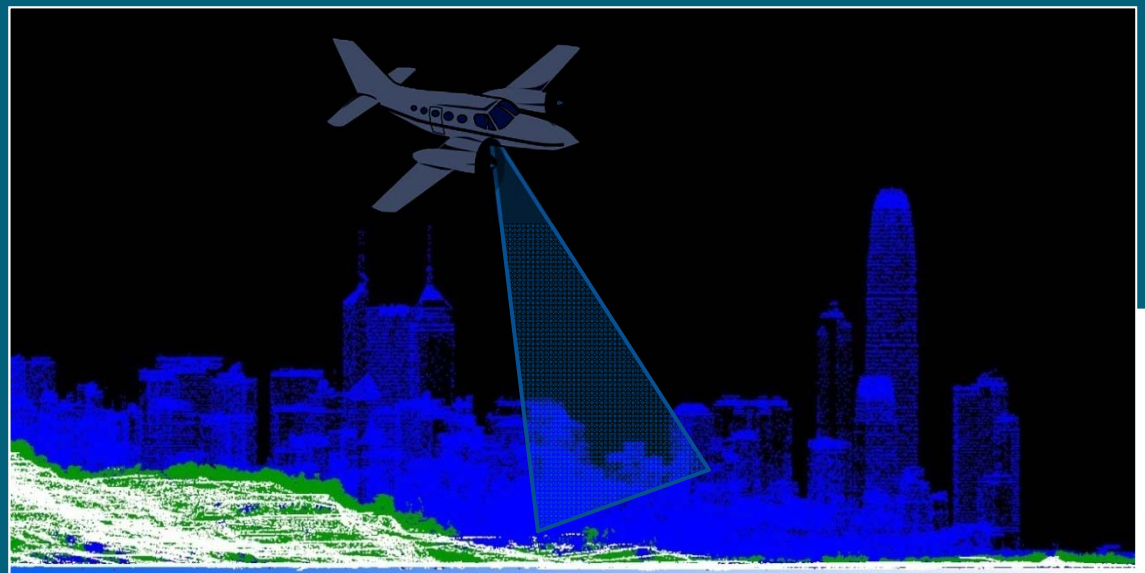
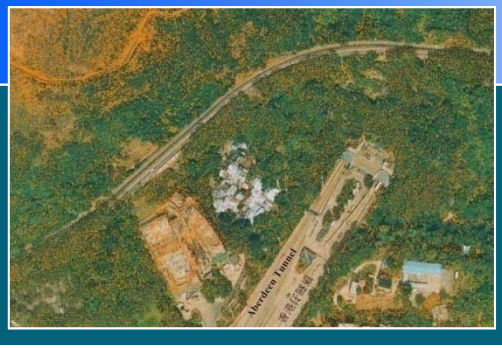
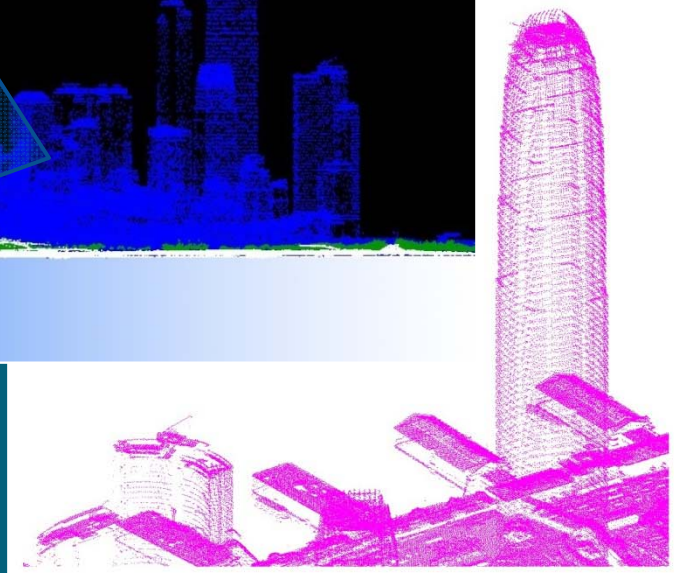
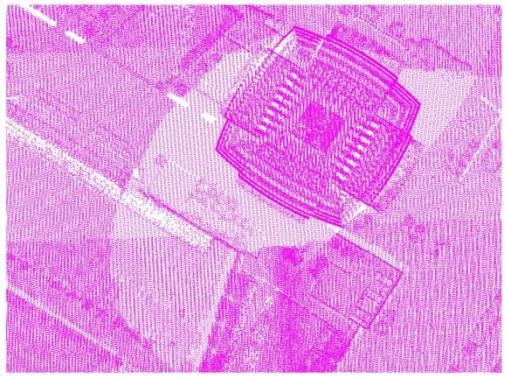
Airborne LiDAR Survey with SatRef Data Services









20 February 2013

CEDD

Survey Division, Ben CHOI (LS/PS)

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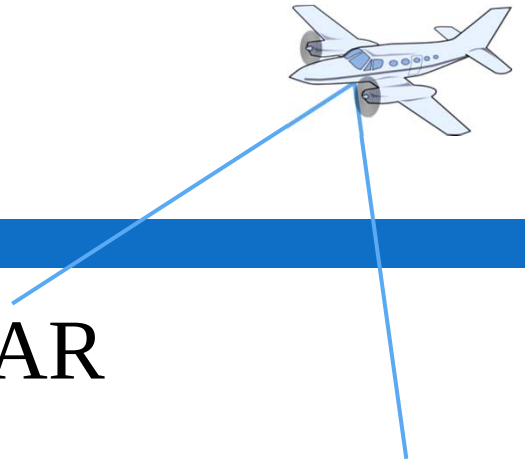
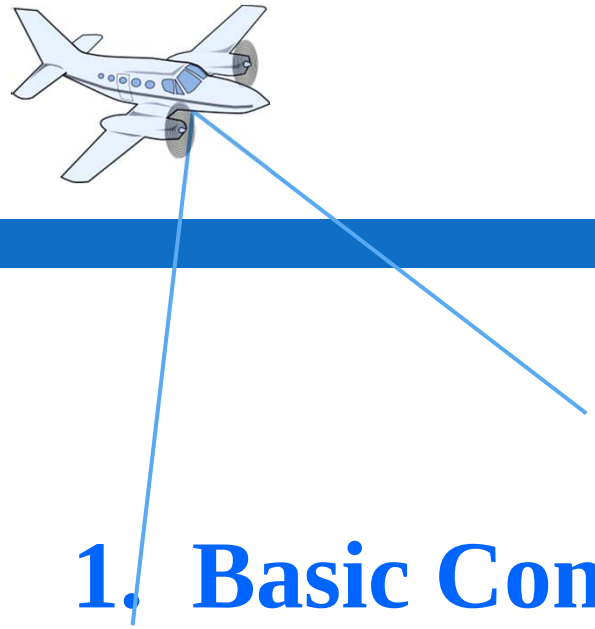
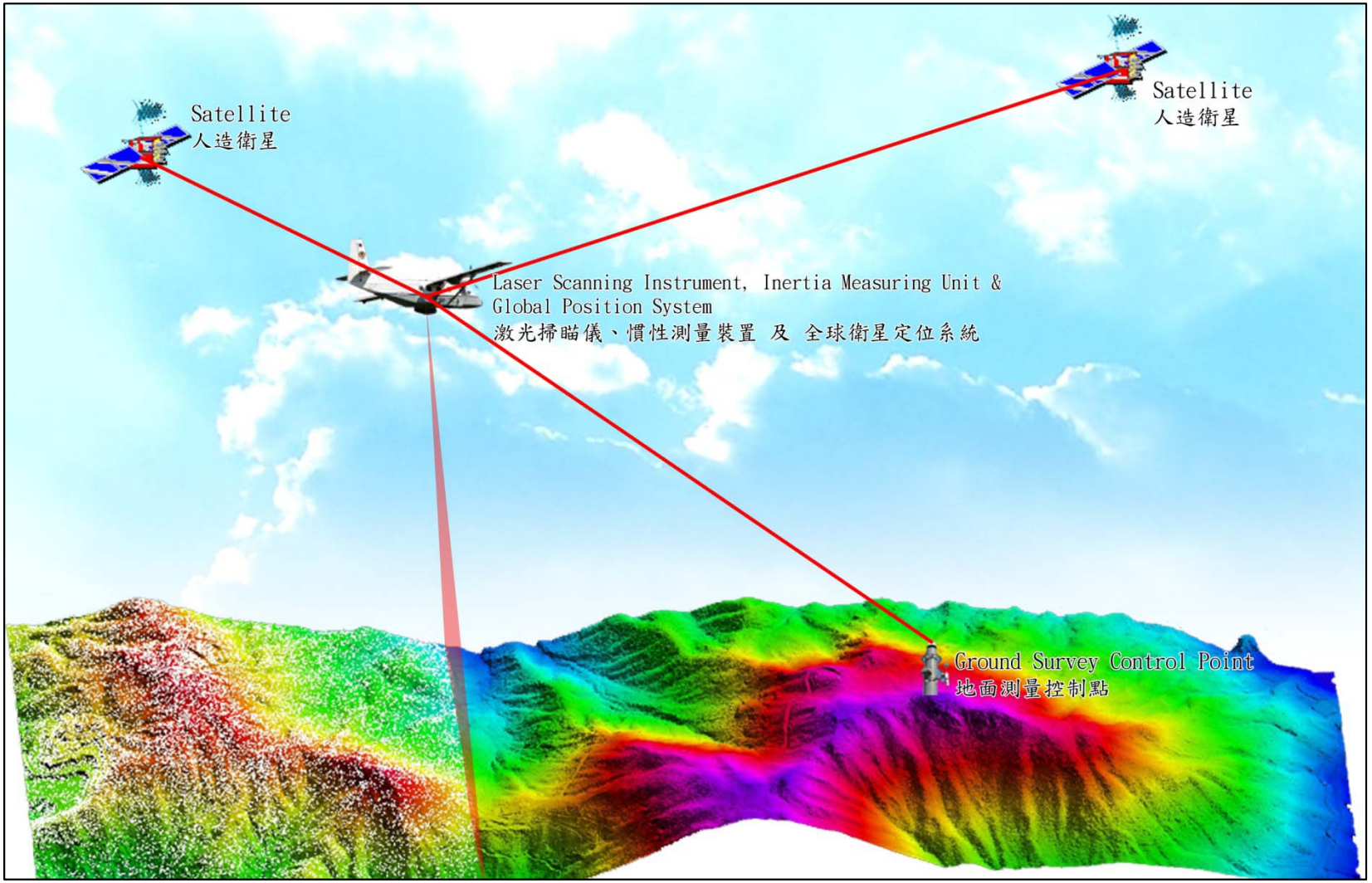


