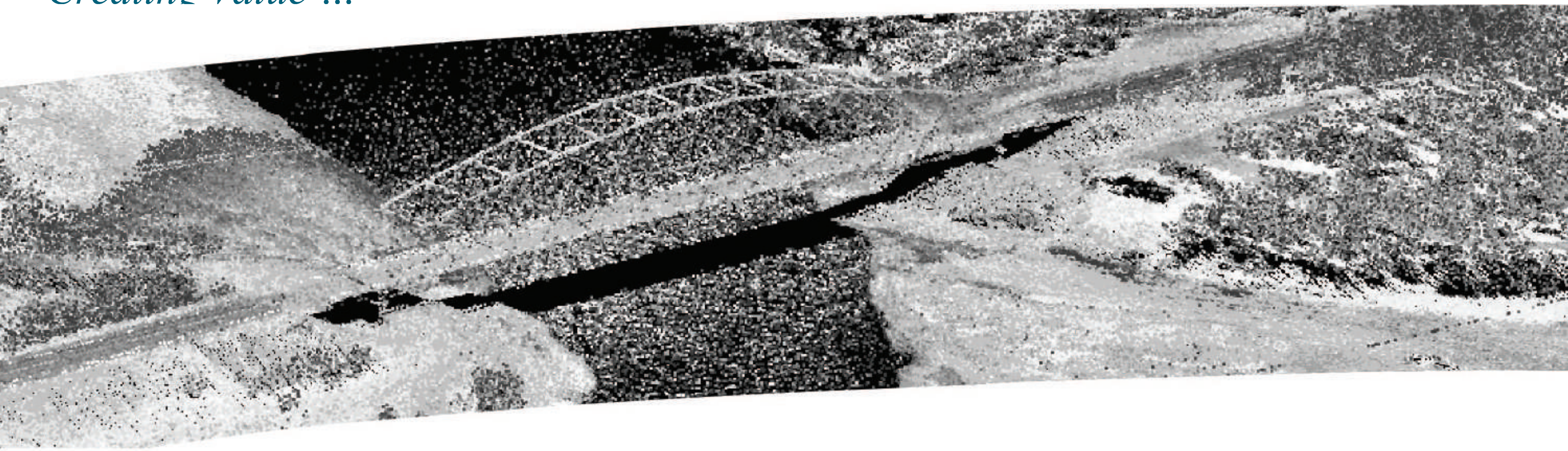
Creating Value …



LiDAR: Applications in Transportation

The Parks Highway Project

Presentation to Institute of Transportation Engineers, Alaska Section

Charles Barnwell, GIT Manager

April 3, 2012

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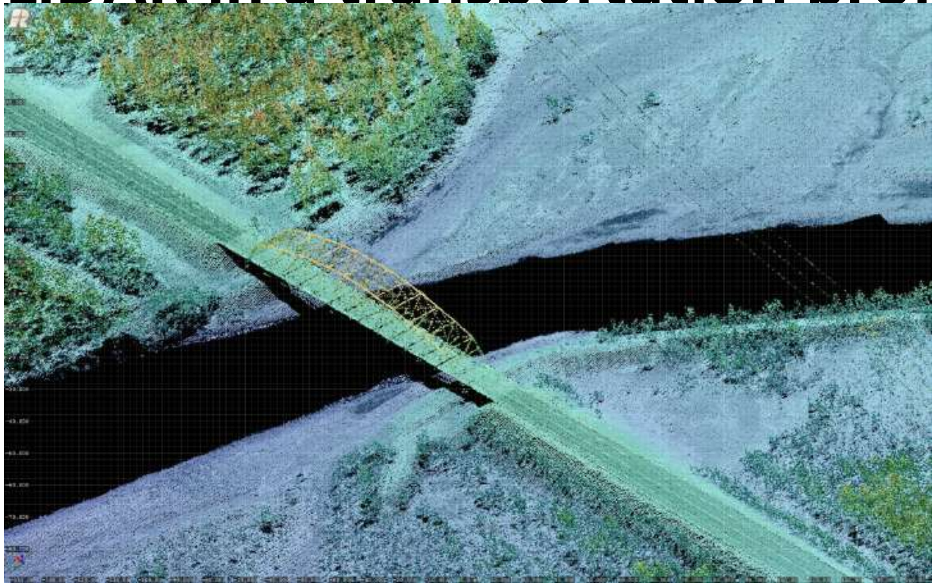
Agenda

- **Overview of LiDAR**
  - **Review benefits and issues of LiDAR as compared to traditional methods**
  - **How LiDAR is used with GIS and CAD**
- **Use a challenging Alaskan project to explain the benefits of LiDAR in a transportation project**



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- **In Alaska since 1942**
- **75 year old company, 3,800 employees**
- **Headquartered in Pennsylvania**
- **Transportation-focused**
- **Geographic information technology (GIT) is one of Baker's core disciplines**

What LiDAR Is:

- **LIght Detection And Ranging**
  - Active Sensing System: Uses its own energy source, rather than reflected natural light or naturally emitted energy
  - Detection of features from reflected light energy
  - Ranging of the reflecting object based on time difference between emission and reflection
  - Direct terrain data acquisition, not inferential like photogrammetry
  - Day or Night operation

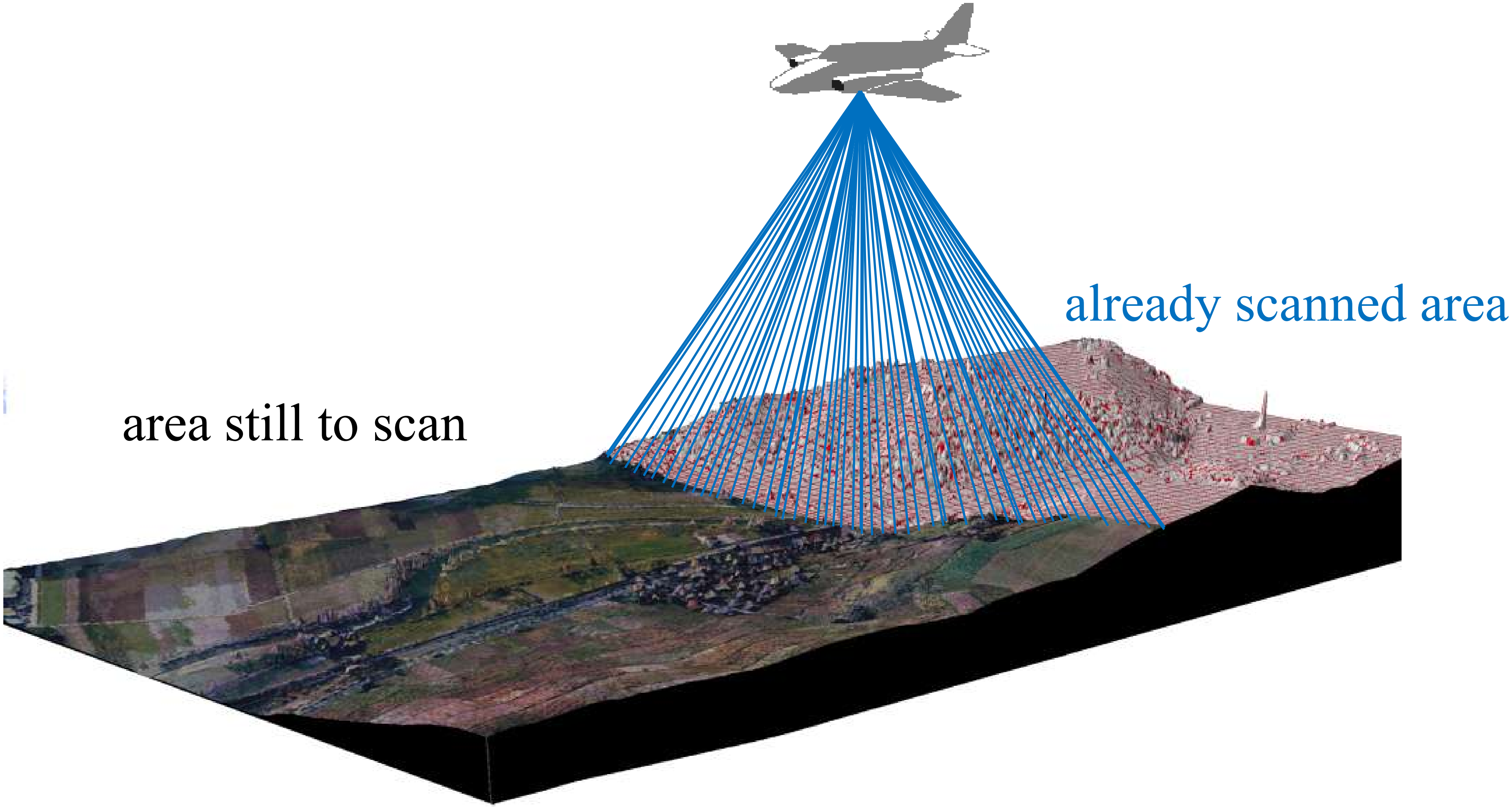
LiDAR

- **LiDAR Systems employ enabling technologies that include**
  - LASER instrumentation
  - GPS (Global Positioning System)
  - IMU (Inertial Measurement Unit)
  - High Performance Computing hardware and software
- **Two General Types**
  - Airborne
    - Fixed wing platform (airplane)
    - Rotary platform (helicopter)
  - ial / Mobile
    - , ATV, boat, Hi-Rail, stationary tripod

LiDAR – Why Now?

