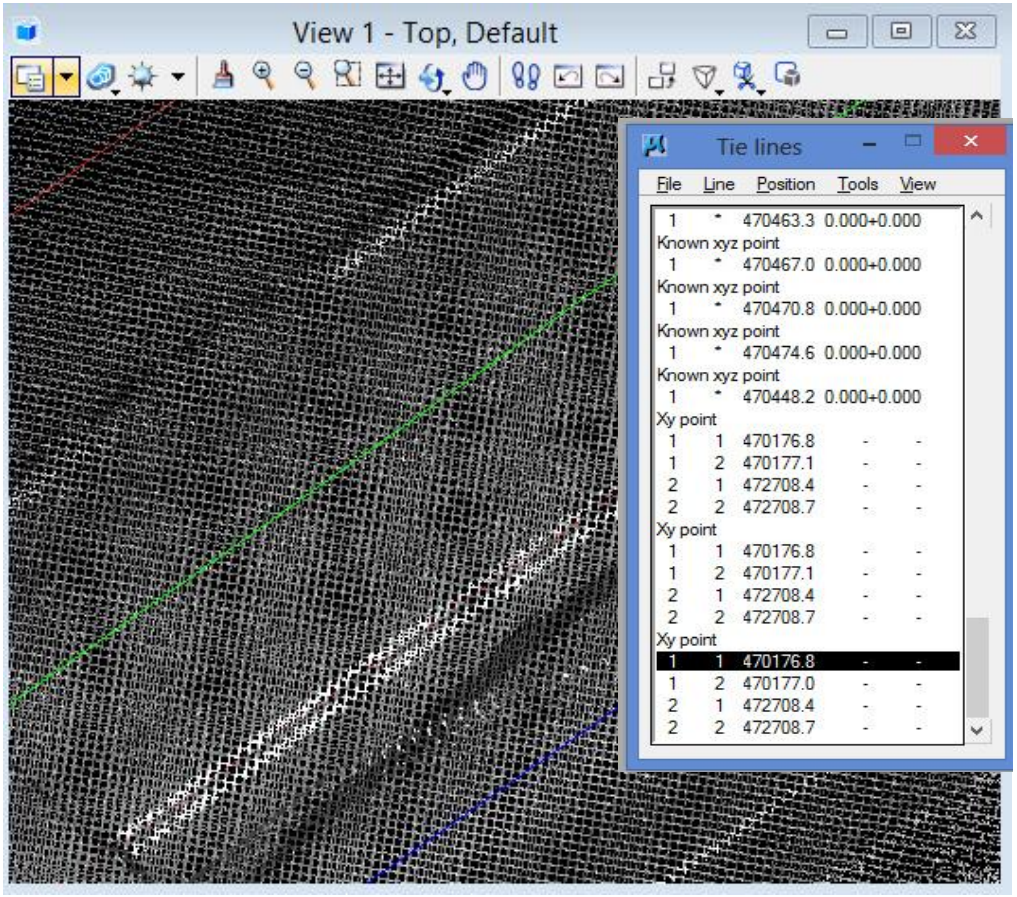
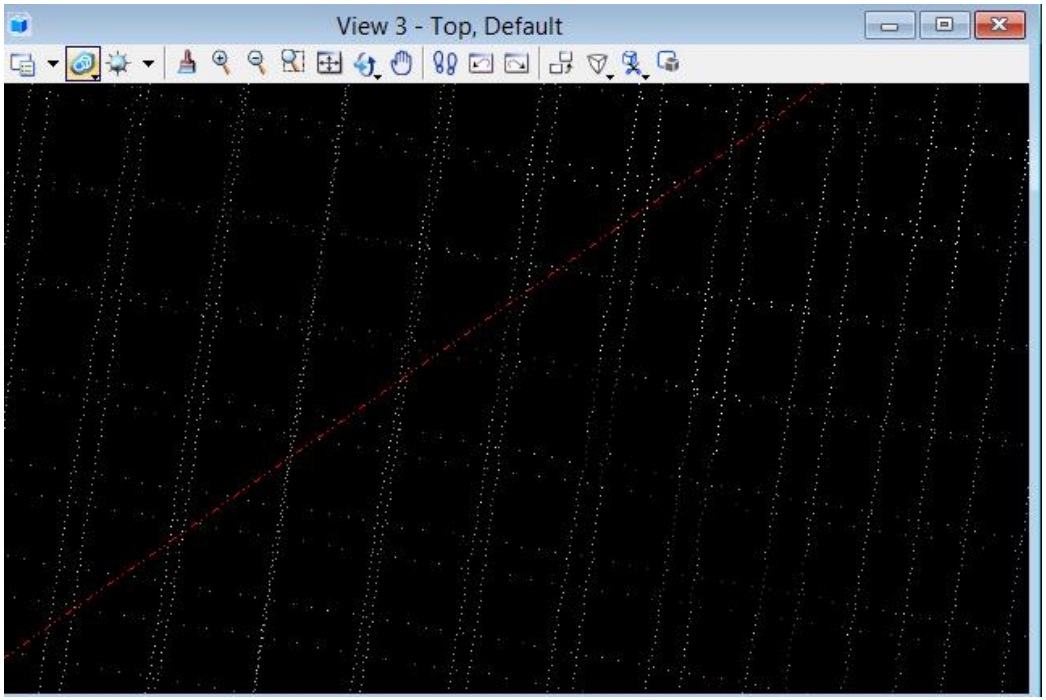
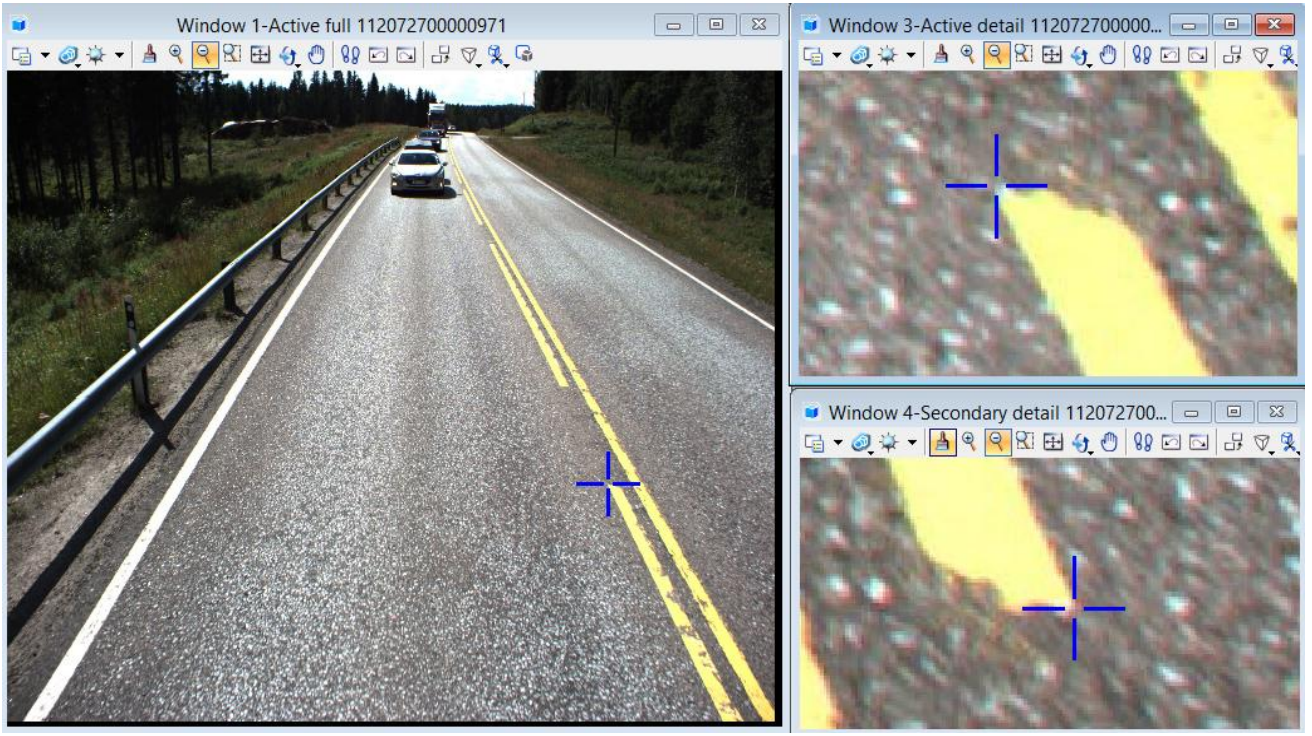
Positional Correction from LiDAR





