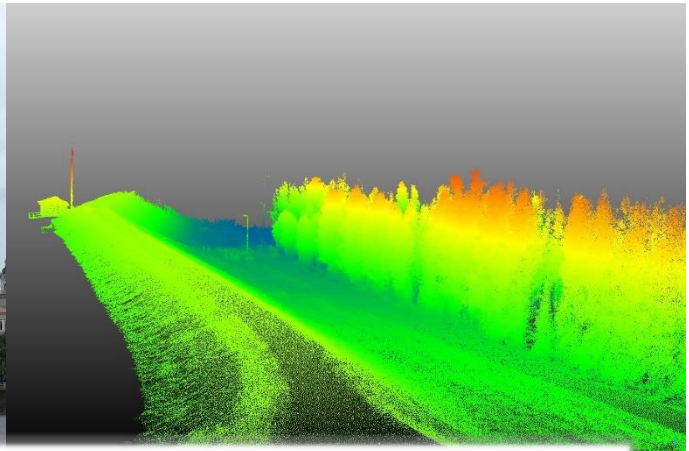
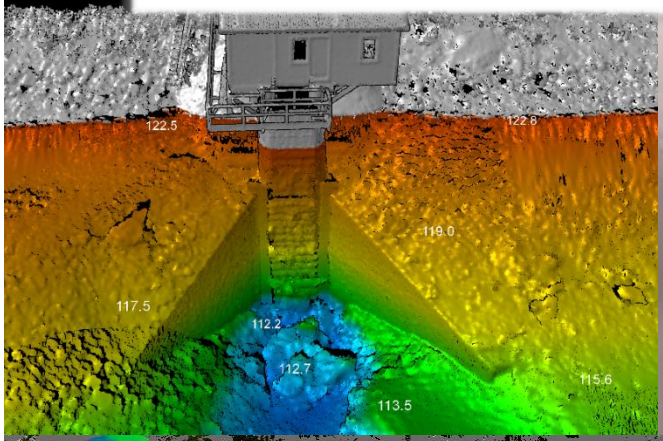
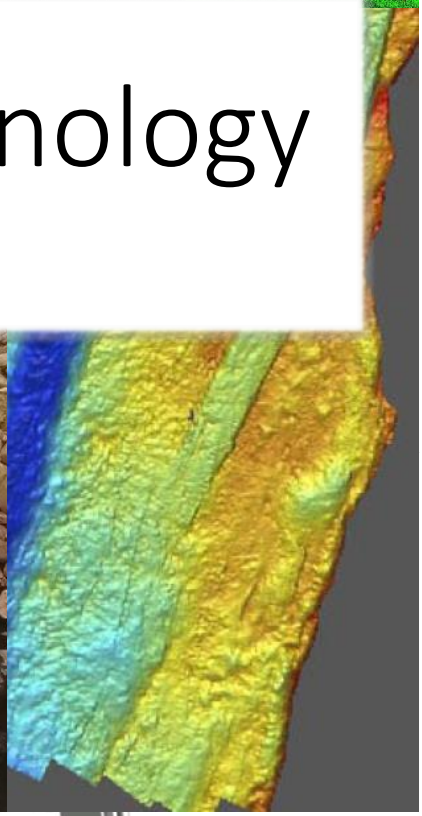
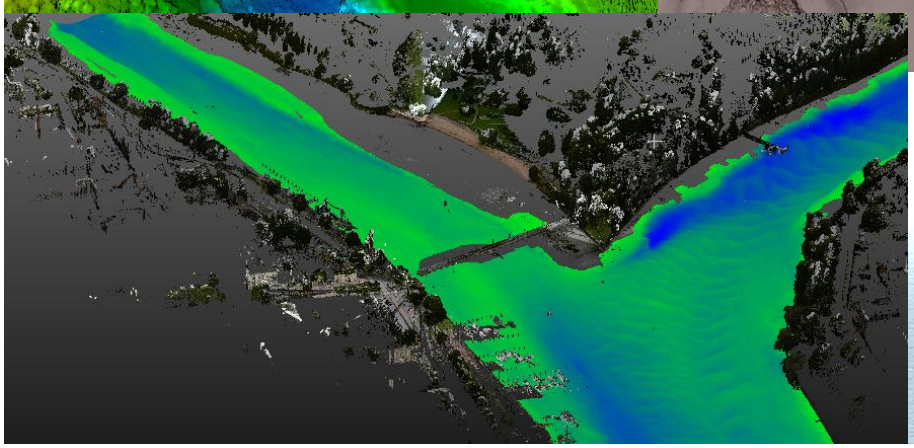


# Dam Safety Technology
# PATOTEC





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# Participating organisations

**ELY Centres**
www.ely-keskus.fi/en/web/ely-en/
www.environment.fi/damsafety

**Fluvial Research Group**
www.utu.fi/fluvial/

**Mitta Oy**
www.mitta.fi/en/home/

**Solid Potato**
www.solidpotato.com

**VRT Finland**
www.vrt.fi

**VTT Technical Research Centre of Finland**
www.vttresearch.com/

Project funded by: mmm.fi MINISTRY OF AGRICULTURE AND FORESTRY

# Project idea and goals

- Purpose is to establish cooperation between China and Finland in the field of dam safety.
- Implementation by sharing experiences, **testing new technologies and by developing monitoring methods and systems for risk management** purposes.
- Further purpose to **create cooperation opportunities and commercial openings** for R&D institutes and consulting companies from both countries.
- This **brochure demonstrates technologies and approaches studied, developed and tested in practice**.

