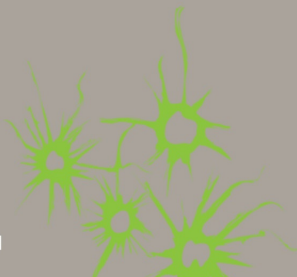# FROM NATIONWIDE POINT CLOUDS TO NATIONWIDE 3D LANDSCAPE MODELS

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3D PILOT NL

Initiated in 2010 by

- Kadaster
- Dutch Geodetic Commission
- Geonovum
- Ministry of Infrastructure and the Environment

Goal: Stimulate applications of 3D geo-information by

- Establishing a standard for 3D geo-information
- Cooperate on use cases with 3D data in a test area
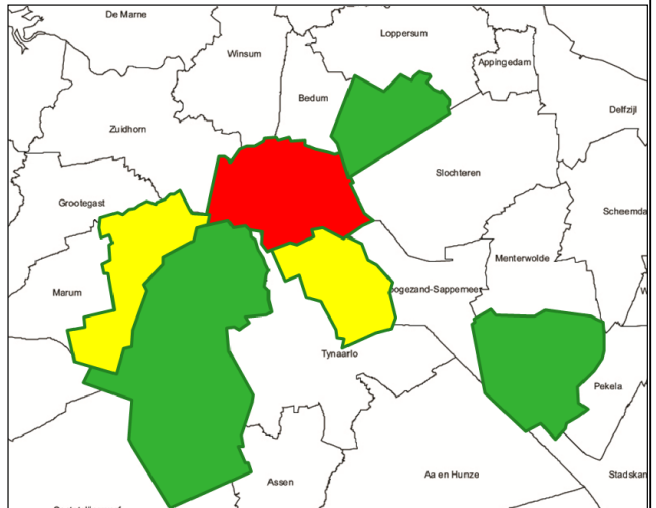- Exchange knowledge, technology and needs

70 organisations, 3D geo-information congress with 300 participants

3D PATCH WORK

- Various initiatives at city level
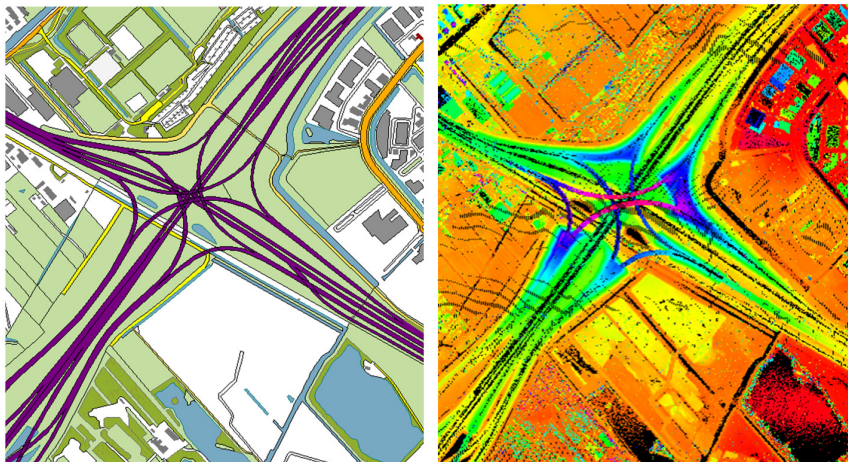- Different LODs
- Different definitions of building outlines

Regional applications hampered by

- Incomplete coverage
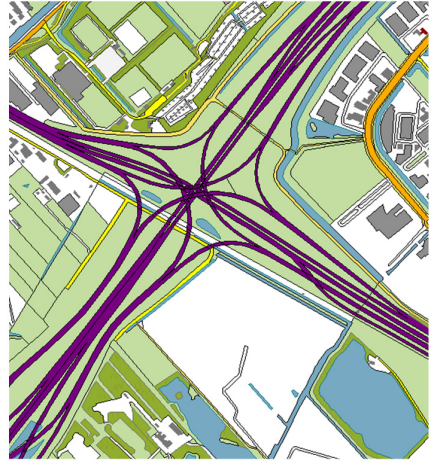- Different models

3D NATIONAL LANDSCAPE MODEL

Can we fuse the national topographic database TOP10NL with the national elevation data AHN-2?

