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Final Report

For project:

Peterborough LiDAR

Prepared for:

**Ontario Ministry of Natural Resources and Forestry –
Provincial Mapping Unit
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Introduction

The Ontario Ministry of Natural Resources & Forestry contracted Airborne Imaging, A Clean Harbors Company, in the fall of 2016 to acquire and deliver digital elevation data derived from airborne LiDAR (Light Detection and Ranging) to cover three regions in Ontario: Cochrane, Peterborough and Lake Erie Watershed.

This report covers the fall 2016 and spring 2017 acquisitions of the Peterborough project and focuses on LiDAR acquisition details, such as flight parameters, project control, ground truthing results, data processing technique and deliverables.

This project started in early November 2016 but snow fall in early December prevented further data collection for 2016. The remaining data was acquired in the spring of 2017, with one more flight taking place in the fall of 2017. The Peterborough project totals 6815 km².

Project Schedule & Personnel

Roly Tang, an Airborne Imaging surveyor was sent to the Peterborough area on October 22, 2016 to establish the geodetic network and collect ground truth points. The go ahead from the Ontario government for the “leaf-off” condition for the Peterborough area was given on November 1st, 2016. The aircraft and Lidar system arrived in Peterborough on November 5. Since a second aircraft and Lidar system was assigned to the Cochrane area, Airborne Imaging juggled the two Lidar systems according to local weather forecasts to acquire Lidar data where the weather was most suitable. Priority was given to the Cochrane area.

A typical Lidar acquisition crew consisted of one Project Manager, one Lidar Operator and one Pilot. Due to crew rotation, various individuals were assigned to this project. Below is a list of personnel:

Project Manager

John Anderson
Paul Williams
Oscar Duran
Peter Stupan
Allyson Fox

Lidar Operator

Don Tarr
Gord Westergard
Andrew Blair
Roger Rutledge
Chris Johnson

Pilot

Pauline Seiter
Sebastian Proulx
Daniel Kockel
Thomas Sornasse
Owen Kamerman
Daniel Thibeault

The two aircrafts were dedicated to the Cochrane and Peterborough projects the entire time. Weather was unfortunately less than optimal in the Peterborough area and a total of eight missions were flown before snow and low temperatures halted acquisition with snow fall in southern Ontario the week-end of December 10, 2016.

On November 10, Airborne Imaging had the honor to show the airplane and Lidar system to Jeff Leal, the Ontario Minister of Agriculture, Food and Rural Affairs, and other government members involved with this project.

After snow melted in the Peterborough area, data acquisition resumed. Ten missions were flown between April 27 and May 23, 2017. By May 23rd, the amount of leaves in the trees reached a point where it was decided to halt acquisition until the fall of 2017. One more mission was collected on October 18, 2017 to wrap up data acquisition.

LiDAR System & Flight Parameters

KASI Aviation, from Montreal and Aries Aviation from Calgary provided the Piper Navajo aircrafts for this project. For the fall 2016 acquisition, the KASI aircrafts assigned to this project were C-GKSI and C-GMEC. For the spring 2017 acquisition, Aries aircraft C-FFRY was used as well as KASI C-GMEC. The aircraft used to fly the last mission in the fall of 2017 was KASI's C-GKSI.

The LiDAR systems utilized on this project were Leica ALS70-HP (serial numbers 7179 & 7207), capable of laser pulse rates up to 500,000 Hz with Multiple Pulse in the Air (MPIA) technology.

Flight Height: 1000 m AGL

Speed: 140 knots

Flightline Spacing: 550 m

Single Pass Swath width: 690 m

Overlap: 20%

Scan Angle or FOV: 38° effective (40° minus 1° clipped on each side of the scan edge)

Scan Frequency: 53Hz

Scan Pulse Rate: 500 KHz

Density: 8 Points per m²

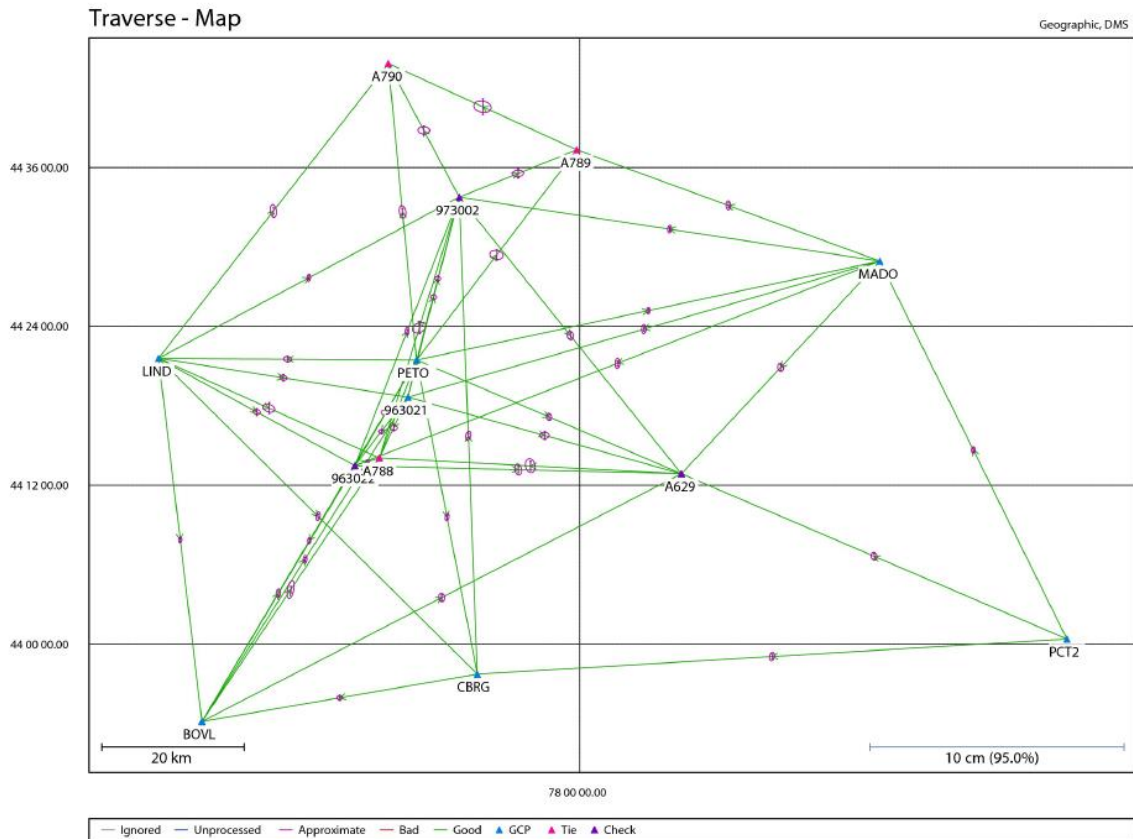
Project Control

A full geodetic network was observed locally to support the Lidar acquisition. Nine published government control stations were included in the network plus four newly established base stations to be used during Lidar collection and ground truth collection (A629 & A788 to A790). Six of the nine government stations are Canned permanent tracking stations (BOVL, CBRG, LIND, MADO, PCT2 & PETO). The other three government stations are permanent monuments (concrete pillars named Peterborough, Kendry and Burleigh Falls). The six Canned stations plus station Peterborough (963021) were held fixed in the fully constrained least-squares adjustment. The control network and therefore all subsequent Lidar data are based on the Nad83 CSRS (epoch 2010.0) horizontal datum and the CGVD2013 vertical datum. See summary table below for the points in our geodetic network.

Peterborough Control Listing

Station Name	Unique Id	Latitude	Longitude	Easting UTM17	Northing UTM17	H-Ellips (m)	Undul CGG2013	H-Orthom (m)
PETERBOROUGH	963021	44 18 38.77679	-78 18 10.44779	715107.561	4909928.492	208.280	-35.147	243.427
KENDRY	963022	44 13 28.37109	-78 23 45.98252	707977.946	4900110.699	165.691	-35.298	200.989
BURLEIGH FALLS	973002	44 33 45.82967	-78 12 44.99872	721363.720	4938157.128	212.683	-34.757	247.439
A629		44 12 52.45662	-77 49 15.30398	753963.472	4900621.081	109.718	-35.019	144.737
A788		44 14 03.08402	-78 21 10.82909	711385.808	4901291.840	154.032	-35.278	189.309
A789		44 37 20.21655	-78 00 19.42400	737567.752	4945355.077	228.560	-34.517	263.077
A790		44 43 51.95543	-78 20 13.81123	710851.905	4956529.143	283.998	-34.600	318.598
cannet-BOVL	BOVL	43 54 09.43395	-78 39 56.37639	687461.524	4863706.032	60.045	-35.876	95.921
cannet-CBRG	CBRG	43 57 43.04898	-78 10 49.66334	726201.775	4871512.832	54.756	-35.745	90.501
cannet-LIND	LIND	44 21 35.16869	-78 44 32.14729	679915.783	4914311.894	239.631	-35.219	274.851
cannet-MADO	CMAD	44 28 55.58591	-77 28 16.43241	780618.376	4931480.531	135.048	-34.283	169.331
cannet-PCT2	CPI2	44 00 23.00114	-77 08 30.37157	809305.342	4879823.175	66.987	-34.790	101.777
cannet-PETO	CPET	44 21 27.54136	-78 17 14.34069	716178.174	4915176.717	208.506	-35.068	243.573

Below is an overview map of the geodetic network.



See Appendix G at the end of this report for the Full Control Report with listings of:

- Final Adjusted Coordinates
- Traverse Overview
- Control Sheets
- Control Point Photos
- Traverse Report
- Minimally Constrained Network Adjustment
- Fully Constrained Network Adjustment

Check Points

Control check points were surveyed from different methods to use as vertical check and accuracy assessment. The kinematic method was used for calibration purposes, Fast Static and RTK methods for Non-Vegetated Vertical Accuracy Assessment (NVA) and the RTK method in vegetated areas for the Vegetated Vertical Accuracy Assessment (VVA).

Kinematic GPS

The first method called kinematic are profiles surveyed on open roads from a truck-mounted GPS receiver while driving. The post-processed kinematic coordinates, collected at an interval of one second are derived from a base station that is part of our geodetic network.

Whenever possible, we try to select roads that are perpendicular to the flight line azimuth so the control points intersect as many Lidar strips as possible. Kinematic points were collected along the roads following the green dots on the map below.

The output coordinates are analyzed and filtered to ensure only very reliable positions are kept. All points collected while moving slower than 2 meters per second are rejected. This removes all points when the truck was stationary that could skew the statistics.

The following points are also rejected:

- Points with a Quality Level worse than 1.
- Points with a forward/reverse vertical separation worse than 3 cm.
- Points with less than two solutions (forward & reverse).
- Points with a standard deviation worse than 2sigma.

Ten sections of road were surveyed throughout the project giving us more than 20,000 surveyed points on the road. We estimate that the vertical accuracy of these points is better than 5 cm.

During the calibration of the Lidar strips, the Lidar strips are matched vertically to these reliable kinematic points. These points are not used for the vertical accuracy assessment of the Lidar point cloud, but rather just for calibration monitoring and shifting.

Fast Static GPS

In order to meet the recommended ASPRS minimum number of points for a 6085 square kilometer project, fast static and RTK points were surveyed in areas distributed throughout the project.

The second method called Fast Static are individual points surveyed on open roads from a truck-mounted GPS receiver while staying stationary during a minimum of five minutes. The post-processed static coordinates are derived from a base station that is part of our geodetic network.

127 points were surveyed on the Peterborough project.

See the green circles on the map below.

These points are used just for the vertical accuracy assessment of the Lidar point cloud, and were not used to determine any vertical shift applied to the point cloud.

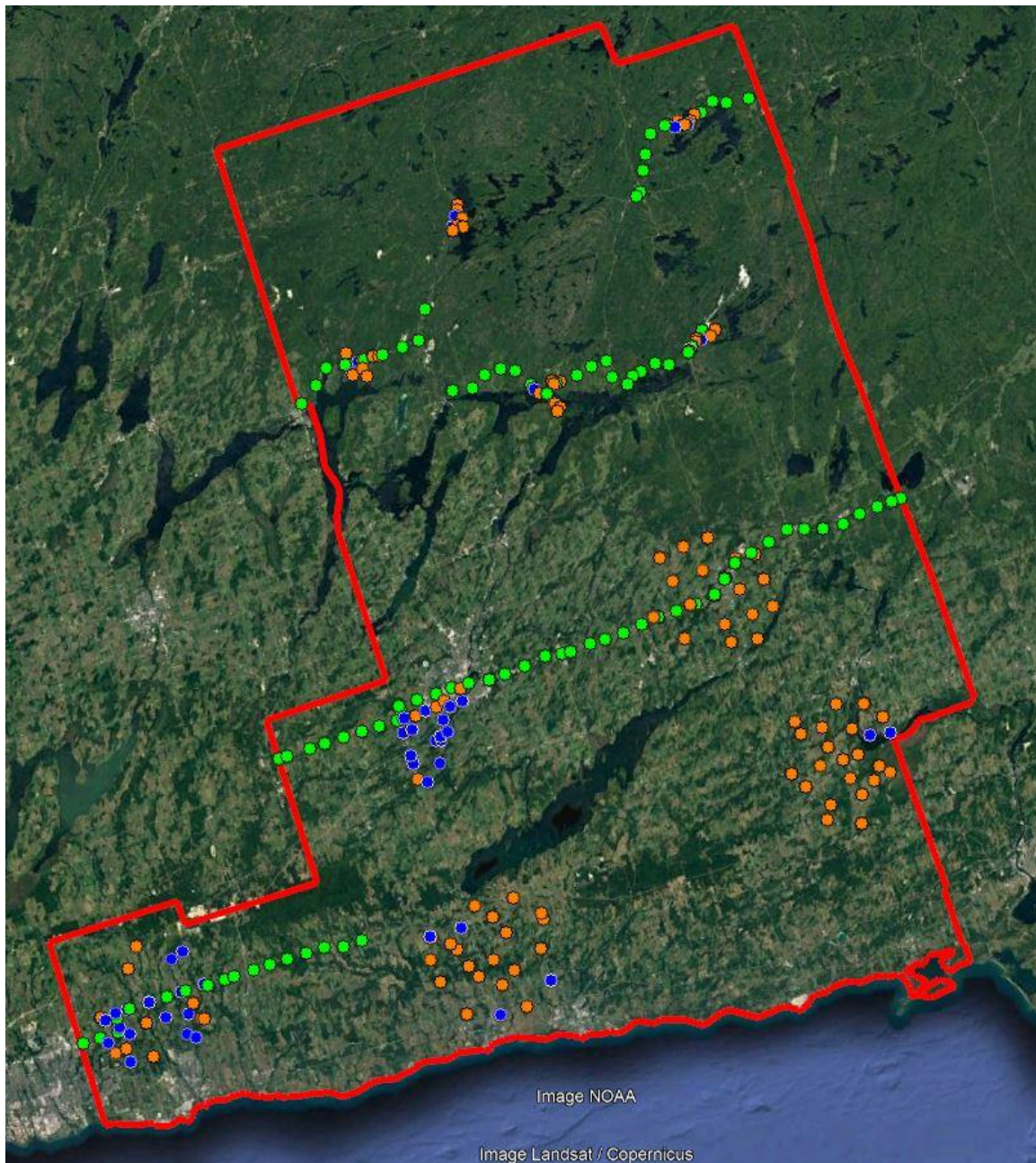
Real-time Kinematic GPS (RTK)

The third method called Real-Time Kinematic are individual points surveyed on open surfaces from a pole-mounted GPS receiver, surveyed while walking to various locations. A nearby base station broadcasted via radio modem the differential corrections to the roving GPS receiver. The surveyor held the pole and antenna in a fixed position for a period necessary for the differential corrections from the base station to indicate that a fixed solution was acquired. The static period usually last about six epochs (6 seconds). A full loss of lock on the satellites was intentionally induced by turning the antenna upside down and the points surveyed again as a check.

Another 223 points were surveyed in open areas distributed throughout the project. These points are used to assess the Non-Vegetated vertical Accuracy (NVA). See the orange circles on the map below.

These points are used just for the vertical accuracy assessment of the Lidar point cloud, and were not used to determine any vertical shift applied to the point cloud.

The same RTK method was used to survey points in vegetated areas like tall grass, crops, brush, weeds and different tree type covers. These points are used to assess the Vegetated Vertical Accuracy (VVA). 208 VVA points were surveyed in the same general areas as the NVA points. See the blue circles on the map below.



Red = project outline
Green = Fast Static, also corresponds to location of Kinematic ground truth runs
Orange = RTK (NVA)
Blue = RTK (VVA)

Field Calibration of Lidar Strips

Since the Peterborough Municipal Airport can be used as a base of operation for the entire project, only one calibration site has been established near the airport. The calibration site consists of a primary control station, and surveyed kinematic points on a road adjacent to the airport. Approximately 2km long strips of Lidar data are then flown with two passes in opposing directions during each mission. The flight lines are orientated perpendicular and centered over the kinematic points and nearby buildings. They are flown once at the start of mission, and a second time at the end of mission.

Calibration of raw LiDAR data for each flight mission is essential to meet the required accuracy. Airborne Imaging spends the extra time and effort to fly two calibration passes at the beginning and two more at the end of each mission. As the field Project Manager produces the point cloud in the field, he/she uses these calibration passes to calibrate the point cloud to the best of his ability. The boresight values between the mounted sensors are solved and monitored twice per mission. The inertial errors associated with aircraft sensor roll, pitch, and heading are normally stable and consistent. For the most part the changes between calibrations are minimal but monitoring it within missions and between missions gives us a better control on the systems' behaviors.

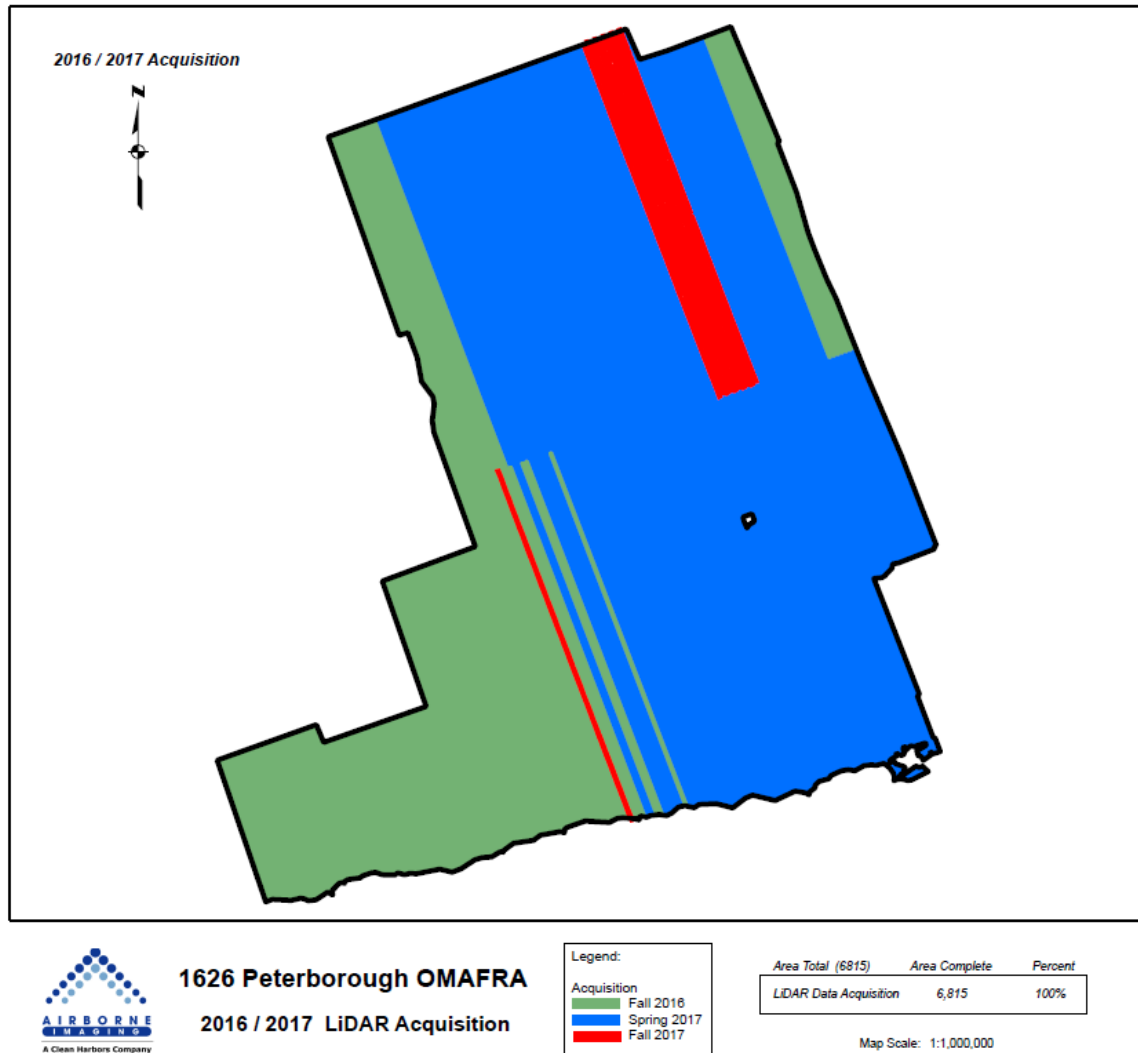
A final, more in depth calibration takes also place later when the field produced point cloud arrives in the office in Calgary.

Lidar Acquisition

The intent was to collect the entire 6815 square kilometer Peterborough project during the fall of 2016. Unfortunately, bad weather and the priority on the Cochrane area prevented the entire area from being all acquired during that short period. As mentioned in the "Project Schedule and Personnel" section above, two Lidar systems were used to acquire data on the Cochrane and Peterborough areas according to weather patterns between the two areas. Between the first week of November and the first week of December 2016, eight missions were acquired on the Peterborough project for a total of 2231 square kilometers.

After snow melted in the Peterborough area, data acquisition resumed. Ten missions were flown between April 27 and May 23, 2017. By May 23rd, the amount of leaves in the trees reached a point where it was decided to halt acquisition until the fall of 2017. One more mission was collected on October 18, 2017 to wrap up data acquisition.

See map below for the areas covered during the three seasons.



See Appendix A for the Daily Lidar Field Acquisition Report and Appendix B for the Mission Flightlogs.

LiDAR Data Processing

Tiling

Even though the project straddles UTM zones 17 and 18, the Ontario government instructed Airborne Imaging to deliver the entire Peterborough project in UTM zone 17. The point cloud is therefore tiled into 1000m X 1000m tiles based on the UTM17 projection. The extents fall on the even integer and the tiles named according to the lower left Easting and Northing (truncated). The software used for point cloud manipulation is TerraSolid's TerraScan/TerraModeler applications. At this stage, the files are stored in .las version 1.2.

Mission (lift) and flight line naming convention

Airborne Imaging's convention for naming missions (or lifts) is the following:

e.g. 0716288a where

07 is the Lidar system unique identifier. System 07 and 79 are Leica ALS70-HP.
16 is the collection year (2016)
288 is the Julian day of acquisition (sequential day of the year since January 1)
a is the sequential mission or lift of the day (a = 1st mission, b = 2nd mission, ...)

While importing the raw point cloud strips into tiles, the flight line numbers adopted are as follows.

e.g. 071628804 where

The first seven characters are the same as described in the mission folder name above, plus a sequential strip number for that day:

"04" is the fourth strip acquired that day, 05 is the fifth, ...

Note that the Leica ALS70 sensor measures data from two channels on each strip which we separate for calibration and manipulation purposes. Because of limitations of the 64bit field to store the strip identifier, we typically add 300 to the Julian day for the second channel.

So basically from sensor 07, on Julian Day 288, there would be two .las files for strip 04 named: 071628804 and 071658804.

Inside all .las files, the strip number (28804 and 58804) corresponds to the point source ID in the .las files. The Lidar system number is also stored in the .Las files in the "user_data" field.

Calibration

During field processing and after each mission, the point cloud strips from the "calibration passes" are compared to each other to ensure relative accuracy. The outside edges of scan can be compared in open areas to detect vertical differences which would point to roll or scale miss-calibration values. Man-made features such as pitched-roof buildings are also useful to check for horizontal alignment. If the calibration values (angles between the laser sensor and the IMU) are found to have changed from the previous mission, it would show in the repeatability of the measured data sets. Corrective measures would then be taken to fine tune the proper angular values. Once the data fit well together, it is compared to a ground profile to validate the elevations in an absolute accuracy point of view. Statistics and visual graphs of the elevation differences are produced to confirm accuracy requirements. Once the calibration values are obtained, the mission point cloud data is then generated in the field as preliminary calibrated. The point cloud and supporting files are burned to Blue-Ray discs and shipped to the processing center in Calgary.

Once the data has arrived in the office, an experienced calibration specialist reviews the field calibration. The strips are imported into tiles and the TerraMatch software is used to

assess and improve any flight line separation between passes. Typically, the adjustments are made on the entire mission for roll and pitch. Occasionally, further corrections are required by individual flight lines for roll, pitch and DZ.

Once the flight lines fit well relatively to one another, the unclassified point cloud is compared to the kinematic profiles surveyed on roads. If any vertical biases are observed, an elevation correction (DZ) is applied to the mission.

Below is a table of calibration tracking and statistical results after calibration and shifts.

1626_Peterborough Calibration/Kinematic results						
Mission	Tmach (yes/no)	Tmatch Description	DZ Applied	Statistics after Tmatch and after shift		
				Kinematic		
				Dz	Std Dev	RMS
7916311a	Y	RZ 3P	-1cm	-0.5cm	3.5cm	3.6cm
7916312a	Y	RZ 3P	+2cm	-0.4cm	2.0cm	2.1cm
7916315a	Y	RZ2 P	-1cm	-0.3cm	2.4cm	2.5cm
7916322a	Y	RZ2 P	+1cm	+0.5cm	3.7cm	3.7cm
7916322a_gaps	N	N/A	No	N/A	N/A	N/A
7916323a	Y	RZ P	-1cm	-0.0cm	1.8cm	1.8cm
7916339a	Y	RZ P	No	+0.0cm	2.6cm	2.6cm
7916339a_gaps	N	N/A	No	N/A	N/A	N/A
7917117a	Y	RPHZ	No	+0.8cm	1.6cm	1.8cm
7917119a	Y	RPZ	No	-0.6cm	3.3cm	3.4cm
7917124a	Y	RPZ	varies	-2.9cm	3.3cm	4.4cm
7917131a	Y	RPZ	varies	+0.3cm	3.4cm	3.4cm
7917135a	N	N/A	varies	-2.2cm	3.5cm	4.2cm
7917136a	Y	RPZ	+3cm	+0.2cm	4.7cm	4.7cm
7917137a	Y	RPZ	+3cm	-1.2cm	4.2cm	4.3cm
7917140a	Y	RPZ	No	+0.1cm	4.3cm	4.3cm
7917143a	Y	RPZ	+6cm	-0.4cm	5.0cm	5.1cm
7917144a	Y	RPZ	+4cm	-1.6cm	3.4cm	3.6cm
0716314a	Y	RZ P	-1cm	+0.2cm	2.2cm	2.2cm
0716315a	Y	P RZ2	-1cm	-0.1cm	2.8cm	2.8cm
0717291a	Y	RP	varies	+0.3cm	4.5cm	4.5cm

Intensity normalization

The native intensity values collected normally range between approximately 0 and 1000. They were then normalized to 16bit by multiplying their values by 64 with the Lastools software. The resulting intensities range between 0 and 65535.

