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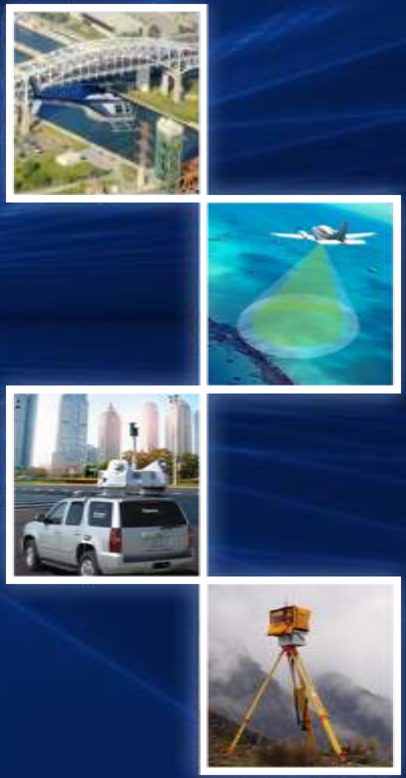
LATIN AMERICA GEOSPATIAL FORUM

Quality Assurance and Quality Control Procedures for Survey-Grade Mobile Mapping Systems

Presenter: Albert Iavarone

Latin America Geospatial Forum
November, 2015



Accuracy & Productivity Matter

Agenda

1. **Who is Teledyne Optech**
2. **The Lynx Mobile Mapper**
3. **Mobile Mapping vs. Mobile Surveyor**
4. **LMS Pro: Quality Assurance**
5. **LMS Pro: Quality Control**
6. **Executing Difficult projects**

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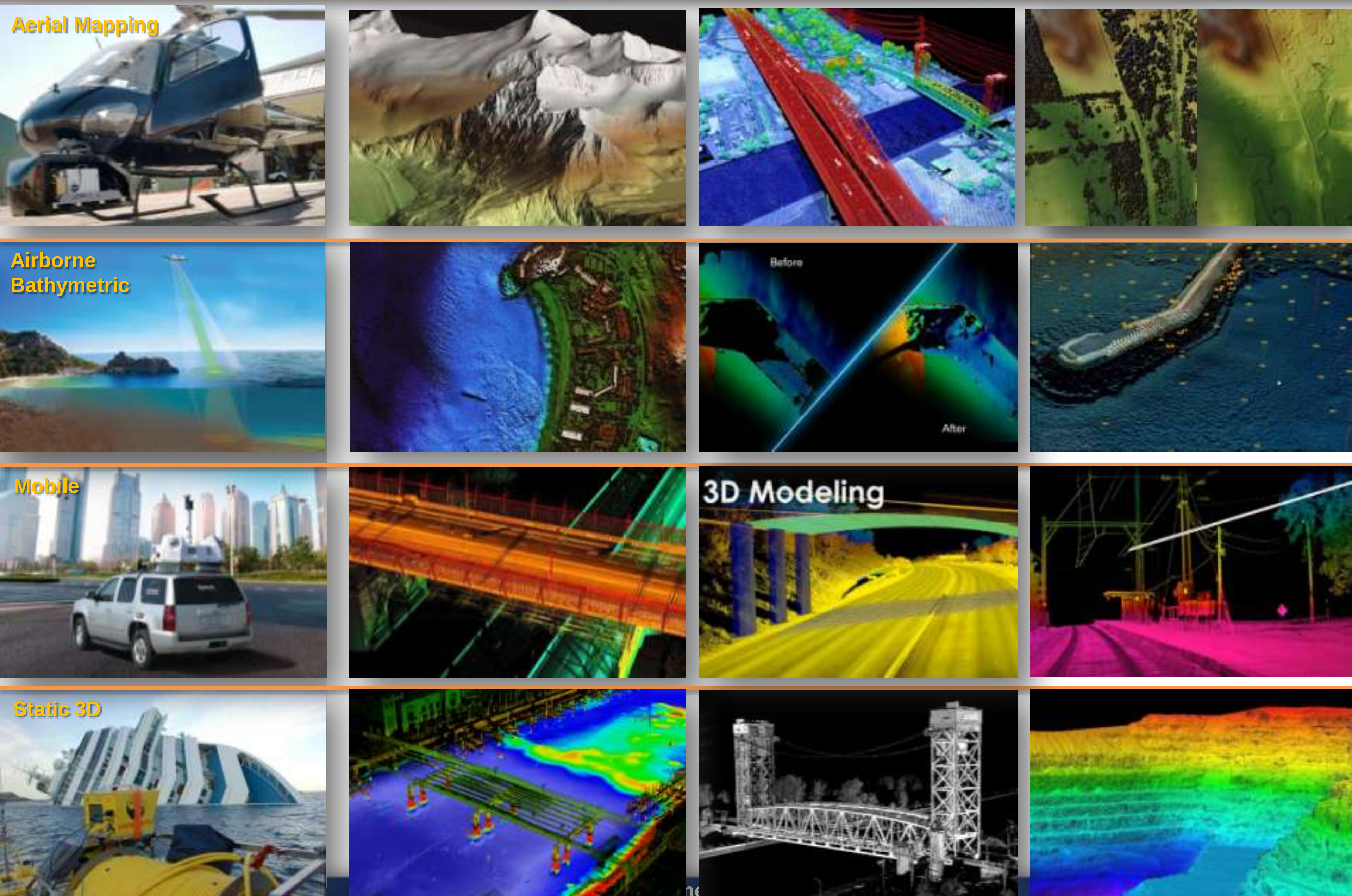
Accurate 3D Mapping Solutions



Lynx MG & SG-S Mobile Systems

- High density & Accuracy
- Easy Installation
- Ideal for Asset Management

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Mobile Lidar

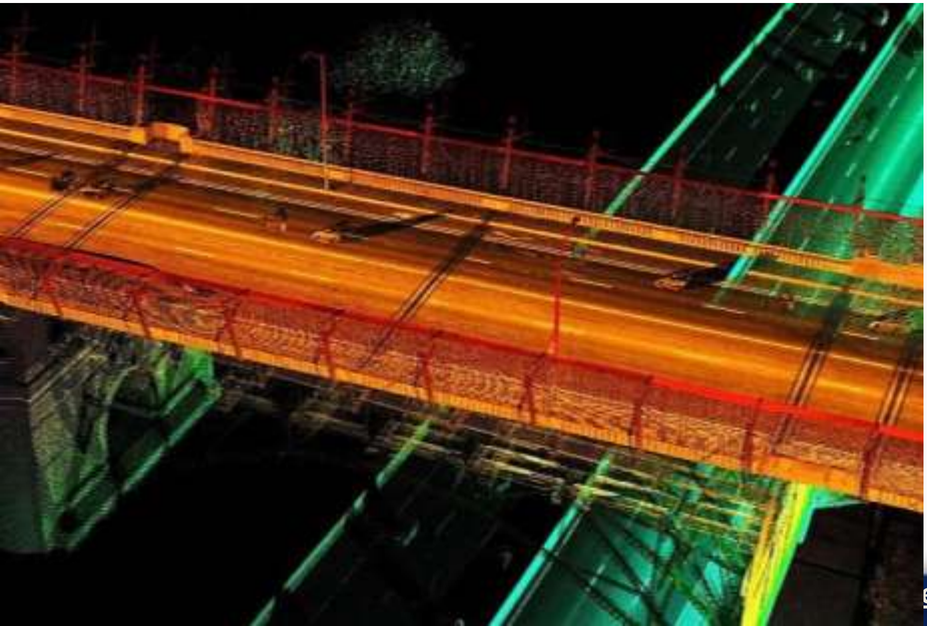
Demonstrations Available Outside

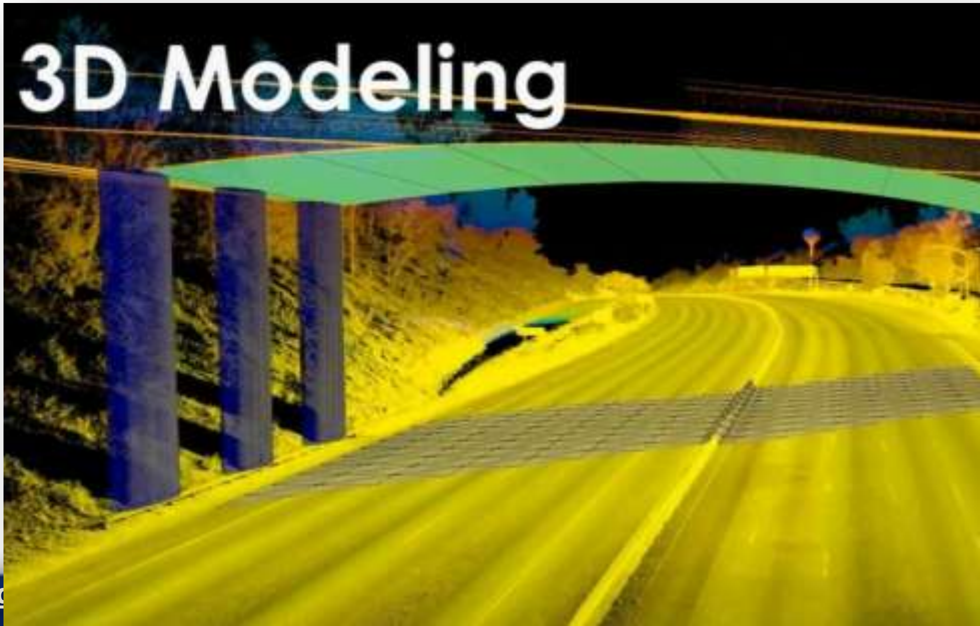
Lynx SG1

- Accurate measurement moving vehicle
- Engineering Grade CAD
- Collect at Hwy Speeds

Lynx System

1.2 Million Points/Sec & cm accuracy

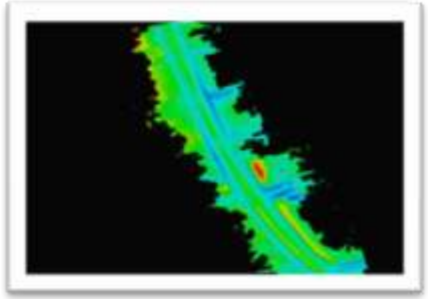




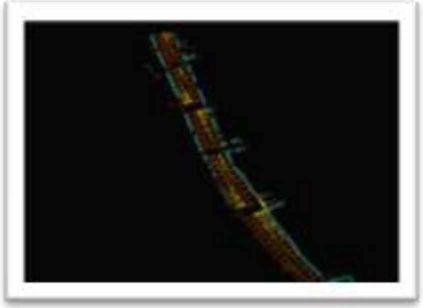
Generated Deliverables

What information can be generated from the data?

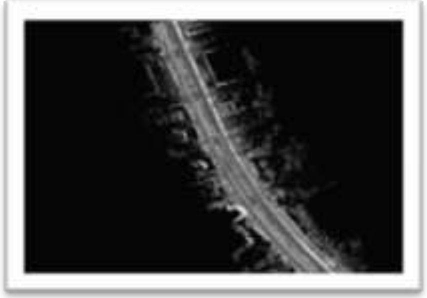
Raw Point Cloud



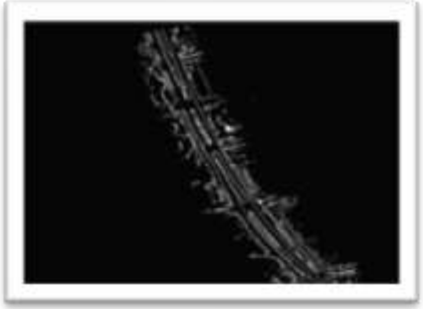
Digital Elevation Model



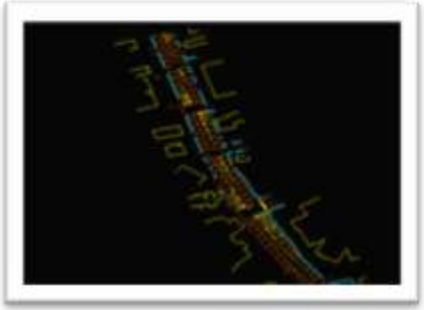
Roads & Sidewalks



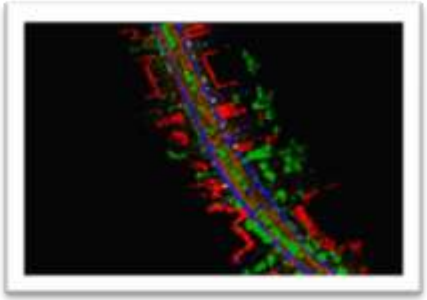
Intensity Point Cloud



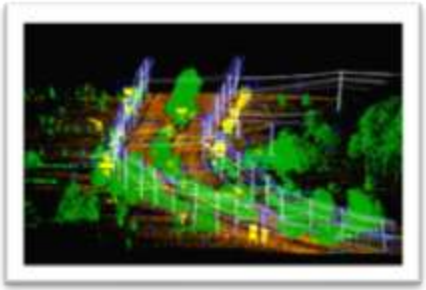
Contours



Building/Improvements



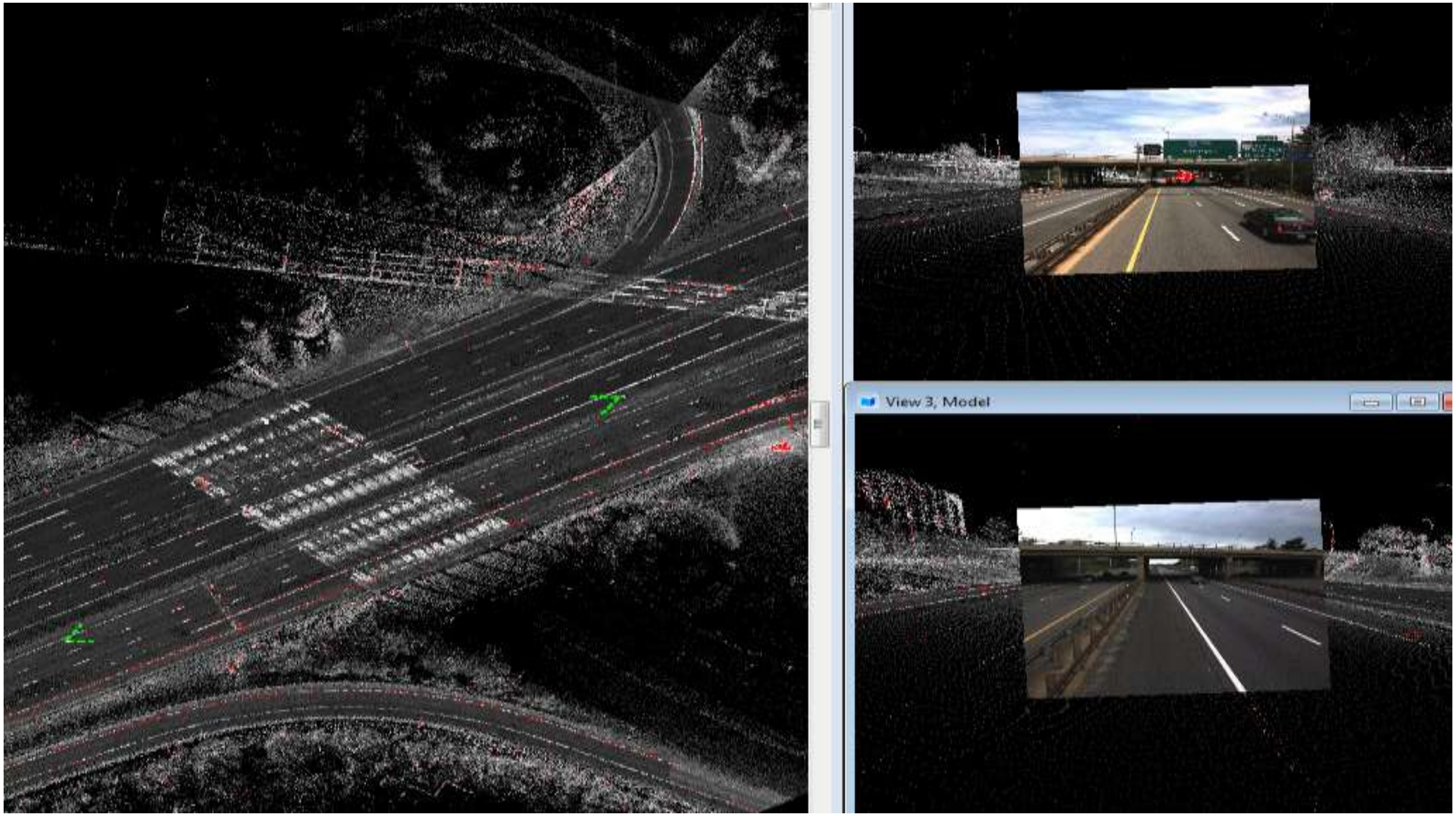
Classified Point Cloud



Linear Utilities

Complete Planimetrics

Feature Extraction

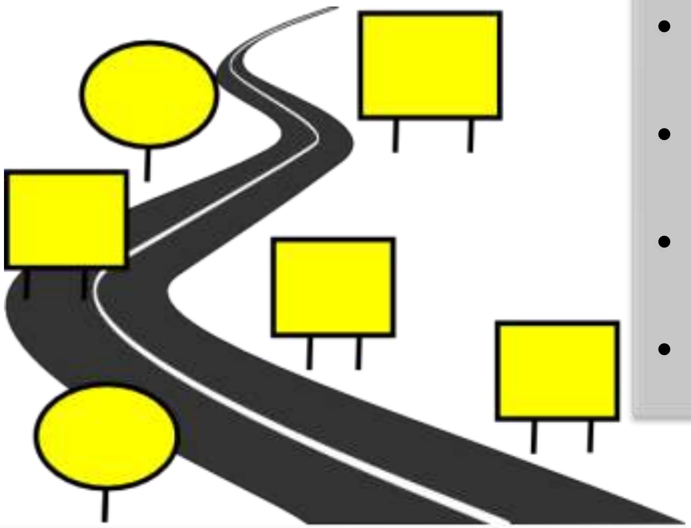


- Photos used to aid feature identification
- Also aids in project navigation due to better visuals