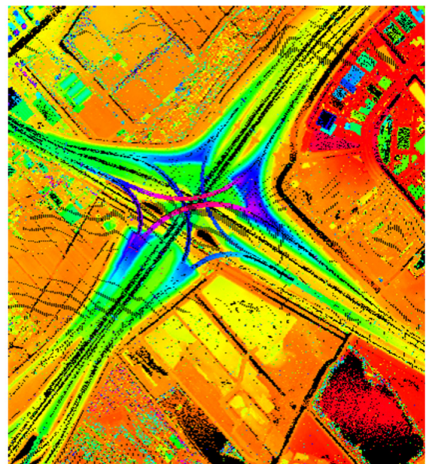# TOP10NL TOPOGRAPHIC DATABASE

- Object based
- 15,000,000 objects
- 1:10,000 scale
- 1-2 m accuracy
- Slightly generalised
- Land use, water, and road provide complete partitioning
- Open data

AHN-2 ELEVATION DATA

- Captured by airborne laser scanning 2007-2012
- Minimum of 8-10 points / m^2
- 600,000,000,000 points
- 5-10 cm accuracy
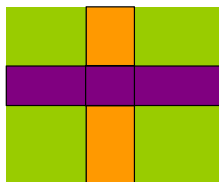- Classified terrain / non-terrain
- Open data

MODEL SPECIFICATIONS

- 3D surface model without gaps
- Modelling of bridges and multi-level road crossings
- Focus on areal objects (no point or line objects)
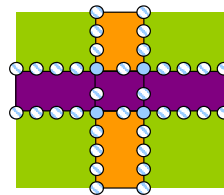- Buildings modelled at LOD1 (flat roofs)
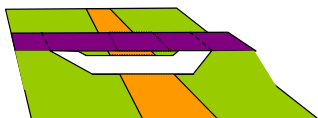
MODELLING APPROACH

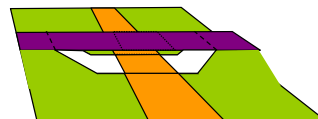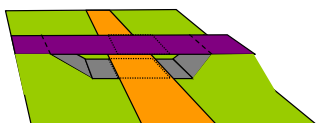Based on earlier work (Oude Elberink and Vosselman, 2009)
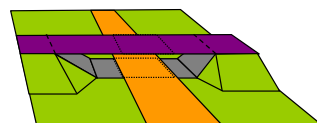

2D map

Densification of map points

3D boundaries

Add hidden road

Add new terrain pieces

Add height to surface

MODELLING APPROACH

Object class dependent modelling

- For object surfaces
    - Water : Horizontal plane
    - Road   : Smooth surface, only triangulate road side points
    - Terrain : Reduce point set and triangulate remaining points

- For object boundaries
    - Water – Terrain : Use water height
    - Road – Terrain : Use road height
    - Road – Building : Keep both heights, generate walls
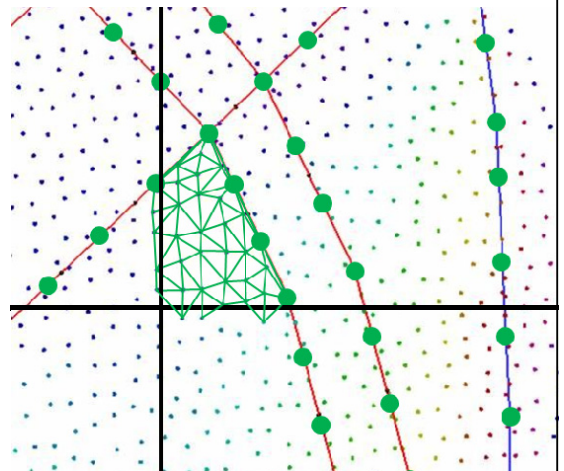

MODELLING APPROACH FOR TILE-BASED PROCESSING

Need for tiling
- Memory requirements
- Parallel processing

Tile-wise modelling
- Tile boundaries not visible in 3D landscape model
- Repeated reconstruction around tile boundaries
- Only store TIN mesh in tile model if mesh centre is inside tile bounds

IMPLEMENTATION AND COMPUTATION

Data and software preparation
- National point cloud split into 30,000 tiles of 1 km^2
- For each tile: select TOP10NL polygons that overlap with tile
- Software installation on a SARA supercomputer