1. Basic Concept of Airborne LiDAR
2. CEDD 2010 LiDAR Survey
3. Contribution of SatRef in 2010 LiDAR Survey



1. Basic Concept of Airborne LiDAR

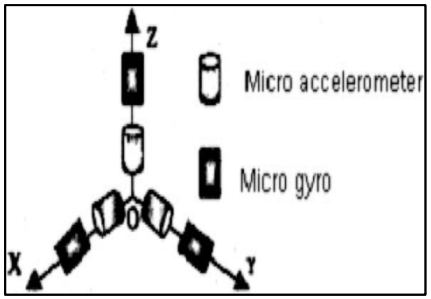
Airborne LiDAR - Light Detection and Ranging -- Mobile Mapping System (MMS) in the air



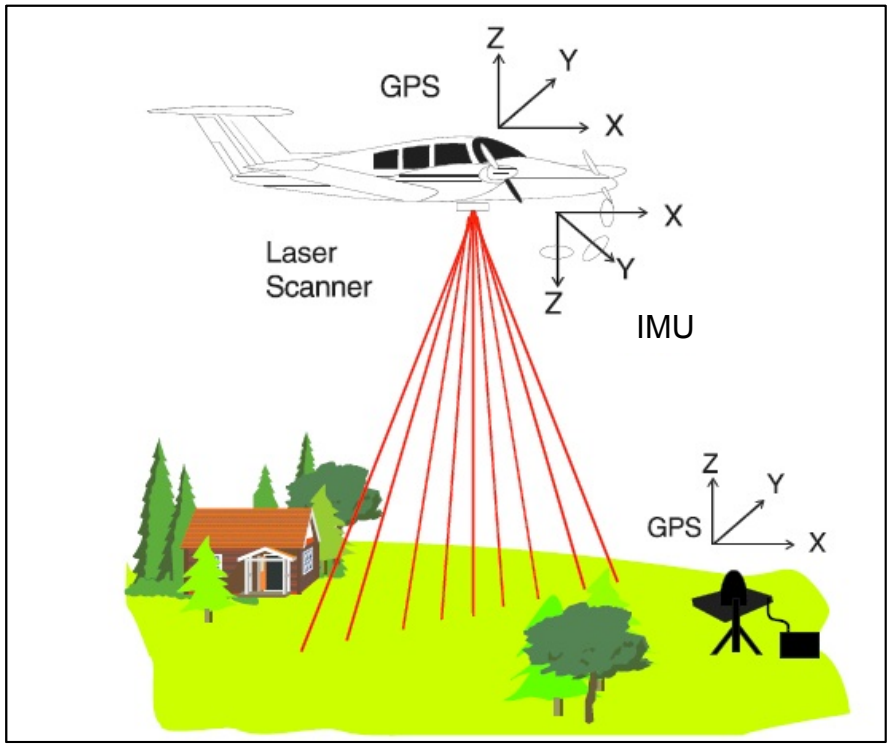
Airborne LiDAR Working Principle

- An integrated system composed of:

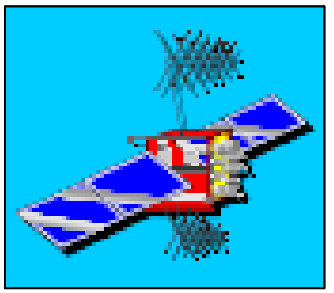
Laser Scanner



Inertial Measuring Unit (IMU)



May be integrated with Digital Aerial Camera to produce orthophoto and for data editing