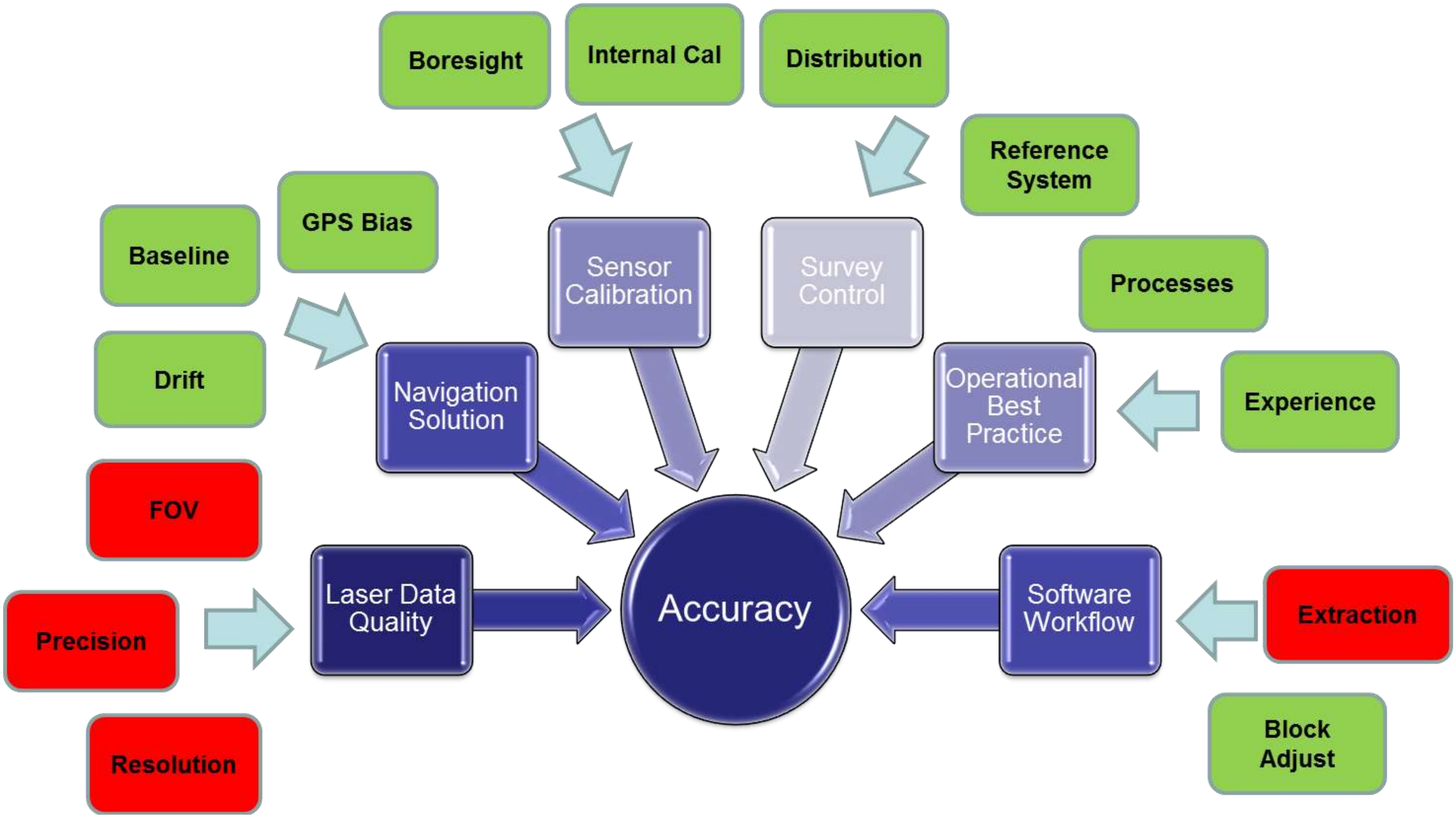
Mobile Mapping Systems: Types

- Available systems can be classified as “mapping-grade” or “survey-grade” depending on the system’s attainable accuracy.

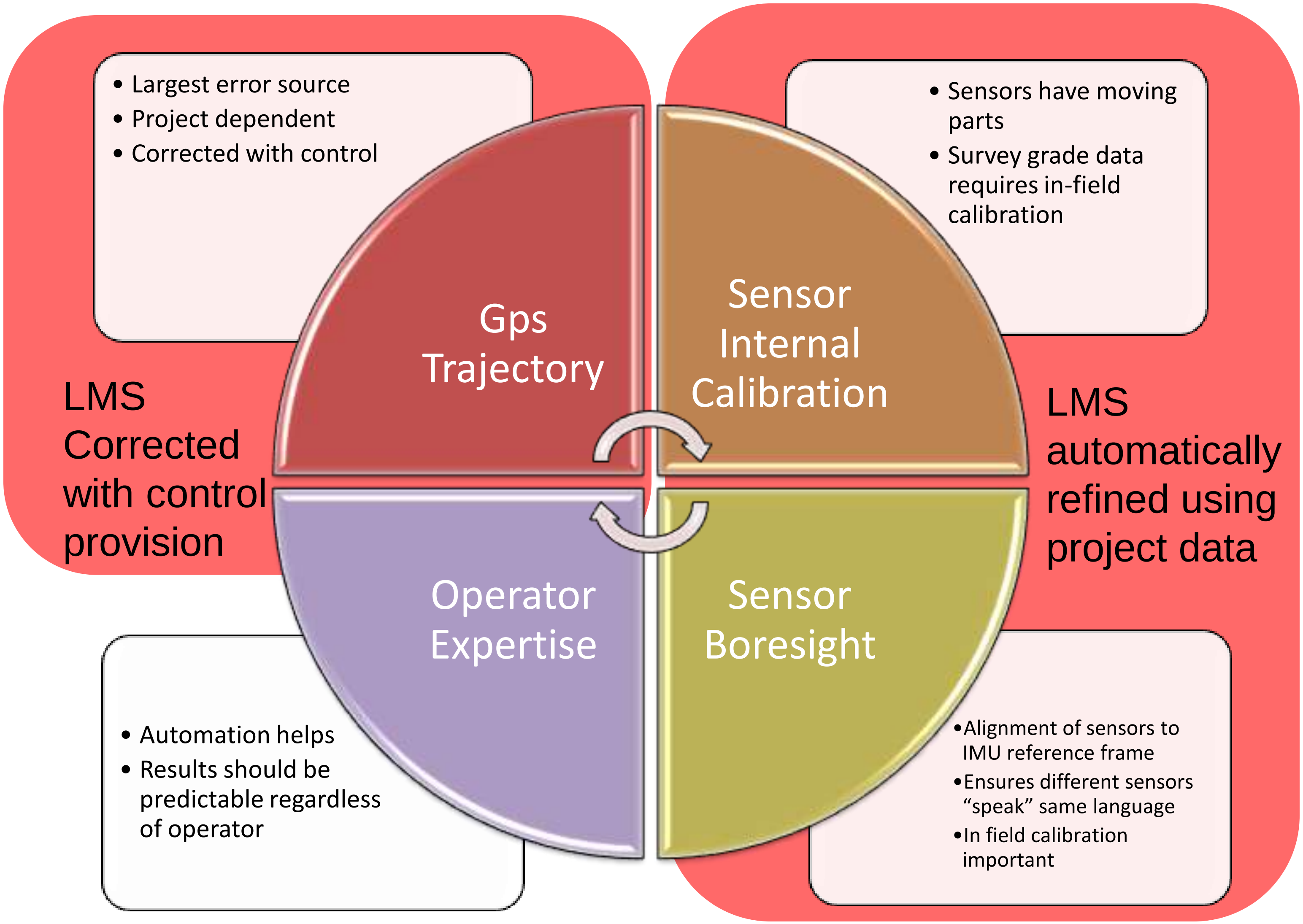
Survey Projects	Mapping Projects
• Smaller project size • 1-3cm absolute accuracy • 5mm relative accuracy • Control survey required • Validation of accuracy mandatory • Engineering drawings a typical deliverable • Higher cost per mile	• Typically large projects • Absolute accuracy 10-20cm • Relative accuracy 2cm • Control not required • Asset database a typical deliverable • Lower cost per mile



Factors Affecting Accuracy



LMS: *Understanding Major Error Sources*



Teledyne Optech Philosophy

Hardware

- Best of class lidar
- Best of class positioning
- Excellent support

Software

- Improve project accuracy
- Designed for production
- Project validation

Combining Sensor and Efficient Workflow

LMS Pro Overview

Teledyne Optech LMS Pro: Positioned as a hub for processing the entire project

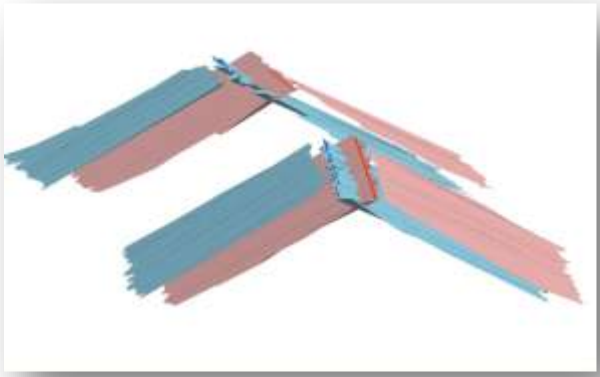
Primary Data Processing Environment

Quality Assurance	Accuracy Optimization
Quality Control	Project Validation
Project Productivity	Minimum Processing Time
Interoperability	Output project data in compatible format to third party software

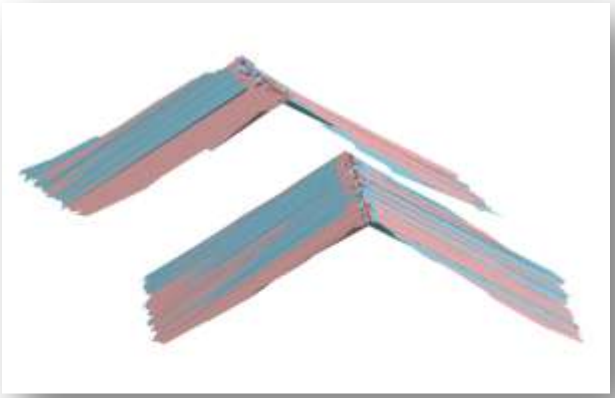
LMS Pro Self-Calibration: Methodology

- **LMS Self-Calibration Engine:**
  - Improve compatibility between overlapping lidar passes and their absolute accuracy
  - Achieve the potential accuracy of the lidar system

Before self-calibration



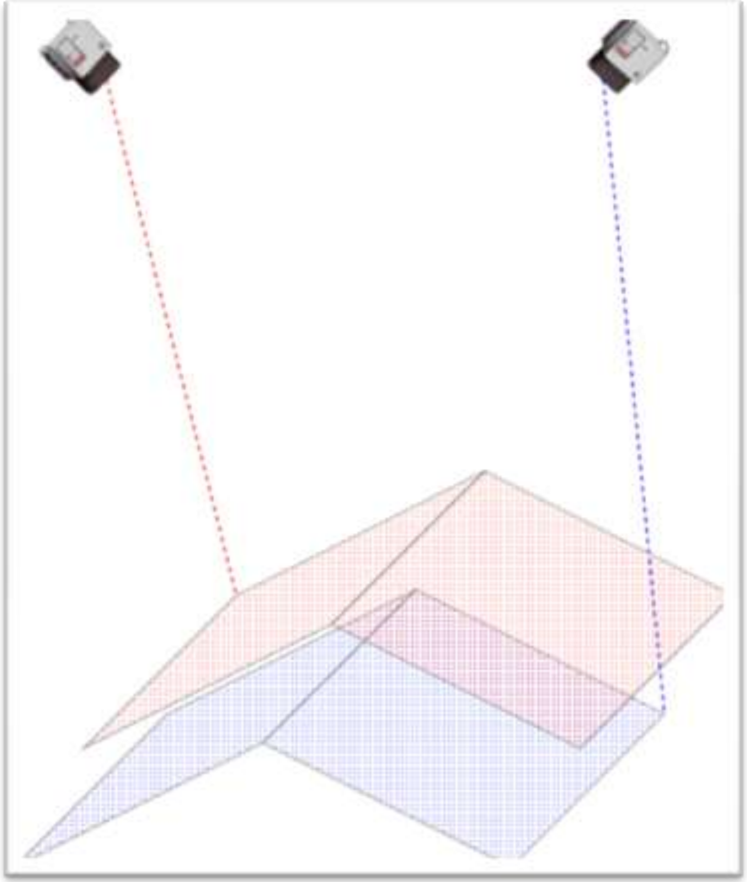
After self-calibration



LMS Pro Self-Calibration: Methodology

- **Objective:**
  - Estimate corrections to the instrument calibration parameters and system observations
- **Conceptual Basis:**
  - Block adjustment using planes as tie features and the lidar rigorous geometric model

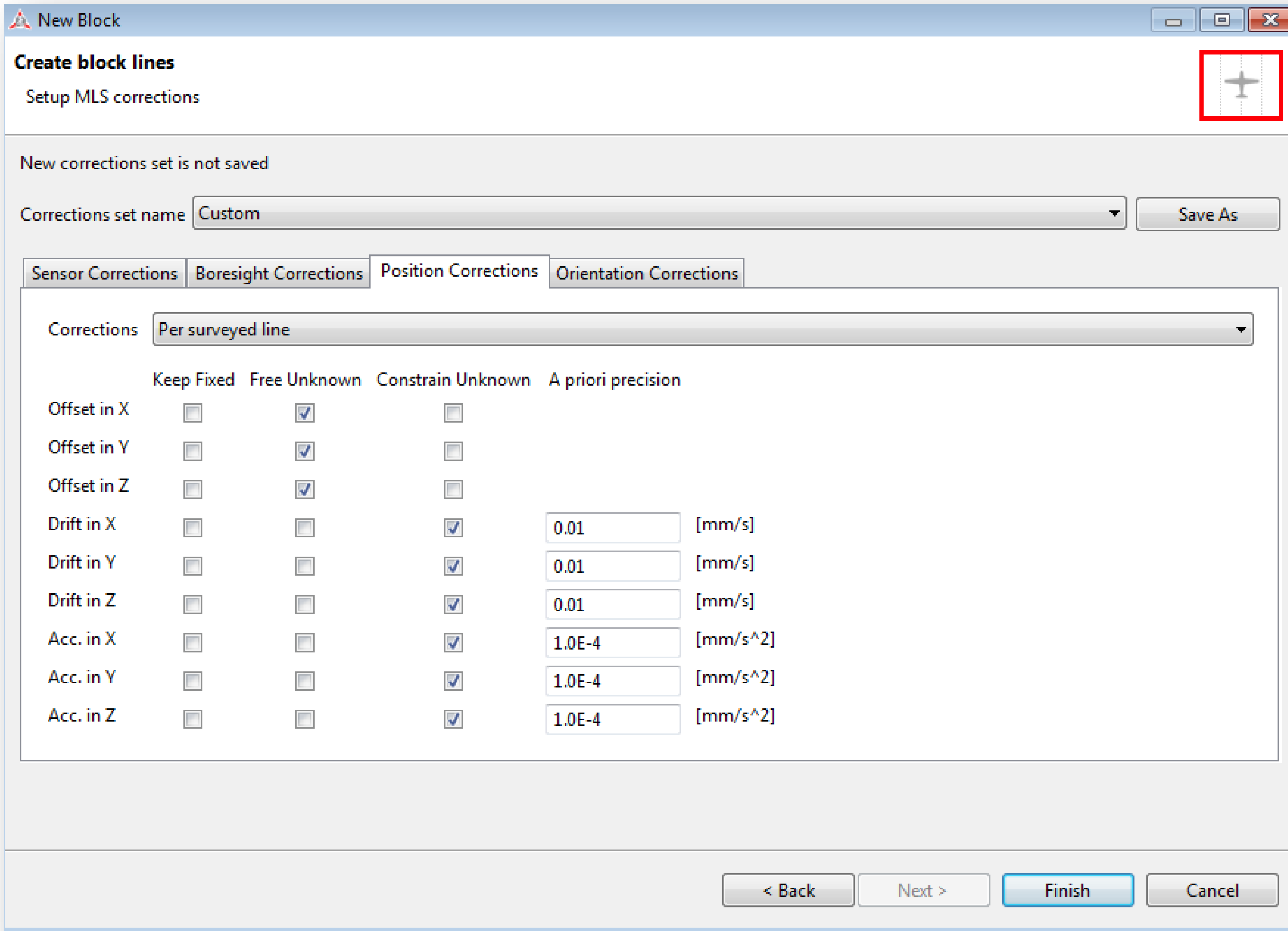
Laser point Computation
↓
Planar Surface Extraction
↓
Planar Surface Correspondence
↓
Tie Plane Selection
↓
Parameter Estimation (LSA)
↓
Refined Laser Point Computation



Requirement: redundancy

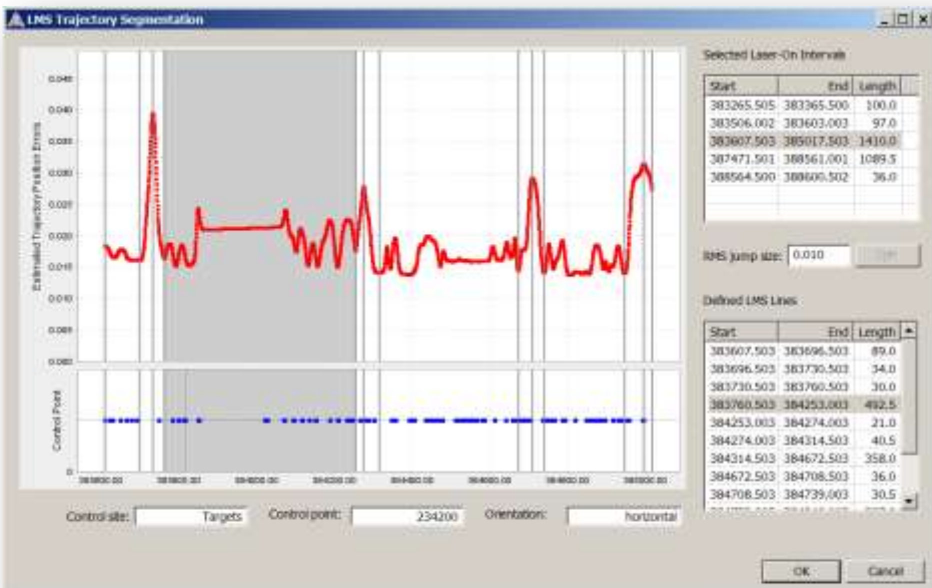
LMS Pro Self-Calibration: Trajectory Corrections