# Technologies and data

## Terrestrial laser scanning (TLS)

- Measures accurate geometry from surrounding objects with relative accuracy better than 1 mm.
- 3D point clouds containing millions of points, which can be used to create very accurate digital 3D-models of the world.
- Such models can be utilised in dam safety inspections to analyse dam structures and slope.
- Can be combined with bathymetric measurements, to analyse for example flood embankments' ability to handle extreme flood events and assess flood hazard likelihood.
- 3D point clouds can acquire real colours from simultaneuous images.
- Data collection is cost-effective and fast; field measurements of the 900 m long demo area were conducted a day of fieldwork.


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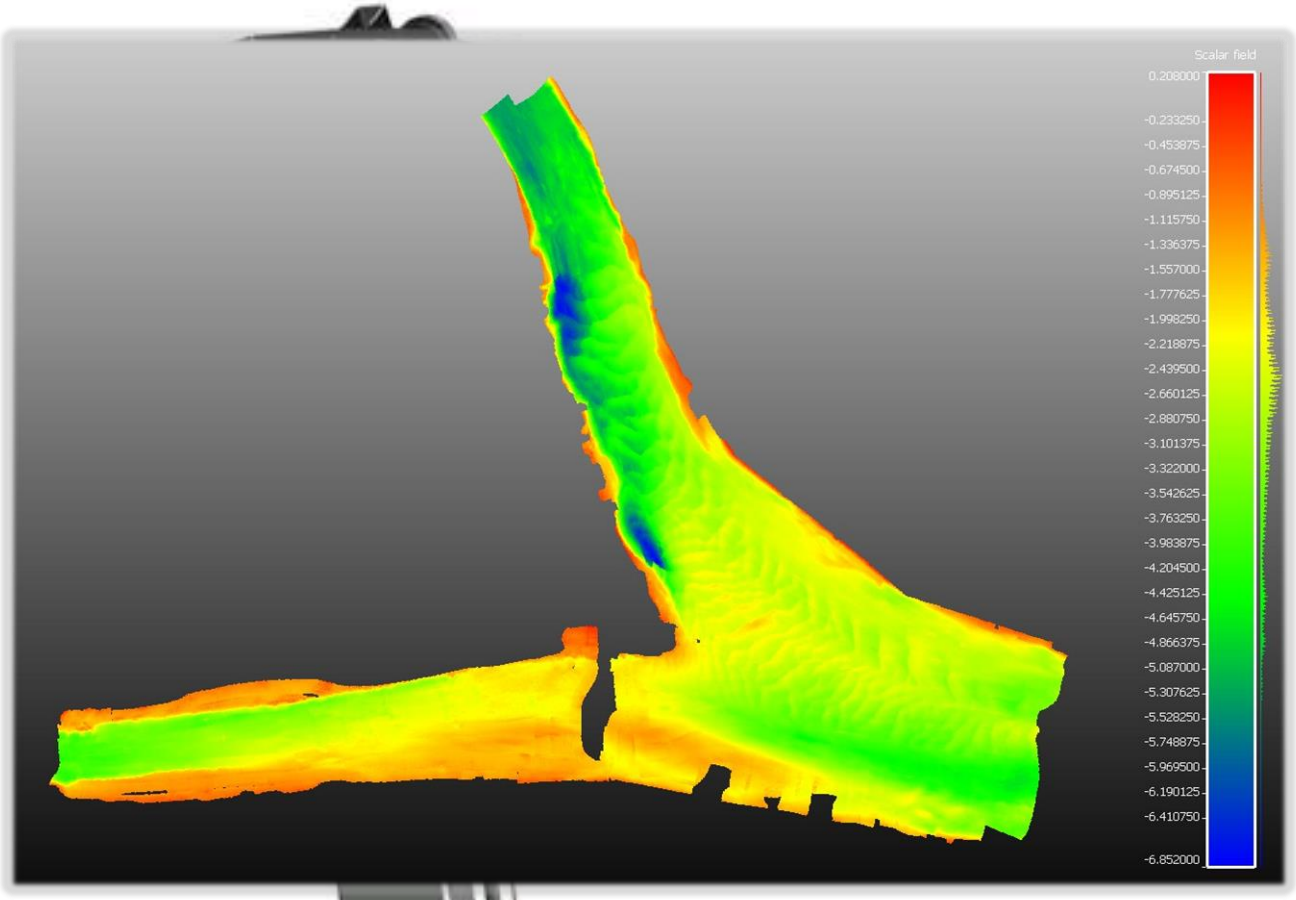
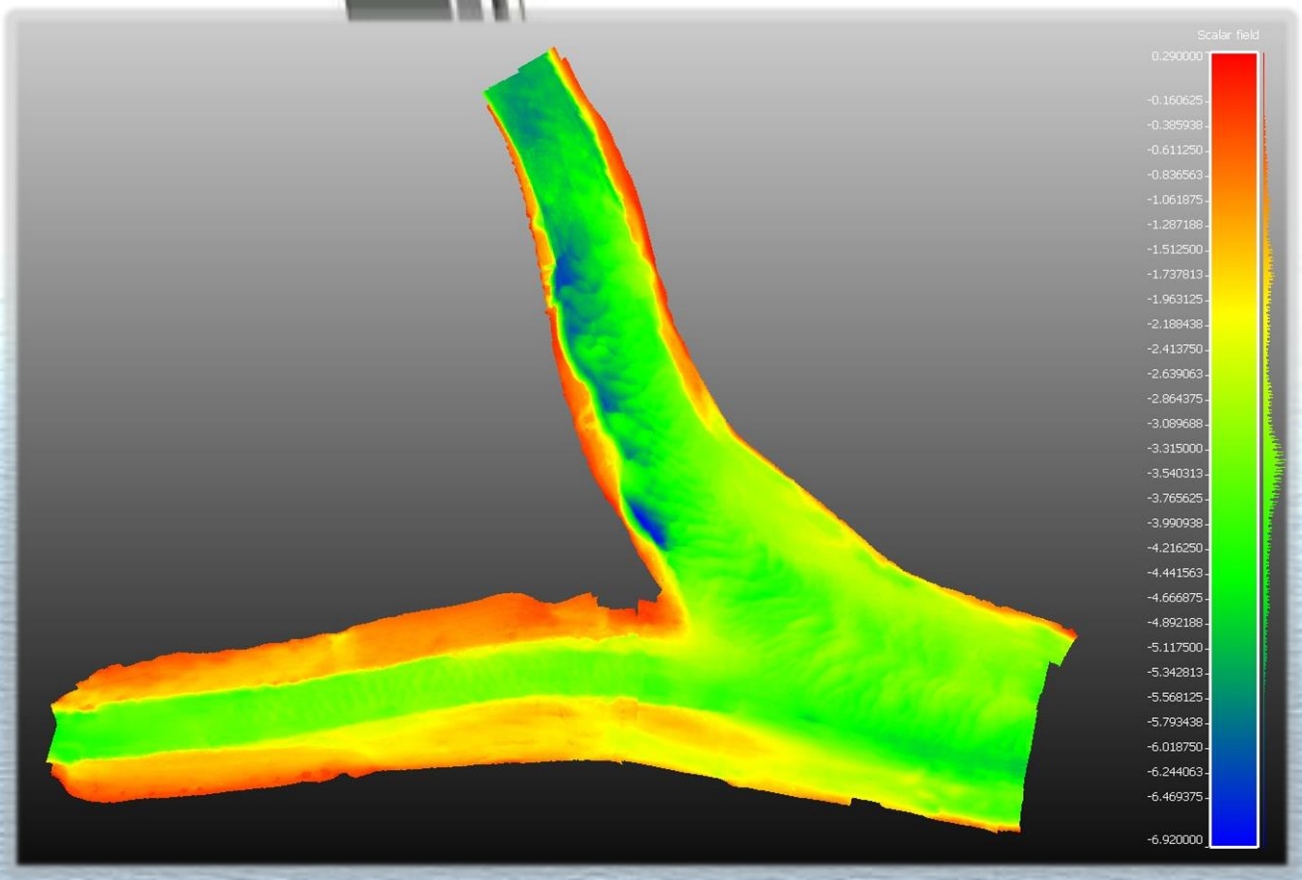
## AquaticSonar ”Swathe Surveyor”

