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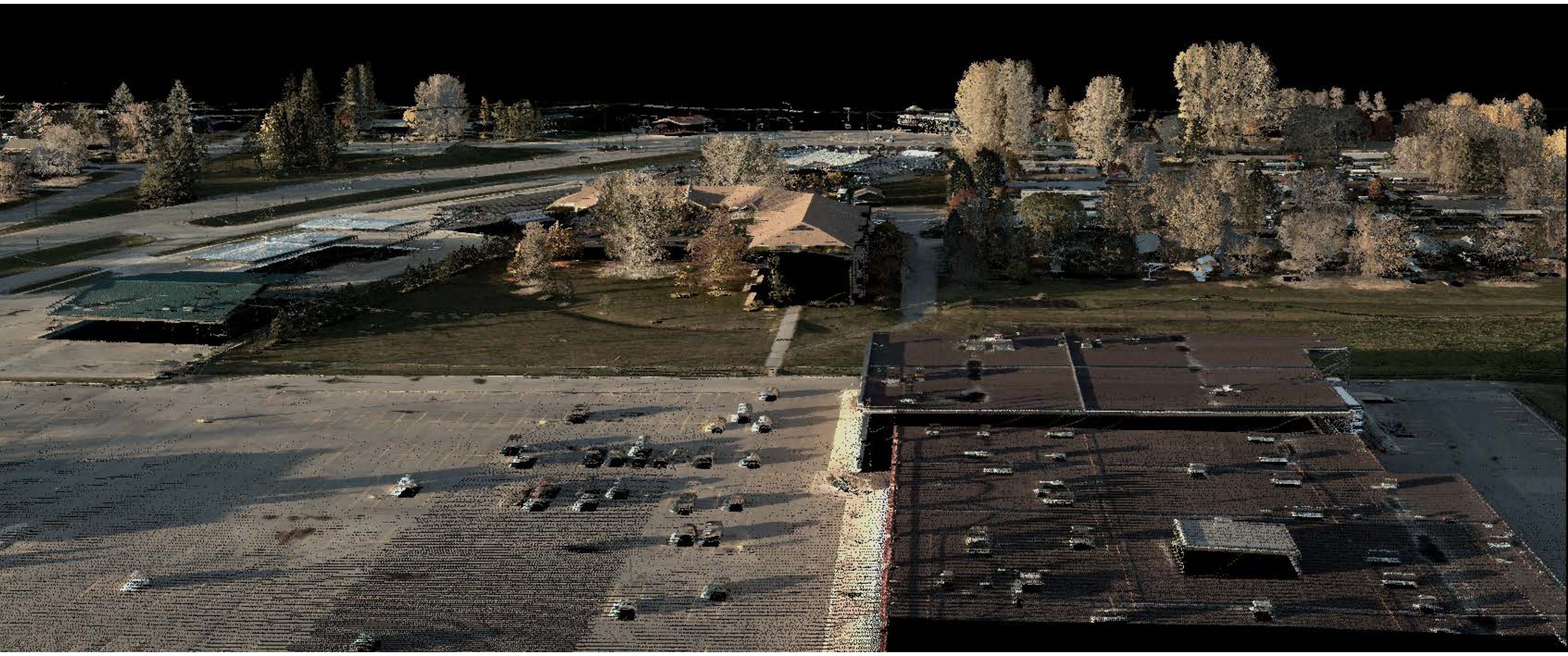
APPENDIX 9

2015 Atlis Lidar Survey Technical Report



Gold Corp Inc.
Chapleau - Borden
Gold Project

Final LiDAR Report
AGI Project:#15-1539

Nathalie Prud'homme, P.Geo.
Corporate Geologist

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Toronto, Ontario
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Cell: 613-298-4144

Table of Contents

Project Description

Overview

ATLIS Geomatics was contracted by GOLDCORP Inc. on September 2015, to provide an aerial survey to acquire LIDAR data over Borden Lake area (Near Chapleau, Ontario). The purpose of the project is exploration. The project AOI was about 500 km^2, and planned with 55 flight lines of about 1,000 km.
This report provides the details of the aerial acquisition, processing, and quality control performed throughout the acquisition and processing cycle of the project.

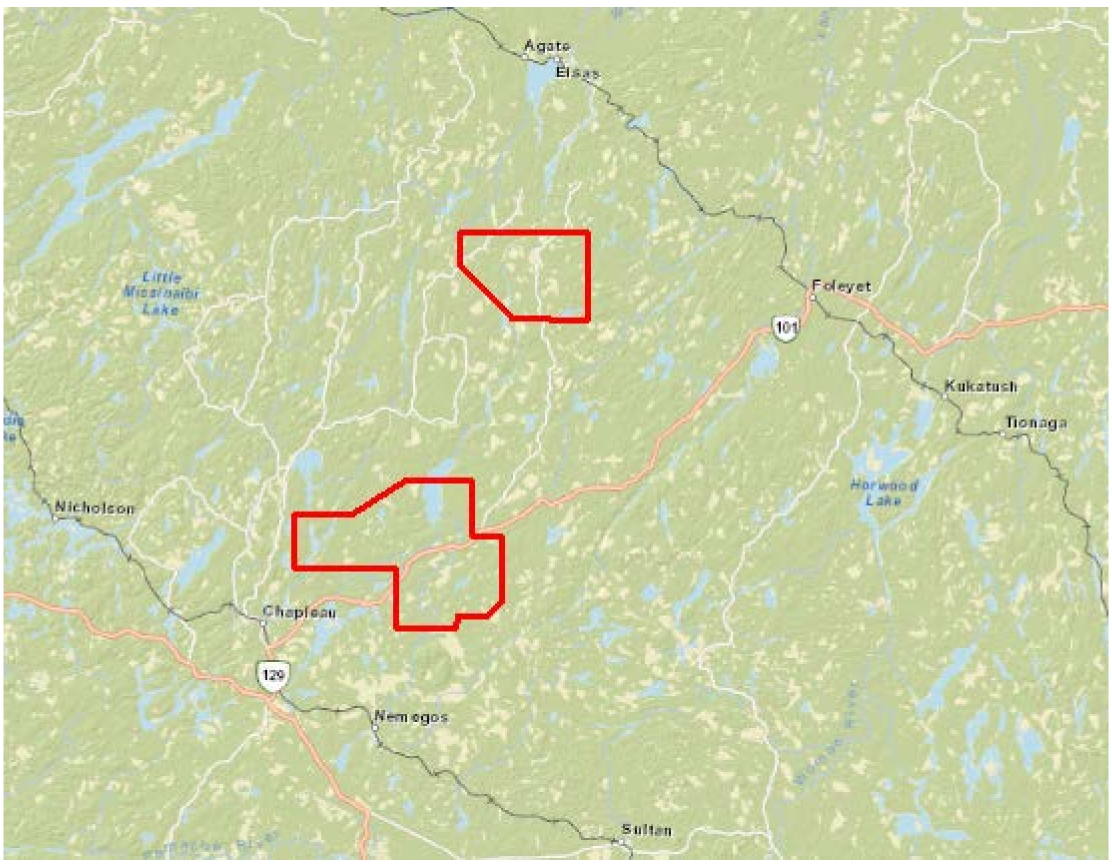


Figure 1: AOI

Coordinate System

Projection	UTM 17
Horizontal Datum	NAD83 (CSRS) 1997
Vertical Datum	CGVD28
Geoid Model	HTv2

Ellipsoid	GRS80

Equipment/Sensors

Sensor	Manufacture	Serial Numbers
LiDAR Sensor	LEICA ALS70-HP	SN7229_HP
Airborne GPS/IMU	LEICA IPAS CUS6	Honeywell uIRS
Ground GNSS receivers	LEICA GS14	Base: 2806019,Rover: 2806012

Figure 2: LEICA ALS70-HP

Software

Process	Software
Ground Processing	Leica Geo Office (LGO)
GNSS/IMU Processing	Novatel Inertial Explorer 8.60
LiDAR recovery	Cloud Pro
Calibration/Classification	Terra Solid (TerraScan, TerraMatch),
QA/QC	LP360, ArcGIS
Deliverables Production	Global Mapper, ArcGIS

Personnel

For acquisition phase, a crew of two (2) personnel were assigned to acquire the LiDAR data, which included one (1) System Operator, one (1) Pilot. In addition, ATLIS land surveyor was assigned to provide a ground control inside the AOI area. The Program Manager of this project, Daniel Brooker, had a key role ensuring the project was completed within the required time frame and crews were deployed accordingly.

Production of deliverables

Team Member	Production Area
Michael Derevnin	Ground Control Processing, AGPS processing
Andrew Brooker	QA/QC Ground survey
Michael Kolisnyk	LIDAR recovery
Eric Gareau	QA/QC LIDAR recovery
Michael Kolisnyk	Point Cloud Calibration and Classification
Neel Chooneidass	QA/QC Calibration +Classification

Project Schedule

ATLIS crew performed aerial data acquisition on 3 lifts. which were planned to meet weather specifications. Ground control for survey, vertical and photogrammetric checks was performed on October 21, 2015

Production schedule

Activity	Date
LiDAR Acquisition	10/21/2015, 10/26/2015, 11/8/2015
Ground Control Acquisition	10/21/2015
Data Processing and Delivery	11/01/2015 - 01/15/2016

Data Processing Workflow

- Ground Control Processing, including QA/QC reference station.
- GNSS/IMU trajectories computation using post processing of static and kinematic data.
- LiDAR data recovery
- Quality Control Procedures - coverage, density and point cloud comparison to ground vertical checks.
- Calibration - adjustment of flight lines using tie lines and cross flight data.
- Classification of point cloud for pre-defined classes.
- Deliverables production

Data Acquisition

LiDAR Acquisition

The aircraft assigned to this project is a twin engine Piper Navajo PA-31 with tail number N44-RL, and is owned and operated by Aries Aviation Services International, an air charter company located in Springbank, Alberta.

The LiDAR system utilized on this project was a Leica ALS70-HP, capable of laser pulse rates up to 500,000 Hz with Multiple Pulse in the Air (MPIA) technology. For this project the LiDAR data was acquired at an altitude of 1300m AGL (Above Ground Level) resulting in a total density of 15 p/m2. The total density is based on two overlapping flight line swaths flown in opposing directions to provide redundancy and to ensure there are no data holes (or slivers). The following details the flight parameters used:

	Calculated	Planned	Check
Flying Height (AGL)	1300- 1350 m	1350 m	V
Speed	140 Kts	140 Kts	V
Overlap	20%	20%	V
Field of View (FOV)	50.1 degrees	50 degrees	V
Scan Frequency	47Hz	47Hz	V
Pulse Rate	500 kHz	500 kHz	V
Total Density	~15 p/m^2	~5 p/m^2average inland	V

Flight Plan:

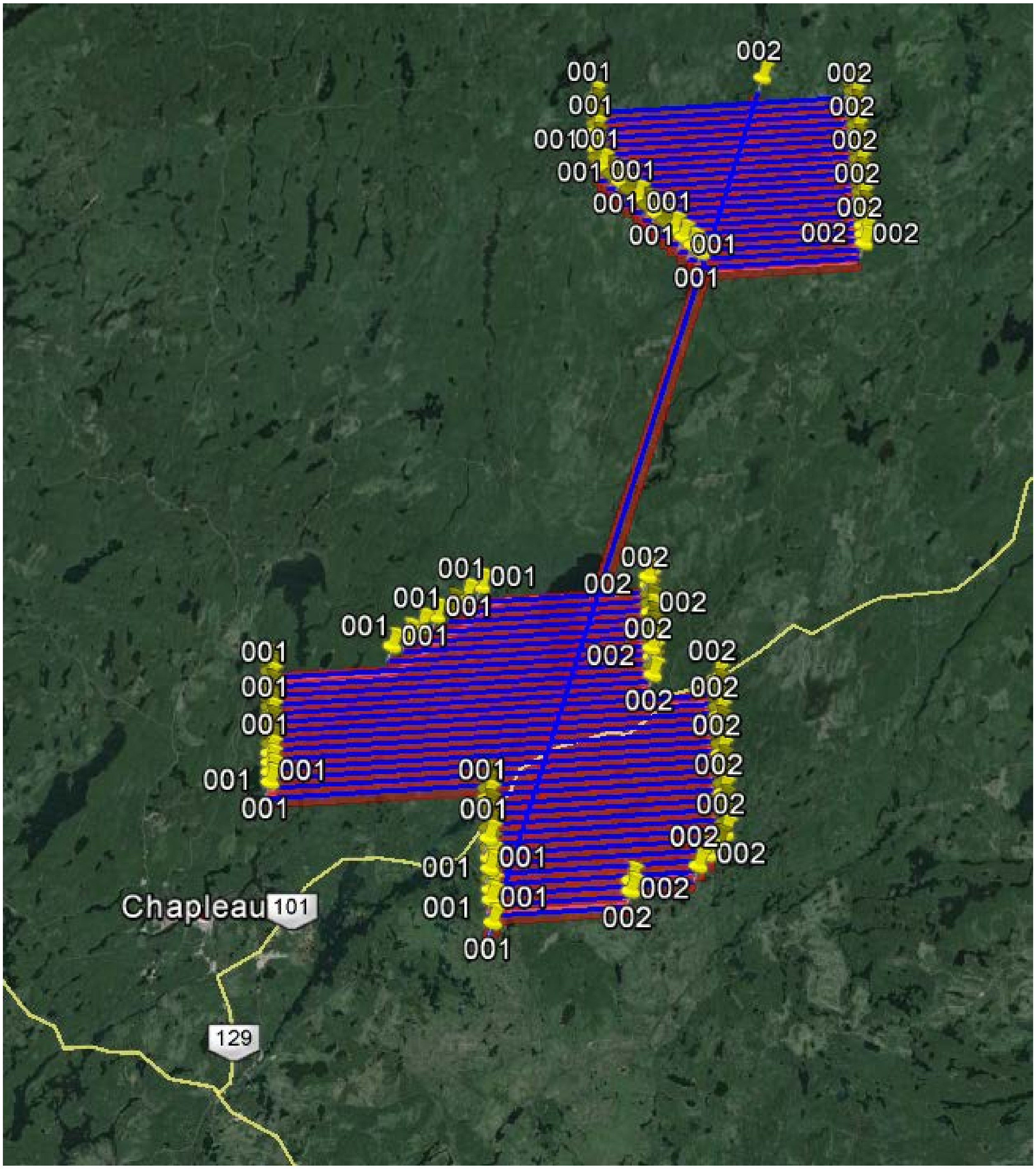


Figure 3: Flight lines

Processing

Ground Control

Methodology

To provide quality ground control for the project, ATLIS Geomatics used dual frequency survey-grade Leica receivers **GS14**. Ground control surveyed with **Real Time Kinematic** (RTK) method.

Base station

ATLIS planned to use **CHAPAIR** monument as a reference for airborne and ground operations, however the monument wasn't found in the field during thorough investigation. ATLIS established new base station at the Chapleau Airport - **AGIBASECH,** to provide DGPS corrections for airborne operation and ground operation (layout of ground control vertical checks).

Control calculation and checks

Ground Reference Station (GRS) coordinates AGIBASECH was calculated with **PPP** (3 days of observations), and in order to provide quality control, AGIBASECH was checked with **Height Precision 3D monument (HPN) - 84U075**. Vertical checks distributed across the south AOI , since the North site found inaccessible. Highway 101 (Timmins - Chapleau) was identified as a suitable location for flat and solid vertical checks. Check results are described in the report.

Ground Control Check

AGIBASECH coordinates derived with **Precise Point Positioning (PPP)** technique , for each day of October 26, 27 and November 8.The difference between independent observations is within project's requirements.

PPP data for 3 days of observations upon **AGIBASECH**:

AGIBASECH NAD83(CSRS) UTM 17, Geoid HTv2		
N [m]	E [m]	H_ortho [m]
October 26, 4h 46 m		
5298865.994	323431.832	446.251
October 27, 2h 34 m		
5298865.990	323431.849	446.269
November 8, 2h 40m		
5298865.987	323431.857	446.283

RMSn	0.003
RMSe	0.010
RMSh	0.013

Survey check for known **High Precision 3D monument (HPN) (Appendix 4 - 84U075**) - within project's accuracy requirements.

