

# CE671-Lecture 2

## LiDAR Introduction I

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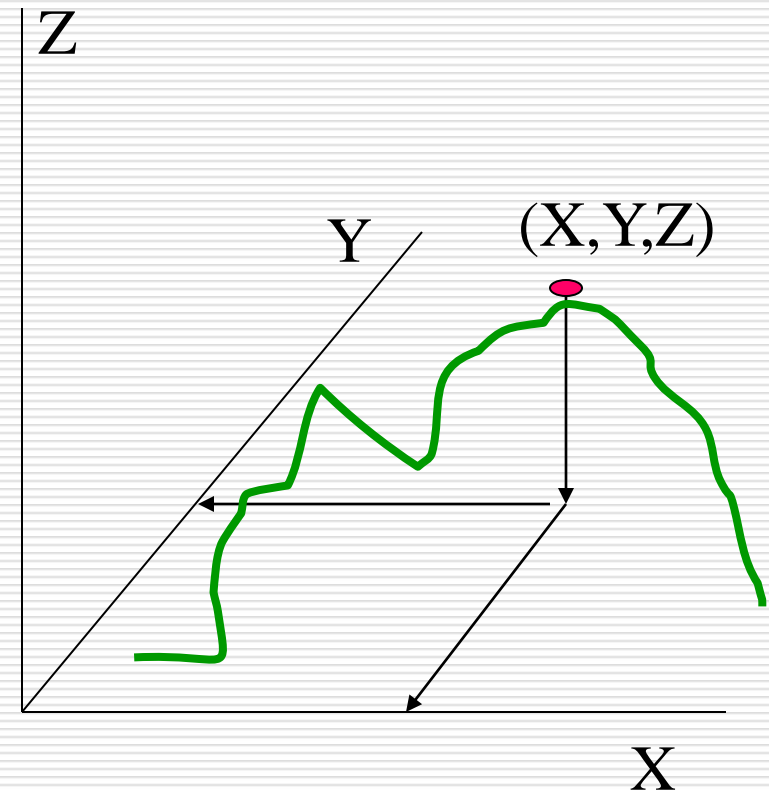
# What is topographic data?

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□ Two basic components:

1. Measurement  
(i.e. What is where?)

2. Identification  
(i.e. what is what?)



# Available Methods for Topographic Data

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- ❑ Total Station
- ❑ GPS/GNSS
- ❑ Satellite Imageries
- ❑ Drone Photogrammetry
  
- ❑ LiDAR Technology
  - *Drone*
  - *Manned aircraft*

# Comparison of Methods

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☐ Total Station

Slow, Not reliable, Not suitable for remote and inaccessible places

☐ GPS/GNSS

☐ Satellite Imageries

Less accurate, No data under forest and crops, No data in texture-less terrain

☐ Drone Photogrammetry

Not suitable for large area, No data under forest and crop, No data in texture-less terrain

☐ LiDAR Technology

■ *Drone*

■ *Manned aircraft*

Best technology with no limitations

# A new technique: Airborne altimetric LiDAR

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- Topographic data with the **speed of light.**
  - Complimentary technique eliminating several limitations of conventional methods.
  - Technology known by different names:
    - Airborne altimetric LiDAR
    - Laser altimetry
    - Laser range finder
    - Laser radar
    - Laser mapper
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# What is laser ?

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□ Laser (Light Amplification by the Stimulated Emission of Radiation)

- highly monochromatic,
  - coherent,
  - directional, and
  - can be sharply focused
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# How is laser generated ? stimulated emission

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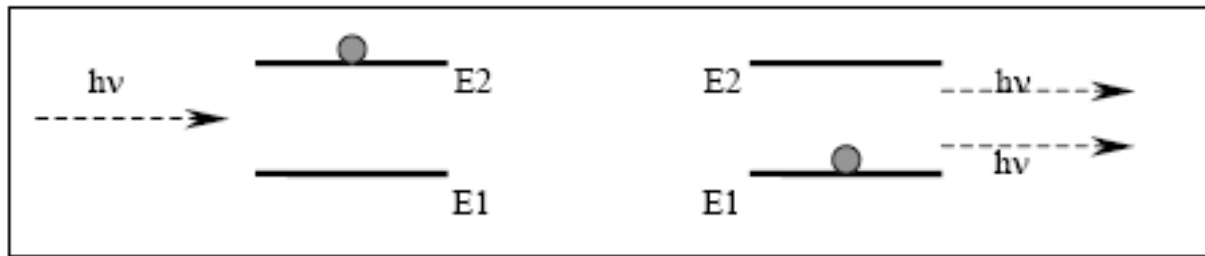
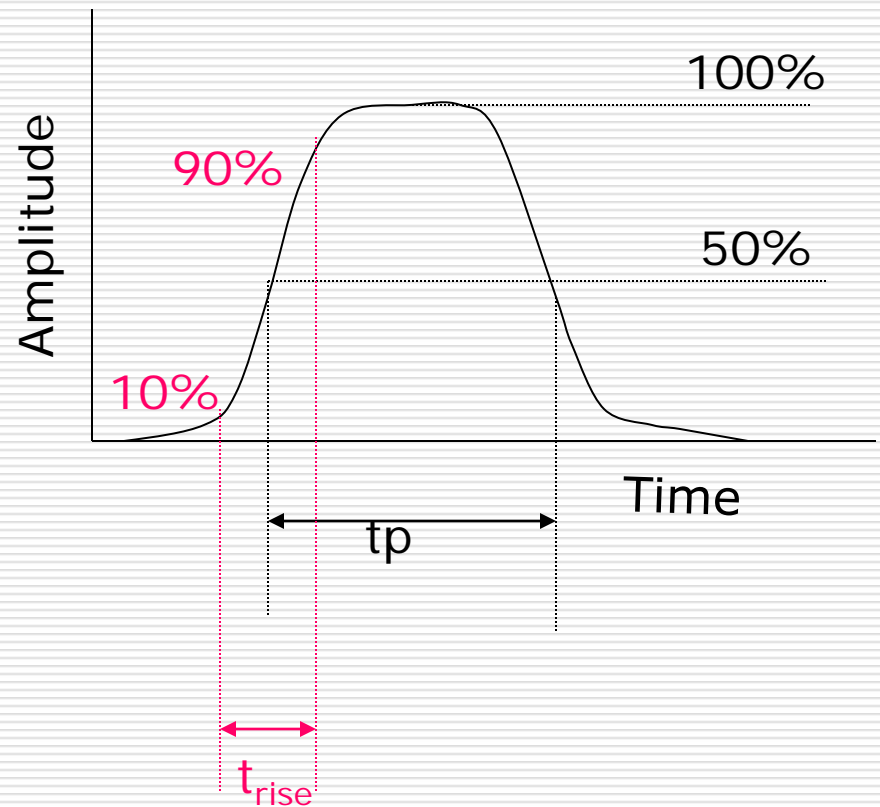


Figure 3-1 Simulated emission.