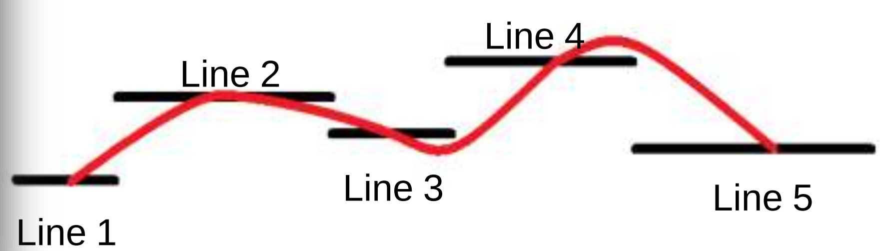
- Polynomial correction for trajectory position



LMS Pro Self-Calibration: Trajectory Corrections

- Trajectory Quality is variable in mobile surveys. A single set of corrections cannot be applied to the entire mission.
- LMS Pro 3.0 provide means to segment according to GPS quality then apply polynomial corrections ensuring transition areas are smooth
  - More integrated positional solution
  - CRUCIAL for project accuracy

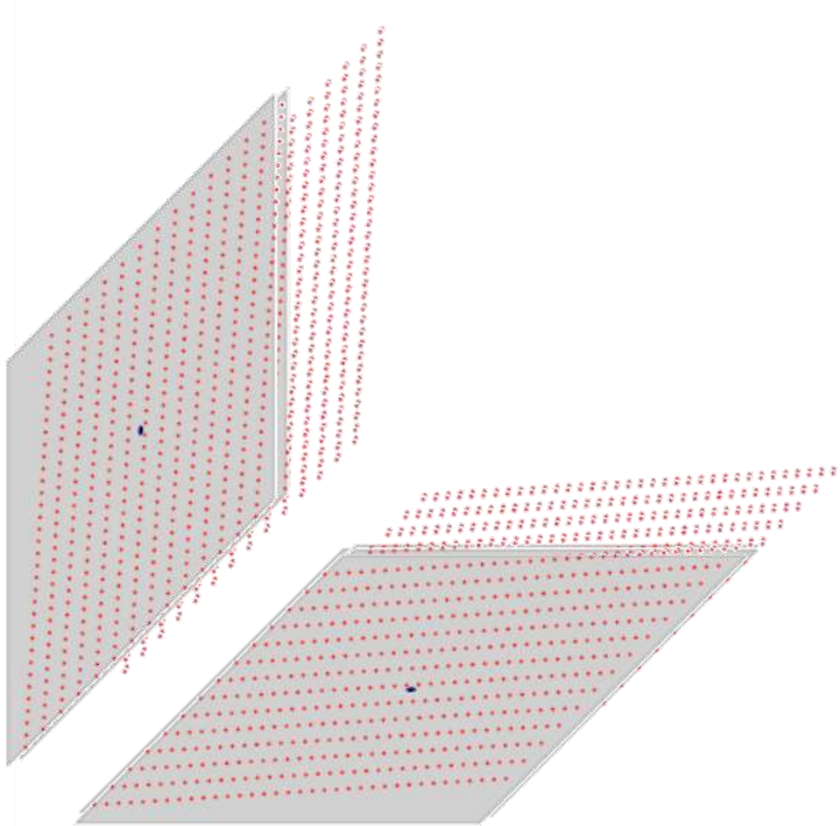




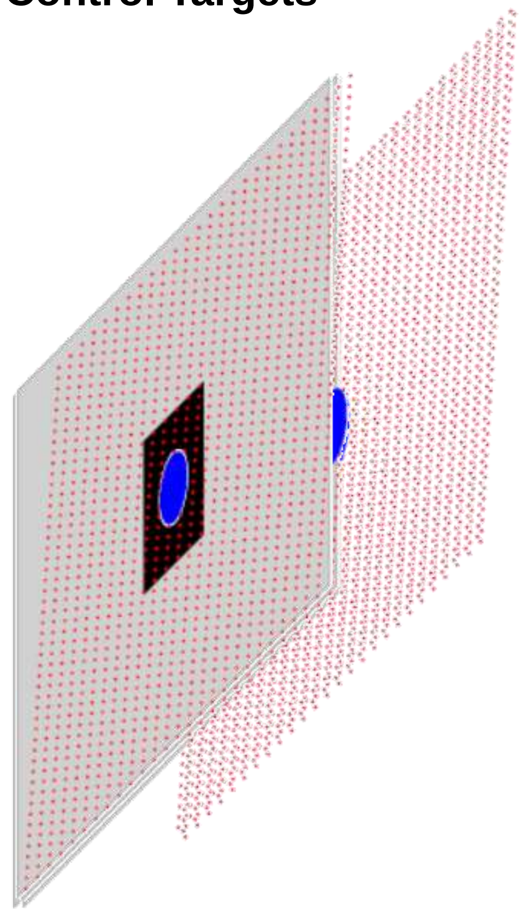
LMS Pro Self-Calibration: *Leveraging Survey Control*

- Two types of control information can be used in the self-calibration:

Control Located on Planar Surfaces

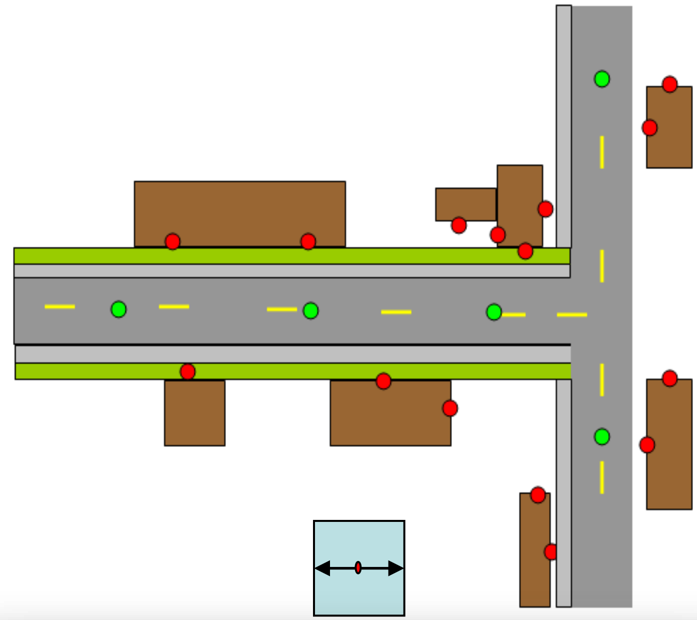


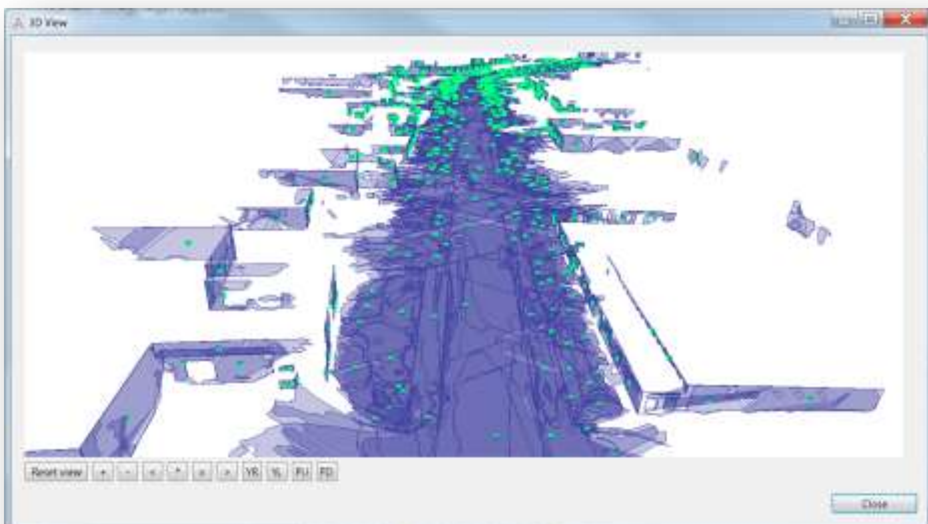
Control Targets



Control Located on Planar Surfaces

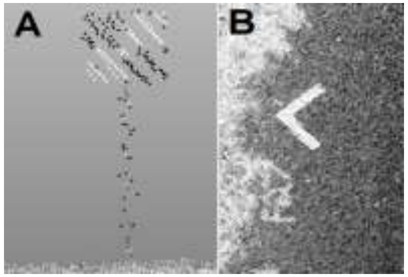
- **Control Located on Planar Surfaces**
  - Ideal in locations where there is a lot of vertical and horizontal surfaces
  - Easy to collect
  - Can be collected before or after the lidar survey
  - Facilitates complete automation

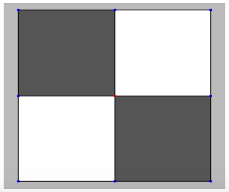


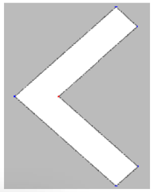


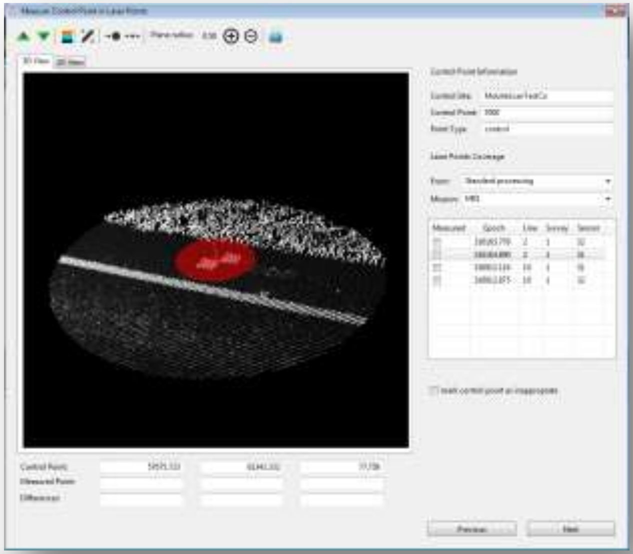
LMS Pro Self-Calibration: *Leveraging Survey Control*

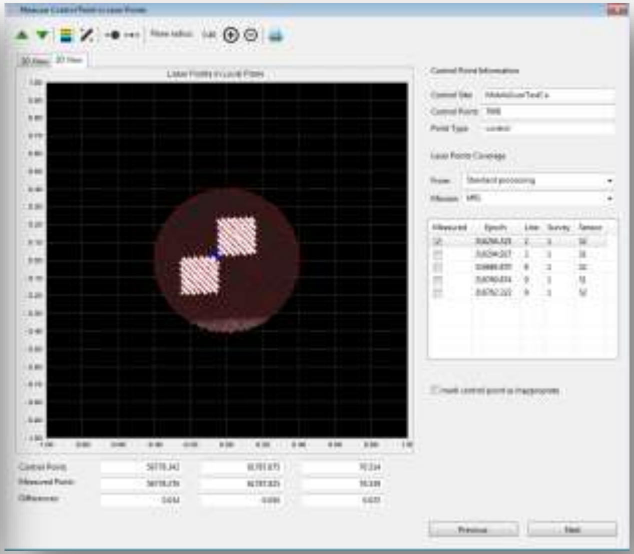
- Control Target
  - Identify traditional survey targets in the data
  - Targets can be used in addition to traditional LMS planar control adjustment.
  - Important supplement in areas without significant planar geometry











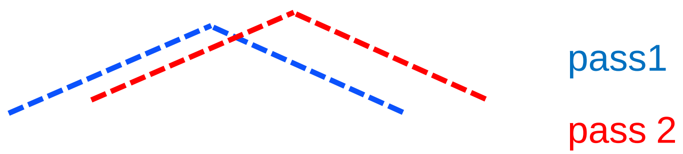
LMS: Quality Control

Project validation

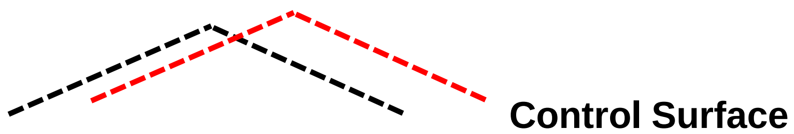
↓

Check whether
the desired quality
(accuracy)
has been achieved.

- LMS allows for project validation by providing:
  - Internal/relative QC measures



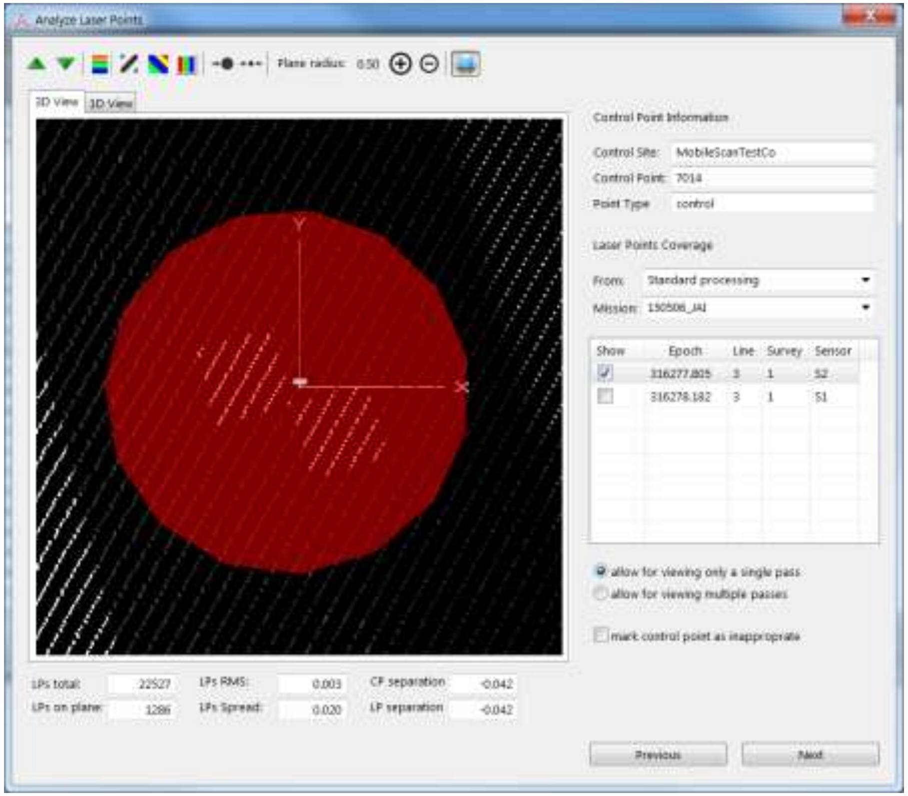
  - External/absolute QC measures

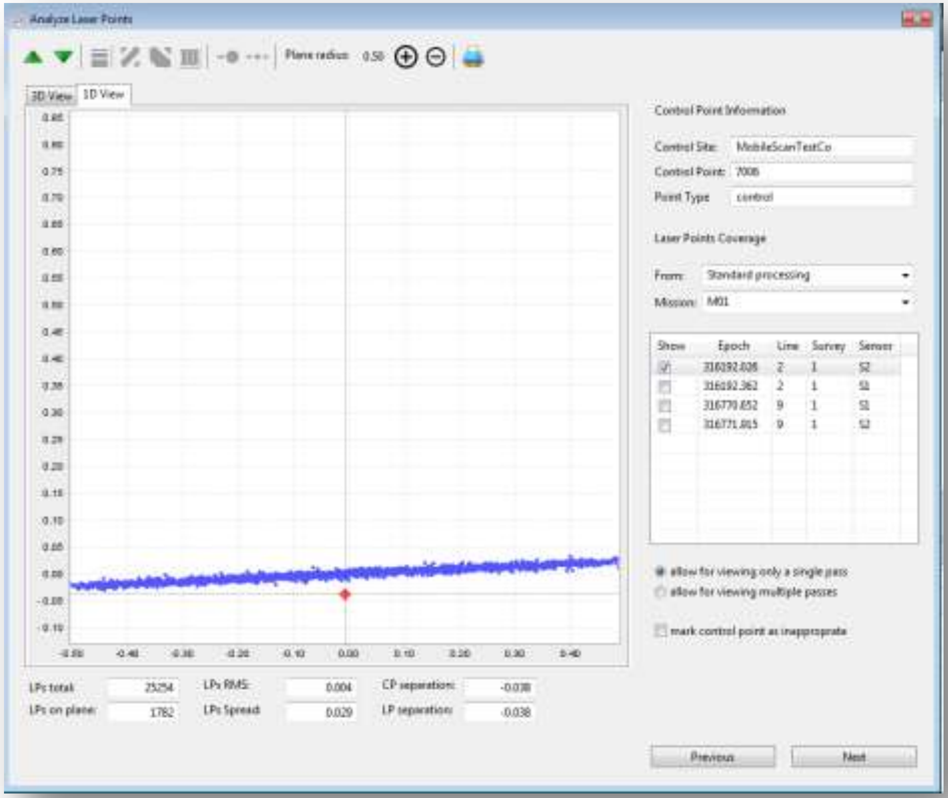


  - Quality control of multi-sensor integration

LMS: Quality Control

- First data quality check can be performed at a very early stage



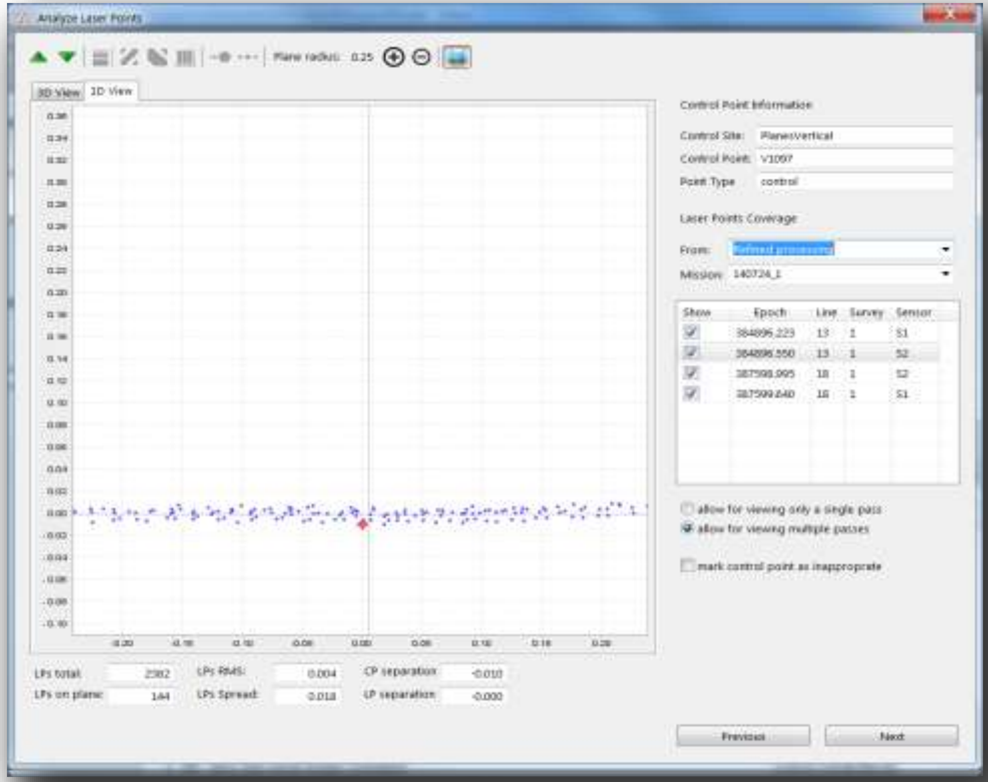


On-the-fly computation of the lidar point cloud in the vicinity of the control points

