Helsinki Tram LiDAR Survey

Terrasolid

Terrasolid

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Terrasolid Ltd.

- Privately held company based in Finland
- Founded in 1989, 12 employees
- Last fiscal year revenues 4,5 M€
- 23+ years of software development on MicroStation and other Bentley applications
- 15+ years of point cloud software development
- Over 4000 TerraScan licenses sold in over 90 countries
- Global market leader in airborne and mobile laser scanned point cloud processing with an estimated 85% market share

Terrasolid products for LiDAR

- TerraScan – Classify and handle point clouds
- TerraMatch – Match multiple flight / drive passes
- TerraPhoto – True ortho production and texturing
- TerraModeler – DTM and contour production
- TerraSurvey – Field control measurements

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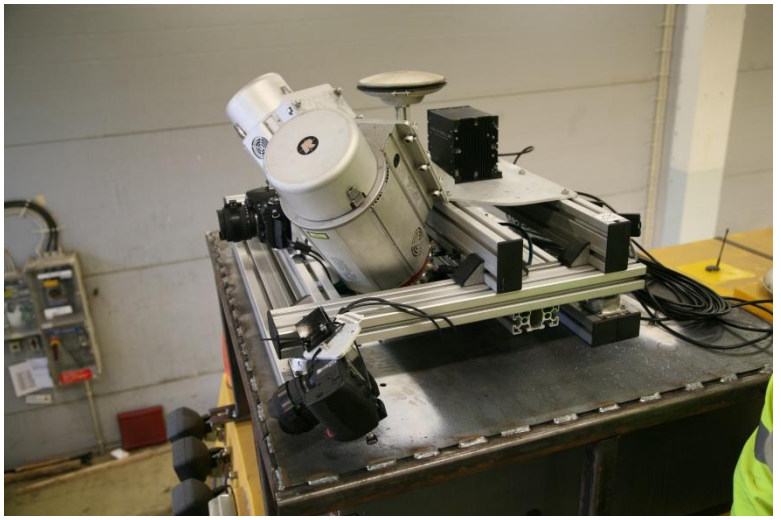
Helsinki Tram Network

- About 200 000 passengers per day
- Lines 1, 1A, 3T, 3B, 4, 4T, 6, 7A, 7B, 8, 9, 10
- 85 kilometers of commuter track
- 97 kilometers of track in total

Helsinki Tram Survey

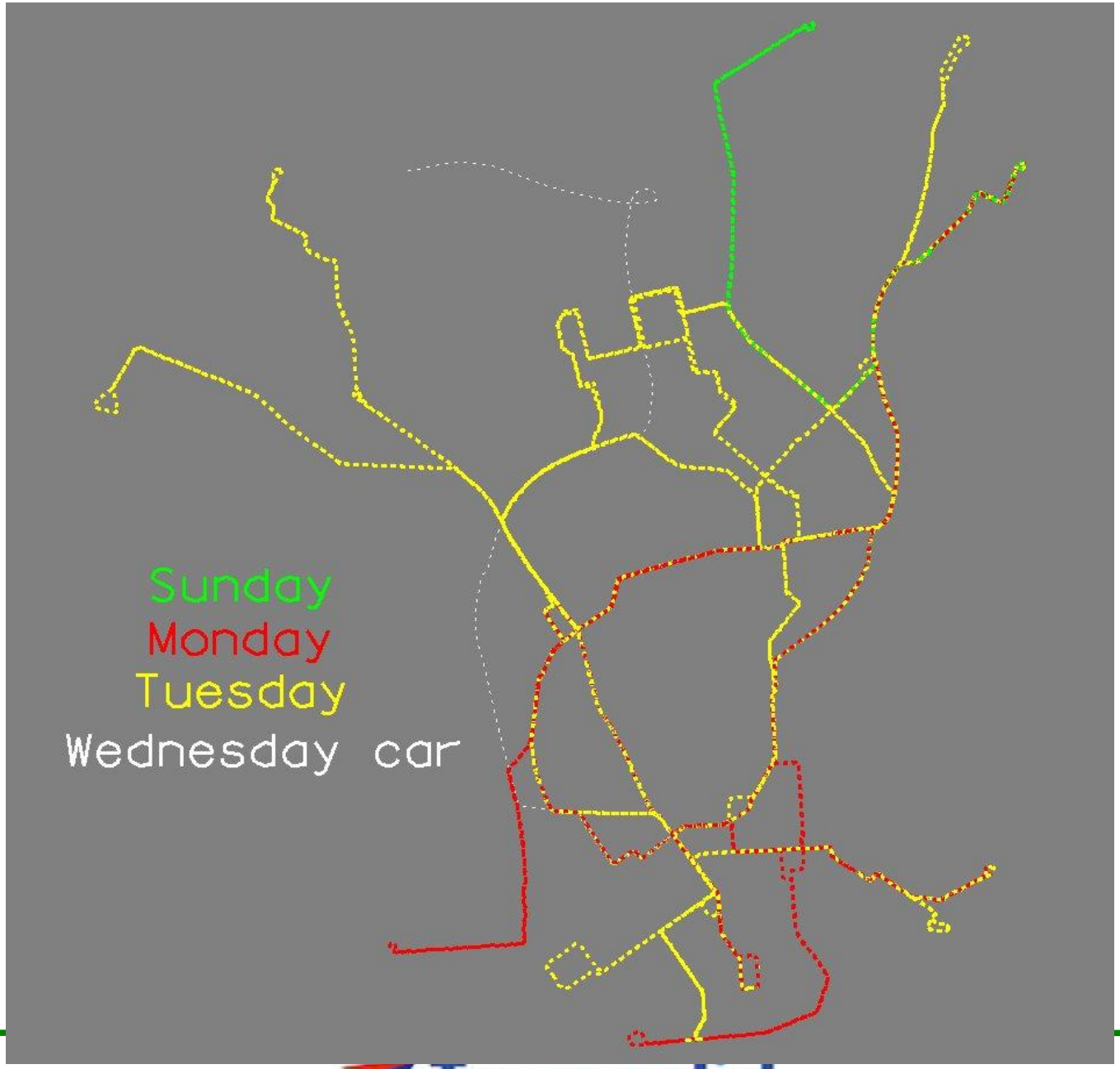
1. Obtain precise data for maintenance system
2. Simulate new trams
3. ”High-asphalt” calculation

Data Collection



- Carried out by 3D Laser Mapping
- StreetMapper mounted on a tram
  - 2 * 200 000 Hz scanner
  - Forward looking 2144 * 1424 camera
- Tram installation 29th May 2011
- Data collection drives 29th - 31st May 2011
- Some images collected with system mounted on a car 1st June 2011

