

RAILWAY CATENARY DIGITAL TWIN: STRUCTURE, REPRESENTATION AND ANALYTICS

AI Factory Team

Division of Operation and Maintenance

Luleå University of Technology

AIF/R - CONSORTIUM

Main Partners



ALSTOM



BOMBARDIER

Tåg företagen
• almea

SWECO



INFRANORD

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Damill AB

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TRANSITIO

Assoc. Partners

- BDX
- Tåg i Bergslagen
- X-Trafik
- Euromaint
- Atkins

Collaborative & Technology Platforms

JVTC LULEÅ RAILWAY
RESEARCH CENTER
at Luleå University of Technology

eMaintenance LAB

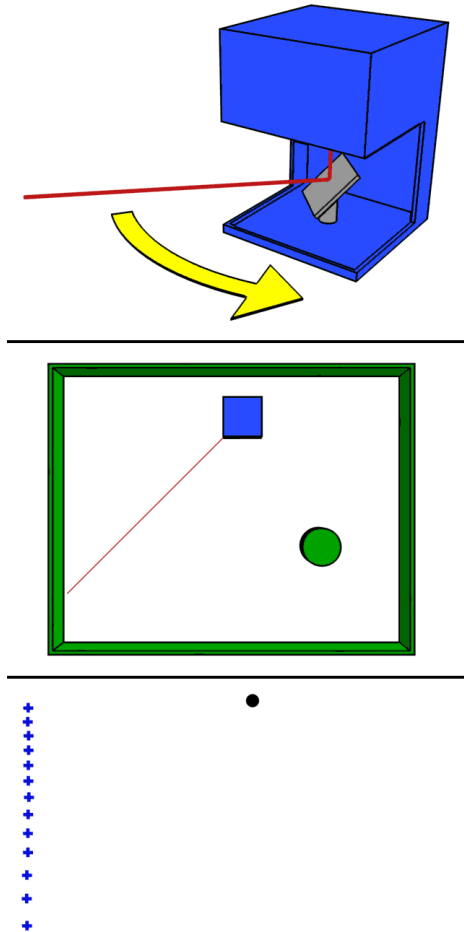
Purpose

To analyze and develop technology and business model requirements for railway catenary decision support system using LiDAR scanning in a distributed multistakeholder environment



Railway Catenary

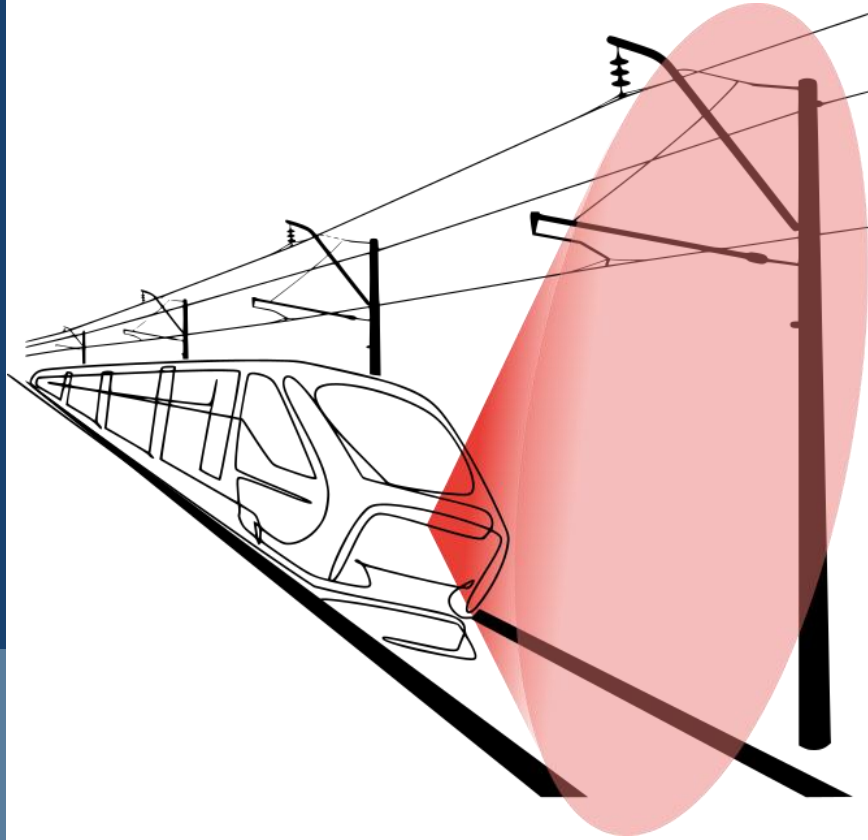
- European union
 - 200 tkm
- Inspection and maintenance
 - Limited focus and data
 - Consumes precious timeslot



LiDAR

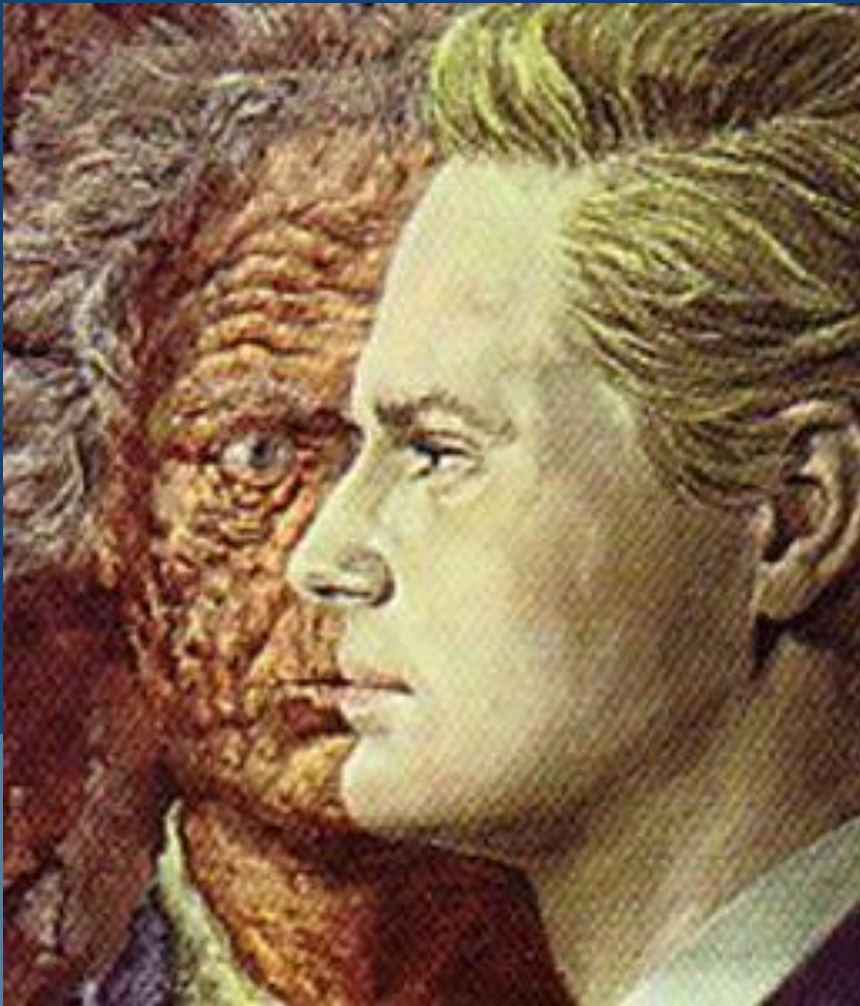
Light detection and ranging

- Transmit LASER beam
- Scanned by rotating mirrors
- Reflection sampled
- Time of flight / phase difference to measure distance



LiDAR Scan

- Locomotive mounted LiDAR scanner
- 30 km/h
- 100x50x50 meter scan
- Generates 3D point cloud data
 - Sub-cm level resolution
 - Geographical position aware
- Typical data file
 - 200 meters
 - 250 MB
 - 8.5 million points



Digital Twin

- Digital Twin
 - integrated multi-physics, multi-scale simulation
 - uses available models and information updates
 - physical asset ↔ data connection ↔ virtual assets
- Virtual time machine
- Diagnostics, prognostics and predictive support

