

An aerial view of a city's point cloud visualization. The buildings and streets are rendered in a dark blue color, while the trees and vegetation are in a light blue. A prominent red cone of light is visible on the left side of the image, pointing towards the center. The overall scene is a dense urban environment.

# Scalable Visualization of Massive Point Clouds

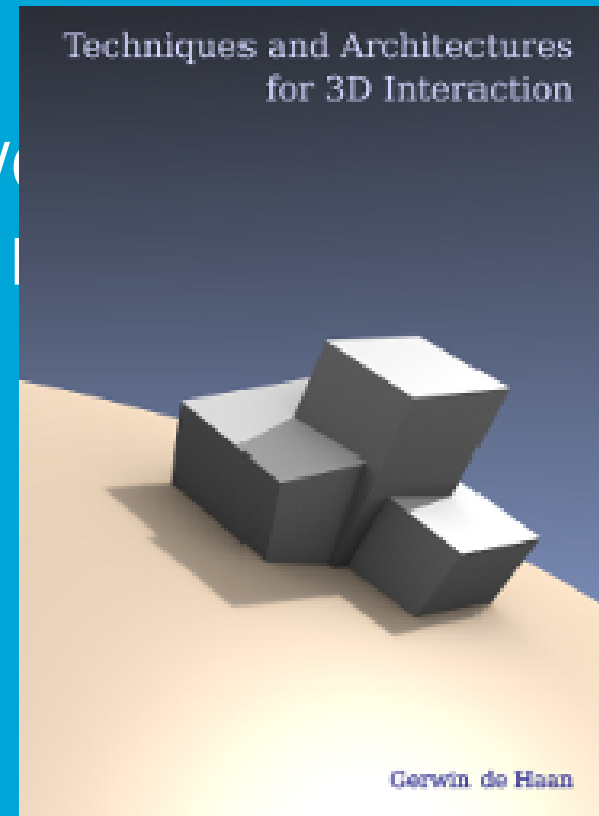
Dr. Ir. Gerwin de Haan

November 26th, 2009

1

# About me

- TUDelft Computer Graphics & CAD/CAE
- Msc (2002), Visualization in Virtual Reality
- PhD (2004 - September 2009)
- PostDoc



PointClouds: 2008 RGI 3D TOPO (TuDelft GIS group)

November 26th, 2009

2

# Why Visualize Point Clouds ?

- Because we can !

Because we need to:

**Visual inspection** of “raw” measurements

Visualization: **“From numbers to insight”**

# Scalable Visualization?

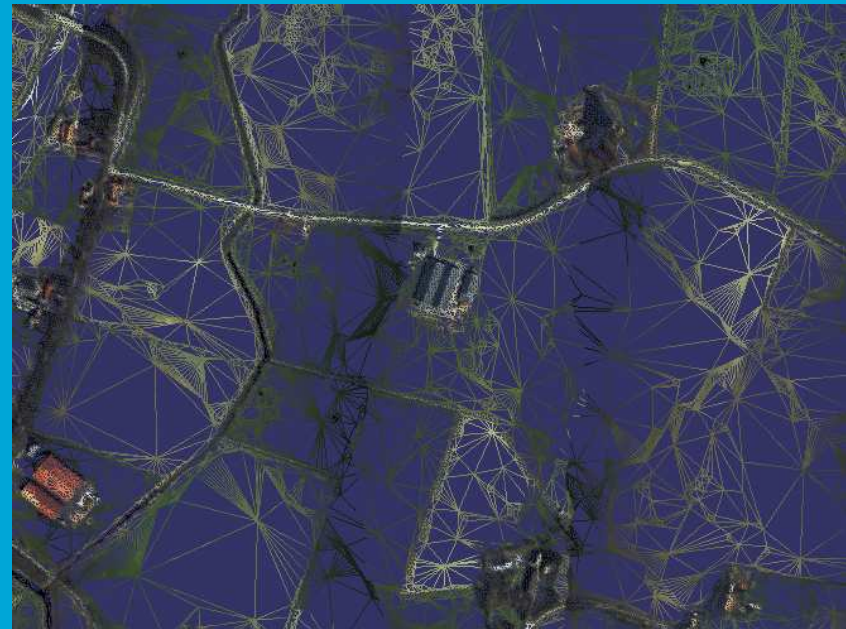
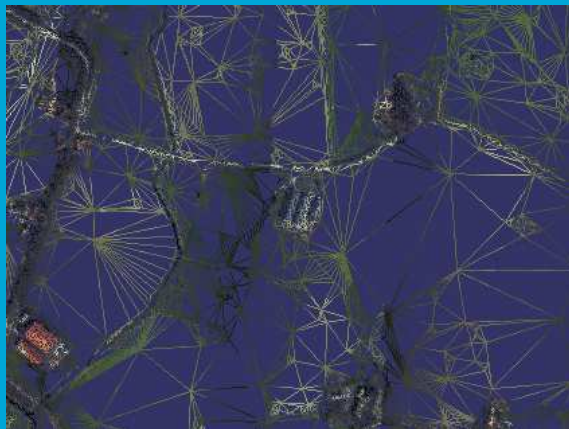
- From bigger (?) **data** to bigger **insights** ?
  - Too big for one graphics card
  - Too big for one machine
  - Too big to see on one screen
  - Too big for one person to comprehend
  - Too big to physically distribute
- Rendering >> Visualization >> Interaction

