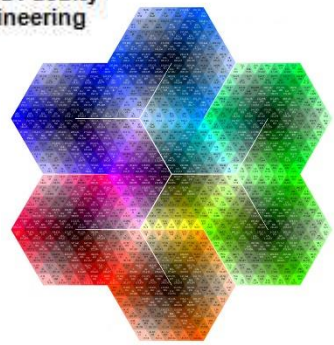
Benha University

Shoubra Faculty of Engineering

Photogrammetry 2B
Lecture 8: Introduction to Lidar



Dr. Eng. Hassan Mohamed Hassan

Hassan.hussein@feng.bu.edu.eg

Geomatics Department

What is Lidar?

LIDAR (Light Detection And Ranging) is an optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the target with light, often using pulses from a laser.

A narrow laser beam can be used to map physical features with very high resolution.

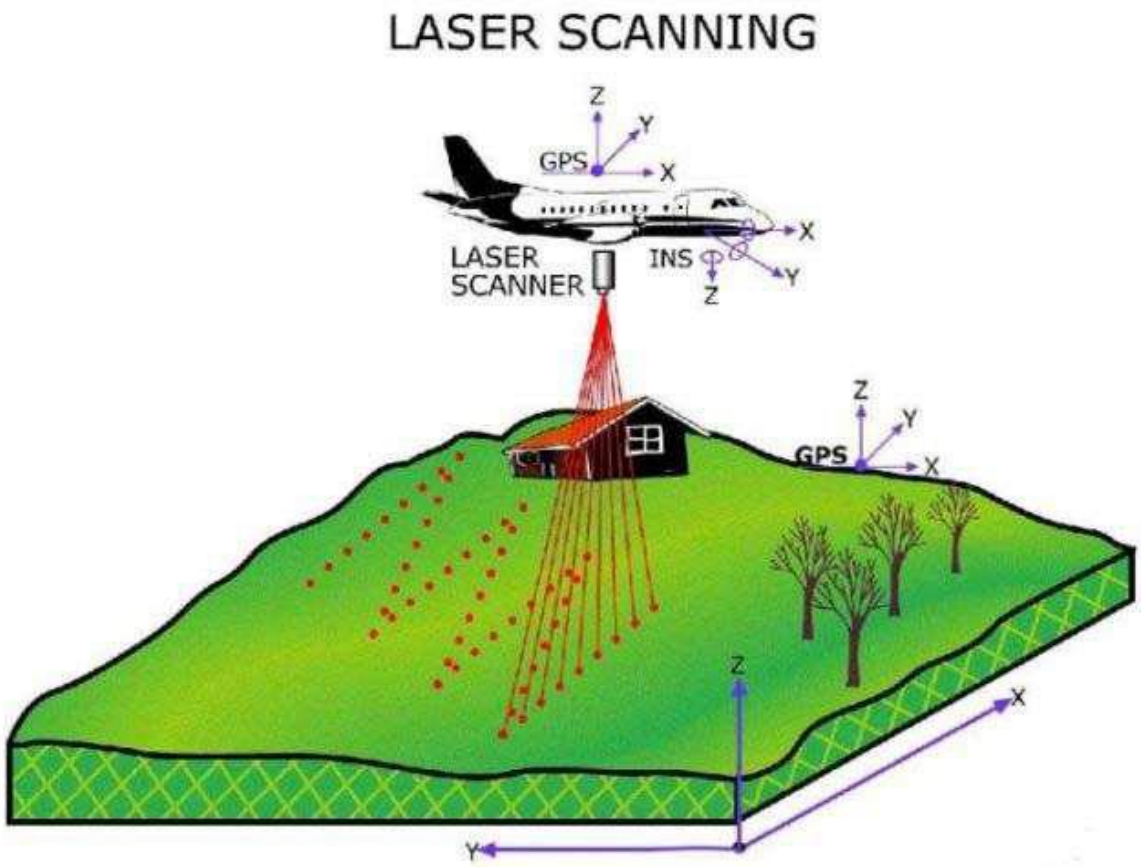
Components used in Lidar

1)Laser

2)Scanner and optics

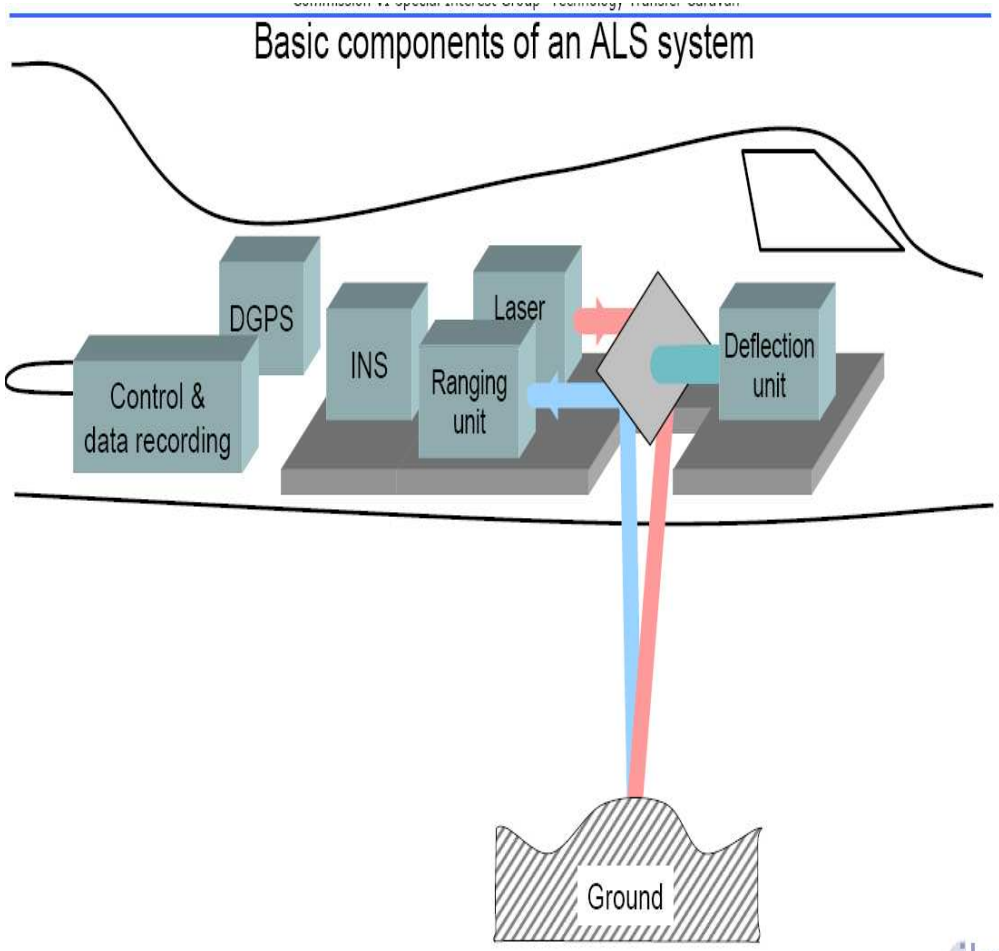
3)Photodetector and receiver electronics