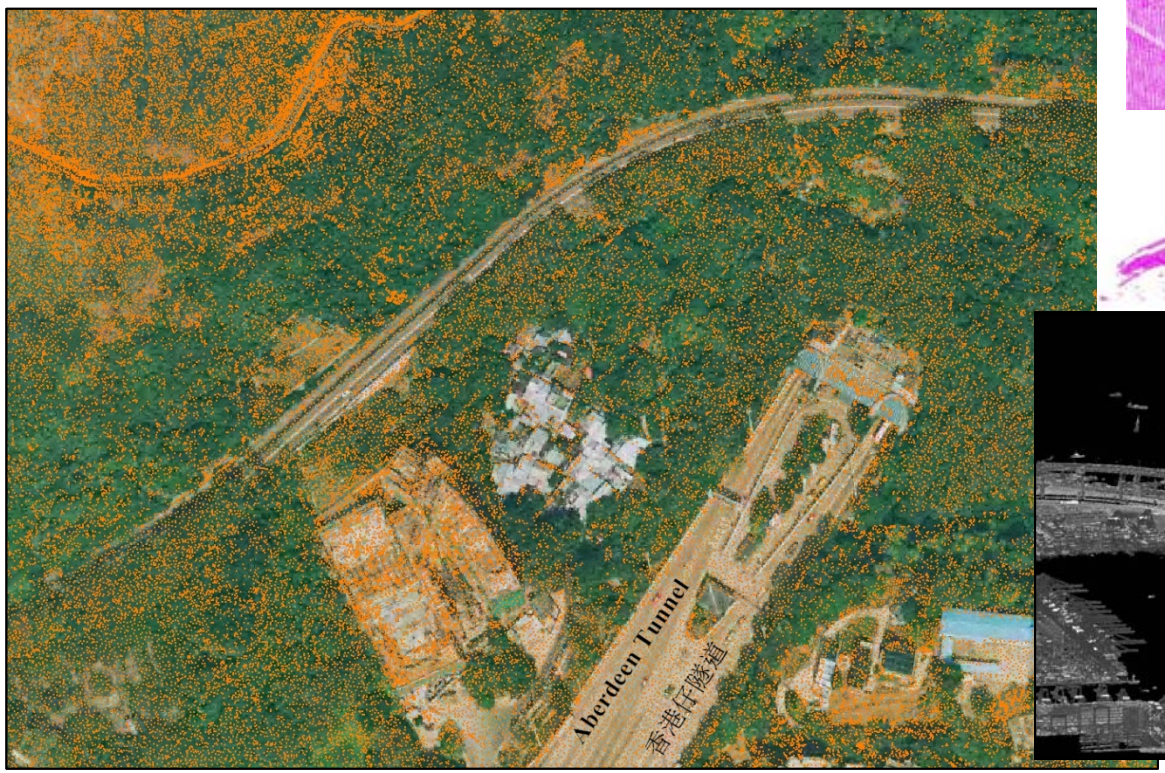
GNSS Satellites

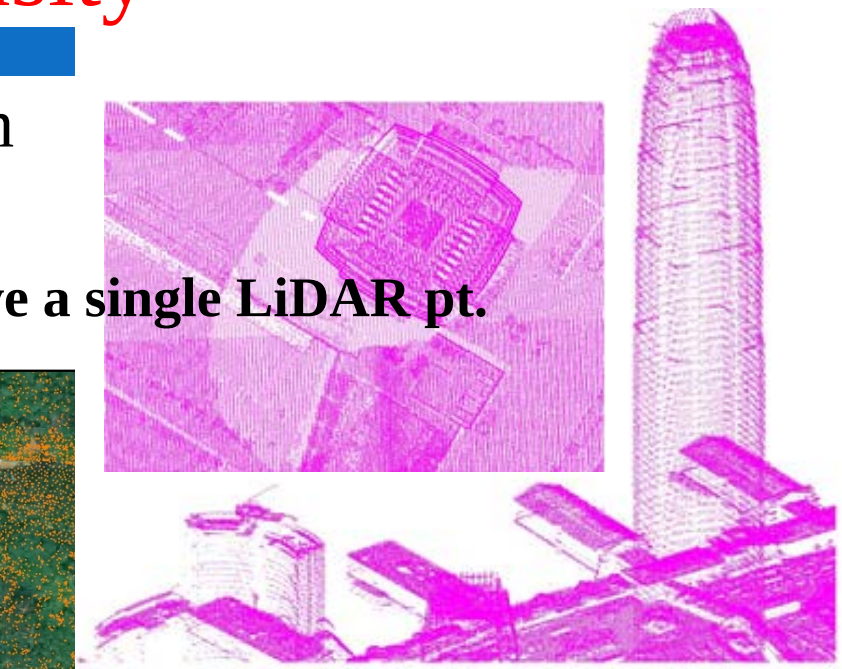
Reference Ground Station

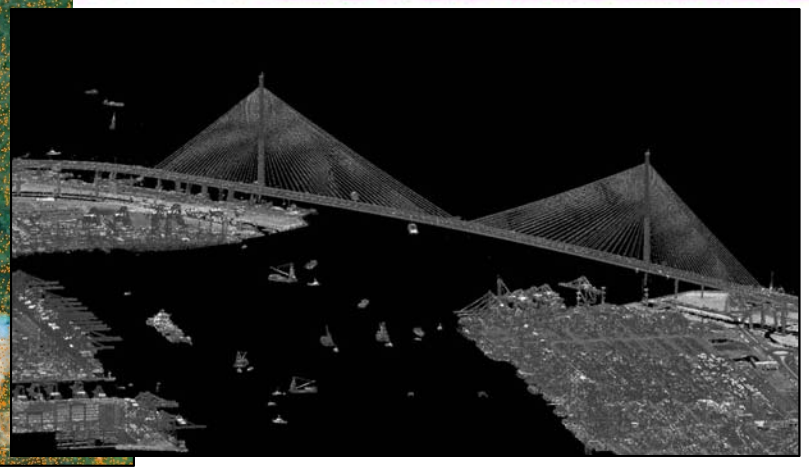
Characteristics of Airborne LiDAR ---

1) High sampling density

- Adjustable sampling resolution
  - → **upto Sub-meter resolution**
  - → **your every outdoor steps have a single LiDAR pt.**

