
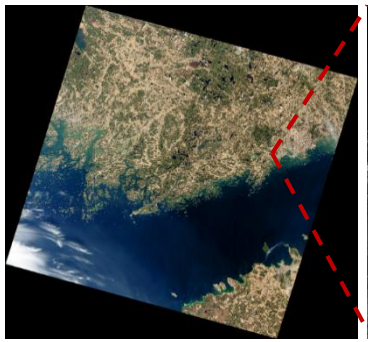
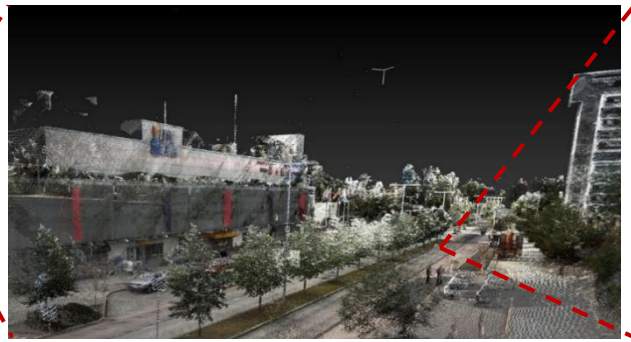


ENY-C2005 Geoinformation in Environmental Modeling, 2019

Lecture 5: **PHOTOGRAMMETRY**

Part I, Matti Vaaja (*matti.t.vaaja@aalto.fi*)

PHOTOGRAMMETRY and LASER SCANNING at AALTO UNIVERSITY

DEPARTMENT OF BUILT ENVIRONMENT

Education and research in the field of Geoinformatics
MeMo3D Research institute
Centre of Excellence in Laser Scanning Research (2014 - 2019)

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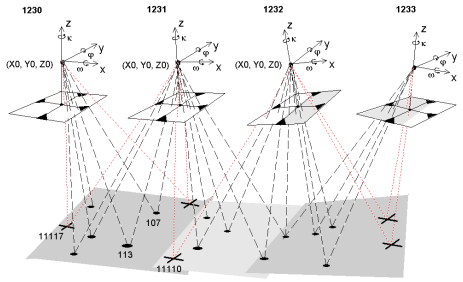
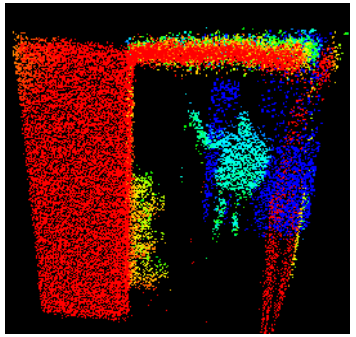
Learning objectives

- To realize potential applications of photogrammetric data
- To understand photogrammetric instruments
- To know the most important photogrammetric products
- To understand principles of photogrammetric measurements

Photogrammetry and Remote Sensing



- The art, science, and technology of
  - obtaining reliable information
  - from noncontact **imaging** and **other sensor** systems
  - about the Earth and its environment, and other physical objects, and processes
  - through recording, measuring, analyzing and representation.



➢3D maps and models of physical phenomena

- Photogrammetry: The name comes from Greek "photos" (light), "gramma" (something written or drawn) and "metron" (measure)

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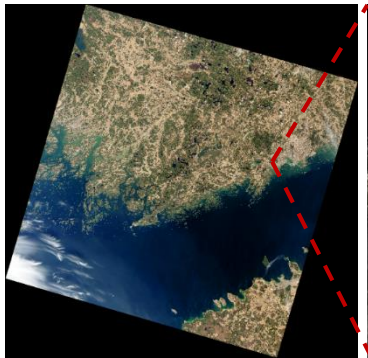
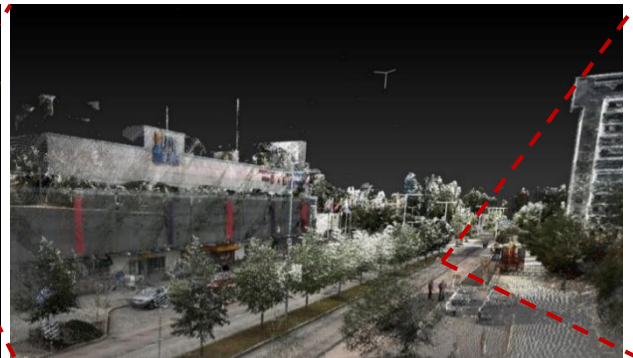
Photogrammetry

- **Categorization** by camera position and object distance (d, distance from sensor to object)
  - **Satellite photogrammetry** — d > ~200 km
  - **Aerial photogrammetry** — d > ~300 m
  - **Close-range photogrammetry** — d < ~300 m
  - **Macro photogrammetry** — image scale > 1, (micro-scope imaging)

- **Different measurement/object scales: planets – nationwide mapping – forests – cities – buildings – road surface – dust particles**

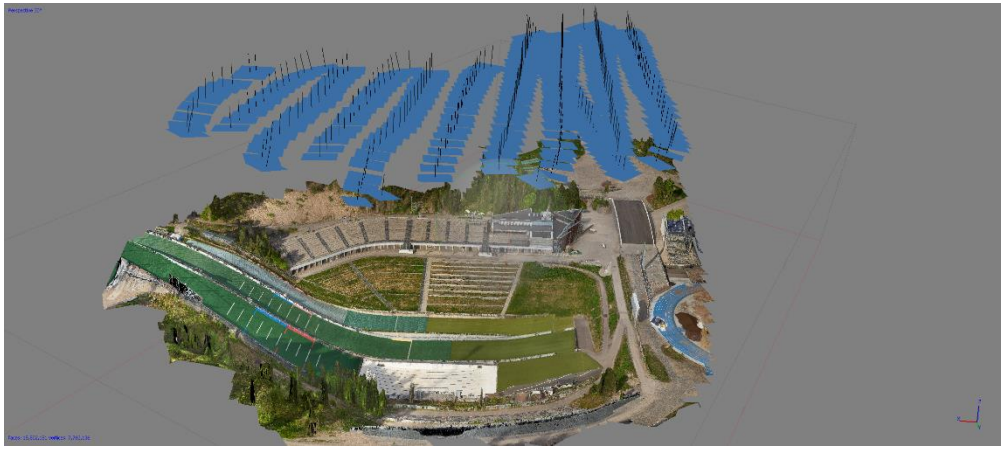

Photogrammetry

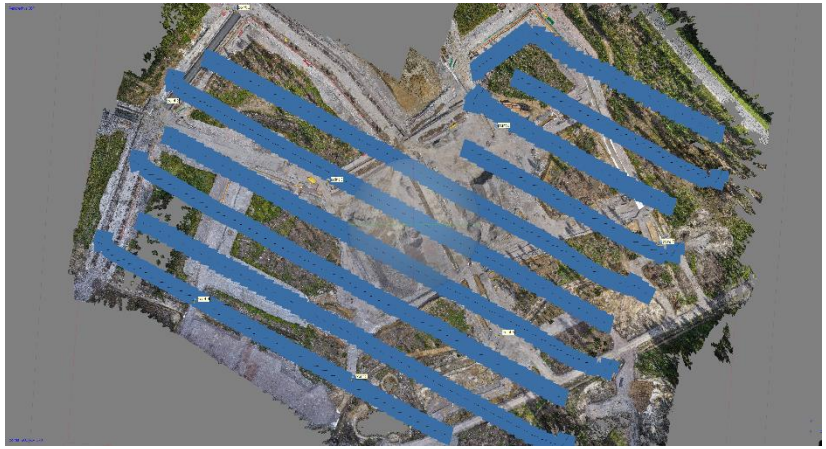
- Categorization by number of measurement images
  - **Single image photogrammetry**

  (single image processing, mono-plotting, rectification, orthophotographs)
  - **Stereophotogrammetry**

  (dual image processing, stereoscopic measurement)
  - **Multi-image photogrammetry**

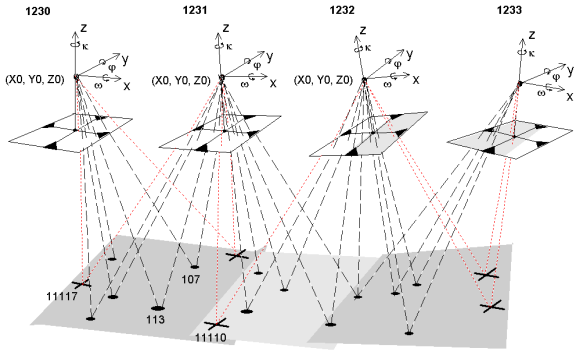
  (more than 2 overlapping images)