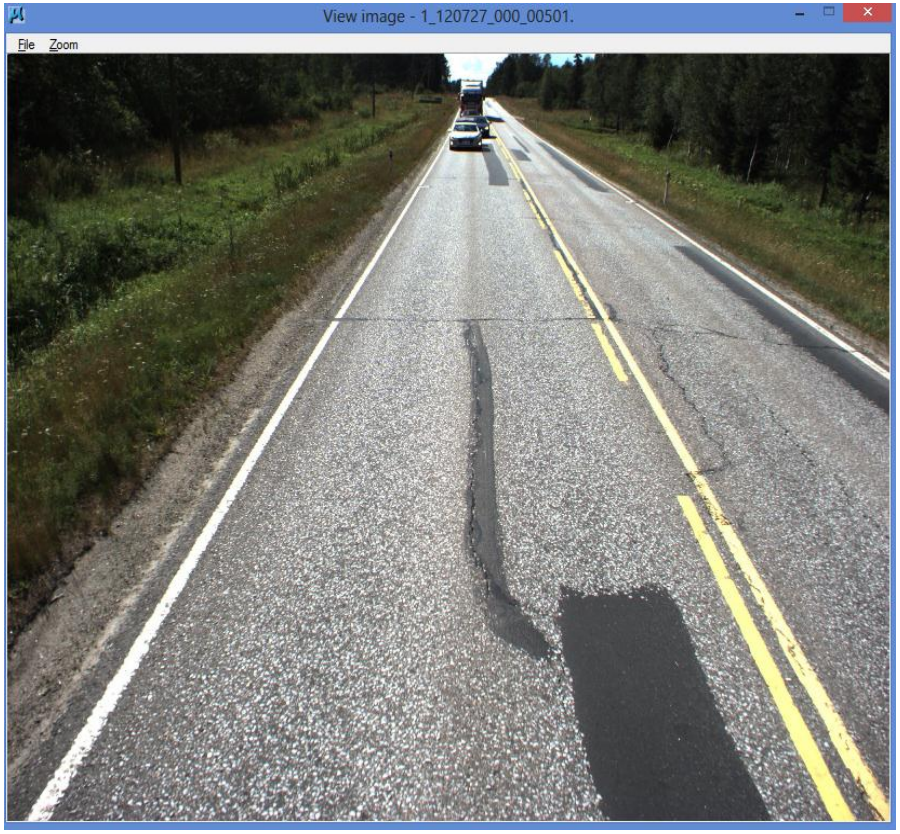
Positional accuracy of picking intensity features from laser data is limited by laser point density

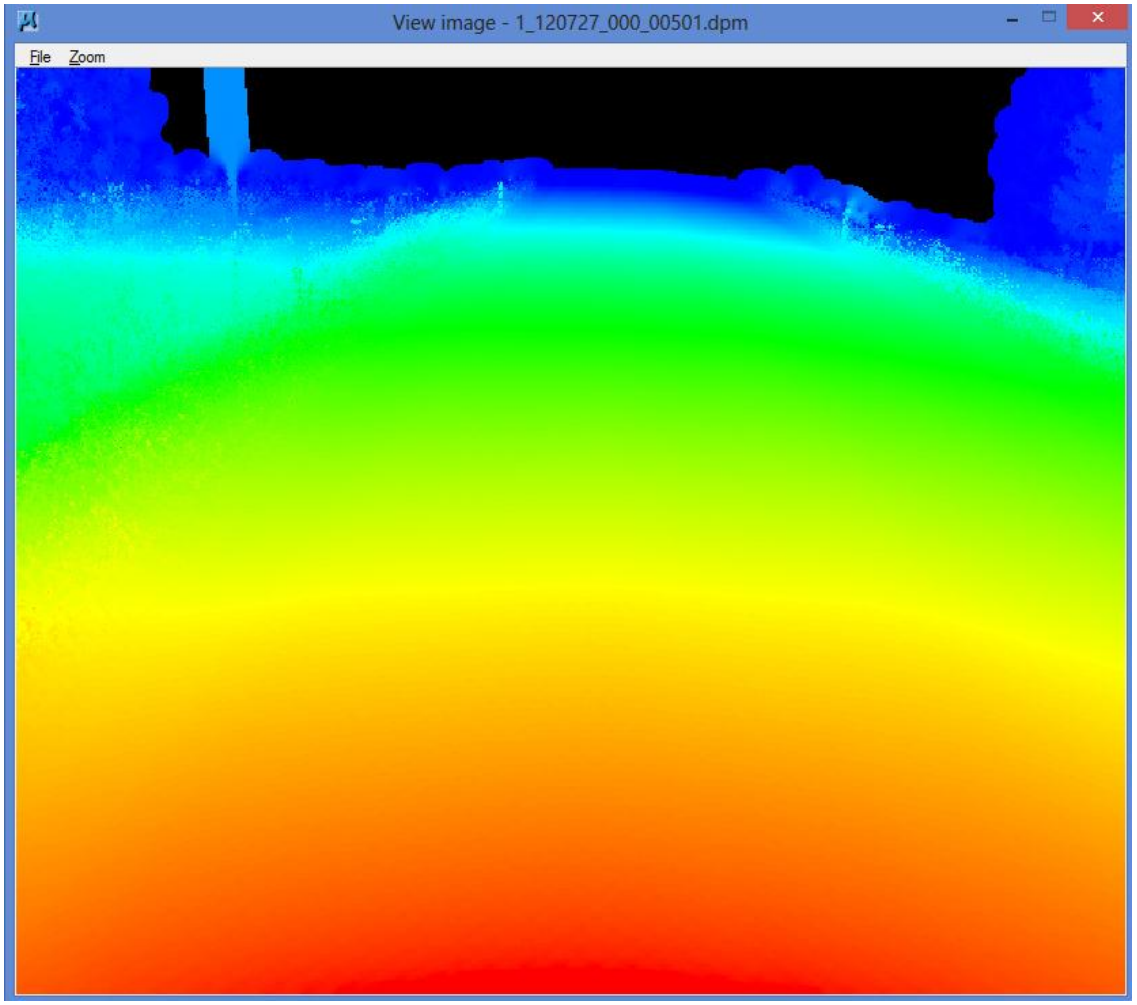
Positional Correction from Images



- **Find Tie Line Fluctuations** supports using image tie points as observations
- Makes it possible to match mobile drive passes to each other more precisely in xy
  - Positional accuracy of picking intensity features from laser data is limited by laser point density
  - Images provide higher resolution data on paint markings

Depth Maps





- Software calculates the distance, how far each image can see
- Requires classified laser points (ground, high vegetation, buildings)
- Red: closest targets; blue: the farthest ; black no information
- Software uses Depth Maps to get xyZ position to each pixel of images

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What can we extract from mobile laser data + images?