- **Several recent technological advances have made LiDAR possible:**
  - **Airborne GPS**
  - **Inertial Measurement**
  - **Advances in computer technology (processing speed, performance, storage, data transfer)**
  - **Availability of affordable lasers and advances in specialized materials and sensors**
  - **Advances in computer software to filter and analyze LiDAR data**

Airborne LiDAR = Laserscanning

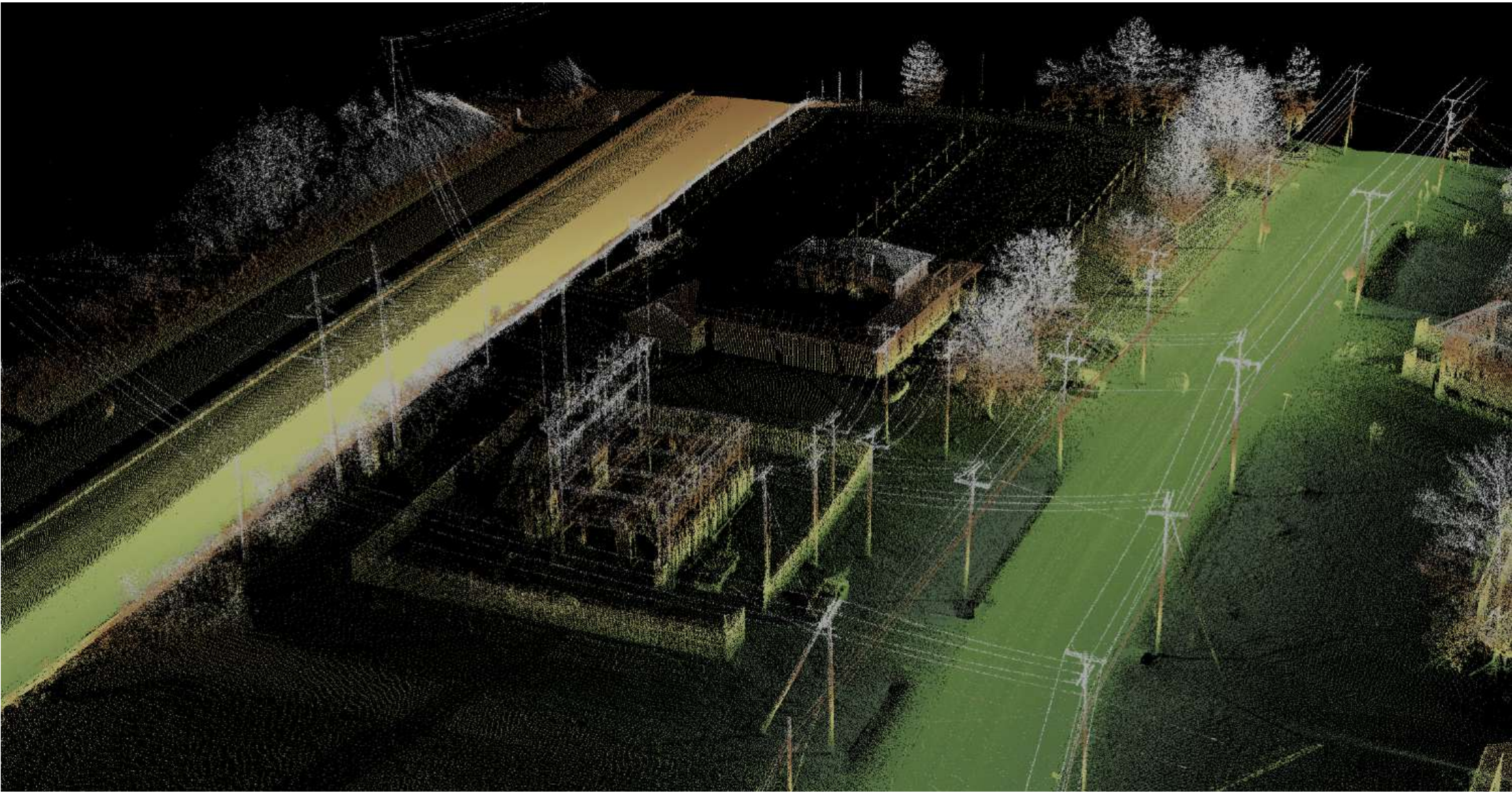


Key Factors for Good LiDAR Data

- Fly height
- Sensor parameters
- System accuracy
- Control
- Terrain
- Vegetation
- Weather (no fog or haze)