Images: Heikki Kauhanen

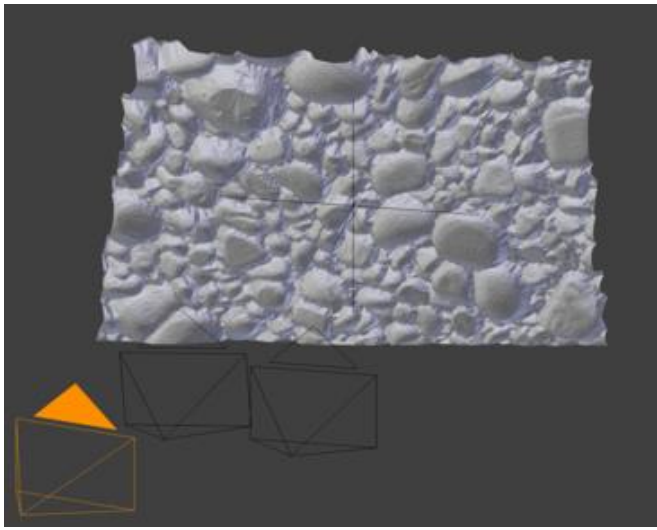
Photogrammetric Process



From object to object model:

Typical phases of the process

- **Camera calibration** (corrections to image distortions)
- **Image acquisition** (typically in stereo or multi-image approach)
- **Preprocessing of images** (improving image quality)
- **Image orientations**
- **Corresponding point measurements** (manual or automatic approach e.g. with dense image matching)
- **Object reconstruction / Automatic 3D modeling**



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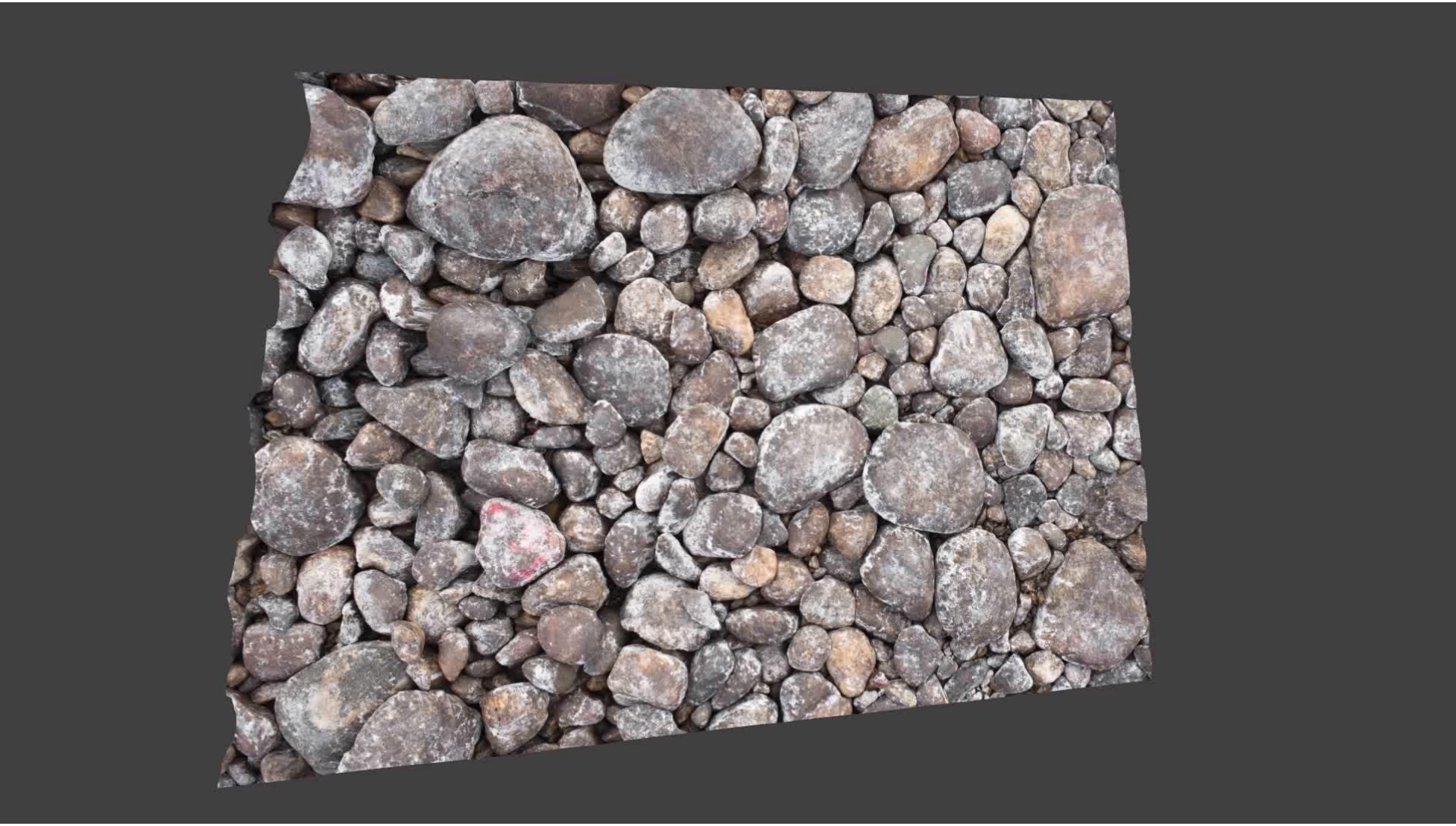
Images by Matti Kurkela

Photogrammetric object model



Video by Matti Kurkela

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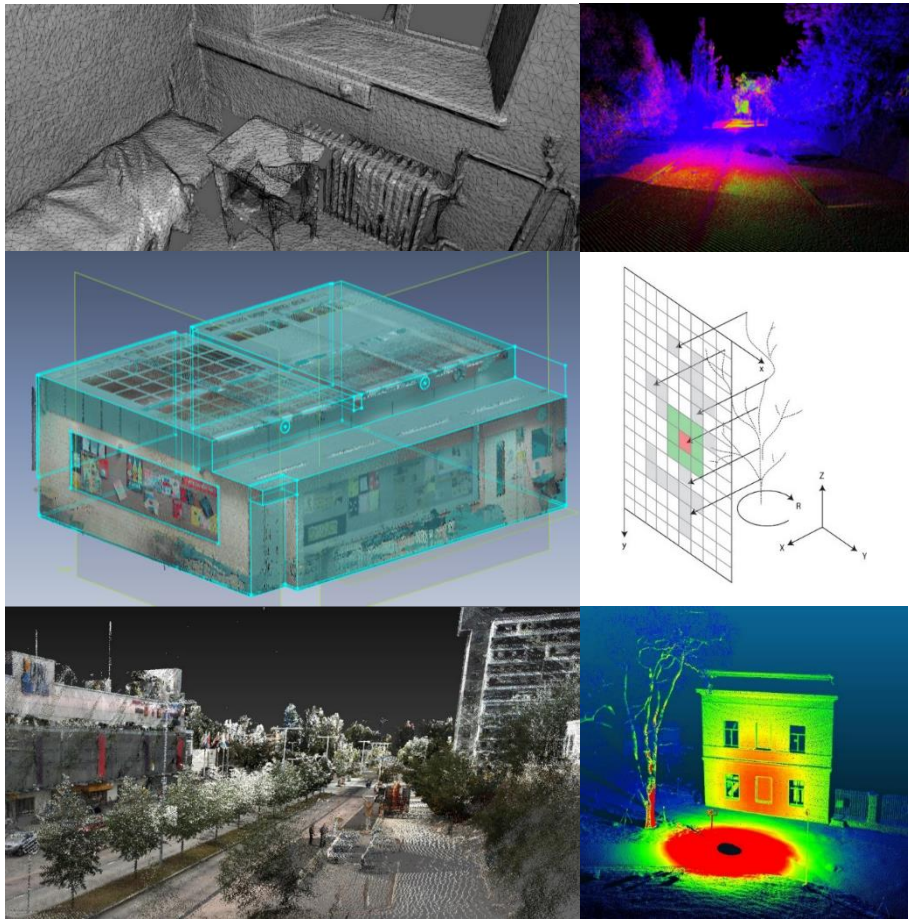
Obtaining information about the Earth

Information obtained or computed based on images (or laser scanning)

- **Geometric** (2D image or 3D point cloud (x, y, z))
- **Radiometric** (RGB, spectral)
- **Semantic** (object recognition)
- **Temporal** (change detection)
- **Attributes** (e.g. stem diameter, biomass, surface roughness etc.)



Images by JP. Virtanen (Aalto University)

(3D) point cloud data

- **A set of points *p* in 3D space (x, y, z)**
- Additional attribute as **RGB-values** from images and laser scanning **intensity**

Espoo Cultural Centre indoor model created with laser scanning and images

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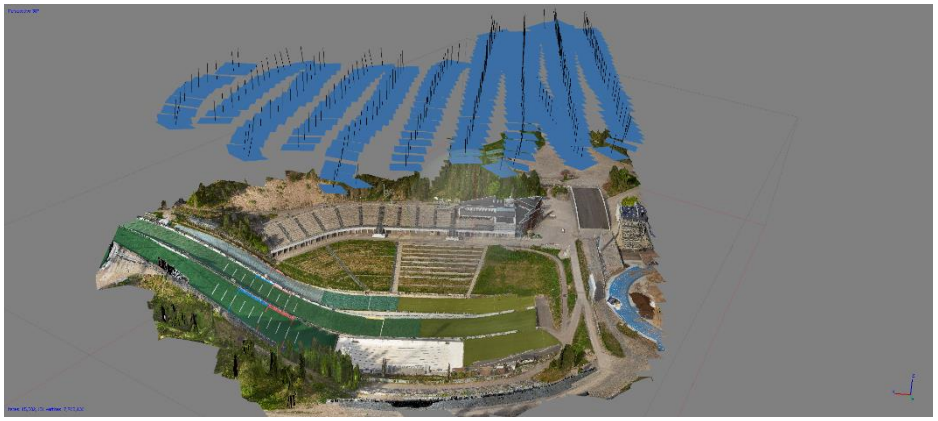
(3D) point cloud data from UAV-imaging



Images: Heikki Kauhanen, Aalto Univ.