4)Position and navigation systems.



Components used in Lidar

- Airborne Laser Swaths / Flight Operations
- Data Management System
- Laser Pulse Generation
- Laser Pulse Detection
- Post-Processing / Error Corrections
- Post-Processing / Data Filtering
- Digital Modeling
- Image Production



How Lidar Works

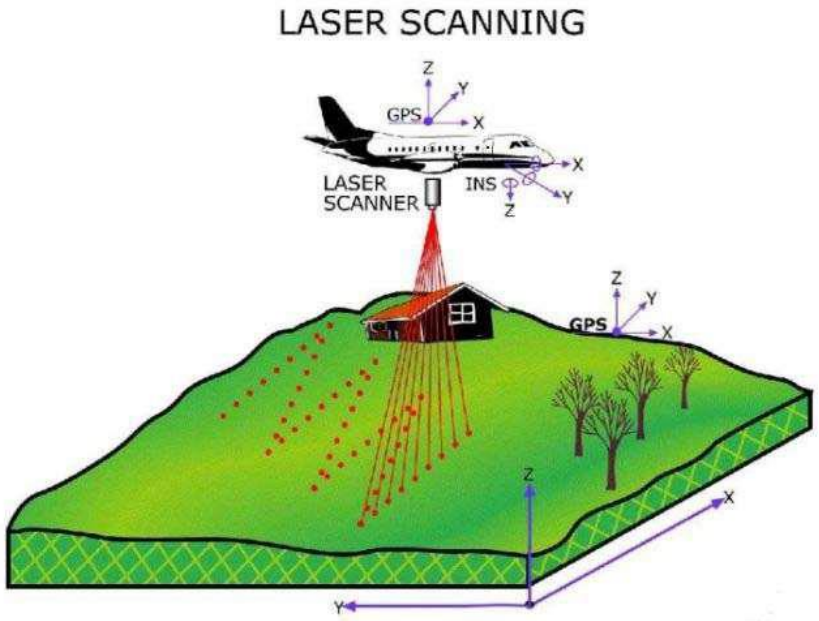
1- LIDAR sensor measures time from when pulse sent to when received.

2- This translates to distance from sensor to object.

3- GPS knows location of sensor.

4- (X,Y,Z) Coordinates are assigned to each pulse.

5- Result is a "cloud of points“ each point has its own coordinates & height.