- Water bed topography from survey vessel with relative accuracy better than 5 cm
- Survey depth 1–80 m
- Survey coverage width is 10 times water depth in all cases
- Wide coverage enables data collection from shoreline without the need to sail in hazardous shoreline waters
- High data density to produce detailed bathymetric data, for e.g. dredging projects, flood protection & sedimentation control
- Data collection is fast; field measurements of the 900 m long demo area were conducted in half a day of fieldwork.




Kokemäenjoki River in Pori centre before (above) and after dredging.

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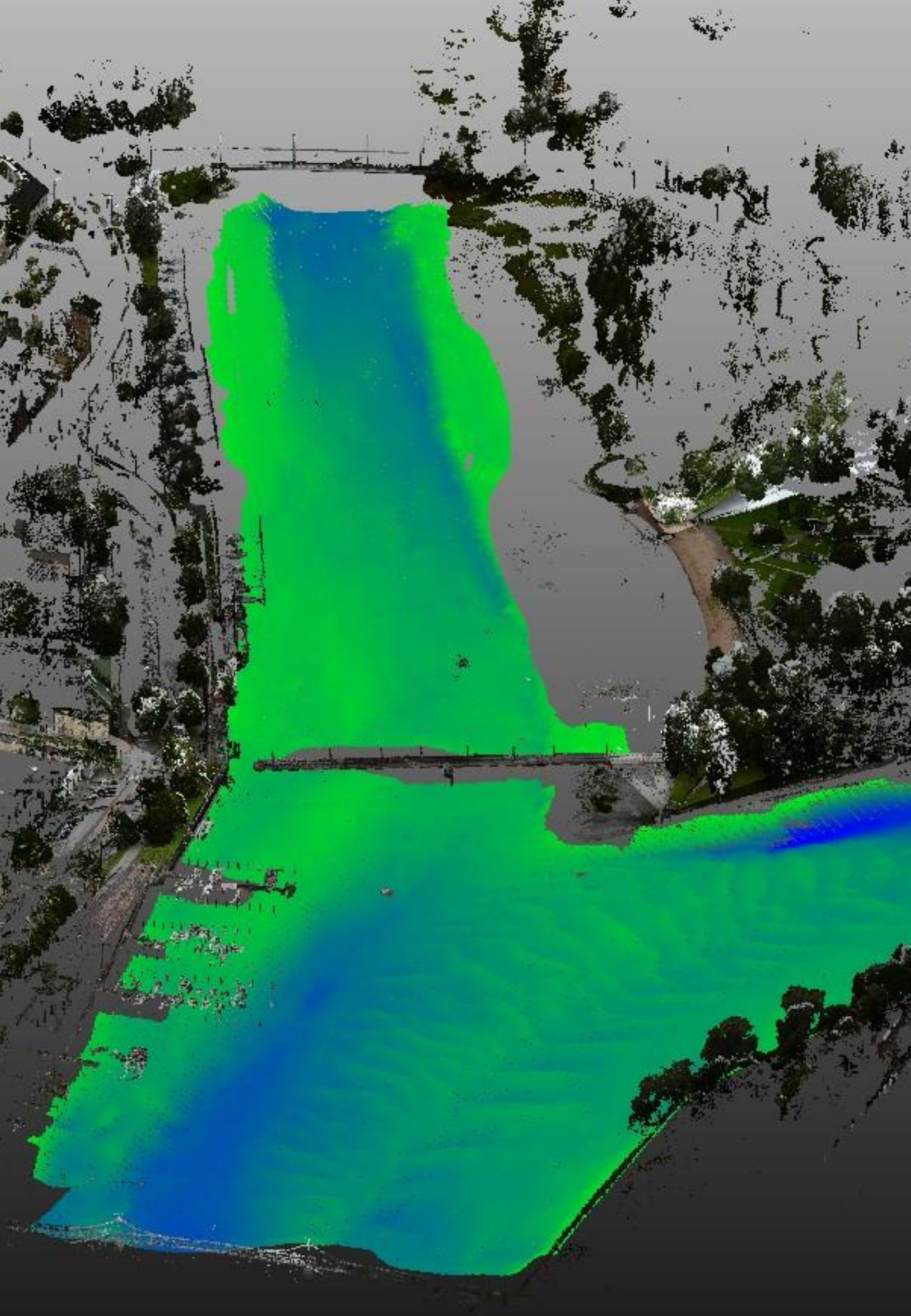