Data Collection



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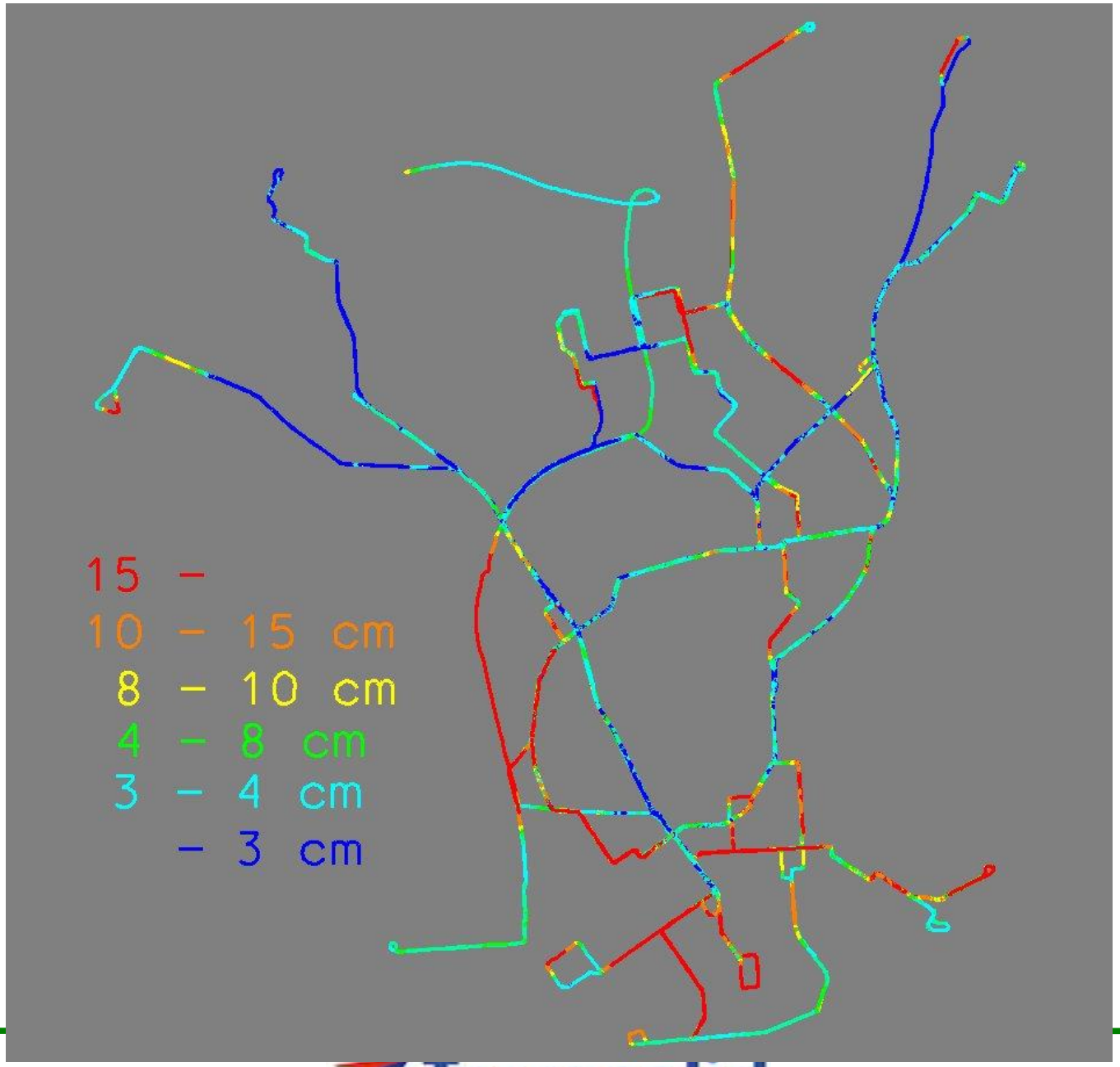
Trajectory Solution Accuracy



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Data Volume

- 14 603 216 184 laser points collected
  - 462 GB as .las files

- 19 628 forward looking images recorded
  - 15 GB as .jpg images

Forward Looking Images

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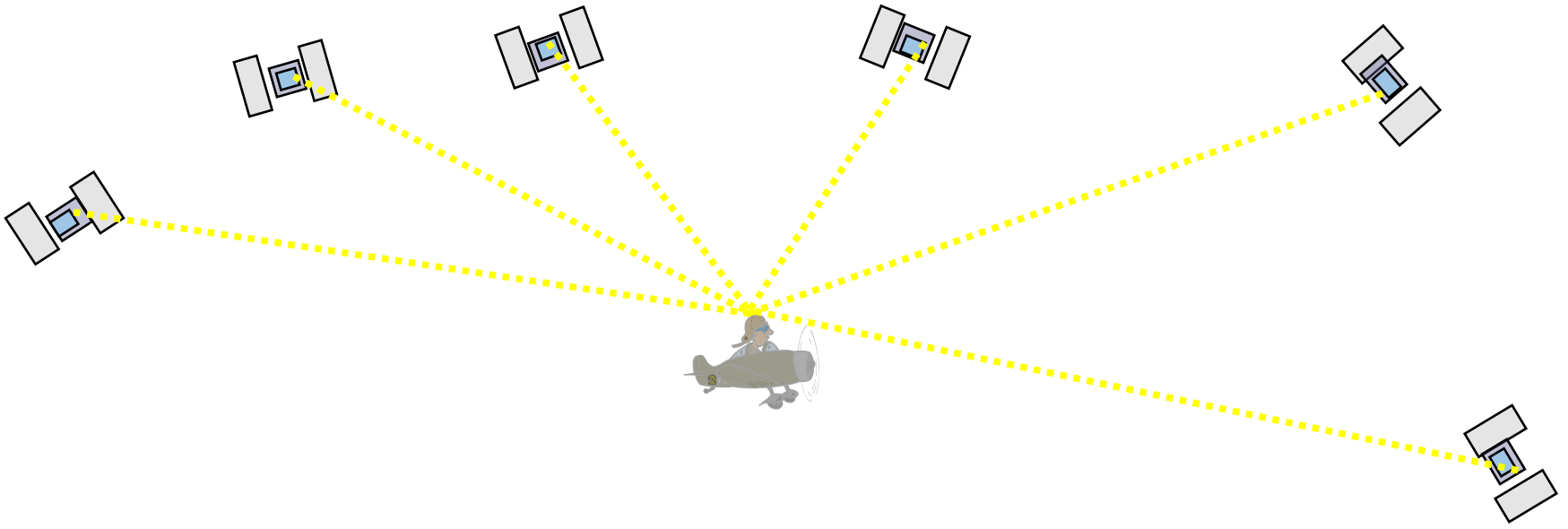
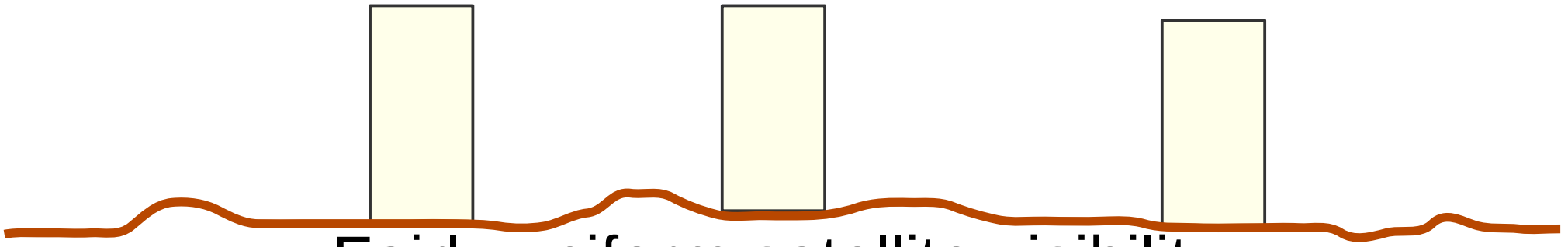
Airborne Positioning