84U075 published NAD83(CSRS) UTM 17 HTv2					
N [m]	**E [m]**	**H [m]**	**dN [m]**	**dE [m]**	**dH [m]**
5291290.368	320991.598	442.596			
84U075 calculated NAD83(CSRS) UTM 17 HTv2			-0.024	-0.012	0.016
5291290.392	320991.61	442.580			

Vertical Checks

46 points were established for vertical checks and photogrammetric control in 5 sites along highway 101 (Timmins - Chapleau). Painted line's edges surveyed when possible for horizontal accuracy estimation. Power poles surveyed for aerial identification.

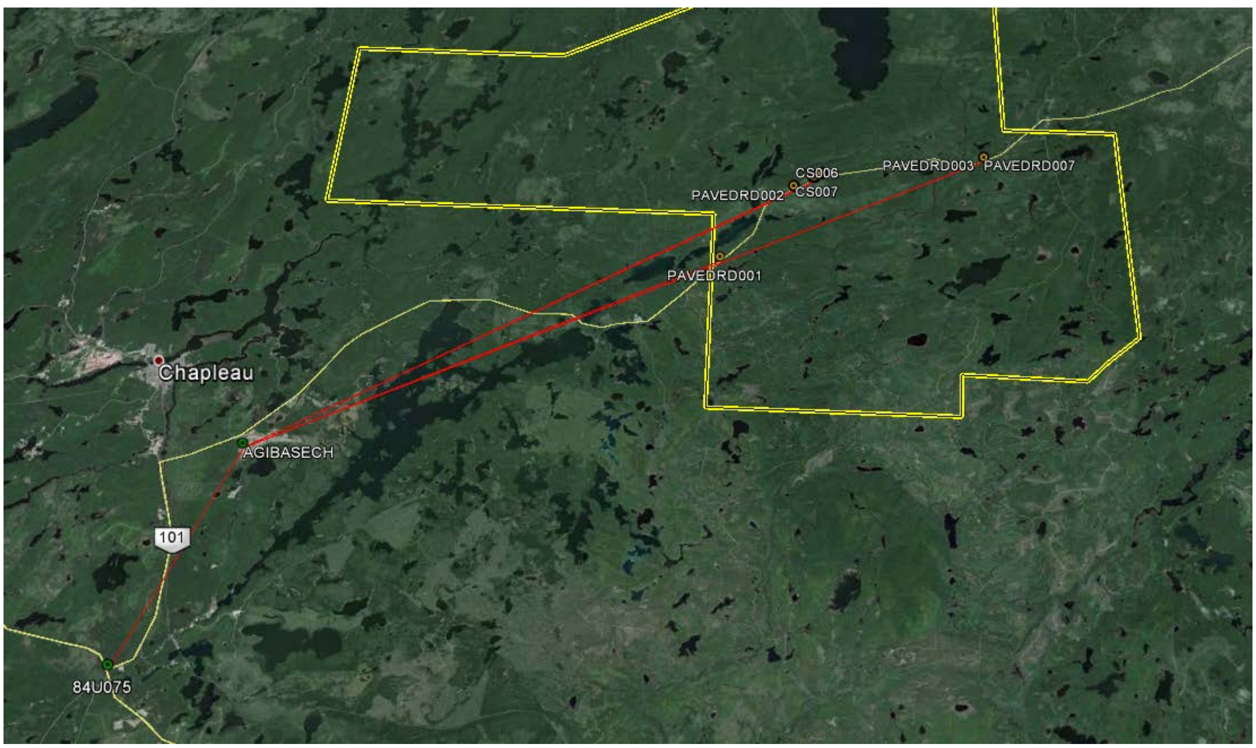


Figure 4: Ground Control Scheme

Airborne GPS

Methodology

ATLIS Geomatics used **Novatel Inertial Explorer 8.60** (IE 8.60) software to perform airborne GNSS and IMU raw data integration to provide Direct Geo – referencing (DG) of LiDAR data. Ground Reference station (GRS) was established **AGIBASECH** (at the Airport) in order to correct GNSS airborne data via post processing Differential GNSS (DGNSS) technique. Data acquisition was done in 3 lifts during 3 days :

Lift	Date	Reference Station	Average Baseline [km]
1	26/10/2015	**AGIBASECH**	22
2	27/10/2015	**AGIBASECH**	33
3	08/11/2015	**AGIBASECH**	50

In the next step, corrected airborne GNSS data integrated with IMU raw data to solve the external orientation of the LiDAR sensor. ATLIS Geomatics computed the flight trajectories, with investigating the GNSS and IMU data quality at each production phase.

Reference Station

AGIBASECH Reference base station (Chapleau Airport) collected concurrent observations to airborne receiver for each lift, and was post-processed with IMU data. Reference base station was calculated with Precise Point Positioning (PPP) service and checked to known **HPN** monument - **84U075** (for more information see Ground Survey chapter).

Reference Station AGIBASECH coordinates:

NAD83(CSRS) 1997, Geographic		
Lat	**Long**	**H_ell [m]**
47º 49’ 08.0369’’	-83º 21’ 31.7860’’	410.657
NAD83(CSRS) 1997 CGVD28 HTv2 UTM17		
N [m]	**E [m]**	**H_Ortho [m]**
5298865.994	323431.832	446.251

Data QA/QC

Appendix 1 - data plots

Lift 1 - 10/26/2015

- GNSS fixed solution achieved during entire data acquisition.
- Below **2 mm** difference between forward and reverse solution indicates consistency and solid trajectory calculation.
- Good GNSS condition **PDOP < 2.5** and **13 satellites** in average during entire project.
- Between 153000-154000 sec position accuracy drop (figure2), correspond to PDOP increase (2.5), while reasonable and still good.

Lift 2 - 10/27/2015

- GNSS fixed solution achieved during entire data acquisition.
- **Below 1 mm difference** between forward and reverse solution indicates consistency and solid trajectory calculation.
- Good GNSS condition **PDOP < 2.5** (most of the time below 1.6) and 13 satellites in average
- Till 245000 sec position accuracy drop, correspond to PDOP increase (around 2.5), and reasonable.

Lift 1 - 11/08/2015

- GNSS fixed solution achieved during entire data acquisition.
- **Below 1 mm difference** between forward and reverse solution indicates consistency and solid trajectory calculation.
- Reasonable GNSS conditions PDOP < 3.5 (most of the time **Good <1.5**) and 12 satellites in average
- Between 63000-64500 sec position accuracy drop, correspond to PDOP increase, and reasonable.

Calculated Trajectories -

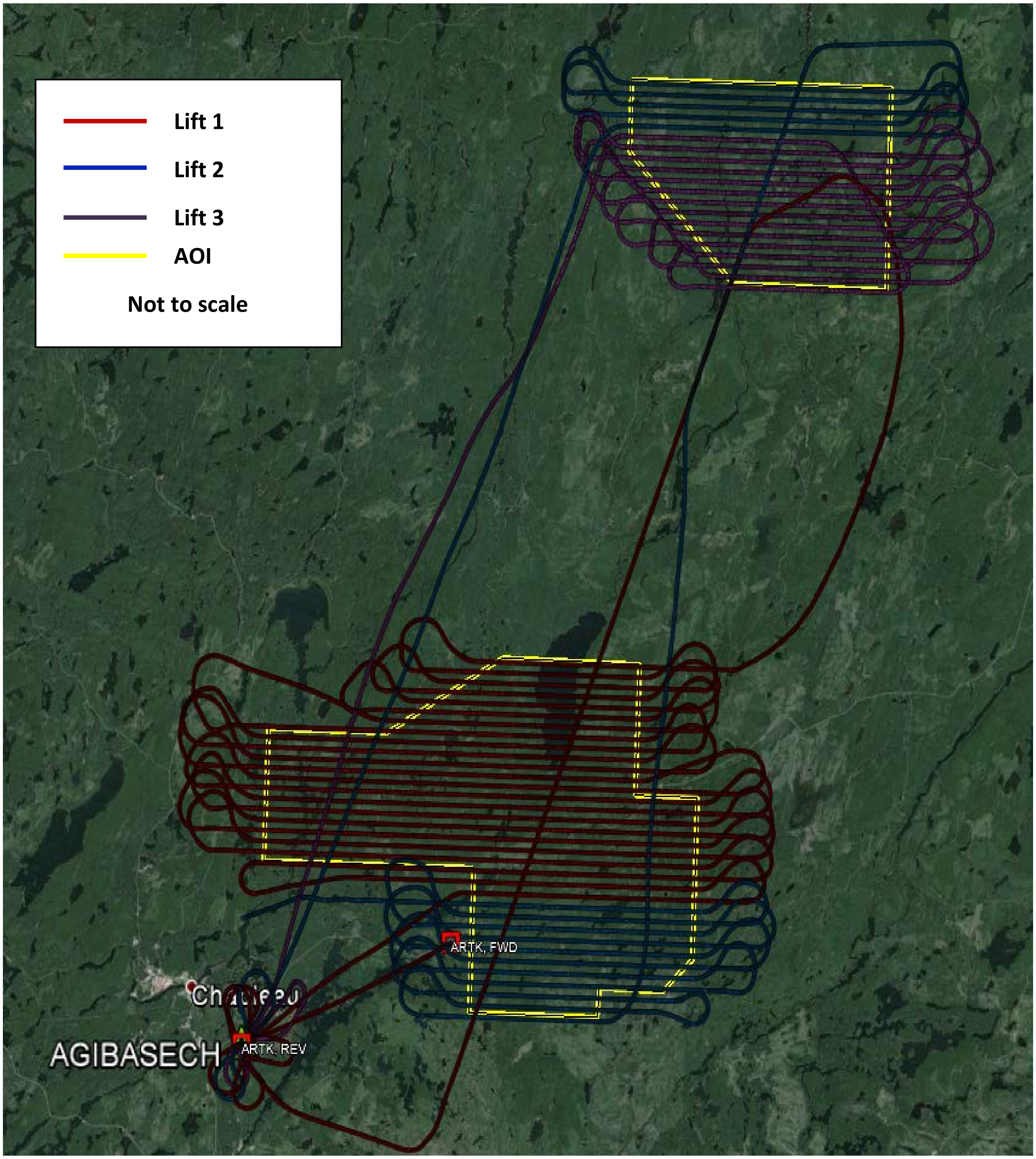


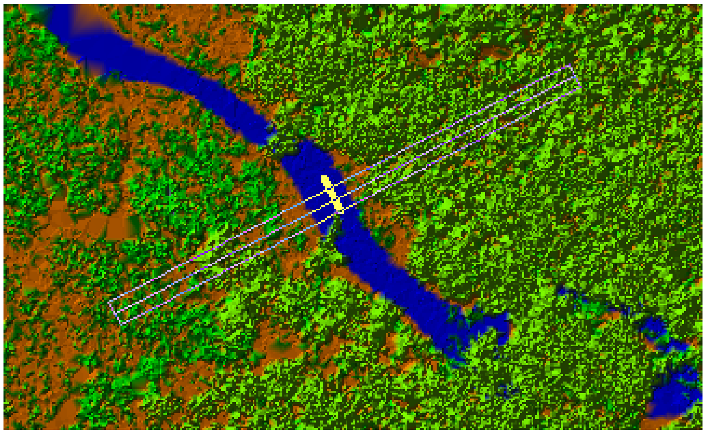
Figure 5: Calculated Trajectories

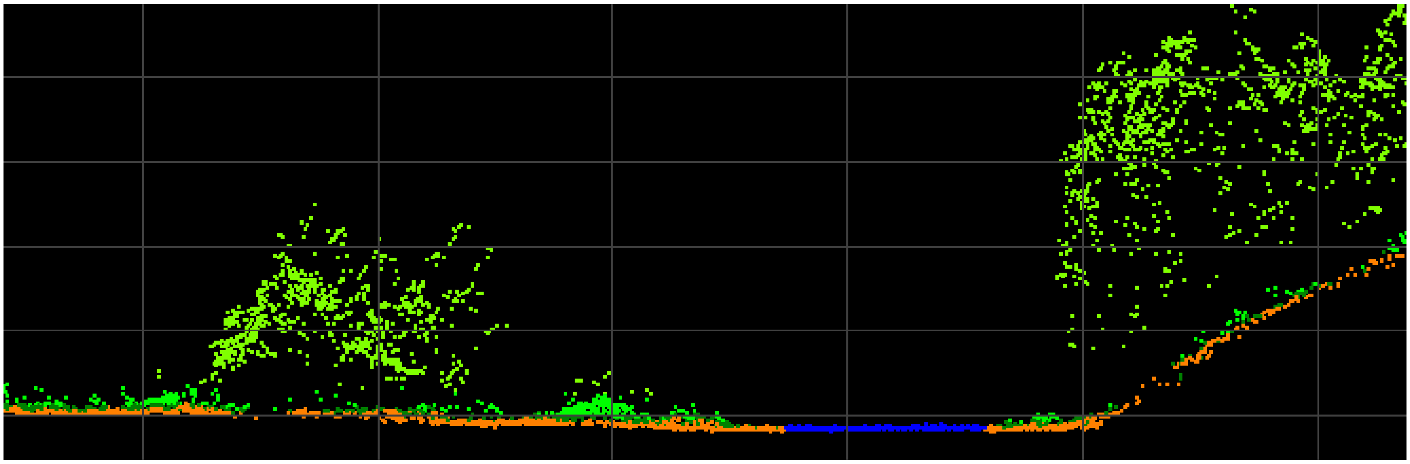
LIDAR Classification

The Point Cloud was Classified with Microstation v8 (TerraScan software), while using macros that are set-up to measure the angles and distances between points to determine what classification a point should be. The lower points are generally classified as ground returns, with the points above separated in low, medium and high vegetation. Low vegetation is usually between zero and one meter above the ground surface and is not used in the Full Feature product generation. Medium vegetation is typically between one and two meters above ground and high vegetation is everything above two meters. Error points (low point class) are determined to be either high (spikes) or low (pits) outlier points, often beyond 3-sigma from the rest of the data set; clouds, birds, pollution, or noise in the data can cause error points.

After an automated macro is run to determine classes, a manual QC is performed to fine tune and manually correct the classification of points among the different categories. To better understand areas for improvement, the points that are classified as bare earth are extracted and turned into viewable TIN and grid surfaces. These surfaces are inspected for areas that appear rough, artificially flattened or truncated, no data areas, or have other viewable errors.

In cleaning up ground points, the focus 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, water bodies, low reflectivity objects, or too aggressive values with the macro.





Quality Control

ATLIS developed several data quality analysis, to insure data completeness and high standard. Quality control practices performed at each phase of planning, acquisition and processing.

Data Coverage

Laser coverage was validated during the acquisition phase, and found complete according to the AOI boundaries (Red boundary in Figure 6). A buffer was applied in the planning phase to insure complete coverage of the AOI.