# Our Tools of Choice

- **OpenSceneGraph**
  - Most popular FOSS **scene graph** engine
  - Integration, Compatibility, File Formats
  - Based on Flight-simulator software (not GIS)
- OpenSceneGraph-based **VRMeer** software
- Python abstraction layers

# Real-Time Terrain Rendering

- OpenSceneGraph + **VirtualPlanetBuilder**
  - **TIN** generation, Level-Of-Detail, Tiling
  - **Paged** file-based access, also from **network**



# From Terrain ...



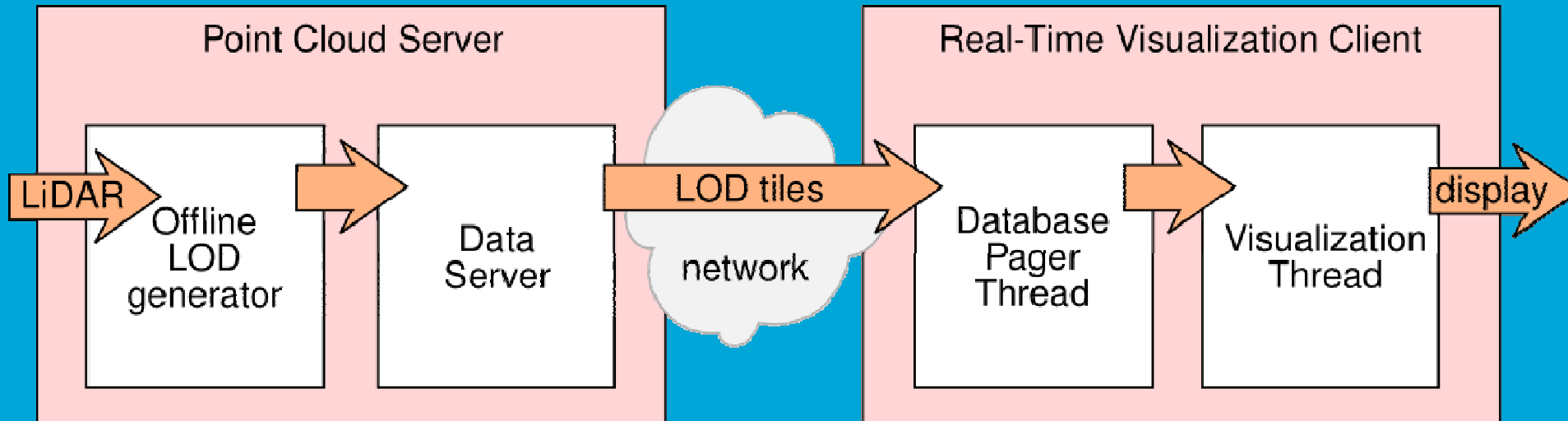
- AHN2 "raw" DEM 0,5m grid size, RGB "raw" photos

## ... to Point Clouds



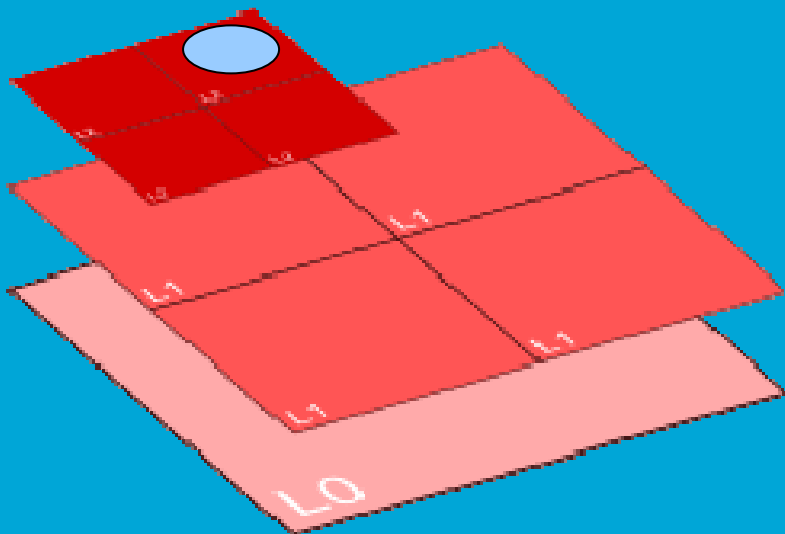
- $\sim 2$  million points at interactive rates, but which ones ?