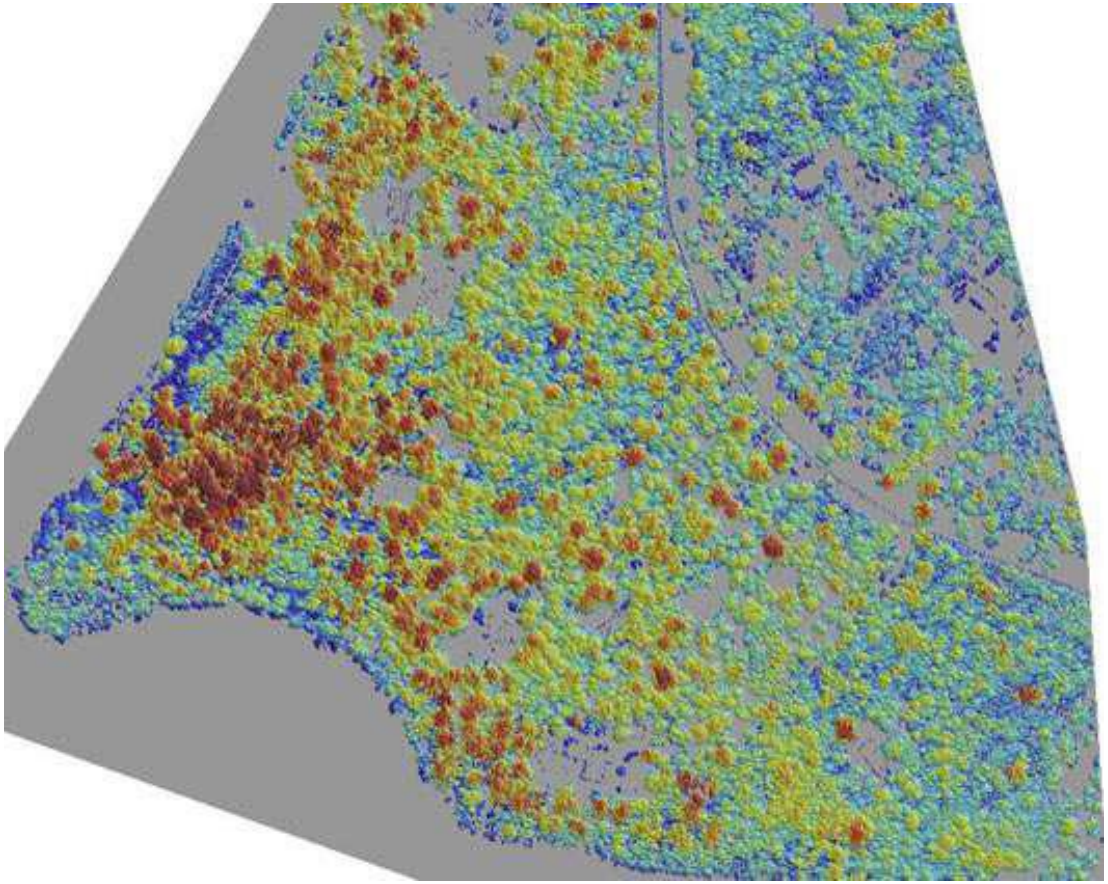


How many points?

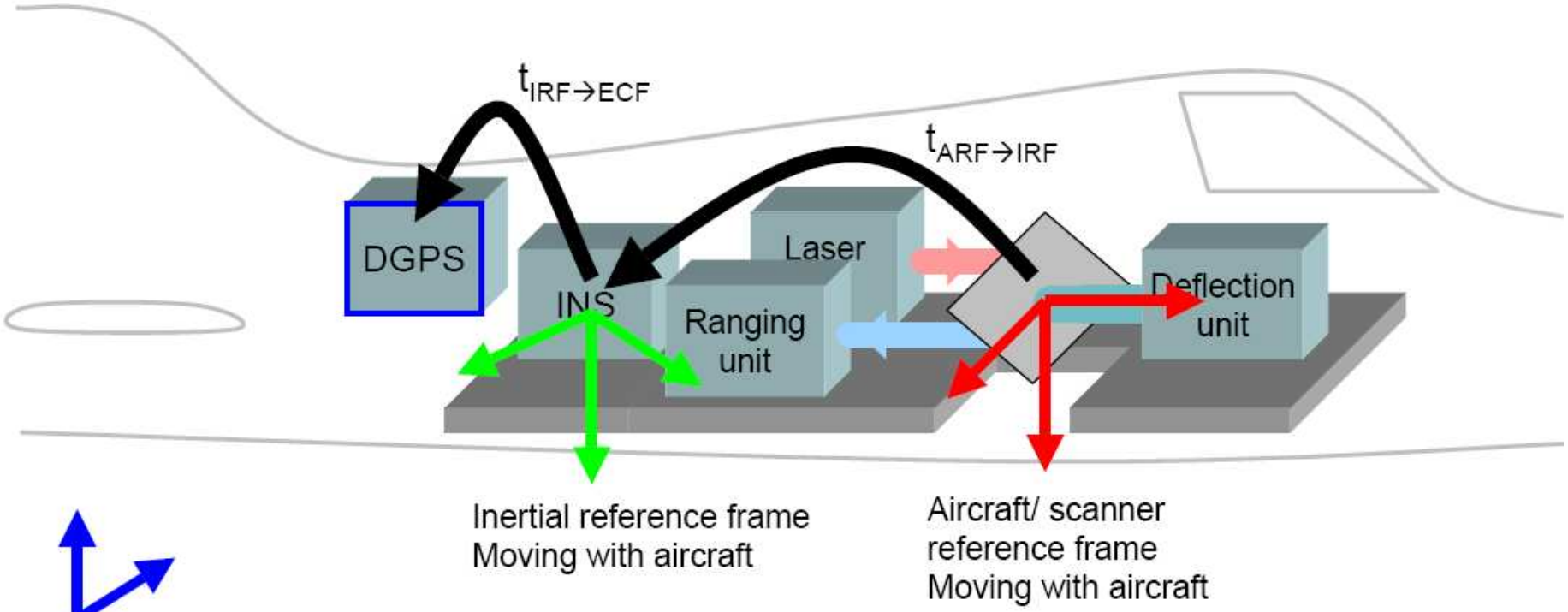
Points equals resolution.

Dependent on these variables:

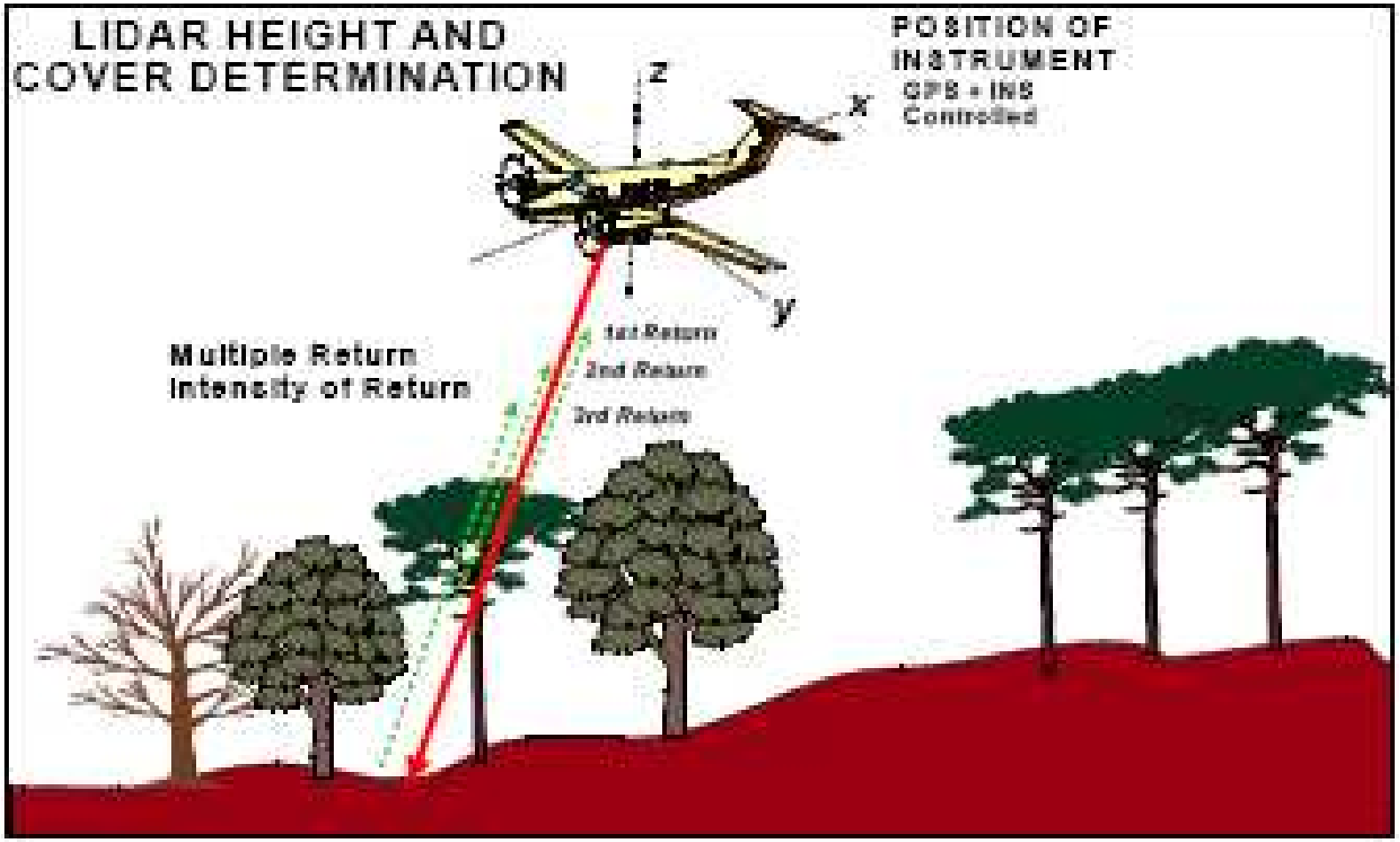
1. Number of pulses.
2. Flying height.
3. Flying speed.
4. Scan angle.



Coordinates Systems



Laser Pulse Generators



Laser Pulse Generators

LIDAR sensors that are mounted on mobile platforms such as airplanes or satellites require instrumentation to determine the absolute position and orientation of the sensor.- Such devices generally include a Global Positioning System receiver and an Inertial Measurement Unit (IMU).

Airborne topographic mapping lidars - use 1064 nm diode-pumped YAG lasers

Bathymetric systems generally use 532 nm diode-pumped YAG lasers

Better target resolution is achieved with shorter pulses, provided the LIDAR receiver detectors and electronics have sufficient bandwidth.

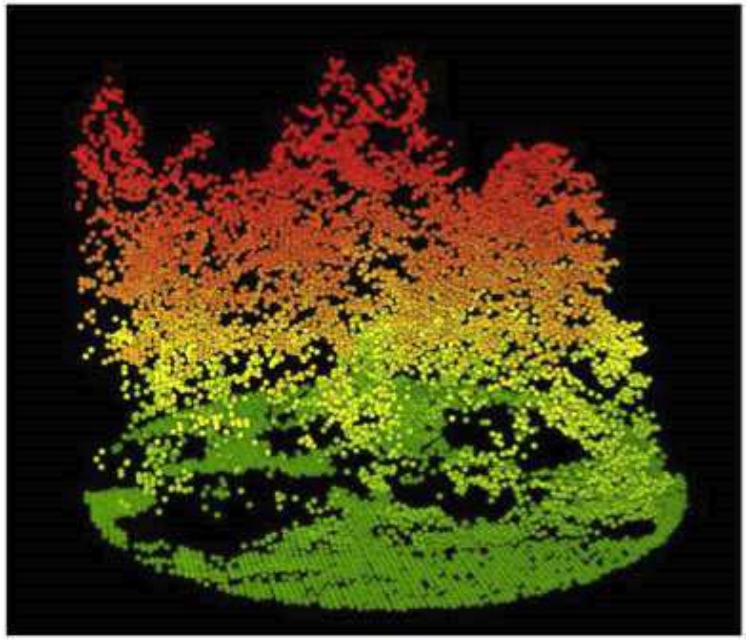
Two types of LIDAR sensors

Discrete

– Individual points

– Small footprint (5-30 cm)

