

Optimizing Mobile Mapping Workflow by Implementing Deep Learning for Transportation Projects

March 12, 2024



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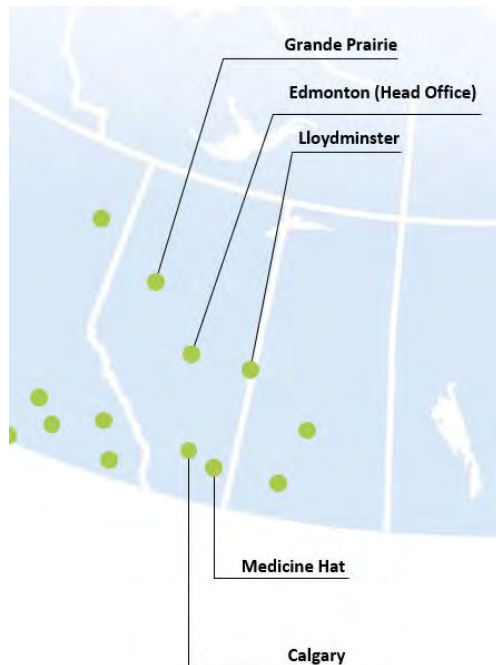


1. Introduction
2. Asset Management
3. Geospatial
4. Mobile Mapping System
5. Deep Learning for Transportation Projects

1

Introduction

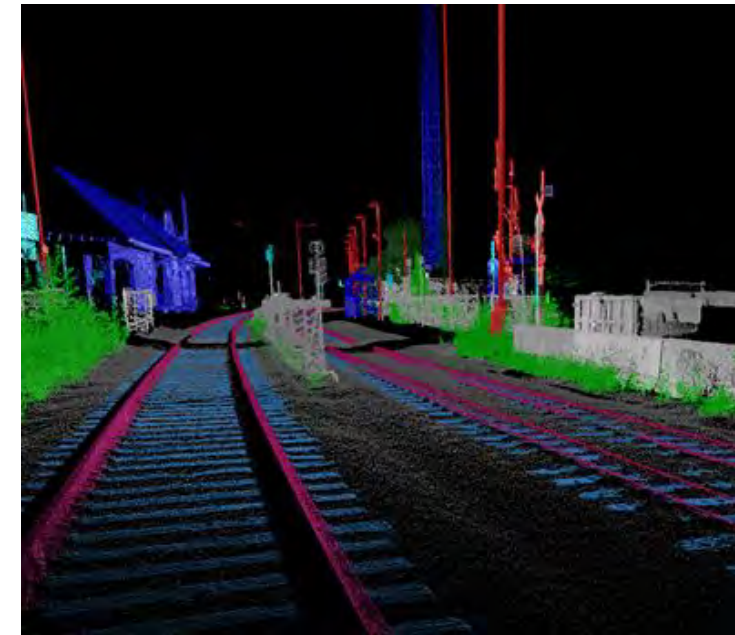
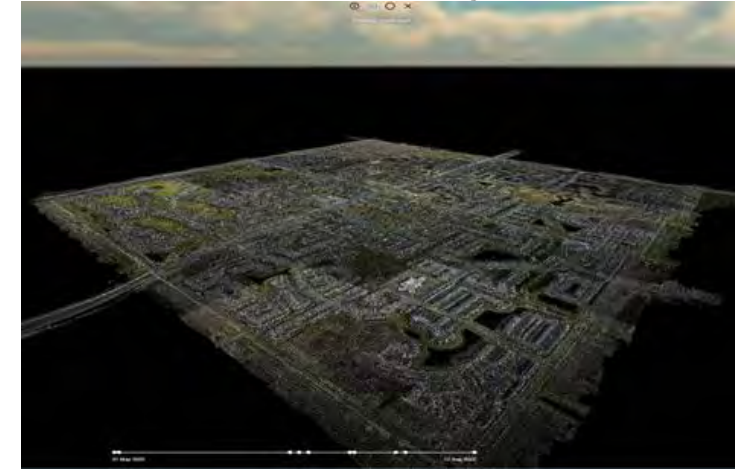
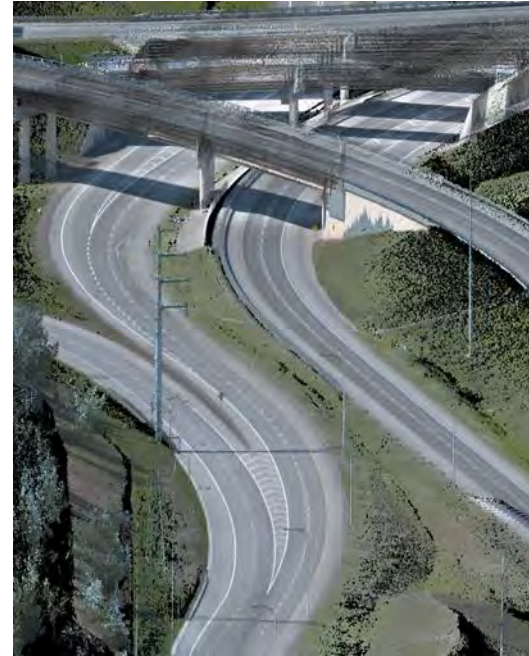
GeoVerra is well-positioned for a rapidly-changing future, but our roots in the industry stretch back over 100 years. We have continued to evolve as a fusion of specialties brought together through mergers and acquisitions of various geomatics firms across Canada: WSP, Altus Geomatics, among others.



Alex Garcia



- Bachelor and Master of Science in Geomatics Engineering
- 7 Years of experience executing Mobile Mapping Projects
- Collected more than 45,000 Miles of Mobile Mapping data
- Highways
- Railways
- Urban Areas
- Municipalities
- Unpaved roads
- Powerline corridors
- Survey Grade (High Accuracy)
- Asset Grade (lower Accuracy)



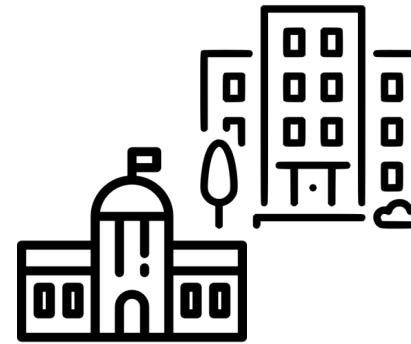
2

Asset Management

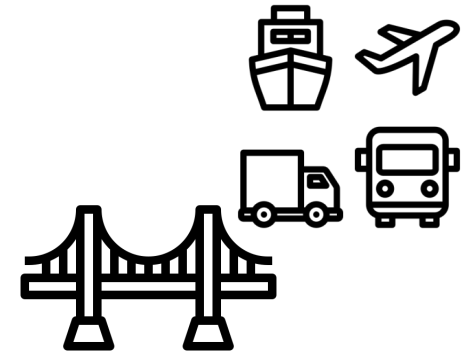
Asset Management /What is it?

Asset management is the process of making decisions about the use and care of infrastructure to deliver services in a way that considers current and future needs, manages risks and opportunities, and makes the best use of resources.

- **WHAT** DO WE OWN?
- **WHERE** IS IT?
- WHAT ARE THE **ATTRIBUTES**?
- **WHEN** WAS IT INSTALLED?
- WHAT WILL IT **COST** TO REPLACE?
- WHAT **CONDITION** IS IT IN?
- HOW LONG WILL IT **LAST**?



Municipalities



Transportation

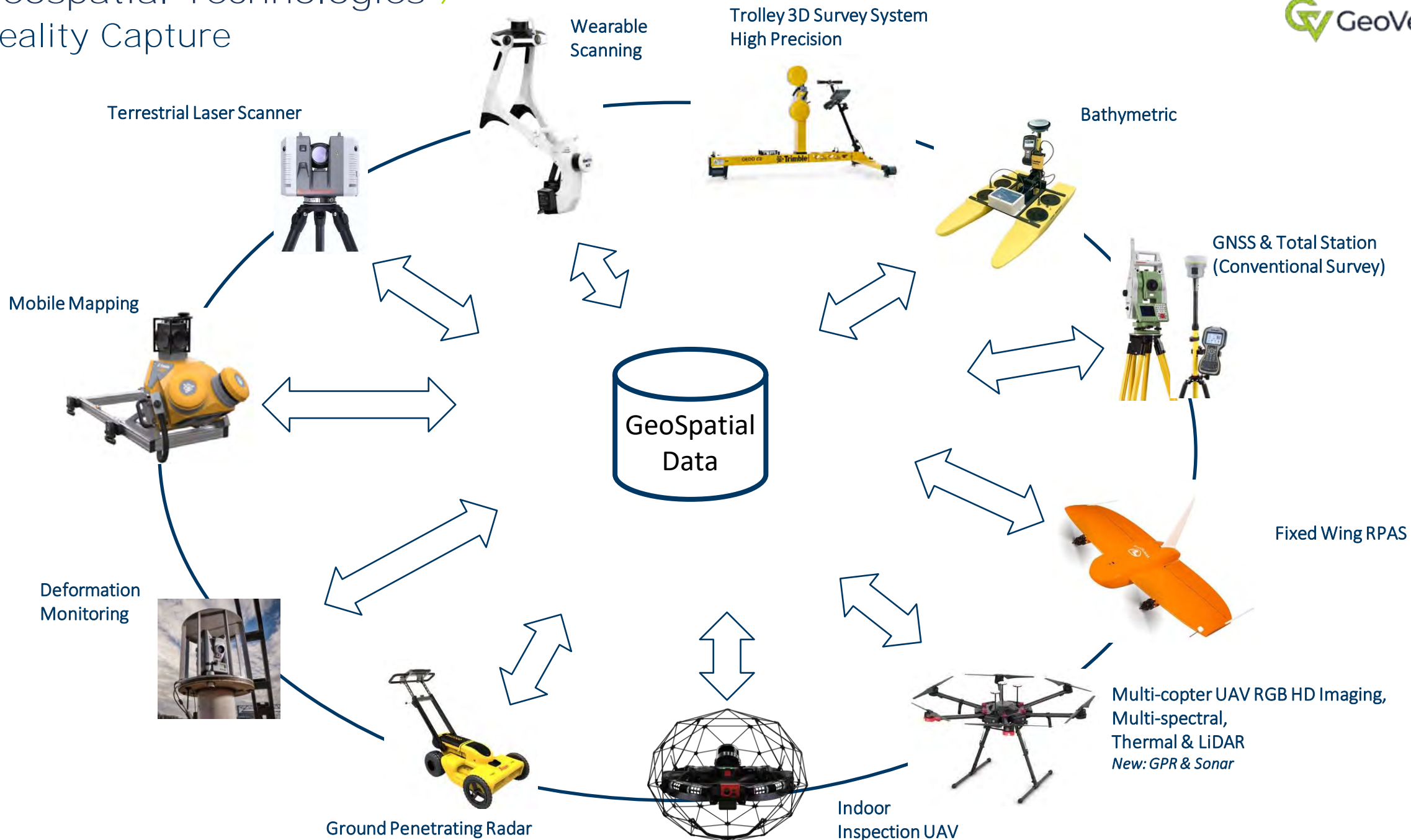
- Start with the asset categories that have the **biggest value** or potentially pose the biggest risk of failure.
- Set up your **inventory** with all the fields, even if you don't currently have information available to fill the fields.
- **Field verification** of information can be very useful when setting up your inventory. This can also be a good time **to collect observations** about condition, maintenance, etc.
- **Storing asset information in GIS** provides an easy way to access information and allows for export of spreadsheets as needed. If you don't have GIS resources, consider the use of a cloud-based
- GIS subscription service that can be tailored to your needs.



3

Geospatial

Geospatial Technologies / Reality Capture



“Geospatial technologies and Services can provide municipalities and transportation agencies with the tools to manage their assets more effectively by offering detailed spatial insights, improving decision-making processes, enhancing efficiency, and ultimately leading to more resilient and sustainable infrastructure management practices.”