- ☐ A photon interacts with an atomic system in its upper state
  - ☐ System is driven down to its lower state ( $h\nu = E_2 - E_1$ ) and two photons exit
  - ☐ Emitted photon identical with the triggering or stimulating photon
  - ☐ Same energy, direction, phase, and state of polarisation.
  - ☐ Further chain reaction
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# Laser pulse

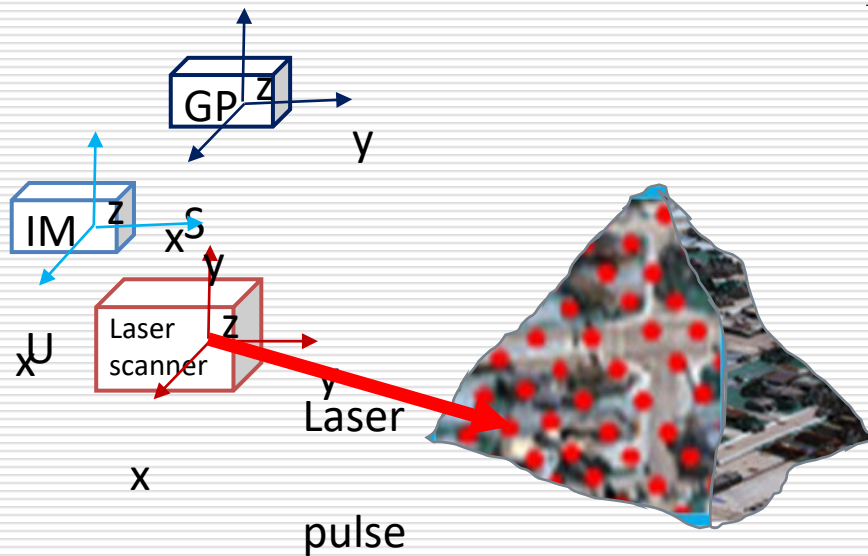
- ❑ Diode pumped solid state lasers
- ❑ Nd-Yag laser
- ❑ Pulse width of order of 2ns-10 ns
- ❑ Rise time of order 1 ns
- ❑ Ranging accuracy 2-7 cm





# LiDAR technology

- Initial laser vector is transformed through a series of reference systems to yield object coordinates in a chosen Coordinate System.