Point Cloud Classification

Point classification is done with the TerraScan software, using macros that are set-up to measure the angles and distances between points to determine what classification a point should be: ground, non-ground, ... The angle and distance values in the macros can be varied to be more or less aggressive with the classification of points from the

unclassified class to ground by varying the incidence angles and estimated distances among neighboring points.

Following the USGS minimum classification scheme, the points are classified in the following classes:

Code	Description
1	Processed, but unclassified
2	Bare earth
7	Low noise
9	Water
10	Ignored ground (near a breakline)
17	Bridge decks
18	High noise

To better understand areas where the classification (mathematical models) did not represent the ground accurately, the points that are classified as bare earth are extracted and turned into viewable TIN and grid surfaces. These surfaces are viewed in conjunction with the point cloud for inspection of areas that appear rough, artificially flattened or cut, no data areas, or have other viewable anomalies. In cleaning up ground points, an effort is concentrated in areas where few ground points have been left in the bare earth model and the ground appears rough or lower and flatter than it may be in reality. The scarcity of ground points may be a result from no penetration through a dense vegetation layer, or too aggressive values with the macro. A manual inspection of these areas plays a major role in resolving any issues or irregularities with the bare earth model. A manual effort is also made to make sure that bridge decks have been classified to class 17. Both Bare Earth and Full Feature grids are created to visually inspect the data. The Bare Earth grids are produced by using the ground classified points, where the grid is created from the TIN. The Full Feature grids are produced by using all non-noise points and creating a grid surface of the highest elevations within the cell size.

Water Classification & Hydro-Flattening

Once the ground class has reached the final level of classification accuracy, the water delineation process is initiated. The rivers and water bodies are digitized as break lines according to USGS specifications of a minimum of 8000 m² for water bodies and 30 m nominal width for streams and rivers. Ponds and lakes have their elevations set constant to just below ground. Stream and river hydro lines are collected using the downstream method. Once all hydro lines have been collected for an area, the ground points inside the hydro lines are classified to class 9 – Water. The ground points outside of the hydro lines but within 35 cm are classified to class 10 – Ignored ground (near breaklines). Using the TIN of class 2 – Bare earth, the hydro lines are used as constraints to generate the final 50 cm hydro-flattened DEMs in XYZ format, then converted to Erdas .img format with the Global Mapper software.

Deliverables

Raw Point Cloud strips re-construction

Since the missions had to be tiled into manageable file sizes at the calibration stage, the Raw Point Cloud strips had to be re-constructed from the final calibrated and shifted tiles. Using the TerraScan and Lastools software, the strips were re-exported from the tiles, sorted by time and converted to .las version 1.4 with the proper datum information in OGC-WKT format. The strips were then compressed from .las to .laz format.

As mentioned above, even though the Peterborough project straddles the UTM zones 17 and 18, the entire project is projected in UTM zone 17 as per the client's instructions.

See below for a table of the folder structure and description of each deliverables.

Folder	Sub-Folder	Content and Description	
PETERBOROUGH_EPSG2958	DTM	Hydro-flattened 50cm Bare Earth DEMs, 1km X 1km (ERDAS Imagine .img format)	e.g. 1km176720487702016LPETERBOROUGH.img
	METADATA	Metadata, FGDC compliant (.xml format) for each of the following deliverables: Breaklines DEM Las Project Vertical comparisons between Lidar point cloud TIN surface and kinematic surveyed points (Excel format) Vertical comparisons between Lidar point cloud TIN surface and NVA Fast Static surveyed points (Excel format) Vertical comparisons between Lidar point cloud TIN surface and NVA RTK surveyed points (Excel format) Vertical comparisons between Lidar point cloud TIN surface and VVA RTK surveyed points (Excel format) Vertical comparisons between Lidar point cloud TIN surface and Ground Control surveyed points (Excel format) List of Lifts with flight parameters (Excel format) List of Geodetic control points with coordinates (Excel format) Final Lidar report (Word format) Final Lidar report (PDF format)	Peterborough_Lidar_metadata_Breaklines.xml Peterborough_Lidar_metadata_DEM.xml Peterborough_Lidar_metadata_LAS.xml Peterborough_Lidar_metadata_Project.xml Peterborough_NVA_Kinematic_comparisons_Final.xlsx Peterborough_NVA_FastStatic_comparisons_Final.xlsx Peterborough_NVA_RTK_comparisons_Final.xlsx Peterborough_VVA_RTK_comparisons_Final.xlsx Peterborough_Ground_control_comparisons_Final.xlsx Peterborough_lifts.xlsx Peterborough_ControlStationListing.xlsx Peterborough Lidar Final Report May 2018.doc Peterborough Lidar Final Report May 2018.pdf
	POINTCLOUD	Classified Point Cloud, 1km X 1km (zipped .las v1.4 format)	e.g. 1km176720487702016LPETERBOROUGH.laz
	PROJECT_POLYGON	Metadata per lift (or missions) with flight parameters, flight line number, ... (ESRI shape format) Hydro break lines (ESRI shape format) Project extent (ESRI shape format) Tile index (ESRI shape format)	e.g. 0716288a_Lift_metadata.shp Peterborough_hydro_breaklines_Final_revision_2018-04-10.shp Peterborough_project_extent.shp Peterborough_TileIndex.shp
	RAWPOINTCLOUD	Calibrated Raw Point cloud strips (one folder per lift), each strip separated for channel 1 & 2 (zipped .las v1.4 format)	e.g. 0716301a/071630103.laz (for channel 1) e.g. 0716301a/071660103.laz (for channel 2)

Vertical Accuracy Assessment

Kinematic

Below is a summary of the statistics between the point cloud TIN from the ground class and the kinematic points surveyed on the road:

Number of points:	20064	
Average dz:	-0.006	m
Minimum dz:	-0.174	m
Maximum dz:	0.147	m
Average magnitude:	0.027	m
Root mean square:	0.035	m
Std deviation:	0.034	m

Kinematic Vertical

Accuracy (95%): 0.069 m

For a complete listing of the kinematic points and their differences, please refer to the spreadsheet named "Peterborough_NVA_Kinematic_comparisons_Final.xlsx" provided with the deliverables.

This Kinematic vertical accuracy assessment is provided only as a reference. It is biased because during calibration, the point cloud was vertically shifted to these points. It should not be used as an independent check for accuracy assessments.

The independent assessment of vertical accuracy is made against the two "Non-Vegetated" points surveyed (Fast Static and RTK).

Fast Static

Below is a summary of the statistics between the point cloud TIN from the ground class and the fast static points surveyed on the road:

Number of points:	127	
Average dz:	-0.003	m
Minimum dz:	-0.154	m
Maximum dz:	0.156	m
Average magnitude:	0.032	m
Root mean square:	0.044	m
Std deviation:	0.044	m

Fast Static Vertical

Accuracy (95%): 0.086 m

See Appendix C for the List of Vertical Differences for the Fast Static points. The listing was also included as a spreadsheet with the deliverables. Please refer to the spreadsheet named "Peterborough_NVA_FastStatic_comparisons_Final.xlsx" provided with the deliverables.

This Fast Static vertical accuracy assessment can be used as an independent check for the Non-Vegetated Accuracy (NVA).

RTK (NVA)

Below is a summary of the statistics between the point cloud TIN from the ground class and the RTK points surveyed on the road (NVA):

Number of points:	223	
Average dz:	0.024	m
Minimum dz:	-0.145	m
Maximum dz:	0.137	m
Average magnitude:	0.037	m
Root mean square:	0.048	m
Std deviation:	0.042	m

RTK Vertical

Accuracy (95%): 0.094 m

See Appendix D for the List of Vertical Differences for the RTK (NVA) points. The listing was also included as a spreadsheet with the deliverables. Please refer to the

spreadsheet named "Peterborough_NVA_RTK_comparisons_Final.xlsx" provided with the deliverables.

This RTK vertical accuracy assessment can be used as an independent check for the Non-Vegetated Accuracy (NVA).

The required QLO NVA vertical accuracy for the project is 0.096 cm (95%). The above two independent checks prove that the data meets the NVA vertical accuracy requirements.

Geodetic Points

As an extra check, the points from the geodetic network that were flush with ground level were also compared to the Lidar ground surface.

Six stations are permanent tracking stations and three are mounted on concrete pillars. These nine stations can't be used as checks as their elevations are not referenced to ground level. Four of our stations (A629, A788, A789 & A790) have been compared to the Lidar elevations.

See Appendix E for the List of Vertical Differences for the Geodetic Points.

RTK (VVA)

The elevations of the points surveyed in various vegetated land cover types were compared to the Lidar ground surface. Since the elevation differences for this type of accuracy does not follow a normal distribution, the percentile method is used and not the 95% confidence level. For the 208 VVA points surveyed, sorting the absolute differences from the smallest to the largest gives the accuracy at the 95th percentile. For this sample, the 198th difference gives the accuracy at the 95th percentile.

For this project, the VVA accuracy is therefore 17.4 cm.

This is slightly above the required specifications of 14.7 cm (the QLO VVA specification).

See Appendix F for the List of Vertical Differences for the Vegetated Points. The listing was also included as a spreadsheet with the deliverables. Please refer to the spreadsheet named "Peterborough_VVA_RTK_comparisons_Final.xlsx" provided with the deliverables.

Conclusion

This is the final report covering the 2016 and 2017 portions of the Peterborough Lidar project. Topics such as field operations, control, data processing and final accuracy results were explained. The area was unfortunately not entirely acquired as originally planned within one season (mainly due to poor weather) but the full project was eventually entirely acquired in 2017. Vertical accuracies of non-vegetated surfaces meet the QLO requirement for this project.

Appendix A

Daily Lidar Field Acquisition Report

Project: 1626_OMAFRA_Peterborough

Date	Data Acquisition?	Mission 1	Mission 2	Description
November 1, 2016	No			Approval to fly the Peterborough area
November 2, 2016	No			Mobilization to Ontario
November 3, 2016	No			Mobilization to Ontario
November 4, 2016	No			Mobilization to Ontario
November 5, 2016	No			Aircraft C-GMEC arrives in Peterborough (System 79)
November 6, 2016	Yes	7916311a		One mission flown
November 7, 2016	Yes	7916312a		One mission flown
November 8, 2016	No			Aircraft maintenance 100-hr inspection
November 9, 2016	Yes	0716314a		One mission flown
November 10, 2016	Yes	7916315a	0716315a	Two missions flown & Minister Photo Op
November 11, 2016	No			Bad weather & repositioning to Cochrane
November 12, 2016	No			Two aircrafts in Cochrane
November 13, 2016	No			Two aircrafts in Cochrane
November 14, 2016	No			Bad weather & aircraft maintenance
November 15, 2016	No			Bad weather & aircraft maintenance
November 16, 2016	No			Aircraft with system 79 repositioning to Peterborough
November 17, 2016	Yes	7916322a		One mission flown
November 18, 2016	Yes	7916323a		One short mission flown
November 19, 2016	No			Bad weather
November 20, 2016	No			Bad weather / snow
November 21, 2016	No			Bad weather / snow
November 22, 2016	No			Bad weather / low occasional clouds
November 23, 2016	No			Bad weather
November 24, 2016	No			Bad weather
November 25, 2016	No			Bad weather
November 26, 2016	No			Bad weather
November 27, 2016	No			Bad weather
November 28, 2016	No			Bad weather
November 29, 2016	No			Bad weather
November 30, 2016	No			Bad weather
December 1, 2016	No			Bad weather
December 2, 2016	No			Bad weather
December 3, 2016	No			Bad weather
December 4, 2016	Yes	0716339a		One mission cut short by clouds
December 5, 2016	No			Bad weather
December 6, 2016	No			Bad weather

Daily Lidar Field Acquisition Report

Project: 1626_OMAFRA_Peterborough2017

	Aircraft One	C-FFRY	Leica (79)	Aircraft Two	C-GKSI	Leica (07)	
Date	Acquisition?	Mission 1	Mission 2	Acquisition?	Mission 1	Mission 2	Description
April 25, 2017	No			No			Poor weather. Aircraft and crew mobilize to Peterborough (C-FFRY/7109)
April 26, 2017	No						Poor weather
April 27, 2017	Yes	7917117a					System on Lake Erie project
April 28, 2017	No						Ceiling @ 3000' MSL; aborted mission with no lines completed
April 29, 2017	Yes	7917119a					System on Lake Erie project
April 30, 2017	No						Rain/low cloud
May 1, 2017	No						Periods of heavy rain
May 2, 2017	No						Rain showers
May 3, 2017	No						Clouds broken @ 4000' MSL
May 4, 2017	Yes	7917124a					System on Lake Erie project
May 5, 2017	No						Rain
May 6, 2017	No						Rain
May 7, 2017	No						Rain showers
May 8, 2017	No						Clouds broken @ 2000' MSL; isolated rain showers
May 9, 2017	No						Clouds broken @ 2000' MSL
May 10, 2017	No						Clouds scattered @ 3000' MSL
May 11, 2017	Yes	7917131a					System on Lake Erie project
May 12, 2017	No						Clouds broken @ 3000' MSL
May 13, 2017	No						Rain showers
May 14, 2017	No						Rain Showers; hail
May 15, 2017	Yes	7917135a					System on Lake Erie project
May 16, 2017	Yes	7917136a					Rain shower ended the mission

	Aircraft One	C-FFRY	Leica (79)	Aircraft Two	C-GMEC	Leica (79)	
Date	Acquisition?	Mission 1	Mission 2	Acquisition?	Mission 1	Mission 2	Description
May 17, 2017	Yes	7917137a		No			
May 18, 2017	No			No			Poor weather. Aircraft C-FFRY fly to Montreal. System 79 installed in C-GMEC
May 19, 2017	No			No			Clouds overcast @ 3000'. System 79 back in Peterborough.
May 20, 2017	No			YES	7917140a		
May 21, 2017	No			No			Rain
May 22, 2017	No			No			Rain showers
May 23, 2017	No			YES	7914143a		Clouds scattered @ 3000' MSL; 4 lines completed
May 24, 2017	No			YES	7917144a		
May 25, 2017	No			No			Acquisition stopped, leaf-on status reached. Demobilize from project area.
May 26, 2017	No			No			
May 27, 2017	No			No			
May 28, 2017	No			No			
May 29, 2017	No			No			
May 30, 2017	No			No			
Date	Aircraft One	C-FFRY	Leica (79)	Aircraft Two	C-GKSI	Leica (07)	Description
October 17, 2017				No			Ground crew mobilized to Peterborough
October 18, 2017				Yes	0717291a		C-GKSI mobilized to Peterborough, mission flown in the afternoon
October 19, 2017				No			C-GKSI mobilized to CYKF Kitchener for work on the Lake Erie project

Appendix B

Mission Flightlogs

Julian Day	311	Flight	A
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Date	2016/11/06	Aircraft	C5MRC
Project	1626 Peterborough	Pilot	Owen
Location	CYPQ	Operator	BRIAR
Mission Objective			

LIDAR Flight Log

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEM V
Roll Comp.	
Data Drive	4

Additional Notes	W - 230°C ZKTS Temp - 2 Ceiling - clear 012-30.41
	1493



Aircraft Block Time			
Engine On	1324	Ramp Out	Takeoff 1346
Engine Off	2040	Ramp In	Landing 2040
Total	7.4 hrs	Total	6.9 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40°

Static Alignment		GPS Time	
Pre Mission	1334	Start	End
Post Mission	2042	1339	2047

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	ALS Time Stamp	Comments
			Start	End	Time	nmi to End	
Calib CYPQ	791631101	072°	1357	1358		161106-135732	
Calib CYPQ	02	252°	1402	1402		140202	
Run In	-	G	1404	1409			
Kore BOVL	-	G	1410	1415			
1	03	341°	1420	1425		142009	
2	04	161°	1428	1433		142829	
3	05	341°	1437	1442		143722	
4	06	161°	1445	1451		145558	
5	07	341°	1454	1500		145458	
6	08	161°	1503	1508		150346	
7	09	341°	1513	1518		151317	
8	10	161°	1522	1527		152214	
9	11	341°	1532	1537		153205	
10	12	161°	1541	1546		154114	
11	13	341°	1550	1555		155026	

Julian Day 311	Flight 10
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Date 2016/11/06	Aircraft CGMEC
Project 1626 Peterborough	Pilot Owens
Location CYPG	Operator BJOR
Mission Objective	

LIDAR Flight Log

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEM V
Roll Comp.	
Data Drive	4

Additional Notes
WIND - 230° @ 2 kts
Temp - 2°C
Ceiling - Clear
Altimeter - 30.41



Aircraft Block Time			
Engine On 1324	Ramp Out	Takeoff 1341	
Engine Off 2048	Ramp In	Landing 2040	
Total 7A hrs	Total hrs	Total 6.9 hrs	

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	5000 Hz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
	Start	Start	End
Pre Mission	1334		1339
Post Mission	2042		2047

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		ALS Time Stamp	Comments
			Start	End	Time	nmi to End		
12	14	161°	1559	1604			161106-155924	
13	15	341°	1608	1614			160835	
14	16	161°	1617	1622			161744	
15	17	341°	1627	1633			162737	
16	18	161°	1636	1642			163645	
17	19	341°	1646	1652			164646	
18	20	161°	1655	1701			165552	
19	21	341°	1705	1711			170551	
20	22	161°	1714	1719			171445	
21	23	341°	1724	1730			172444	
22	24	161°	1733	1738			173328	
23	25	341°	1743	1748			174324	
24	26	161°	1752	1757			175216	
25	27	341°	1802	1807			180210	
26	28	161°	1811	1816			181106	



LIDAR Flight Log

Julian Day 311	Flight A
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Date 2016/11/06	Aircraft CGMEC
Project 1626 Peterborough	Pilot Owen
Location CYPQ	Operator BLOJAC
Mission Objective	

System	Leica ALS70
Unit	Z179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEM V
Roll Comp.	
Data Drive	4

Additional Notes
WIND - 230° @ 2Kts
Temp - 2°C
Ceiling clear
Altitude - 30.41

Aircraft Block Time			
Engine On 1324	Ramp Out	Takeoff 1346	
Engine Off 2048	Ramp In	Landing 2040	
Total 7.4 hrs	Total	hrs	Total 6.9 hrs

Mission Plan				
AGL Height	1000 m	Laser Pulse Rate	500K Hz	
Target Speed	140 kts	Scan Rate	53 Hz	
Laser Current	150 %	FOV	40 Deg's	

Static Alignment		GPS Time	
Pre Mission	1334	Start	End
Post Mission	2042	2042	2047

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	ALS Time Stamp	Comments
			Start	End	Time nmi to End		
27	29	341°	1821	1826		16106-182100	
28	30	161°	1830	1835		183037	
29	31	341°	1839	1844		183958	
30	32	161°	1848	1853		184820	
31	33	341°	1857	1902		185748	
32	34	161°	1906	1911		190618	
33	35	341°	1915	1920		191548	
34	36	161°	1924	1929		192416	
35	37	341°	1933	1939		193356	
36	38	161°	1942	1947		194239	
37	39	341°	1951	1956		195111	
XTIE	40	251°	2001	2011		200152	
KAR BOUL	-	G	2015	2020			
Calib CYPQ	41	072°	2030	2030		203026	
Calib CYPQ	42	252°	2033	2034		203349	

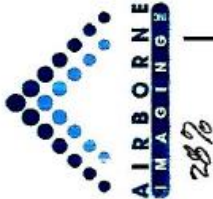
Julian Day 312	Flight A
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Date 2016/11/07	Aircraft CGMEP
Project 1626 Peterborough	Pilot Owen
Location CYPG	Operator B. AIR
Mission Objective	

LIDAR Flight Log

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEM V
Roll Comp.	
Data Drive	7179(1)

Additional Notes
 Wind - 200' @ 4Kts
 Temp 9°C
 Ceiling - Unlimited
 Vis - 15nm
 Altimeter - 30.43



Aircraft Block Time			
Engine On 1514	Ramp Out	Takeoff 1535	
Engine Off 1914	Ramp In	Landing 1905	
Total 4.0 hrs	Total	hrs	3.5

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500K Hz
Target Speed	140 kts	Scan Rate	5-3 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	1521	Start	End
Post Mission	1908	1526	1913

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		ALS Time Stamp	Comments
			Start	End	Time	nmi to End		
611b CYPG	791631201	072°	1543	1544			161107-154354	
611b CYPG	02	252°	1548	1549			154836	
Road To	—	G	1550	1555			—	
Kel Boul	—	G	1557	1602			—	
38	03	341°	1608	1613			160846	
39	04	161°	1618	1623			161808	
40	05	341°	1627	1632			162705	
41	06	161°	1636	1641			163638	
42	07	341°	1645	1651			164539	
43	08	161°	1655	1700			165525	
44	09	341°	1704	1710			170451	
45	10	161°	1714	1719			171440	
46	11	341°	1723	1729			172353	
47	12	161°	1734	1739			173401	
48	13	341°	1743	1748			174326	

AIRBORNE
IMAGING

Static Alignment	GPS Time	
	Start	End
Pre Mission	1521	1526
Post Mission	1808	1913

Pg 2 of 2



LIDAR Flight Log

Julian Day 314	Flight A
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Date 2016/11/09	Aircraft CGKSI
Project 1626 Peterborough	Pilot SOLWASSE
Location CYPR	Operator BLOIR
Mission Objective	

System Leica ALS70
Unit 7207
IMU Honeywell Micro IRS
GPS Rx NovAtel OEM V
Roll Comp.
Data Drive 7179 (1)

Additional Notes
Wind - 360° @ 12kts
Temp - 8°C
Ceiling - Unlimited
Vis - 15nm
RH - 30.03

230%

Aircraft Block Time			
Engine On 1958	Ramp Out	Takeoff 2020	
Engine Off 2357	Ramp In	Landing 2346	
Total 4.0 hrs	Total	hrs	3.4

Mission Plan			
AGL Height 1000 m	Laser Pulse Rate 500 kHz		
Target Speed 140 kts	Scan Rate 53 Hz		
Laser Current 100 %	FOV 40	Deg's	

Static Alignment		GPS Time	
Pre Mission	2010	Start	End
Post Mission	2351	2015	2356

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	ALS Time Stamp	Comments
			Start	End	Time	nmi to End	
Calib CYPR	071631401	252°	2028	2029			
Calib CYPR	02	072°	2033	2033			161109-202840
Rund In	—	G	2035	2040			203325
Kore A789	—	G	2045	2050			—
276	03	341°	2054	2100			205436
275	04	161°	2104	2116			210458
274	05	341°	2120	2132			212027
273	06	161°	2136	2147			213617
272	07	341°	2151	2203			215157
271	08	161°	2206	2217			220638
270	09	341°	2221	2233			222140 Possible mist @ end of line
269	10	161°	2236	2248			223658
276	11	341°	2252	2258			225234
Kore A789	—	G	2302	2307			—
Kore A788	—	G	2316	2321			—

Julian Day 315	Flight A
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Date 2016/11/10	Aircraft CGRCSI
Project 1626 Peterborough	Pilot THOMAS
Location CYPB	Operator BAZAR
Mission Objective	

System	Leica ALS70
Unit	7207
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEM V
Roll Comp.	
Data Drive	7/79(1)

Additional Notes
WIND 220° @ 6
Temp - 4°C
Ceiling - Unlimited
Vis - 15nm
Alt - 29.92



Aircraft Block Time			
Engine On 1311	Ramp Out	Takeoff 1329	
Engine Off 2008	Ramp In	Landing 1959	
Total 7.0 hrs	Total	hrs	6.5 hrs

Mission Plan			
AGL Height 1000	m	Laser Pulse Rate 500	Hz
Target Speed 140	kts	Scan Rate 53	Hz
Laser Current 100	%	FOV 40	Deg's

Static Alignment		GPS Time	
Pre Mission	1322	Start	End
Post Mission	2002	1327	2007

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	ALS Time Stamp	Comments
			Start	End	Time	nmi to End	
601b CYPB	071631501	072°	1336	1337			161110-133658
601b CYPB	02	252°	1342	1342			134208
53	03	161°	1348	1354			134846 HALF Line
54	04	341°	1359	1409			135907
55	05	161°	1413	1423			141355
56	06	341°	1427	1438			142738
57	07	161°	1442	1452			144226
58	08	341°	1456	1507			145632
59	09	161°	1510	1520			151057
60	10	341°	1525	1535			152517
61	11	161°	1540	1549			154019
62	12	341°	1553	1604			155341
63	13	161°	1608	1618			160859
64	14	341°	1622	1633			162255
65	15	161°	1637	1646			163717

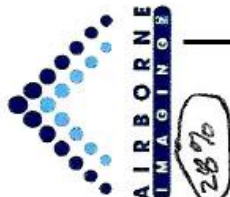
Julian Day 315	Flight A
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Date 2016/11/10	Aircraft CGKSI
Project 1626 Peterborough	Pilot Thomas
Location CYPQ	Operator Blair
Mission Objective	

LIDAR Flight Log

System	Leica ALS70
Unit	7207
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEM V
Roll Comp.	
Data Drive	7179(1)

Additional Notes
 Wind - 220° @ 6 kts
 Temp - 4°C
 Ceiling - unlimited
 Vis - 15nm
 Altitude - 29,92



Aircraft Block Time			
Engine On 1311	Ramp Out	Takeoff 1329	
Engine Off 2008	Ramp In	Landing 1959	
Total 7.0 hrs	Total	hrs	6.5 hrs

Mission Plan			
AGL Height 1000 m	Laser Pulse Rate 500 Hz		
Target Speed 140 kts	Scan Rate 53 Hz		
Laser Current 100 %	FOV 40 Deg's		

Static Alignment		GPS Time	
Pre Mission	1322	Start	End
Post Mission	2002	2002	2007

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	ALS Time Stamp	Comments
			Start	End	Time	nml to End	
66	16	341°	1650	1701			16110-165019
67	17	161°	1704	1713			170425
68	18	341°	1718	1729			171812
69	19	161°	1733	1742			173302
70	20	341°	1747	1757			174711
71	21	161°	1802	1812			180201
72	22	341°	1815	1826			181559
73	23	161°	1830	1840			183022
74	24	341°	1844	1859			184431
75	25	161°	1900	1912			190034
76	26	341°	1916	1928			191607
53	27	161°	1933	1937			27° Bank
Calib CYPQ	28	072°	1947	1947			Half line
Calib CYPQ	29	752°	1953	1954			194723
							1953