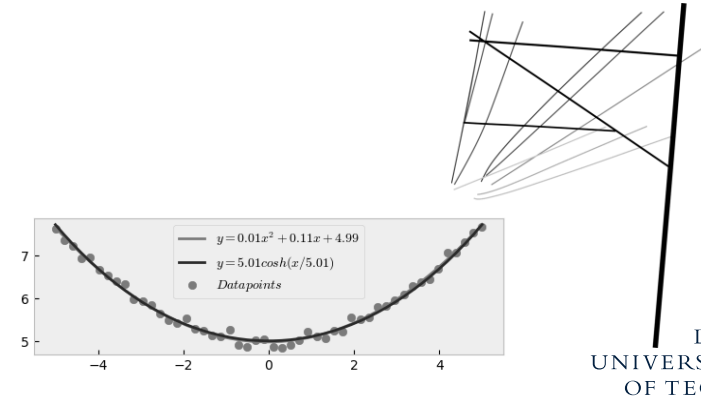
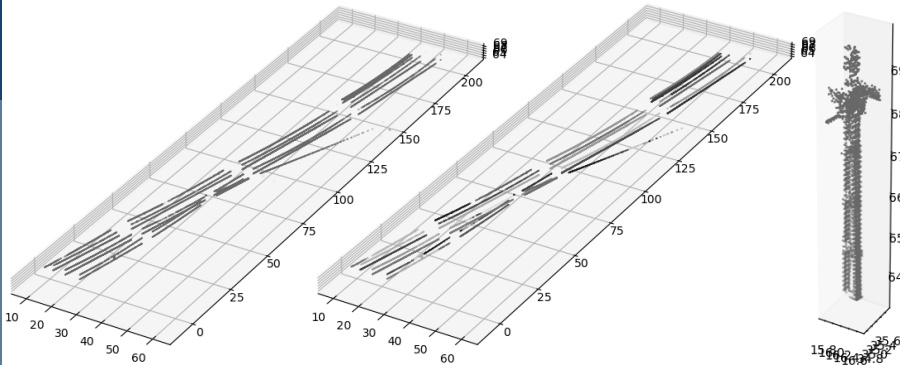
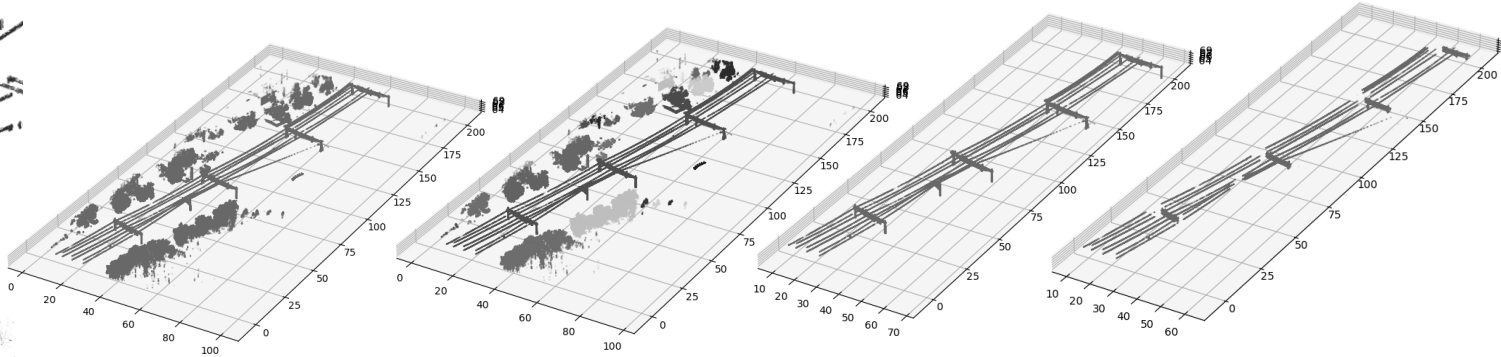


Not a Digital Twin of Mr. Dorian Gray
(missing data interface)

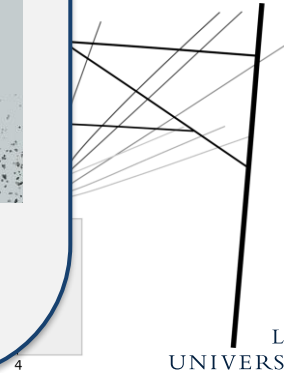
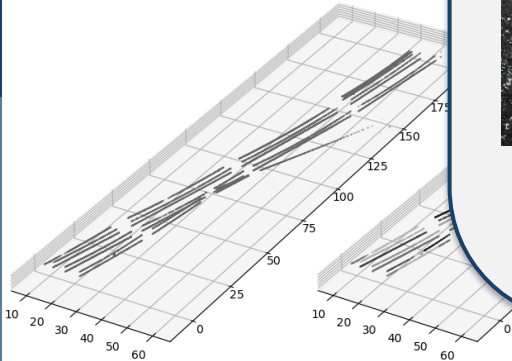
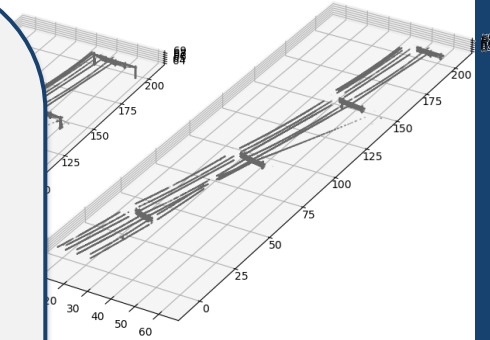
Information Extraction

- Possible extraction of
 - Masts
 - Portals
 - Catenary
 - Tracks
 - Sleepers
 - Vegetation
 - Low
 - High