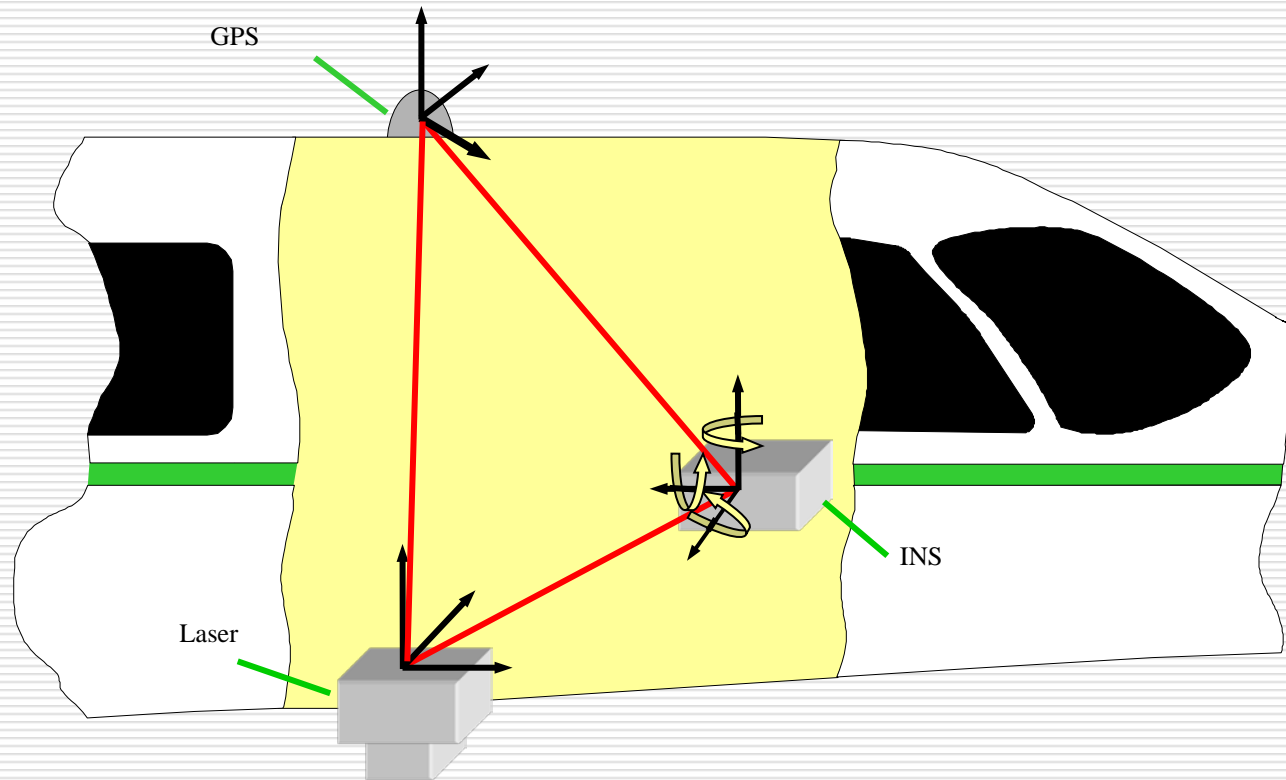
$$d = c * t / 2$$

$c$  = Velocity of light

$t$  = Time of travel of laser pulse

# Sensor configuration

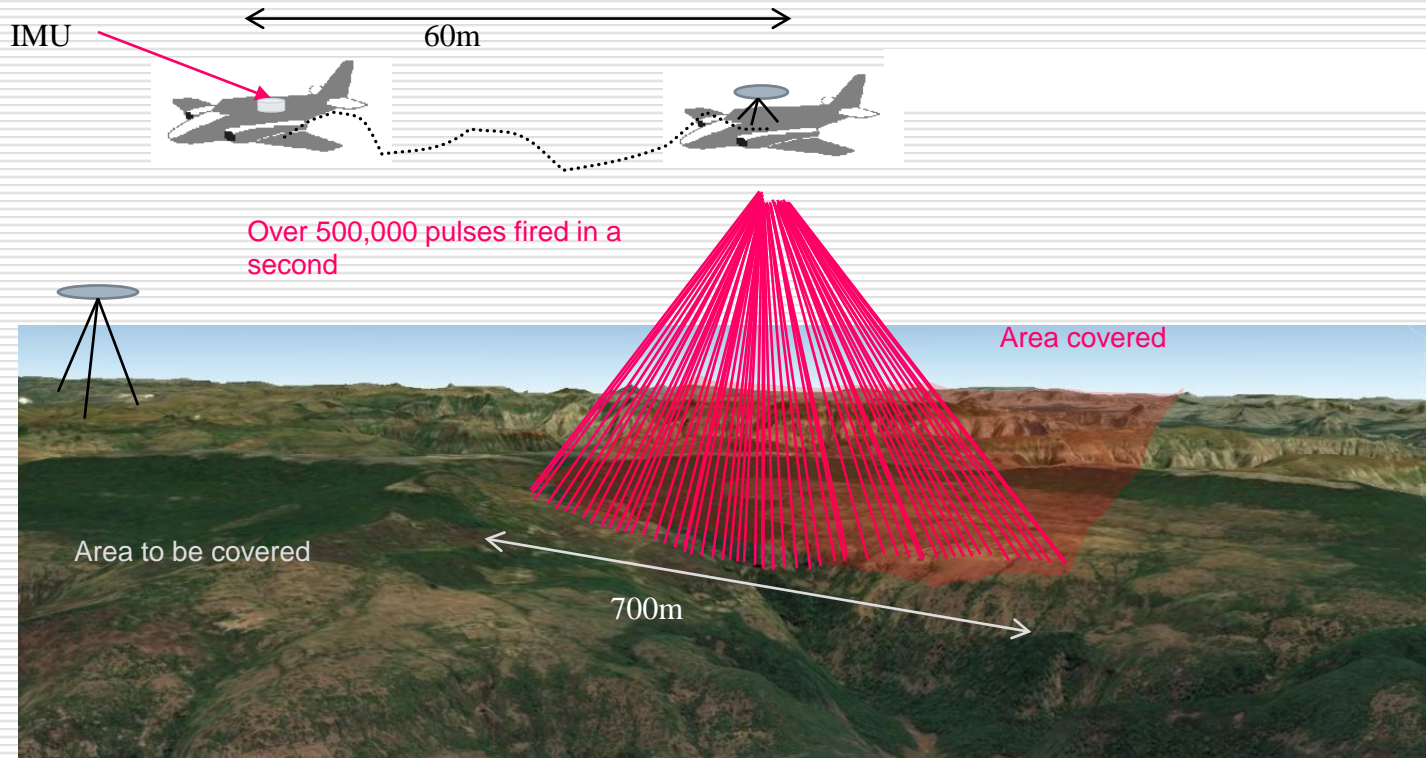
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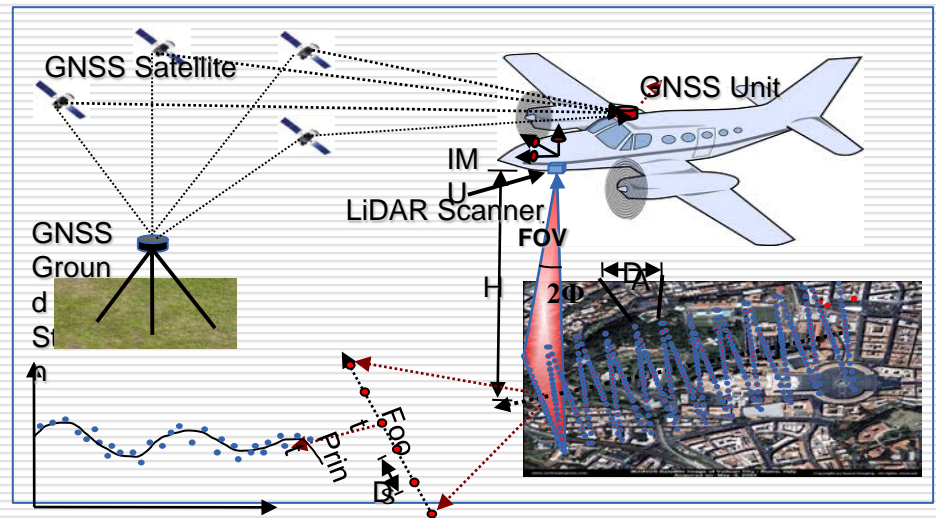
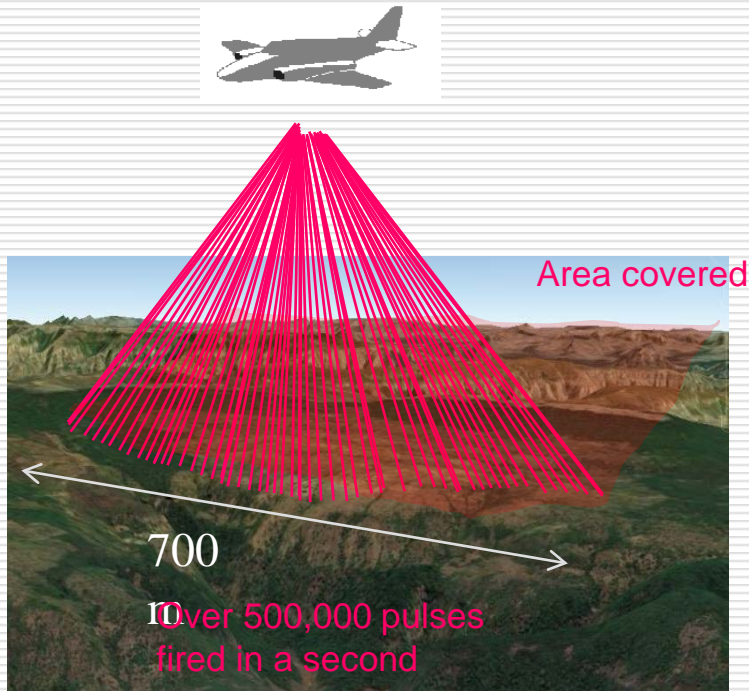
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# Principle of scanning LiDAR

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# Airborne LiDAR and its Sensors

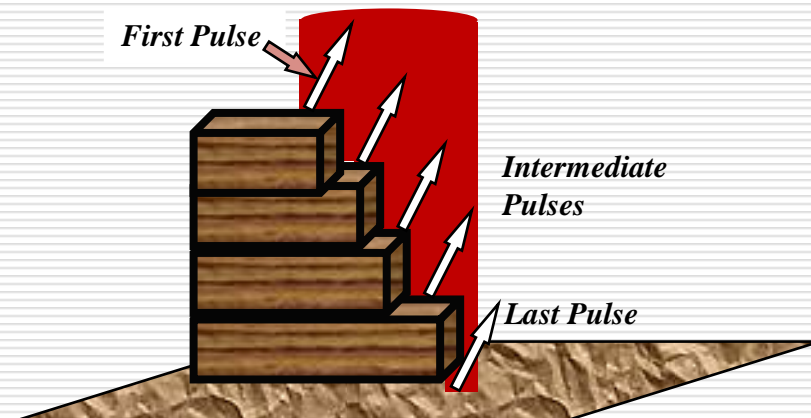


Laser measures range from aircraft to the point hit in ground. This range is converted to the coordinates of the points in ground using on-board GPS and IMU. The final result is large number of points with their known coordinates along with coloured images of entire ground.

