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15-19 January, 2018, Hyderabad, India

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Multispectral Lidar and Application Opportunities

GeoSpatial World Forum 2015, Portugal

Michael R. Sitar MES BSc.
Business Manager
Airborne Mapping Solutions

Optech announces Titan, the world's first multispectral airborne lidar sensor

November 24, 2014 — Optech is pleased to announce the latest addition to its innovative line of airborne laser terrain mappers (ALTM), the Optech Titan, launching a new era in remote sensing. For the first time ever, multispectral active imaging of the environment can occur day or night, enabling new vertical applications and information extraction capabilities for lidar.

In the past, single or dual-wavelength sensors were developed for specific market verticals and application requirements. Titan breaks away from this convention by combining three beams with separate wavelengths, increasing the information content that can be derived from the target surface and allowing surveying professionals to address many more applications using a single sensor solution. Whether the goal is high-precision, high-density topographic surveying, land cover classification, vegetation mapping, or shallow water bathymetry, the Optech Titan can accommodate them all.

According to Michael Sitar, Optech's Business Manager for Airborne Mapping Solutions, "Titan is a paradigm shift from what has traditionally been possible using airborne lidar. By combining multiple wavelengths we not only improve current methods and results for existing applications, but also open up completely new opportunities and market verticals for lidar moving forward. Titan represents a premium environmental mapping solution capable of much more than simple coordinate measurement."

Vegetation discrimination using the new Optech Titan multispectral lidar sensor

Multispectral Lidar - One Sensor, Many Applications

Multispectral lidar Sensor Advantages

- Multiple wavelengths provide increased surface information extraction
- Day/night operation (radiometrically consistent)
- Inherently ortho-rectified
- High-accuracy ground models

One Sensor, Many Applications

- High-density topographic surveying
- Vegetation discrimination
- Land cover classification
- Shallow water bathymetry

Latest in Technology Innovation

- Three independent active imaging channels
- Real time point display
- Discrete and full waveform data capture
- Narrow pulse width lasers for consistent data precision
- Gyro-stabilized
- Embedded CS-series camera options including: RGB/CIR/NIR; thermal; 3-5 band multispectral

Metric Cameras

Titan CS-6500 Aerial Digital QA Camera – Standard Equipment

- The CS-6500 is a 29MP, metric, scalable and versatile camera in a small and reliable form factor. With a pixel resolution of 5.5 μ, and a field of view of 6,500 pixels across by 4,300 pixels along the flight line, the CS-6500 delivers reliability and performance.

CS-6500 Advantages

- Electronic shutter (no moving parts)
- Extremely fast frame rates (1 frame/sec)
- Compact size
- Maximum reliability

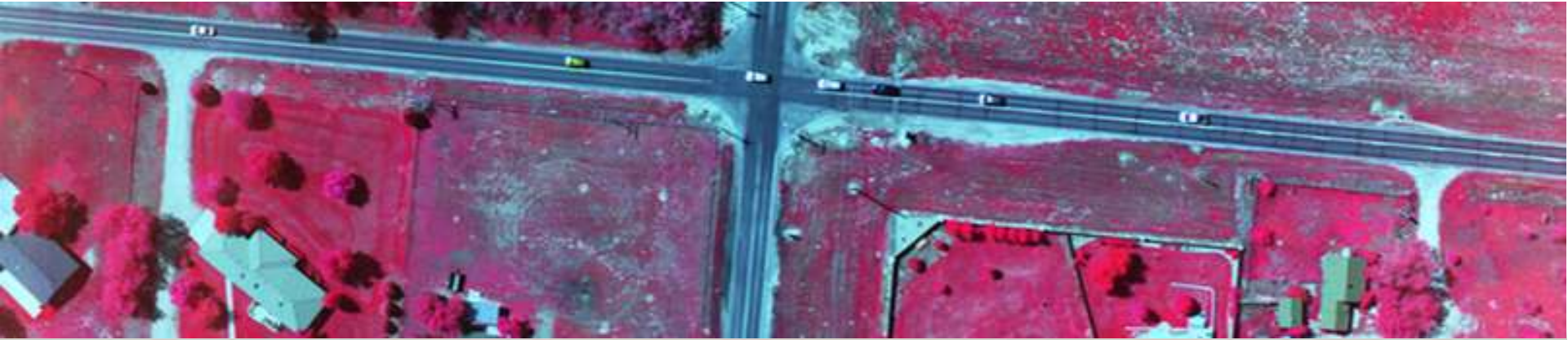
Metric Cameras

Titan CS-MS1920 Aerial Multispectral Camera – Optional Equipment

- The CS-MS1920 is a metric multispectral mapping camera is based on a patented 3-CCD camera design with color-separating optics
- A pixel resolution of 7.2 μ and a rapid frame rate of ~4 frames/sec makes the CS-MS1920 the perfect passive sensor complement for Titan

CS-MS1920 Advantages

- Independent 3-CCD configuration for true-color imagery
- Progressive-scan technology ensures maximum reliability
- Custom band options for specific applications (3-5 bands)

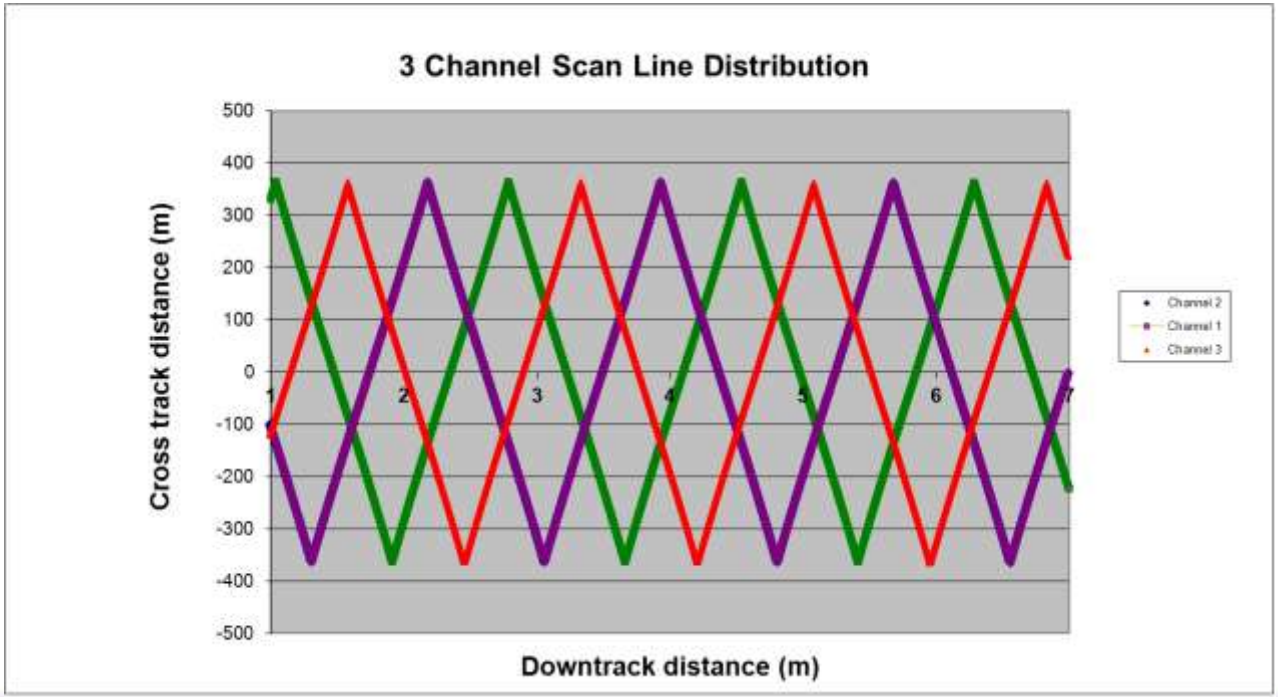


Titan MW900 - Scan Pattern

Forward angle separation = 3.5° (~ 60 mrad)