– More common sensor



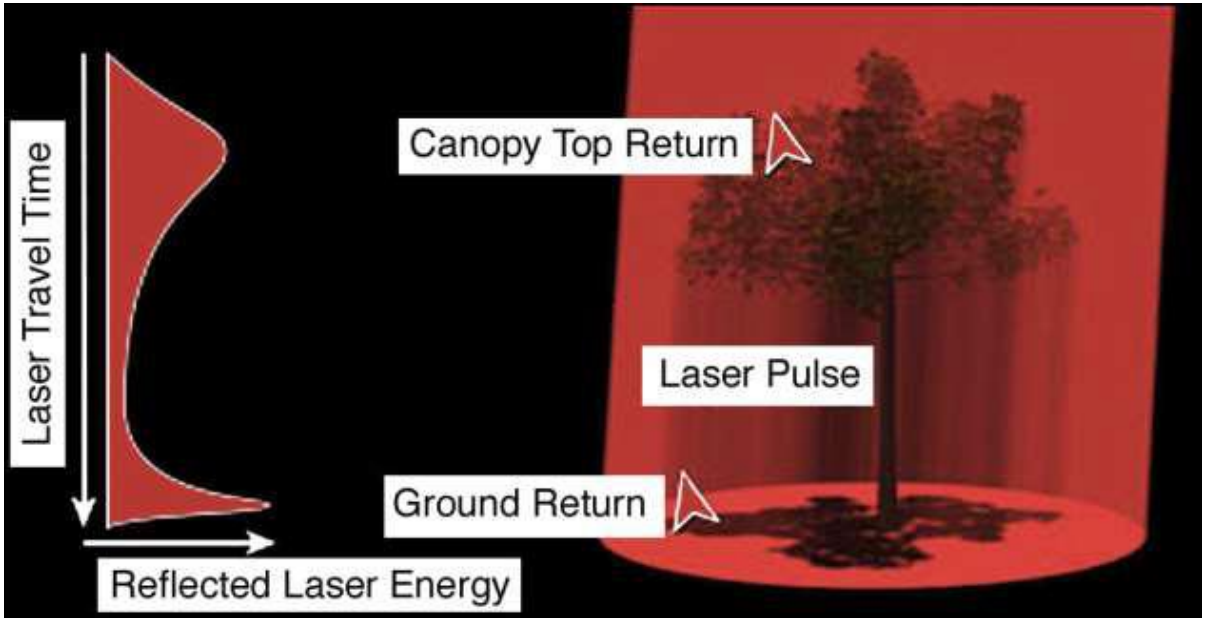
Two types of LIDAR sensors

Waveform

– Continuous vertical return

– Better for forest biometrics

– Less cost

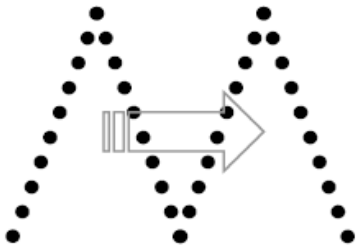


LIDAR sensors

Scanning Mechanisms and Ground Patterns

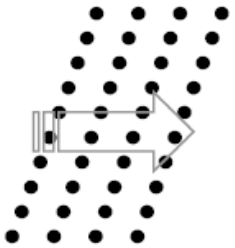
Oscillating mirror

Z-shaped, sinusodial



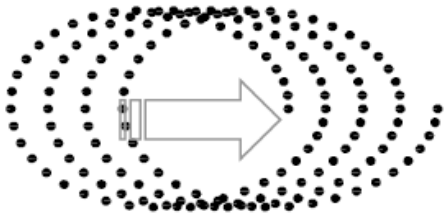
Rotating polygon

Parallel lines

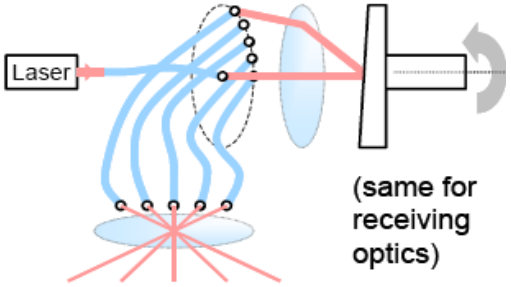


Nutating mirror (Palmer scan)

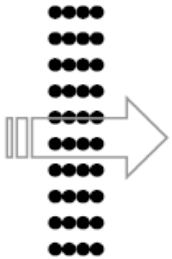
"Elliptical"