LMS: Quality Control

LMS Absolute/Relative QC Measures

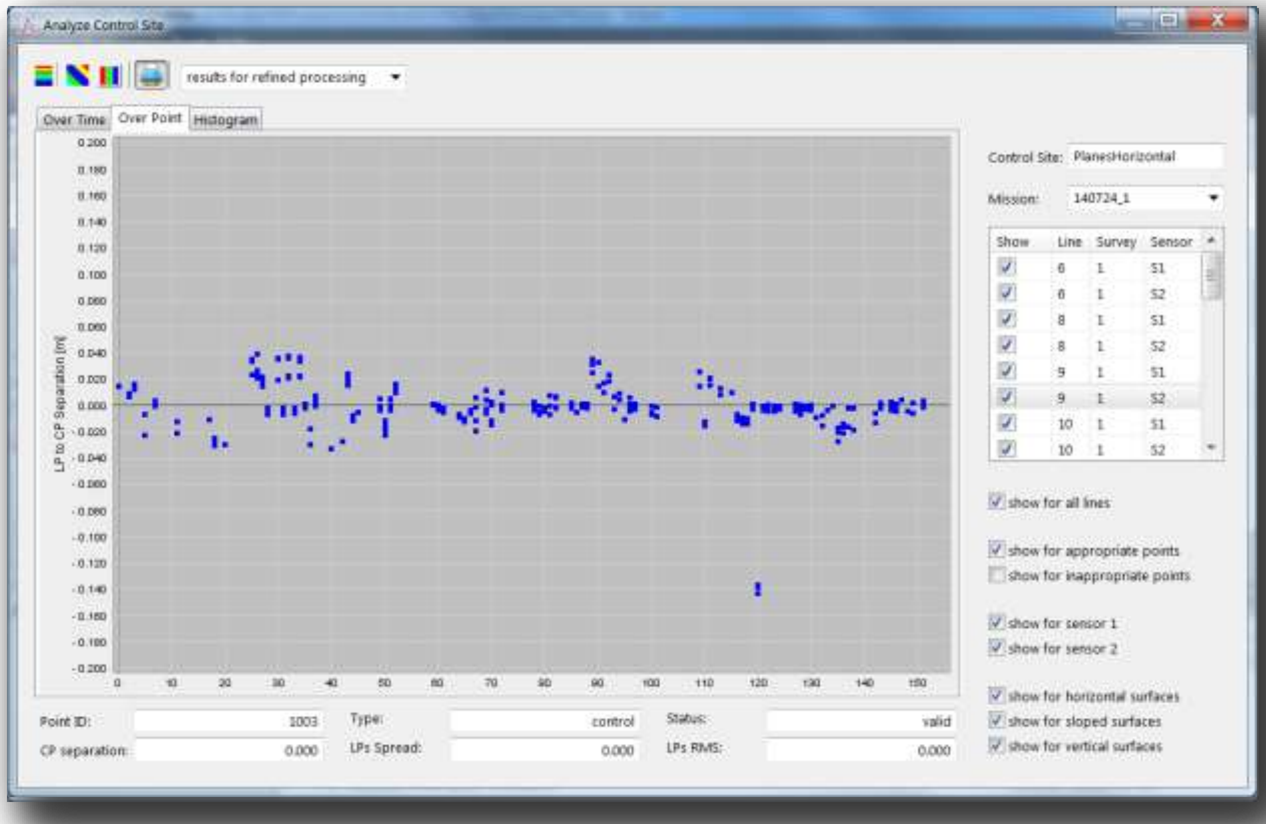
- Near real-time before/after assessment of individual control points and the neighboring lidar points.



LMS: Quality Control

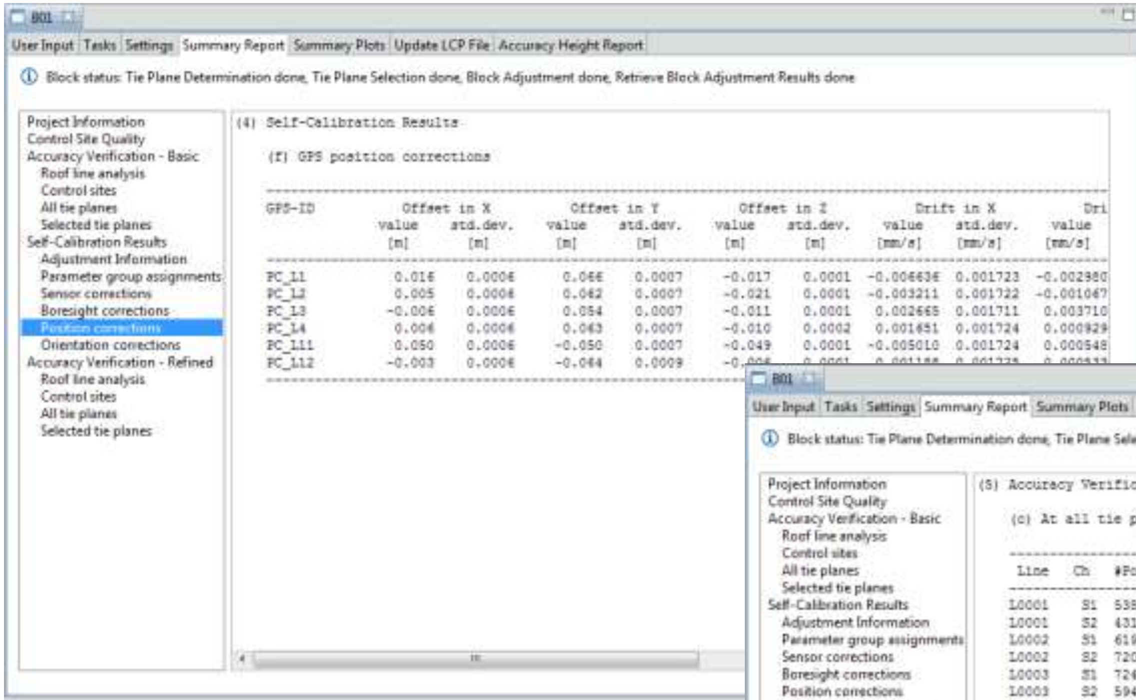
LMS Absolute QC Measures

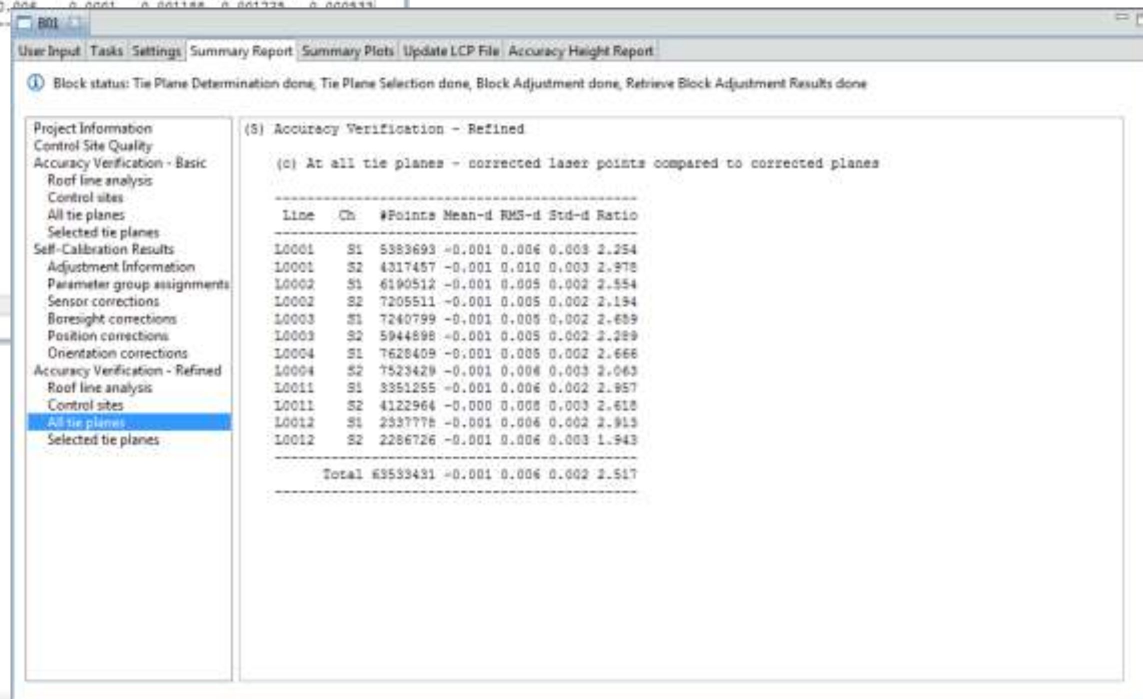
- Lidar and Control Point Separation – Before and After Self-Calibration



LMS: Quality Control

- Summary Report

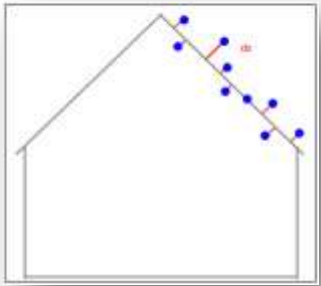


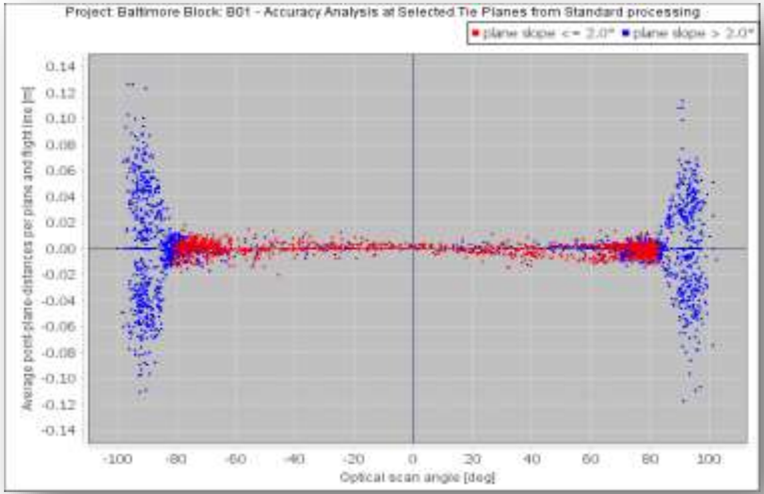


LMS: Quality Control

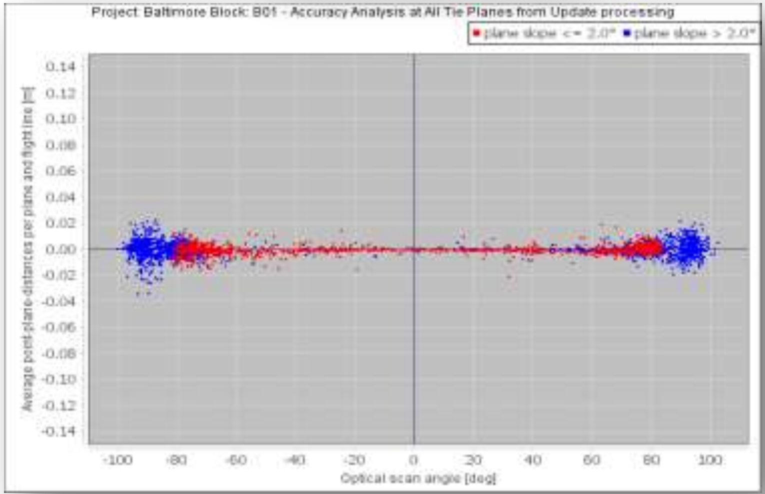
LMS Relative QC Measures

- Planar statistics from lidar self-calibration (graphical analysis and report generation)
- Summary Plots