1. **Create** or **Update** Asset Inventory and Monitoring
2. Spatial **Visualization** and Analysis
3. Improved **Decision-Making**
4. Predictive **Maintenance** and **Risk Management**
5. Resource Optimization and **Cost Savings**
6. Enhanced Public Engagement and **Transparency**
7. Regulatory **Compliance** and **Reporting**
8. **Disaster Management** and Response



4

Mobile Mapping System

Advantages of Mobile Mapping Over Traditional Technologies

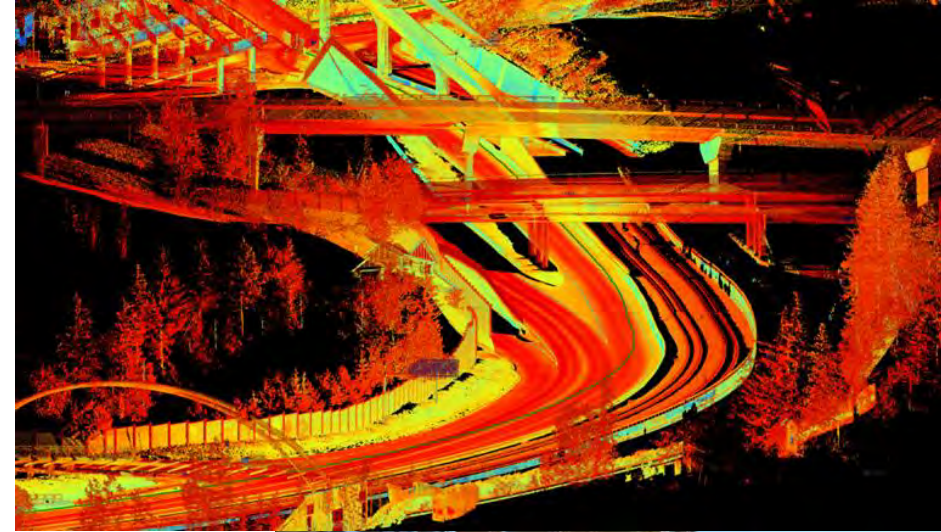
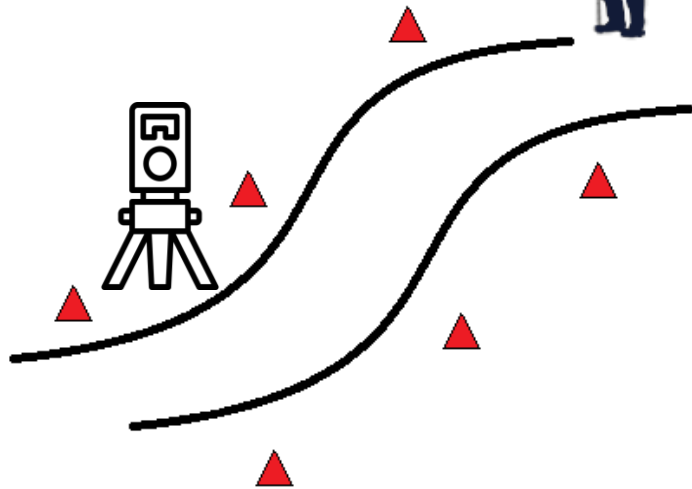
Traditional Technologies

Boots on the ground

Collecting point by point and entering the features manually on the data controller in the field



Manual Annotations



Geospatial Technologies

Remotely collecting from a moving vehicle massive amount of High Resolution of 3D information





Understanding Mobile Mapping

A **Mobile Mapping System (MMS)** is an advanced, adaptable platform used for the collection of geospatial data on the go. Not limited to vehicle mounting, an MMS can also be deployed as a backpack unit, allowing for flexibility in various environments.

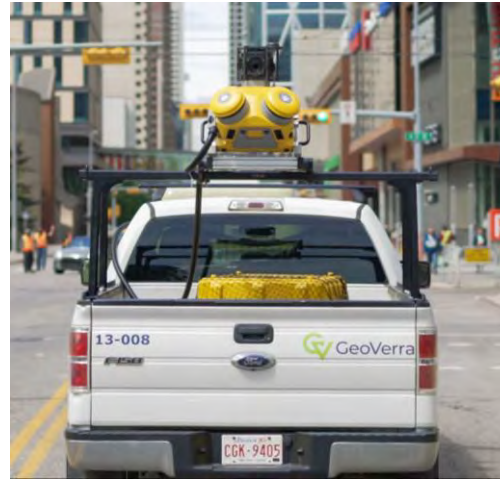
Core Sensors

- Navigation Satellite System (GNSS),
- Inertial Measurement Unit (IMU),
- Simultaneous Localization and Mapping (SLAM)

Mobile Mapping Services / Equipment Experience



LiDAR USA - Reigl



Trimble Mx50



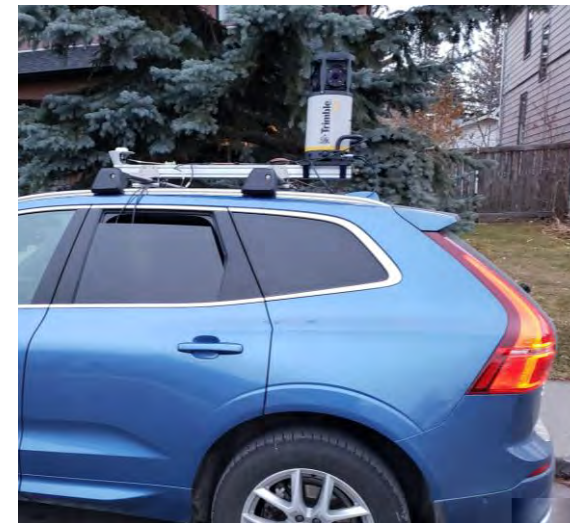
Leica Pegasus Ultimate



Trimble Mx9



Navis VLX 2/3



Trimble Mx7



LiDAR USA - Velodyne

What is mobile mapping? / Hardware



Ground Penetrating Radar (GPR)



Bike and Sidewalk Maintenance and Inspection (Solid State LiDAR)

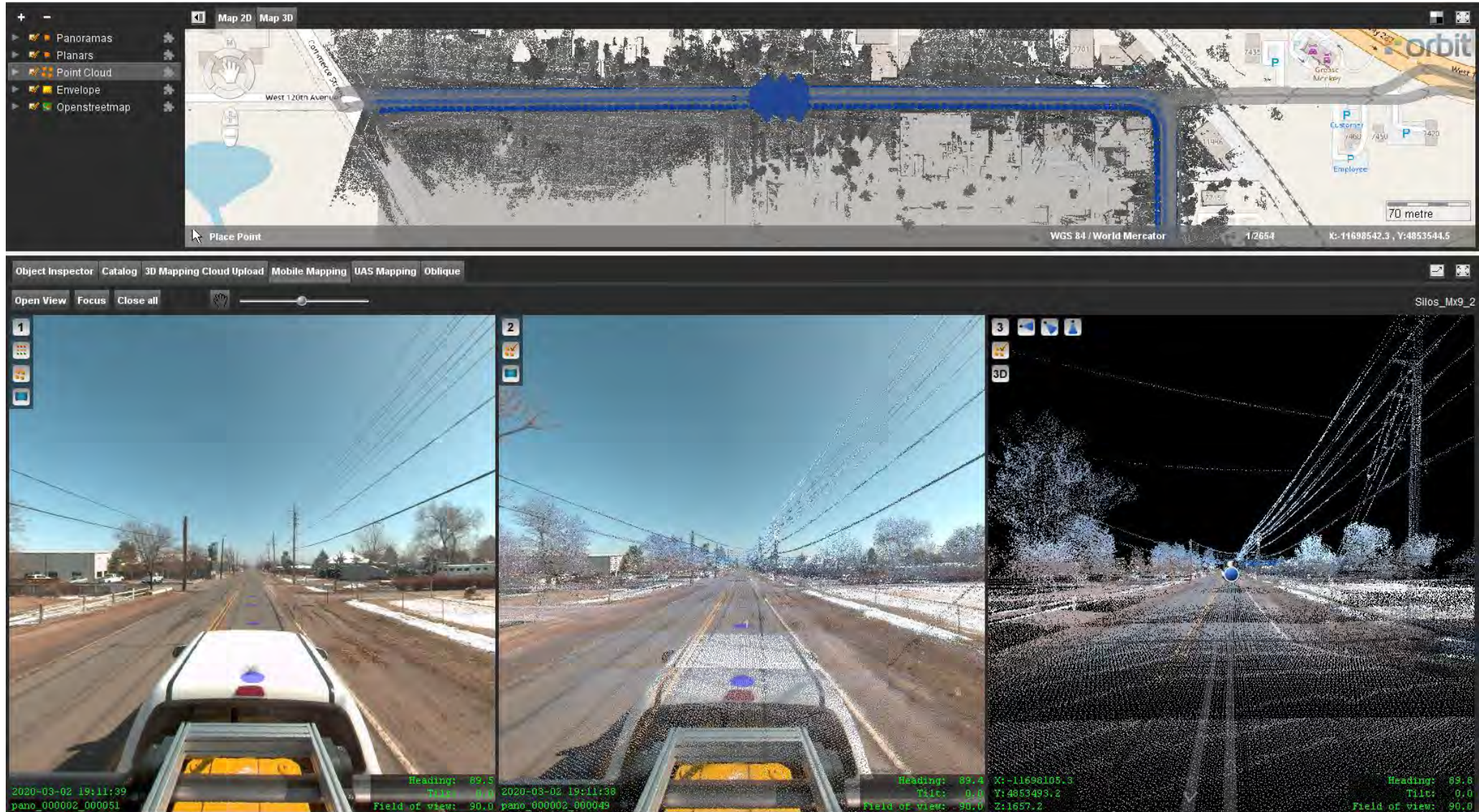


Laser Crack Measurement System (LCMS-2)



RGB and Infrared Camera Cameras

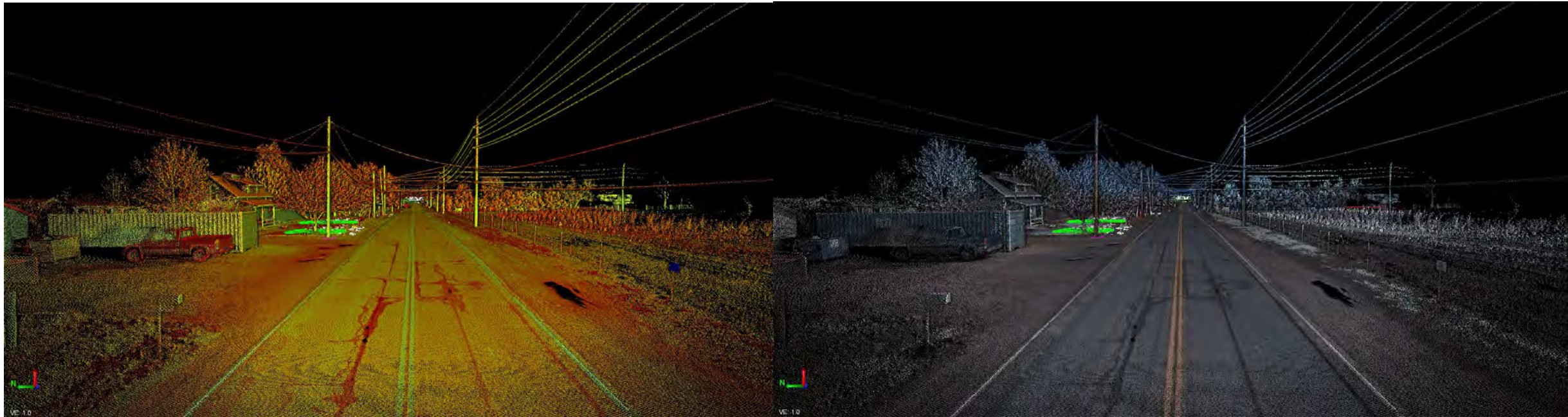
What is mobile mapping? / Typical MMS Collected data



What is mobile mapping? / Typical MMS Collected data



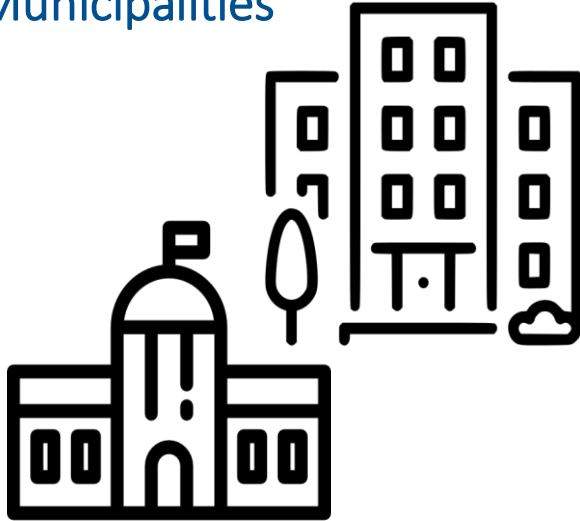
What is mobile mapping? / Typical MMS Collected data



What does mobile mapping enable above and beyond other technologies?

