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Key Drivers; Lidar Sensor Selection

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Points of Discussion

- The Industry
- The Specifications
- The Hardware
  - Airborne lidar Specifications
  - Specification Mix
- Scanner Types
  - Fiber Scanner
  - Rotating Polygon
  - Oscillating Mirror
- Drivers
  - Altitude
  - Beam Divergence
  - Waveform Digitizer
  - Automatic Roll Compensation
- Summary

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The Industry

Key Non-Technical Drivers:

- Reputation
- Reliability
- Solutions / Turnkey
- Support
- Market Share
- Service
- Market Focus
- Data Processing Power
- Upgradeability
- Financial
- Leadership

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The Customer's Search for the Best

- Most errors come from the scanner, the rangefinder, the POS, the GPS and the spot size
  - Ex. No point in superior POS accuracy without addressing scanner accuracy
- The "Best" system has minimal and "balanced" error contributions from each source
- The "Best" system is adaptable to multiple survey needs
- Programmability in laser rep rate, spot spacing, swath width, flying altitude and spot size all contribute to the "Best" system

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The Specifications

Hardware specifications similar:

- 50 m to 3500 m (2000 m typical)
- 5 cm to 75 cm accuracy (15 cm typical)
- 20° to 75° scan (40° typical)
- 12 kHz to 125 kHz laser (~70 kHz typical)
- Most with reflectance (intensity)

The Hardware

- The 4 systems under review:
  - Optech 3100
  - Leica ALS-50
  - Toposys Falcon III
  - IGI LM5600

- Specifications summarized in GIM International article (Product Survey on Airborne Laser scanners, May 2004) and manufacturer's websites

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Airborne Lidar Specifications

- **Optech - ALTM3100**
  - Swath Width 60°
  - Roll Accuracy 0.005°
  - Max Alt. 3500 m
  - Laser Rate / Eff. Laser Rate 100 kHz / 97 kHz
  - Divergence 0.2 & 0.8 mrad
- **Leica - ALS50**
  - Max Alt. 5000 m (Standard system – 3000 m)
  - Swath Width 75°
  - Roll Accuracy 0.005°
  - Laser Rate / Eff. Laser Rate 83 kHz / 65 kHz
  - Divergence 0.33 mrad

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Airborne Lidar Specifications

- **TopoSys – Falcon III**
  - Max Alt. 2500 m
  - Swath Width 20°
  - Roll Accuracy 0.01°
  - Laser Rate / Eff. Laser Rate 125 kHz / 25 kHz
  - Divergence 0.7mrad
- **IGI - LM560**
  - Max Alt. 1600 m
  - Swath Width 60°
  - Roll Accuracy 0.01°
  - Laser Rate / Eff. Laser Rate 100 kHz / 66 kHz
  - Divergence 0.5 mrad

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Specification Mix

- Altitude, Scan Rate, FOV, Range Accuracy, Laser Measurement Rate (kHz) are all routinely quoted as separate items to demonstrate superiority of a particular system
- True system efficiency = the sum of all system specifications, where the balance is planned and expected.

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Scanner Types

The systems use three different types of scanner:

- Fiber Scanner (TopoSys)
- Rotating Polygon (IGI)
- Oscillating Mirror (Optech and Leica)

The scanner to a large extent determines system accuracy, programmability, spot density, swath width and area coverage rate

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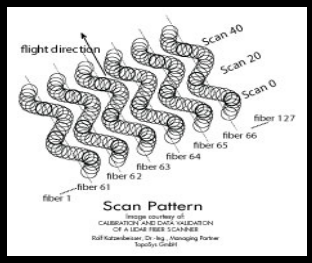
Fiber Scanner



- 300 spots across track (about every 1.1 m) along track depends on laser rate and aircraft speed (about 15 cm typical)

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Fiber Scanner - Advantages

- Rigid relationship between pixels
- After a lab calibration the fibers should never move
- Repeatable scan pattern

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Fiber Scanner - Disadvantages

- Fixed FOV of 20° total, which limits swath width to 35% of altitude, creating the need more flying with a greater operational cost
- Very uneven scan pattern; 1.1 m across track and 10 cm along track, leading to ground details not being acquired
- Laser footprint of 70 cm; a heavy over-sampling dropping the effective data capture rate by 80%
- Requires more flying for area coverage due to pointing limitations

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Fiber Scanner - Conclusions

- DTM or contour software may not like irregular density of resulting data
- No built-in roll compensation
- No possibility to point scanner for special survey applications
- Cannot reduce angle of scan (to avoid data absence shadows in urban areas) without discarding data

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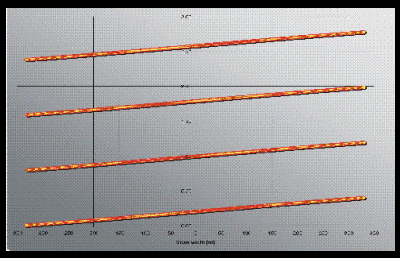
Rotating Polygon