# LiDAR in multiple return mode

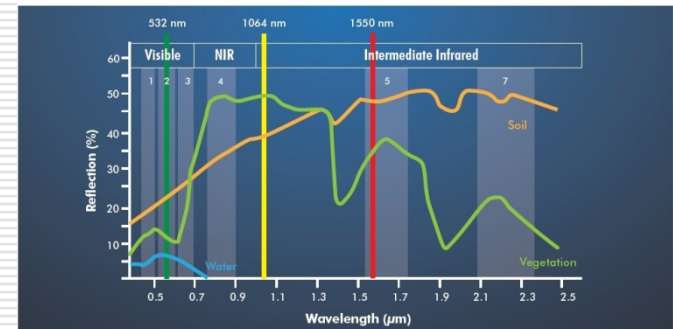
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- ❑ Instrument is timed to pickup signals at certain intervals.
- ❑ First pulse to survey the top of objects while the last pulse is used to survey the ground below.
- ❑ Intermediate pulses convey information about vertical structure of object.



# Multi-spectral LiDAR

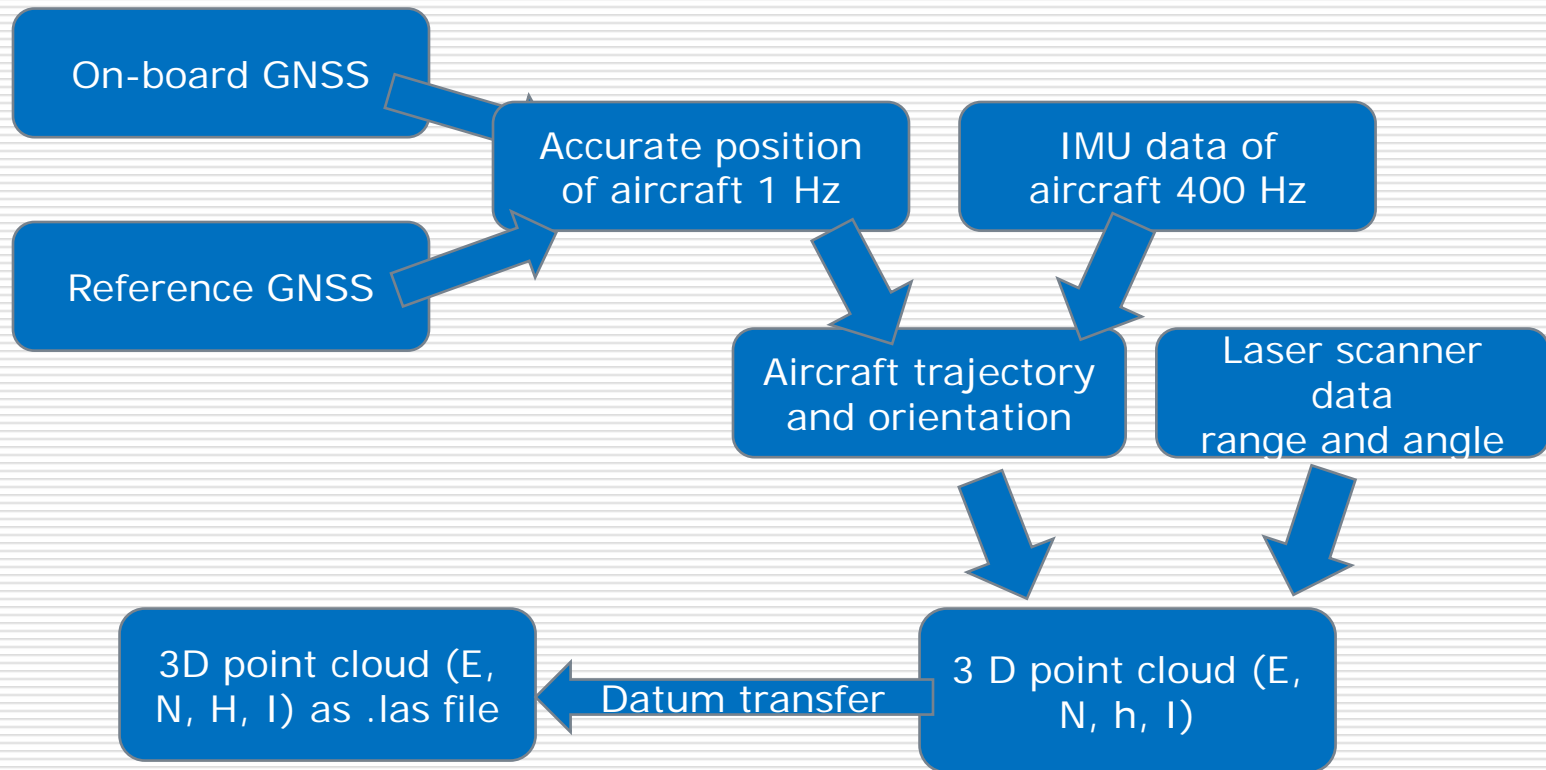
- ❑ Optech Titan
- ❑ Operates at 532 nm, 1064 nm and 1550 nm
- ❑ Each beam has a 300 kHz effective sampling rate for a combined ground sampling rate of 900 kHz.





# Initial data processing

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# Format for LiDAR data

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- ❑ ASPRS format LAS
- ❑ Versions 1.0, 1.1, 1.2, 1.3, 1.4
- ❑ <http://asprs.org/Committee-General/LASer-LAS-File-Format-Exchange-Activities.html>
  
- ❑ LASUtility to download from
- ❑ <http://home.iitk.ac.in/~blohani/download.htm>



# Header information

Header Information		
Property	Value	
File Signature:	LASF	▲ ☰ ▼
Version:	1.2	
Generating software:	TerraScan	
No. of points:	474343	▼ ☰ ▲
Header size:	227	
Point data record length:	34	
No. of variable length fields:	0	
Offset to data:	229	
Point data format ID:	3	
Maximum-X, Minimum-X:	657871.127 m ,657277.961 m	☰ ▼ ▲
Maximum-Y, Minimum-Y:	4772643.062 m ,4772187.988 m	
Maximum-Z, Minimum-Z:	176.610 m ,61.692 m	
X-Scale,Y-Scale,Z-Scale:	0.001 ,0.001 ,0.001	
X-Offset,Y-Offset,Z-Offset:	500000.000 ,4500000.000 ,-0.000	
		☰ ▼ ▲
No. of return 1:	474343	
No. of return 2:	0	
No. of return 3:	0	
No. of return 4:	0	

