Quality Assessment of Aerial LiDAR Data for IIT Kanpur Campus: A Comprehensive Analysis

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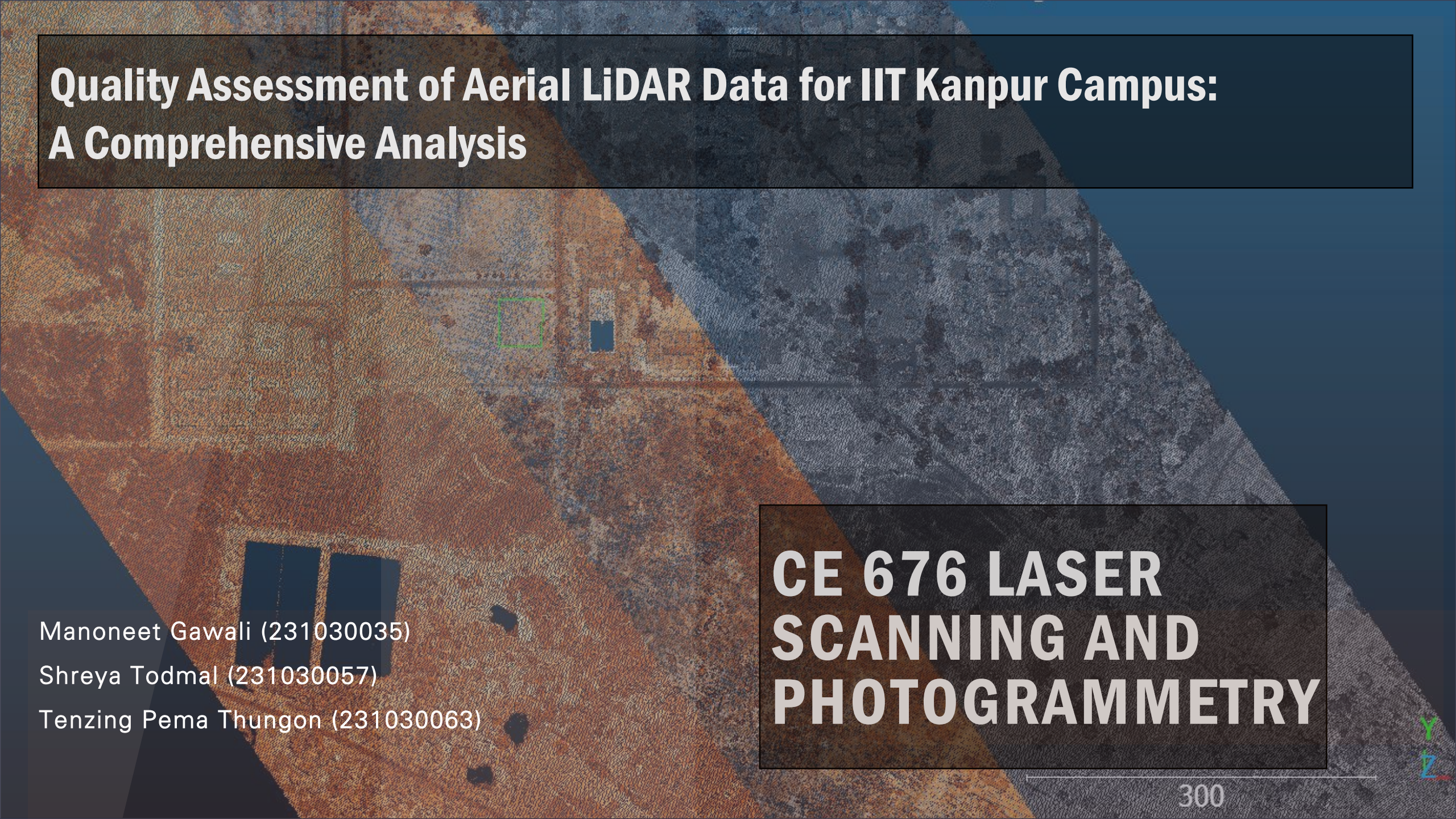
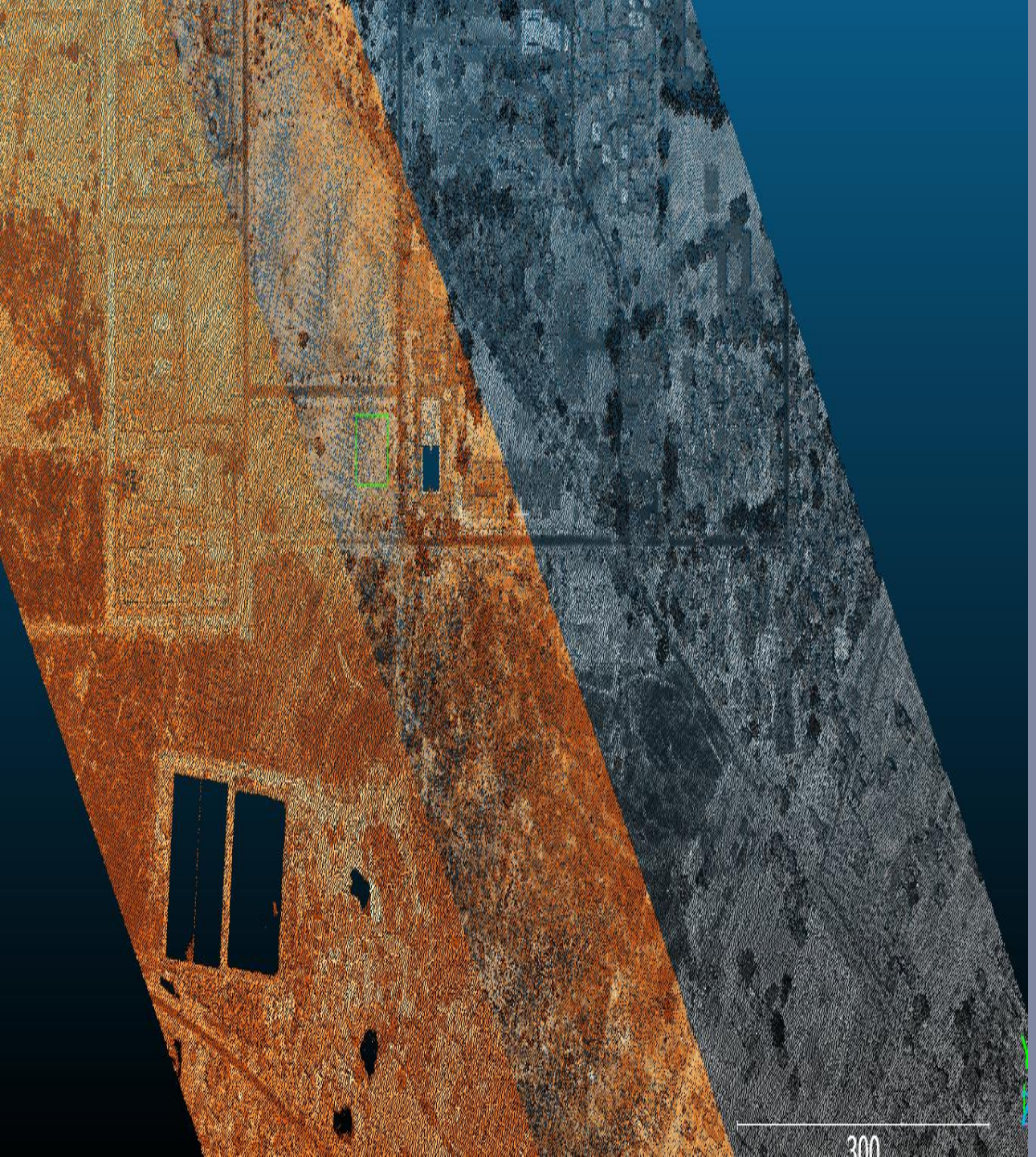
CE 676 LASER SCANNING AND PHOTOGRAMMETRY