Fiber switch



Parallel lines

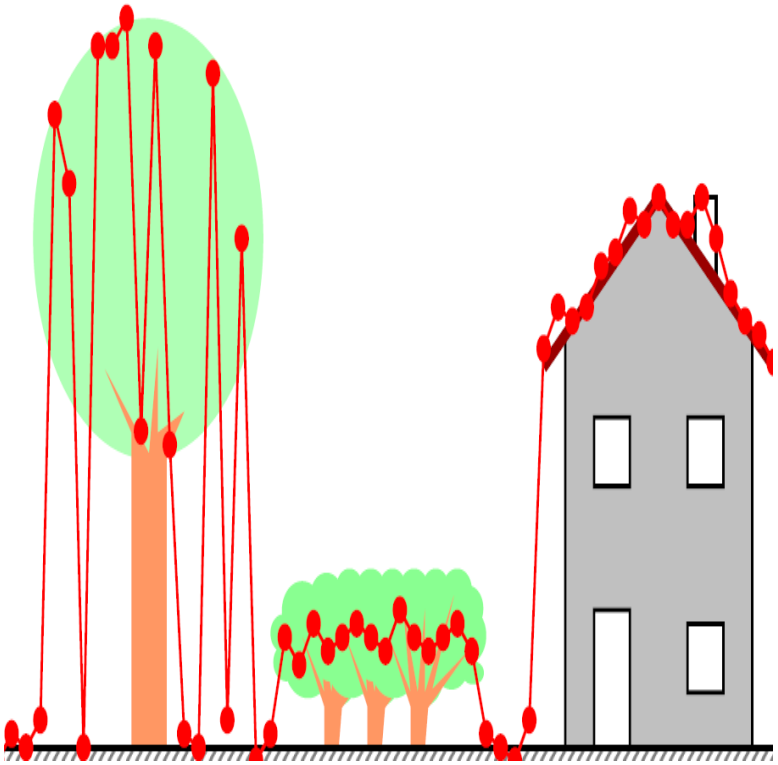


Scanner Examples

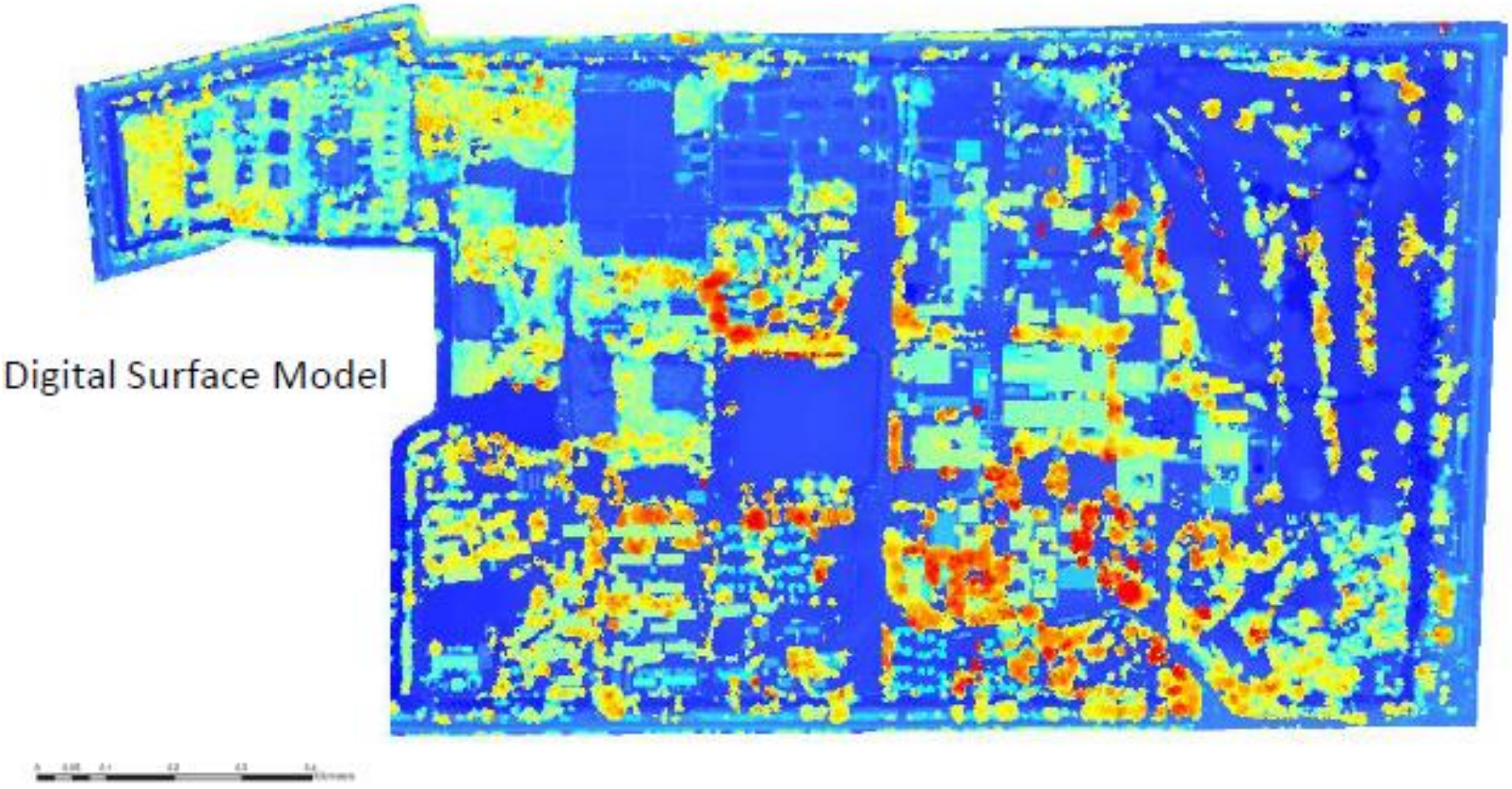
System	Optech ALTM 3100EA	Riegl LMS-Q560	TopoSys Falcon II
Laser	1064 nm	near IR	1540 nm
Altitude	80 – 3500 m	30 – 1500 m	60 – 1600 m
Range measurements	up to 4	full waveform	first and last
Scan frequency	max. 70 Hz	max. 160 Hz	max. 630 Hz
Scan angle	max. ± 25°	max. ± 30°	± 7° (fixed)
Pulse rate	max. 100 kHz	max. 100 kHz, 50 kHz @ ± 22.5°	83 kHz
Beam divergence	0.3 mrad	0.5 mrad	0.5 mrad
Beam pattern	oscillating, sawtooth	rotating polygon, parallel	fiber switch, parallel

Filtering Cloud Points

- Digital elevation model (DEM), digital terrain model (DTM): “Ground”
- Digital surface model (DSM): “top surface”
- In open terrain, the separation surface between air and bare earth
- DEM is different from measured laser points due to **very different reasons:**
  - **Measurement errors** of ALS system (position, orientation, range...)
  - **Interaction with target** (mixed points in vegetation)
  - **Interpretation** (buildings are not part of the DEM by definition)
- Filtering: classification of points into terrain and off-terrain
- Basis for DTM generation, detection of topographic objects