- **High productivity** - kilometers of roads mapped in a single day
- **Increased safety** - Removing surveyors from traffic on roadways
- **High accuracy/precision** - cm accuracy level / mm precision level for 2D clearance analysis
- **Rich 3D dataset** - High 3D data density for close range acquisition
- **Cost Reductions** - Reduce field visits to plan, scope, inspect and audit
- **Multiple Sensors** - Different sensors can easily be integrated to the MMS. For instance, GPR, thermo Camera, High definition 360 camera, extra sensors for pavement/asphalt analysis, etc.
- **Extract automatic and semi-automatic** features from Point Cloud and Imagery
- One of the key potential benefits of MMS technology is that a **single acquired dataset** can be **used** for a **variety of applications**. The data also can possibly be “mined” for additional information that may not have been a focus of the original acquisition e.g., Mapping, Surveying, Engineering, GIS, etc.

Municipalities



Municipal Applications:

1. Utility Infrastructure:

- **Manholes and Catch Basins:** Location, depth, and condition.
- **Hydrants and Valves:** Positions, operational status, and type.
- **Electricity Poles and Wires:** Height, condition, and line sag measurement.
- **Pipelines and Conduits:** Above and below-ground routing and depth.

2. Environmental Monitoring:

- **Tree Canopy and Vegetation:** Coverage, health indicators, and species identification.
- **Water Bodies:** Shoreline mapping, volume estimation, and water quality assessment.

3. Public Amenities:

- **Park Equipment:** Benches, tables, playground structures, and their conditions.
- **Street Furniture:** Waste bins, lighting, bus stops, and signage.

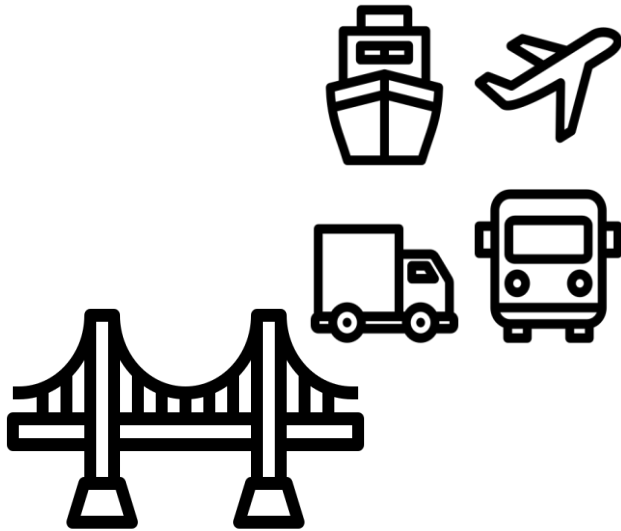
4. Building and Zoning:

- **Structures:** Building footprints, roof structures, and façade details.
- **Land Use:** Property boundaries, land use classification, and zoning compliance.

5. Public Safety and Emergency Planning:

- **Risk Assessment:** Flood zones, fire hydrant locations, and disaster response routes.
- **Security Features:** Barrier locations, security cameras, and access control points.

Transportation



Transportation Applications:

1. Roadway Infrastructure:

- **Pavement Analysis:** Surface condition, cracks, and potholes.
- **Lane Markings:** Visibility, wear, and compliance with standards.
- **Signage:** Type, location, and reflectivity condition.

2. Traffic Management:

- **Traffic Signals:** Position, type, and pedestrian crossing indicators.
- **Roadway Geometry:** Curvature, grade, and cross-slope for safety analysis.

3. Bridge Inspection:

- **Structural Elements:** Bridge deck, girders, piers, and bearings condition assessment.
- **Clearance Measurements:** Vertical clearance under overpasses and bridges.

4. Asset Management:

- **Guardrails and Barriers:** Length, location, and damage.
- **Culverts and Drainage:** Position, diameter, material, and blockage status.

5. Rail and Transit Networks:

- **Rail Lines:** Track geometry, switches, and crossings.
- **Transit Assets:** Station platforms, shelters, and associated infrastructure.

6. Pedestrian and Cycling Infrastructure:

- **Sidewalks and Paths:** Width, surface type, and connectivity.
- **Bicycle Lanes:** Location, delineation, and connection to the broader network.

5

Deep Learning for Transportation Projects

Mobile Mapping Workflow



CAPTURE

Quickly obtain asset data

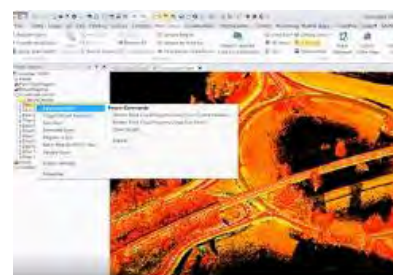
High-quality colorized point clouds and 360° immersive imagery with simple, smart device operation and single cable sensor connection.



PROCESS

Process vehicle trajectory

Trajectory data processing using tightly coupled GNSS and inertial data incorporated into Trimble Business Center software.



EXTRACT

High-quality deliverables

Create survey, engineering and GIS deliverables using existing data schemas and connect to existing asset databases.



SHARE

Publish & collaborate

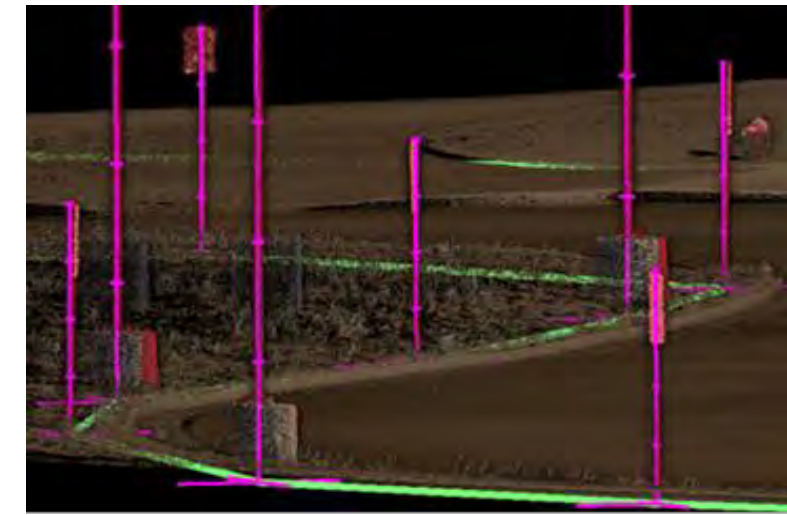
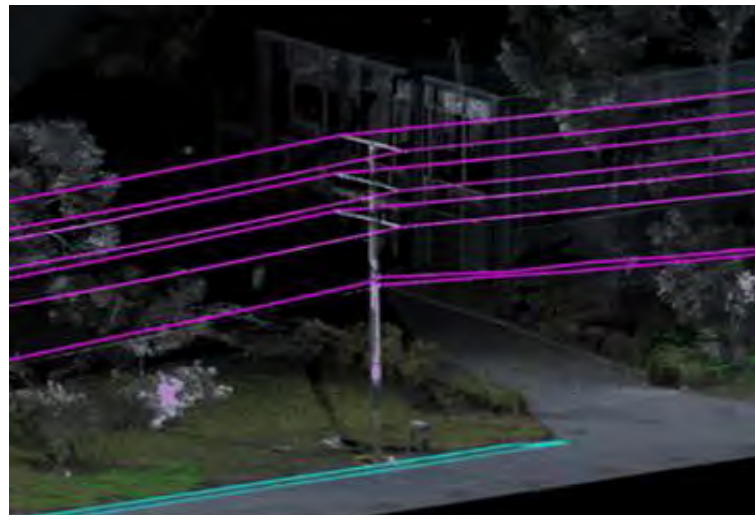
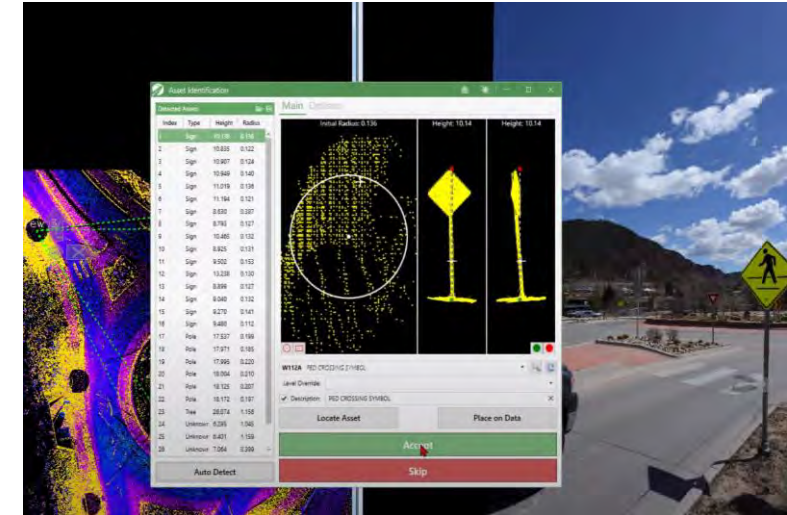
Share for collaboration point clouds and images with overlaid existing asset data. Extract new assets and store them in databases.



Manual and Semi Manual Asset Extraction

- **Algorithm-based** and templates Approach
- **Lots of clicks** when performing feature extraction
- **Manual or Semi Manual** extraction of **attributes**
- **Productivity** becomes a problem and offset the time gained in the field
- **Complex scenes** and objects is a **problem** for this this approach
- Very Inefficient approach for large scale projects

Diversity of Assets is a huge problem when feature extraction is based on Template and Algorithm-based

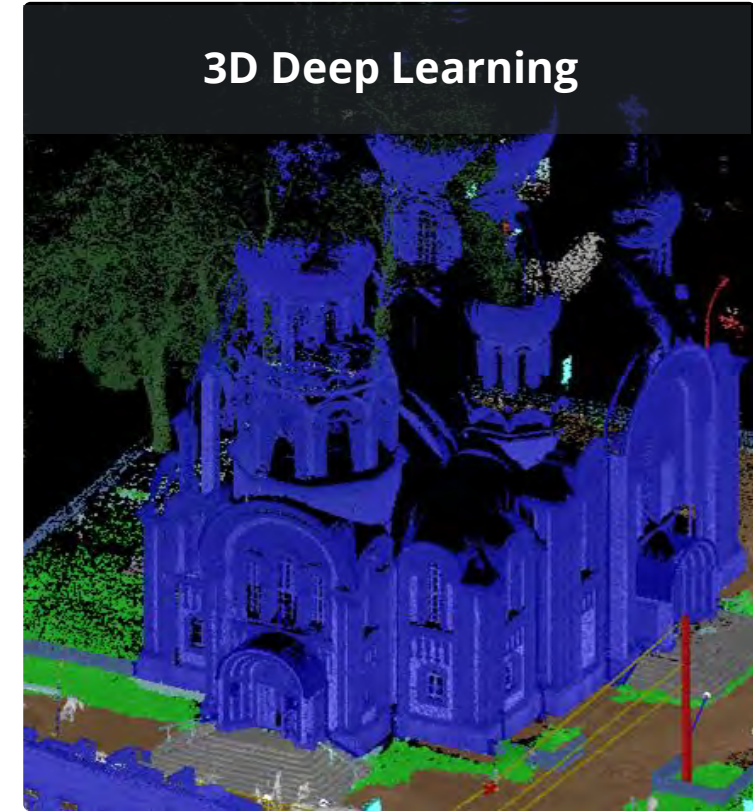
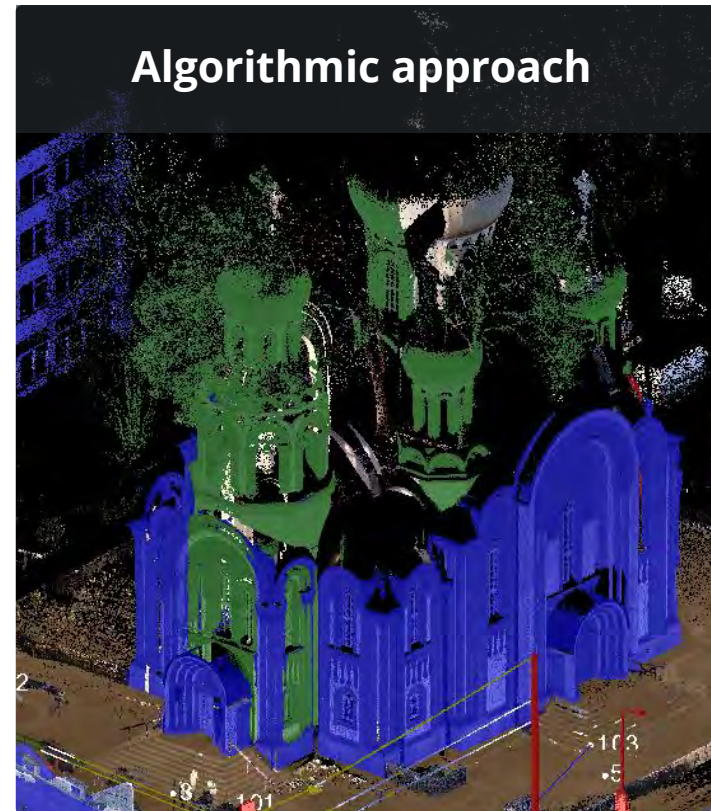