AGENDA

Introduction

Quality assessment

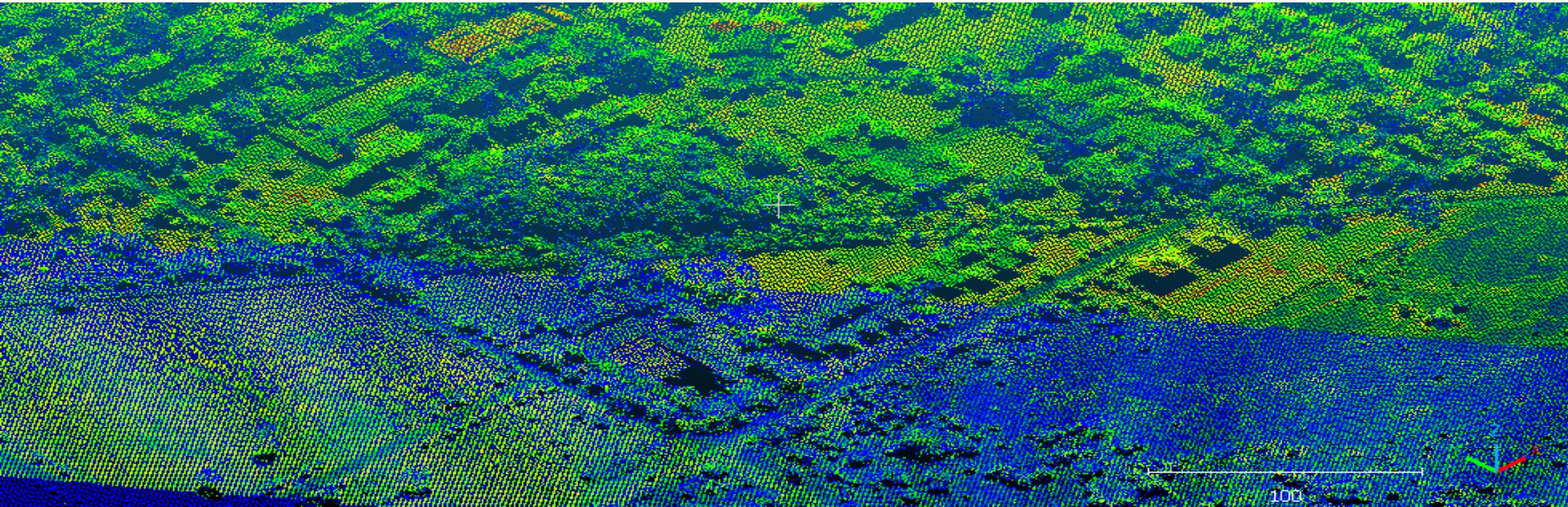
- Return number
- Overlap
- Accuracy: VA, HA, RA
- NPS
- Data density
- Data voids
- Spatial distribution

Result

- Combined data
- Analysis

INTRODUCTION

This project aims to evaluate the quality of aerial LiDAR data covering the region of IIT Kanpur. Through a comprehensive assessment, various quality parameters such as LiDAR returns, overlap between flight lines, vertical and horizontal accuracy, relative accuracy, point density, data voids, and spatial distribution will be analyzed.