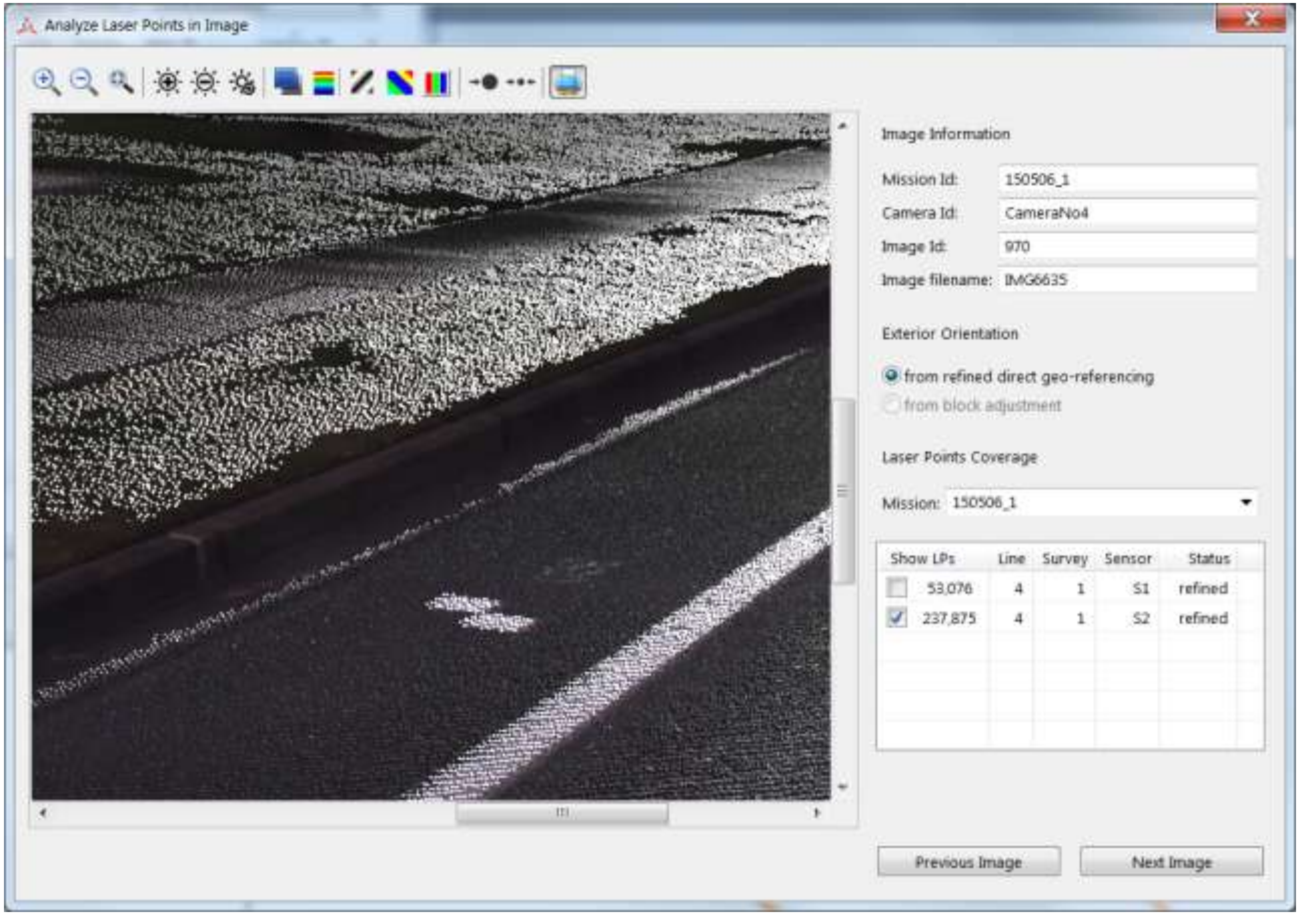
Before Self-Calibration



After Self-Calibration

Quality Control of Multi-Sensor Integration

- In LMS 3.0 users can visualize image/lidar alignment



Quality Control of Multi-Sensor Integration

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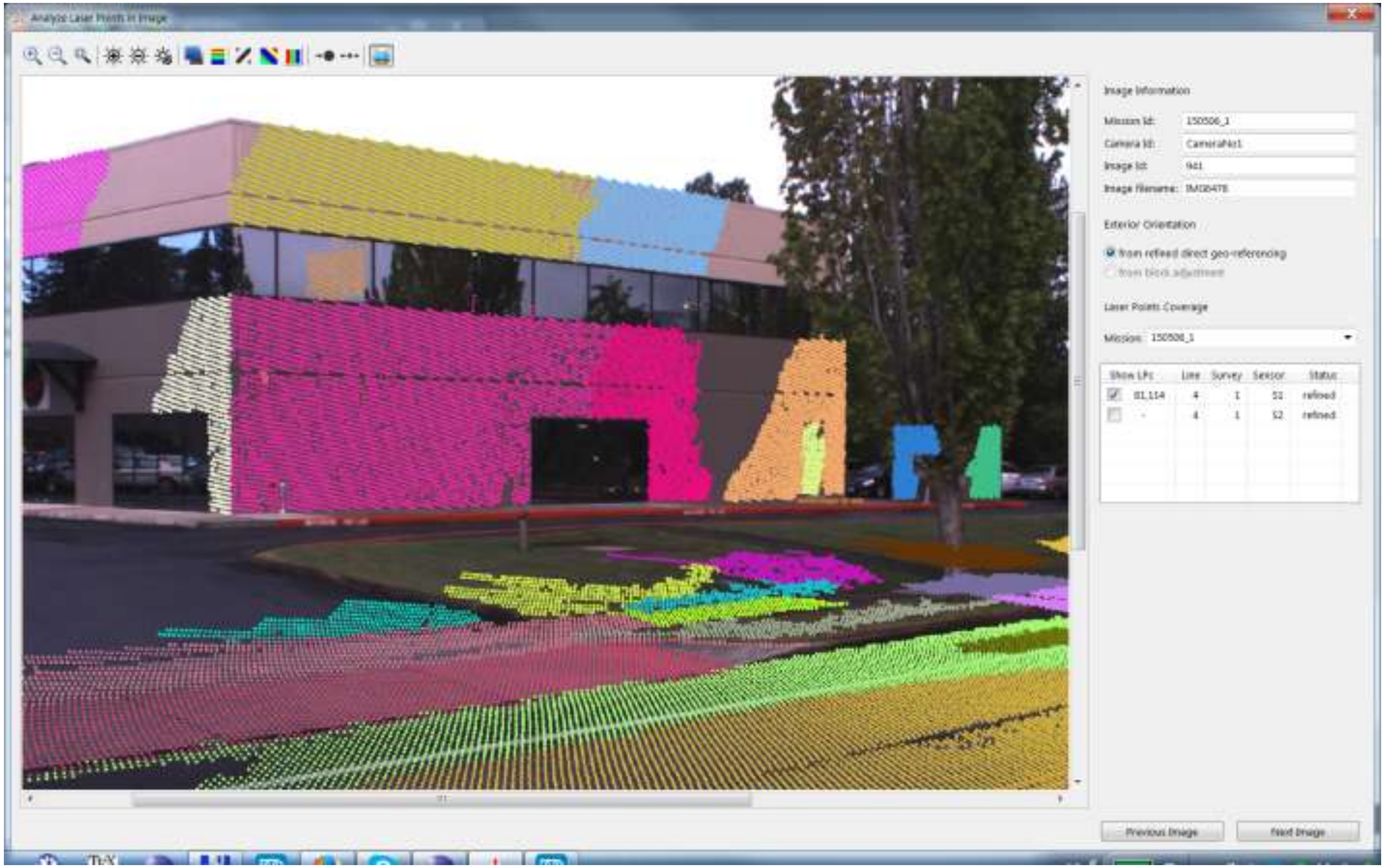
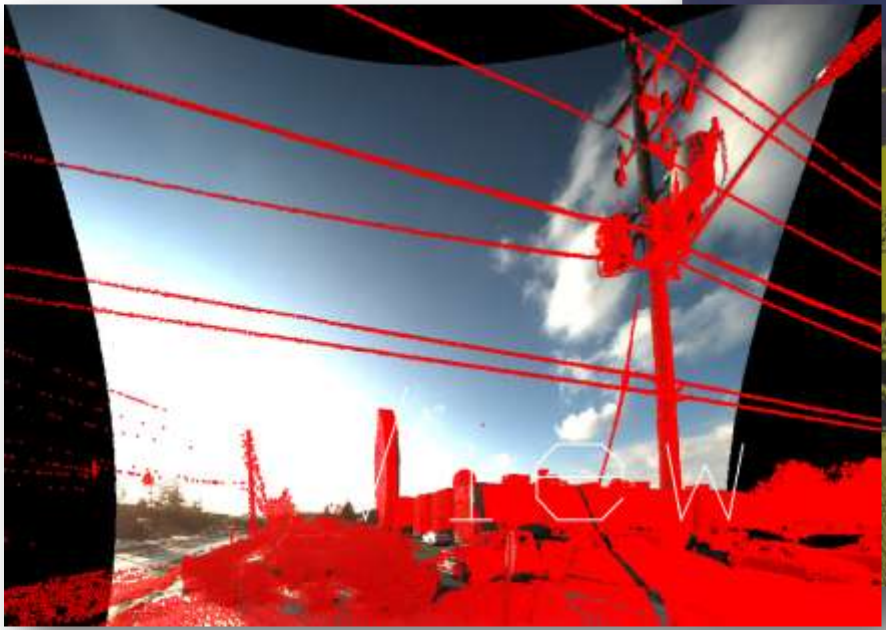


LMS: Interoperability

- Orbit

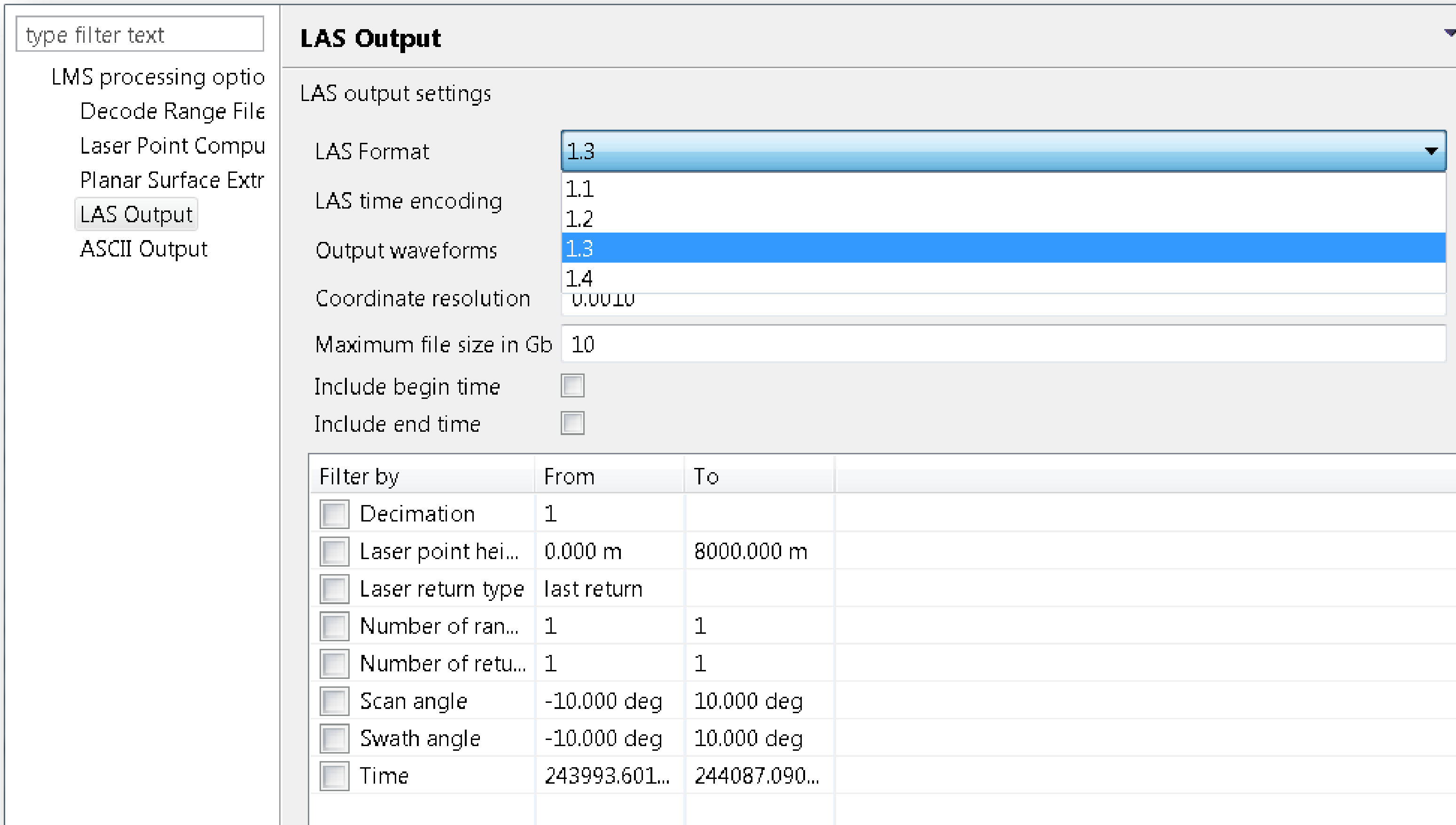
LMS: Interoperability

- TopoDOT, Terraphoto



LMS: Interoperability

- LAS 1.1 - 1.4 & customisable ASCII outputs



Industry standard outputs

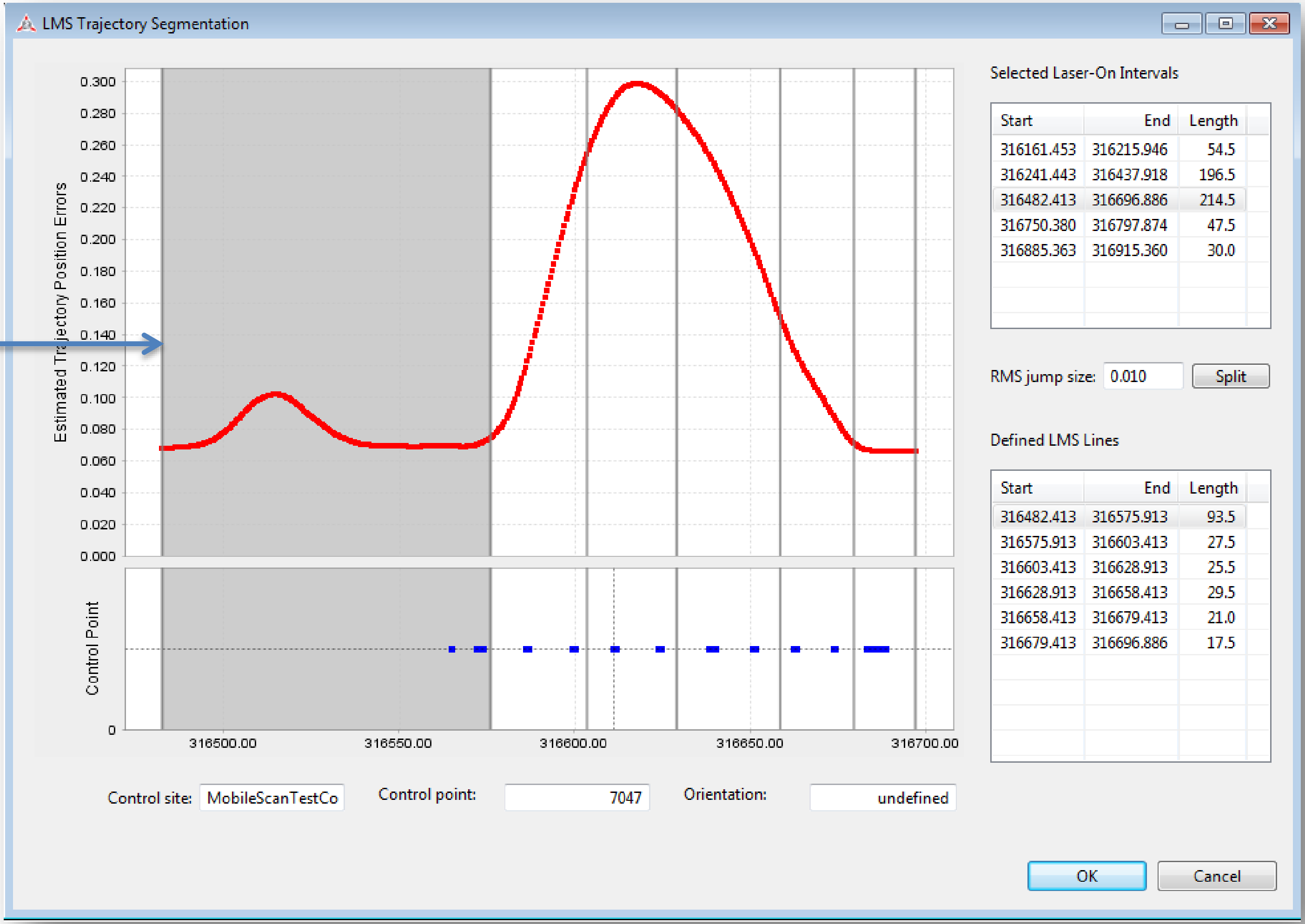
Experimental Results

- To demonstrate the validity of the discussed QA and QC procedures, experimental results using a real dataset with very poor GNSS quality have been performed.