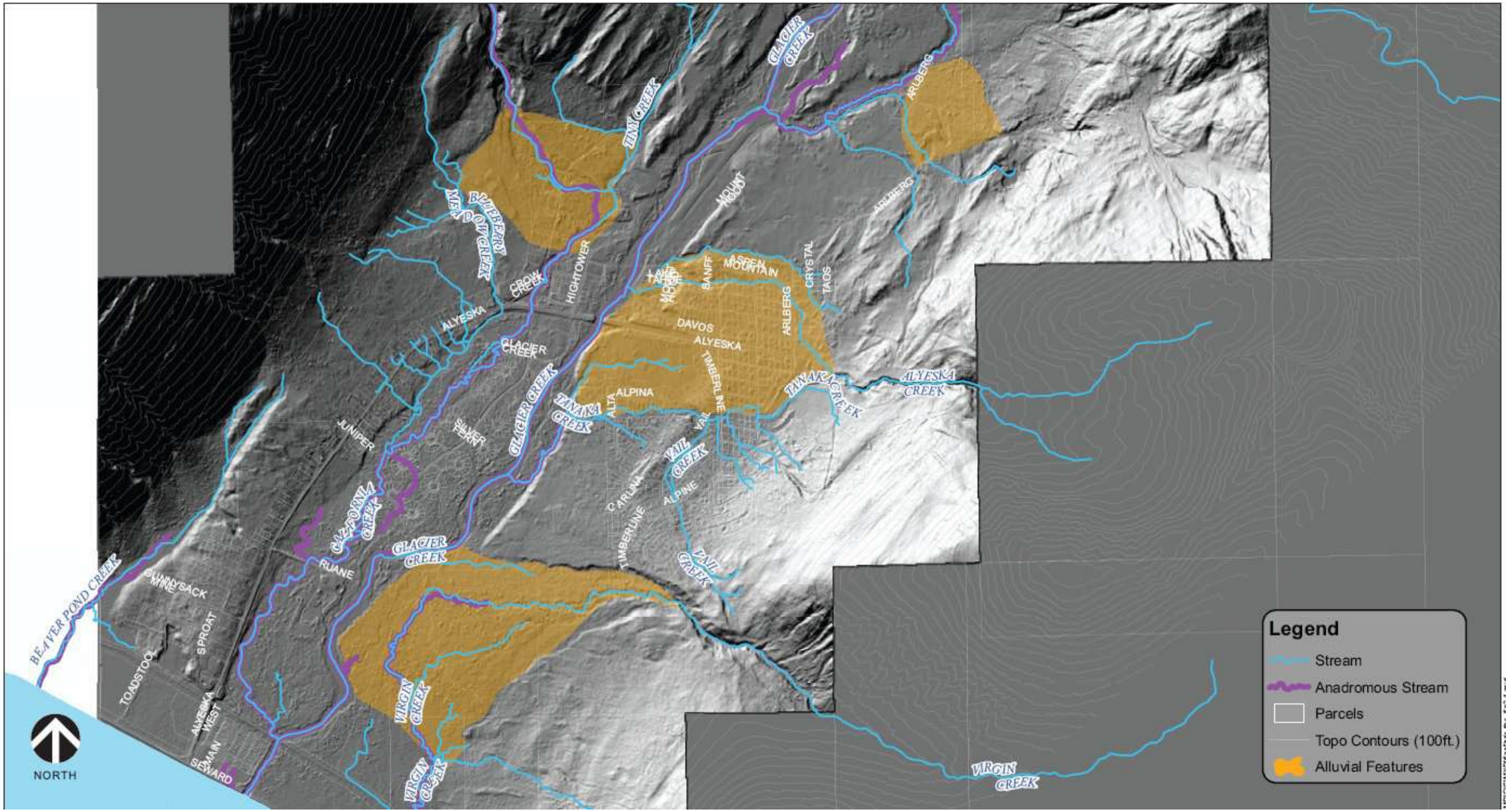
Point Cloud



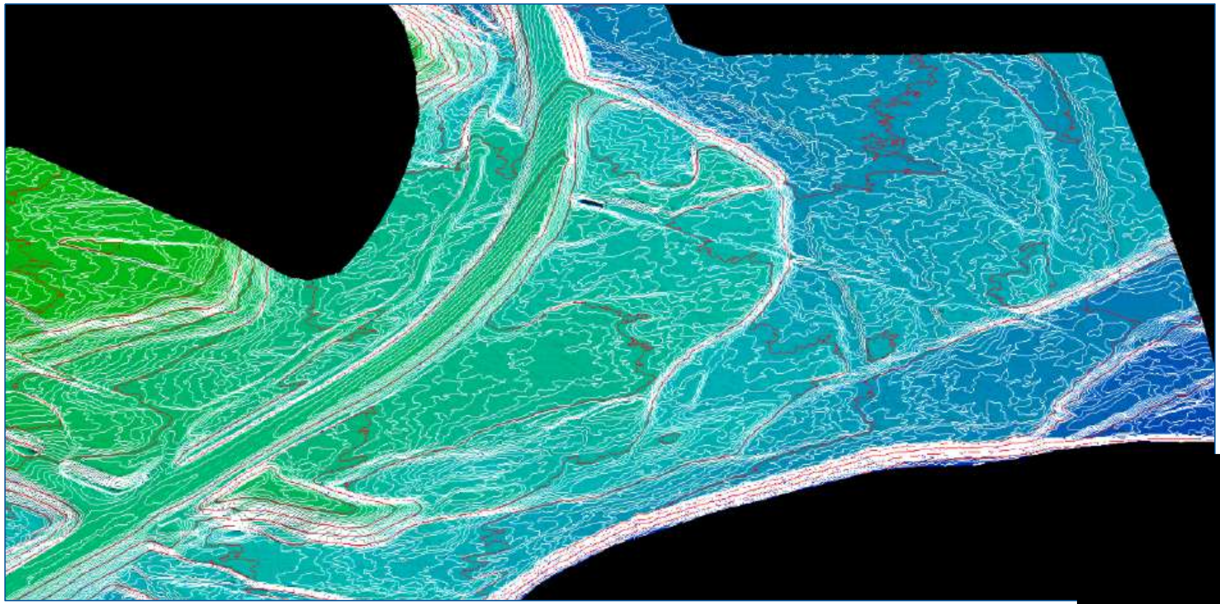
The entire LiDAR dataset is commonly referred to as the "point cloud"

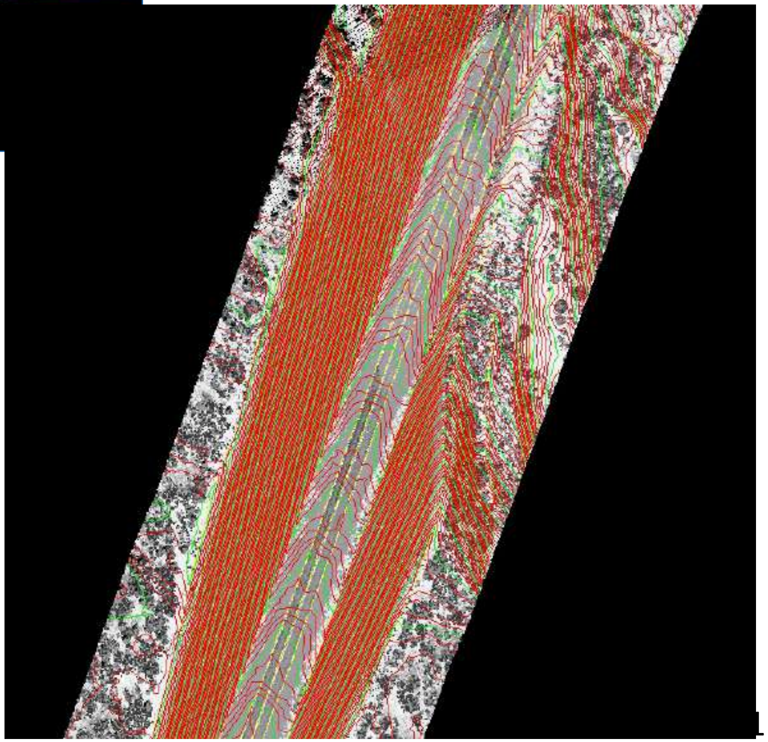
LiDAR Products

(Example: Girdwood)



LiDAR Products: Engineering Level



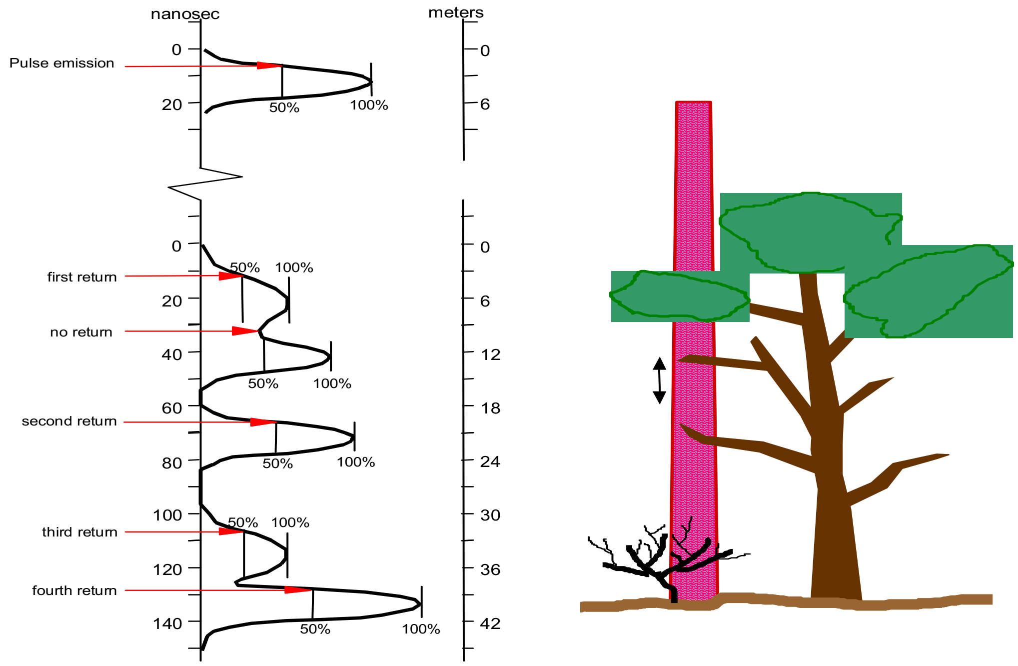


Products:
- TIN
- CAD topo contours
- DEM, DTM in GIS and CAD format
- Intensity Imagery