REGION IDENTIFICATION

Feature identification in LiDAR data via satellite imagery on Google Earth Pro

Major features are highlighted for identification

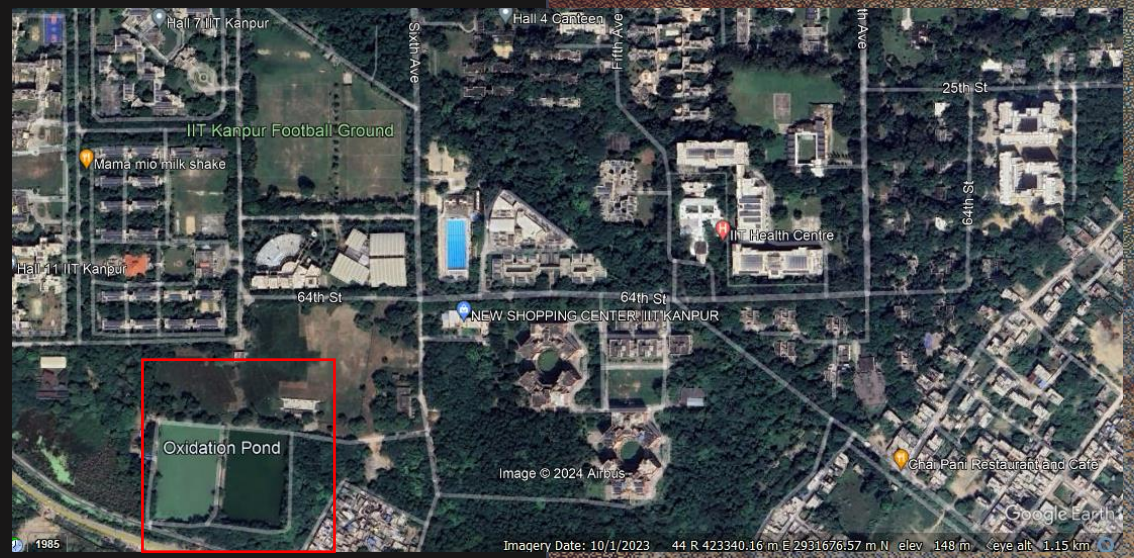


Fig: Satellite imagery on Google Earth Pro of IIT K

Fig: LiDAR data visualized in Cloud Compare

NUMBER OF RETURNS

Number of returns are determined by a MATLAB code

Number of returns: 3

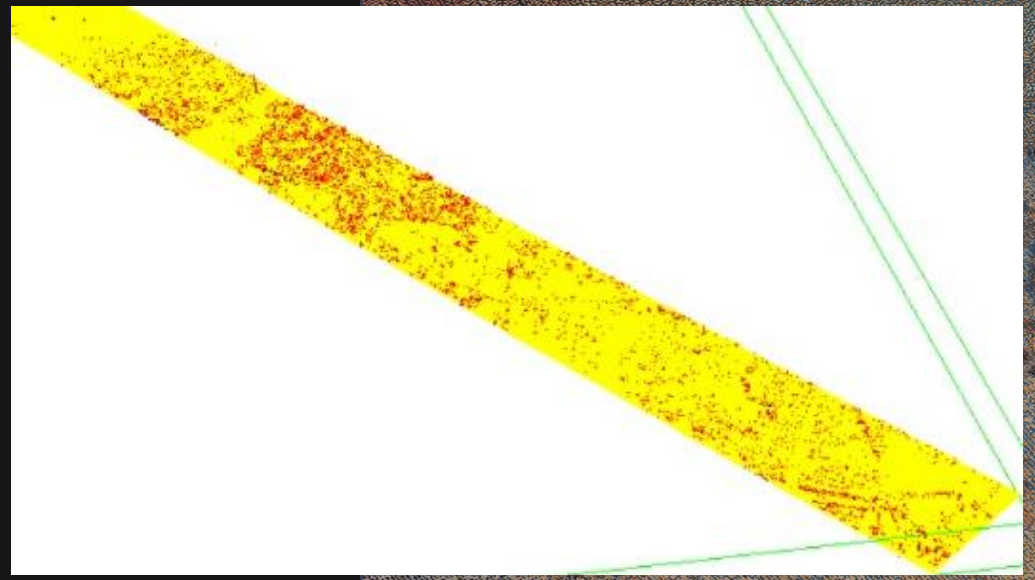


Fig: LiDAR data displayed in QGIS by number of returns

Fig: Zoomed view of above image, showing three colors

PERCENTAGE OVERLAP

Methodology:

- Multiple test sites segmented
- DEM generated
- Surface area calculated
- Percentage overlap determined

