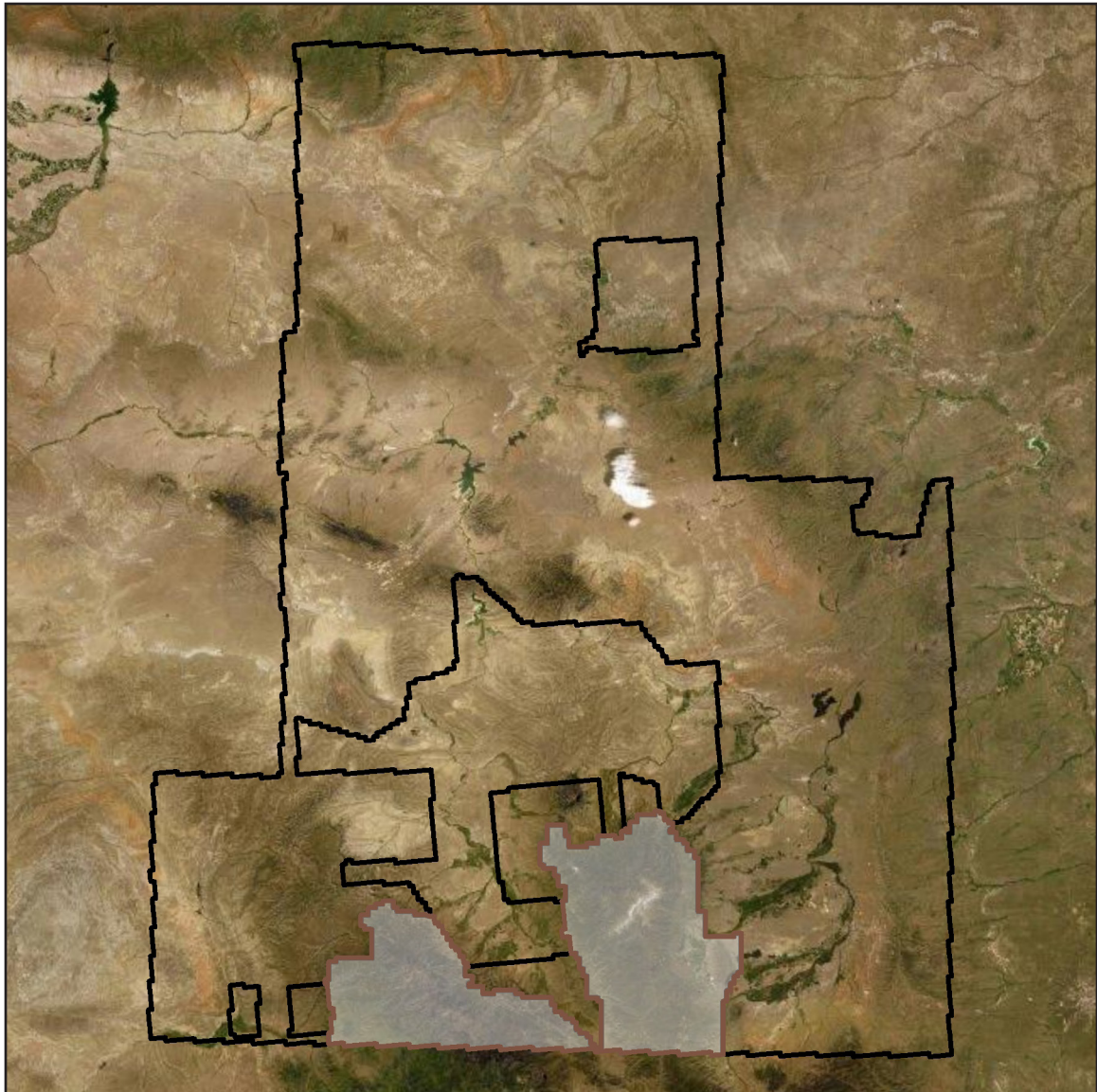


WY South Central 2020 D20

Lidar Mapping Report
Work Unit 197416 - 226068

April 2022



Contract # G16PC00022
Task Order # 140G0220F0171



Contractor Woolpert
Project # 80997

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1. Overview

About

This project contains a comprehensive outline of the 14G0220F0171 - WY South Central 2020 D20 task order issued by the United States Geological Survey's National Geospatial Technical Operations Center (USGS-NGTOC). This task order called for the acquisition and processing of QL1 and QL2 data covering approximately 15,307 square miles in south central Wyoming (Figure 1-1).

This report encompasses the Work Unit 226068 area of interest (Figure 1-2). This AOI totals approximately 1,598 square miles and includes the following counties:

- Carbon
- Albany

Purpose

This project will support the 3DEP mission, the Natural Resources Conservation Service (NRCS) high resolution elevation enterprise program and the Federal Emergency Management Agency (FEMA) Risk Mapping.

Specifications

Data for this task order was acquired and produced to meet USGS Lidar Base Specification 2021 version A standards and the American Society of Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data (Edition 1, Version 1.0).

Spatial Reference

Geospatial data products were produced using the following horizontal and vertical spatial data reference system information listed in Table 1-1.

Table 1-1. Spatial Reference System

Horizontal	EPSG Code	6342
	Datum	NAD83 (2011)
	Projection	UTM Zone 13
	Units	Meters
Vertical	Datum	NAVD88
	Geoid	GEOID18
	Units	Meters
	Height Type	Orthometric

Figure 1-1. Project Area

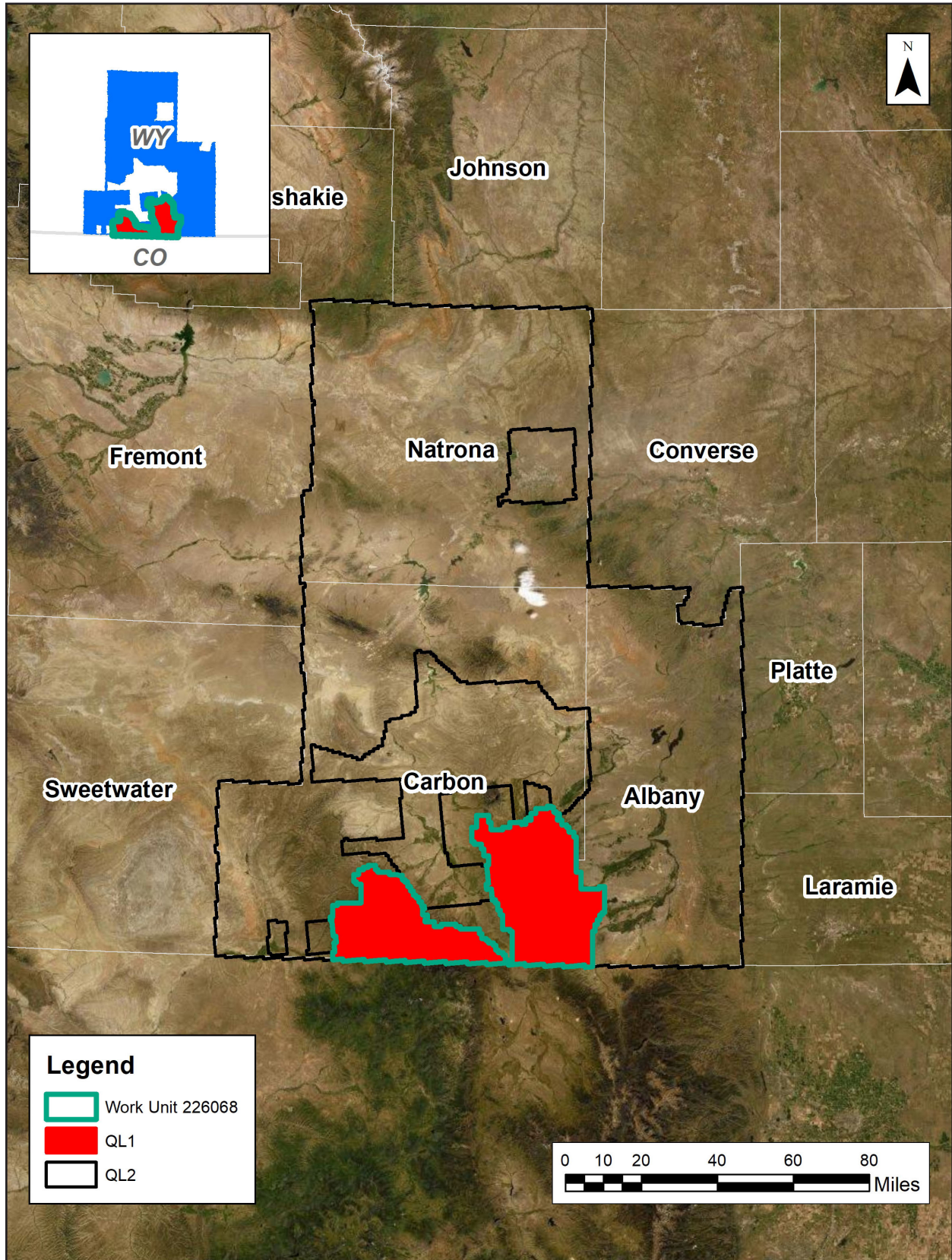
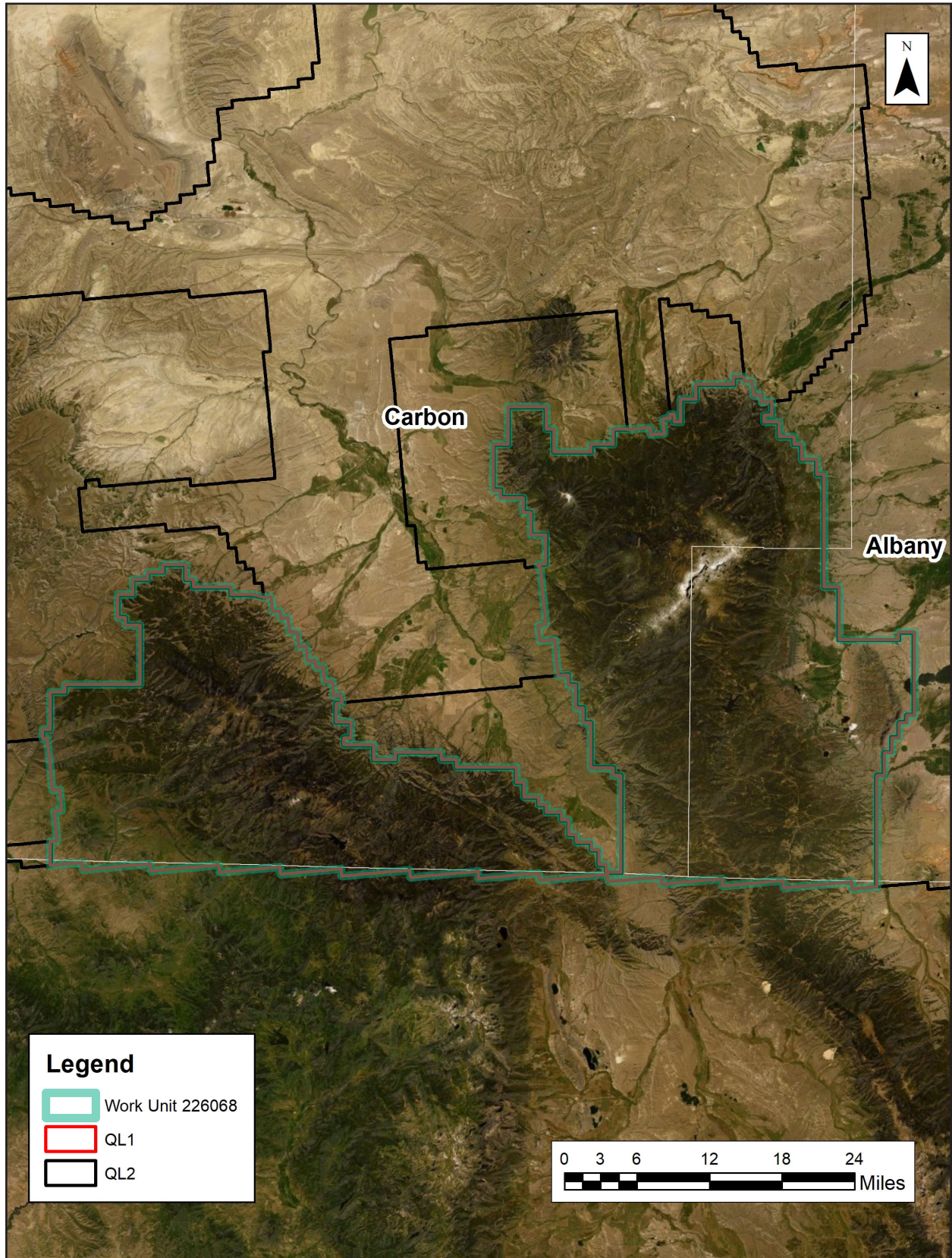


Figure 1-2. Project Area - Work Unit 226068



Task Order Deliverables

All data products produced as part of this task order are listed in Table 1-2. All tiled deliverables had a tile size of 500-meters x 500-meters. Tile names are derived from the US National Grid.

This delivery’s tiled dataset contains a total of 17,365 tiles. One tile was excluded as it fell over a water body.

Excluded tile

- 13TCF425435

Table 1-2. Deliverables

Lidar Data	
Classified lidar point cloud data	Tiles in LAS v1.4 format Classes <ul style="list-style-type: none"> • 1 – Processed, not Classified • 2 – Ground • 7 – Noise • 9 – Water • 17 – Bridge Decks • 18 – High Noise • 20 – Ignored Ground • 21 – Snow • 22 – Temporal Exclusion
Breaklines used for hydro-flattening	<ul style="list-style-type: none"> • Lake and River features as feature classes in an Esri file geodatabase <ul style="list-style-type: none"> • Water bodies greater than 2 acres as polygon features • Rivers 30.5 meters / 100 feet and greater in width as polyline features • Bridges used in DEM generation as point features in Esri shapefile format
Hydro-flattened bare earth digital elevation model (DEM)	0.5-meter pixel size size, 32-bit floating-point; no bridges or overpass structures GeoTIFF format
Intensity imagery	0.5-meter pixel size, 8-bit gray-scale (linear rescaling from 16-bit intensity) GeoTIFF format
Vertical Accuracy Data	
Ground control survey report	Survey report in PDF format
Calibration control points	Esri shapefile format
NVA and VVA checkpoints	Esri shapefile format
Interswath and intraswath test results	Esri shapefile format

Table 1-2: Deliverables (continued)

Spatial Metadata	
Data extent	Esri shapefile format
Tile index	Esri shapefile format
Swath polygons	Georeferenced, polygonal representation of the detailed extents of each lidar swath Polygon feature class in an Esri file geodatabase
Swath separation images	1-meter pixel size, 8-bit, GeoTIFF format
Maximum surface height rasters	0.5-meter pixel size, 32-bit floating point, GeoTIFF format
Metadata and Reports	
XML metadata	Deliverable-level FGDC CSDGM/USGS MetaParser Compliant metadata in XML format
Lidar mapping report	Project report with ancillary data in PDF format

2. Acquisition

Flight Planning

Acquisition was planned based on the task order specifications listed in Table 2-1.

Table 2-1. Acquisition Requirements

Specification	Target
Resolution	<ul style="list-style-type: none"> • 8 points per square meter • 0.35-meter nominal point spacing
Overlap	At contractor's discretion, but enough to ensure there are no data gaps between usable portions of the swath and to ensure the aggregate nominal point density (ANPD) is achieved
Acquisition Window	A period of annual minimal water level in the spring of 2020 leaf off window running through April, 2021
Data Voids	Not allowed except <ul style="list-style-type: none"> • Where caused by water bodies • Where caused by areas of low near infra-red (NIR) reflectivity (i.e. asphalt or composition roofing) • Where caused by lidar shadowing from buildings or other features • Where appropriately filled-in by another swath
Data Acquisition Conditions	Atmospheric <ul style="list-style-type: none"> • Cloud and fog-free between the aircraft and ground Ground <ul style="list-style-type: none"> • Snow free • No unusual flooding or inundation, except in cases where the goal of the collection is to map the inundation Vegetation <ul style="list-style-type: none"> • Leaf-off is preferred Time of Day <ul style="list-style-type: none"> • Time of day is not of concern

Flight plans were created using Leica Mission Pro software.

Lidar Sensor Information

Aerial lidar data was acquired for this project using the following lidar sensor systems:

- Terrain Mapper - serial number 90515, last calibrated June 27, 2019
- Terrain Mapper - serial number 91511, last calibrated July 3, 2019
- Terrian Mapper - serial number 91557, last calibrated July 1, 2020

Table 2-2 depicts a summary of sensor information. See Appendix 1 for the sensor calibration reports.

Table 2-2. Leica Terrain Mapper Sensor Info

Sensor Specifications	
Operating Altitude (m AGL)	300 - 5,500 at 10% reflective target
Maximum Measurement Rate (kHz)	2,000
Scan Angle	20 - 40
Scan Width	Up to 70% of flight altitude
Scan Frequency	Programmable up to 125 Hz (7,500 RPM), 250 scan lines per second
Number of Returns	15
Number of intensity measurements	15
Pulse Mode(s)	Up to 35 pulses in air
Laser Specifications	
Laser Beam Divergence	0.25 mrad (1/e)
Laser Classification	Class 4 laser product
Accuracy	
Range Resolution	< 1 cm RMS
Elevation Accuracy	< 5 cm 1 σ
Horizontal Accuracy	< 13 cm 1 σ
Physical Specifications	
Size (cm), Weight (kg) • Scanner • Control Electronics	<ul style="list-style-type: none"> • 37 W x 68 L x 26 H cm, 47 kg • 45 W x 47 D x 25 H cm, 33 kg
Operating Temperature • Scanner • Control Electronics	<ul style="list-style-type: none"> • 0 - 40°C cabin-side temperature • 0 - 40°C
Flight Management	Leica FlightPro
Power Consumption	922 W @ 22.0 – 30.3 VDC

Source: Leica TerrainMapper Data Sheet
<https://leica-geosystems.com/en-US/products/airborne-systems/topographic-lidar-sensors/leica-terrainmapper>

Lidar Sensor Settings

Aerial lidar was acquired using the sensors and settings listed in the Table 2-3.

Table 2-3. Lidar Sensor Settings

Settings	East and West
Max. Number of Returns	15
Nominal Point Spacing	0.35 m
Nominal Point Density	8 ppsm
Flying Height Above Ground Level	1,650 m
Flight Speed	150 knots
Scan Angle	34°
Scan Rate Used	150 Hz
Pulse Rate Used	1400 kHz
Multi-Pulse in Air	Enabled
Swath Width	1,009 m
Swath Overlap	25%

Timeline

Lidar data was collected on August 28, 2020 through October 13, 2020. A total of 596 individual flight lines were collected. Figure 2-1 shows aerial lidar coverage by lift.

For more information, see the Flight Logs in Appendix 2.

GNSS and IMU Equipment

Prior to mobilizing to the project site, flight crews coordinated with the necessary air traffic control personnel to ensure airspace access. Crews were on-site, operating a Global Navigation Satellite System (GNSS) Base Station for the airborne GPS support.

Flight navigation during acquisition was performed using IGI CCNS (Computer Controlled Navigation System). The pilots are skilled at maintaining their planned trajectory, while holding the aircraft steady and level. If atmospheric conditions are such that the trajectory, ground speed, roll, pitch and/or heading cannot be properly maintained, the mission is aborted until suitable conditions occur.

Base stations were set by acquisition staff and was used to support the aerial data acquisition. Table 2-4 lists the Station ID and coordinates for all base stations operated during acquisition.

For more information, see the GPS/IMU graphics in Appendix 3.

Figure 2-1. Flight Coverage

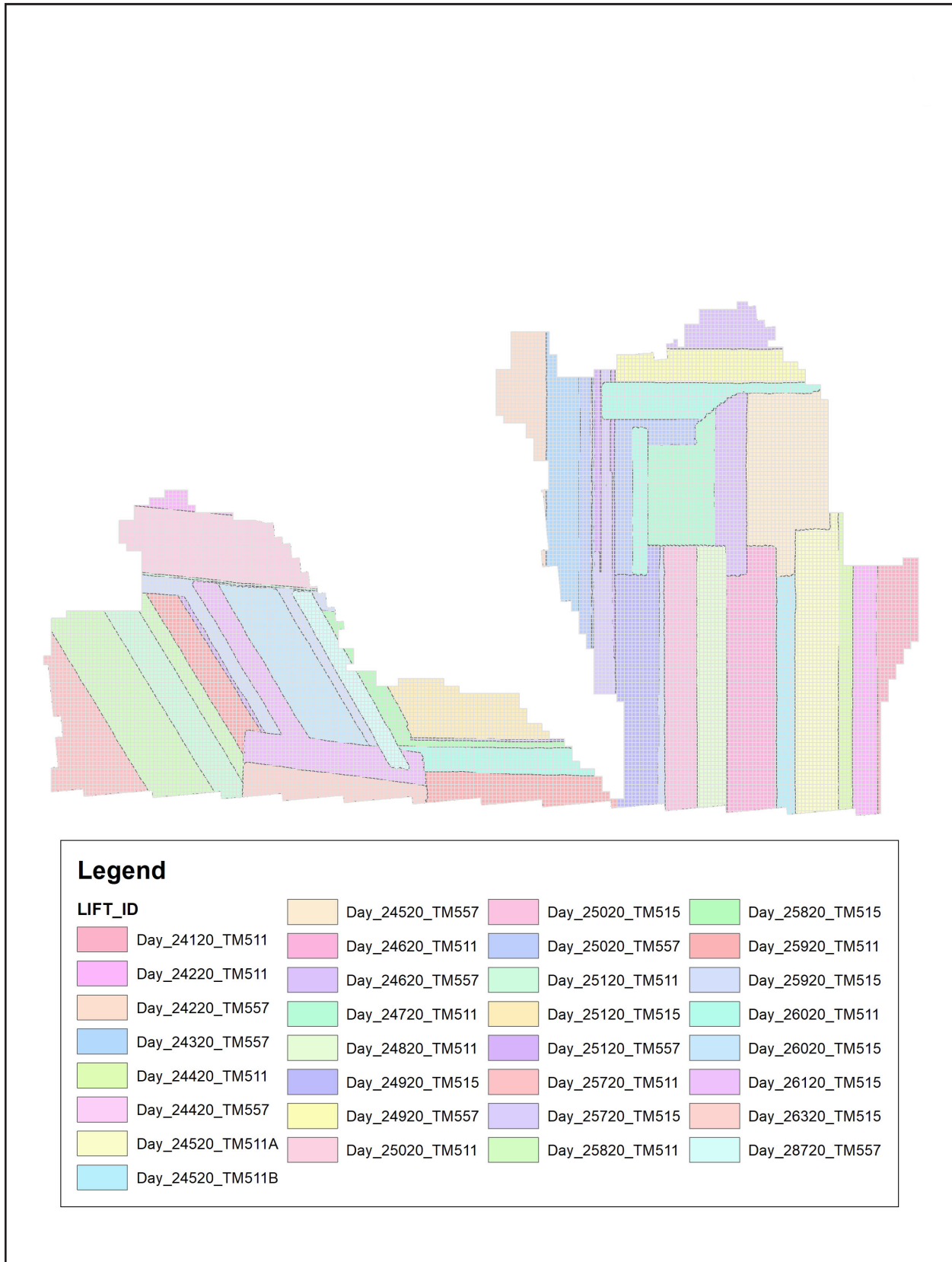


Table 2-4. GNSS Base Stations

Station Name	Longitude (DMS)	Latitude (DMS)	Ellipsoid Height L1 Phase Center (Meters)
KLAR_Airport	41°19'10.93091"	105°40'05.18412"	2204.005
P032_CORS	41°44'30.00330"	107°15'21.27878"	2168.178
WYLC_CORS	41°06'16.29488"	-104°46'31.29307"	1824.826
WYRF_CORS	42°49'50.36453	106°19'38.49771"	1634.444

Acquisition Quality Assurance

An initial quality control process was immediately performed on to review the data coverage, airborne GPS data, and trajectory solution.

Woolpert developed a quality assurance and validation plan to ensure the acquired lidar data meets the USGS Base Specification requirements. For quality assurance purposes, the lidar data was processed immediately following acquisition to verify the coverage has appropriate density, distribution, and no unacceptable data voids. Accompanying GPS data was post processed using differential and Kalman filter algorithms to derive a best estimate of trajectory. The quality of the solution was verified to be consistent with the accuracy requirements of the task order. Any required re-flights were scheduled at the earliest opportunity.

The spatial distribution of the geometrically usable first return lidar points was reviewed for density requirements as well as regular and uniform point distribution - verifying the lidar data is spaced so that 90% of the cells in a 2*NPS grid placed over the data contain at least one lidar point. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath. Additionally, the data was reviewed for unacceptable data voids – verifying no area greater than or equal to $(4 \times \text{ANPS})^2$ exhibited data coverage gaps.

3. Processing

Processing Summary

Once the lidar data passed initial QC, the dataset was corrected for aircraft orientation and movement. This process used airborne inertial, orientation, and GPS data collected during acquisition along with ground-based GPS data. The data went through a geometric calibration that further corrected each laser point. This calibrated data set was used to create the LAS point cloud. The LAS point data was initially classified into “ground” and “non-ground”, then further refined using the classes specified in this task order. Breaklines were drawn to denote hydrological features. After the hydro-flattening process, the final deliverables products were created.

GPS-IMU Trajectory Processing

Kinematic corrections for the aircraft position were resolved using aircraft GPS and static ground GPS (1-Hz) for each geodetic control (base station) for three subsystems: inertial measurement unit (IMU), sensor orientation information, and airborne GPS data.

Post-processing of the IMU system data and aircraft position with attitude data was completed to compute an optimally accurate, blended navigation solution based on Kalman filtering technology, or the smoothed best estimate of trajectory (SBET).

For more information, see the GPS/IMU graphics in Appendix 3.

Software: POSPac Software v. 5.3, IPAS Pro v.1.35., Novatel Inertial Explorer v8.60.6129

Trajectory Quality

The GNSS trajectory and high-quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the combined separation, the estimated positional accuracy, and the positional dilution of precision (PDOP).

Combination Separation

Combined separation is a measure of the difference between the forward-run and the backward-run solution of the trajectory. The Kalman filter was processed in both directions to remove the combined directional anomalies. In general, when these two solutions match closely, an optimally accurate and reliable solution is achieved.

The data for this task order was processed with a goal to maintain a combined separation difference of less than ten (10) centimeters.

Estimated Positional Accuracy

Estimated positional accuracy plots the standard deviations of the east, north, and vertical directions along a time scale of the trajectory. It illustrates loss of satellite lock issues, as well as issues arising from long baselines, noise, and/or other atmospheric interference.

PDOP

The PDOP measures the precision of the GPS solution in regard to the geometry of the satellites acquired

and used for the solution.

The data for this task order was processed with a goal to maintain an average PDOP value below 3.0. Brief periods of PDOP over 3.0 are acceptable due to the calibration and control process if other metrics are within specification.

Geometric Calibration

After the initial phase was complete, a formal reduction process was performed on the data. Laser point position was calculated by associating the SBET position to each laser point return time, scan angle, intensity, etc. Raw laser point cloud data was created for the whole project area in LAS format. Automated line-to-line calibrations were then performed for system attitude parameters (pitch, roll, heading), mirror flex (scale) and GPS/IMU drift. Statistical reports were generated for comparison and used to make the necessary adjustments to remove any residual systematic error.

For more information, see the Sensor Calibration Report(s) in Appendix 1.

Software: Proprietary Software, TerraMatch v20, Leica CloudPro 1.2.4

Relative Accuracy: Interswath (Overlap) Consistency

Interswath or overlap consistency was assessed at multiple locations within overlap in non-vegetated areas containing only single returns and located in areas with slopes of less than 10 degrees. To the extent allowed by the data, test areas were chosen where the full width of the overlap was represented. These overlap areas include adjacent, overlapping parallel swaths within a project, cross-tie swaths and a sample of intersecting project swaths in both flight directions, and adjacent, overlapping lifts.

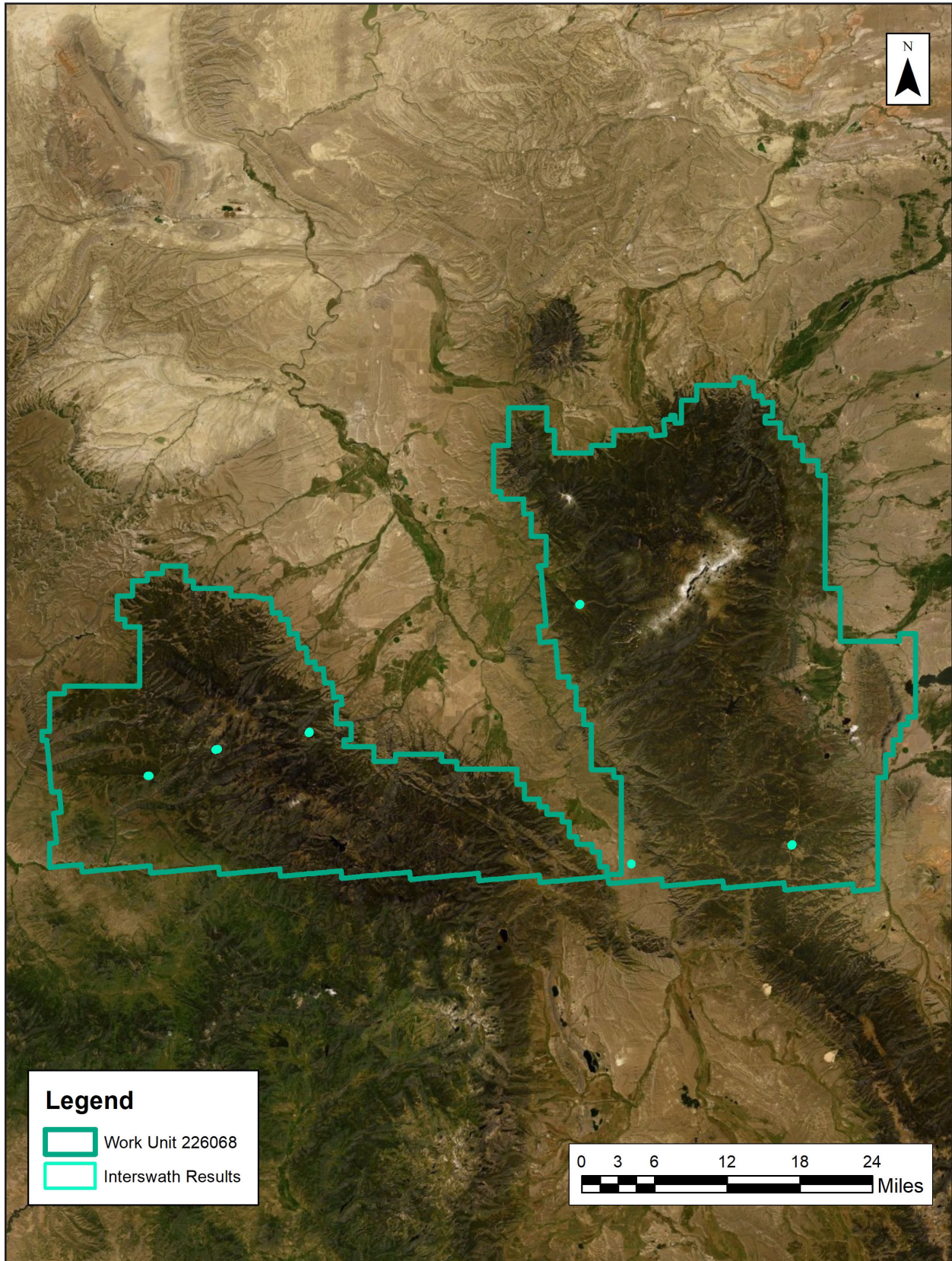
This project required the interswath accuracy to meet ≤ 8 cm RMSDz. Accuracy was assessed in accordance with the USGS Base Specification v2021 revision A.

The interswath consistency results were produced as polygon features in Esri shapefile format. Table 3-1 lists the interswath test results. Figure 3-1 depicts the location of the interswath test locations.

Table 3-1. Interswath Results

Minimum (m)	Maximum (m)	RMSDz (m)
-0.02500000000	0.03300000000	0.01400000000
-0.01300000000	0.11800000000	0.01500000000
-0.05800000000	0.04000000000	0.01600000000
-0.05800000000	0.03300000000	0.01700000000
-0.02500000000	0.03800000000	0.01100000000
-0.02600000000	0.05300000000	0.01200000000

Figure 3-1. Interswath Testing Locations



Relative Accuracy: Intraswath Precision

Intraswath precision (or smooth surface precision) was performed on hard surfaces with areas consisting of approximately 100 pixels (ex.: parking lots, large rooftops) and containing only single return lidar points. Sample areas were selected where full width of the swath(s) (left, center, and right) were represented to the extent the data allowed.

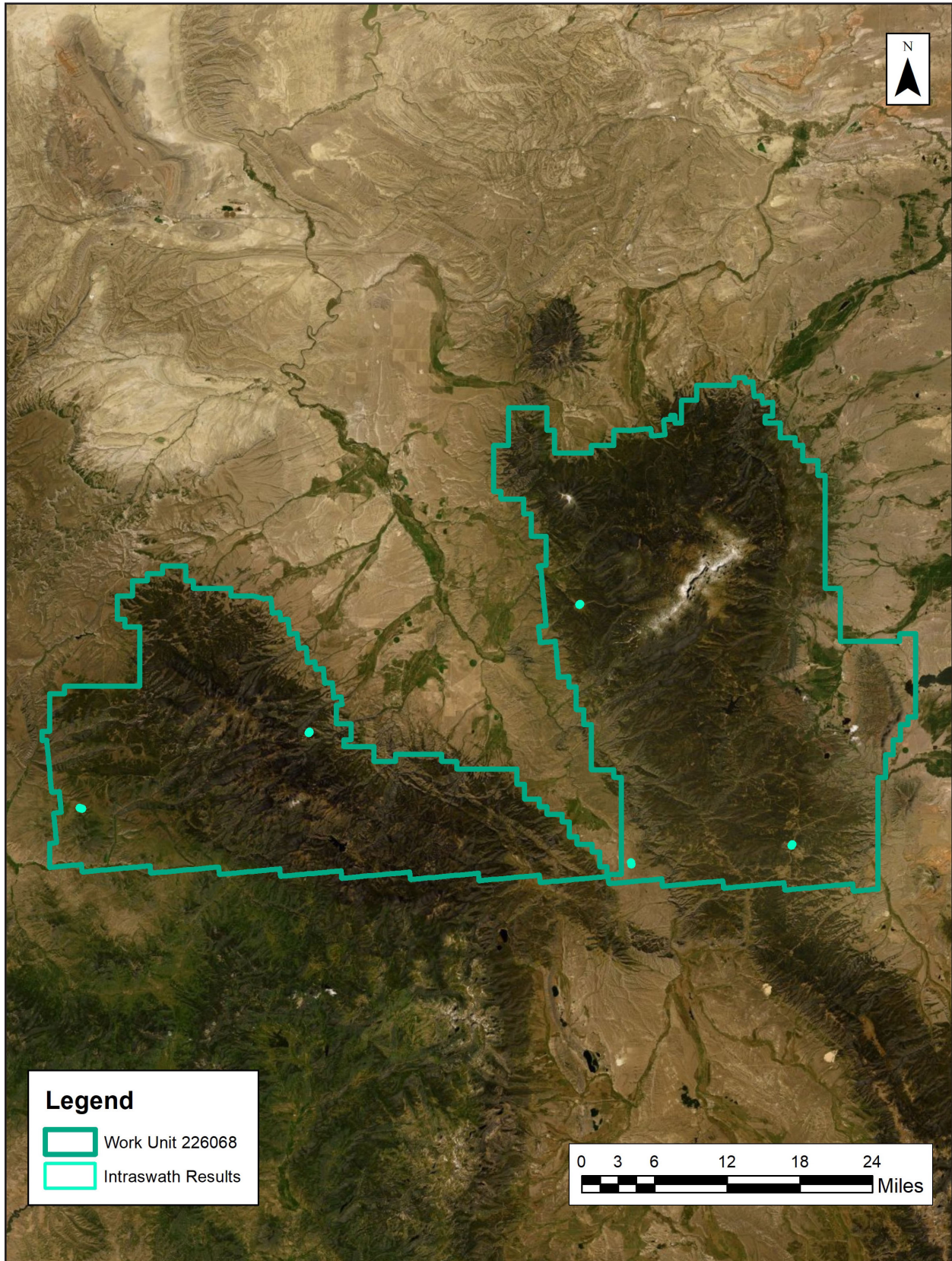
This project required the intraswath accuracy to meet ≤ 6 cm RMSDz. Accuracy was assessed in accordance with the USGS Base Specification v2021 revision A.

The intraswath precision results were produced as polygon features in Esri shapefile format. Table 3-2 lists the intraswath test results. Figure 3-2 depicts the location of the intraswath test locations.

Table 3-2. Intraswath Results

Minimum (m)	Maximum (m)	RMSDz (m)
-0.061000000000	0.071000000000	0.012000000000
-0.058000000000	0.040000000000	0.014000000000
-0.076000000000	0.070000000000	0.034000000000
-0.082000000000	0.060000000000	0.036000000000
-0.063000000000	0.040000000000	0.026000000000

Figure 3-2. Intraswath Testing Locations



Lidar Data Classification

LAS data was initially classified as ground and non-ground points “first and only” as well as “last of many” lidar returns. Additional filters were created to meet the task order classification specifications. Statistical absolute accuracy was assessed via direct comparisons of ground classified points to ground RTK survey data. Based on the statistical analysis, the lidar data was then adjusted to reduce the vertical bias when compared to the survey ground control of higher accuracy.