Multiple Return Schematic

Multiple Return LIDAR

EarthData Aeroscan Multiple Return LIDAR



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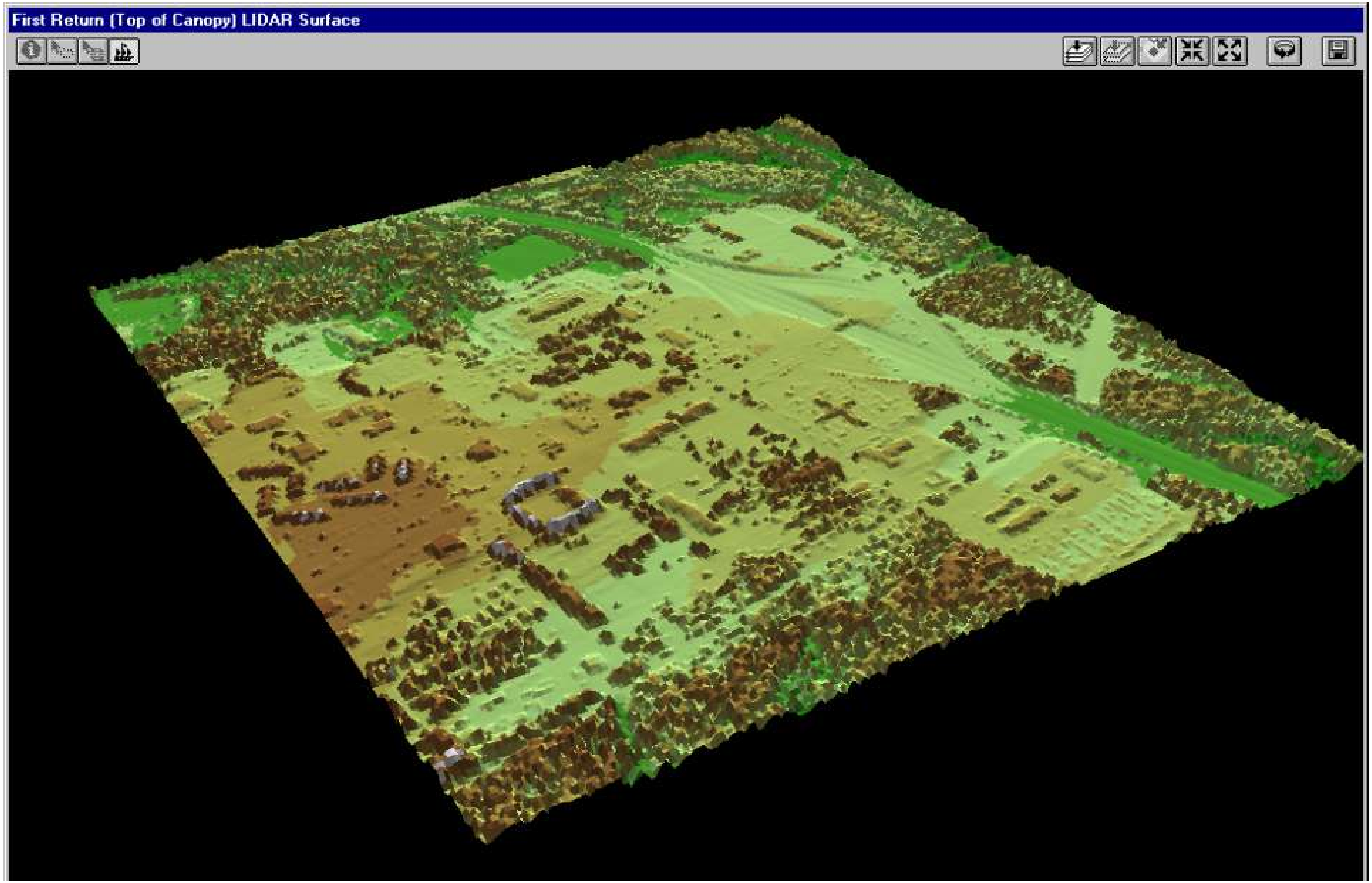
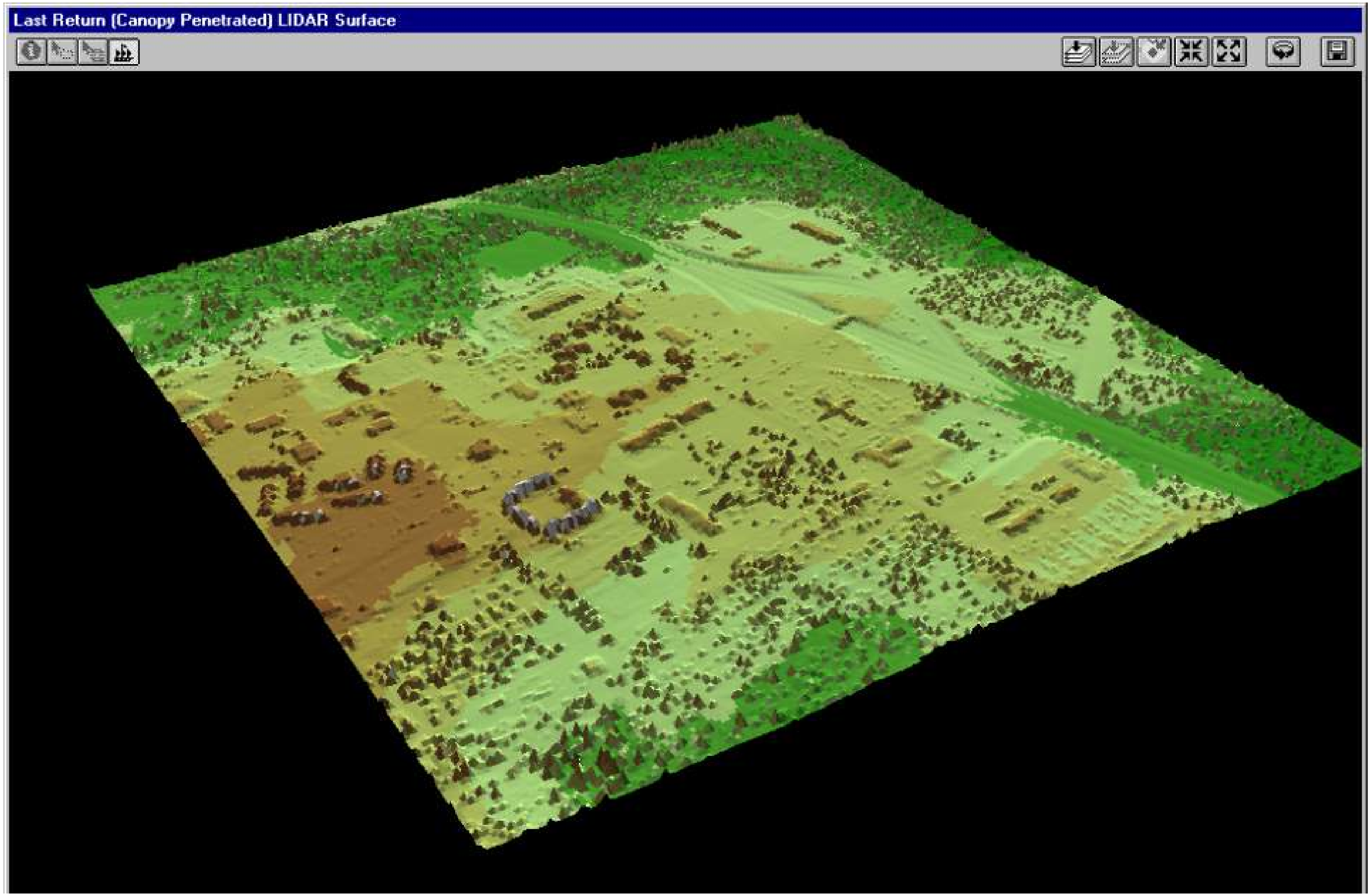
Raw FIRST Return LiDAR Data



