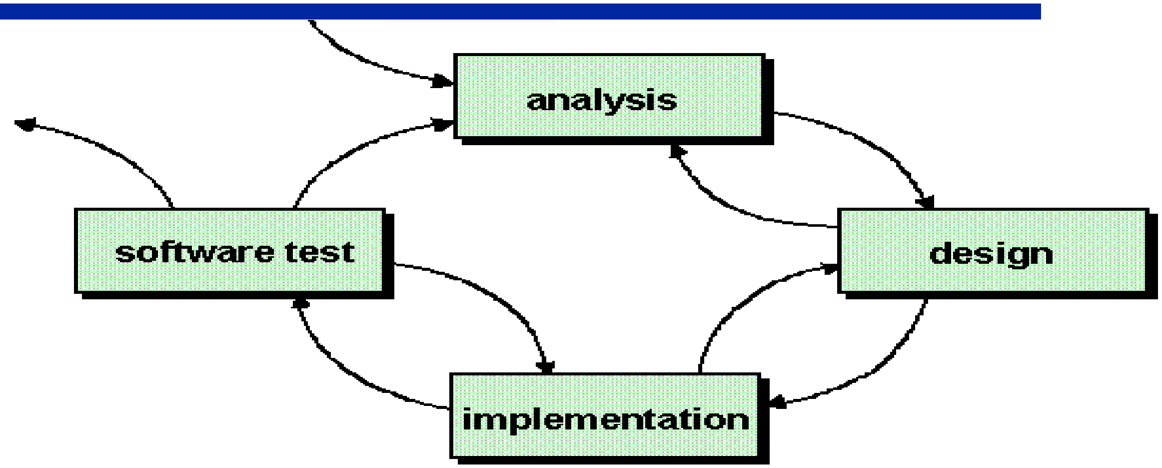

Object-oriented software engineering for designing an aerial survey LiDAR Simulator

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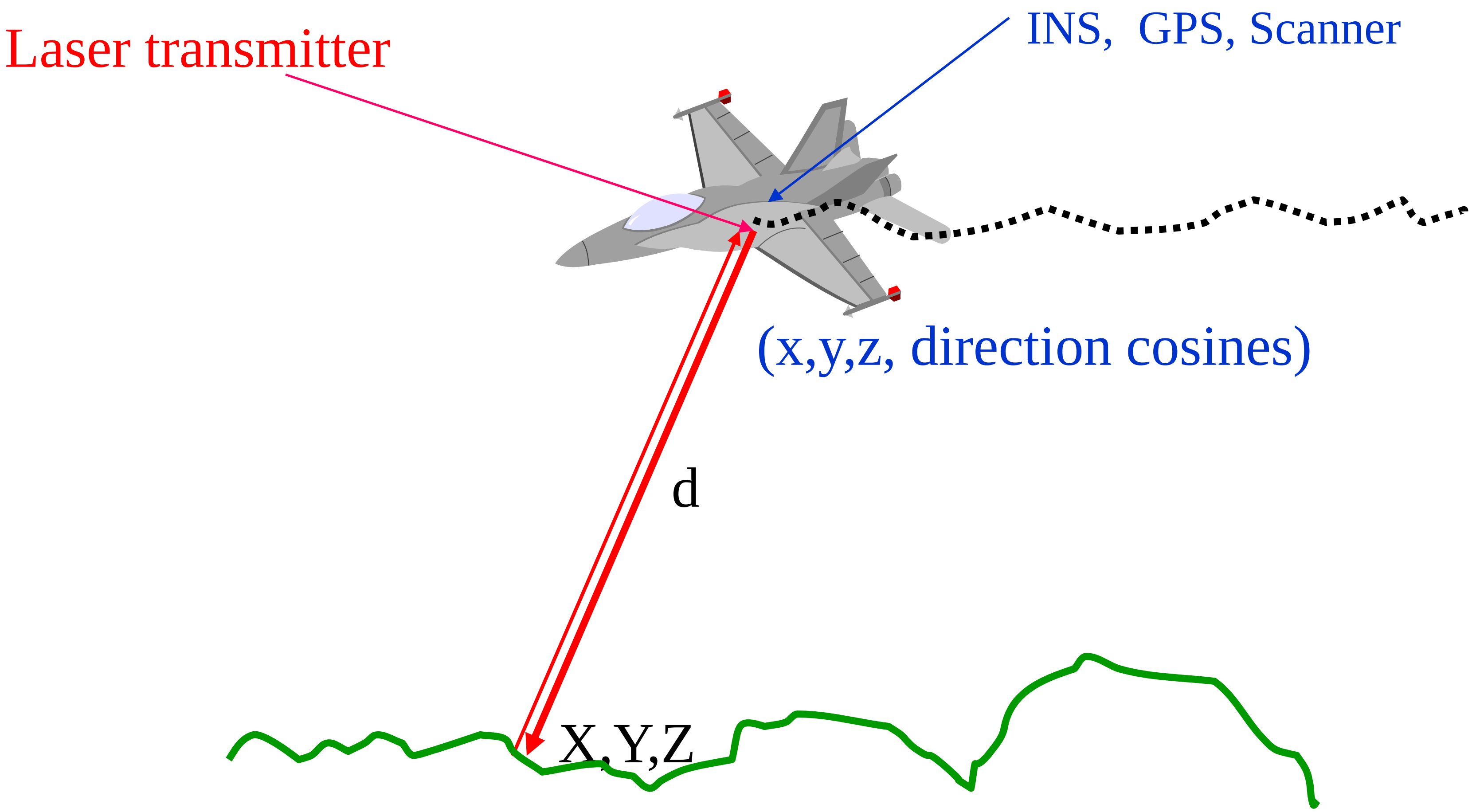
Geoinformatics division
Indian Institute of Technology Kanpur
Kanpur, INDIA

Principal of LiDAR



LiDAR Technology

❑ Provides accurate topographic data at high speed

❑ Data collection with higher density, accuracy & less time

❑ Weather and light independent

Applications:

- DEM generation
- Flood hazard zonation
- Cellular networks etc.

Object-oriented software engineering for software development

Initial investigation (Why simulator ?)

- ❑ LiDAR data is not available in most of the countries
- ❑ LiDAR data is not available for teaching as required
- ❑ LiDAR data is not available for research as required
- ❑ Software for flight planning

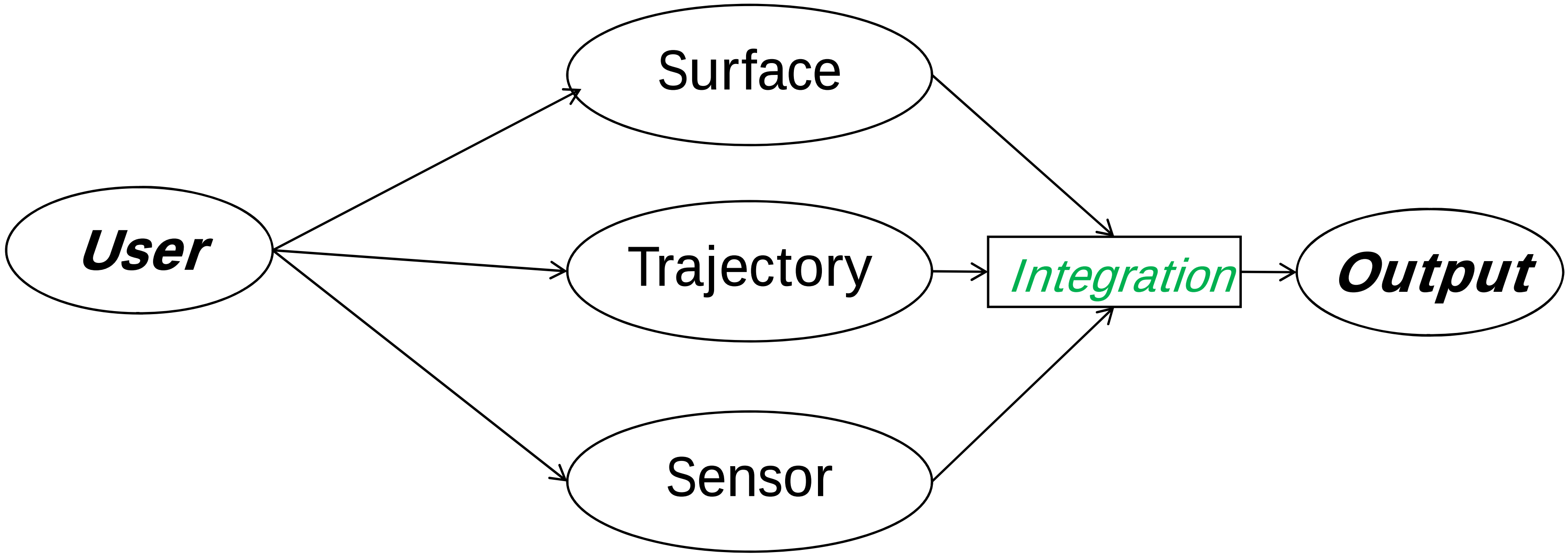
Requirements

- User friendly GUI
- Simulation of generic as well as commercial sensors
- Simulation of earth like surfaces
- Flight trajectory as in case of actual flight
- Possibilities of error introduction
- Output data in common format
- Help and tutorial

Feasibility study

- Sufficient background is available for the system development
- The system can be engineered using current technology
- Development can be done within the budget & time
- Developed system will be useful for the user group

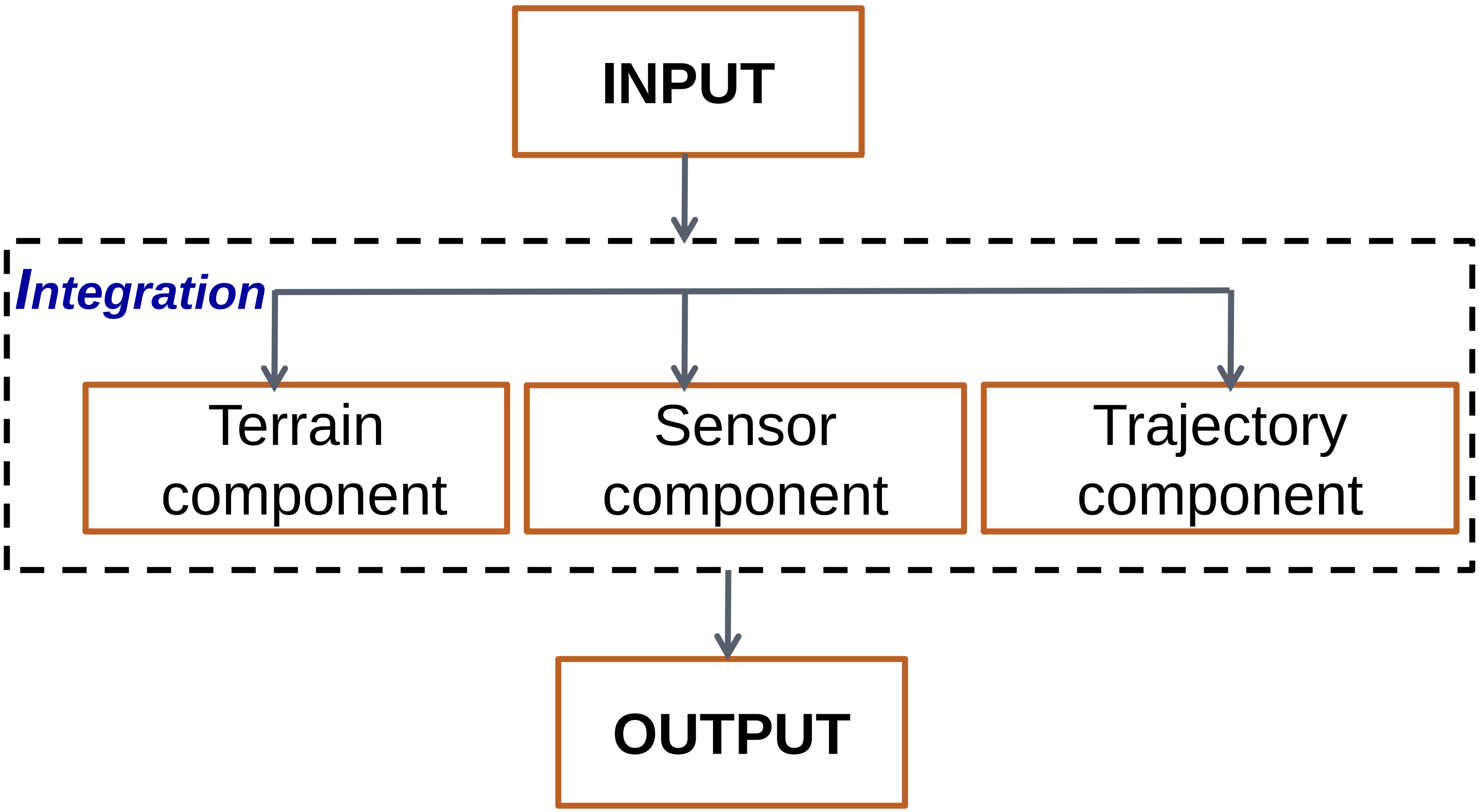
Object-oriented analysis



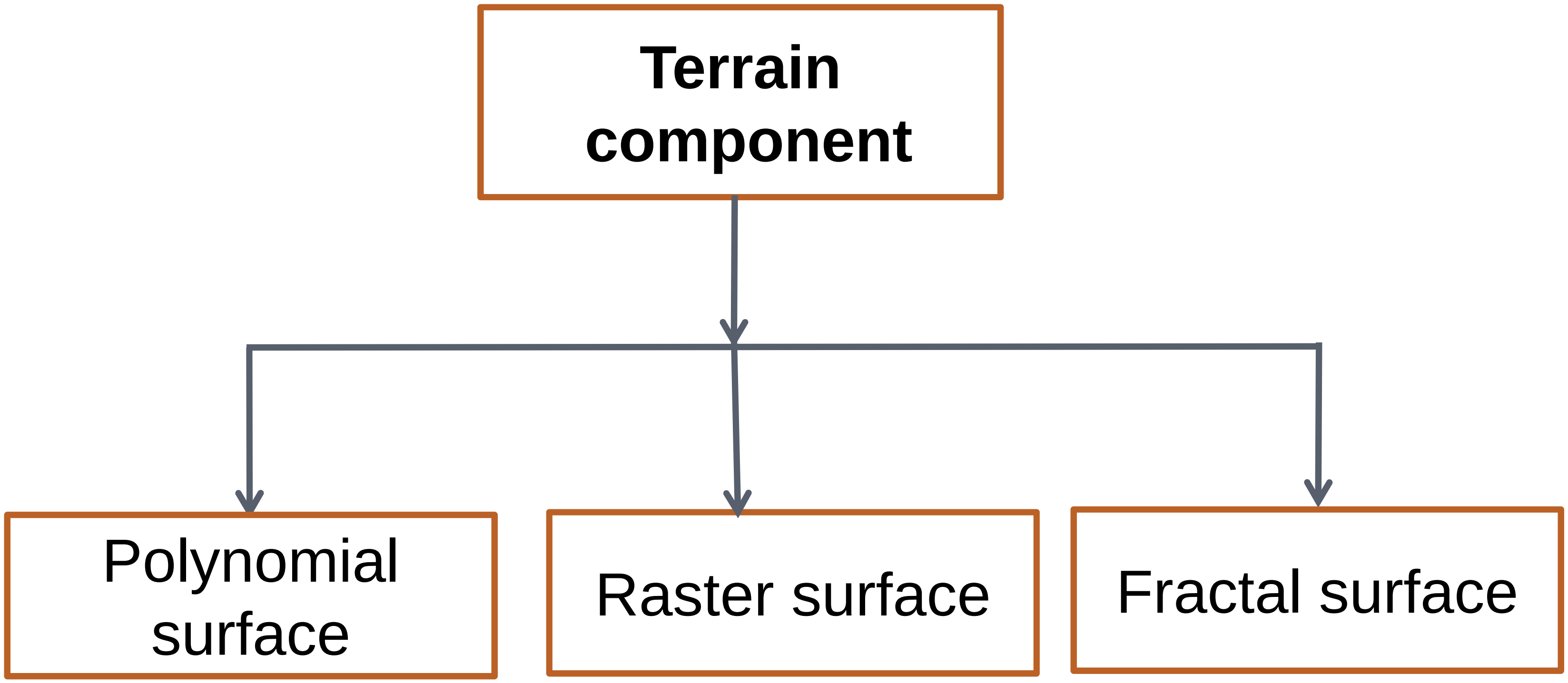
Use case diagram

- Objects in the problem domain is identified
- Object relationships are made
- Object state table is developed
- Inheritance diagram for objects is made