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Sensors

- Typical sensors and methods for producing 3D point clouds

  - **Digital camera**
    - 2D image
    - 3D point cloud (x, y, z, RGB) from overlapping images
  - **Laser scanner**
    - 3D point cloud (x, y, z, intensity)
  - **Range camera**
    - Range image or 3D point cloud (x, y, z, RGB)

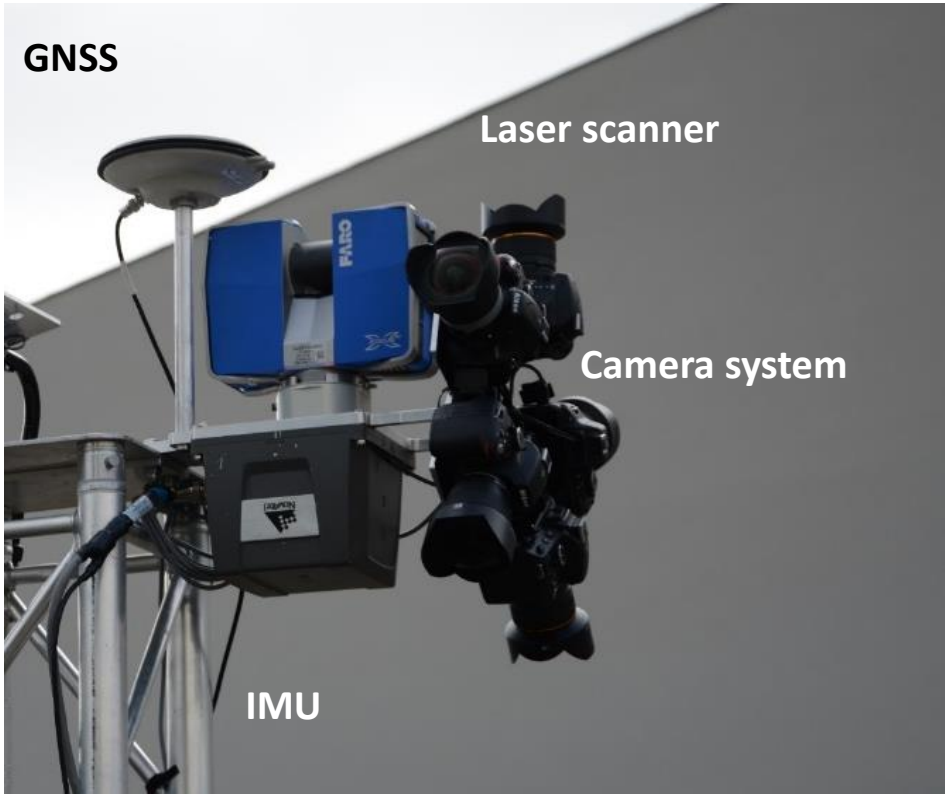
  - In addition: e.g. Radar and Sonar

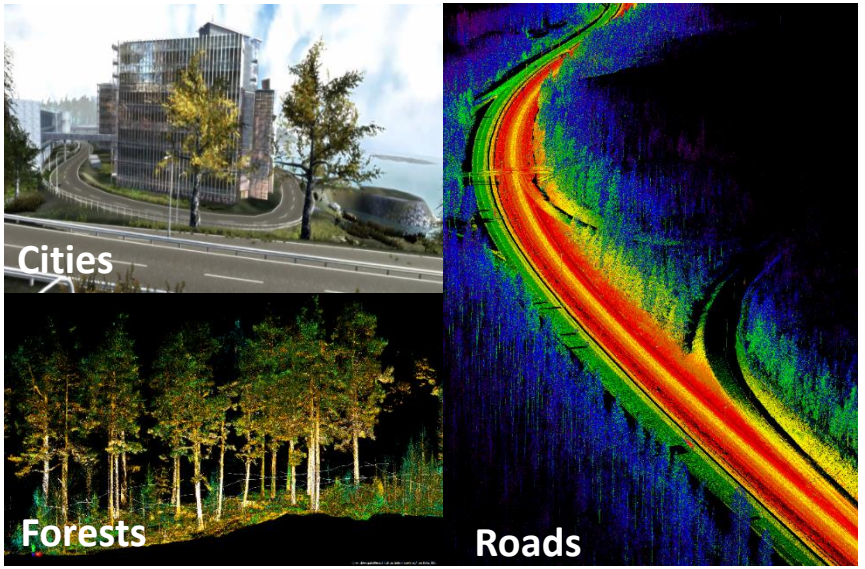
➢Often different methods are combined in the same platform

➢SENSOR INTEGRATION

Sensor integration

- For example, **Mobile mapping systems**
  - Individual cameras, panoramic / 360-degree camera systems
  - Laser scanner (one or many)
  - Positioning and trajectory computation (GNSS-IMU)





Images © A.Kukko, T.Turppa, M.Kurkela, J-P. Virtanen, M. Vaaja

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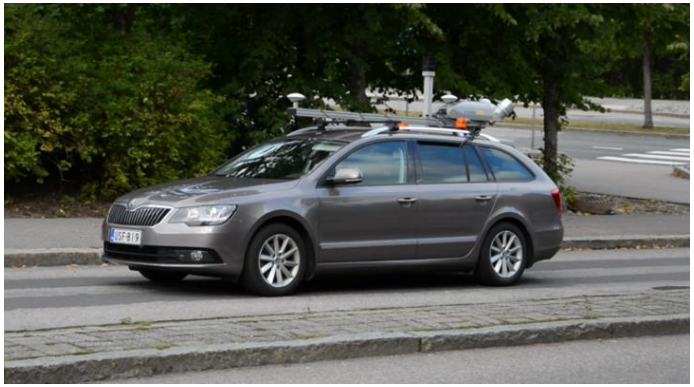
Mobile mapping methods



MX2 mobile mapping sytems

UAV-mapping

AhkaR3 backpack system developed by Antero Kukko FGI

Handheld GeoSLAM ZebREVO - scanner

Close-range single camera approach

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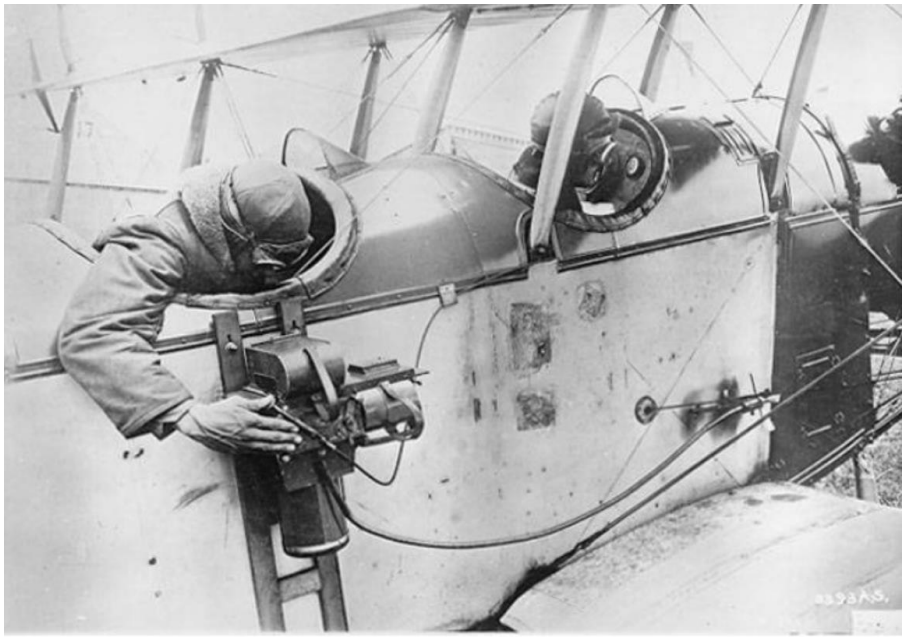
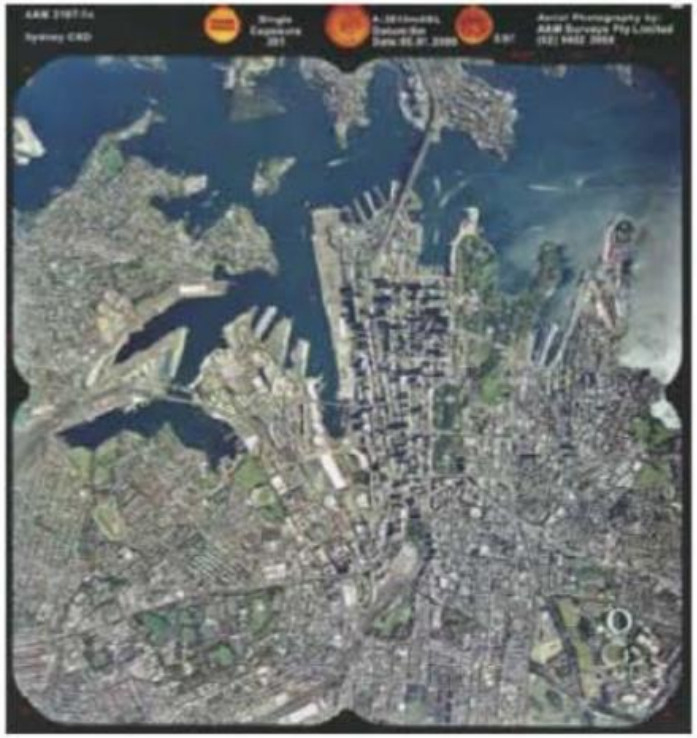
History