Raw LAST Return LiDAR Data



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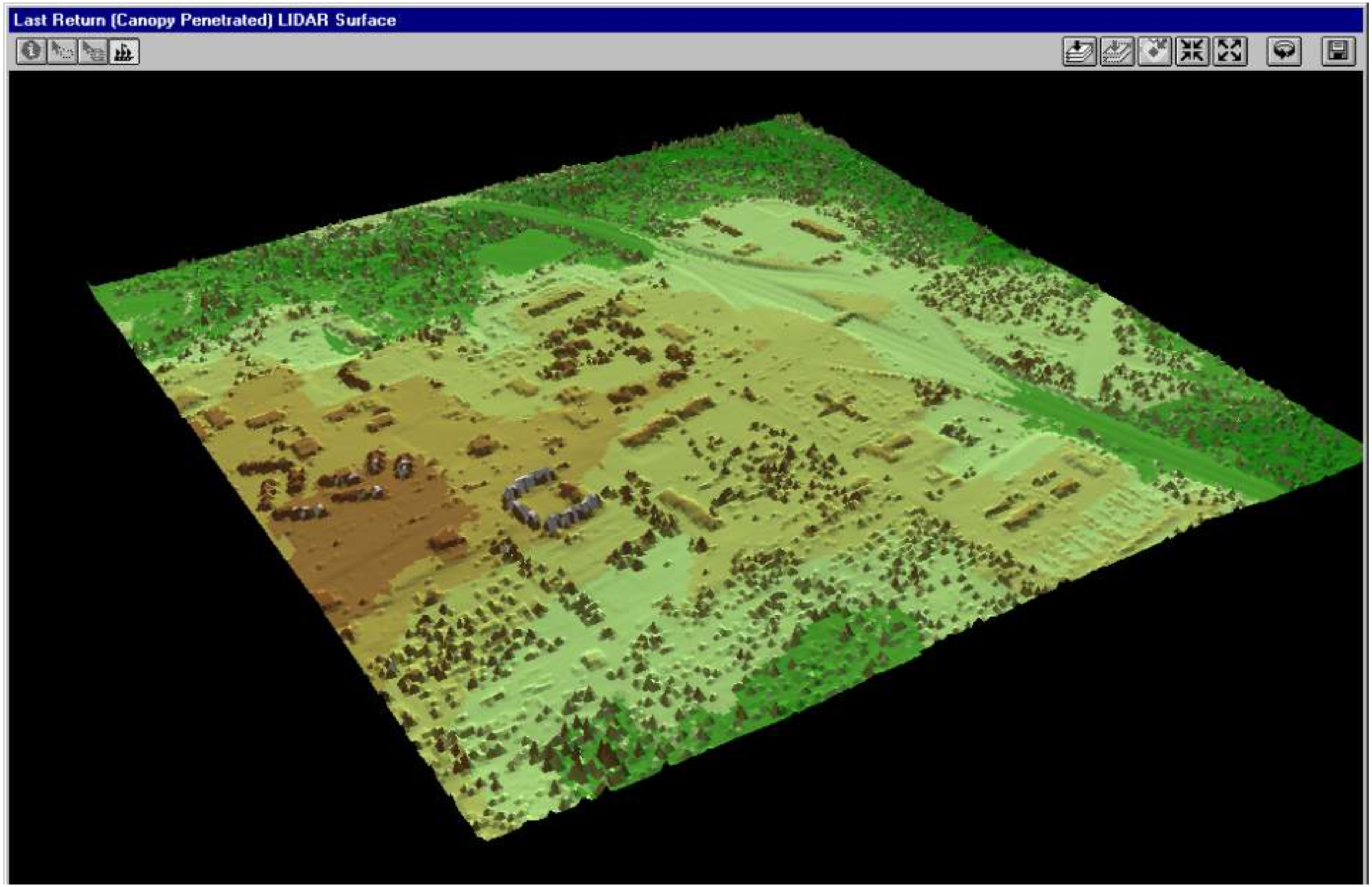
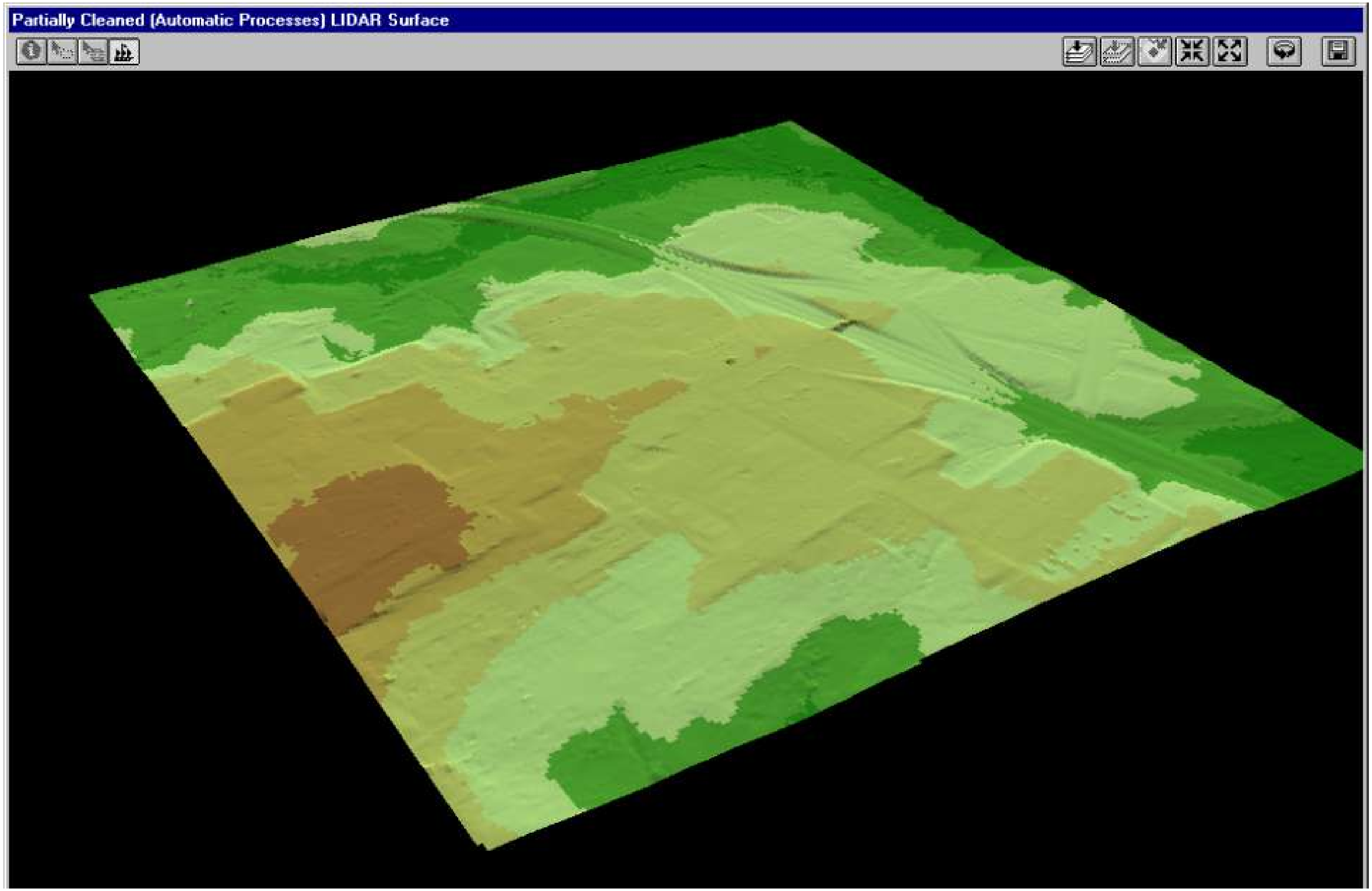
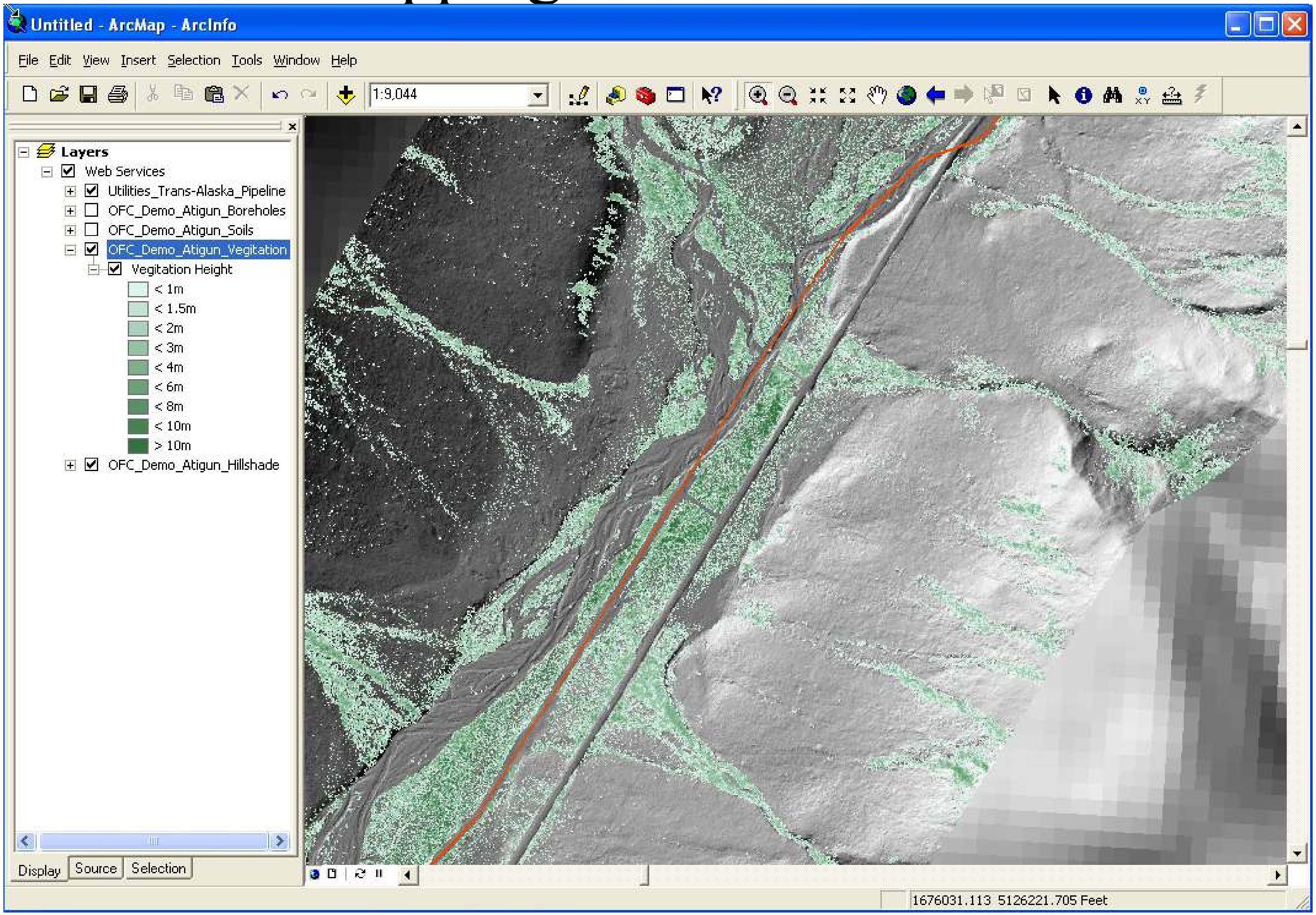
Before…



After…



Derivative LiDAR products – Vegetation Data and Mapping



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Efficiency

- **Cost Effective**
  - **Realize up to 40% cost-savings over traditional surveys**
  - **Capture more data, and in fine-detail**
- **Less Down Time**
  - **Collect day or night**
- **Stay on Schedule**
  - **Large project areas collected faster than traditional surveys**
- **Fewer Staff, Higher Safety**
  - **Never a need for more than 2-person collection crew**

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Data Confidence

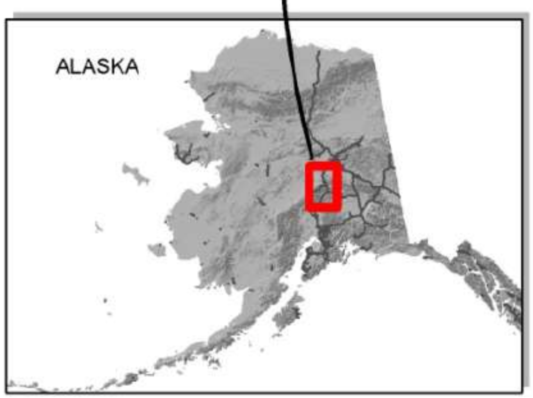
- **Everything is Captured**
  - Inundate the site with high-density scan information
  - Each pixel is assigned an X,Y,Z coordinate with Intensity
- **Images (easy scene comprehension)**
  - Revisit the project site from your desktop
  - Images are geo-referenced
- **Quality Deliverables**
  - Complete scenes, not just linear and points
  - Ability to visualize data in many ways
  - Configured for any users environment – CADD, Geodatabase
- **High-precision promotes Change Detection**
  - Repeatable, reliable results allow for seamless integration with past surveys