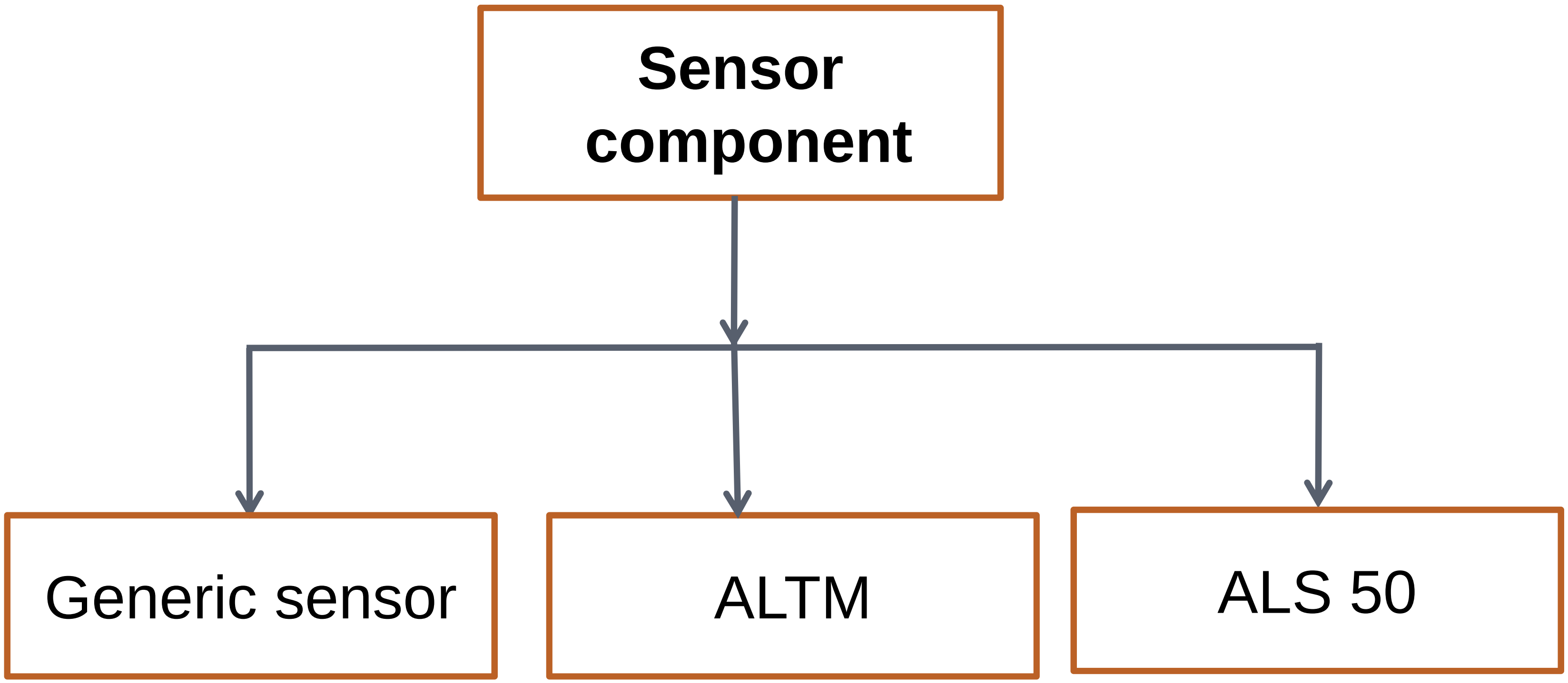
Object-oriented design



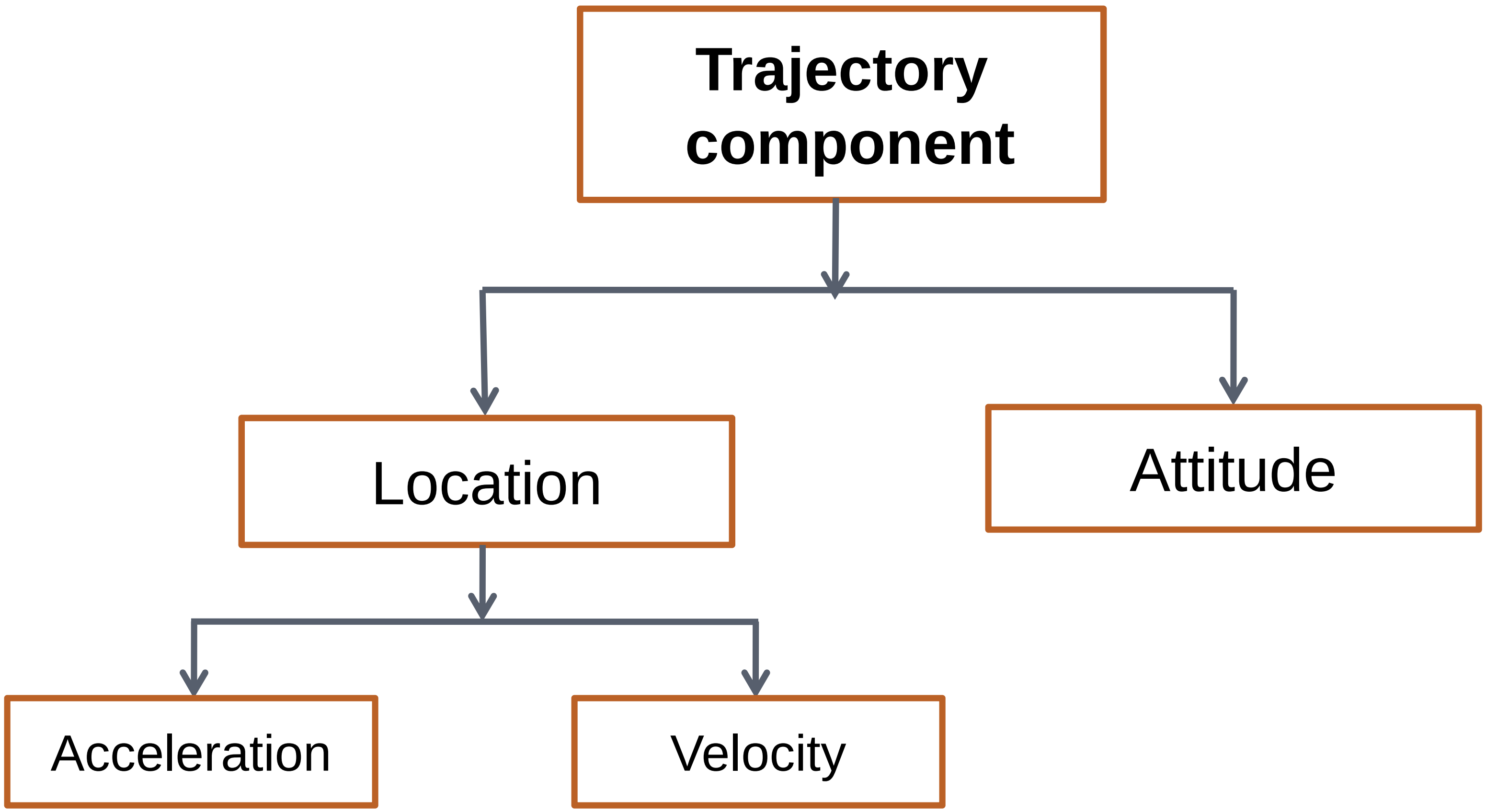
Terrain components



Sensor components



Trajectory components



Class design

- Identify classes from the components
- Identify subclass within each class
- Identify abstraction in each class
- Identify the common behaviour of classes

System implementation

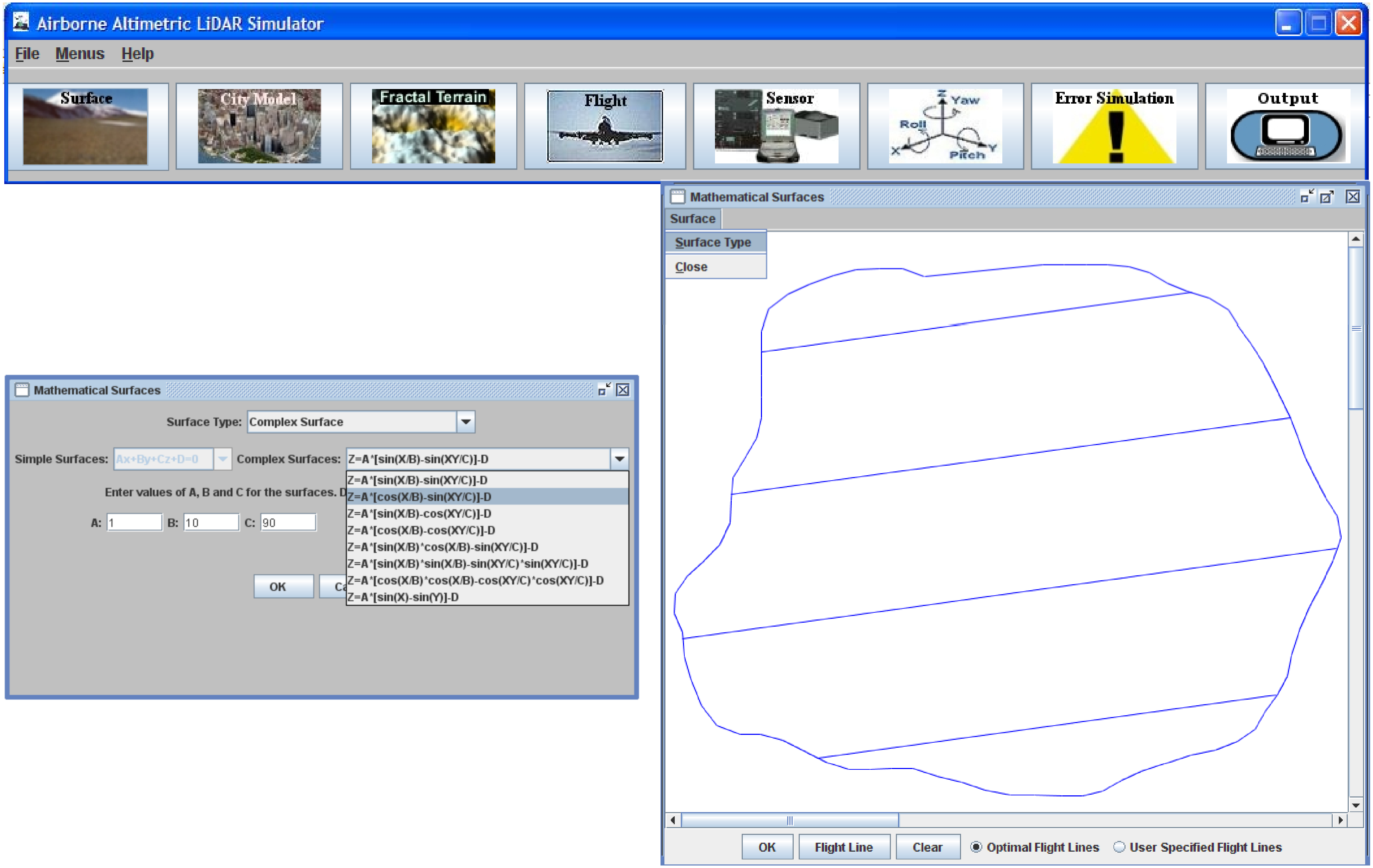
- Java is used to realize the design
- Each classes are implemented with its relationship
- Standard way of coding is used
- Methods are designed for each basic task