Experimental Results

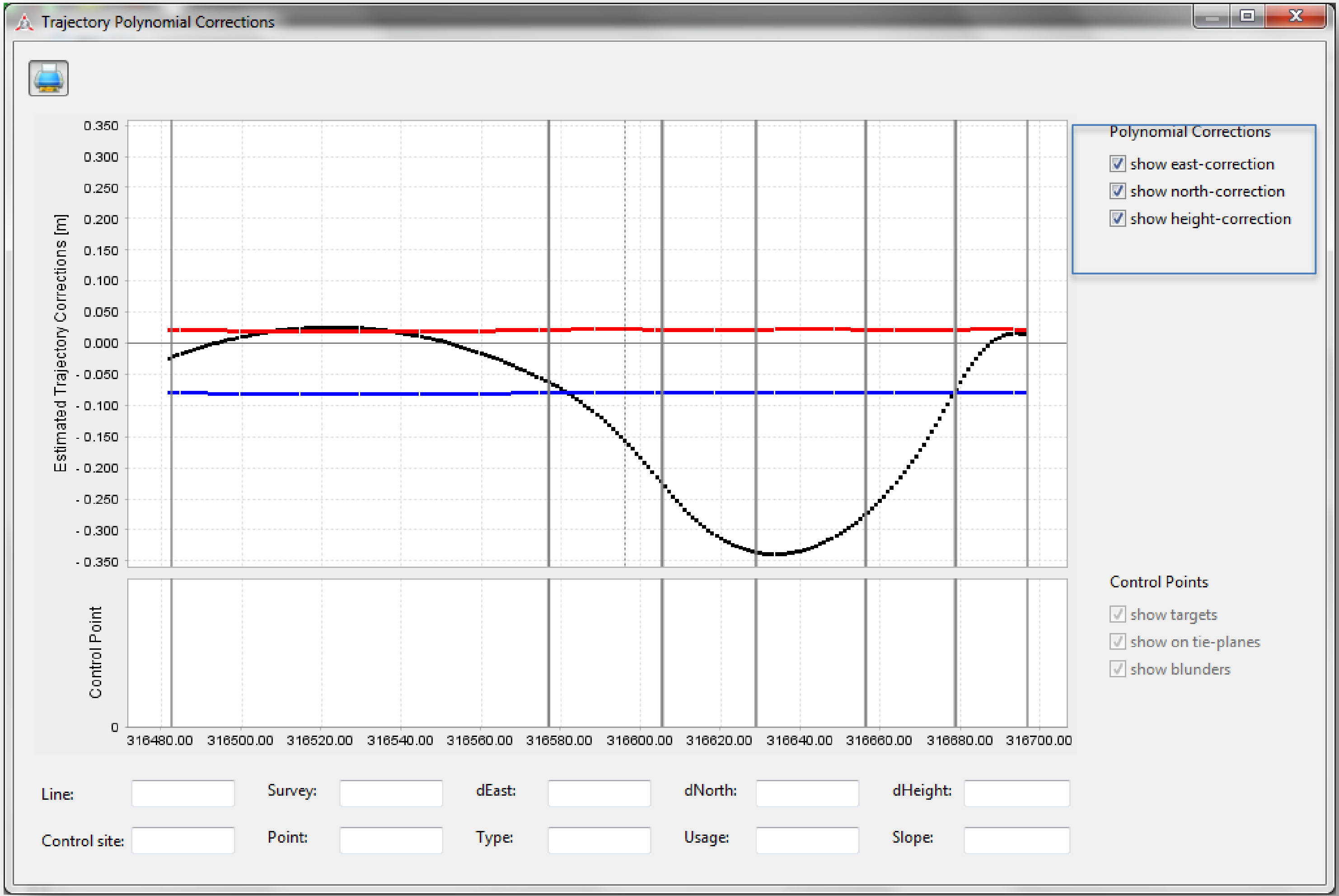
- Trajectory Segmentation

Total RMS

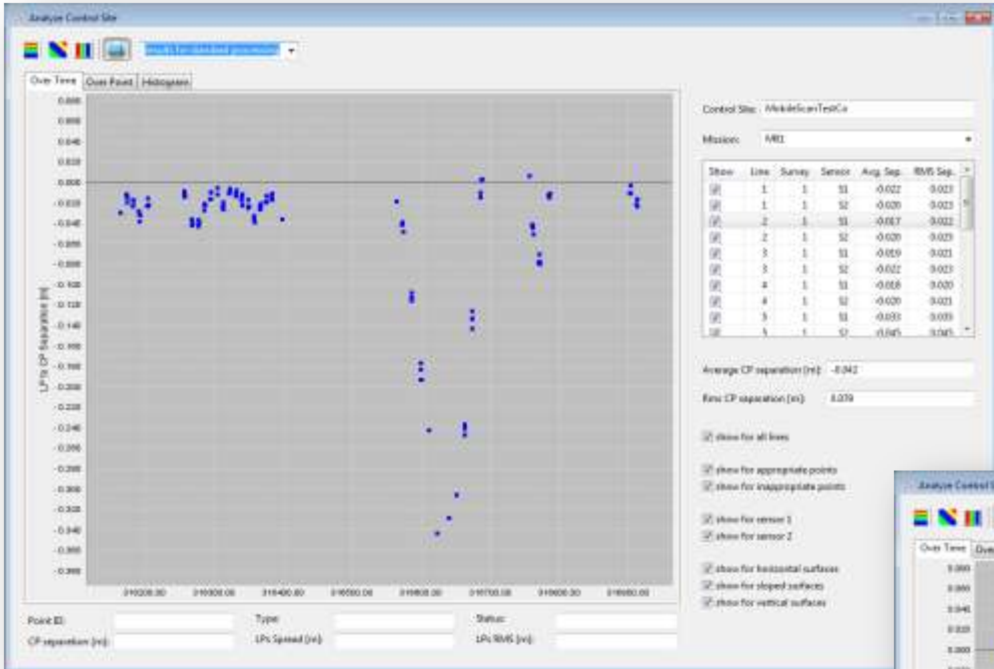


Experimental Results

- Trajectory polinomial corrections

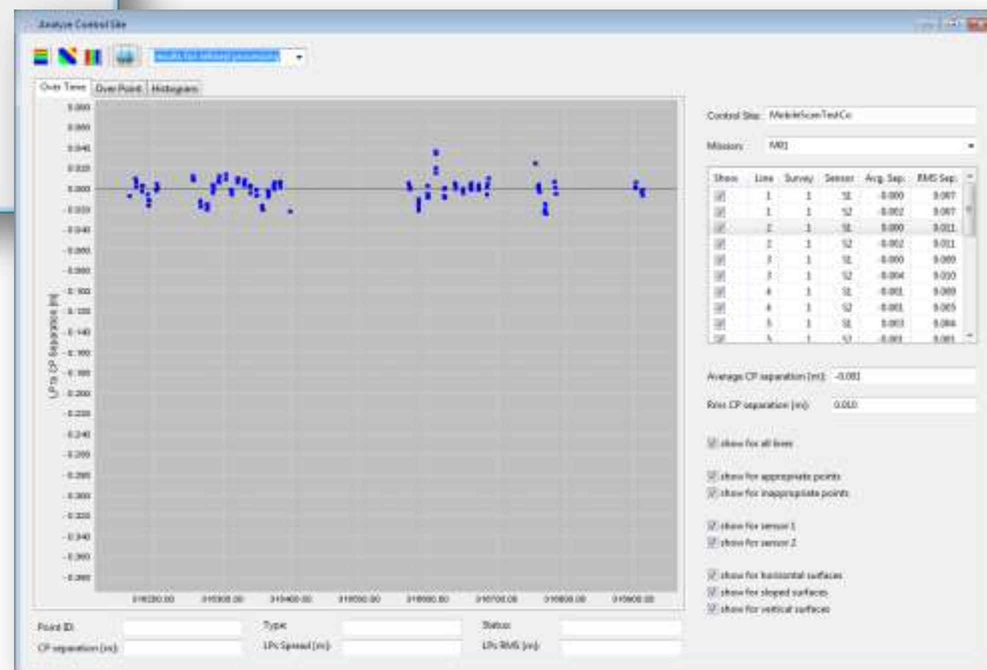


Project Validation

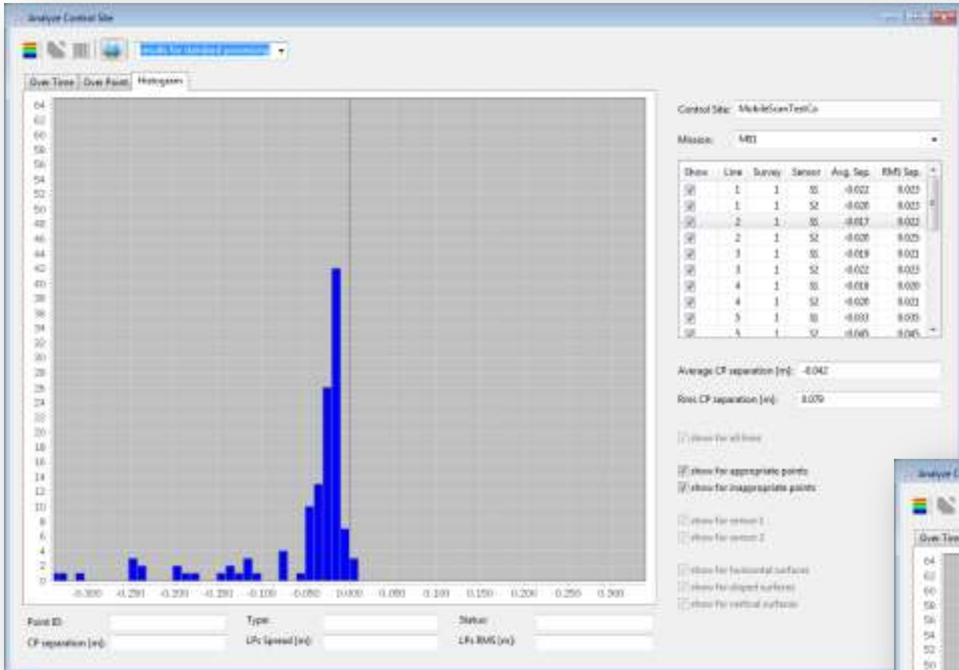


Before self-calibration

After self-calibration

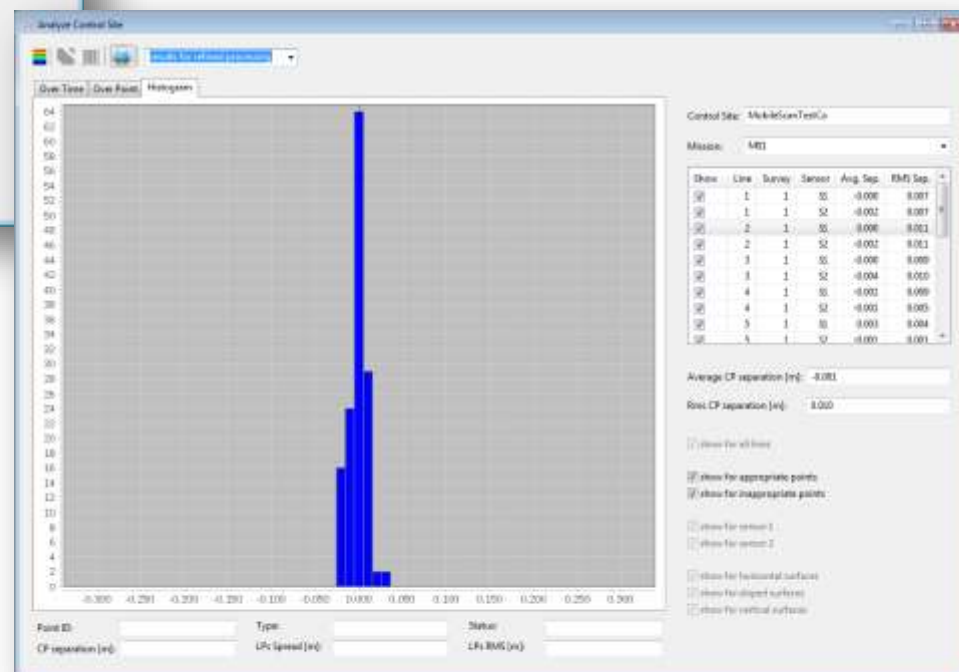


Project Validation



Before self-calibration

After self-calibration



THANK YOU

Doing Business in the middle east

Key Considerations:

1. Clients Level of Expertise

2. Pricing contingencies for:
   - *Requirements changes*
   - *Low level of expertise*
   - *Potential payment delays*

3. Post Project Support
   - Expect significant post project support
   - Projects requirements need to be very clear
   - “culture” of mistrust

4. Local partner is critical and often necessary

5. It’s HOT!

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Riyadh Metro Project

Navmatica has been awarded 2 project

Segments in the Riyadh Metro Project

1. GNSS Network Establishment

- **200 Permanent Reference Markers (PRM)**

2. 3D Topo

- **500 line km collected with Lynx SG1**
- **Duration: 2 months**
- **Deliverables: LAS, vectors, DTM, Contours, and road assets**
- **Urban canyons & Hi-rise buildings**
- **Traffic is challenging even at odd hours**

The System: Lynx SG1

LB5
Camera

2x600 KHz
Scanner

4x5mp
Cameras

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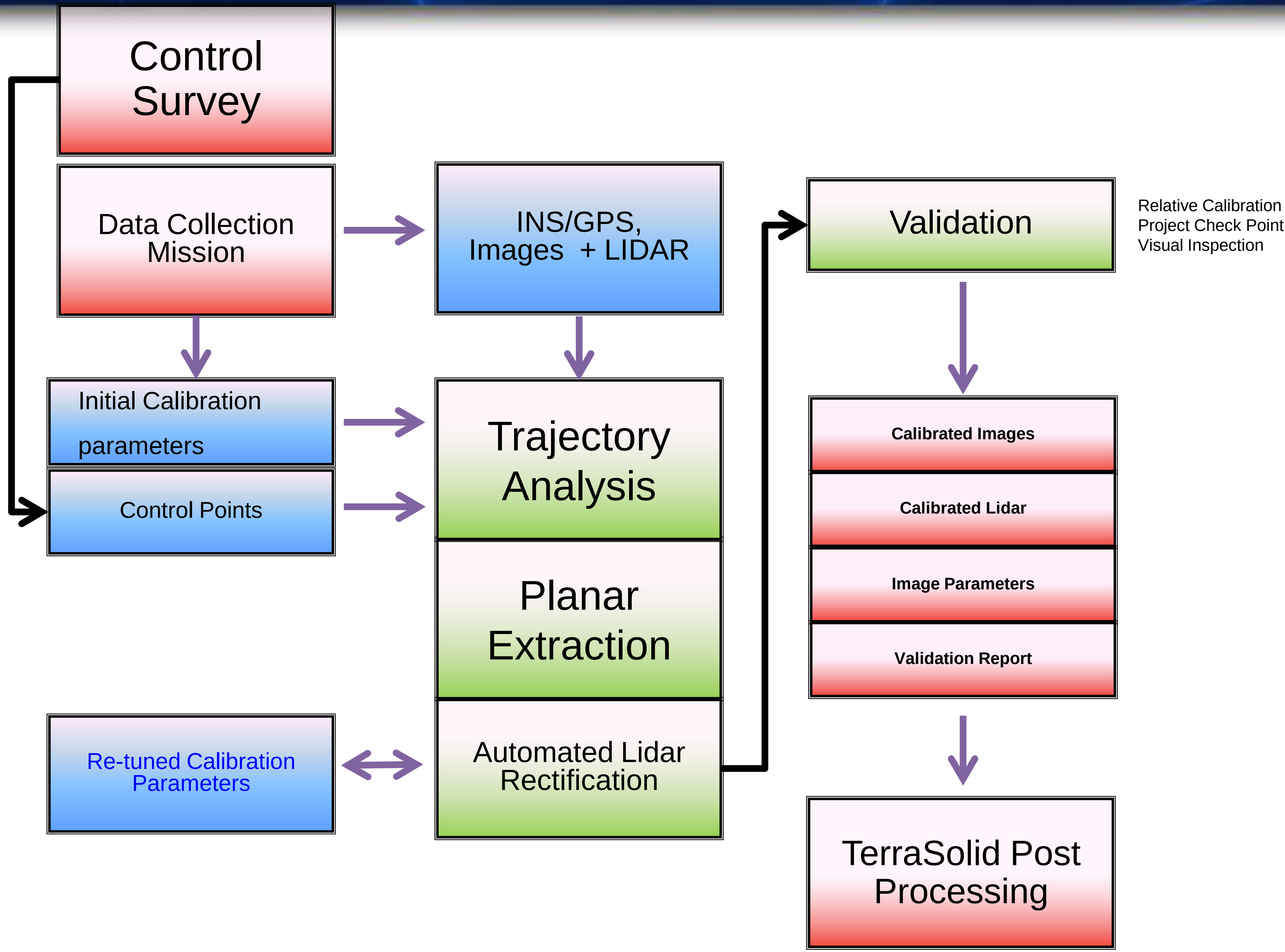
Processing Workflow



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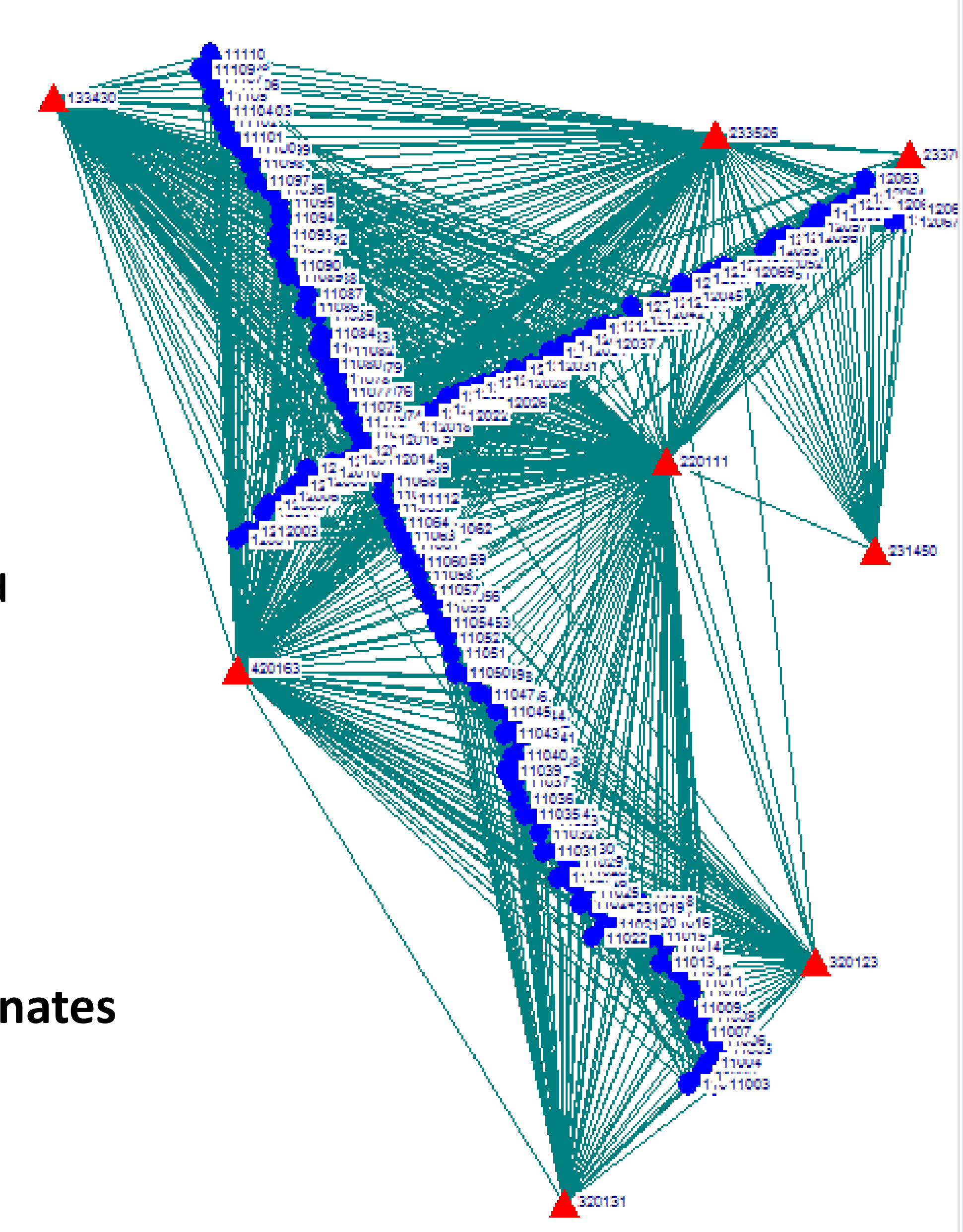
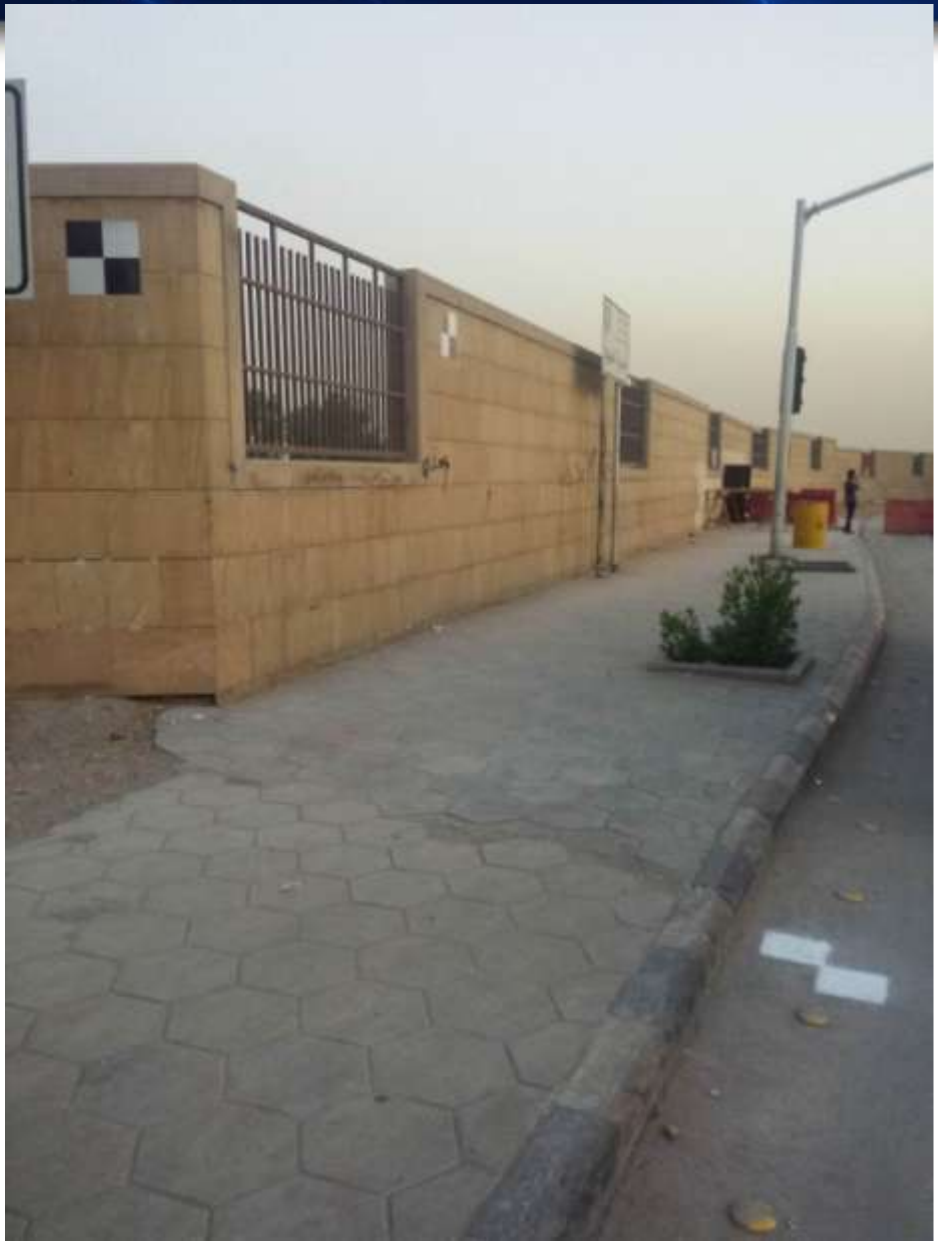
GNSS PRM Network

- **Established 200 PRM's**
- **Techno:**
  - **18 geodetic GNSS receivers**
  - **Long observation duration**
  - **Leap frogging**
  - **Precise Orbits, Sat Clk Corrections, Iono grid**
  - **Constrained Network Adjustment**
- **Absolute Positioning Accuracy = 9 mm**
- **Relative Precision: 4 mm**
- **PRMs are used to compute GCP coordinates**
  - **GCP accuracy: 1cm (1σ)**