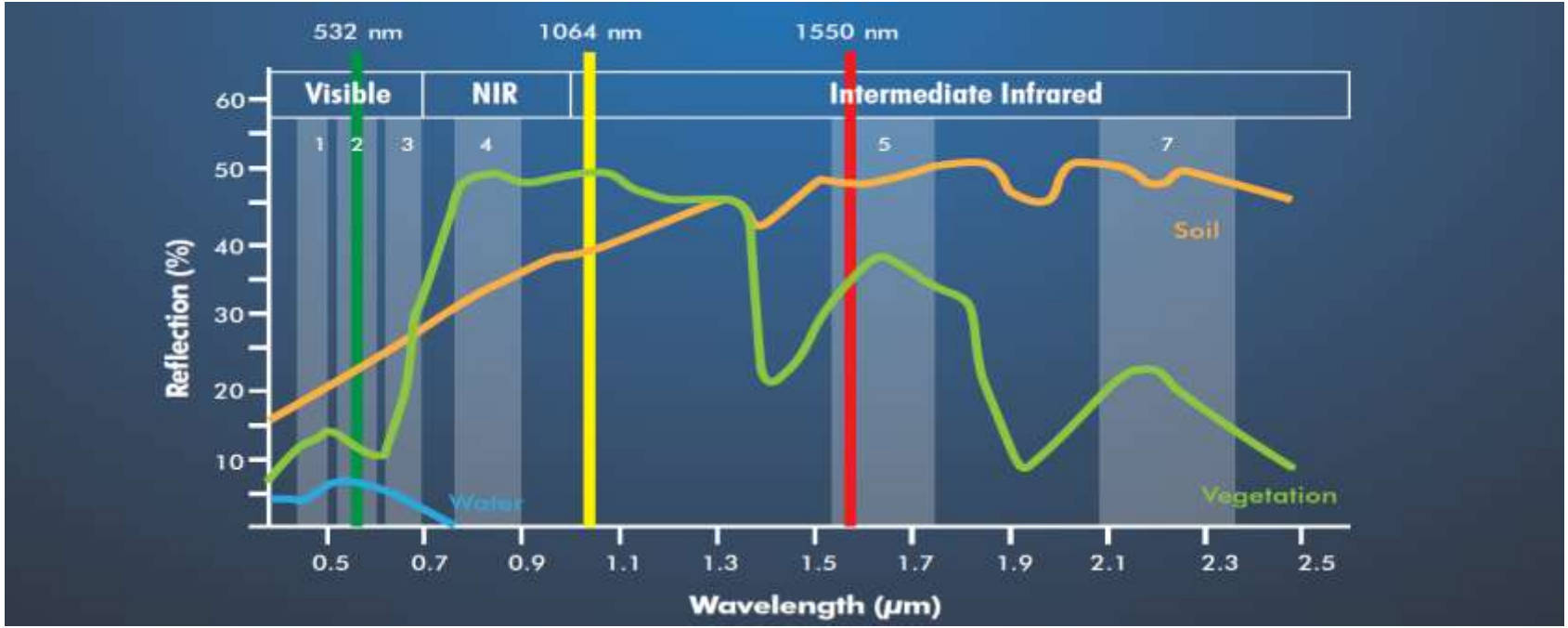
1064 nm (0°) 1550 nm (3.5°) 532 nm (7°)

Flight Direction



Lidar Wavelength Sensitivities

- Vegetation is strongly reflective at 1064 nm
- Soils reflect well at 1550 nm
- Water is best penetrated using 532 nm



Radiometric Correction - 532 nm

Radiometric Correction - 1064 nm

Radiometric Correction - 1550 nm

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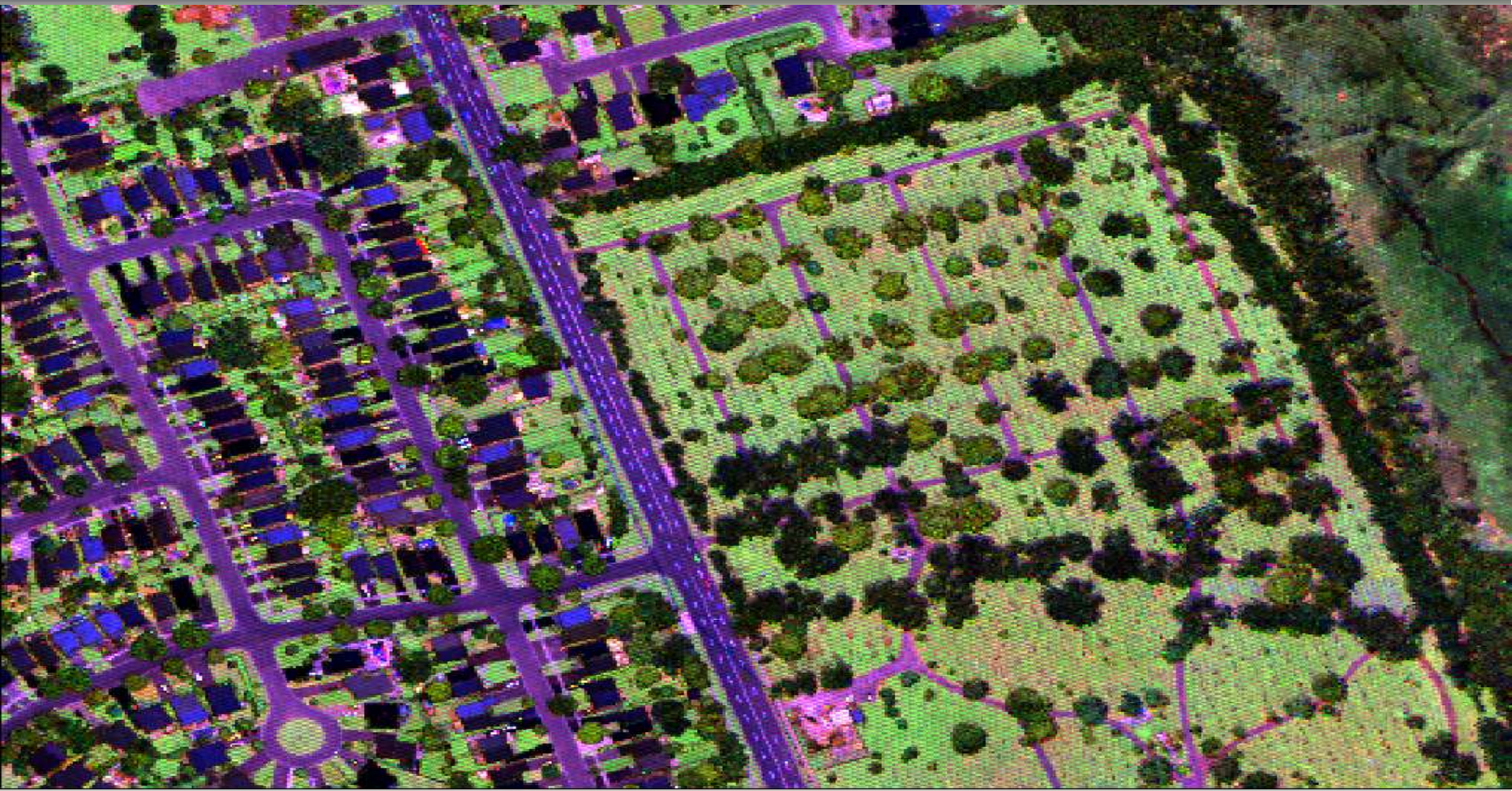
Lidar Wavelength Sensitivities

532nm

1064 nm

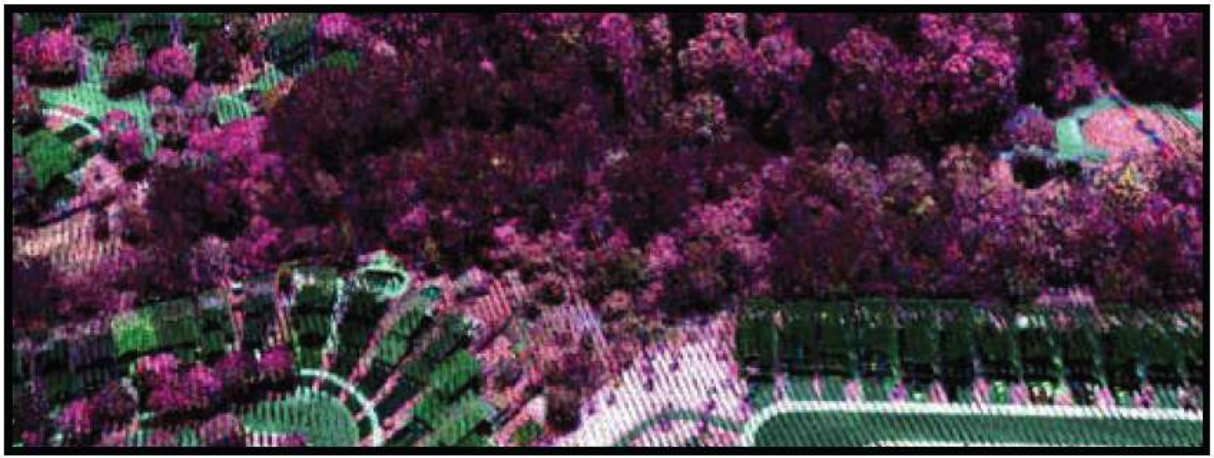
1550 nm

Multispectral Lidar - Natural Color Composite



Multispectral Lidar Applications

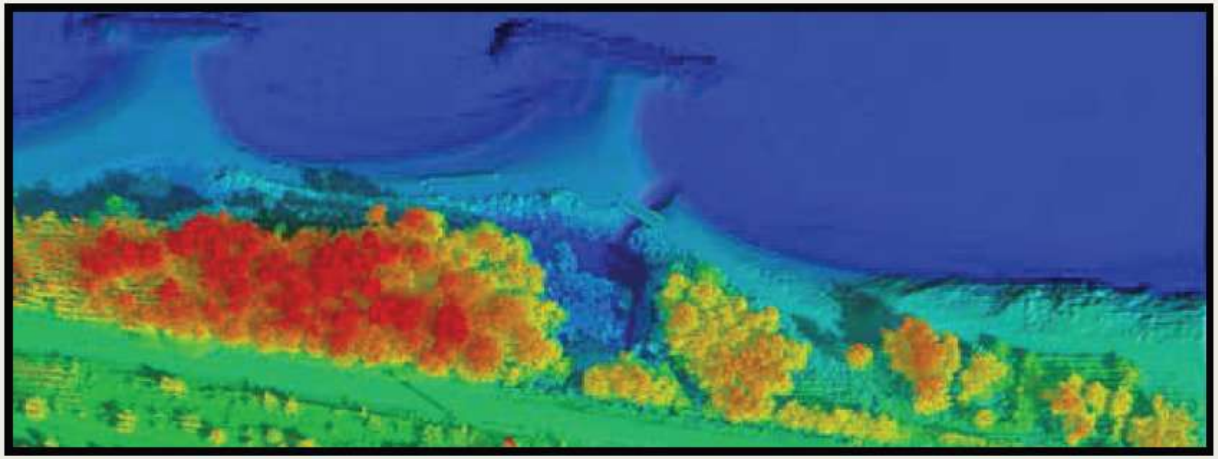
3D land cover classification:
Significantly improve land cover classification accuracies with 3D multispectral intensity analysis