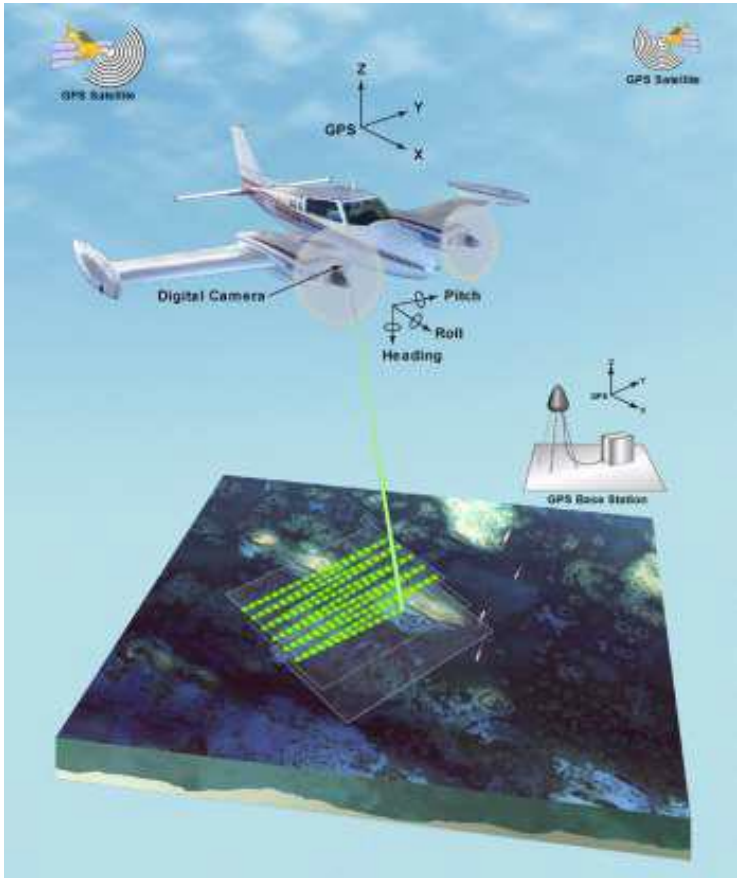


Filtering Cloud Points



Lidar Accuracies

- Laser measurement (range, angle: electronics aging & drift)
- DGPS (receiver, satellite constellation, ground reference constellation)
- INS (receiver: frequency, drift)
- Offset / alignment between GPS, INS, laser scanner
- Dynamic bend of IMU / scanner mounting plate
- Time synchronization and interpolation (GPS: 1-10/s, INS 200/s, turbulent flight)
- Transformation to local coordinate system



Advantages of Lidar

The other methods of topographic data collection are land surveying, GPS, and photogrammetry. LiDAR technology has some advantages in comparison to these methods, which are being listed below:

1) Higher accuracy
2) Fast acquisition and processing
3) Minimum human dependence- As most of the processes are automatic unlike photogrammetry, GPS or land surveying.
4) Weather/Light independence- Data collection independent of sun inclination and at night and slightly bad weather.