Ground Control Points in multiple planes



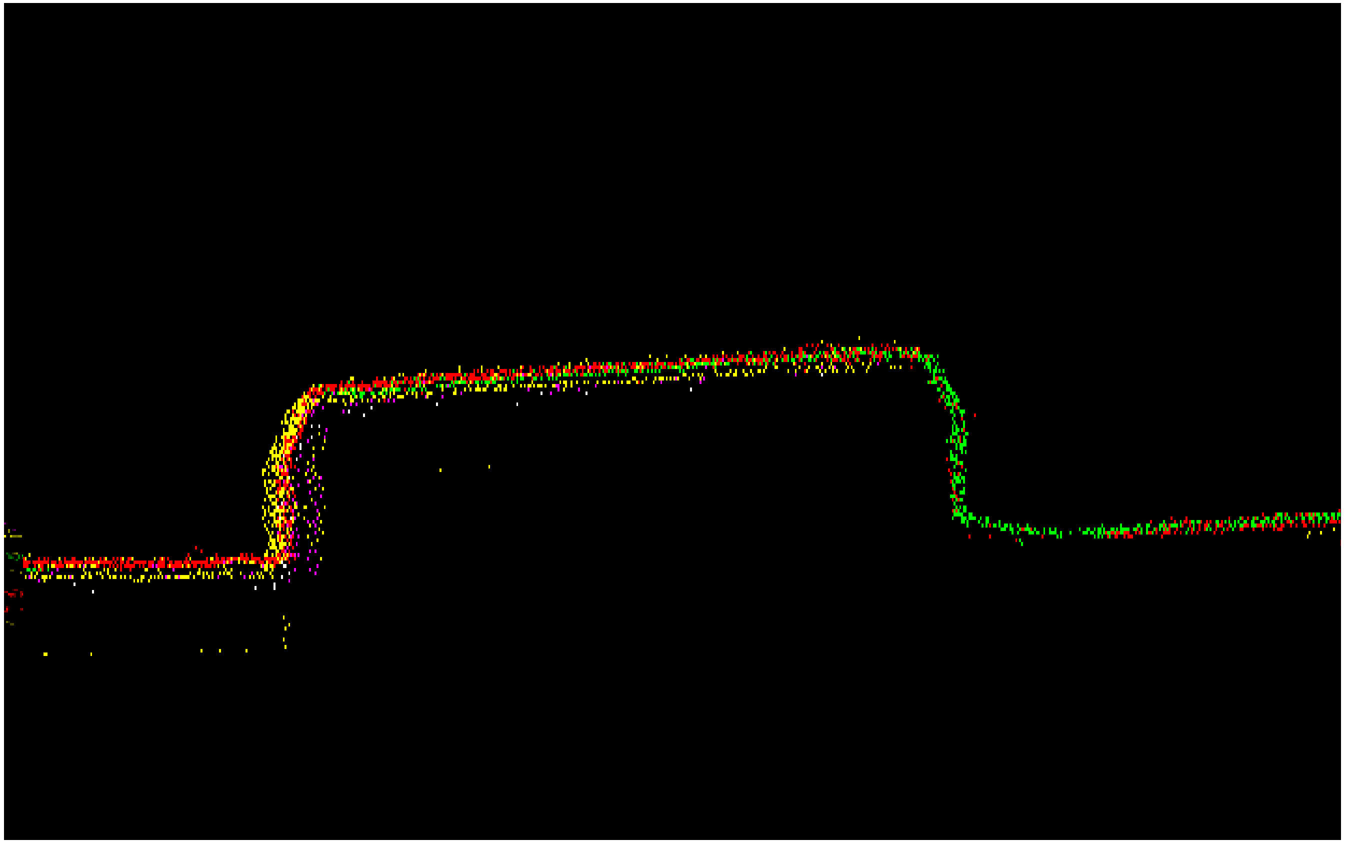
Ground Control Points

Tunnel Ground Control Points

- **Established GCPs in Tunnels**
- **GCP's Surveyed using Total Stations tied to the PRM Network**
- **Logistical challenges**

Multiple-Mission Registration

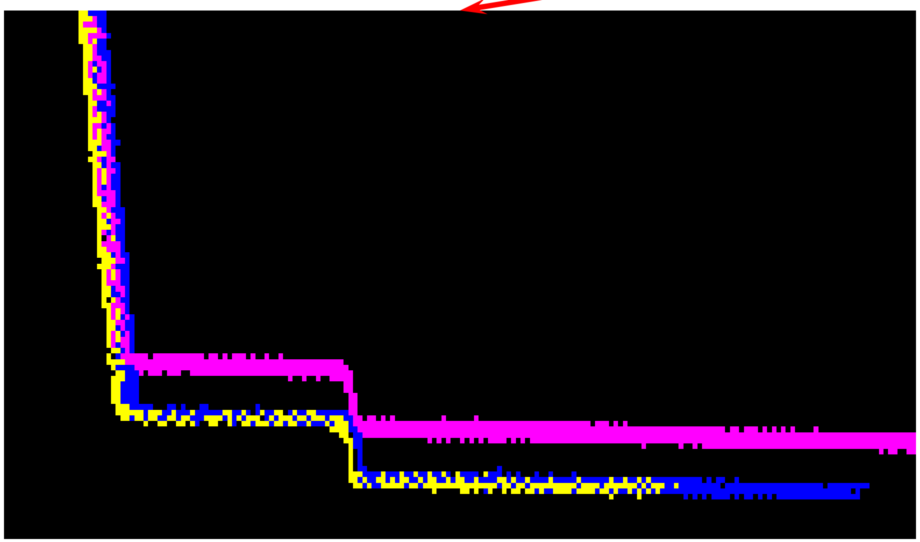
before
after

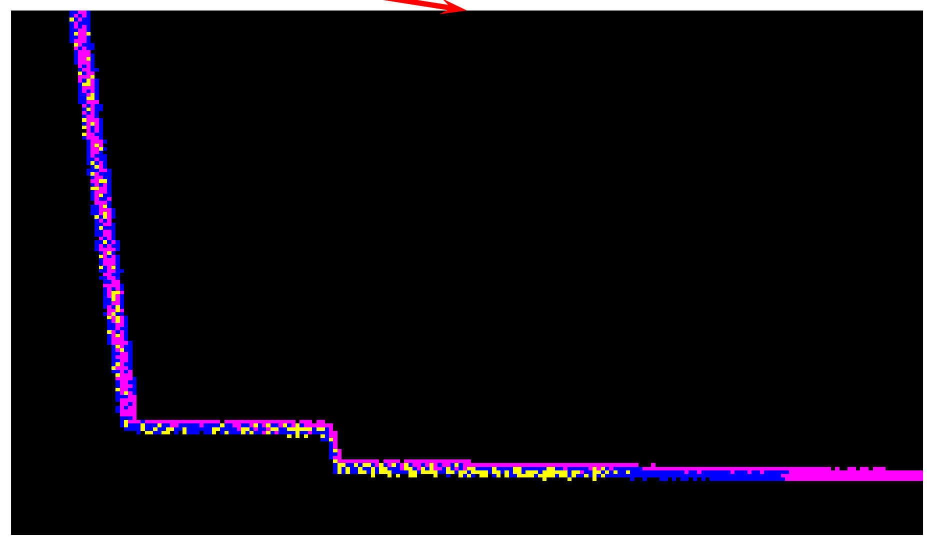


Multi Pass Alignment in outage areas

before

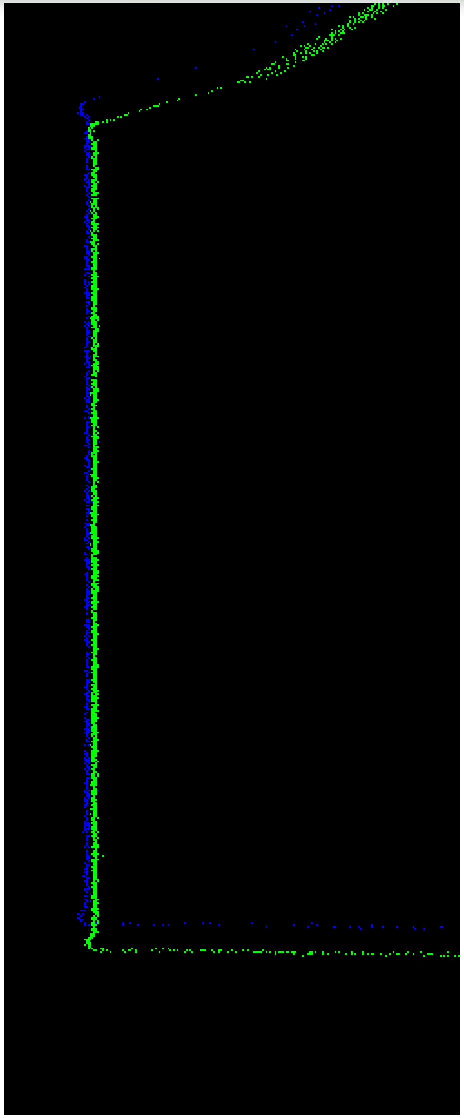
after



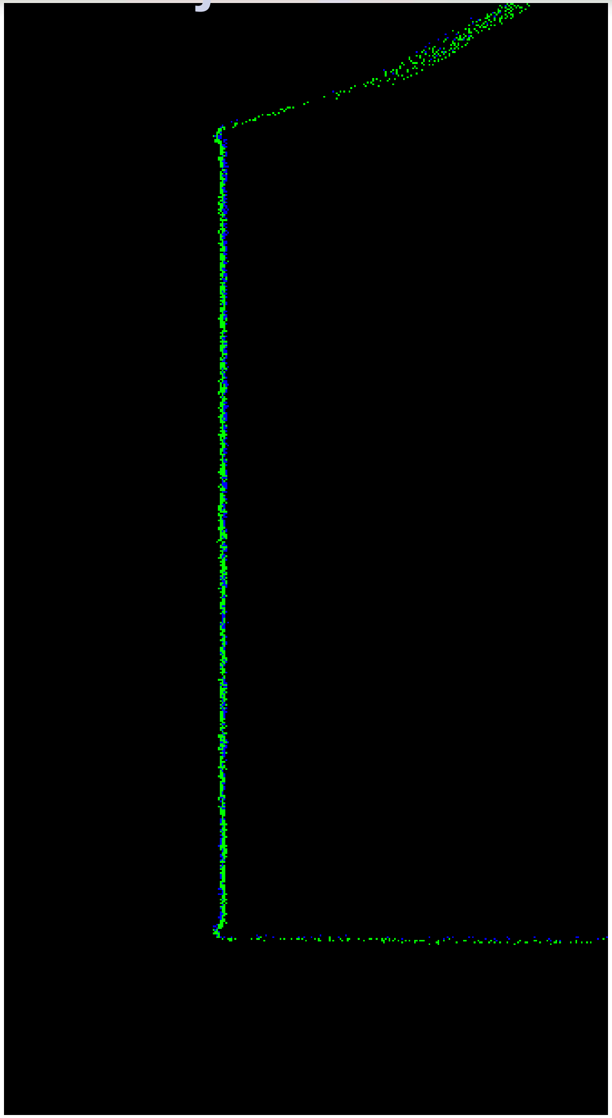


Statistics	Before	After
Mean	15.4 cm	**0.9 cm**
Std Dev	1.4 cm	**1.4 cm**
RMS	15.6 cm	**1.7 cm**