Complexities handled

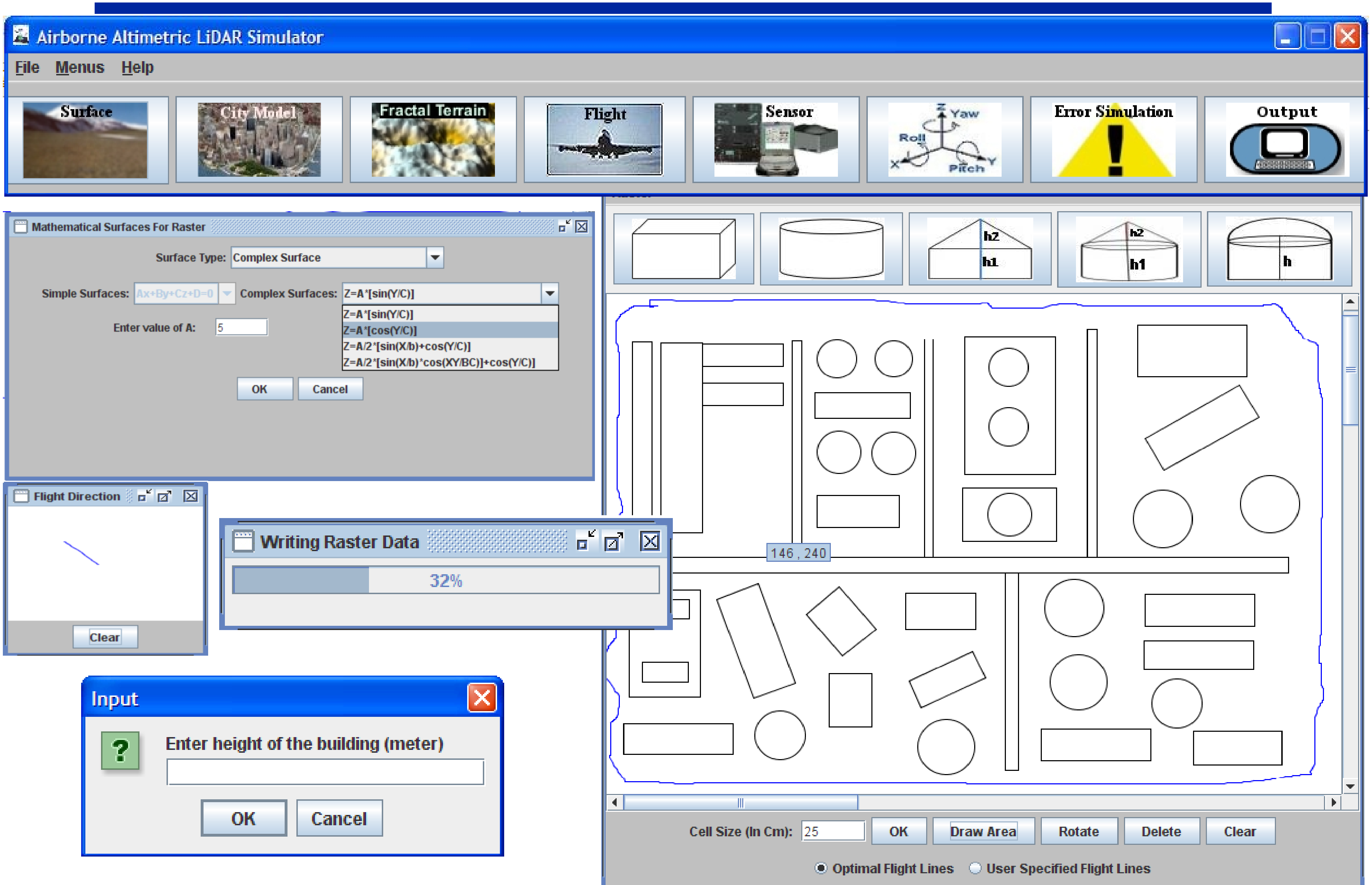
- Efficient algorithms are designed
- Threads are used to optimize software execution
- Special data structures are designed to handle memory problems
- New file formats are designed to improve I/O.

GUI Screenshots

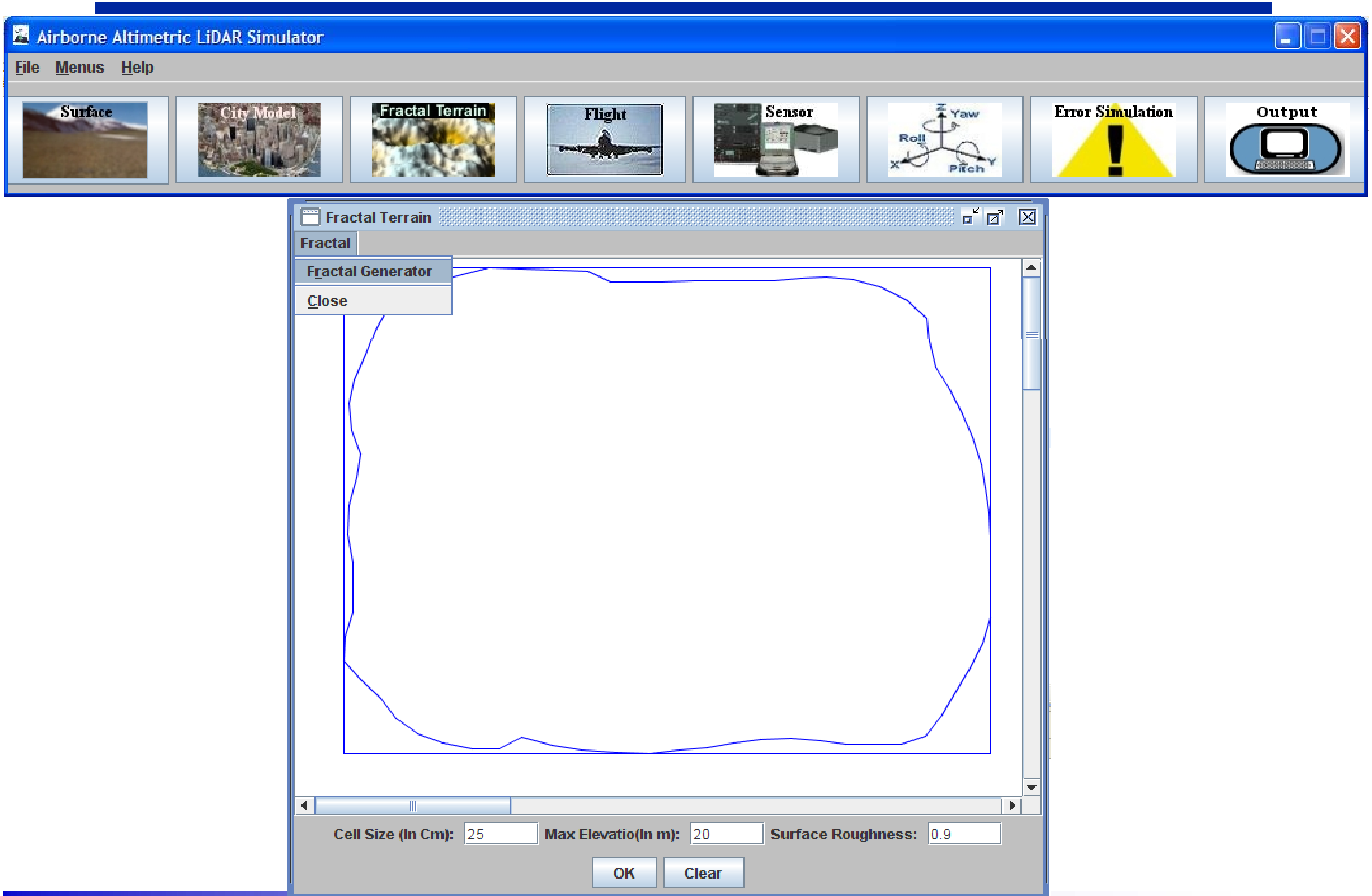
Polynomial surface



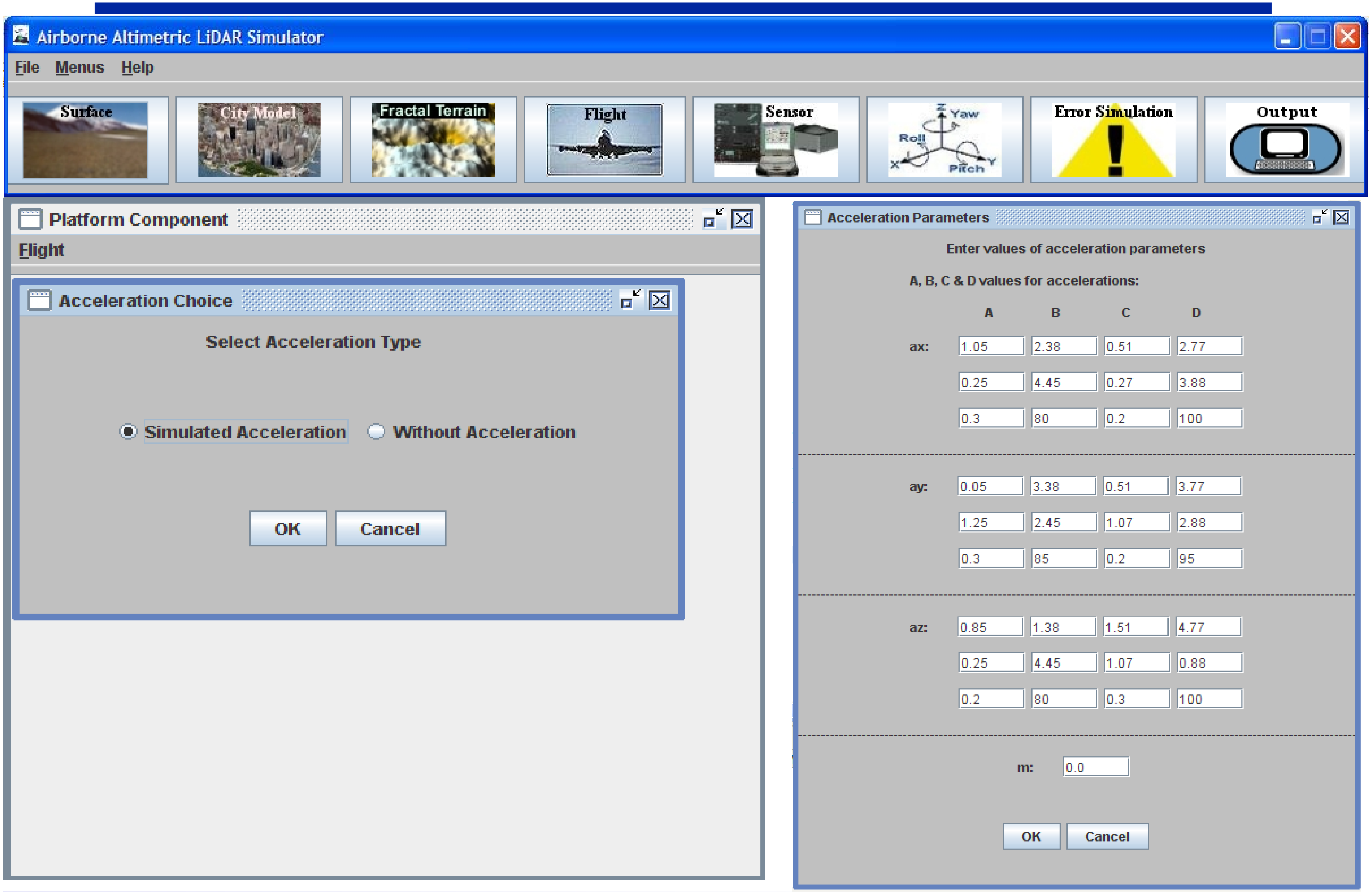
Raster surface(City model)