The bare-earth (Class 2 - Ground) lidar points underwent a manual QA/QC step to verify the quality of the DEM as well as a peer-based QC review. This included a review of the DEM surface to remove artifacts and ensure topographic quality. After the bare-earth surface is finalized, it is then used to generate all hydro-breaklines through a semi-automated process.

All ground (Class 2) lidar data inside of the Lake Pond and Double Line Drain hydro flattening breaklines were then classified to water (Class 9) using TerraScan/LP360 macro functionality. A buffer of 0.7 meters was also used around each hydro-flattened feature to classify these ground (Class 2) points to Ignored Ground (Class 20). All Lake Pond Island and Double Line Drain Island features were checked to ensure that the ground (Class 2) points were reclassified to the correct classification after the automated classification was completed.

All overlap data was processed through automated functionality provided by TerraScan to classify the overlapping flight line data to approved classes by USGS. The overlap data was classified using standard LAS overlap bit. These classes were created through automated processes only and were not verified for classification accuracy. Due to software limitations within TerraScan, these classes were used to trip the withheld bit within various software packages. These processes were reviewed and accepted by USGS through numerous conference calls and pilot study areas.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper was used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files. Woolpert proprietary software and LP360 was used to perform final statistical analysis of the classes in the LAS files, on a per tile level to verify final classification metrics and full LAS header information.

Table 3-3 lists the point classifications used.

Table 3-3. Classified Point Breakdown

Class Number	Class Name
Class 1	Processed, but unclassified
Class 2	Bare earth
Class 7	Low noise
Class 9	Water
Class 17	Bridge deck
Class 18	High noise
Class 20	Ignored ground
Class 21	Snow
Class 22	Temporal exclusion

Hydrologic Flattening

The lidar task order required compilation of breaklines defining the following types of water body features:

Lakes, reservoirs, ponds	Minimum of 2-acres or greater Compiled as closed polygons, collected at a constant elevation
Rivers, streams	Nominal width of 30.5 meters / 100 feet Compiled in direction of flow, with both sides maintaining an equal elevation gradient
Bridge breaklines	Breaklines used to enforce a logical terrain surface below a bridge

Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing lidar data:

1. The newly acquired lidar data was utilized to manually compile the hydrologic features in a 2D environment using the lidar intensity and bare earth surface. Open Source imagery was used as reference when necessary.
2. An integrated software approach was applied to combine the lidar data and 2D breaklines. This process “drapes” the 2D breaklines onto the 3D lidar surface model to assign an elevation. A monotonic process is performed to ensure the streams are consistently flowing in a gradient manner. A secondary step within the program verifies an equally matching elevation of both stream edges. The breaklines that characterize the closed water bodies are draped onto the 3D lidar surface and assigned a constant elevation at or just below ground elevation.
3. All classified ground points from inside the hydrologic feature polygons were reclassified to water, class nine (9).
4. All classified ground points were reclassified from within a buffer along the hydrologic feature breaklines to buffered ground, class twenty (20). The buffer distance was approximately the task order designed nominal pulse spacing distance.
5. Breaklines used for bridge removal during the hydrologic flattening were included with the hydrologic breakline geodatabase deliverable. The purpose of these breaklines is for a more aesthetically pleasing DEM appearance.
6. The lidar ground points and breaklines were used to generate a digital elevation model (DEM).
7. QA/QC for this task was performed by reviewing the hydrologically flattened DEM and hydrologic breakline features. Additionally, a combined approach utilizing commercial off the shelf software and proprietary methods were used to review the overall connectivity of the hydrologic breaklines.

TerraScan was used to add the hydrologic breakline vertices and export the lattice models.

Breaklines defining the water bodies greater than 2-acres were provided as polygon features. Rivers and streams with a nominal minimum width of 30.5 meters (100 feet) were provided as polyline features. All lake and river breaklines compiled as part of the flattening process were provided in an Esri file geodatabase.

Breaklines used for DEM generation were provided as point features in Esri shapefile format.

Software: TerraScan v20, TerraModeler v20, Esri ArcMap v10.7, LP360 v2019.1.30.4

Digital Elevation Model

TerraScan was used to add the hydrologic breakline vertices and export the lattice models. Class 2 (ground) lidar points in conjunction with the hydro breaklines and bridge breaklines were used to create 0.5-meter hydro-flattened bare-earth raster DEM files. Using automated scripting routines within ArcMap, a 32-bit floating point raster GeoTIFF file was created for each tile. Files were clipped to the data extent. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

Software: TerraScan v20, GDAL 2.4.0, Esri ArcMap v10.7, Global Mapper v20.0

Intensity Imagery

Lidar intensity data derived from the acquired lidar data was linearly rescaled from 16-bit intensity and provided as 0.5-meter pixel, 8-bit, 256 gray scale GeoTIFF files. Files were clipped to the data extent.

Software: TerraScan v20, Esri ArcMap v10.7

Swath Separation Image

A swath separation image is generated to visualize the DZ between the overlapping areas of the flight lines. To generate this surface a point insertion method is used as the primary algorithm. All returns for all point classes except classes 7 and 18 are used in the calculation for each cell. GSD and color ramp values are dependent on the Quality Level and point spacing for the project. The GSD for the surface is no more than 4 times the NPS of the lidar data rounded to an appropriate whole number. The color ramp for the following QL levels are as follows:

QL1 + QL2

- Less than 8 cm – Green
- 8 cm to 16 cm – Yellow
- Greater than 16 cm – Red

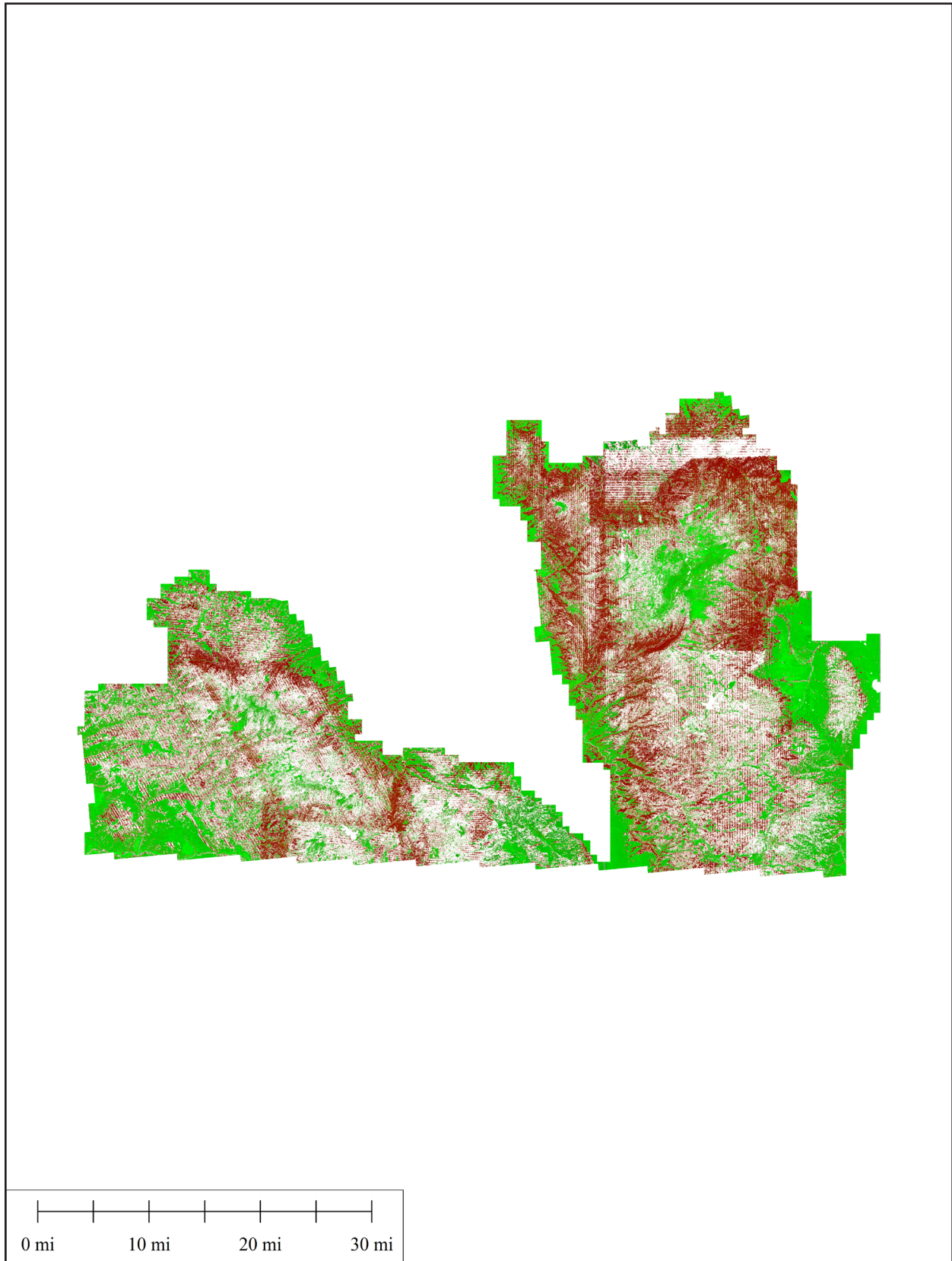
QL0

- Less than 4 cm – Green
- 4 cm to 8 cm – Yellow
- Greater than 8 cm – Red

Intensity values are modulated to 50% to ensure that there is no oversaturation of intensities values throughout the surface. After all calculations and surfaces have been made the images were delivered per tile in GeoTIFF format covering the DPA.

Software: LP360 v2018.2.59.5

Figure 3-3. Swath Separation Image



Metadata

FGDC CSDGM/USGS MetaParser-compliant metadata was produced in XML format. The metadata includes a complete description of the task order client information, contractor information, project purpose, lidar acquisition and ground survey collection parameters, lidar acquisition and ground survey collection dates, spatial reference system information, data processing including acquisition quality assurance procedures, GPS and base station processing, geometric calibration, lidar classification, hydrologic flattening, intensity imagery development, and final product development.

Other metadata deliverables included Esri shapefiles of the ground control and QA/QC points, interswath and intraswath test results, data extent, and tile index. A georeferenced, polygonal representation of the detailed extents of each acquired lidar swath was produced as a polygon feature class in an Esri file geodatabase. Swath separation images were produced in GeoTIFF format. Maximum height separation rasters were produced in GeoTIFF format.

4. Accuracy Assessment

Horizontal Accuracy

The data set was produced to meet ASPRS “Positional Accuracy Standards for Digital Geospatial Data” (2014) for a 0.162 cm RMSE_x / RMSE_y Horizontal Accuracy Class which equates to Positional Horizontal Accuracy = +/- 0.397 cm at a 95% confidence level.

Classified Lidar Point Cloud Testing

This project required Non-Vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA) to be tested on the classified lidar point cloud data. The dataset was required to meet a target NVA value of 19.6 cm at a 95% confidence level using an RMSE_z target value of 10 cm x 1.9600 and a target VVA value of 30 cm at the 95th percentile. Testing was assessed and reported using guidelines developed by the National Digital Elevation Program (NDEP) and the American Society for Photogrammetry and Remote Sensing (ASPRS).

The NVA and VVA values were calculated using independent checkpoints that were not used in the calibration or post processing of the lidar point cloud data. Checkpoints were distributed throughout the project area. NVA checkpoints were located in bare earth and urban (non-vegetated) land cover classes. VVA checkpoints were located in brush/tall grass/weeds (vegetated) land cover classes. These checkpoints were surveyed using GPS techniques. See the survey report for acquisition methodologies.

Testing was performed using TINs created from the final calibrated and controlled swath data. For each NVA checkpoint, an elevation value was derived from the TIN at the point’s x,y location. This value was compared to the checkpoint’s surveyed elevation value.

The classified lidar point cloud accuracy test results are listed below in Table 4-1.

Table 4-1. Classified Point Cloud Vertical Accuracy

	Result	Points Used
NVA	0.046 m RMSE _z 0.090 m at 95% CL	23
VVA	0.123 m at 95th Percentile	17

Digital Elevation Model Testing

This project required Non-Vegetated Accuracy (NVA) and Vegetated Vertical Accuracy (VVA) testing of the digital elevation model (DEM) dataset. The calculated NVA value was required to meet 19.6 cm at a 95% confidence level using an RMSE_z target value of 10 cm x 1.9600. VVA was required to meet 0.30 cm at the 95th percentile error. Testing was assessed and reported using guidelines developed by the National Digital Elevation Program (NDEP) and the American Society for Photogrammetry and Remote Sensing (ASPRS).

Testing was performed using the bare earth DEM created as part of this task order. For each checkpoint, an elevation value was derived from the DEM at the point’s x,y location. This value was compared to the checkpoint’s surveyed elevation value.

The NVA and VVA values were calculated using independent checkpoints that were not used in the calibration or post processing of the lidar point cloud data. Checkpoints were distributed throughout the project area. NVA checkpoints were located in bare earth and urban (non-vegetated) land cover classes. VVA checkpoints were located in brush/tall grass/weeds (vegetated) land cover classes. These checkpoints were surveyed using GPS techniques. See the survey report for acquisition methodologies.

The classified lidar point cloud accuracy test results are listed below in Table 4-2.

Table 4-2. DEM Accuracy

	Result	Points Used
NVA	0.048 m RMSEz 0.094 m at 95% CL	23
VVA	0.127 m at 95th Percentile	17

Appendix 1: Sensor Calibration Report

- when it has to be **right**



Leica Geosystems Leica TerrainMapper-L Calibration Certificate

Product	Leica TerrainMapper-L
Serial Number	90515
Date	12 December 2018
Inspector	Robert Bosch





1. System Components

Component	Type	Serial Number
Pod	Terrainmapper Pod	90515
GNSS/IMU	Litef LCI-100C 500 Hz	1226
LiDAR Unit	Hyperion2 LiDAR Unit	5516

2. Estimation Process

		Passed	Date	Inspector
LiDAR Flight	completed	ok	29.11.2018	Philip Benz
LiDAR Quality Check	checked	ok	06.12.2018	Rene Heierli
LiDAR Calibration and Accuracy	completed	ok	12.12.2018	Robert Bosch
LiDAR Misalignment Update	completed			

3. Inspectors

Name	Bernhard Riedl	12.12.2018	
Position	Production Manager		
Name	Robert Bosch	12.12.2018	
Position	Support Engineer		

4. Remarks

5. LiDAR Calibration Results

The calibration results for the LiDAR Unit are only valid for:

- IMU and Pod as listed in the System Components section

5.1 LiDAR Geometric Calibration Results

IMU Misalignment		Value	Unit
	ω	-0.022555	degree
	Φ	0.056357	degree
	κ	0.000504	degree
Boresight		Value	Unit
	Θ	0.015419	degree
	Φ	-0.001923	degree
Receiver 1		Value	Unit
Range	Δ Offset	0.000000	meters
Wedge 0		Value	Unit
Wedge	Δ Alpha	-0.043014	degree
Wedge Position	Δ Offset	0.442789	degree
Position Correction	X	-0.012826	degree
	Y	0.000012	degree
Mount	Roll	0.045379	degree
	Pitch	0.210132	degree
Rotation Axis	Roll	0.031087	degree
	Pitch	0.076675	degree
Wedge 1		Value	Unit
Wedge	Δ Alpha	-0.005517	degree
Wedge Position	Δ Offset	0.559649	degree
Position Correction	X	0.030760	degree
	Y	-0.001169	degree
Mount	Roll	0.012366	degree
	Pitch	0.054254	degree
	Speed Pitch	1.50E-06	degree/rps ²
Rotation Axis	Roll	0.032485	degree
	Pitch	-0.029191	degree
LiDAR Geometric Calibration File			
HYPERION_GEOMETRY_LIDARUNIT-5516-C-855570-DATETIME-20181204-161828.XML			
	Date	04.12.2018	
LiDAR Misalignment Flight	Date	-	
LiDAR Misalignment Update Completed	Date	-	

5.2 LiDAR Unit Accuracy Check

Accuracy checks:

- Deviation of two perpendicular lines to GCP's
- Difference of two perpendicular lines
- Difference of forward and backward scan of one line

5.2.1 Multi-line accuracy of two perpendicular lines to ground control points

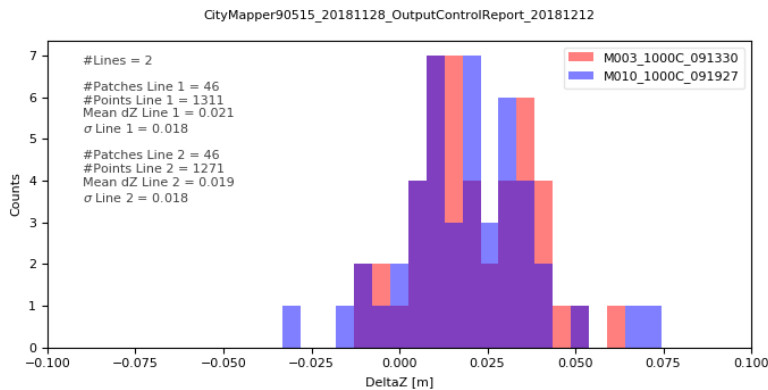


Figure 1 Vertical distance to ground control points at 1000 m AGL.

5.2.2 Difference of forward and backward scan of one line

M010_1000C_091927

303355 valid patches with size of 2 m found. Only patches with standard deviation < 0.05 m and minimum of 5 points are included.

Color	Limits [m]	Number of patches	Proportion of total number of patches [%]
Green	≤ 0.04	302593	99.75
Yellow	0.04-0.07	716	0.24
Orange	0.07-0.1	17	0.01
Red	> 0.1	29	0.01



Figure 2 Vertical difference between forward and backward scan at 1000 m AGL.

5.2.3 Multi-line accuracy between two perpendicular lines

M003_1000C_091330_vs_M010_1000C_091927

29588 valid patches with size of 2 m found. Only patches with standard deviation < 0.05 m and minimum of 5 points are included.

Color	Limits [m]	Number of patches	Proportion of total number of patches [%]
Blue	<=0.04	29546	99.86
Orange	0.04-0.07	38	0.13
Green	0.07-0.1	1	0.00
Red	>0.1	3	0.01



Vertical difference

Figure 3 Vertical difference between two perpendicular lines at 1000 m AGL.

- when it has to be **right**



Leica Geosystems Leica TerrainMapper-LN Calibration Certificate

Product	Leica TerrainMapper-LN
Serial Number	91511
Date	03 July 2019
Inspector	Mark O'Neal






1. System Components

Component	Type	Serial Number
Pod	TerrainMapper Pod	91511
GNSS/IMU	Litef LCI-100C 500 Hz	1139
LiDAR Unit	Hyperion2 LiDAR Unit	5511
Camera Head	CH82	82659
Lens	NAT-D 2.8/80	80254

2. Estimation Process

		Passed	Date	Inspector
Image Flight	completed	ok	10.05.2019	Philip Benz
Image Quality Check	checked	ok	16.05.2019	Philip Benz
Image Calibration	completed	ok	18.05.2019	Xu Wang
Image Misalignment Update	completed	ok	02.07.2019	Mark O'Neal
LiDAR Flight	completed	ok	10.17.2018	Deniz Arslan
LiDAR Quality Check	checked	ok	23.10.2018	Rene Heirli
LiDAR Calibration and Accuracy	completed	ok	24.10.2018	Robert Bosch
LiDAR Misalignment Update	completed			

3. Inspectors

Name	Bernhard Riedl	15.11.2018	
Position	Production Manager		
Name	Robert Bosch	23.05.2019	
Position	Support Engineer		
Name	Michael Vetter	03.07.2019	
Position	Support Engineer		

4. Remarks

5. LiDAR Calibration Results

The calibration results for the LiDAR Unit are only valid for:

- IMU and Pod as listed in the System Components section

5.1 LiDAR Geometric Calibration Results

IMU Misalignment		Value	Unit
	ω	-0.138877	degree
	Φ	0.130994	degree
	κ	-0.006412	degree
Boresight		Value	Unit
	Θ	0.001052	degree
	Φ	-0.001885	degree
Receiver 1		Value	Unit
Range	Δ Offset	0.000000	meters
Wedge 0		Value	Unit
Wedge	Δ Alpha	0.001241	degree
Wedge Position	Δ Offset	-0.426898	degree
Position Correction	X	-0.019523	degree
	Y	0.007883	degree
Mount	Roll	-0.020901	degree
	Pitch	0.107683	degree
Rotation Axis	Roll	0.103712	degree
	Pitch	0.124140	degree
Wedge 1		Value	Unit
Wedge	Δ Alpha	-0.009545	degree
Wedge Position	Δ Offset	0.412993	degree
Position Correction	X	0.004000	degree
	Y	0.011085	degree
Mount	Roll	0.102859	degree
	Pitch	0.025756	degree
	Speed Pitch	1.50E-06	degree/rps ²
Rotation Axis	Roll	0.114811	degree
	Pitch	-0.080531	degree

LiDAR Geometric Calibration File

HYPERION_GEOMETRY_LIDARUNIT-5511-C-855570-DATETIME-20181023-153458.XML

Date 23.10.2018

LiDAR Misalignment Flight Date -

LiDAR Misalignment Update Completed Date -

5.2 LiDAR Unit Accuracy Check

Accuracy checks:

- Deviation of two perpendicular lines to GCP's
- Difference of two perpendicular lines
- Difference of forward and backward scan of one line

5.2.1 Multi-line accuracy of two perpendicular lines to ground control points

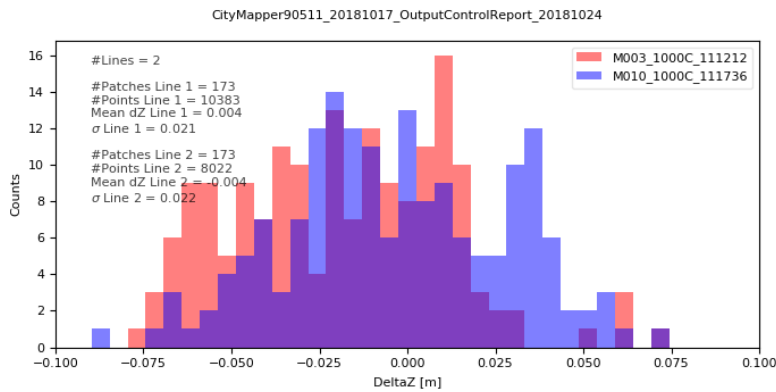


Figure 1 Vertical distance to ground control points at 1000 m AGL.

5.2.2 Difference of forward and backward scan of one line

M010_1000C_111736

314314 valid patches with size of 2 m found. Only patches with standard deviation < 0.05 m and minimum of 5 points are included.

Color	Limits [m]	Number of patches	Proportion of total number of patches [%]
Green	≤ 0.04	293823	93.48
Yellow	0.04-0.07	20386	6.49
Orange	0.07-0.1	89	0.03
Red	> 0.1	16	0.01



Figure 2 Vertical difference between forward and backward scan at 1000 m AGL.

5.2.3 Multi-line accuracy between two perpendicular lines

M003_1000C_111212_vs_M010_1000C_111736

39940 valid patches with size of 2 m found. Only patches with standard deviation < 0.05 m and minimum of 5 points are included.

Color	Limits [m]	Number of patches	Proportion of total number of patches [%]
Dark Green	<=0.04	32066	80.29
Light Green	0.04-0.07	7841	19.63
Yellow	0.07-0.1	21	0.05
Red	>0.1	12	0.03



Vertical difference

Figure 3 Vertical difference between two perpendicular lines at 1000 m AGL.

6. Imaging Sensors Estimation Results

The estimation results for the camera head and lens combination are only valid for:

- IMU and Pod as listed in the System Components section.
- Camera Head, lens and specified position as listed in the Estimation Results sections.

6.1 Camera Model of distortion free images

All factory calibration results contain fixed nominal focal lengths and zero principal point offsets. Leica HxMap applies the grid to create distortion-free images of nominal focal length and pixel size.

6.1.1 CH8x Model

Camera Head		Component	
Lens		CH82	
		NAT-D 2.8/80	
Camera Model			
Focal Length		Distance [mm]	
	c		83.00
Radial Symmetric Distorsion		Distance [mm]	
	k ₀		0.0000
	k ₁		0.0000
	k ₂		0.0000
Decentering Distortion		Distance [mm]	
	p ₁		0.0000
	p ₂		0.0000
Non-Orthogonality Distortion		Distance [mm]	
	b ₁		0.0000
	b ₂		0.0000
Pixel Size (Height and Width)		Distance [mm]	
	RGB		0.0052
	NIR		0.0120
Rows and Columns		Rows	Columns
	Active RGB	7752	10320
	Raw RGB	7788	10336
	Active NIR	3654	4478
	Raw NIR	3366	4500

6.2 Results of Geometric Calibration

6.2.1 Calibration method for Green Reference Band

Estimation of additional parameters (focal length, principal point, radial symmetric distortion, correction grid) and IMU misalignment in simultaneous bundle adjustment

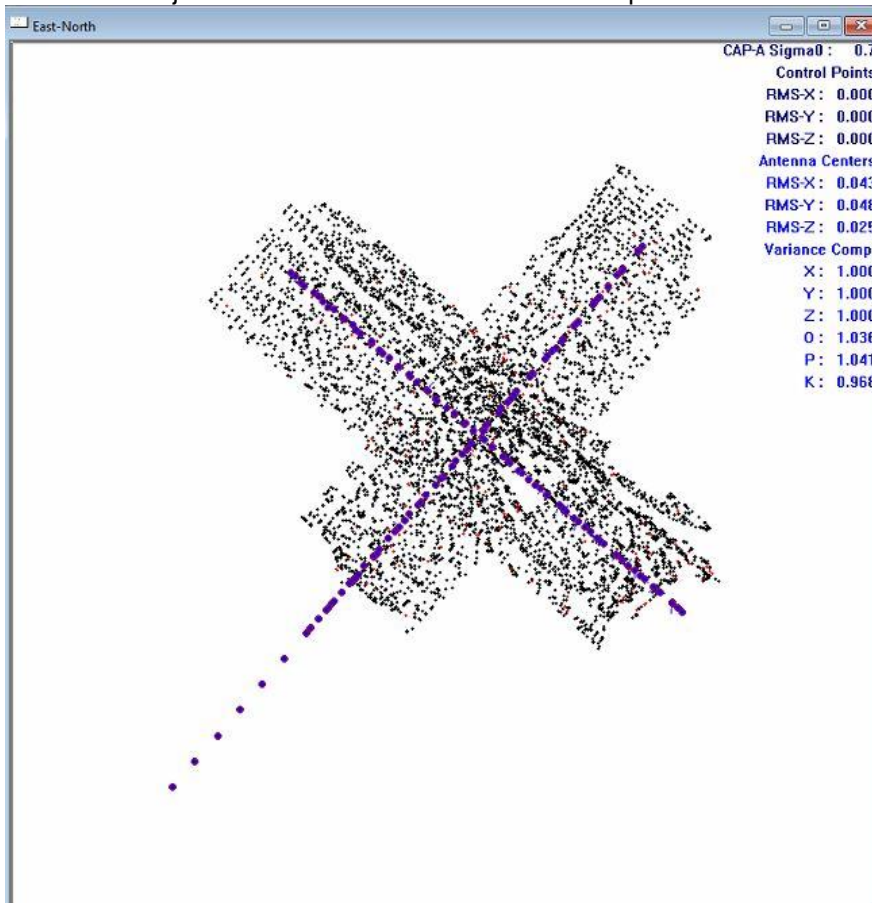
Reference band (green)

Distance [mm]

Resulting sigma naught of bundle adjustment:

0.0007

Final bundle adjustment results after elimination of tie point blunders:



6.2.2 Calibration method for Other Spectral Bands

Estimation of additional parameters (correction grid), based on the result for green in simultaneous bundle adjustment

Other Spectral Bands

Distance [mm]

Co-registration to green better than:

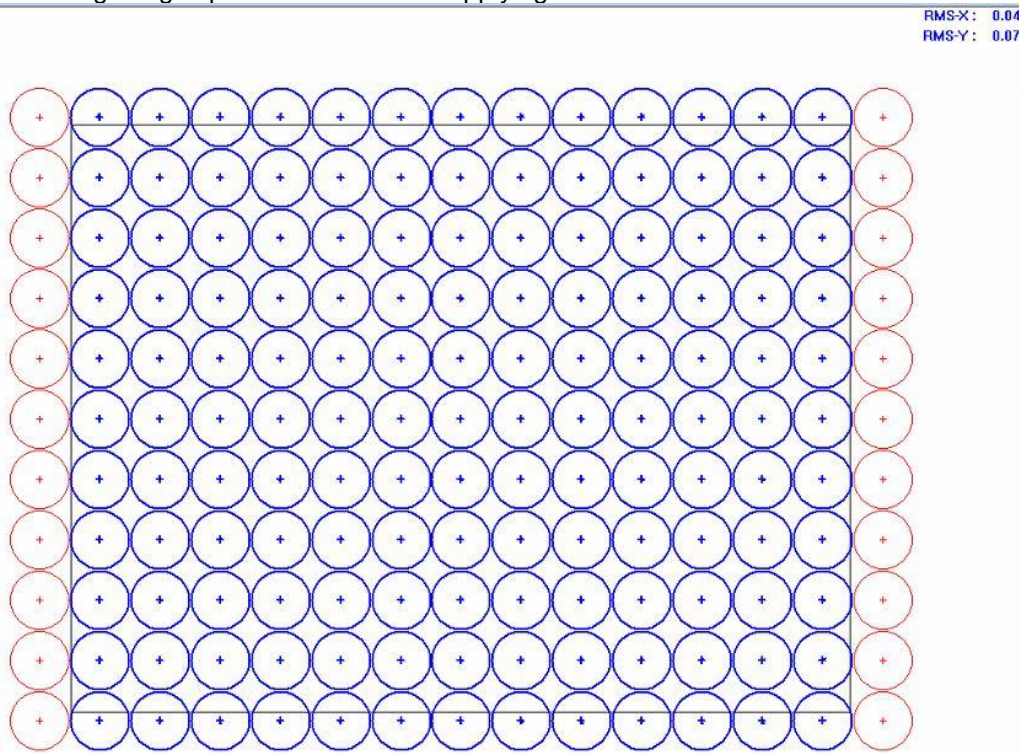
0.002

Leica HxMap applies the grid to create distortion-free images of nominal focal length and fixed pixel size of 0.0052 mm.

6.3 Estimation Results for Nadir Camera Head and Lens

	Component	Serial Number
Camera Head	CH82	82659
Lens	NAT-D 2.8/80	80254
View Direction in Pod Position	Nadir	
IMU Misalignment	Angle [degree]	
	ω	-0.00815
	ϕ	0.00028
	κ	-0.26654
Principal Point	Distance [mm]	
	x	0.0000
	y	0.0000
Focal Length	Distance [mm]	
	c	83.00
Geometric Calibration File		
RCD30_Geometry_CameraHead-82659-E-798528_LensSystem-80254-B-785423_DateTime-20190518-214751.xml		
Geometric Calibration Date	Date	18.05.2019
Radiometric Calibration Date	Date	05.02.2019
Misalignment Flight	Date	23.06.2019
Misalignment Update Completed	Date	02.07.2019

Remaining image space residuals after applying the calibration results



Radius of circles is 0.0007 mm

- when it has to be **right**



Leica Geosystems Leica TerrainMapper-LN Calibration Certificate

Product	Leica TerrainMapper-LN
Serial Number	91557
Date	01 July 2020
Inspector	Ivan Belchev






1. System Components

Component	Type	Serial Number
Pod	TerrainMapper Pod	91557
GNSS/IMU	Litef LCI-100C 500 Hz	1346
LiDAR Unit	Hyperion2 LiDAR Unit	5561
Camera Head	CH82	82673
Lens	NAT-D 2.8/80	80264

2. Estimation Process

		Passed	Date	Inspector
Image Flight	completed	ok	23.06.2020	Deniz Arslan
Image Quality Check	checked	ok	29.06.2020	Bernhard Riedl
Image Calibration	completed	ok	29.06.2020	Zoltan Poth
Image Misalignment Update	completed			
LiDAR Flight	completed	ok	23.06.2020	Deniz Arslan
LiDAR Quality Check	checked	ok	26.06.2020	Rene Heierli
LiDAR Calibration and Accuracy	completed	ok	25.06.2020	Michael Vetter
LiDAR Misalignment Update	completed			

3. Inspectors

Name	Bernhard Riedl	01.07.2020	
Position	Production Manager		
Name	Ivan Belchev	01.07.2020	
Position	Workflow Specialist		
Name	Michael Vetter	01.07.2020	
Position	Support Engineer		

4. Remarks

5. LiDAR Calibration Results

The calibration results for the LiDAR Unit are only valid for:

- IMU and Pod as listed in the System Components section

5.1 LiDAR Geometric Calibration Results

IMU Misalignment		Value	Unit
	ω	-0.063987	degree
	Φ	-0.049738	degree
	κ	-0.005305	degree
Boresight		Value	Unit
	Θ	-0.001796	degree
	Φ	-0.003034	degree
Receiver 1		Value	Unit
Range	Δ Offset	0.000000	meters
Wedge 0		Value	Unit
Wedge	Δ Alpha	-0.045434	degree
Wedge Position	Δ Offset	0.352942	degree
Position Correction	X	-0.014623	degree
	Y	0.020330	degree
Mount	Roll	0.210896	degree
	Pitch	0.426854	degree
Rotation Axis	Roll	0.232742	degree
	Pitch	0.169968	degree
Wedge 1		Value	Unit
Wedge	Δ Alpha	0.003457	degree
Wedge Position	Δ Offset	0.393122	degree
Position Correction	X	0.019198	degree
	Y	-0.002307	degree
Mount	Roll	0.020583	degree
	Pitch	0.038667	degree
	Speed Pitch	1.50E-06	degree/rps ²
Rotation Axis	Roll	0.061823	degree
	Pitch	0.034555	degree

LiDAR Geometric Calibration File

HYPERION_GEOMETRY_LIDARUNIT-5561-D-855570-DATETIME-20200625-085747.XML

	Date	25.06.2020
LiDAR Misalignment Flight	Date	-
LiDAR Misalignment Update Completed	Date	-

5.2 LiDAR Unit Accuracy Check

Accuracy checks:

- Deviation of two perpendicular lines to GCP's
- Difference of two perpendicular lines
- Difference of forward and backward scan of one line

5.2.1 Multi-line accuracy of two perpendicular lines to ground control points

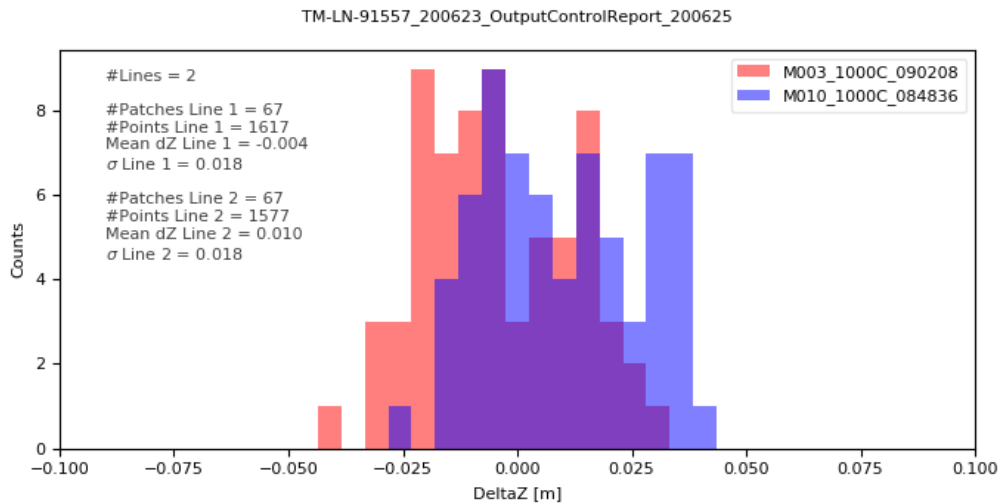


Figure 1 Vertical distance to ground control points at 1000 m AGL.

5.2.2 Difference of forward and backward scan of one line

M003_1000C_090208

377750 valid patches with size of 2 m found. Only patches with standard deviation < 0.05 m and minimum of 5 points are included.

Color	Limits [m]	Number of patches	Proportion of total number of patches [%]
Dark Green	≤ 0.04	372019	98.48
Bright Green	0.04-0.07	5529	1.46
Yellow	0.07-0.1	169	0.04
Red	> 0.1	33	0.01



Figure 2 Vertical difference between forward and backward scan at 1000 m AGL.

5.2.3 Multi-line accuracy between two perpendicular lines

M003_1000C_090208_vs_M010_1000C_084836

50693 valid patches with size of 2 m found. Only patches with standard deviation < 0.05 m and minimum of 5 points are included.