Lidar data analytics

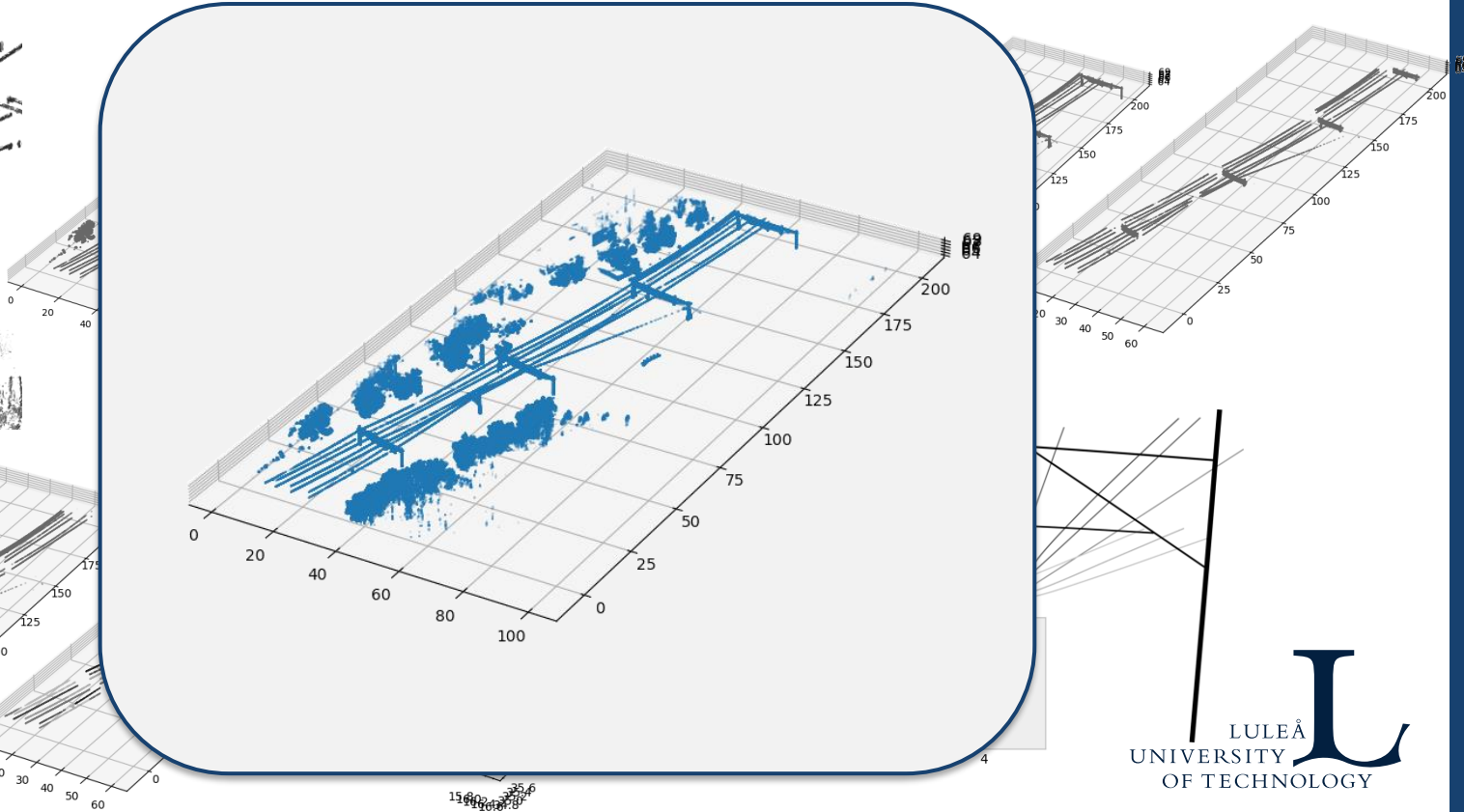


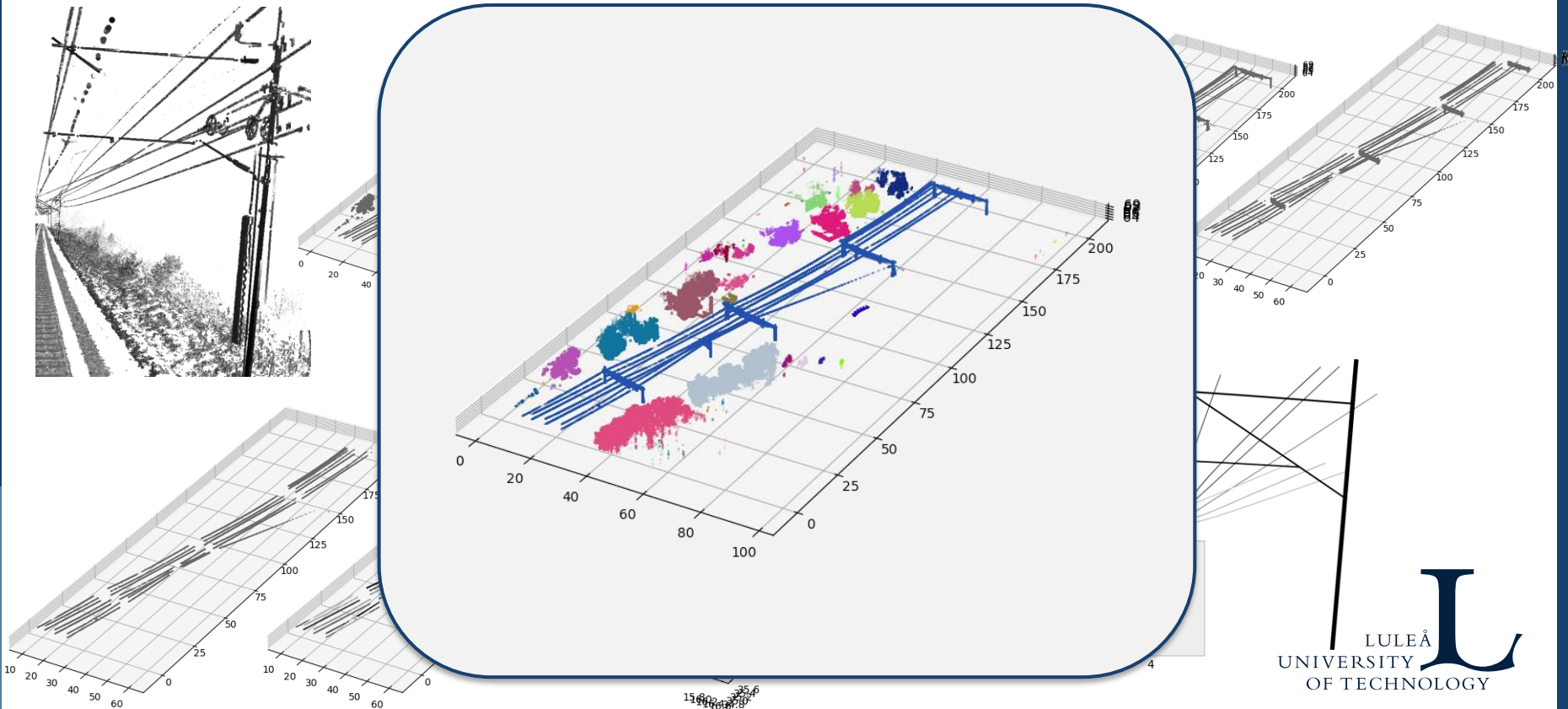
Point Cloud Data



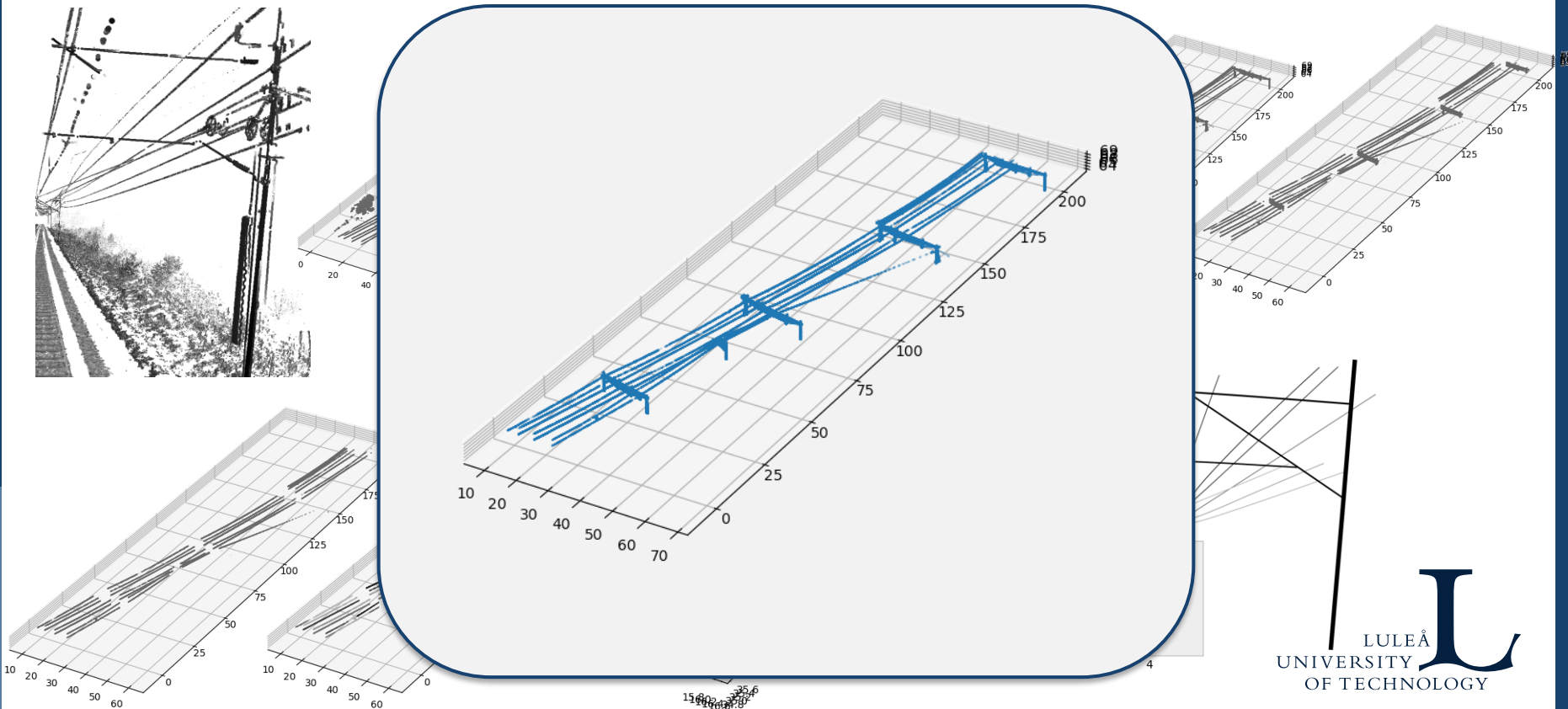
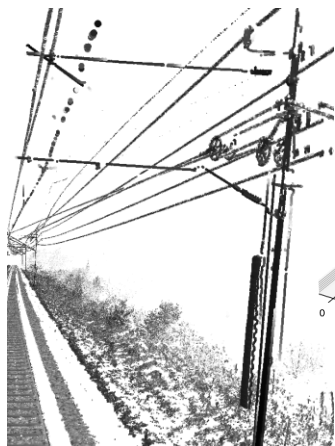
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OF TECHNOLOGY