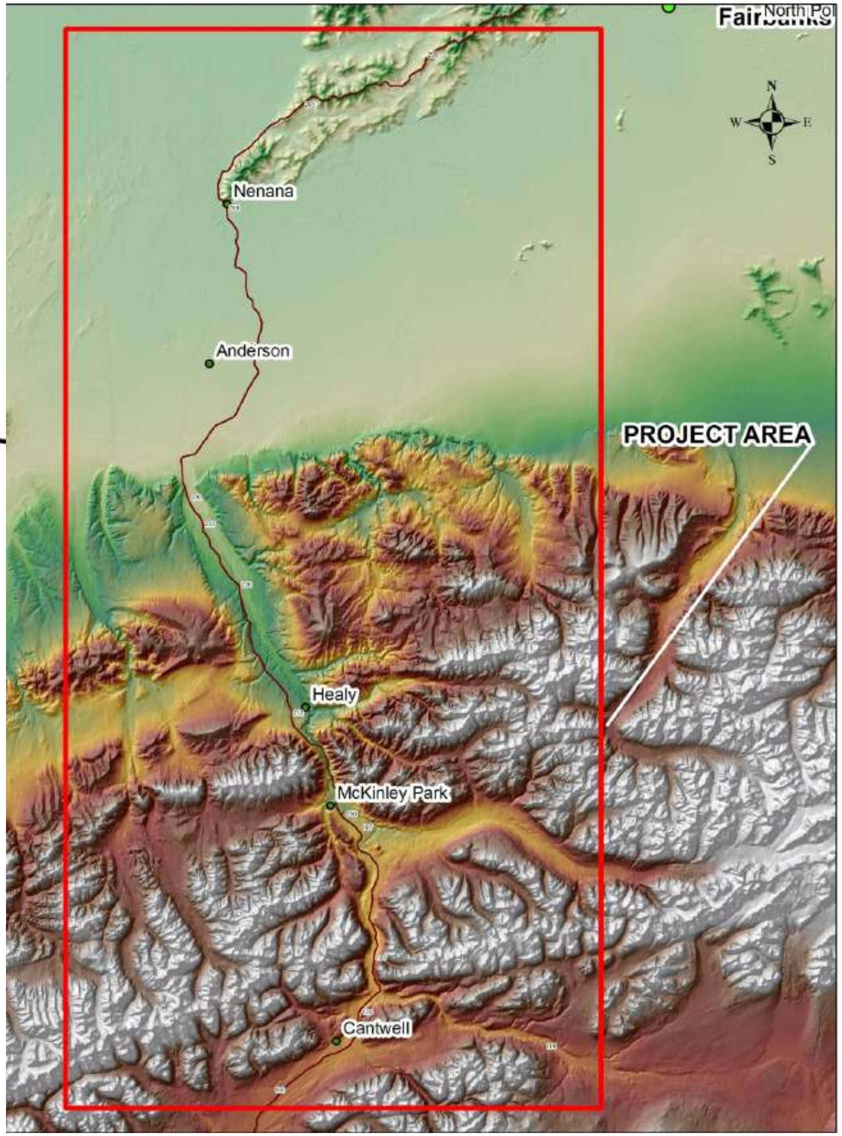
Resolution

Point density (pt./sq.m)	Resolution	Vertical Accuracy (cm.)	Applications
8	High Resolution	3-100 (sloped terrain, e.g. Parks Hwy)	Highway engineering
6	High Resolution	3-100 (even, flat terrain)	Highway engineering
4	High Resolution	8-15 25-30 sloped terrain	Road planning
2	Medium Resolution	18-20 (beaches) 40-61 (sand dunes) 7 (flat)	Coastal, river management
1	Medium Resolution	7-14	Flood zone management
0.25	Low Resolution	8-22	General terrain mapping
0.04	Low Resolution	30-100	Tsunami flooding analysis

Parks Highway—Case Example

Project Location





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Project Objectives

- **Produce topographic contours with 5- and 2- foot intervals**
- **Produce TINs for use in AutoCAD Civil 3D**
- **Other:**
  - **Perform a vertical accuracy assessment on LiDAR elevations**
  - **Produce a "bare-earth" Digital Elevation Model (DEM) of the corridor**
  - **Produce 3D break lines using LiDARGrammetry**

Project Steps & Sequence

1. **LiDAR acquisition**
2. **LiDAR raw data processing**
3. **Establish Coordinate System for project; LiDAR data calibration with survey control**
4. **LiDARGrammetry to produce breaklines, DTM, DEM**
    1. **Breaklines mapped using intensity imagery and DEM**
    2. **DTM produced and used in CAD to produce contours and TINs**
5. **Product generation: TIN, topo contours**

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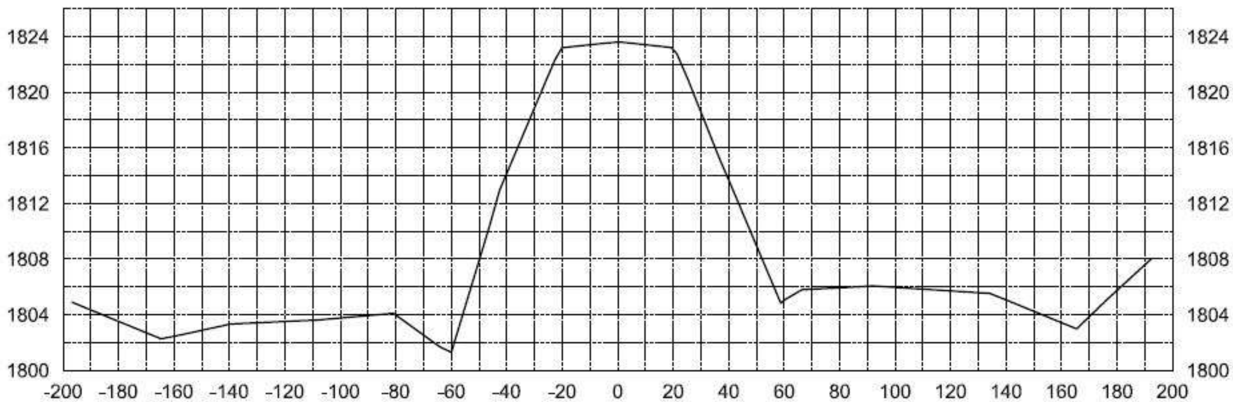
Coordinate System

- **This Parks Highway LiDAR project was done in a local, plane coordinate system in US Survey feet**
- **Translated from Alaska State Plane, Zone 4, NAD83, US Survey feet to the local project coordinate system**
- **Project elevations are orthometric, NAVD88 vertical datum, in feet, computed with Geoid09.**

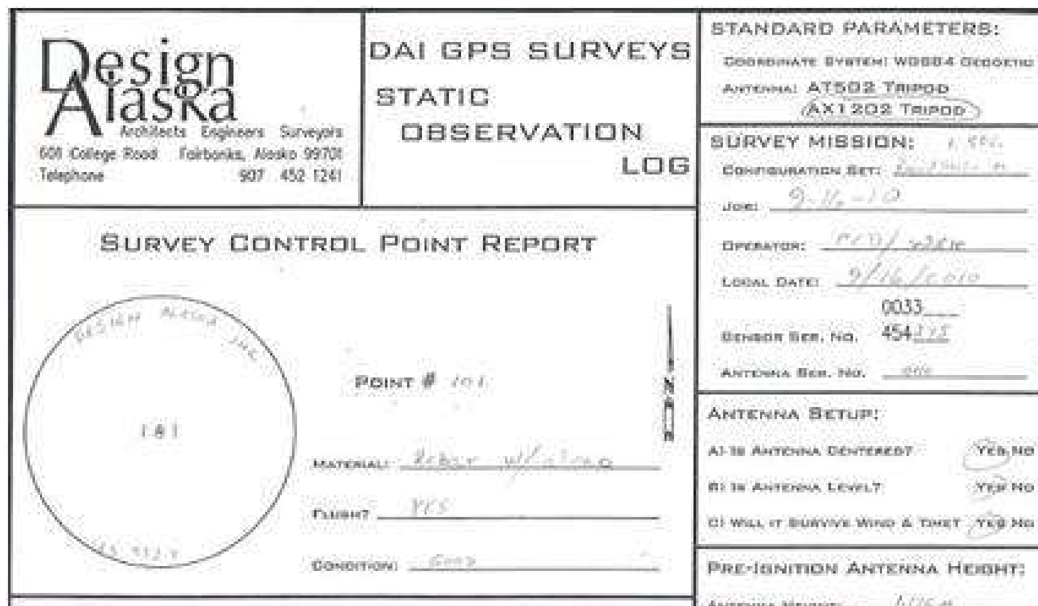
Survey Control

900+50



SURVEYED CROSS SECTION

Control point



Design Alaska
Architects Engineers Surveyors
601 College Road Fairbanks, Alaska 99701
Telephone 907 452 1241

DAI GPS SURVEYS
STATIC OBSERVATION LOG

SURVEY CONTROL POINT REPORT

POINT #

MATERIAL:

FLUSH?