South AOI: TIN + AOI

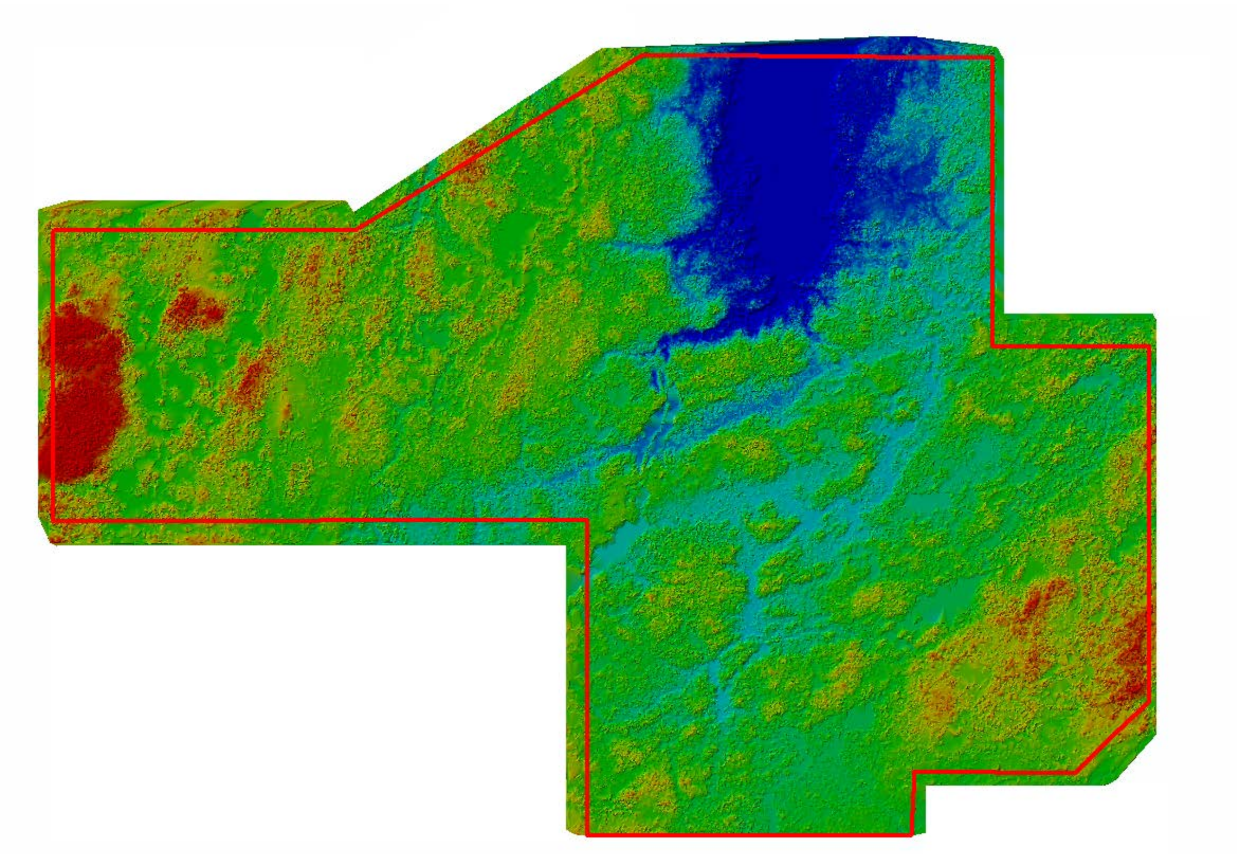


Figure 7: LiDAR Coverage

North AOI: TIN + AOI

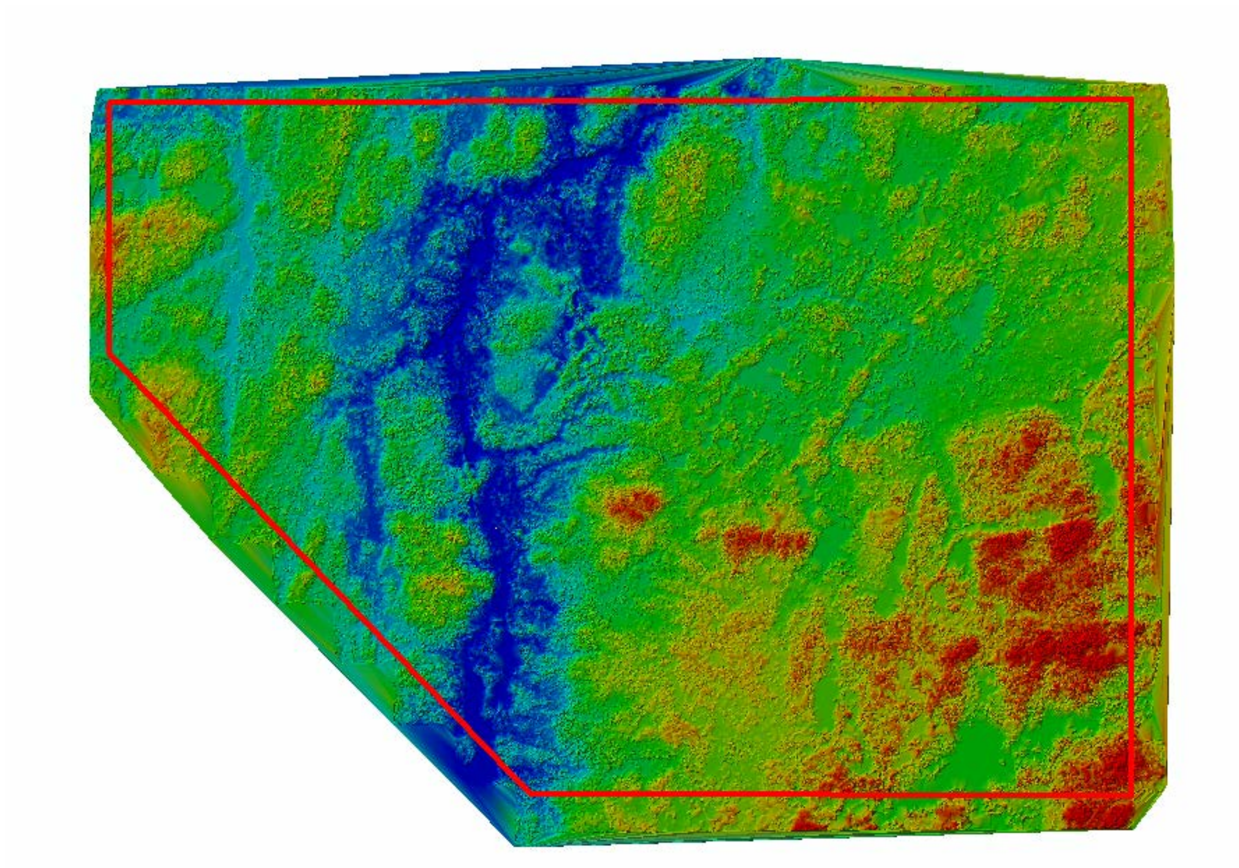


Figure 7: LiDAR Coverage

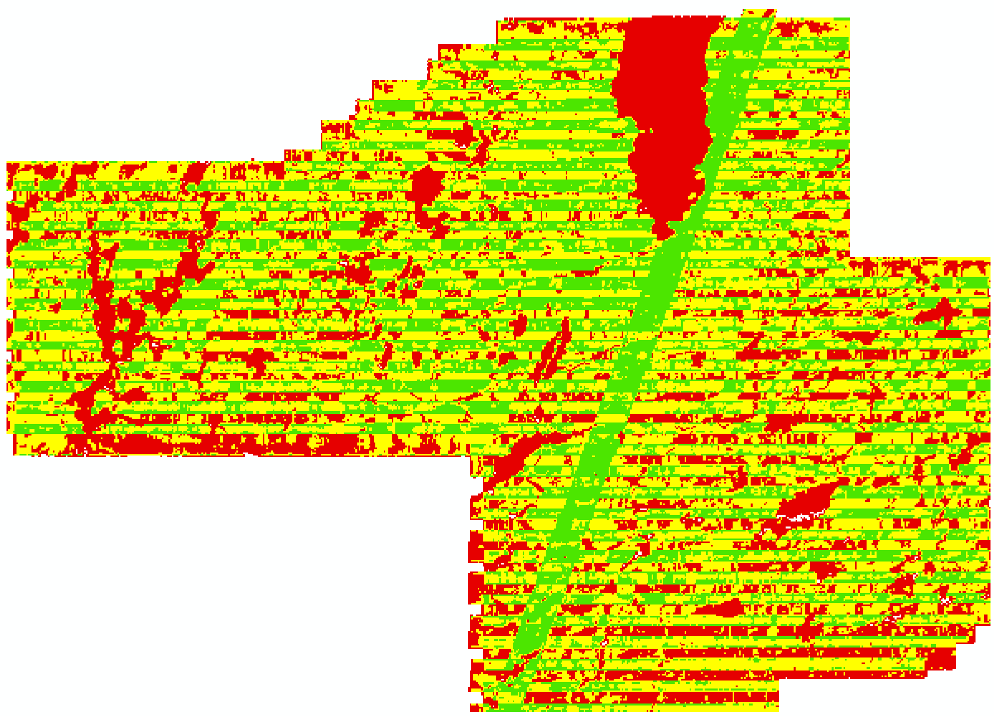
LiDAR Points Density

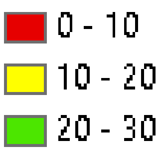
Occurrence of voids (low density areas) was checked during density evaluation and found as correlated to water bodies, due to the weak reflection over such surfaces .

LiDAR density was validated in the post processing phase. The amount of points per m^2 calculated, and found to be 15 points/ m^2 in average inside the AOI (for all returns). Ground points class density (Class 2+8)was calculated for both North and South sites. Average density for ground surfaces was found to be 4 points/ m^2.

<u>South:</u>

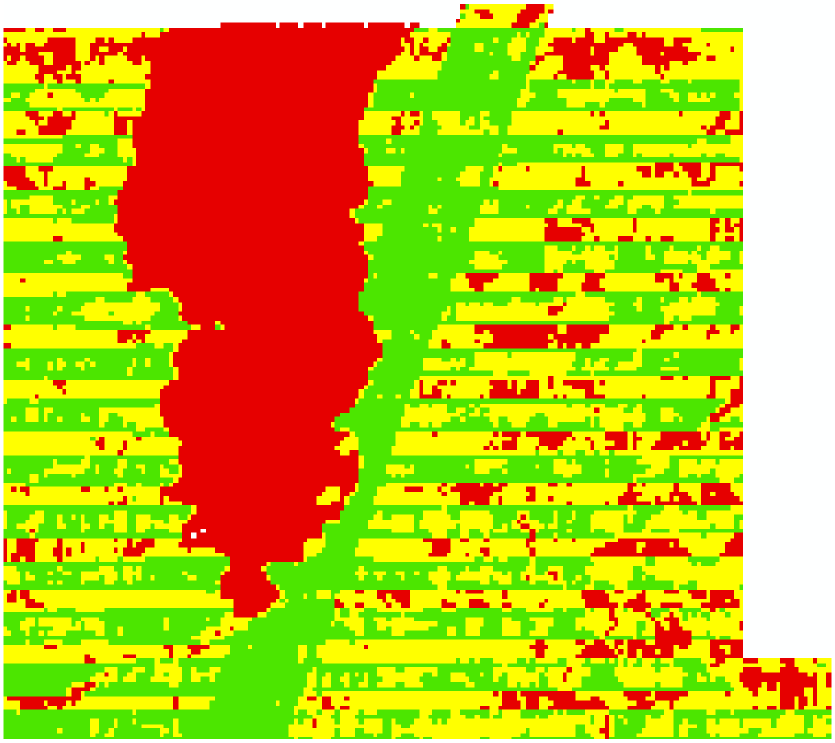
All returns density:



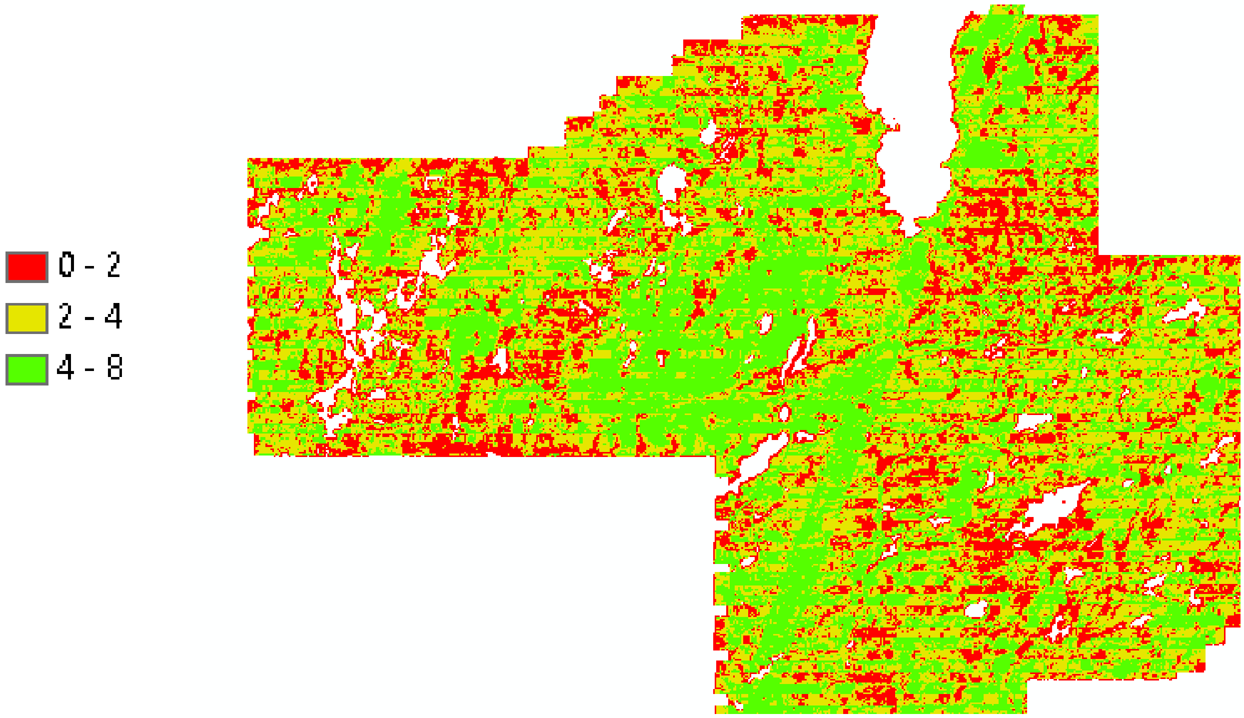


Nemegosenda Lake - low density areas correspond with water bodies:

Red area with water low reflectivity surface, while additional strip (cross line for calibration) increases the density.