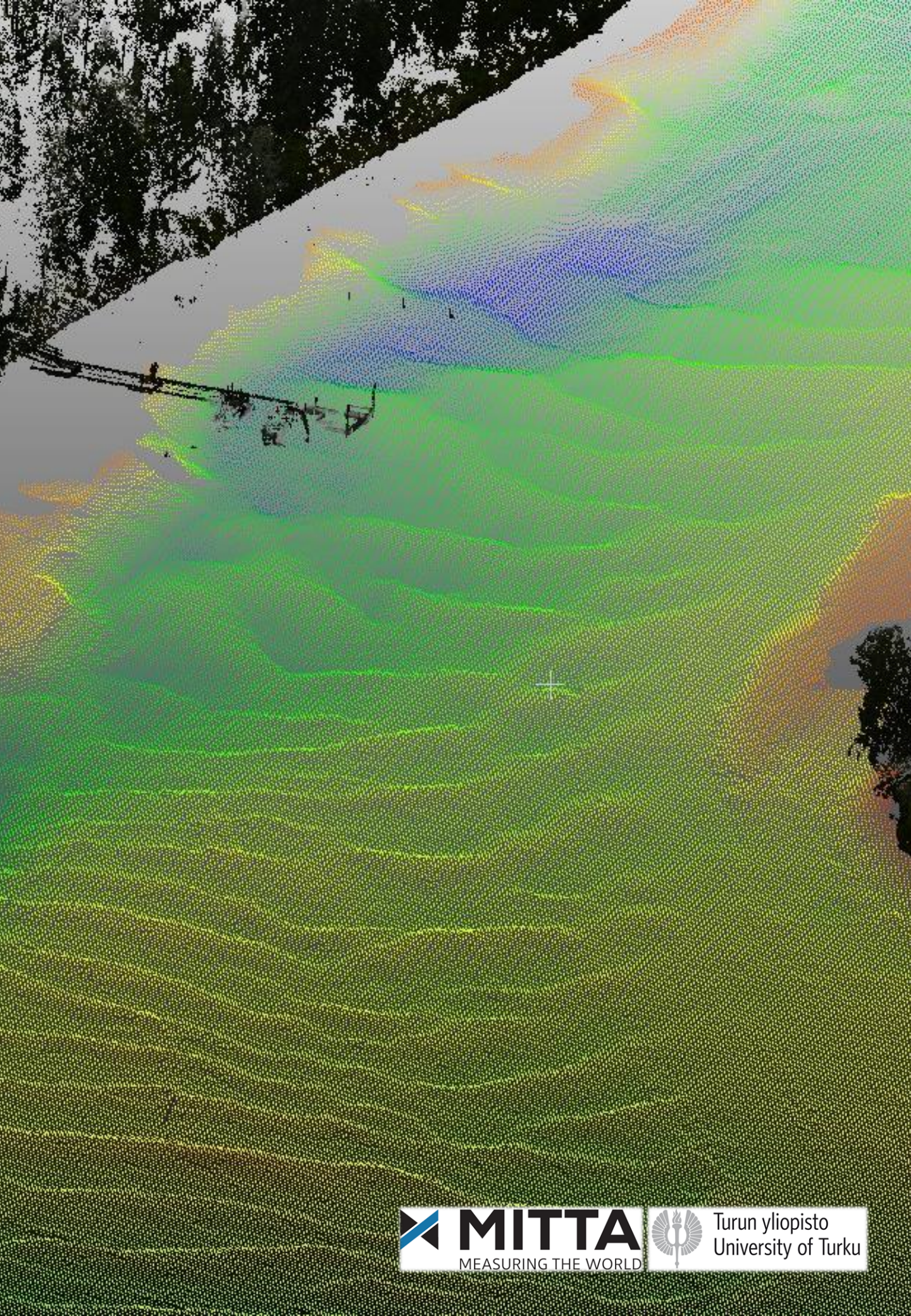
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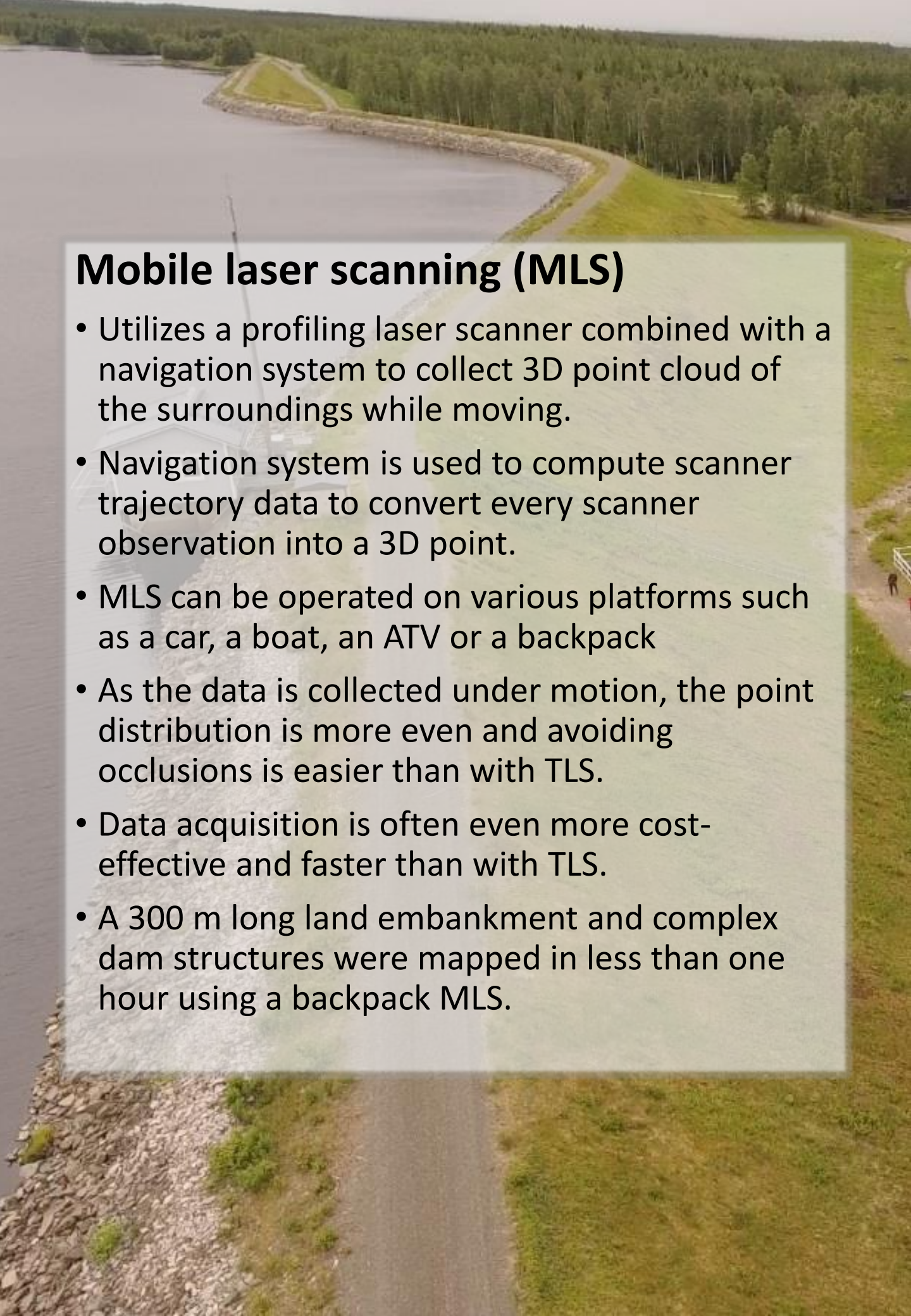