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

Multispectral Lidar Applications

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

Land Cover Classification

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)

Class	Color
Buildings	
Trees	
Roads	
Grass	
Soil	
Water	

Radiometric Correction

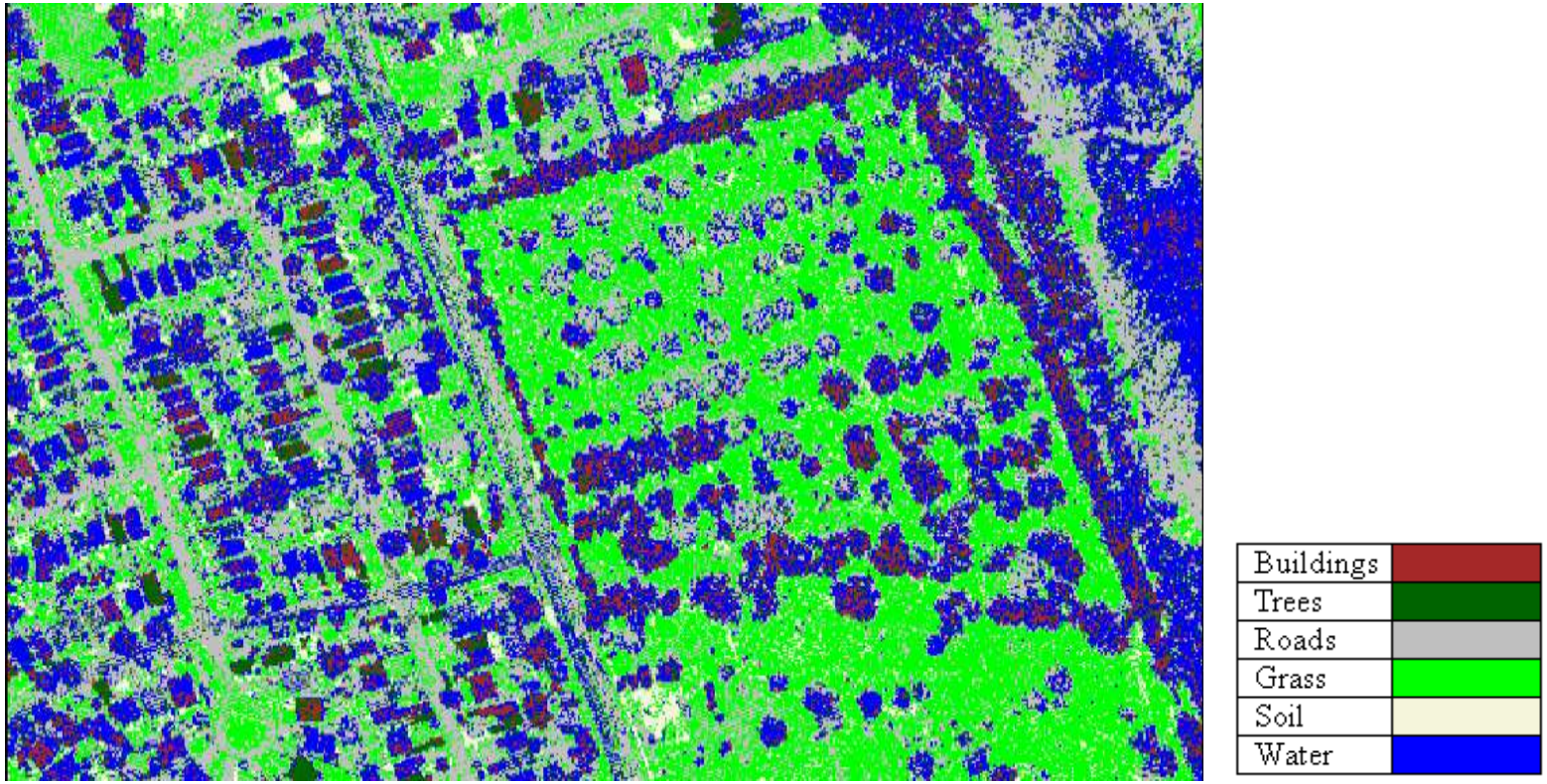
Results of the Radiometric Correction

Coefficient of variation (CoV) for Original Intensity (OI) and for Radiometric Corrected Intensity (RCI). Percentages describe changes in CoV.

Class		Buildings	Trees	Roads	Grass	Soil	Water
Channel 1 1550 nm	OI	2.88	1.94	2.83	5.74	5.88	3.32
	RCI	2.77 (↓3.82%)	1.96 (↑1.03%)	2.88 (↑1.77%)	5.40 (↓5.92%)	5.68 (↓3.40%)	3.30 (↓0.60%)
Channel 2 1064 nm	OI	1.83	1.56	2.31	3.81	4.13	3.24
	RCI	1.77 (↓3.28%)	1.56 (0.00%)	2.20 (↓4.76%)	3.74 (↓1.84%)	4.19 (↑1.45%)	3.24 (0.00%)
Channel 3 532 nm	OI	2.22	2.02	2.69	6.22	7.30	3.76
	RCI	2.16 (↓2.7%)	2.01 (↓0.50%)	2.62 (↓2.60%)	5.83 (↓6.27%)	6.73 (↓7.81%)	3.55 (↓5.59%)

Classification Results

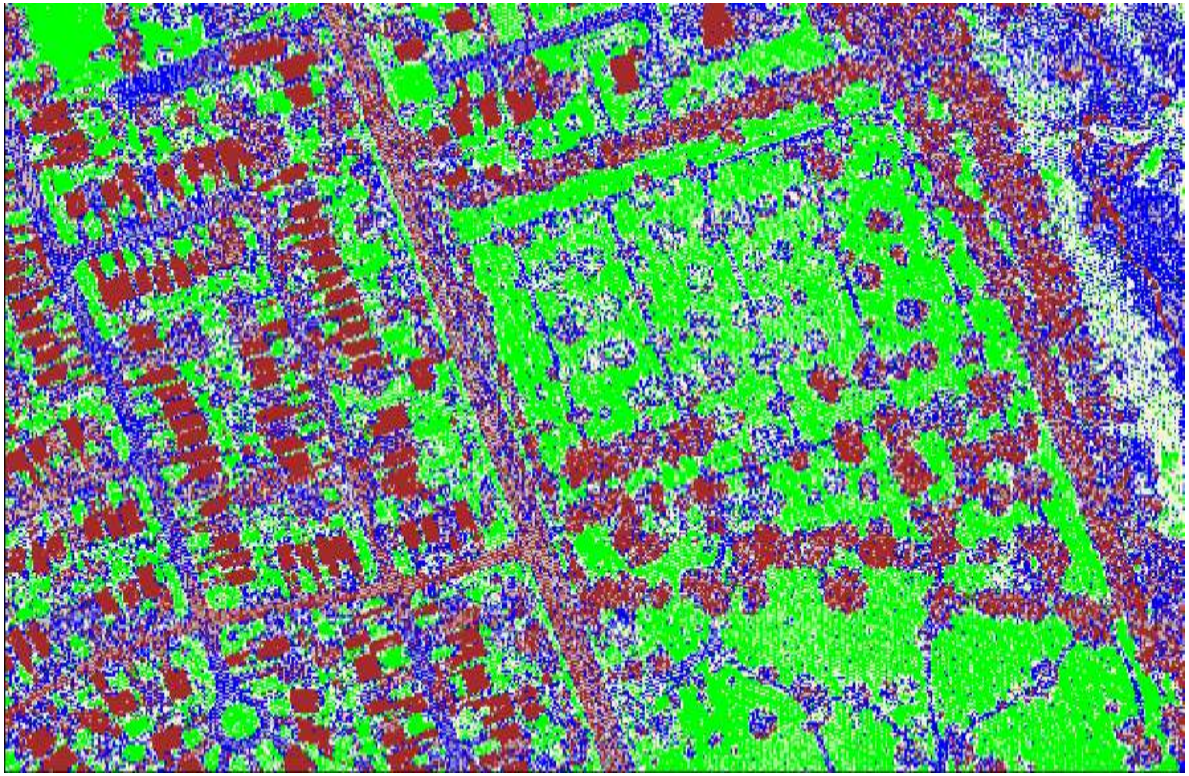
Classification results of Channel 1 (1550 nm) intensity data