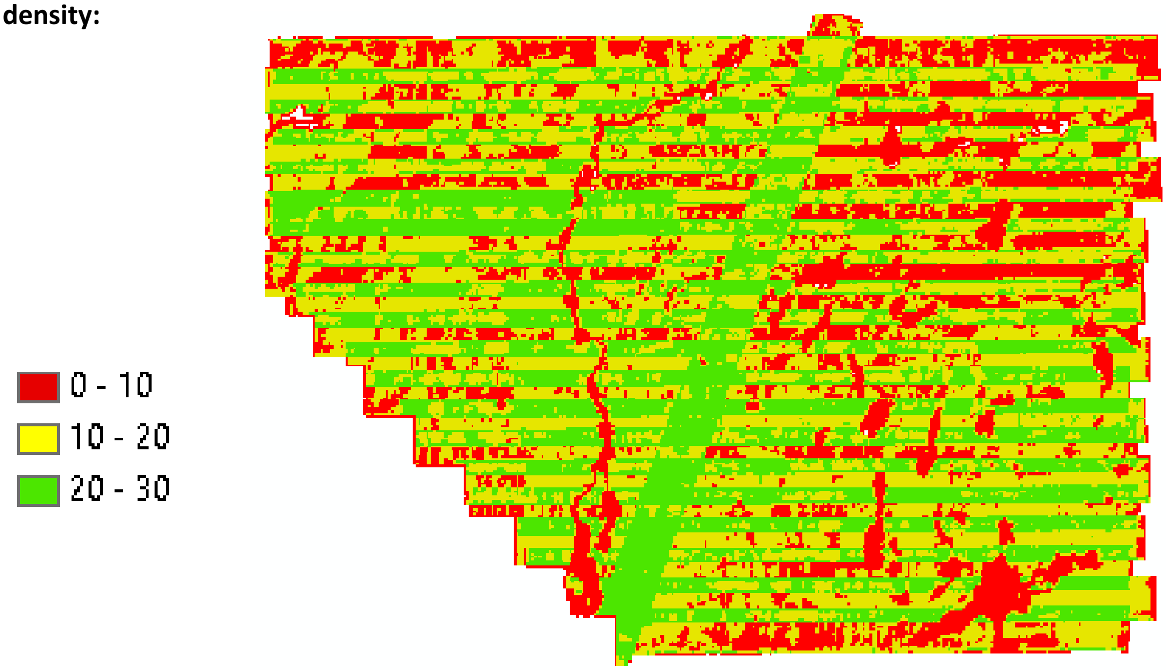


Ground surface density - 4 points/ m^2

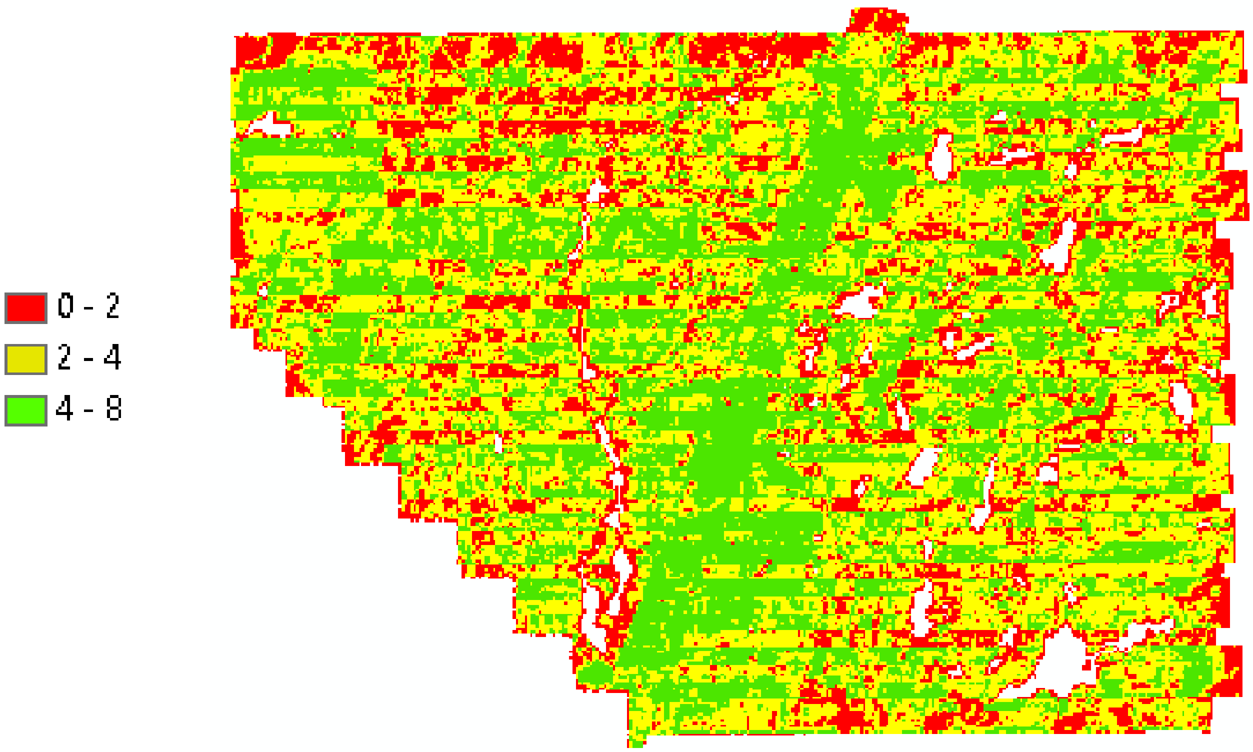


<u>North Site:</u>

All returns density:



Ground surface density - 4 points/ m^2



Accuracy

Vertical accuracy was calculated by comparison of the LiDAR bare earth points to the ground surveyed vertical checkpoints. Vertical checkpoints elevation values then compared to interpolated (TIN) bare-earth LiDAR derived surface, by the horizontal position.

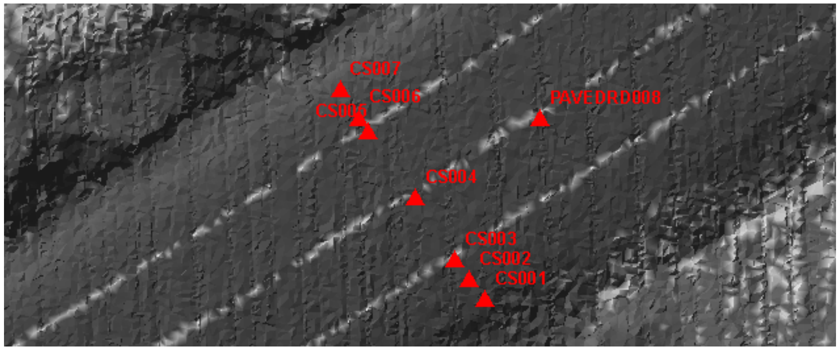
ATLIS performed vertical accuracy assessment according to National Digital Elevation Program (NDEP) and American Society for Photogrammetry and Remote Sensing (ASPRS). The vertical accuracy is calculated at the 95% confidence level using the Root Mean Square Error (RMSE). This method is called FVA (Fundamental Vertical Accuracy),where vertical accuracy at the 95% confidence level equals RMSEz x 1.9600.

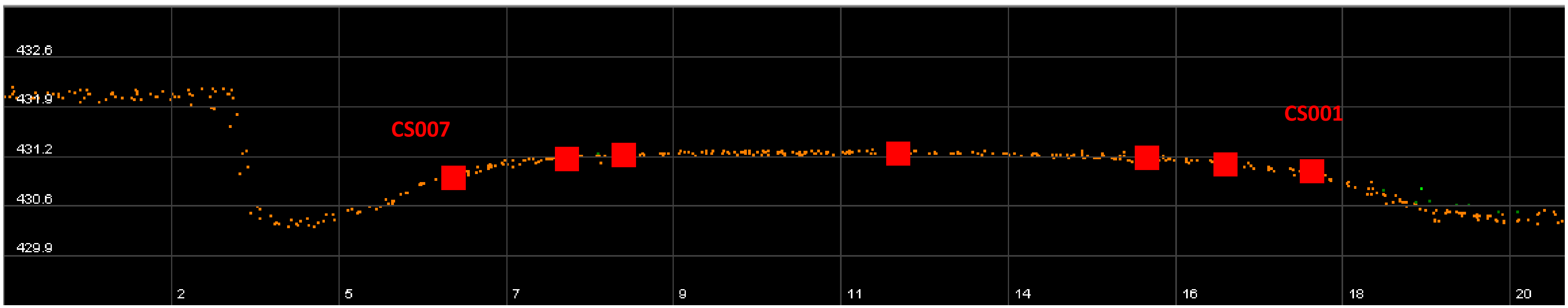
Control Points:

Name	East [m]	North [m]	Elevation Z [m]	Laser Z [m]	dZ [m]
PAVEDRD001	338026.472	5306893.676	425.796	425.831	-0.035
PAVEDRD002	340467.085	5310120.199	425.550	425.555	-0.004
PAVEDRD003	347124.171	5311732.681	430.850	430.820	0.030
PAVEDRD004	347121.926	5311736.068	430.955	430.961	-0.006
PAVEDRD005	347119.412	5311740.062	430.777	430.813	-0.036
PAVEDRD006	347129.408	5311740.282	431.032	430.970	0.062
PAVEDRD007	347113.432	5311731.437	430.796	430.790	0.006
PAVEDRD008	341439.087	5310727.279	431.337	431.340	-0.003
PAVEDRD009	341454.342	5310736.889	431.422	431.462	-0.040
PAVEDRD010	341468.993	5310745.809	431.514	431.536	-0.023
PAVEDRD011	341484.254	5310754.954	431.605	431.603	0.003
PAVEDRD012	341506.618	5310767.505	431.735	431.707	0.028
PL001	341164.551	5310555.939	429.705	429.719	-0.014
PL002	341157.103	5310551.298	429.657	429.669	-0.012
PL003	341149.472	5310546.486	429.630	429.616	0.015
PL004	341149.423	5310546.562	429.628	429.610	0.018
PL005	341146.866	5310544.948	429.595	429.614	-0.019
PL006	341146.918	5310544.878	429.576	429.606	-0.030
PL007	341142.080	5310541.881	429.564	429.565	-0.001
PL008	341134.535	5310537.170	429.507	429.508	-0.001
PL009	341126.909	5310532.367	429.461	429.458	0.003

Statistical Parameter	Value [m]
Vertical Error Mean	-0.003
Vertical Error Range	[-0.040,0.062]
Vertical RMSEz	0.024
FVA 95%	±5

Cross Section - Highway 101 (Timmins - Chapleau): aligned with road profile:



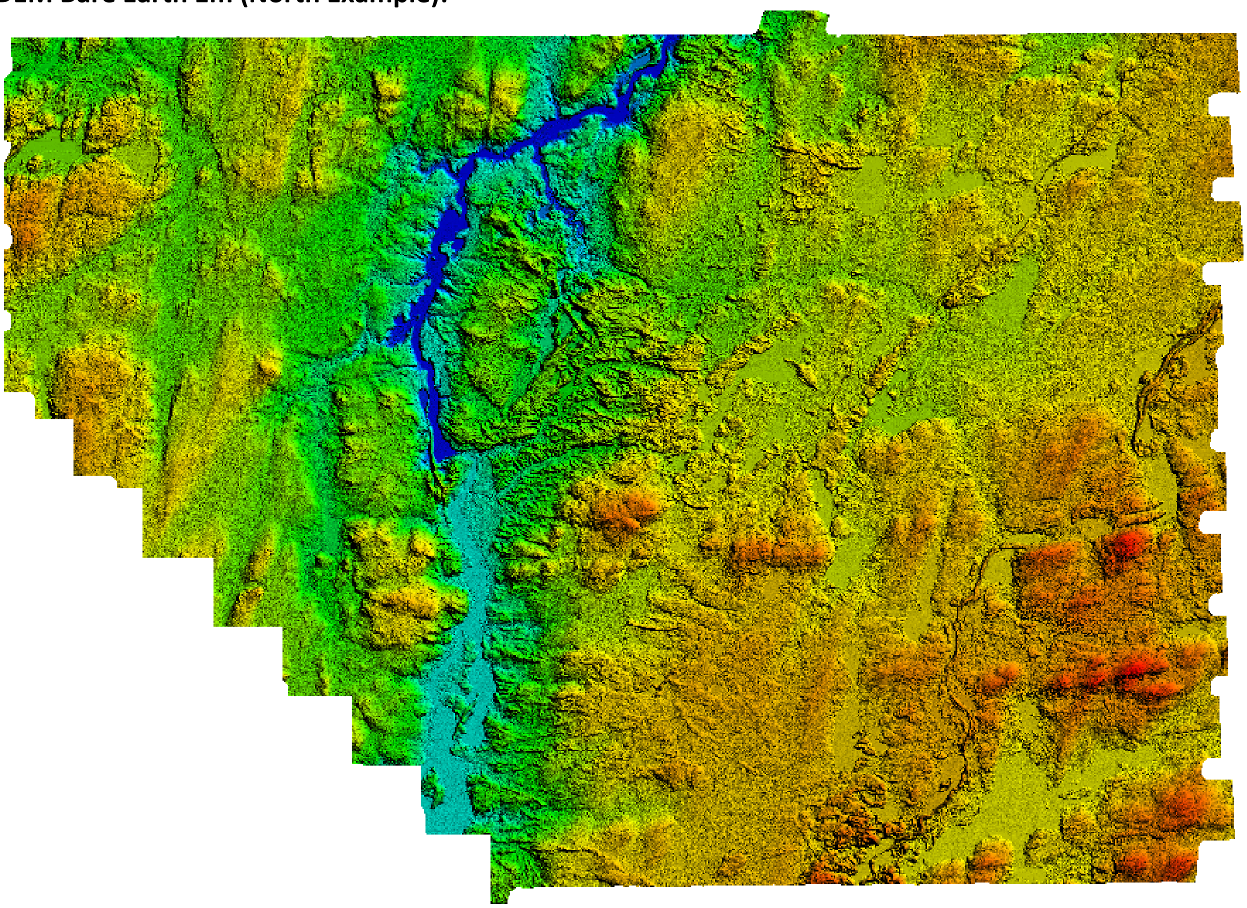


Deliverables

The following is a list of final deliverables provided as part of this survey

Deliverable	File Format
Classified LAS	.LAS v1.2
DEM Bare Earth 1m	ASCII Grid & XYZ
Hillshade 1m	ECW
Model key points	ASCII Grid & XYZ
Contours	DXF

DEM Bare Earth 1m (North Example):



Hillshade 1 m:

Conclusions

- Three flights were conducted to complete cover the AOI area with project's requirements.
- Flight Trajectories calculation (GNSS/IE) - evaluated with forward/reverse solution comparison, and found within mm mismatch, which indicates solid trajectories computation. In addition GNSS conditions were good over the time period of data acquisition (PDOP<2, 14 satellites in average) in all flights.
- Coverage - Acquired LiDAR data completely covers the AOI.
- Density - 15 points/ m^2in average for inland area.
- Accuracy - vertical accuracy of 5 cm (FVA).