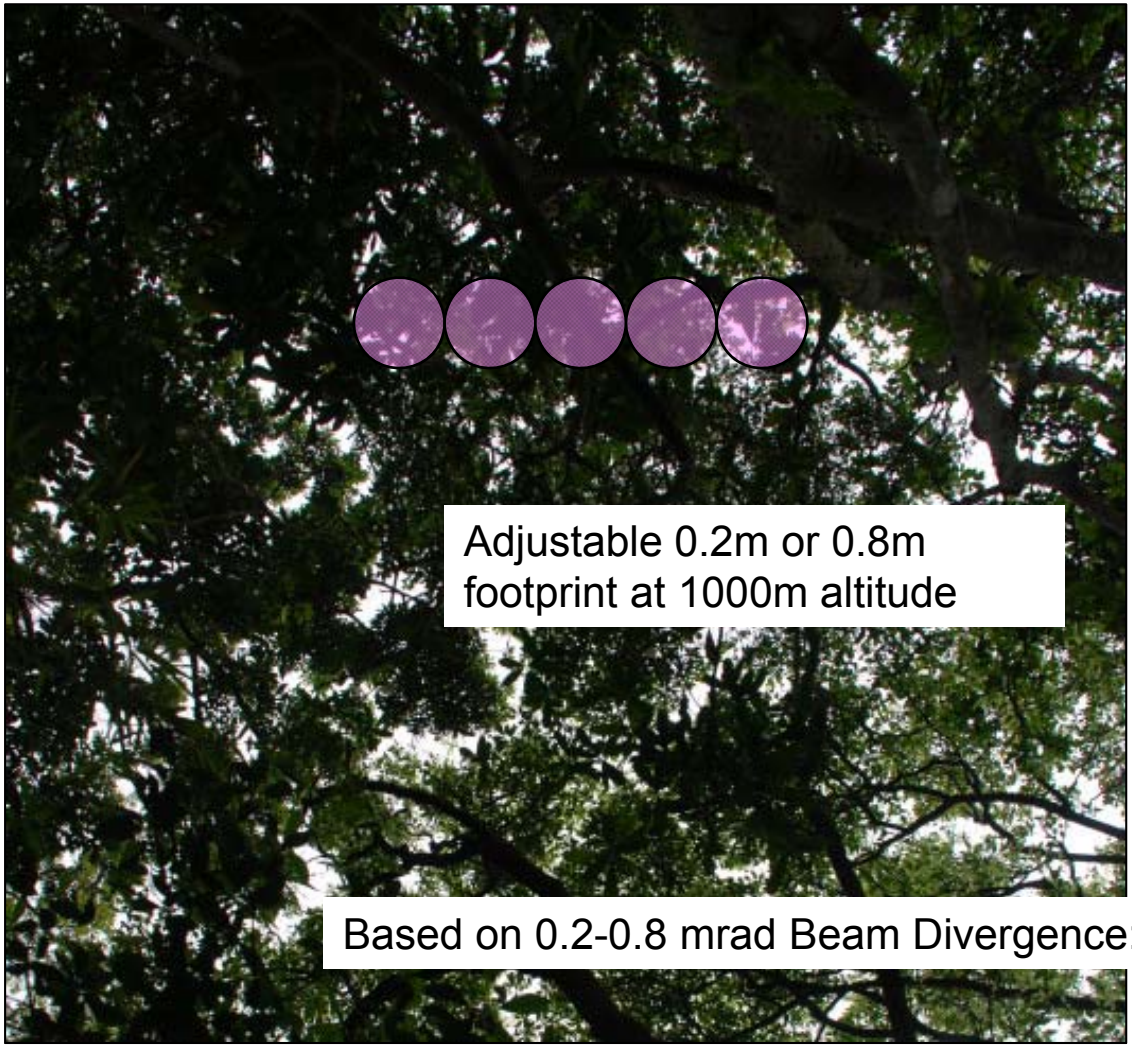


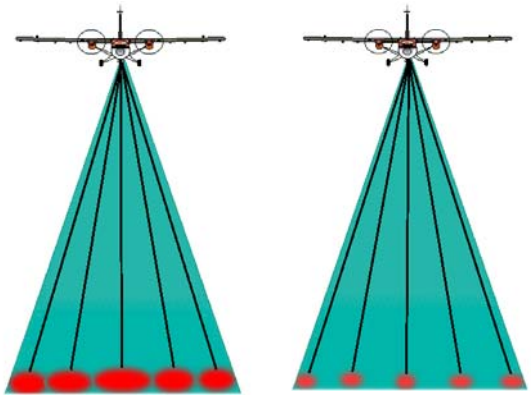




Characteristics of Airborne LiDAR ---

2) Penetration into Vegetation



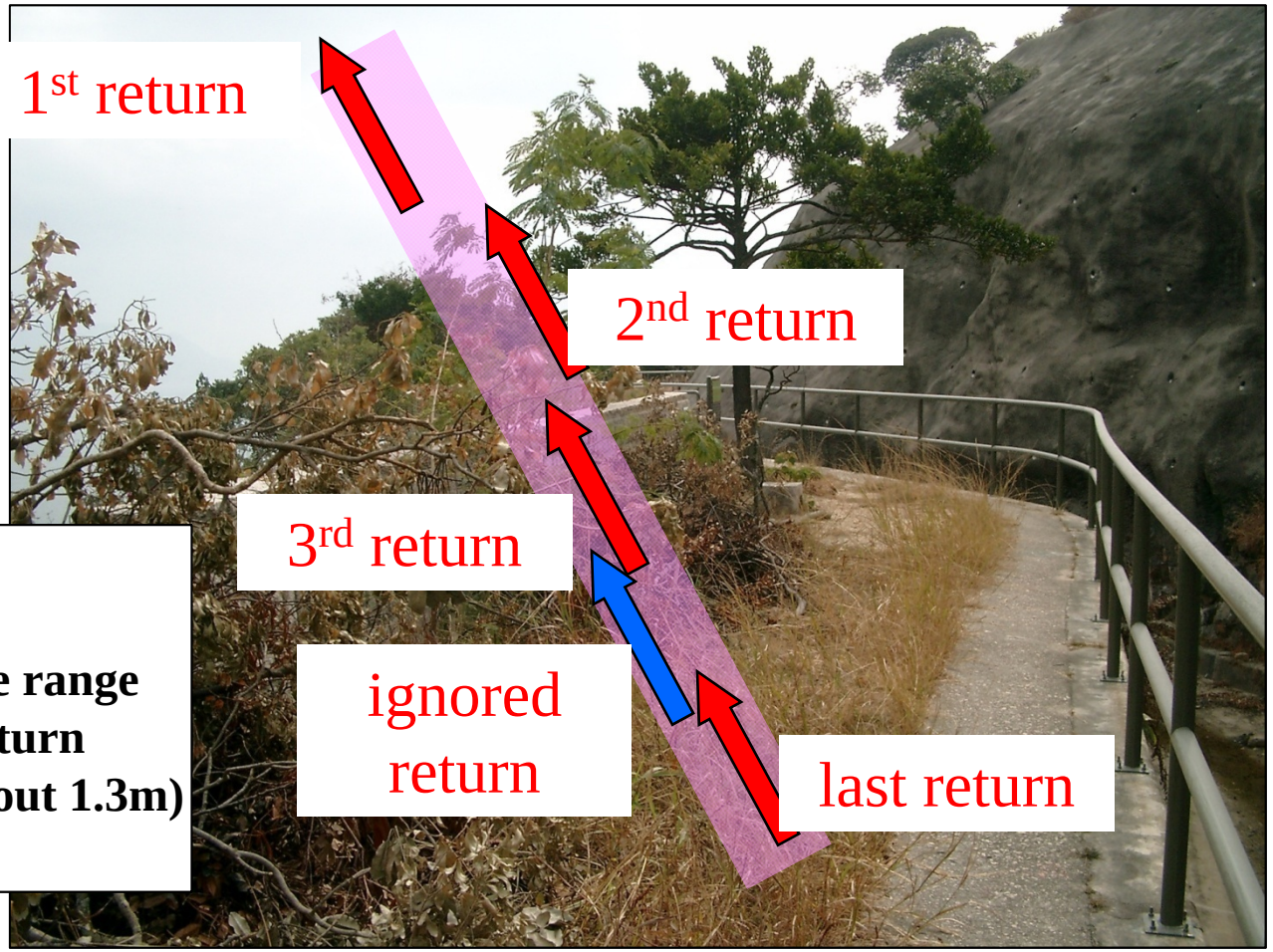


- Adjustable spot size
- Narrow Spot (0.2 mrad)
  - Higher penetration power
  - Higher geometrical accuracy

Based on 0.2-0.8 mrad Beam Divergence:. AL=2h tan (γ/ 2)

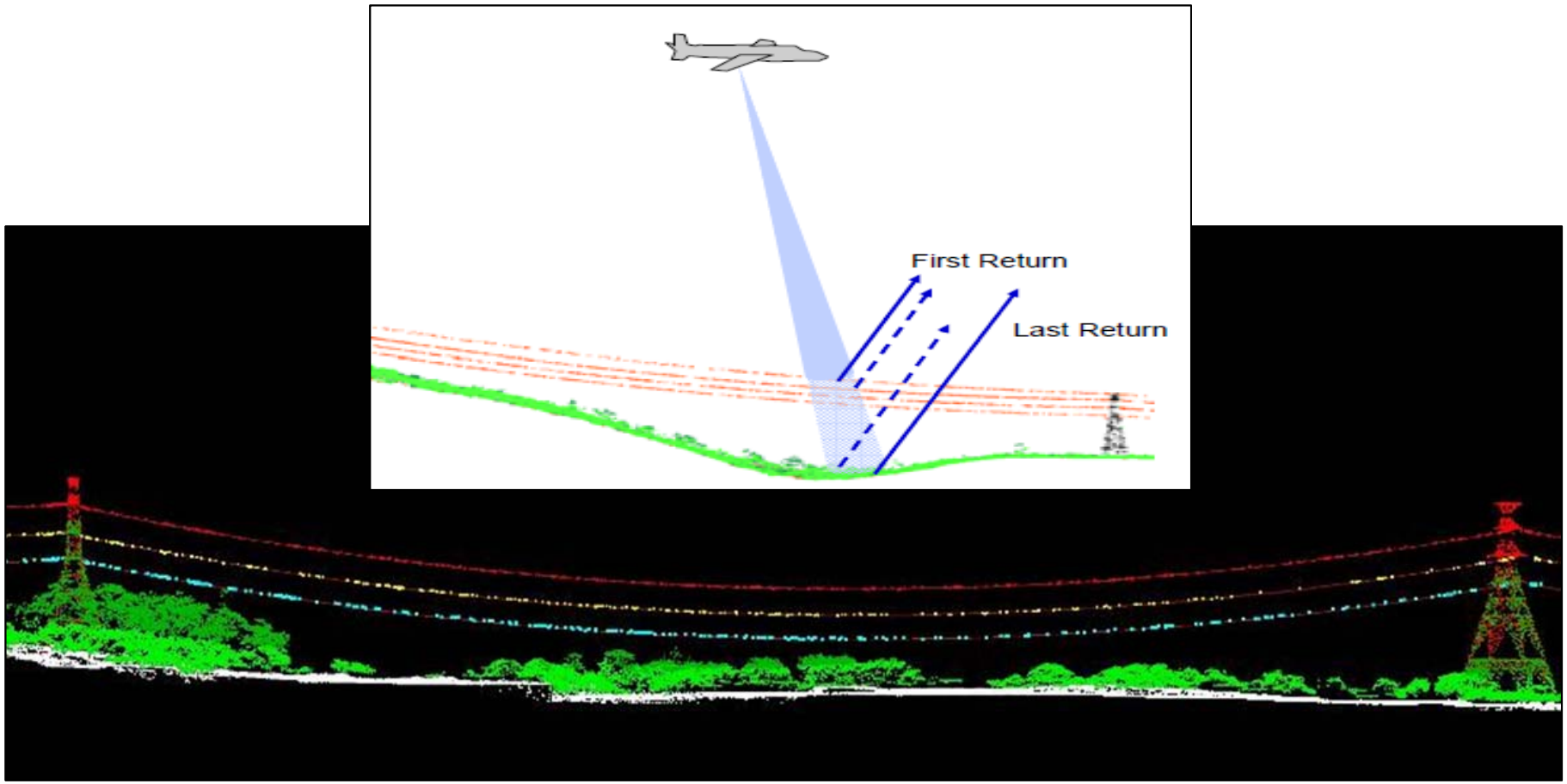
Characteristics of Airborne LiDAR --- 3) Detection of Multiple Return Signals