Maximum Overlap: 19.223%
Minimum Overlap: 17.591%
Average Overlap : 18.047%

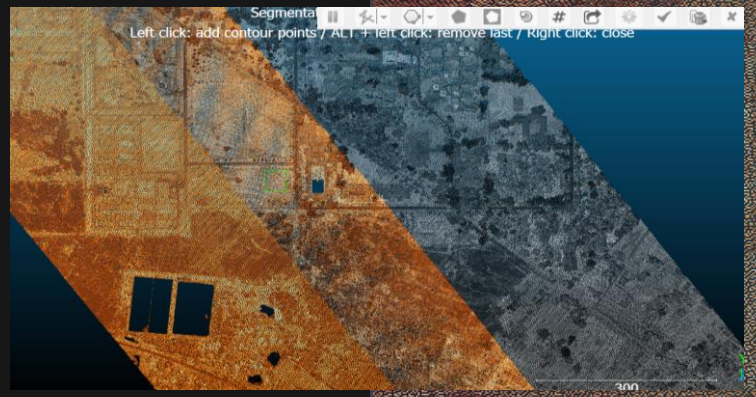


Fig: LiDAR data overlap visualization

Fig: DEM generated by CSF filter

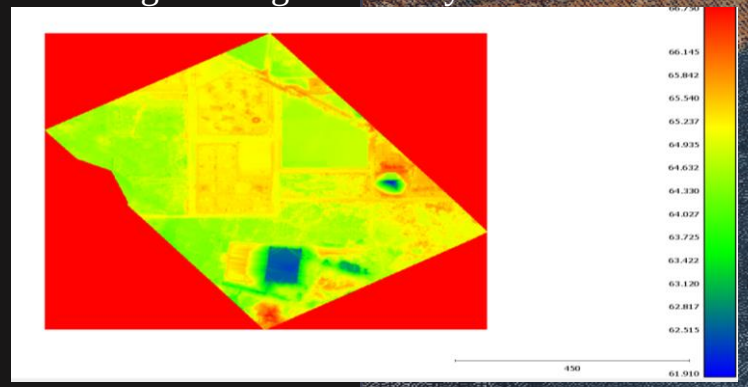


Fig: Surface Area calculation for first return

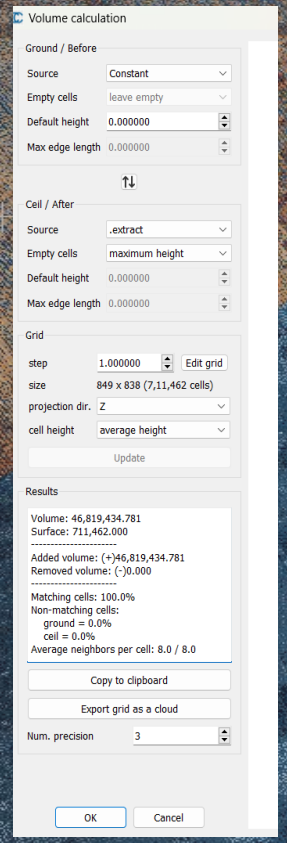


Fig: Surface Area

DATA COLLECTION

GCP data collection criteria:

1. 30 points per test site
2. Open to sky
3. Well distributed over the test site
4. Plain ground data (for first return)

Datum: WGS 84

Data collected in RTK mode by GNSS R10 receiver

Accuracy of check point > 3* vertical accuracy of data

Datum: WGS 84

Fig: Test site selection

Fig: GCP Data collection by GNSS receiver

Fig: GCP overlaid on test site

VERTICAL ACCURACY: NON VEGETATED VERTICAL ACCURACY

Methodology:

1. TIN generated of GCP
2. Interpolating LiDAR heights in TIN
3. Calculating $RMSE_Z$

$$RMSE_Z \sqrt{\sum(Z_{Lidar}^2 - Z_{GCP}^2)/n}$$

4. $Accuracy_z = 1.96 * RMSE_Z$

RMSE: 23.7 cm
NVA: 46.45 cm

Fig: Elevation view of LiDAR data and GCP

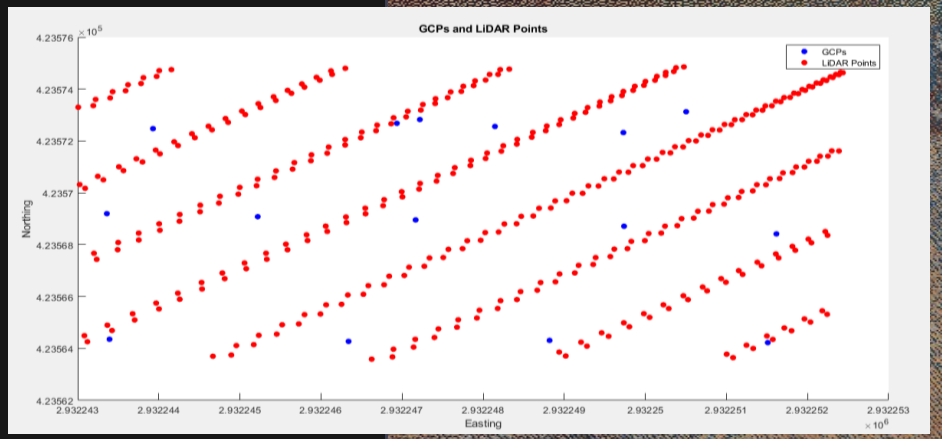


Fig: Data distribution

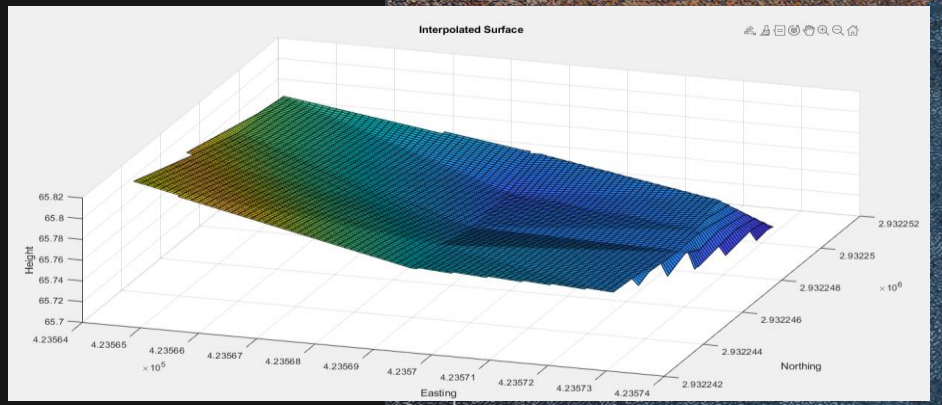


Fig: Interpolated TIN of GCPs

VERTICAL ACCURACY: VEGETATED VERTICAL ACCURACY

Methodology:

1. Collecting GCP data in vegetated area
2. Calculating difference in elevation of LiDAR and GCP points
3. $\text{Accuracy}_z = 1.96 * \text{RMSE}_Z$

VVA: 360.5 cm

Fig: Test site GCPs overlaid on LiDAR data

Fig: Test site 1

PLANIMETRIC ACCURACY

Methodology:

1. Collecting GCP data
2. Calculating $\mathrm{RMSE_x}$

$$RMSE_x \sqrt{\sum(X_{Lidar}^2 - X_{GCP}^2)/n}$$

4. $\mathrm{Accuracy_r} = 1.738 * \mathrm{RMSE_r}$

$\mathrm{RMSE_x}$: 44cm
$\mathrm{RMSE_y}$: 77 cm
$\mathrm{RMSE_r}$: 88.68 cm
Planimetric accuracy: 154.134 cm

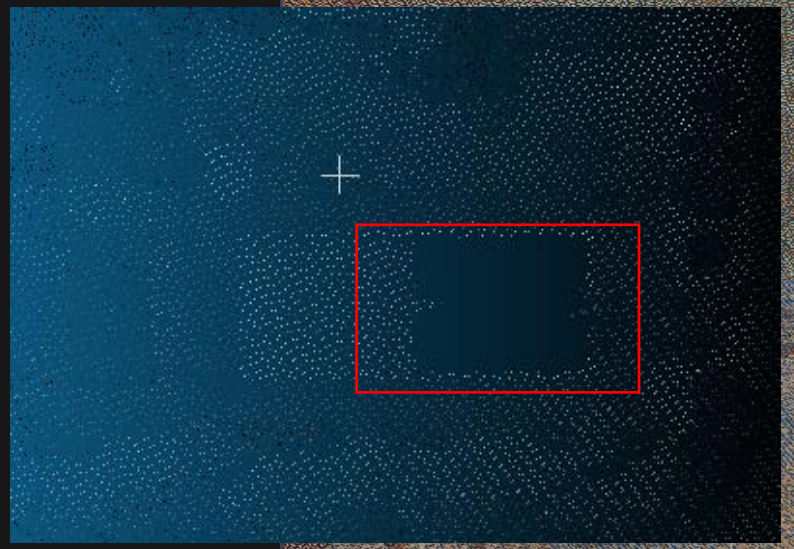


Fig: Test site for HA

Fig: Taking GCP readings

RELATIVE ACCURACY

Methodology:

1. Segmenting various test sites
2. Calculating standard deviation for each site
3. Reporting relative accuracy

Relative accuracy:
Flight line 1: 3.768 cm
Flight line 2: 8.0516cm
Overlap region: 19.1502 cm

Fig: Elevation view of single flight line

Fig: Elevation view of overlap area

DATA DENSITY

Methodology:

1. Selecting 90% of each swath, taking first return value only.
2. Create 2D Delaunay triangle
3. Calculate average length of edges for each point
4. Calculate 95th percentile of spacing values