Appendix 1 - GNSS/IMU plots

Lift 1 - 10/26/2015

Figure 1 - Smoothed LC Combined - Map

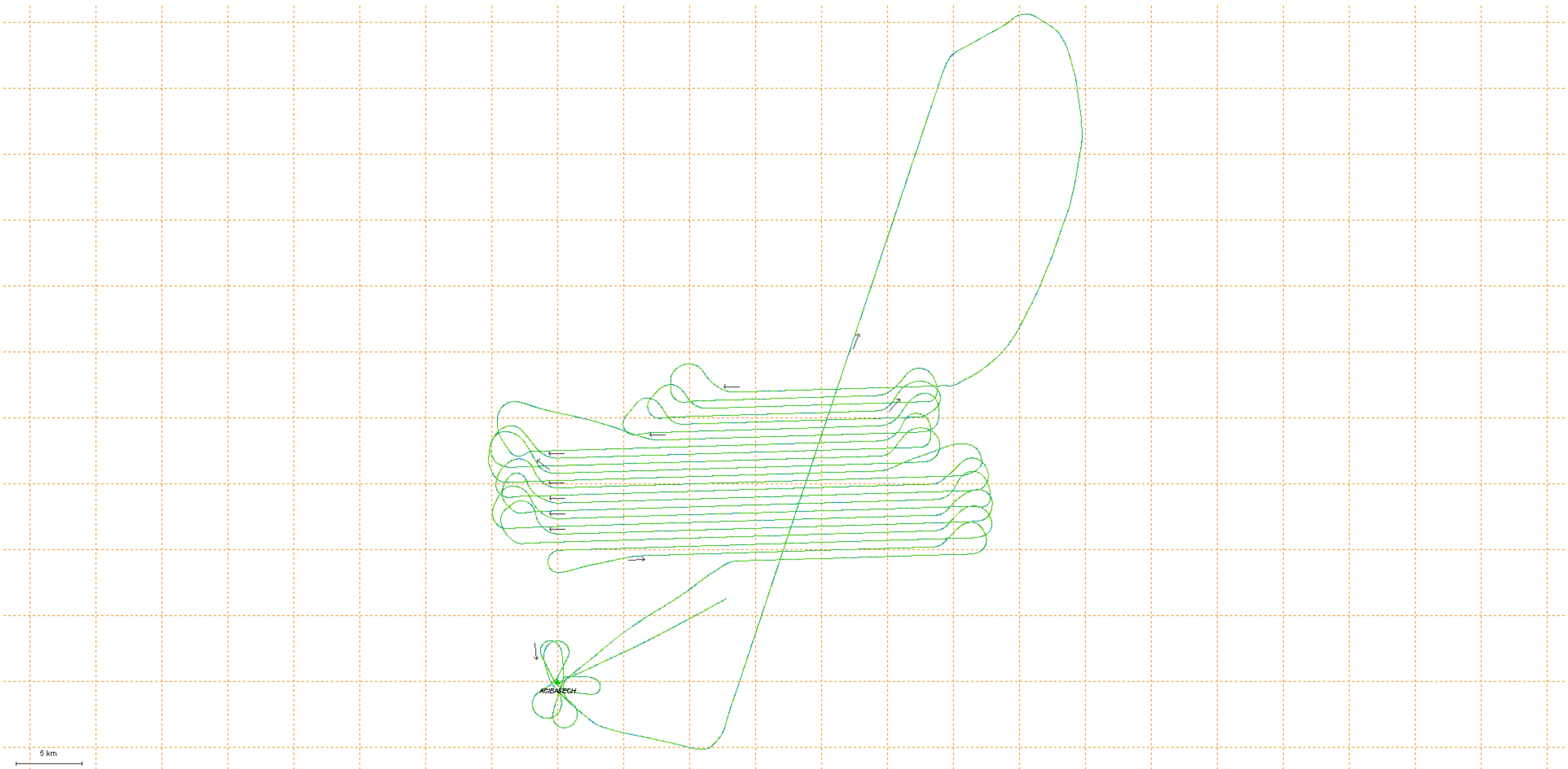


Figure 2: 10/26 - Estimated Position Accuracy Plot

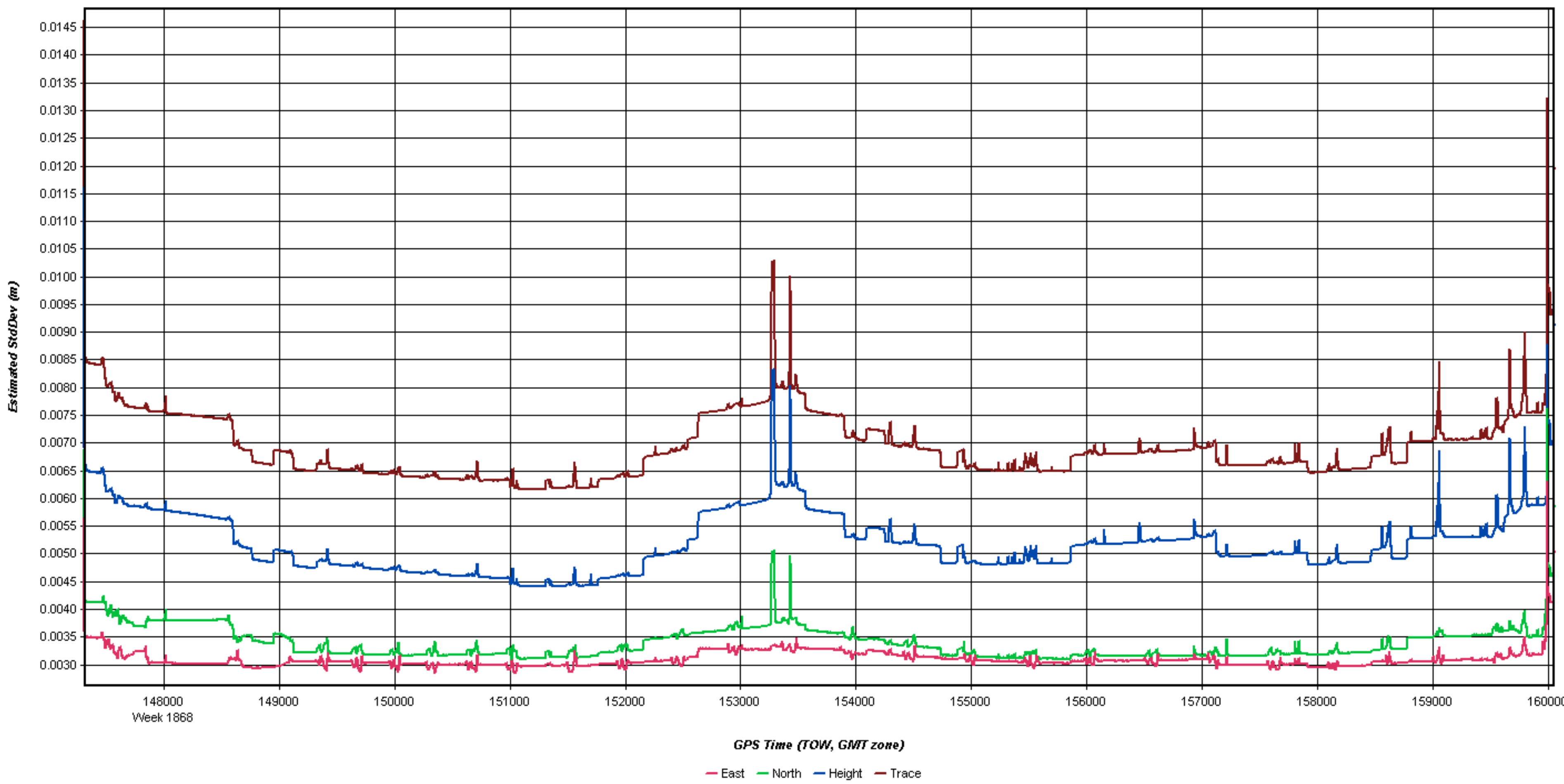


Figure 3: 10/26 - Height Profile Plot

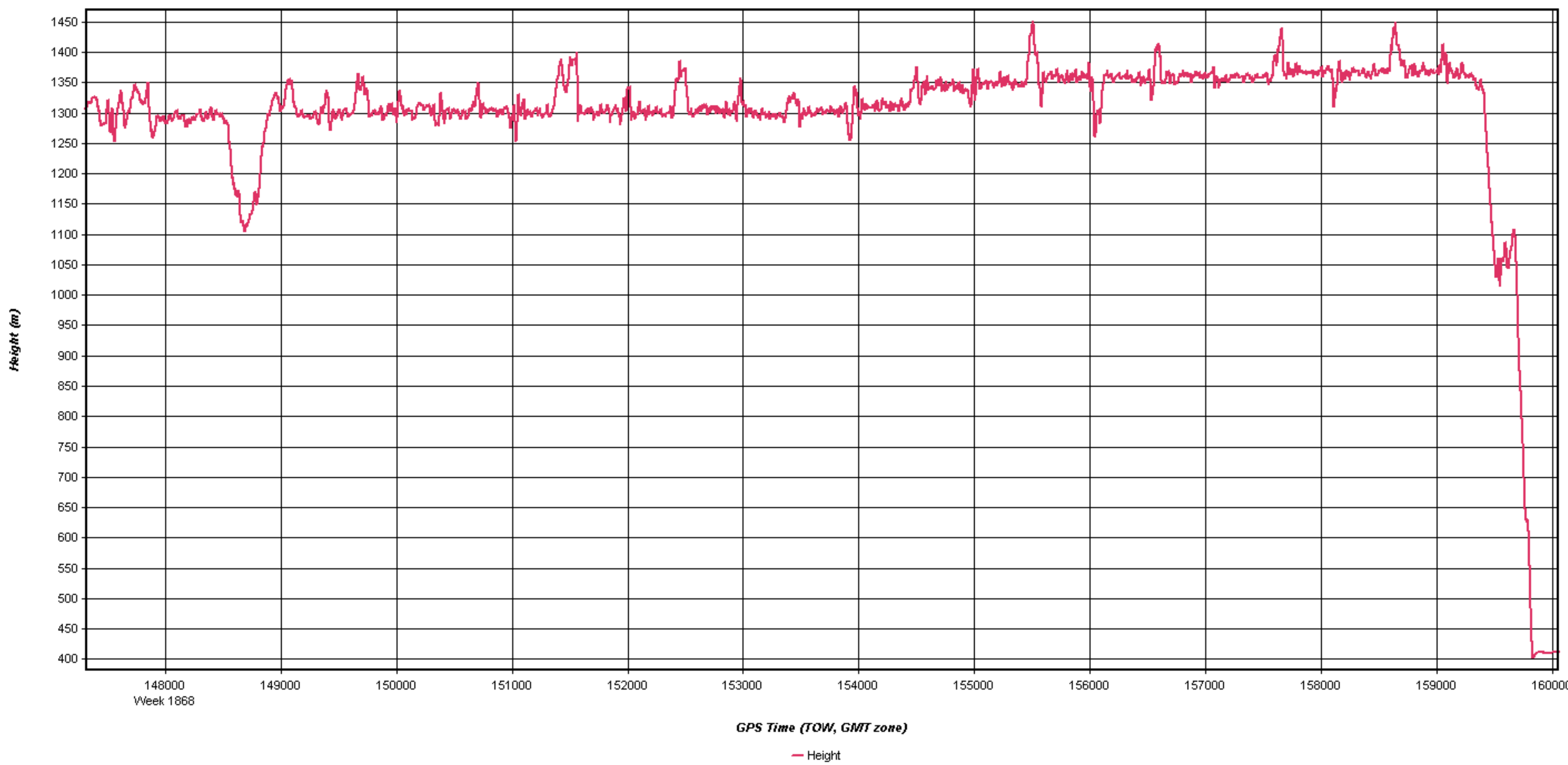


Figure 4: 10/26 - Forward/Reverse or Combined Separation Plot

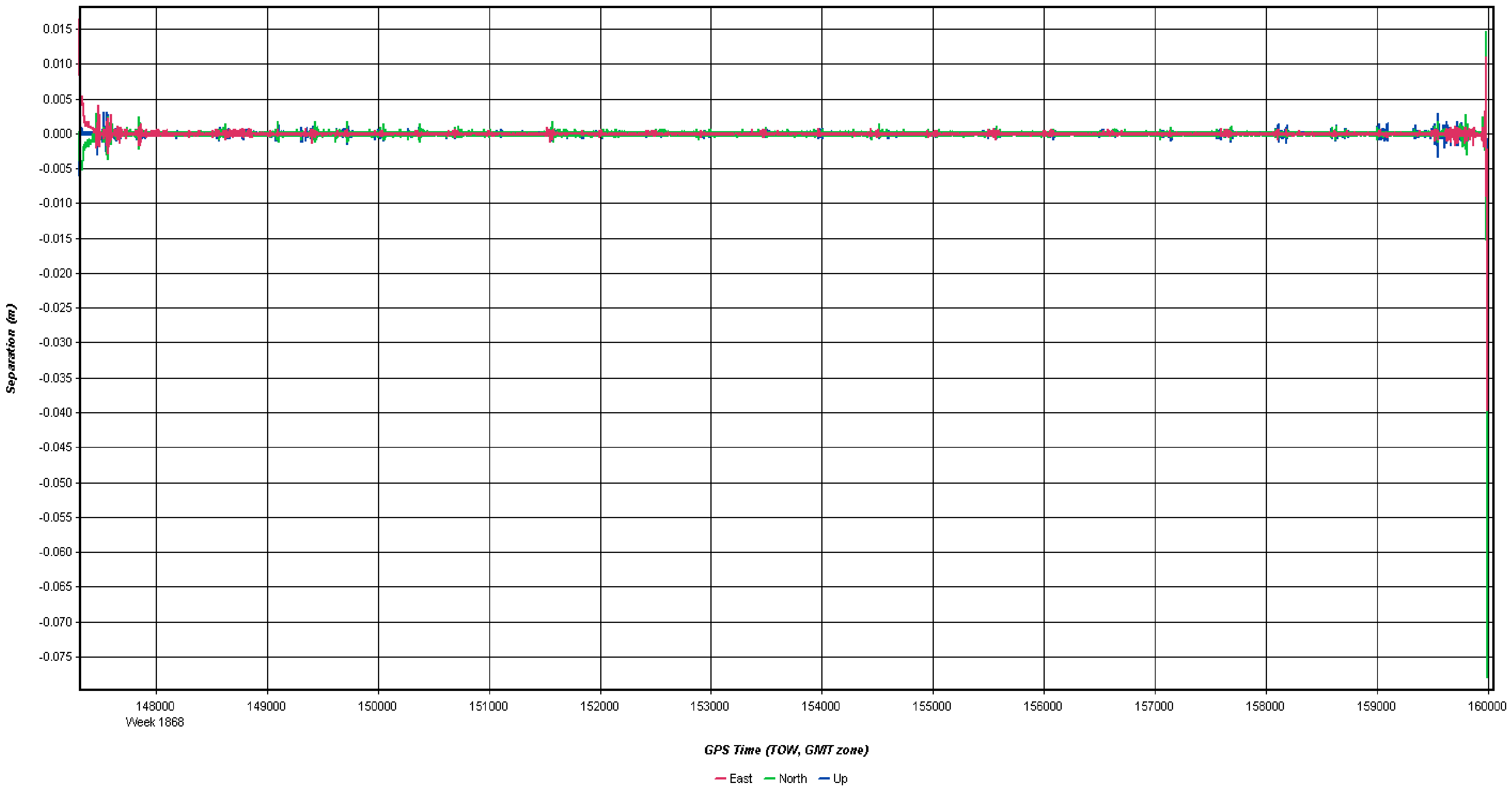


Figure 5: 10/26 - PDOP Plot

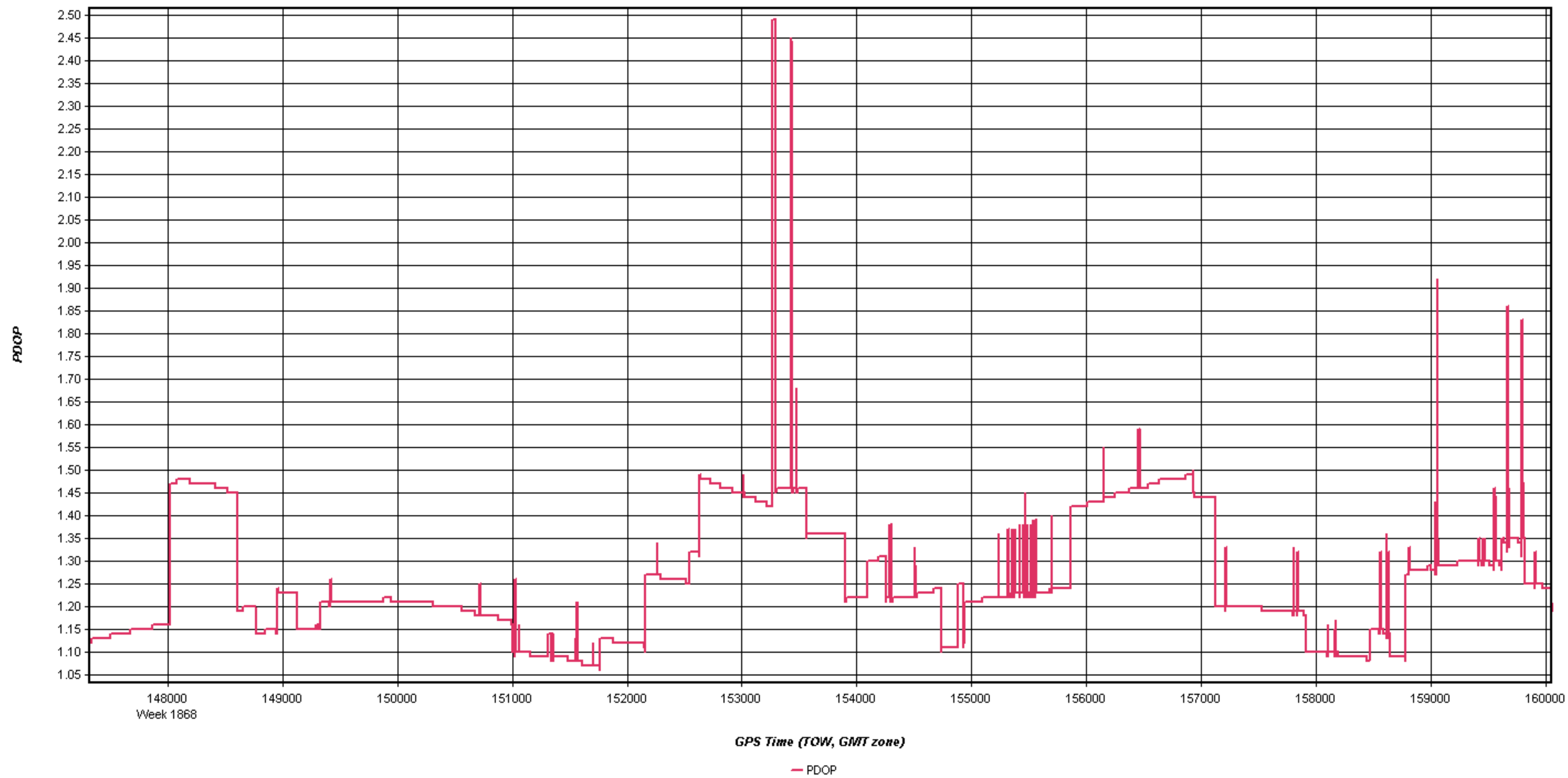


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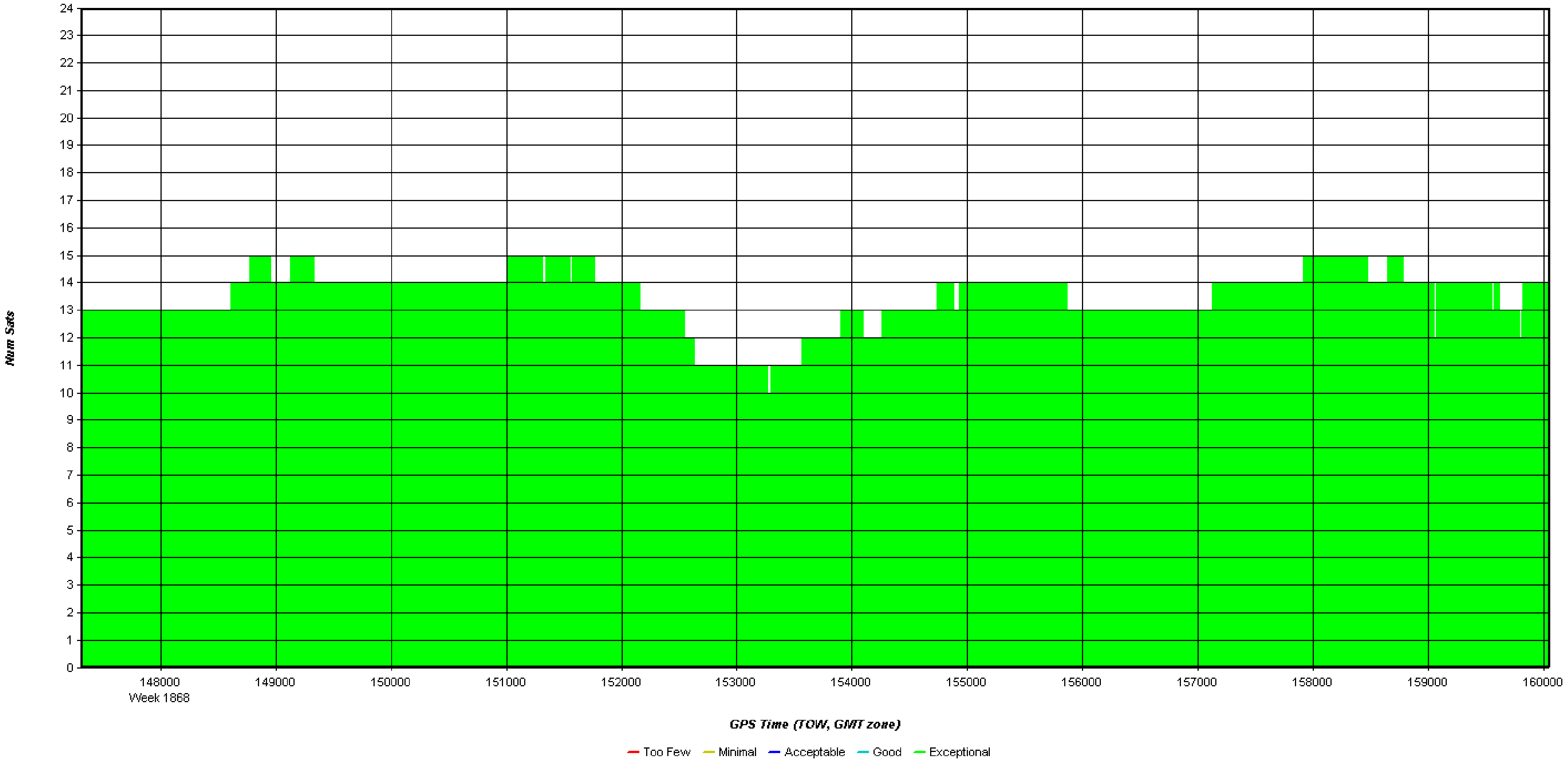
Figure 6: 10/26 - Number of Satellites Bar Plot