Overall classification accuracy = **38 %**

Classification Results

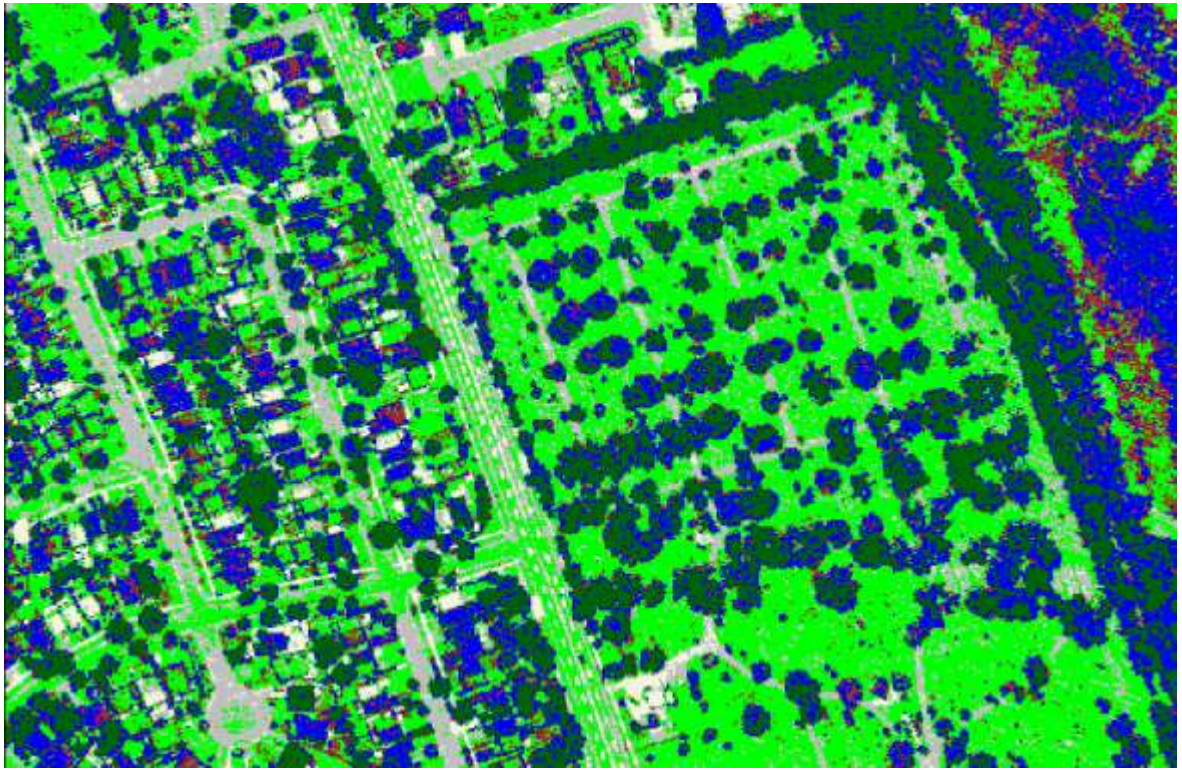
Classification results of Channel 2 (1064 nm) intensity data



Overall classification accuracy = **46 %**

Classification Results

Classification results of Channel 3 (532 nm) intensity data



Buildings	
Trees	
Roads	
Grass	
Soil	
Water	

Overall classification accuracy = 52.5 %

Classification Results

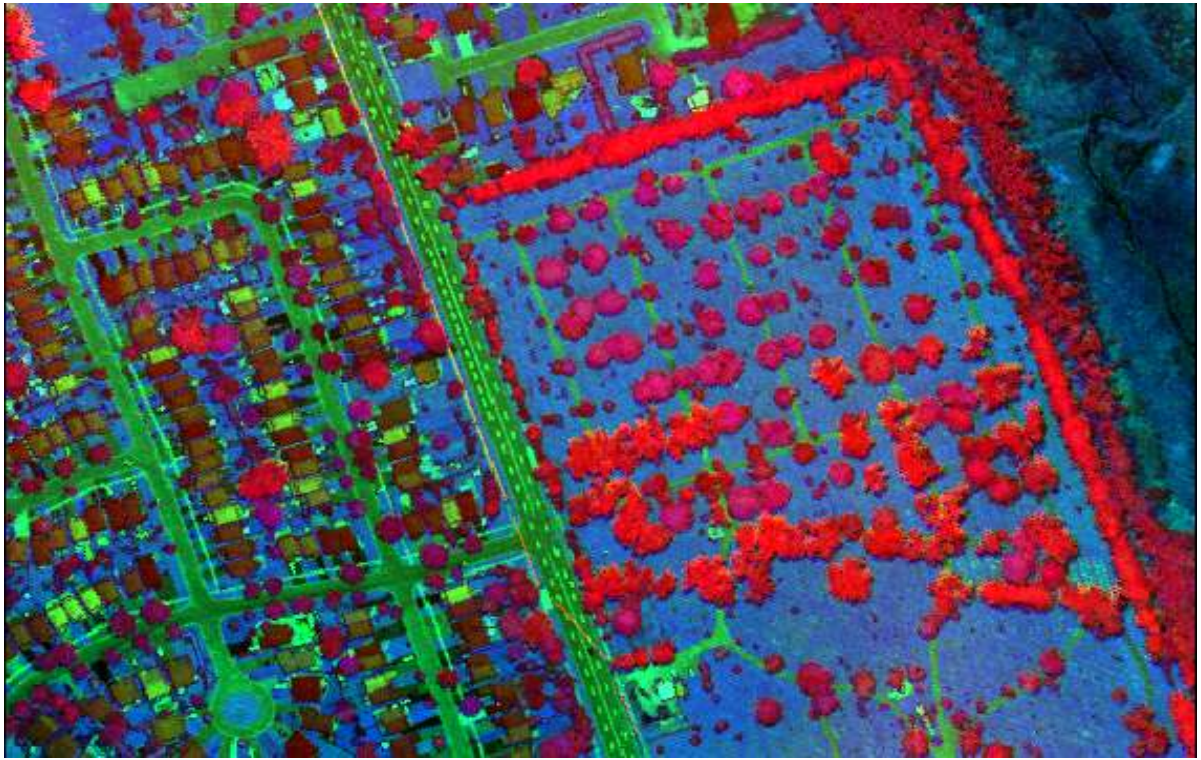
Combined classification results of Channels 1,2 and 3 (1550/1064/532 nm)

Buildings	
Trees	
Roads	
Grass	
Soil	
Water	

Overall classification accuracy = 69 %

Classification Results

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

Classification Results

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

Overall classification accuracy = 78 %

Lidar Composites – Land Classification Accuracies

Summary of lidar classification results using multispectral Titan data and Maximum Likelihood classifier algorithm (6 classes)

RYERSON UNIVERSITY

Lidar Data (Band) Combination	Overall Accuracy
1 Band (1550 nm)	38%
1 Band (1064 nm)	46%
1 Band (532 nm)	53%
3 Bands (1550 nm & 1064 nm &532 nm)	**69%**
3 Bands (1550 nm & 1064 nm &532 nm) + DSM	**78%**

Accuracy assessment using 200 checkpoints

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Multispectral Lidar - False Color Composite