Fairly uniform satellite visibility

Fairly uniform positional accuracy

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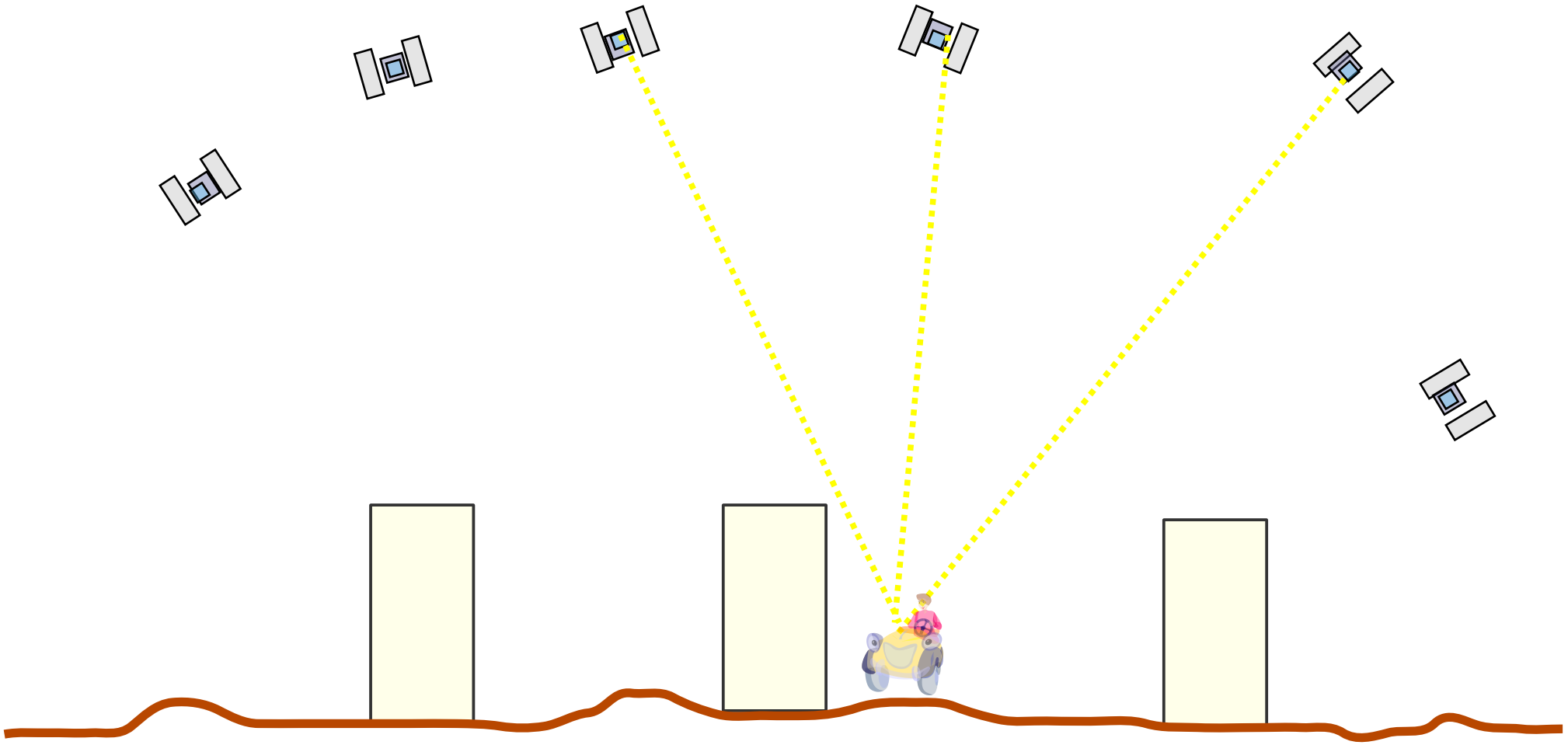
Mobile Trajectory Solution



Satellite visibility varies
Positioning accuracy varies

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Airborne vs Mobile

- Good satellite visibility
- Consistent positioning
- Free design for flight pattern
- Not many surprises
- Consistent point density

- Sees objects from above
- Less details: mapping level
- Fairly consistent light conditions for images

- Varying satellite visibility
- Accuracy varies
- Has to follow the road network
- Suprises: road work, traffic...
- High density on the road
- Low density off from the road

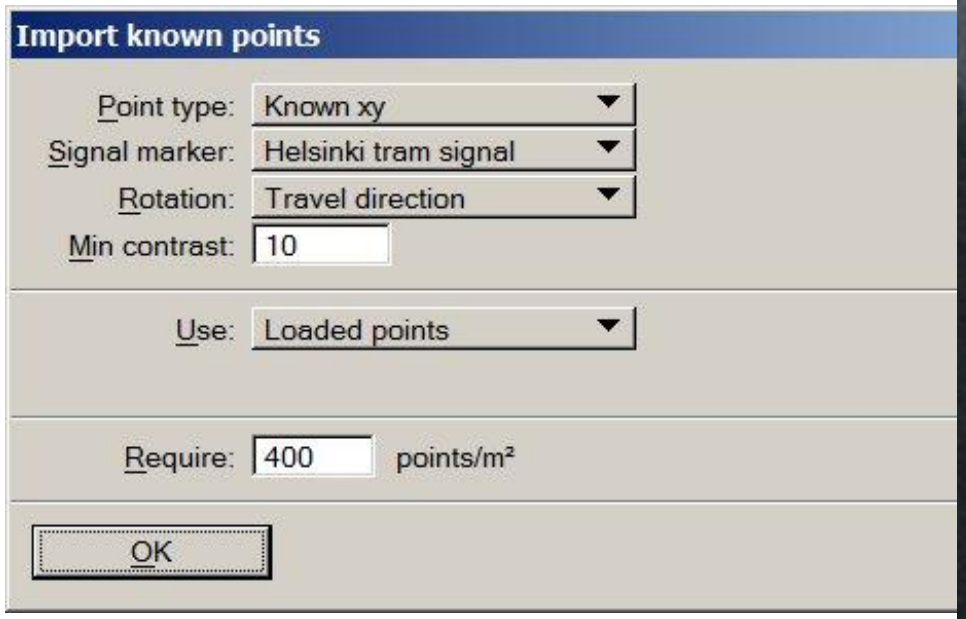
- Sees object from all directions
- More details: engineering level
- Light conditions vary all the time: dark/bright images

Combine airborne and mobile

- With airborne LiDAR you'll get more precise Z- and positional accuracy
- With airborne you'll see the building roofs → automatically vectorized buildings
- Use oblique images to texture building walls
- With mobile much more detail and relative precision
- Use both for maximum accuracy and detail

Automatic Search for Signal Markers

- Automatic search for known pattern control points
- Software finds location (and rotation) with biggest intensity difference between bright and dark polygons
- Rotation can be fixed or come from closest trajectory travel direction