Lift 2 - 10/27/2015

Figure 1: Smoothed LC Combined - Map

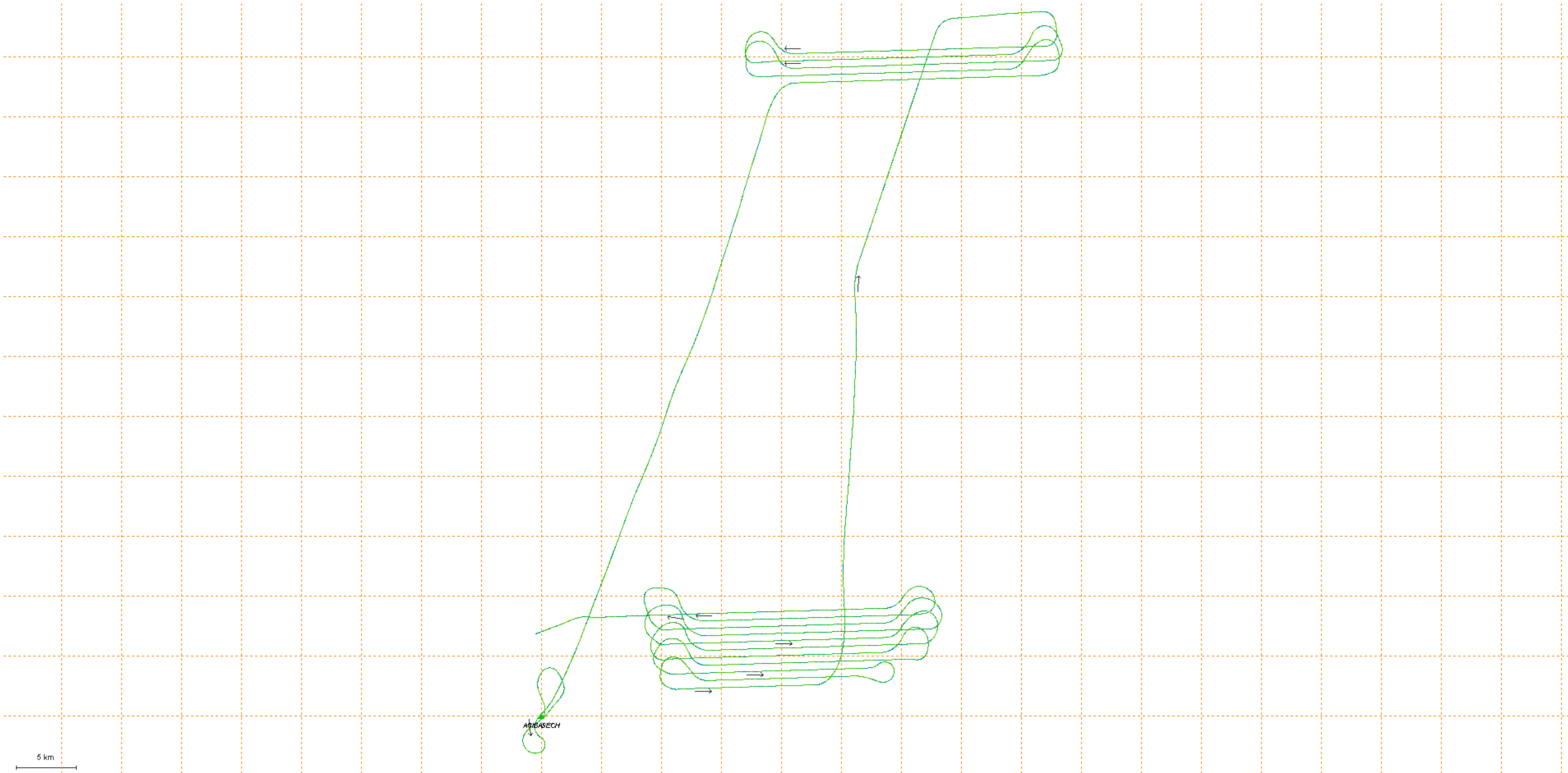


Figure 2: 10/27 - Estimated Position Accuracy Plot

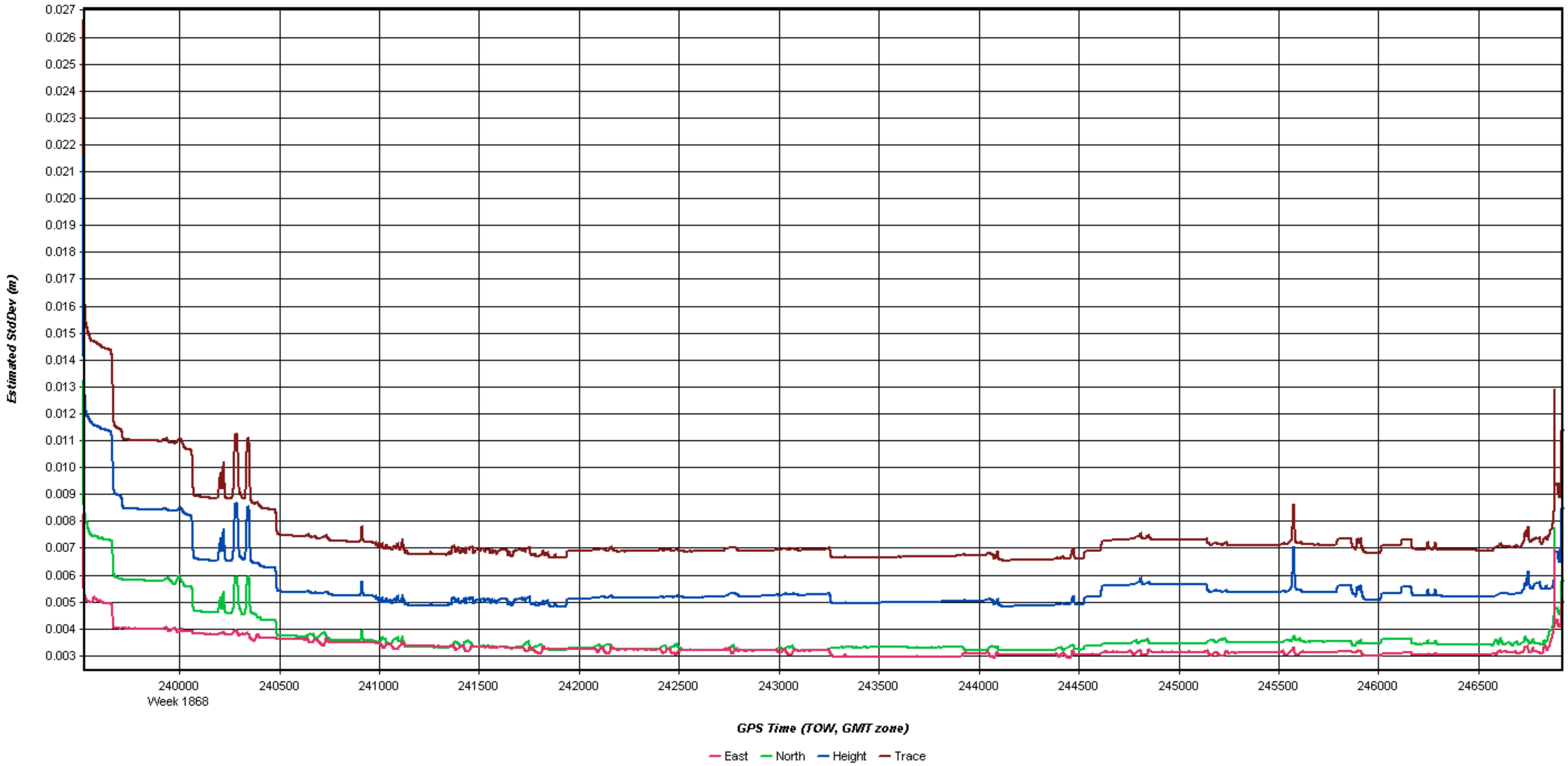


Figure 3: 10/27 - Height Profile Plot

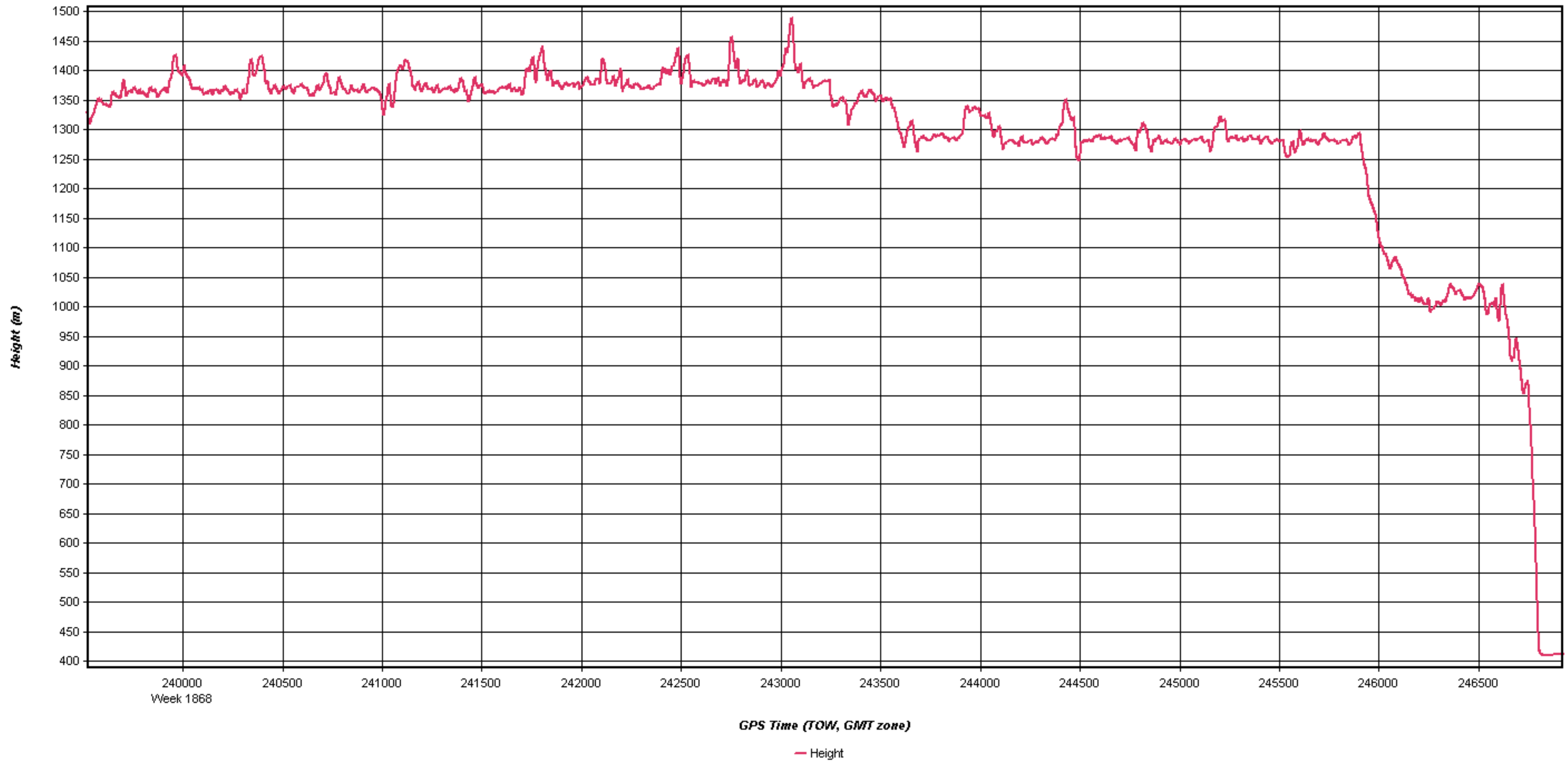


Figure 4: 10/27 - Forward/Reverse or Combined Separation Plot

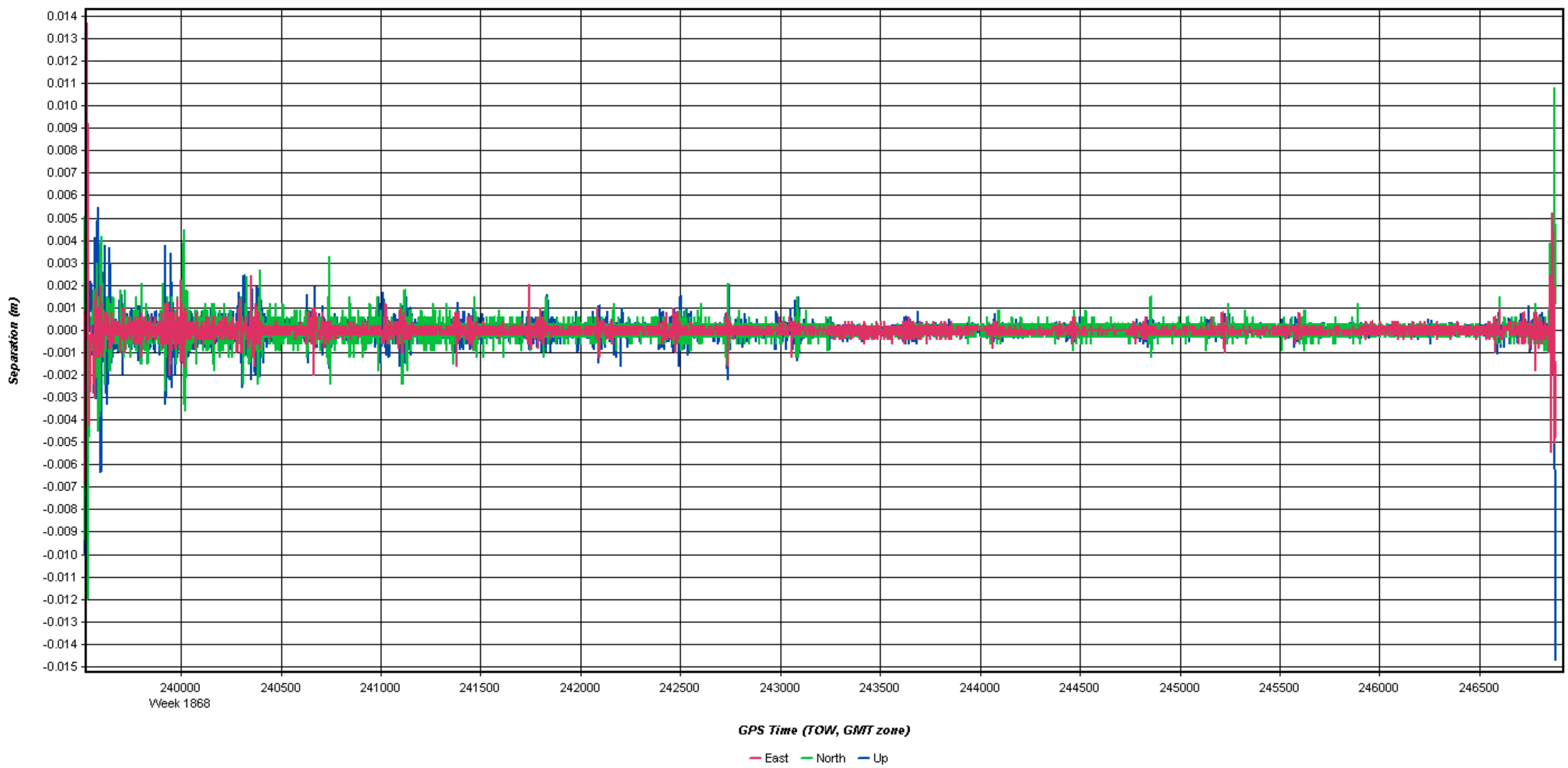


Figure 5: 10/27 - PDOP Plot

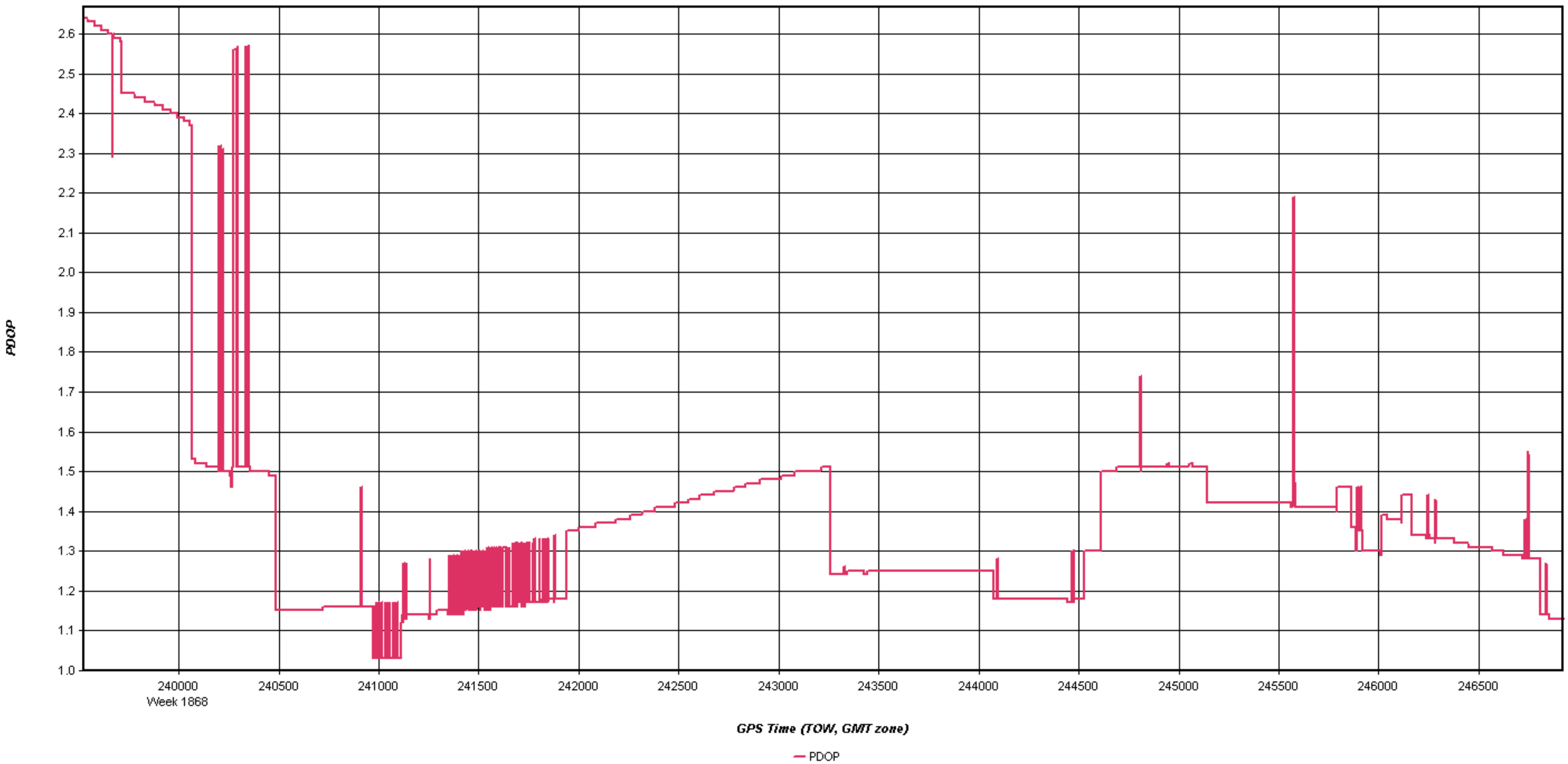


Figure 6: 10/27 - Number of Satellites Bar Plot

Lift 3 - 11/08/2015

Figure 1: Smoothed LC Combined - Map

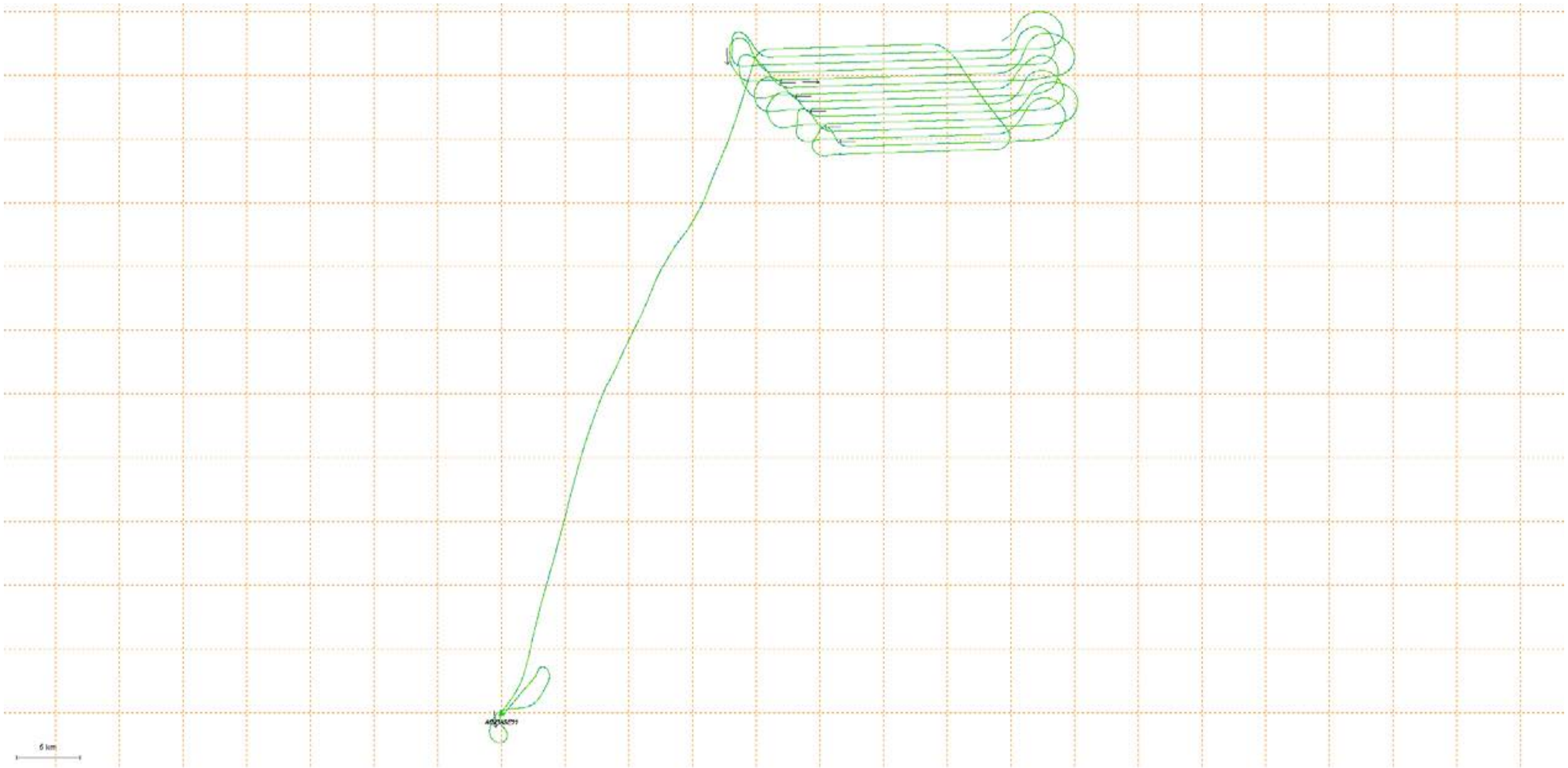


Figure 2: 11/08 - Estimated Position Accuracy Plot