CONDITION:

STANDARD PARAMETERS:
COORDINATE SYSTEM: WGS84 GEODETIC
ANTENNA: AT502 TRIPOD
AX1202 TRIPOD

SURVEY MISSION:
CONFIGURATION SET:
JOB:
OPERATOR:
LOCAL DATE:
SENSOR SER. NO. 0033 454
ANTENNA SER. NO.

ANTENNA SETUP:
A) IS ANTENNA CENTERED? YES NO
B) IS ANTENNA LEVEL? YES NO
C) WILL IT SURVIVE WIND & THEFT YES NO

PRE-IGNITION ANTENNA HEIGHT:
ANTENNA HEIGHT:

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Calibration of LiDAR Data to Survey Control

Number (control pt.)	Easting	Northing	Known Z (ft.)	Laser Z (ft.)	Dz (ft.)
ARR410	1823062.41	3546276.93	1826.4	1826.43	0.03
DA101	1784062.20	3760259.48	565.79	565.96	0.17
DA102	1798792.15	3610006.29	1452.93	1453.01	0.08
DA103	1835744.13	3459445.4	2154.53	2154.4	-0.13
DA104	1754570.32	3367478.46	2111.35	2111.04	-0.31
PARKS159.0	1697503.31	3271632.28	1647.42	1647.59	0.17
PARKS200.5	1780211.45	3405710.21	2389.84	2390.01	0.17
PARKS268.8	1760531.34	3701654.92	887.59	887.42	-0.17
PARKS296.8	1790373.12	3823737.67	414.6	414.81	0.21

Average dz	0.024
Minimum dz	-0.31
Maximum dz	0.21
Average magnitude	0.16
Root mean square	0.176
Std deviation	0.185

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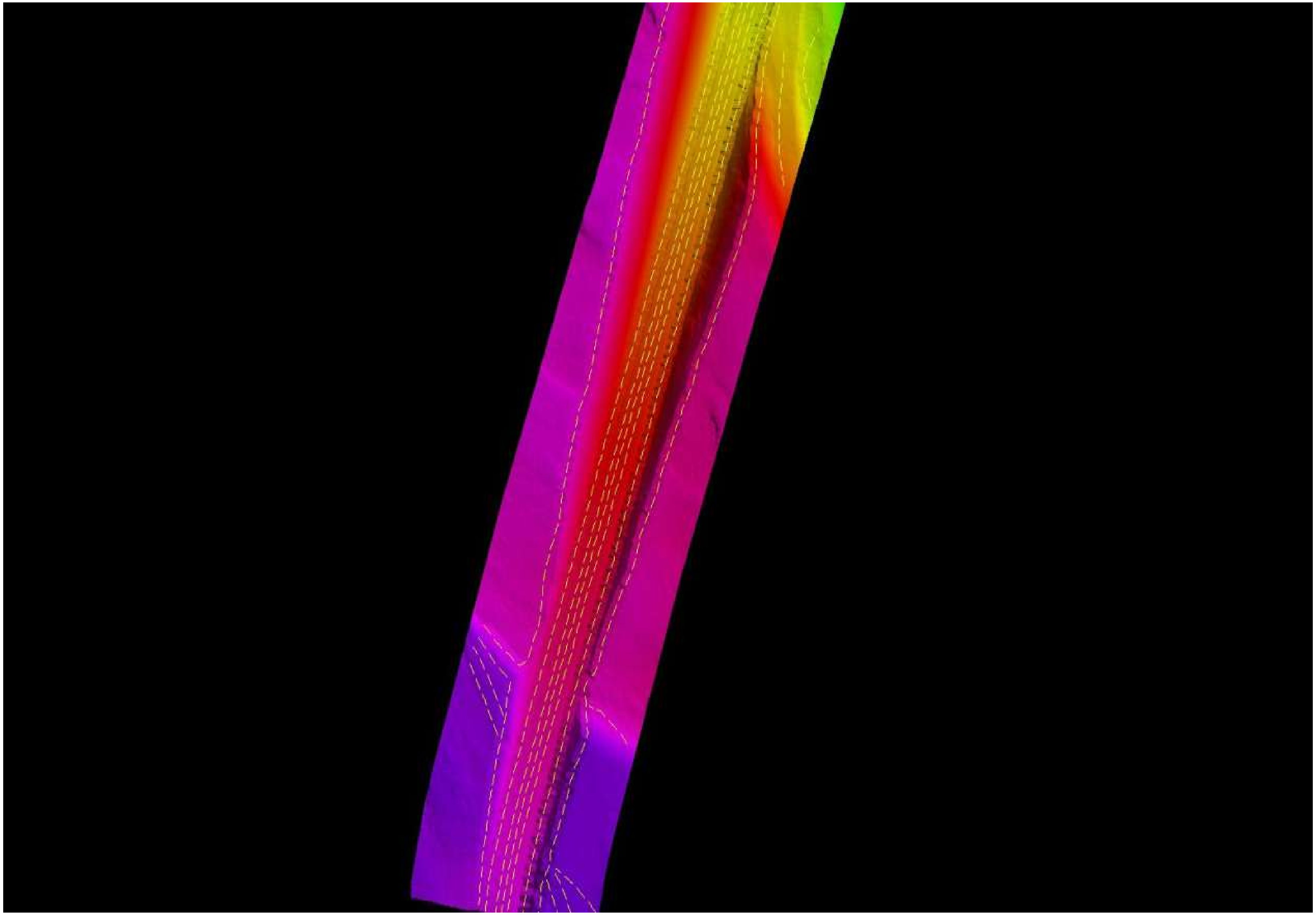
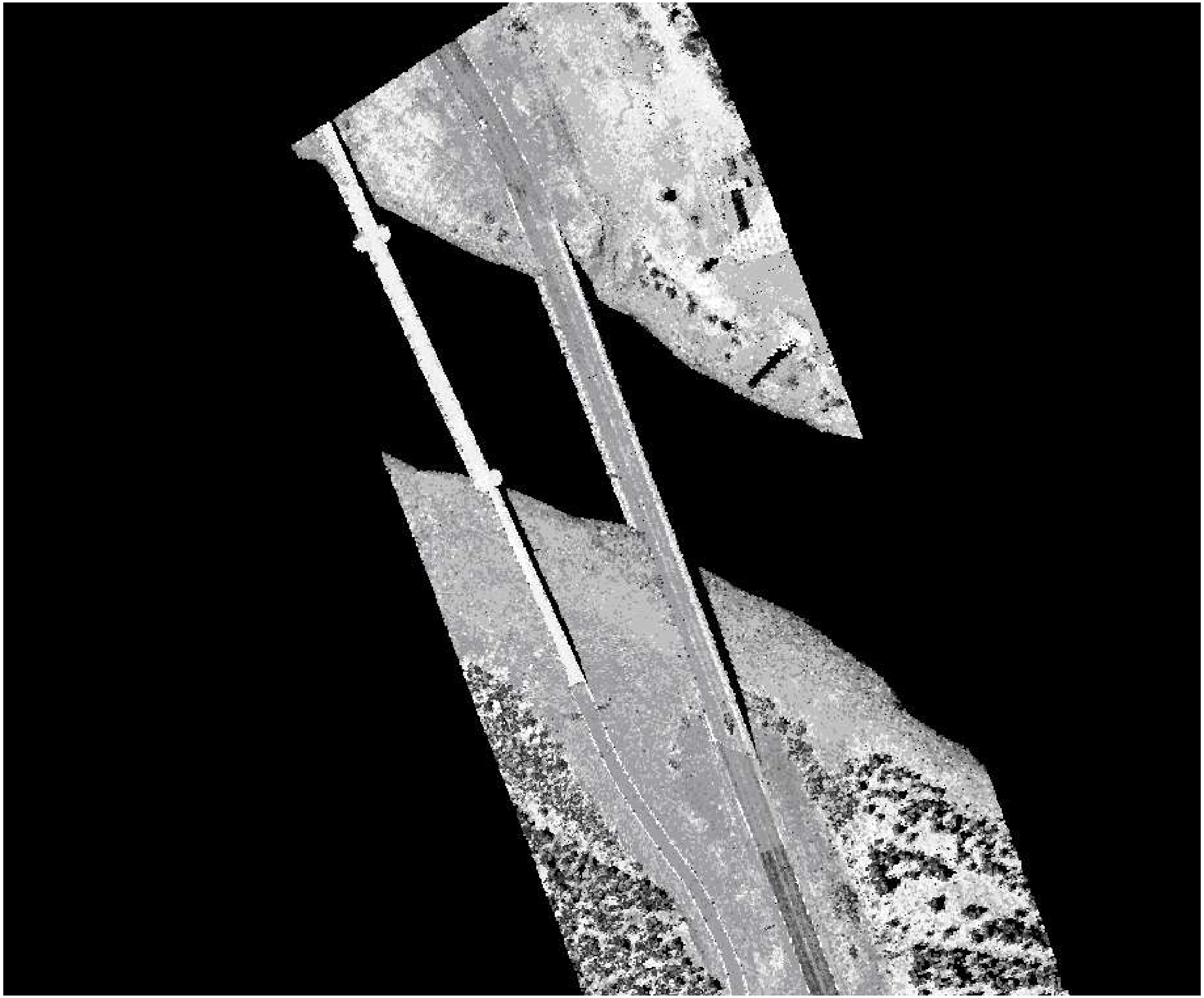
QA/QC