- e.g. Detection of up to 4 returns from single Laser pulse



There is a minimum measurable range between return signals (about 1.3m)

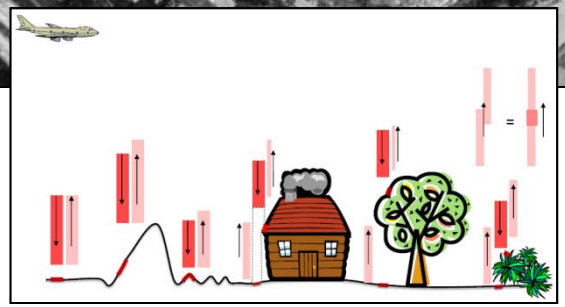
Characteristics of Airborne LiDAR ---
3) Detection of Multiple Return Signals

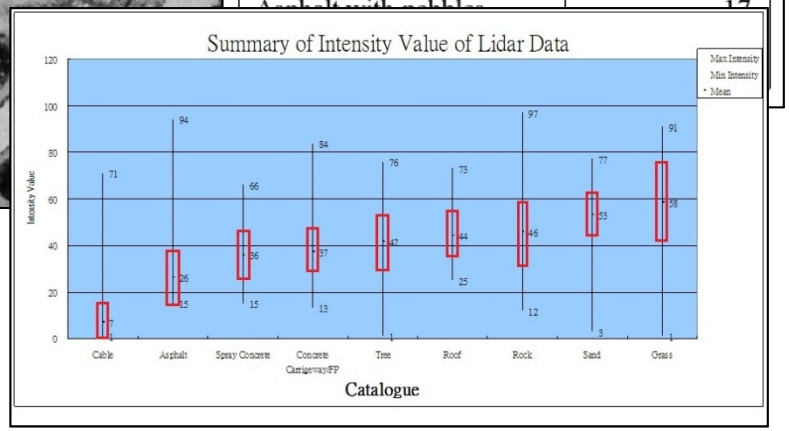


Characteristics of Airborne LiDAR ---

4) Intensity Range of Returned Signal

Materials	Reflectivity(%)
White paper	Up to 100
Dimension lumber	94
Snow	80~90
Beer foam	88
White masonry	85
Limestone, clay	Up to 75
Newspaper with print	69
Tissue paper, with ply	60
Deciduous trees	Typ. 60
Carbonate sand(dry)	57
Beach sands	Typ. 50
Carbonate sand(wet)	41
Coniferous trees	Typ. 30
Rough wood pallet (clean)	25
Concrete, smooth	24