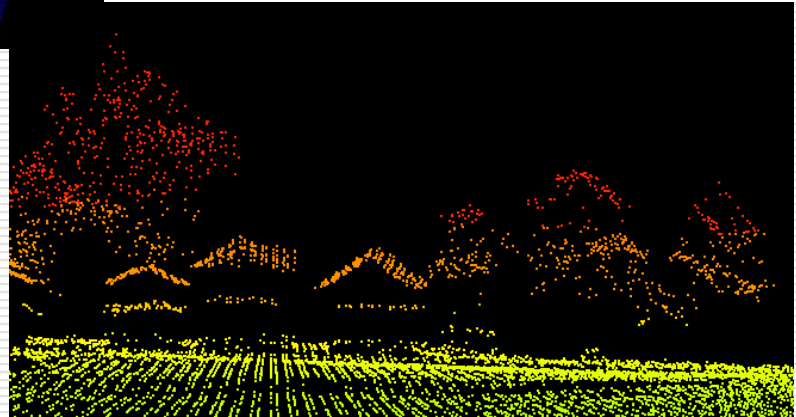
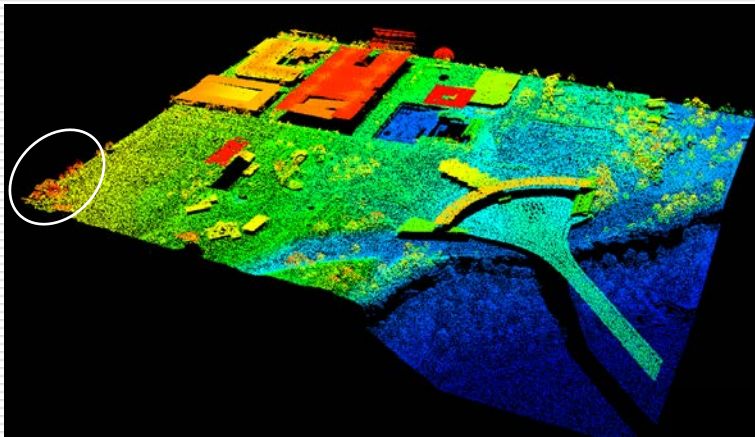
# LAS File point data records

Point Data Record

PtNo.	X	Y	Z	Inten...	Retu...	No. ...	Scan...	Edg...	Clas...	Scan...	User...	Sour...	GPS Time	Red	Green	Blue
1	657285.313	4772547....	62.696	1	0	6	0	0	2	0	0	5	405614.960	54	87	112
2	657284.375	4772542....	62.630	1	0	6	0	0	2	0	0	5	405615.041	63	91	108
3	657282.563	4772539....	62.347	2	0	6	0	0	2	0	0	5	405615.102	54	94	105
4	657284.313	4772486....	62.196	1	0	6	0	0	2	0	0	5	405615.960	84	99	113
5	657283.625	4772485....	62.134	1	0	6	0	0	2	0	0	5	405615.979	65	84	102
6	657285.438	4772483....	62.259	2	0	6	0	0	2	0	0	5	405616.021	135	137	148
7	657284.500	4772483....	62.300	1	0	6	0	0	2	0	0	5	405616.021	105	111	128
8	657284.125	4772482....	61.913	3	0	6	0	0	2	0	0	5	405616.040	99	111	130
9	657282.938	4772482....	61.862	1	0	6	0	0	2	0	0	5	405616.041	86	96	114
10	657279.813	4772476....	62.143	1	0	6	0	0	2	0	0	5	405616.142	94	82	97
11	657282.875	4772474....	64.509	5	0	6	0	0	2	0	0	5	405616.163	146	104	114