Computation
- 2.5 hours processing per tile
- 8.5 years for 30,000 tiles on a single CPU
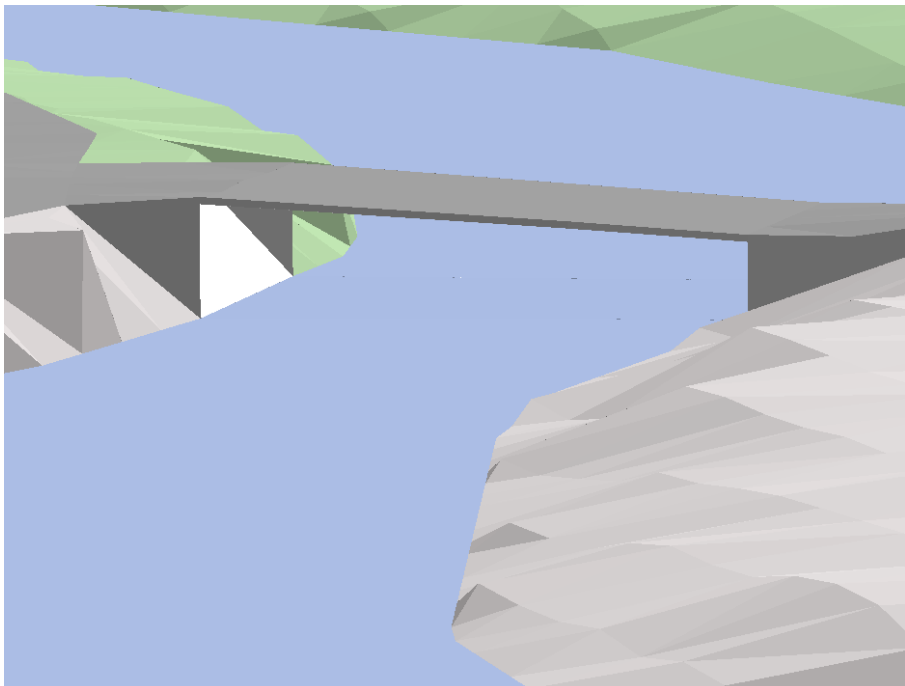- Job done in one month on 100 cores
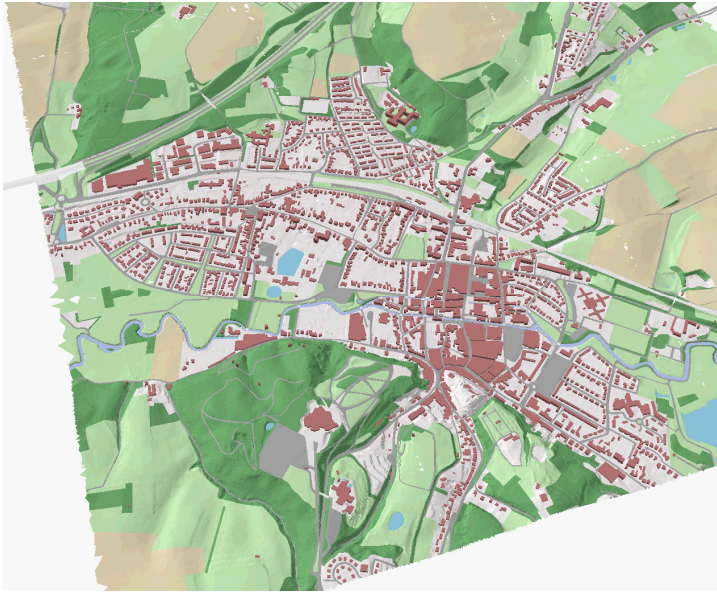