Demonstration of new features:

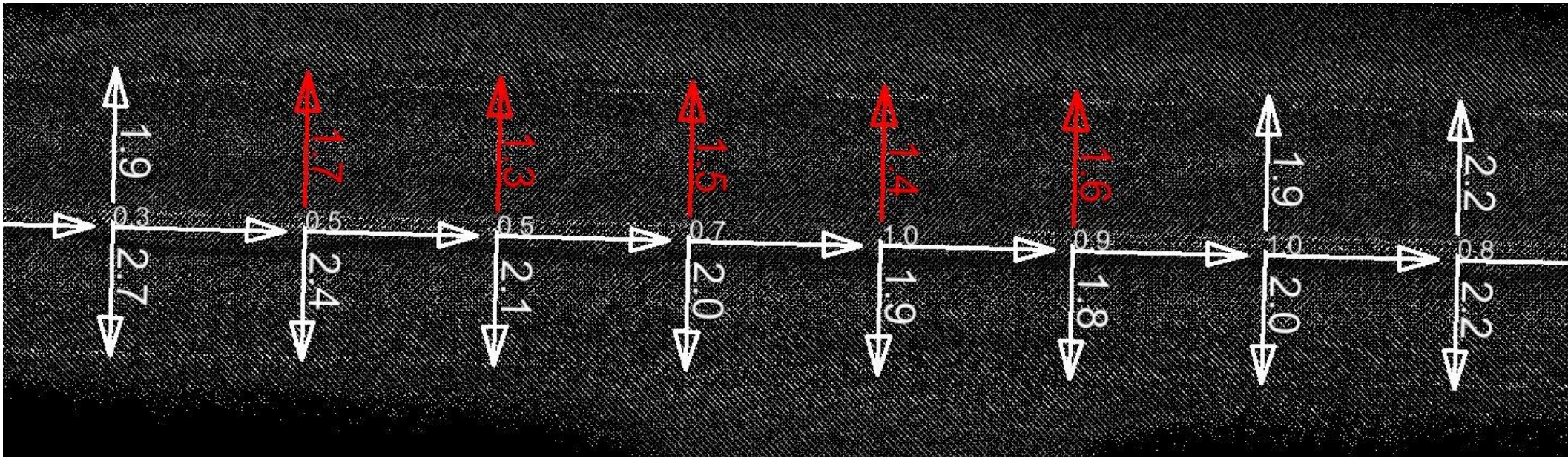
- Draw slope arrows
- Display road drainage
- Search road geometry components
- Design new asphalt surface

Ruts & Pot Holes

- Detection of ruts and pot holes on the road surface
- Measurement of rut depth and surface area

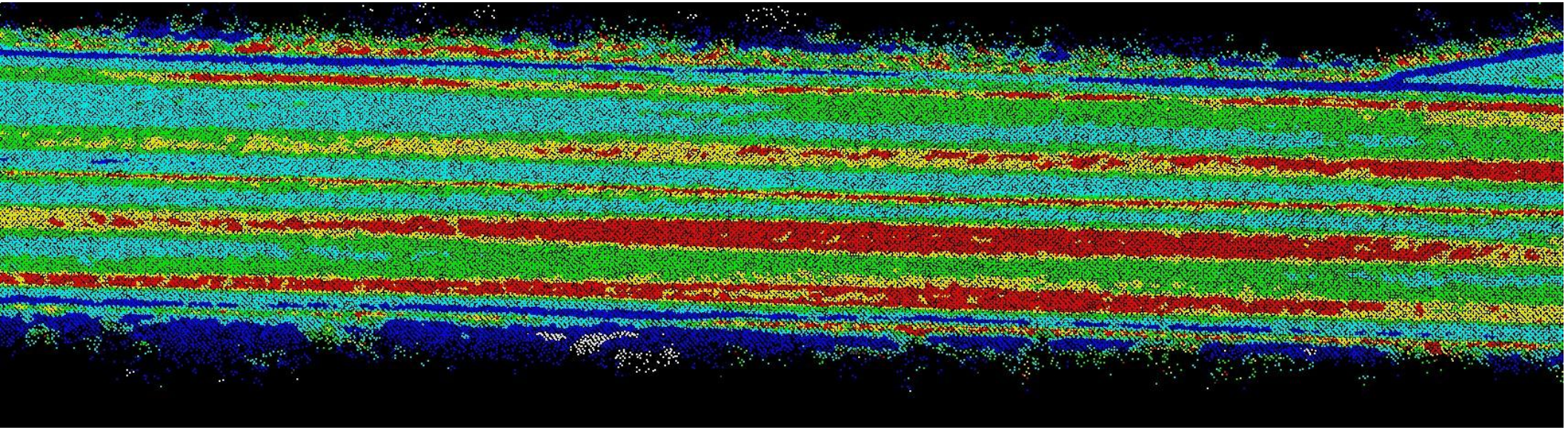
Superelevation

- Software can automatically label side and longitudinal slope angles along the road



Water Flow on Road Surface

- High density of mobile laser data makes it possible to analyze water flow on the road surface at fine level of detail
- Image below shows road surface colored by slope:
  - Red is less than 1% total slope
  - Yellow is 1 – 2% total slope
  - Green is 2 – 4% total slope
  - Blue is 4 – 20% total slope



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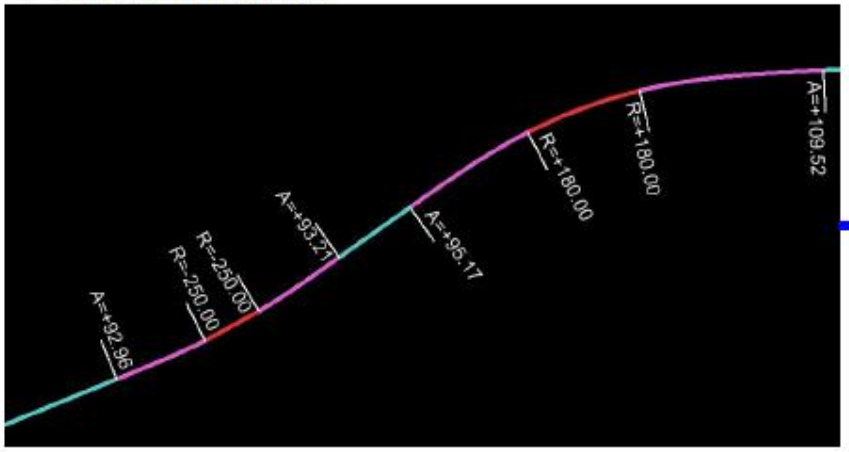
Road Design