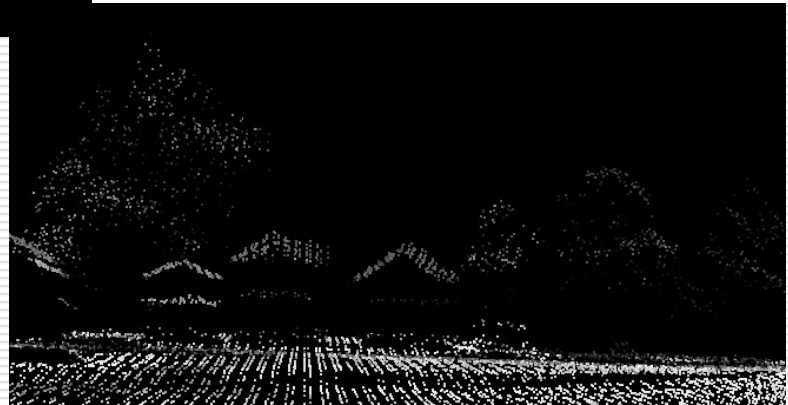
# LiDAR data example-Elevation

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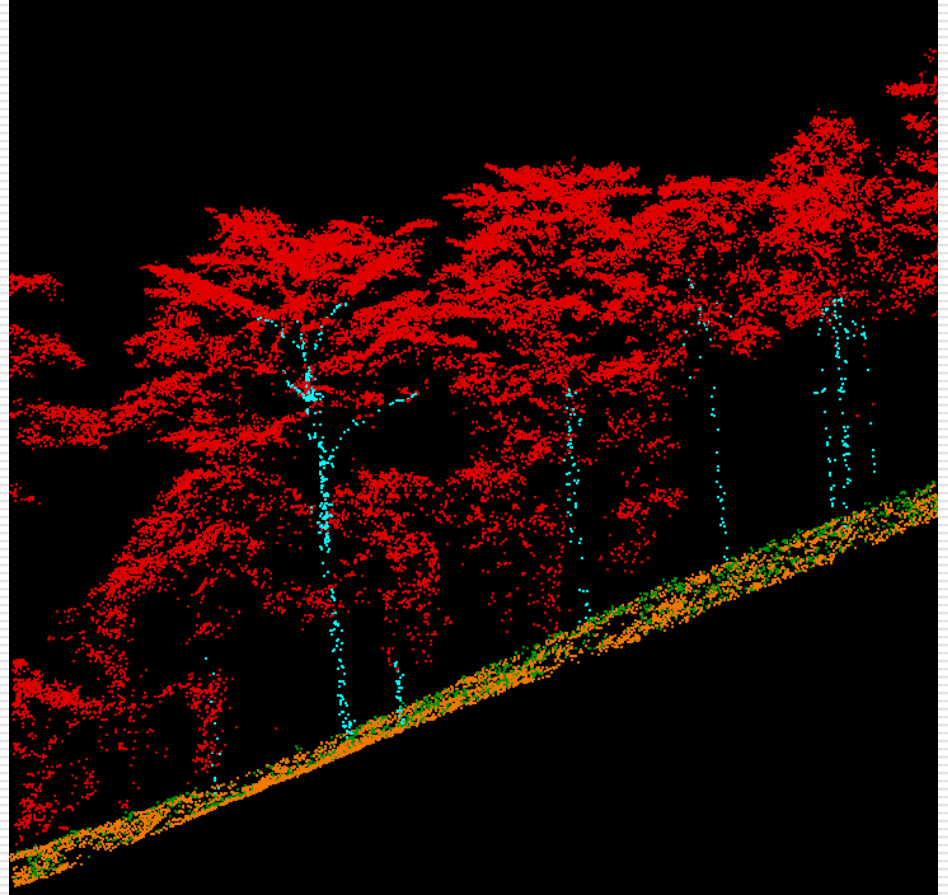
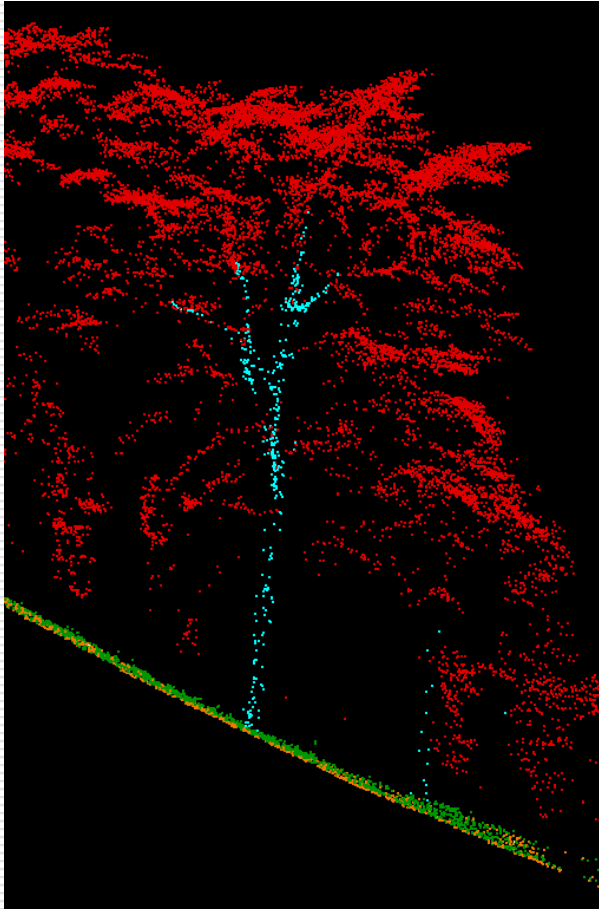
# LiDAR data example- Intensity

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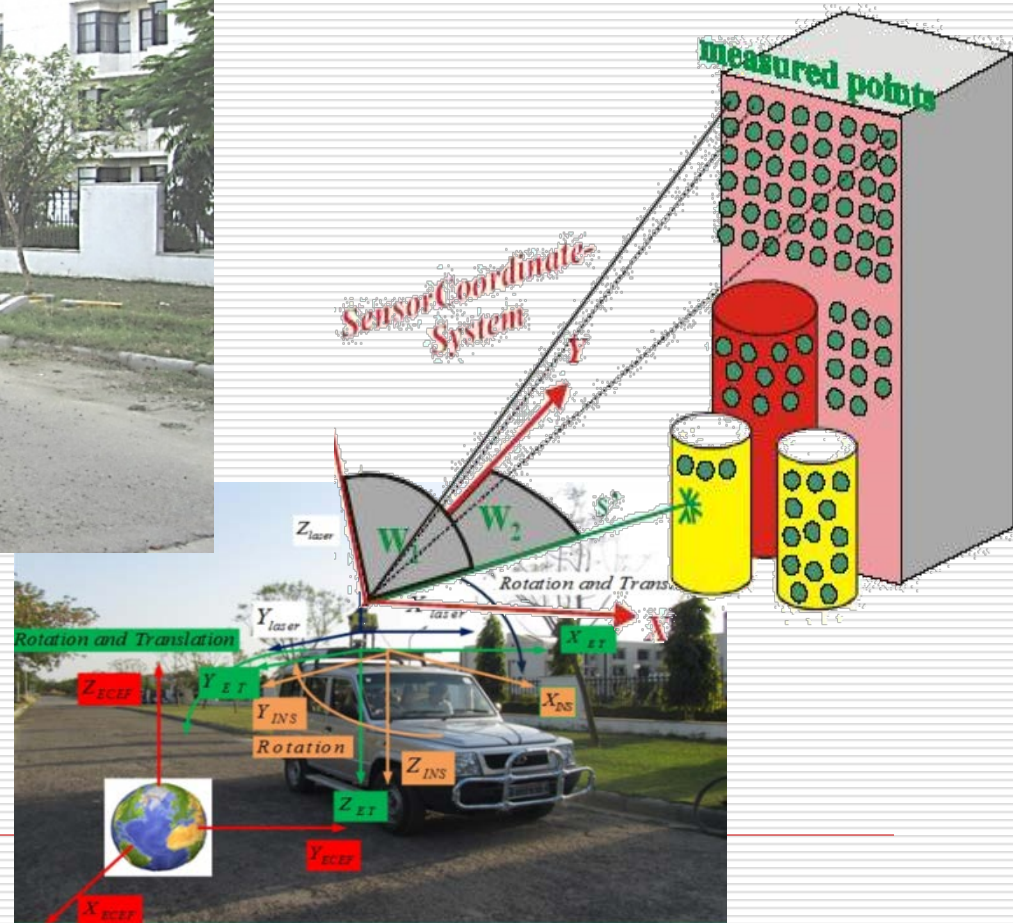


# Classified tree in LiDAR data.

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# Mobile Laser Scanning (MLS)