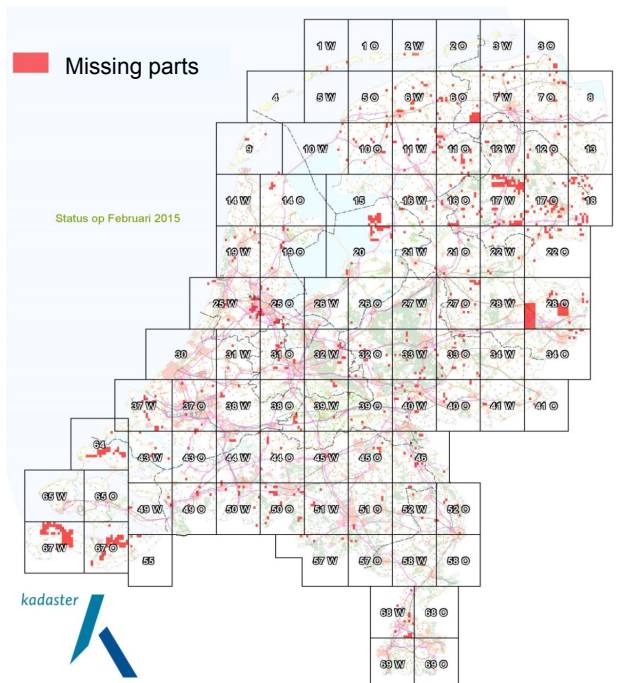# SOME RESULTS

SOME RESULTS

SOME RESULTS

SOME RESULTS

BUGS, LEAKS, CRASHES, AND OTHER PROBLEMS

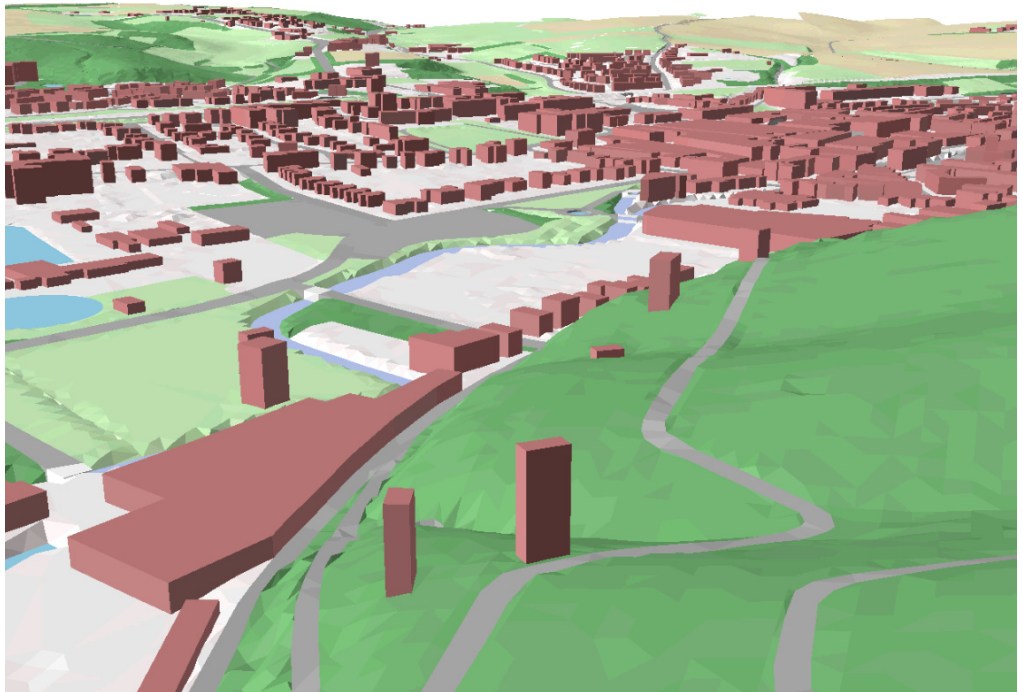- Initially 90% complete
- Now at 97%
- 64 bit implementation needed

Modelling errors
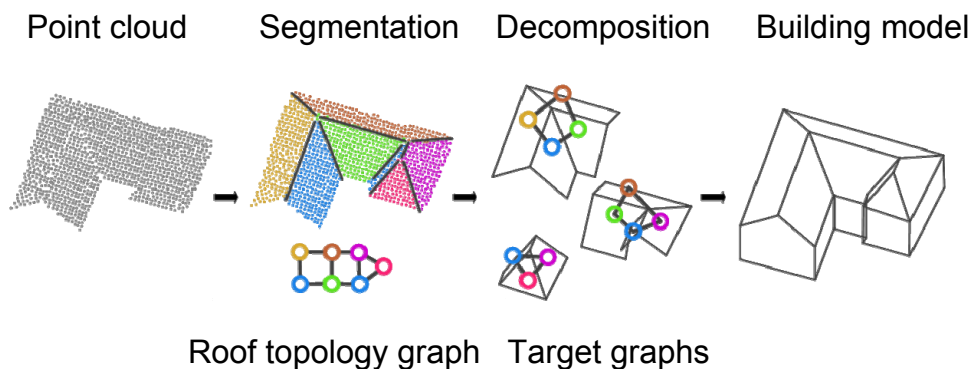- Bumps in terrain caused by points on walls
- Peaks in forest surfaces
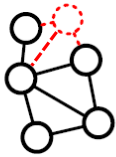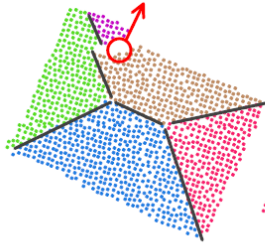
3D TOP10NL NOW AVAILABLE AS OPEN DATA