# Our Current System



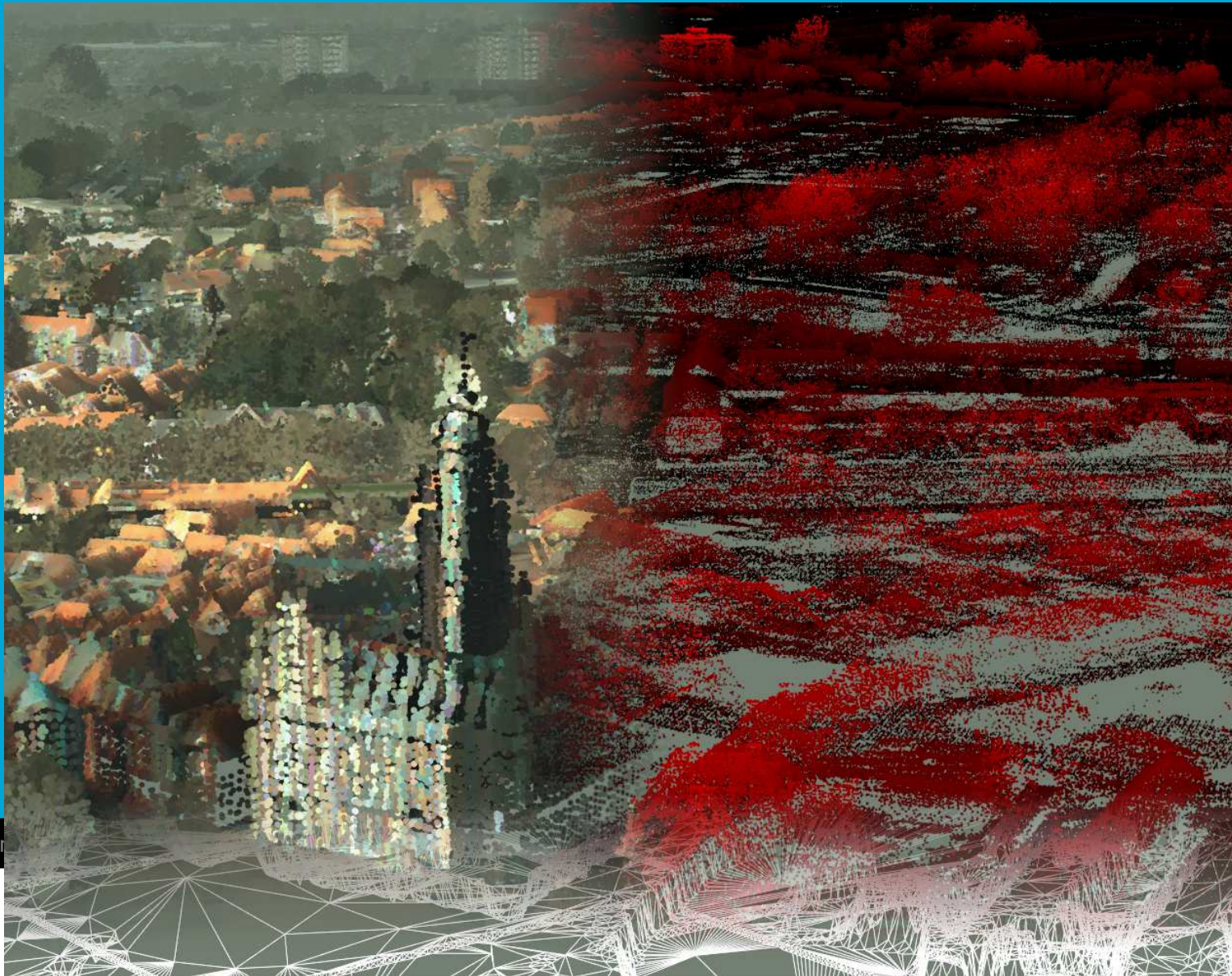
# Point Cloud Datastructure

- Discrete LOD, Tile-based, Quad-Tree,
- Simple sampling , no duplication



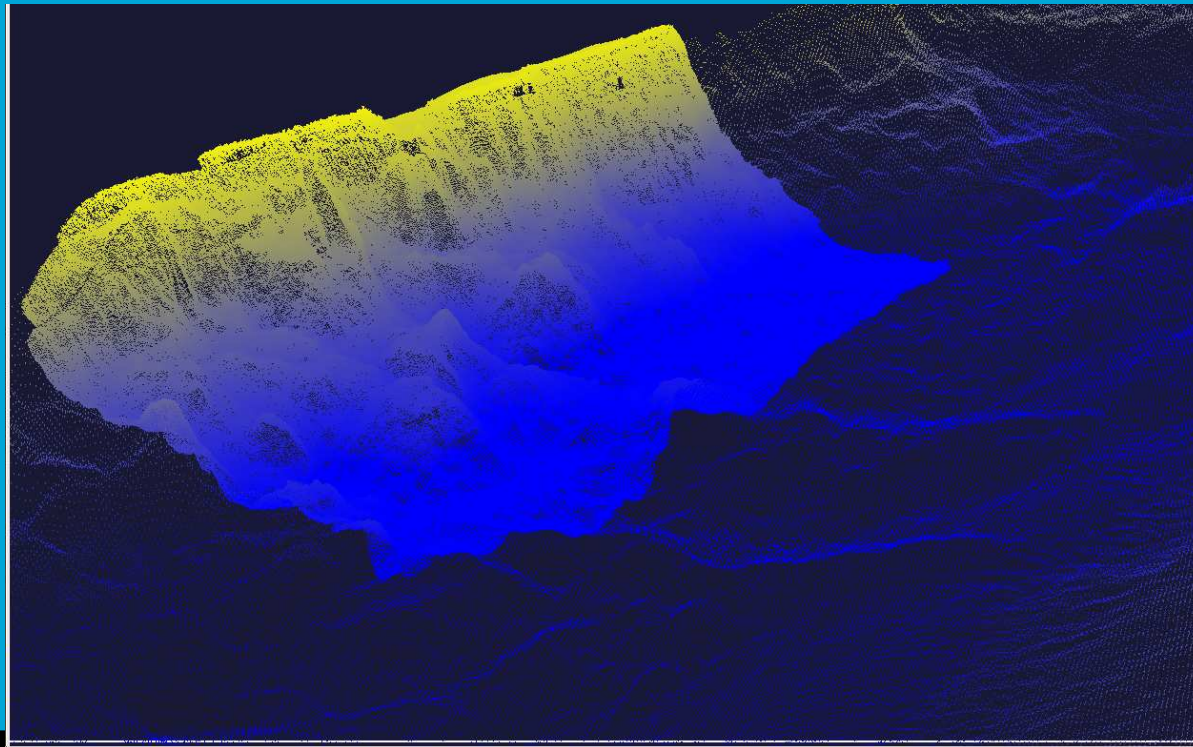
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# Point Cloud Visualization



# Point Cloud Rendering Issues

- Sampling vs. Density (what is important?)
- Rendering Scalable Enough? (It depends!)