Color	Limits [m]	Number of patches	Proportion of total number of patches [%]
Dark Green	<=0.04	50354	99.33
Light Green	0.04-0.07	327	0.65
Yellow	0.07-0.1	6	0.01
Red	>0.1	6	0.01

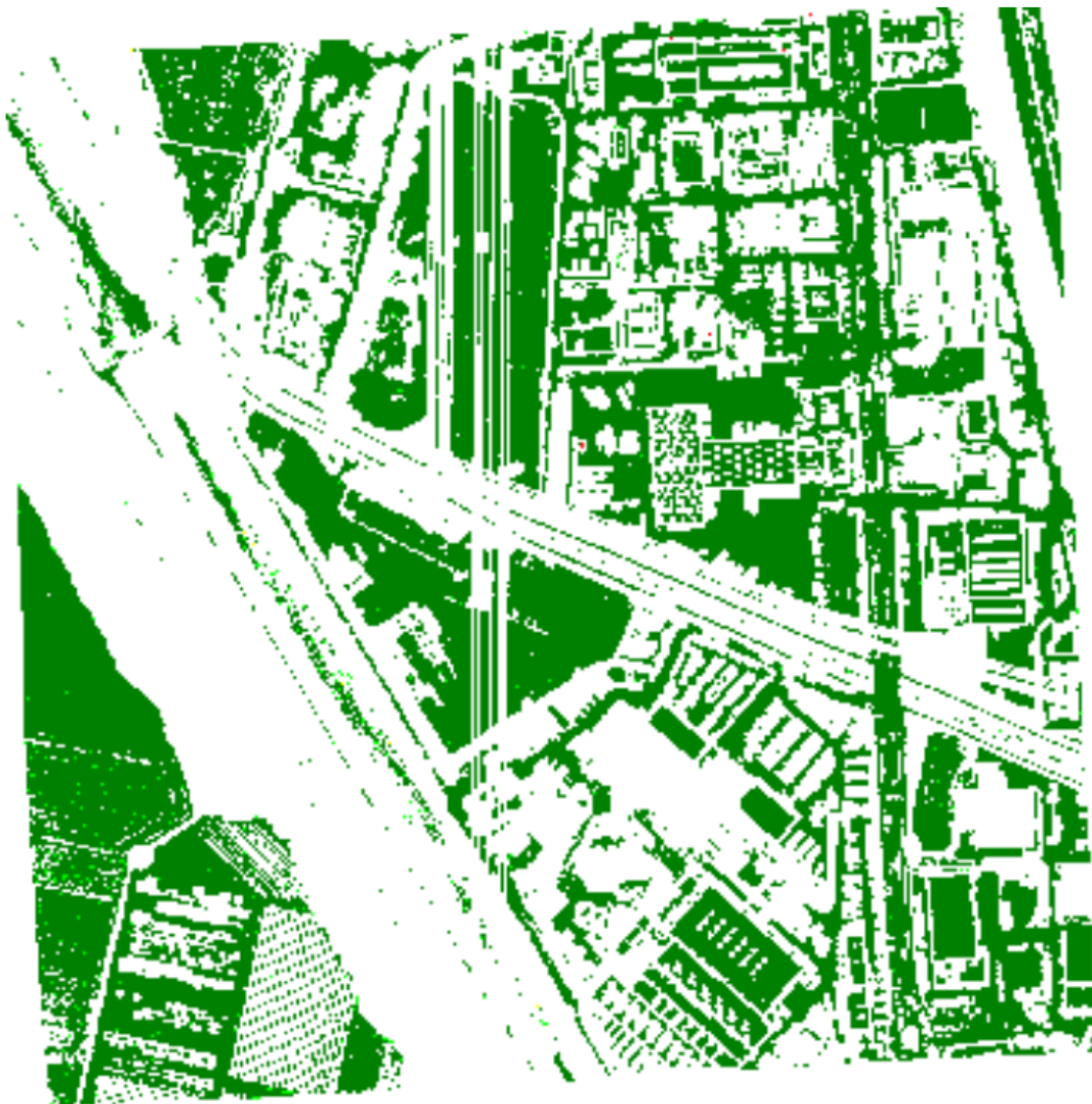


Figure 3 Vertical difference between two perpendicular lines at 1000 m AGL.

6. Imaging Sensors Estimation Results

The estimation results for the camera head and lens combination are only valid for:

- IMU and Pod as listed in the System Components section.
- Camera Head, lens and specified position as listed in the Estimation Results sections.

6.1 Camera Model of distortion free images

All factory calibration results contain fixed nominal focal lengths and zero principal point offsets. Leica HxMap applies the grid to create distortion-free images of nominal focal length and pixel size.

6.1.1 CH8x Model

Camera Head		Component	
Lens		CH82	
		NAT-D 2.8/80	
Camera Model			
Focal Length		Distance [mm]	
	c		83.00
Radial Symmetric Distorsion		Distance [mm]	
	k ₀		0.0000
	k ₁		0.0000
	k ₂		0.0000
Decentering Distortion		Distance [mm]	
	p ₁		0.0000
	p ₂		0.0000
Non-Orthogonality Distortion		Distance [mm]	
	b ₁		0.0000
	b ₂		0.0000
Pixel Size (Height and Width)		Distance [mm]	
	RGB		0.0052
	NIR		0.0120
Rows and Columns		Rows	Columns
	Active RGB	7752	10320
	Raw RGB	7788	10336
	Active NIR	3654	4478
	Raw NIR	3366	4500

6.2 Results of Geometric Calibration

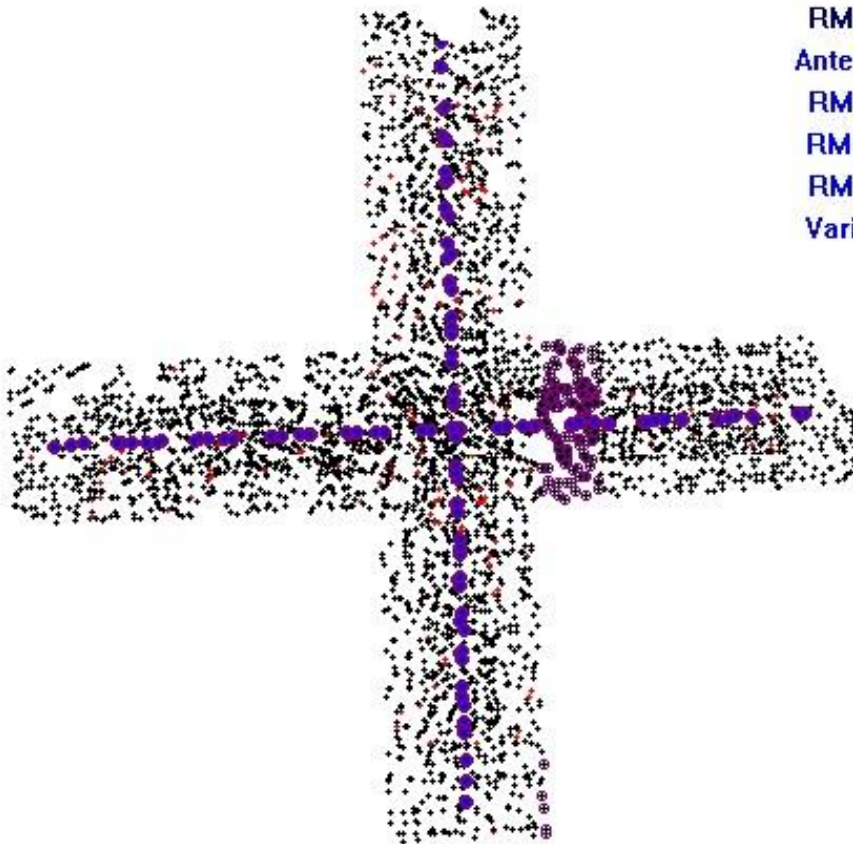
6.2.1 Calibration method for Green Reference Band

Estimation of additional parameters (focal length, principal point, radial symmetric distortion, correction grid) and IMU misalignment in simultaneous bundle adjustment

Reference band (green)	Distance [mm]
Resulting sigma naught of bundle adjustment:	0.0010

Final bundle adjustment results after elimination of tie point blunders:

CAP-A Sigma0 :	1.0
Control Points	
RMS-X :	0.000
RMS-Y :	0.000
RMS-Z :	0.000
Antenna Centers	
RMS-X :	0.029
RMS-Y :	0.026
RMS-Z :	0.032
Variance Comp.	
X :	1.000
Y :	1.000
Z :	1.000
O :	1.035
P :	1.127
K :	1.067



6.2.2 Calibration method for Other Spectral Bands

Estimation of additional parameters (correction grid), based on the result for green in simultaneous bundle adjustment

Other Spectral Bands	Distance [mm]
Co-registration to green better than:	0.002

Leica HxMap applies the grid to create distortion-free images of nominal focal length and fixed pixel size of 0.0052 mm.

6.3 Estimation Results for Nadir Camera Head and Lens

	Component	Serial Number
Camera Head	CH82	82673
Lens	NAT-D 2.8/80	80264
View Direction in Pod Position	Nadir	
IMU Misalignment	Angle [degree]	
	ω	0.03017
	Φ	-0.01221
	κ	-0.25213
Principal Point	Distance [mm]	
	x	0.0000
	y	0.0000
Focal Length	Distance [mm]	
	c	83.00

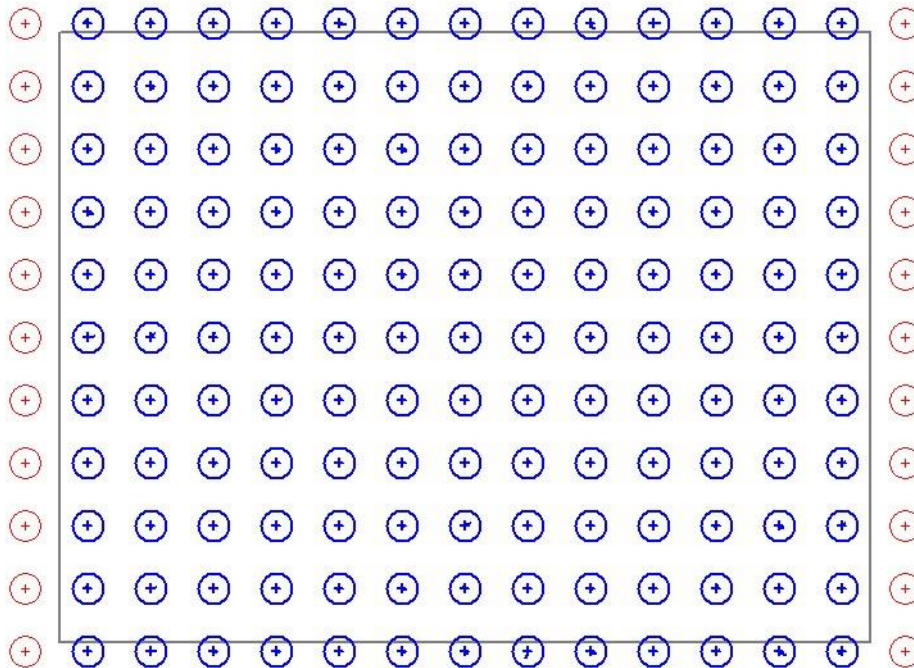
Geometric Calibration File

RCD30_Geometry_CameraHead-82673---798528_LensSystem-80264-B-785423_DateTime-20200629-142416.xml

Geometric Calibration Date	Date	29.06.2020
Radiometric Calibration Date	Date	30.01.2020
Misalignment Flight	Date	-
Misalignment Update Completed	Date	-

Remaining image space residuals after applying the calibration results

RMS-X: 0.13
RMS-Y: 0.11



Radius of circles is 0.0010 mm

Appendix 2: Flight Logs

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day242_90511	08/29/2020	242		

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Dar Perl	Cessna 404 Titan - N404CP	7965.8	08:30:00	14:30:00	KLAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90511	7969.4	12:00:00	18:00:00	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
0	0	8	11,600	Overcast	18	7	30.21
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		5,413	12,821	7,284			

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
312	N	14:46:00	14:54:00	00:08:00	19	1.2	QL1_East
311	S	14:57:00	15:04:00	00:07:00	19	1.2	
310	N	15:08:00	15:15:00	00:07:00	19	1.2	
309	S	15:19:00	15:26:00	00:07:00	18	1.2	
308	N	15:29:00	15:37:00	00:08:00	17	1.2	
307	S	15:40:00	15:48:00	00:08:00	18	1.2	
306	N	15:52:00	15:59:00	00:07:00	19	1.1	
305	S	16:03:00	16:10:00	00:07:00	18	1.1	
304	N	16:14:00	16:22:00	00:08:00	18	1.2	
							QL1_West
1	W	16:42:00	16:43:00	00:01:00	14	1.6	
2	E	16:47:00	16:48:00	00:01:00	14	1.9	
3	W	16:52:00	16:54:00	00:02:00	14	1.9	
4	E	16:58:00	17:00:00	00:02:00	18	1.3	
5	W	17:04:00	17:07:00	00:03:00	20	1.2	
6	E	17:11:00	17:14:00	00:03:00	20	1.2	
7	W	17:19:00	17:24:00	00:05:00	20	1.2	

Page 1 **Verify S-Turns After Mission**

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	WY SC QL1 EastBlock		Day243_90557_A			08/30/2020	243	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Comer		Reims 406 - N406SD			5368.5	08:12:00	14:12:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90557			5373.2	13:18:00	19:18:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
270	0	10	40,000	Clear	12	6	30.05	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	12,800	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
22	N	14:48:00	14:55:00	00:07:00	22	1.1	QL1 East BLK It minor PAV pitch errors	
23	S	14:58:00	15:06:00	00:08:00	22	1.2	Clear	
24	N	15:10:00	15:18:00	00:08:00	22	1.3		
25	S	15:21:00	15:29:00	00:08:00	20	1.3		
26	N	15:32:00	15:39:00	00:07:00	20	1.4		
27	S	15:43:00	15:51:00	00:08:00	20	1.3		
28	N	15:54:00	16:01:00	00:07:00	22	1.2		
29	S	16:04:00	16:11:00	00:07:00	22	1.3		
30	N	16:14:00	16:21:00	00:07:00	23	1.1		
31	S	16:24:00	16:32:00	00:08:00	20	1.2		
32	N	16:35:00	16:42:00	00:07:00	18	1.4		
33	S	16:45:00	16:53:00	00:08:00	16	2		
34	N	16:55:00	17:03:00	00:08:00	19	1.2		
35	S	17:06:00	17:13:00	00:07:00	21	1.2		
36	N	17:18:00	17:26:00	00:08:00	21	1.2		
37	S	17:29:00	17:37:00	00:08:00	22	1.2		
38	N	17:41:00	17:50:00	00:09:00	21	1.2		
39	S	17:52:00	18:00:00	00:08:00	20	1.2		
40	N	18:04:00	18:12:00	00:08:00	18	1.4		
41	S	18:19:00	18:28:00	00:09:00	18	1.3		
42	N	18:31:00	18:40:00	00:09:00	18	1.2		
43	S	18:43:00	18:52:00	00:09:00	19	1.1	end lift for increasing turbulence	
							Verify S-Turns After Mission	Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day244_90511	08/31/2020	244		

Crew		Equipment		Time			Airports				
Pilot	Operator	Aircraft Make / Model / Tail #	Sensor Make / Model / Serial #	Hobbs Start	Hobbs End	Local Start	Local End	UTC Start	UTC End	Departing	Arriving
Dar Perl	Nardone	Cessna 404 Titan - N404CP	Leica Terrain Mapper - 90511	7969.8	7971.4	08:30:00	10:10:00	14:30:00	16:10:00	KLAR	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
210	20	10		Clear	18	7	30.21
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		5,413		12,821		7,284	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
303	N	14:55:00	15:03:00	00:08:00	24	1.2	QL1_East
302	S	15:07:00	15:17:00	00:10:00	26	1.2	
301	N	15:20:00	15:29:00	00:09:00	24	1.2	
300	S	15:32:00	15:42:00	00:10:00	24	1.2	
299	N	15:45:00	15:55:00	00:10:00	25	1.2	
298	S	15:58:00	15:59:00	00:01:00	25	1.1	Pulled off, turbulence

Page 1 **Verify S-Turns After Mission**

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name	Unique ID		Flight Date (UTC)	Day of Year	Flight #		
80997	WY SC QL1 EastBlock	Day244_90557_A		08/31/2020	244	A		
Crew		Equipment			Time		Airports	
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing			
Comer	Reims 406 - N406SD	5373.2	08:20:00	14:20:00	LAR			
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving			
Stanton	Leica Terrain Mapper - 90557	5376.4	11:43:00	17:43:00	LAR			
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
270	0	10	40,000	Clear	2	2	30.05	
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)					
150	5,413	12,800	7,284					
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)			
0.35		34	150	1400	100			
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
44	N	14:53:00	15:03:00	00:10:00	24	1.2	QL1 East BLK 1 PAV pitch errors	
45	S	15:06:00	15:17:00	00:11:00	25	1.2	pitch errors all lines	
46	N	15:20:00	15:30:00	00:10:00	21	1.4		
47	S	15:33:00	15:43:00	00:10:00	24	1.2		
48	N	15:45:00	15:55:00	00:10:00	24	1.2		
49	S	15:58:00	16:08:00	00:10:00	25	1.1		
50	N	16:11:00	16:21:00	00:10:00	23	1.1		
51	S	16:24:00	16:34:00	00:10:00	21	1.2		
52	N	16:37:00	16:47:00	00:10:00	19	1.7		
53	S	16:49:00	17:00:00	00:11:00	21	1.2	increasing turbulence	
54	N	17:02:00	17:12:00	00:10:00	22	1.2	end for turbulence	
						Page 1	Verify S-Turns After Mission	Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	WY SC QL1 EastBlock		Day245_90557_A			09/01/2020	245	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Comer		Reims 406 - N406SD			5376.4	07:41:00	13:41:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90557			5382.3	13:51:00	19:51:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
230	7	10	40,000	Clear	4	-1	30.16	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	14,000	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
199	N	14:12:00	14:16:00	00:04:00	18	1.3	QL1 East BLK 1 PAV pitch errors	
198	S	14:19:00	14:24:00	00:05:00	19	1.3	minor pitch errors all lines	
197	N	14:28:00	14:32:00	00:04:00	21	1.1		
196	S	14:36:00	14:40:00	00:04:00	20	1.3		
195	N	14:43:00	14:47:00	00:04:00	20	1.3		
194	S	14:53:00	14:57:00	00:04:00	20	1.3		
193	N	15:00:00	15:05:00	00:05:00	21	1.1		
192	S	15:08:00	15:12:00	00:04:00	21	1.1		
191	N	15:16:00	15:20:00	00:04:00	19	1.4		
190	S	15:24:00	15:28:00	00:04:00	20	1.3		
189	N	15:31:00	15:36:00	00:05:00	20	1.4		
188	S	15:39:00	15:43:00	00:04:00	21	1.4		
187	N	15:46:00	15:51:00	00:05:00	22	1.4		
186	S	15:54:00	15:59:00	00:05:00	22	1.3		
185	N	16:02:00	16:06:00	00:04:00	21	1.7		
184	S	16:09:00	16:15:00	00:06:00	20	1.4		
183	N	16:18:00	16:24:00	00:06:00	19	1.4		
182	S	16:27:00	16:33:00	00:06:00	18	1.4		
181	N	16:37:00	16:42:00	00:05:00	17	1.9		
180	S	16:46:00	16:51:00	00:05:00	22	1.3		
179	N	16:55:00	17:01:00	00:06:00	22	1.2		
178	S	17:04:00	17:09:00	00:05:00	21	1.3		
177	N	17:13:00	17:19:00	00:06:00	22	1.3		
176	S	17:22:00	17:28:00	00:06:00	22	1.2		
175	N	17:31:00	17:37:00	00:06:00	21	1.2		
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date			
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #		
80997	WY SC QL1 EastBlock	Day245_90557_A	09/01/2020	245	A		
Crew		Equipment		Time			Airports
Pilot		Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
Comer		Reims 406 - N406SD		5376.4	07:41:00	13:41:00	LAR
Operator		Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90557		5382.3	13:51:00	19:51:00	LAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
230	7	10	40,000	Clear	4	-1	30.16
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		5,413	14,000	7,284			

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
174	S	17:40:00	17:46:00	00:06:00	21	1.1		
173	N	17:49:00	17:55:00	00:06:00	20	1.3		
172	S	17:58:00	18:03:00	00:05:00	18	1.3		
171	N	18:06:00	18:12:00	00:06:00	19	1.2		
55	S	18:18:00	18:28:00	00:10:00	19	1.2		
56	N	18:31:00	18:41:00	00:10:00	20	1.1		
170	S	18:47:00	18:52:00	00:05:00	18	1.3		
169	N	18:56:00	19:01:00	00:05:00	17	1.4		
168	S	19:05:00	19:10:00	00:05:00	18	1.2		
167	N	19:15:00	19:21:00	00:06:00	18	1.2		
166	S	19:24:00	19:29:00	00:05:00	19	1.1		

Page 2	Verify S-Turns After Mission
Additional Comments	

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day245_90511	09/01/2020	245		

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Dar Perl	Cessna 404 Titan - N404CP	7971.4	09:15:00	15:15:00	KLAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90511	7975.7	01:45:00	19:45:00	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
210	20	10		Clear	18	7	30.21
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	5,413	12,821	7,284				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
298	N	15:45:00	15:55:00	00:10:00	22	1.4	
297	S	15:58:00	16:08:00	00:10:00	22	1.2	
296	N	16:11:00	16:20:00	00:09:00	21	1.2	
295	S	16:23:00	16:32:00	00:09:00	21	1.2	
294	N	16:35:00	16:45:00	00:10:00	19	1.9	
293	S	16:48:00	16:57:00	00:09:00	23	1.2	
292	N	17:00:00	17:10:00	00:10:00	22	1.2	
291	S	17:13:00	17:22:00	00:09:00	22	1.2	
290	N	17:25:00	17:35:00	00:10:00	23	1.1	
289	S	17:38:00	17:47:00	00:09:00	21	1.2	
288	N	17:51:00	18:01:00	00:10:00	20	1.3	
287	S	18:04:00	18:13:00	00:09:00	18	1.3	
286	N	18:17:00	18:26:00	00:09:00	19	1.1	
285	S	18:29:00	18:39:00	00:10:00	19	1.2	
284	N	18:41:00	18:51:00	00:10:00	18	1.3	
283	S	18:53:00	19:02:00	00:09:00	18	1.3	
282	N	19:05:00	19:15:00	00:10:00	18	1.2	
281	S	19:18:00	19:27:00	00:09:00	19	1.1	

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Verify S-Turns After Mission

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #			
80997	QL1_East_SouthCentral, WY	Day245_90511	09/01/2020	245				
Crew		Equipment		Time			Airports	
Pilot		Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing	
Dar Perl		Cessna 404 Titan - N404CP		7975.7	03:27:00	21:37:00	KLAR	
Operator		Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving	
Nardone		Leica Terrain Mapper - 90511		7977.9	05:40:00	23:40:00	KLAR	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
210	20	10		Clear	18	7	30.21	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	12,821	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)			
0.35		34	150	1400	100			
						Verify S-Turns Before Mission		
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
280	N	21:50:00	22:00:00	00:10:00	21	1.2	QL1_East_B	
279	S	22:03:00	22:12:00	00:09:00	21	1.2		
278	N	22:16:00	22:25:00	00:09:00	21	1.2		
277	S	22:28:00	22:37:00	00:09:00	22	1.2		
276	N	22:40:00	22:49:00	00:09:00	24	1.1		
275	S	22:52:00	23:00:00	00:08:00	26	1		
274	N	23:03:00	23:11:00	00:08:00	27	1		
Page 1						Verify S-Turns After Mission		
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day246_90511	09/02/2020	246		

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Dar Perl	Cessna 404 Titan - N404CP	7978.2	09:15:00	15:15:00	KLAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90511	7982.4	01:21:00	19:21:00	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
200	7	10		Clear	16	-1	30.25
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	5,413	12,821	7,284				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
273	N	15:28:00	15:36:00	00:08:00	22	1.3	QL1_East
272	S	15:39:00	15:46:00	00:07:00	22	1.2	
271	N	15:51:00	15:59:00	00:08:00	23	1.1	
270	S	16:02:00	16:10:00	00:08:00	22	1.1	
269	N	16:14:00	16:22:00	00:08:00	20	1.1	
268	S	16:25:00	16:33:00	00:08:00	17	1.8	
267	N	16:36:00	16:44:00	00:08:00	17	1.5	
266	S	16:47:00	16:55:00	00:08:00	22	1.1	
265	N	16:58:00	17:06:00	00:08:00	23	1.2	
264	S	17:09:00	17:17:00	00:08:00	25	1.2	
263	N	17:21:00	17:28:00	00:07:00	25	1.2	
262	S	17:32:00	17:40:00	00:08:00	25	1.2	
261	N	17:43:00	17:50:00	00:07:00	24	1.3	
260	S	17:54:00	18:02:00	00:08:00	22	1.3	
259	N	18:05:00	18:13:00	00:08:00	23	1.2	
258	S	18:16:00	18:24:00	00:08:00	22	1.2	
257	N	18:27:00	18:35:00	00:08:00	24	1.1	
256	S	18:38:00	18:46:00	00:08:00	22	1.2	
255	N	18:48:00	18:56:00	00:08:00	21	1.3	

Verify S-Turns After Mission

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	WY SC QL1 EastBlock			Day246_90557_A		09/02/2020	246	A
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Comer	Reims 406 - N406SD			5382.9	07:31:00	13:31:00	LAR	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Stanton	Leica Terrain Mapper - 90557			5387.6	12:29:00	18:29:00	LAR	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
170	4	10	40,000	Clear	7	-3	30.26	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	14,000	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
57	W	14:02:00	14:04:00	00:02:00	18	1.3	QL1 East BLK 1, Clear, PAV pitch warnings	
58	E	14:08:00	14:10:00	00:02:00	19	1.3	minor pitch warnings all lines	
59	W	14:14:00	14:16:00	00:02:00	19	1.3		
60	E	14:19:00	14:21:00	00:02:00	21	1.2		
61	W	14:24:00	14:27:00	00:03:00	21	1.2		
62	E	14:30:00	14:32:00	00:02:00	20	1.3		
63	W	14:36:00	14:39:00	00:03:00	20	1.3		
64	E	14:43:00	14:46:00	00:03:00	19	1.3		
65	W	14:49:00	14:52:00	00:03:00	19	1.3		
66	E	14:55:00	14:59:00	00:04:00	19	1.3		
67	W	15:02:00	15:05:00	00:03:00	19	1.3		
68	E	15:08:00	15:12:00	00:04:00	20	1.2		
69	W	15:15:00	15:19:00	00:04:00	20	1.2		
70	E	15:22:00	15:26:00	00:04:00	20	1.2		
71	W	15:29:00	15:33:00	00:04:00	20	1.3		
72	E	15:36:00	15:40:00	00:04:00	20	1.2		
73	W	15:43:00	15:48:00	00:05:00	22	1.2		
165	S	15:55:00	16:01:00	00:06:00	21	1.2		
164	N	16:04:00	16:10:00	00:06:00	21	1.2	PAV roll warnings	
163	S	16:14:00	16:19:00	00:05:00	20	1.1		
162	N	16:23:00	16:28:00	00:05:00	18	1.3		
161	S	16:31:00	16:37:00	00:06:00	17	1.8		
160	N	16:40:00	16:46:00	00:06:00	20	1.3		
159	S	16:49:00	16:55:00	00:06:00	22	1.1		
158	N	16:58:00	17:04:00	00:06:00	23	1.2	PAV roll warnings	
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	WY SC QL1 EastBlock	Day246_90557_A	09/02/2020	246	A	

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Comer	Reims 406 - N406SD	5382.9	07:31:00	13:31:00	LAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Stanton	Leica Terrain Mapper - 90557	5387.6	12:29:00	18:29:00	LAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
170	4	10	40,000	Clear	7	-3	30.26
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)			
150		5,413	14,000	7,284			

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

						Verify S-Turns Before Mission	Yes
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
157	S	17:07:00	17:13:00	00:06:00	23	1.2	
156	N	17:16:00	17:22:00	00:06:00	25	1.2	
155	S	17:25:00	17:31:00	00:06:00	26	1.2	
154	N	17:35:00	17:40:00	00:05:00	25	1.2	
153	S	17:44:00	17:49:00	00:05:00	24	1.3	
152	N	17:53:00	17:58:00	00:05:00	22	1.3	
151	S	18:02:00	18:07:00	00:05:00	22	1.3	

Page 2	Verify S-Turns After Mission
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Additional Comments

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day247_90511	09/03/2020	247		

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Dar Perl	Cessna 404 Titan - N404CP	7982.4	08:40:00	14:40:00	KLAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90511	7987.4	01:50:00	19:50:00	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
140	8	10		Clear	14	1	30.34
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	5,413	12,821	7,284				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
150	N	15:10:00	15:16:00	00:06:00	22	1.2	QL1_East
149	S	15:19:00	15:25:00	00:06:00	21	1.2	
148	N	15:28:00	15:34:00	00:06:00	23	1.2	
147	S	15:37:00	15:42:00	00:05:00	23	1.2	
146	N	15:45:00	15:51:00	00:06:00	23	1.1	Eye safety triggered
146	S	15:55:00	16:00:00	00:05:00	23	1	Turned off eye safety, 146 South Bounds
145	N	16:04:00	16:09:00	00:05:00	23	1	
144	S	16:12:00	16:17:00	00:05:00	20	1.2	
143	N	16:21:00	16:26:00	00:05:00	20	1.5	
142	S	16:29:00	16:34:00	00:05:00	20	1.3	
141	N	16:37:00	16:42:00	00:05:00	21	1.1	
140	S	16:45:00	16:50:00	00:05:00	22	1.1	
139	N	16:54:00	16:59:00	00:05:00	22	1.1	
138	S	17:02:00	17:07:00	00:05:00	22	1.1	
137	N	17:11:00	17:16:00	00:05:00	24	1.1	
136	S	17:19:00	17:24:00	00:05:00	24	1.1	
135	N	17:27:00	17:32:00	00:05:00	24	1.1	
134	S	17:35:00	17:40:00	00:05:00	24	1.1	
133	N	17:43:00	17:48:00	00:05:00	24	1.1	
132	S	17:51:00	17:56:00	00:05:00	21	1.3	
131	N	17:59:00	18:03:00	00:04:00	22	1.2	
130	S	18:07:00	18:11:00	00:04:00	21	1.2	
129	N	18:14:00	18:18:00	00:04:00	21	1.2	
128	S	18:22:00	18:26:00	00:04:00	20	1.2	
127	N	18:29:00	18:33:00	00:04:00	19	1.3	More flight lines on page 2

Page 1 **Verify S-Turns After Mission**

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	QL1_East_SouthCentral, WY			Day247_90511		09/03/2020	247	
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Dar Perl	Cessna 404 Titan - N404CP			7982.4	08:40:00	14:40:00	KLAR	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Nardone	Leica Terrain Mapper - 90511			7987.4	01:50:00	19:50:00	KLAR	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
140	8	10		Clear	14	1	30.34	
Air Speed (kts)	Altitude AGL (ft)		Altitude MSL (ft)	Airfield Elevation (ft)				
150	5,413		12,821	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
						Verify S-Turns Before Mission		
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
126	S	18:36:00	18:40:00	00:04:00	19	1.3		
125	N	18:43:00	18:47:00	00:04:00	18	1.4		
124	S	18:51:00	18:55:00	00:04:00	18	1.4		
123	N	18:58:00	19:02:00	00:04:00	18	1.3		
122	S	19:05:00	19:10:00	00:05:00	18	1.3		
121	N	19:13:00	19:17:00	00:04:00	20	1.1		
120	S	19:20:00	19:24:00	00:04:00	21	1		
Page 2						Verify S-Turns After Mission		
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day248_90511	09/04/2020	248		

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Dar Perl	Cessna 404 Titan - N404CP	7987.4	08:55:00	14:55:00	KLAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 90511	7990.6	12:00:00	18:00:00	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
210	4	10		Clear	15	-2	30.43
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		5,413		12,821		7,284	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
254	S	15:27:00	15:35:00	00:08:00	19	1.1	
253	N	15:38:00	15:46:00	00:08:00	19	1.1	
252	S	15:49:00	15:57:00	00:08:00	19	1.2	
251	N	16:00:00	16:08:00	00:08:00	17	1.2	
250	S	16:11:00	16:19:00	00:08:00	16	1.3	
249	N	16:25:00	16:33:00	00:08:00	17	1.5	
248	S	16:36:00	16:44:00	00:08:00	21	1.1	
247	N	16:46:00	16:54:00	00:08:00	20	1.1	
246	S	16:56:00	17:04:00	00:08:00	20	1.2	
245	N	17:06:00	17:14:00	00:08:00	21	1.2	
244	S	17:16:00	17:24:00	00:08:00	21	1.1	
243	N	17:26:00	17:34:00	00:08:00	24	1.1	
242	S	17:37:00	17:45:00	00:08:00	23	1.2	

Page 1 Verify S-Turns After Mission

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	South Central Wyoming		Day249_90515_A			09/05/2020	249	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gebhart		Cessna 404 Titan - N7079F			2881.5	08:58:00	14:58:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
DeHart		Leica Terrain Mapper - 90515				01:46:00	19:46:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
230	5	10	12,000	Clear	22.8	1.1	30.39	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
160		7,306	14,590	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35	10	40		89	600	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
200	S	14:58:00	15:03:00	00:05:00	19	1.1	QL1- EAST	
201	N	16:08:00	15:16:00	23:08:00	19	1.1		
202	S	15:20:00	15:29:00	00:09:00	19	1.1		
203	N	15:31:00	15:40:00	00:09:00	20	1.1		
204	S	15:42:00	15:51:00	00:09:00	18	1.2		
205	N	15:53:00	16:01:00	00:08:00	17	1.2		
206	S	16:07:00	16:16:00	00:09:00	17	1.2		
207	N	16:18:00	16:26:00	00:08:00	15	1.7	Eye safe error	
207	S	16:29:00	16:30:00	00:01:00	18	1.2		
208	S	16:35:00	16:43:00	00:08:00	20	1.2		
209	N	16:45:00	16:53:00	00:08:00	20	1.2		
210	S	16:56:00	17:04:00	00:08:00	20	1.2		
211	N	17:06:00	17:15:00	00:09:00	21	1.1	Eye safe err	
211	S	17:17:00	17:18:00	00:01:00	19	1.3		
212	S	17:26:00	17:35:00	00:09:00	20	1.4		
213	N	17:37:00	17:45:00	00:08:00	20	1.4		
214	S	17:48:00	17:56:00	00:08:00	20	1.3		
215	N	17:58:00	18:07:00	00:09:00	19	1.3		
216	S	18:09:00	18:18:00	00:09:00	20	1.2		
217	N	18:20:00	18:29:00	00:09:00	20	1.2		
218	S	18:31:00	18:40:00	00:09:00	19	1.3		
219	N	18:42:00	18:52:00	00:10:00	18	1.3		
220	S	18:54:00	19:02:00	00:08:00	18	1.2		
221	N	19:04:00	19:12:00	00:08:00	20	1.1		
222	S	19:15:00	19:24:00	00:09:00	20	1.1		
Page 1						Verify S-Turns After Mission		Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	WY SC QL1 EastBlock		Day249_90557_A			09/05/2020	249	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Comer		Reims 406 - N406SD			5389	07:12:00	13:12:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90557			5394.1	12:28:00	18:28:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
150	7	6	40,000	Clear	8	-2	30.48	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	13,800	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
74	W	13:35:00	13:41:00	00:06:00	21	1.1	QL1 East BLK 1, Clear, PAV pitch warnings	
75	E	13:44:00	13:49:00	00:05:00	20	1.1	minor pitch warnings all lines	
76	W	13:53:00	13:59:00	00:06:00	20	1.2		
77	E	14:02:00	14:08:00	00:06:00	20	1.2		
78	W	14:11:00	14:17:00	00:06:00	20	1.1		
79	E	14:20:00	14:26:00	00:06:00	20	1.2		
80	W	14:30:00	14:36:00	00:06:00	20	1.3		
81	E	14:39:00	14:45:00	00:06:00	20	1.2		
82	W	14:49:00	14:55:00	00:06:00	19	1.1		
83	E	14:58:00	15:04:00	00:06:00	19	1.1		
84	W	15:07:00	15:14:00	00:07:00	19	1.1		
85	E	15:17:00	15:23:00	00:06:00	19	1.1		
86	W	15:26:00	15:32:00	00:06:00	20	1.1		
87	E						mount rotation rngc obstructed restarted lne	
87	E	15:41:00	15:47:00	00:06:00	19	1.1	warning for rotation obstructed stays on	
88	W	15:50:00	15:56:00	00:06:00	18	1.1	however PAV behaves normal, some bumps	
89	E	16:00:00	16:05:00	00:05:00	17	1.2	some bumps middle of line	
90	W	16:09:00	16:13:00	00:04:00	17	1.2		
91	E	16:16:00	16:20:00	00:04:00	15	1.7		
92	W	16:23:00	16:26:00	00:03:00	17	1.7		
93	E	16:30:00	16:33:00	00:03:00	18	1.2		
94	W	16:37:00	16:40:00	00:03:00	20	1.2		
95	E	16:43:00	16:46:00	00:03:00	20	1.2		
96	W	16:49:00	16:52:00	00:03:00	20	1.2		
97	E	16:55:00	16:58:00	00:03:00	20	1.2		
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	WY SC QL1 EastBlock	Day249_90557_A	09/05/2020	249	A	

Crew	Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
Comer	Reims 406 - N406SD		5389	07:12:00	13:12:00	LAR
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Stanton	Leica Terrain Mapper - 90557		5394.1	12:28:00	18:28:00	LAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
150	7	6	40,000	Clear	8	-2	30.48
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		5,413		13,800		7,284	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission Yes

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
98	W	17:02:00	17:05:00	00:03:00	21	1.1	PAV stabilization is low warning turbulence increasing
99	E	17:08:00	17:11:00	00:03:00	20	1.1	
119	S	17:19:00	17:23:00	00:04:00	19	1.3	roll warnings end block for turbulence
118	N	17:26:00	17:30:00	00:04:00	20	1.4	
117	S	17:33:00	17:36:00	00:03:00	20	1.4	
116	N	17:40:00	17:44:00	00:04:00	20	1.4	
8	W	17:54:00	17:55:00	00:01:00	21	1.2	move to QL1 WestBlock cut line at start for turbulence end mission for turbulence