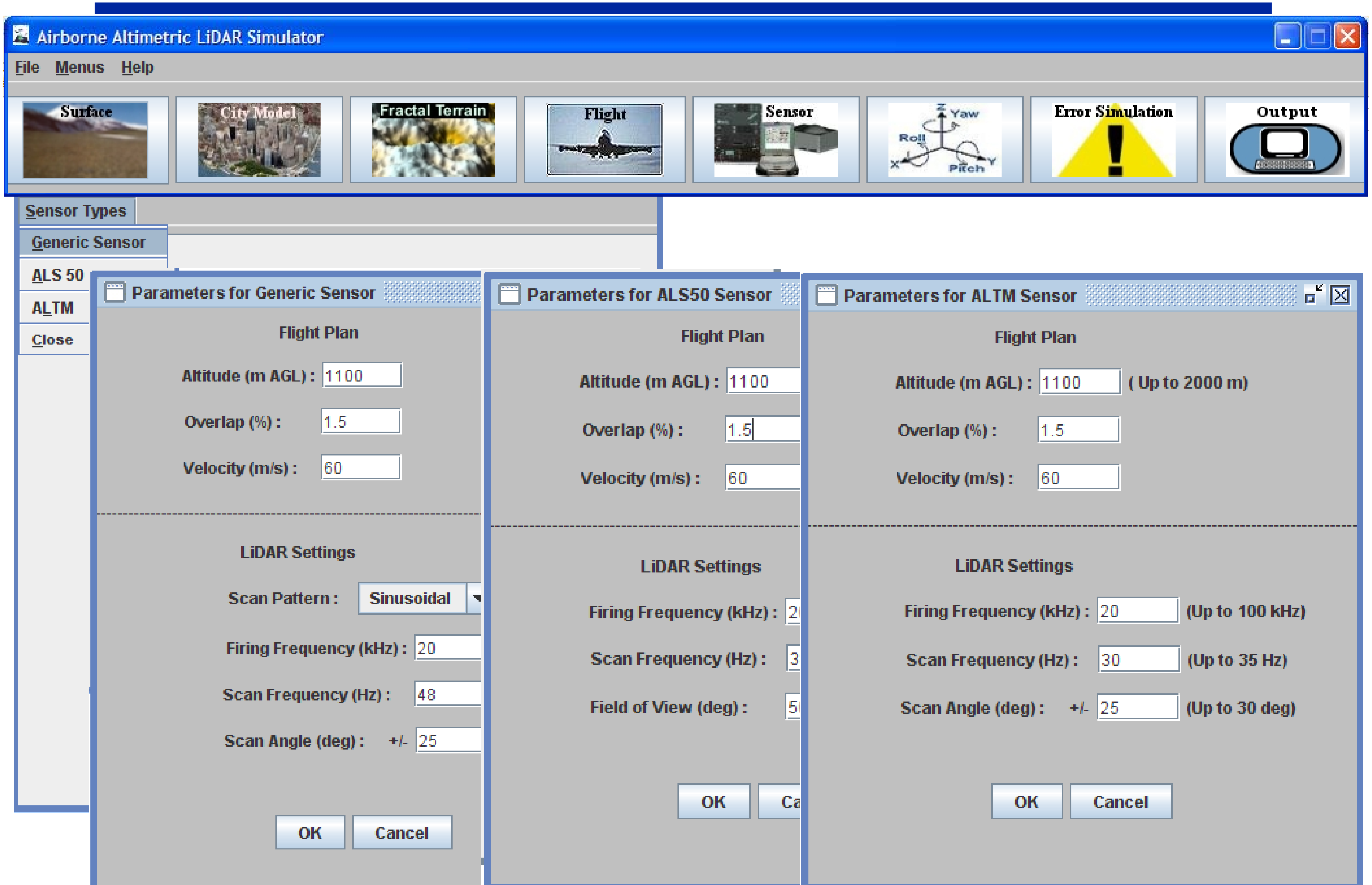
Fractal surface



Acceleration

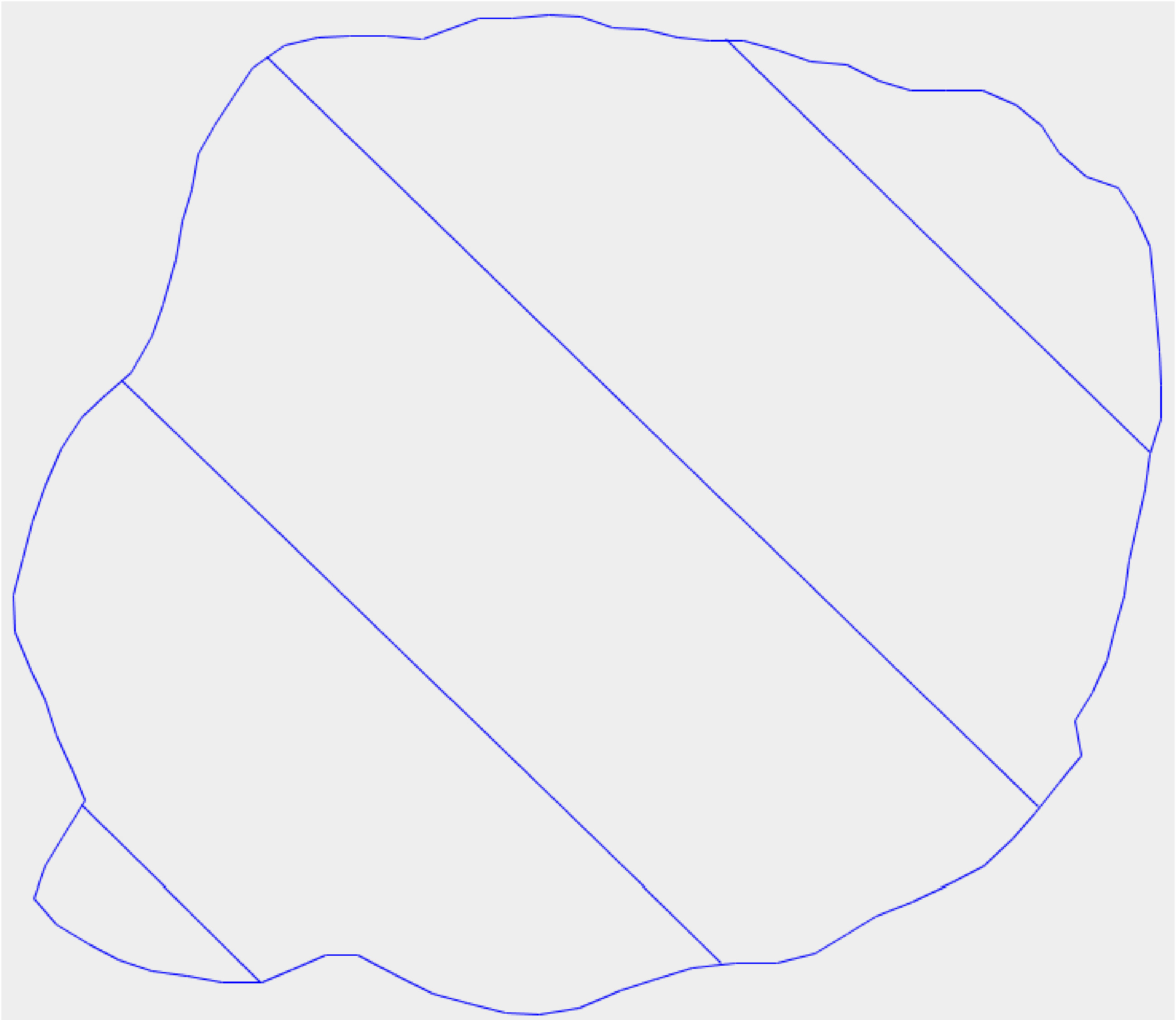


Sensor component

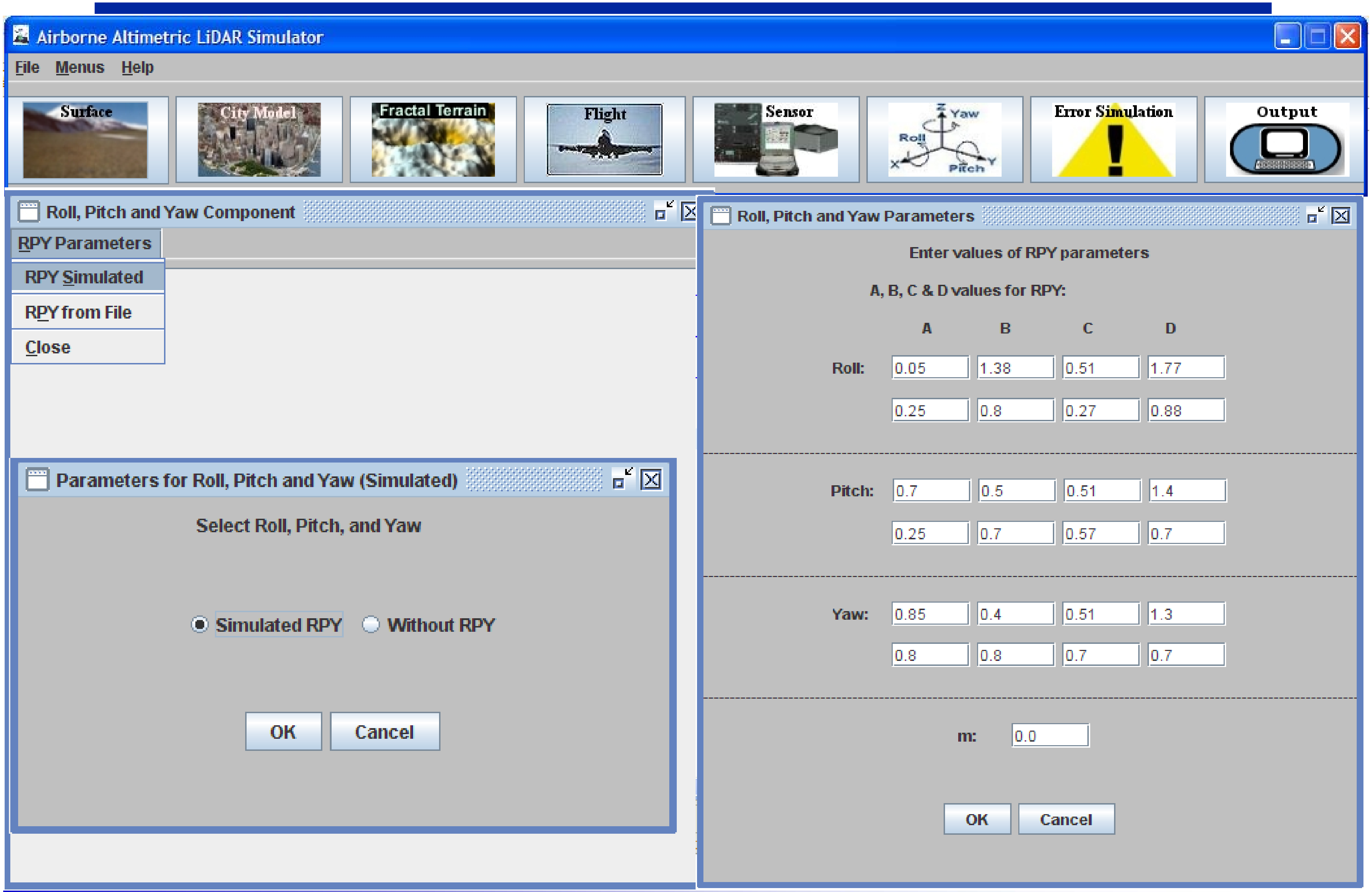


System defined optimal flight lines

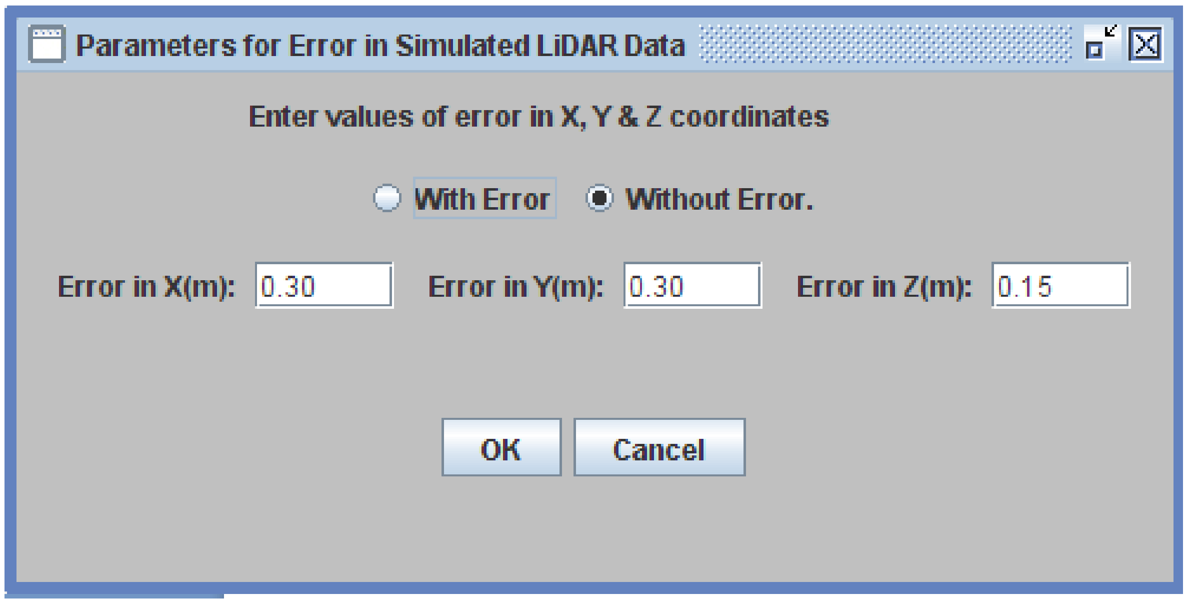
User defined optimal flight lines



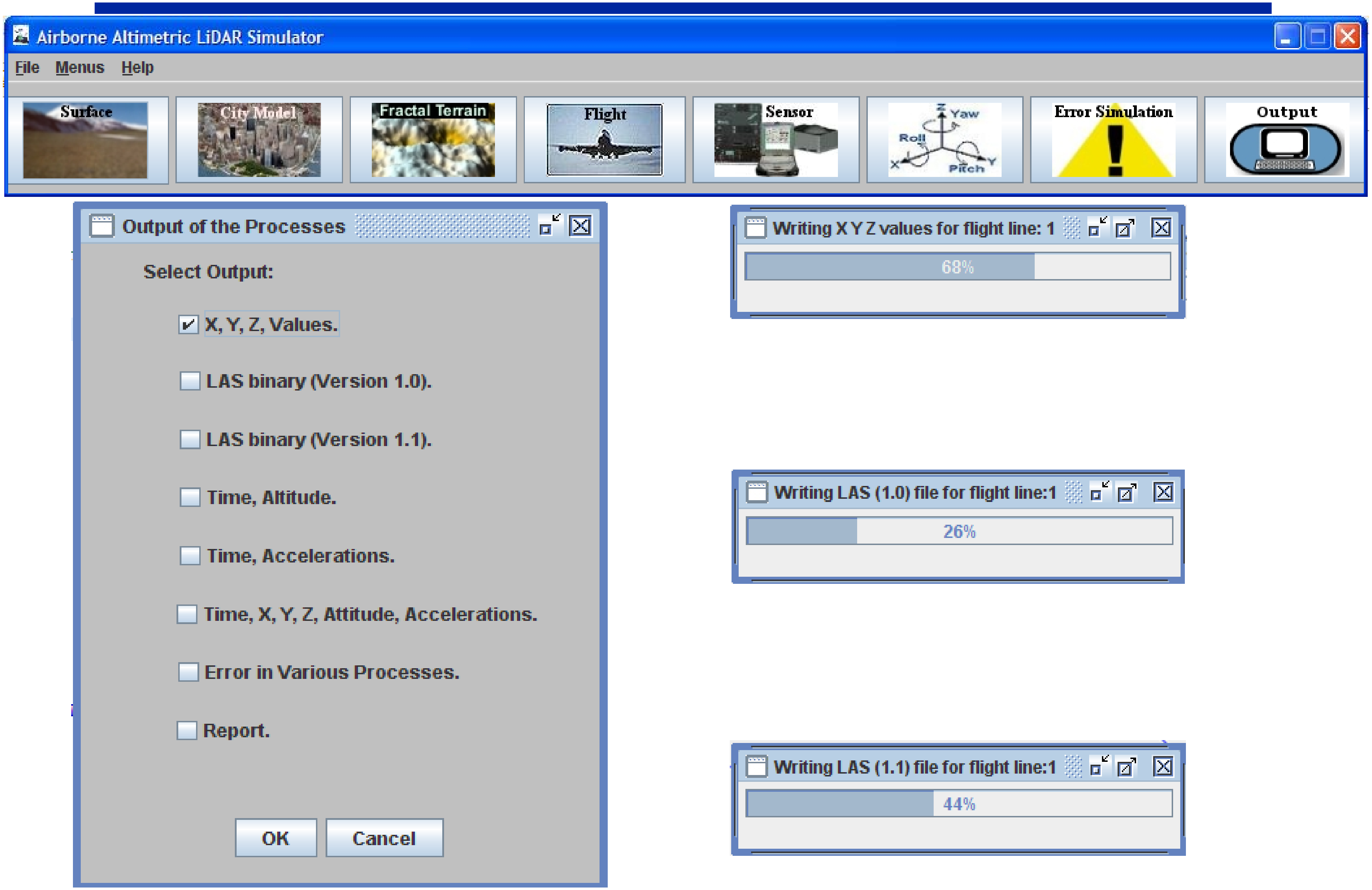
Attitude


Airborne Altimetric LiDAR Simulator
File
Menus
Help
Surface
City Model
Fractal Terrain
Flight
Sensor
Yaw
Roll
Pitch
Error Simulation
Output
Roll, Pitch and Yaw Component
RPY Parameters
RPY Simulated
RPY from File
Close
Parameters for Roll, Pitch and Yaw (Simulated)
Select Roll, Pitch, and Yaw
Simulated RPY
Without RPY
OK
Cancel
Roll, Pitch and Yaw Parameters
Enter values of RPY parameters
A, B, C & D values for RPY:
A
B
C
D
Roll:
0.05
1.38
0.51
1.77
0.25
0.8
0.27
0.88
Pitch:
0.7
0.5
0.51
1.4
0.25
0.7
0.57
0.7
Yaw:
0.85
0.4
0.51
1.3
0.8
0.8
0.7
0.7
m:
0.0
OK
Cancel