Multispectral Lidar - False Color Composite

Topographic Surveying – Antarctica, 2015

Antarctic Expedition 2014/2015

- Optech Titan installation in a Twin Otter

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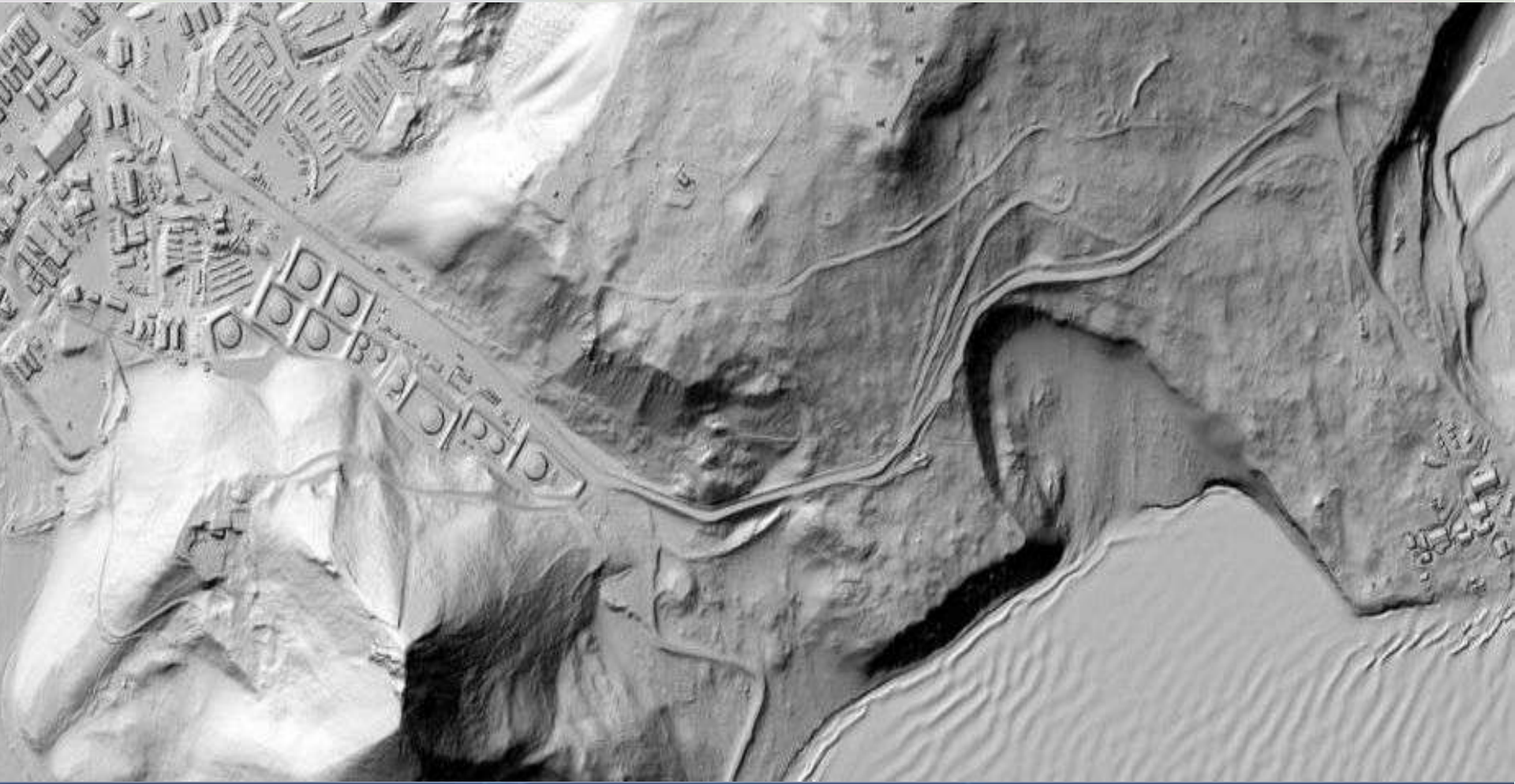
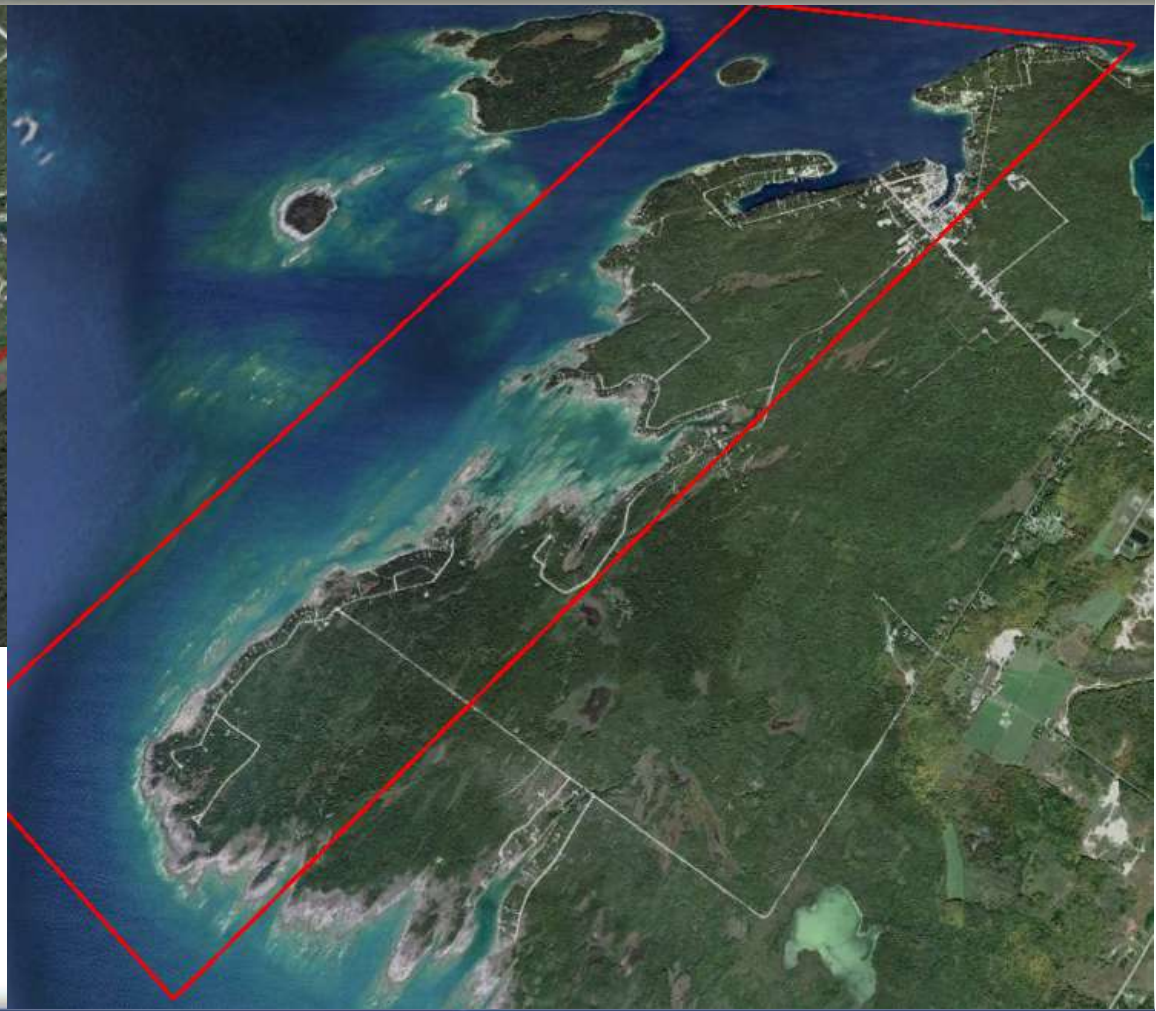
Topographic Surveying – Antarctica, 2015