Ground plane removal

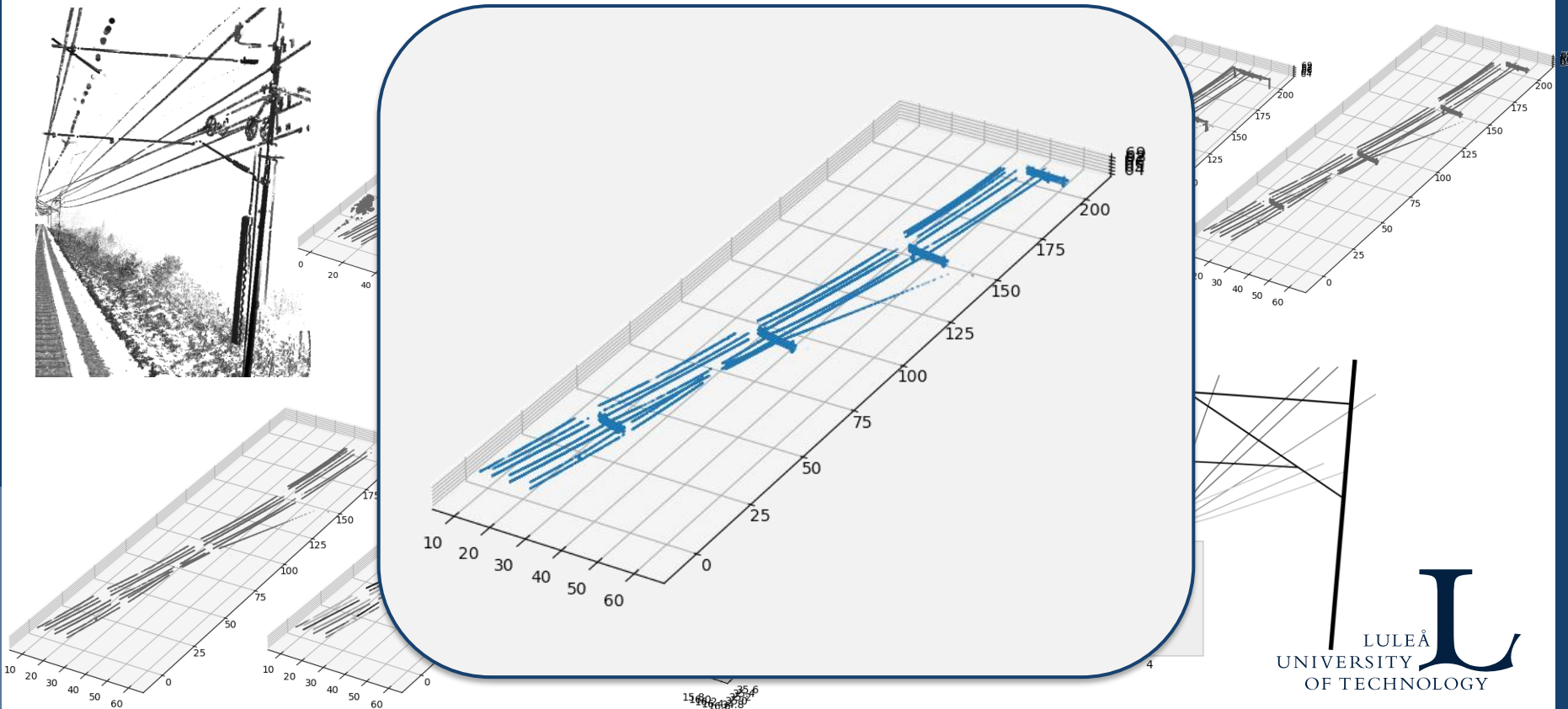
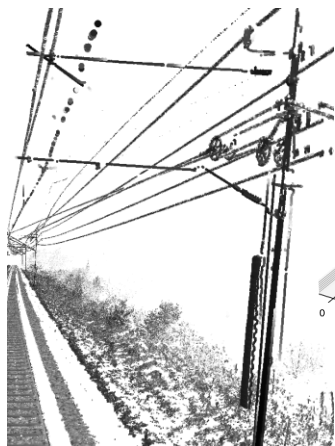