Error simulation



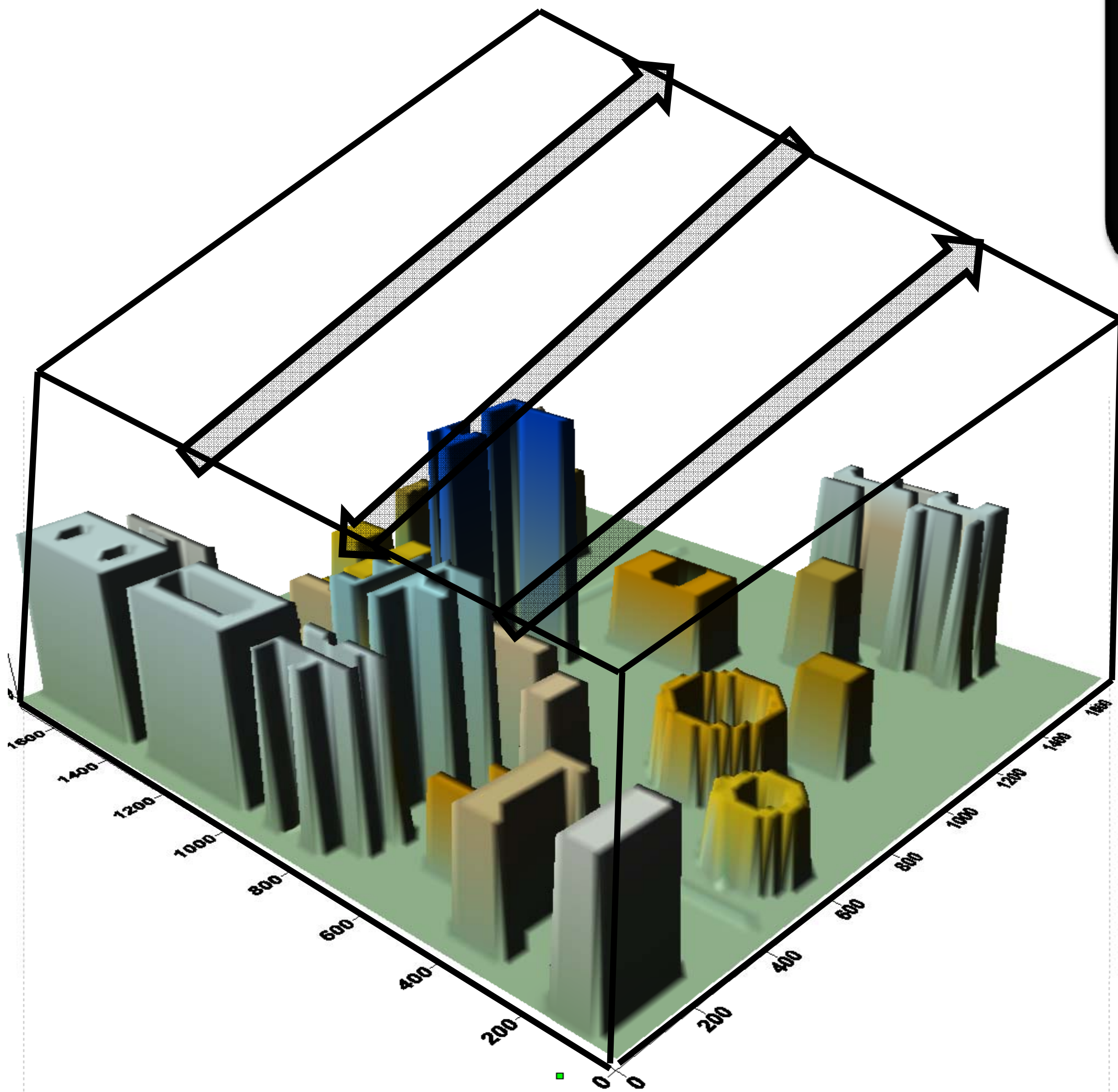
Output generation



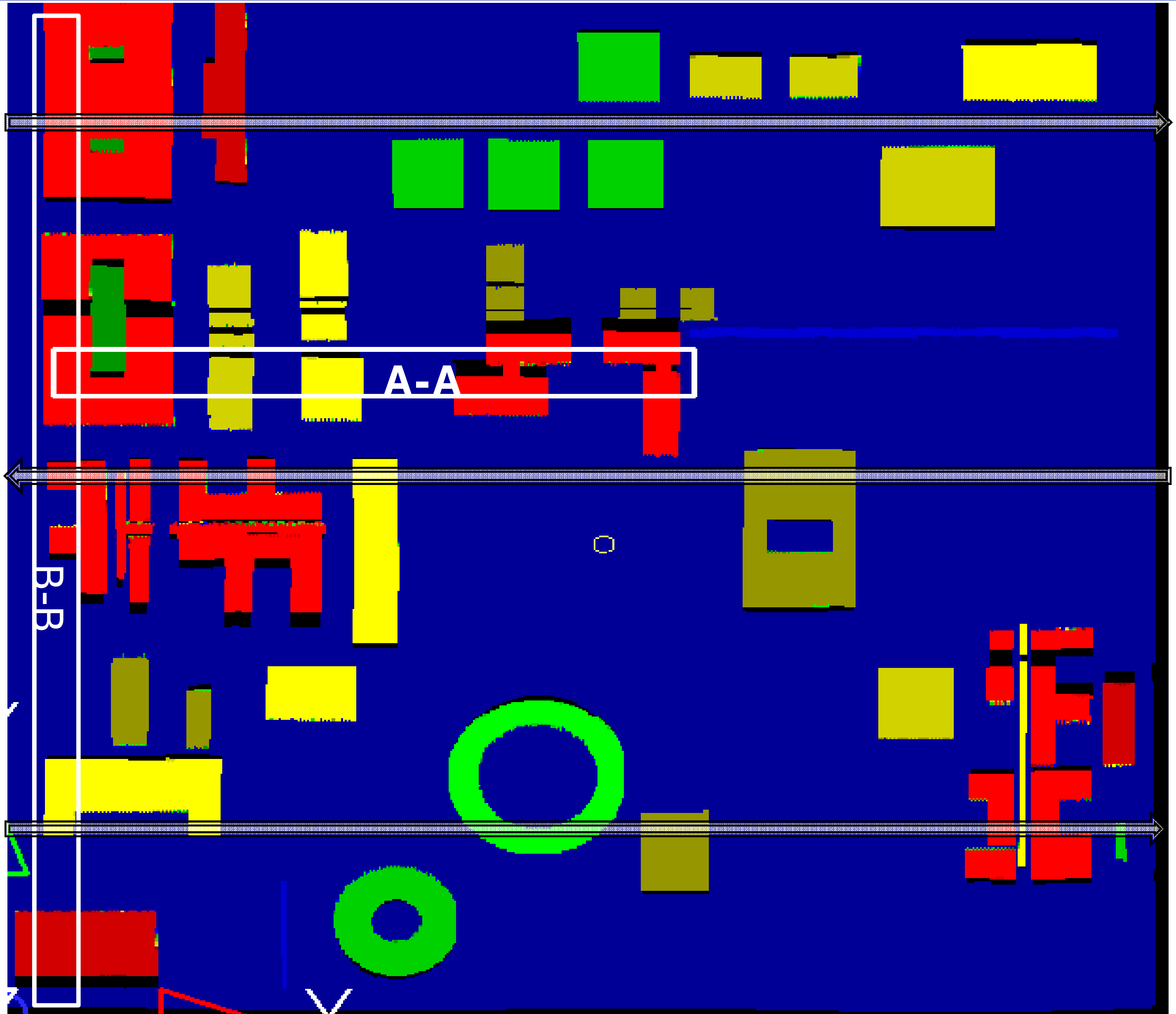
Simulator Results

3D Raster terrain (Displayed in Surfer)

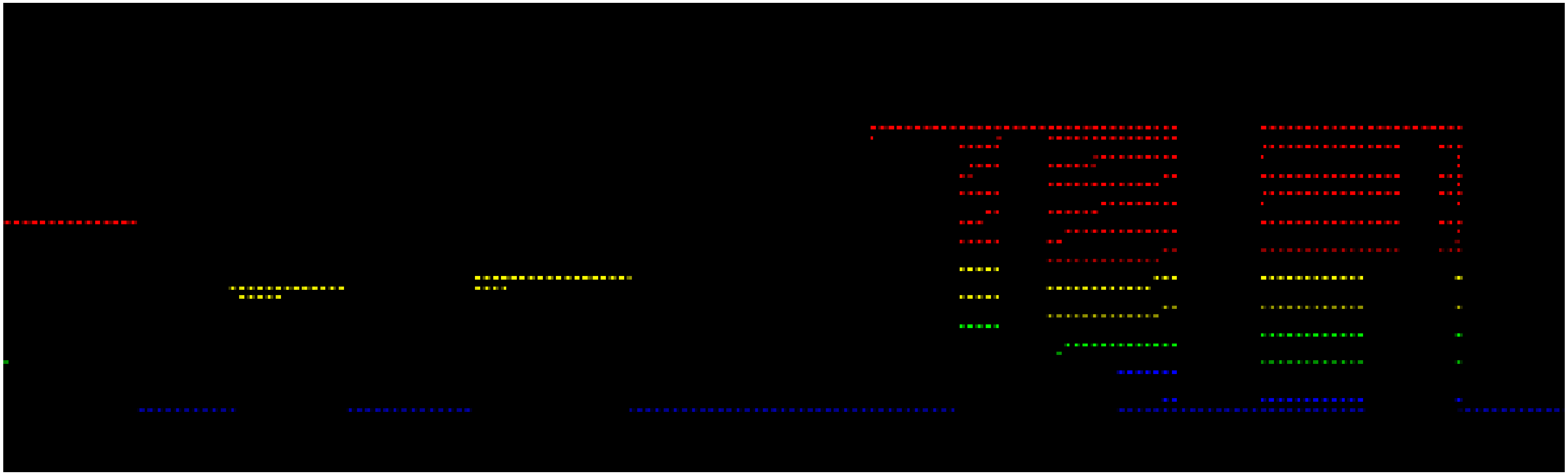
Altitude=210m
Overlap=4%
Velocity=60m/s
Sensor-ALS-50
Firing frequency=20KHz
Scan frequency=48Hz
Scan angle=40°
Flight area=430m×430m