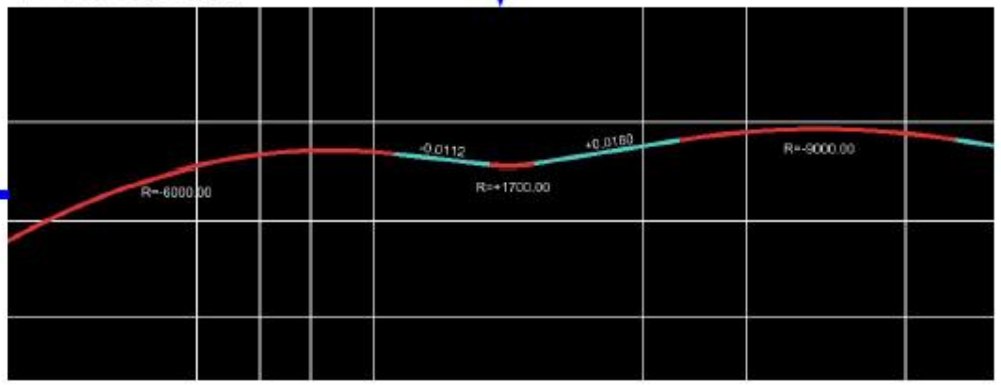
Horizontal



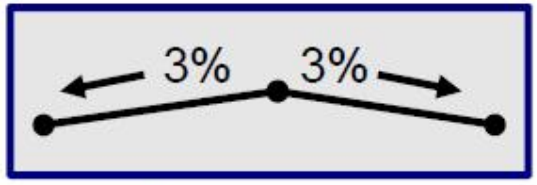
Road alignment geometry

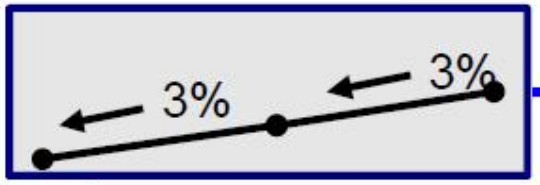
Center line, width, edge of pavement...

Vertical



Pavement/Superelevation





- Additional alignments
- Intersections
- ...

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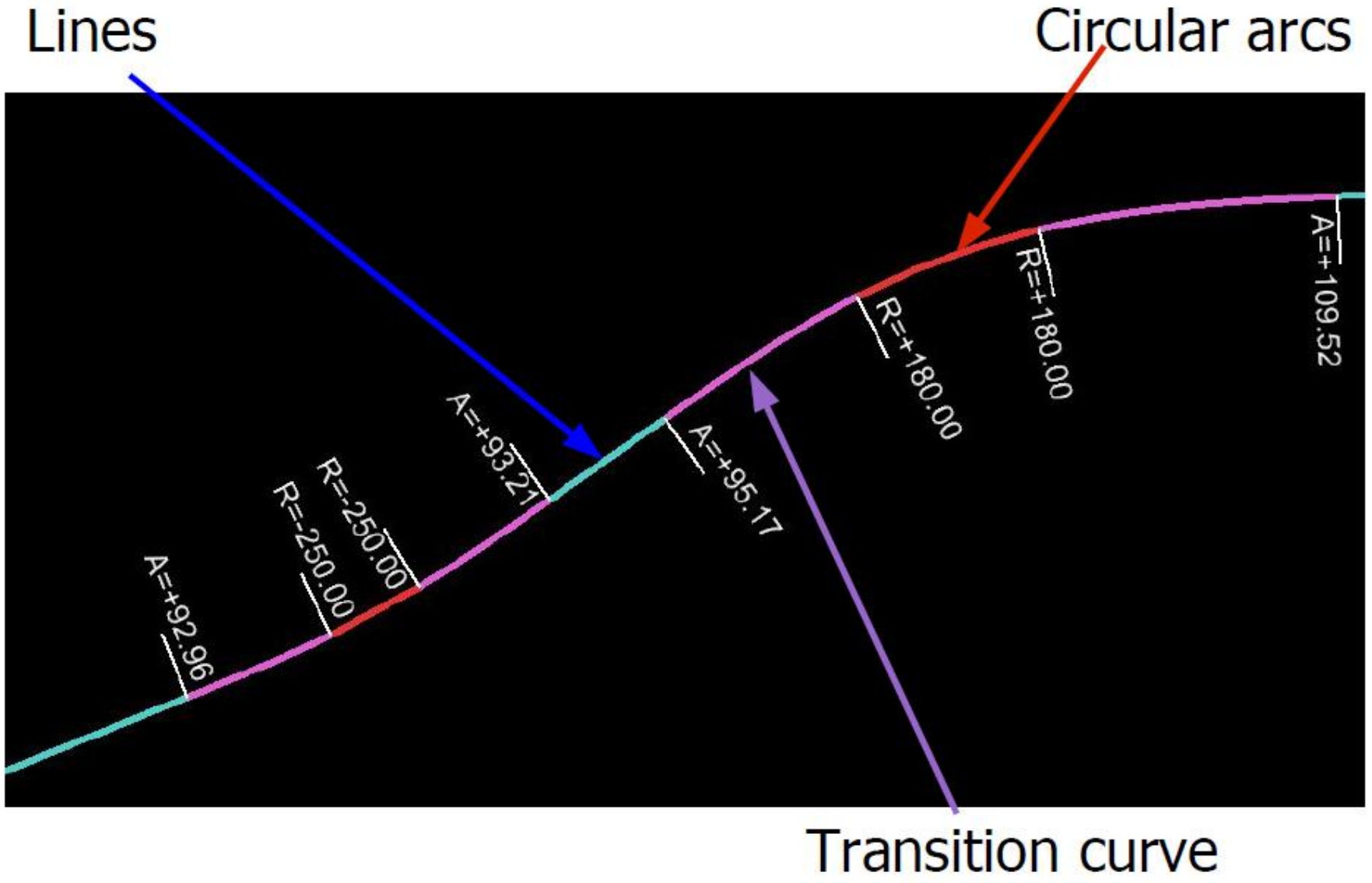
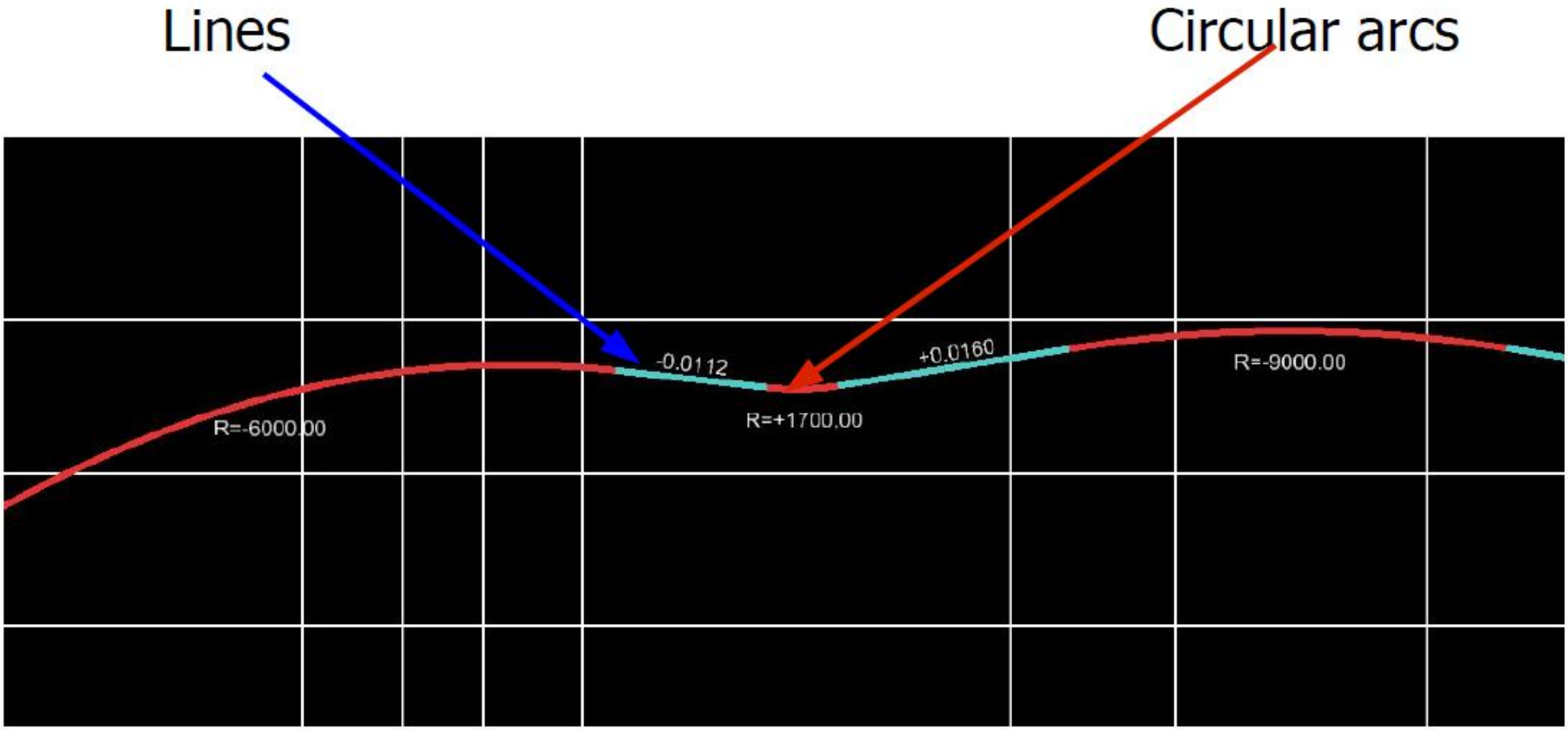
Horizontal Geometry