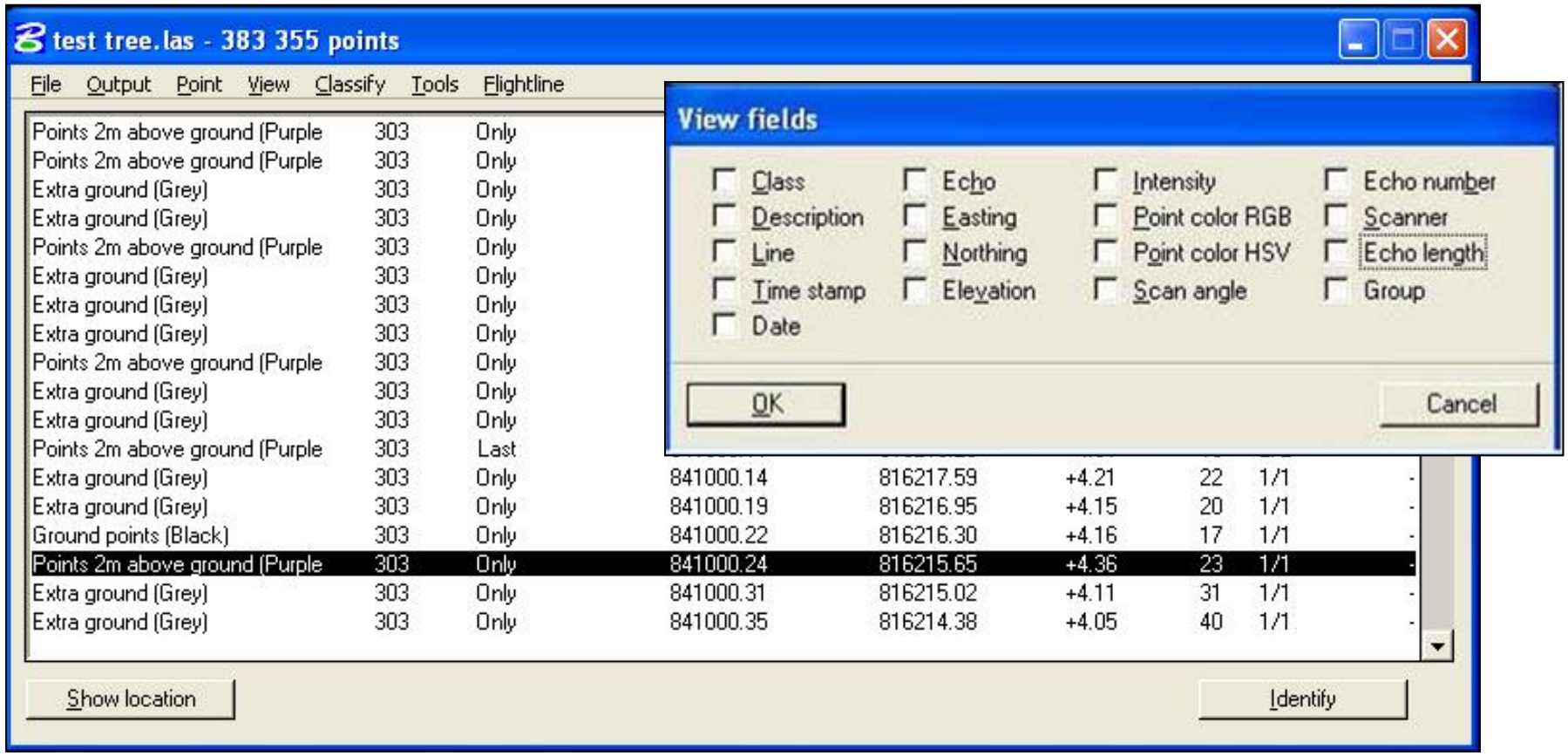


Courtesy: Tukaj Mapping Central Europe

Characteristics of Airborne LiDAR ---
5) Rich information in LiDAR data

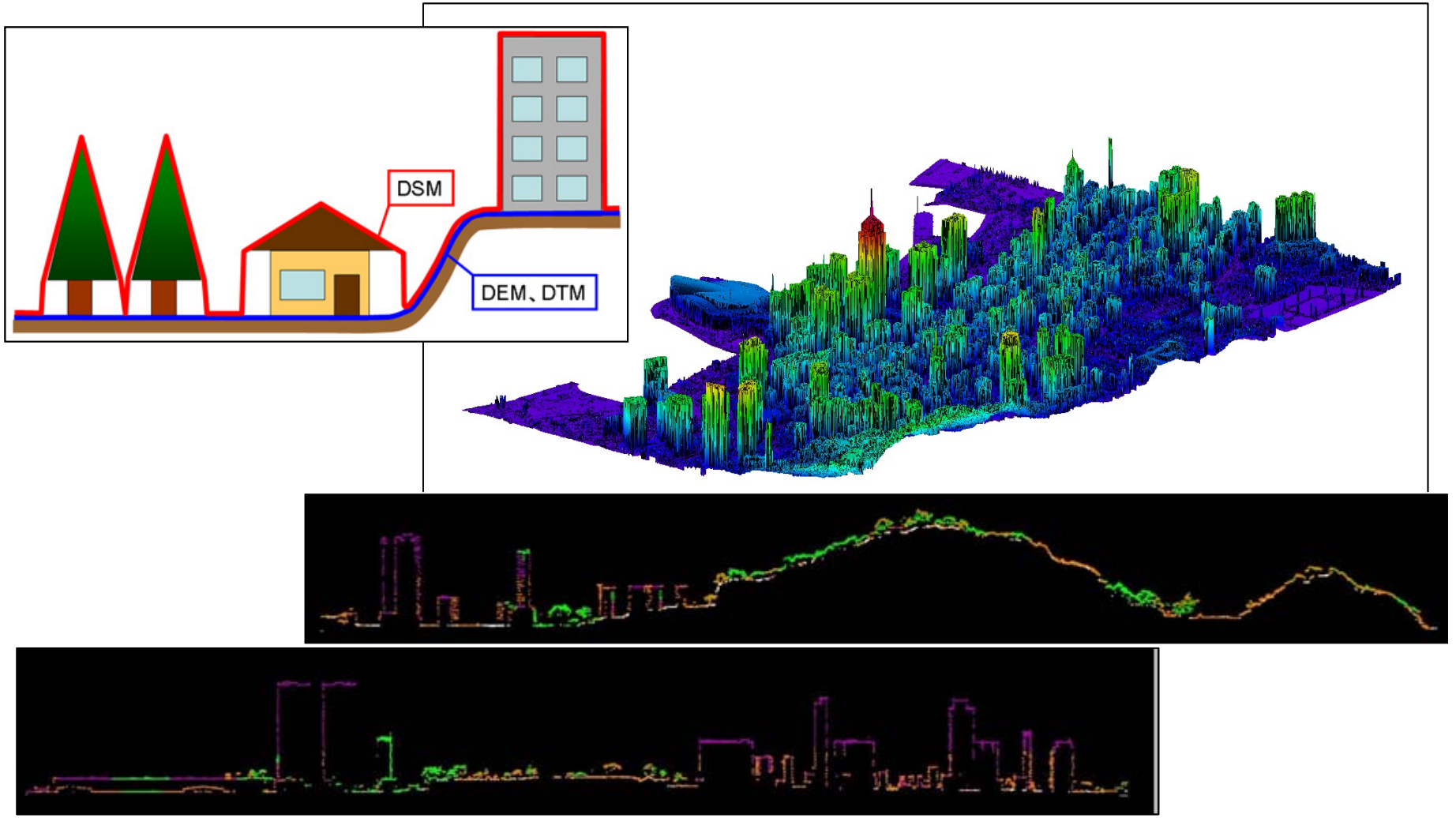
- Rich information stored in the LiDAR data

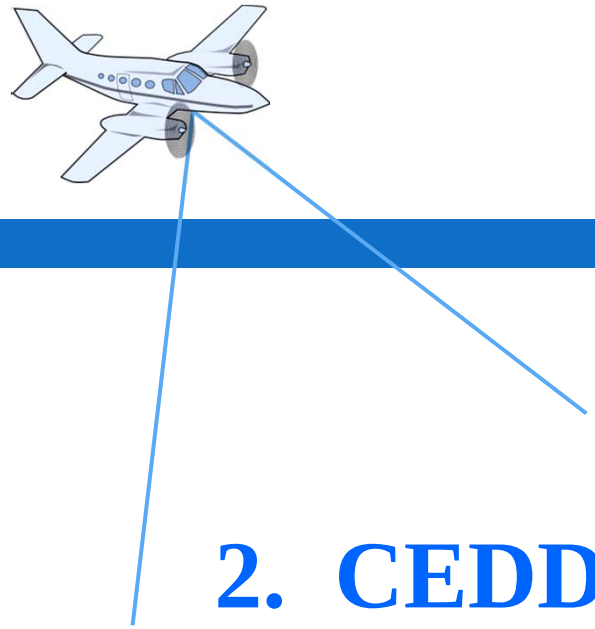
Class Name, Date & Time, Echo number, RGB Color, X, Y, Z, Intensity Value ….



Characteristics of Airborne LiDAR ---

6) Production of DTM and DSM …..etc.

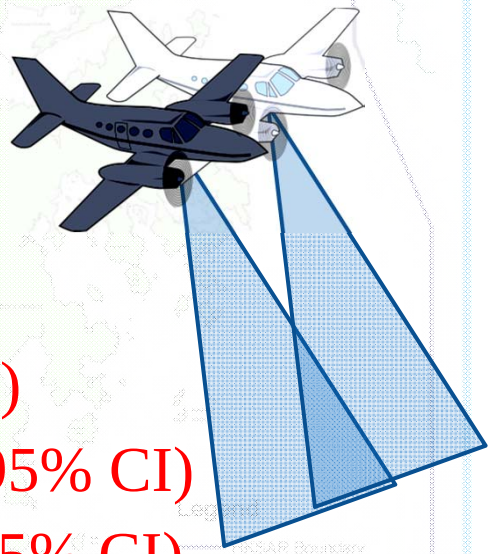




2. CEDD 2010 LiDAR Survey

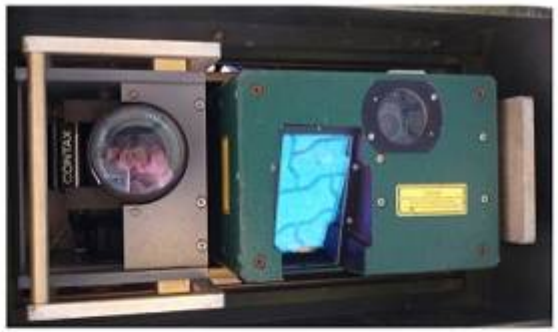
CEDD 2006 and 2010 LiDAR Survey

- Awarded to AAM Pty Ltd. (Australia)
- 2010 LiDAR Survey Contract Specifications:
  - Coverage: Whole territories
  - FOV 0° to ±20°
  - 40% overlapping
  - Up to 4 returns for each pulse
  - Average point spacing: 0.5 m (4 pt /m^2)
  - Horizontal accuracy: 0.3 m (2 sigma, 95% CI)
  - Vertical accuracy : 0.1 m (2 sigma, 95% CI)



Optech Gemini ALTM (Airborne Laser Terrain Mapper)