FEASIBILITY OF NATIONWIDE LOD2 BUILDING MODELLING

- Various approaches (data-driven, model-driven)
- Roof topology graphs and target graph libraries

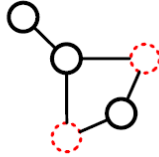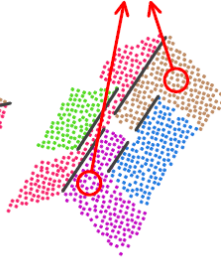Point cloud   Segmentation   Decomposition   Building model

Roof topology graph   Target graphs
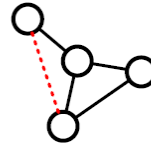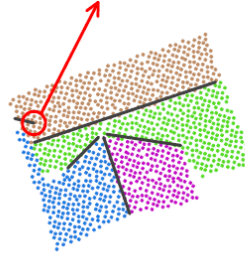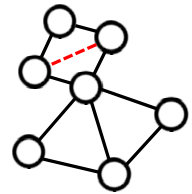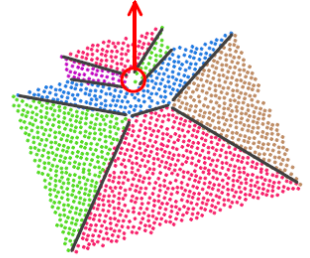
ERRORS IN ROOF TOPOLOGY GRAPHS

