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Airborne Bathy Lidar Tender Specifications: Modifications from Lessons Learned

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Overview of Airborne Lidar Projects
2016 - 2017

Canada
USA
Quebec
Ontario
Nova Scotia
Gulf of St Law
Island of Newfou
Georgian Bay
Ottawa
New Brunswick
Prince Edward Island
Northumberland Strait
Maine
Vermont
Bay of Fundy
Nova Scotia
Nova Scotia
Lake Ontario
Adirondack Mountains
New York
New Hampshire
Lake Erie
Image NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
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Google Ea

Summary
• 22 flight blocks
• 8,380 sq. km
• 480,000 camera exposures
Cape Breton Island
Nova Scotia
Bay of Fundy
Nova Scotia
300km
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
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Summary

- 12 flight blocks
- 550,000 camera exposures
- 10,852 sq km
- 2 Hyperspectral Missions

Summary
• 22 flight blocks
• 3,401 sq. km
• 476 flight lines
• 195,500 camera exposures
Ontario
Lake Huron
Georgian Bay
Michigan
Ottawa
Montreal
Vermont
Adirondack Mountains
600km
Toronto
Lake Ontario
New York
Lake Erie
Image NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
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Google Earth

Project Overview – Total Area

Project	Area (Sq Km)	Notes
Quebec 16'	1,745	
Central 16'	1,381	
Atlantic '16	2,079	
Atlantic '17	6,301	
	11,506	
Quebec 2017	9,107	
Central 2017	2,020	Continuing collection in April/May 2018
2016/2017 Total	**22,633**	

Equipment

Item	Serial Number / Version
Aircraft	Piper Navajo
LiDAR	CZMIL #06
Digital Camera	CM-4800

Mandatory and Optional Survey Blocks

Summary
- 22 flight blocks
- 3,401 sq. km
- 476 flight lines
- 195,500 camera exposures

Reflectance

Reflectance data

Requirement

Collect lidar reflectance and to perform an unsupervised classification (of bottom type/substrates).

Notes:

- No other specifications are provided
- No consideration is put into ground truthing and associated costs
  - Therefore no way to compare reflectance or add information to help refine the classification

Results;

- Best guess

Depth image

HydroFusion V1.3.5 [12/15/2017]
File View Tools Configuration Help
0: Master Control
1: Data Download Synchronization
2: Point-Cloud Auto-Processor
3: Manual Point-Cloud Editor
4: Image Generation
5: Feature-Extraction/Classification
6: Environmental Products Processor
Process Manager
Pre Proc Feat Ex ROI Gen Feat Opt Cls
Median basic filter
Clip Image
Median threshold filter
Generate Blob
Median adaptive filter
Layer Stack
Generate Mask
Band Math
Import from Miscellaneous
Layer Manager
Miscellaneous
P2_Dec20_water_only_reflectance_v2
P2_depth_resample_2meter
Resize (czmil_depth_161220_1352_A.img_0_cl
Planner
Polygons
Flightlines
Shape Files
Flight Lines
ROI
Environment
Data Manager
CZMIL
Central
Projects
P2Central
P_161220_1352
P_161220_1352_A
Products
SHOALS
Globe
Search
Parameters
Automated where the land/water boundary is taken as zero depth

Lidar reflectance image

Rugosity image (surface roughness)

K-means clustering

Shows like areas based on the inputs (depth, rugosity, reflectance)

Photography

Photography

Requirement

4. Overlapping digital vertical color photographs at 1 HZ intervals along the flight path must be collected.

Notes:

- No other specifications are provided just “digital imagery”
- No cameral pixel resolution defined.
- Results in a large number of photos (e.g. +1,2M photos)
- “orthophotos” is not the same as “digital imagery”
- Understand the purpose of digital imagery (“bathy lidar editing and QC”… not to create accurate digital orthophotos – objects, wrecks, shoals, etc)
- General rule
  - Ortho photo horizontal accuracy is 3 times pixel resolution
  - Lidar camera approach is normally approx 20cm pixel resolution = 60cm accuracy
  - Controlling the imagery and improving the accuracy requires collecting photo control
  - 3 band (RGB) vs 4 band (RGB & Near Infrared - remote sensing)

Wrecks and objects observed

Beacon Observed

Ortho Mosaic (20 cm) - Ontario

Hyperspectral Imagery

The hyperspectral imagery is used for unsupervised (and supervised) feature classification/analysis. For example, in conjunction with various lidar datasets (reflectance, depth, rugosity, etc.) to classify bottom type.