Page 2 Verify S-Turns After Mission

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	WY SC QL1 WestBlock		Day250_90511_A			09/06/2020	250	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Dar Perl		Cessna 404 Titan - N404CP			7991.9	07:57:00	13:57:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90511			7996.5	12:46:00	18:46:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
150	6	10	40,000	Clear	16	-6	30.37	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	13,000	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
8	W	14:38:00	14:43:00	00:05:00	25	1.2	QL1 West BLK 1, hazey from smoke	
9	E	14:46:00	14:51:00	00:05:00	25	1.2		
10	W	14:55:00	14:59:00	00:04:00	22	1.2		
11	E	15:03:00	15:08:00	00:05:00	22	1.2		
12	W	15:12:00	15:18:00	00:06:00	22	1.2		
13	E	15:21:00	15:26:00	00:05:00	22	1.2		
14	W	15:29:00	15:35:00	00:06:00	23	1.2		
15	E	15:38:00	15:43:00	00:05:00	21	1.4		
16	W	15:46:00	15:52:00	00:06:00	20	1.2		
17	E	15:55:00	16:00:00	00:05:00	19	1.2		
18	W	16:03:00	16:09:00	00:06:00	18	1.4		
19	E	16:12:00	16:18:00	00:06:00	17	1.8		
20	W	16:21:00	16:27:00	00:06:00	18	1.8		
21	E	16:30:00	16:35:00	00:05:00	20	1.2		
22	W	16:38:00	16:44:00	00:06:00	21	1.2		
23	E	16:47:00	16:53:00	00:06:00	21	1.2		
24	W	16:56:00	17:02:00	00:06:00	22	1.2		
25	E	17:05:00	17:10:00	00:05:00	22	1.2		
26	W	17:14:00	17:19:00	00:05:00	21	1.1		
27	E	17:22:00	17:27:00	00:05:00	20	1.1		
28	W	17:30:00	17:36:00	00:06:00	18	1.4		
29	E	17:39:00	17:44:00	00:05:00	18	1.4		
30	W	17:48:00	17:53:00	00:05:00	19	1.2	bumpy	
31	E	17:56:00	18:02:00	00:06:00	19	1.2	roll warning, turbulencer building	
32	W	18:05:00	18:11:00	00:06:00	19	1.2	turbulent, end mission	
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	South Central Wyoming		Day250_90515_A			09/06/2020	250	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gebhart		Cessna 404 Titan - N7079F			2887.6	10:10:00	16:10:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
DeHart		Leica Terrain Mapper - 90515			2892.2	01:27:00	19:27:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
250	12	10	12,000	Clear	21	-4	30.26	
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)		
160		7,306		14,590		7,284		
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)		Pulse Rate (kHz)	Laser Power (%)	
0.35	10	40		89		600	100	
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
225	S	15:27:00	15:33:00	00:06:00	24	1.1	QL1- EAST, Camera NADIR malf	
225	S	16:10:00	16:19:00	00:09:00	17	1.8		
226	N	16:21:00	16:30:00	00:09:00	18	1.6		
227	S	16:35:00	16:44:00	00:09:00	18	1.5		
228	N	16:46:00	16:56:00	00:10:00	21	1.2		
229	S	16:59:00	17:07:00	00:08:00	22	1.2		
230	N	17:10:00	17:19:00	00:09:00	21	1.2		
231	S	17:24:00	17:33:00	00:09:00	18	1.4		
232	N	17:35:00	17:44:00	00:09:00	18	1.4		
233	S	17:47:00	17:56:00	00:09:00	19	1.2		
234	N	17:58:00	18:06:00	00:08:00	19	1.2		
235	S	18:09:00	18:18:00	00:09:00	20	1.1		
236	N	18:20:00	18:30:00	00:10:00	18	1.2		
237	S	18:32:00	18:42:00	00:10:00	17	1.3		
238	N	18:44:00	18:53:00	00:09:00	17	1.3		
239	S	18:55:00	19:04:00	00:09:00	20	1.1		
240	N	19:06:00	19:16:00	00:10:00	17	1.5		
241	S	19:18:00	19:27:00	00:09:00	17	1.5		
							Verify S-Turns After Mission	Yes
Additional Comments								
Had to shut down and restart system, refly base due to NADIR FAILURE								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day250_91557	09/06/2020	250		

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Comer	Reims 406 - N406SD	5394.1	07:35:00	13:35:00	KLAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 91557	5397.5	11:07:00	17:07:00	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
140	5	10		Clear	12	-7	30.38
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	5,413	12,821	7,284				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
100	W	13:54:00	13:56:00	00:02:00	24	1.1	444.8 Hobbs
101	E	14:00:00	14:02:00	00:02:00	24	1.2	QL1_East
102	W	14:06:00	14:09:00	00:03:00	26	1.1	
103	E	14:12:00	14:14:00	00:02:00	25	1.2	
104	W	14:18:00	14:20:00	00:02:00	25	1.2	
105	E	14:23:00	14:26:00	00:03:00	25	1.2	
106	W	14:29:00	14:32:00	00:03:00	25	1.2	
107	E	14:35:00	14:38:00	00:03:00	25	1.2	
108	W	14:40:00	14:43:00	00:03:00	25	1.2	
109	S	14:48:00	14:52:00	00:04:00	24	1.2	
110	N	14:55:00	14:59:00	00:04:00	21	1.4	
111	S	15:02:00	15:06:00	00:04:00	21	1.3	
112	N	15:13:00	15:17:00	00:04:00	22	1.2	
113	S	15:20:00	15:24:00	00:04:00	24	1.1	
114	N	15:27:00	15:31:00	00:04:00	24	1.1	
115	S	15:34:00	15:38:00	00:04:00	23	1.2	
40	N	15:43:00	15:52:00	00:09:00	22	1.1	Reflights
41	S	15:57:00	16:06:00	00:09:00	19	1.2	Reflights
42	N	16:10:00	16:19:00	00:09:00	17	1.2	Reflights
43	S	16:22:00	16:30:00	00:08:00	18	1.6	Reflights
46	N	16:35:00	16:45:00	00:10:00	20	1.2	Reflights
							449.3

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Verify S-Turns After Mission

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	South Central Wyoming		Day251_90515_A			09/07/2020	251	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gebhart		Cessna 404 Titan - N7079F			2892.2	09:15:00	15:15:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
DeHart		Leica Terrain Mapper - 90515			2896.4	12:41:00	18:41:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
200	4	10	12,000	Clear	14.4	3.9	30.02	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
160		7,306	14,590	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35	10	40		89	600	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
203	W	15:15:00	15:17:00	00:02:00	21	1.2	QL1- West	
204	E	15:20:00	14:23:00	23:03:00	21	1.2		
205	W	15:25:00	15:29:00	00:04:00	22	1.1		
206	E	15:31:00	15:35:00	00:04:00	23	1.1		
207	W	15:38:00	15:44:00	00:06:00	21	1.1		
208	E	15:47:00	15:51:00	00:04:00	19	1.3		
209	W	15:54:00	16:00:00	00:06:00	20	1.2		
210	E	16:03:00	16:07:00	00:04:00	16	1.9		
211	W	16:11:00	16:16:00	00:05:00	16	1.9		
212	E	16:20:00	16:24:00	00:04:00	20	1.3		
213	W	16:27:00	16:34:00	00:07:00	22	1.1		
214	E	16:37:00	16:43:00	00:06:00	22	1.2		
215	W	16:44:00	16:50:00	00:06:00	22	1.2		
216	E	16:53:00	16:57:00	00:04:00	23	1.2		
217	W	17:00:00	17:06:00	00:06:00	23	1.2		
218	E	17:08:00	17:13:00	00:05:00	21	1.2		
219	W	17:15:00	17:21:00	00:06:00	21	1.2		
220	E	17:24:00	17:29:00	00:05:00	21	1.3		
221	W	17:32:00	17:38:00	00:06:00	18	1.4		
222	E	17:40:00	17:46:00	00:06:00	17	1.3		
223	W	17:49:00	17:55:00	00:06:00	18	1.2		
224	E	17:58:00	18:03:00	00:05:00	18	1.2		
225	W	18:07:00	18:14:00	00:07:00	20	1		
226	E	18:17:00	18:22:00	00:05:00	17	1.2		
227	W	18:25:00	18:32:00	00:07:00	16	1.3		
Page 1						Verify S-Turns After Mission		Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	QL1_East_SouthCentral, WY	Day251_91557	09/07/2020	251		

Crew	Equipment		Time			Airports
Pilot	Aircraft Make / Model / Tail #		Hobbs Start	Local Start	UTC Start	Departing
Comer	Reims 406 - N406SD		5398.4	08:15:00	14:15:00	KLAR
Operator	Sensor Make / Model / Serial #		Hobbs End	Local End	UTC End	Arriving
Nardone	Leica Terrain Mapper - 91557		5402.1	12:02:00	18:05:00	KLAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
230	20	10		Clear	18	-11	30.08
Air Speed (kts)	Altitude AGL (ft)		Altitude MSL (ft)	Airfield Elevation (ft)			
150	5,413		12,821	7,284			

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

Verify S-Turns Before Mission

Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
298	S	14:34:00	14:43:00	00:09:00	23	1.2	Hobbs: 450.5 QL1_East
54	N	14:52:00	15:01:00	00:09:00	21	1.2	
54	S	15:06:00	15:15:00	00:09:00	21	1.2	
53	N	15:19:00	15:29:00	00:10:00	22	1.1	
52	S	15:33:00	15:43:00	00:10:00	22	1.1	
51	N	15:45:00	15:55:00	00:10:00	20	1.2	
50	S	15:59:00	16:09:00	00:10:00	16	1.9	
49	N	16:12:00	16:22:00	00:10:00	18	1.5	
48	S	16:25:00	16:35:00	00:10:00	22	1.2	
47	N	16:39:00	16:49:00	00:10:00	22	1.5	
							QL1_West
41	SE	17:05:00	17:11:00	00:06:00	23	1.1	
42	NW	17:13:00	17:19:00	00:06:00	22	1.2	
43	SE	17:22:00	17:28:00	00:06:00	21	1.3	
44	NW	17:32:00	17:37:00	00:05:00	18	1.4	
							Hobbs: 454.6

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Verify S-Turns After Mission

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name		Unique ID			Flight Date (UTC)	Day of Year	Flight #
80997	WY So Cen QL1 WestBlock		Day257_90511_A			09/13/2020	257	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Diepenbroek		Cessna 404 Titan - N404CP			8007.5	09:27:00	15:27:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90511			8012	14:06:00	20:06:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
140	3	10	40,000	Clear	12	0	30.39	
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)		
150		5,413		13,000		7,284		
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)		Pulse Rate (kHz)	Laser Power (%)	
0.35	8	34		150		1400	100	
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
34	W	16:05:00	16:11:00	00:06:00	21	1.2	Clear, some snow in trees middle at high ell no snow rest of lines	
79	SE	16:17:00	16:18:00	00:01:00	21	1.2		
80	NW	16:20:00	16:22:00	00:02:00	21	1.2		
81	SE	16:24:00	16:26:00	00:02:00	22	1.1		
82	NW	16:28:00	16:30:00	00:02:00	22	1.1		
83	SE	16:32:00	16:33:00	00:01:00	22	1.1		
84	NW	16:36:00	16:37:00	00:01:00	22	1.1		
85	SE	16:40:00	16:42:00	00:02:00	21	1.3		
86	NW	16:44:00	16:46:00	00:02:00	20	1.2		
87	SE	16:49:00	16:51:00	00:02:00	20	1.2		
88	NW	16:53:00	16:56:00	00:03:00	20	1.3		
89	SE	16:58:00	17:01:00	00:03:00	20	1.3		
90	NW	17:03:00	17:06:00	00:03:00	18	1.4		
91	SE	17:09:00	17:12:00	00:03:00	18	1.4		
92	NW	17:14:00	17:17:00	00:03:00	18	1.3		
93	SE	17:20:00	17:23:00	00:03:00	19	1.2		
94	NW	17:26:00	17:30:00	00:04:00	18	1.3		
95	SE	17:32:00	17:36:00	00:04:00	18	1.3		
96	NW	17:39:00	17:42:00	00:03:00	20	1.2		
97	SE	17:45:00	17:49:00	00:04:00	21	1.1		
98	NW	17:52:00	17:56:00	00:04:00	18	1.2		
99	SE	17:58:00	18:03:00	00:05:00	17	1.3		
100	NW	18:05:00	18:11:00	00:06:00	17	1.3		
101	SE	18:13:00	18:18:00	00:05:00	17	1.3		
102	NW	18:20:00	18:25:00	00:05:00	16	1.2		
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info				Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #	
80997	WY So Cen QL1 WestBlock	Day257_90511_A	09/13/2020	257	A	

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Diepenbroek	Cessna 404 Titan - N404CP	8007.5	09:27:00	15:27:00	LAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Stanton	Leica Terrain Mapper - 90511	8012	14:06:00	20:06:00	LAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
140	3	10	40,000	Clear	12	0	30.39
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		5,413		13,000		7,284	

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35	8	34	150	1400	100

					Verify S-Turns Before Mission	Yes
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
103	SE	18:28:00	18:33:00	00:05:00	19	1	
104	NW	18:35:00	18:41:00	00:06:00	20	1	
105	SE	18:43:00	18:48:00	00:05:00	18	1	
106	NW	18:50:00	18:56:00	00:06:00	17	1.1	shutter error
107	SE	18:58:00	19:04:00	00:06:00	17	1.4	
108	NW	19:06:00	19:12:00	00:06:00	17	1.2	
109	SE	19:14:00	19:21:00	00:07:00	18	1.1	
110	NW	19:23:00	19:30:00	00:07:00	17	1.2	end for increasing turbulence

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	Central WY QL1 East Re flights, QL1 West, Block 7 Re			Day257_90515_1		09/13/2020	257	1
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gebhart		Cessna 404 Titan - N7079F			2896.4	09:28:00	15:28:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Kennedy		Leica Terrain Mapper - 90515			2901.7	14:47:00	20:47:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
180	4	10		Clear	10	0	30.39	
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)	Airfield Elevation (ft)			
150		4,757			7,284			
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
47	S	15:47:00	15:52:00	00:05:00	18	1.7	Patch	
48	N	15:55:00	15:58:00	00:03:00	20	1.2	Patch	
49	S	16:06:00	16:10:00	00:04:00	21	1.2	Patch	
50	N	16:13:00	16:23:00	00:10:00	21	1.2	Full line	
51	S	16:31:00	16:36:00	00:05:00	22	1.1	Patch	
52	N	16:39:00	16:50:00	00:11:00	21	1.1	Full line	
53	S	16:55:00	17:03:00	00:08:00	19	1.4	Patch	
54	N	17:06:00	17:07:00	00:01:00	17	1.4	Patch	
229	W	17:18:00	17:24:00	00:06:00	19	1.3	Start QL1 West @ 5413 AGL	
41	W	17:35:00	17:46:00	00:11:00	19	1.2	Start Block 7 Re flights @	
40	E	17:51:00	18:00:00	00:09:00	18	1.2	Patch	
39	W	18:03:00	18:09:00	00:06:00	17	1.3	Patch	
38	E	18:14:00	18:24:00	00:10:00	17	1.3	Patch	
37	W	18:27:00	18:34:00	00:07:00	19	1	Patch	
36	E	18:38:00	18:44:00	00:06:00	18	1.1	Patch	
35	W	18:46:00	18:53:00	00:07:00	17	1.1	Patch	
34	E	18:55:00	19:02:00	00:07:00	16	1.4	Patch	
33	W	19:06:00	19:23:00	00:17:00	17	1.2	Full line	
32	E	19:28:00	19:45:00	00:17:00	17	1.2	Full line	
31	W	19:50:00	20:05:00	00:15:00	19	1	Full line	
							Verify S-Turns After Mission	Yes

Additional Comments

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	WY So Cen QL1 WestBlock			Day258_90511_A		09/14/2020	258	A
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Diepenbroek	Cessna 404 Titan - N404CP			8012	07:44:00	13:44:00	LAR	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Stanton	Leica Terrain Mapper - 90511			8016.9	12:53:00	18:53:00	LAR	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
150	8	10	40,000	Clear	5	-1	30.46	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	13,000	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35	8	34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
111	NW	14:30:00	14:37:00	00:07:00	20	1.2	Clear	
112	SE	14:39:00	14:45:00	00:06:00	20	1.2		
113	NW	14:47:00	14:54:00	00:07:00	20	1.2		
114	SE	14:57:00	15:03:00	00:06:00	19	1.2		
115	NW	15:05:00	15:12:00	00:07:00	17	1.4		
116	SE	15:15:00	15:21:00	00:06:00	18	1.2		
117	NW	15:24:00	15:31:00	00:07:00	20	1.1		
118	SE	15:33:00	15:40:00	00:07:00	18	1.4		
119	NW	15:42:00	15:49:00	00:07:00	16	1.8		
120	SE	15:51:00	15:58:00	00:07:00	21	1.2		
121	NW	16:00:00	16:07:00	00:07:00	22	1.2		
122	SE	16:10:00	16:17:00	00:07:00	21	1.2		
123	NW	16:19:00	16:26:00	00:07:00	22	1.2		
124	SE	16:28:00	16:35:00	00:07:00	22	1.2		
125	NW	16:37:00	16:44:00	00:07:00	21	1.2		
126	SE	16:47:00	16:53:00	00:06:00	21	1.1		
127	NW	16:56:00	17:03:00	00:07:00	21	1.1		
128	SE	17:05:00	17:12:00	00:07:00	17	1.4		
129	NW	17:14:00	17:21:00	00:07:00	18	1.3		
142	SE	17:23:00	17:31:00	00:08:00	18	1.2		
143	NW	17:33:00	17:40:00	00:07:00	18	1.2		
144	SE	17:43:00	17:50:00	00:07:00	18	1.2		
145	NW	17:52:00	18:00:00	00:08:00	17	1.3		
146	SE	18:02:00	18:10:00	00:08:00	16	1.3		
147	NW	18:12:00	18:19:00	00:07:00	16	1.3		
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	Central WY QL1 East Reflights, QL1 West, Block 7 Re			Day258_90515_1		09/14/2020	258	1
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Gibilaro	Cessna 404 Titan - N7079F			2901.7	08:04:00	14:04:00	LAR	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Kennedy	Leica Terrain Mapper - 90515			2906.1	12:28:00	18:28:00	LAR	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
180	9	10		Clear	4	-2	30.44	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		8,202	13,310	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.7		40		90	600	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
32	N	14:20:00	14:38:00	00:18:00	18	1.4	eyesafe mode shutoff on north end	
32	S	14:41:00	14:44:00	00:03:00	21	1.1	partial reflight of 32	
33	S	14:51:00	15:09:00	00:18:00	21	1.1		
202	SE	15:39:00	15:43:00	00:04:00	16	1.8	Start QL1 West @ 5413 AGL	
201	NW	15:46:00	15:51:00	00:05:00	19	1.6	Settings: 34/150/1400, .35m	
200	SE	15:54:00	15:59:00	00:05:00	21	1.2	Frequent turbulence throughout	
199	NW	16:02:00	16:07:00	00:05:00	21	1.2		
198	SE	16:10:00	16:16:00	00:06:00	21	1.2		
197	NW	16:20:00	16:25:00	00:05:00	22	1.2		
196	SE	16:29:00	16:34:00	00:05:00	22	1.2		
195	NW	16:37:00	16:43:00	00:06:00	20	1.2		
194	SE	16:47:00	16:52:00	00:05:00	20	1.2		
193	NW	16:56:00	17:01:00	00:05:00	20	1.2		
192	SE	17:05:00	17:11:00	00:06:00	16	1.6		
191	NW	17:14:00	17:19:00	00:05:00	17	1.5		
190	SE	17:23:00	17:28:00	00:05:00	17	1.3		
189	NW	17:31:00	17:37:00	00:06:00	18	1.2		
230	E	17:45:00	17:51:00	00:06:00	18	1.2	Relocation for turbulence	
231	W	17:54:00	18:00:00	00:06:00	16	1.3		
232	E	18:03:00	18:08:00	00:05:00	16	1.3	more turbulence, snow on mountains	
							Verify S-Turns After Mission	Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	WY So Cen QL1 WestBlock			Day259_90511_A		09/15/2020	259	A
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Diepenbroek	Cessna 404 Titan - N404CP			8016.9	07:40:00	13:40:00	LAR	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Stanton	Leica Terrain Mapper - 90511			8021.7	12:45:00	18:45:00	LAR	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
160	9	10	40,000	Clear	7	-4	30.4	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	13,000	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35	8	34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
148	NW	14:24:00	14:31:00	00:07:00	20	1.2	hazy from smoke all lift	
149	SE	14:34:00	14:41:00	00:07:00	20	1.2		
150	NW	14:43:00	14:50:00	00:07:00	20	1.2		
151	SE	14:52:00	14:59:00	00:07:00	20	1.2		
152	NW	15:01:00	15:08:00	00:07:00	18	1.3		
153	SE	15:10:00	15:16:00	00:06:00	19	1.2		
154	NW	15:19:00	15:25:00	00:06:00	20	1.2		
155	SE	15:28:00	15:34:00	00:06:00	19	1.2		
156	NW	15:37:00	15:42:00	00:05:00	17	1.9		
157	SE	15:44:00	15:50:00	00:06:00	19	1.6		
261	E	15:54:00	16:01:00	00:07:00	24	1.1		
260	W	16:03:00	16:10:00	00:07:00	23	1.2		
259	E	16:12:00	16:19:00	00:07:00	22	1.2		
258	W	16:21:00	16:28:00	00:07:00	23	1.2		
257	E	16:30:00	16:37:00	00:07:00	23	1.2		
256	W	16:39:00	16:46:00	00:07:00	22	1.2		
255	E	16:48:00	16:55:00	00:07:00	23	1.2		
254	W	16:58:00	17:04:00	00:06:00	21	1.4		
253	E	17:06:00	17:13:00	00:07:00	21	1.4		
252	W	17:15:00	17:22:00	00:07:00	21	1.3		
251	E	17:24:00	17:30:00	00:06:00	20	1.2		
250	W	17:33:00	17:39:00	00:06:00	20	1.2		
249	E	17:41:00	17:48:00	00:07:00	21	1.1		
248	W	17:50:00	17:56:00	00:06:00	19	1.3		
247	E	17:58:00	18:04:00	00:06:00	19	1.2		
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	SC WY QL East reflight, Block 7 reflight, QL1Wesr			Day259_90515_1		09/15/2020	259	1
Crew		Equipment			Time			Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing	
Gibilaro	Cessna 404 Titan - N7079F			2906.1	07:59:00	13:59:00	LAR	
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving	
Kennedy	Leica Terrain Mapper - 90515			2910.8	12:37:00	18:37:00	LAR	
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
150	6	10		Clear	8	-4	30.4	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	13,310	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35		34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
224	N	14:20:00	14:28:00	00:08:00	21	1.1		
42	W	14:40:00	14:57:00	00:17:00	20	1.2	Block 7 @ Settings: 40/90/600 .7m	
188	NW	15:25:00	15:31:00	00:06:00	20	1.2	Start QL1 West @ 5413 AGL	
187	SE	15:33:00	15:39:00	00:06:00	17	1.9	Settings: 34/150/1400, .35m	
186	NW	15:42:00	15:48:00	00:06:00	19	1.5	Frequent turbulence throughout	
185	SE	15:51:00	15:57:00	00:06:00	24	1.2		
184	NW	16:00:00	16:05:00	00:05:00	23	1.2		
34	W	16:12:00	16:17:00	00:05:00	22	1.2		
35	E	16:21:00	16:26:00	00:05:00	23	1.2		
36	W	16:30:00	16:35:00	00:05:00	23	1.2		
37	E	16:38:00	16:44:00	00:06:00	23	1.2		
38	W	16:47:00	16:53:00	00:06:00	21	1.4		
39	E	16:57:00	17:03:00	00:06:00	21	1.4		
40	W	17:06:00	17:12:00	00:06:00	21	1.4		
45	SE	17:16:00	17:21:00	00:05:00	20	1.2		
46	NW	17:24:00	17:30:00	00:06:00	20	1.2		
47	SE	17:33:00	17:39:00	00:06:00	22	1.2		
48	NW	17:42:00	17:47:00	00:05:00	21	1.1		
49	SE	17:51:00	17:57:00	00:06:00	20	1.2		
50	NW	18:00:00	18:06:00	00:06:00	19	1.2		
						Page 1	Verify S-Turns After Mission	Yes
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name			Unique ID		Flight Date (UTC)	Day of Year	Flight #
80997	WY So Cen QL1 East and West Blocks			Day260_90511_A		09/16/2020	260	A
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Diepenbroek		Cessna 404 Titan - N404CP			8021.7	07:36:00	13:36:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Stanton		Leica Terrain Mapper - 90511			8025.8	11:56:00	17:56:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
210	8	8	40,000	Clear	4	-4	30.47	
Air Speed (kts)		Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150		5,413	13,000	7,284				
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)		
0.35	8	34		150	1400	100		
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
87	W	14:01:00	14:07:00	00:06:00	22	1.3	QL1 East Block reflight lines, hazey fr smoke	
88	E	14:09:00	14:15:00	00:06:00	23	1.1		
89	W	14:18:00	14:24:00	00:06:00	21	1.3		
90	E	14:26:00	14:30:00	00:04:00	22	1.2		
91	W	14:32:00	14:36:00	00:04:00	22	1.2		
92	E	14:38:00	14:42:00	00:04:00	24	1.2		
93	W	14:44:00	14:47:00	00:03:00	24	1.2		
94	E	14:49:00	14:52:00	00:03:00	24	1.2		
95	W	14:54:00	14:58:00	00:04:00	24	1.2		
96	E	15:00:00	15:03:00	00:03:00	21	1.4		
97	W	15:05:00	15:08:00	00:03:00	22	1.2		
98	E	15:11:00	15:13:00	00:02:00	21	1.3		
99	W	15:16:00	15:18:00	00:02:00	18	1.4		
116	S	15:21:00	15:25:00	00:04:00	19	1.4		
117	N	15:27:00	15:31:00	00:04:00	17	1.9		
118	S	15:33:00	15:38:00	00:05:00	17	1.9		
119	N	15:40:00	15:44:00	00:04:00	19	1.3		
244	W	15:55:00	16:01:00	00:06:00	22	1.2	QL1 West Block, hazey from smoke	
243	E	16:04:00	16:10:00	00:06:00	23	1.2		
242	W	16:12:00	16:18:00	00:06:00	25	1.2		
241	E	16:21:00	16:27:00	00:06:00	24	1.3		
240	W	16:29:00	16:35:00	00:06:00	23	1.3		
239	E	16:39:00	16:45:00	00:06:00	22	1.2		
238	W	16:47:00	16:53:00	00:06:00	22	1.4		
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date		
Project #	Project Name	Unique ID				Flight Date (UTC)	Day of Year	Flight #
80997	SC WY QL1 West	Day260_90515_1				09/16/2020	260	1
Crew		Equipment			Time			Airports
Pilot		Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gibilaro		Cessna 404 Titan - N7079F			2910.8	08:03:00	14:03:00	LAR
Operator		Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Kennedy		Leica Terrain Mapper - 90515			2914.5	11:47:00	17:47:00	LAR
Conditions								
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)	
220	6	8		Clear	4	-4	30.47	
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)		
150		5,413				7,284		
Settings								
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)		Pulse Rate (kHz)	Laser Power (%)	
0.35		34		150		1400	100	
							Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments	
78	NW	14:29:00	14:34:00	00:05:00	22	1.2		
77	SE	14:37:00	14:43:00	00:06:00	22	1.3		
76	NW	14:46:00	14:52:00	00:06:00	22	1.3		
75	SE	14:55:00	15:00:00	00:05:00	24	1.2		
74	NW	15:04:00	15:09:00	00:05:00	20	1.3		
73	SE	15:12:00	15:18:00	00:06:00	18	1.4		
72	NW	15:21:00	15:26:00	00:05:00	19	1.4		
71	SE	15:29:00	15:35:00	00:06:00	17	1.9		
70	NW	15:38:00	15:43:00	00:05:00	19	1.5		
69	SE	15:47:00	15:52:00	00:05:00	22	1.1		
68	NW	15:55:00	16:01:00	00:06:00	23	1.2		
67	SE	16:04:00	16:10:00	00:06:00	23	1.2		
66	NW	16:13:00	16:19:00	00:06:00	25	1.2		
65	SE	16:21:00	16:27:00	00:06:00	23	1.3		
64	NW	16:30:00	16:36:00	00:06:00	23	1.3		
63	SE	16:39:00	16:45:00	00:06:00	22	1.2		
62	NW	16:47:00	16:53:00	00:06:00	22	1.4		
61	SE	16:56:00	17:01:00	00:05:00	21	1.4		
60	NW	17:04:00	17:10:00	00:06:00	21	1.4		
59	SE	17:13:00	17:19:00	00:06:00	22	1.2		
Page 1						Verify S-Turns After Mission	Yes	
Additional Comments								

Woolpert Lidar Acquisition Log

Project Info						Date	
Project #	Project Name	Unique ID		Flight Date (UTC)	Day of Year	Flight #	
80997	SC WY QL1 West	Day261_90515_1		09/17/2020	261	1	
Crew		Equipment			Time		Airports
Pilot	Aircraft Make / Model / Tail #			Hobbs Start	Local Start	UTC Start	Departing
Gibilaro	Cessna 404 Titan - N7079F			2914.5	07:58:00	13:58:00	LAR
Operator	Sensor Make / Model / Serial #			Hobbs End	Local End	UTC End	Arriving
Kennedy	Leica Terrain Mapper - 90515			2918.3	11:45:00	17:45:00	LAR
Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
170	7	5		Clear	5	-1	30.39
Air Speed (kts)		Altitude AGL (ft)		Altitude MSL (ft)		Airfield Elevation (ft)	
150		5,413				7,284	
Settings							
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)		Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)	
0.35		34		150	1400	100	
						Verify S-Turns Before Mission	Yes
Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
58	NW	14:27:00	17:32:00	00:05:00	20	1.4	Considerable haze/smoke
57	SE	14:36:00	14:42:00	00:06:00	20	1.4	
56	NW	14:46:00	14:51:00	00:05:00	20	1.4	
55	SE	14:55:00	15:01:00	00:06:00	19	1.7	
54	NW	15:04:00	15:09:00	00:05:00	19	1.4	
53	SE	15:13:00	15:18:00	00:05:00	18	1.4	
52	NW	15:22:00	15:27:00	00:05:00	18	1.4	
51	SE	15:31:00	15:36:00	00:05:00	16	1.9	
158	E	15:42:00	15:47:00	00:05:00	21	1.2	
159	W	15:51:00	15:55:00	00:04:00	22	1.2	
160	E	15:59:00	16:03:00	00:04:00	22	1.2	
161	W	16:08:00	16:12:00	00:04:00	24	1.2	
162	E	16:15:00	16:19:00	00:04:00	24	1.2	
163	W	16:23:00	16:28:00	00:05:00	22	1.2	
164	E	16:30:00	16:36:00	00:06:00	22	1.2	
165	W	16:39:00	16:44:00	00:05:00	22	1.1	
166	E	16:47:00	16:52:00	00:05:00	19	1.4	
167	W	16:55:00	17:00:00	00:05:00	19	1.3	
168	E	17:03:00	17:08:00	00:05:00	21	1.2	
169	W	17:12:00	17:17:00	00:05:00	20	1.2	
Page 1						Verify S-Turns After Mission	Yes
Additional Comments							

Woolpert Lidar Acquisition Log

Project Info			Date		
Project #	Project Name	Unique ID	Flight Date (UTC)	Day of Year	Flight #
80997	SC WY QL1 West	Day263_90515_1	09/19/2020	263	1

Crew	Equipment	Time			Airports
Pilot	Aircraft Make / Model / Tail #	Hobbs Start	Local Start	UTC Start	Departing
Gibilaro	Cessna 404 Titan - N7079F	2918.3	08:01:00	14:01:00	LAR
Operator	Sensor Make / Model / Serial #	Hobbs End	Local End	UTC End	Arriving
Kennedy	Leica Terrain Mapper - 90515	2921.1	10:55:00	16:55:00	LAR

Conditions							
Wind Dir (°)	Wind Speed (kts)	Visibility (mi)	Ceiling (ft)	Cloud Cover	Temp. (°C)	Dew Point (°C)	Pressure ("Hg)
250	8	9		Clear	12	-3	30.21
Air Speed (kts)	Altitude AGL (ft)	Altitude MSL (ft)	Airfield Elevation (ft)				
150	5,413		7,284				

Settings					
Point Spacing (m)	Point Density (ppsm)	Scan Angle/FOV (°)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power (%)
0.35		34	150	1400	100

							Verify S-Turns Before Mission	Yes
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Line #	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line	Satellite	PDOP	Line Notes/Comments
170	W	14:38:00	14:43:00	00:05:00	22	1.2	
171	E	14:47:00	14:52:00	00:05:00	21	1.2	
172	W	14:56:00	15:01:00	00:05:00	21	1.1	
173	E	15:05:00	15:10:00	00:05:00	20	1.1	
174	W	15:14:00	15:19:00	00:05:00	16	1.8	
175	E	15:22:00	15:27:00	00:05:00	16	1.9	
176	W	15:31:00	15:36:00	00:05:00	19	1.1	
177	E	15:40:00	15:44:00	00:04:00	21	1.1	
178	W	15:49:00	15:53:00	00:04:00	21	1.1	
179	E	15:57:00	16:01:00	00:04:00	22	1.1	
180	W	16:05:00	16:09:00	00:04:00	22	1.1	
181	E	16:12:00	16:16:00	00:04:00	21	1.1	
182	W	16:20:00	16:23:00	00:03:00	22	1.1	
183	E	16:27:00	16:30:00	00:03:00	21	1.1	

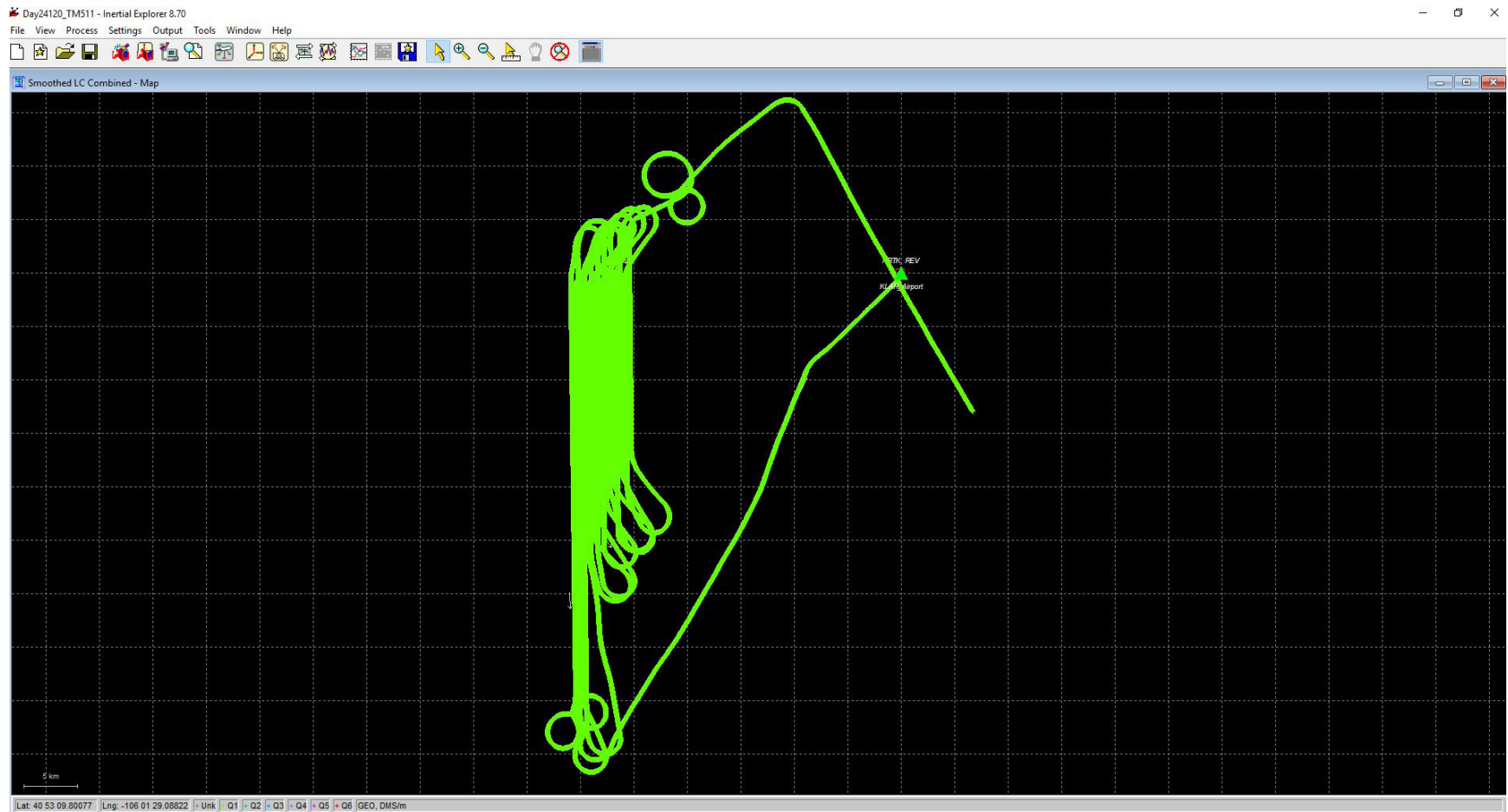
Page 1							Verify S-Turns After Mission	Yes
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Additional Comments