Additional Notes

System: Leica ALS70
 Unit: 7000 7179
 IMU: Honeywell Micro IRS
 GPS Rx: NovAtel OEMV
 Roll Comp.
 Data Drive: 4

Julian Day: 315 Flight: A
 Date: Nov 10, 2016 Aircraft: C-5 MEC
 Project: 1626 OMAERA Peterborough Pilot: P. Seiter
 Location: CYPQ Operator: O. Duran
 Mission Objective:

LIDAR Flight Log

Static Alignment		GPS Time	
Pre Mission	Post Mission	Start	End
14:00	19:52	14:05	19:57

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Aircraft Block Time			
Engine On	13:47	Ramp Out	14:09
Engine Off	20:00	Ramp In	19:52
Total	6.2 hrs	Total	5.7 hrs

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	ALS Time Stamp	Comments
			Start	End	Time	nmi to End	
CAL CYPQ	791631501	72	14:16	14:16		161110 - 141628	
CAL CYPQ	02	252	14:21	14:21		142107	
KAR A790	—	G	14:59	15:04		—	
177	03	161	15:14	15:20		151415	
178	04	341	15:25	15:37		152511	
179	05	161	15:41	15:53		154120	
180	06	341	15:56	16:08		155655	
181	07	161	16:12	16:24		161232	
182	08	341	16:28	16:39		162800	
183	09	161	16:44	16:55		164415	
184	10	341	16:59	17:12		165935	
185	11	161	17:16	17:28		171619	
186	12	341	17:32	17:44		173222	
187	13	161	17:48	18:00		174824	
188	14	341	18:04	18:16		180427	

Julian Day 322	Flight A
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Date 2016/11/17	Aircraft C6MFC
Project 1626 Peterborough	Pilot Seiter
Location CYPQ	Operator BJAIR
Mission Objective	

LIDAR Flight Log

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEM V
Roll Comp.	
Data Drive	/

Additional Notes
 WIND - 200° @ 3 kts
 Temp - 12°C
 Vis - 15km
 Ceiling - Unlimited
 Alt - 30,007

Aircraft Block Time			
Engine On 1808	Ramp Out	Takeoff 1823	
Engine Off 2239	Ramp In	Landing 2223	
Total 4.5 hrs	Total	hrs	4.0 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	520 kHz
Target Speed	140 kts	Scan Rate	54 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	1816	Start	End
Post Mission	2227	1821	2232

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		ALS Time Stamp	Comments
			Start	End	Time	nml to End		
Calib CYPQ	791632201	072°	1829	1830			16116-182942	
Calib CYPQ	02	252°	1833	1833			183328	
Gap 26	03	161°	1839	1840			183941	
Gap 24	04	341°	1843	1843			184300	
Gap 23	05	162°	1846	1847			184641	
Gap 27	06	341°	1851	1852			185130	
Gap 28	07	162°	1855	1856			185559	
Gap 21	08	162°	1900	1901			190007	
Gap 22	09	341°	1904	1905			190445	
Gap 29	10	161°	1908	1908			190829	
Gap 32	11	341°	1911	1912			19156	
Gap 31	12	161°	1916	1916			191623	
Gap 30	13	162°	1918	1919			191836	
Gap 25	14	162°	1921	1922			192155	
Gap 77	15	161°	1927	1928			192712	

Julian Day 322	Flight A
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LIDAR Flight Log



Date 2016/11/17	Aircraft CGMER
Project 1626 Peterborough	Pilot Senter
Location CYPQ	Operator BLAIR
Mission Objective	

System Leica ALS70
Unit 7179
IMU Honeywell Micro IRS
GPS Rx NovAtel OEM V
Roll Comp.
Data Drive 1

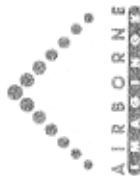
Additional Notes
 Wind-200° @ 3Kts
 Temp-12°C
 Vis-15nm
 Ceiling-unmixed
 Alt-30.07

Aircraft Block Time			
Engine On 1808	Ramp Out	Takeoff 1823	
Engine Off 2239	Ramp In	Landing 2223	
Total 4.5 hrs	Total hrs	Total 4.0 hrs	

Mission Plan			
AGL Height 1000 m	Laser Pulse Rate 500 Hz		
Target Speed 140 Kts	Scan Rate 54 Hz		
Laser Current 100 %	FOV 40 Deg's		

Static Alignment		GPS Time	
Pre Mission	1816	Start	End
Post Mission	2227	Start	End

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Abort		ALS Time Stamp	Comments
			Start	End	Time	nmi to End		
78	16	341°	1931	1943			161116-193122	
79	17	161°	1946	1958			194637	
80	18	341°	2001	2013			200124	
81	19	161°	2017	2028			201707	
82	20	341°	2032	2044			203204	
83	21	161°	2047	2059			204723	
84	22	341°	2102	2114			210249	
85	23	161°	2118	2129			211801	
86	24	341°	2132	2145			213250	
77	25	161°	2149	2200			214913	ABORT mission Due to Fog
Calib CYPQ	26	072°	2210	2211			221043	
Calib CYPQ	27	252°	2214	2215			221433	



LIDAR Flight Log

Julian Day 117	Flight A
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Date 27- APR - 2017	Aircraft PA-31 C-FFRY
Project 1628 OMAFRA Peterborough	Pilot D. Thibault
Location CYPQ Peterborough ON	Operator E. R. Rutledge
Mission Objective	

System Leica ALS 70
Unit 7179
IMU Honeywell Micro IRS
GPS Rx NovAtel OEMV
MPIA ENABLED
Data Drive 7179-4

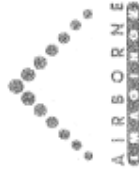
Additional Notes

Aircraft Block Time			
Engine On 12:53	Ramp Out 13:05	Takeoff 13:09	
Engine Off 14:25	Ramp In 14:18	Landing 14:15	
Total 6.5 hrs	Total hrs	Total 6.1 hrs	

Mission Plan			
AGL Height 1000 m	Pulse Rate 500,000 Hz		
Target Speed 140 kts	Scan Rate 53.4 Hz		
Laser Current 100 %	FOV 40 Deg's		

Static Alignment		GPS Time	
Pre Mission	12:58	Start	End
Post Mission	14:18	19:28	19:23

Flight Line	LDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End		
TEST STRIP		C	13:11	13:14			170427_131115	
CYPQ CALIB	TH11701	072.4°	13:15	13:15			131531	
CYPQ CALIB	02	252.4°	13:19	13:20			131936	
091	03	160.9°	13:28	13:40			132847	
092	04	340.9°	13:43	13:55			134330	
095	05	160.9°	13:58	14:11			135830	
096	06	340.9°	14:13	14:25			141357	
097	07	160.9°	14:29	14:42			142942	
098	08	340.9°	14:45	14:57			144530	
099	09	160.9°	15:00	15:12			150033	
101	10	340.9°	15:18	15:30			151843	
102	11	160.9°	15:34	15:47			153435	
103	12	340.9°	15:50	16:02			155053	
104	13	160.9°	16:07	16:19			160704	RANGE GATE 7 SOUTH END
105	14	340.9°	16:22	16:34			162249	



LIDAR Flight Log

Julian Day 117	Fight A
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Date 27-APR-2017	Aircraft PA-31 C-FRY
Project 1626 OMAFRA Peterborough	Pilot D. Thibault
Location CYPQ Peterborough ON	Operator E. R. Rutledge
Mission Objective	

System Leica ALS 70
Unit 7179
IMU Honeywell Micro IRS
GPS Rx NovAtel OEMV
MPIA E11A3442
Data Drive 7179-A

Additional Notes

Aircraft Block Time			
Engine On 12:53	Ramp Out 13:05	Takeoff 13:09	
Engine Off 19:25	Ramp In 19:18	Landing 19:15	
Total 6.5 hrs	Total hrs	Total 6.1 hrs	

Mission Plan			
AGL Height 1000 m	Pulse Rate 500,000 Hz		
Target Speed 140 kts	Scan Rate 53.4 Hz		
Laser Current 100 %	FOV 40	Deg's	

Static Alignment		GPS Time	
Pre Mission	12:58	Start	End
Post Mission	19:18	19:18	19:23

Fight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	Mission ID	Comments
			Start	End			
106	7179115	160.9°	16:33	16:52		170427_163851	
107	16	340.9°	16:55	17:07		165524	
108	17	160.9°	17:11	17:23		171119	
109	18	340.9°	17:23	17:40		172842	
110	17	160.9°	17:43	17:56		174353	
111	20	340.9°	18:00	18:12		180008	
112	21	160.9°	18:15	18:29		181559	
113	22	340.9°	18:32	18:44		183217	
X-TIE	23	251 +/-	18:50	18:57		185052	X-TIE LVL 140 → 090
CYPQ CALIB	24	072.4°	19:02	19:03		190250	
CYPQ CALIB	25	252.4°	19:07	19:07		190710	



**AIRBORNE
IMAGING**
A Clean Harbors Company

LIDAR Flight Log

Julian Day	119	Flight A
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Date	29-APR-2017	Aircraft	PA-31 C-FRYY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibault
Location	CYPQ Peterborough ON	Operator	E.R. Rudtledge
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPA	ENABLED
Data Drive	7179 - 1

Additional Notes	
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Aircraft Block Time			
Engine On	12:20	Ramp Out	12:32
Engine Off	17:56	Ramp In	17:48
Total	5.6 hrs	Total	5.2 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	12:27	Start	End
Post Mission	17:49	17:54	

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted	Time Stamp	Comments
			Start	End	Time	nmi to End	
TEST STRIP		G	12:39	12:41		170429 123916	
CYPQ CALIB	71711701	072.4°	12:42	12:43		124256	
CYPQ CALIB	02	252.4°	12:48	12:49		124842	
114	03	160.9°	12:57	13:09		125708	
115	04	340.9°	13:13	13:26		131351	
116	05	160.9°	13:30	13:42		133005	
117	06	340.9°	13:46	13:59		134632	HINT OF VIRGA, MIDDLE
118	07	160.9°	14:02	14:15		140243	
119	08	340.9°	14:19	14:31		141907	
120	09	160.9°	14:35	14:48		143526	
121	10	340.9°	14:52	15:05		145247	
122	11	160.9°	15:11	15:24		151147	HINT OF VIRGA, SOUTH END
123	12	340.9°	15:28	15:42		152857	
124	13	160.9°	15:45	15:58		154540	
125	14	340.9°	16:01	16:15		160153	

Flight A

Date	04-May-2017	Aircraft	PA-31 C-FFRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibeault
Location	CYPQ Peterborough ON	Operator	E.R. Rutledge
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPIA	EA1A3LED
Data Drive	7179 - A

Additional Notes

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A I R B O R N E

IMAGING

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Aircraft Block Time			
Engine On 12:10	Ramp Out 12:21	Takeoff 12:27	
Engine Off 13:22	Ramp In 13:35	Landing 13:42	
Total 66.2 hrs	Total	53 hrs	

Mission Plan		
AGL Height	1000 m	Laser Pulse Rate 500 KHz
Target Speed	140 kts	Scan Rate 53 Hz
Laser Current	100 %	FOV 40 Deg's

Static Alignment	GPS Time	
	Start	End
Pre Mission	12:15	12:20
Post Mission	12:15	12:20

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
TESS SERIP	—	G	12:29	12:32			170504_122913	
CPOCALIB	71712A01	252.4°	12:33	12:34			123353	
CPOCALIB	02	072.4°	12:37	12:38			123737	
AG29 KAR	—	G	12:46	12:51			N/A	
161	03	340.9°	12:53	13:00			125339	
130	04	160.9°	13:06	13:19			130629	
131	05	340.9°	13:23	13:36			132321	
132	06	160.9°	13:39	13:53			133429	
133	07	340.9°	13:56	14:09			135636	
134	08	160.9°	14:12	14:26			141245	
135	09	340.9°	14:29	14:41			142937	
136	10	160.9°	14:45	14:58			144529	SMALL BUOY FIRE w/ smoke
137	11	340.9°	15:02	15:14			150215	APPROX. 10 NM. FROM BOU
138	12	160.9°	15:18	15:31			151844	
139	13	340.9°	15:34	15:47			153451	

Julian Day 131 Flight 1A

LIDAR Flight Log

Date	May 11, 2017	Aircraft	PA-31 C-FFRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPVA	
Data Drive	1

Additional Notes	
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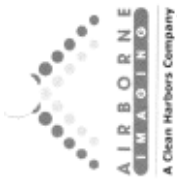


Aircraft Block Time			
Engine On	11:30	Ramp Out	Takeoff
Engine Off	18:15	Ramp In	Landing
Total	6.7 hrs	Total	6.2 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	11:42	Start	End
Post Mission	18:08	11:47	18:13

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
146	71713101	252.4	12:00	12:00			170511120008	
147	02	072.4	12:04	12:04			120427	
148		G	12:14	12:19				
149	c3	340.9	12:23	12:31			122355	
150	c1	160.9	12:35	12:48			123501	
151	c5	340.9	12:51	13:04			125135	
152	c6	160.9	13:08	13:21			130801	
153	c7	340.9	13:24	13:38			132443	
154	c8	160.9	13:43	13:56			134320	
155	c7	340.9	14:00	14:13			140000	
156	c0	160.9	14:16	14:30			141622	
	11	340.9	14:34	14:47			143403	
	12	160.9	14:51	15:04			145111	
	13	340.9	15:07	15:22			150743	
	14	160.9	15:24	15:38			152435	



LIDAR Flight Log

Julian Day 131 Flight 1A

Date	Nov 11/2017	Aircraft	PA-31 C-FRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibeault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MP/A	
Data Drive	1

Additional Notes	
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Aircraft Block Time			
Engine On	11:31	Ramp Out	Takeoff 11:54
Engine Off	18:15	Ramp In	Landing 18:05
Total	6.7 hrs	Total	6.2 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	11:42	Start	End
Post Mission	18:08	11:47	18:13

Flight Line	LIDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Time Stamp	Comments
157	71712115	340.9	15:42	15:55			154232	
158	16	160.9	15:58	16:12			155859	
159	17	340.9	16:16	16:29			161600	
160	18	160.9	16:32	16:45			163224	
KAR	—	G	16:52	16:57				
164	17	160.9	17:09	17:16			170925	
165	20	340.9	17:20	17:27			172005	
162	21	160.9	17:30	17:37			173011	
KAR	—	G	17:39	17:44				
CAL	22	252.4	17:53	17:53			175309	
CAL	23	072.4	17:56	17:57			175658	



LIDAR Flight Log

Julian Day 135 Flight 1A

Date	15.2017	Aircraft	PA-31 C-FRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibeault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPA	
Data Drive	H

Additional Notes	
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Aircraft Block Time			
Engine On	Ramp Out	Takeoff	18:54
Engine Off	Ramp In	Landing	
Total	hrs	hrs	hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	18:45	Start	End
Post Mission			18:50

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
CAL	17113501	072.4	18:59	19:00			170515185943	
CAL	02	252.4	19:03	19:03			190329	
KAR		05	19:13	19:18				
158	03	160.9	19:24	19:33			192455	REFLY SOUTH 2/Nmi
159	04	340.9	19:37	19:41			193717	REFLY SOUTH 9 Nmi
165	05	340.9	19:43	19:51			194345	
166	06	160.9	19:55	20:02			195511	
167	07	340.9	20:06	20:13			200601	
168	08	160.9	20:16	20:23			201629	
169	09	340.9	20:27	20:34			202700	
170	10	160.9	20:37	20:44			203743	
171	11	340.9	20:48	20:55			204842	
172	12	160.9	20:59	21:06			205926	
173	13	340.9	21:10	21:17			211020	
174	14	160.9	21:20	21:27			212058	

Julian Day 135 Flight 1A

LIDAR Flight Log

Date	May 15/17	Aircraft	PA-31 C-FRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPA	
Data Drive	4

Additional Notes	
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Aircraft Block Time			
Engine On	1840	Ramp Out	Takeoff 18:54
Engine Off	0110	Ramp In	Landing 01:00
Total	6.5 hrs	Total	6.5 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	18:45	Start	End
Post Mission	01:01	01:06	

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Abort		Time Stamp	Comments
			Start	End	Time	nmi to End		
175	71791515	340.9	21:31	21:39			213151	
176	71791515	160.9	21:42	21:49			214245	
KAR		G	21:53	21:58				A788
KAR		G	22:14	22:19				A790
177		160.9	22:25	22:31			222519	
191		340.9	22:36	22:48			223626	
192		160.9	22:51	23:03			225120	
193		340.9	23:06	23:18			230634	
194		160.9	23:21	23:33			232128	
195		340.9	23:36	23:49			233656	
196		160.9	23:52	00:04			235217	
197		340.9	00:08	00:20			000807	
198		160.9	00:23	00:27			002314	North 9 NM, FLOWN
KAR		G	00:30	00:35				
CAL		252.4	00:45	00:46			004556	
CAL		072.4	00:49	00:56			004947	

Julian Day 1360 Flight 1A

LIDAR Flight Log



System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MP/A	
Data Drive	1

Date	May 16, 2017	Aircraft	PA-31 C-FFRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

Additional Notes	
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Aircraft Block Time			
Engine On	13:32	Ramp Out	Takeoff 13:47
Engine Off	18:37	Ramp In	Landing 18:27
Total	5.1 hrs	Total	4.7 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	13:37	Start	End
Post Mission	18:29	13:37	13:42
		18:29	18:34

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
198	7117135-01	072.4	13:55	13:55			170516135507	170516 135507
199	02	252.4	13:59	13:59			135901	
200	03	0	14:10	14:15			142043	South 19 NMI
201	04	160.9	14:20	14:29			143227	
202	05	340.9	14:32	14:44			144723	
203	06	160.9	14:47	14:59			150242	5 NMI South END OFF LINE
204	07	340.9	15:02	15:14			151800	
205	08	160.9	15:18	15:29			153254	
206	09	340.9	15:32	15:44			154757	
207	10	160.9	16:03	16:15			160319	
208	11	340.9	16:18	16:30			1618	
209	12	160.9	16:33	16:45			16330	
	13	340.9	16:48	17:00			164837	
	14	160.9	17:04	17:16			170413	

Julian Day	136	Fight 1A
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LIDAR Flight Log



Date	May 16, 2017	Aircraft	PA-31 C-FFRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibeault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit#	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPIA	
Data Drive	

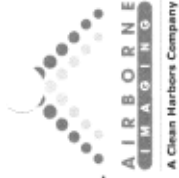
Additional Notes

Aircraft Block Time			
Engine On	3:32	Ramp Out	Takeoff
Engine Off	8:37	Ramp In	Landing
Total	5 hrs	Total	47 hrs

Mission Plan		
AGL Height	1000 m	Laser Pulse Rate 500 KHz
Target Speed	140 kts	Scan Rate 53 Hz
Laser Current	100 %	FOV 40 Deg's

Static Alignment	GPS Time	
	Start	End
Pre Mission	13:37	13:42
Post Mission	18:29	18:34

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LIDAR Flight Log

Julian Day	137	Flight	1A
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Date	May 17, 2017	Aircraft	PA-31 C-FFRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibeault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MP/A	
Data Drive	4

Additional Notes	
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Aircraft Block Time			
Engine On	12:31	Ramp Out	Takeoff 12:45
Engine Off	18:55	Ramp In	Landing 18:45
Total	6.4 hrs	Total	6.0 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	12:37	Start	End
Post Mission	18:47	12:41	18:52

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
212	791712701	072.4	12:50	12:51			125036	170517 125036
213	02	252.4	12:55	12:55			125522	
214		0	13:06	13:11			131441	South 18.55 nmi
215	03	160.9	13:14	13:22			132608	
216	04	340.9	13:26	13:38			134124	
217	05	160.9	13:41	13:53			135626	
218	06	340.9	13:56	14:08			14207	
219	07	160.9	14:12	14:24			142721	
220	08	340.9	14:27	14:39			144236	
221	09	160.9	14:42	14:54			145812	
222	10	340.9	14:58	15:10			151345	
223	11	160.9	15:13	15:25			152907	
	12	340.9	15:29	15:41			154457	
	13	160.9	15:44	15:56			160024	
	14	340.9	16:00	16:12				

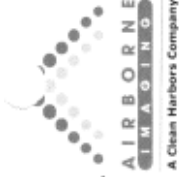
Julian Day 137 Flight 1A

LIDAR Flight Log

Date	May 17, 2017	Aircraft	PA-31 C-FFRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibeault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPIA	
Data Drive	4

Additional Notes



Aircraft Block Time			
Engine On	12:31	Ramp Out	Takeoff 12:45
Engine Off	18:55	Ramp In	Landing 18:45
Total	6.4 hrs	Total	6.0 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment		GPS Time	
Pre Mission	12:37	Start	12:41
Post Mission	18:47	End	18:52

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
224	7117315	160.9	16:15	16:27			161552	
225	16	340.9	16:31	16:43			163119	
226	17	160.9	16:47	16:59			164706	
227	18	340.9	17:02	17:14			1702	
228	19	160.9	17:18	17:20			171836	
229	20	340.9	17:33	17:45			173356	
230	21	160.9	17:49	18:01			174938	
231	22	340.9	18:05	18:12			180518	South 18 nmi flown
KAR	23	G	18:15	18:20			18	
CAL	23	252.4	18:33	18:34			183343	
CAL	24	072.4	18:37	18:37			183700	



LIDAR Flight Log

Julian Day	140	Flight	2A
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Date	May 20, 2017	Aircraft	PA-31 C-FFRY
Project	1626 OMAFRA Peterborough	Pilot	D. Thibeault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPIA	
Data Drive	I

Additional Notes	
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Aircraft Block Time			
Engine On	16:58	Ramp Out	Takeoff
Engine Off	22:35	Ramp In	Landing
Total	5.6 hrs	Total	5.1 hrs

Mission Plan			
AGL Height	1000 m	Laser Pulse Rate	500 KHz
Target Speed	140 kts	Scan Rate	53 Hz
Laser Current	100 %	FOV	40 Deg's

Static Alignment	GPS Time	
Pre Mission	Start	End
Post Mission	17:02	17:07
	22:25	22:30

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nm1 to End		
261	71714001	252.4	17:22	17:23			172241	170520
262	02	072.4	17:28	17:28			172808	
263		0	17:40	17:45				A790
264	03	070	17:53	18:07			175330	U1001
265	04	160.9	18:17	18:28			181744	
266	05	340.9	18:32	18:43			183218	
267	06	160.9	18:47	18:58			184739	
268	07	340.9	19:01	19:13			190152	
269	08	160.9	19:16	19:27			191639	
270	09	340.9	19:30	19:42			193059	
271	10	160.9	19:45	19:56			194517	
272	11	340.9	19:59	20:10			195919	
273	12	160.9	20:14	20:24			201355	
274	13	340.9	20:28	20:39			202800	
275	14	160.9	20:42	20:53			204241	

LIDAR Flight Log

Date	May 20, 2017	Aircraft	PA-31 C-FFRY
Project	1626 OMATRA Peterborough	Pilot	D. ThiBeault
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MPIA	
Data Drive	

Additional Notes

Aircraft Block Time				
Engine On	16:58	Ramp Out	Takeoff	17:16
Engine Off	20:35	Ramp In	Landing	22:22
Total	5.6 hrs	Total	5.1 hrs	

Mission Plan		
AGL Height	1000 m	Laser Pulse Rate 500 KHz
Target Speed	140 kts	Scan Rate 53 Hz
Laser Current	100 %	FOV 40 Deg's

Static Alignment	GPS Time	
	Start	End
Pre Mission	17:02	17:07
Post Mission	22:25	22:30

[illegible]

Julian Day	144	Flight 1A
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Date	May 24, 2017	Aircraft	PA-31 C-GMCE
Project	1626 OMAFRA Peterborough	Pilot	T. Sornasse
Location	CYPQ Peterborough ON	Operator	C. Johnson
Mission Objective			

System	Leica ALS70
Unit	7179
IMU	Honeywell Micro IRS
GPS Rx	NovAtel OEMV
MpiA	MpiA
Data Drive	A

Additional Notes

AIRBORNE
IMAGING

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LIDAR Flight Log

Aircraft Block Time			
Engine On	12:25	Ramp Out	Takeoff
Engine Off	16:30	Ramp In	Landing
Total	3.9 hrs	Total	3.4 hrs

Mission Plan		
AGL Height	1000 m	Laser Pulse Rate 500 KHz
Target Speed	140 kts	Scan Rate 53 Hz
Laser Current	100 %	FOV 40 Deg's

Static Alignment	GPS Time	
	Start	End
Pre Mission	12:32	12:37
Post Mission	16:12	16:17

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Time Stamp	Comments
			Start	End	Time	nmi to End		
CAL	791714A01	072.4	12:51	12:51			125131	170524
CAL	02	252.4	12:55	12:55			125525	
KAR		G	13:06	13:11				
231	03	340.9	13:19	13:24			131913	FLOW N NORTH 10.6 nmi
234	04	160.9	13:27	13:40			132744	
235	05	340.9	13:43	13:55			134316	
236	06	160.9	13:58	14:11			135851	
237	07	340.9	14:14	14:26			141440	20 nmi From The South Light
238	08	160.9	14:29	14:42			142940	11 nmi From The North Light
239	09	340.9	14:45	14:57			1445	13 nmi From The South Light
240	10	160.9	15:00	15:12			150014	7 nmi From The North Light
241	11	340.9	15:15	15:27			151508	20 nmi From The South Light
242	12	160.9	15:30	15:36			153038	FLOW N 12.6 nmi From North
KAR		G	15:40	15:45				2.7 nmi From North Light
CAL	13	252.4	15:58	15:58			155825	
CAL	14	072.4	16:02	16:03			160240	



LIDAR Flight Log

Julian Day 291 Flight A

Date 2017/10/18 Aircraft CGK51
 Project 1666 Overlook Ridge Road Pilot Brock 18
 Location CYPQ Operator R101R
 Mission Objective
 Complete A+ Black 2 and
 1 missing line from Black 1

System Leica ALS70
 Unit 7207
 IMU Honeywell Micro IRS
 GPS Rx NovAtel OEM V
 Roll Comp.
 Data Drive 7207/2

Additional Notes

Aircraft Block Time			
Engine On 1616	Ramp Out	Taxiout 1649	
Engine Off 2047	Ramp In	Landing 2034	
Total 4.5 hrs	Total hrs	Total 3.8 hrs	

Mission Plan			
AGL Height 1000 m	Laser Pulse Rate 500 Hz		
Target Speed 140 kts	Scan Rate 53 Hz		
Laser Current 100 %	FOV 40 Deg's		