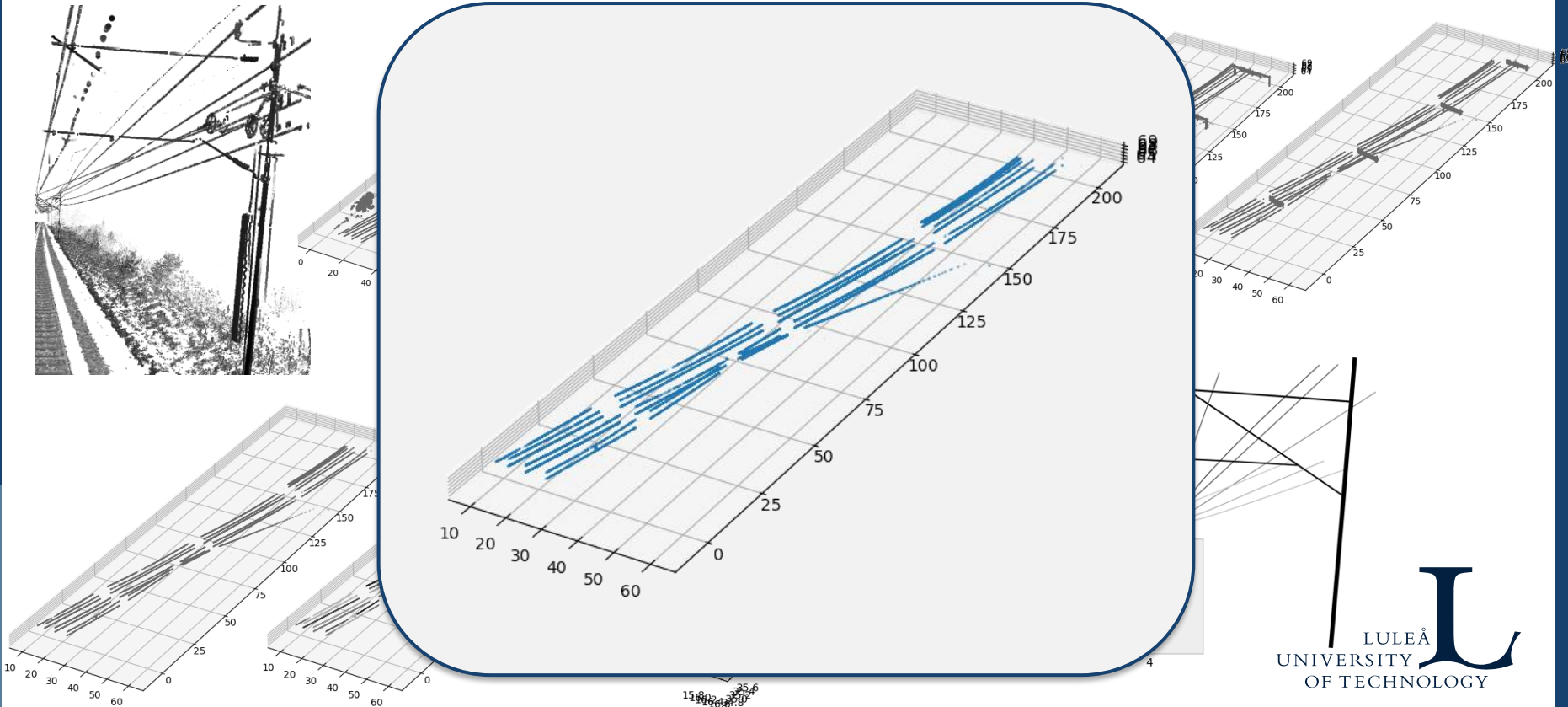
Region of interest



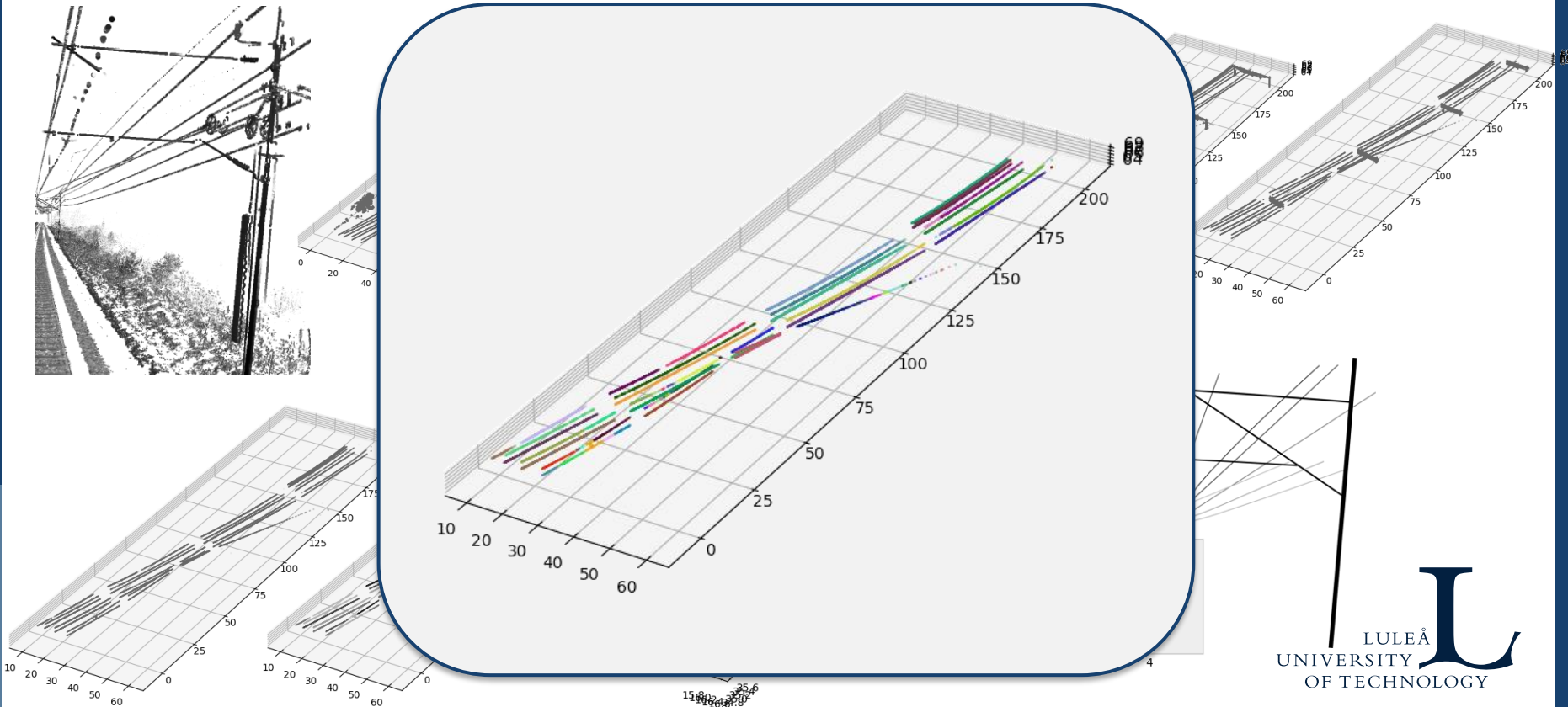
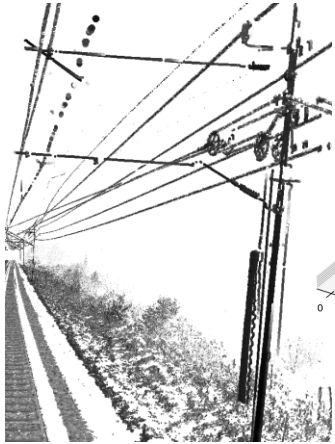
Masts detection



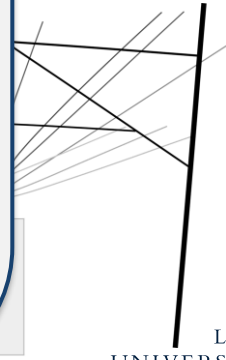
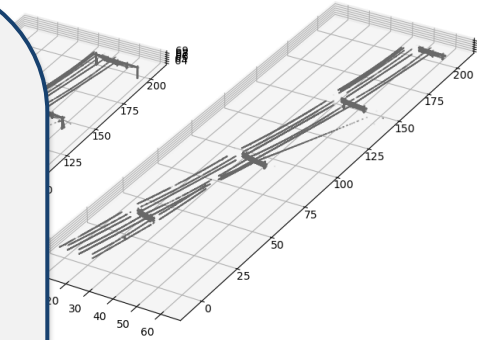
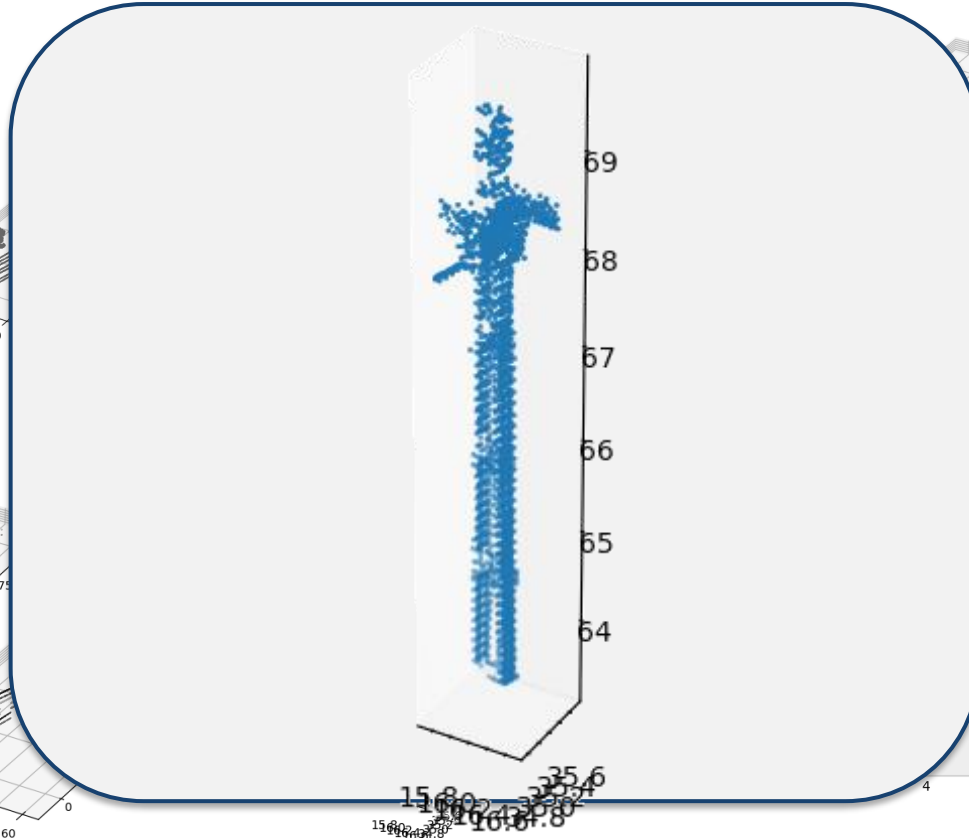
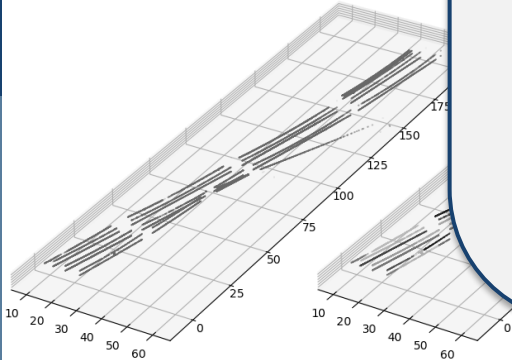
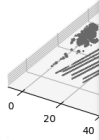
Portals detection