Deep Learning model to Classify Assets

**For algorithm-based approach,
diversity is problem;**

**For deep learning approach, it is
an opportunity to learn**

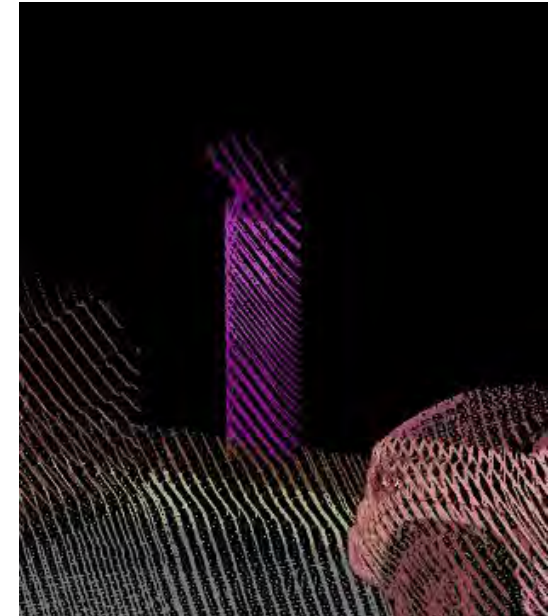
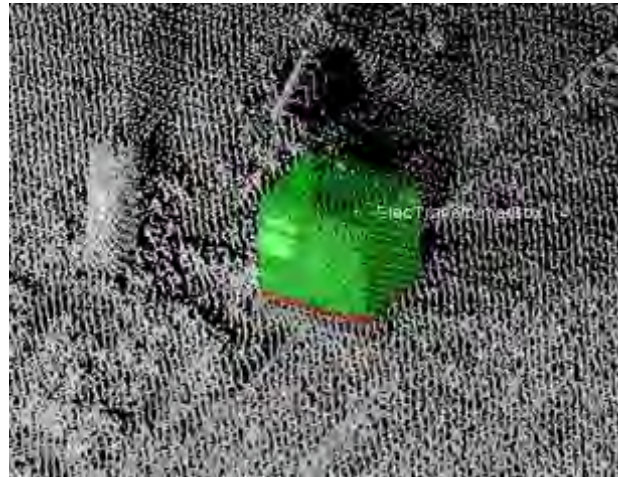
- **Flexibility** without constraints
- Overcome limitations even for **complex objects and scenes**
- Easily **customizable** solutions
- **Reliable input** for automated and manual **feature extraction**



Train and Create Assets Transportation Models

Create an Asset Library by training data (Point Cloud and Imagery)

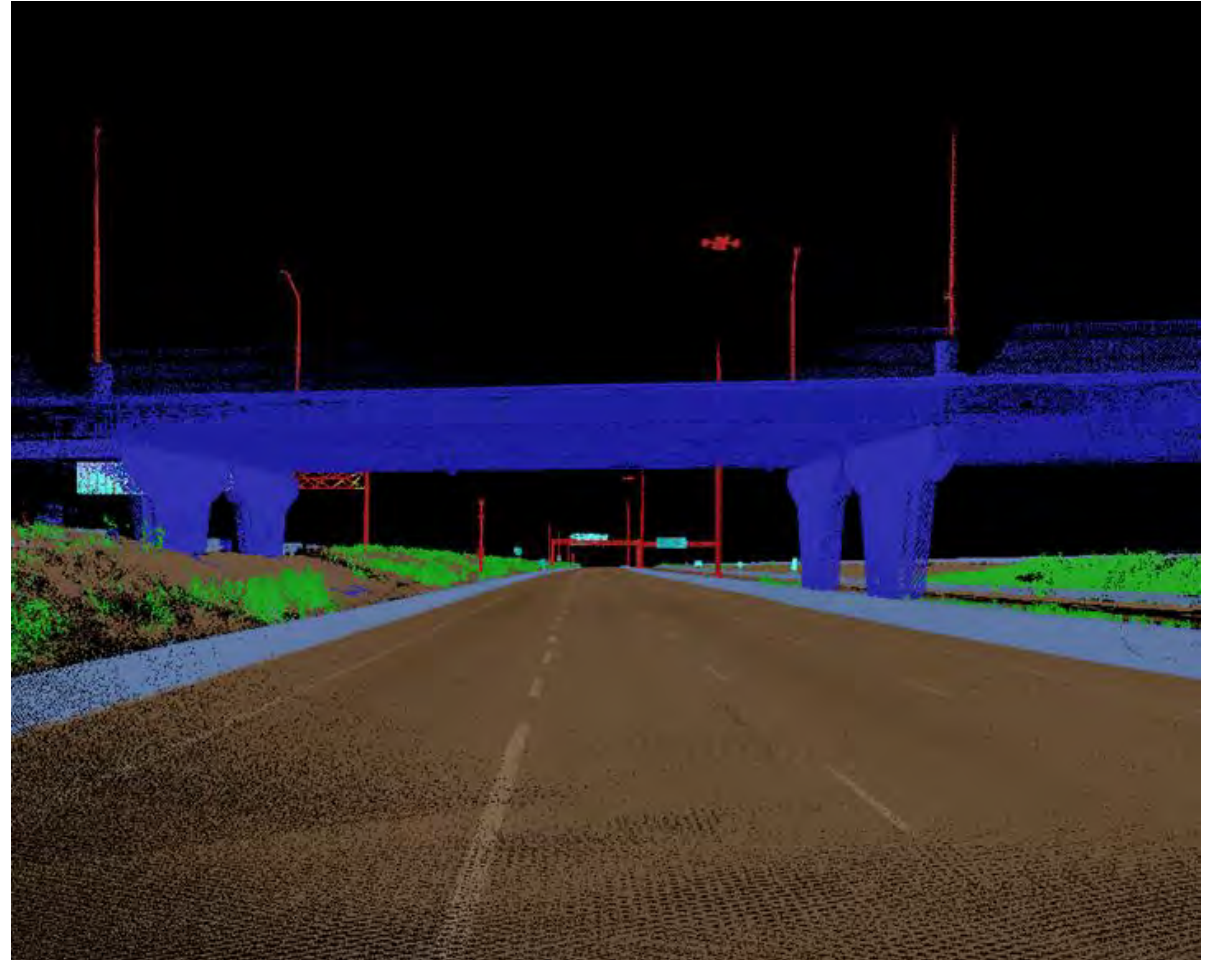
- Provinces
- Major Cities
- Department of Transportation
- Roads
- Highways
- Clients Sites
- Government
- Airports



Train and Create Assets Transportation Models

Why using deep learning to classify non-pre-defined point cloud classes?

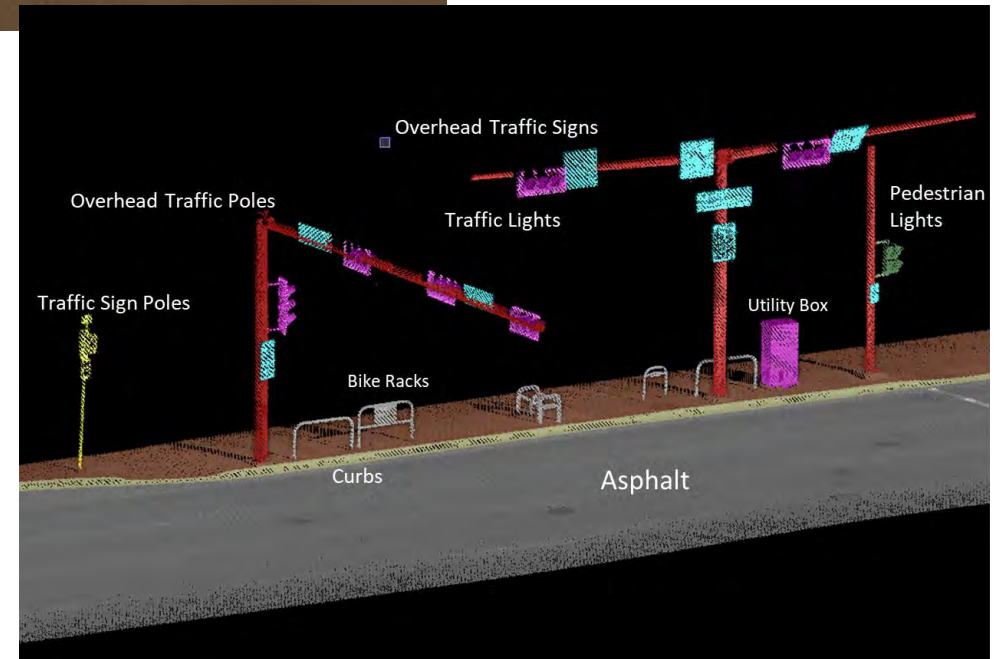
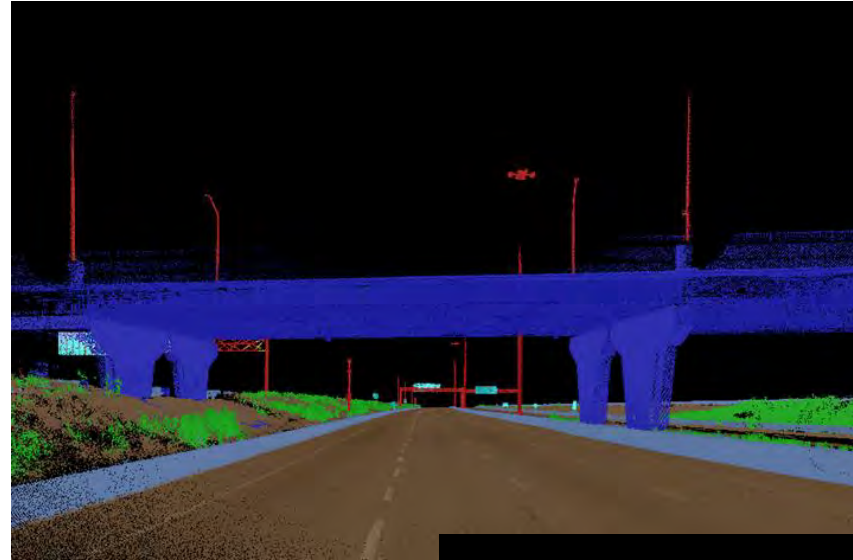
- Save time when uploading, downloading or sharing Point Cloud among the production team
- Make it easier to extract linear features using less clean data and save time
- Classify specific assets
- Reduce the time searching for the assets along the corridor
- Extracted assets can be used to extract location and attributes of these assets automatically using AI again
- Solve the tasks specific to **each domain** and **geographic location**



Train and Create Assets Transportation Models

Asset Management (Examples)

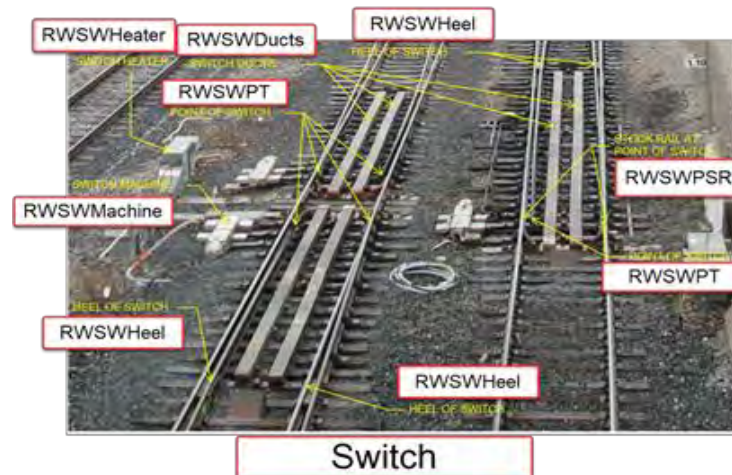
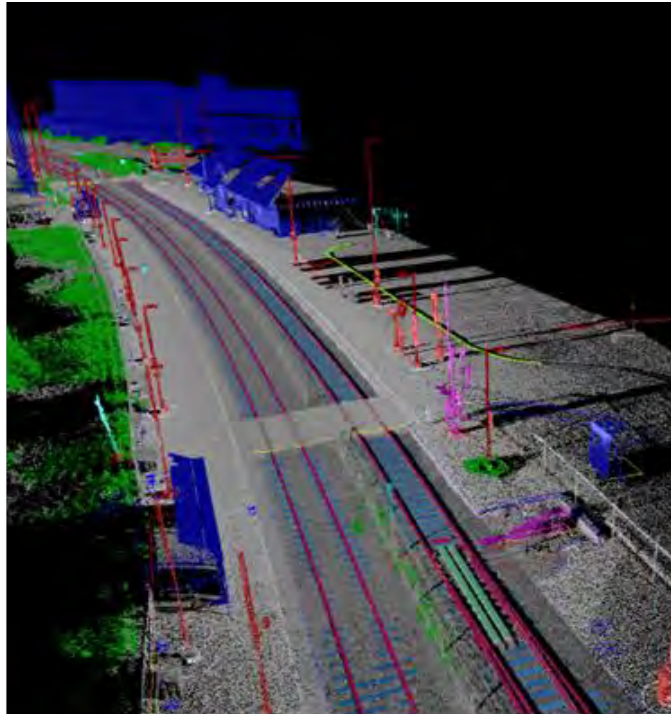
- Differentiate types of Poles; Lights only, Traffic only,
- Utility Box
- Fire Hydrant
- Traffic Signs
- Traffic Lights
- Pedestrian Lights
- Lights
- Electric Power Poles parts: Insulator; crossarm; transformer; Guy wire
- Bus Stop
- Benches
- Bins, Bollards & Bicycle Parking
- Jersey Barrier
- Overhead Traffic Sign
- Overhead Traffic Poles
- Different types of Poles
- Traffic Signs on Poles
- Bridge Deck
- Overhead Power/Communication Lines



