Mobile LiDAR in Road Surface Quality Control and Renovation
- Latest Development of Terrasolid Software

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## 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

<table>
<thead>
<tr>
<th>Control spacing</th>
<th>100 m</th>
<th>200 m</th>
<th>500 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z average magnitude</td>
<td>0.003 m</td>
<td>0.005 m</td>
<td>0.025 m</td>
</tr>
<tr>
<td>Z standard deviation</td>
<td>0.005 m</td>
<td>0.007 m</td>
<td>0.019 m</td>
</tr>
<tr>
<td>XY average magnitude</td>
<td>0.013 m</td>
<td>0.018 m</td>
<td>0.024 m</td>
</tr>
</tbody>
</table>

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
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
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
Road Design

Horizontal

Road alignment geometry

Vertical

Pavement/Superelevation

- Additional alignments
- Intersections
- ...

Terasolid
Horizontal Geometry

Lines

Circular arcs

Transition curve

$A=+92.96$

$R=250.00$

$A=+93.27$

$R=250.00$

$A=+95.17$

$R=+180.00$

$A=+109.52$

$R=+180.00$
Vertical Geometry

Lines

Circular arcs

R = 6000.00
R = 1700.00
R = 9000.00
Geometry Components

Local or national guidelines

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

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<table>
<thead>
<tr>
<th>Speed (km/h)</th>
<th>Min. radius (m)</th>
<th>Recommended (m)</th>
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<td></td>
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<tr>
<td>60</td>
<td>170</td>
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<td>70</td>
<td>250</td>
<td>350-700</td>
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<tr>
<td>80</td>
<td>350</td>
<td>500-1000</td>
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<table>
<thead>
<tr>
<th>Speed (km/h)</th>
<th>Min. radius (m)</th>
<th>Recommended: Crest (m)</th>
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<tbody>
<tr>
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<td>Min. radius (m)</td>
<td>Crest</td>
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<tr>
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<td>2400-4100</td>
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<tr>
<td>80</td>
<td>3900</td>
<td>3900-6500</td>
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</tbody>
</table>

(Inspection of designs and construction)
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.
TerraScan Component Fitting

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

compared to reasonable components.
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
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
“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
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:

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