Static Alignment		GPS Time	
Pre Mission	1628	Start	End
Post Mission	2038	1628	1633

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		ALS Time Stamp	Comments
			Start	End	Time	nm to End		
241b CYPQ	071729101	072°	1655	1656			171018/165546	1001 mag @ 138 Kts
241b CYPQ	02	252°	1700	1701			170040	1017 mag @ 126 Kts
Run In	-	G	1703	1708				
242	03	340°	1711	1723			171127	
243	04	160°	1727	1739			172718	
244	05	340°	1742	1754			174247	
245	06	160°	1758	1810			175827	
246	07	340°	1814	1826			181419	
247	08	160°	1829	1841			182954	
248	09	340°	1845	1857			184527	
249	10	160°	1900	1912			190041	
250	11	340°	1916	1927			191604	
251	12	160°	1931	1943			193121	
XTIE	13	250°	1946	1951			194635	
67	14	160°	2000	2012			200000	

Appendix C

List of Vertical Differences for the Fast Static points

Number	Easting	Northing	Known Z	Laser Z	Dz
7-1_01	751026.78	4924891.30	198.28	198.29	0.01
7-1_02	753148.73	4925436.59	201.16	201.19	0.04
7-1_03	754864.03	4926567.68	193.32	193.24	-0.08
7-1_04	756699.33	4927376.51	199.69	199.62	-0.07
7-1_05	758173.21	4928000.44	199.94	199.91	-0.03
7-1_06	759159.70	4928347.28	188.76	188.69	-0.07
7-1_07	751026.51	4924888.65	198.30	198.27	-0.03
7-1_08	749058.41	4924770.99	212.39	212.39	0.00
7-1_09	747218.62	4924663.69	213.72	213.73	0.01
7-1_10	745333.92	4923275.39	218.41	218.43	0.02
7-1_11	743522.12	4922083.86	221.32	221.34	0.02
7-1_12	741827.79	4920964.87	214.44	214.46	0.02
7-1_13	751026.25	4924888.81	198.31	198.27	-0.04
7-2_01	733901.02	4915008.58	215.83	215.80	-0.03
7-2_02	735820.63	4915718.39	214.82	214.82	0.00
7-2_03	737809.80	4916504.79	209.63	209.62	-0.01
7-2_04	739773.62	4917589.70	200.07	200.07	0.00
7-2_05	740787.03	4919216.22	198.55	198.51	-0.04
7-2_06	740827.44	4919383.46	202.26	202.25	-0.01
7-2_07	741828.61	4920964.25	214.43	214.43	0.00
7-2_08	740830.67	4919385.47	202.29	202.20	-0.09
7-2_09	740773.53	4919210.85	198.71	198.61	-0.10
7-2_10	733908.71	4915006.29	215.96	215.95	-0.01
7-2_11	732178.17	4914189.05	206.58	206.57	-0.01
7-2_12	730280.30	4913210.07	234.53	234.48	-0.05
7-2_13	728347.46	4912479.81	234.10	234.06	-0.04
7-2_14	726802.90	4911964.31	204.61	204.62	0.01
7-2_15	724738.06	4911045.10	223.87	223.86	-0.01
7-2_16	733901.62	4915007.39	215.82	215.82	0.00
7-3_01	716240.69	4907825.82	198.15	198.13	-0.02
7-3_02	717870.77	4908471.33	201.47	201.47	0.00
7-3_03	719957.33	4909385.15	203.51	203.50	-0.01
7-3_04	722089.24	4910508.90	209.87	209.89	0.02
7-3_05	723854.25	4910824.47	224.84	224.84	0.00
7-3_06	724731.74	4911043.01	223.86	223.89	0.03
7-3_07	716312.35	4907866.07	199.57	199.54	-0.03
7-3_08	714073.32	4907395.77	191.52	191.53	0.01
7-3_09	712290.08	4906831.47	195.98	195.99	0.01
7-3_10	710675.11	4906141.36	237.22	237.19	-0.03
7-3_11	708658.70	4905453.22	271.55	271.47	-0.08
7-3_12	706765.81	4904732.00	254.49	254.48	-0.01
7-3_13	716241.01	4907825.58	198.19	198.16	-0.03
C62001	734922.93	4966984.33	343.11	343.13	0.02
C62002	736684.16	4968331.35	329.67	329.66	-0.01
C62003	737882.03	4969569.94	314.20	314.23	0.03
C62004	739344.10	4969476.67	346.10	346.08	-0.02
C62005	741712.23	4969996.16	317.23	317.23	0.00
C62007	734939.84	4966983.13	343.06	343.04	-0.02
C62008	732911.13	4966830.39	343.57	343.61	0.04

C62009	731414.57	4965901.31	343.54	343.57	0.03
C62010	730935.22	4963723.42	331.40	331.41	0.01
C62011	730764.11	4962001.15	318.71	318.78	0.07
C62012	730555.13	4959703.85	304.65	304.61	-0.04
C62013	730134.95	4959252.91	301.36	301.41	0.05
C62014	734922.87	4966984.04	343.15	343.14	-0.01
CR3601	701880.88	4941070.52	278.95	278.95	0.01
CR3602	699923.35	4940475.77	263.44	263.48	0.04
CR3603	697928.45	4940080.07	249.02	249.02	0.00
CR3604	696898.18	4938194.14	269.12	269.11	-0.01
CR3605	695438.46	4936218.69	268.29	268.31	0.02
CR3607	701891.39	4941080.22	279.90	279.95	0.05
CR3608	703826.76	4941662.56	265.27	265.29	0.02
CR3609	705907.88	4942525.59	287.05	286.99	-0.06
CR3610	707613.57	4943303.16	296.54	296.62	0.08
CR3611	708168.74	4946621.53	303.26	303.30	0.04
CR3612	701856.58	4941079.58	278.71	278.75	0.04
gn1_01	681264.44	4872597.90	175.18	175.14	-0.04
gn1_02	679228.41	4871872.24	198.46	198.47	0.01
gn1_03	677952.43	4870797.65	197.67	197.64	-0.03
gn1_04	678116.84	4869343.03	168.27	168.25	-0.02
gn1_05	676248.79	4868680.69	186.17	186.18	0.02
gn1_06	674446.33	4868043.66	174.04	174.04	0.00
gn1_08	681247.45	4872590.73	175.25	175.25	0.00
gn1_09	683169.61	4873264.39	191.39	191.44	0.05
gn1_10	685139.44	4873969.75	216.06	216.05	-0.01
gn1_11	687474.48	4874630.13	195.43	195.59	0.16
gn1_12	689257.71	4875288.26	204.50	204.52	0.02
gn1_13	690229.92	4875657.37	232.27	232.37	0.10
gn1_14	681264.85	4872597.63	175.19	175.16	-0.03
gn2_01	697786.55	4878359.61	193.88	193.89	0.01
gn2_02	695825.23	4877688.47	216.61	216.58	-0.03
gn2_03	693987.01	4877048.17	297.39	297.34	-0.05
gn2_04	692281.86	4876418.28	266.98	266.89	-0.09
gn2_05	690229.45	4875657.07	232.35	232.37	0.02
gn2_06	697815.73	4878370.68	193.32	193.34	0.02
gn2_07	699681.05	4879048.48	187.66	187.66	0.00
gn2_08	701723.11	4879191.17	206.38	206.37	-0.01
gn2_09	701723.11	4879191.17	206.38	206.37	-0.01
gn2_10	703659.41	4879906.63	202.40	202.38	-0.02
gn2_11	697785.43	4878359.28	193.93	193.92	-0.01
h28_01	721364.32	4938124.29	243.00	242.97	-0.03
h28_02	722304.08	4939275.16	253.36	253.37	0.02
h28_03	724457.17	4940173.95	251.71	251.71	0.00
h28_04	725973.18	4941148.23	280.57	280.69	0.12
h28_05	727532.24	4941797.41	260.12	260.15	0.03
h28_06	728207.81	4940104.86	262.33	262.30	-0.03
h28_07	729857.83	4939410.64	245.44	245.36	-0.08
h28_08	730382.94	4940290.80	244.22	244.21	-0.01
h28_09	731223.53	4940779.50	244.42	244.38	-0.04

h28_10	729861.01	4939407.98	245.32	245.27	-0.05
h28_11	721357.27	4938187.56	243.05	243.05	0.00
h28_12	719626.64	4939035.83	246.18	246.17	-0.01
h28_13	717921.76	4940448.54	250.02	250.04	0.02
h28_14	716365.11	4940586.62	281.48	281.50	0.02
h28_15	714713.71	4939903.94	301.64	301.68	0.04
h28_16	713457.86	4938451.67	254.20	254.14	-0.06
h28_17	711374.47	4938109.92	245.05	244.97	-0.08
h28_18	721364.64	4938123.74	243.06	243.00	-0.06
Stew01	702947.10	4901938.95	285.01	285.04	0.03
Stew02	701028.79	4901263.31	271.54	271.53	-0.01
Stew03	699067.36	4900531.24	252.68	252.69	0.01
Stew04	697499.26	4899936.48	331.88	331.90	0.03
Stew05	695114.08	4899058.69	351.47	351.45	-0.02
Stew06	694265.07	4898756.51	348.42	348.41	-0.01
Stew07	702950.89	4901924.61	284.60	284.68	0.08
Stew08	704767.94	4902556.56	247.61	247.66	0.05
Stew09	706652.76	4903216.27	252.85	252.89	0.04
Stew10	706953.34	4904395.17	252.06	252.07	0.01
Stew11	706764.30	4904729.61	254.54	254.51	-0.03
Stew12	702947.73	4901937.26	284.97	285.01	0.05
ston01	737559.70	4945340.99	263.15	263.00	-0.15
ston02	736507.61	4943578.58	247.96	247.97	0.01
ston03	736178.99	4942981.68	245.94	245.98	0.04
ston04	734173.08	4941620.64	241.32	241.37	0.05
ston05	732707.76	4941714.12	248.21	248.26	0.05
ston06	731225.53	4940780.11	244.45	244.41	-0.04
ston07	737560.12	4945338.35	263.20	263.14	-0.06

Average dz -0.003 m
 Minimum dz -0.154 m
 Maximum dz 0.156 m
 Average magnitude 0.032 m
 Root mean square 0.044 m
 Std deviation 0.044 m

Appendix D

List of Vertical Differences for the RTK points

Number	Easting	Northing	Known Z	Laser Z	Dz
1006	711369.74	4901293.13	190.07	190.05	-0.02
1007	711349.25	4901294.88	189.29	189.29	0.01
1008	710826.42	4901233.80	190.97	190.99	0.02
1009	710835.29	4901234.54	190.89	190.92	0.03
1010	710841.72	4901244.67	191.20	191.18	-0.02
1011	712030.47	4902192.76	187.82	187.78	-0.04
1012	711514.07	4903420.21	190.90	190.88	-0.02
1013	711531.90	4903433.44	190.02	190.03	0.01
1014	712202.92	4904857.29	190.58	190.66	0.08
1015	712210.41	4904881.10	190.63	190.66	0.03
1016	713463.02	4905468.50	188.81	188.86	0.05
1017	713415.22	4905460.92	189.62	189.67	0.05
1018	713239.93	4906809.28	191.30	191.34	0.04
1019	713264.78	4906783.40	191.14	191.17	0.03
1020	711583.54	4905439.04	194.57	194.64	0.07
1021	710692.63	4904777.63	212.14	212.17	0.03
1022	710744.84	4904768.73	209.64	209.70	0.06
1023	709592.37	4904310.27	247.21	247.22	0.01
1024	708592.93	4903762.91	226.57	226.56	-0.01
1025	708578.83	4903766.05	226.21	226.26	0.05
1027	708112.45	4902246.34	210.00	210.10	0.10
1028	707339.35	4903493.09	244.78	244.88	0.10
1029	707317.99	4903465.34	245.34	245.41	0.07
1030	707363.00	4901943.01	200.96	201.00	0.04
1031	708480.98	4898683.41	200.25	200.29	0.04
1032	708484.00	4898710.50	200.39	200.38	-0.01
1033	709037.52	4897085.21	194.25	194.26	0.01
1034	710047.57	4896842.02	190.36	190.40	0.04
1035	711312.14	4898846.73	187.03	187.06	0.03
1036	711300.44	4898825.64	187.11	187.11	0.01
1037	708211.69	4899553.70	200.84	200.85	0.02
1038	681267.03	4872589.97	175.49	175.48	-0.01
1039	679005.27	4871785.66	200.41	200.40	-0.01
1040	676221.24	4870803.48	208.14	208.15	0.01
1041	676233.73	4870822.32	207.43	207.47	0.04
1042	676245.54	4870838.82	207.38	207.38	0.00
1043	676715.42	4870569.19	205.61	205.64	0.03
1044	676767.97	4870532.30	206.40	206.51	0.12
1045	677786.67	4871381.27	201.16	201.16	0.00
1046	677777.74	4871347.26	200.98	200.88	-0.10
1047	678281.70	4869854.55	171.53	171.50	-0.03
1048	677118.90	4868178.25	163.04	163.06	0.02
1049	677892.09	4867078.14	150.05	150.08	0.03
1050	677939.94	4867121.66	151.28	151.29	0.01
1051	679560.46	4866207.21	150.47	150.44	-0.03
1053	679049.91	4867629.39	152.28	152.28	0.00
1054	679362.29	4869177.19	165.21	165.21	0.00
1055	681992.77	4866773.23	155.23	155.21	-0.02
1056	681946.22	4866913.61	155.29	155.30	0.01

1057	681078.83	4870428.80	165.22	165.19	-0.03
1058	681063.05	4870411.78	166.17	166.19	0.02
1059	681071.37	4870429.02	165.45	165.40	-0.05
1060	683109.55	4871104.24	178.57	178.57	0.00
1061	685526.67	4871556.07	165.50	165.48	-0.02
1062	685422.05	4869401.67	147.51	147.47	-0.04
1064	687209.41	4871081.91	153.12	153.13	0.01
1065	686916.37	4871094.17	152.80	152.80	0.00
1066	686000.64	4872688.55	159.90	159.87	-0.03
1067	686006.03	4872689.94	159.52	159.55	0.03
1068	684714.08	4873803.60	197.81	197.83	0.03
1069	684720.71	4873830.62	198.54	198.55	0.01
1070	687060.09	4874644.71	191.46	191.46	0.00
1071	683526.70	4877260.75	233.54	233.53	-0.01
1072	683522.71	4877252.53	232.73	232.77	0.04
1073	684669.35	4878113.61	295.73	295.71	-0.02
1074	679780.81	4878482.47	263.67	263.68	0.01
1075	678965.92	4876075.71	250.51	250.45	-0.06
1076	678967.22	4876056.80	249.85	249.84	-0.01
1077	739725.38	4917461.00	197.51	197.62	0.11
1078	739772.30	4917465.15	198.21	198.24	0.03
1079	740965.43	4914479.41	213.67	213.71	0.04
1080	741700.02	4912619.99	230.49	230.52	0.03
1081	741695.07	4912623.91	230.13	230.23	0.10
1082	744476.37	4913048.71	213.90	213.95	0.05
1083	744471.20	4913034.92	214.38	214.42	0.04
1084	743841.90	4915616.05	223.68	223.72	0.04
1085	745972.35	4916518.58	203.83	203.94	0.11
1086	744932.63	4919340.52	239.20	239.20	0.00
1087	744919.22	4919355.68	238.58	238.66	0.08
1088	743886.69	4921943.15	222.21	222.26	0.05
1089	743876.72	4921953.05	222.18	222.30	0.13
1090	741859.44	4921411.46	233.68	233.71	0.03
1091	738866.62	4923512.25	235.88	235.84	-0.04
1092	738832.59	4923490.68	235.78	235.74	-0.04
1093	736317.71	4922502.49	232.75	232.75	0.00
1094	733873.69	4921245.40	222.84	222.93	0.09
1095	735315.58	4918830.73	230.58	230.62	0.04
1096	738432.60	4920061.98	216.33	216.35	0.02
1097	742426.62	4918200.06	222.77	222.77	0.00
1098	736769.75	4912815.43	196.00	196.02	0.02
1099	733413.99	4914979.98	197.01	197.02	0.01
1101	737225.38	4916445.62	222.36	222.34	-0.02
1102	737274.61	4916313.04	214.59	214.54	-0.05
1103	717660.67	4878327.70	189.01	188.99	-0.02
1104	718674.97	4875719.46	114.86	114.87	0.01
1105	718682.01	4875722.95	114.95	114.93	-0.02
1106	721320.32	4873495.28	112.18	112.17	-0.01
1107	721328.53	4873508.73	111.88	111.93	0.05
1108	718602.23	4872450.78	122.64	122.66	0.02

1109	715019.84	4872493.02	145.50	145.53	0.03
1110	714994.98	4872515.27	144.77	144.77	0.01
1111	712100.33	4875803.63	146.62	146.59	-0.03
1112	712097.83	4875817.19	147.20	147.30	0.10
1113	711000.73	4878086.86	181.47	181.50	0.03
1114	715078.73	4877562.81	162.26	162.28	0.02
1115	715073.60	4877580.70	163.31	163.30	-0.01
1116	716148.49	4876499.23	144.08	144.09	0.01
1117	716172.61	4876522.44	145.47	145.46	-0.01
1118	713772.08	4879267.91	175.89	175.92	0.03
1119	713036.72	4879851.41	207.86	207.89	0.03
1120	713044.47	4879859.81	207.30	207.31	0.02
1121	711053.06	4880396.67	194.63	194.59	-0.04
1122	710832.26	4880501.43	199.08	199.12	0.04
1124	715476.58	4883944.49	206.13	206.17	0.04
1125	717424.02	4882851.12	230.41	230.44	0.03
1126	717419.00	4882864.30	230.91	230.93	0.02
1127	719539.67	4884928.30	253.76	253.81	0.05
1128	719528.44	4884941.44	253.80	253.88	0.08
1129	718899.16	4881242.06	221.87	221.86	-0.01
1130	718897.66	4881261.92	222.39	222.38	-0.01
1131	722555.32	4883430.69	302.69	302.75	0.06
1132	722796.84	4882801.10	306.42	306.51	0.09
1133	722627.50	4879674.52	168.47	168.61	0.14
1134	722641.49	4879676.70	168.53	168.58	0.06
1136	719891.34	4877290.19	154.84	154.93	0.09
1137	719901.23	4877275.55	154.77	154.82	0.05
1139	737553.53	4945360.88	262.89	262.74	-0.15
1140	736962.58	4944426.01	261.44	261.43	-0.01
1141	736957.53	4944465.28	260.61	260.67	0.06
1142	736886.33	4944131.53	257.70	257.67	-0.03
1143	736558.70	4943636.68	248.90	248.88	-0.02
1144	736240.50	4943156.02	248.97	249.05	0.08
1145	736231.69	4943162.11	249.61	249.64	0.03
1146	738469.22	4944778.18	277.55	277.53	-0.02
1147	738932.05	4945470.34	273.95	273.97	0.02
1148	738940.36	4945466.77	274.00	273.99	-0.01
1149	721403.43	4938162.54	242.68	242.65	-0.03
1150	721415.97	4938136.00	242.49	242.52	0.03
1151	722732.61	4939458.04	256.92	256.96	0.04
1152	722056.95	4939178.34	254.36	254.39	0.03
1153	721874.77	4939492.35	265.26	265.32	0.07
1154	721830.03	4939469.48	263.44	263.51	0.07
1155	722231.94	4937104.56	239.98	240.01	0.03
1156	722535.21	4936336.26	262.37	262.46	0.09
1157	722523.89	4936332.41	263.06	263.10	0.04
1158	722814.73	4936728.04	261.93	261.99	0.06
1159	720579.47	4938145.46	244.71	244.71	0.00
1160	719942.51	4938677.05	246.67	246.65	-0.02
1161	753960.07	4900607.62	144.36	144.41	0.05

1162	753991.62	4900613.05	143.76	143.82	0.06
1163	755499.88	4901230.06	123.59	123.64	0.05
1164	755484.77	4901240.50	123.51	123.52	0.01
1165	754793.91	4903888.90	120.46	120.49	0.03
1166	754806.07	4903884.83	120.07	120.16	0.09
1167	753021.33	4906458.13	157.18	157.24	0.06
1168	755946.88	4906588.08	131.98	132.03	0.06
1169	755959.49	4906588.85	132.08	132.18	0.10
1170	756059.31	4906552.15	132.12	132.18	0.06
1171	758019.07	4905260.65	135.99	136.09	0.10
1172	758022.47	4905256.12	136.11	136.14	0.03
1173	756744.23	4903266.44	135.62	135.75	0.13
1174	756808.22	4903301.20	127.20	127.26	0.07
1175	758886.51	4903570.77	115.64	115.64	0.00
1176	751634.96	4903942.21	152.53	152.59	0.06
1177	748726.61	4904476.55	197.90	198.00	0.10
1178	748712.88	4904463.42	198.16	198.18	0.02
1179	749393.95	4903176.47	165.30	165.29	-0.01
1180	749383.51	4903182.38	164.69	164.72	0.03
1181	748552.09	4898957.55	142.45	142.45	0.00
1182	748539.84	4898956.60	142.69	142.75	0.06
1183	748564.32	4898933.33	142.85	142.87	0.02
1184	751558.14	4899910.11	135.88	135.88	0.00
1185	752305.43	4901896.50	127.84	127.90	0.06
1186	752308.18	4901877.91	127.52	127.56	0.05
1187	754793.76	4898675.16	116.98	117.08	0.10
1189	756089.07	4897019.64	128.23	128.22	-0.01
1190	756099.91	4897015.98	127.51	127.58	0.07
1192	757308.30	4898534.34	125.48	125.54	0.07
1193	758977.99	4899462.11	115.54	115.60	0.06
1194	757809.14	4900084.96	121.82	121.89	0.07
1195	757784.11	4900115.12	118.82	118.91	0.09
1196	756140.69	4893953.75	129.42	129.46	0.04
1197	756159.75	4893924.47	129.84	129.87	0.03
1198	756139.99	4893898.48	130.06	130.10	0.04
1199	752494.69	4894231.53	212.21	212.18	-0.03
1200	752835.20	4895833.60	183.91	183.97	0.06
1201	752802.06	4895816.34	184.94	184.92	-0.02
1202	750092.98	4897651.44	136.51	136.54	0.03
1203	750076.72	4897641.33	136.74	136.81	0.07
1204	711015.94	4956570.45	316.64	316.60	-0.04
1205	710769.82	4955436.91	313.39	313.37	-0.02
1206	711328.87	4955562.72	301.46	301.45	-0.01
1207	710821.48	4955012.62	312.96	313.01	0.05
1208	710857.07	4955010.15	314.06	314.11	0.05
1209	711243.63	4957733.91	312.70	312.72	0.02
1210	711223.76	4957731.80	313.21	313.29	0.08
1211	711228.01	4957201.13	313.25	313.27	0.02
1212	711774.28	4956324.64	304.85	304.86	0.01
1213	711904.99	4955407.14	297.77	297.80	0.03

1214	711887.50	4955408.54	298.07	298.13	0.06
1215	701666.42	4941004.91	268.35	268.33	-0.02
1216	702829.98	4941464.43	286.97	286.98	0.01
1217	702826.74	4941480.86	286.45	286.42	-0.03
1218	702890.31	4941507.42	287.20	287.18	-0.02
1219	703453.85	4941512.01	281.50	281.49	-0.01
1220	702263.92	4939348.93	271.55	271.54	-0.01
1221	701768.90	4940155.09	270.49	270.47	-0.02
1222	699970.17	4941704.40	277.74	277.72	-0.02
1223	699802.17	4940432.62	262.66	262.66	0.00
1224	700758.75	4939438.08	261.79	261.77	-0.02
1225	701224.37	4940878.84	267.53	267.64	0.11
1226	701241.65	4940863.31	268.41	268.44	0.04
1227	735010.77	4966977.26	342.89	342.88	-0.01
1228	734901.98	4966991.04	342.95	342.96	0.01
1229	734226.14	4967312.72	346.70	346.71	0.01
1230	735574.22	4967400.79	355.08	355.11	0.03
1231	735556.86	4967393.16	354.89	354.88	-0.01
1232	735978.85	4968090.89	335.28	335.28	0.00
1233	735340.56	4967075.91	343.90	343.91	0.02
1234	733154.65	4966934.34	344.92	344.97	0.05
1497	733868.36	4921227.87	223.39	223.41	0.02
1498	676228.64	4870791.79	208.15	208.22	0.07
1499	711549.64	4905426.79	196.84	196.87	0.03

Average dz 0.024 m
 Minimum dz -0.145 m
 Maximum dz 0.137 m
 Average magnitude 0.037 m
 Root mean square 0.048 m
 Std deviation 0.042 m

Appendix E

List of Vertical Differences for the Geodetic Points

Peterborough Geodetic Control versus Lidar Ground Surface

Station Name	Easting UTM17	Northing UTM17	H-Orthom (m)	Lidar Ground Elev	DZ	Comment
PETERBOROUGH	715107.561	4909928.492	243.427	removed	*	Monument on top of a concrete pillar
KENDRY	707977.946	4900110.699	200.989	removed	*	Monument on top of a concrete pillar
BURLEIGH FALLS	721363.720	4938157.128	247.439	outside	*	Monument on top of a concrete pillar
A629	753963.472	4900621.081	144.737	144.890	0.153	
A788	711385.808	4901291.840	189.309	189.250	-0.059	
A789	737567.752	4945355.077	263.077	263.100	0.023	
A790	710851.905	4956529.143	318.598	318.570	-0.028	
cannet-BOVL	687461.524	4863706.032	95.921	removed	*	Permanent tracking station
cannet-CBRG	726201.775	4871512.832	90.501	outside	*	Permanent tracking station
cannet-LIND	679915.783	4914311.894	274.851	outside	*	Permanent tracking station
cannet-MADO	780618.376	4931480.531	169.331	outside	*	Permanent tracking station
cannet-PCT2	809305.342	4879823.175	101.777	outside	*	Permanent tracking station
cannet-PETO	716178.174	4915176.717	243.573	outside	*	Permanent tracking station

Average dz	0.022
Minimum dz	-0.059
Maximum dz	0.153
Average magnitude	0.066
Root mean square	0.084
Std deviation	0.093