Vertical Geometry



Geometry Components

Local or national guidelines

- Minimum radius based on the speed and road type
  - for horizontal and vertical geometries
- Sight distances

(Inspection of designs and construction)

Finnish transport agency guidelines for horizontal geometry

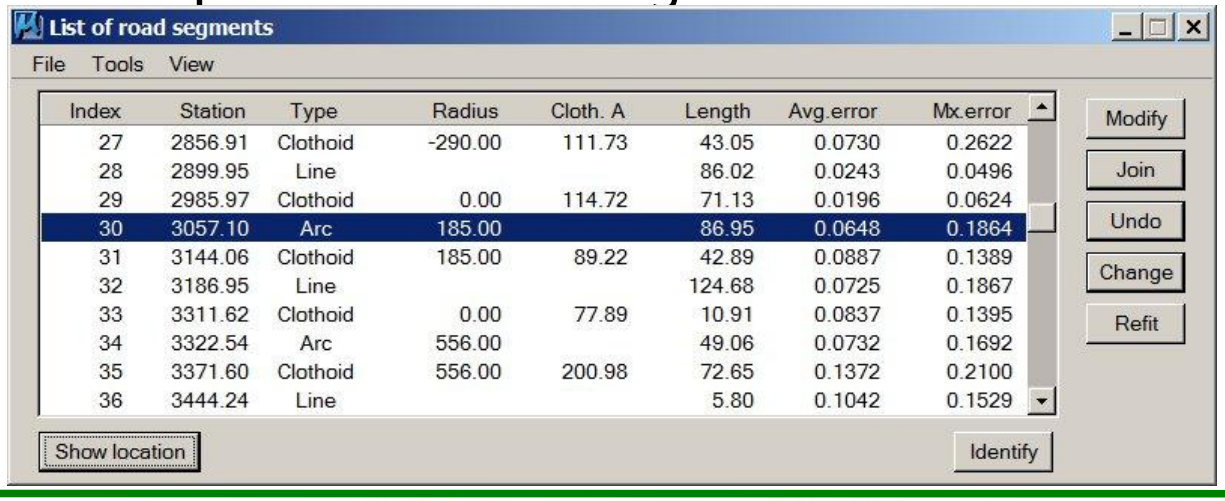
Speed (km/h)	Min.radius (m)	Recommended (m)
...		
60	170	250-500
70	250	350-700
80	350	500-1000

for vertical geometry

Speed (km/h)	Min. radius (m)		Recommended: Crest (m)
	Crest	Sag	
...			
60	1500	1500	1500-2500
70	2400	2100	2400-4100
80	3900	2800	3900-6500

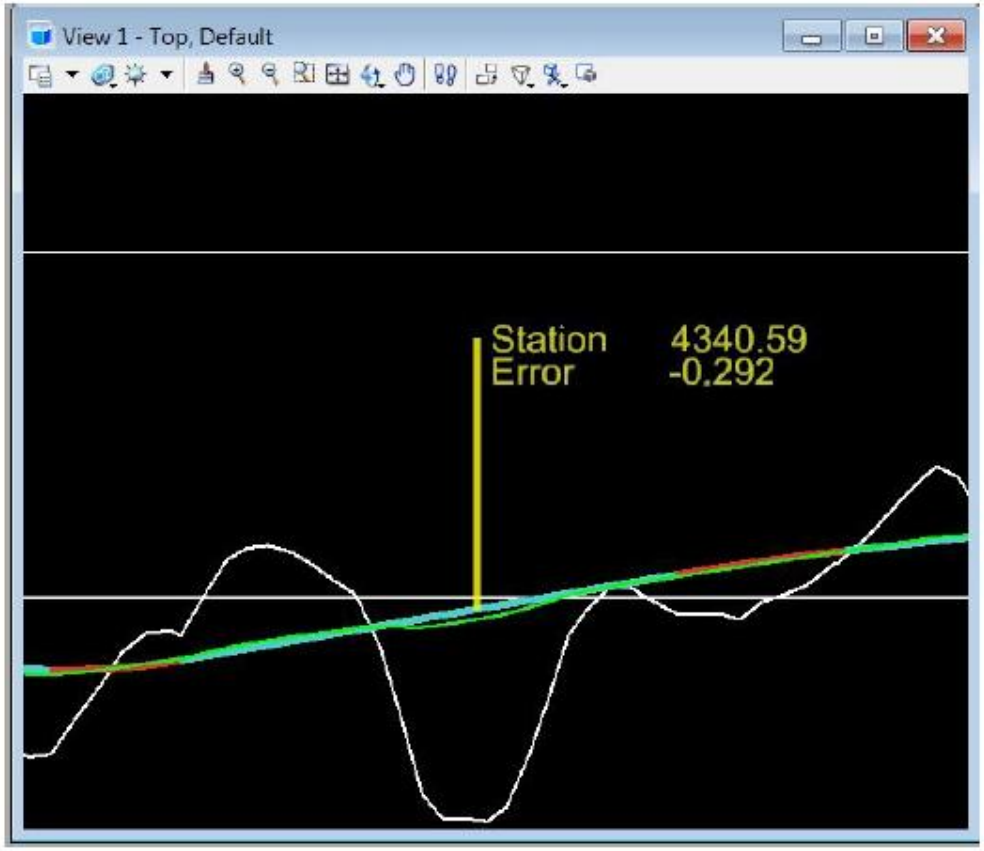
Road Alignment Geometry

- Component fitting tools find design geometry built from lines, arcs and clothoids which best match surveyed alignment of a road or a railroad
- Fitting for both horizontal and vertical geometry
- Goals:
  - View current geometry of road/railroad/pipeline in design software such as Bentley InRoads, Bentley Track etc passing geometry in LandXML or Tekla 11/12 format
  - Find long span deformations
  - Compare components with design recommendations