Appendix 3: GPS / IMU Graphics

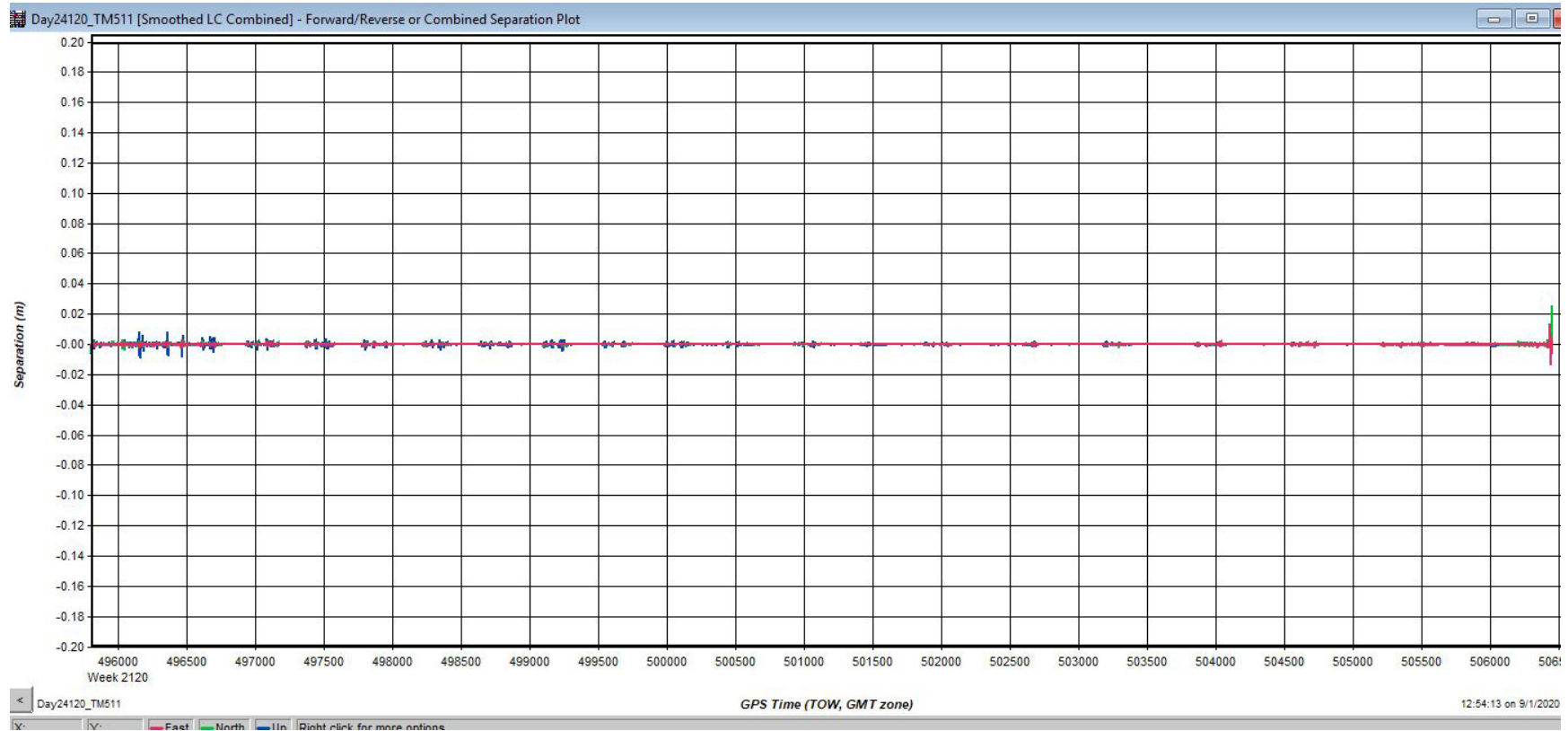
Day24120_TM511

Trajectory



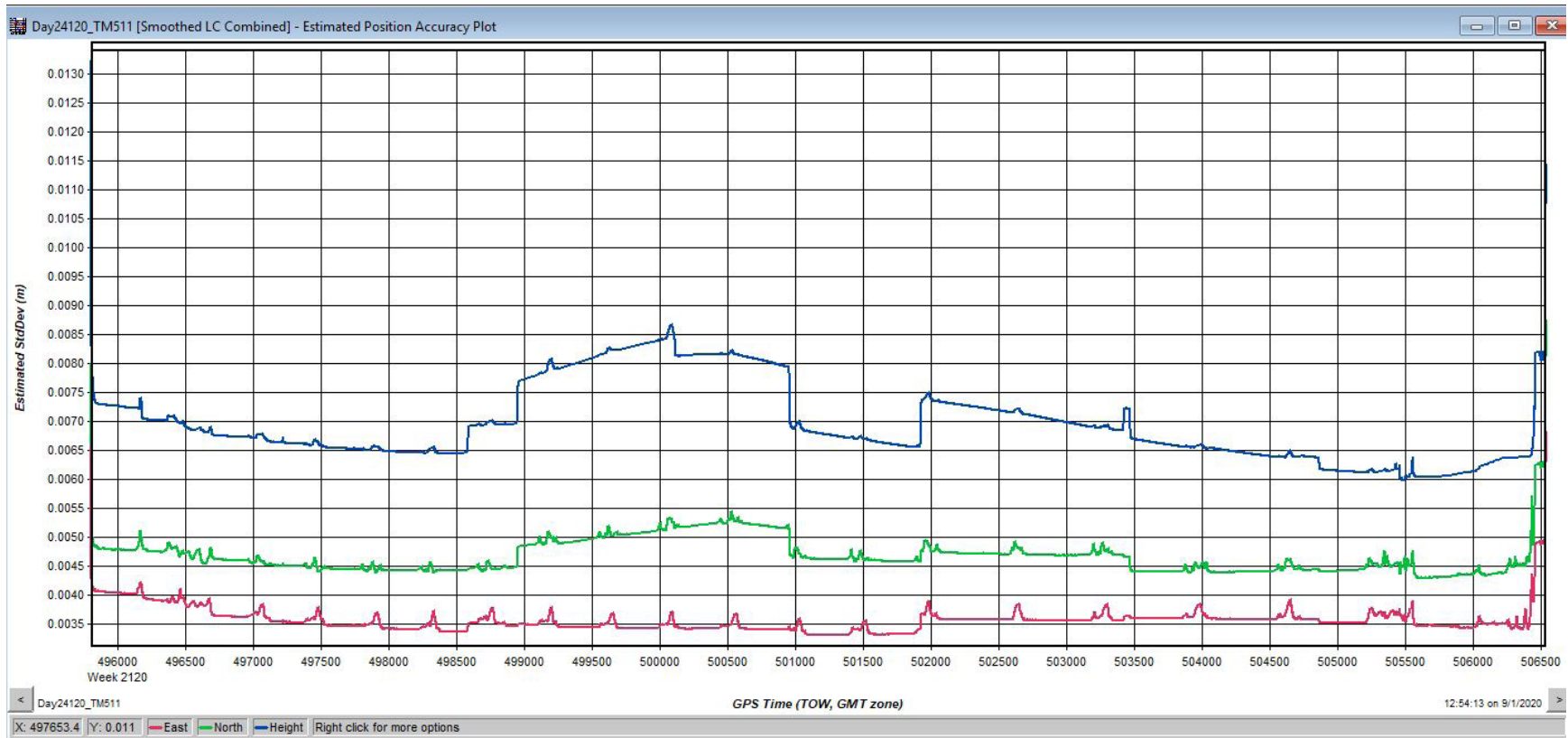
Day24120_TM511

Forward/Reverse or Combined Separation Plot



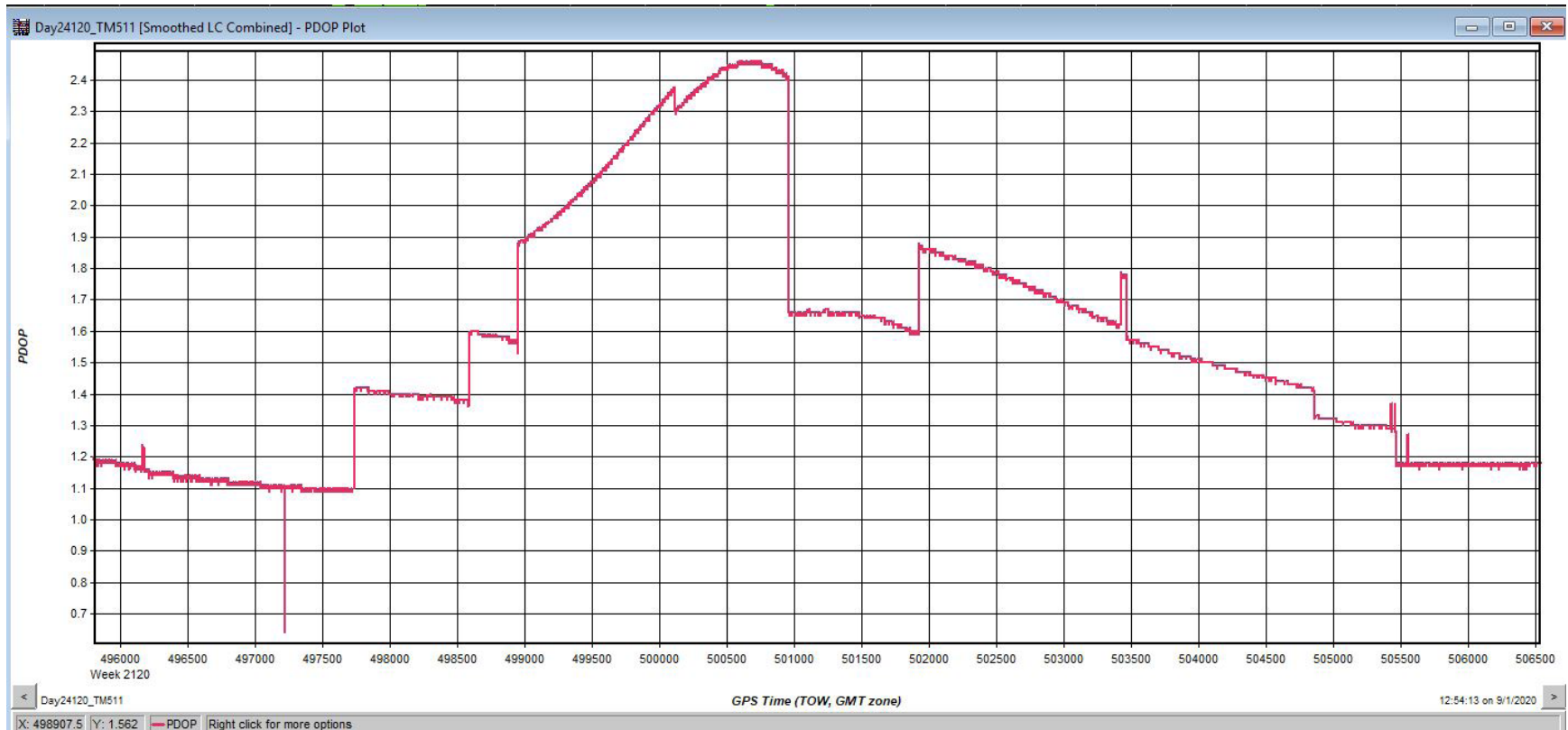
Day24120_TM511

Estimated Position Accuracy



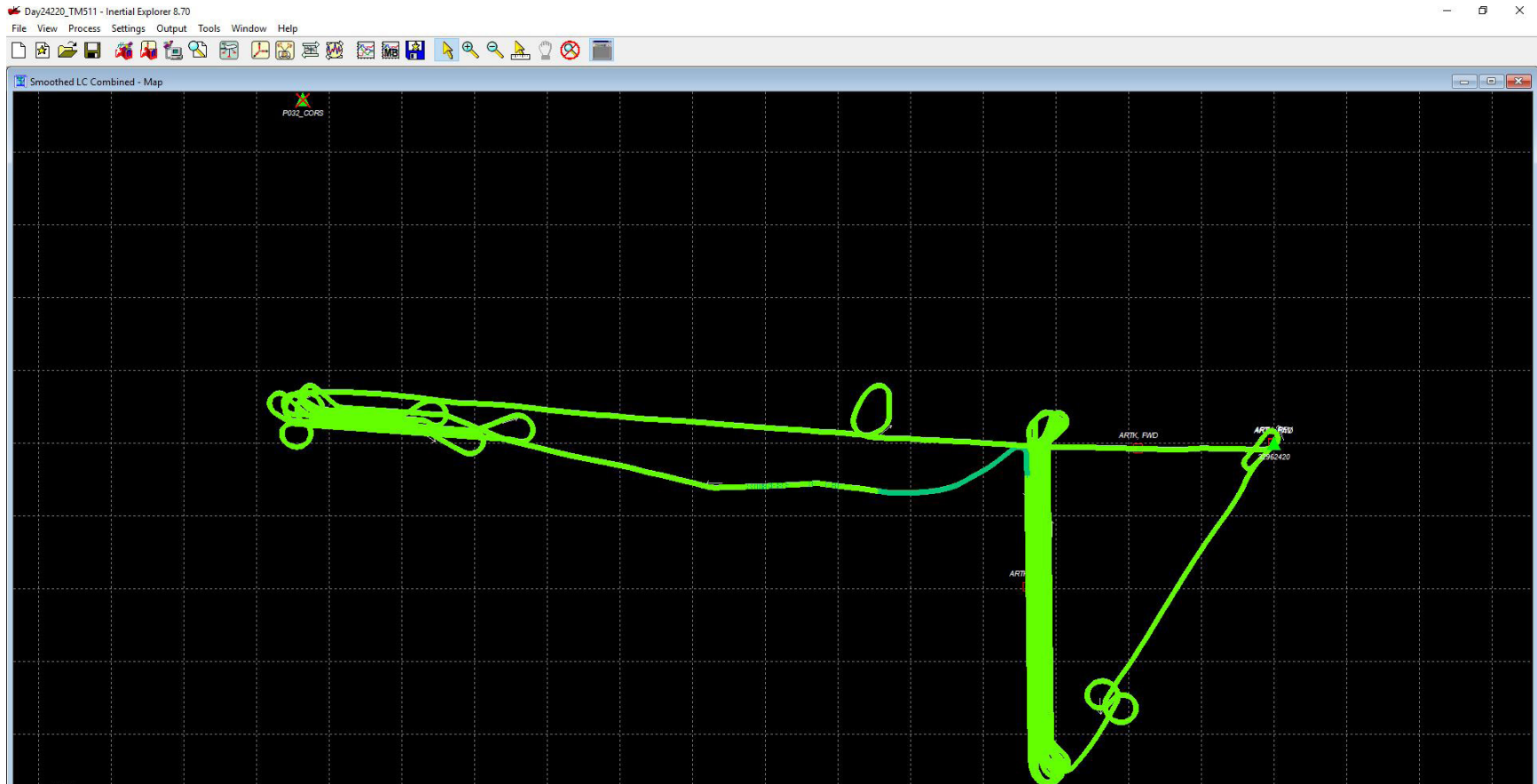
Day24120_TM511

PDOP Plot



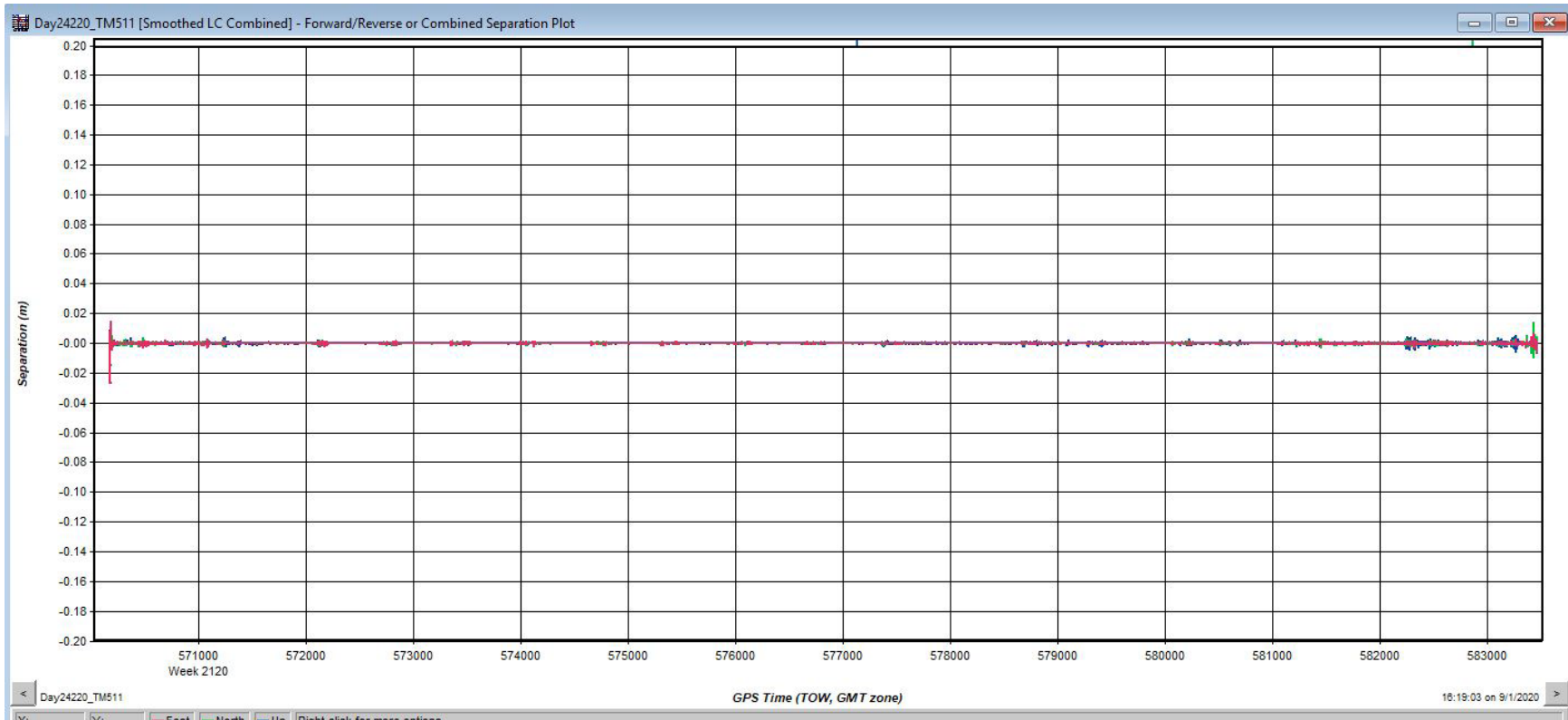
Day24220_TM511

Trajectory



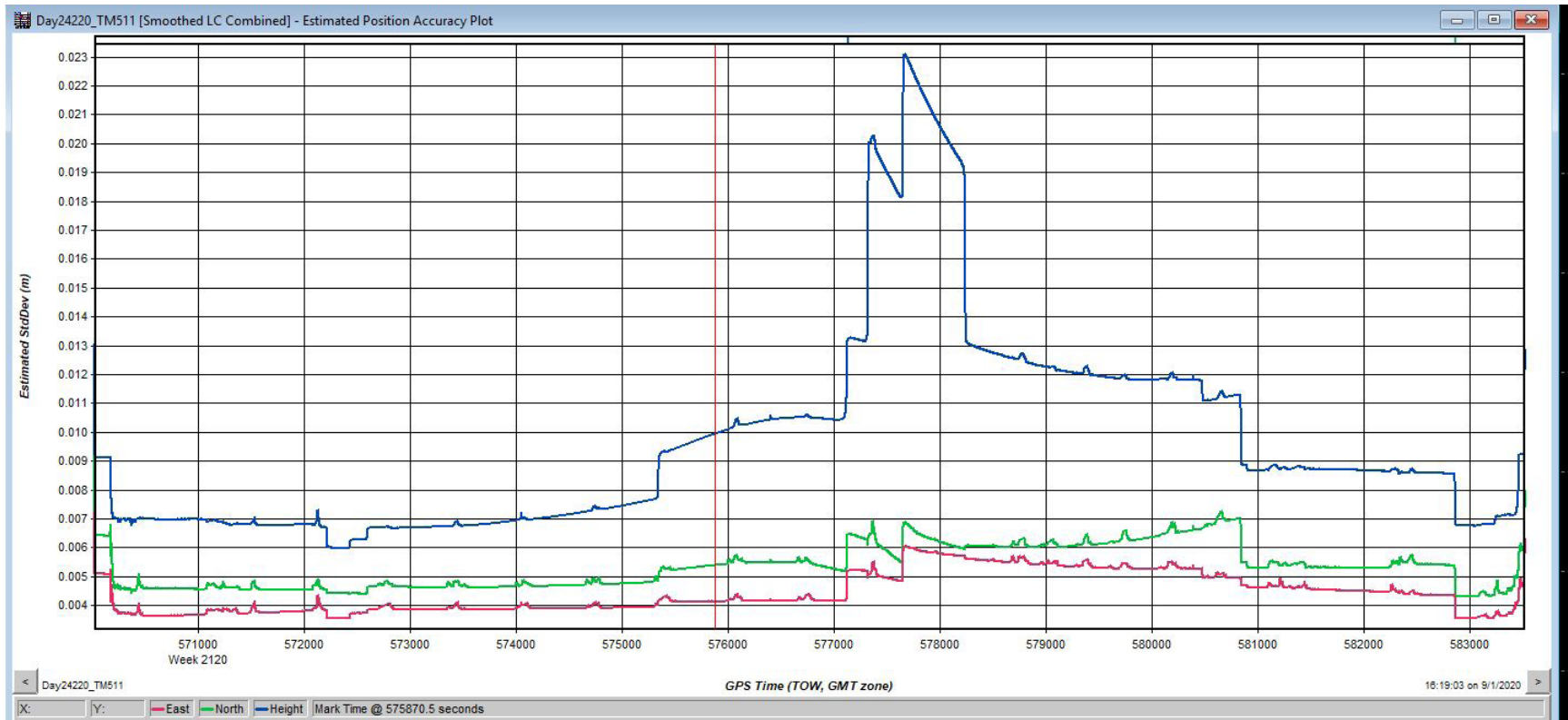
Day24220_TM511

Forward/Reverse or Combined Separation Plot



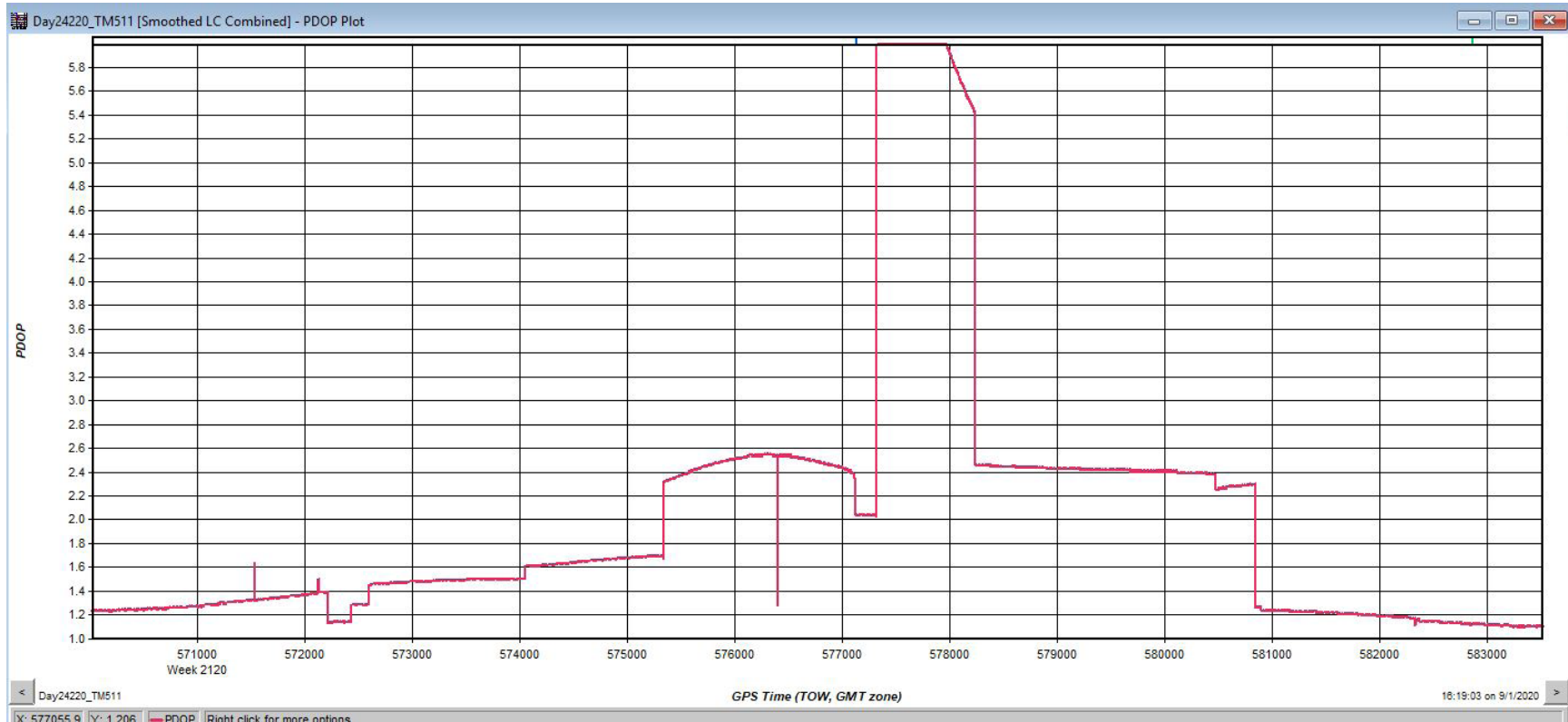
Day24220_TM511

Estimated Position Accuracy

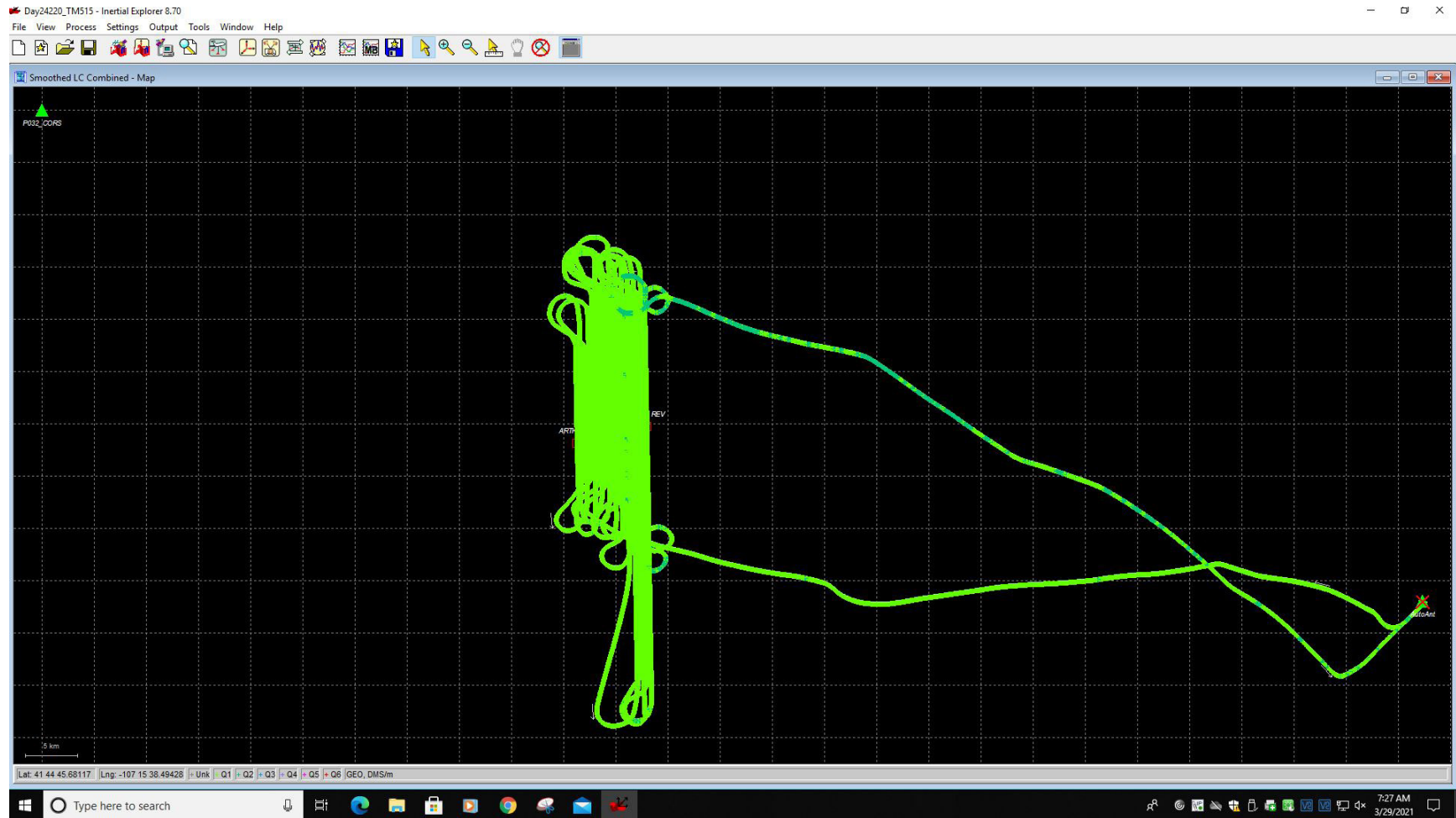


Day24220_TM511

PDOP Plot

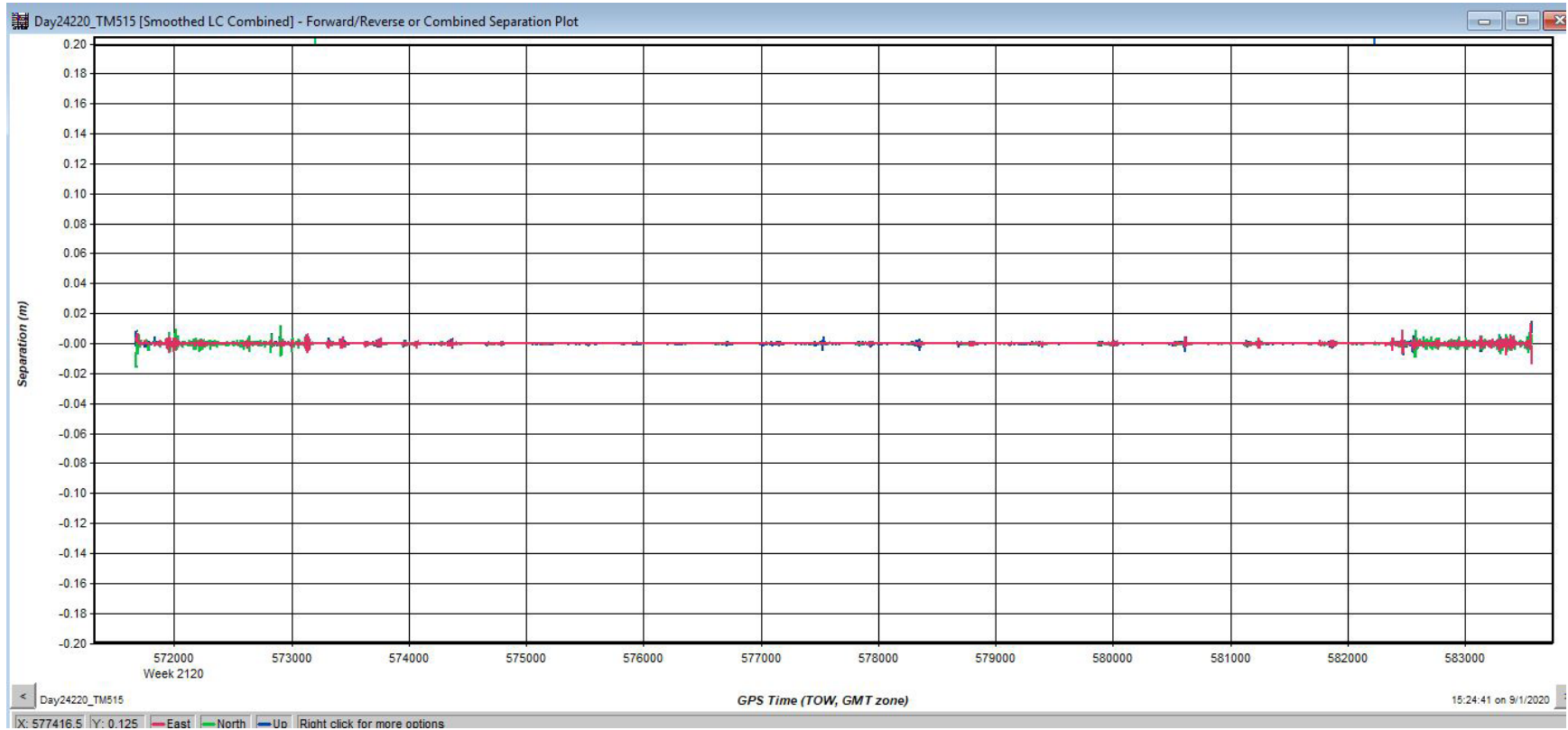


Day24220_TM557 Trajectory



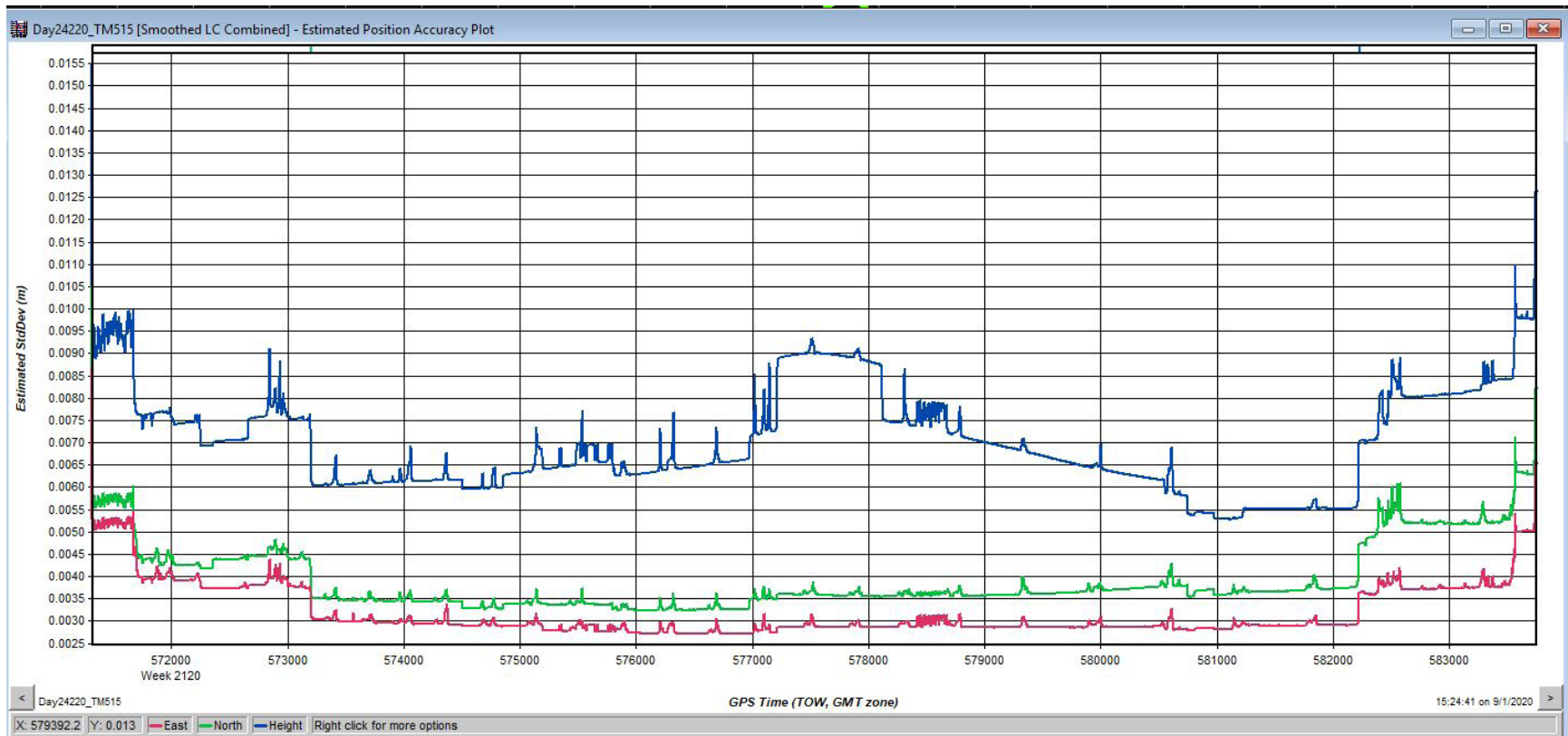
Day24220_TM557

Forward/Reverse or Combined Separation Plot