Data density: 0.744 points/m^2

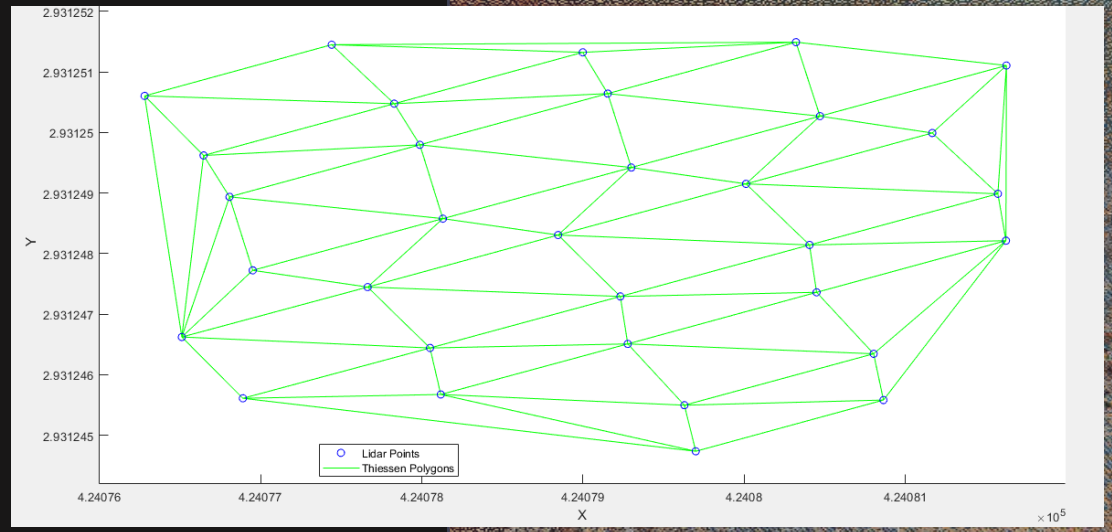


Fig: Vornoi diagram of test site

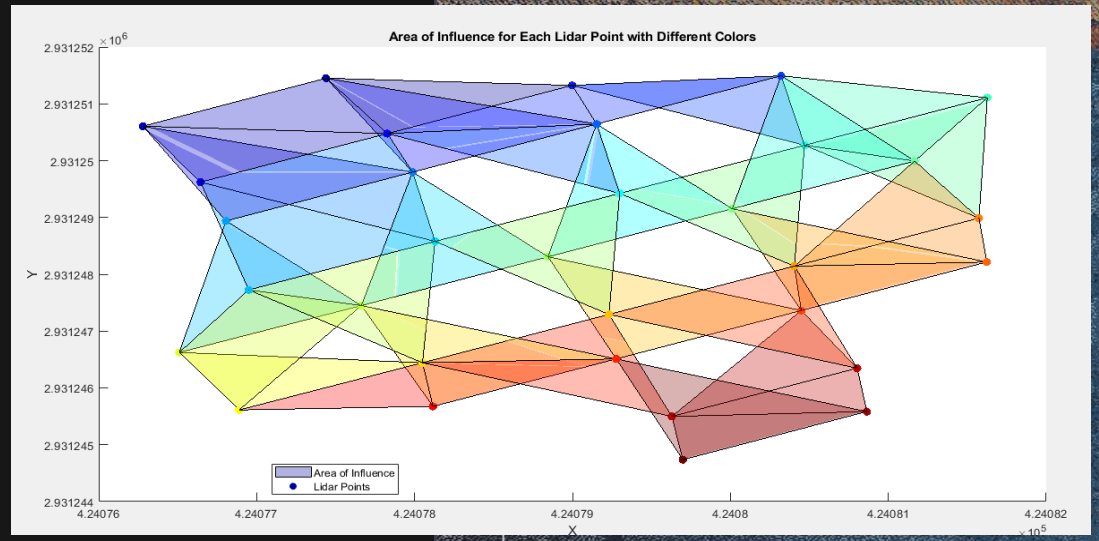


Fig: Thessian polygon for site representing area of influence

NOMINAL PULSE SPACING

Methodology:

1. Selecting 90% of each swath, taking first return value only.
2. Create 2D Delaunay triangle
3. Calculate average length of edges for each point
4. Calculate 95th percentile of spacing values

NPS
Flight line 1: 1.469 m
Flight line 2: 1.505 m

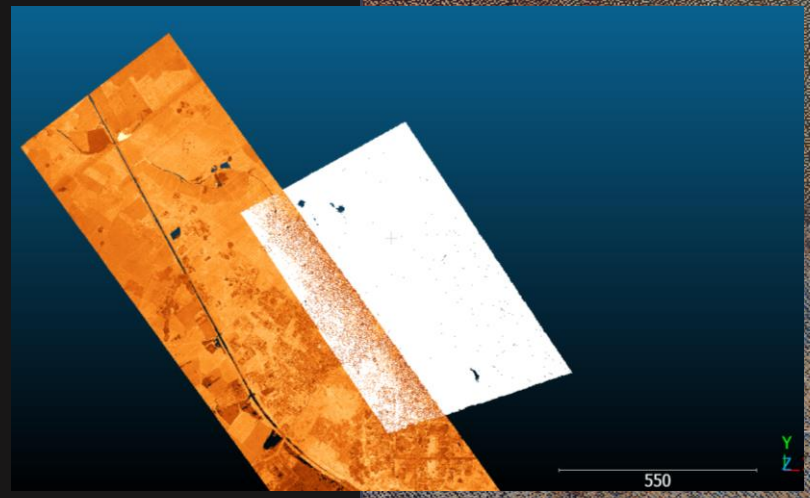


Fig: Segmenting test sites for NPS and data density

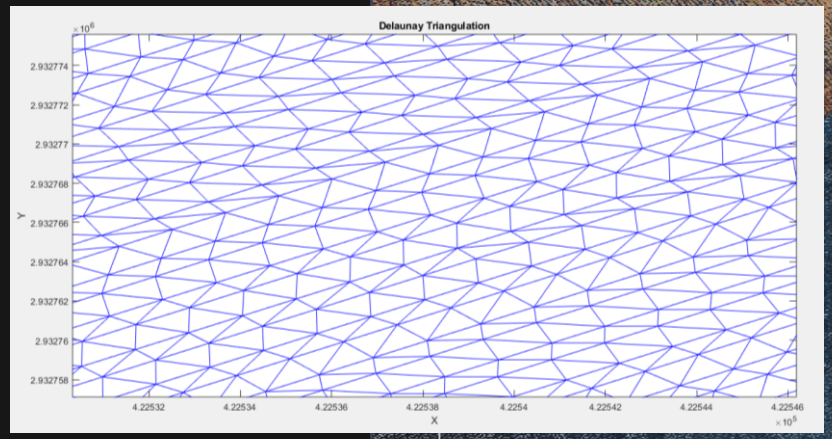


Fig: Delaunay Triangulation of data set

DATA VOIDS

Methodology:

1. Calculating total area
2. Calculating data voids area
3. If Area > 4*(NPS)2 data void is unacceptable

Plotting spatial distribution of data, for check consistency and checking 90% grids are filled or not