Train and Create Assets Transportation Models

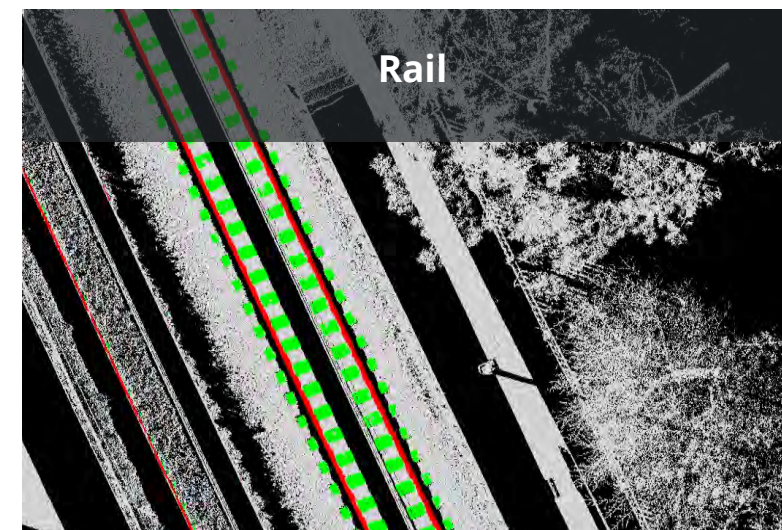
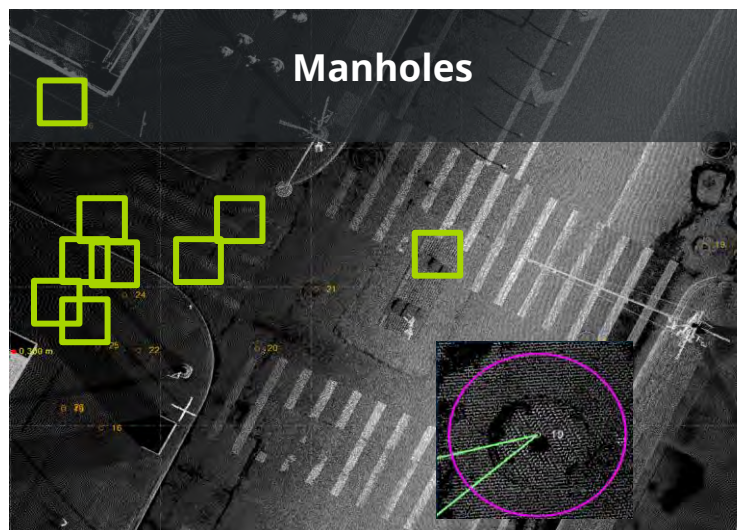
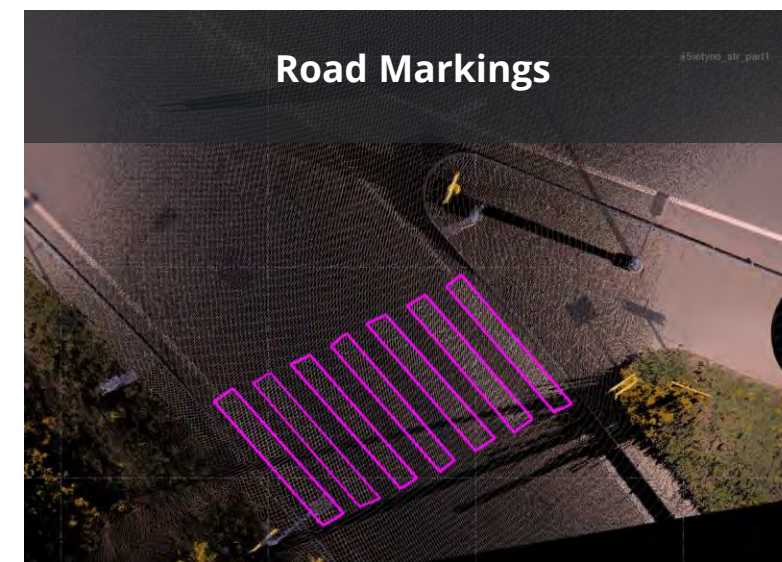
Asset Management LRT/Railway (Examples)

- Ballast
- Sleeper
- Tracks
- Switch Machine
- Switch Ducts
- Railway Junction Box
- Traffic Signs
- Traffics Light/Pole
- Power Pole
- Railway Bump
- Bridge Decks



Train and Create Assets Transportation Models

- Automatic Feature Extraction powered by fusion of various AI techniques.
- Fast & easy extraction of attributes and geometry of each individual object with minimal user interaction



Automated Pavement Condition Inspection Using AI

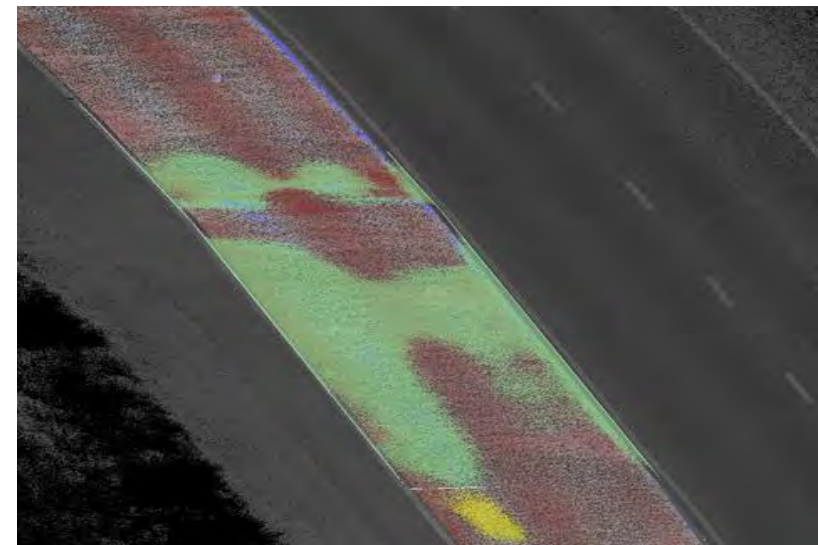
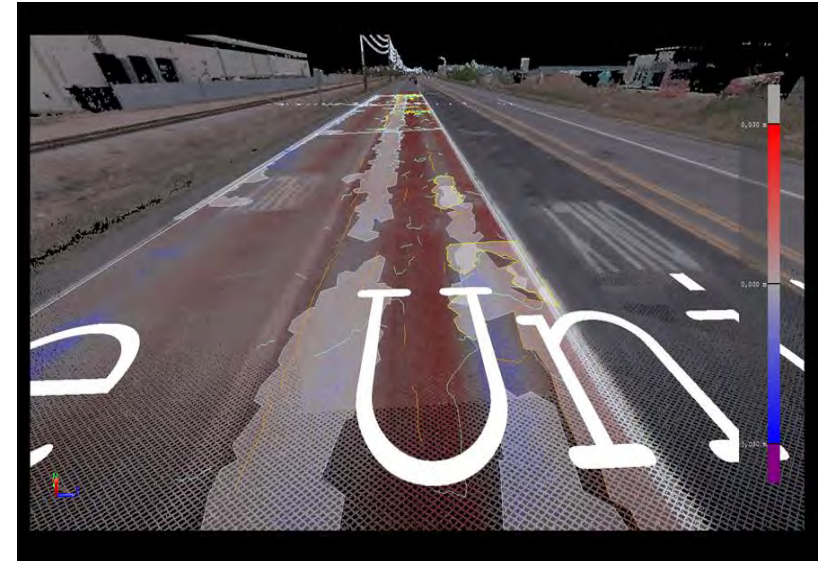
- Comprehensive, highly-automated workflow tailored for mobile mapping users
- Leveraging point cloud and image data to detect and classify broad spectrum of road conditions including automated crack detection
- Pavement Condition Index calculation and reporting based on internationally recognized ASTM standard

Detect

- Depression
- Pothole
- Bump
- Rutting
- Corrugation
- Alligator Cracking
- Trans./Long. Cracking
- Other Types of Cracks

Classification

- **Low**
- **Medium**
- **High**



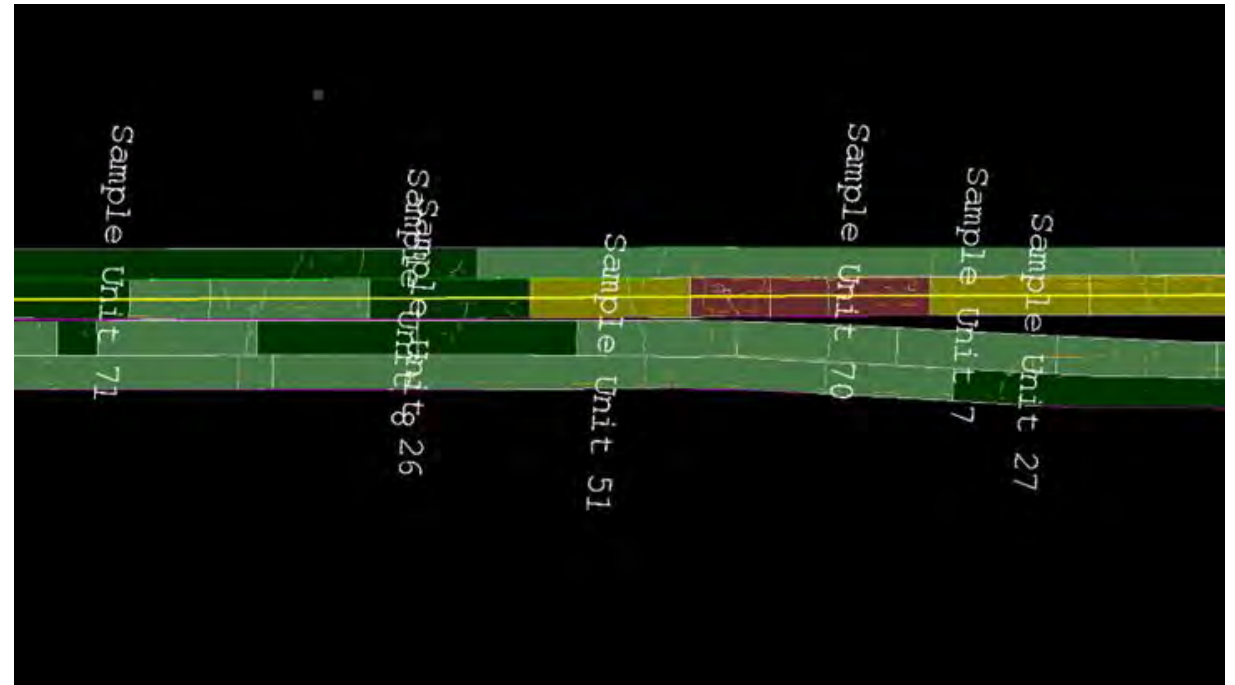
Automated Pavement Condition Inspection Using AI