Appendix F

List of Vertical Differences for the Vegetated Points

Number	Easting	Northing	Known Z	Laser Z	Dz
2007	711374.92	4901263.08	188.65	188.72	0.07
2008	711272.06	4901675.89	189.12	189.25	0.13
2009	710810.33	4901219.97	191.11	191.13	0.02
2010	712021.12	4902183.46	187.65	187.72	0.07
2011	712036.20	4902180.30	187.88	187.84	-0.04
2012	711522.05	4903414.58	190.69	190.76	0.08
2013	712197.43	4904875.23	190.47	190.50	0.03
2014	712222.76	4904858.76	190.56	190.71	0.16
2015	713476.43	4905479.38	188.20	188.34	0.14
2016	713470.35	4905478.82	188.45	188.55	0.10
2018	711600.18	4905474.19	194.25	194.37	0.13
2019	711574.44	4905390.87	194.82	194.96	0.14
2020	710656.15	4904729.35	212.54	212.61	0.07
2021	710676.24	4904737.95	211.91	212.05	0.15
2022	709612.59	4904335.57	246.58	246.68	0.10
2025	708255.19	4902307.23	208.27	208.37	0.10
2026	707366.75	4903482.51	245.37	245.61	0.24
2027	707348.97	4901931.69	200.84	200.84	0.00
2028	708497.93	4898697.40	200.22	200.34	0.12
2029	709025.82	4897080.35	193.77	193.85	0.08
2030	710059.33	4896821.74	188.43	188.61	0.18
2031	711309.91	4898858.28	186.86	186.94	0.08
2032	708222.23	4899569.57	200.15	200.28	0.13
2033	681309.16	4872619.98	174.84	174.90	0.06
2034	681245.70	4872625.69	175.01	175.10	0.09
2035	679011.84	4871775.85	199.33	199.34	0.01
2037	678954.05	4871777.23	201.68	201.71	0.03
2038	676207.68	4870812.99	206.47	206.55	0.08
2039	676741.65	4870570.64	205.03	205.07	0.04
2040	676752.02	4870536.64	207.02	207.06	0.04
2041	677799.09	4871346.60	201.19	201.14	-0.05
2043	678268.04	4869854.58	171.33	171.46	0.13
2044	677110.96	4868165.72	162.30	162.38	0.08
2045	677103.59	4868169.61	161.87	161.97	0.10
2046	677885.66	4867083.39	150.10	150.24	0.14
2047	677896.43	4867072.22	149.71	149.68	-0.03
2048	677920.51	4867102.38	150.68	150.73	0.05
2049	679521.28	4866235.66	149.86	149.93	0.07
2050	679542.10	4866217.89	149.83	149.88	0.05
2052	679369.86	4869119.91	165.35	165.42	0.07
2053	679362.42	4869121.74	165.26	165.28	0.02
2054	679341.01	4869202.03	165.13	165.23	0.10
2055	681980.94	4866763.19	155.19	155.24	0.05
2056	681961.97	4866765.81	155.50	155.57	0.07
2057	683118.82	4871092.48	177.81	177.87	0.06
2060	685519.58	4871548.10	165.65	165.71	0.06
2061	685432.47	4869405.48	147.16	147.14	-0.02
2063	686411.49	4869065.98	107.50	107.58	0.08
2064	686881.34	4871088.56	152.85	152.87	0.02

2065	685974.56	4872679.19	159.19	159.21	0.02
2066	684711.75	4873854.90	197.87	197.98	0.11
2067	687079.46	4874762.22	196.74	196.74	0.00
2068	687035.10	4874755.01	196.06	196.12	0.07
2069	683536.75	4877255.27	232.81	232.95	0.14
2070	684681.11	4878107.86	294.58	294.68	0.10
2071	679795.33	4878465.06	263.94	264.26	0.32
2072	679804.79	4878459.53	264.38	264.36	-0.02
2073	739754.20	4917421.05	197.76	197.89	0.14
2074	739767.43	4917410.78	197.74	197.79	0.05
2075	740942.65	4914520.81	212.44	212.59	0.15
2076	740938.04	4914529.74	211.91	211.99	0.08
2077	741698.91	4912646.16	228.83	228.96	0.13
2078	744493.50	4913020.73	213.12	213.20	0.08
2079	744463.45	4913017.45	214.67	214.74	0.07
2080	744479.98	4913066.49	213.70	213.75	0.05
2081	743888.97	4915620.83	226.23	226.27	0.04
2082	745977.24	4916493.79	203.28	203.39	0.11
2083	745981.76	4916541.98	203.62	203.76	0.14
2084	744948.07	4919318.91	239.07	239.13	0.06
2085	743875.88	4921941.77	221.65	221.67	0.02
2086	741849.60	4921423.26	233.47	233.59	0.12
2087	738892.21	4923512.72	234.45	234.45	0.00
2088	736324.75	4922476.24	233.67	233.75	0.08
2089	736329.16	4922494.89	232.83	232.94	0.11
2090	736315.33	4922481.89	233.26	233.33	0.07
2091	733853.67	4921221.56	222.78	222.87	0.09
2092	735304.42	4918837.57	230.09	230.19	0.10
2093	738412.26	4920084.72	215.75	215.76	0.01
2094	738432.92	4920082.22	215.49	215.67	0.18
2095	738417.78	4920072.06	215.71	215.76	0.05
2096	742443.15	4918127.97	218.33	218.38	0.05
2097	742446.57	4918128.16	218.12	218.15	0.03
2098	736782.79	4912800.78	195.71	195.82	0.11
2100	733424.06	4914976.87	196.75	196.80	0.05
2101	733428.14	4914989.00	196.72	196.75	0.03
2102	737238.16	4916451.86	221.97	221.98	0.02
2103	737244.41	4916314.66	216.07	216.14	0.07
2104	717672.23	4878333.25	189.34	189.41	0.07
2105	717648.14	4878326.63	188.05	188.08	0.03
2106	718670.32	4875715.51	114.30	114.33	0.03
2107	718691.65	4875725.01	115.05	115.14	0.09
2108	721346.97	4873521.10	112.70	112.83	0.13
2109	721335.15	4873519.04	112.52	112.57	0.05
2110	721351.23	4873537.26	112.88	112.98	0.10
2111	718582.22	4872553.79	118.66	118.82	0.16
2112	718565.86	4872577.44	119.14	119.38	0.25
2113	715029.62	4872489.04	145.90	145.89	-0.01
2114	715022.33	4872480.69	145.86	145.98	0.12
2115	710990.50	4878070.68	180.21	180.38	0.17

2116	710985.53	4878083.66	180.86	180.92	0.06
2117	715084.04	4877570.96	162.65	162.78	0.14
2118	716139.71	4876545.29	145.10	145.24	0.14
2119	716135.22	4876519.43	144.23	144.52	0.29
2120	713779.09	4879281.07	176.70	176.77	0.07
2121	713775.72	4879259.25	175.44	175.52	0.08
2122	713015.44	4879895.23	207.11	207.27	0.16
2123	713051.32	4879865.81	206.33	206.50	0.17
2124	711065.73	4880410.39	193.90	194.05	0.15
2125	711059.79	4880359.74	193.68	193.75	0.07
2126	710862.20	4880537.85	197.17	197.27	0.10
2128	710841.12	4880571.99	197.45	197.61	0.16
2129	714137.26	4881571.08	247.81	247.86	0.05
2130	714159.50	4881580.80	247.67	247.72	0.05
2132	714122.92	4881605.55	249.32	249.40	0.08
2133	715486.61	4883950.95	205.58	205.64	0.06
2135	719549.86	4884932.74	253.98	254.06	0.08
2136	718884.54	4881234.57	221.55	221.56	0.01
2137	722558.61	4883434.21	302.69	302.88	0.19
2138	722543.64	4883425.01	303.81	303.93	0.12
2139	723754.54	4876327.90	134.29	134.35	0.06
2140	723790.26	4876355.09	136.64	136.73	0.09
2141	719886.10	4877283.79	154.70	154.86	0.16
2142	719890.04	4877209.99	152.90	152.85	-0.05
2143	737531.03	4945353.32	263.77	263.75	-0.02
2144	737562.90	4945369.49	262.91	262.96	0.05
2145	736940.56	4944427.10	260.95	260.99	0.04
2146	736861.71	4944098.19	258.76	258.86	0.10
2147	736551.21	4943664.08	250.74	250.86	0.12
2148	736616.24	4943674.58	249.32	249.51	0.20
2149	736266.26	4943291.66	249.95	250.01	0.06
2150	737480.13	4944354.54	275.01	274.95	-0.06
2151	737460.43	4944381.15	271.03	271.05	0.02
2152	738461.84	4944780.39	276.95	277.00	0.06
2153	738959.29	4945471.90	273.86	273.84	-0.02
2154	721419.41	4938170.58	242.37	242.42	0.05
2155	721458.92	4938141.07	242.72	242.78	0.06
2156	722051.33	4939193.14	254.67	254.74	0.07
2157	722053.84	4939164.01	253.27	253.32	0.05
2158	722200.01	4937115.10	239.33	239.41	0.08
2159	722221.52	4937093.27	239.30	239.33	0.03
2160	722513.27	4936315.44	262.68	262.76	0.09
2161	722788.70	4936726.54	261.80	261.90	0.10
2162	720587.68	4938163.27	244.23	244.35	0.12
2163	719997.85	4938582.48	247.04	247.12	0.09
2164	753992.04	4900676.35	149.59	149.68	0.09
2165	753973.01	4900652.16	147.80	147.91	0.11
2166	753947.51	4900620.78	144.81	144.87	0.06
2167	755469.12	4901231.27	122.07	122.19	0.12
2168	755466.64	4901233.87	122.20	122.27	0.08

2169	754781.82	4903886.17	120.82	120.84	0.02
2170	754772.21	4903895.48	120.56	120.67	0.11
2171	753001.31	4906444.46	160.42	160.50	0.08
2172	753006.05	4906474.39	158.64	158.75	0.11
2173	755939.03	4906493.05	129.23	129.30	0.07
2174	755928.95	4906490.32	128.86	129.11	0.25
2176	758033.64	4905252.73	136.30	136.37	0.07
2177	756722.50	4903328.76	141.58	141.69	0.11
2178	756704.55	4903280.58	137.63	137.78	0.15
2179	758860.73	4903610.48	115.92	116.09	0.17
2180	751620.89	4903928.26	151.04	151.21	0.17
2181	751621.15	4903925.98	151.05	151.16	0.11
2182	748745.72	4904485.06	197.68	197.80	0.12
2183	748779.22	4904496.49	197.82	197.99	0.17
2184	749418.79	4903194.71	164.06	164.11	0.05
2185	751562.12	4899898.44	134.98	135.05	0.07
2186	752312.71	4901896.09	127.59	127.68	0.09
2188	754787.06	4898665.51	116.58	116.68	0.10
2189	754818.38	4898676.50	116.50	116.61	0.11
2190	756085.80	4897008.86	127.81	127.81	0.00
2191	756140.31	4897025.53	126.98	127.23	0.25
2192	758919.99	4899420.65	116.51	116.58	0.07
2193	757823.16	4900077.40	122.43	122.50	0.07
2194	750102.42	4897653.45	136.13	136.15	0.02
2195	752825.81	4895833.76	183.71	183.82	0.11
2196	711032.93	4956544.88	314.95	315.01	0.06
2197	711054.62	4956532.03	314.18	314.27	0.09
2198	710785.83	4955420.68	315.45	315.52	0.07
2199	757291.70	4898558.69	125.50	125.56	0.06
2200	711340.65	4955567.88	301.51	301.56	0.05
2201	711224.98	4957749.21	313.26	313.35	0.09
2202	711244.95	4957187.06	313.08	313.15	0.07
2203	711768.55	4956327.02	304.76	304.80	0.04
2204	711751.70	4956326.33	303.77	303.85	0.08
2205	701661.22	4941017.22	267.70	267.72	0.02
2206	702862.29	4941471.58	288.32	288.39	0.07
2207	702861.99	4941500.61	286.05	286.06	0.01
2208	702880.44	4941517.00	286.44	286.41	-0.03
2209	703463.53	4941497.30	281.87	281.96	0.09
2210	702252.48	4939359.46	271.02	271.05	0.03
2211	701755.95	4940175.41	269.99	270.00	0.01
2212	699952.91	4941711.45	277.27	277.35	0.08
2213	699809.91	4940455.30	263.04	263.03	-0.01
2214	699803.18	4940448.18	262.73	262.85	0.12
2215	699830.39	4940421.93	264.00	264.03	0.03
2216	700702.84	4939630.18	257.78	257.88	0.10
2217	701280.66	4940862.76	267.69	267.77	0.08
2218	734994.21	4966960.11	343.73	343.70	-0.03
2219	735006.06	4966963.51	343.16	343.19	0.03
2220	734213.80	4967337.43	345.55	345.61	0.06

2221	734154.83	4967330.80	346.94	347.03	0.09
2222	735582.89	4967416.80	354.80	354.85	0.05
2223	735994.45	4968115.56	336.19	336.26	0.07
2224	735983.57	4968109.77	336.53	336.60	0.07
2225	735329.87	4967048.84	342.73	342.82	0.09
2226	735298.27	4967024.79	343.47	343.54	0.07
2227	733153.04	4966922.20	344.86	344.93	0.07
2228	733984.81	4966710.69	350.68	350.79	0.11
2499	710804.26	4955419.23	315.07	315.11	0.04

Average dz 0.080 m
 Minimum dz -0.058 m
 Maximum dz 0.319 m
 Average magnitude 0.084 m
 Root mean square 0.100 m
 Std deviation 0.059 m

Appendix G
Full Control Report



NAD83CSRS Static Control Report

- a.) Final Adjusted Coordinates
- b.) Traverse Overview
- c.) Control Sheets
- d.) Control Point Photo's
- e.) Traverse Report
- f.) Minimally Constrained Network Adjustment
- g.) Fully Constrained Network Adjustment



a.) Final Adjusted Coordinates

Project: 1626_OMAFRA-Peterborough_full
Program: GrafNet Version 8.50.4320
Profile: Aii Network Summary
Source: Network

Datum: NAD83CSRS(2010), (processing datum)
Control IDs: PETO, 963021, LIND, BOVL, MADO, CBRG, PCT2
Geoid: CGG2013n83.wpg (Absolute correction)

Map projection Info:

Defined grid: UTM, Zone 17

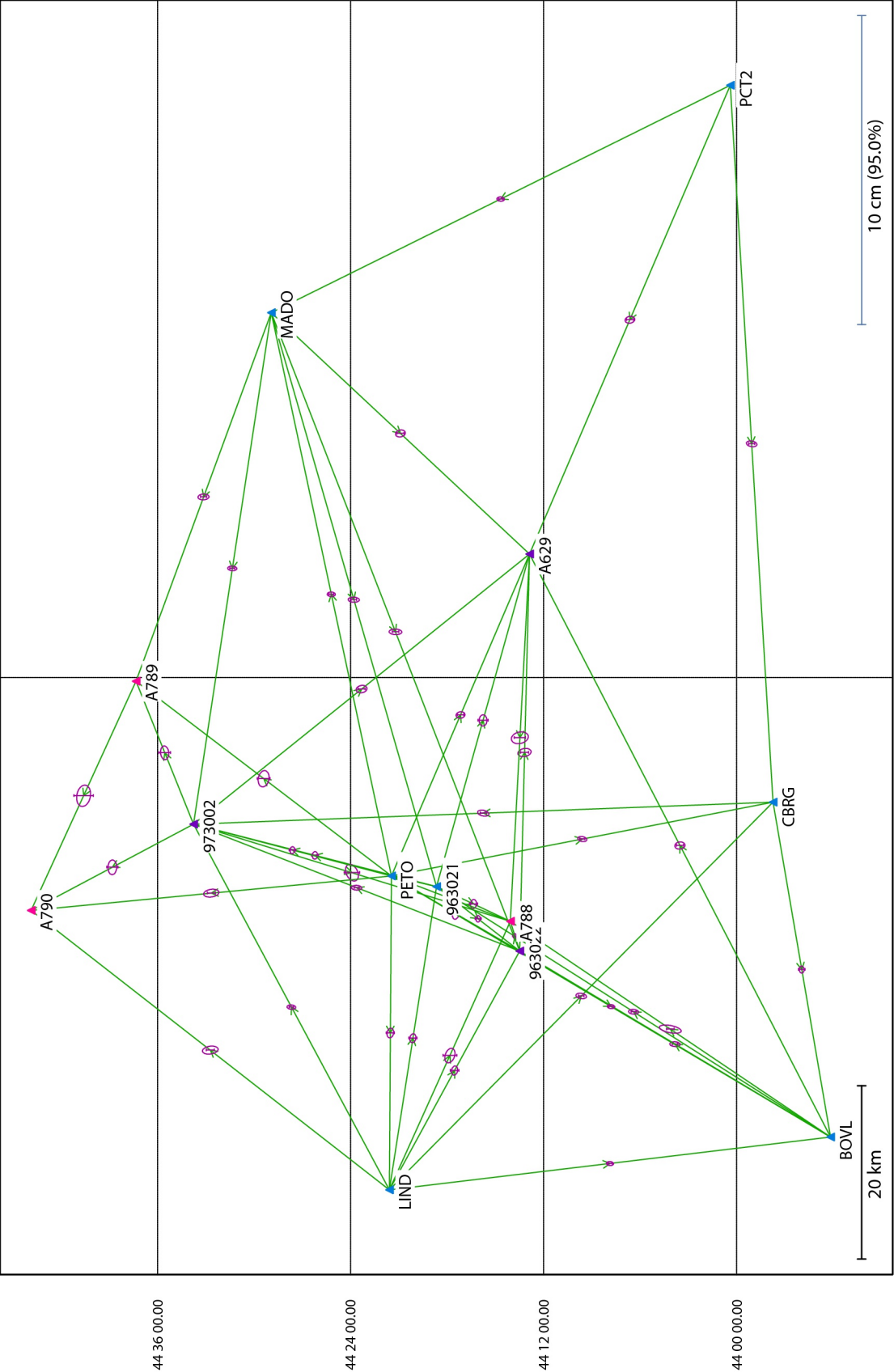
Station	Latitude (+/-D M S)	Longitude (+/-D M S)	H-Ell (m)	Undulation (m)	H-MSL (m)	Northing (m)	Easting (m)
963021	44 18 38.77679	-78 18 10.44779	208.280	-35.147	243.427	4909928.492	715107.561
963022	44 13 28.37109	-78 23 45.98252	165.691	-35.298	200.989	4900110.699	707977.946
973002	44 33 45.82967	-78 12 44.99872	212.683	-34.757	247.439	4938157.128	721363.720
A629	44 12 52.45662	-77 49 15.30398	109.718	-35.019	144.737	4900621.081	753963.472
A788	44 14 03.08402	-78 21 10.82909	154.032	-35.278	189.309	4901291.840	711385.808
A789	44 37 20.21655	-78 00 19.42400	228.560	-34.517	263.077	4945355.077	737567.752
A790	44 43 51.95543	-78 20 13.81123	283.998	-34.600	318.598	4956529.143	710851.905
BOVL	43 54 09.43395	-78 39 56.37639	60.045	-35.876	95.921	4863706.032	687461.524
CBRG	43 57 43.04898	-78 10 49.66334	54.756	-35.745	90.501	4871512.832	726201.775
LIND	44 21 35.16869	-78 44 32.14729	239.631	-35.219	274.851	4914311.894	679915.783
MADO	44 28 55.58591	-77 28 16.43241	135.048	-34.283	169.331	4931480.531	780618.376
PCT2	44 00 23.00114	-77 08 30.37157	66.987	-34.790	101.777	4879823.175	809305.342
PETO	44 21 27.54136	-78 17 14.34069	208.506	-35.068	243.573	4915176.717	716178.174



b.) Traverse Overview

Traverse - Map

Geographic, DMS



78 00 00.00

— Ignored — Unprocessed — Approximate — Bad — Good — GCP — Tie — Check



c.) Control Sheets

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
PETERBOROUGH	Ontario	031D08	963021		GPS

Station Coordinates

CGG2013 is the new default geoid

Coordinates

Geographic

Geoid

CGG2013a

Reference Frame

NAD83(CSRs)

Epoch

2010.0 - Epoch of adjustment

Latitude

N44° 18' 38.776774" ± 0.0023m

Longitude

W78° 18' 10.447774" ± 0.0017m

h (Ellipsoidal Height)(metres)

208.254 ± 0.0105m

Vφ (mm/y)

-1.42 ± 0.25

Vλ (mm/y)

1.71 ± 0.19

Vh (mm/y)

0.72 ± 1.14

N (Geoid Height)(metres)

-35.147 ± 0.010

H (Orthometric Height)(metres)

243.401

Published date and project ID

2013-04-18 M12701

Vertical Data					
Vertical Datum	Elevation (m)	Order	Method	Gravity (mGal)	Published Year
CGVD2013 (2010.0)	243.411	First order	Differential	980464.6 ± .7	2013
CGVD28	243.742	First order	Differential	980464.6 ± .7	1999

Station Marker

Marker Type	Inspected in	Established by	Status	Comments
Self centering plate	1999	Geodetic survey division - nrcan	Good	None

Location
Accessible by passenger car or light truck and a walk of less than 50 m. Peterborough Concrete pillar with steel top plate in grounds of ashburnham memorial park, immediately north of peterborough centennial museum and archives (civic no. 300 hunter street), about 355 m north (measured along access road to park and museum) from centre of hunter street, 123.4 m northeast of northeast corner of museum, 36.8 m southwest of southwest corner of kiwanis club of scott's plains monument (square concrete pier with compass-card on top), 21.3 m west of centre of road to lookout. Elevation taken on top at centre of main circular plate anchored on top of pillar.

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(<mailto:nrcan.geodeticinformationservices.nrcan@canada.ca>)

Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
KENDRY	Ontario	031D01	963022		GPS

Station Coordinates		
CGG2013 is the new default geoid		
Coordinates Geographic		
Geoid CGG2013a		
Reference Frame NAD83(CSRs)		
Epoch 2010.0		
The velocities were interpolated from the national grid.		
Latitude	Longitude	h (Ellipsoidal Height)(metres)
N44° 13' 28.371012"	W78° 23' 45.982628"	165.673
Vφ (mm/y)	Vλ (mm/y)	Vh (mm/y)
-1.43	1.71	0.53
N (Geoid Height)(metres)	H (Orthometric Height)(metres)	Published date and project ID
-35.298 ± 0.012	200.971	2001-01-01 M01707

Vertical Data					
Vertical Datum	Elevation (m)	Order	Method	Gravity (mGal)	Published Year
CGVD2013 (2010.0)	200.977	First order	Differential	980463.0 ± .5	2013
CGVD28	201.324	First order	Differential	980463.0 ± .5	1999

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments

Self centering plate	2004	Geodetic survey division - nrcan	Good	None
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Location
Accessible by passenger car or light truck and a walk of less than 50 m. Kendry Concrete pillar with steel top plate in grass island formed by highway no. 115 south, highway no. 7a and entrance ramp for highway no. 7a and county road 11 traffic to highway no. 115 south, opposite ministry of transportation and communications (mtc) yard, 120 m north of north edge of highway no. 115 overpass, 51.5 m south of centre of entrance ramp to highway no. 115 south and projection of centre of access road to mtc yard, 45.4 m from centre line of highway no. 7a, about 2.5 m above level of highway no. 7a. Elevation taken on top at centre of main circular plate anchored on top of pillar.

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Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
BURLEIGH FALLS	Ontario	031D09	973002		GPS

Station Coordinates			
CGG2013 is the new default geoid			
Coordinates Geographic			
Geoid CGG2013a			
Reference Frame NAD83(CSRs)			
Epoch 1997.0 - Epoch of adjustment			
The velocities were interpolated from the national grid.			
Latitude N44° 33' 45.830518" ± 0.0011m		Longitude W78° 12' 44.99975" ± 0.0010m	
h (Ellipsoidal Height)(metres) 212.674 ± 0.0059m	Vφ (mm/y) -1.51	Vλ (mm/y) 1.56	
Vh (mm/y) 1.19			
N (Geoid Height)(metres) -34.757 ± 0.009	H (Orthometric Height)(metres) 247.431	Published date and project ID 2001-01-01 M01707	

Vertical Data					
Vertical Datum	Elevation (m)	Order	Method	Gravity (mGal)	Published Year
CGVD2013 (2010.0)	247.467	First order	Differential	980484.5 ± .6	2013

CGVD28	247.783	First order	Differential	980484.5 ± .6	1999
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Station Marker				
Marker Type	Inspected in	Established by	Status	Comments
Self centering plate	1999	Geodetic survey division - nrcan	Good	None

Location
Accessible by passenger car or light truck and a walk of less than 50 m. Burleigh Falls Concrete pillar with steel top plate on top of rock cut on northwest side of highway no. 28, at junction with county road 36 (formerly highway no. 36), 34.7 m from centre line of highway, 23.3 m northwest of centre of county road 36, 17.6 m southwest of northeast edge and 12.2 m northwest of southeast edge of cut, about 3 m above level of highway no. 28, about 6 m above level of county road 36. Elevation taken on top at centre of main circular plate anchored on top of pillar.

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Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
cannet-BOVL	Ontario	030M15	CBOV		CANNET

Station Coordinates

CGG2013 is the new default geoid

Coordinates

Geographic

Geoid

CGG2013a

Reference Frame

NAD83(CSR)

Epoch

2010.0 - Epoch of adjustment

The velocities were interpolated from the national grid.

Latitude

N43° 54' 9.433839" ± 0.0004m

Longitude

W78° 39' 56.376371" ± 0.0002m

h (Ellipsoidal Height)(metres)

60.046 ± 0.0007m

Vφ (mm/y)

-1.43

VA (mm/y)

1.77

Vh (mm/y)

-0.10

N (Geoid Height)(metres)

-35.877 ± 0.009

H (Orthometric Height)(metres)

95.923

Published date and project ID

2015-09-24 M15-703

Vertical Data

Use the value of H (Orthometric Height) from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments

Unknown		Cansel (cannet)	None
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Location
No description available

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Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
cannet-CBRG	Ontario	030M16	CCBG		CANNET

Station Coordinates

CGG2013 is the new default geoid

Coordinates

Geographic

Geoid

CGG2013a

Reference Frame

NAD83(CSRs)

Epoch

2010.0 - Epoch of adjustment

The velocities were interpolated from the national grid.

Latitude

N43° 57' 43.049003" ± 0.0008m

Longitude

W78° 10' 49.663353" ± 0.0004m

h (Ellipsoidal Height)(metres)

54.761 ± 0.0013m

Vφ (mm/y)

-1.45

Vλ (mm/y)

1.75

Vh (mm/y)

0.30

N (Geoid Height)(metres)

-35.746 ± 0.009

H (Orthometric Height)(metres)

90.507

Published date and project ID

2015-09-24 M15-703

Vertical Data

Use the value of H (Orthometric Height) from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments

Unknown		Cansel (cannet)	None
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Location
No description available

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Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
cannet-LIND	Ontario	031D07	CLIN		CANNET

Station Coordinates

CGG2013 is the new default geoid

Coordinates

Geographic

Geoid

CGG2013a

Reference Frame

NAD83(CSRs)

Epoch

2010.0 - Epoch of adjustment

The velocities were interpolated from the national grid.

