Multi-Spectral Lidar: A new multi-purpose aerial technology:
Intensity - 1064 nm
Corrected Intensity image from Channel 1 (1550 nm)

Soil is reflective in intermediate IR
Corrected Intensity image from Channel 3 (532 nm)

Vegetation is poorly reflected in the green and appears darker.
Vegetation is strongly reflective in NIR, and slightly so in visible green spectrum.

Either 1064 or 1550 will give good elevation information from typical targets.

Vegetation can be easily distinguished from soil and water (i.e. vegetation versus non-vegetation).

Water is best penetrated using green wavelengths.
Intensity – Wavelength Sensitivities

- 532 nm
- 1064 nm
- 1550 nm
Multi-spectral – Sensor characteristics

- To produce high-resolution conventional Lidar topography
- To enable simultaneous, seamless, high-resolution, high-precision mapping of the near and on-shore environment with no compromise in accuracy and point density
- To enable day/night multispectral collection capability and eliminate the solar collection restrictions associated with passive devices
- To explore new applications spaces made possible via multi-wavelength Lidar configuration
Titan – Key characteristics

- Three independent active imaging channels that support 532, 1064, and 1550 nm wavelengths for multispectral mapping of the earth’s surface, day or night

- A high-resolution “green” channel that ensures high point density for shallow water mapping applications

- Narrow pulse widths, state-of-the-art receiver and timing electronics guarantee the highest range precision possible for maximum data quality

- A fully programmable scanner enables huge increases in point density at narrower FOVs for maximum target resolution and detail over competing sensors
Titan - Scan Pattern

Forward angle separation = 3.5° (~ 60 mrad)

- 1064 nm (0°)
- 532 nm (7°)
- 1550 nm (3.5°)

3 Channel Scan Line Distribution

Cross track distance (m) vs. Downtrack distance (m)

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Titan – Multispectral Lidar point clouds
Titan – Water depth profiles in turbid water
Titan – Water depth profiles in turbid water

Continuous returns through Land/Water Interface

3 m
Titan – Classified with Intensity

Bottom Reflectance
Vegetation is strongly reflective in NIR, and slightly so in visible green spectrum

Vegetation can be easily distinguished from soil and water (i.e. vegetation versus non-vegetation)

Water is best penetrated using green wavelengths
Titan – Wavelength Sensitivities

- 532 nm
- 1064 nm
- 1550 nm
Results and Analysis
Rad. Corr. 1550/1064/532 nm
Image Classification:

- Maximum likelihood classifier is used to classify the intensity data of each channel separately and all combined.

- A DSM band is used with combined three intensity bands.

- 200 random checkpoints distributed overall the study area were used for classification assessment.

- The images were classified to **six classes**.

  - Buildings (Brown color)
  - Trees (Dark Green color)
  - Roads (Gray color)
  - Grass (green color)
  - Soil (Beige color)
  - Water (Blue color)
Classification results of Channel 1 (1550 nm) intensity data

Overall classification accuracy = 38 %
Results and Analysis

Classification results of Channel 2 (1064 nm) intensity data

Overall classification accuracy = 46 %
Results and Analysis

Classification results of Channel 3 (532 nm) intensity data

Overall classification accuracy = 52.5 %
Results and Analysis

Combined classification results of Channels 1, 2 and 3 (1550/1064/532 nm) intensity data

Overall classification accuracy = 69 %
To improve the classification results, a Digital Surface Model (DSM) is added as an additional band to the combined intensity bands used previously.

Bands displayed: DSM in Red, 1550 nm Green, 1064 nm Blue
Results and Analysis

Combined classification results of Channels 1, 2 and 3 (1550/1064/532 nm) intensity data + DSM

Overall classification accuracy = 78 %
### Summary of the Classification Results Using Multi-Spectral Lidar Data (Accuracy assessment using 200 checkpoints)

<table>
<thead>
<tr>
<th>Lidar Data (Band) Combination</th>
<th>Overall Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Band (1550 nm)</td>
<td>38</td>
</tr>
<tr>
<td>1 Band (1064 nm)</td>
<td>46</td>
</tr>
<tr>
<td>1 Band (532 nm)</td>
<td>52.5</td>
</tr>
<tr>
<td>3 Bands (1550 nm &amp; 1064 nm &amp; 532 nm)</td>
<td>69%</td>
</tr>
<tr>
<td>3 Bands (1550 nm &amp; 1064 nm &amp; 532 nm) + DSM</td>
<td>78%</td>
</tr>
</tbody>
</table>
False Color Composite – Lidar intensity only
Multi-Spectral – Imagine the possibilities

**Shallow-water bathymetry:**
Collect seamless data sets across the land-water interface with Titan’s water-penetrating green channel for clear shallow water bathymetry and surface-detecting NIR channels.

**Dense topography:**
Achieve extreme point density and consistent point distribution with Titan’s 900 kHz pulse repetition frequency, 210 Hz scanner rate, and gyro-stabilized sensor configuration.
Multi-Spectral – Imagine the possibilities

**3D land cover classification:**
Significantly improve land cover classification accuracies with 3D multispectral intensity analysis

**Vegetation mapping:**
Map vegetative differences for environmental, forestry and agricultural applications day or night, with high precision and accuracy
Titan

Imagine the possibilities...

with a **multi-spectral** lidar system!