Pavement Condition Inspection Report

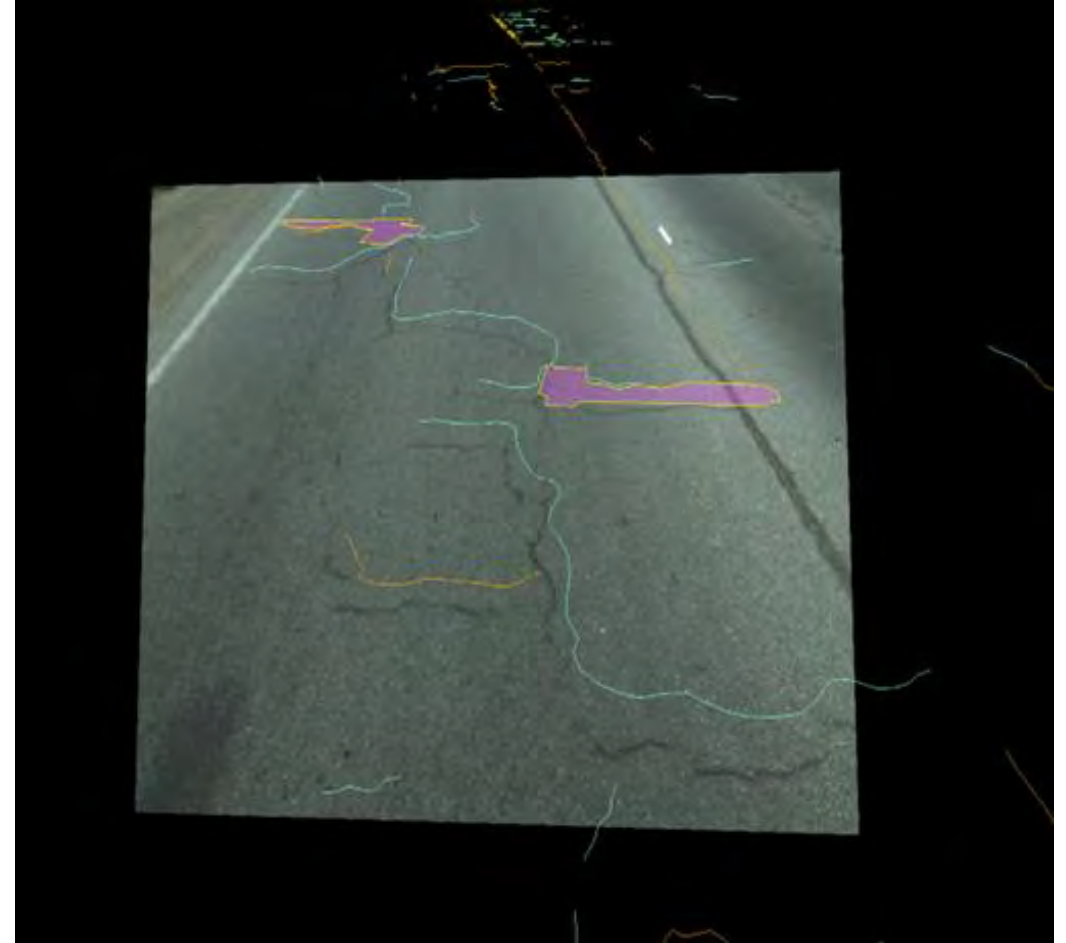
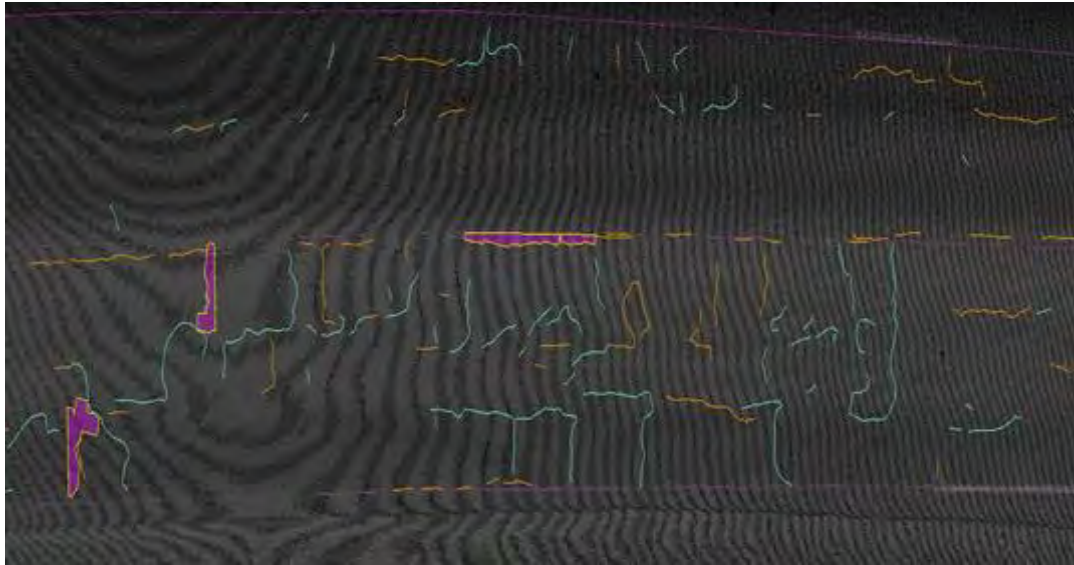
Project file data		Coordinate System	
Name:	D:\Pavement_Analysis Test \\TMX9318061402-000587 - MX9_Demo \\TBC 7\Pavement_Analysis_DemoBPT.vce	Name:	Canada/NAD 1983
Size:	572 KB	Zone:	Modified TM Zone 07
Modified:	9/26/2023 9:42:09 AM (UTC-6)	Datum:	NAD 1983 (Canada)
Time zone:	Mountain Standard Time	Global reference datum:	NAD83(CSRs)v7
Reference number:		Global reference epoch:	2010
Description:		Geoid:	Canada Geoid Model HT2_0
Comment 1:		Vertical datum:	
Comment 2:		Calibrated site:	
Comment 3:			

PCI Rating	Good
PCI Score	86
Total Fill Volume (m ³)	0.09
Total Cut Volume (m ³)	-0.64

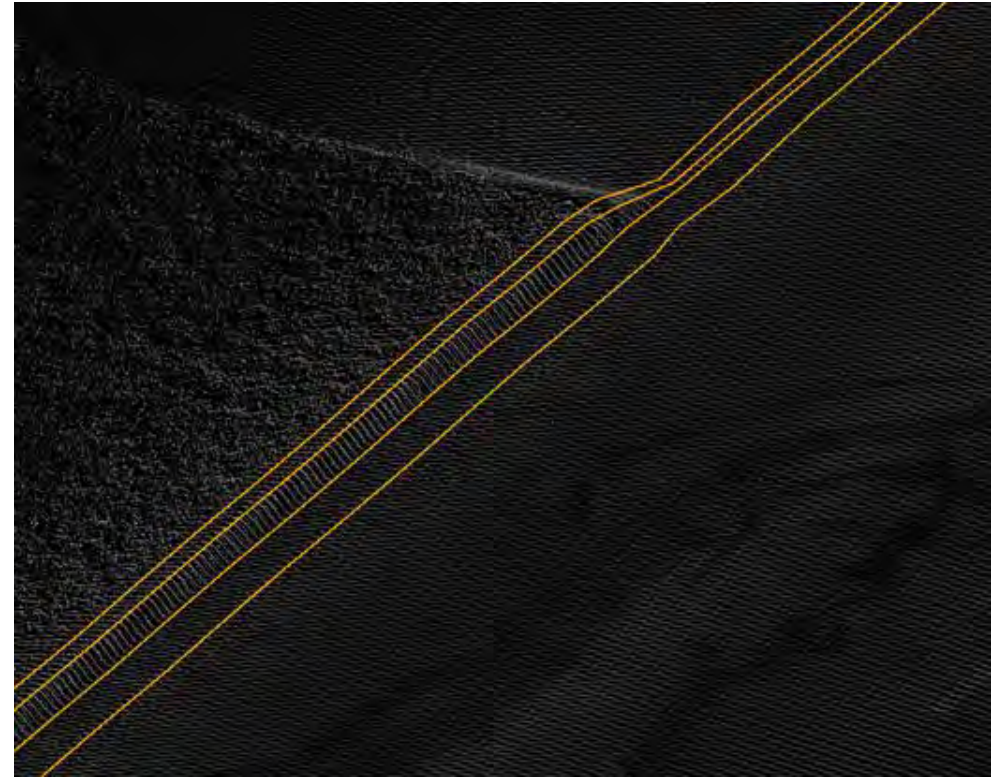
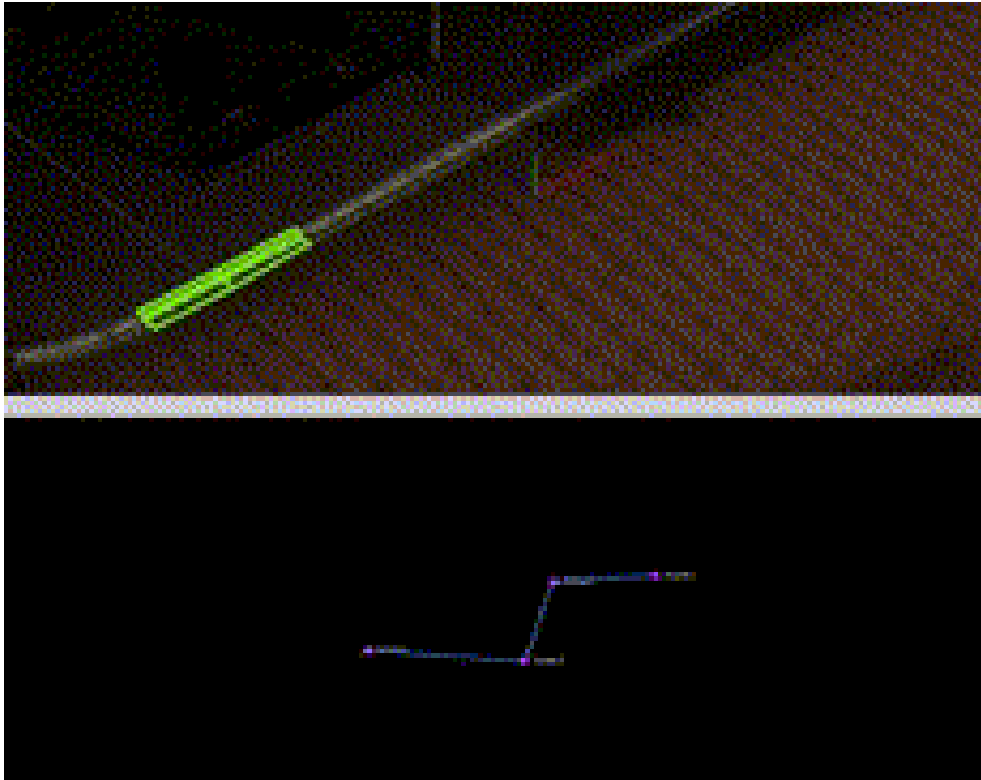
Sample Unit	Number of Segments	Area (m ²)	PCI Rating	PCI Score	Distress Types	Fill Volume (m ³)	Cut Volume (m ³)
Sample Unit 0	4	231.81	Good	89	Alligator Cracking, Rutting, Transv./Long. Cracking	0.00	-0.02
Sample Unit 1	4	230.53	Good	100	Transv./Long. Cracking	0.00	0.00
Sample Unit 2	5	240.25	Satisfactory	76	Other Cracking, Transv./Long. Cracking	0.00	0.00
Sample Unit 3	5	241.64	Good	100	Transv./Long. Cracking	0.00	0.00
Sample Unit 4	4	230.79	Satisfactory	80	Other Cracking, Transv./Long. Cracking	0.00	0.00
Sample Unit 5	4	243.77	Satisfactory	72	Other Cracking, Rutting, Transv./Long. Cracking	0.00	-0.01