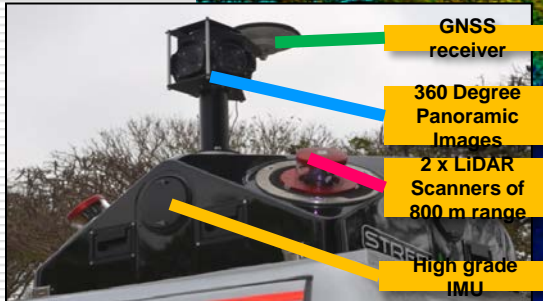




# Mobile LiDAR MLS and Data



STREET MAPPER VEHICLE

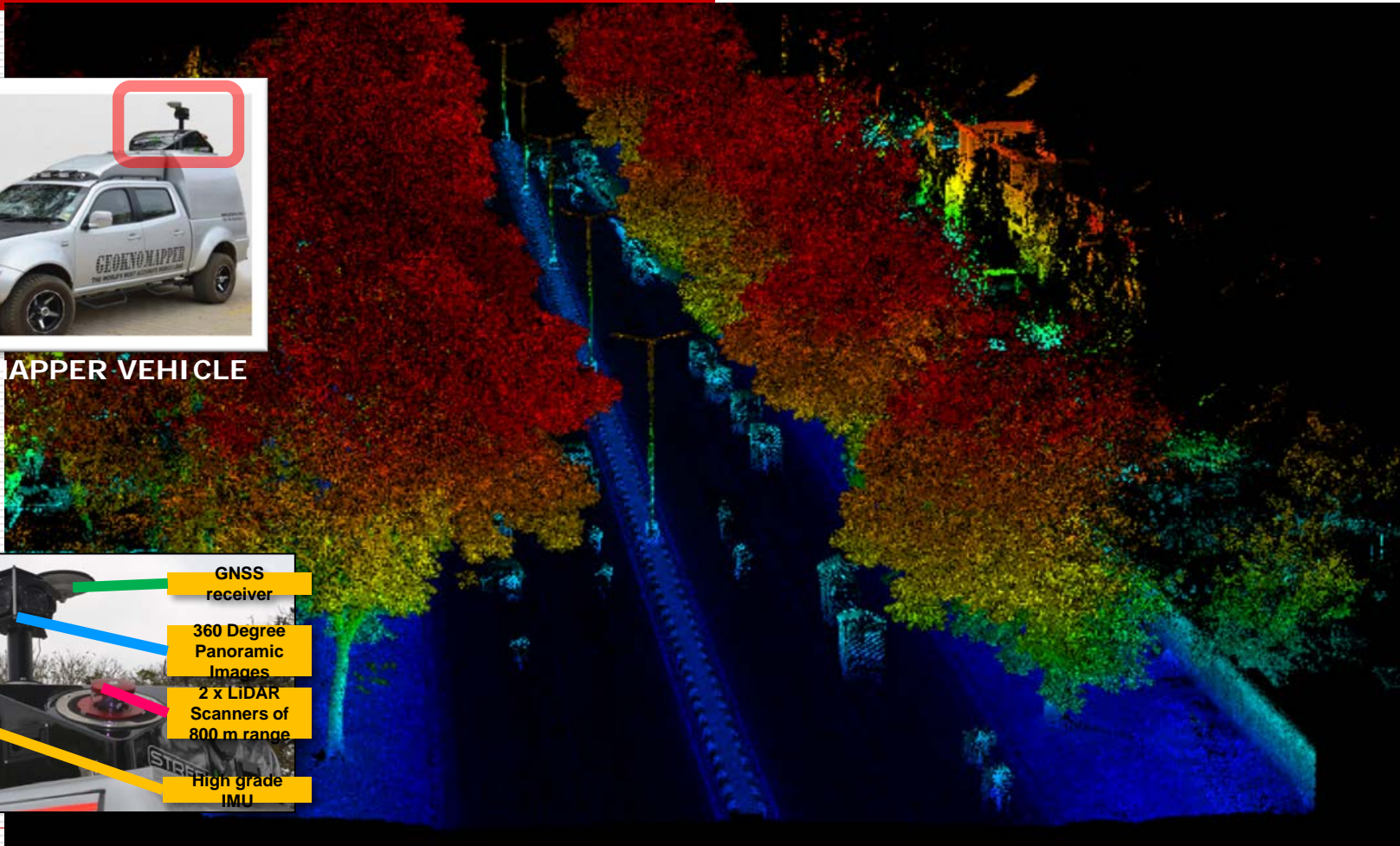


GNSS  
receiver

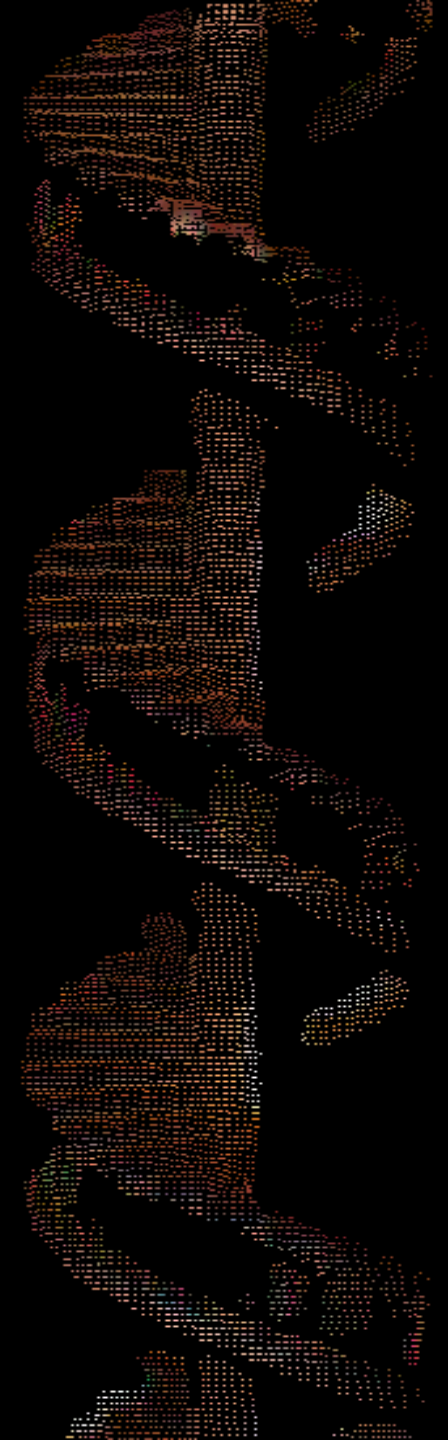
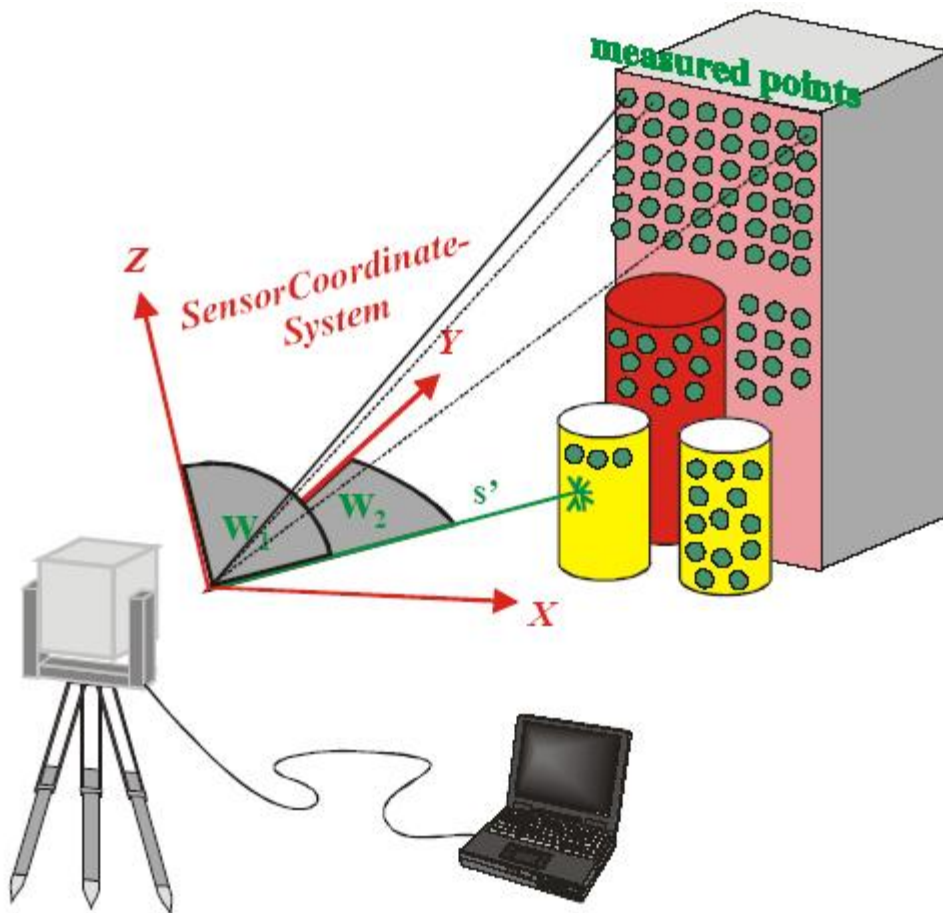
360 Degree  
Panoramic  
Images