- World War 1 has a major impact to development of aerial photography



- After the war the photogrammetric technology was in state to start large scale aerial surveys

Aerial photography block



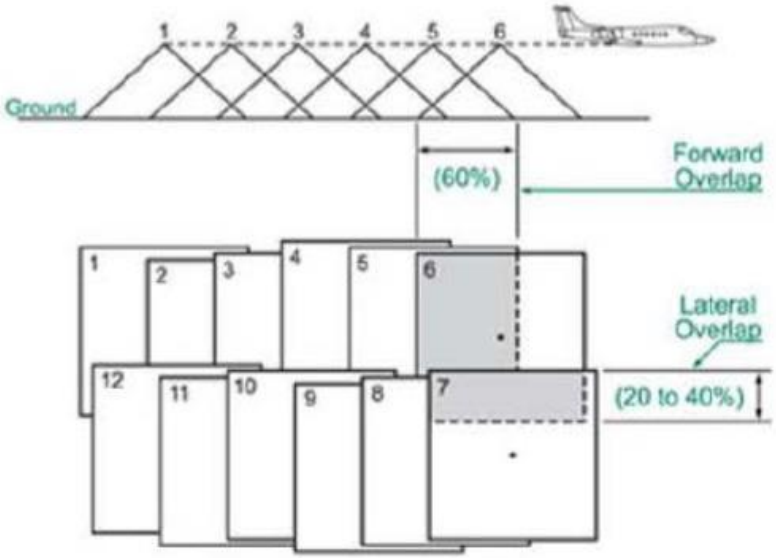
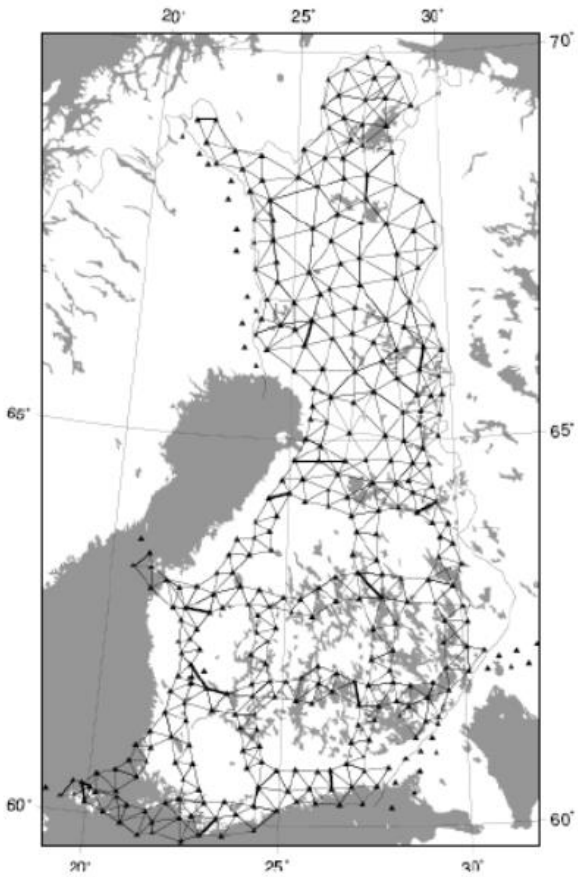