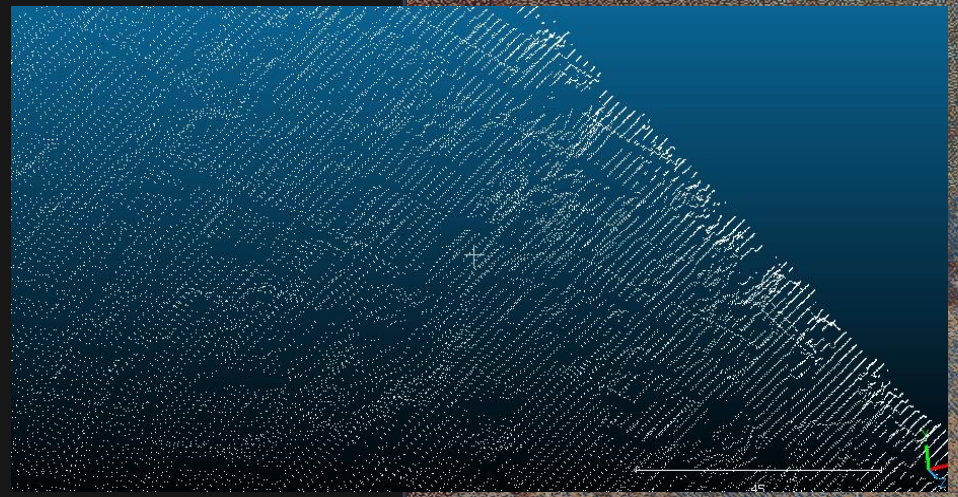


Fig: Test site for data void

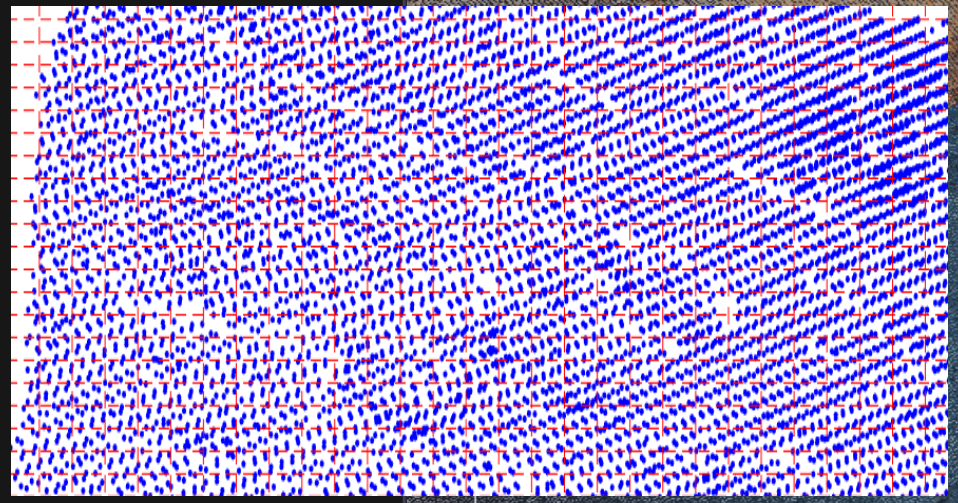


Fig: Spatial distribution plot

SPATIAL DISTRIBUTION

Methodology:

1. Consider 90% of swath
2. Consider only first return
3. Display the data in the grid of size 2*NPS
4. If 90% grids are filled the data is uniform

The data is uniform

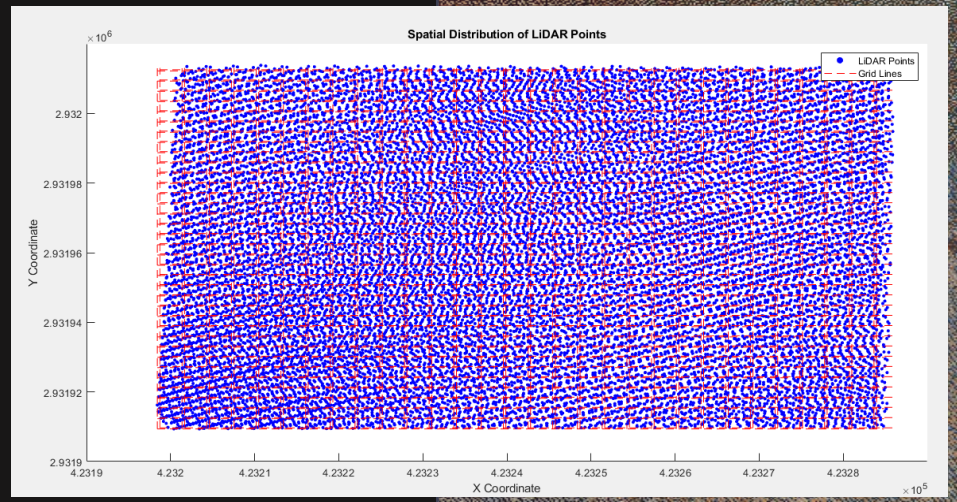


Fig: Grid representation of flight line 1

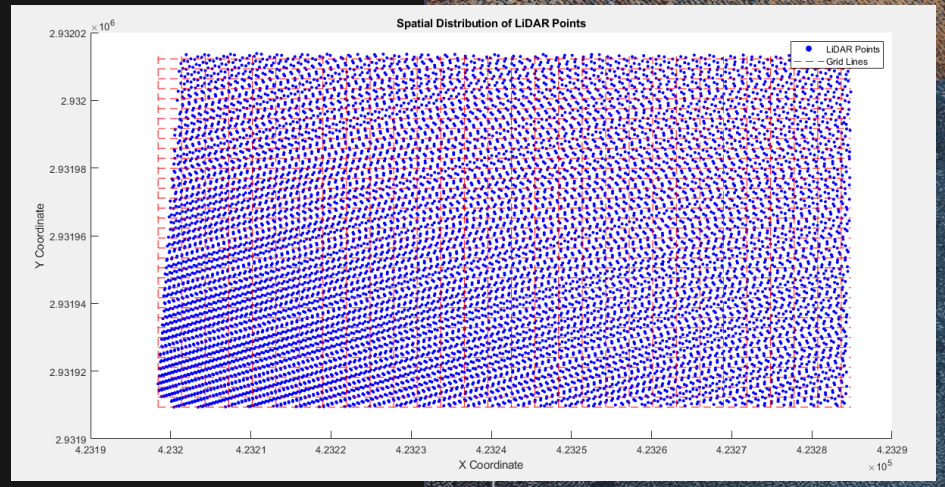


Fig: Grid representation of flight line 2

COMBINED RESULTS

Quality Assessment Parameter	Value	Comment
Number of returns	3	Adequate number of returns per pulse, indicating sufficient data for analysis.
Overlap percentage	17.5903% 19.2237% 18.407%	Minimum Maximum Average:
Relative accuracy	3.7683 cm 8.0516 cm 19.1502 cm	Flight Line 1 Flight Line 2 Overlap Regions
Vertical accuracy	46.7 cm 360.5 cm	Non-vegetated Vegetated
Horizontal accuracy	44 cm 77 cm 88.684 cm 154.134 cm	RMSEy (northing) RMSEx (Easting) RMSE r: Planimetric accuracy
NPS	1.4696 m 1.505 m	Flight Line 1 Flight Line 2
Data density	0.744 points/m^2	Data density is 0.744 points per square meter, providing adequate spatial coverage of the area.
Data voids	Acceptable	All data voids are acceptable as at least one data point is present in 90% of the grid cells, ensuring sufficient data coverage for analysis.
Spatial distribution	Uniform	The data distribution is uniform for both flight lines, with at least one data point present in 90% of the grid cells, indicating consistent coverage.