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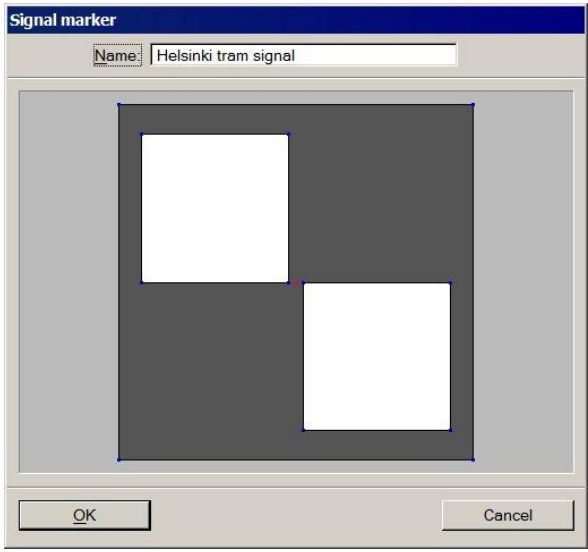
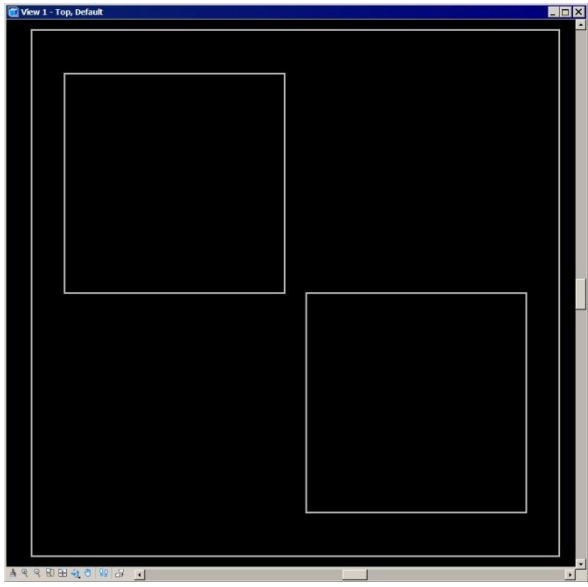
How to Define a Signal Marker

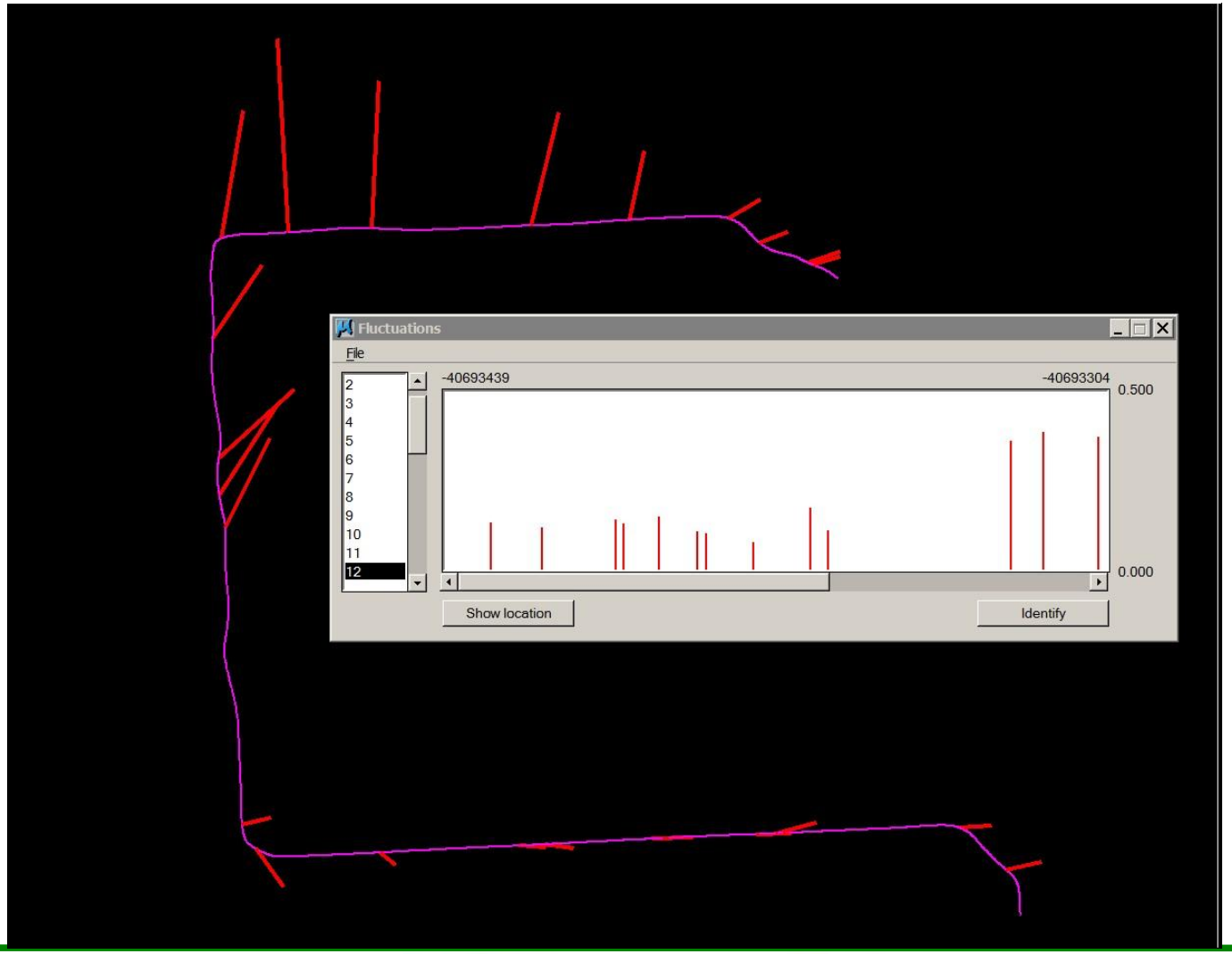
- Draw signal pattern in a top view window
- Draw polygons for bright areas
- Draw larger polygon for dark surrounding
- **Settings** tool and **Signal markers** category
- Select all polygons
- Select **Add**
- Click at location of the control point





Fluctuating Corrections

- Xy correction vectors for drive pass in difficult city environment



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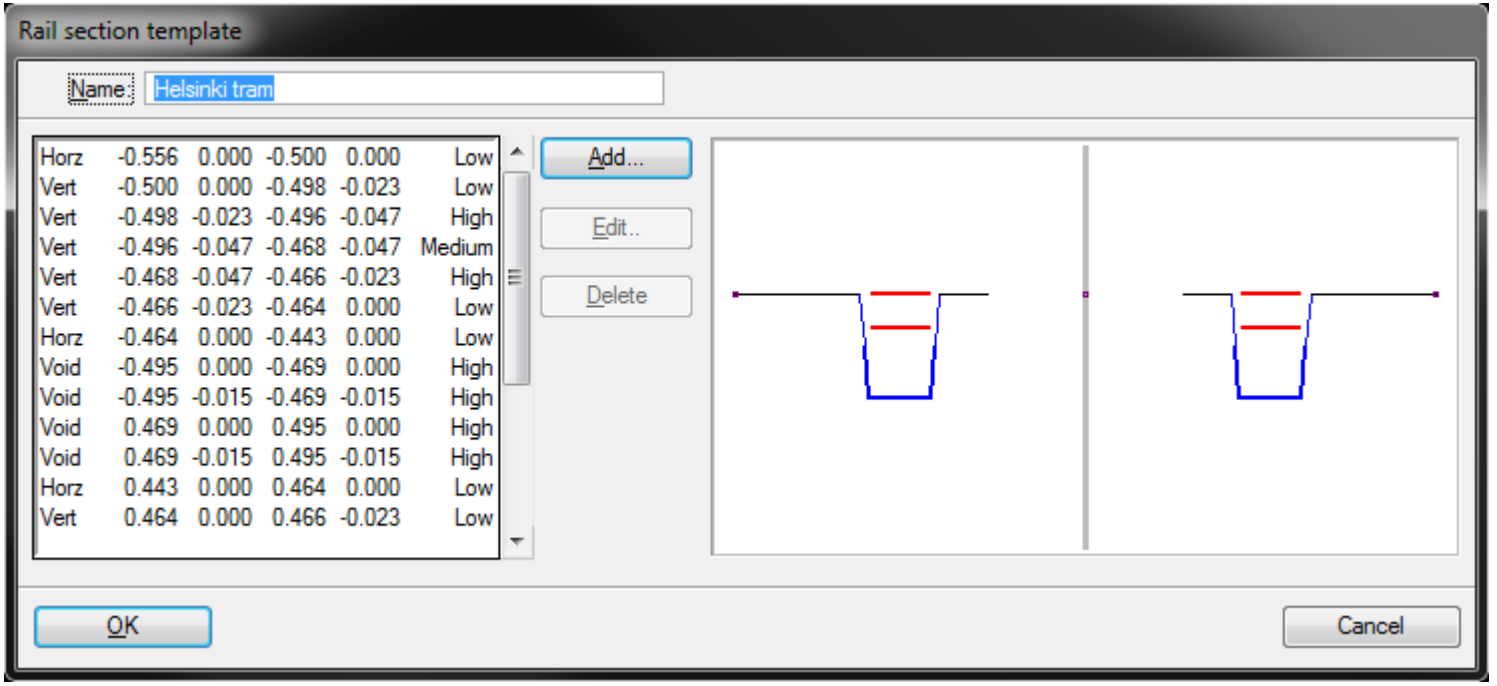
Automatic rail detection