NCALM



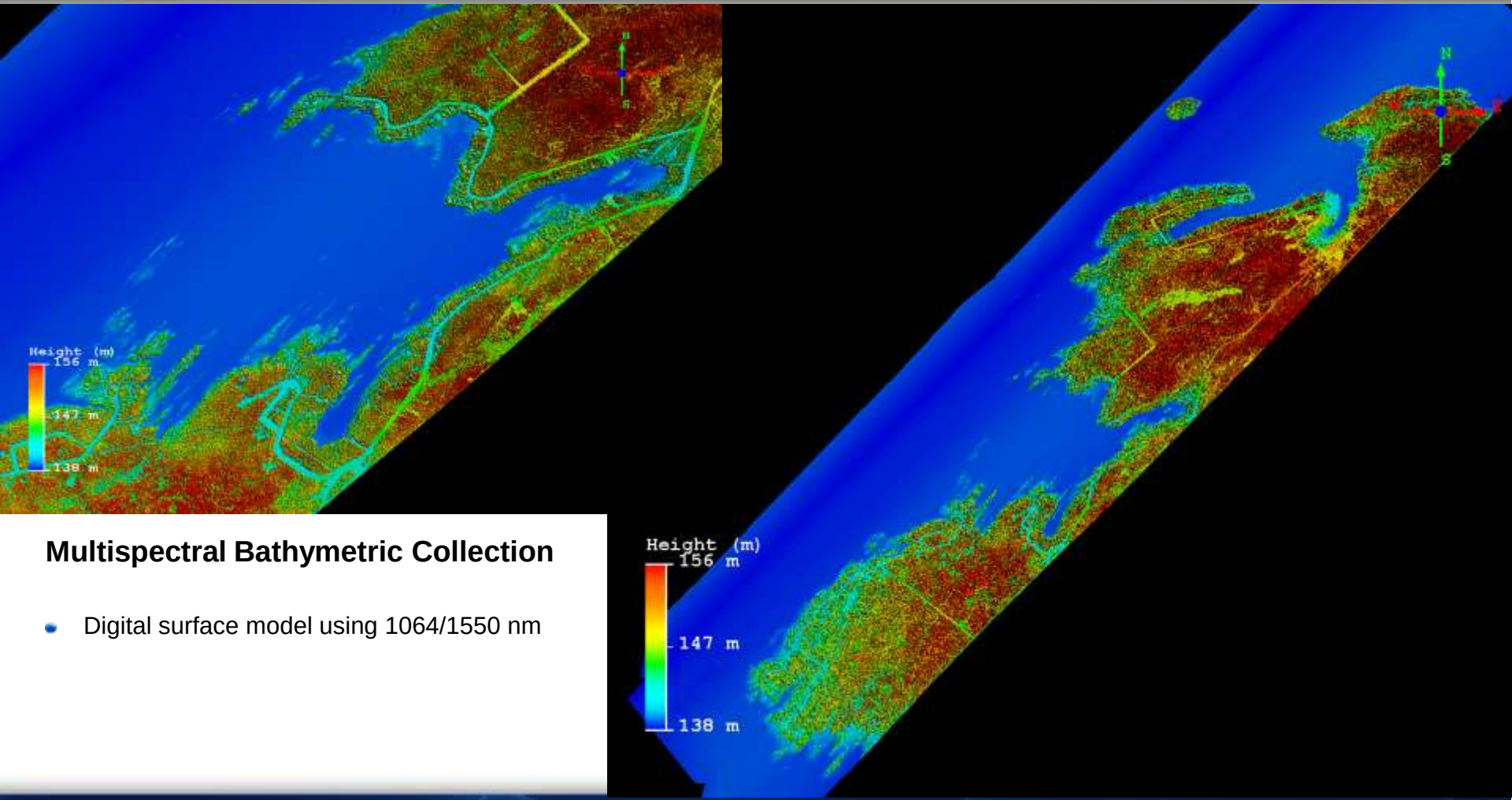
Tobermory, Canada – Lake Huron



Multispectral Bathymetric Collection

- Titan was used to survey rugged near-shore waters to identify shoals
- Goal was to collect 20m depths in relatively clear waters of Lake Huron, Canada

Multispectral Lidar - Digital Surface Model



Multispectral Bathymetric Collection

- Digital surface model using 1064/1550 nm

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532 nm

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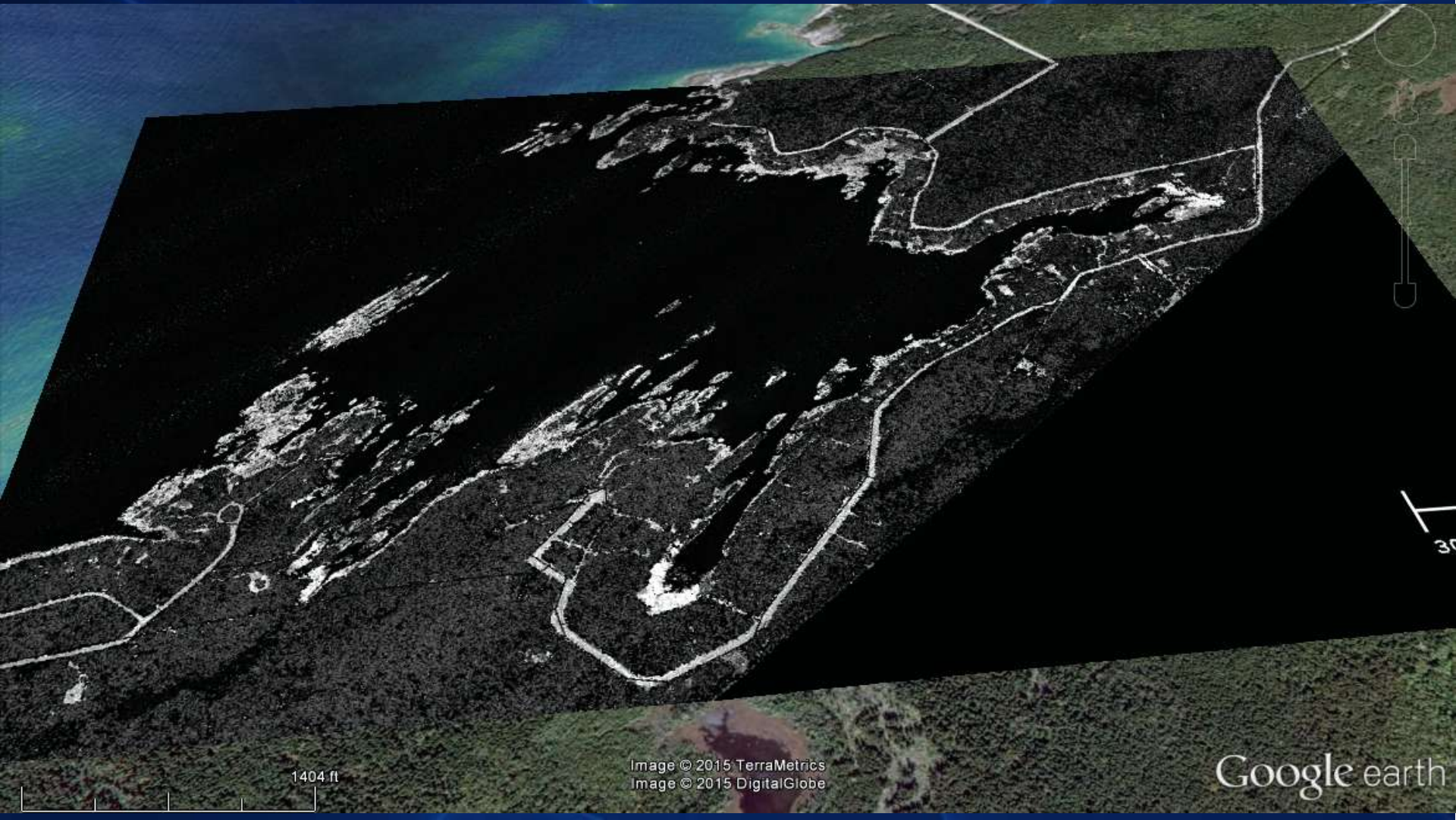
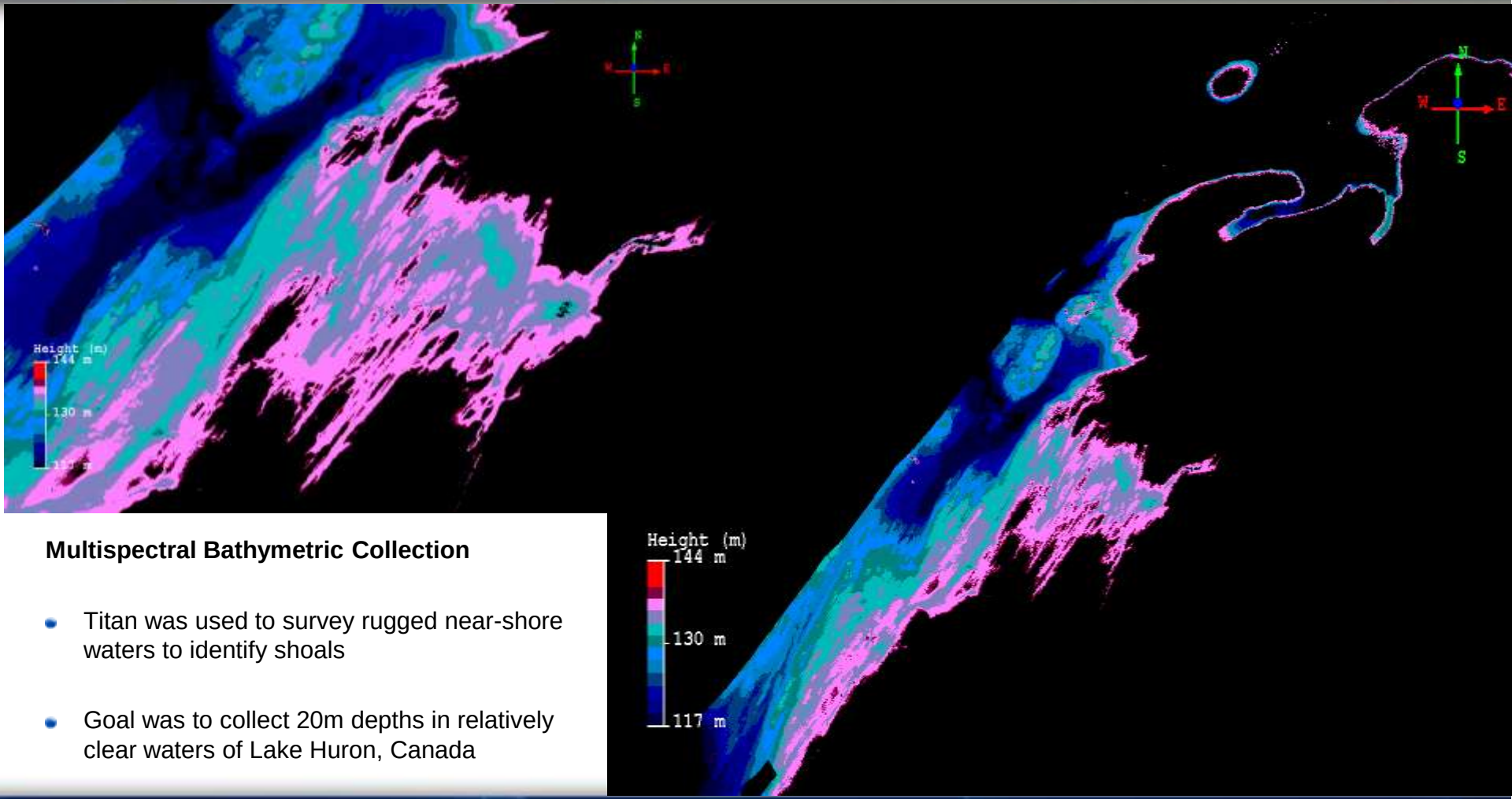
1550 nm