Post-Calibration Adjustment

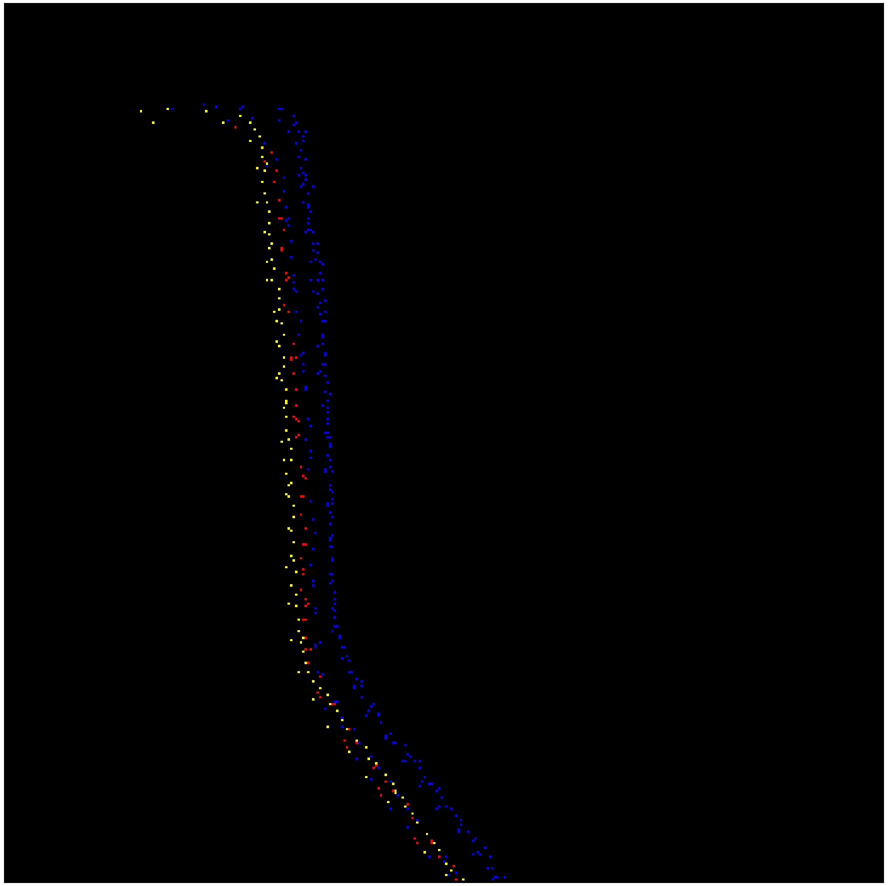


Before

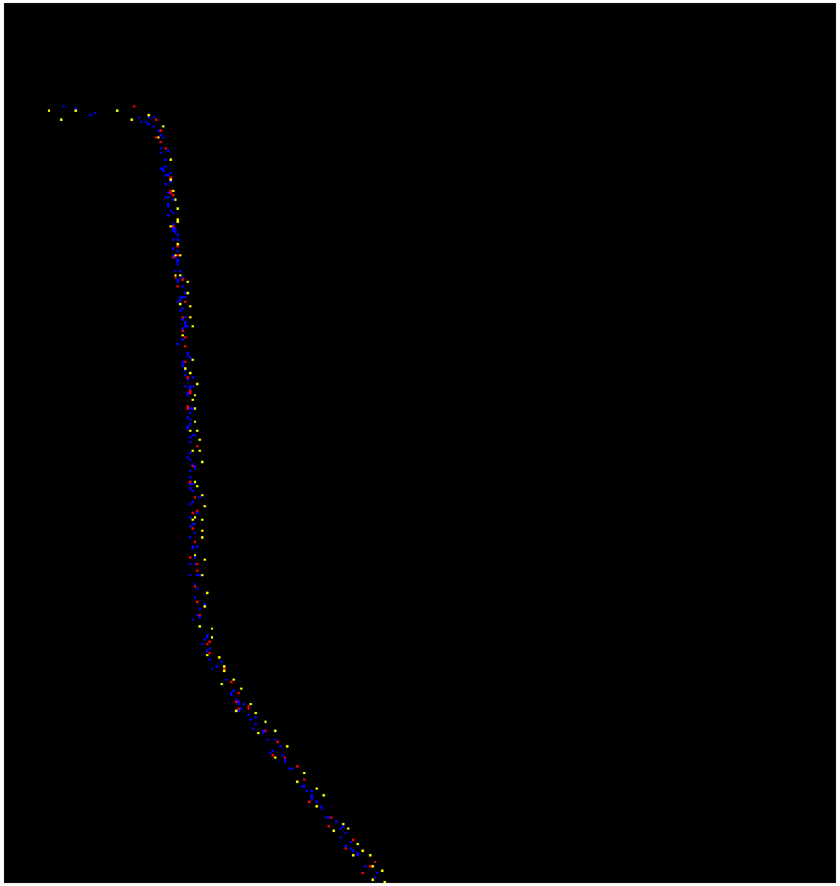


After

Post-Calibration Adjustment



Before

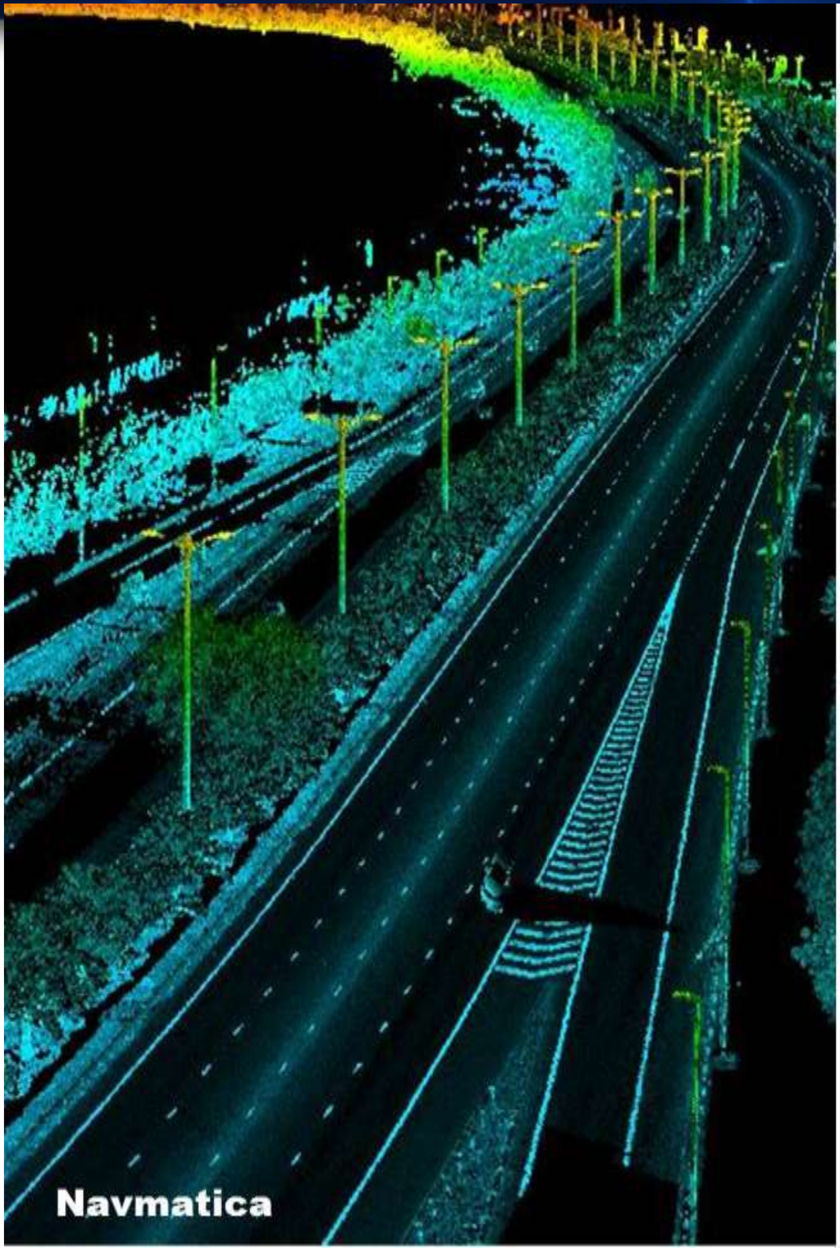


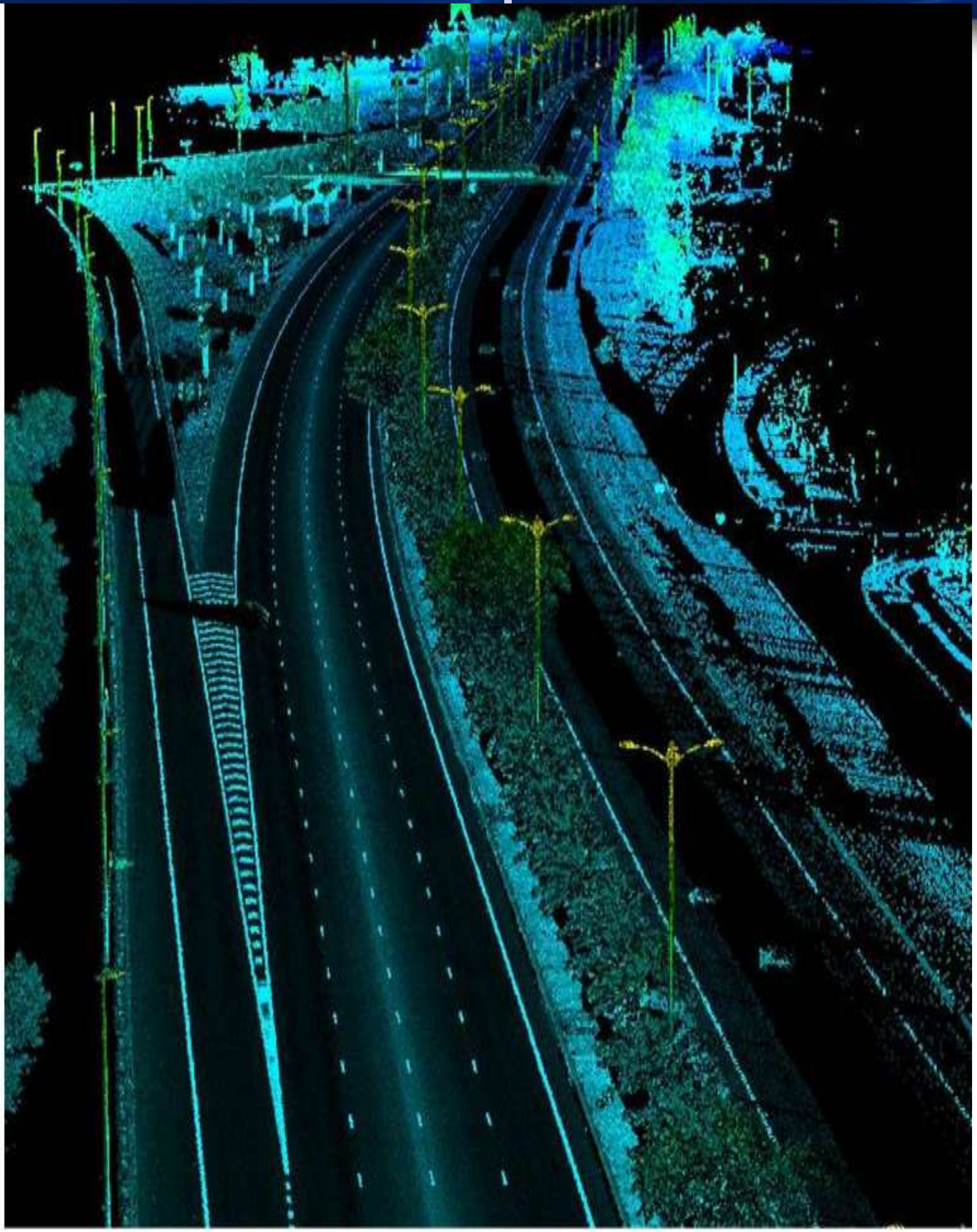
after

Sample Data

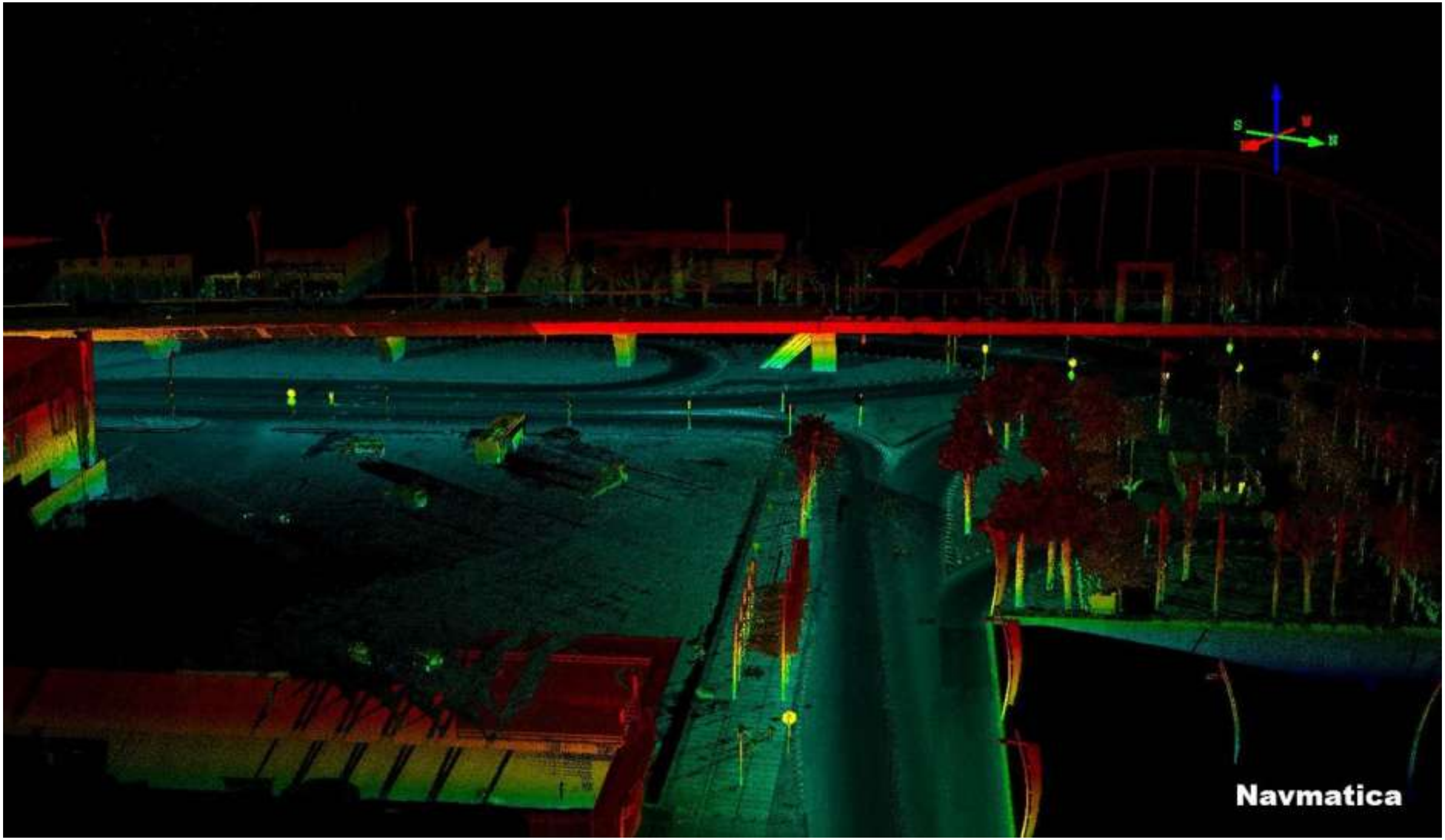
3D Point Cloud Data Samples

3D Point Cloud Sample data

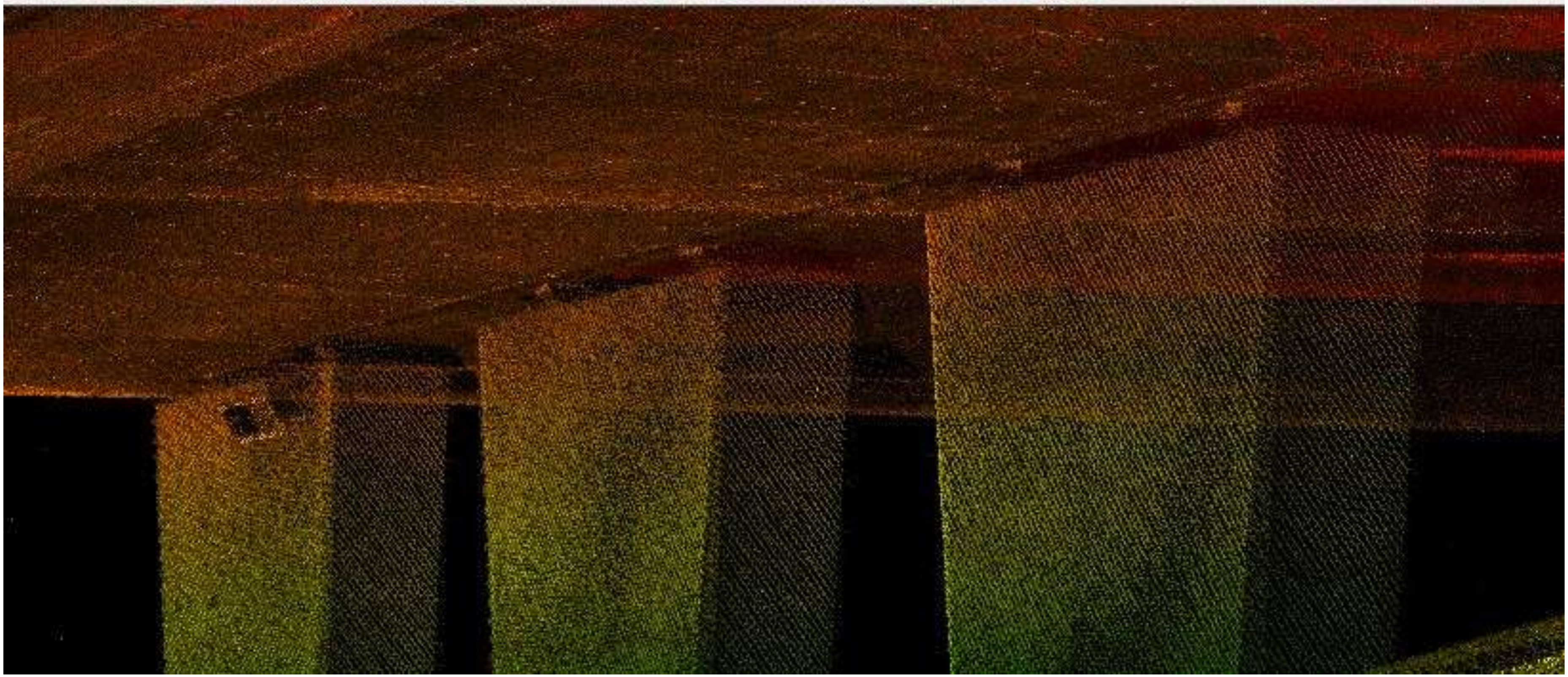




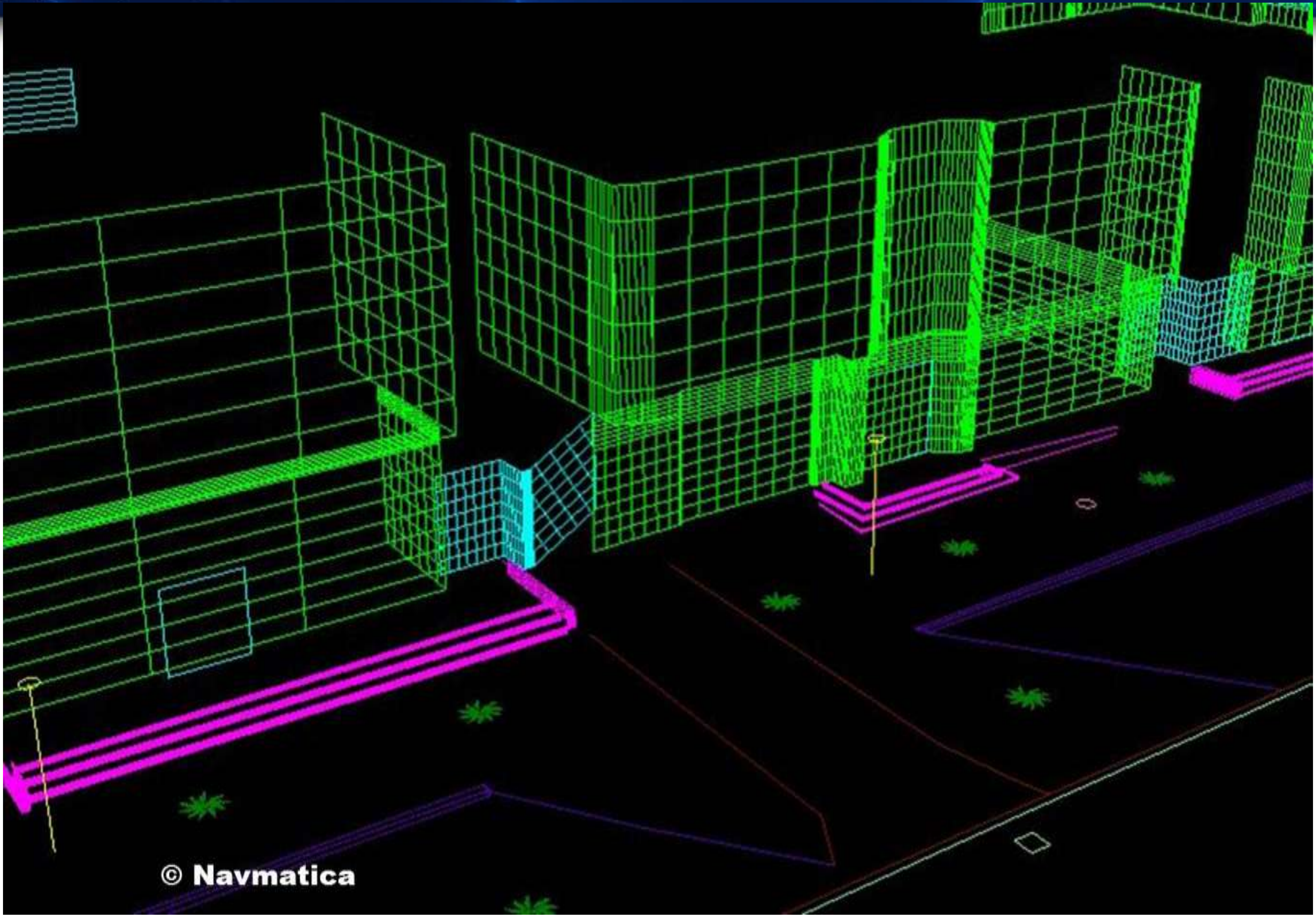
3D Point Cloud Data Samples



3D Point Cloud Data Samples

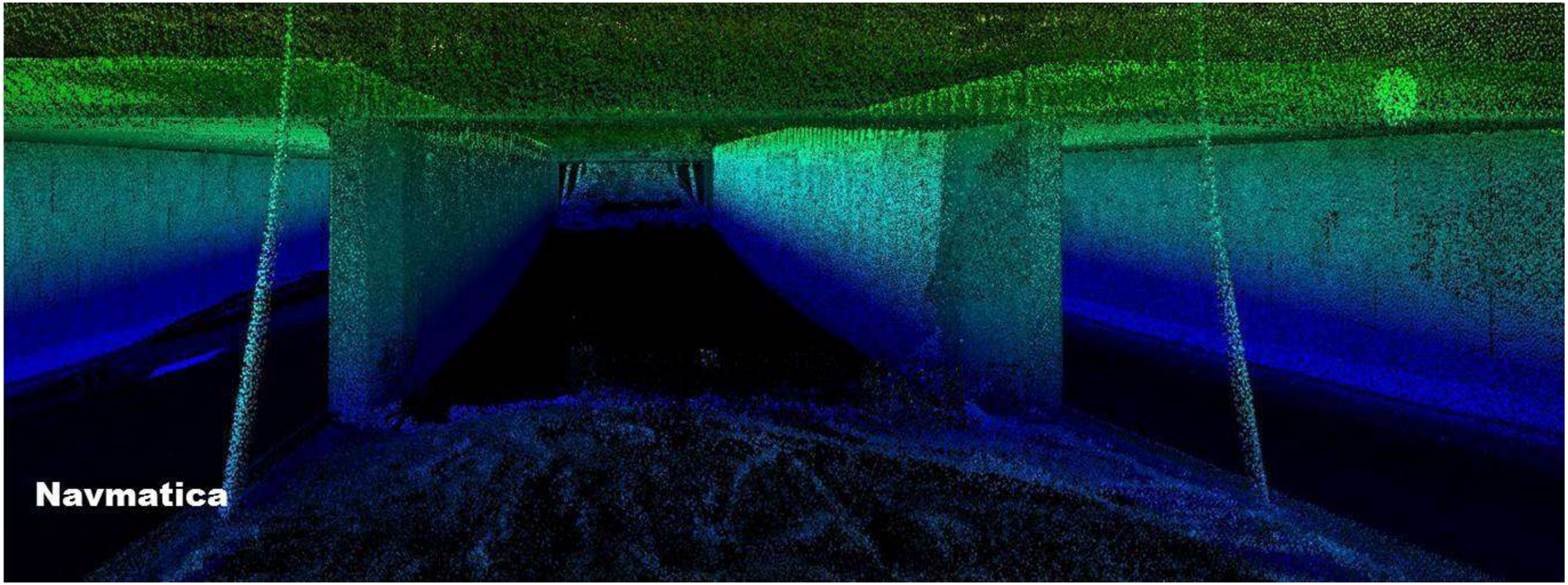


Vectorization



Lessons Learned

- **What you see is what you get – Static Laser Scanning might be needed in obstructed scenes**
- **Proper Mission Planning is a key**
- **Heat is a factor**
- **Urban Centers are challenging for GPS, logistics, permits, etc.**



Thanks for your attention!

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Thank You!