N22C Nomad

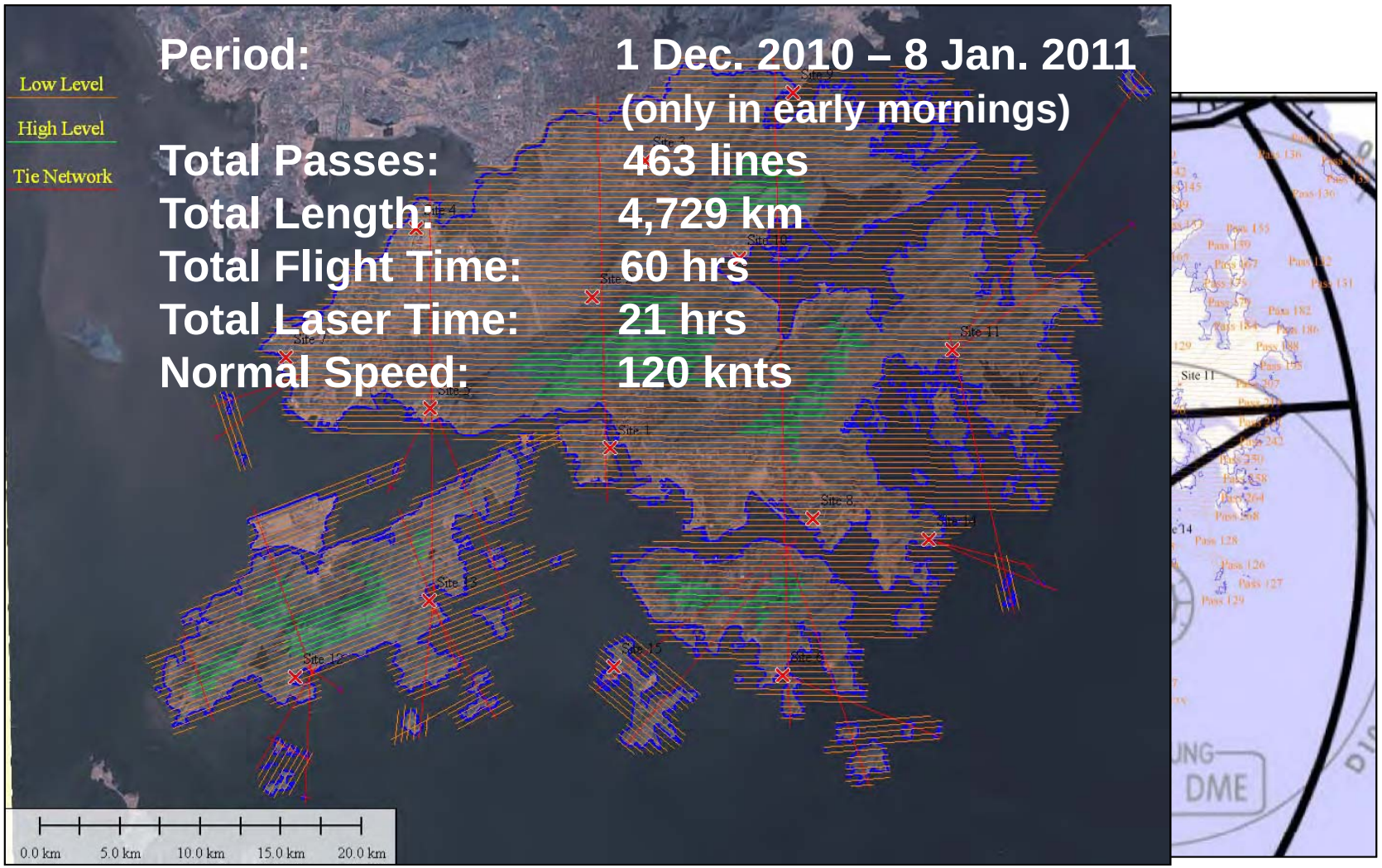


Laser Scanner

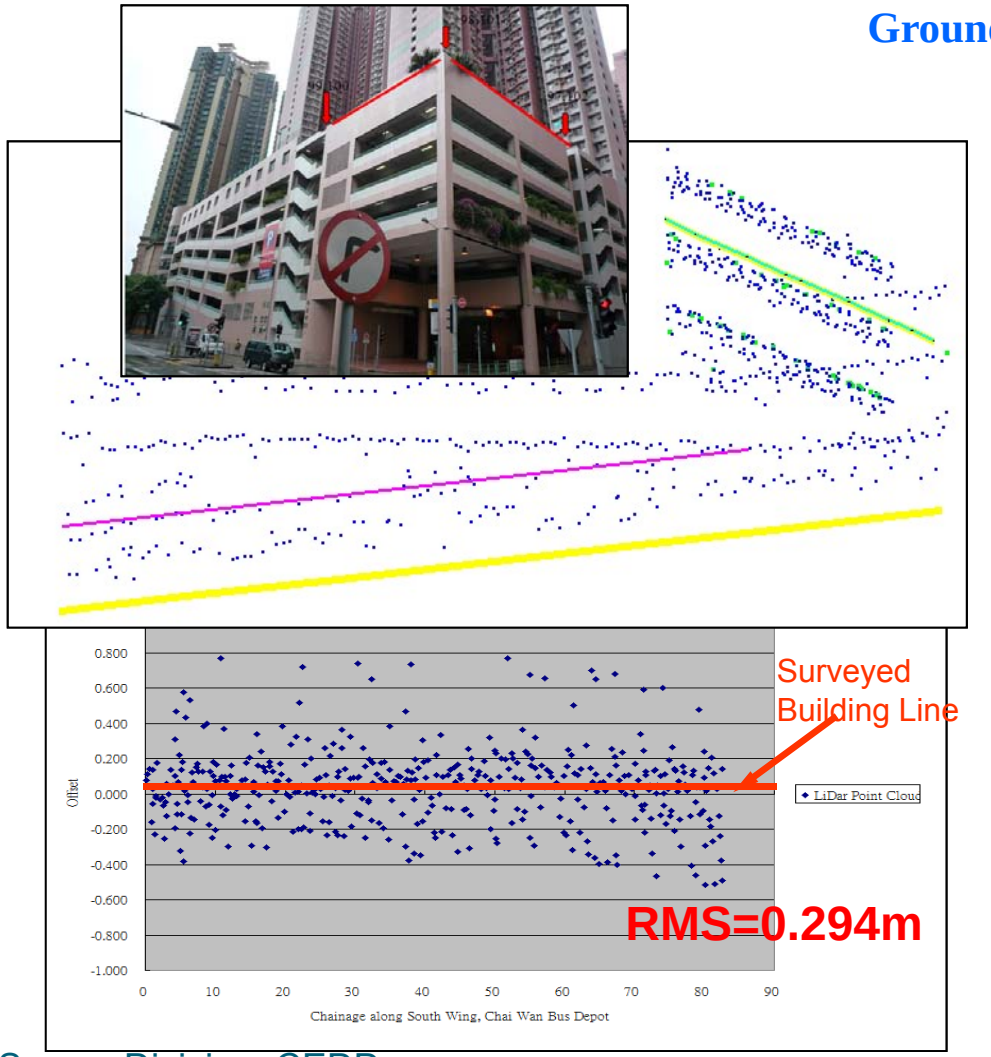
LiDAR Sensor - Optech 3100

IMU

Flight Plan 2010 and Restults



Horizontal Accuracy Assessment of 2010 LiDAR Data



Survey Division, CEDD

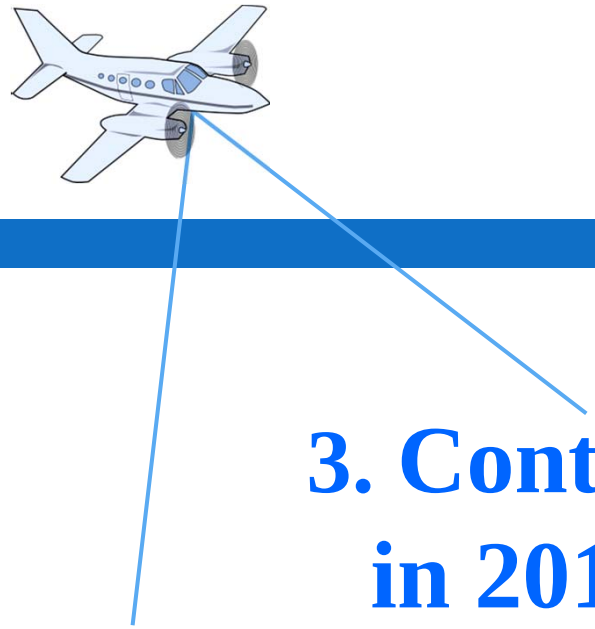
Ground truth survey: By Survey Division, CEDD