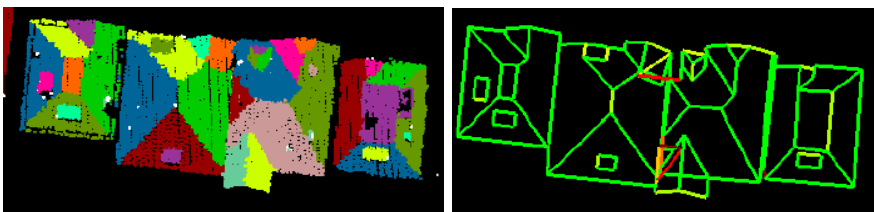Missing segment

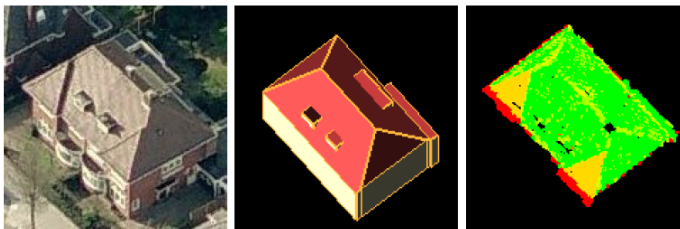Wrong segment

Wrong intersection line

Missing intersection line
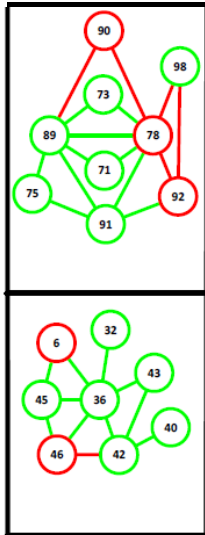

CORRECTING ERRORS IN ROOF TOPOLOGY GRAPHS

- Interactive editing of roof topology graphs
- Recognition of error type – reapplication of earlier graph edits
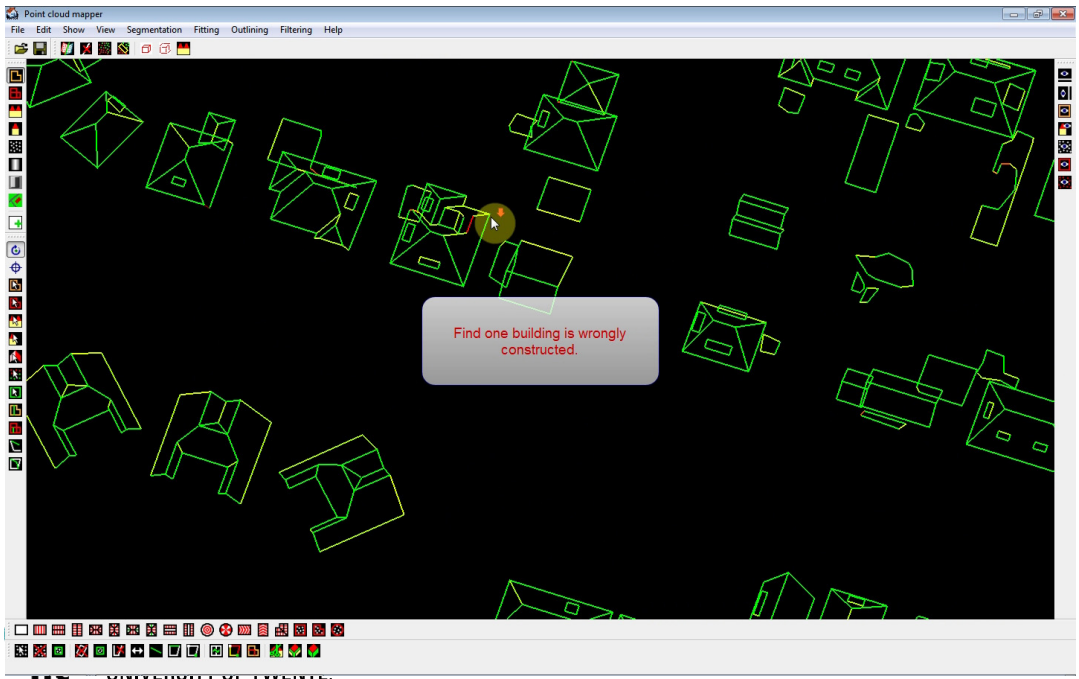- Analyse model quality of roof faces and edges

ERROR RECOGNITION

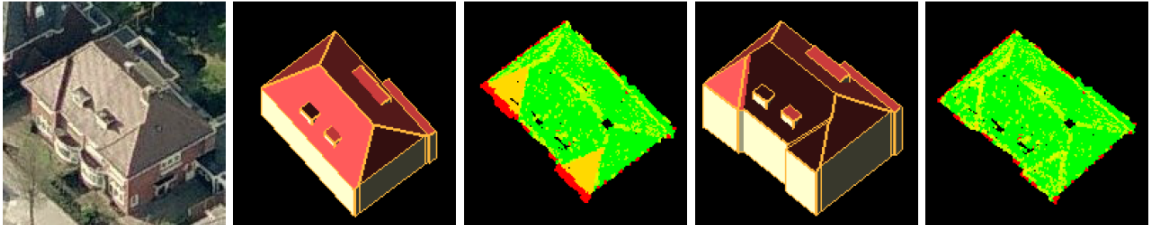# INTERACTIVE CORRECTION OF REMAINING ERRORS

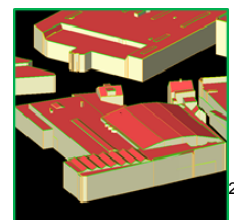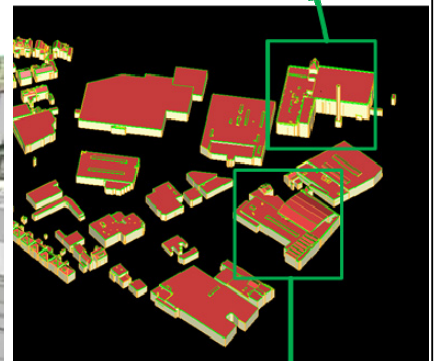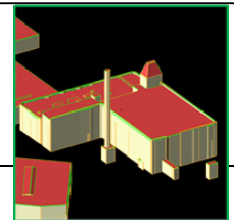Find one building is wrongly constructed.

RECONSTRUCTION PROCESS

- Automated reconstruction with target graph library
- Iterate
  - Analysis of model quality
  - Automated improvement of errors by matching against entries of error library
- Interactive editing of remaining errors

LOD2 MODELLING RESULTS

- 95% buildings correctly modelled

FEASIBILITY OF NATIONWIDE LOD2 BUILDING MODELLING

- 9366 building models reconstructed in Enschede
  - 45 minutes CPU time for automated reconstruction
  - 1 working day for interactive editing of building models

- Scaling up to nationwide LOD2 modelling (4 million building models)
  - 13 days CPU time for automated reconstruction
  - 2 years for interactive editing of building models

CONCLUDING REMARKS

- Nationwide LOD1 modelling nearly complete
  - Collect response from users
  - Some bug fixes
  - Improve modelling of forests and complex road junctions
  - Updating strategy – point clouds from dense matching

- Nationwide LOD2 modelling
  - Editing is still time consuming
  - Further editing experience may improve automated corrections
  - Point clouds from dense matching may require higher overlap

TARGET GRAPH LIBRARY