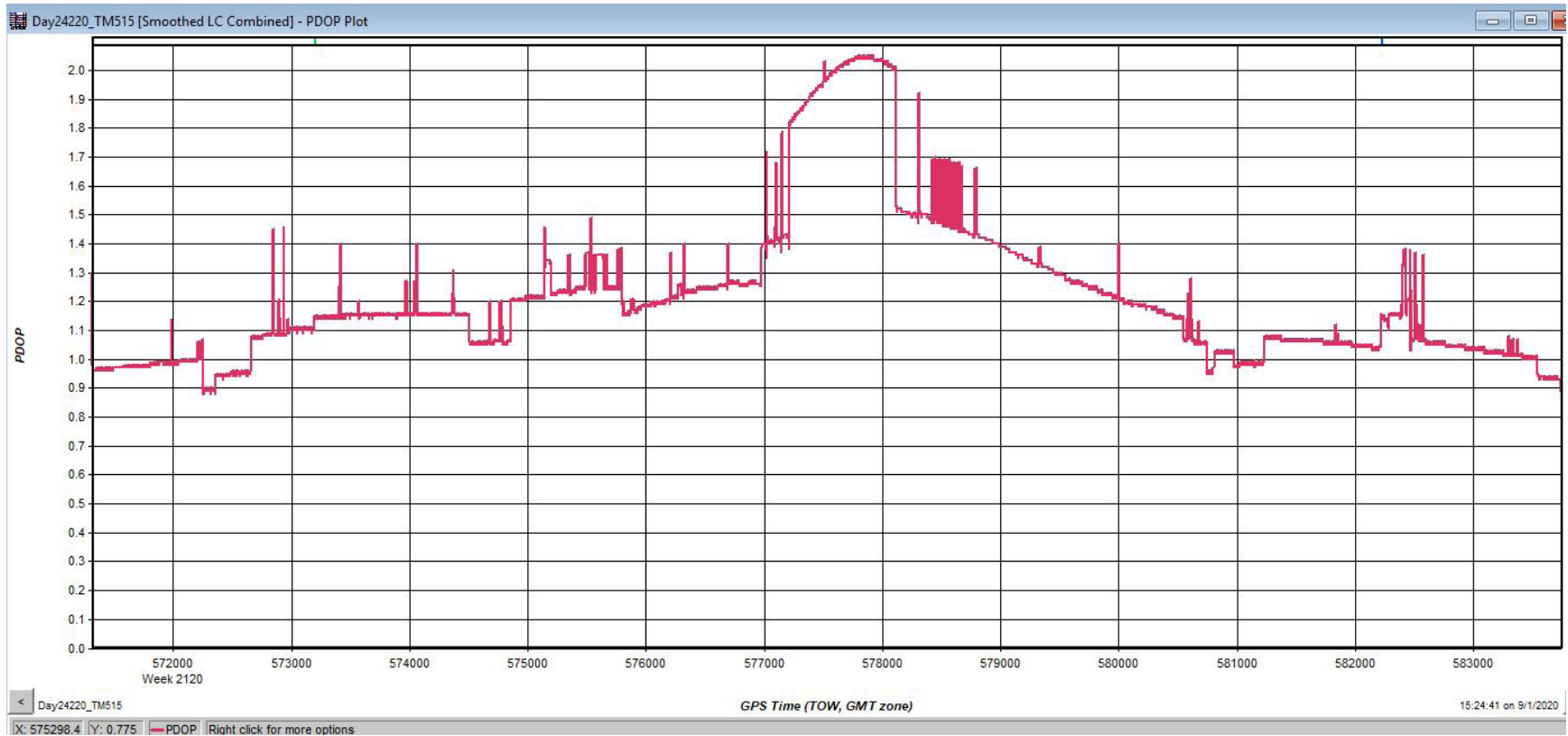
Day24220_TM557

Estimated Position Accuracy



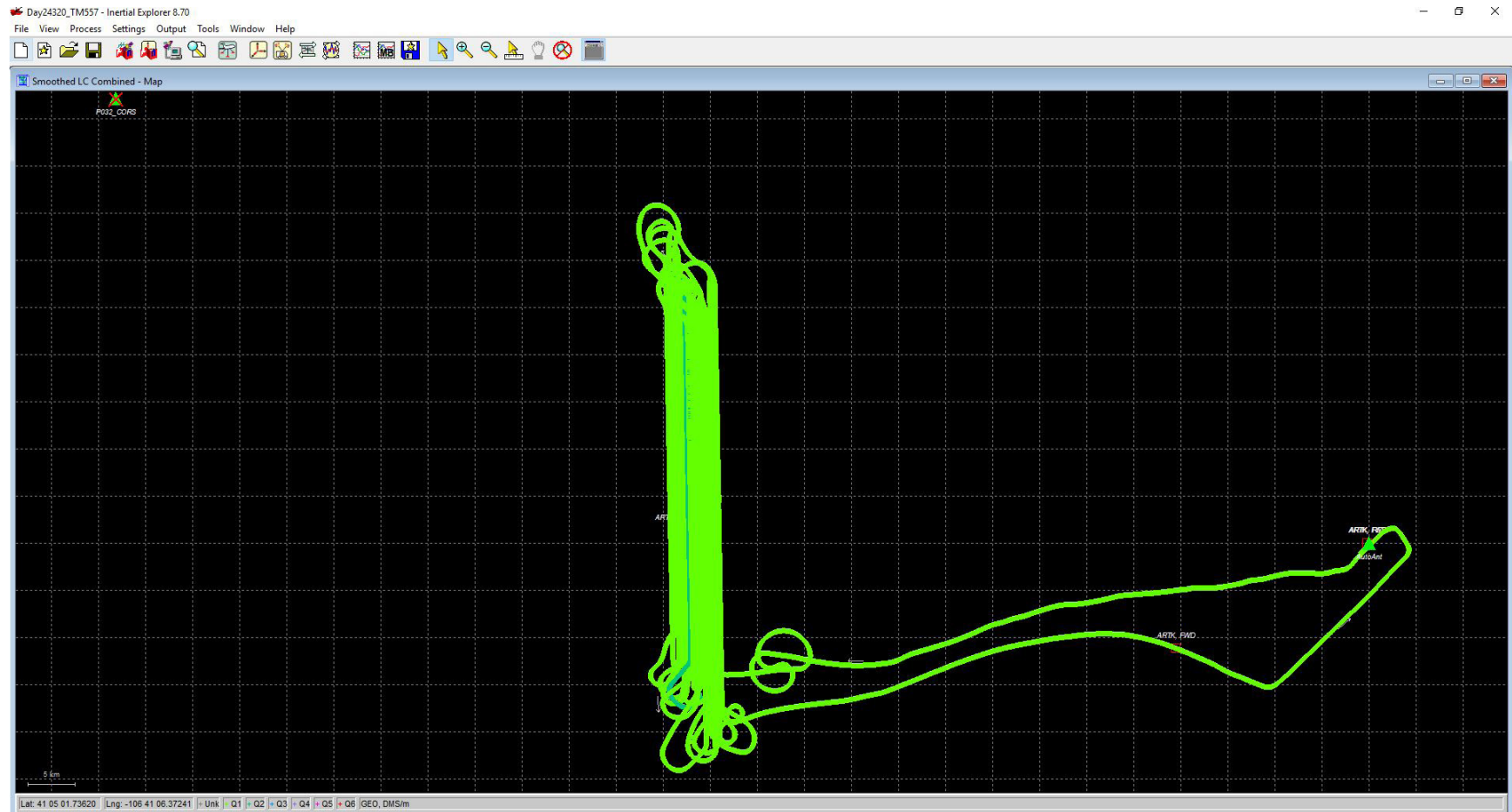
Day24220_TM557

PDOP Plot



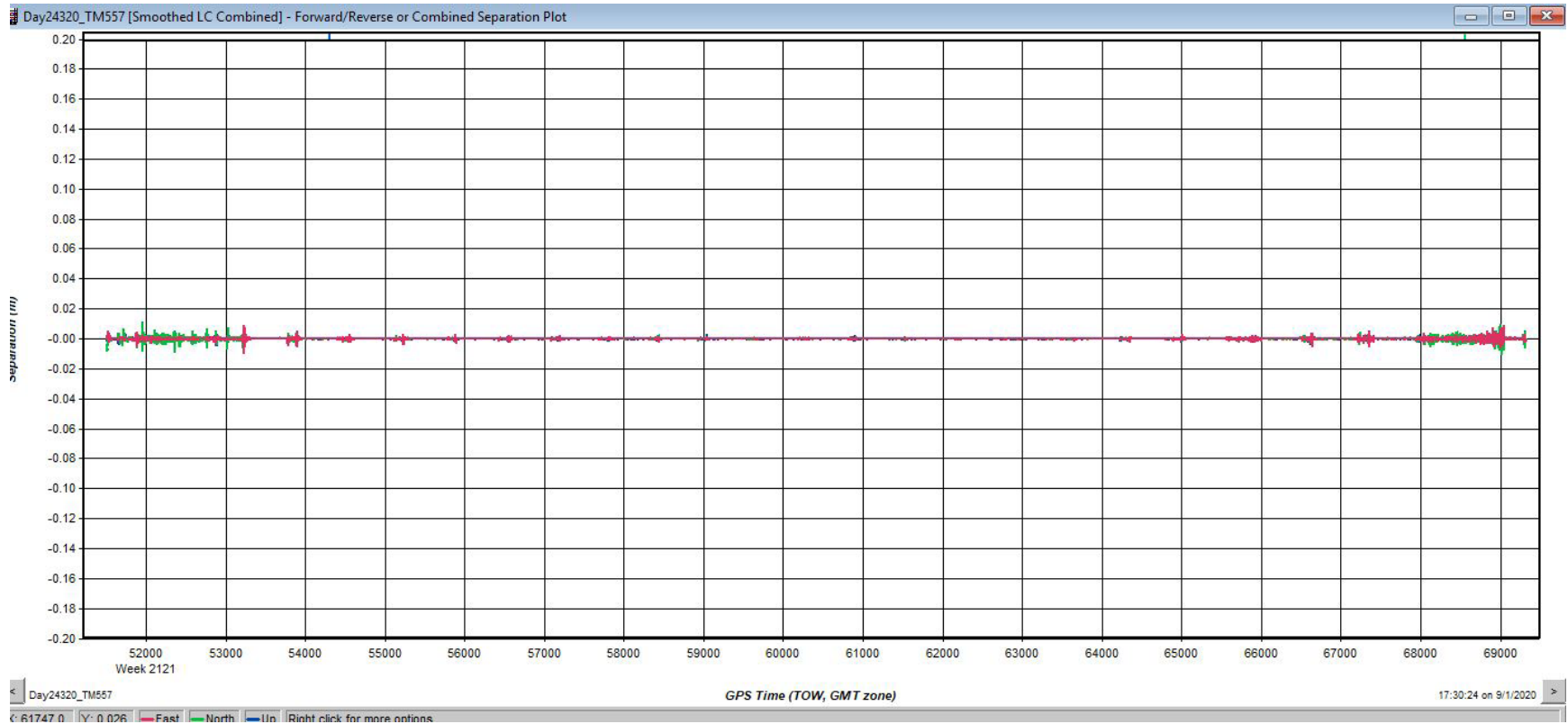
Day24320_TM557

Trajectory



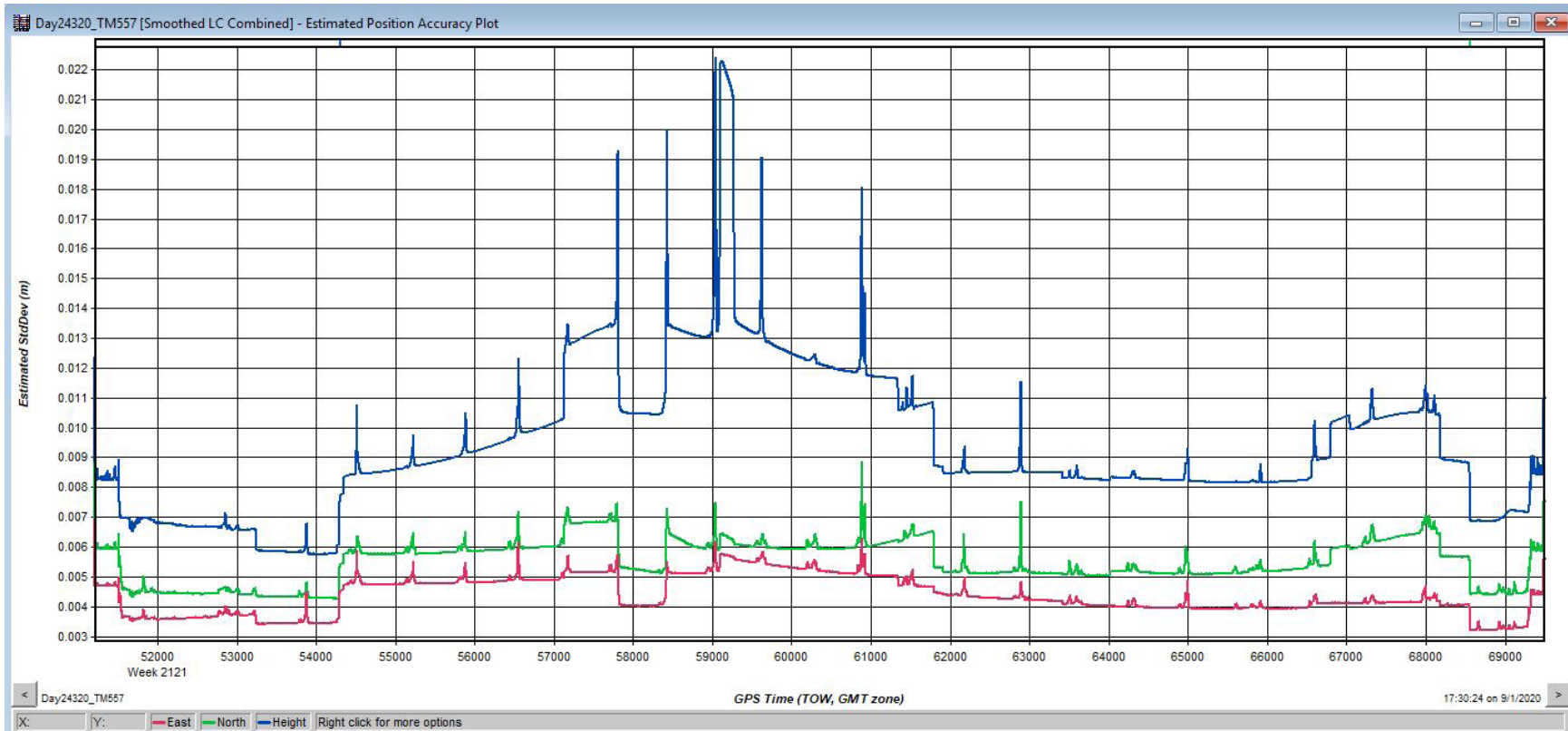
Day24320_TM557

Forward/Reverse or Combined Separation Plot



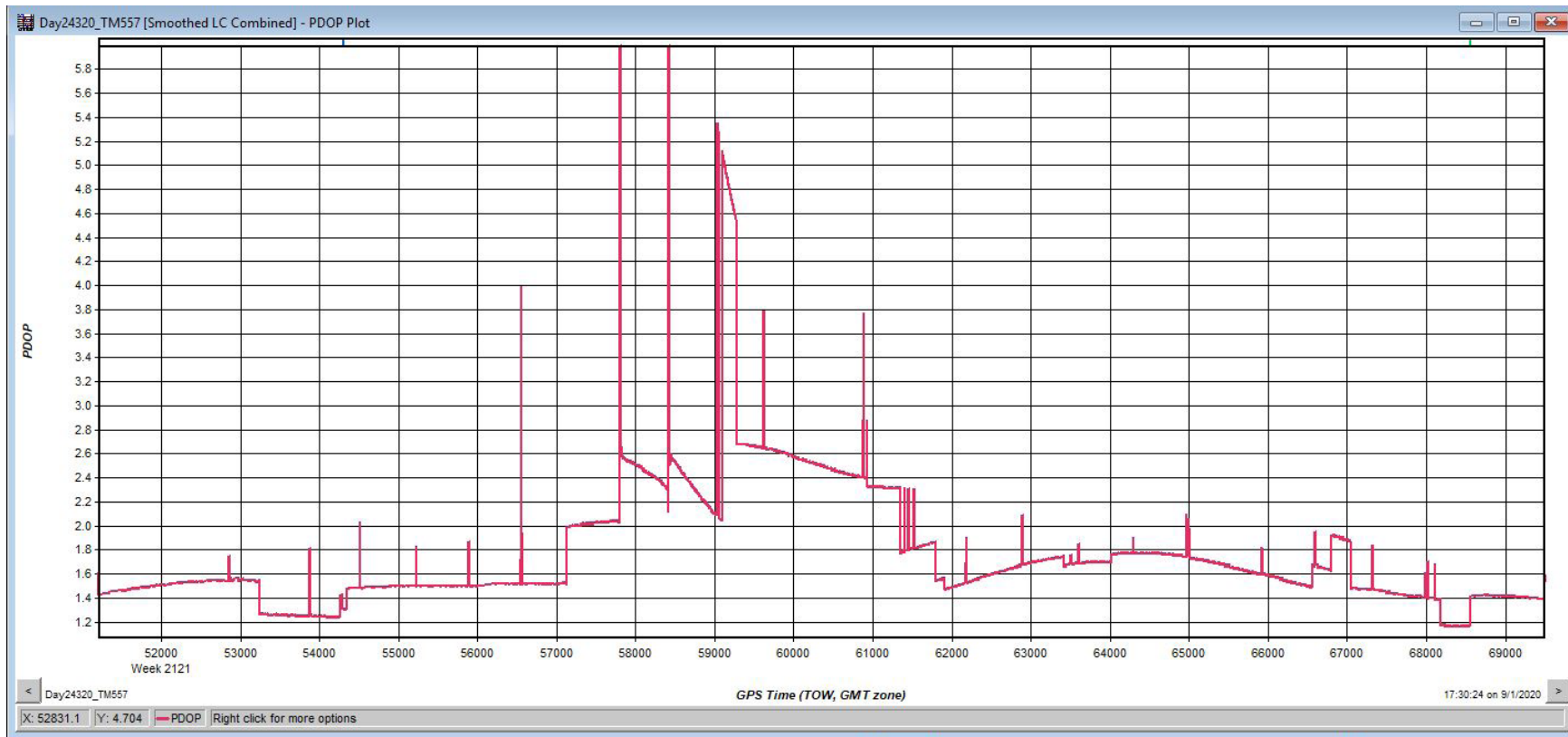
Day24320_TM557

Estimated Position Accuracy



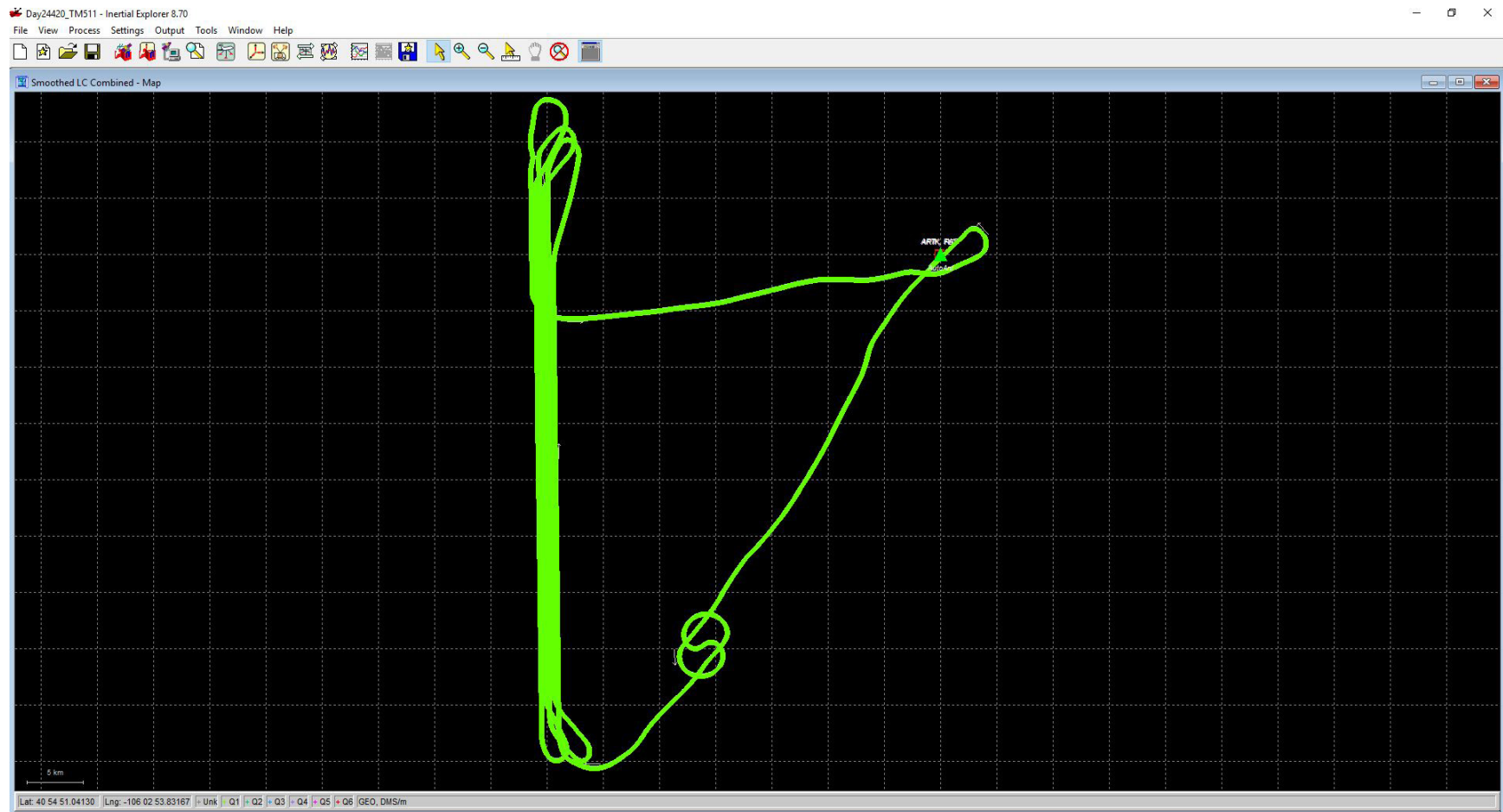
Day24320_TM557

PDOP Plot



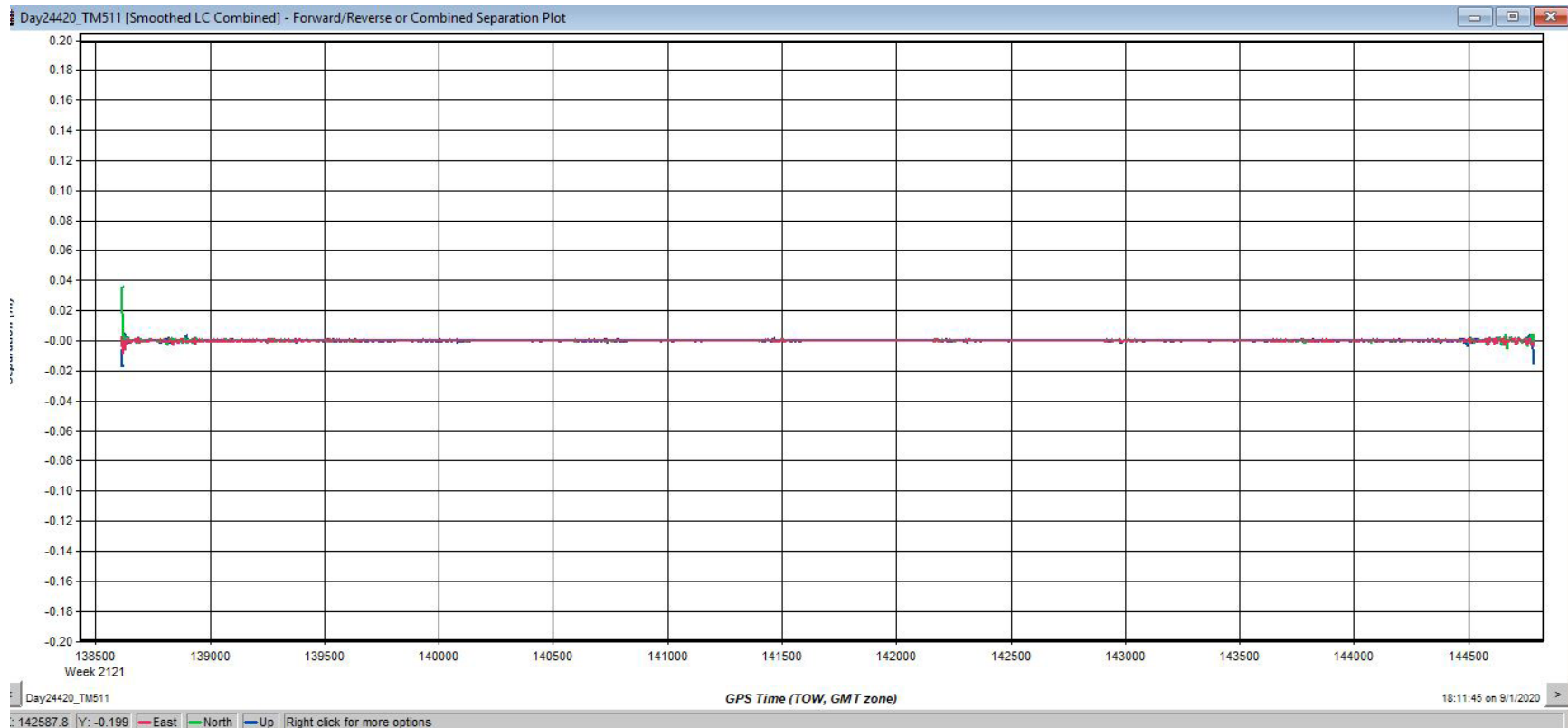
Day24420_TM511

Trajectory



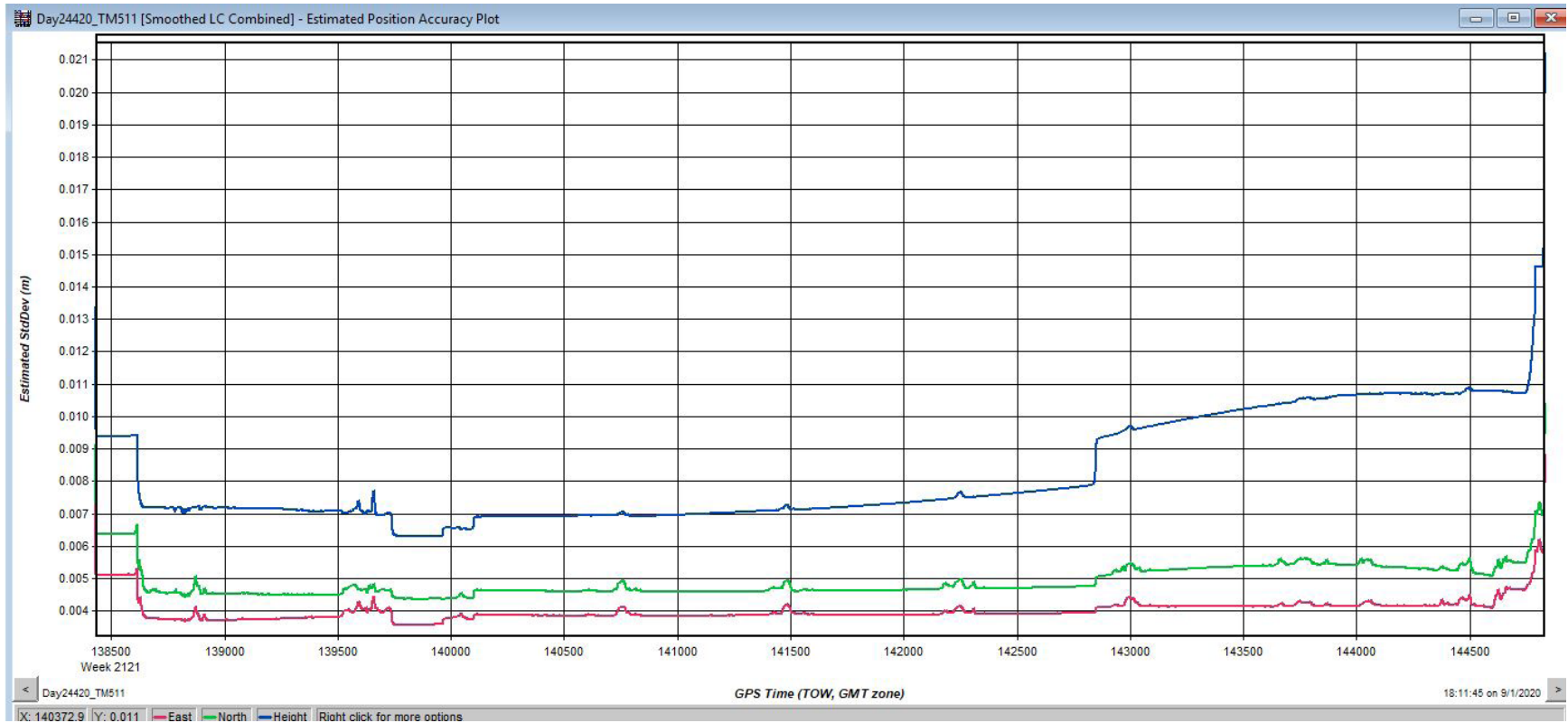
Day24420_TM511

Forward/Reverse or Combined Separation Plot



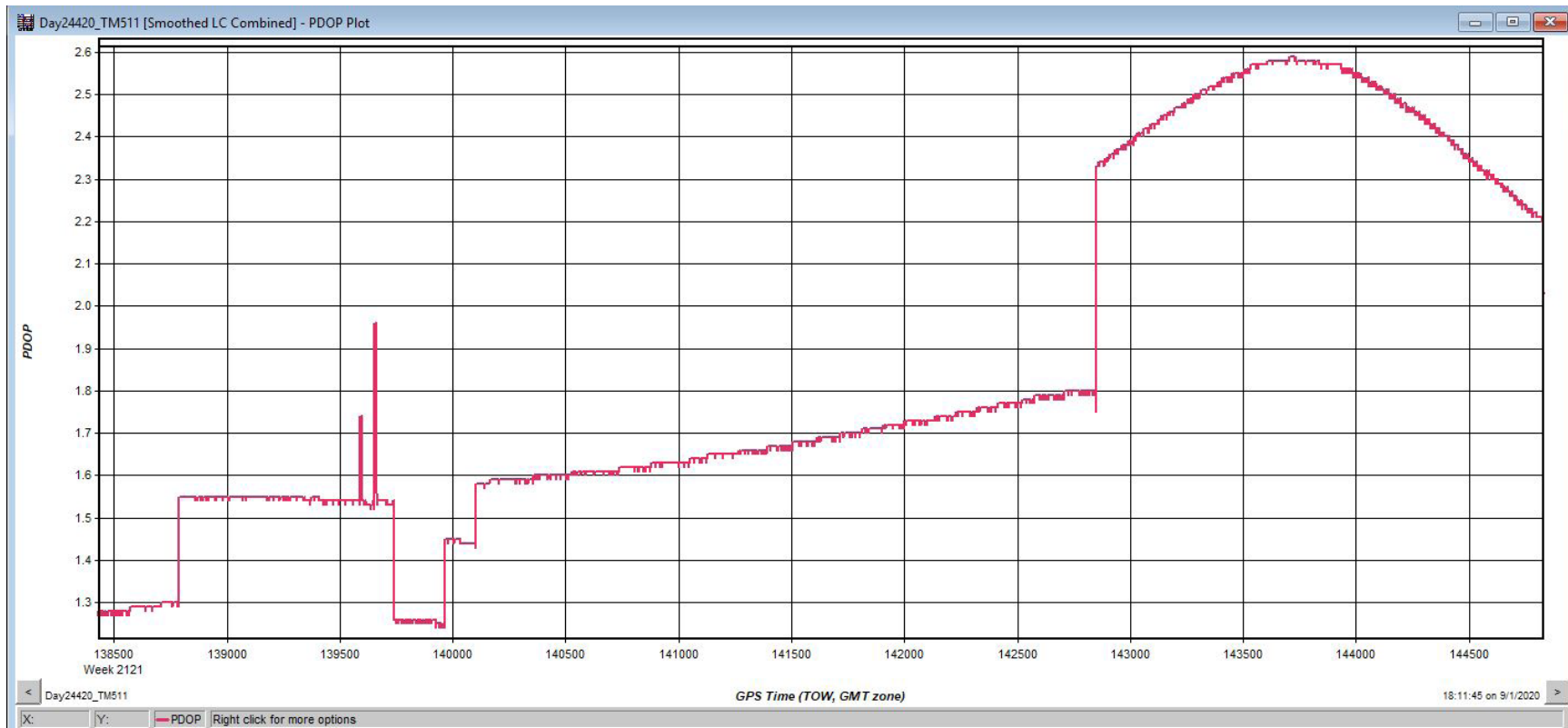
Day24420_TM511

Estimated Position Accuracy



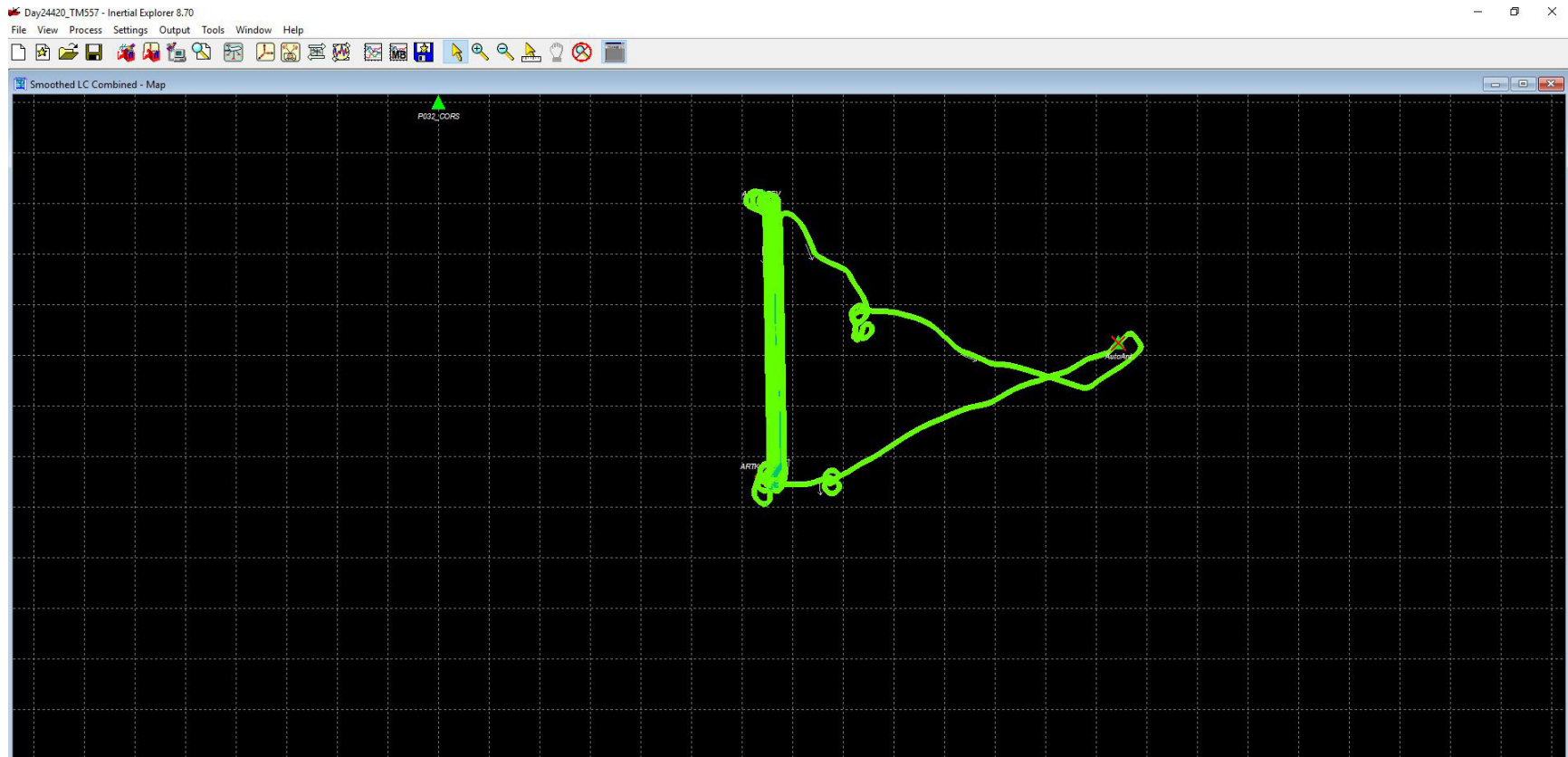
Day24420_TM511

PDOP Plot



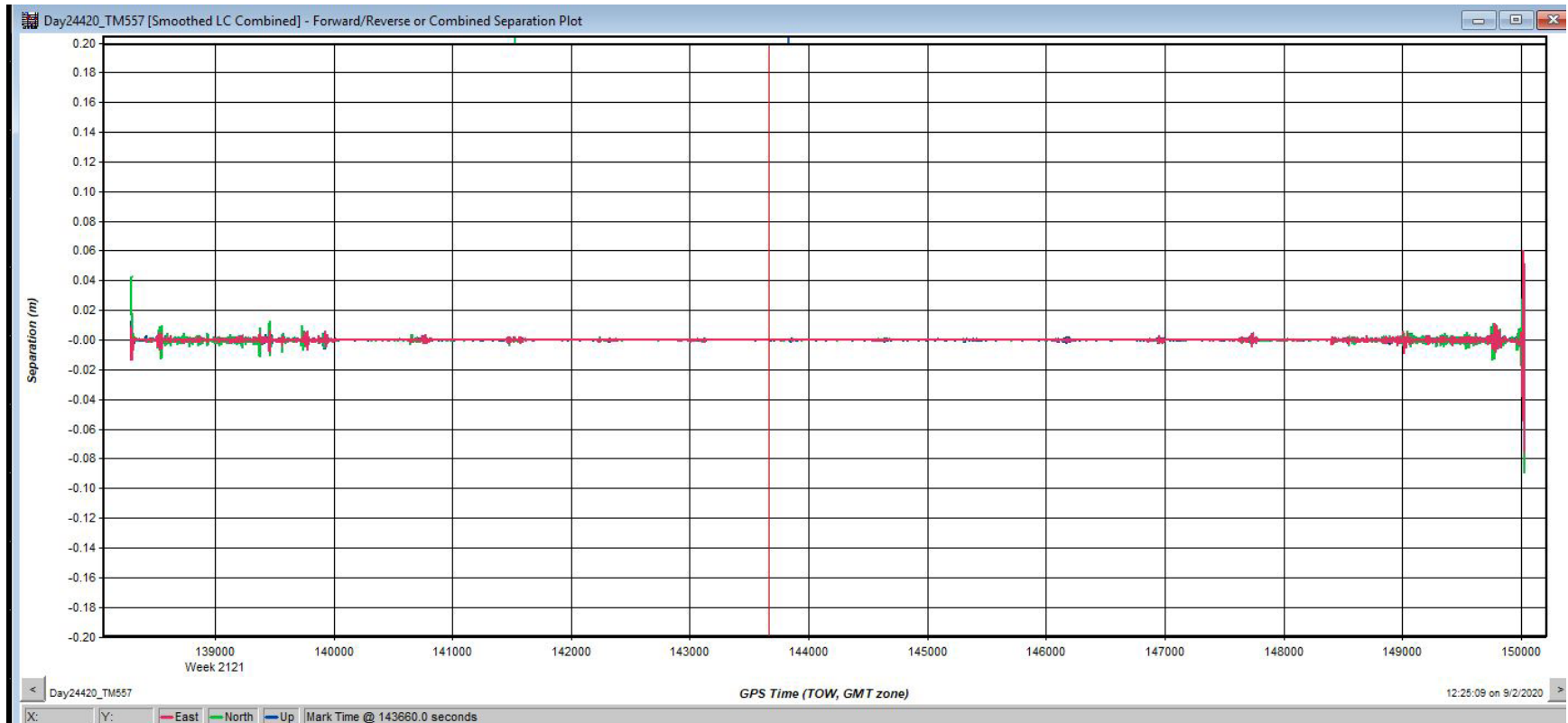
Day24420_TM557

Trajectory