Table: Combined result data

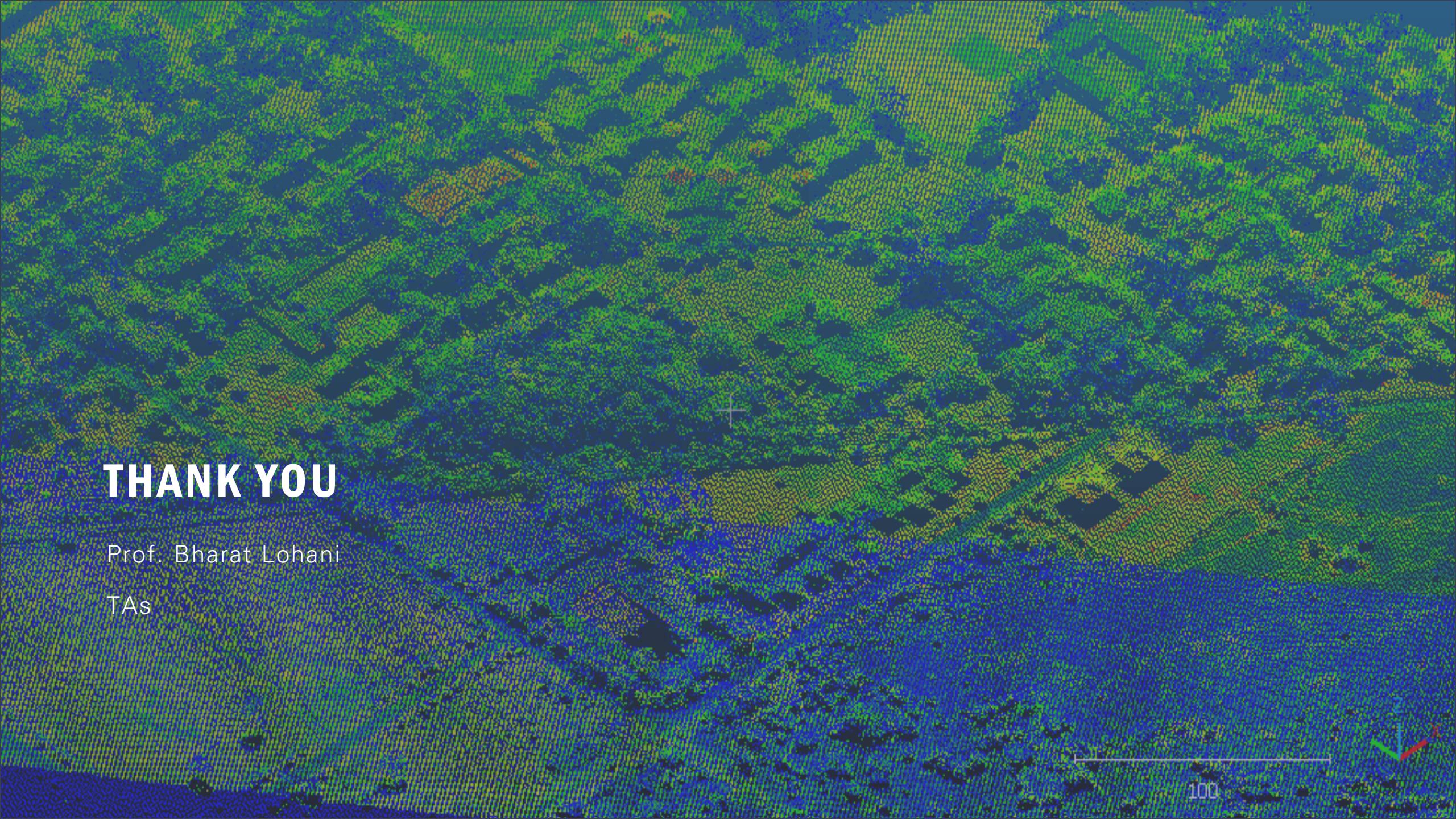
ANALYSIS

As per the ASPRS standards, as the obtained RMSE for NVA is 46.7cm, it falls under the highlighted category. Rest of the values i.e. minimum point density and NPS follow the recommended guidelines.

Here the VVA and NVA are comparatively high in values because the data is old, i.e. of 2008; many places have been reconstructed and the elevation of roads as well as courts have increased.

Vertical Accuracy Class	Absolute Accuracy		Recommended Minimum NPD[8] (pls/m²)	Recommended Maximum NPS[8] (m)
	$RMSE_z$ Non-Vegetated (cm)	NVA at 95% Confidence Level (cm)		
1-cm	1.0	2.0	≥20	≤0.22
2.5-cm	2.5	4.9	16	0.25
5-cm	5.0	9.8	8	0.35
10-cm	10.0	19.6	2	0.71
15-cm	15.0	29.4	1	1.0
20-cm	20.0	39.2	0.5	1.4
33.3-cm	33.3	65.3	0.25	2.0
66.7-cm	66.7	130.7	0.1	3.2
100-cm	100.0	196.0	0.05	4.5
333.3-cm	333.3	653.3	0.01	10.0

Table: ASPRS standard for vertical accuracy
(source: ASPRS, "ASPRS guidelines in reporting vertical accuracy," 2015)


THANK YOU
Prof. Bharat Lohani
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