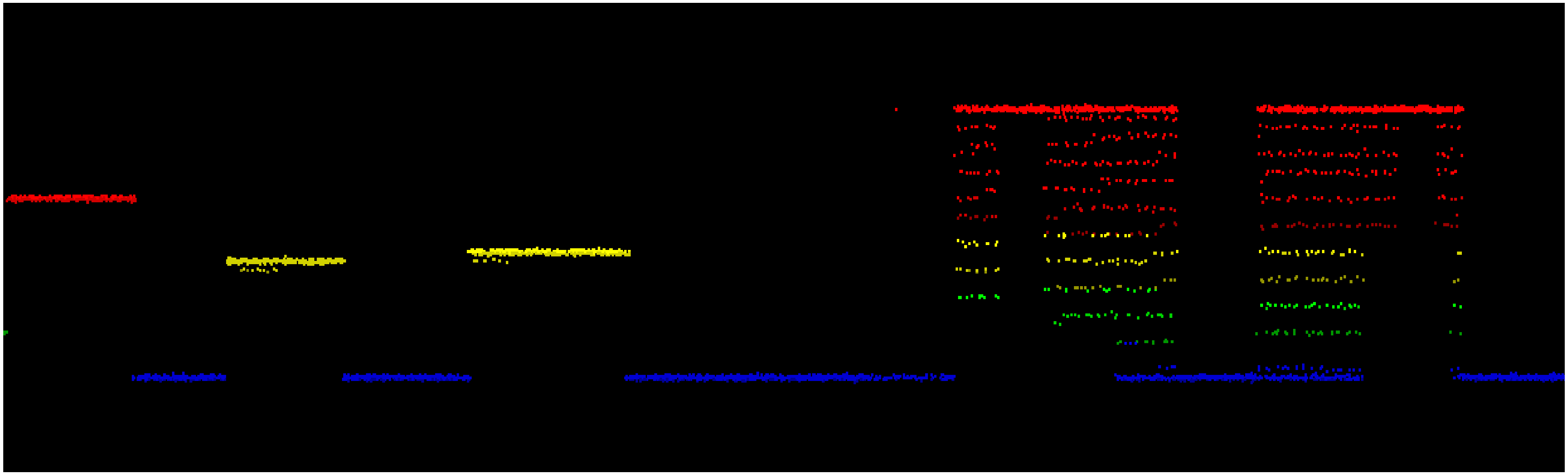


Lidar data plot in plan

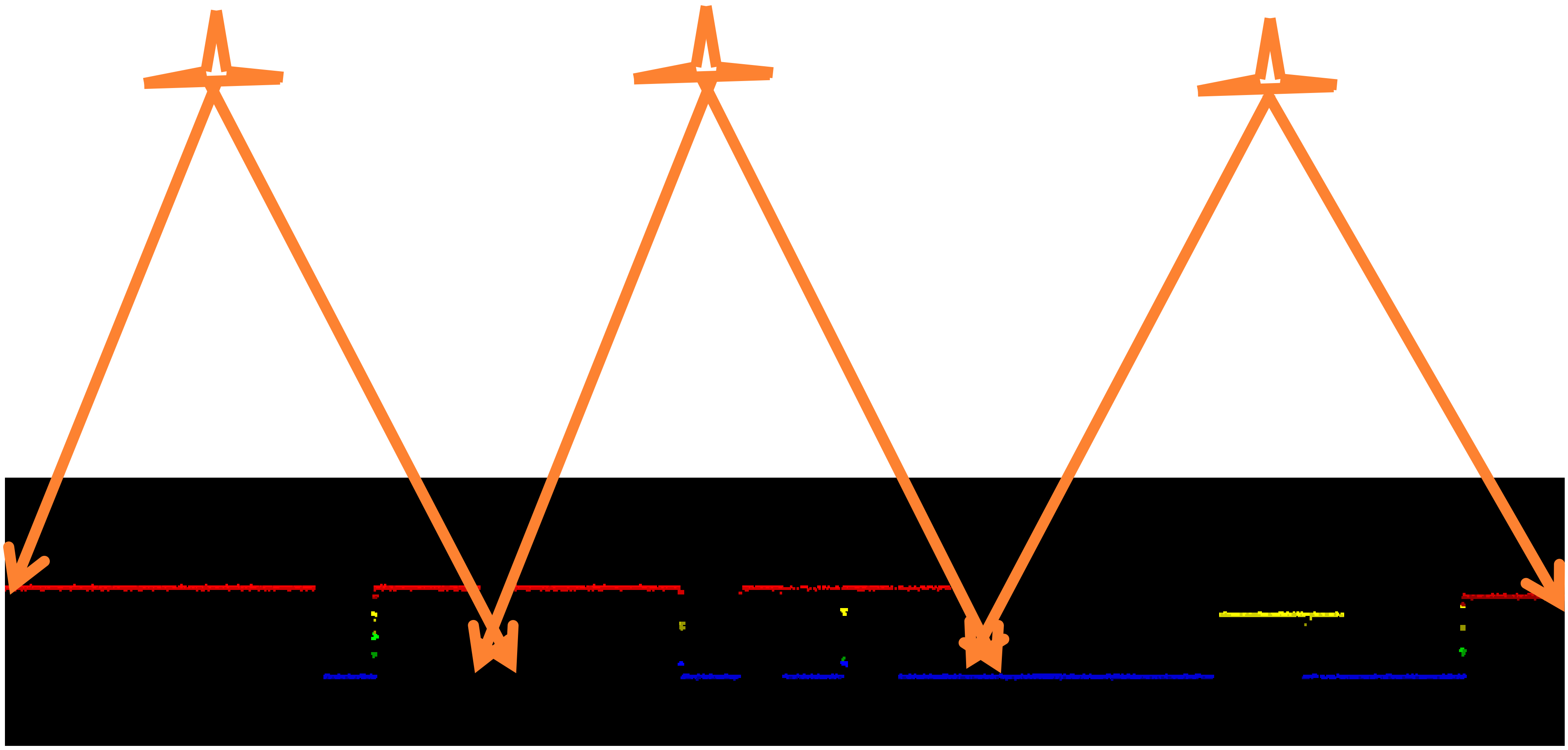


Profile A-A with and without error

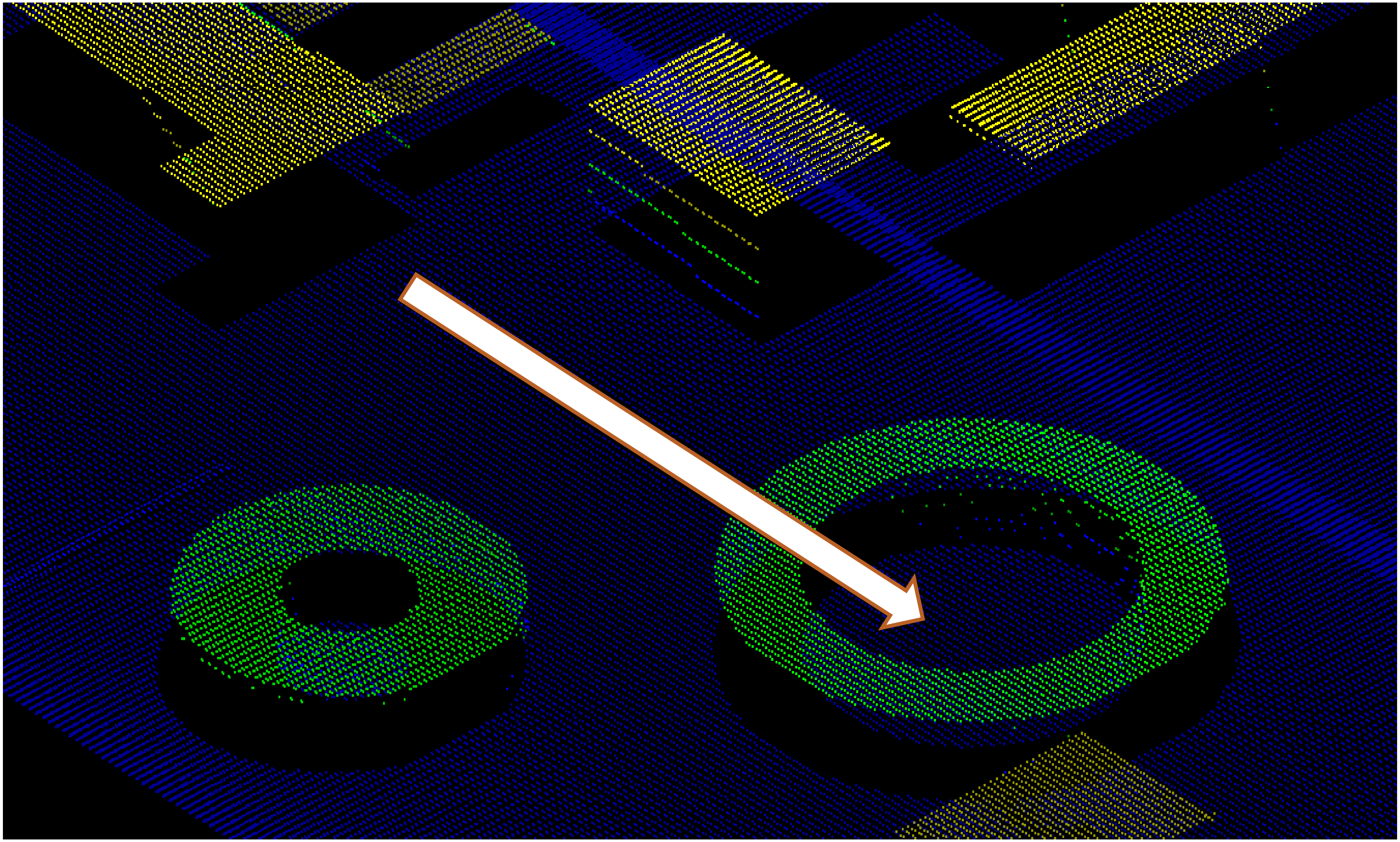




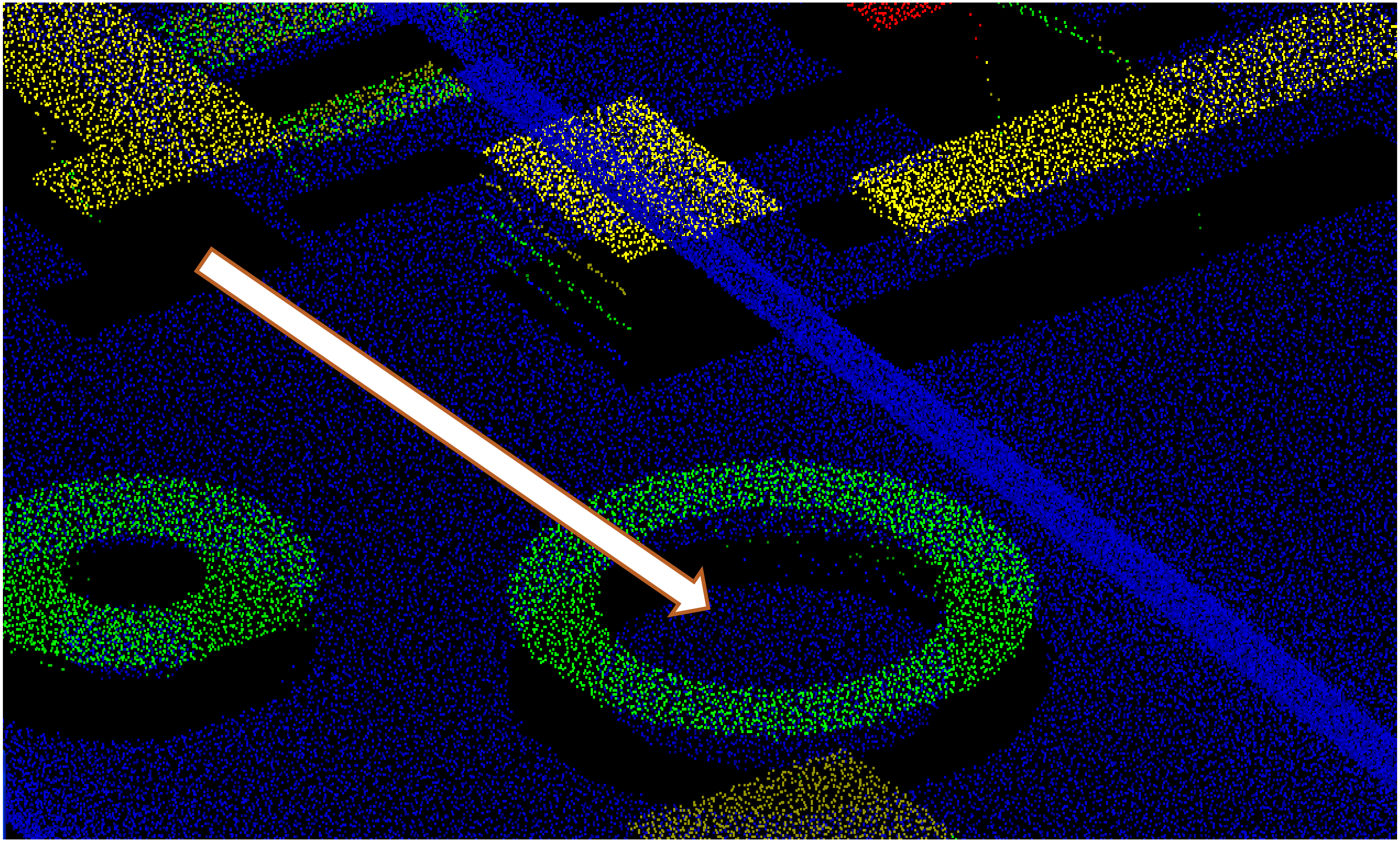
Profile B-B with respect to flight lines