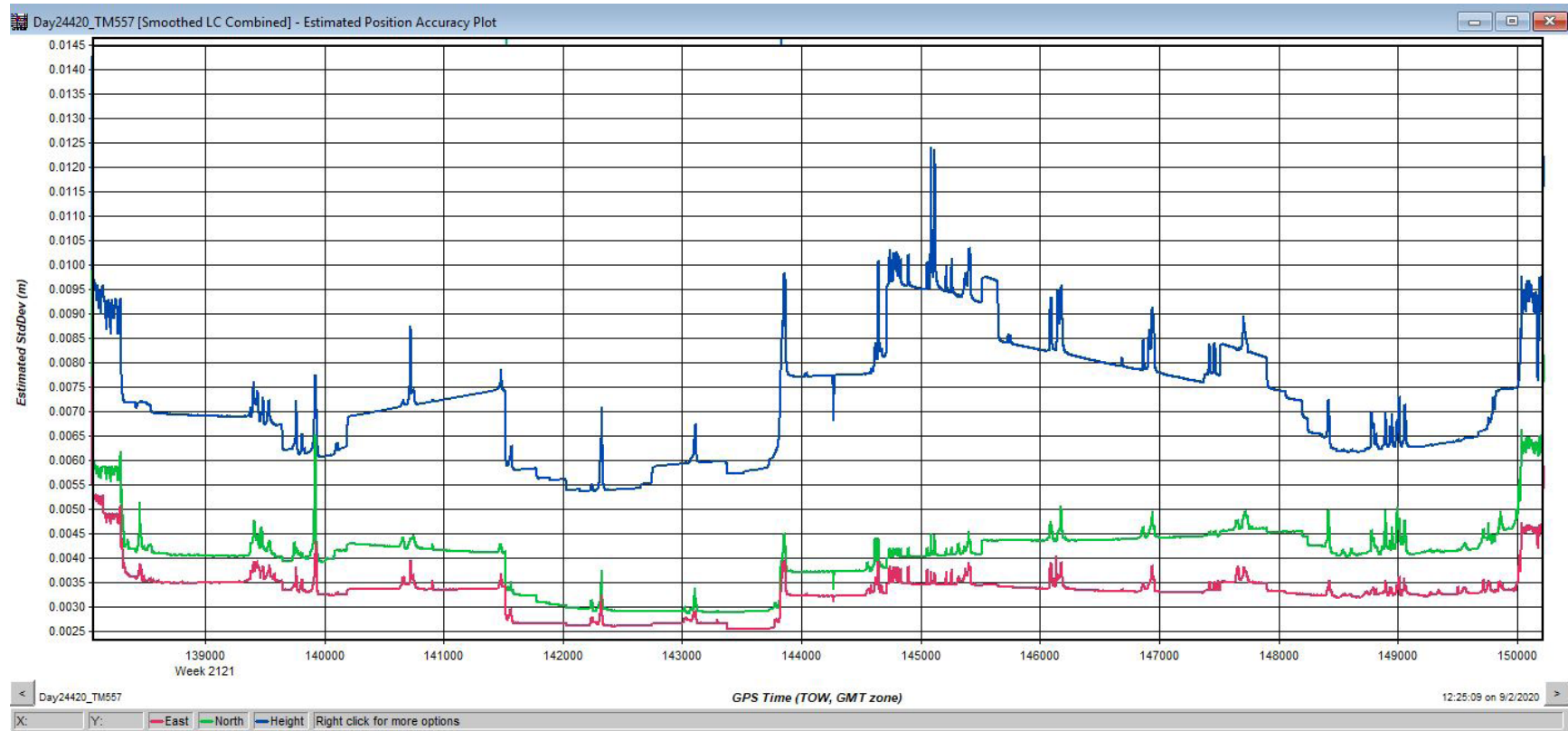
Day24420_TM557

Forward/Reverse or Combined Separation Plot



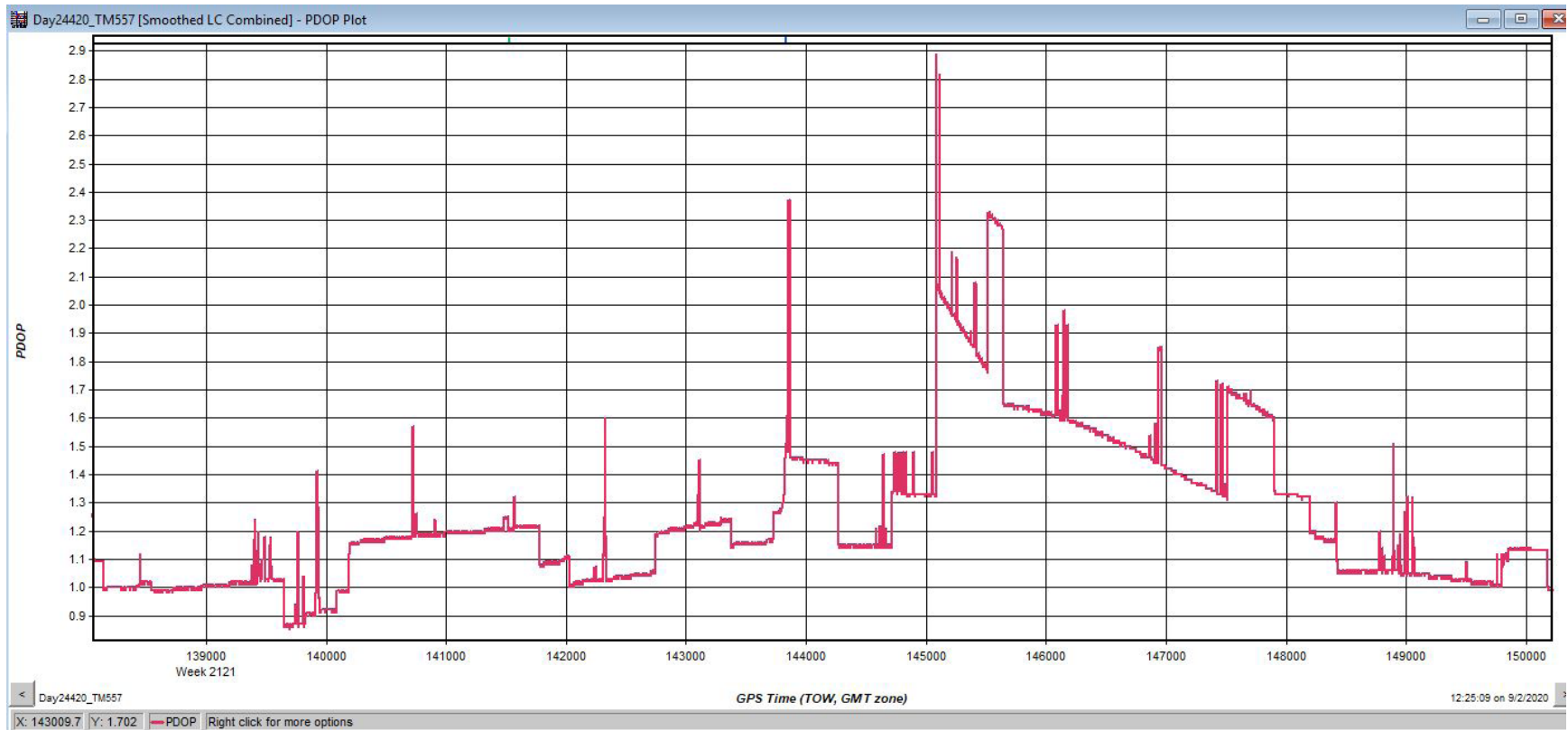
Day24420_TM557

Estimated Position Accuracy



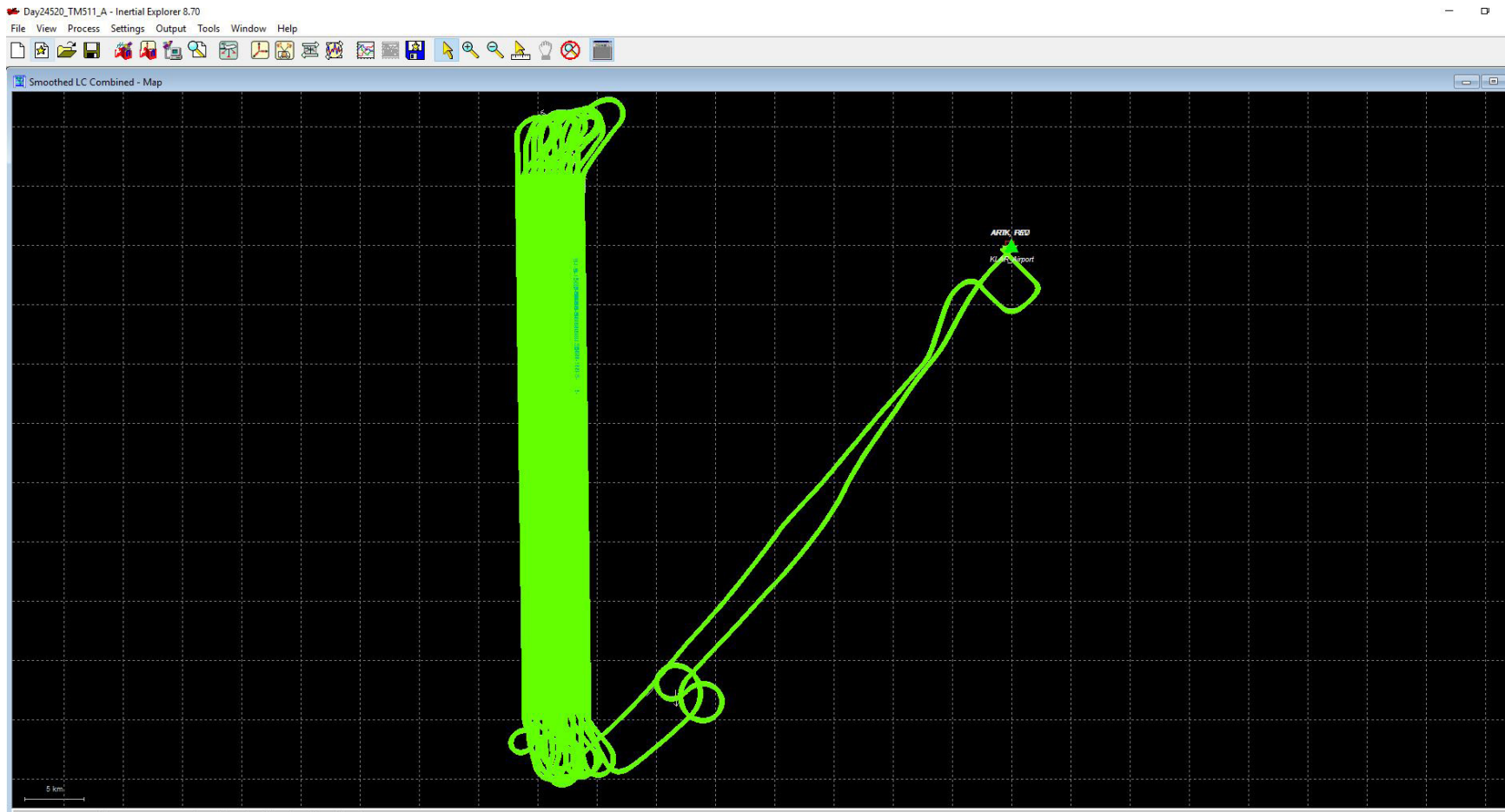
Day24420_TM557

PDOP Plot



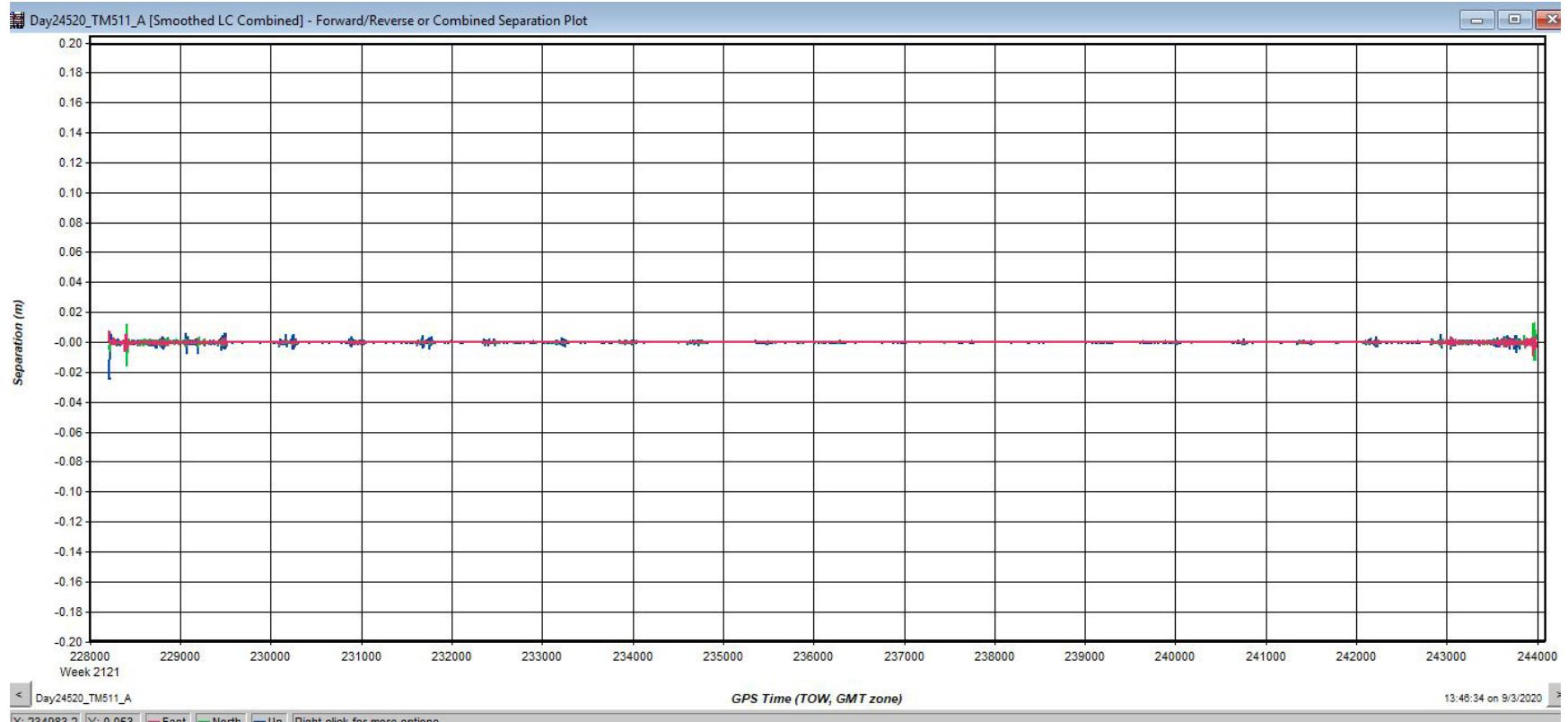
Day24520_TM511_A

Trajectory



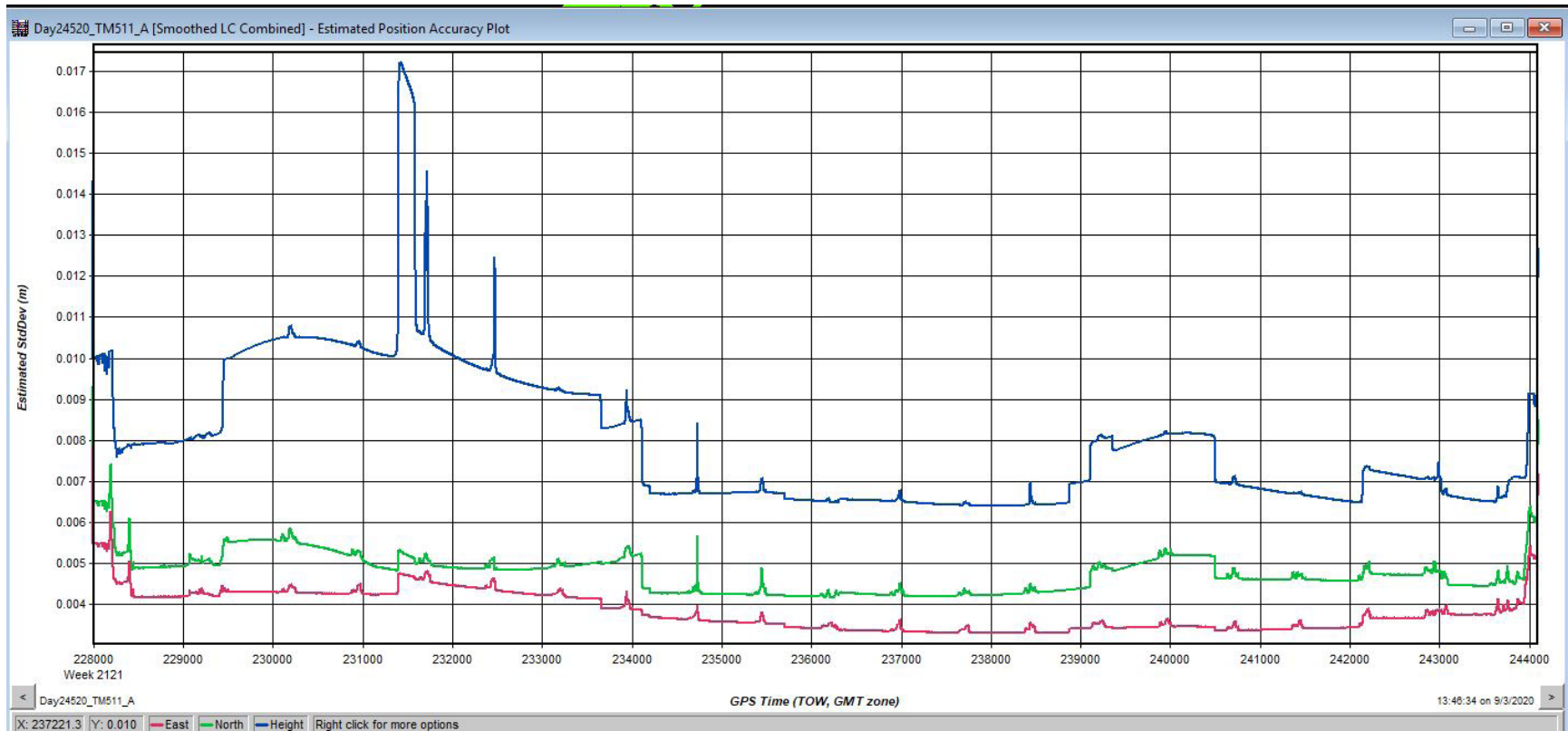
Day24520_TM511_A

Forward/Reverse or Combined Separation Plot



Day24520_TM511_A

Estimated Position Accuracy



Day24520_TM511_A

PDOP Plot

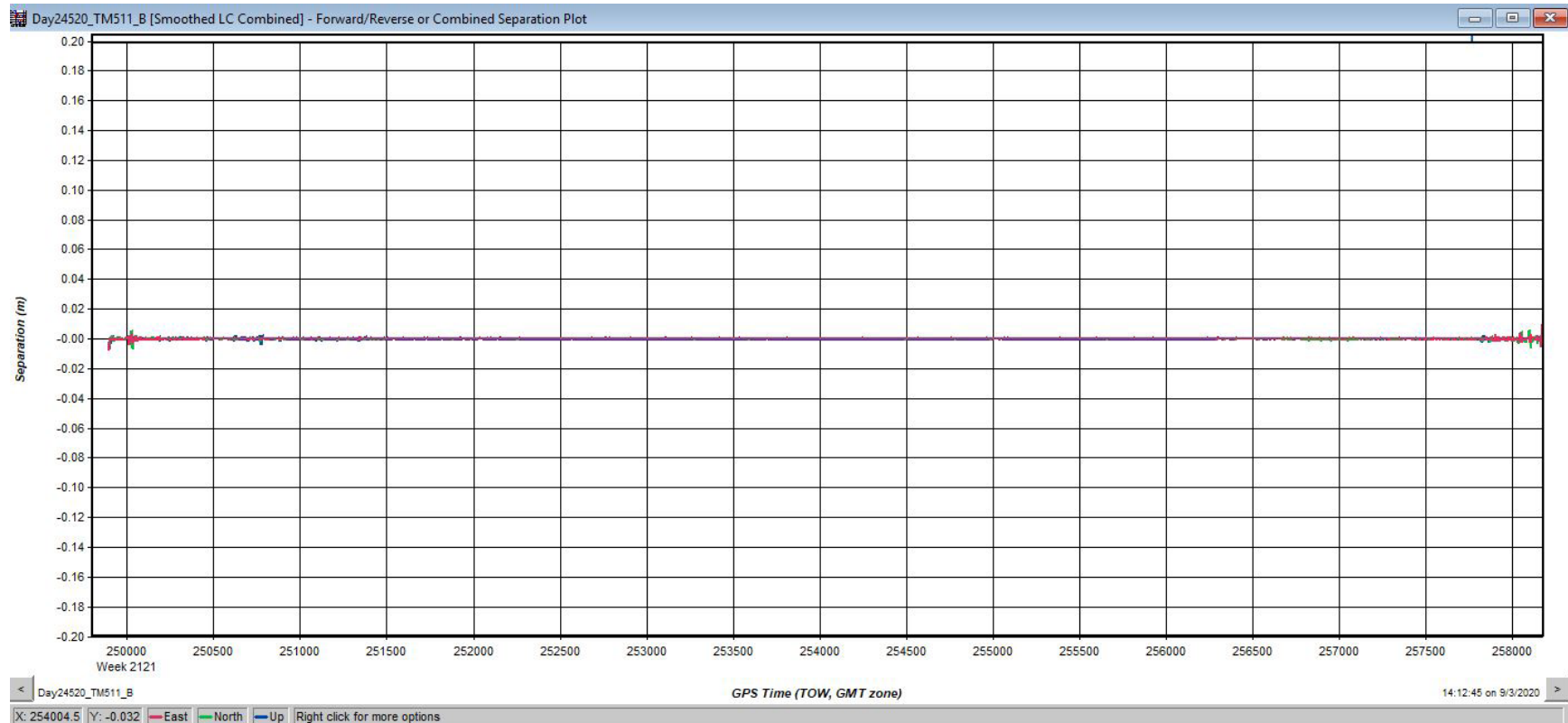


Day24520_TM511_B Trajectory



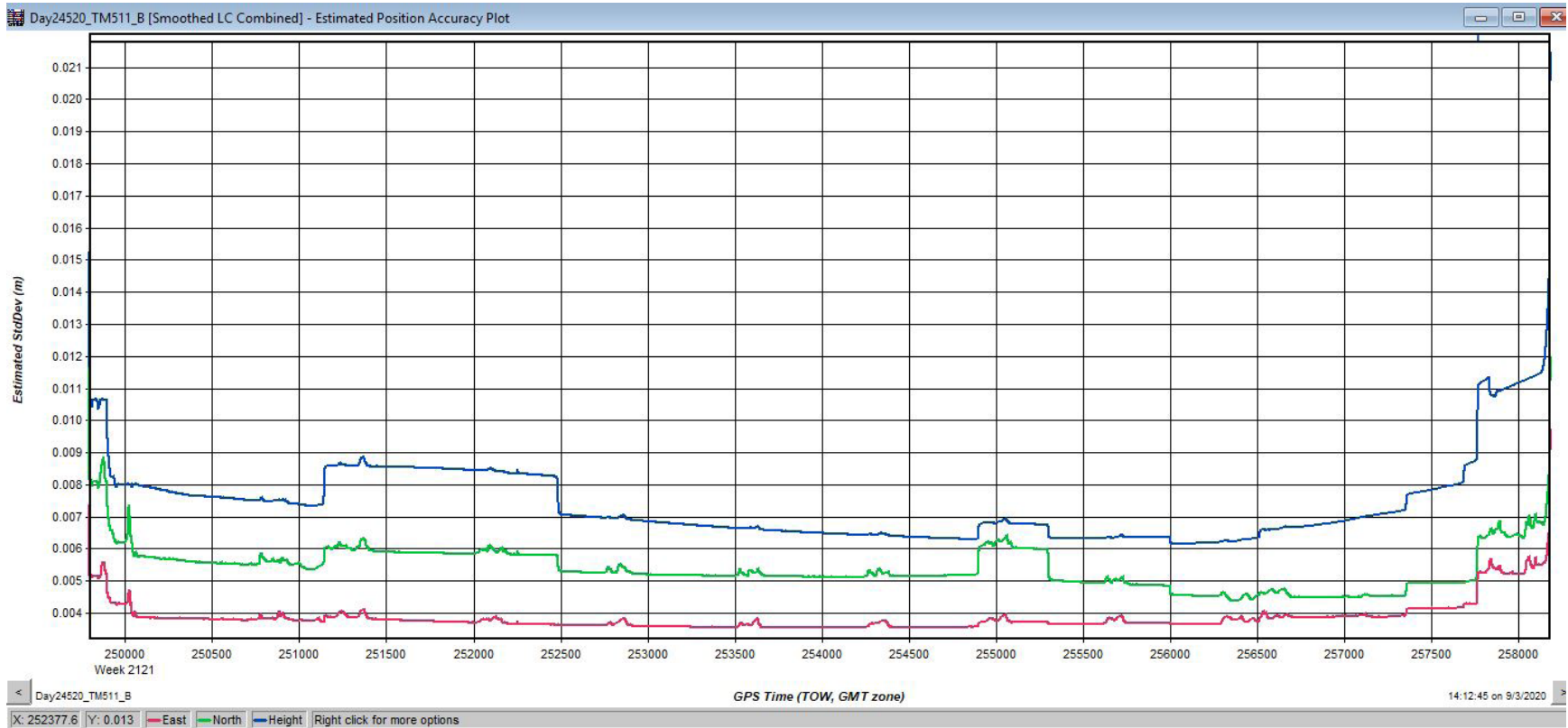
Day24520_TM511_B

Forward/Reverse or Combined Separation Plot



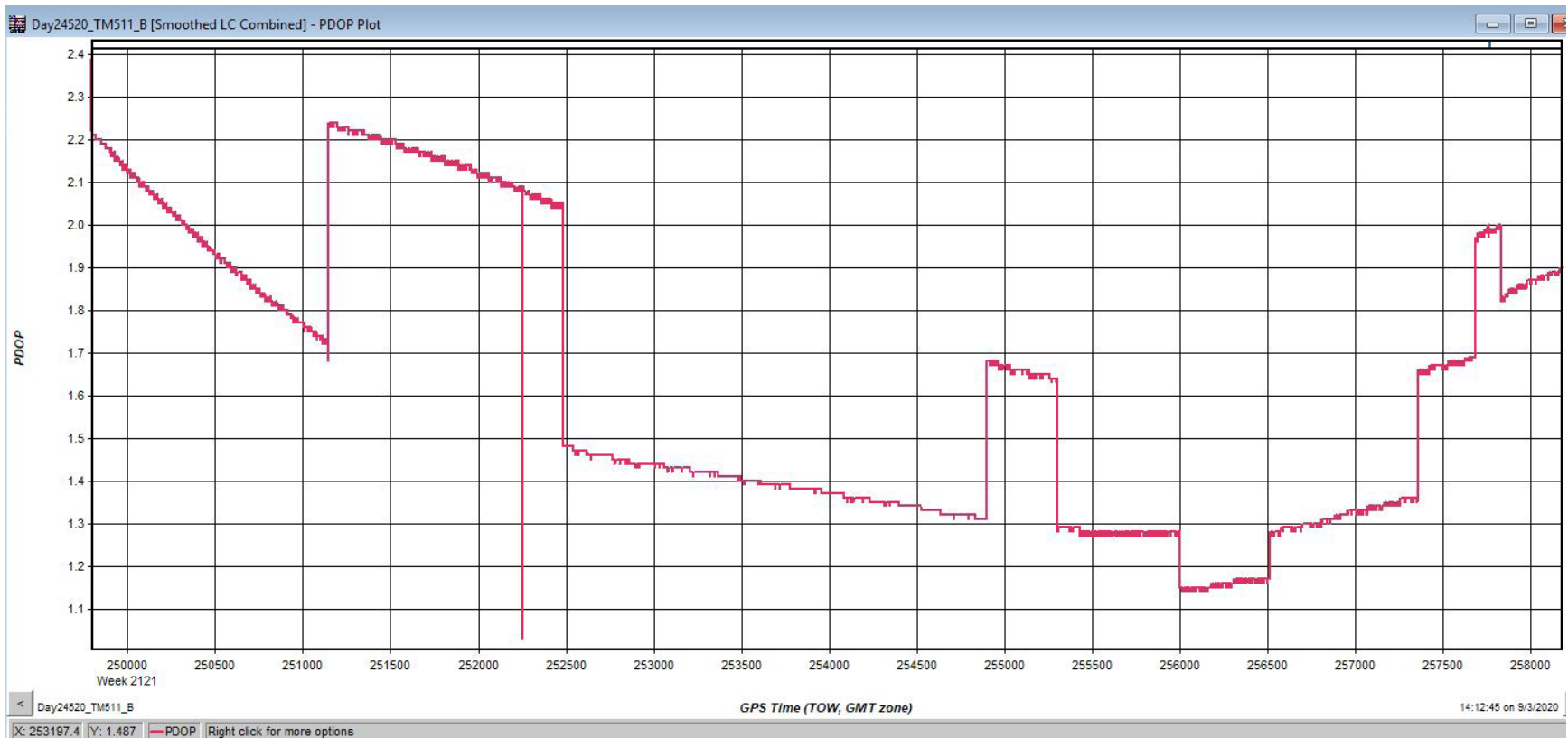
Day24520_TM511_B

Estimated Position Accuracy



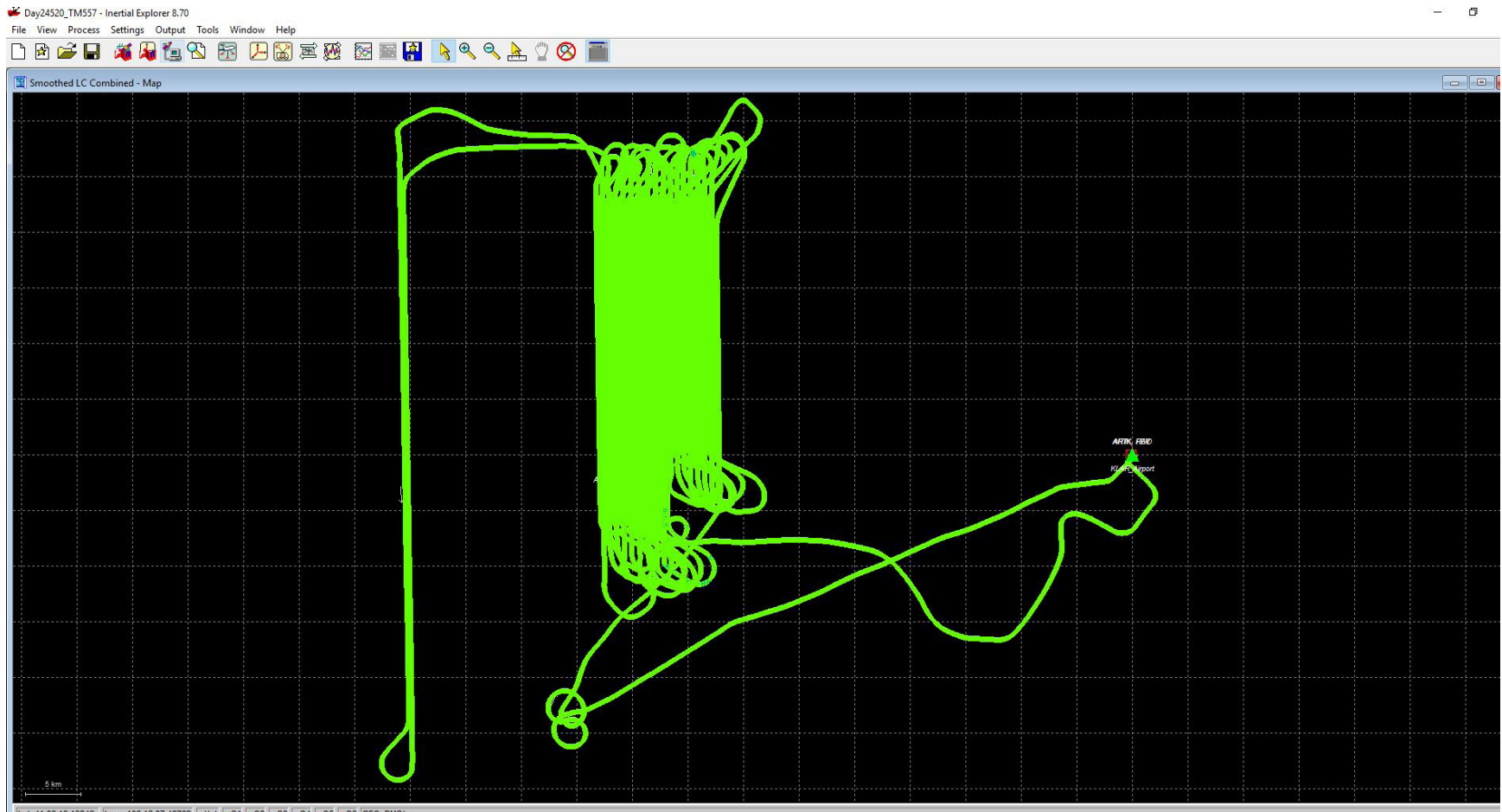
Day24520_TM511_B

PDOP Plot



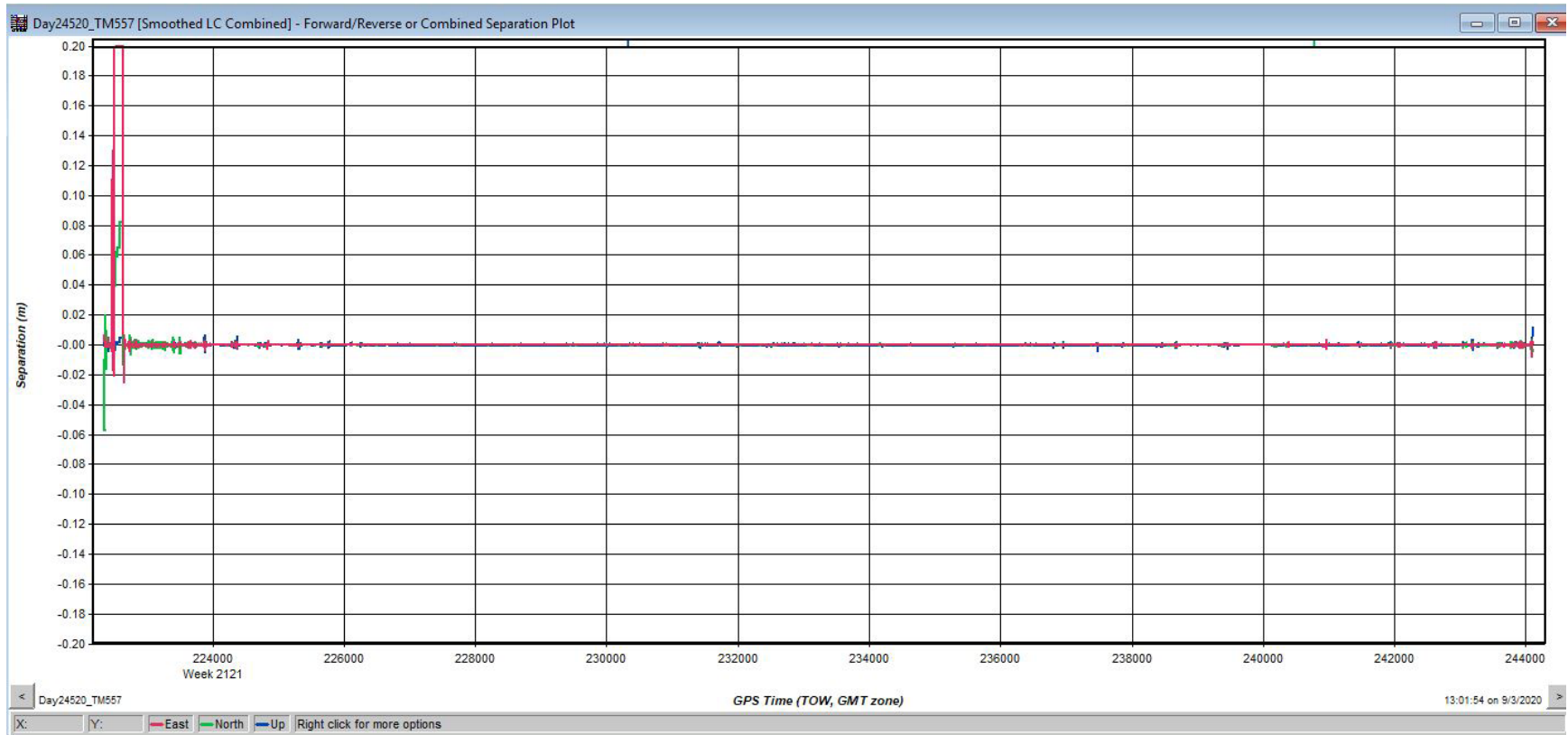