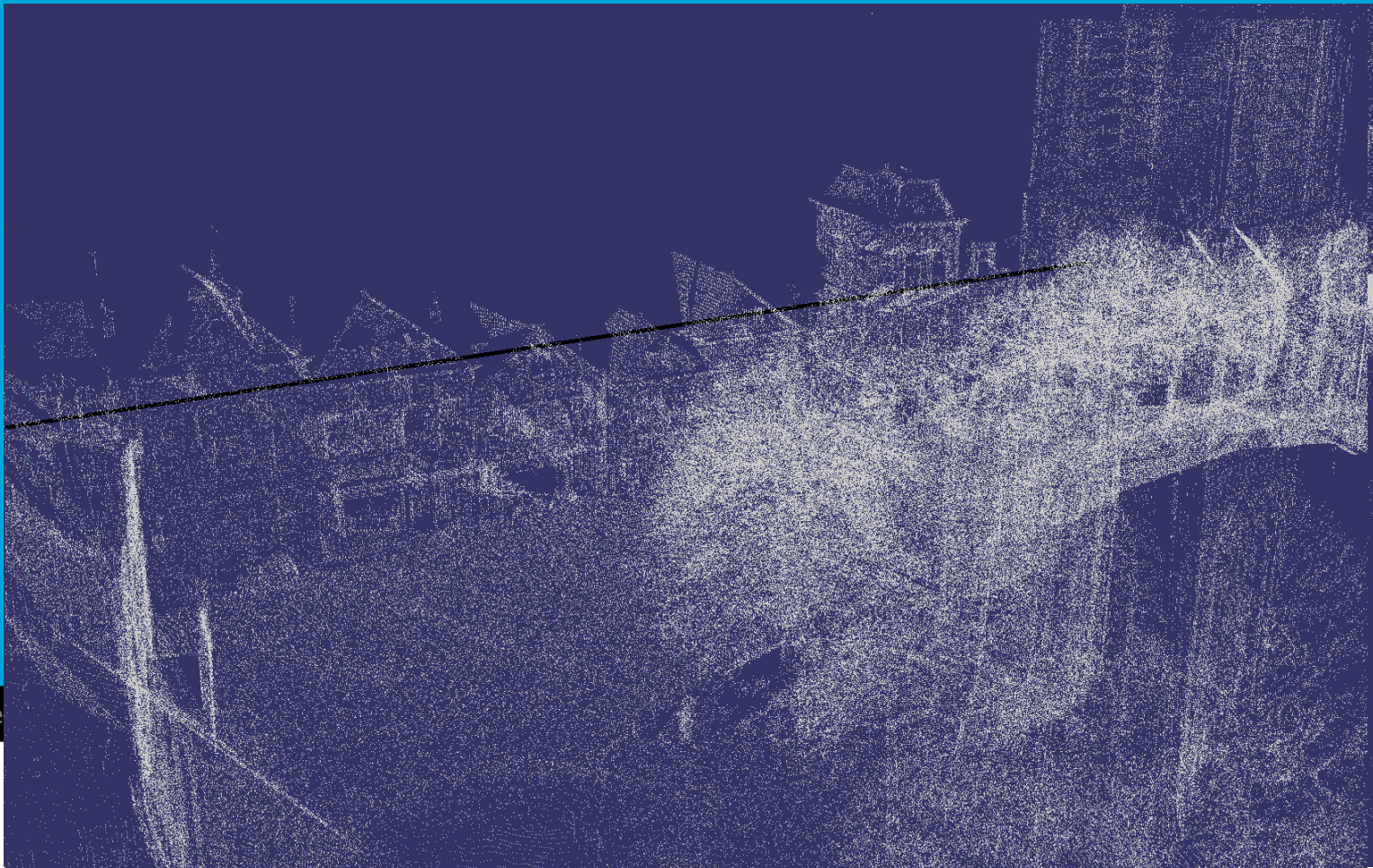


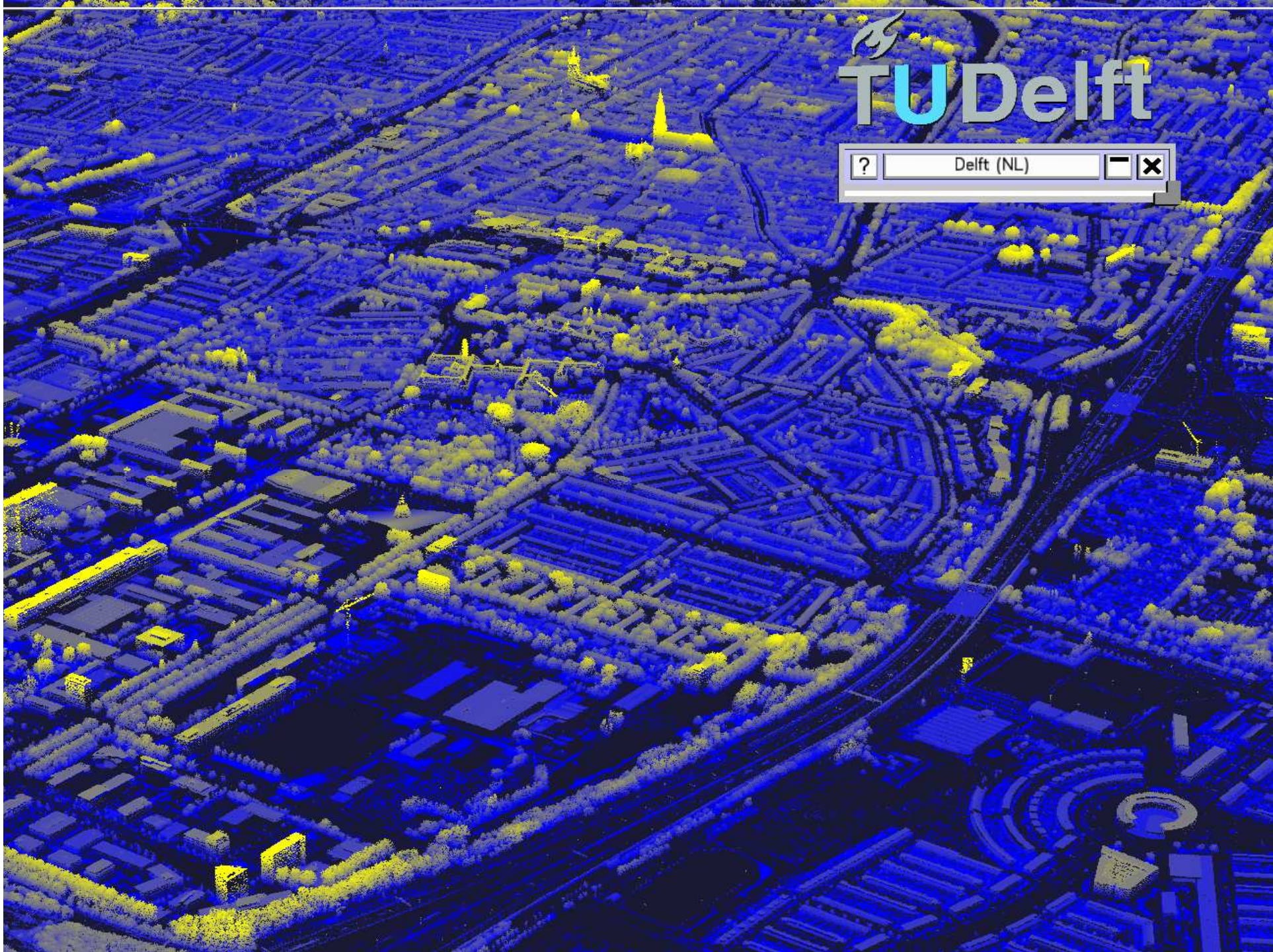
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12