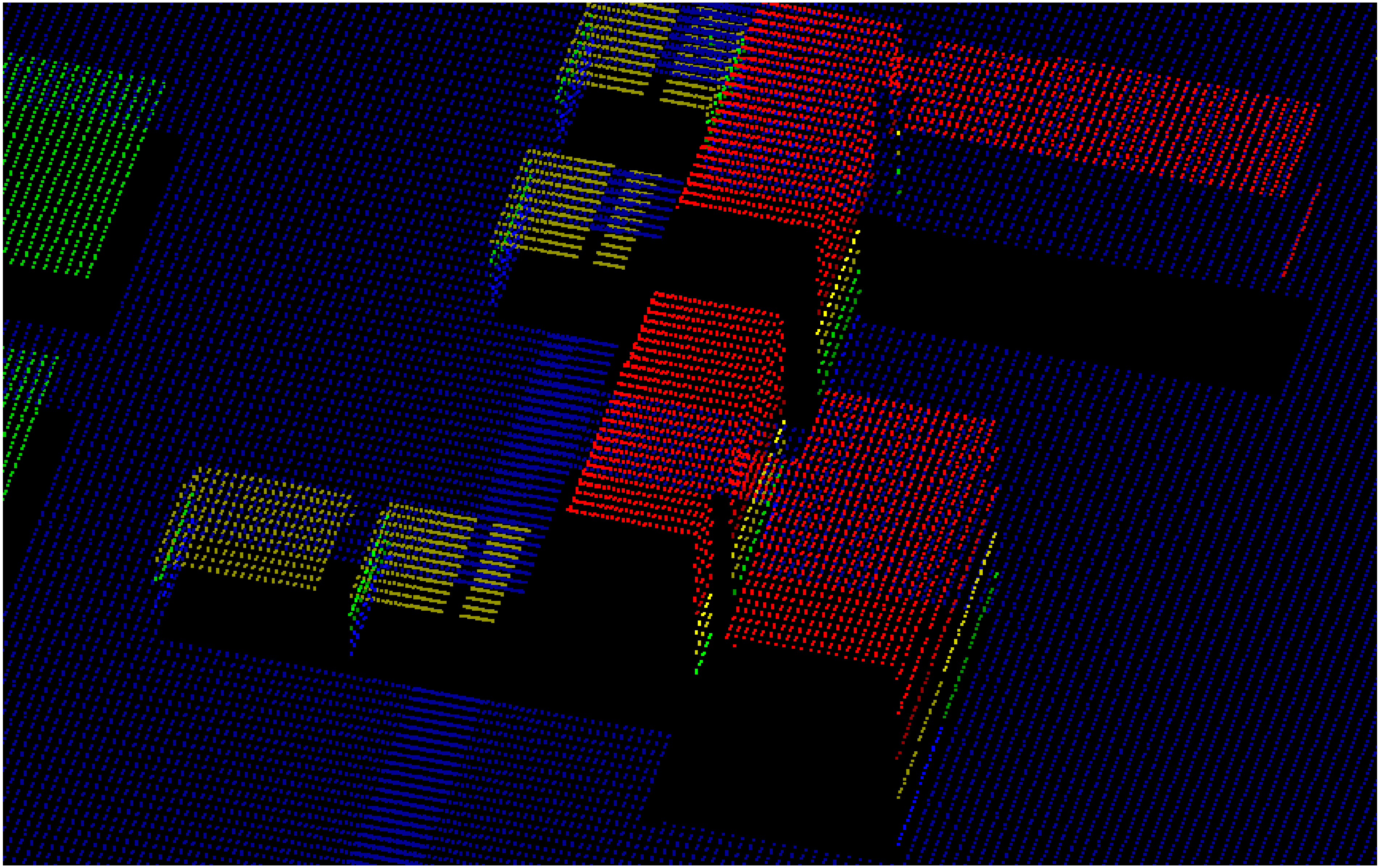
LiDAR data without error



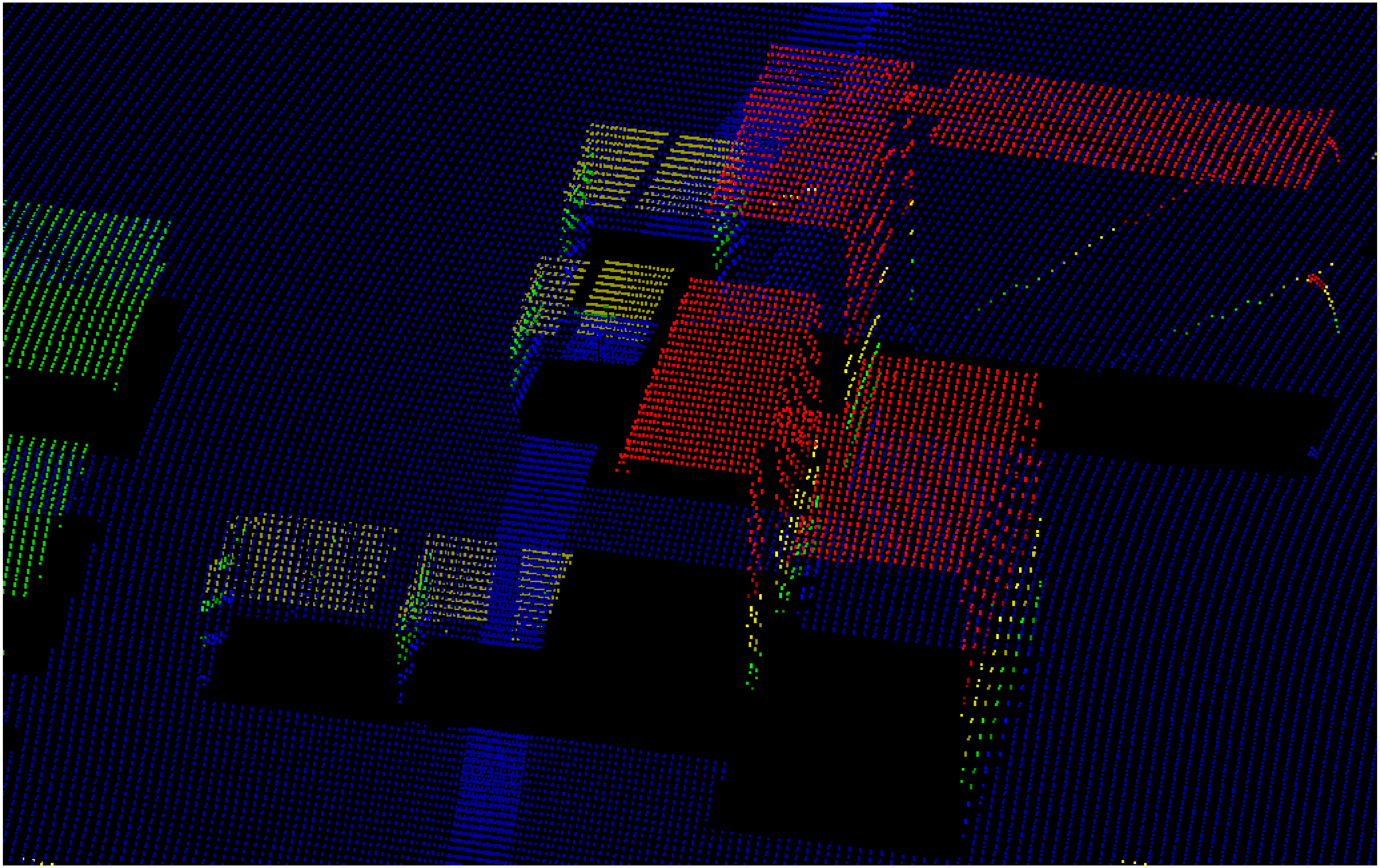
LiDAR data with error



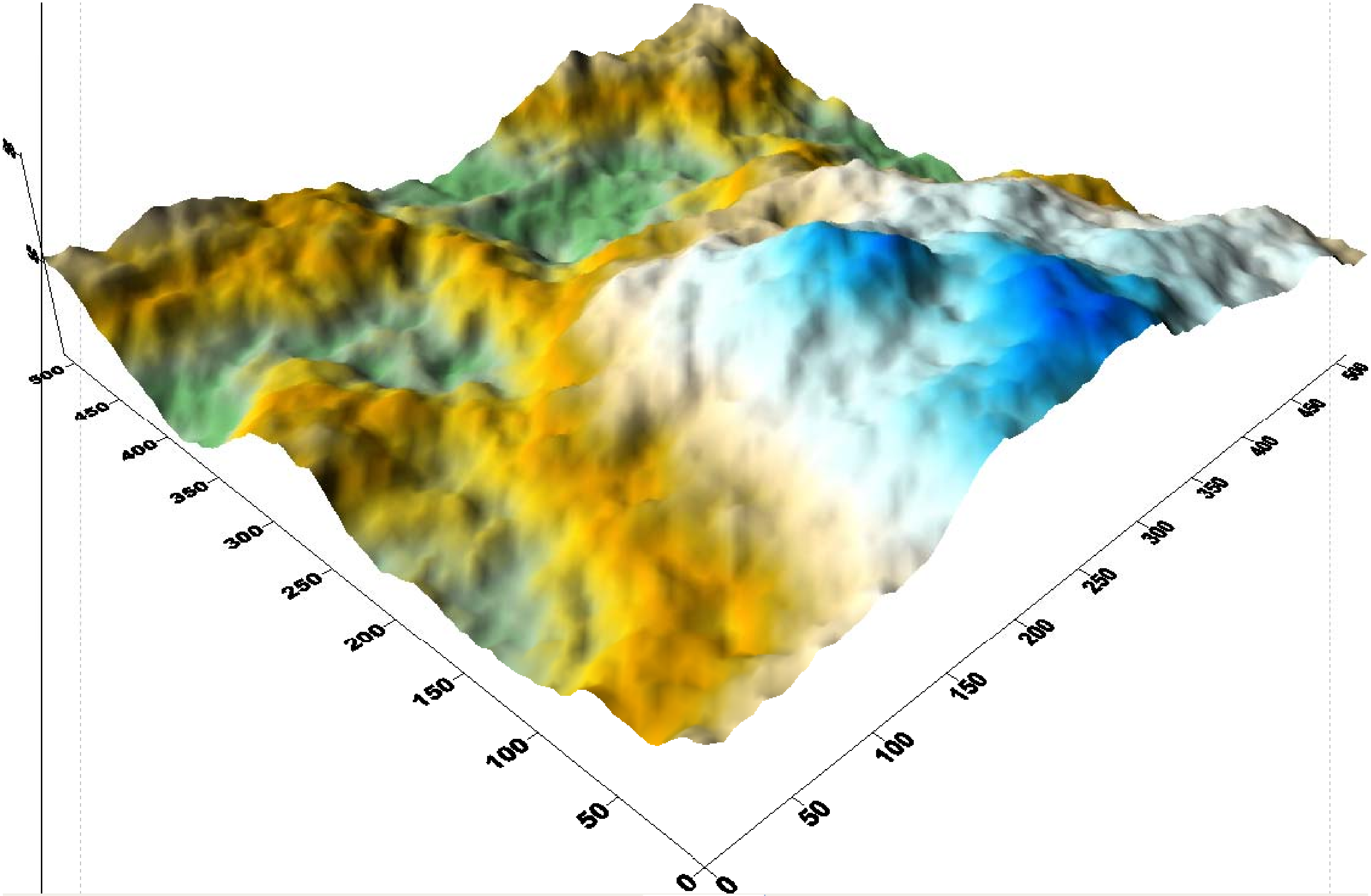
Data without attitude variation



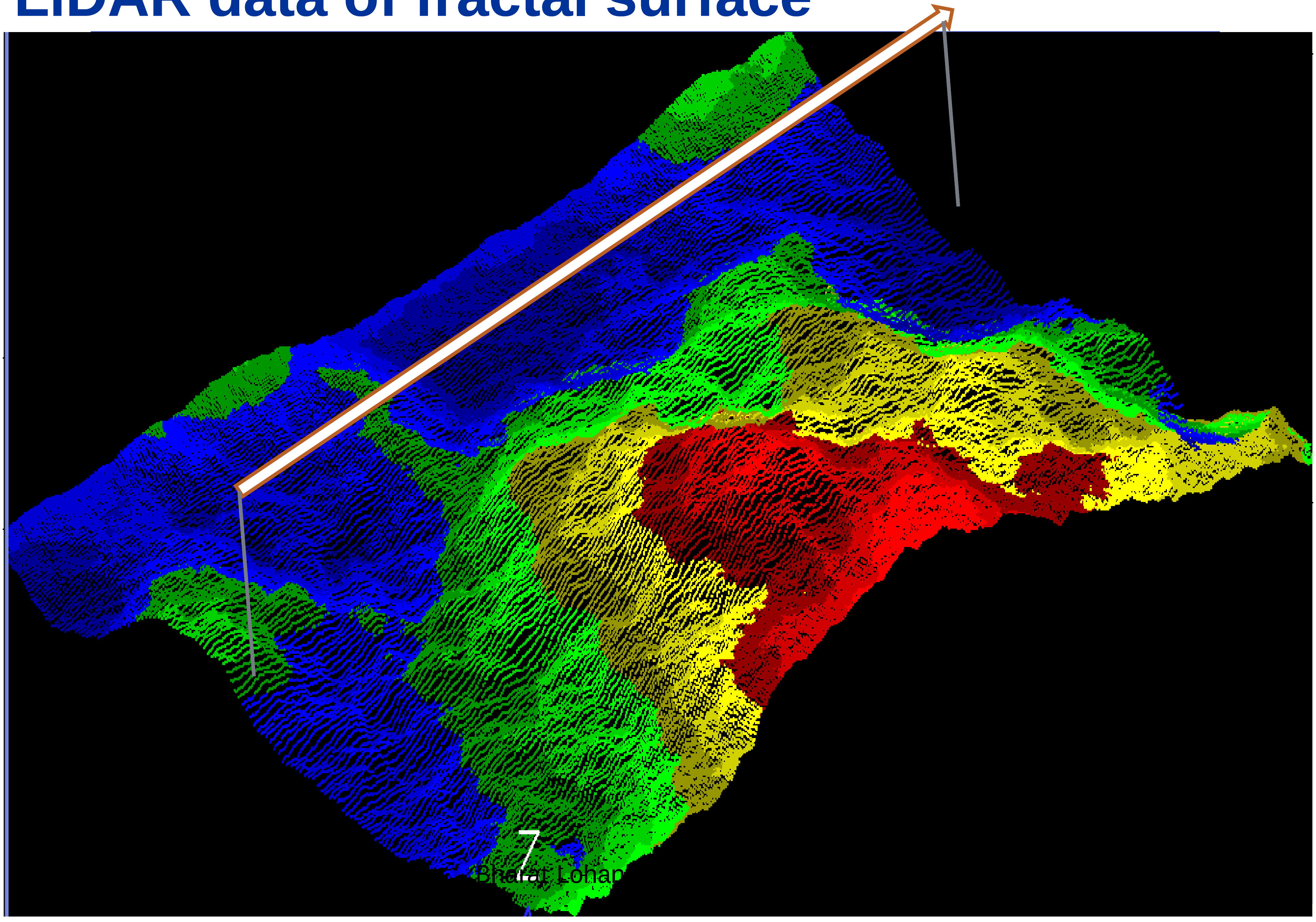
Data with attitude variation



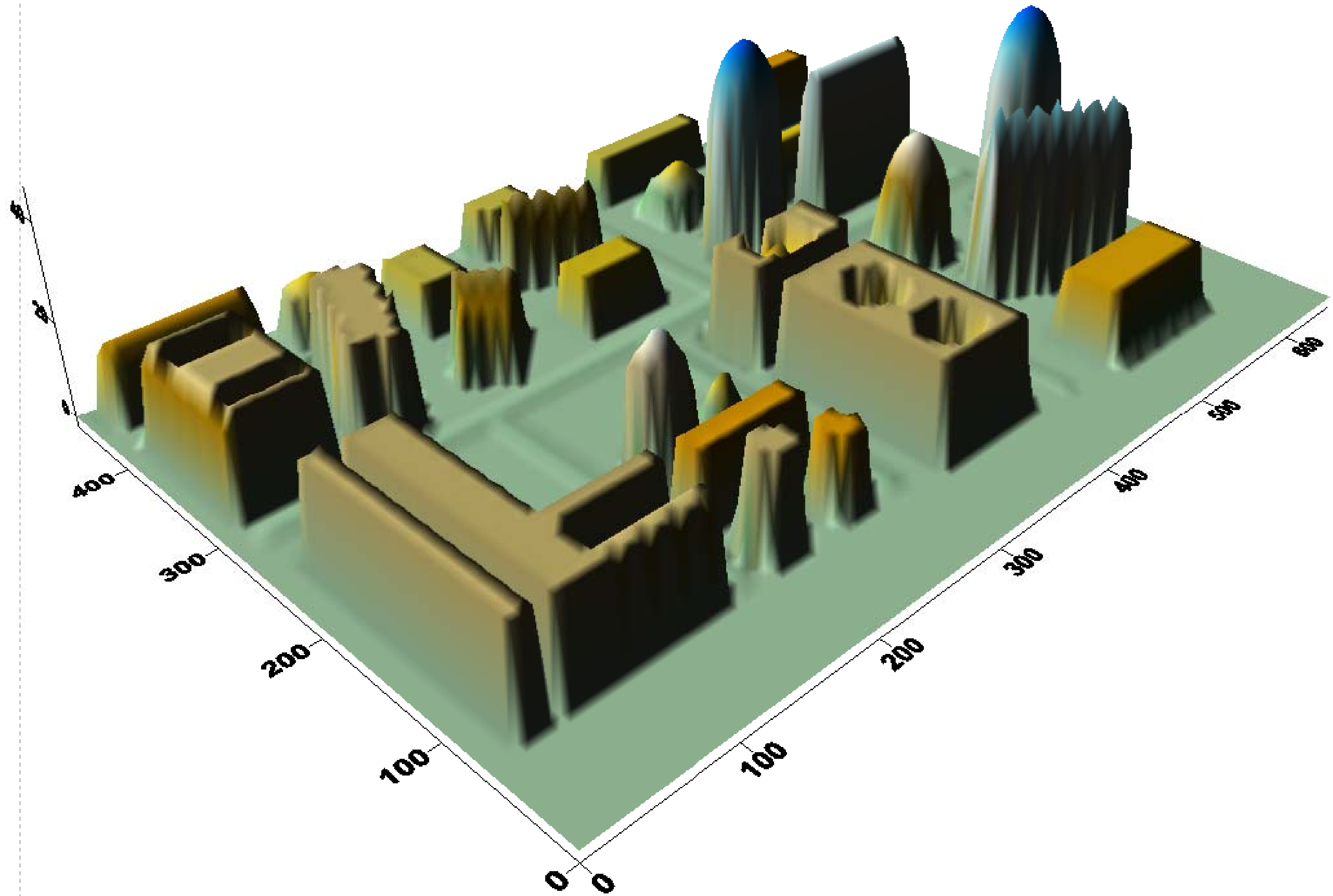
Fractal surface displayed in Surfer



LiDAR data of fractal surface

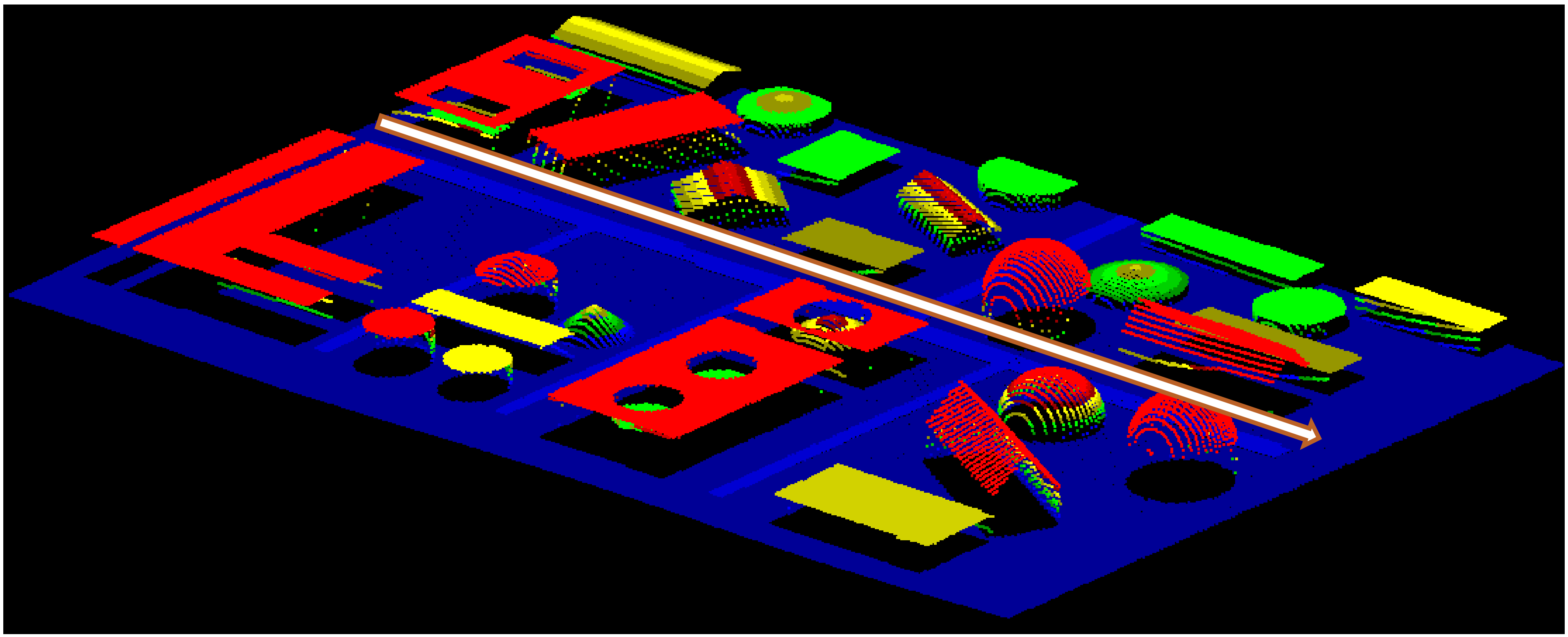


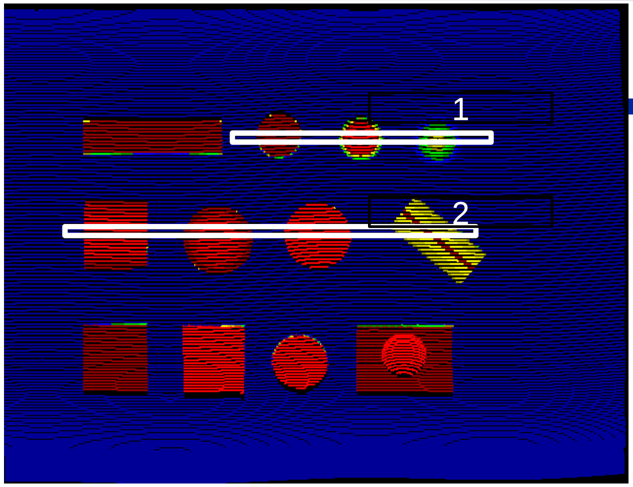
Terrain with objects



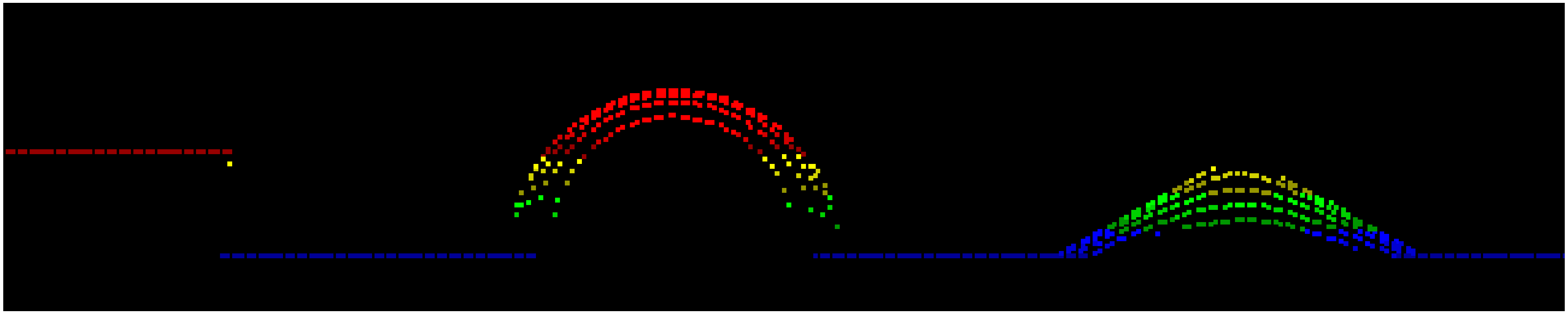
Altitude=490m
Overlap=2%
Velocity=60m/s
Sensor-ALS-50
Firing frequency=20KHz
Scan frequency=48Hz
Scan angle=50°
Flight area=640m×460m

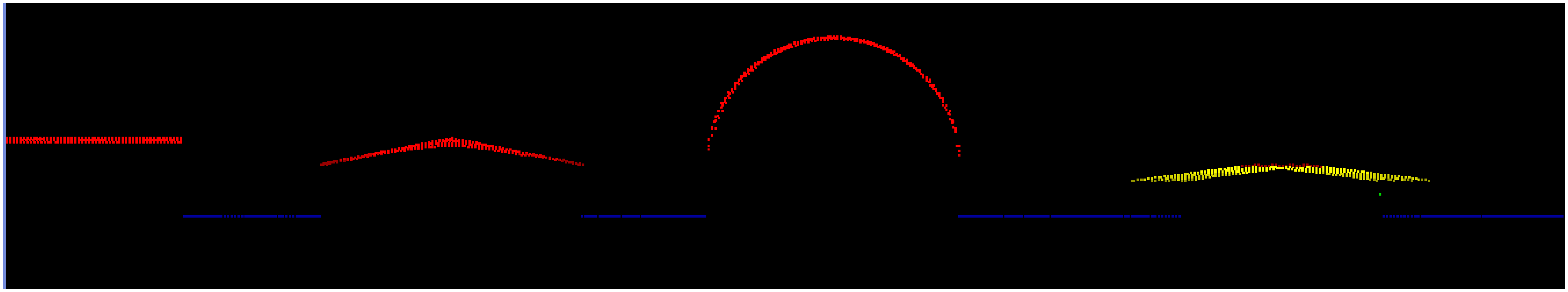
LiDAR data of terrain with objects



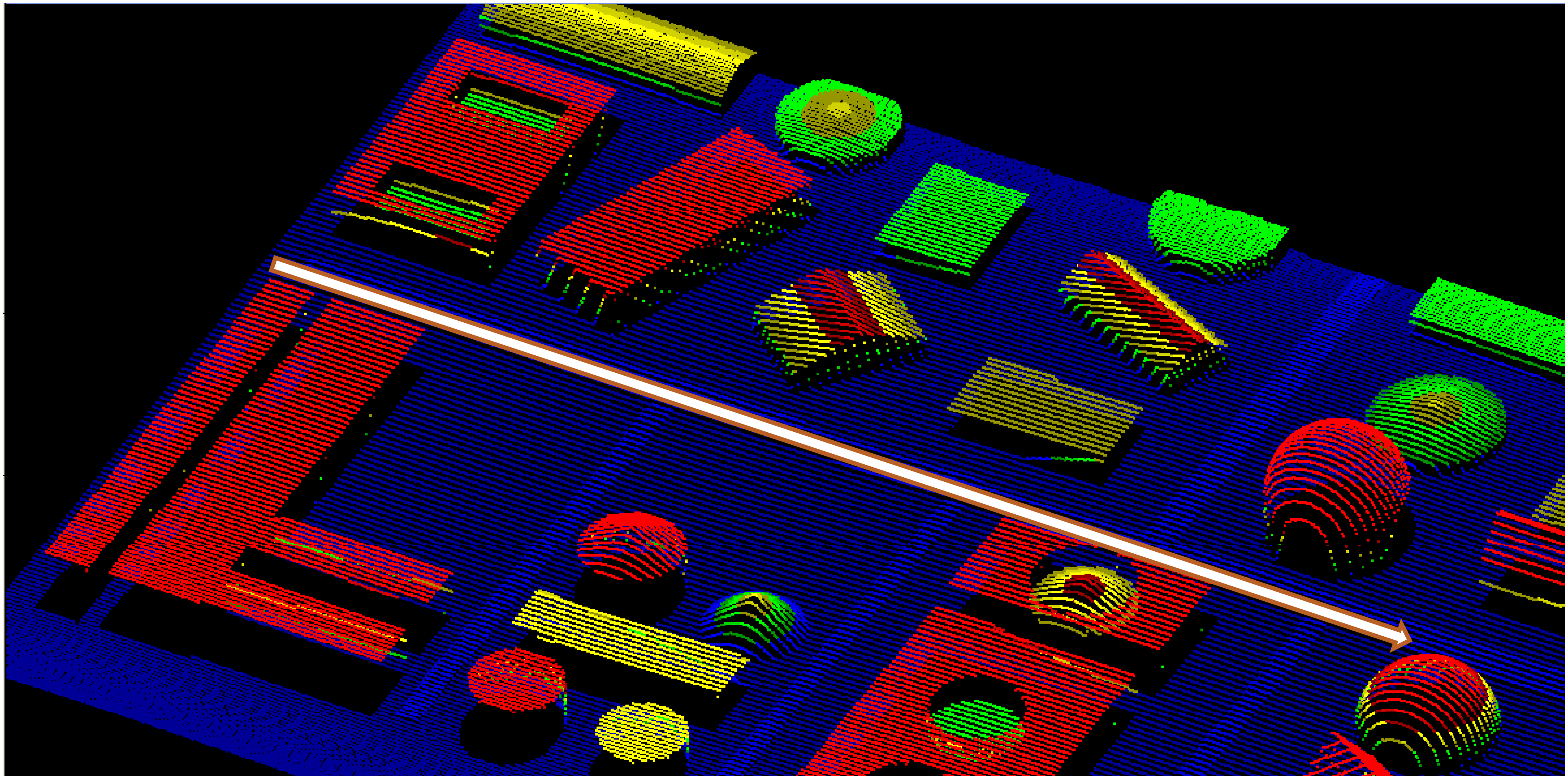


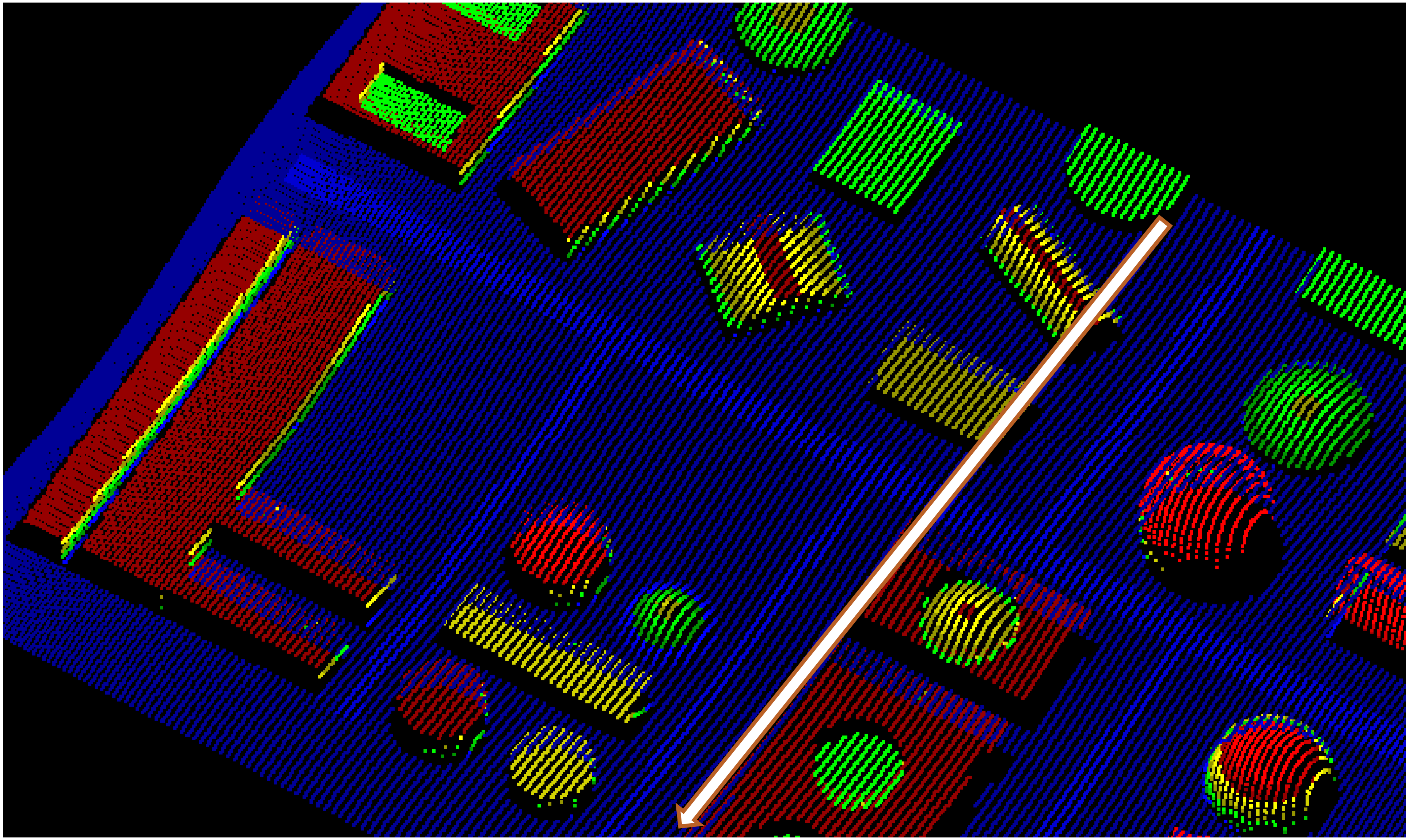
Profile view of buildings





Effect of different flight direction





Use of Simulator

Education

- Process of LiDAR data generation
- Effect of change in various parameters
- Effect of error in data
- Effect of different sensors on LiDAR data
- Generating data of known ground truth
- Conducting various lab exercises

Research

- Evaluation of information extraction algorithms
- Assessing effect of error on performance of algorithms
- Study the effect of parameters on data
- Generate data of different specifications with no cost
- Finding optimal data specification for an application

Flight planning

- Determine the optimal flight line
- Effect of sensor parameters on data
- Effect of data density
- Determine the optimal sensor parameters

Conclusion

- Offers a user friendly GUI based interface
- Simulate the process of LiDAR data collection
- Freedom to set the sensor parameters
- Many data sets can be generated for the same terrain
- Ideal software tool for LiDAR research and education
- OOSE makes it easily maintainable and scalable software

Thanks !!