532 nm

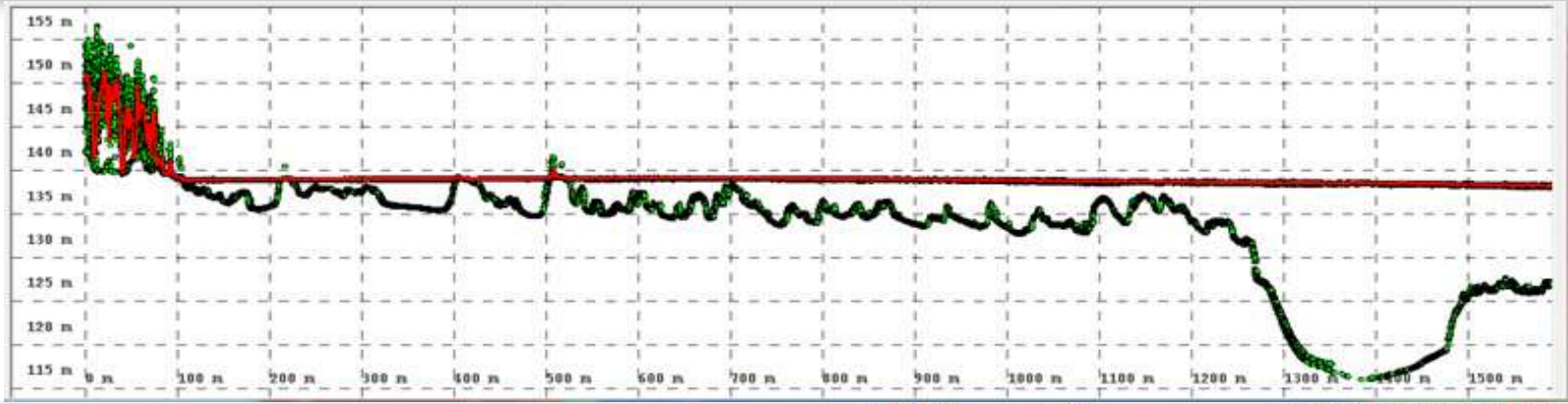


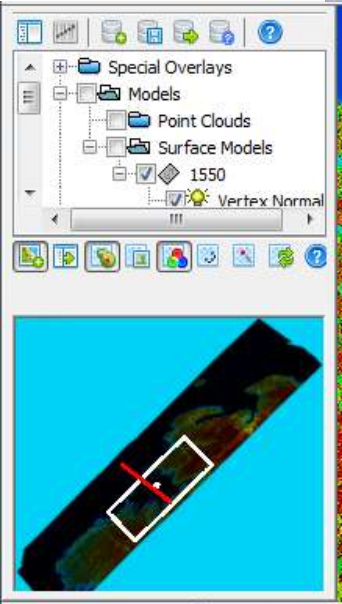
Multispectral Bathymetric Collection

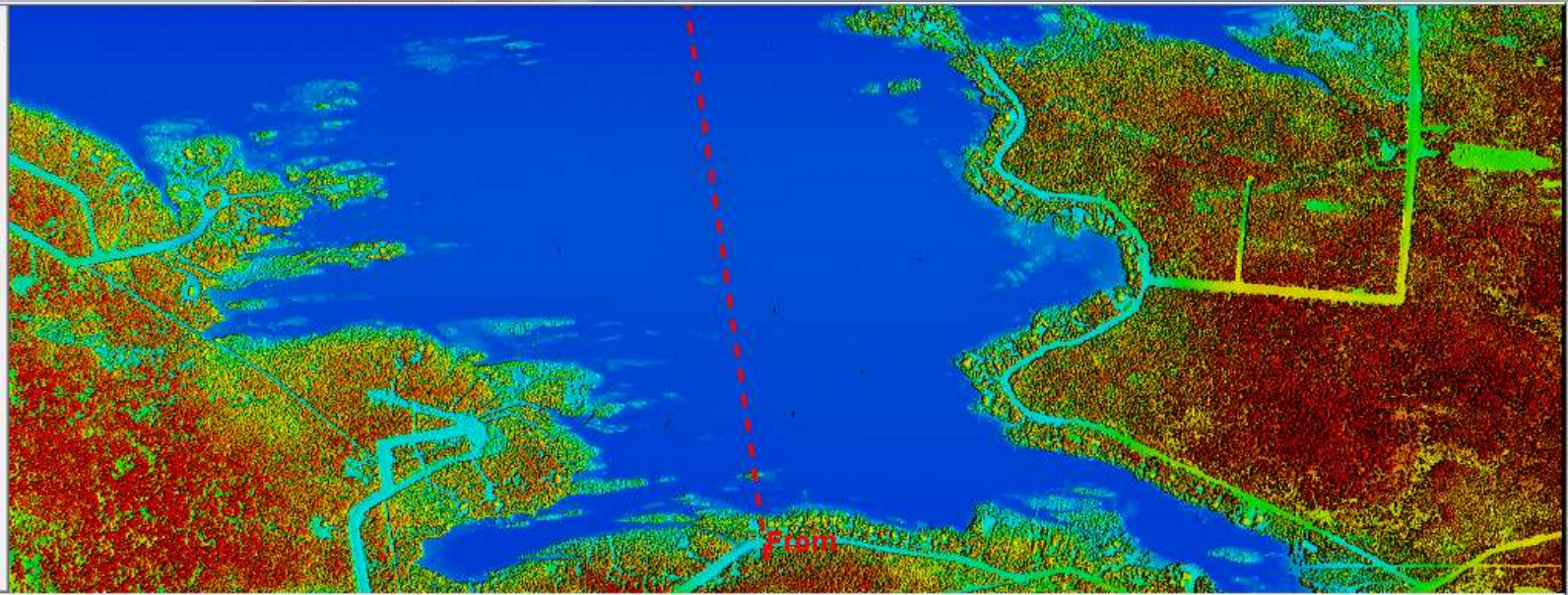
- Titan was used to survey rugged near-shore waters to identify shoals
- Goal was to collect 20m depths in relatively clear waters of Lake Huron, Canada

Depth Profiles

= 138.3 m – 115.9 m
= **22.4 m depth**







Targeted Point | WGS 84 / UTM zone 17N (metre) | E 446,666.95, N 5,010,129.20, Z 143.65 m | 1550