# Importance Sampling

- 10%, Random vs. Metric (e.g. Surface-ness)
- Pre-processing, region/case-specific metric



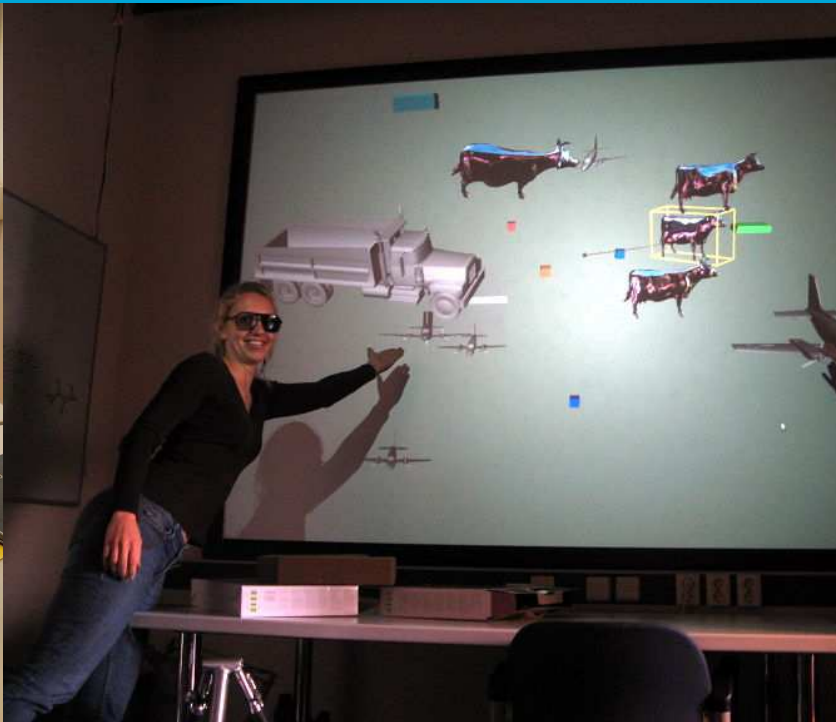


TU Delft

? Delft (NL) [min] [x]

# Scalable Comprehension: Display

- Correct view
  - 3D Perspective setup / head tracking
  - Stereoscopic display!
- Planar, Powerwall, Workbench, PDRIVE (CAVE)



# Scalable Comprehension: Interaction

- 3D Interaction modelling + prototyping
  - Mouse-based, animated 3D navigation
  - Simple Sketching on models
  - Space-mouse, Wii balance board interaction

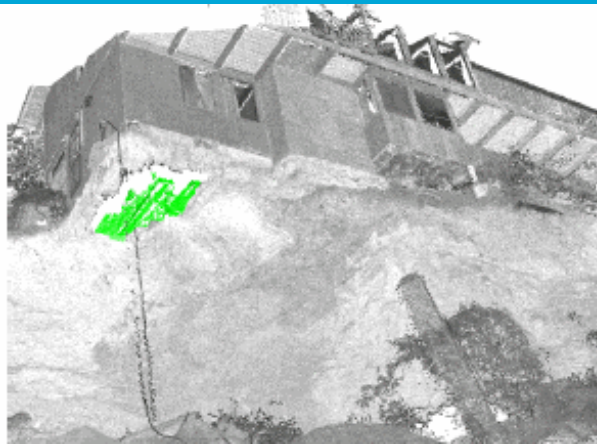


# Application: Flooding

- Hoogheemraadschap Delfland
  - Fast, High Accuracy Flooding Simulation
  - High Fidelity Visualization
  - Communication to general public (color, please)
- [video]

# State of the Art (Academic)

- Much “Point-based Graphics”, but Single Object focus
- [Wand 2008] Point Cloud Rendering & Editing
  - Demonstrated 63GB, limited by disk space
- [Kreylos 2008] VR pointcloud editor, shape matching