- Laser bounced from faces of rotating polygon(square)
- Laser shots from close to edge (corners of polygon) not used

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Rotating Polygon - Advantages

- Data acquisition in parallel lines
- Flexibility on FOV (6-sided polygon=60°, 8-sided polygon=45°)
- Simple mechanical arrangement, stable and easy to calibrate

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Rotating Polygon - Disadvantages

- Questionable efficiency as 35% of laser spots discarded at max swath (60°)
- 50% discarded to meet typical accuracy
- Cannot point data (can only ignore laser shots within 60° field)
- Roll compensation not possible. Compensation depends on discarding data therefore greater flight costs

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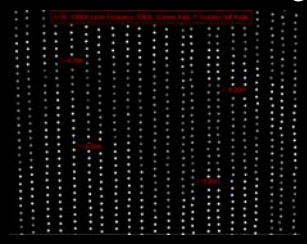
Oscillating Mirror



- Mirror mounted on shaft
- Example of 5° scan at 70 Hz giving approx. 20 cm spacing from 1 km

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Oscillating Mirror - Advantages

- Interleaved parallel lines (zigzag)
- Scan angle and rate independently adjustable and programmable allowing for flexibility
- Greatest pointing flexibility (not limited by fixed pixel positions
- Even spot distribution although two manufacturers have different efficiency.
- Optech scanner 97% efficient, Leica scanner 83% efficient

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Oscillating Mirror - Disadvantages

- Requires careful factory calibration
- Most difficult to implement
- Most expensive
- Needs ultra-stiff lightweight mirrors (beryllium)

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Oscillating Mirror

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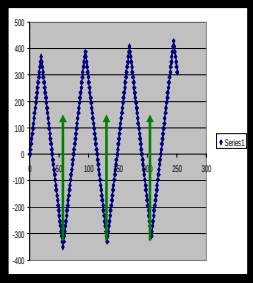
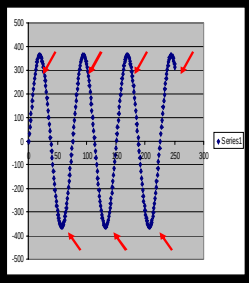


Leica



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Drivers - Altitude Specification

- Leica: 5000 m on custom system, requiring a larger mirror which can degrade performance
- TopoSys: 2500 m with a reduction in normal stated accuracy. 3 metre data gaps at max altitude
- IGI: 1500 m to 80% target - only grass or dry cement is this bright
- Optech: 3500 m to 20% target like pavement

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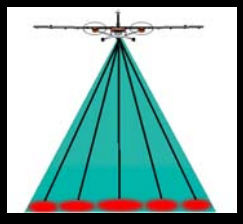
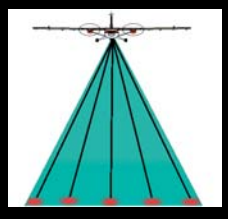
Drivers - Beam Divergence

A. Wide (0.8 mrad)
- Low altitude survey
- More hits on features e.g. wires and poles



B. Narrow (0.2 mrad)
- Presentation through forest canopy
- Better spatial resolution (X-Y position accuracy)



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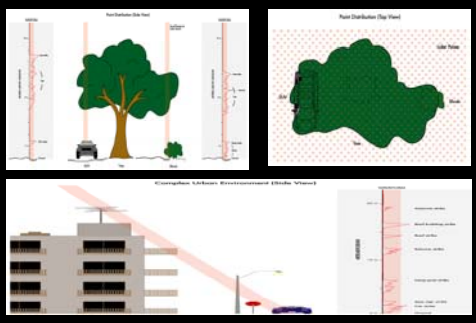
Drivers - Waveform Digitizer

Allows analysis of complex returns:
- Since it captures whole waveform, all complex detail of multiple pulses is retained.

Improved range accuracy:
- Range to multiple returns (>4)
- Relative intensity for each return
- Range between objects that are closer together than 2.5 m (current ALTM receiver electronics limit)

Aid in classification algorithms:
- Shape of pulse – affected by angle of incidence on target, target roughness, target structure.

Drivers – Waveform Digitizer



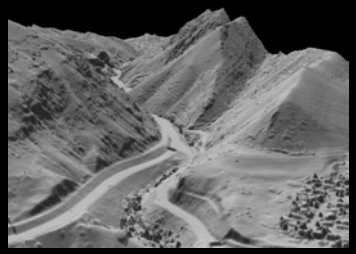
Drivers – Automatic Roll Compensation

- Roll compensation will ensure that the swath does not "wander" and create gap in the flight lines
- 5 Hz Update Rate
- Nominal +/- 5° adjustment of scan dependent on scan angle setting
- E.g. +/- 20 ° deg FOV allows for a +/- 5 ° compensation

Summary

- Very early days in lidar mapping
- Lots of room for growth in service industry (6-8%)
- New lidar capabilities are giving new survey possibilities
- Let overall sensor efficiency be the guide to your technical purchase decision as individual component specification can only be used as a guideline

Thank You



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