Parameters	Control Point Values-- Centerline Profile (ft.)	Cross section Profile (ft.)
Average dz	+0.102	+0.207
Minimum dz	-0.500	-0.290
Maximum dz	+0.592	+1.540
Average magnitude	0.126	0.247
Root mean square	0.158	0.347
Standard deviation	0.121	0.279

Elevation



Intensity Image (Nenana River Bridge at Denali Park)



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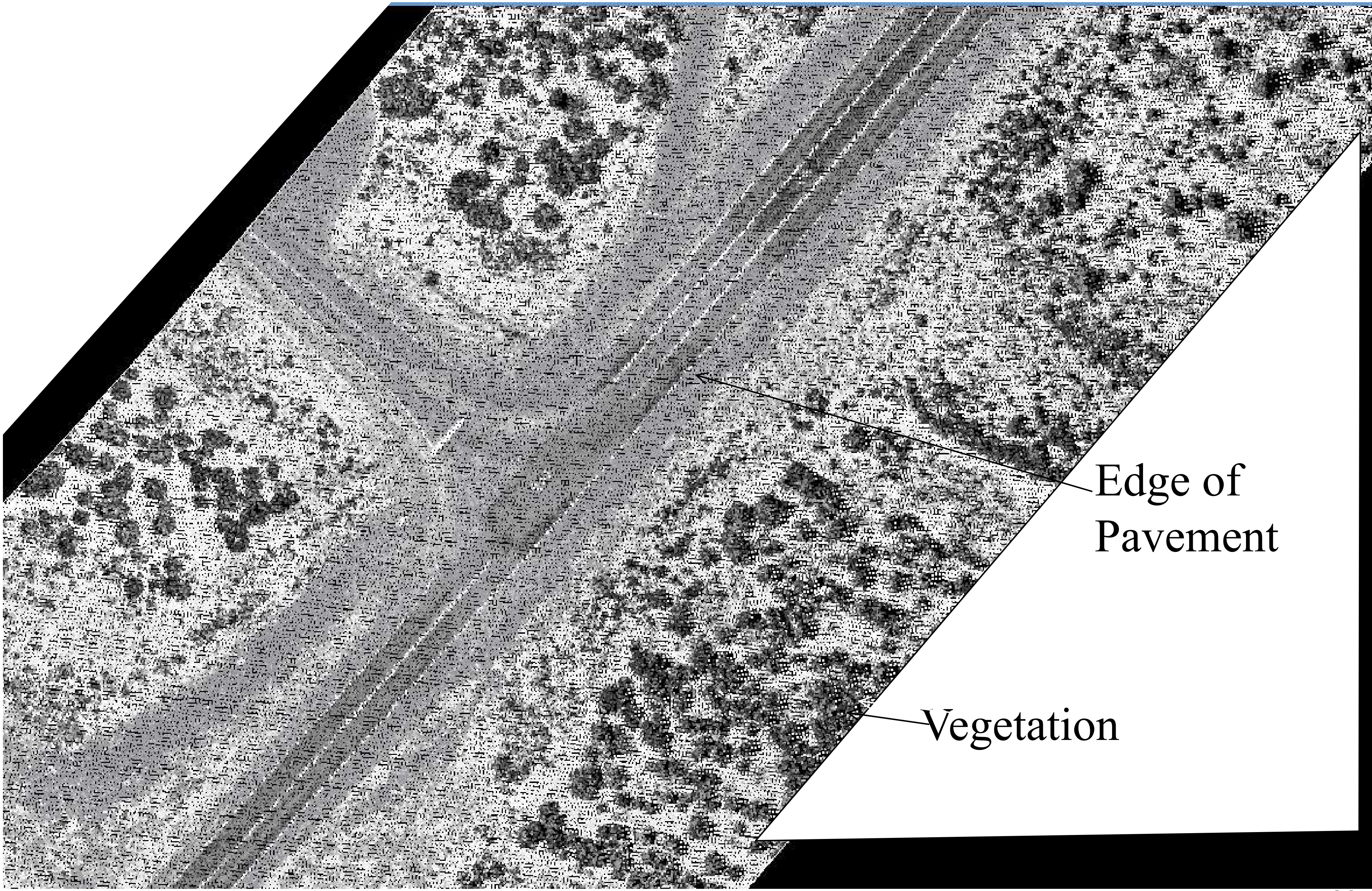
Intensity Image (Parks Hwy/Denali Park Entrance Intersection)



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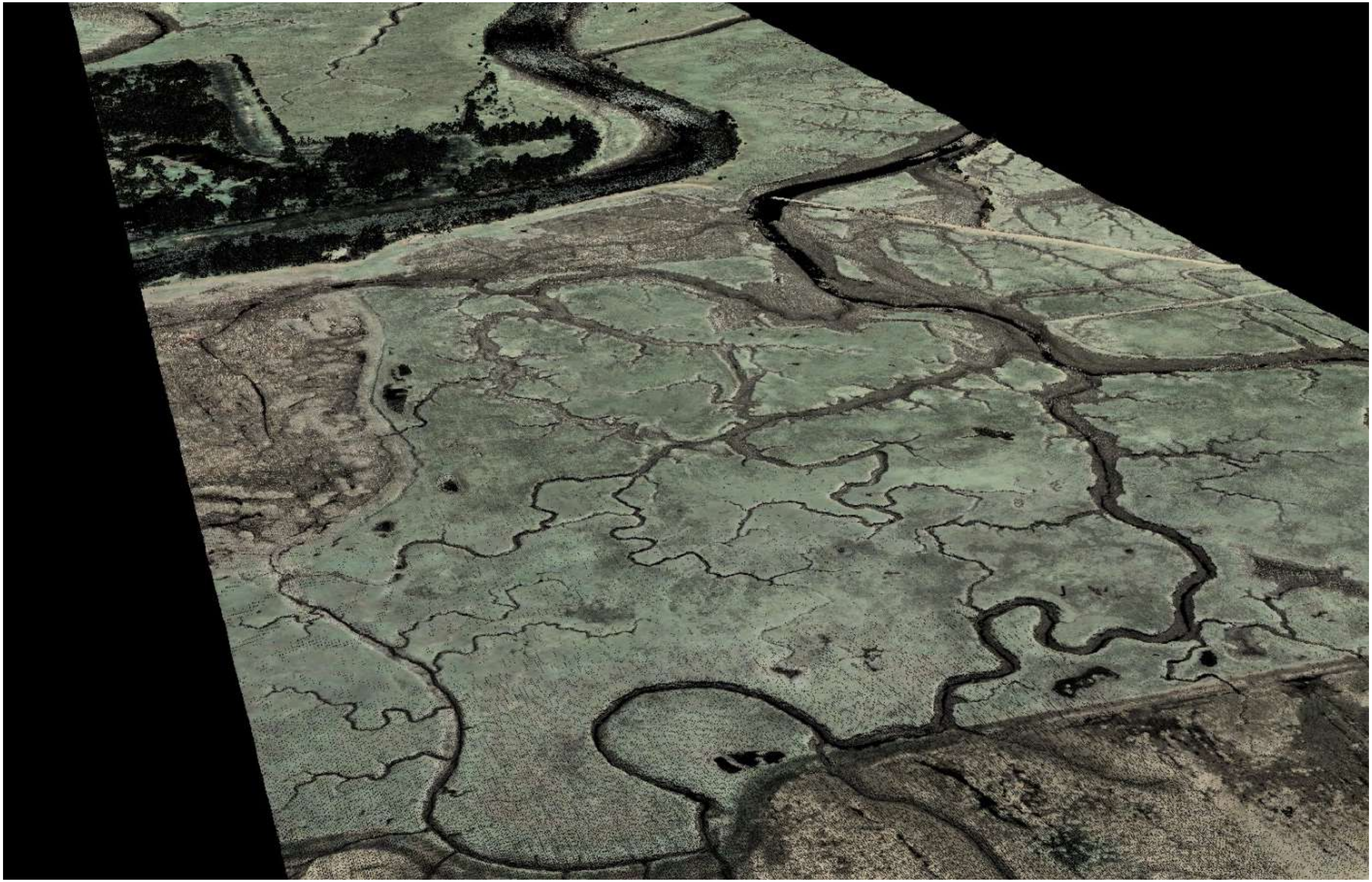
LiDAR Aerial Imagery Combination



GIS: ArcMap Drape Sample

Conclusions

1. **Direct, i.e. digital terrain data is invaluable; can be applied to many uses; and is easily re-usable**
2. **Engineering grade accuracies (horizontal and vertical) are achievable**
3. **High resolution LiDAR offers many advantages at reasonable cost. Up to 40% cost savings can be achieved.**
4. **LiDAR data integrates well now with GIS and CAD software to offer advantages for processing and analysis not seen even 2 years ago**

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