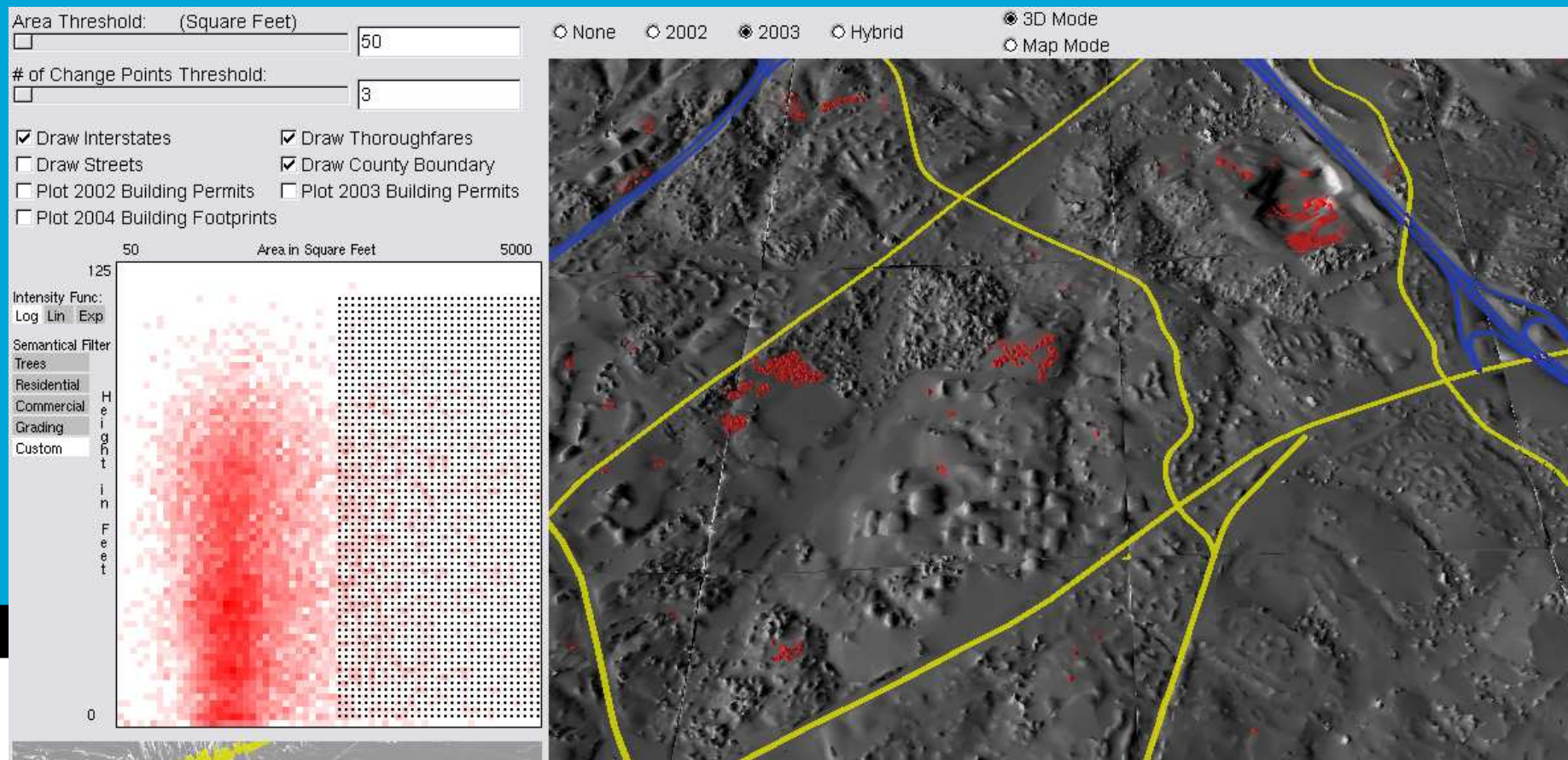


# Future Scalable Approaches

- **Continuous** Level-of-Detail from **Geo Databases**
  - Balance bandwidth + memory vs. visual quality
- **Service-based Visualization** (& processing)
  - Data locality & security
  - Integration with “legacy” GIS apps
  - Tile-server for Web-based Maps (Bing, Gmaps)
  - Mobile Front-end
- From Rendering to **Visual Data Analysis**