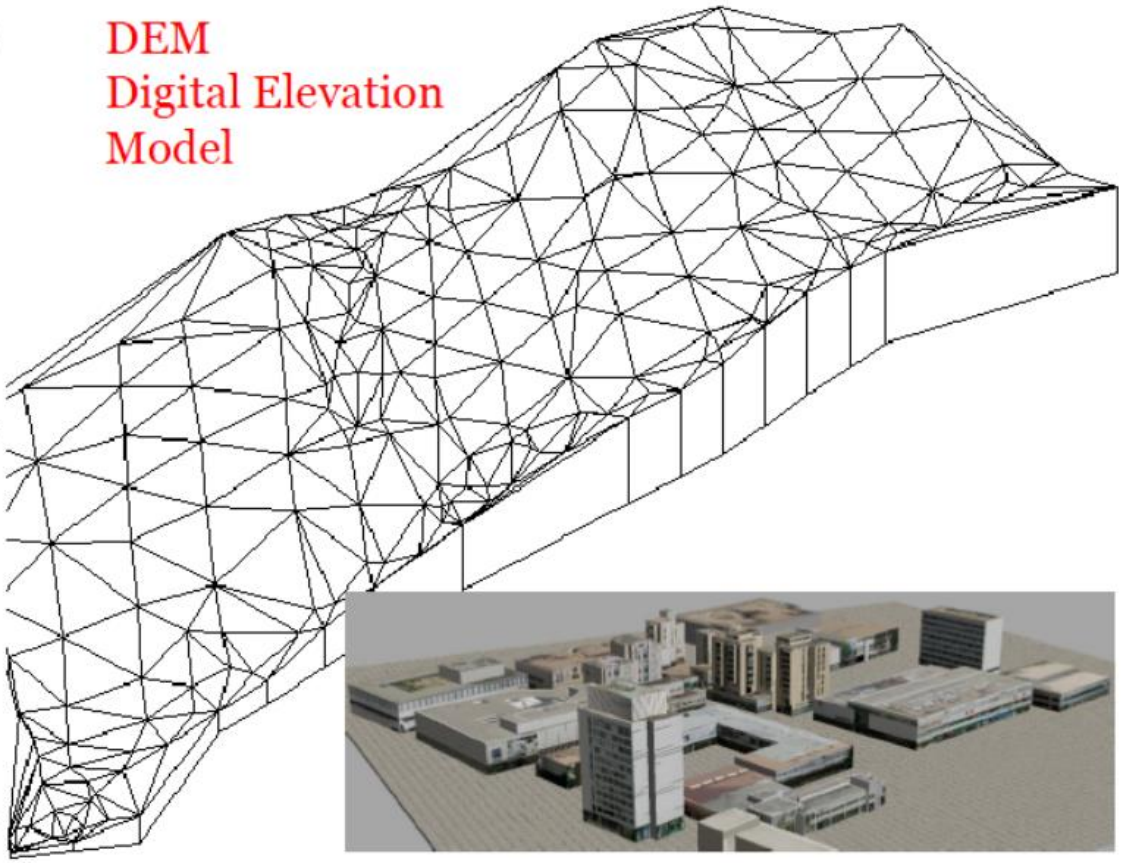
Image: Emeritus prof. Henrik Haggrèn

Aerial photogrammetry

Densification of 3D geometric information



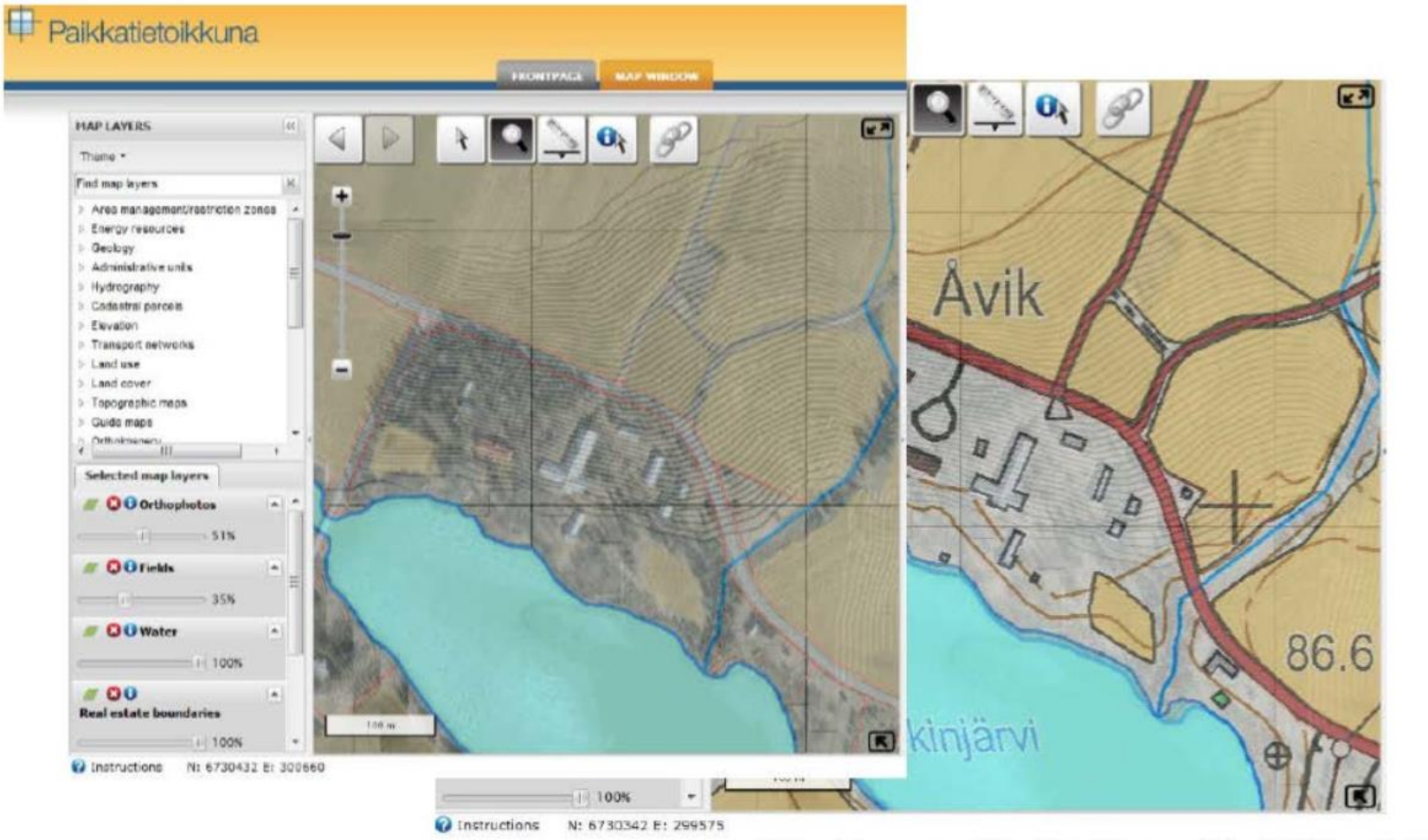
DEM
Digital Elevation
Model



© Geodetic Institute

Aerial photogrammetry

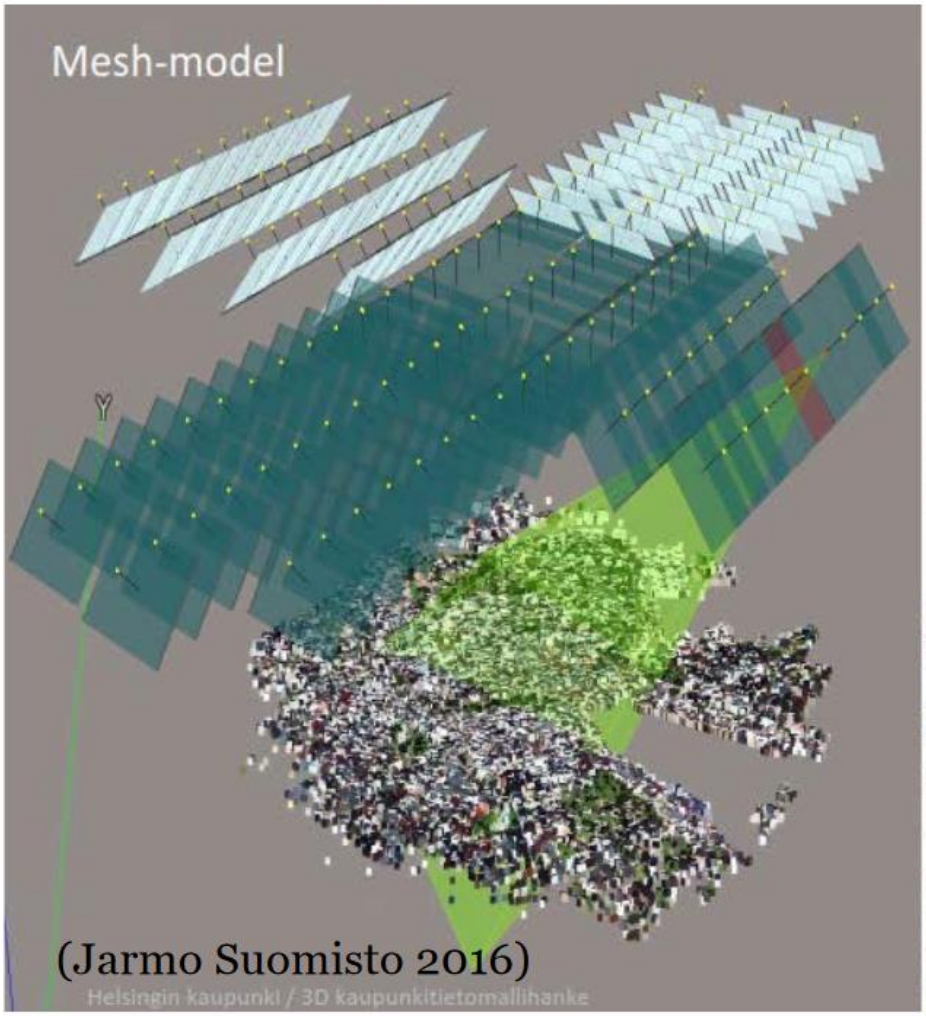
Topographic maps

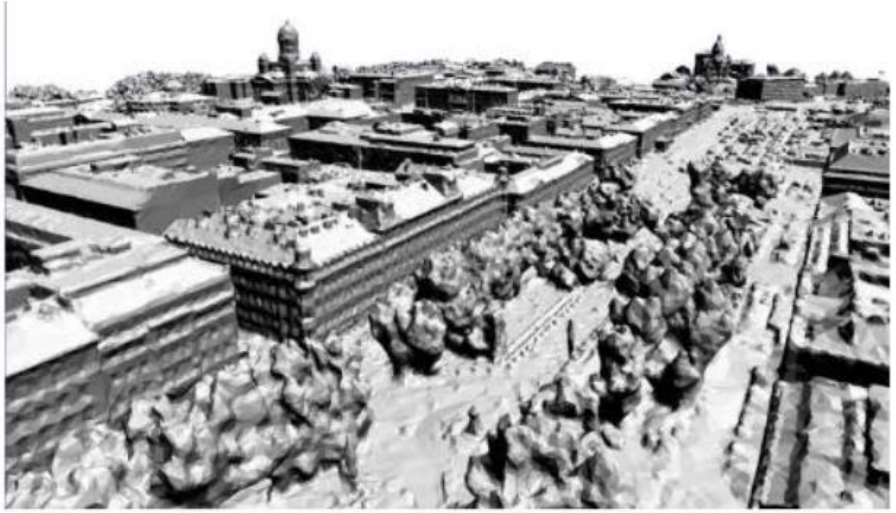


(http://www.paikkatietoikkuna.fi/web/fi/kartta)