# Mobile laser scanning (MLS)

- Utilizes a profiling laser scanner combined with a navigation system to collect 3D point cloud of the surroundings while moving.
- Navigation system is used to compute scanner trajectory data to convert every scanner observation into a 3D point.
- MLS can be operated on various platforms such as a car, a boat, an ATV or a backpack
- As the data is collected under motion, the point distribution is more even and avoiding occlusions is easier than with TLS.
- Data acquisition is often even more cost-effective and faster than with TLS.
- A 300 m long land embankment and complex dam structures were mapped in less than one hour using a backpack MLS.


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# Remotely controlled ADCP

- Remotely controlled acoustic Doppler current profiler (ADCP) uses acoustic beams to measure depth, discharge and flow velocity and direction in 3D.
  - 1 vertical beam and 8 slanted beams
- Depth points are used to create bathymetric models of dam outlet and inlet areas. Further, continuing bed surfaces can be created based on these 3D depth points and calculate volume of dam pools
- ADCP is attached to a remotely controlled mini-boat and is manoeuvrable in shallow and narrow channels where normal-sized boats cannot navigate.
- Measurement ranges
  - Velocity: 0.06–40 m depth and up to 20 m/s velocities
  - Depth measurements in 0.2–80 m with vertical beam and 0.2–40 m with slanted beams
  - Discharge: 0.3–80 m

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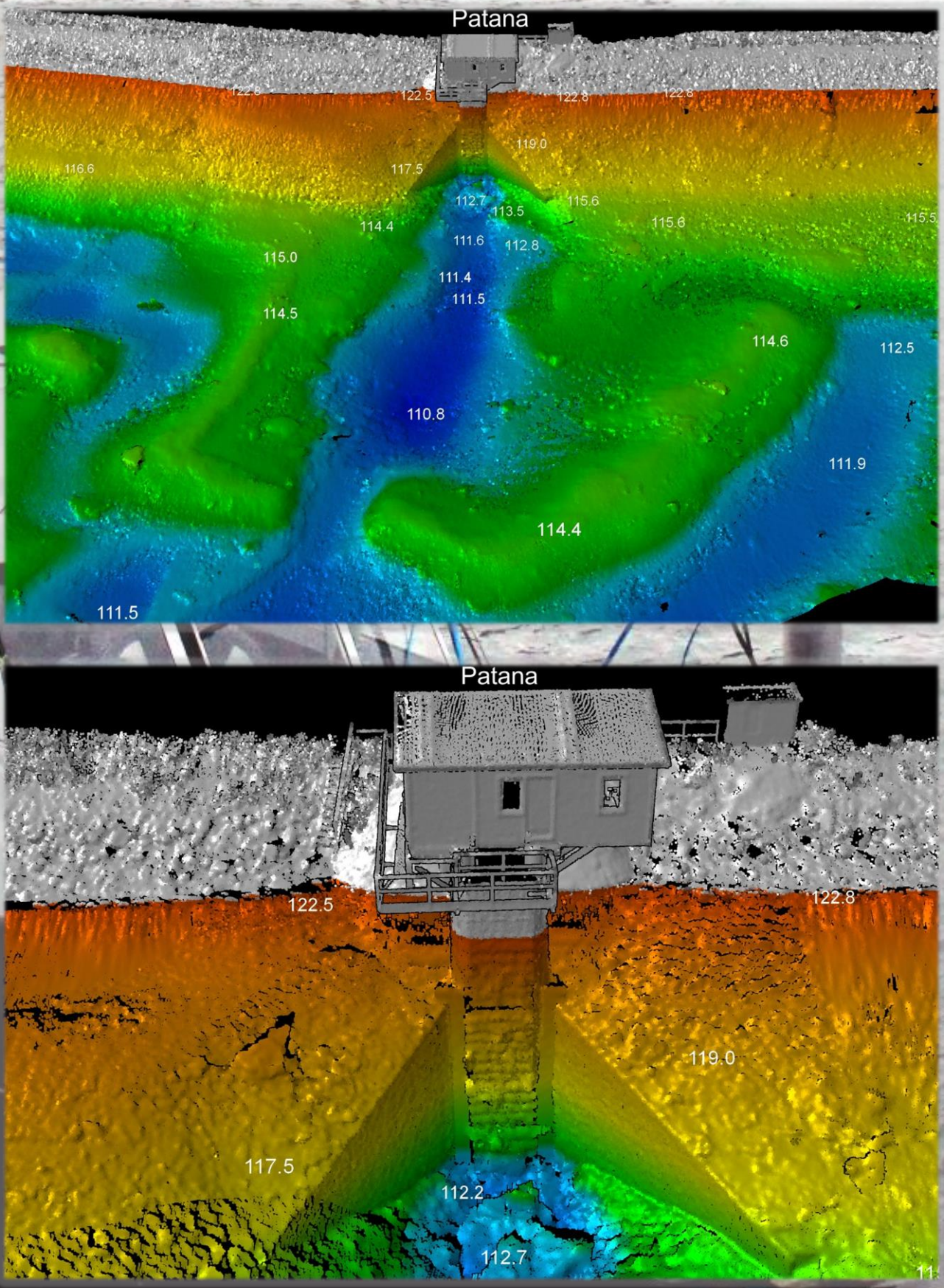
# Multibeam sonar scanning