Hyperspectral Imagery

Requirement
Hyperspectral data shall be collected with bathy lidar data

Notes:
- Flying height
  - Bathy lidar is normally flown between 400m – 600m (below clouds)
  - Hyperspectral optimal data is collected at 3000m (above clouds)
- It is important to have consistency in the collection and resulting imagery
- If collected in two missions or across multiple days, you can end up with different light conditions, atmospheric conditions, etc., which would lead to non-consistent imagery and products
- Hyperspectral missions data are controlled by use of a ground spectrometer. While the plane is flying over, a crew is required on the ground with a spectrometer taking measurements at pre-determined ground truth sites.
- Hyper Spectral data is huge (150 TB for Quebec alone – requires IT infrastructure)

Accuracy

Accuracy

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Requirement

6. LIDAR data must be collected to meet IHO Order 1 b vertical standards as outlined in IHO Standards for Hydrographic Surveys Special Publication No.44, Fifth Edition, Monaco, 2008.
7. LIDAR spot data density shall be at least 5m x 5m with a 'full seafloor search' (as defined by IHO Standards for Hydrographic Surveys Special Publication No.44, Fifth Edition, Monaco, 2008) - commonly referred to as '100% coverage' for all sites.

Notes:

- Flying height
  - 600m flying height can achieve 5mx5m spot density and Order 1b
  - 400m flying height can meets Order 1b but deeper penetration
  - Understand "extinction depth vs spot density vs achievable accuracy"
- Order 1a in vertical is achievable but not when it comes to object detection
- "survey to extinction depth" vs "**must achieve 3 secchi water depth**"
- using a shallow water bathy lidar system does not achieve 3 secchi water depth

Extinction Depth – Panama Canal

12. Results

12.1 LIDAR Data

12.1.1 Overview

Figure 28 presents an overview of the data coverage achieved for the Gatun Lake bathymetric and topographic LiDAR survey. The whole survey area was fully covered with additional land covered around (along the straight line flight path). All the data collected was processed and delivered to ACP-Panama, with the exception of some patches of land outside the survey area in the north due to an issue with the land/water discrimination.

Calibration – topo & bathy lidar

CZMIL topographic calibration site over Oshawa Executive Airport in Oshawa, Ontario

CZMIL bathymetric calibration site over Rouge River, Ontario

Calibration – bathy lidar

Introduction to PP-RTX

Introduction to PP-RTX

Trimble has their own RTX monitoring network that is comprised of approximately 100 high-performance GNSS receivers distributed globally, which track GPS, GLONASS, BDS, QZSS and Galileo. The reference stations used in the network are Trimble survey grade receivers, coupled with high performance geodetic antennas that are fully characterized and calibrated.

Data from the stations in the network are transmitted continuously to redundant operation centers located around the globe. The processing servers continuously monitor the health of the reference stations around the world and automatically reconfigure the network when problems are detected. Network processors then generate the precise orbit, clock and observation biases for any location on the Earth at a rate of 1 Hz.

RTX monitoring network

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Introduction to PP-RTX

- PP-RTX creates virtual base stations along the survey track and uses them to refine the solution.
- For all flights, the single base solution and PP-RTX matched very closely within **2 to 3cm** so within the accuracies requirements
- Applanix technical experts also recommended PP-RTX instead of multi-single base for long flights covering distinct survey areas.

PP-RTX vs PPP

Quebec, PP-TRX Test
Single-PPP
Single-RTX
Aircraft Height Difference (metres)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
18:22:32
18:52:32
19:22:32
19:52:32
20:22:32
Time (UTC hms), JD312 2

How it works: PP-RTX

Take home messages

- Design Surveys based on geographically and prioritized spaced **blocks**
- **Reflectance** needs ground truthing
- Collecting **digital imagery assists in data processing and quality control** and does not mean creating accurate ortho photos.
- **Hyper Spectral** data acquisition means added costs in flying logistics and ground truthing
- Understand "**extinction depth** vs spot density vs achieved accuracy"
- "survey to extinction depth" vs "**must achieve 3 secchi water depth**"
- **PP-RTX** means no need for base stations

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Thanks you