Geometry Components from Survey

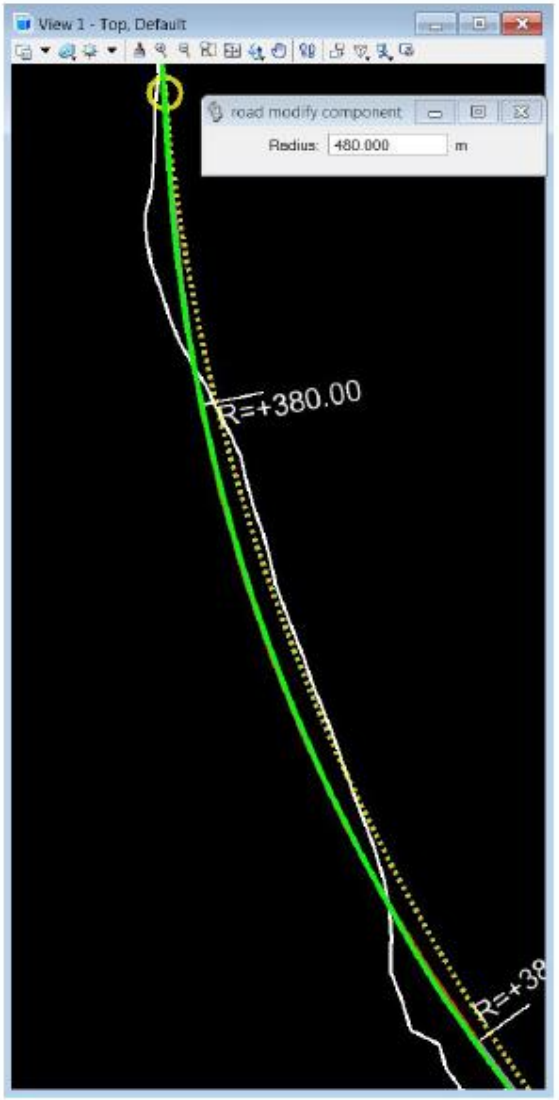
- Maintenance
  - Finding long deformations
  - New surface design
- Identifying hidden safety issues
- Connecting new designs to old



TerraScan Component Fitting

- Creation of preliminary alignments
- Modification: joining, changing and refitting
- Continuity preserved

Goal: Starting point for a design software with information on the quality.



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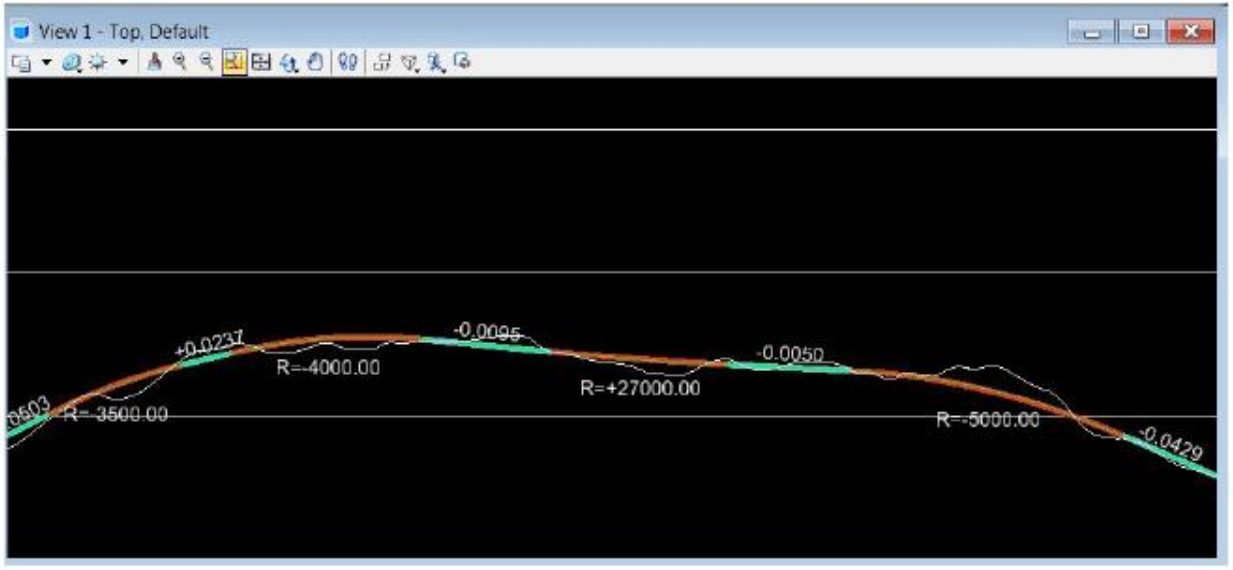
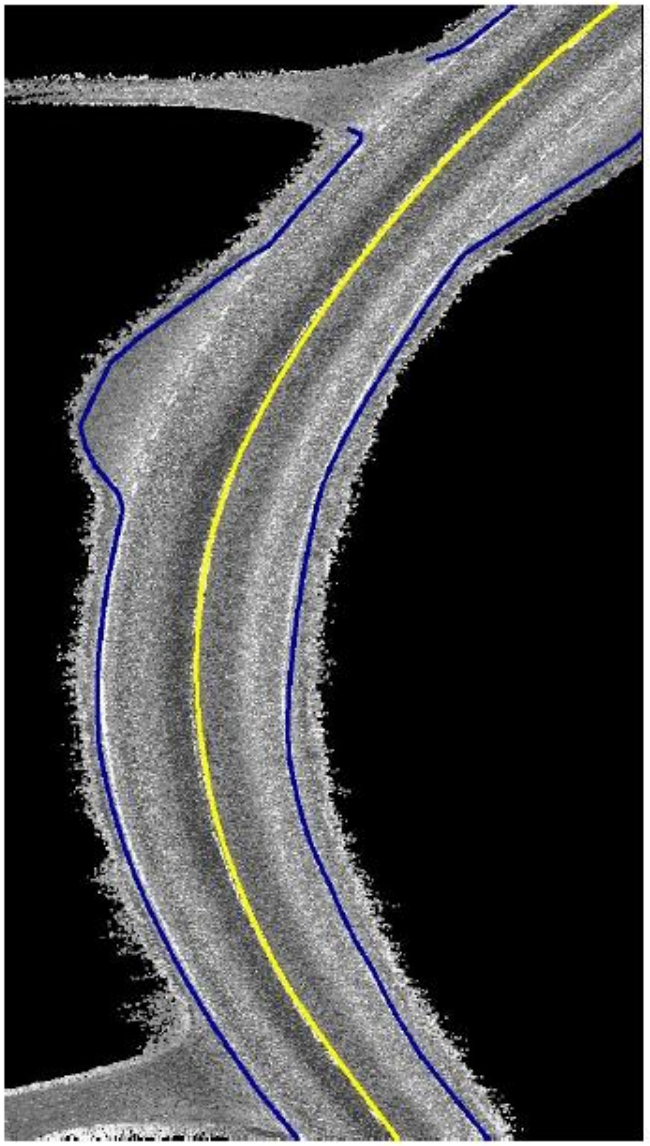
TerraScan Component Fitting

A survey vector

- Road features (e.g. center line)
- Rails
- Vehicle trajectory
- ....

compared to reasonable components.