Latitude

Longitude

N44° 21' 35.168703" ± 0.0004m

W78° 44' 32.147263" ± 0.0002m

h (Ellipsoidal Height)(metres)

Vφ (mm/y)

VA (mm/y)

239.624 ± 0.0006m

-1.45

1.67

Vh (mm/y)

0.45

N (Geoid Height)(metres)

H (Orthometric Height)(metres)

Published date and project ID

-35.220 ± 0.008

274.844

2015-09-24 M15-703

Vertical Data

Use the value of H (Orthometric Height) from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments

Unknown		Cansel (cannet)	None
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Location
No description available

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Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
cannet-MADO	Ontario	031C06	CMAD		CANNET

Station Coordinates

CGG2013 is the new default geoid

Coordinates

Geographic

Geoid

CGG2013a

Reference Frame

NAD83(CSRs)

Epoch

2010.0 - Epoch of adjustment

The velocities were interpolated from the national grid.

Latitude

N44° 28' 55.586031" ± 0.0015m

Longitude

W77° 28' 16.432343" ± 0.0008m

h (Ellipsoidal Height)(metres)

135.057 ± 0.0024m

Vφ (mm/y)

-1.64

VA (mm/y)

1.50

Vh (mm/y)

1.15

N (Geoid Height)(metres)

-34.283 ± 0.010

H (Orthometric Height)(metres)

169.340

Published date and project ID

2015-09-24 M15-703

Vertical Data

Use the value of H (Orthometric Height) from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments

Unknown		Cansel (cannet)	None
---------	--	-----------------	------

Location
No description available

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Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
cannet-PCT2	Ontario	031C03	CPI2		CANNET

Station Coordinates

CGG2013 is the new default geoid

Coordinates

Geographic

Geoid

CGG2013a

Reference Frame

NAD83(CSRs)

Epoch

2010.0 - Epoch of adjustment

The velocities were interpolated from the national grid.

Latitude

N44° 00' 23.00114" ± 0.0009m

Longitude

W77° 08' 30.371821" ± 0.0004m

h (Ellipsoidal Height)(metres)

67.002 ± 0.0014m

Vφ (mm/y)

-1.68

Vλ (mm/y)

1.77

Vh (mm/y)

0.29

N (Geoid Height)(metres)

-34.791 ± 0.011

H (Orthometric Height)(metres)

101.793

Published date and project ID

2015-09-24 M15-703

Vertical Data

Use the value of H (Orthometric Height) from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments

Unknown		Cansel (cannet)	None
---------	--	-----------------	------

Location
No description available

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[Geodetic Reference Systems Information \(mailto:nrcan.geodeticinformationservices.nrcan@canada.ca\)](mailto:nrcan.geodeticinformationservices.nrcan@canada.ca)

Date modified: 2016-12-13

Site Identification					
Name	Province	NTS (National Topographic System) map sheet	Unique Number	Provincial Identifier	Network
cannet-PETO	Ontario	031D08	CPET		CANNET

Station Coordinates

CGG2013 is the new default geoid

Coordinates

Geographic

Geoid

CGG2013a

Reference Frame

NAD83(CSRs)

Epoch

2010.0 - Epoch of adjustment

The velocities were interpolated from the national grid.

Latitude

N44° 21' 27.541353" ± 0.0004m

Longitude

W78° 17' 14.340677" ± 0.0002m

h (Ellipsoidal Height)(metres)

208.499 ± 0.0006m

Vφ (mm/y)

-1.45

Vλ (mm/y)

1.66

Vh (mm/y)

0.81

N (Geoid Height)(metres)

-35.068 ± 0.009

H (Orthometric Height)(metres)

243.567

Published date and project ID

2015-09-24 M15-703

Vertical Data

Use the value of H (Orthometric Height) from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments

Unknown		Cansel (cannet)	None
---------	--	-----------------	------

Location
No description available

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[Geodetic Reference Systems Information \(mailto:nrcan.geodeticinformationservices.nrcan@canada.ca\)](mailto:nrcan.geodeticinformationservices.nrcan@canada.ca)

Date modified: 2016-12-13



d.) Control Point Photo's

963021



963022



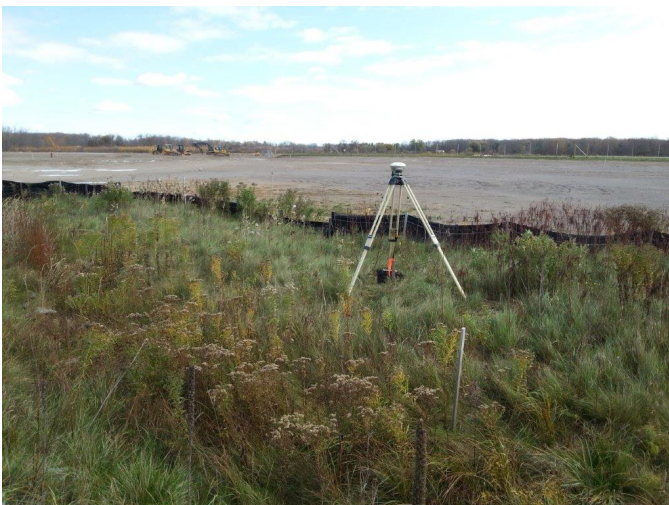
973002



A629



A788





e.) Traverse Report

```

*****
* GrafNet - GRAPHIC GPS NETWORK PROCESSING *
*          SOFTWARE PACKAGE                *
*                                          *
* TRAVERSE SOLUTION:                      *
*                                          *
* Copyright NovAtel Inc. (2014)           *
*                                          *
* Version: 8.50.4320                      *
*                                          *
* PROJECT: 1626_OMAFRA-Peterborough_min   *
*****

```

DATUM: NAD83CSRS(2010)
 GRID: UTM, Zone 17
 UNITS: metres (see Preferences to change)
 GEOID: C:\Users\air019\Documents\AI\Waypoint_GrafNAV\SupportFiles\Geoids\CGG2013n83.wpg

```

*****
STATIONS (STATUS):
*****

```

Station	Type	HgtStatus	Result	Coordinates derived from...
963021	Check-3D	OK	Good	973002
963022	Check-3D	OK	Good	973002
973002	Control-3D	OK	Pub(3D)	(-)
A629	Check-3D	OK	Good	973002
A788	Loop Tie	OK	Good	973002
A789	Traverse	OK	Good	973002
A790	Loop Tie	OK	Good	973002
BOVL	Check-3D	OK	Good	963021 973002
CBRG	Loop Tie	OK	Good	973002
LIND	Check-3D	OK	Good	973002
MADO	Check-3D	OK	Good	973002
PCT2	Loop Tie	OK	Good	A629 973002
PETO	Check-3D	OK	Good	973002

```

*****
STATIONS (COORDINATES):
*****

```

Station	Latitude (D M S)	Longitude (D M S)	Grid-E (m)	Grid-N (m)	EllHgt (m)	OrthoHgt (m)
963021	44 18 38.77699	-78 18 10.44793	715107.558	4909928.499	208.296	243.443
963022	44 13 28.37134	-78 23 45.98292	707977.937	4900110.707	165.698	200.996
973002	44 33 45.82988	-78 12 44.99883	721363.717	4938157.135	212.689	247.446
A629	44 12 52.45698	-77 49 15.30411	753963.469	4900621.092	109.715	144.733
A788	44 14 03.08417	-78 21 10.82917	711385.806	4901291.845	154.043	189.321
A789	44 37 20.21671	-78 00 19.42413	737567.749	4945355.082	228.581	263.097
A790	44 43 51.95570	-78 20 13.81137	710851.902	4956529.151	283.995	318.595
BOVL	43 54 09.43418	-78 39 56.37677	687461.515	4863706.039	60.058	95.934
CBRG	43 57 43.04917	-78 10 49.66347	726201.772	4871512.838	54.755	90.500
LIND	44 21 35.16886	-78 44 32.14741	679915.780	4914311.899	239.623	274.842
MADO	44 28 55.58607	-77 28 16.43257	780618.372	4931480.535	135.068	169.350
PCT2	44 00 23.00159	-77 08 30.37162	809305.340	4879823.189	66.971	101.761
PETO	44 21 27.54159	-78 17 14.34073	716178.173	4915176.724	208.524	243.592

```

*****
LOOP, CHECK & DUPLICATE TIES:
*****

```

Name/Session	Type	Result	DEast (m)	DNorth (m)	DHeight (m)
POINT 963021	CheckPnt	Good	-0.0036	0.0069	0.0321
POINT 963022	CheckPnt	Good	-0.0065	0.0101	0.0255
963021 to 963022	LoopTie	Good	-0.0036	0.0021	-0.0114
POINT A629	CheckPnt	Good	0.0200	-0.0066	0.0116
973002 to A629 (1)	Duplicate	Good	-0.0027	0.0051	-0.0126

963021 to A629 (1)	Duplicate	Good	-0.0000	0.0054	-0.0152
963021 to A629	LoopTie	Good	0.0038	0.0017	-0.0151
963022 to A629 (1)	Duplicate	Good	-0.0049	0.0035	0.0023
963022 to A629	LoopTie	Good	0.0007	0.0042	-0.0047
973002 to A788 (2)	Duplicate	Good	0.0022	-0.0016	0.0177
963021 to A788	LoopTie	Good	-0.0018	-0.0028	0.0035
963021 to A788 (2)	Duplicate	Good	-0.0022	-0.0021	-0.0002
963022 to A788	LoopTie	Good	0.0092	-0.0030	-0.0037
963022 to A788 (2)	Duplicate	Good	0.0097	-0.0033	0.0010
A629 to A788 (1)	Duplicate	Good	0.0002	-0.0074	0.0093
A629 to A788 (2)	Duplicate	Good	0.0016	-0.0048	0.0072
A629 to A788	LoopTie	Good	0.0015	-0.0025	0.0156
973002 to A789 (2)	Duplicate	Good	0.0000	-0.0007	0.0125
973002 to A790 (2)	Duplicate	Good	-0.0020	0.0037	-0.0002
A789 to A790	LoopTie	Good	-0.0021	0.0007	0.0038
POINT BOVL	CheckPnt	Good	-0.0088	0.0106	0.0123
963022 to BOVL	LoopTie	Good	-0.0060	0.0000	0.0072
A629 to BOVL (1)	Duplicate	Good	-0.0051	-0.0055	0.0243
A629 to BOVL	LoopTie	Good	-0.0029	-0.0023	-0.0092
A788 to BOVL	LoopTie	Good	-0.0007	0.0031	0.0077
A788 to BOVL (2)	Duplicate	Good	-0.0048	0.0020	-0.0195
BOVL to CBRG	LoopTie	Good	0.0065	-0.0018	-0.0245
POINT LIND	CheckPnt	Good	-0.0034	0.0050	-0.0012
973002 to LIND (1)	Duplicate	Good	-0.0018	-0.0027	-0.0234
963021 to LIND	LoopTie	Good	-0.0005	-0.0005	-0.0355
963022 to LIND	LoopTie	Good	0.0034	-0.0031	-0.0265
A788 to LIND	LoopTie	Good	0.0040	0.0023	-0.0446
A788 to LIND (2)	Duplicate	Good	0.0011	0.0002	-0.0397
A790 to LIND (1)	Duplicate	Good	-0.0024	-0.0027	-0.0099
A790 to LIND	LoopTie	Good	0.0033	-0.0033	0.0114
BOVL to LIND (1)	Duplicate	Good	0.0073	-0.0023	-0.0259
BOVL to LIND	LoopTie	Good	0.0030	-0.0010	-0.0229
CBRG to LIND	LoopTie	Good	0.0025	-0.0007	-0.0027
POINT MADDO	CheckPnt	Good	-0.0050	0.0011	0.0106
973002 to MADDO (1)	Duplicate	Good	-0.0006	-0.0042	0.0216
963021 to MADDO	LoopTie	Good	0.0057	-0.0038	0.0146
963022 to MADDO	LoopTie	Good	-0.0001	-0.0047	0.0225
A629 to MADDO (1)	Duplicate	Good	-0.0019	-0.0064	0.0304
A629 to MADDO	LoopTie	Good	-0.0007	-0.0072	0.0335
A789 to MADDO (1)	Duplicate	Good	0.0071	0.0020	-0.0102
A789 to MADDO	LoopTie	Good	-0.0009	0.0017	-0.0142
A629 to PCT2 (1)	Duplicate	Good	-0.0041	0.0022	0.0009
CBRG to PCT2	LoopTie	Good	0.0016	0.0087	-0.0288
MADO to PCT2 (1)	Duplicate	Good	0.0010	0.0086	-0.0332
MADO to PCT2	LoopTie	Good	0.0030	0.0085	-0.0278
POINT PETO	CheckPnt	Good	-0.0034	0.0074	0.0248
973002 to PETO (2)	Duplicate	Good	0.0010	0.0042	0.0253
963021 to PETO	LoopTie	Good	0.0021	0.0017	0.0011
963022 to PETO	LoopTie	Good	0.0062	0.0002	0.0114
A629 to PETO (1)	Duplicate	Good	0.0036	-0.0059	0.0204
A629 to PETO	LoopTie	Good	0.0044	-0.0031	0.0199
A788 to PETO	LoopTie	Good	0.0068	0.0066	-0.0040
A788 to PETO (2)	Duplicate	Good	0.0036	0.0005	-0.0085
A789 to PETO	LoopTie	Good	0.0011	0.0038	0.0106
A789 to PETO (2)	Duplicate	Good	0.0015	0.0032	0.0139
A790 to PETO (1)	Duplicate	Good	-0.0030	0.0013	0.0091
A790 to PETO	LoopTie	Good	0.0047	-0.0034	0.0324
BOVL to PETO	LoopTie	Good	0.0088	-0.0008	-0.0029
BOVL to PETO (2)	Duplicate	Good	0.0080	0.0000	0.0146
CBRG to PETO	LoopTie	Good	0.0030	0.0021	0.0203
LIND to PETO	LoopTie	Good	-0.0004	0.0004	0.0253
LIND to PETO (2)	Duplicate	Good	0.0015	0.0008	0.0413
MADO to PETO	LoopTie	Good	0.0050	0.0022	-0.0087

RMS (tie points)			0.0040	0.0038	0.0196
RMS (check points)			0.0091	0.0074	0.0196
			=====		

f.) Minimally Constrained Network
Adjustment

```

*****
* NETWORK - WEIGHTED GPS NETWORK ADJUSTMENT *
* *
* (c) Copyright NovAtel Inc., (2014) *
* *
* Version: 8.50.4320 *
* *
* FILE: 1626_OMAFRA-Peterborough_min.net *
*****

```

```

DATUM:          'NAD83CSRS(2010)'
GRID:           UTM, Zone 17
SCALE FACTOR:   7.9310
CONFIDENCE LEVEL: 95.00 %   (Scale factor is 2.4479)

```

```

*****
INPUT CONTROL/CHECK POINTS
*****

```

STA ID	TYPE	-- LATITUDE --	-- LONGITUDE --	ELLHGT -	HZ-SD	V-SD
963021	CHK-3D	44 18 38.77677	-78 18 10.44777	208.264		
963022	CHK-3D	44 13 28.37101	-78 23 45.98263	165.673		
973002	GCP-3D	44 33 45.82988	-78 12 44.99883	212.689	0.00500	0.00500
A629	CHK-3D	44 12 52.45719	-77 49 15.30501	109.703		
BOVL	CHK-3D	43 54 09.43384	-78 39 56.37637	60.046		
LIND	CHK-3D	44 21 35.16870	-78 44 32.14726	239.624		
MADO	CHK-3D	44 28 55.58603	-77 28 16.43234	135.057		
PETO	CHK-3D	44 21 27.54135	-78 17 14.34058	208.499		

```

*****
INPUT VECTORS
*****

```

SESSION NAME	VECTOR(m)	----- Covariance (m) [unscaled] -----
	DX/DY/DZ	standard deviations in brackets
963021 to 963022 (1)	-5944.3617 -8023.0282 -6890.7342	5.5539e-007 (0.0007) 2.5551e-006 (0.0016) 2.4446e-007 -1.1892e-006 1.9102e-006 (0.0014)
963021 to A629 (1)	39184.2819 731.0070 -7724.2422	2.5115e-006 (0.0016) -1.0358e-006 1.1931e-005 (0.0035) 8.9021e-007 -5.4902e-006 9.1459e-006 (0.0030)
963021 to A629 (2)	39184.2776 731.0088 -7724.2396	1.7834e-006 (0.0013) -1.2099e-006 7.4350e-006 (0.0027) 7.5631e-007 -3.7379e-006 6.5155e-006 (0.0026)
963021 to A788 (1)	-2723.8075 -6588.8777 -6131.1097	1.0289e-006 (0.0010) -6.7748e-007 5.8508e-006 (0.0024) 3.6654e-007 -2.2828e-006 3.1054e-006 (0.0018)
963021 to A788 (2)	-2723.8064 -6588.8807 -6131.1077	1.2175e-006 (0.0011) -9.4271e-007 4.9833e-006 (0.0022) 8.1586e-007 -2.8567e-006 5.1854e-006 (0.0023)
963021 to BOVL (1)	-22178.7153 -36623.3420 -32668.1319	2.7203e-006 (0.0016) -2.0769e-007 1.9239e-006 (0.0014) 3.5195e-007 -1.0485e-006 1.3154e-006 (0.0011)
963021 to LIND (1)	-35093.5223 -3265.6276 3916.3524	9.7668e-007 (0.0010) -4.6964e-007 4.9405e-006 (0.0022) 4.5878e-007 -2.3424e-006 3.9806e-006 (0.0020)
963021 to MADO (1)	61979.2578 26978.6060 13552.6792	3.3138e-006 (0.0018) -1.3562e-007 2.3771e-006 (0.0015) 4.2097e-007 -1.2618e-006 1.5274e-006 (0.0012)

963021 to PETO (1)	478.6757	3.9995e-007	(0.0006)
	3816.8041	-1.9427e-007	2.0096e-006 (0.0014)
	3726.2517	1.8985e-007	-9.4925e-007 1.6208e-006 (0.0013)
963022 to A629 (1)	45128.6510	1.6627e-005	(0.0041)
	8754.0411	-1.5935e-006	6.2006e-006 (0.0025)
	-833.5123	-8.5548e-008	-2.8265e-006 4.0951e-006 (0.0020)
963022 to A629 (2)	45128.6467	4.2904e-006	(0.0021)
	8754.0346	4.3078e-007	5.7913e-006 (0.0024)
	-833.5079	6.2182e-007	-2.3062e-006 2.8564e-006 (0.0017)
963022 to A788 (1)	3220.5499	2.8418e-007	(0.0005)
	1434.1347	-1.8690e-007	1.6183e-006 (0.0013)
	759.6361	1.0139e-007	-6.2986e-007 8.5211e-007 (0.0009)
963022 to A788 (2)	3220.5487	3.3699e-007	(0.0006)
	1434.1381	-2.6107e-007	1.3780e-006 (0.0012)
	759.6330	2.2624e-007	-7.8391e-007 1.4034e-006 (0.0012)
963022 to BOVL (1)	-16234.3432	2.9041e-006	(0.0017)
	-28600.3161	-1.1390e-007	2.0215e-006 (0.0014)
	-25777.3962	3.4456e-007	-1.0920e-006 1.3540e-006 (0.0012)
963022 to LIND (1)	-29149.1605	1.0355e-006	(0.0010)
	4757.3993	-5.8571e-007	5.6519e-006 (0.0024)
	10807.0886	5.3912e-007	-2.5446e-006 4.0414e-006 (0.0020)
963022 to MADO (1)	67923.6293	4.3046e-006	(0.0021)
	35001.6329	-1.7181e-007	2.9726e-006 (0.0017)
	20443.4150	5.6590e-007	-1.5699e-006 1.8505e-006 (0.0014)
963022 to PETO (1)	6423.0372	1.3239e-006	(0.0012)
	11839.8310	-8.7223e-007	5.4438e-006 (0.0023)
	10616.9863	6.5575e-007	-1.4357e-006 4.1385e-006 (0.0020)
973002 to 963022 (1)	-9002.7209	2.8552e-006	(0.0017)
	-28677.0729	-8.3785e-008	1.9753e-006 (0.0014)
	-26885.6218	3.2566e-007	-1.0658e-006 1.3400e-006 (0.0012)
973002 to 963021 (1)	-3058.3536	7.8519e-007	(0.0009)
	-20654.0534	-4.5084e-007	3.4495e-006 (0.0019)
	-19994.8811	3.1725e-007	-1.6767e-006 2.8670e-006 (0.0017)
973002 to A629 (1)	36125.9305	7.8982e-006	(0.0028)
	-19923.0438	-9.0603e-007	3.9444e-006 (0.0020)
	-27719.1248	2.1312e-008	-1.9919e-006 2.8899e-006 (0.0017)
973002 to A629 (2)	36125.9252	3.0025e-006	(0.0017)
	-19923.0320	5.2735e-008	4.7317e-006 (0.0022)
	-27719.1300	4.9017e-007	-1.8880e-006 2.2104e-006 (0.0015)
973002 to A788 (1)	-5782.1620	6.3356e-006	(0.0025)
	-27242.9358	-6.4257e-006	1.9954e-005 (0.0045)
	-26125.9904	2.1412e-006	-8.2637e-006 9.8389e-006 (0.0031)
973002 to A788 (2)	-5782.1669	5.6581e-006	(0.0024)
	-27242.9227	-4.7561e-006	2.0563e-005 (0.0045)
	-26126.0016	1.6082e-006	-6.7706e-006 1.2267e-005 (0.0035)
973002 to A789 (1)	15137.4805	1.8583e-006	(0.0014)
	7923.9496	-8.2457e-007	7.3356e-006 (0.0027)
	4723.8554	1.9517e-007	-4.6142e-006 1.1384e-005 (0.0034)
973002 to A789 (2)	15137.4786	3.6168e-006	(0.0019)
	7923.9587	-1.6484e-006	1.4007e-005 (0.0037)
	4723.8471	6.4070e-007	-5.6491e-006 1.0116e-005 (0.0032)
973002 to A790 (1)	-12345.7453	1.9113e-006	(0.0014)
	10814.6834	-6.6157e-007	9.1723e-006 (0.0030)
	13361.8019	9.5675e-008	-3.8754e-006 9.6861e-006 (0.0031)

973002 to A790 (2)	-12345.7427	3.9536e-006	(0.0020)
	10814.6811	-3.6588e-006	1.4131e-005 (0.0038)
	13361.7994	1.4275e-006	-7.8421e-006 1.0794e-005 (0.0033)
973002 to CBRG (1)	12011.9252	3.5816e-006	(0.0019)
	-44973.7027	-4.4865e-007	2.5394e-006 (0.0016)
	-47918.6018	1.5244e-007	-1.2632e-006 1.6562e-006 (0.0013)
973002 to LIND (1)	-38151.8766	1.9157e-006	(0.0014)
	-23919.6708	-7.4298e-008	1.7325e-006 (0.0013)
	-16078.5356	1.8859e-007	-9.4122e-007 1.1627e-006 (0.0011)
973002 to LIND (2)	-38151.8813	2.0706e-006	(0.0014)
	-23919.6565	-1.1508e-007	1.5413e-006 (0.0012)
	-16078.5539	2.2623e-007	-8.3264e-007 1.0673e-006 (0.0010)
973002 to MADO (1)	58920.9092	2.3721e-006	(0.0015)
	6324.5591	-1.3120e-007	1.9683e-006 (0.0014)
	-6442.2065	2.9823e-007	-1.0317e-006 1.2308e-006 (0.0011)
973002 to MADO (2)	58920.9126	2.2525e-006	(0.0015)
	6324.5411	-1.4738e-007	1.8433e-006 (0.0014)
	-6442.1944	2.6723e-007	-9.7226e-007 1.1806e-006 (0.0011)
973002 to PETO (1)	-2579.6759	5.9738e-007	(0.0008)
	-16837.2484	-2.9046e-007	2.7763e-006 (0.0017)
	-16268.6274	2.5826e-007	-1.4025e-006 2.5429e-006 (0.0016)
973002 to PETO (2)	-2579.6800	4.8600e-006	(0.0022)
	-16837.2339	-2.3346e-006	1.2551e-005 (0.0035)
	-16268.6481	2.2012e-007	-6.9788e-006 1.6354e-005 (0.0040)
A629 to A788 (1)	-41908.0898	1.7422e-005	(0.0042)
	-7319.8922	-1.6381e-006	6.3992e-006 (0.0025)
	1593.1384	-1.3954e-007	-2.8604e-006 4.1198e-006 (0.0020)
A629 to A788 (2)	-41908.0905	8.0759e-004	(0.0284)
	-7319.8958	8.9977e-005	1.7600e-004 (0.0133)
	1593.1380	5.1327e-005	-4.7517e-005 1.1050e-004 (0.0105)
A629 to A788 (3)	-41908.0913	7.2318e-006	(0.0027)
	-7319.8914	1.3984e-007	1.1499e-005 (0.0034)
	1593.1305	1.3087e-006	-4.3373e-006 5.2192e-006 (0.0023)
A629 to BOVL (1)	-61362.9933	5.6610e-006	(0.0024)
	-37354.3413	-7.3534e-007	3.7993e-006 (0.0019)
	-24943.8959	1.2574e-007	-1.8621e-006 2.5481e-006 (0.0016)
A629 to BOVL (2)	-61362.9903	2.6418e-006	(0.0016)
	-37354.3676	-2.3385e-007	4.5925e-006 (0.0021)
	-24943.8750	4.4427e-007	-1.9125e-006 2.1205e-006 (0.0015)
A629 to MADO (1)	22794.9835	4.8979e-006	(0.0022)
	26247.5991	-5.8516e-007	3.4517e-006 (0.0019)
	21276.9188	9.5279e-008	-1.6487e-006 2.1317e-006 (0.0015)
A629 to MADO (2)	22794.9818	2.4559e-006	(0.0016)
	26247.6015	-3.5226e-008	4.3227e-006 (0.0021)
	21276.9172	4.2961e-007	-1.6852e-006 1.7982e-006 (0.0013)
A629 to PCT2 (1)	56561.7160	5.2752e-006	(0.0023)
	-3902.7635	-5.8806e-007	3.5687e-006 (0.0019)
	-16638.7446	3.1549e-008	-1.8484e-006 2.5070e-006 (0.0016)
A629 to PCT2 (2)	56561.7118	2.3269e-006	(0.0015)
	-3902.7636	-2.6082e-008	4.2672e-006 (0.0021)
	-16638.7423	3.5546e-007	-1.8059e-006 2.0326e-006 (0.0014)
A629 to PETO (1)	-38705.6085	4.5810e-006	(0.0021)
	3085.8012	-4.9502e-007	3.0649e-006 (0.0018)
	11450.4926	1.9502e-008	-1.5638e-006 2.1428e-006 (0.0015)