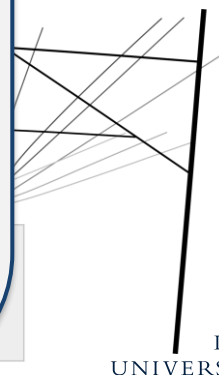
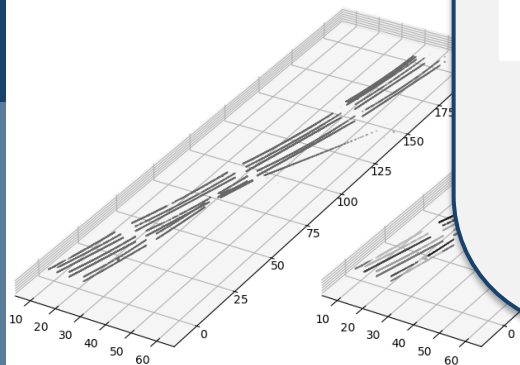
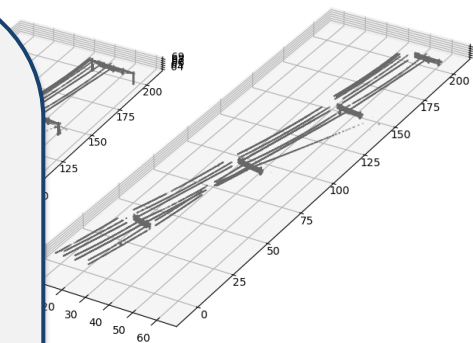
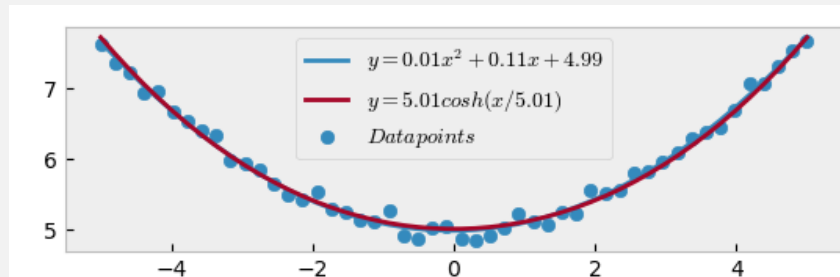
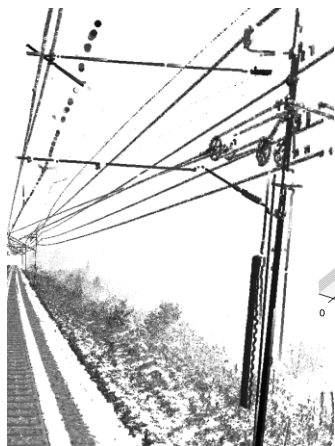
Catenary clustering



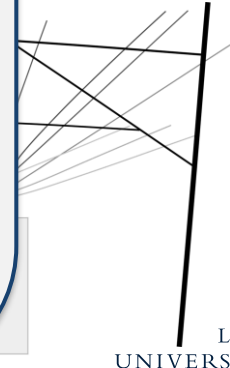
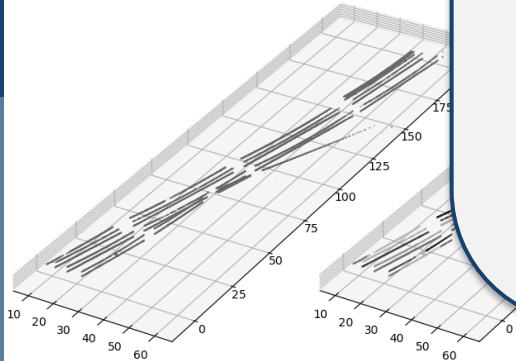
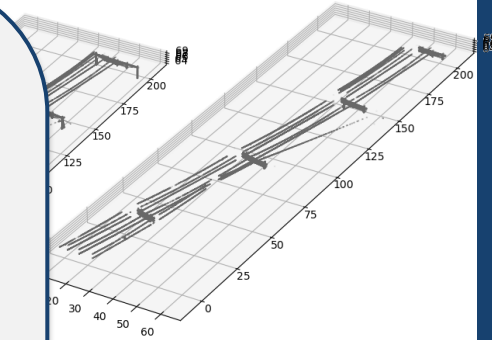
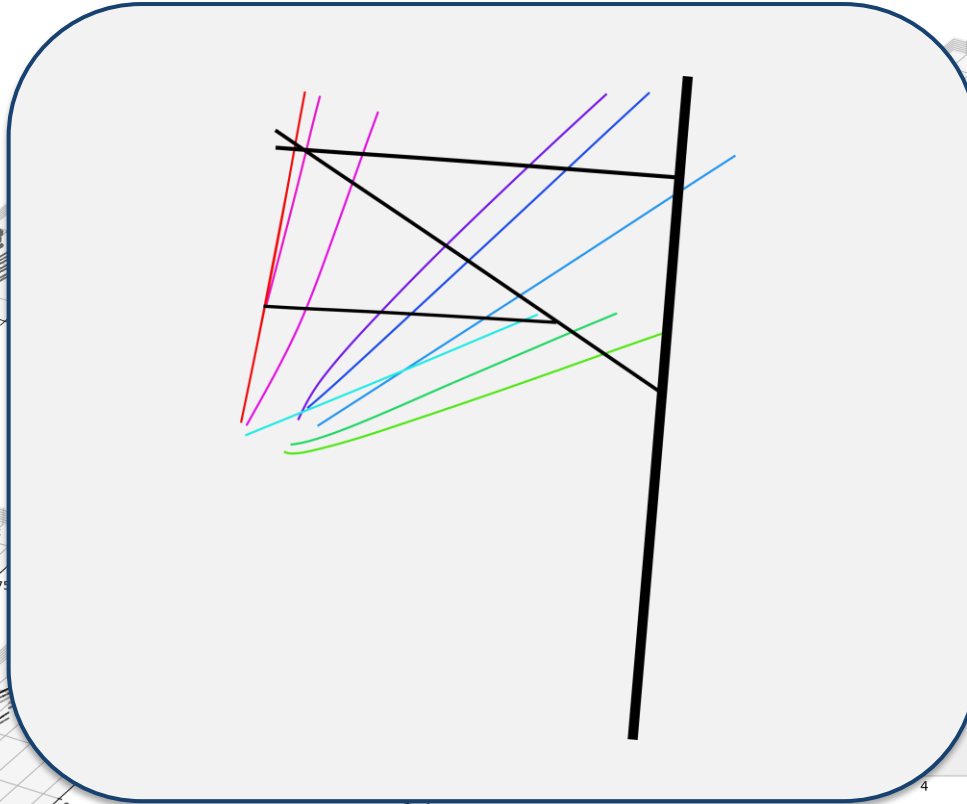
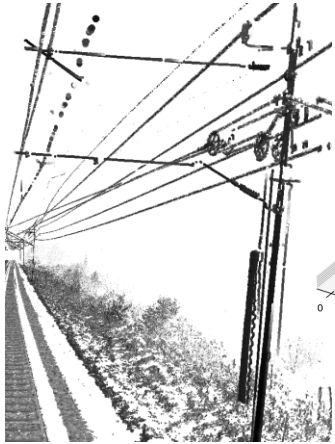
Masts extraction