- Multibeam sonar equipment is installed on a VRT survey vessel.
- Scanning is done by steering a vessel along specified lines. GPS and inertial measurement units gather data for accurate location and position, simultaneously with the sonar observations.
- Hundreds of data points are received simultaneously to form a dense 3D point cloud of underwater topography and vertical structures.
- When inspecting structures, the scanning is performed as close to the target as possible and with the highest possible frequency (~ 700 kHz) to produce a sharp result. Point density is less than 5 cm.
- A relatively extensive area can be scanned in a relatively short time
  - In Patana dam approximately 3 kilometers of dam structures were scanned in 3 days.

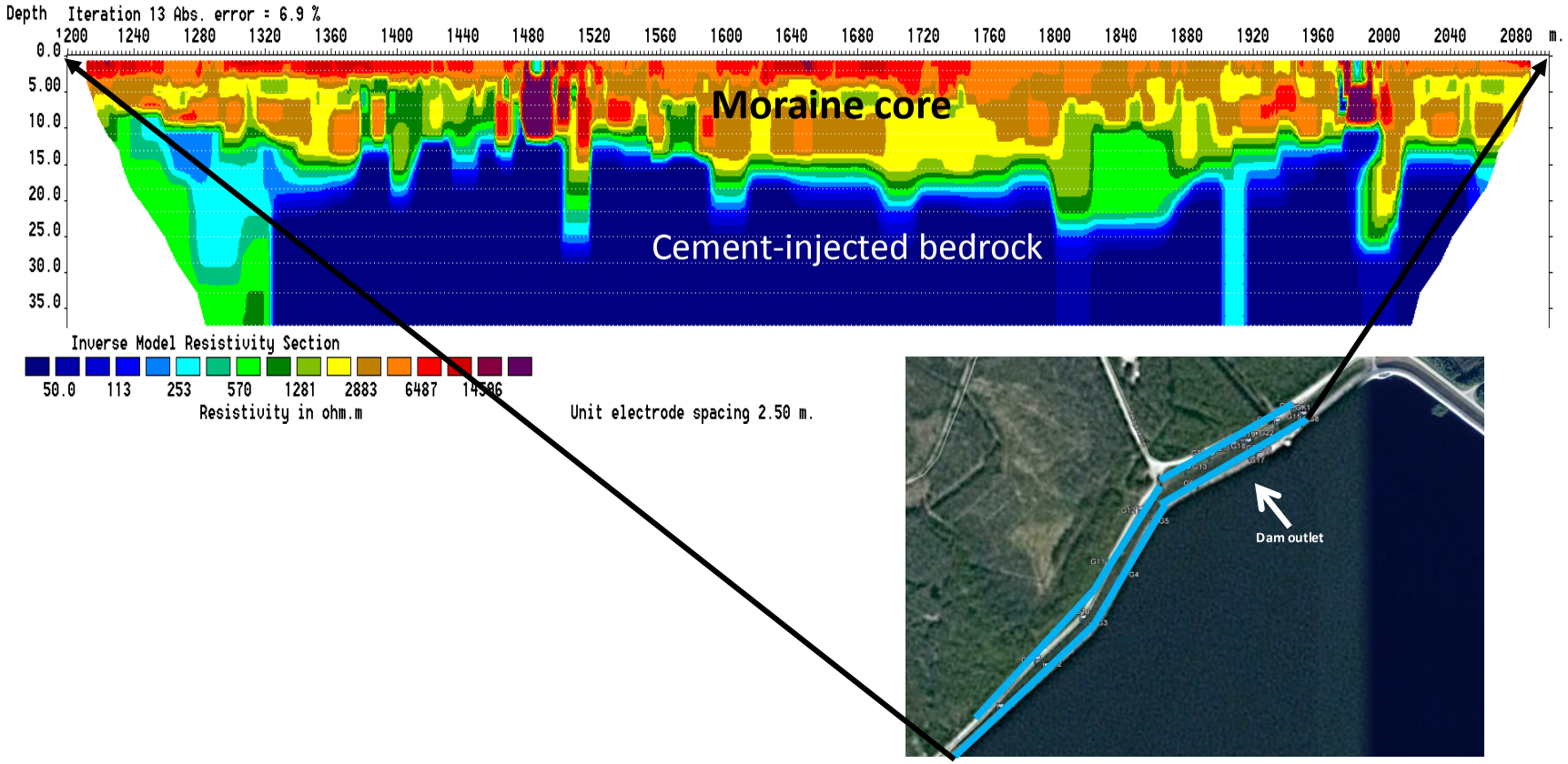


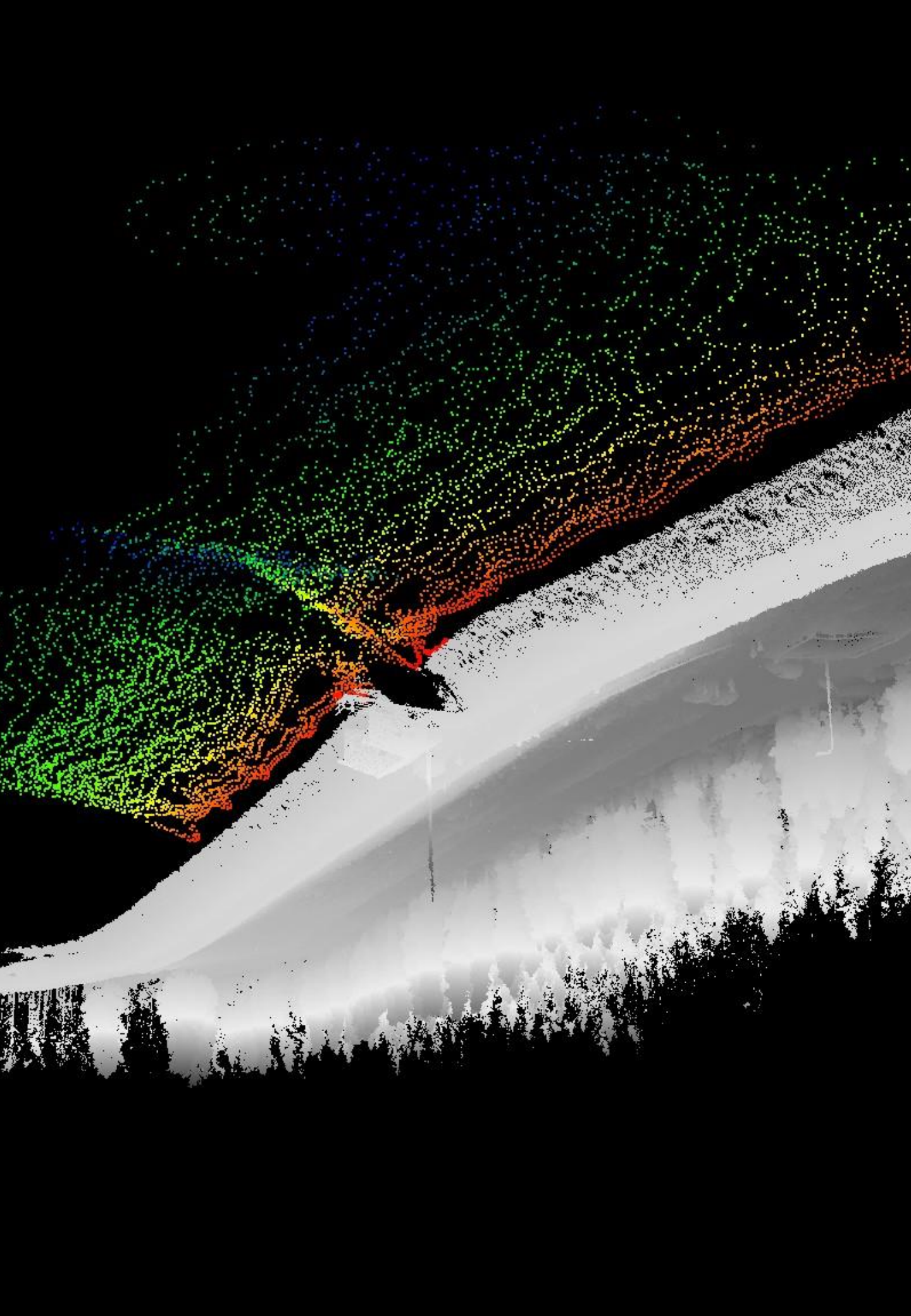

Patana dam basin and outlet in multibeam sonar data.

# Electrical resistivity tomography in 3D

- Electrical resistivity tomography (ERT) is a geophysical technique for imaging sub-surface structures from electrical resistivity measurements.
- Measurement lines (~200 meter long) are scanned automatically and measurements made mostly at the surface, but can also be made in one or more boreholes.
- VTT has applied ERT for applications such as soil structures and their behavior and properties in the embankment dams to reveal possible internal erosion and seepage processes.
- The ERT method has the obvious advantages of being non-destructive, non-invasive and continuous in the sense that it may measure on a large earth volume.
- The recent VTT development has concentrated to improve 3D/4D inversion (tomographic) process using geological constraints.
- 3D/4D inversion of full waveform electrical resistivity data can be applied to image both resistivity distribution and resistivities as a function of frequencies (simultaneously also induced polarization information).
- VTT ERT scanning instrument delivers the highest possible accuracy and resolution.

ERT data from Patana earthfill dam reveals dam internal structure.






MLS and ADCP data from Patana dam outlet channel (left) and on top of the embankment.

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