- Define rail section template
- Detect rails

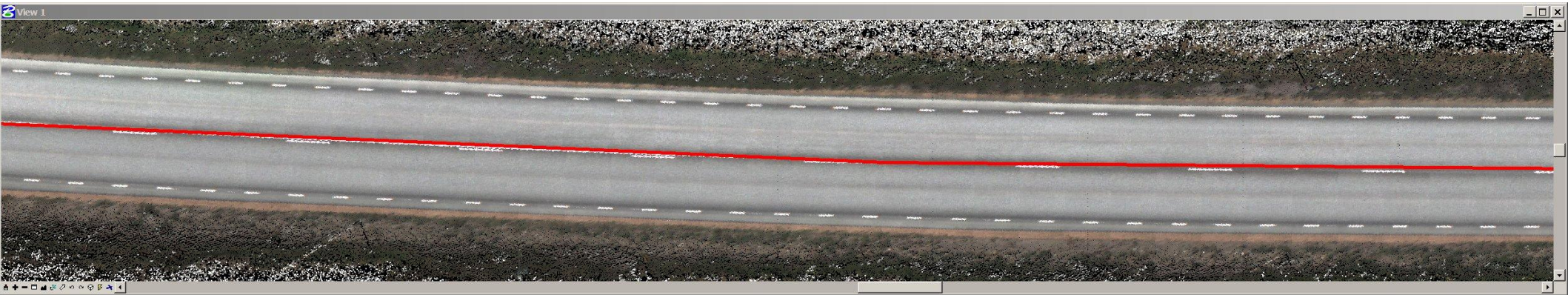


Geometry Component Fitting

- Finds 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 as LandXML file or similar
  - Is curvature right for this category of road?
  - Do component changes follow design principles?
  - Find long span deformations

Source Information

- Components are fitted to a design file vector
- Vector can be created as a result of:
  - Automatic/manual placement of 3D road centerline based on an airborne or a mobile LiDAR+camera survey
  - Fitting railroad cross section to mobile LiDAR surveys of track
  - Trajectory solution of survey vehicle



Horizontal Geometry

List of road segments

File Tools View

Index	Station	Type	Radius	Cloth. A	Length	Avg.error	Mx.error
27	2856.91	Clothoid	-290.00	111.73	43.05	0.0730	0.2622
28	2899.95	Line			86.02	0.0243	0.0496
29	2985.97	Clothoid	0.00	114.72	71.13	0.0196	0.0624
30	3057.10	Arc	185.00		86.95	0.0648	0.1864
31	3144.06	Clothoid	185.00	89.22	42.89	0.0887	0.1389
32	3186.95	Line			124.68	0.0725	0.1867
33	3311.62	Clothoid	0.00	77.89	10.91	0.0837	0.1395
34	3322.54	Arc	556.00		49.06	0.0732	0.1692
35	3371.60	Clothoid	556.00	200.98	72.65	0.1372	0.2100
36	3444.24	Line			5.80	0.1042	0.1529