Aerial photogrammetry

3D City maps

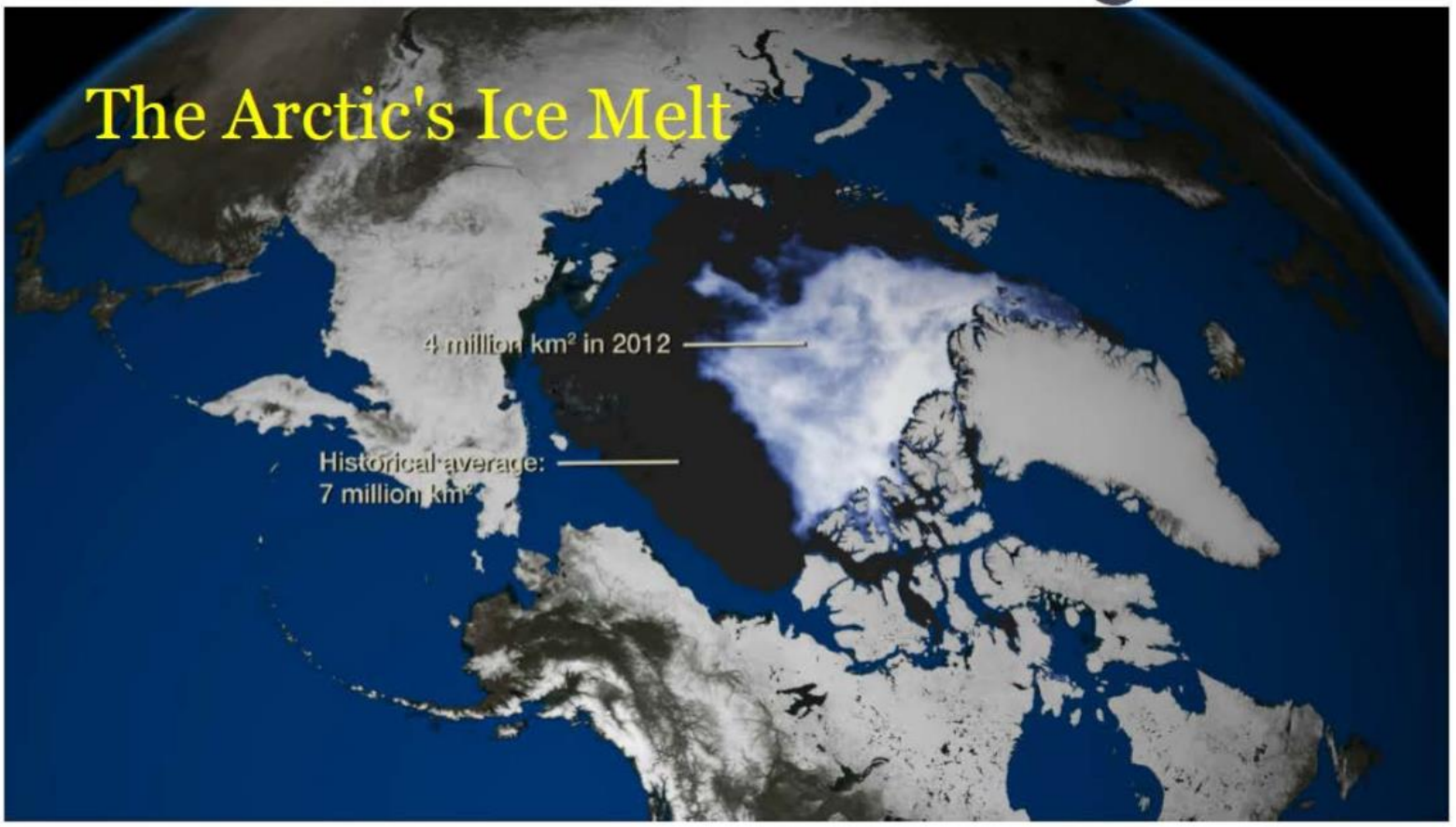




https://kartta.hel.fi/3d/mesh/

Satellite photogrammetry

Environmental monitoring

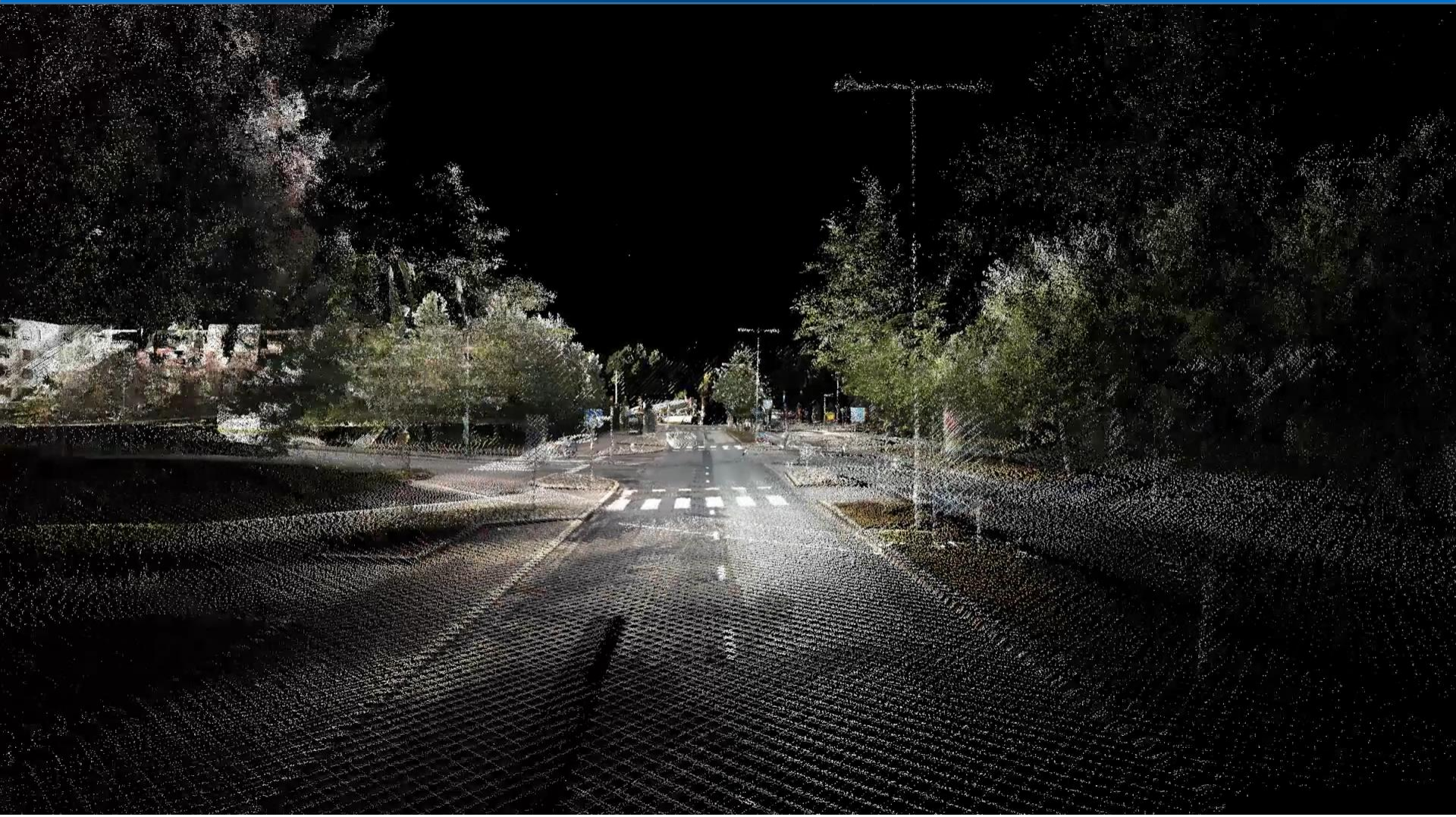


Arctic Sea Ice timelapse from 1978 to 2009

https://www.youtube.com/watch?v=6j8SGs_gnFk

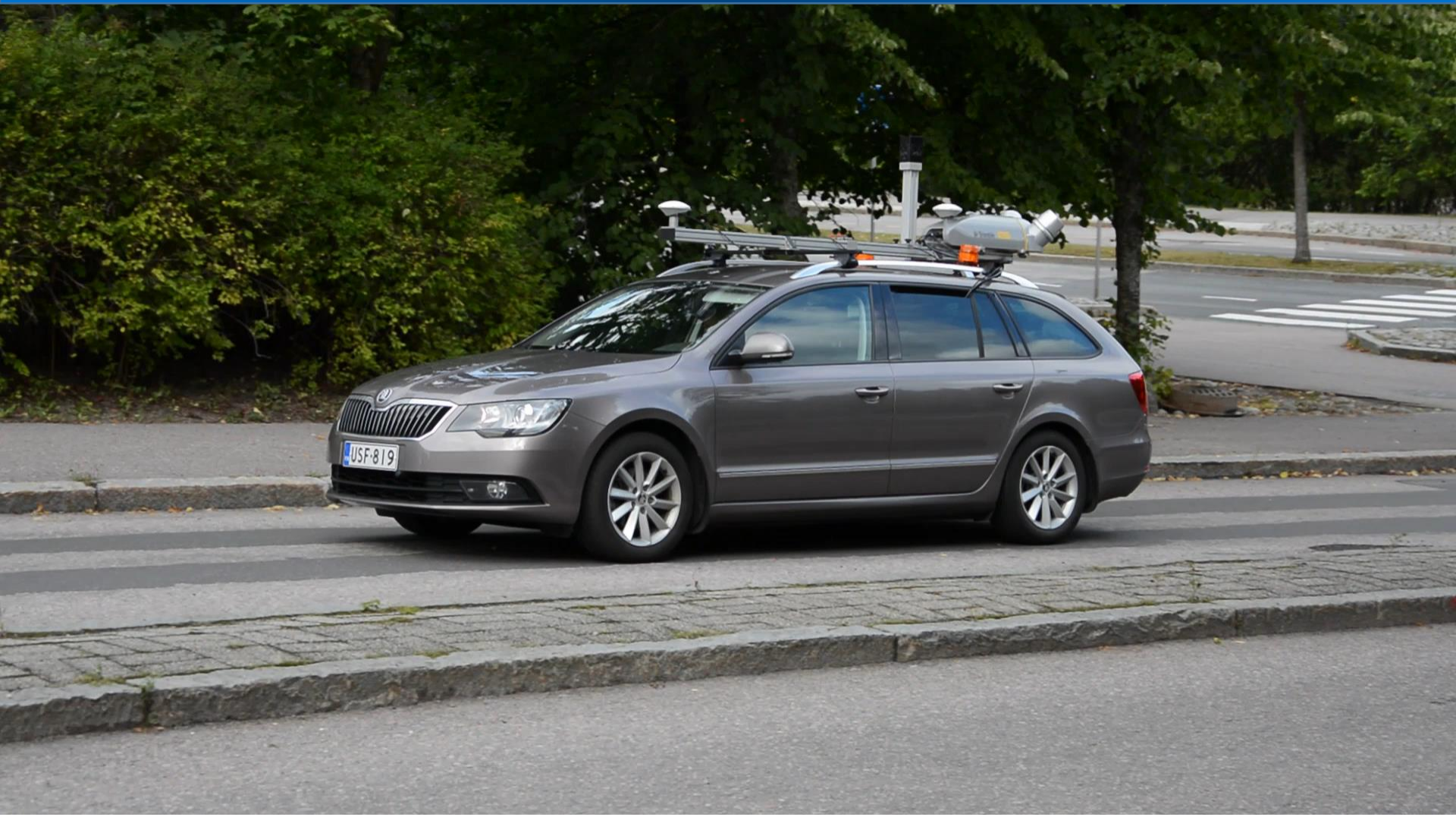
Activation tasks:

For which measurement method the video material is based on?