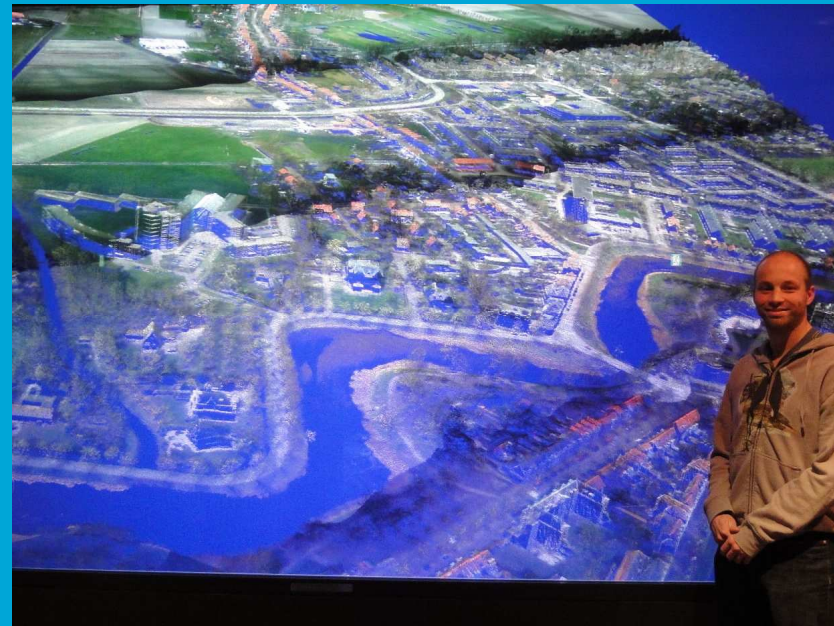
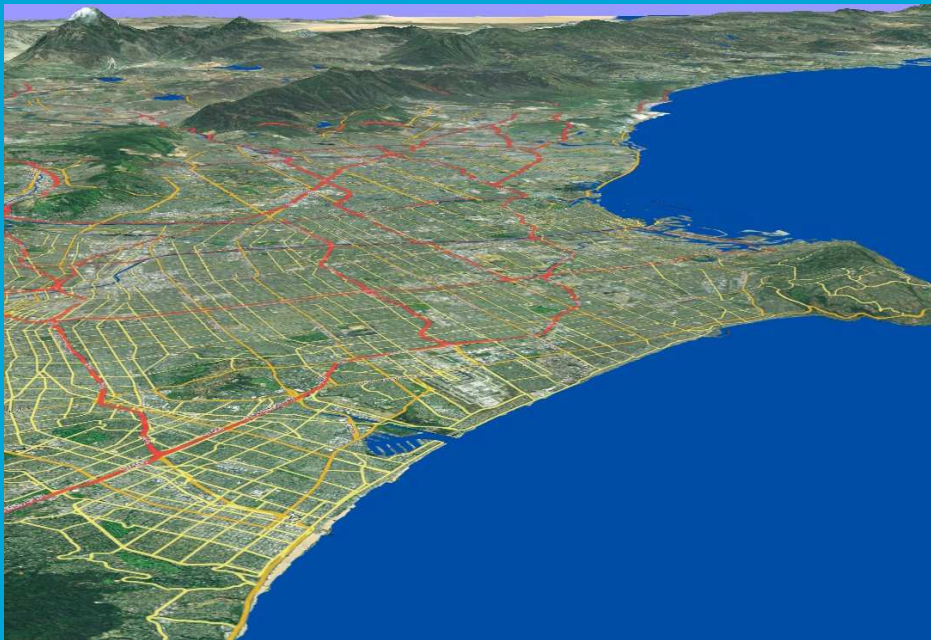
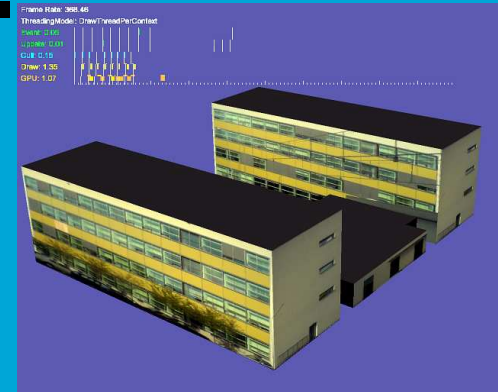
# Visual Data Analysis

- Urban Change Visualization [Butkiewicz 2008]
- Linking Abstract Views with Spatial Views



# OpenSceneGraph leverage ...

- Integration, Compatibility, File Formats
- GIS: GDAL, COLLADA, etc.
- From high-end <-> mobile



November 15th 2009 [OSGGis, OSGEarth]

[4K projectors]

21

# Software, Videos or Demos ?

- E-mail: [gdehaan@tudelft.nl](mailto:gdehaan@tudelft.nl)
- Web: [graphics.tudelft.nl/GerwinDeHaan](http://graphics.tudelft.nl/GerwinDeHaan)
- Datasets and cases are welcome !

(minor 3D Virtual Earth)



# Additional Slides

# Agenda

- Why
- Current system
- Data structures
- Results and Videos
- State of the Art
- Future Directions

# Terrain Rendering

- AHN2 Test Dataset
  - “Raw” pointcloud



November 26th, 2009

25