2 x LiDAR  
Scanners of  
800 m range

High grade  
IMU

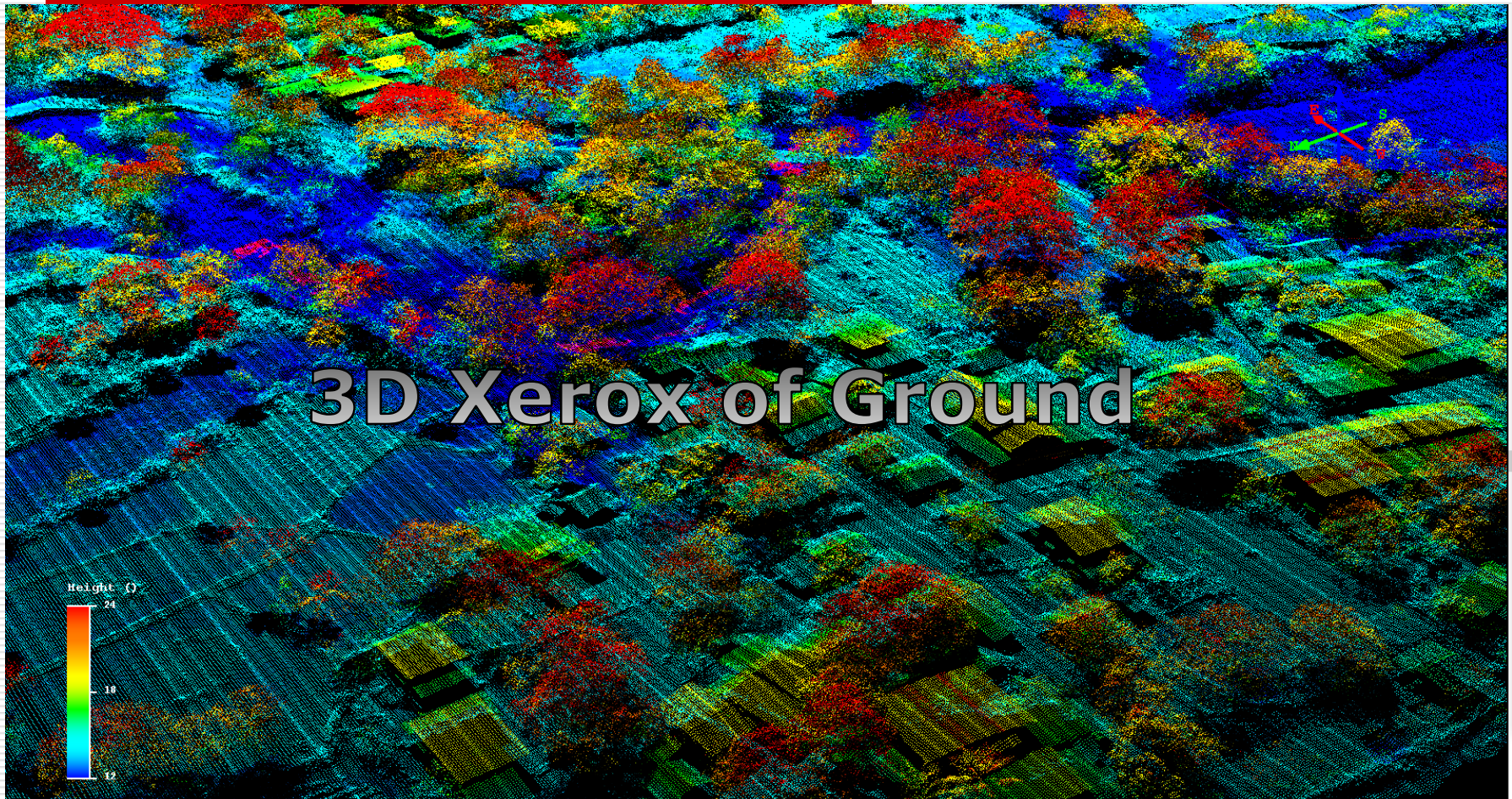


# Terrestrial laser scanning (TLS) and data





# Example of LiDAR Data-Accuracy $< 10$ cm





# Example of Simultaneously Captured Aerial Image 10 cm GSD



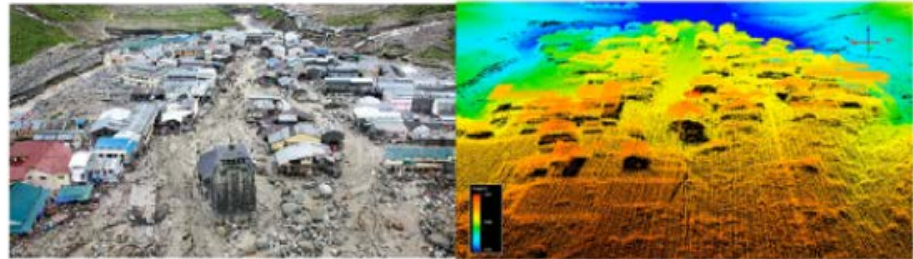
# Video of Survey of India Project

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## Uttarakhand LiDAR Survey By



Survey of India



**Geokno**  
THE LIDAR COMPANY

(Lead Vendor: M/S Geokno India Private Limited)

# Examples of data

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- ❑ See following video to visualize data and their impact
- ❑ <https://youtu.be/Cz9zBhrDMlc>
- ❑ Many more available in internet

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# Thanks

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