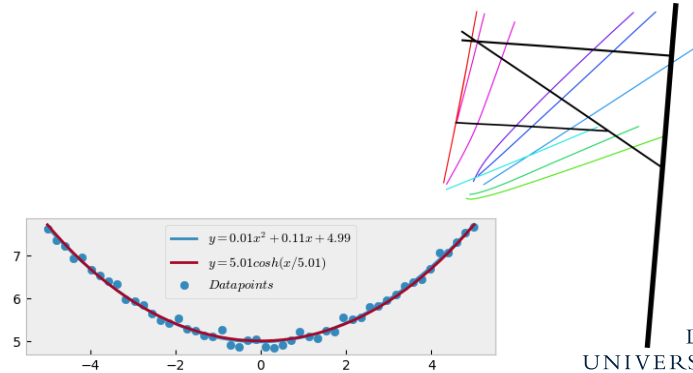
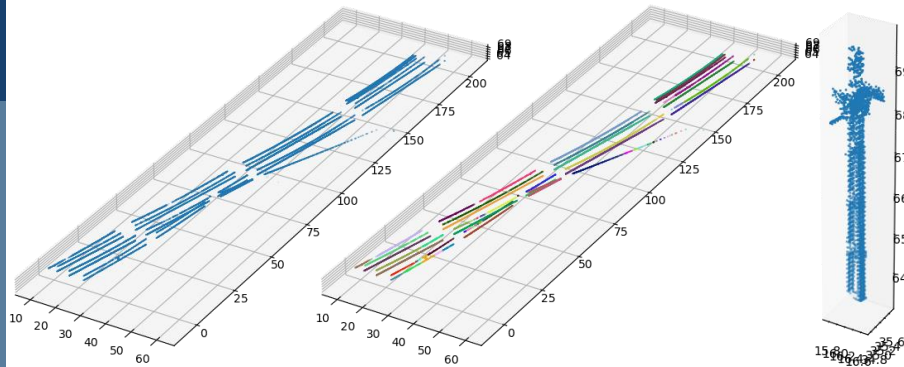
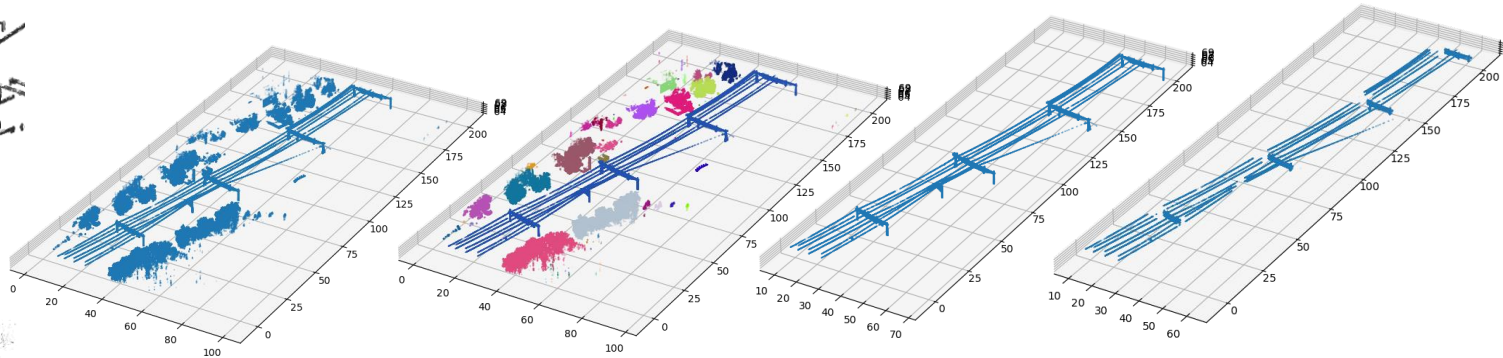
Line extraction