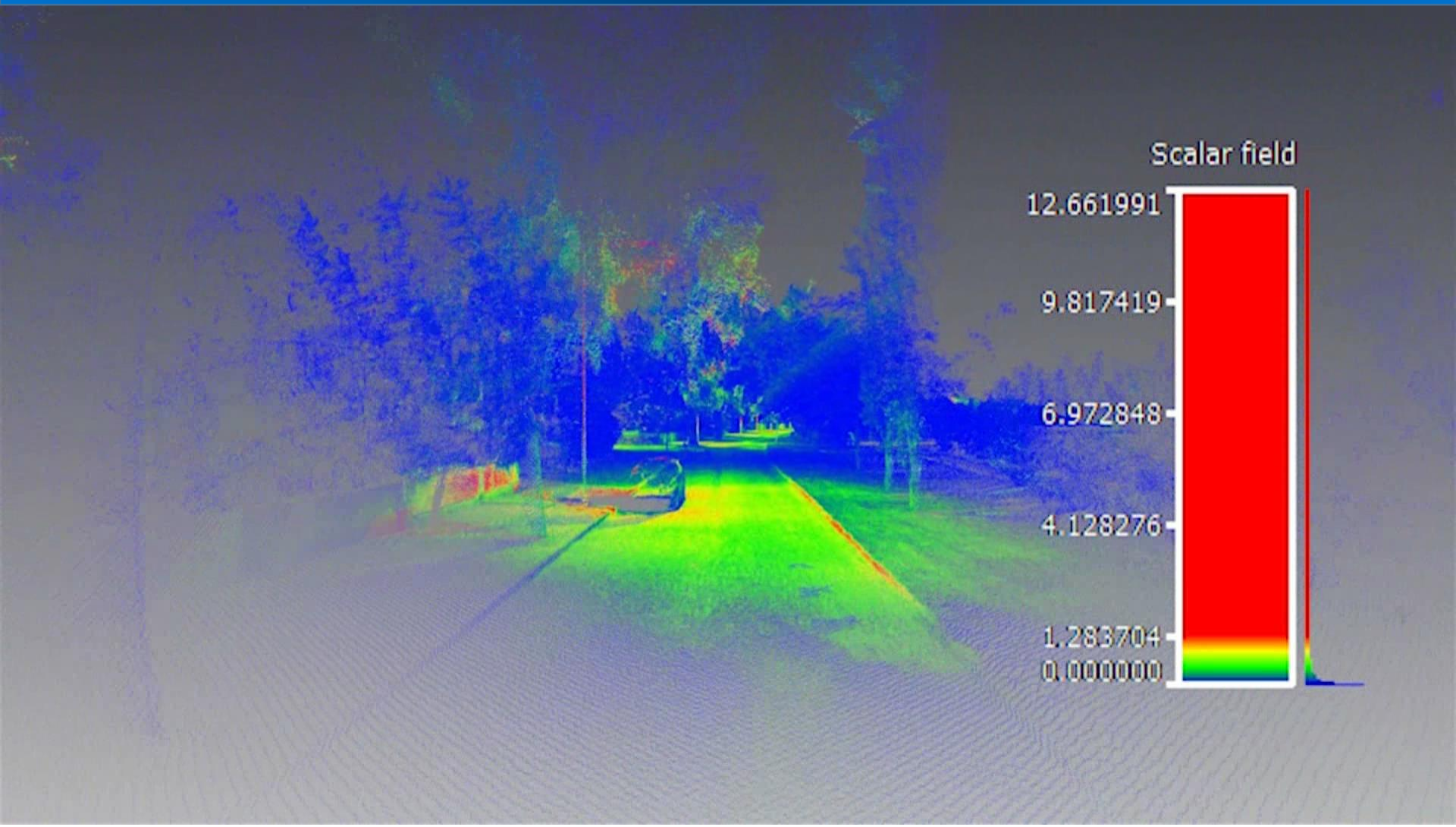
A) Mobile mapping B) Aerial imaging C) Panoramic imaging

A) Mobile mapping



Mobile mapping (Trimble MX2-system: 2*laser scanner + panoramic camera + GNSS-IMU positioning)

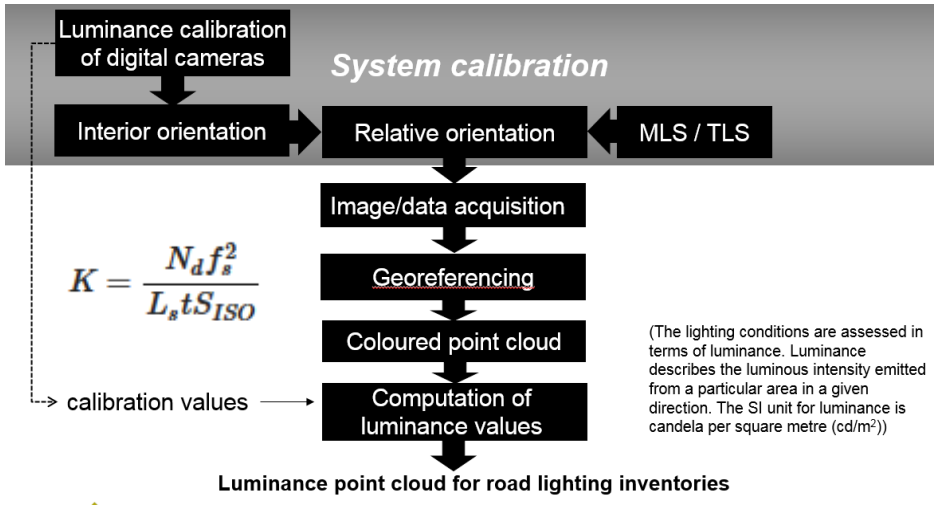
For which application the video material is based on?

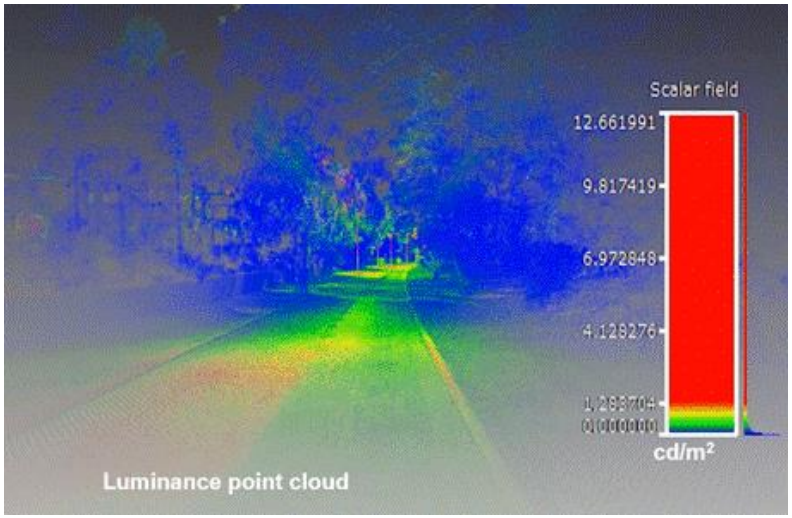


Evaluation of ***A) Solar energy B) Lighting conditions C) Road surface roughness***