Modify Join Undo Change Refit

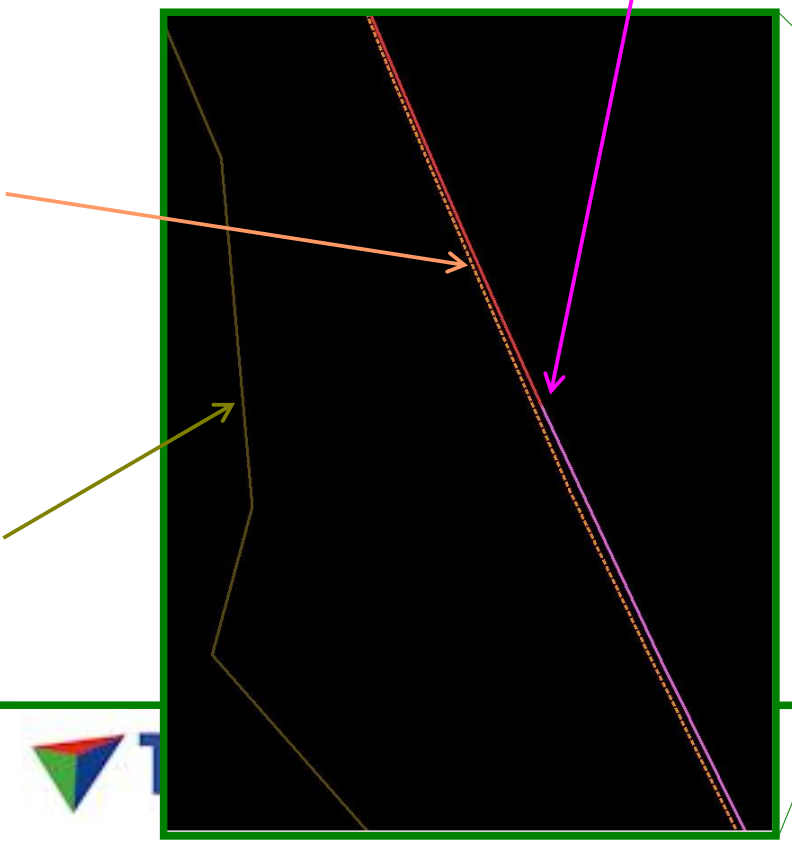
Show location Identify

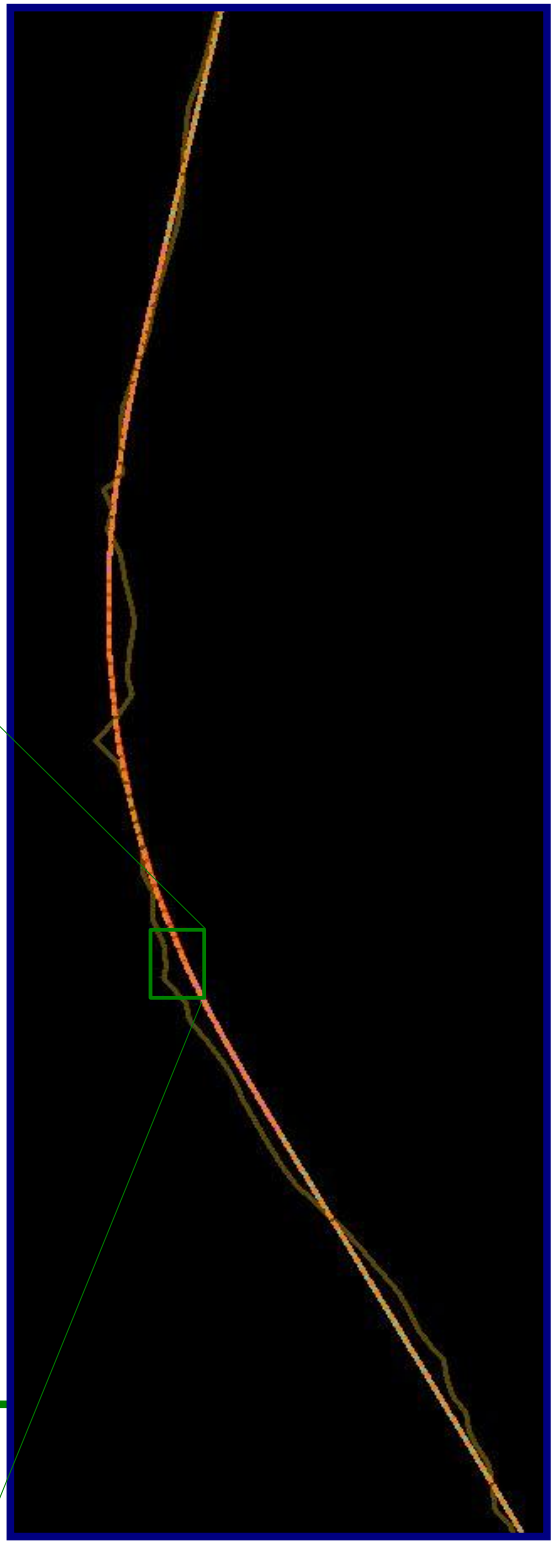
Fitted components and differences to survey

Fitted components

Surveyed alignment

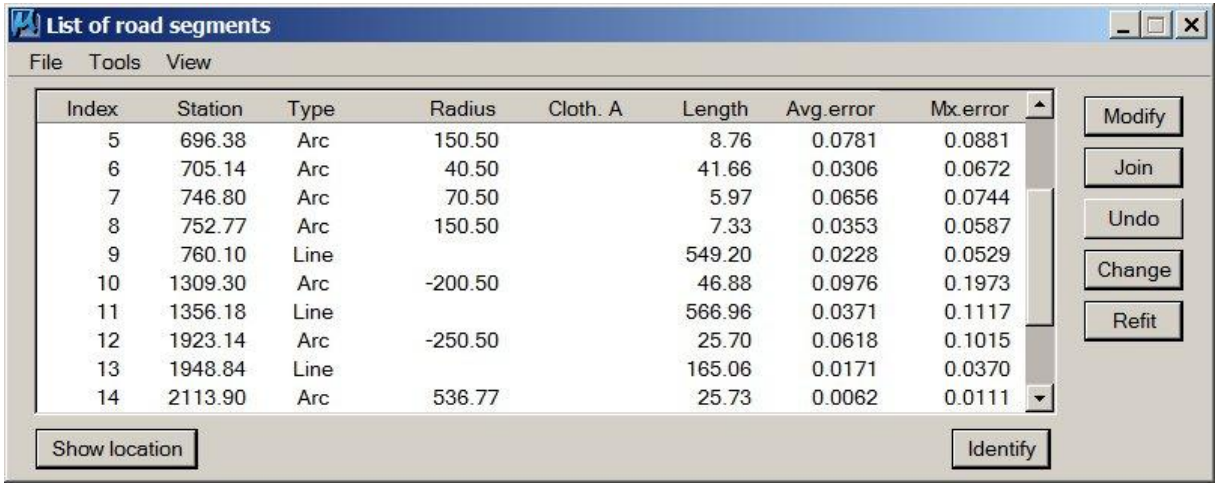
Exaggerated difference





Normal Radius Table

- Optional table of arc radiuses normally uses
- Software will fix arc radiuses to table values if close enough



Fitted horizontal components for a tram line

20.5
25.5
30.5
40.5
70.5
100.5
150.5
250.5

Radius table

Vertical Geometry

List of road segments

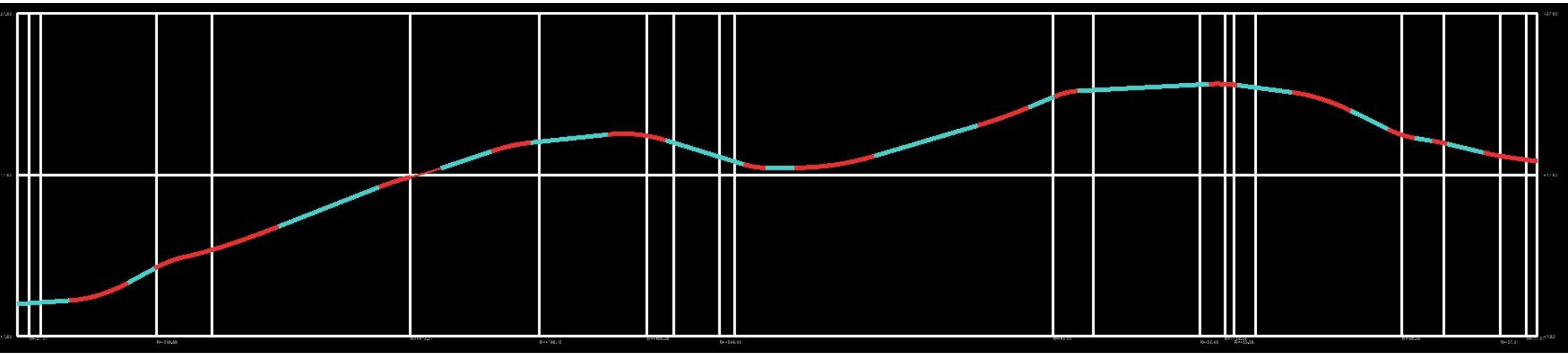
File Tools View

Index	Station	Type	Radius	Cloth. A	Length	Avg.error	Mx.error
20	644.28	Arc	-400.00		14.59	0.0051	0.0073
21	658.87	Line			81.57	0.0070	0.0363
22	740.44	Arc	-950.00		17.53	0.0136	0.0346
23	757.97	Line			33.80	0.0072	0.0178
24	791.77	Arc	-1020.00		36.77	0.0143	0.0294
25	828.52	Line			23.30	0.0113	0.0326
26	851.79	Arc	500.00		16.55	0.0195	0.0458
27	868.33	Line			10.82	0.0132	0.0196
28	879.15	Arc	-1220.00		9.41	0.0095	0.0185
29	888.56	Line			23.32	0.0063	0.0156