Automated Pavement Condition Inspection Using AI

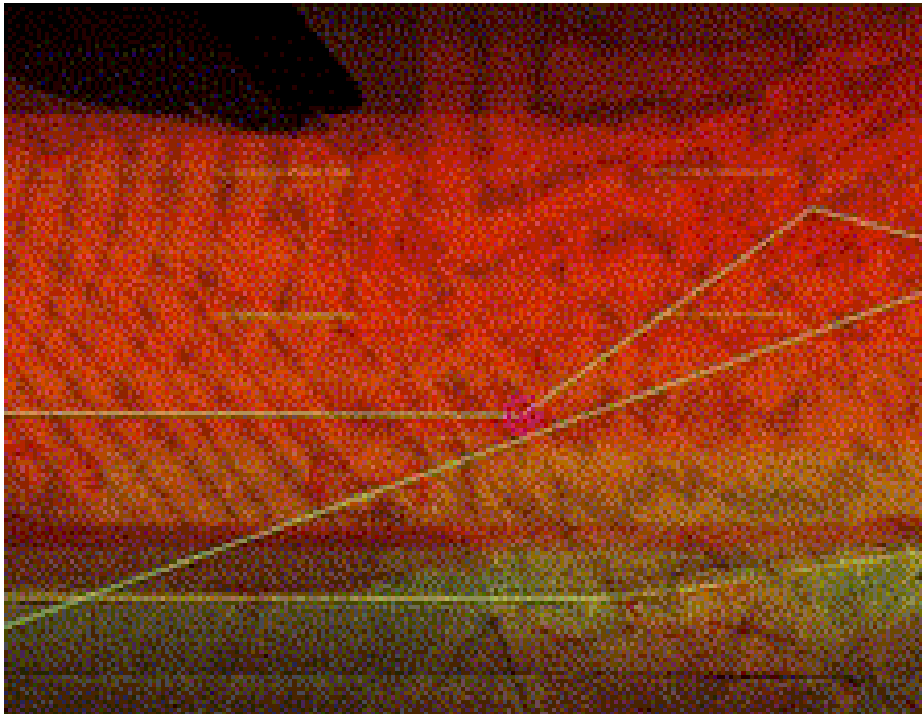


Feature Extraction Using AI

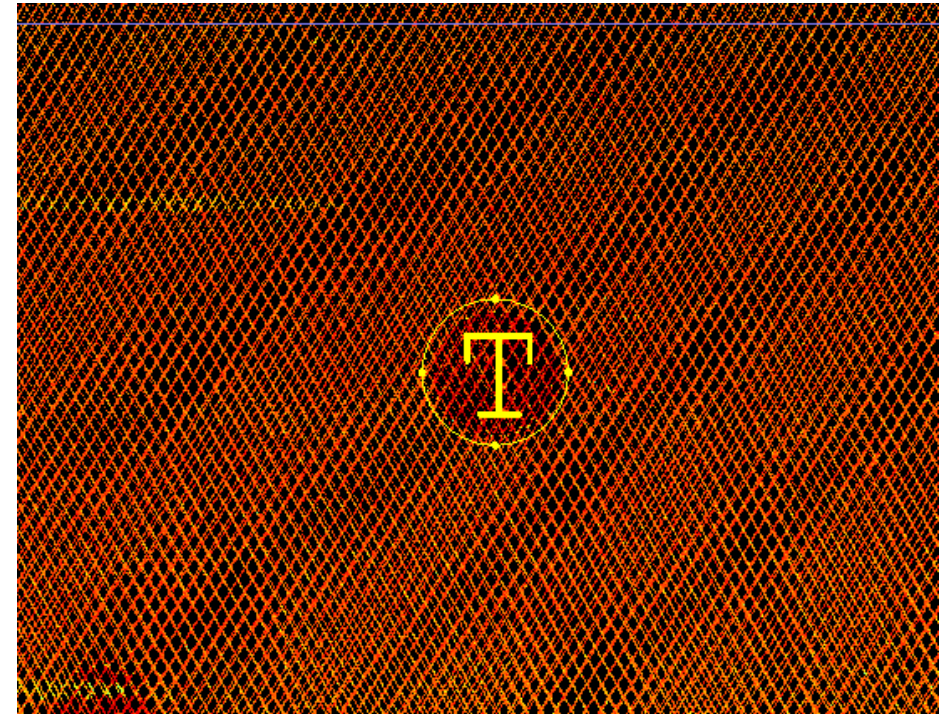


Curbs and Gutters

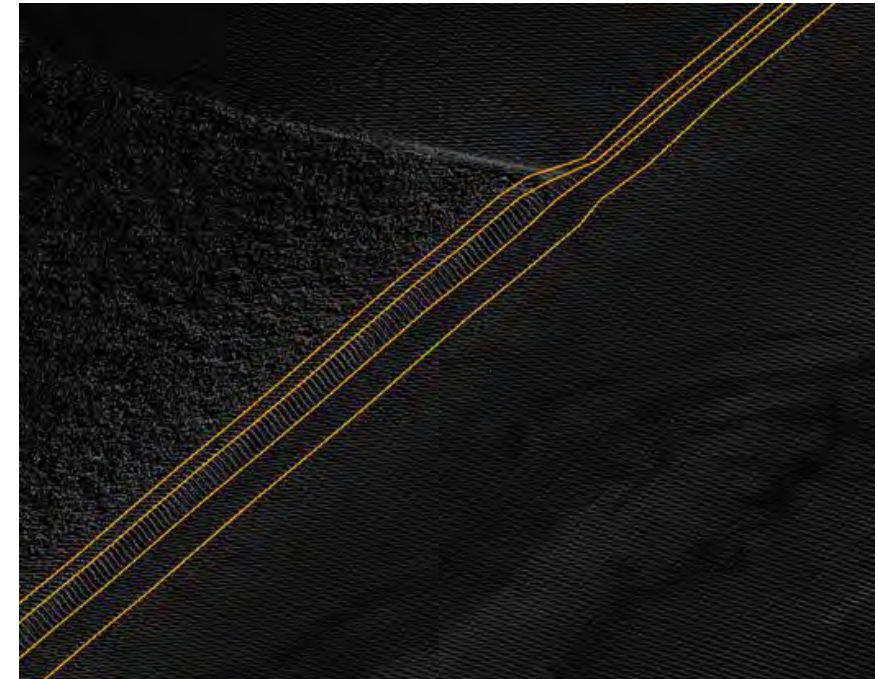
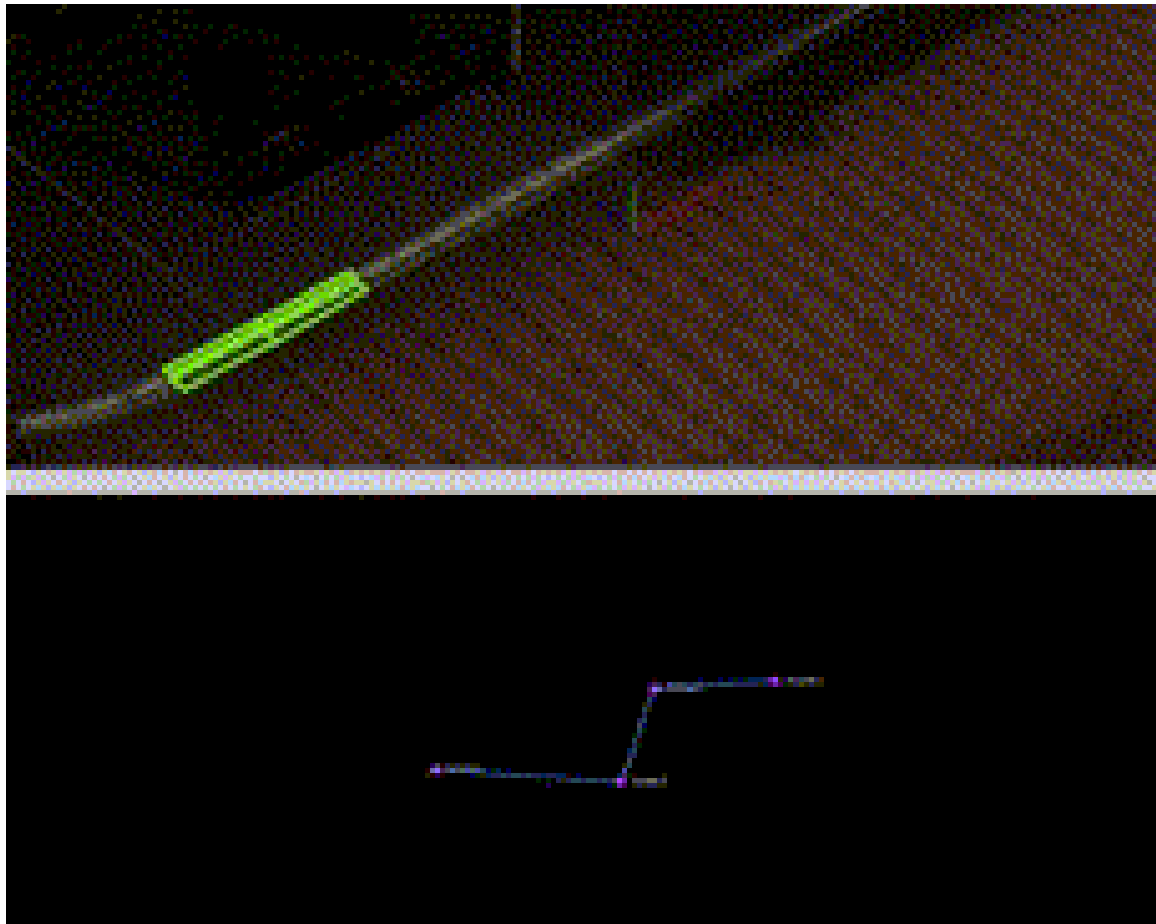
Feature Extraction Using AI



Manholes

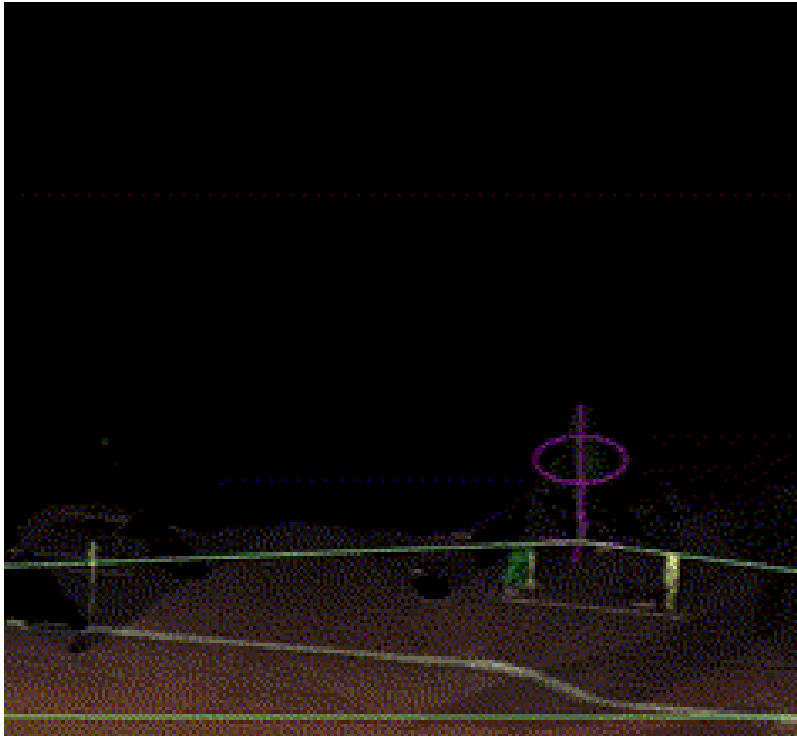


Feature Extraction Using AI

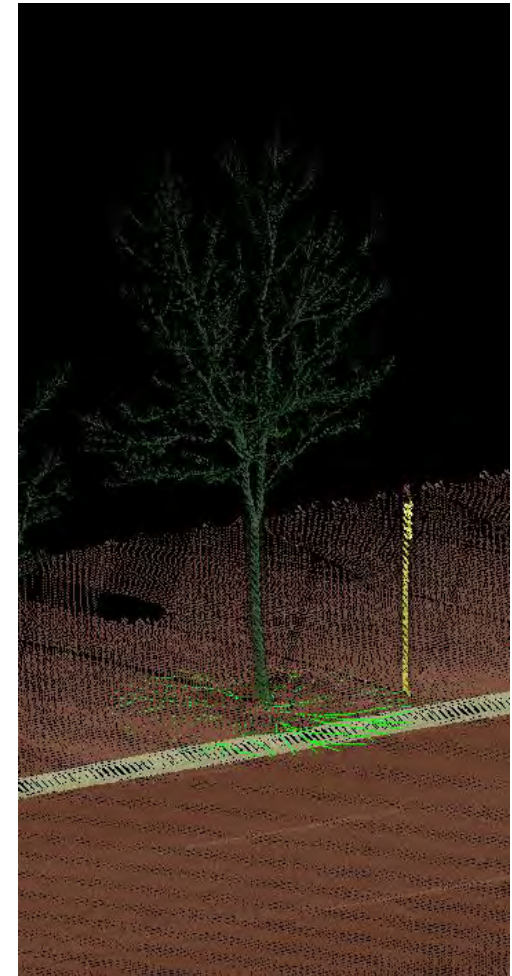
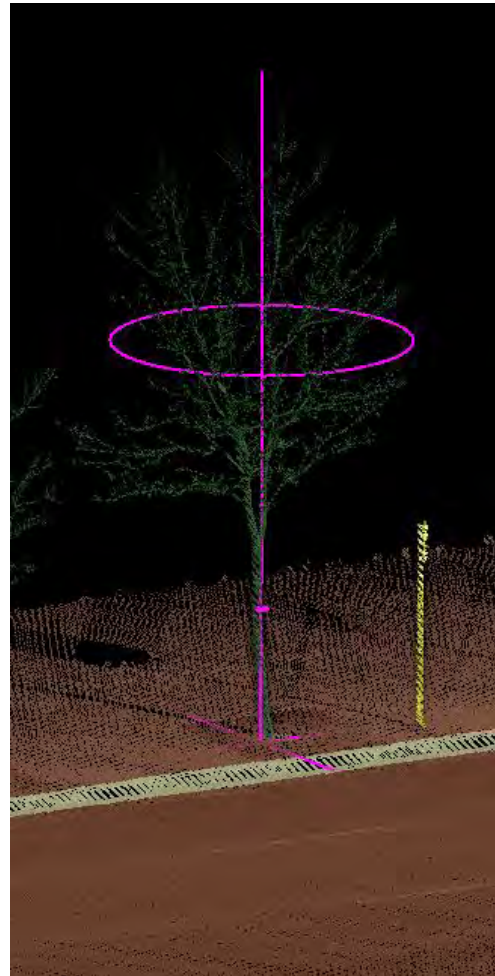