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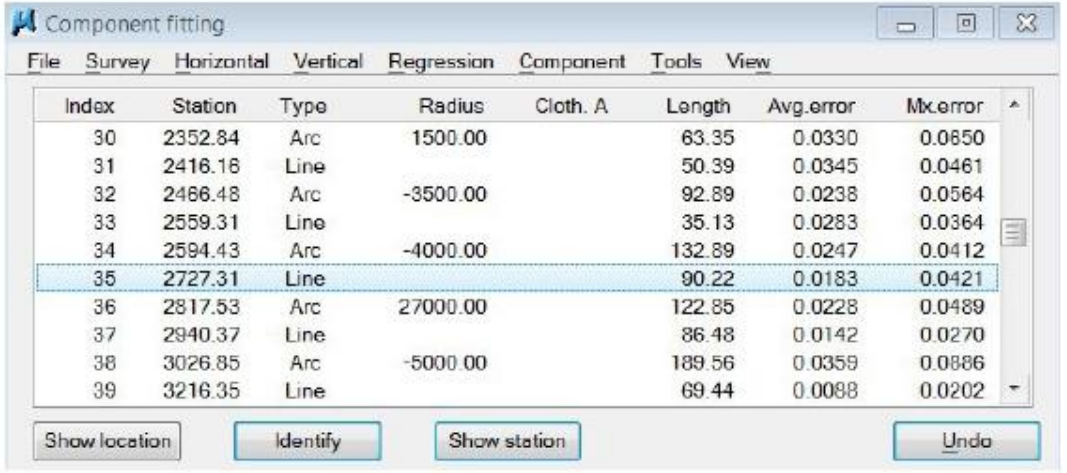
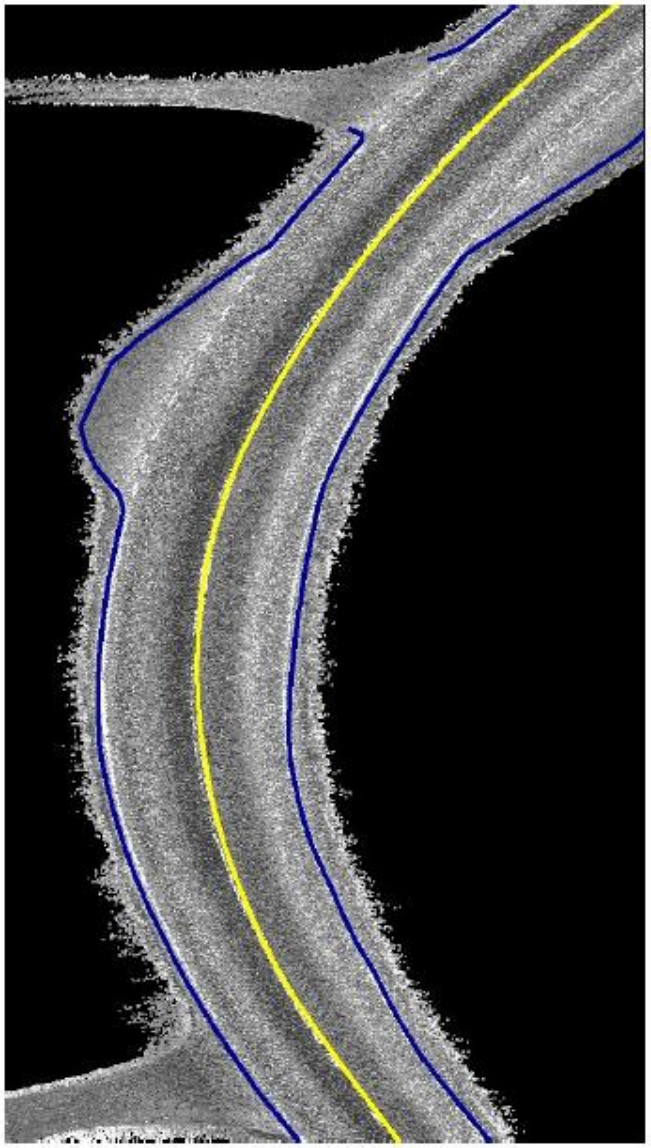
TerraScan Component Fitting

From a survey vector

- Road features (e.g. center line)
- Rails
- Vehicle trajectory
- ....

to geometry components for design software e.g. with LandXML





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Example Data

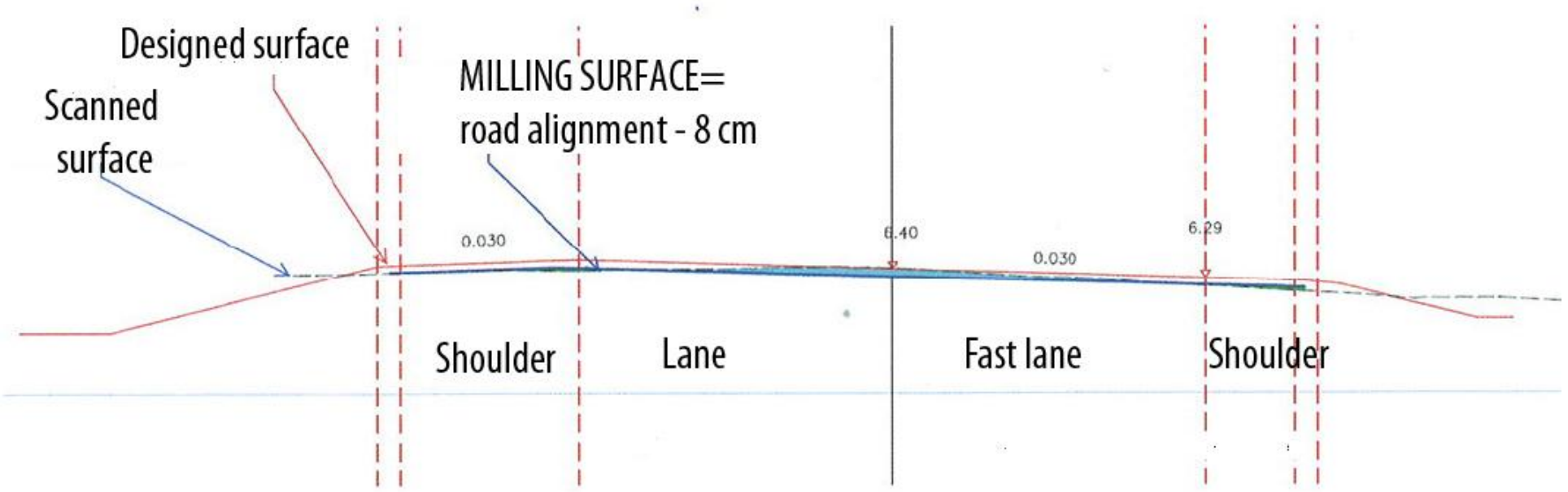
- VT6 road improvement – length 22 km

Driven in two directions with Trimble MX8

Purpose:

- design new asphalt surface for the road
- remove ruts
- smoothen vertical geometry
- fix superelevation issues

Example Data



- VT6 road improvement – length 22 km
- Starting point – valid surface
- Each road component were adjusted one by one to get an optimised solution (mill and fill)
- Follow standards of road geometry
- Deliveries to construction phase: breaklines, visualised 3D models, cross sections

Road Asphalt Milling and Replacing with New Asphalt

"With a model basing re-design and construction we were working in completely different planet compared earlier ways", Mr. Erkki Tukiainen, the project leader, NCC-Road