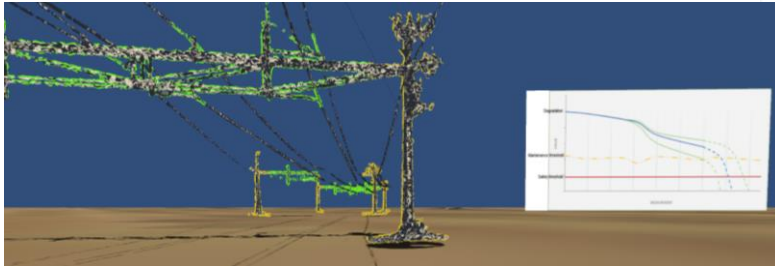
Catenary model



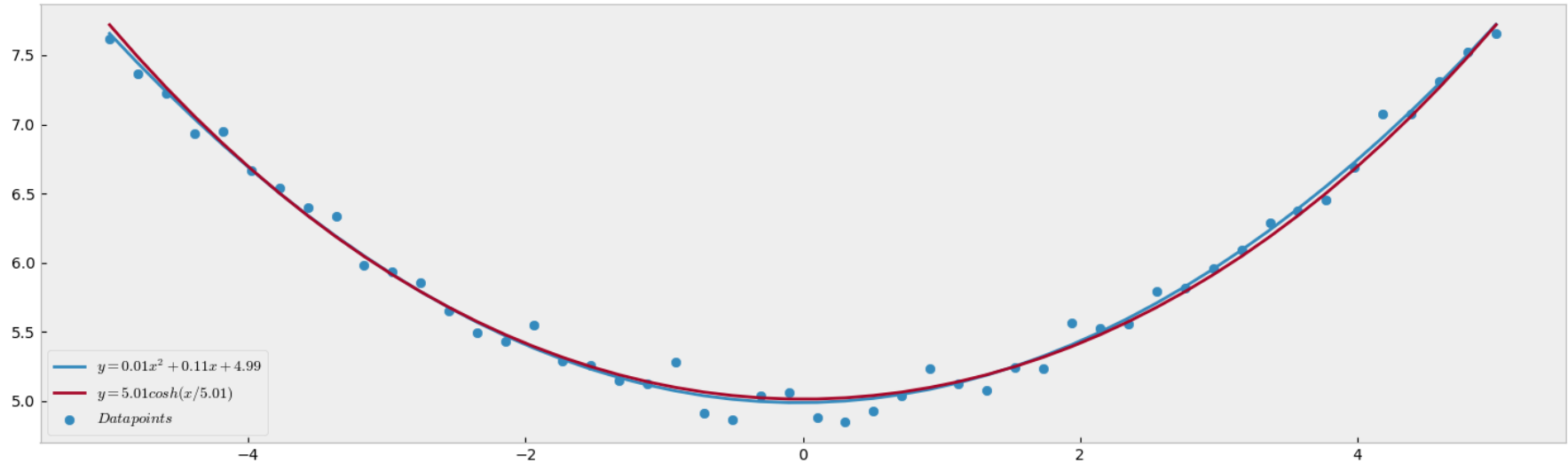
Lidar data processing



Physical to digital asset - 3D



Physical to digital asset - Mathematical



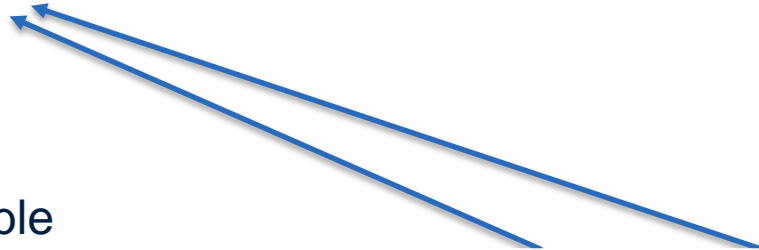
Physical to digital asset - database

Mast Table

Priemery key	Date	Ref Id	Location	Representation	Classification
				Bounding Box	

Wire Table

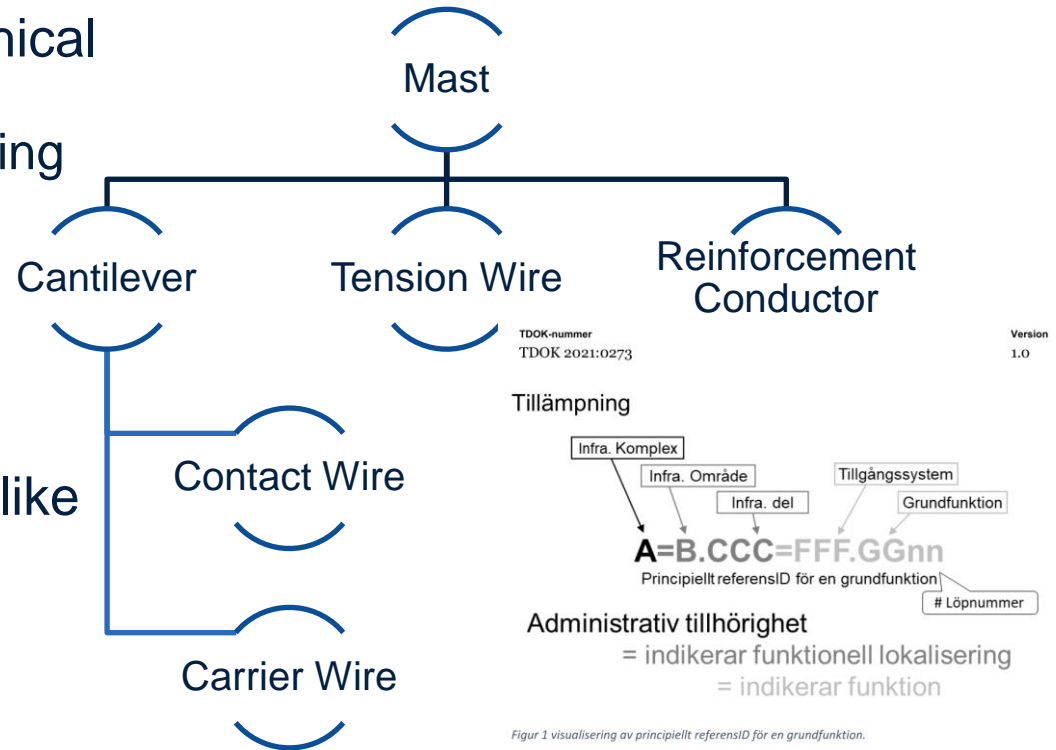
Priemery key	Date	Ref Id	Mast low	Mast High	Representation	Classification
					Equation	



Physical to digital asset – system model

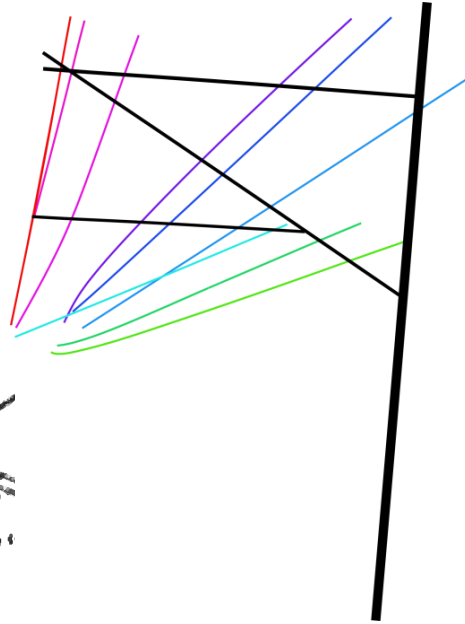
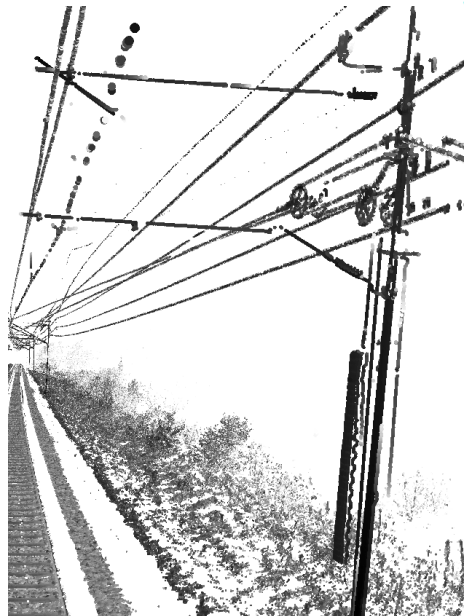
- Asset properties as hierarchical set of mathematical models
 - Mast – Positions / Bounding Box
 - Wire – Equations
 - Vegetation

Analysis and condition assessment based on factors like time, weather,



Figur 1 visualisering av principiellt referensID för en grundfunktion.

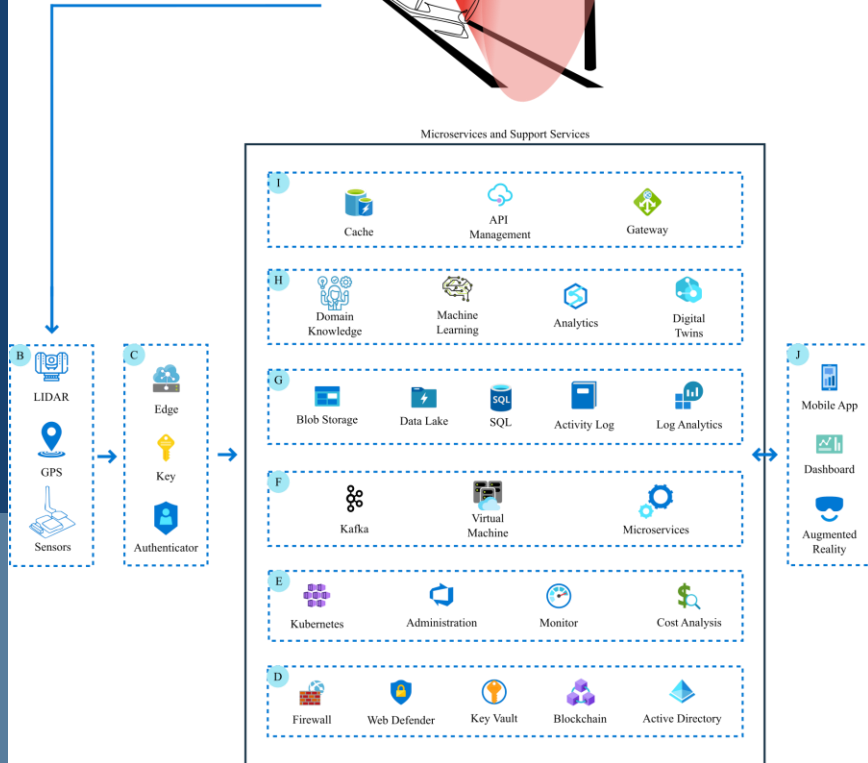
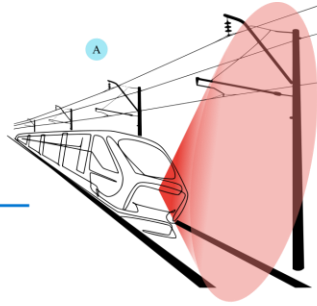
Trafikverket (2021)



Digital Twin

- PCD Analytics
- Asset information representation
- Domain knowledge representation
- Decision support analytics
- Decision support interface
- System access API
- Cybersecurity

System Architecture



Digital Twin Architecture

- Distributed
 - Multistakeholder environment
- Event driven
 - Resources scaling
 - Cost Management
 - Real Time
- Microservices
 - Distributed development



Thank You

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