

Inuvik to Tuktoyaktuk and Dempster Highway Orthomosaic (2019)

Summary

In July and August of 2019, a remotely piloted aircraft system (RPAS) project was undertaken in Canada's western Arctic along the Inuvik to Tuktoyaktuk (ITH) and Dempster highways. The objective of this project was to test long-range RPAS missions for photogrammetric data acquisition and processing of these two Arctic highway corridors with embankments, bridges and culverts at risk of changing environmental and climatic regimes. The imagery was used to derive an orthomosaic and digital elevation model that could be used to measure road infrastructure and landscape change over time (e.g., fish habitat).

The RPAS missions were conducted with a Griffon SeaHunter and full-frame DSLR sensor and scoped to obtain <10 cm spatial resolution imagery along a combined 396 linear km. The final deliverables covered over 22,000 ha and 29,000 ha for the ITH and Dempster Highways, respectively, and represent one of the first non-military beyond-visual-line-of-sight RPAS data products of its kind and scale in Canada, and likely elsewhere. At the time of collection the data constituted the most current and detailed photo surveys of two of Canada's most northern highways constructed over ice-rich permafrost terrain, and will provide a valuable baseline to study past and future landscape change.

Description

In July and August of 2019, a remotely piloted aircraft system (RPAS) project was undertaken in Canada's western Arctic in the Mackenzie Delta region along the Inuvik to Tuktoyaktuk and Dempster highways. The objective of this project was to test long-range RPAS missions for photogrammetric data acquisition and processing of two remote Arctic highway corridors with embankments, bridges and culverts at risk of changing environmental and climatic regimes. The imagery was used to derive an orthomosaic and digital elevation model that could be used to measure road infrastructure and landscape change over time (e.g., fish habitat).

Missions were conducted in accordance with the *Canadian Aviation Regulations* (CARs) and *Aeronautics Act*, and were based at Inuvik (Mike Zubko) airport, NWT (ICAO: CYEV); under Special Flight Operations Certificate #940010 which excluded data gathering near urban areas and airports. Missions were conducted at 0.9 km to 1.2 km altitude (allowing for 6-9 cm spatial resolution imagery) during a fifteen-day window that included 7 flight days. Ground control points (GCPs) and checkpoints (CP) were measured with differential GPS systems to assist data processing and independent accuracy assessment purposes (n = 141 targets). The RPAS missions were conducted with a Griffon SeaHunter (8-hour endurance) with a Nikon D850 full-frame Digital Single Reflex camera (46 Megapixels) payload. An external storage device was used to store tens of thousands of images (JPEG) and observational data.

The image data volume was sufficiently large that this could not be processed within a single photogrammetric block, therefore, data was processed in chunks in Agisoft Metashape whereby high-quality GCPs were used to optimize georeferencing and reduce edge effects in overlapping areas. The Agisoft output products (7 orthomosaics, 7 DEMs) required additional post-

production steps in ESRI ArcGIS Pro, including mosaicking, seamline corrections, artefact removal, resampling and tiling.

The final deliverables (500x500 m orthomosaic and DEM tiles) covered over 22,000 ha and 29,000 ha for the ITH and Dempster Highways, respectively, and represent one of the first non-military beyond-visual-line-of-sight RPAS data products of its kind and scale in Canada, and likely elsewhere. At the time of collection the data constituted the most current and detailed photo surveys of two of Canada's most northern highways constructed over ice-rich permafrost terrain, and will provide a valuable baseline to study past and future landscape change.

Project Partners

- Fisheries and Oceans Canada
- Government of Northwest Territories – NWT Centre for Geomatics
- Transport Canada
- University of Alaska – Alaska Center for Unmanned Aircraft Systems Integration (ACUASI)

Resource Quality

- Data capture was restricted to solar elevation angles >32 degrees above the horizon to avoid excessive illumination contrasts (e.g., on July 31 2019 this resulted in an observation window from 11:48 to 18:15 local time; 6 hours and 27 min).
- Images for the ITH missions were inspected and found to not be as sharp or clear as expected due to vibration of the camera and aperture settings which affected image focus and exposure. Camera adjustments were made prior to the Dempster missions but there was insufficient time to re-fly the ITH corridor to improve the image quality. Orthomosaics were “upscaled” from 6 cm to 10 cm resolution to reduce file size and effects of image blurriness.
- For the RPAS flights, the geotags of the JPEG images were post-processed using observation data at the Inuvik and Tuktoyaktuk Canadian Active Control Stations (CACS). Angular Inertial Measurement Unit observations were not used to constrain photogrammetric solutions. The GNSS base survey files for the GCP network were post-processed via Natural Resources Canada Precise Point Positioning (PPP) service, with average uncertainties of <0.01 m in latitude, longitude and 0.02 m ellipsoidal height.
- The positional quality of the orthomosaics and DEM chunks was measured by a select number of independent checkpoints, indicating a Root Mean Square Error (RMSE) of 0.20 m (X), 0.09 m (Y), and 0.16 m (Z) for the ITH datasets (n=8) and a RMSE of 0.23 m (X), 0.11 m (Y), and 0.15 m (Z) for the Dempster datasets (n=5). These metrics are within the expected uncertainties of 1-2 pixels horizontally, and <3 pixels vertically.
- The final DEM was water-masked based on a semi-automated classification of 2018 SPOT6/7 imagery. Vertical elevation data quality was assessed for the final mosaicked DEM using lower altitude RPAS surveys and 2011 LiDAR in bare-to-low vegetation areas, identified based on 2015 Natural Resources Canada 2015 landcover information. Vertical RMSEs ranged from 0.28 m (RPAS) to 0.47 m (LiDAR) for the ITH, or 4.5 to 7.6 pixels. Vertical RMSEs ranged from 0.19 m to

0.16 m for the Dempster, or 1.9 to 2.2 pixels. Improvements in image quality thus resulted in improved vertical accuracy.

Resource Dates

- July 26, 27, 28 of 2019 for ITH
- August 8, 2019 for Dempster

Resource Resolution

Original images and data chunks: 0.06-0.09 m

Post-processed: Pixel ground resolution: 0.1m (orthomosaic), 0.5 m (DEM)