A629 to PETO (2)	-38705.6088	2.0496e-006	(0.0014)
	3085.7987	-1.3324e-007	3.7140e-006 (0.0019)
	11450.4909	3.4062e-007	-1.5830e-006 1.7900e-006 (0.0013)
A788 to BOVL (1)	-19454.9069	1.3230e-005	(0.0036)
	-30034.4561	-1.1197e-006	4.1835e-006 (0.0020)
	-26537.0302	2.0380e-007	-2.0648e-006 2.7013e-006 (0.0016)
A788 to BOVL (2)	-19454.8991	7.3204e-006	(0.0027)
	-30034.4737	7.9100e-008	1.1624e-005 (0.0034)
	-26537.0106	1.3313e-006	-4.4033e-006 5.2890e-006 (0.0023)
A788 to LIND (1)	-32369.7167	2.3547e-006	(0.0015)
	3323.2457	-7.0151e-007	1.7404e-005 (0.0042)
	10047.4660	7.9385e-007	-6.9496e-006 8.1208e-006 (0.0028)
A788 to LIND (2)	-32369.7148	2.6335e-006	(0.0016)
	3323.2510	-2.1350e-006	1.2413e-005 (0.0035)
	10047.4641	2.2849e-006	-6.4407e-006 1.3532e-005 (0.0037)
A788 to PETO (1)	3202.4808	1.3751e-006	(0.0012)
	10405.6787	-4.2695e-007	1.0102e-005 (0.0032)
	9857.3611	4.7903e-007	-4.0185e-006 4.7240e-006 (0.0022)
A788 to PETO (2)	3202.4838	1.5351e-006	(0.0012)
	10405.6803	-1.2414e-006	7.1967e-006 (0.0027)
	9857.3685	1.3303e-006	-3.7105e-006 7.8124e-006 (0.0028)
A789 to A790 (1)	-27483.2241	5.8036e-006	(0.0024)
	2890.7364	-4.0110e-006	2.6389e-005 (0.0051)
	8637.9433	4.2012e-006	-1.2732e-005 2.3245e-005 (0.0048)
A789 to MADO (1)	43783.4270	6.5907e-006	(0.0026)
	-1599.4185	-1.5759e-007	6.6368e-006 (0.0026)
	-11166.0441	1.8674e-008	-2.5042e-006 3.7104e-006 (0.0019)
A789 to MADO (2)	43783.4353	3.2016e-006	(0.0018)
	-1599.4193	-6.9716e-008	3.0726e-006 (0.0018)
	-11166.0411	5.9479e-007	-1.4678e-006 1.7660e-006 (0.0013)
A789 to PETO (1)	-17717.1585	3.5203e-006	(0.0019)
	-24761.1934	-2.0219e-006	1.3509e-005 (0.0037)
	-20992.4930	1.9739e-006	-4.7717e-006 1.0109e-005 (0.0032)
A789 to PETO (2)	-17717.1595	2.5501e-006	(0.0016)
	-24761.1908	-1.4936e-006	6.6694e-006 (0.0026)
	-20992.4948	5.8609e-007	-4.1173e-006 7.0191e-006 (0.0026)
A790 to LIND (1)	-25806.1326	1.0606e-005	(0.0033)
	-34734.3445	-9.7677e-007	5.2977e-006 (0.0023)
	-29440.3469	-1.8318e-007	-2.5794e-006 3.9847e-006 (0.0020)
A790 to LIND (2)	-25806.1413	6.0913e-006	(0.0025)
	-34734.3303	7.0883e-007	5.5001e-006 (0.0023)
	-29440.3614	9.5424e-007	-2.3688e-006 3.1716e-006 (0.0018)
A790 to PETO (1)	9766.0712	8.0362e-006	(0.0028)
	-27651.9257	-1.0794e-006	4.8178e-006 (0.0022)
	-29630.4366	-1.5160e-007	-2.3005e-006 3.4328e-006 (0.0019)
A790 to PETO (2)	9766.0596	5.8097e-006	(0.0024)
	-27651.9078	5.9832e-007	5.3326e-006 (0.0023)
	-29630.4495	9.4780e-007	-2.2985e-006 3.0196e-006 (0.0017)
BOVL to CBRG (1)	37248.9911	6.9915e-007	(0.0008)
	12303.6752	-4.8404e-007	2.9049e-006 (0.0017)
	4744.4295	2.7033e-007	-1.4409e-006 2.4684e-006 (0.0016)
BOVL to LIND (1)	-12914.8163	1.6884e-006	(0.0013)
	33357.7208	-8.7657e-008	1.4201e-006 (0.0012)
	36584.4788	1.5280e-007	-7.3428e-007 9.1361e-007 (0.0010)

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BOVL to LIND (2)      -12914.8122  1.3518e-006 (0.0012)
                      33357.7228 -1.1244e-007 1.4167e-006 (0.0012)
                      36584.4759 1.3080e-007 -7.4125e-007 8.9452e-007 (0.0009)

BOVL to PETO (1)      22657.3846 1.4890e-006 (0.0012)
                      40440.1436 -1.1533e-007 1.4134e-006 (0.0012)
                      36394.3882 1.2686e-007 -7.2525e-007 8.8814e-007 (0.0009)

BOVL to PETO (2)      22657.3830 1.4164e-006 (0.0012)
                      40440.1555 -1.1765e-007 1.4900e-006 (0.0012)
                      36394.3753 1.4499e-007 -7.8285e-007 9.4502e-007 (0.0010)

CBRG to LIND (1)      -50163.8087 3.0116e-006 (0.0017)
                      21054.0444 -2.4380e-007 2.2682e-006 (0.0015)
                      31840.0503 9.2191e-008 -1.1135e-006 1.4153e-006 (0.0012)

CBRG to PCT2 (1)      80675.7162 3.0310e-006 (0.0017)
                      21147.8807 -3.5918e-007 2.5975e-006 (0.0016)
                      3560.7433 1.3187e-007 -1.2636e-006 1.5904e-006 (0.0013)

CBRG to PETO (1)      -14591.6067 2.2528e-006 (0.0015)
                      28136.4665 -2.8609e-007 1.9359e-006 (0.0014)
                      31649.9587 1.0655e-007 -9.3770e-007 1.1893e-006 (0.0011)

LIND to PETO (1)      35572.2021 1.2985e-006 (0.0011)
                      7082.4256 -8.0493e-007 4.9097e-006 (0.0022)
                      -190.0915 8.1075e-007 -1.8779e-006 3.8047e-006 (0.0020)

LIND to PETO (2)      35572.1980 1.3815e-006 (0.0012)
                      7082.4361 -8.4174e-007 5.4041e-006 (0.0023)
                      -190.1029 9.0721e-007 -2.0736e-006 4.2092e-006 (0.0021)

MADO to PCT2 (1)      33766.7301 1.6863e-006 (0.0013)
                      -30150.3661 -7.9669e-008 1.7836e-006 (0.0013)
                      -37915.6611 1.7269e-007 -9.1936e-007 1.0561e-006 (0.0010)

MADO to PCT2 (2)      33766.7272 1.5826e-006 (0.0013)
                      -30150.3626 -1.2308e-007 1.5956e-006 (0.0013)
                      -37915.6648 1.8417e-007 -8.1018e-007 9.5223e-007 (0.0010)

MADO to PETO (2)      -61500.5919 1.7283e-006 (0.0013)
                      -23161.7981 -6.8539e-008 1.8400e-006 (0.0014)
                      -9826.4285 1.7285e-007 -9.2833e-007 1.0657e-006 (0.0010)

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      OUTPUT VECTOR RESIDUALS (East, North, Height - Local Level)
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SESSION NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)	- PPM -	DIST - (km)	STD - (m)
963021 to 963022 (1)	0.0021	0.0009	-0.0050	0.449	12.1	0.0063
963021 to A629 (1)	-0.0002	0.0009	0.0009	0.034	39.9	0.0137
963021 to A629 (2)	0.0036	-0.0028	0.0011	0.118	39.9	0.0112
963021 to A788 (1)	-0.0032	-0.0008	0.0056	0.695	9.4	0.0089
963021 to A788 (2)	-0.0037	-0.0000	0.0020	0.442	9.4	0.0095
963021 to BOVL (1)	0.0053	-0.0005	0.0005	0.100	53.9	0.0069
963021 to LIND (1)	-0.0008	0.0005	-0.0124	0.351	35.5	0.0089
963021 to MADO (1)	0.0061	-0.0018	0.0067	0.134	68.9	0.0076
963021 to PETO (1)	-0.0002	0.0012	-0.0029	0.585	5.4	0.0057
963022 to A629 (1)	-0.0107	0.0002	0.0121	0.351	46.0	0.0146
963022 to A629 (2)	-0.0052	0.0008	0.0051	0.159	46.0	0.0101
963022 to A788 (1)	0.0021	0.0002	-0.0080	2.290	3.6	0.0047
963022 to A788 (2)	0.0026	-0.0001	-0.0033	1.161	3.6	0.0050
963022 to BOVL (1)	-0.0065	0.0006	0.0013	0.159	41.8	0.0071
963022 to LIND (1)	-0.0027	-0.0009	-0.0097	0.322	31.4	0.0092
963022 to MADO (1)	-0.0053	-0.0014	0.0082	0.125	79.1	0.0085
963022 to PETO (1)	-0.0018	0.0009	0.0010	0.129	17.2	0.0093
973002 to 963022 (1)	0.0063	-0.0010	-0.0005	0.159	40.3	0.0070

973002 to 963021 (1)	0.0006	0.0002	-0.0069	0.240	28.9	0.0075
973002 to A629 (1)	-0.0023	0.0007	-0.0034	0.083	49.7	0.0108
973002 to A629 (2)	0.0004	-0.0044	0.0092	0.206	49.7	0.0089
973002 to A788 (1)	-0.0008	0.0022	-0.0048	0.139	38.2	0.0169
973002 to A788 (2)	0.0014	0.0005	0.0129	0.340	38.2	0.0175
973002 to A789 (1)	0.0004	0.0018	-0.0151	0.860	17.7	0.0128
973002 to A789 (2)	0.0004	0.0011	-0.0027	0.164	17.7	0.0148
973002 to A790 (1)	0.0006	-0.0016	0.0101	0.486	21.2	0.0128
973002 to A790 (2)	-0.0014	0.0021	0.0099	0.484	21.2	0.0151
973002 to CBRG (1)	0.0004	0.0011	0.0059	0.089	66.8	0.0079
973002 to LIND (1)	-0.0015	-0.0015	-0.0073	0.158	47.8	0.0062
973002 to LIND (2)	0.0002	0.0012	0.0162	0.339	47.8	0.0061
973002 to MADO (1)	0.0005	-0.0021	0.0068	0.119	59.6	0.0066
973002 to MADO (2)	0.0009	0.0022	-0.0148	0.251	59.6	0.0065
973002 to PETO (1)	-0.0017	-0.0004	-0.0109	0.468	23.6	0.0069
973002 to PETO (2)	-0.0007	0.0038	0.0144	0.633	23.6	0.0164
A629 to A788 (1)	-0.0011	-0.0009	-0.0047	0.116	42.6	0.0149
A629 to A788 (2)	0.0003	0.0018	-0.0068	0.165	42.6	0.0932
A629 to A788 (3)	0.0002	0.0040	0.0016	0.102	42.6	0.0138
A629 to BOVL (1)	0.0002	-0.0016	0.0086	0.115	76.0	0.0098
A629 to BOVL (2)	0.0026	0.0017	-0.0248	0.329	76.0	0.0086
A629 to MADO (1)	-0.0012	0.0003	0.0064	0.161	40.8	0.0091
A629 to MADO (2)	-0.0000	-0.0006	0.0095	0.233	40.8	0.0082
A629 to PCT2 (1)	-0.0048	0.0002	0.0090	0.173	59.1	0.0095
A629 to PCT2 (2)	-0.0006	-0.0021	0.0081	0.142	59.1	0.0083
A629 to PETO (1)	0.0014	-0.0019	0.0003	0.060	40.5	0.0088
A629 to PETO (2)	0.0022	0.0009	-0.0002	0.060	40.5	0.0077
A788 to BOVL (1)	0.0060	0.0006	0.0061	0.192	44.6	0.0126
A788 to BOVL (2)	0.0019	-0.0004	-0.0211	0.476	44.6	0.0139
A788 to LIND (1)	0.0052	0.0013	-0.0236	0.711	34.1	0.0149
A788 to LIND (2)	0.0022	-0.0008	-0.0188	0.556	34.1	0.0151
A788 to PETO (1)	0.0059	0.0040	-0.0101	0.841	14.7	0.0113
A788 to PETO (2)	0.0027	-0.0020	-0.0146	1.019	14.7	0.0115
A789 to A790 (1)	-0.0019	-0.0027	0.0290	1.009	29.0	0.0210
A789 to MADO (1)	0.0076	0.0024	-0.0099	0.281	45.2	0.0116
A789 to MADO (2)	-0.0004	0.0021	-0.0139	0.310	45.2	0.0080
A789 to PETO (1)	-0.0010	0.0017	0.0149	0.406	37.0	0.0147
A789 to PETO (2)	-0.0005	0.0011	0.0181	0.491	37.0	0.0113
A790 to LIND (1)	-0.0029	0.0000	-0.0039	0.092	52.3	0.0126
A790 to LIND (2)	0.0028	-0.0006	0.0174	0.338	52.3	0.0108
A790 to PETO (1)	-0.0054	0.0025	-0.0119	0.319	41.7	0.0114
A790 to PETO (2)	0.0024	-0.0022	0.0113	0.283	41.7	0.0106
BOVL to CBRG (1)	0.0009	-0.0003	-0.0122	0.311	39.5	0.0069
BOVL to LIND (1)	0.0017	-0.0008	-0.0032	0.072	51.2	0.0056
BOVL to LIND (2)	-0.0027	0.0006	-0.0003	0.054	51.2	0.0054
BOVL to PETO (1)	0.0012	-0.0008	-0.0073	0.126	58.9	0.0055
BOVL to PETO (2)	0.0004	0.0001	0.0102	0.173	58.9	0.0055
CBRG to LIND (1)	0.0023	-0.0005	0.0077	0.128	63.0	0.0073
CBRG to PCT2 (1)	0.0007	0.0012	-0.0173	0.208	83.5	0.0076
CBRG to PETO (1)	0.0009	0.0007	0.0036	0.084	44.8	0.0065
LIND to PETO (1)	-0.0023	-0.0012	-0.0018	0.086	36.3	0.0089
LIND to PETO (2)	-0.0003	-0.0008	0.0142	0.393	36.3	0.0093
MADO to PCT2 (1)	-0.0005	0.0002	-0.0010	0.019	59.0	0.0060
MADO to PCT2 (2)	0.0016	0.0000	0.0044	0.079	59.0	0.0057
MADO to PETO (2)	0.0025	-0.0004	-0.0048	0.081	66.4	0.0061

RMS	0.0031	0.0016	0.0107
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\$ - This session is flagged as a 3-sigma outlier

CHECK POINT RESIDUALS (East, North, Height - Local Level)

STA. NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)
963021	-0.0030	0.0070	0.0252
963022	-0.0002	0.0091	0.0249
A629	0.0205	-0.0110	0.0208
BOVL	-0.0029	0.0102	0.0058
LIND	-0.0032	0.0062	0.0150
MADO	-0.0040	0.0033	-0.0042
PETO	-0.0051	0.0070	0.0139

RMS	0.0084	0.0081	0.0176

CONTROL POINT RESIDUALS (ADJUSTMENT MADE)

STA. NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)
973002	0.0000	-0.0000	-0.0000

RMS	0.0000	0.0000	0.0000

OUTPUT STATION COORDINATES (LAT/LONG/HT)

STA_ID	-- LATITUDE --	-- LONGITUDE --	- ELLHGT -	ORTHOHGT
963021	44 18 38.77700	-78 18 10.44790	208.2892	243.4357
963022	44 13 28.37131	-78 23 45.98264	165.6980	200.9958
973002	44 33 45.82988	-78 12 44.99883	212.6890	247.4458
A629	44 12 52.45683	-77 49 15.30409	109.7238	144.7425
A788	44 14 03.08424	-78 21 10.82921	154.0384	189.3164
A789	44 37 20.21677	-78 00 19.42411	228.5654	263.0819
A790	44 43 51.95565	-78 20 13.81134	284.0054	318.6052
BOVL	43 54 09.43417	-78 39 56.37650	60.0518	95.9279
CBRG	43 57 43.04920	-78 10 49.66345	54.7611	90.5061
LIND	44 21 35.16890	-78 44 32.14740	239.6390	274.8583
MADO	44 28 55.58614	-77 28 16.43252	135.0528	169.3354
PCT2	44 00 23.00138	-77 08 30.37164	66.9882	101.7782
PETO	44 21 27.54158	-78 17 14.34081	208.5129	243.5807

OUTPUT STATION COORDINATES (GRID)

STA_ID	- EASTING - (m)	- NORTHING - (m)	- ELLHGT - (m)	ORTHOHGT (m)
963021	715107.5581	4909928.4987	208.2892	243.4357
963022	707977.9430	4900110.7057	165.6980	200.9958
973002	721363.7168	4938157.1348	212.6890	247.4458
A629	753963.4698	4900621.0875	109.7238	144.7425
A788	711385.8055	4901291.8468	154.0384	189.3164
A789	737567.7495	4945355.0838	228.5654	263.0819
A790	710851.9023	4956529.1499	284.0054	318.6052
BOVL	687461.5209	4863706.0385	60.0518	95.9279
CBRG	726201.7720	4871512.8392	54.7611	90.5061
LIND	679915.7804	4914311.9003	239.6390	274.8583
MADO	780618.3732	4931480.5375	135.0528	169.3354
PCT2	809305.3399	4879823.1821	66.9882	101.7782
PETO	716178.1709	4915176.7234	208.5129	243.5807

 OUTPUT VARIANCE/COVARIANCE

STA_ID	SE/SN/SUP (95.00 %) (m)	2 CX matrix (m)----- (not scaled by confidence level) (ECEF, XYZ cartesian)
963021	0.0126	2.6662e-005
	0.0126	-5.0564e-007 2.9229e-005
	0.0136	4.2809e-007 -2.1383e-006 2.8053e-005
963022	0.0127	2.6971e-005
	0.0125	-4.6090e-007 2.8800e-005
	0.0135	4.2950e-007 -1.9175e-006 2.7567e-005
973002	0.0122	2.5000e-005
	0.0122	1.9004e-020 2.5000e-005
	0.0122	1.9141e-020 3.3039e-019 2.5000e-005
A629	0.0129	2.7712e-005
	0.0125	-3.6337e-007 2.8770e-005
	0.0134	3.6668e-007 -1.7978e-006 2.7325e-005
A788	0.0127	2.6982e-005
	0.0127	-6.6283e-007 2.9914e-005
	0.0138	5.0421e-007 -2.3344e-006 2.8293e-005
A789	0.0131	2.9014e-005
	0.0131	-1.2333e-006 3.4548e-005
	0.0151	9.2802e-007 -4.6729e-006 3.1925e-005
A790	0.0134	3.0069e-005
	0.0130	-9.9800e-007 3.4215e-005
	0.0150	7.8699e-007 -4.5366e-006 3.1476e-005
BOVL	0.0128	2.7662e-005
	0.0125	-3.6288e-007 2.8403e-005
	0.0133	3.5902e-007 -1.7518e-006 2.7278e-005
CBRG	0.0131	2.9089e-005
	0.0127	-7.2814e-007 3.0155e-005
	0.0139	3.9918e-007 -2.5654e-006 2.8400e-005
LIND	0.0127	2.6919e-005
	0.0125	-3.1336e-007 2.7954e-005
	0.0132	3.2749e-007 -1.5320e-006 2.7022e-005
MADO	0.0129	2.7883e-005
	0.0125	-2.5287e-007 2.8129e-005
	0.0132	3.7112e-007 -1.5977e-006 2.7007e-005
PCT2	0.0135	3.0422e-005
	0.0127	-5.0043e-007 3.0993e-005
	0.0141	5.8212e-007 -3.0065e-006 2.8703e-005
PETO	0.0126	2.6397e-005
	0.0125	-3.5128e-007 2.7974e-005
	0.0132	2.9294e-007 -1.4876e-006 2.7074e-005

 VARIANCE FACTOR = 1.0000

Note: Values < 1.0 indicate statistics are pessimistic, while
 values > 1.0 indicate optimistic statistics. Entering this
 value as the network adjustment scale factor will bring
 variance factor to one.



g.) Fully Constrained Network Adjustment

```

*****
* NETWORK - WEIGHTED GPS NETWORK ADJUSTMENT *
* *
* (c) Copyright NovAtel Inc., (2014) *
* *
* Version: 8.50.4320 *
* *
* FILE: 1626_OMAFRA-Peterborough_full.net *
*****

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DATUM:          'NAD83'
GRID:           UTM, Zone 17
SCALE_FACTOR:   8.7430
CONFIDENCE LEVEL: 95.00 %   (Scale factor is 2.4479)

```

```

*****
INPUT CONTROL/CHECK POINTS
*****

```

STA_ID	TYPE	-- LATITUDE --	-- LONGITUDE --	ELLHGT -	HZ-SD	V-SD
963021	GCP-3D	44 18 38.77677	-78 18 10.44777	208.264	0.00500	0.00500
963022	CHK-3D	44 13 28.37101	-78 23 45.98263	165.673		
973002	CHK-3D	44 33 45.82988	-78 12 44.99883	212.689		
A629	CHK-3D	44 12 52.45719	-77 49 15.30501	109.703		
BOVL	GCP-3D	43 54 09.43384	-78 39 56.37637	60.046	0.00500	0.00500
CBRG	GCP-3D	43 57 43.04900	-78 10 49.66335	54.761	0.00500	0.00500
LIND	GCP-3D	44 21 35.16870	-78 44 32.14726	239.624	0.00500	0.00500
MADO	GCP-3D	44 28 55.58603	-77 28 16.43234	135.057	0.00500	0.00500
PCT2	GCP-3D	44 00 23.00114	-77 08 30.37182	67.002	0.00500	0.00500
PETO	GCP-3D	44 21 27.54135	-78 17 14.34058	208.499	0.00500	0.00500

```

*****
INPUT VECTORS
*****

```

SESSION NAME	VECTOR(m)	----- Covariance (m) [unscaled] -----
	DX/DY/DZ	standard deviations in brackets
963021 to 963022 (1)	-5944.3617 -8023.0282 -6890.7342	5.5539e-007 (0.0007) 2.5551e-006 (0.0016) 2.4446e-007 -1.1892e-006 1.9102e-006 (0.0014)
963021 to 973002 (1)	3058.3537 20654.0532 19994.8813	7.8501e-007 (0.0009) -4.5068e-007 3.4517e-006 (0.0019) 3.1661e-007 -1.6758e-006 2.8651e-006 (0.0017)
963021 to A629 (1)	39184.2819 731.0070 -7724.2422	2.5115e-006 (0.0016) -1.0358e-006 1.1931e-005 (0.0035) 8.9021e-007 -5.4902e-006 9.1459e-006 (0.0030)
963021 to A629 (2)	39184.2776 731.0088 -7724.2396	1.7834e-006 (0.0013) -1.2099e-006 7.4350e-006 (0.0027) 7.5631e-007 -3.7379e-006 6.5155e-006 (0.0026)
963021 to A788 (1)	-2723.8075 -6588.8777 -6131.1097	1.0289e-006 (0.0010) -6.7748e-007 5.8508e-006 (0.0024) 3.6654e-007 -2.2828e-006 3.1054e-006 (0.0018)
963021 to A788 (2)	-2723.8064 -6588.8807 -6131.1077	1.2175e-006 (0.0011) -9.4271e-007 4.9833e-006 (0.0022) 8.1586e-007 -2.8567e-006 5.1854e-006 (0.0023)
963022 to 973002 (1)	9002.7209 28677.0730 26885.6219	2.8586e-006 (0.0017) -8.3573e-008 1.9777e-006 (0.0014) 3.2550e-007 -1.0651e-006 1.3378e-006 (0.0012)
963022 to A629 (1)	45128.6510 8754.0411 -833.5123	1.6627e-005 (0.0041) -1.5935e-006 6.2006e-006 (0.0025) -8.5548e-008 -2.8265e-006 4.0951e-006 (0.0020)

963022 to A629 (2)	45128.6467	4.2904e-006	(0.0021)
	8754.0346	4.3078e-007	5.7913e-006 (0.0024)
	-833.5079	6.2182e-007	-2.3062e-006 2.8564e-006 (0.0017)
963022 to A788 (1)	3220.5499	2.8418e-007	(0.0005)
	1434.1347	-1.8690e-007	1.6183e-006 (0.0013)
	759.6361	1.0139e-007	-6.2986e-007 8.5211e-007 (0.0009)
963022 to A788 (2)	3220.5487	3.3699e-007	(0.0006)
	1434.1381	-2.6107e-007	1.3780e-006 (0.0012)
	759.6330	2.2624e-007	-7.8391e-007 1.4034e-006 (0.0012)
973002 to A629 (1)	36125.9305	7.8982e-006	(0.0028)
	-19923.0438	-9.0603e-007	3.9444e-006 (0.0020)
	-27719.1248	2.1312e-008	-1.9919e-006 2.8899e-006 (0.0017)
973002 to A629 (2)	36125.9252	3.0025e-006	(0.0017)
	-19923.0320	5.2735e-008	4.7317e-006 (0.0022)
	-27719.1300	4.9017e-007	-1.8880e-006 2.2104e-006 (0.0015)
973002 to A788 (1)	-5782.1620	6.3356e-006	(0.0025)
	-27242.9358	-6.4257e-006	1.9954e-005 (0.0045)
	-26125.9904	2.1412e-006	-8.2637e-006 9.8389e-006 (0.0031)
973002 to A788 (2)	-5782.1669	5.6581e-006	(0.0024)
	-27242.9227	-4.7561e-006	2.0563e-005 (0.0045)
	-26126.0016	1.6082e-006	-6.7706e-006 1.2267e-005 (0.0035)
973002 to A789 (1)	15137.4805	1.8583e-006	(0.0014)
	7923.9496	-8.2457e-007	7.3356e-006 (0.0027)
	4723.8554	1.9517e-007	-4.6142e-006 1.1384e-005 (0.0034)
973002 to A789 (2)	15137.4786	3.6168e-006	(0.0019)
	7923.9587	-1.6484e-006	1.4007e-005 (0.0037)
	4723.8471	6.4070e-007	-5.6491e-006 1.0116e-005 (0.0032)
973002 to A790 (1)	-12345.7453	1.9113e-006	(0.0014)
	10814.6834	-6.6157e-007	9.1723e-006 (0.0030)
	13361.8019	9.5675e-008	-3.8754e-006 9.6861e-006 (0.0031)
973002 to A790 (2)	-12345.7427	3.9536e-006	(0.0020)
	10814.6811	-3.6588e-006	1.4131e-005 (0.0038)
	13361.7994	1.4275e-006	-7.8421e-006 1.0794e-005 (0.0033)
A629 to A788 (1)	-41908.0898	1.7422e-005	(0.0042)
	-7319.8922	-1.6381e-006	6.3992e-006 (0.0025)
	1593.1384	-1.3954e-007	-2.8604e-006 4.1198e-006 (0.0020)
A629 to A788 (3)	-41908.0913	7.2318e-006	(0.0027)
	-7319.8914	1.3984e-007	1.1499e-005 (0.0034)
	1593.1305	1.3087e-006	-4.3373e-006 5.2192e-006 (0.0023)
A789 to A790 (1)	-27483.2241	5.8036e-006	(0.0024)
	2890.7364	-4.0110e-006	2.6389e-005 (0.0051)
	8637.9433	4.2012e-006	-1.2732e-005 2.3245e-005 (0.0048)
BOVL to 963021 (1)	22178.7152	2.7241e-006	(0.0017)
	36623.3420	-2.0783e-007	1.9269e-006 (0.0014)
	32668.1319	3.5208e-007	-1.0477e-006 1.3128e-006 (0.0011)
BOVL to 963022 (1)	16234.3432	2.9072e-006	(0.0017)
	28600.3162	-1.1374e-007	2.0240e-006 (0.0014)
	25777.3962	3.4450e-007	-1.0912e-006 1.3519e-006 (0.0012)
BOVL to A629 (1)	61362.9932	5.6691e-006	(0.0024)
	37354.3413	-7.4059e-007	3.8071e-006 (0.0020)
	24943.8959	1.2935e-007	-1.8614e-006 2.5443e-006 (0.0016)
BOVL to A629 (2)	61362.9903	2.6424e-006	(0.0016)
	37354.3676	-2.2568e-007	4.5962e-006 (0.0021)
	24943.8751	4.4287e-007	-1.9087e-006 2.1161e-006 (0.0015)