Evaluation of road and street lighting conditions

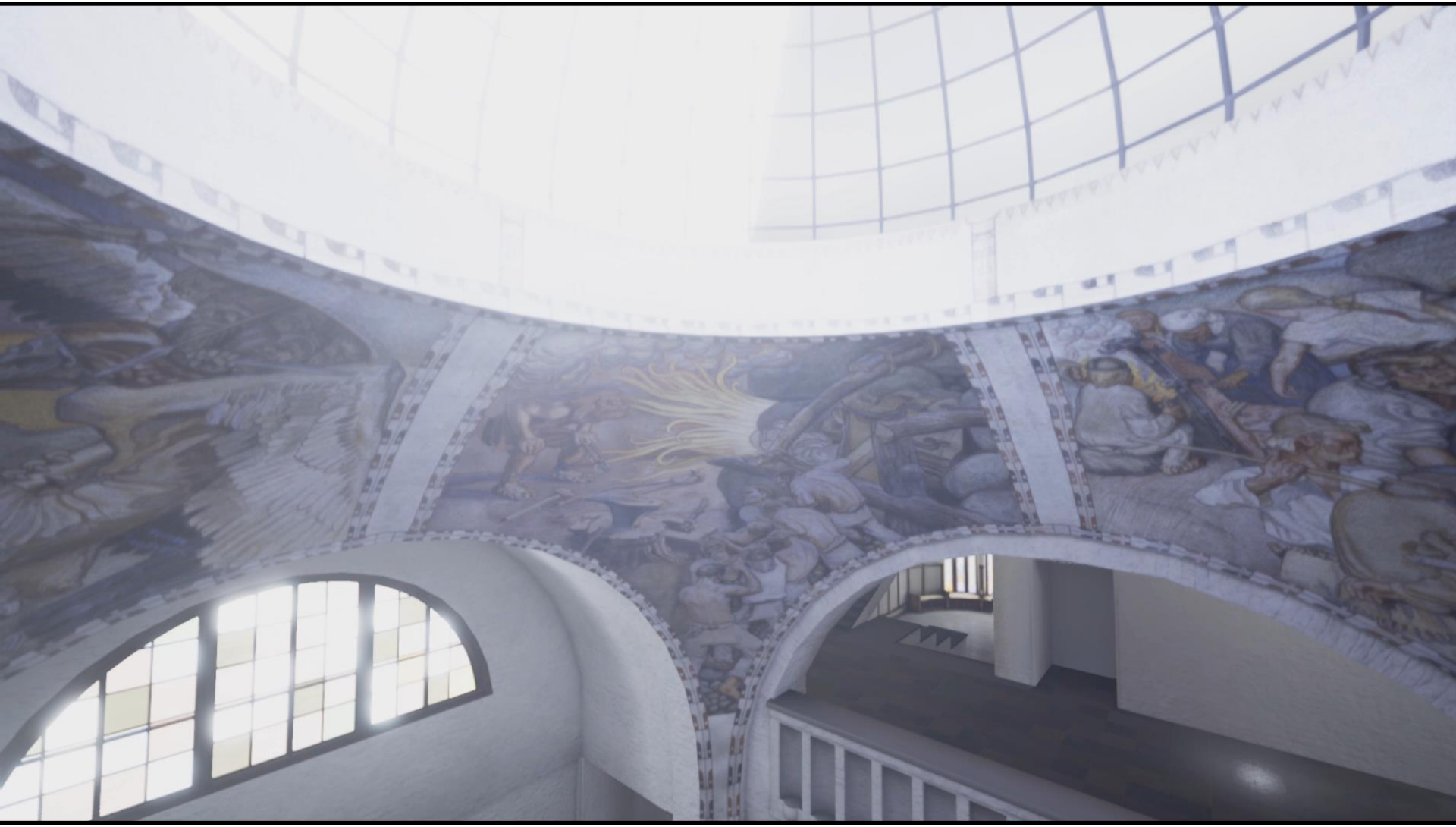
- Based on **mobile mapping system**
- **Night-time measurements**
- Road and street lighting is the only light source
- 3D Luminance Point Cloud (luminance cd/m²) for lighting measurement and maintenance purposes





- Vaaja, M., Kurkela, M., Maksimainen, M., Virtanen, J.P., Kukko, A., Lehtola, V.V., Hyyppä, J. and Hyyppä, H., 2018. **Mobile mapping of night-time road environment lighting conditions**. *Photogrammetric Journal of Finland*, *26*(1).

3D digitalization of cultural sites - The National Museum of Finland



3D Cultural Hub project by Aalto University

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3D digitalization of cultural sites - The National Museum of Finland

3D Cultural Hub project by Aalto University

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The Crowd Route Visualization for Event Production:

Lahti ski jumping stadium

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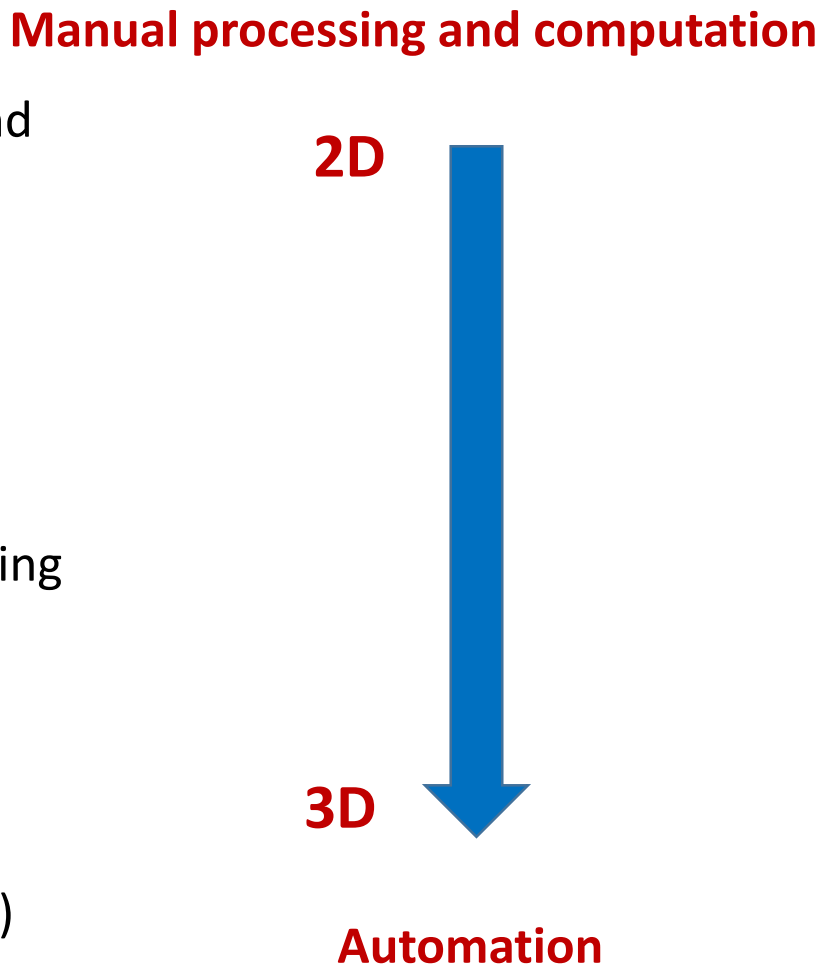
Products, methods and trends in field of Photogrammetry

- 2D maps, aerial image, orthoimage, stereoimaging, Digital elevation, terrain and surface models (DEM, DTM, DSM), change detection…
- Multi-spectral imaging
- Satellite and aerial imaging
- Static terrestrial imaging

- 3D point clouds by images and laser scanning
- 3D city model and Indoor modeling
- SLAM-based mapping systems
- UAVs and mobile mapping systems
- Low-cost and lightweight systems
- Data collection with autonomous cars
- Virtual reality (VR), Augmented reality (AR)
- 360-imaging systems
- Hyperspectral imaging
- ….



Future of photogrammetry

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- Photogrammetry **is developing in cooperation with the other fields** including **Automation, Computer vision, Robotics, IT, Geodesy**…
- **Many different application areas**: Civil engineering, Traffic Engineering, Archeology, Geography, Forest Sciences, Game & Entertainment, Culture, Sport…
- **Sensor and data integration is needed** in many application (for example 3D city models)
- **Sensors are lighter and cheaper** (partly due to robotics applications)
- **New types of mapping systems**:
  UAVs, mobile mapping, handheld scanners, solidstate sensors, indoor measurement systems, personal measurement systems





Lots of career options for photogrammetry professionals

- Many international companies like Google, Apple, Samsung, Microsoft and numerous car manufacturers (Mercedes, Audi, Toyota, etc.) are also developing applications for 3D measurement and modeling as well as their geospatial applications.

Read and learn more

- E-books from Aalto library:
  - **Applications of 3D Measurement from Images**. (2007). John Fryer et al.
  - **Close-range photogrammetry and 3D imaging**. (2014) Thomas Luhmann et al.

- Brief history of photogrammetry
  - **https://alicevision.github.io/#history**
- Photogrammetry in game development
  - **unity.com/solutions/photogrammetry**

- Follow the research in Finland and the World
  - **ISPRS** - International Society for Photogrammetry and Remote Sensing, **www.isprs.org**
  - Centre of Excellence in Laser Scanning Research (in Finland), **www.laserscanning.fi**
  - MeMo3D Research institute at Aalto Univ., **foto.aalto.fi/memo/**

Centre of Excellence in Laser Scanning Research

MeMo3D Measuring & Modeling

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