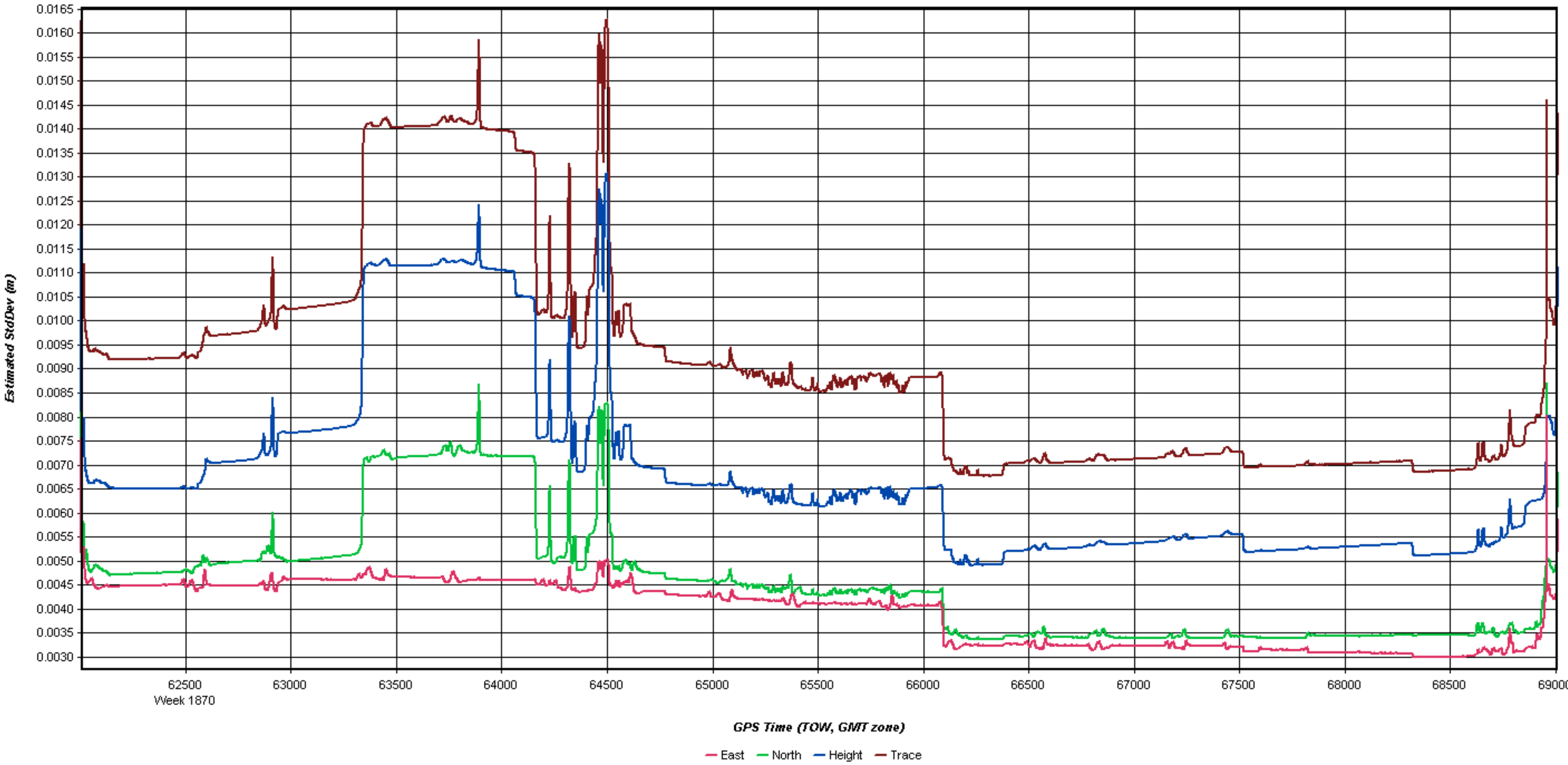


Figure 3: 1108 - Height Profile Plot

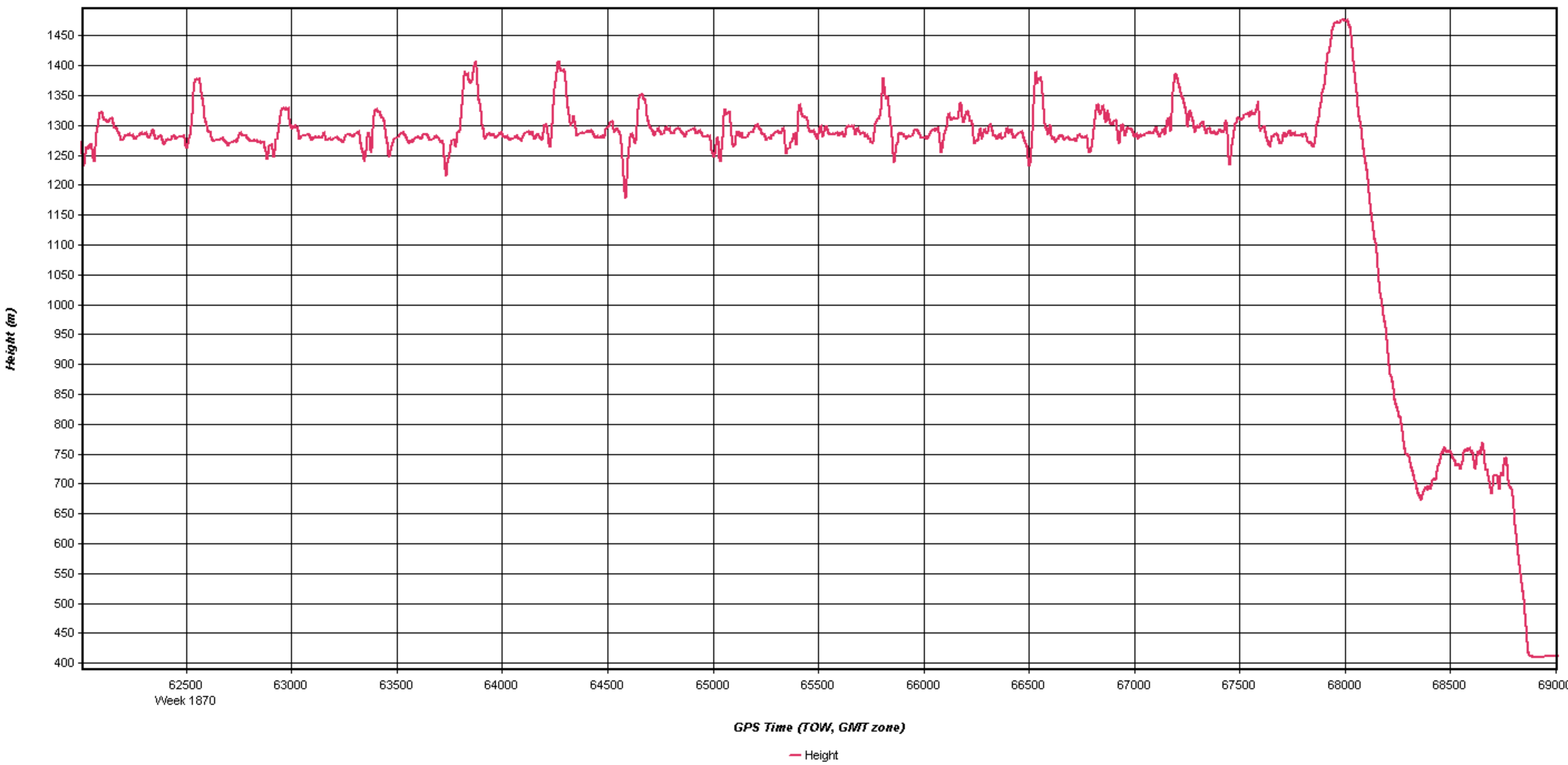


Figure 4: 11/08 - Forward/Reverse or Combined Separation Plot

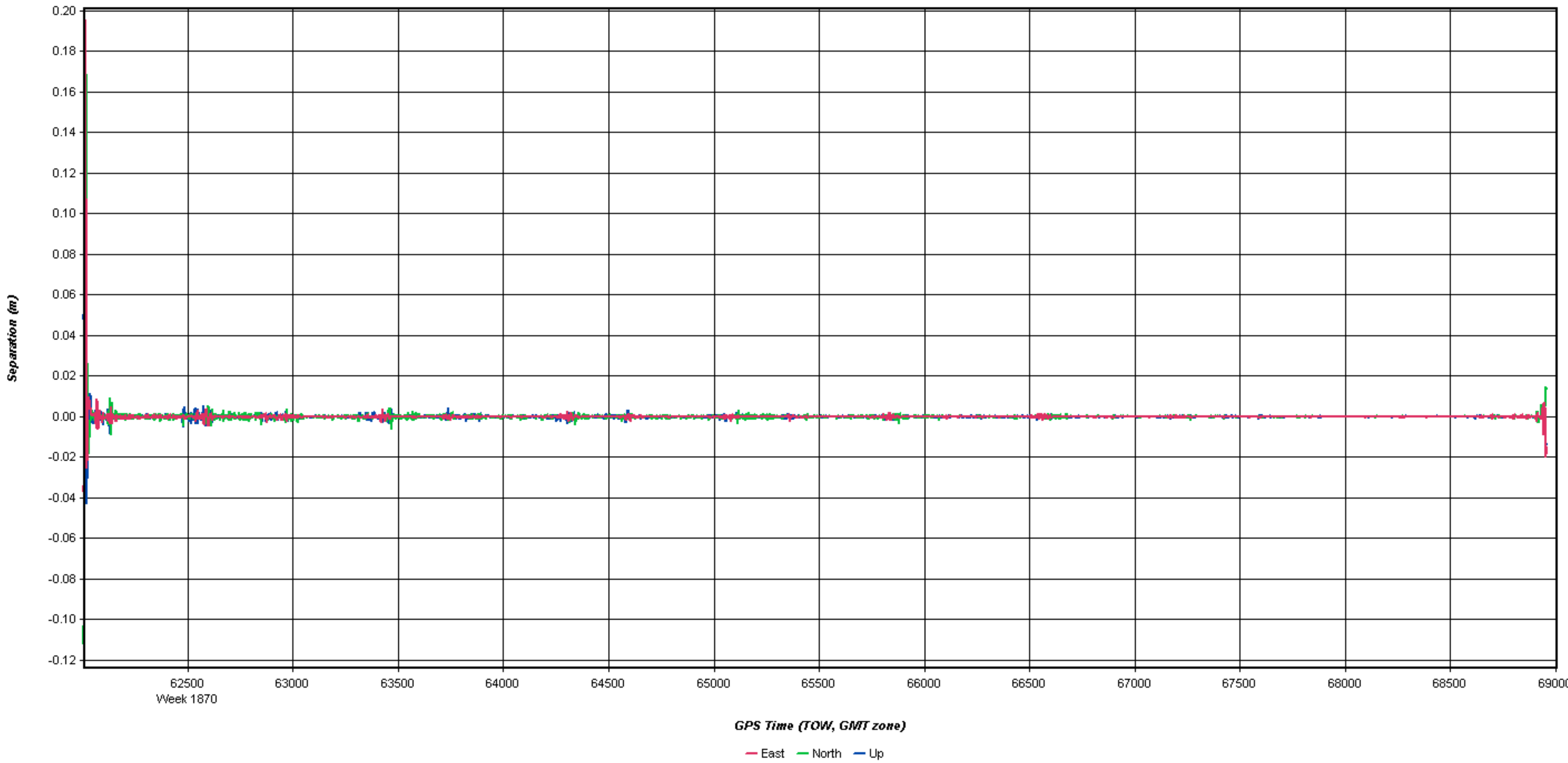


Figure 5: 11/08 - PDOP Plot

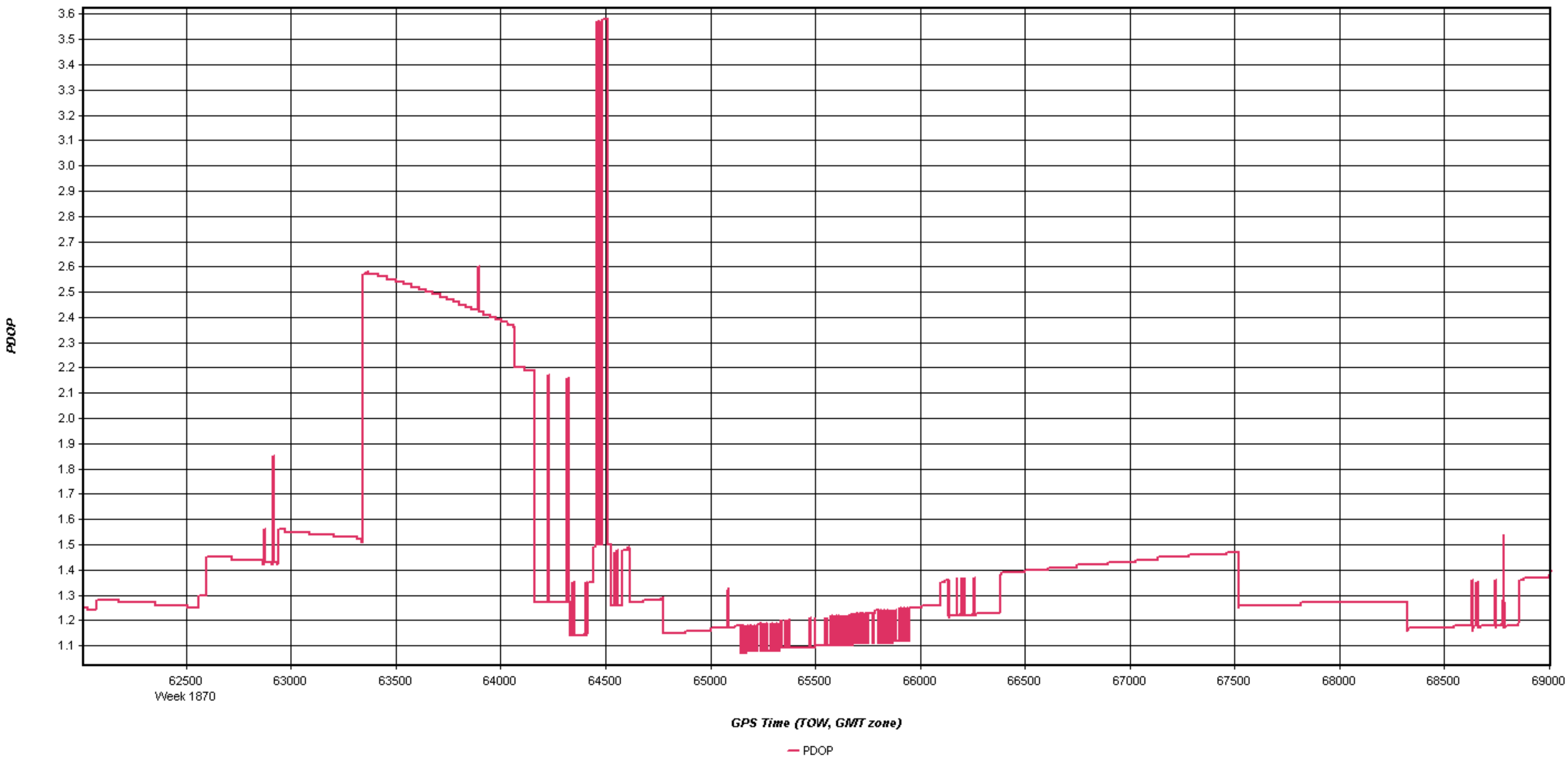
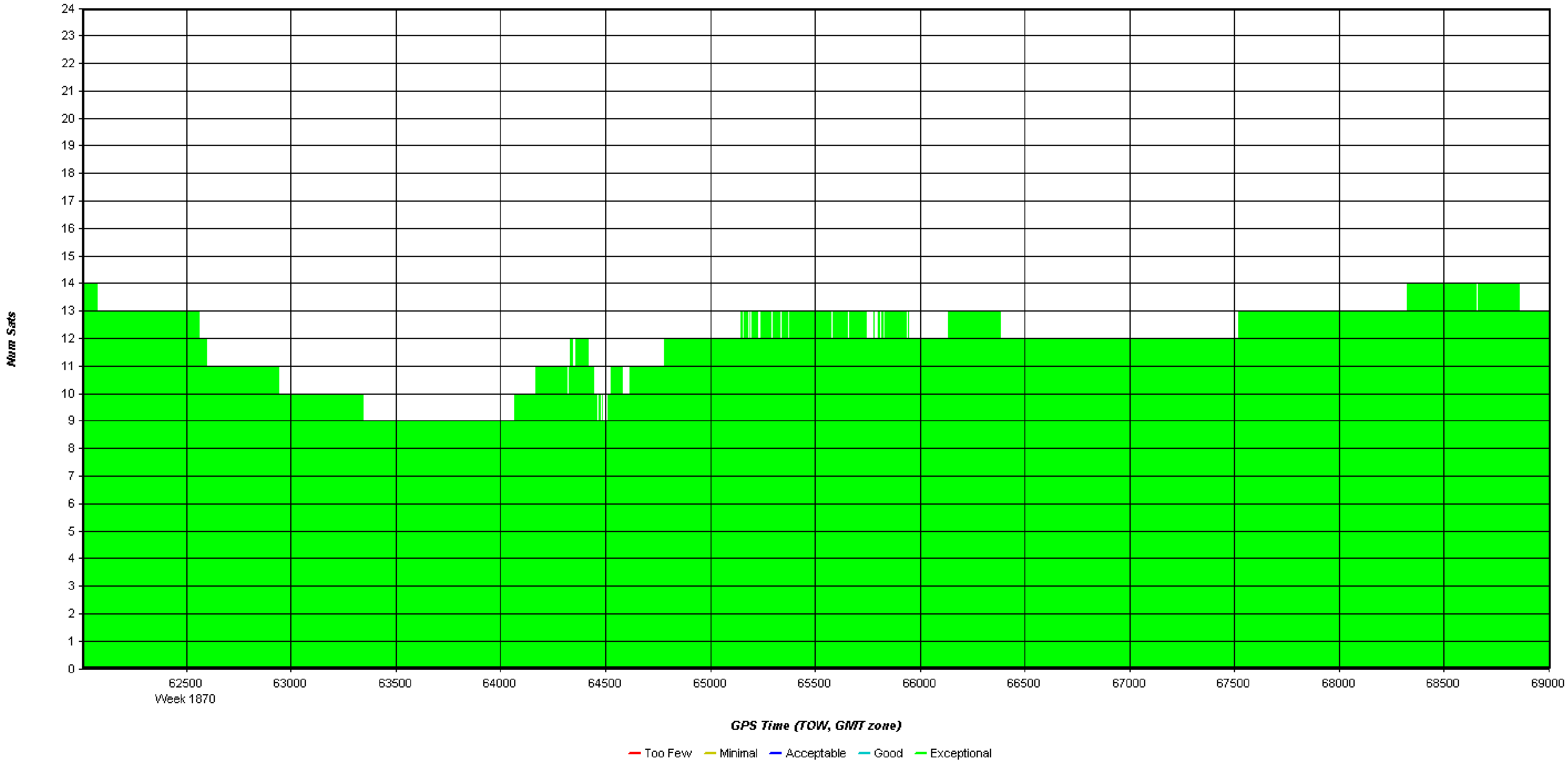


Figure 6: 11/08 - Number of Satellites Bar Plot



APPENDIX 10

2015 Lidar Hillshade and Structural interpretation Map at 1:25,000

345000
350000
355000
360000
5350000
5345000
N
Bare Earth Hillshade
and Structural interpretation
Esker
Fault
Boulder
Potential outcrop
Property outline
Main Road
1:25,000
0
0.5
1
2
Km

APPENDIX 11

2015 Lidar Hillshades Survey and Contours Map at 1:25,000

345000
350000
355000
360000
5350000
5345000
N
Bare Earth Hillshade and Contours
Lidar Contours at 10m
Esker
Fault
Boulder
Potential outcrop
Property outline
Main Road
1:25,000
0
0.5
1
2
Km

APPENDIX 12

2015 Lidar Hillshade Survey and Lithologies Map at 1:25,000


345000
350000
355000
360000
5350000
5345000
N
Bare Earth Hillshade and Contours
Outcrop lithology
Felsic Gneiss
Amphibolite
Diabase
Pegmatite
Esker
Fault
Potential outcrop
Lithology
Foliated tonalite suite
Metasedimentary rocks
Migmatized supracrustal rocks
Property outline
Main Road
1:25,000
0 0.5 1 2
Km