BOVL to A788 (1)	19454.9070	1.3243e-005 (0.0036)
	30034.4561	-1.1265e-006 4.1904e-006 (0.0020)
	26537.0302	2.0623e-007 -2.0637e-006 2.6979e-006 (0.0016)
BOVL to A788 (2)	19454.8991	7.3247e-006 (0.0027)
	30034.4737	8.8919e-008 1.1628e-005 (0.0034)
	26537.0106	1.3280e-006 -4.3942e-006 5.2784e-006 (0.0023)
CBRG to 973002 (1)	-12011.9252	3.5895e-006 (0.0019)
	44973.7027	-4.4874e-007 2.5438e-006 (0.0016)
	47918.6017	1.5077e-007 -1.2611e-006 1.6517e-006 (0.0013)
CBRG to BOVL (1)	-37248.9911	6.9974e-007 (0.0008)
	-12303.6753	-4.8560e-007 2.9030e-006 (0.0017)
	-4744.4294	2.7218e-007 -1.4402e-006 2.4676e-006 (0.0016)
LIND to 963021 (1)	35093.5223	9.7588e-007 (0.0010)
	3265.6274	-4.6644e-007 4.9417e-006 (0.0022)
	-3916.3523	4.5571e-007 -2.3432e-006 3.9808e-006 (0.0020)
LIND to 963022 (1)	29149.1605	1.0346e-006 (0.0010)
	-4757.3994	-5.8258e-007 5.6520e-006 (0.0024)
	-10807.0884	5.3664e-007 -2.5459e-006 4.0426e-006 (0.0020)
LIND to 973002 (1)	38151.8767	1.9168e-006 (0.0014)
	23919.6708	-7.3719e-008 1.7343e-006 (0.0013)
	16078.5356	1.8883e-007 -9.4086e-007 1.1615e-006 (0.0011)
LIND to 973002 (2)	38151.8813	2.0720e-006 (0.0014)
	23919.6565	-1.1544e-007 1.5429e-006 (0.0012)
	16078.5539	2.2686e-007 -8.3236e-007 1.0663e-006 (0.0010)
LIND to A788 (1)	32369.7170	2.3536e-006 (0.0015)
	-3323.2467	-6.9013e-007 1.7405e-005 (0.0042)
	-10047.4650	7.8713e-007 -6.9552e-006 8.1255e-006 (0.0029)
LIND to A788 (2)	32369.7150	2.6290e-006 (0.0016)
	-3323.2521	-2.1268e-006 1.2414e-005 (0.0035)
	-10047.4631	2.2754e-006 -6.4408e-006 1.3532e-005 (0.0037)
LIND to A790 (1)	25806.1326	1.0624e-005 (0.0033)
	34734.3445	-9.8458e-007 5.3064e-006 (0.0023)
	29440.3469	-1.7855e-007 -2.5774e-006 3.9785e-006 (0.0020)
LIND to A790 (2)	25806.1413	6.0988e-006 (0.0025)
	34734.3303	7.1208e-007 5.5061e-006 (0.0023)
	29440.3614	9.5471e-007 -2.3656e-006 3.1660e-006 (0.0018)
LIND to BOVL (1)	12914.8163	1.6851e-006 (0.0013)
	-33357.7208	-8.7815e-008 1.4183e-006 (0.0012)
	-36584.4788	1.5325e-007 -7.3522e-007 9.1569e-007 (0.0010)
LIND to BOVL (2)	12914.8122	1.3492e-006 (0.0012)
	-33357.7228	-1.1252e-007 1.4151e-006 (0.0012)
	-36584.4759	1.3120e-007 -7.4226e-007 8.9665e-007 (0.0009)
LIND to CBRG (1)	50163.8087	3.0069e-006 (0.0017)
	-21054.0444	-2.4471e-007 2.2666e-006 (0.0015)
	-31840.0502	9.4290e-008 -1.1149e-006 1.4177e-006 (0.0012)
MADO to A629 (2)	-22794.9818	2.4541e-006 (0.0016)
	-26247.6015	-3.8541e-008 4.3203e-006 (0.0021)
	-21276.9172	4.3014e-007 -1.6881e-006 1.8014e-006 (0.0013)
MADO to 963021 (1)	-61979.2578	3.3139e-006 (0.0018)
	-26978.6059	-1.3518e-007 2.3747e-006 (0.0015)
	-13552.6792	4.1955e-007 -1.2623e-006 1.5287e-006 (0.0012)
MADO to 963022 (1)	-67923.6293	4.3044e-006 (0.0021)
	-35001.6329	-1.7140e-007 2.9679e-006 (0.0017)
	-20443.4150	5.6456e-007 -1.5704e-006 1.8527e-006 (0.0014)

MADO to 973002 (1)	-58920.9092	2.3745e-006	(0.0015)
	-6324.5591	-1.3124e-007	1.9682e-006 (0.0014)
	6442.2065	2.9716e-007	-1.0315e-006 1.2302e-006 (0.0011)
MADO to 973002 (2)	-58920.9126	2.2547e-006	(0.0015)
	-6324.5411	-1.4707e-007	1.8433e-006 (0.0014)
	6442.1944	2.6610e-007	-9.7219e-007 1.1803e-006 (0.0011)
MADO to A629 (1)	-22794.9835	4.8918e-006	(0.0022)
	-26247.5991	-5.8294e-007	3.4476e-006 (0.0019)
	-21276.9188	9.4483e-008	-1.6501e-006 2.1345e-006 (0.0015)
MADO to A789 (1)	-43783.4270	6.5929e-006	(0.0026)
	1599.4185	-1.5558e-007	6.6434e-006 (0.0026)
	11166.0441	1.3408e-008	-2.5056e-006 3.7105e-006 (0.0019)
MADO to A789 (2)	-43783.4354	3.2053e-006	(0.0018)
	1599.4193	-7.0921e-008	3.0729e-006 (0.0018)
	11166.0410	5.9405e-007	-1.4673e-006 1.7646e-006 (0.0013)
PCT2 to A629 (1)	-56561.7160	5.2779e-006	(0.0023)
	3902.7635	-5.8569e-007	3.5676e-006 (0.0019)
	16638.7446	2.7950e-008	-1.8464e-006 2.5045e-006 (0.0016)
PCT2 to A629 (2)	-56561.7117	2.3298e-006	(0.0015)
	3902.7636	-3.1506e-008	4.2666e-006 (0.0021)
	16638.7423	3.5595e-007	-1.8049e-006 2.0307e-006 (0.0014)
PCT2 to CBRG (1)	-80675.7162	3.0319e-006	(0.0017)
	-21147.8807	-3.5829e-007	2.5948e-006 (0.0016)
	-3560.7433	1.2966e-007	-1.2636e-006 1.5911e-006 (0.0013)
PCT2 to MADO (1)	-33766.7301	1.6900e-006	(0.0013)
	30150.3661	-7.9880e-008	1.7862e-006 (0.0013)
	37915.6611	1.7210e-007	-9.1820e-007 1.0534e-006 (0.0010)
PCT2 to MADO (2)	-33766.7272	1.5860e-006	(0.0013)
	30150.3626	-1.2334e-007	1.5978e-006 (0.0013)
	37915.6648	1.8360e-007	-8.0907e-007 9.4983e-007 (0.0010)
PETO to BOVL (1)	-22657.3847	1.4866e-006	(0.0012)
	-40440.1436	-1.1560e-007	1.4112e-006 (0.0012)
	-36394.3882	1.2694e-007	-7.2619e-007 8.9023e-007 (0.0009)
PETO to 963021 (1)	-478.6757	3.9996e-007	(0.0006)
	-3816.8043	-1.9429e-007	2.0095e-006 (0.0014)
	-3726.2516	1.8991e-007	-9.4937e-007 1.6210e-006 (0.0013)
PETO to 963022 (1)	-6423.0372	1.3243e-006	(0.0012)
	-11839.8312	-8.7275e-007	5.4428e-006 (0.0023)
	-10616.9861	6.5666e-007	-1.4366e-006 4.1398e-006 (0.0020)
PETO to 973002 (1)	2579.6760	5.9729e-007	(0.0008)
	16837.2483	-2.9040e-007	2.7775e-006 (0.0017)
	16268.6276	2.5789e-007	-1.4019e-006 2.5415e-006 (0.0016)
PETO to 973002 (2)	2579.6800	4.8588e-006	(0.0022)
	16837.2337	-2.3352e-006	1.2562e-005 (0.0035)
	16268.6482	2.1887e-007	-6.9806e-006 1.6344e-005 (0.0040)
PETO to A629 (1)	38705.6085	4.5794e-006	(0.0021)
	-3085.8013	-4.9654e-007	3.0654e-006 (0.0018)
	-11450.4926	2.1722e-008	-1.5649e-006 2.1441e-006 (0.0015)
PETO to A629 (2)	38705.6088	2.0476e-006	(0.0014)
	-3085.7988	-1.2988e-007	3.7141e-006 (0.0019)
	-11450.4909	3.4029e-007	-1.5835e-006 1.7910e-006 (0.0013)
PETO to A788 (1)	-3202.4806	1.3750e-006	(0.0012)
	-10405.6798	-4.2772e-007	1.0096e-005 (0.0032)
	-9857.3601	4.7964e-007	-4.0198e-006 4.7258e-006 (0.0022)

```

PETO to A788 (2)      -3202.4836  1.5357e-006 (0.0012)
                      -10405.6814 -1.2421e-006 7.1963e-006 (0.0027)
                      -9857.3675  1.3317e-006 -3.7117e-006 7.8163e-006 (0.0028)

PETO to A789 (1)      17717.1588  3.5171e-006 (0.0019)
                      24761.1924 -2.0203e-006 1.3521e-005 (0.0037)
                      20992.4939  1.9676e-006 -4.7677e-006 1.0102e-005 (0.0032)

PETO to A789 (2)      17717.1598  2.5484e-006 (0.0016)
                      24761.1897 -1.4930e-006 6.6777e-006 (0.0026)
                      20992.4959  5.8263e-007 -4.1171e-006 7.0141e-006 (0.0026)

PETO to A790 (1)      -9766.0711  8.0476e-006 (0.0028)
                      27651.9257 -1.0802e-006 4.8228e-006 (0.0022)
                      29630.4367 -1.5373e-007 -2.2980e-006 3.4272e-006 (0.0019)

PETO to A790 (2)      -9766.0596  5.8169e-006 (0.0024)
                      27651.9078  5.9937e-007 5.3379e-006 (0.0023)
                      29630.4495  9.4697e-007 -2.2958e-006 3.0140e-006 (0.0017)

PETO to BOVL (2)      -22657.3830  1.4141e-006 (0.0012)
                      -40440.1555 -1.1822e-007 1.4878e-006 (0.0012)
                      -36394.3753  1.4522e-007 -7.8387e-007 9.4729e-007 (0.0010)

PETO to CBRG (1)      14591.6067  2.2496e-006 (0.0015)
                      -28136.4665 -2.8613e-007 1.9341e-006 (0.0014)
                      -31649.9587  1.0734e-007 -9.3890e-007 1.1915e-006 (0.0011)

PETO to LIND (1)      -35572.2020  1.3005e-006 (0.0011)
                      -7082.4257 -8.0738e-007 4.9083e-006 (0.0022)
                      190.0915  8.1358e-007 -1.8762e-006 3.8039e-006 (0.0020)

PETO to LIND (2)      -35572.1980  1.3837e-006 (0.0012)
                      -7082.4362 -8.4455e-007 5.4027e-006 (0.0023)
                      190.1030  9.1037e-007 -2.0718e-006 4.2083e-006 (0.0021)

PETO to MADO (2)      61500.5919  1.7286e-006 (0.0013)
                      23161.7981 -6.7600e-008 1.8408e-006 (0.0014)
                      9826.4285  1.7335e-007 -9.2760e-007 1.0647e-006 (0.0010)

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*****
      OUTPUT VECTOR RESIDUALS (East, North, Height - Local Level)
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SESSION NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)	- PPM -	DIST - (km)	STD - (m)
963021 to 963022 (1)	0.0020	0.0007	-0.0026	0.278	12.1	0.0066
963021 to 973002 (1)	-0.0007	-0.0004	0.0095	0.328	28.9	0.0079
963021 to A629 (1)	-0.0004	0.0006	0.0043	0.109	39.9	0.0144
963021 to A629 (2)	0.0035	-0.0031	0.0044	0.161	39.9	0.0117
963021 to A788 (1)	-0.0032	-0.0009	0.0079	0.912	9.4	0.0093
963021 to A788 (2)	-0.0037	-0.0002	0.0042	0.595	9.4	0.0100
963022 to 973002 (1)	-0.0064	0.0010	0.0010	0.161	40.3	0.0073
963022 to A629 (1)	-0.0109	0.0001	0.0130	0.369	46.0	0.0153
963022 to A629 (2)	-0.0053	0.0007	0.0061	0.176	46.0	0.0106
963022 to A788 (1)	0.0021	0.0002	-0.0081	2.323	3.6	0.0049
963022 to A788 (2)	0.0026	-0.0001	-0.0034	1.188	3.6	0.0052
973002 to A629 (1)	-0.0024	0.0006	-0.0029	0.076	49.7	0.0113
973002 to A629 (2)	0.0003	-0.0045	0.0097	0.216	49.7	0.0093
973002 to A788 (1)	-0.0008	0.0022	-0.0054	0.153	38.2	0.0178
973002 to A788 (2)	0.0014	0.0006	0.0123	0.325	38.2	0.0183
973002 to A789 (1)	0.0004	0.0017	-0.0141	0.800	17.7	0.0134
973002 to A789 (2)	0.0004	0.0011	-0.0016	0.110	17.7	0.0156
973002 to A790 (1)	0.0007	-0.0015	0.0093	0.447	21.2	0.0135
973002 to A790 (2)	-0.0014	0.0022	0.0091	0.446	21.2	0.0159
A629 to A788 (1)	-0.0010	-0.0007	-0.0058	0.140	42.6	0.0156
A629 to A788 (3)	0.0003	0.0042	0.0005	0.099	42.6	0.0145
A789 to A790 (1)	-0.0018	-0.0026	0.0271	0.943	29.0	0.0220

BOVL to 963021 (1)	-0.0053	0.0008	-0.0026	0.110	53.9	0.0072
BOVL to 963022 (1)	0.0064	-0.0006	-0.0010	0.156	41.8	0.0074
BOVL to A629 (1)	-0.0002	0.0015	-0.0074	0.099	76.0	0.0103
BOVL to A629 (2)	-0.0027	-0.0018	0.0260	0.345	76.0	0.0090
BOVL to A788 (1)	-0.0061	-0.0005	-0.0059	0.191	44.6	0.0133
BOVL to A788 (2)	-0.0020	0.0005	0.0213	0.479	44.6	0.0146
CBRG to 973002 (1)	-0.0003	-0.0008	-0.0072	0.108	66.8	0.0083
CBRG to BOVL (1)	-0.0008	0.0004	0.0101	0.256	39.5	0.0073
LIND to 963021 (1)	0.0008	-0.0003	0.0107	0.301	35.5	0.0093
LIND to 963022 (1)	0.0027	0.0007	0.0103	0.340	31.4	0.0097
LIND to 973002 (1)	0.0014	0.0014	0.0085	0.183	47.8	0.0065
LIND to 973002 (2)	-0.0002	-0.0013	-0.0149	0.313	47.8	0.0064
LIND to A788 (1)	-0.0052	-0.0014	0.0229	0.691	34.1	0.0156
LIND to A788 (2)	-0.0022	0.0008	0.0180	0.533	34.1	0.0158
LIND to A790 (1)	0.0029	-0.0001	0.0043	0.099	52.3	0.0132
LIND to A790 (2)	-0.0028	0.0006	-0.0170	0.329	52.3	0.0114
LIND to BOVL (1)	-0.0017	0.0006	0.0038	0.082	51.2	0.0059
LIND to BOVL (2)	0.0027	-0.0007	0.0009	0.057	51.2	0.0057
LIND to CBRG (1)	-0.0024	0.0003	-0.0051	0.090	63.0	0.0076
MADO to A629 (2)	-0.0000	0.0006	-0.0109	0.267	40.8	0.0087
MADO to 963021 (1)	-0.0060	0.0021	-0.0114	0.189	68.9	0.0079
MADO to 963022 (1)	0.0053	0.0017	-0.0105	0.151	79.1	0.0089
MADO to 973002 (1)	-0.0004	0.0023	-0.0086	0.150	59.6	0.0070
MADO to 973002 (2)	-0.0008	-0.0020	0.0129	0.220	59.6	0.0068
MADO to A629 (1)	0.0011	-0.0001	-0.0078	0.193	40.8	0.0096
MADO to A789 (1)	-0.0075	-0.0023	0.0091	0.266	45.2	0.0122
MADO to A789 (2)	0.0005	-0.0019	0.0131	0.293	45.2	0.0084
PCT2 to A629 (1)	0.0055	0.0004	-0.0133	0.243	59.1	0.0100
PCT2 to A629 (2)	0.0013	0.0026	-0.0124	0.215	59.1	0.0087
PCT2 to CBRG (1)	0.0001	-0.0007	0.0139	0.167	83.5	0.0079
PCT2 to MADO (1)	0.0013	0.0003	-0.0019	0.039	59.0	0.0063
PCT2 to MADO (2)	-0.0007	0.0004	-0.0073	0.124	59.0	0.0060
PETO to BOVL (1)	-0.0011	0.0007	0.0076	0.131	58.9	0.0058
PETO to 963021 (1)	0.0002	-0.0010	0.0008	0.241	5.4	0.0059
PETO to 963022 (1)	0.0017	-0.0009	-0.0008	0.124	17.2	0.0098
PETO to 973002 (1)	0.0016	0.0002	0.0116	0.498	23.6	0.0072
PETO to 973002 (2)	0.0007	-0.0039	-0.0137	0.604	23.6	0.0172
PETO to A629 (1)	-0.0016	0.0018	0.0011	0.065	40.5	0.0093
PETO to A629 (2)	-0.0024	-0.0010	0.0017	0.076	40.5	0.0081
PETO to A788 (1)	-0.0060	-0.0040	0.0089	0.780	14.7	0.0119
PETO to A788 (2)	-0.0027	0.0020	0.0134	0.942	14.7	0.0120
PETO to A789 (1)	0.0009	-0.0018	-0.0142	0.389	37.0	0.0154
PETO to A789 (2)	0.0004	-0.0012	-0.0177	0.479	37.0	0.0119
PETO to A790 (1)	0.0053	-0.0025	0.0120	0.320	41.7	0.0119
PETO to A790 (2)	-0.0024	0.0022	-0.0112	0.281	41.7	0.0111
PETO to BOVL (2)	-0.0004	-0.0002	-0.0099	0.168	58.9	0.0058
PETO to CBRG (1)	-0.0010	-0.0009	-0.0013	0.042	44.8	0.0069
PETO to LIND (1)	0.0022	0.0012	0.0013	0.078	36.3	0.0094
PETO to LIND (2)	0.0003	0.0008	-0.0147	0.406	36.3	0.0098
PETO to MADO (2)	-0.0027	0.0000	0.0075	0.120	66.4	0.0064

RMS	0.0031	0.0016	0.0107
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\$ - This session is flagged as a 3-sigma outlier

CHECK POINT RESIDUALS (East, North, Height - Local Level)

STA. NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)
963022	0.0023	0.0024	0.0181
973002	0.0025	-0.0066	-0.0064
A629	0.0229	-0.0177	0.0150
RMS	0.0133	0.0110	0.0141

CONTROL POINT RESIDUALS (ADJUSTMENT MADE)

STA. NAME	-- RE -- (m)	-- RN -- (m)	-- RH -- (m)
963021	-0.0004	0.0005	0.0160
BOVL	-0.0004	0.0035	-0.0012
CBRG	0.0003	-0.0007	-0.0048
LIND	-0.0006	-0.0003	0.0073
MADO	-0.0016	-0.0036	-0.0086
PCT2	0.0056	0.0000	-0.0153
PETO	-0.0025	0.0004	0.0066

RMS	0.0024	0.0019	0.0099

OUTPUT STATION COORDINATES (LAT/LONG/HT)

STA_ID	-- LATITUDE --	-- LONGITUDE --	- ELLHGT -	ORTHOHGT
963021	44 18 38.77679	-78 18 10.44779	208.2800	243.4266
963022	44 13 28.37109	-78 23 45.98252	165.6911	200.9890
973002	44 33 45.82967	-78 12 44.99872	212.6826	247.4395
A629	44 12 52.45662	-77 49 15.30398	109.7180	144.7367
A788	44 14 03.08402	-78 21 10.82909	154.0315	189.3095
A789	44 37 20.21655	-78 00 19.42400	228.5601	263.0766
A790	44 43 51.95543	-78 20 13.81123	283.9982	318.5979
BOVL	43 54 09.43395	-78 39 56.37639	60.0448	95.9209
CBRG	43 57 43.04898	-78 10 49.66334	54.7562	90.5012
LIND	44 21 35.16869	-78 44 32.14729	239.6313	274.8507
MADO	44 28 55.58591	-77 28 16.43241	135.0484	169.3310
PCT2	44 00 23.00114	-77 08 30.37157	66.9867	101.7767
PETO	44 21 27.54136	-78 17 14.34069	208.5056	243.5734

OUTPUT STATION COORDINATES (GRID)

STA_ID	- EASTING - (m)	- NORTHING - (m)	- ELLHGT - (m)	ORTHOHGT (m)
963021	715107.5609	4909928.4923	208.2800	243.4266
963022	707977.9457	4900110.6991	165.6911	200.9890
973002	721363.7195	4938157.1282	212.6826	247.4395
A629	753963.4725	4900621.0808	109.7180	144.7367
A788	711385.8083	4901291.8403	154.0315	189.3095
A789	737567.7522	4945355.0772	228.5601	263.0766
A790	710851.9050	4956529.1434	283.9982	318.5979
BOVL	687461.5237	4863706.0318	60.0448	95.9209
CBRG	726201.7747	4871512.8324	54.7562	90.5012
LIND	679915.7831	4914311.8938	239.6313	274.8507
MADO	780618.3759	4931480.5307	135.0484	169.3310
PCT2	809305.3419	4879823.1749	66.9867	101.7767
PETO	716178.1736	4915176.7169	208.5056	243.5734

 OUTPUT VARIANCE/COVARIANCE

STA_ID	SE/SN/SUP	----- CX matrix (m)-----
	(95.00 %)	(not scaled by confidence level)
	(m)	(ECEF, XYZ cartesian)
963021	0.0052	4.5481e-006
	0.0052	-2.3396e-007 5.7870e-006
	0.0063	2.1874e-007 -1.0503e-006 5.1991e-006
963022	0.0054	5.0102e-006
	0.0053	-3.6717e-007 6.6126e-006
	0.0068	3.4536e-007 -1.4855e-006 5.6046e-006
973002	0.0054	4.9541e-006
	0.0050	-2.2187e-007 5.6007e-006
	0.0062	2.0496e-007 -1.0404e-006 4.9646e-006
A629	0.0058	5.6162e-006
	0.0052	-2.5104e-007 6.3481e-006
	0.0065	2.5004e-007 -1.2740e-006 5.1923e-006
A788	0.0054	5.0339e-006
	0.0055	-5.2976e-007 7.6174e-006
	0.0073	4.0897e-007 -1.8518e-006 6.2437e-006
A789	0.0068	8.0101e-006
	0.0066	-1.2556e-006 1.3217e-005
	0.0100	1.0033e-006 -4.6665e-006 1.0447e-005
A790	0.0075	9.5422e-006
	0.0064	-9.0004e-007 1.2768e-005
	0.0098	8.3421e-007 -4.4547e-006 9.8874e-006
BOVL	0.0053	4.8129e-006
	0.0049	-1.3960e-007 5.0221e-006
	0.0058	1.4675e-007 -7.1401e-007 4.5259e-006
CBRG	0.0058	5.7529e-006
	0.0053	-3.7197e-007 6.2878e-006
	0.0066	1.6064e-007 -1.2535e-006 5.4044e-006
LIND	0.0053	4.6632e-006
	0.0050	-1.6499e-007 5.2530e-006
	0.0059	1.7652e-007 -8.0706e-007 4.7155e-006
MADO	0.0056	5.2578e-006
	0.0050	-1.0464e-007 5.2399e-006
	0.0059	1.8531e-007 -8.1434e-007 4.6188e-006
PCT2	0.0062	6.5648e-006
	0.0053	-1.9574e-007 6.6056e-006
	0.0067	2.4472e-007 -1.4113e-006 5.4652e-006
PETO	0.0051	4.3262e-006
	0.0049	-1.3648e-007 4.8670e-006
	0.0056	1.2574e-007 -6.1064e-007 4.4419e-006

 VARIANCE FACTOR = 1.0319

Note: Values < 1.0 indicate statistics are pessimistic, while
 values > 1.0 indicate optimistic statistics. Entering this
 value as the network adjustment scale factor will bring
 variance factor to one.