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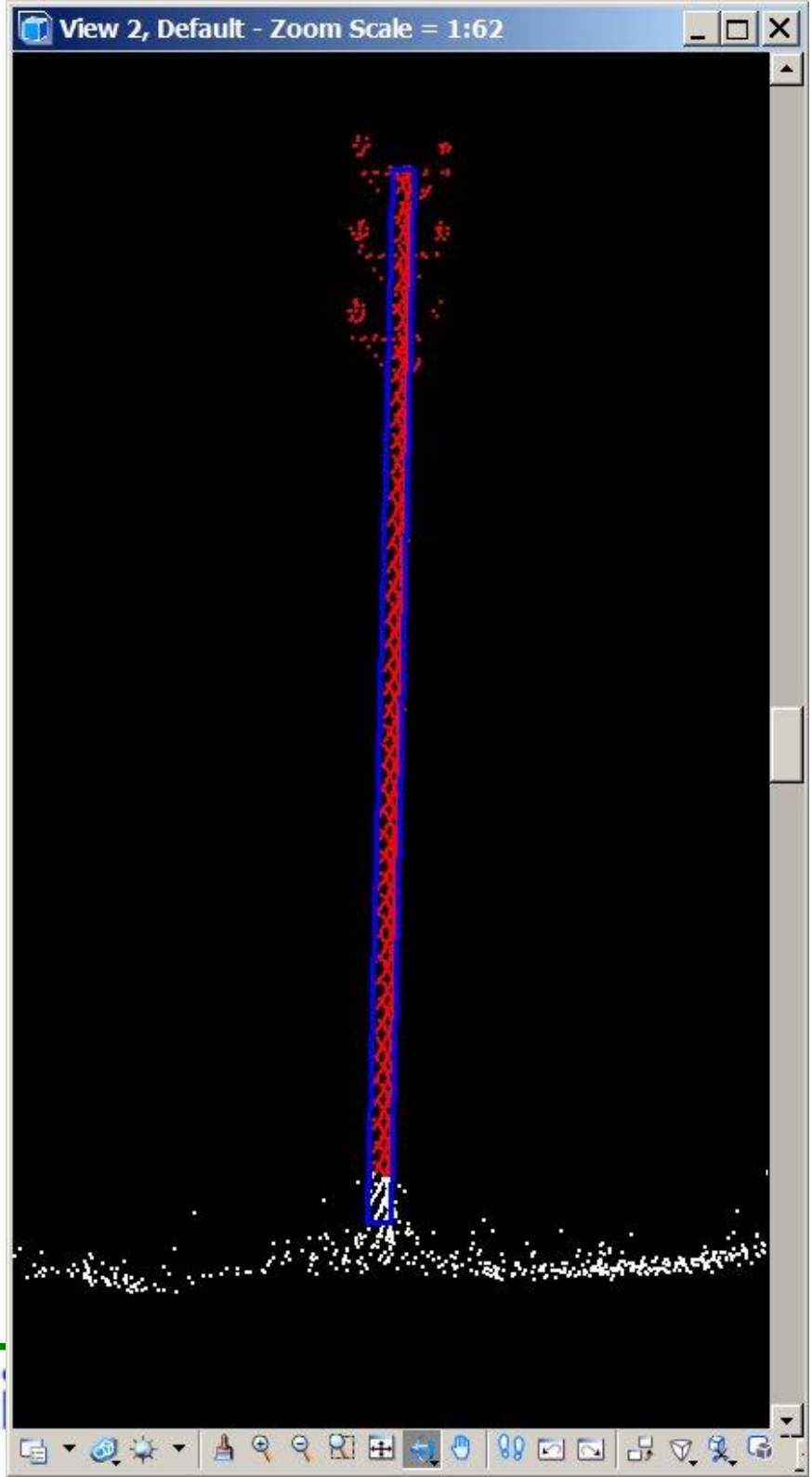
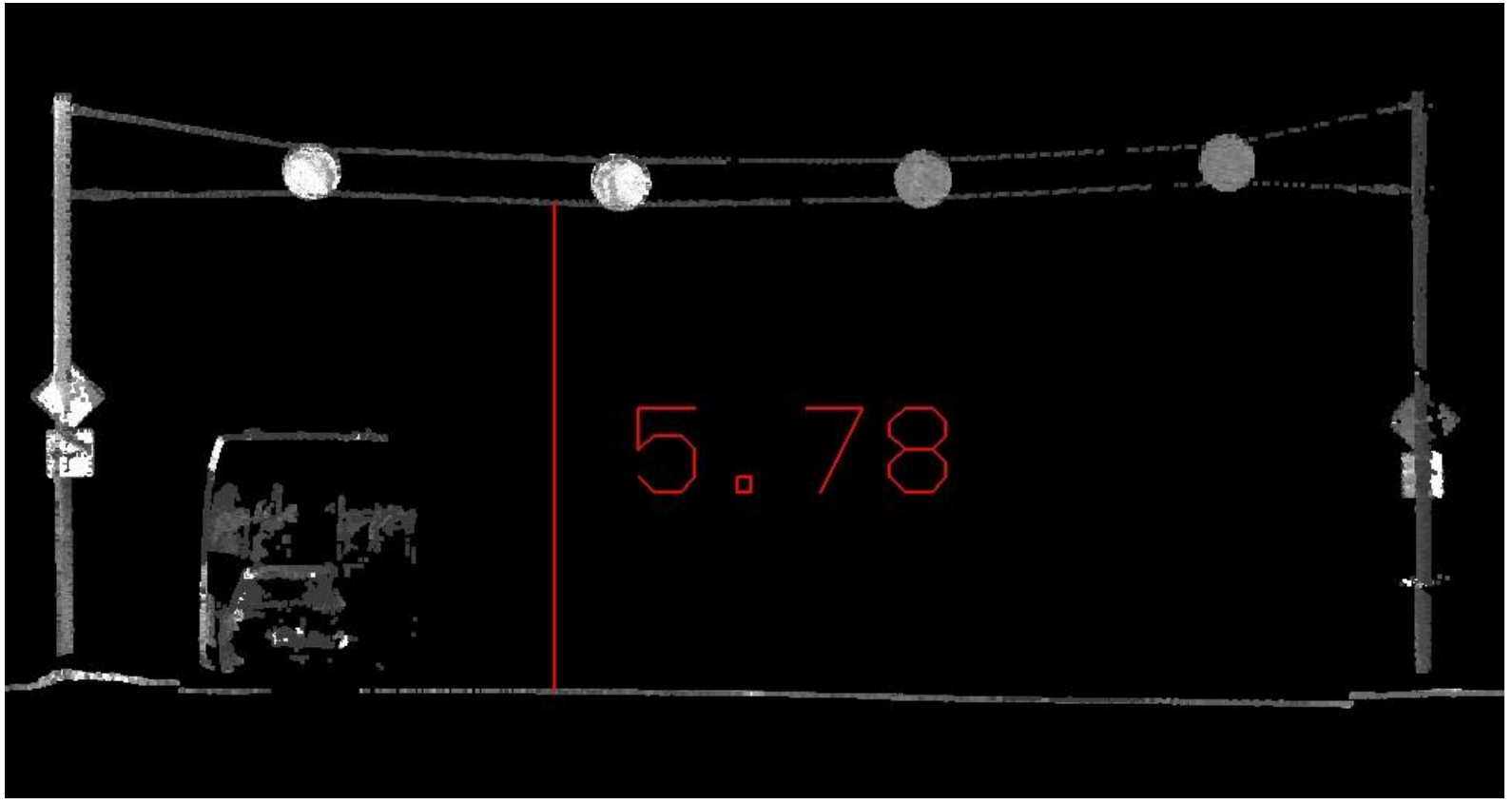
Poles etc.

- Detection of poles and placement of 3D vector models matching the measured point cloud
- Not yet implemented



Clearance to Bridges and Wires

- Measure minimum height difference between road surface and various overhead structures



Version 013.xxx

- Computer ID changes in licenses
- Send new computer ID to Terrasolid if using:
  - Server pool licenses (server ID and name)
  - Permanent licenses

- Versions 013.001 and 013.002 will be released next week
- Version 012.099 works with 012.xxx temporary licenses, with 013.xxx server licenses and 013.xxx permanent licenses
- Version 013.001 has identical functionality with last 012.xxx version

Thank you for your interest to Terrasolid.

For further information:

www.terrasolid.com

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