Modify Join Undo Change Refit

Show location Identify

Fitted vertical components for a tram line



Fitted vertical components as a profile

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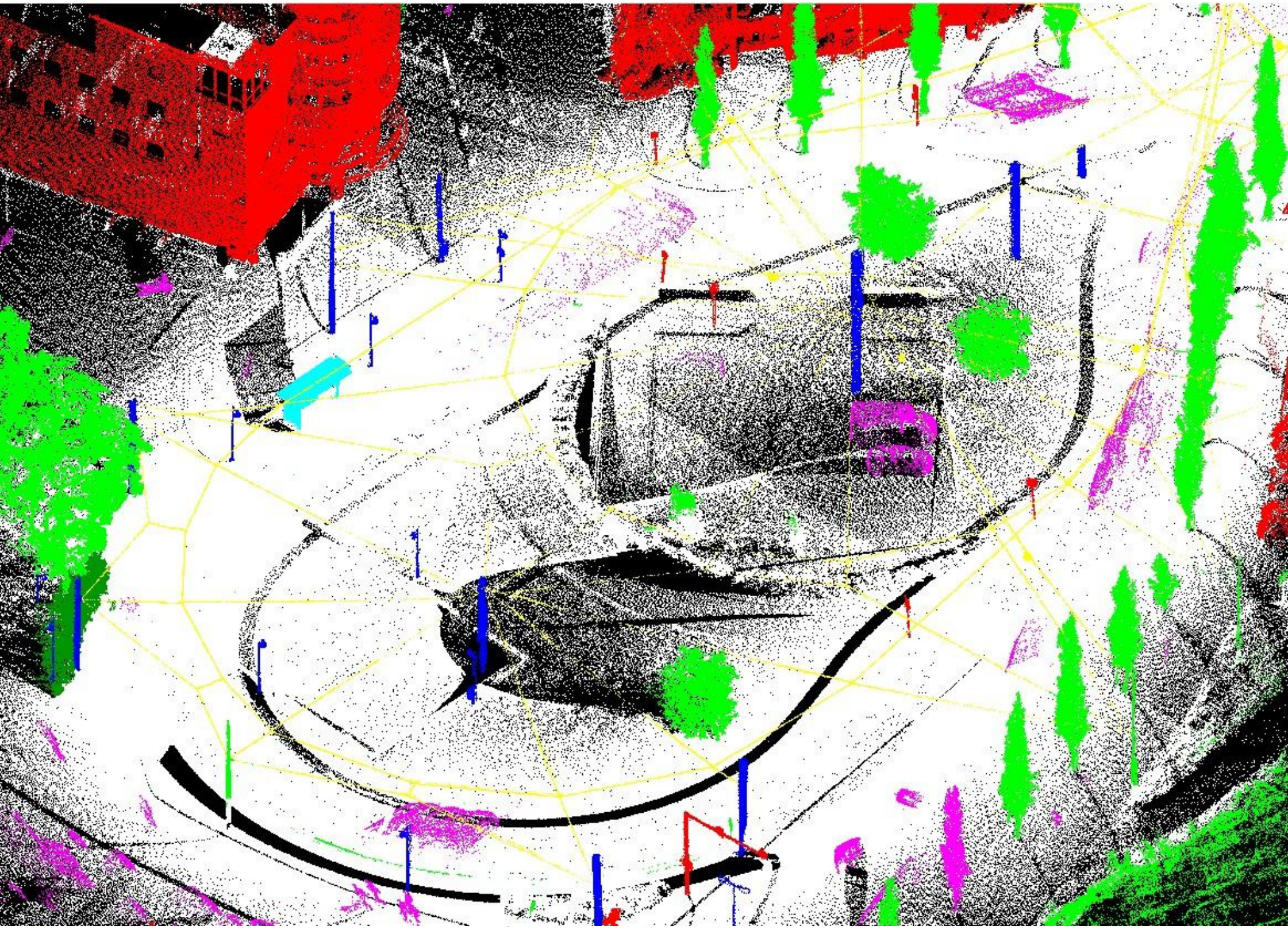