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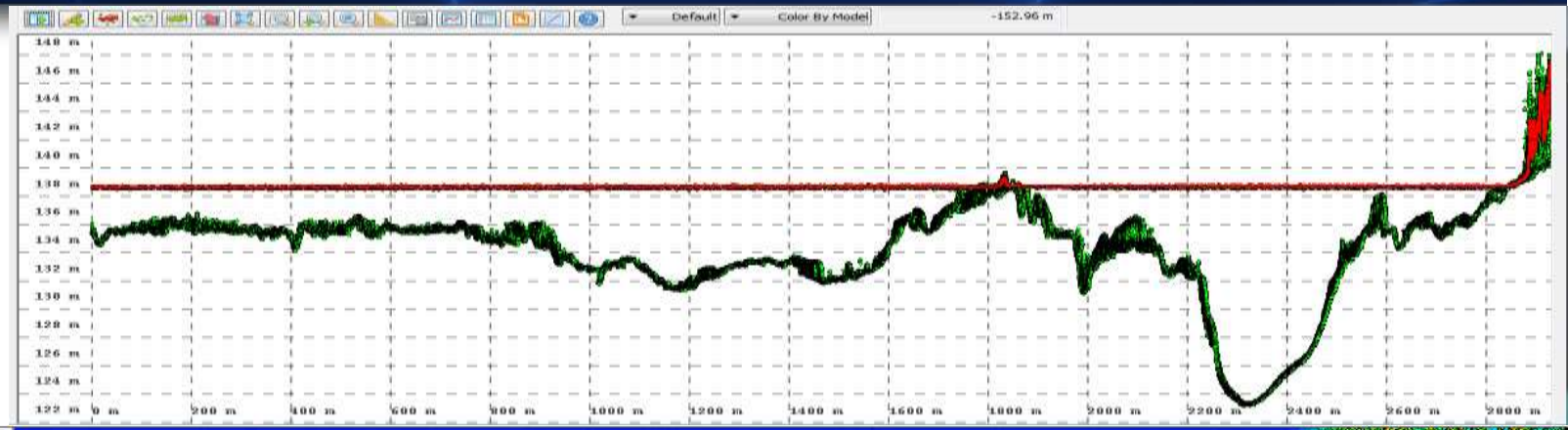
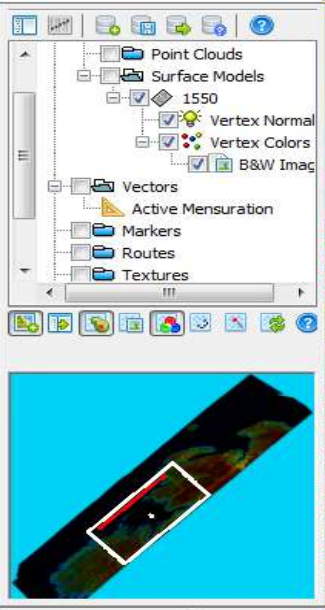
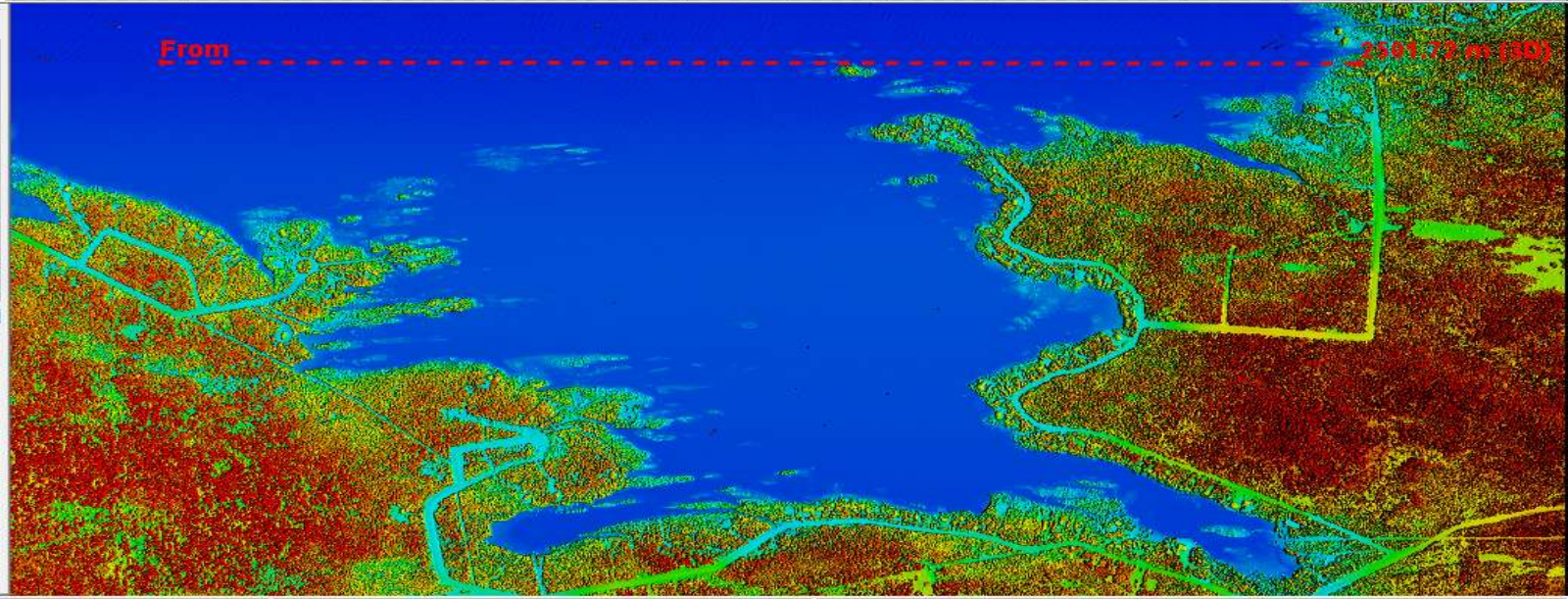
Depth Profiles

= 138.3 m – 123.8 m
= **14.5 m depth**

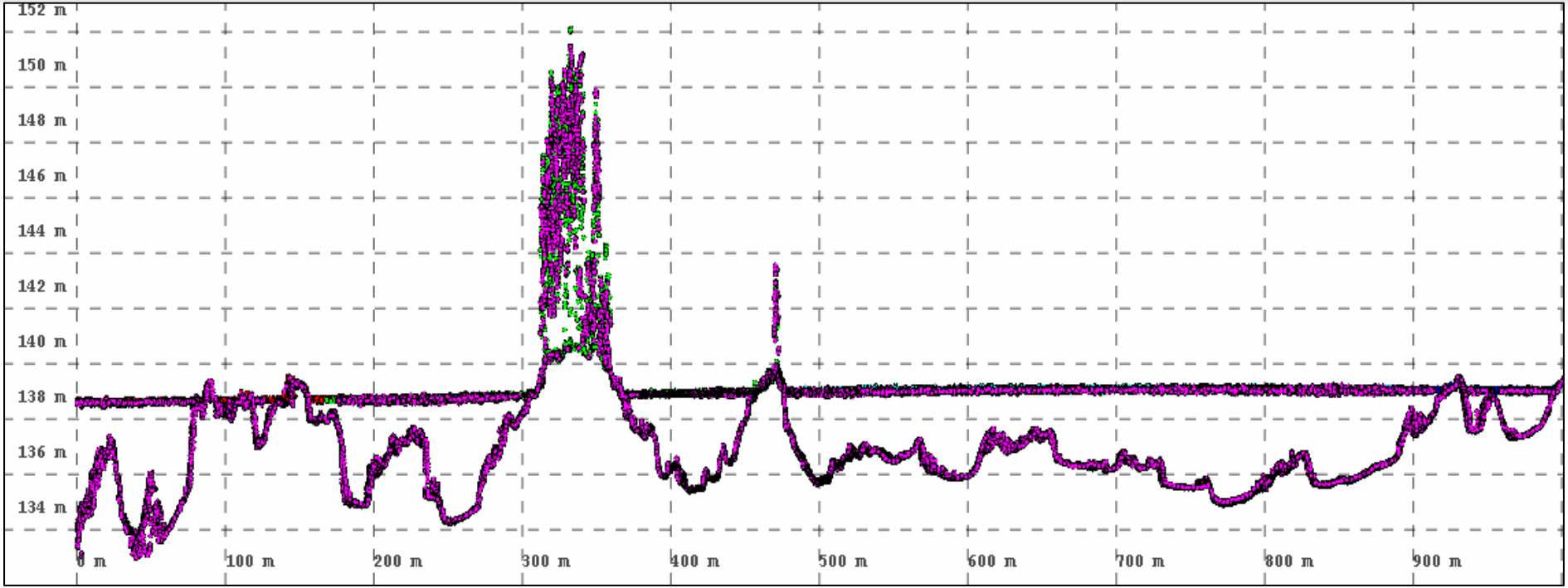






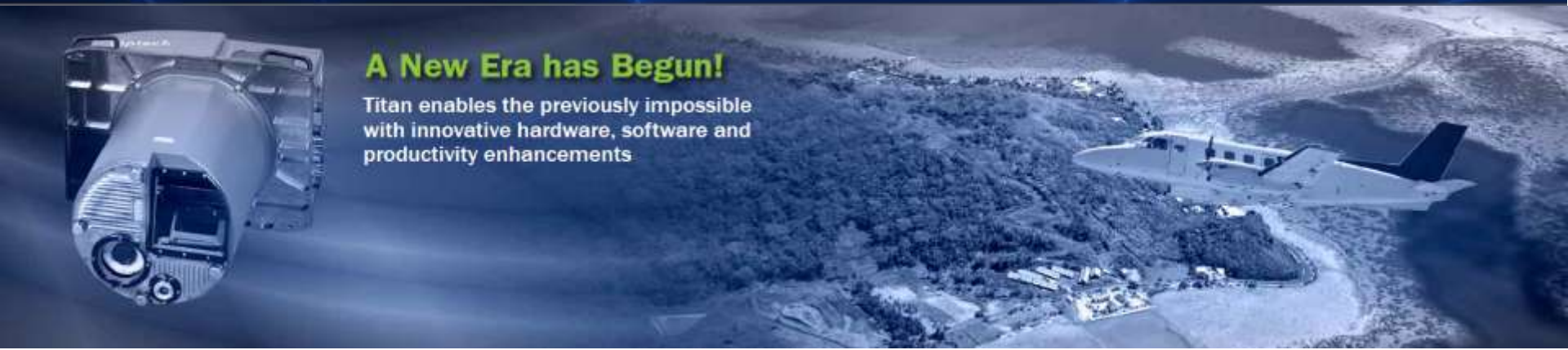
Targeted Point | WGS 84 / UTM zone 17N (metre) | E 445,167.66, N 5,010,506.60, Z 138.59 m | 1550

Seamless land/water interface



Multispectral Lidar – Embedded QA camera

Conclusions



- Multispectral lidar provides additional information/meta data for increased application opportunities (eg. vegetation discrimination)
- Additional wavelengths create higher quality output products (eg. bathymetry)
- Application-specific wavelength combinations may provide higher value in the future
- Lidar now more than simply coordinate measurement