Curbs and Gutters

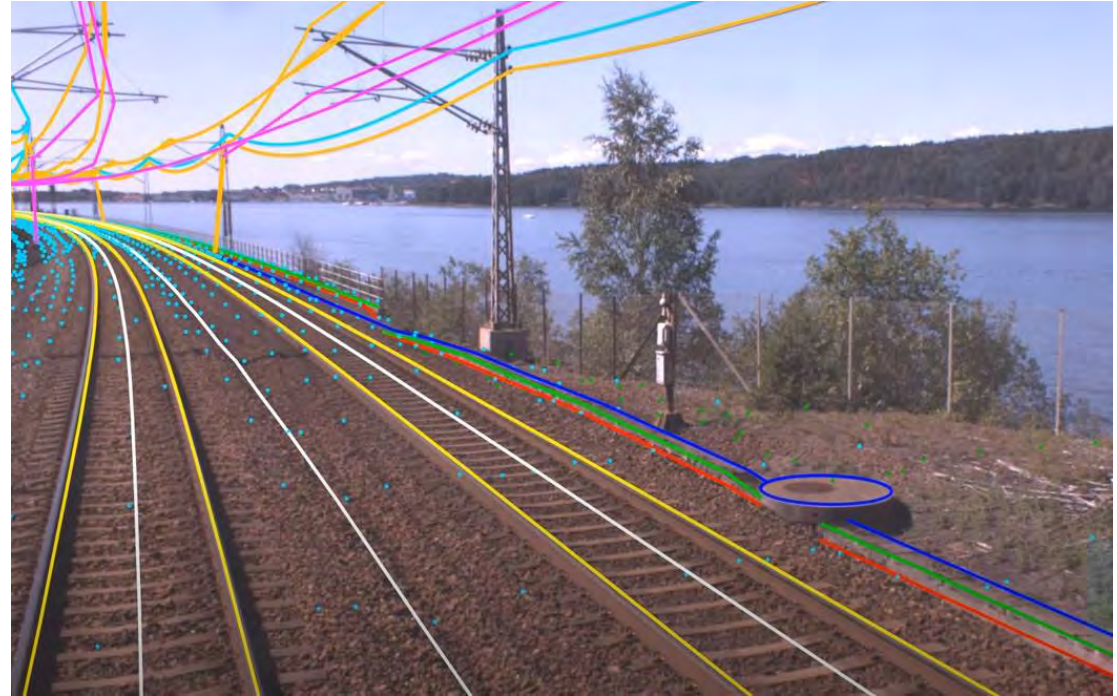
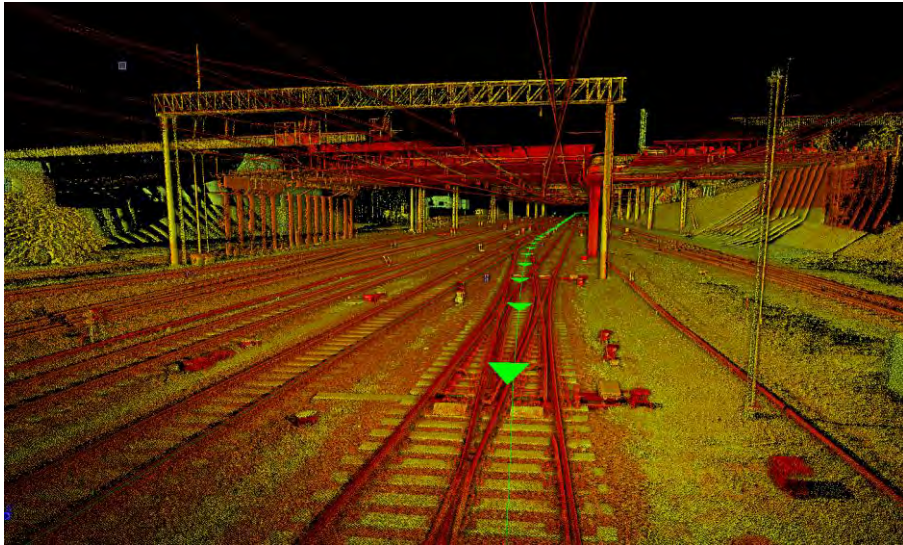
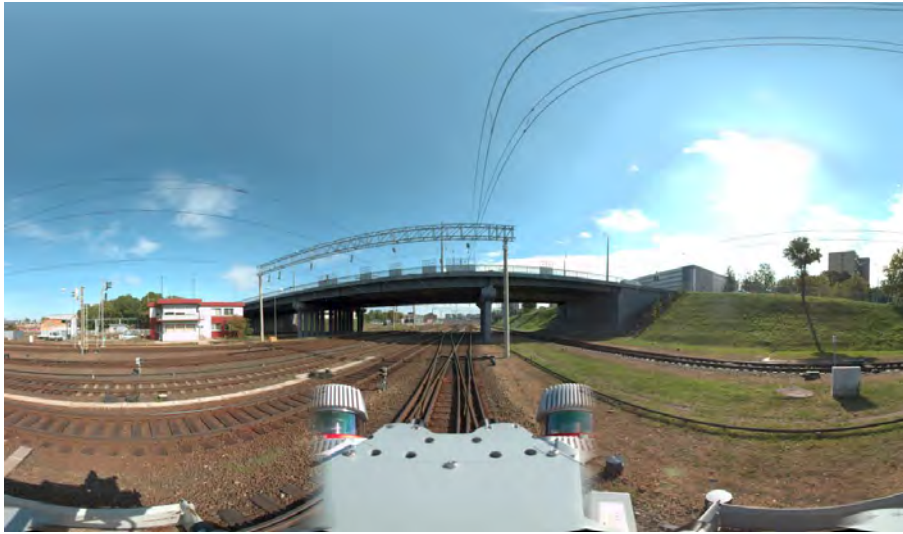
Feature Extraction Using AI



Trees



Feature Extraction Using AI



Rail Assets

Feature Extraction Using AI

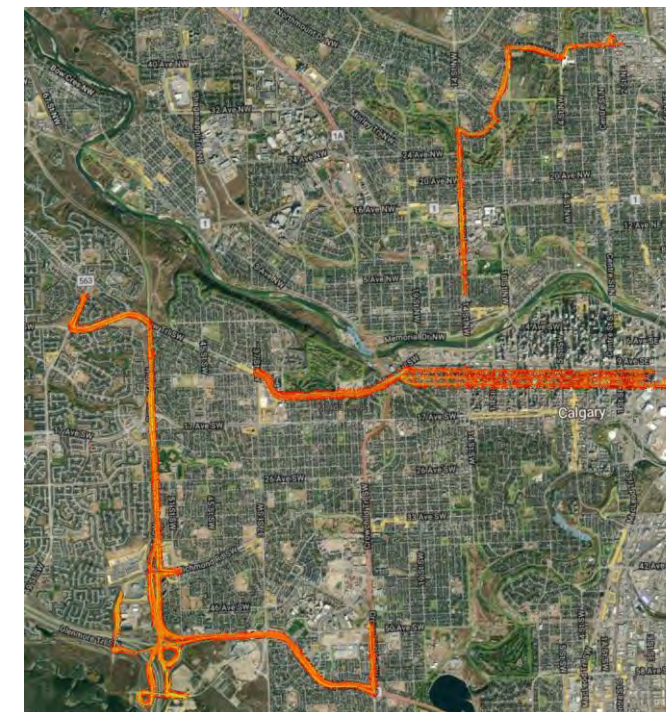
Manhole

- Humid ground is problem
- Approximately 100 % of the manholes on the 8 Km streets were identified
- Approximately 90 % of the manholes outside of the streets (Sidewalks) were identified
- 9% false positives

Curbs and Gutter

- 8km continuous line in 55 min

Features	Accuracy	False Positive
Fire Hydrant	100%	08%
Garbage Bin	100%	11%
Utility Box	98%	16%
Traffic Lights	93%	14%
Traffic Signs	100%	9%
Bicycle Parking	100%	3%
Traffic Poles	100%	0%
Pedestrian Lights	96%	04%

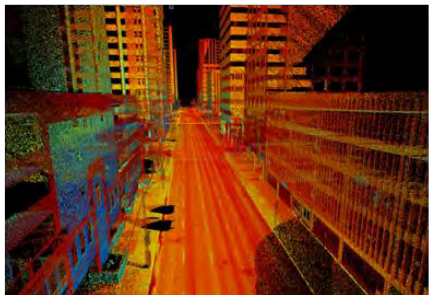
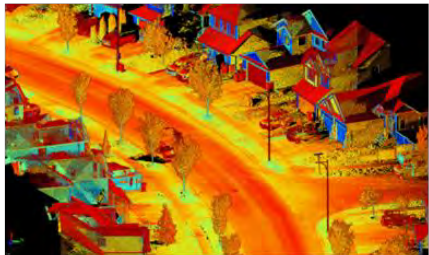


City Environment
 Points: 10,000,000,000.00
 Classification Time: 49 min

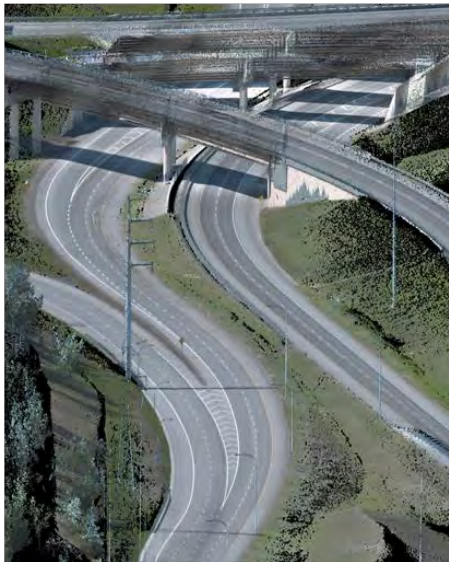
AI – Efficiency Results

- **Enhance Productivity:** Delegate monotonous, repetitive tasks to always-on machines, freeing up human talent for complex, high-value work.
- **Lower Service Costs:** Streamline operations to cut down expenses.
- **Accelerated Client Deliveries:** Deliver services to clients more rapidly.
- **Improved Accuracy and Reliability:** Ensure precise feature extraction and point cloud classification.
- **Simplified Software Deployment:** Use fewer, more specialized software solutions tailored to specific regions and client types.

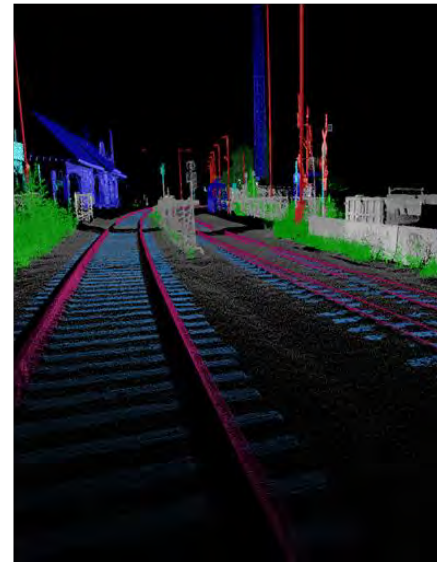
Municipalities



Highways



Railroads





Thank you

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