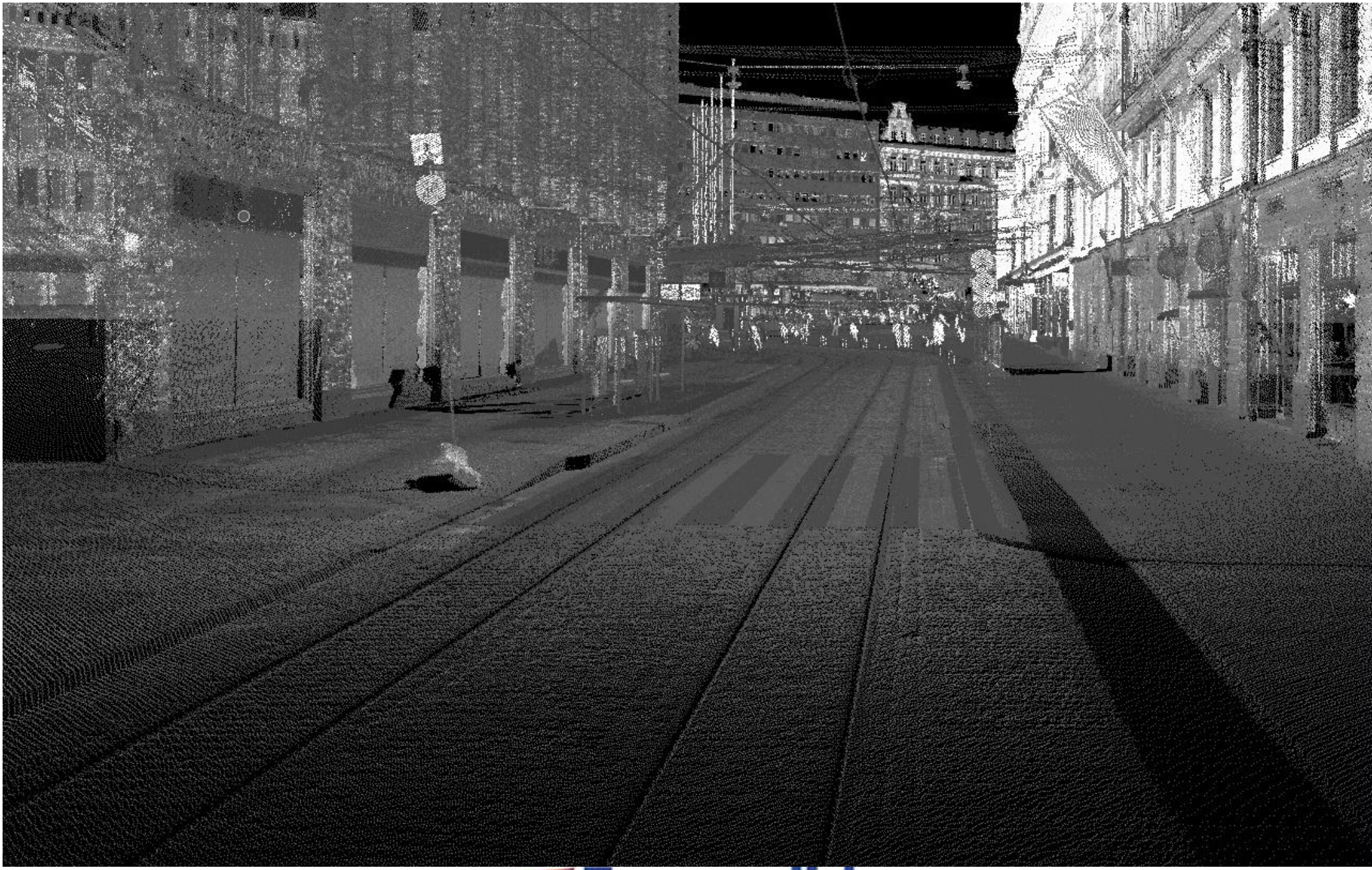

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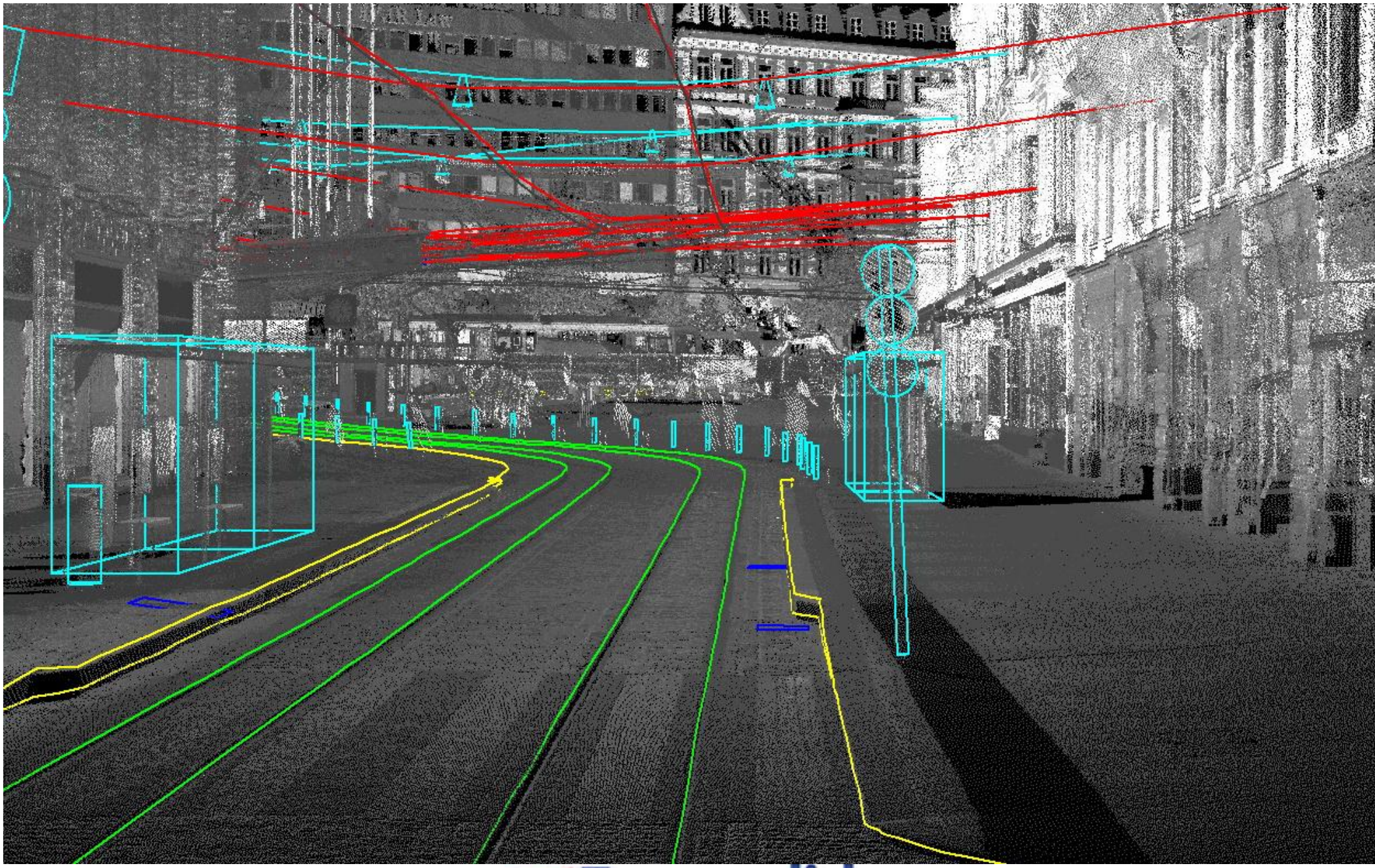

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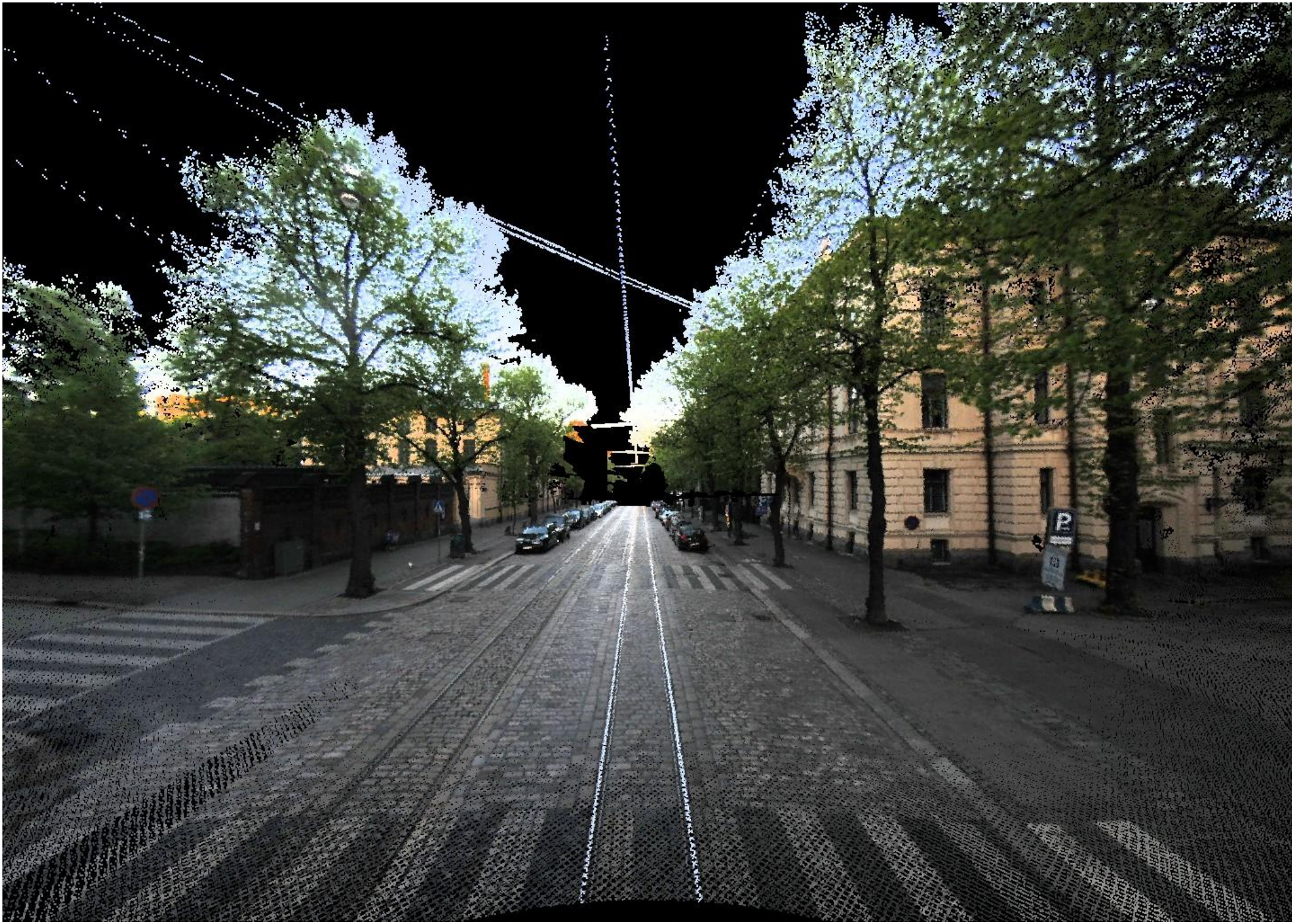


Helsinki Tram Survey
Data collection: 3D Laser Mapping
StreetMapper System
Data processing: Arttu Soininen
Animation: Friederike Schwarzbach
Terrasolid, January 2012