Item	Value (m)
Number of Points	5575
Average offset	-0.002
Minimum offset	-0.537
Maximum offset	0.986
Average magnitude	0.113
Root mean square	0.147
Accuracy at 95% CI (Confidence Interval)	0.294 **(meet 0.3m requirement)**
Std deviation	0.094

Vertical Accuracy Assessment of 2010 LiDAR Data

LiDAR against test point in orthometric heights (HKPD) --- By CEDD

Item		Flat Clear Ground (m)	Low Veg (m)	Med Veg (m)	High Veg (m)
Number of Points		1566	339	148	109
Average dz					
Minimum dz					
Maximum dz			0.794	1.221	0.388
Average magnitude		0.036	0.263	0.150	0.113
Root mean square	1 Sigma	0.046	0.334	0.244	0.151
Accuracy at 95% CI	2 Sigma	0.092 **(meet 0.1m requirement)**	0.668	0.488	0.302
Std deviation		0.046	0.245	0.244	0.146

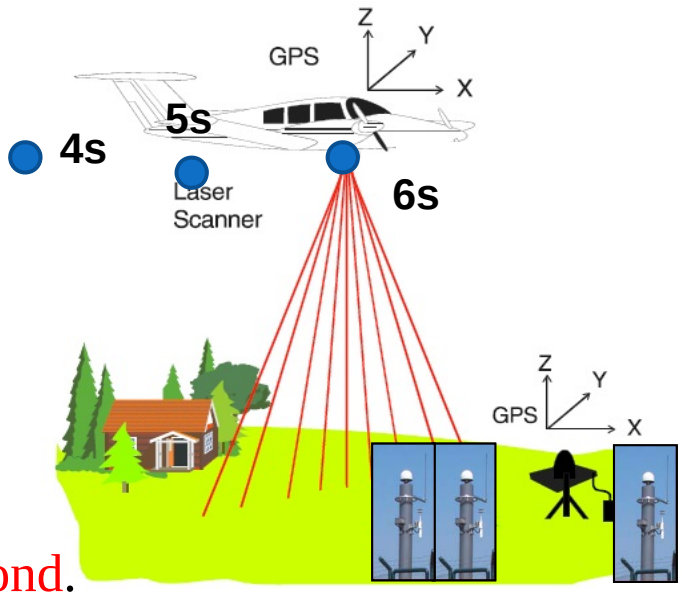


3. Contribution of SatRef. in 2010 LiDAR Survey

Aircraft's Position and Orientation

Aircraft Position (via POS + DGPS)

- LiDAR unit's POS system records GPS signals at 1Hz, so as to post-process the position of the aircraft's trajectory.
- DGPS processing requires having the base station observations recorded at the same frequency. (i.e. 1Hz)



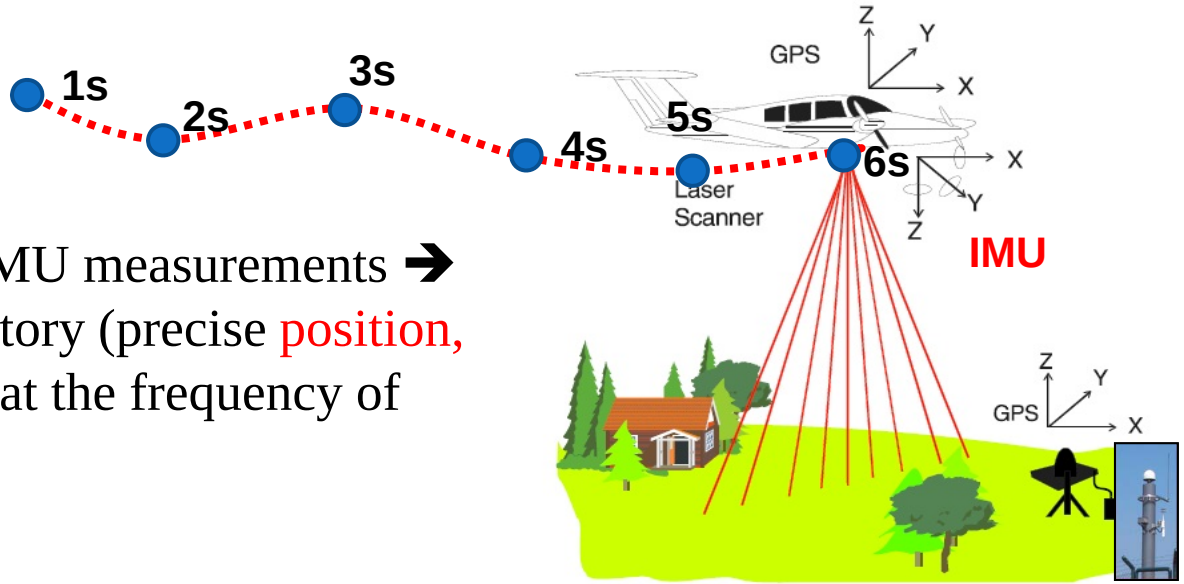
- **SMO temporarily increased the recording rate of the SatRef** base stations from **5s** to **1s** and provided a download link for CEDD to obtain the required data.
- Aircraft GPS + SatRef GPS observations

  ➔ precise position of the aircraft in every second.

Aircraft's Position and Orientation

Aircraft Orientation (via IMU)

- LiDAR unit measures the orientation of the aircraft at 200Hz using an Inertial Measuring Unit (IMU).
- IMU measurements are introduced to refine the 1Hz GPS position of the aircraft.



- GPS measurements + IMU measurements ➔ smoothed aircraft trajectory (precise position, roll, pitch, and heading at the frequency of 200Hz)

Alternative solution if NO SatRef

If without SatRef Data Service:

- Possible to **interpolate** 1 Hz measurements from less frequent GPS observations onbroad, but will introduce another source error ➔ may not meet project requirements.
- Need to setup "x" GPS units across HKSAR, each < 30km from the aircraft. For redundancy ➔ "2x" GPS units are required.
- All "2x" GPS units need to be running and coordinated ➔ depend on the weather and ATC instructions.

Complicated the project !

Alternative solution if NO SatRef

If without SatRef Data Service:

- Will **substantially increase project costs** (logistic, coordination, computation, time …)

e.g (3 person/site x 12 sites x 20 days) = 720 man days

- Will introduce **extra project risks, errors** and **uncertainty**.

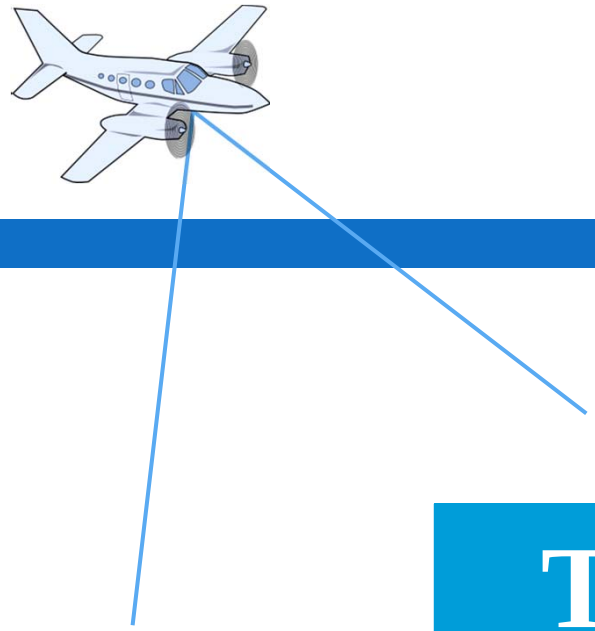
Risks

Merits of Using SatRef Data Service in 2010 LiDAR Survey

With SatRef Data Service:

- Reduced project cost
- Reduced project complexity and risk
- **Efficiency** and **Quality** Guaranteed

Thank You SatRef !



Thank You