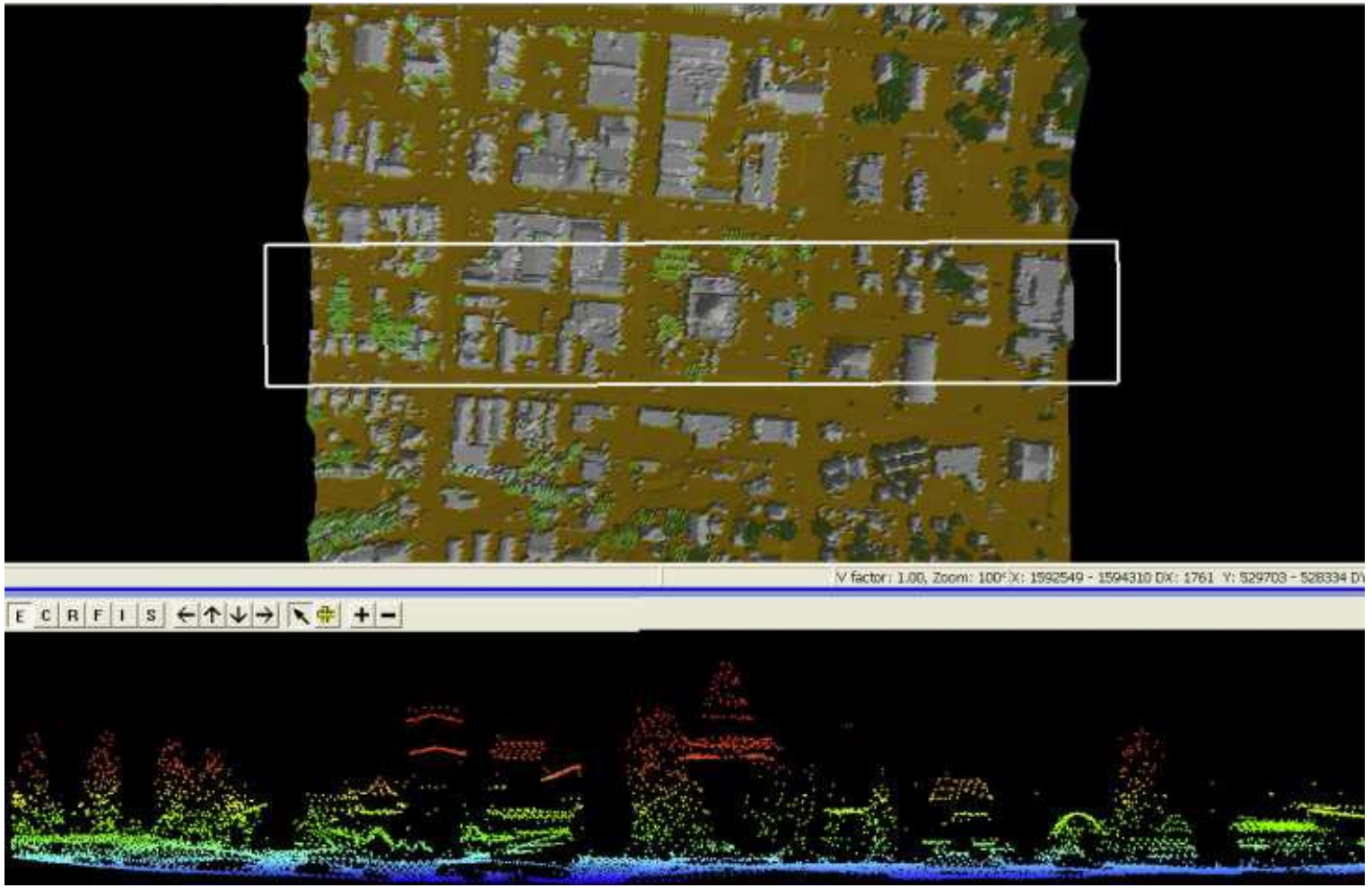
Advantages of Lidar

5) Canopy penetration-LiDAR pulses can reach beneath the canopy thus generating measurements of points there unlike photogrammetry.
6) Higher data density - Up to 167,000 pulses per second. More than 24 points per m2 can be measured. n Multiple returns to collect data in 3D.
7) Cost - Is has been found by comparative studies that LiDAR data is cheaper in many applications.
This is particularly considering the speed, accuracy and density of data.

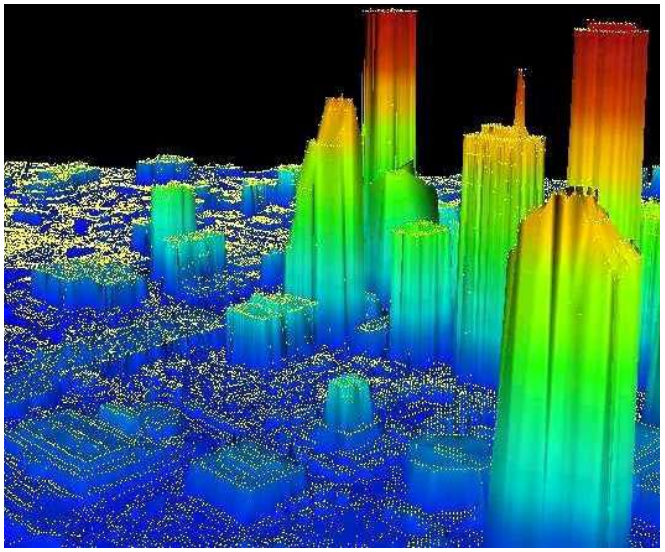
Disadvantages of Lidar

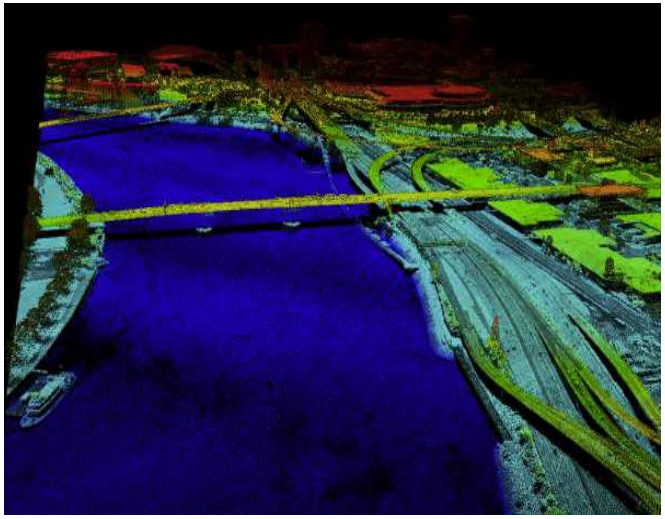
1. High operating costs (> £10k / hour)
2. Ineffective during heavy rain and/or low cloud/mist
3. Degraded at high Sun angles and reflections
4. Unreliable for water depth (< 2m) and breaking/turbulent waves
5. Lack of foliage/vegetation penetration
6. Precise alignment must be maintained

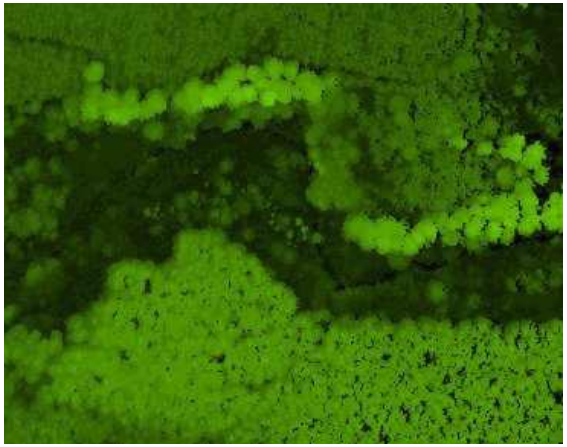
Applications of Lidar

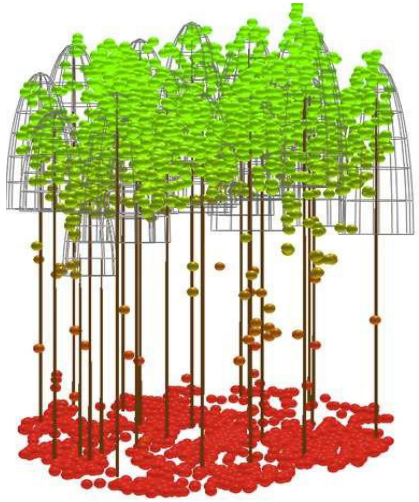


Applications of Lidar









Supplementary files:

- https://www.youtube.com/watch?v=H2-Yp30TGk4
- https://www.youtube.com/watch?v=EYbhNSUnIdU
- https://www.youtube.com/watch?v=kTRqnB0usO8

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Thanks

Dr.Eng. Hassan Mohamed