Day24520_TM557

Trajectory



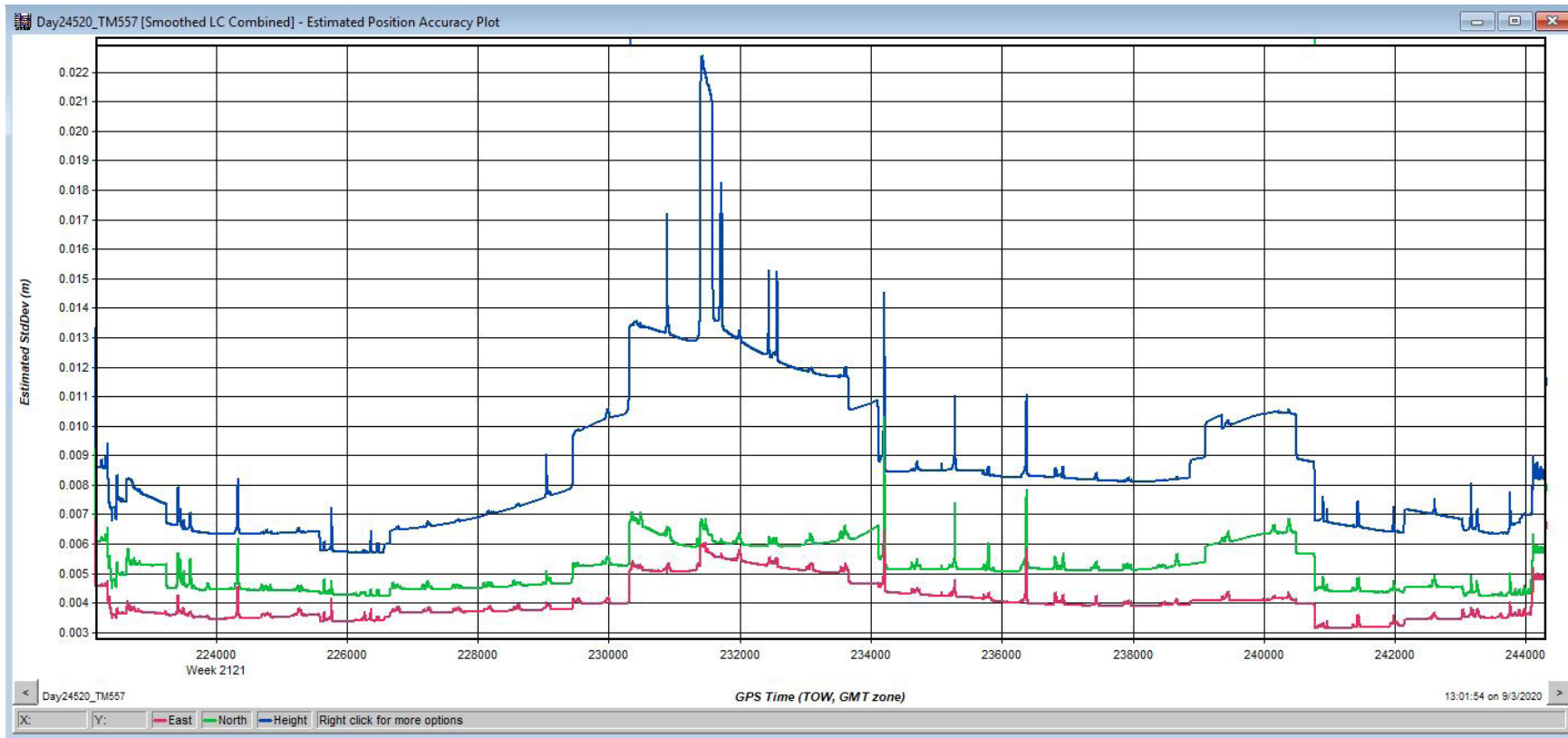
Day24520_TM557

Forward/Reverse or Combined Separation Plot



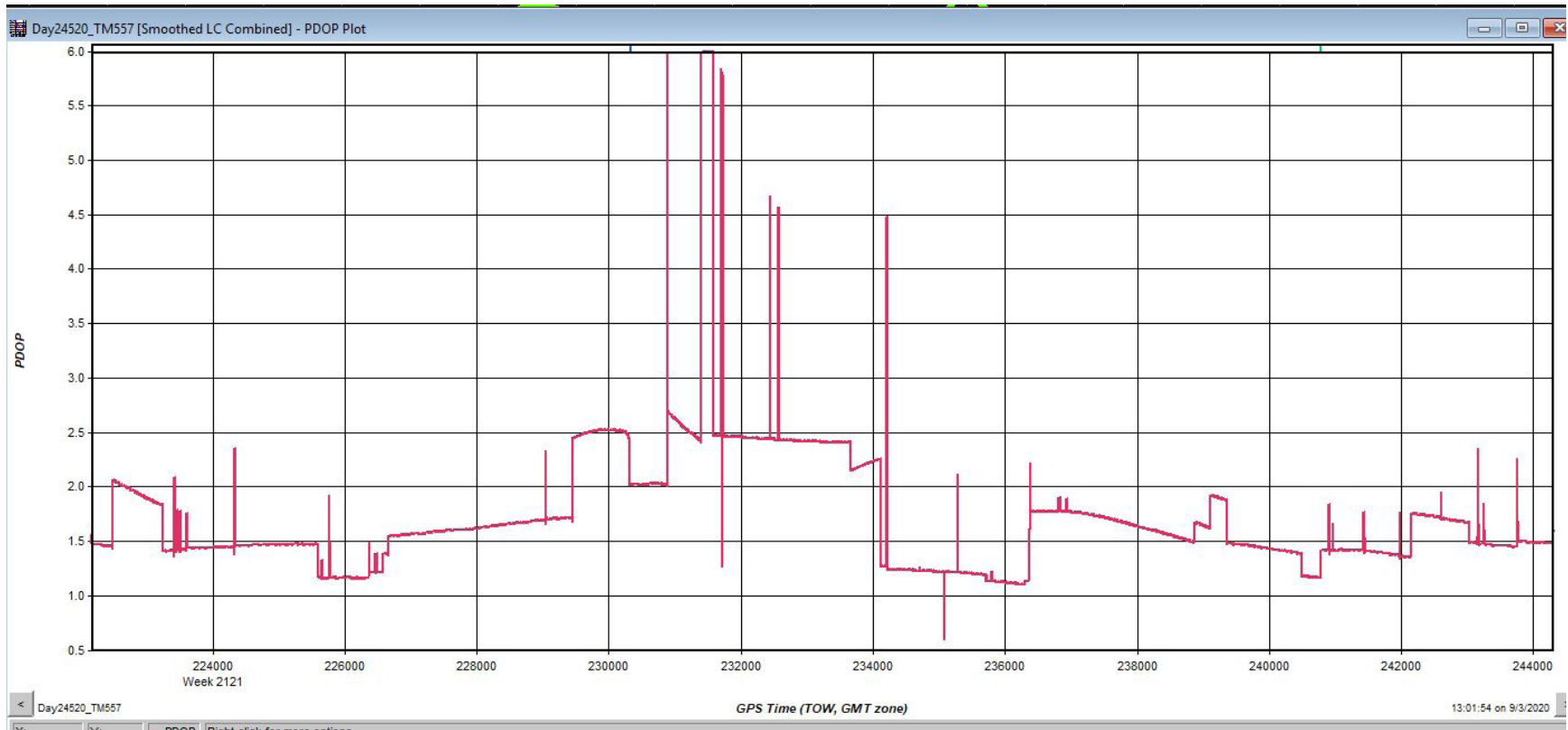
Day24520_TM557

Estimated Position Accuracy



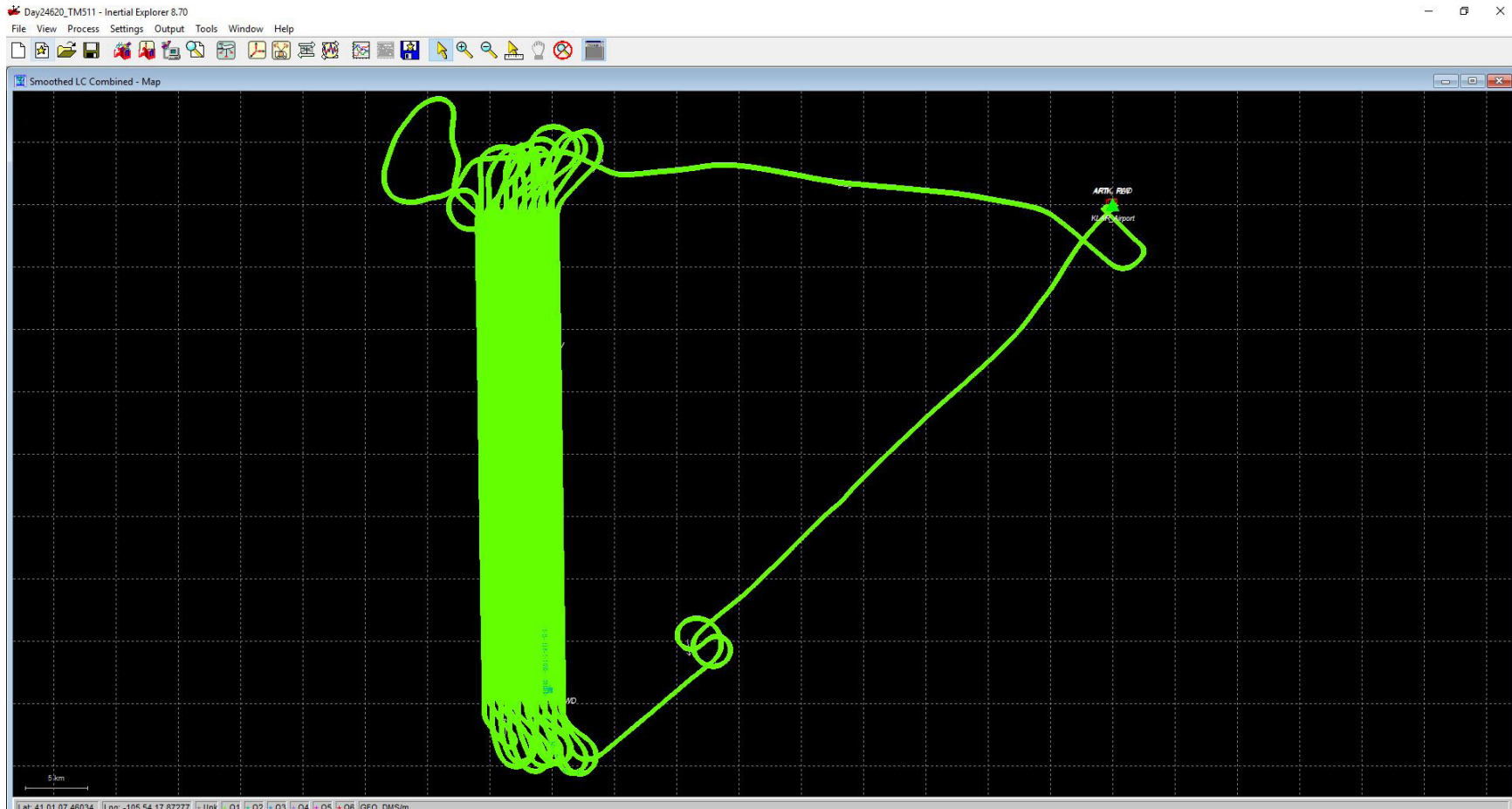
Day24520_TM557

PDOP Plot



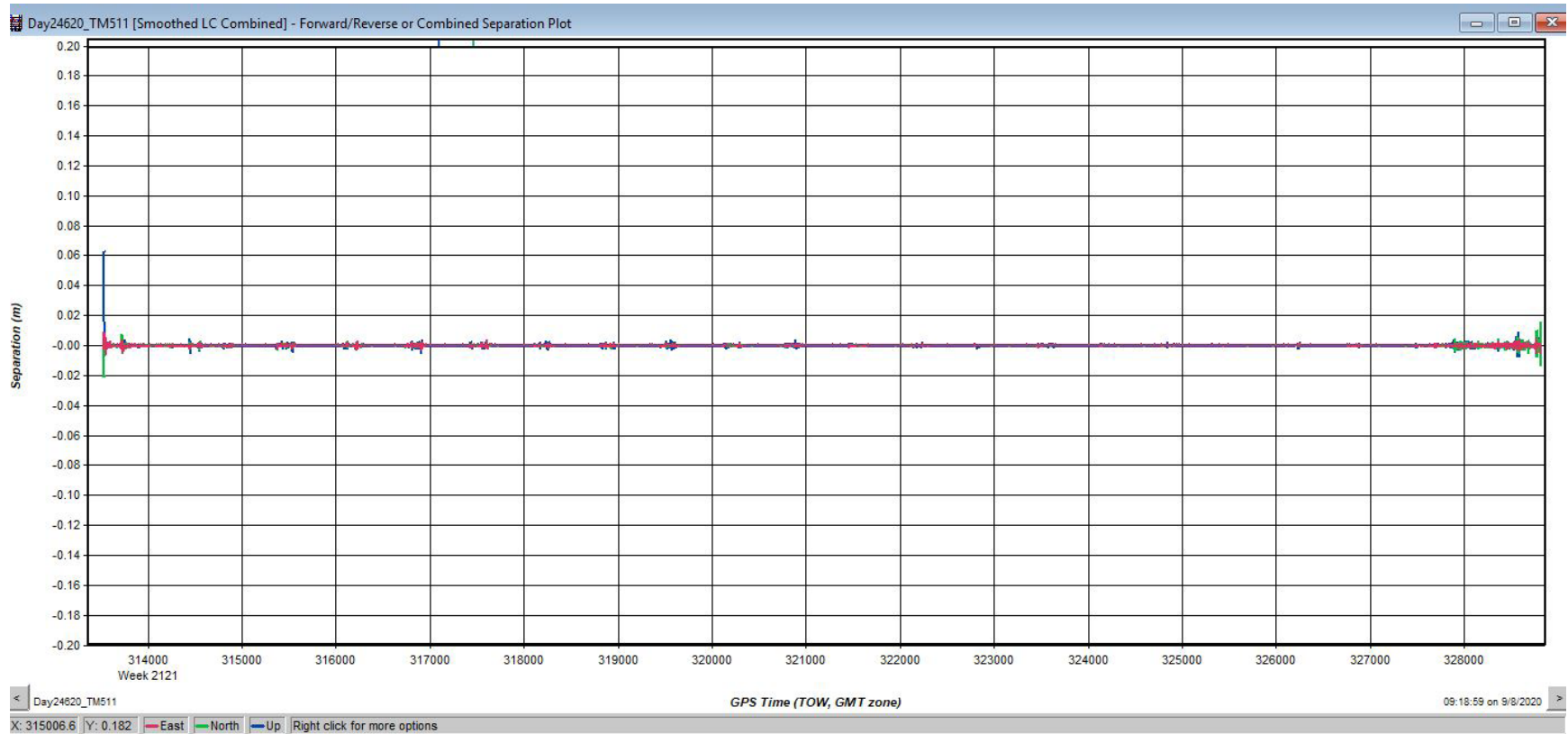
Day24620_TM511

Trajectory



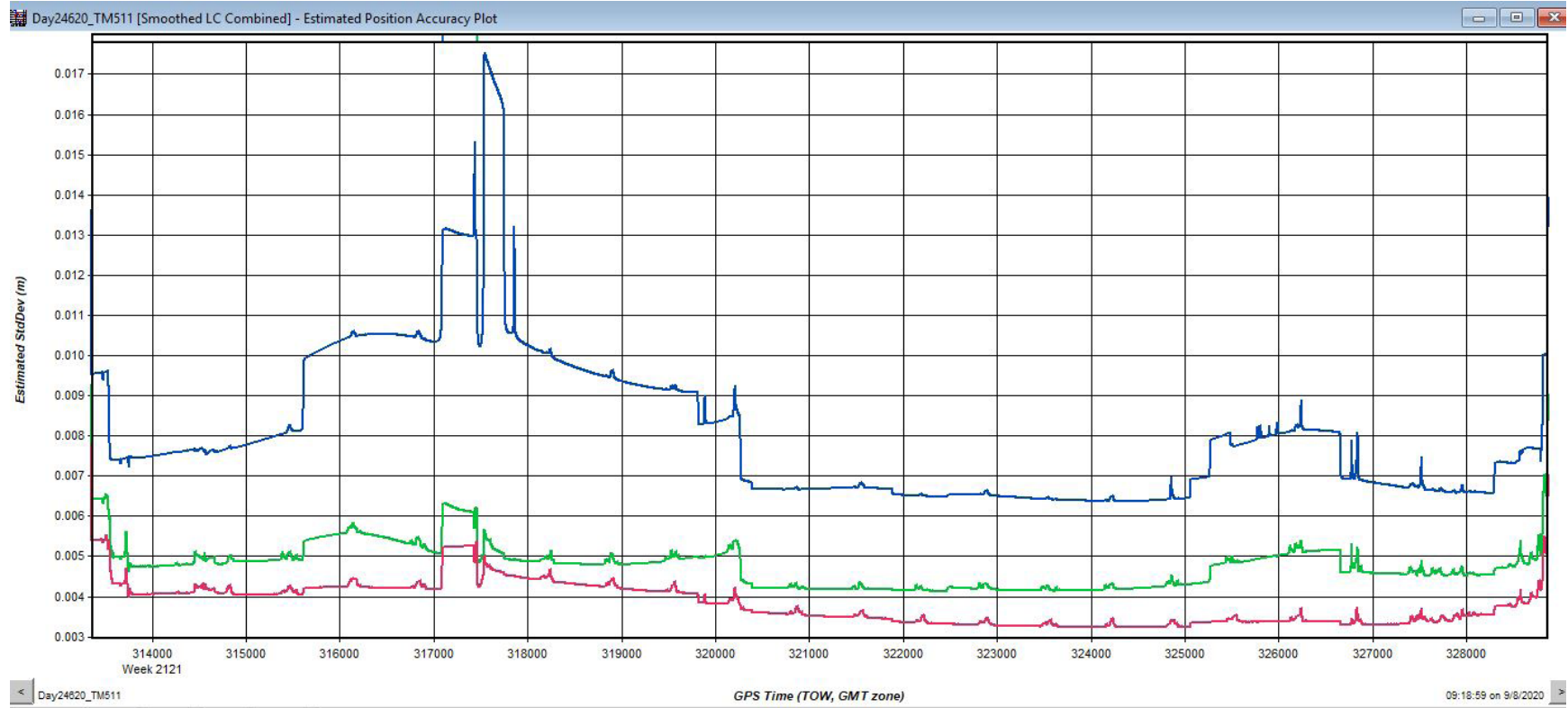
Day24620_TM511

Forward/Reverse or Combined Separation Plot



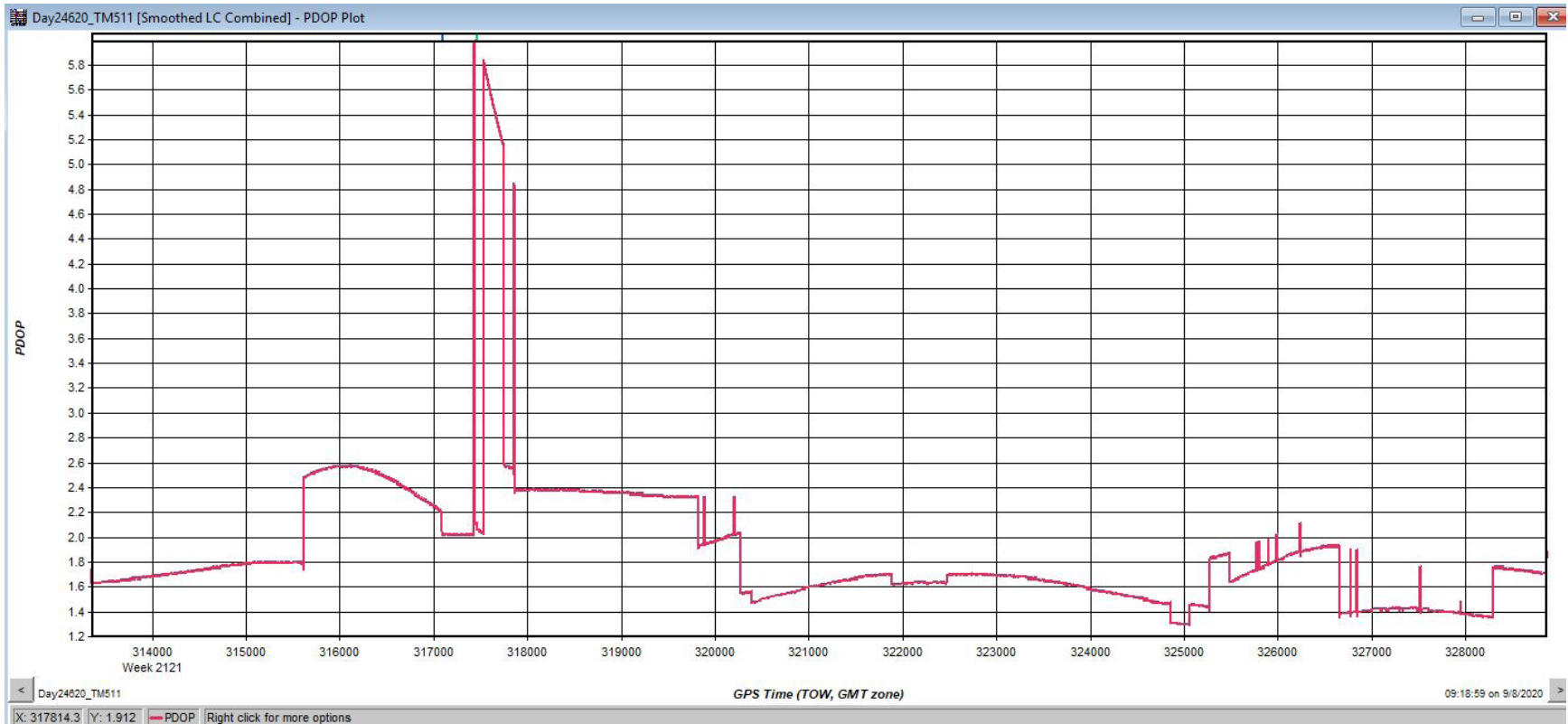
Day24620_TM511

Estimated Position Accuracy



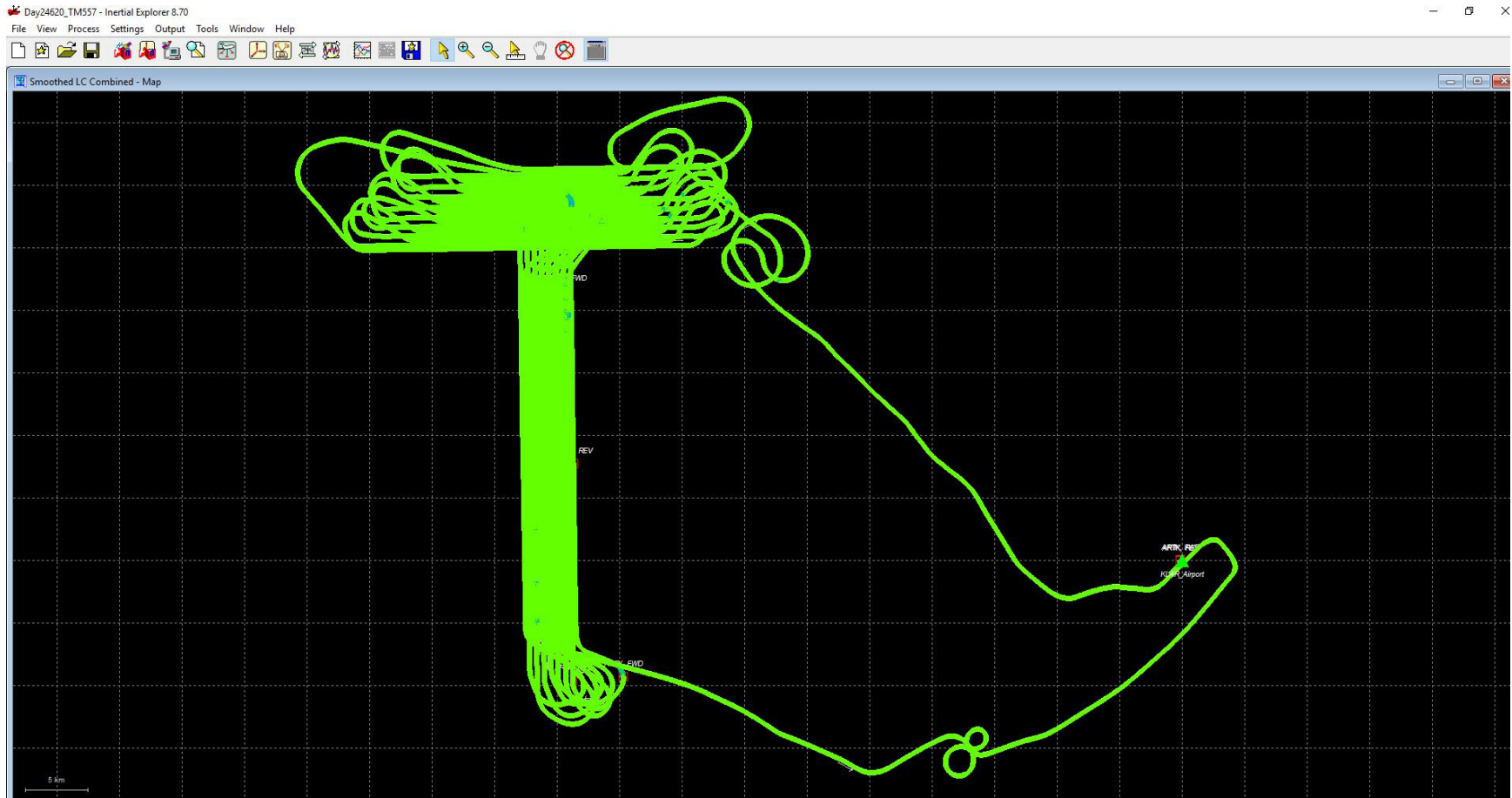
Day24620_TM511

PDOP Plot



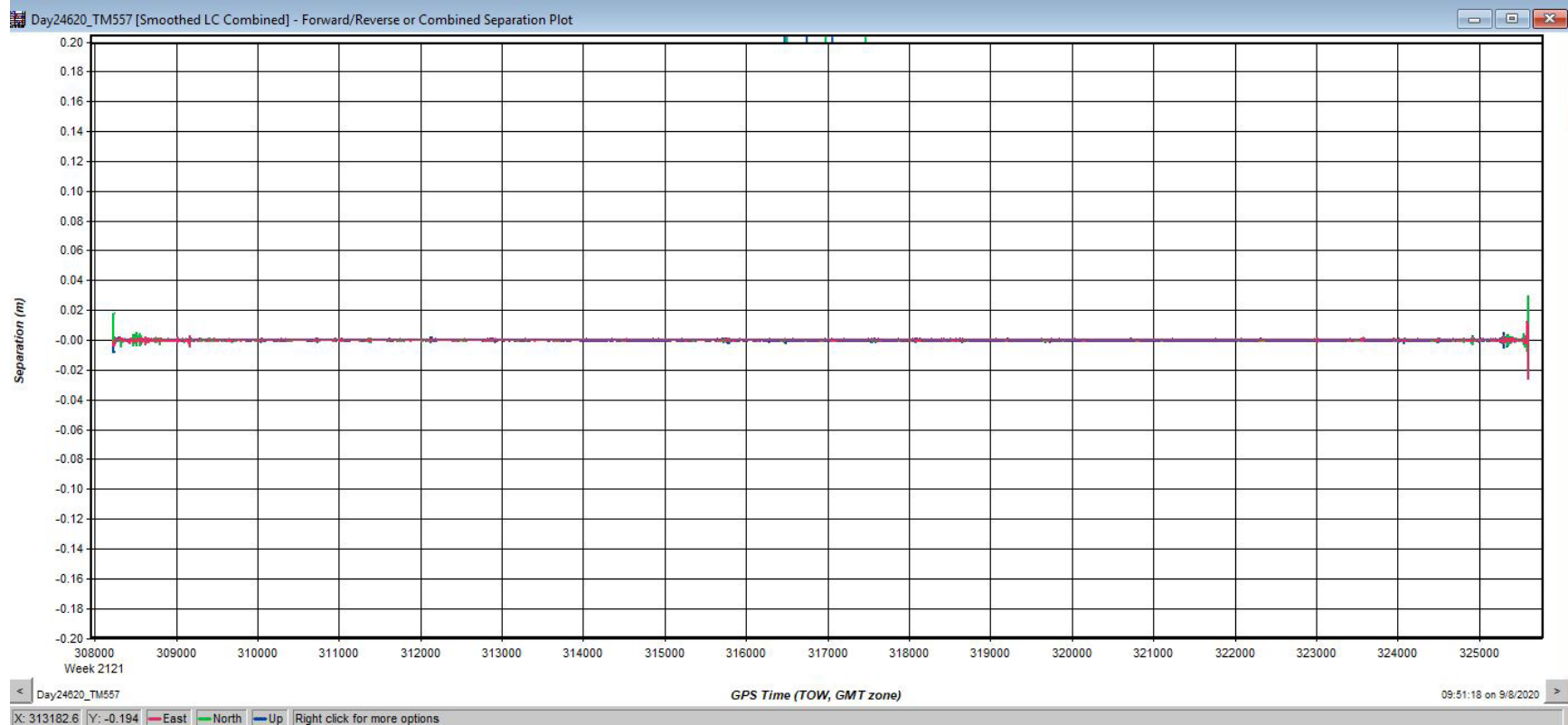
Day24620_TM557

Trajectory



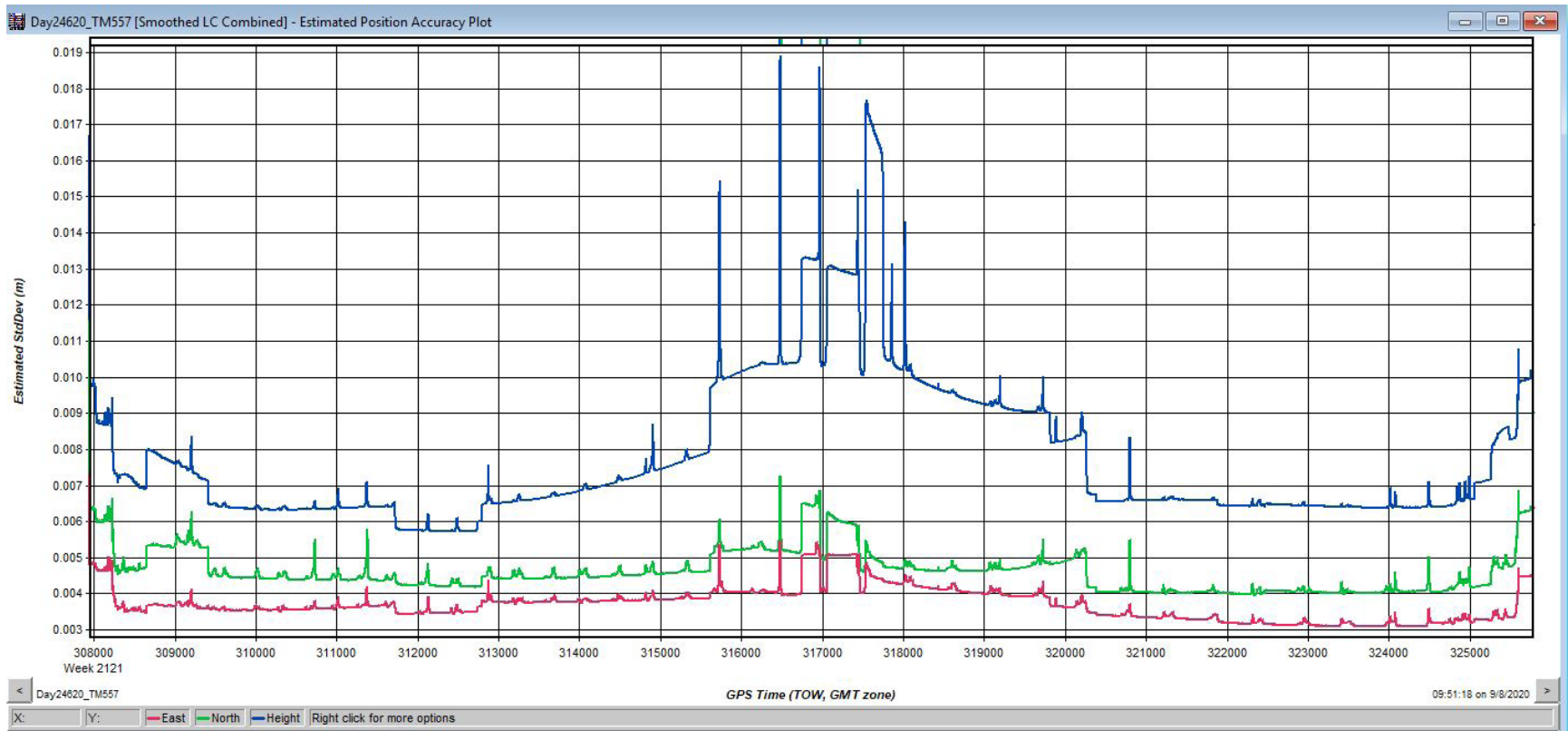
Day24620_TM557

Forward/Reverse or Combined Separation Plot



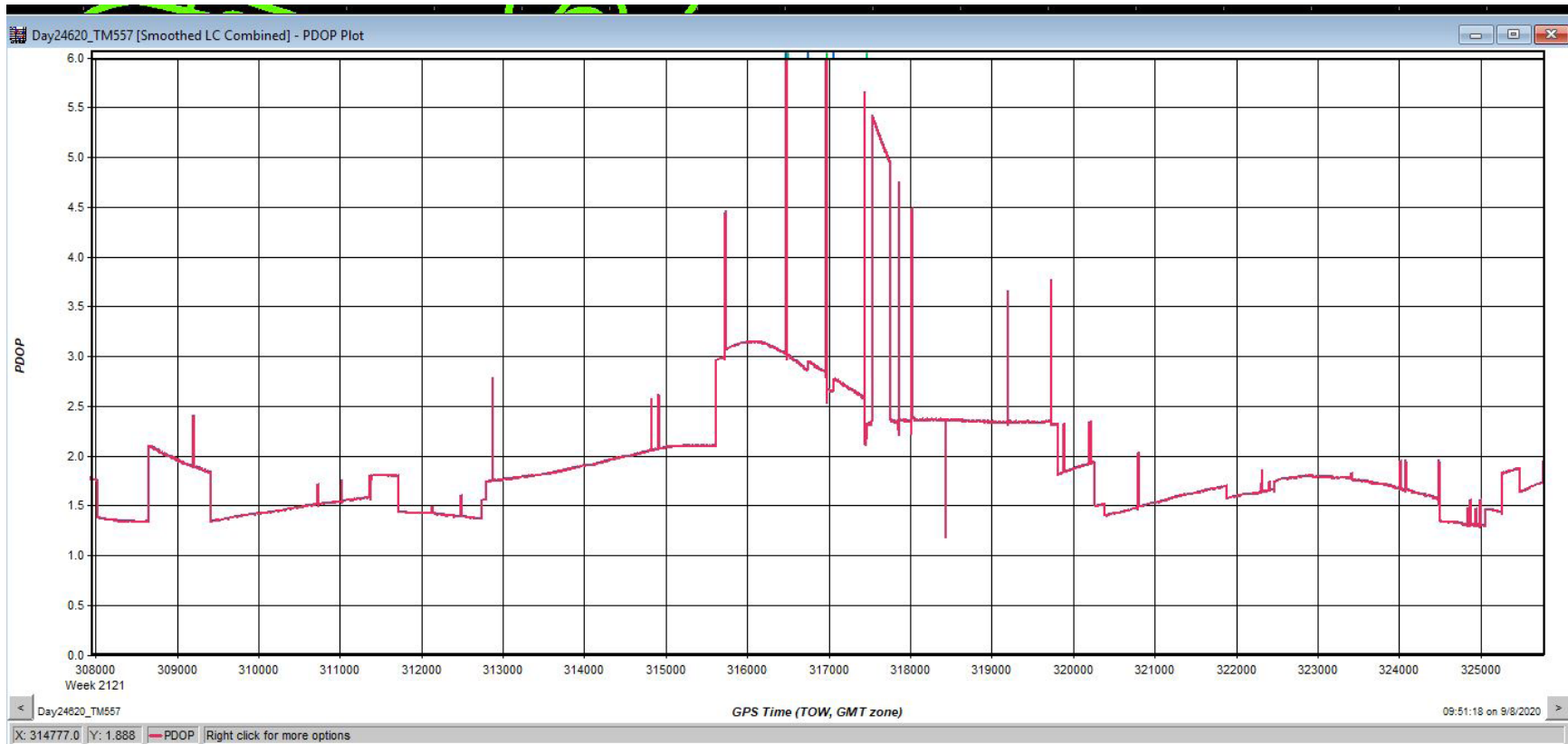
Day24620_TM557

Estimated Position Accuracy



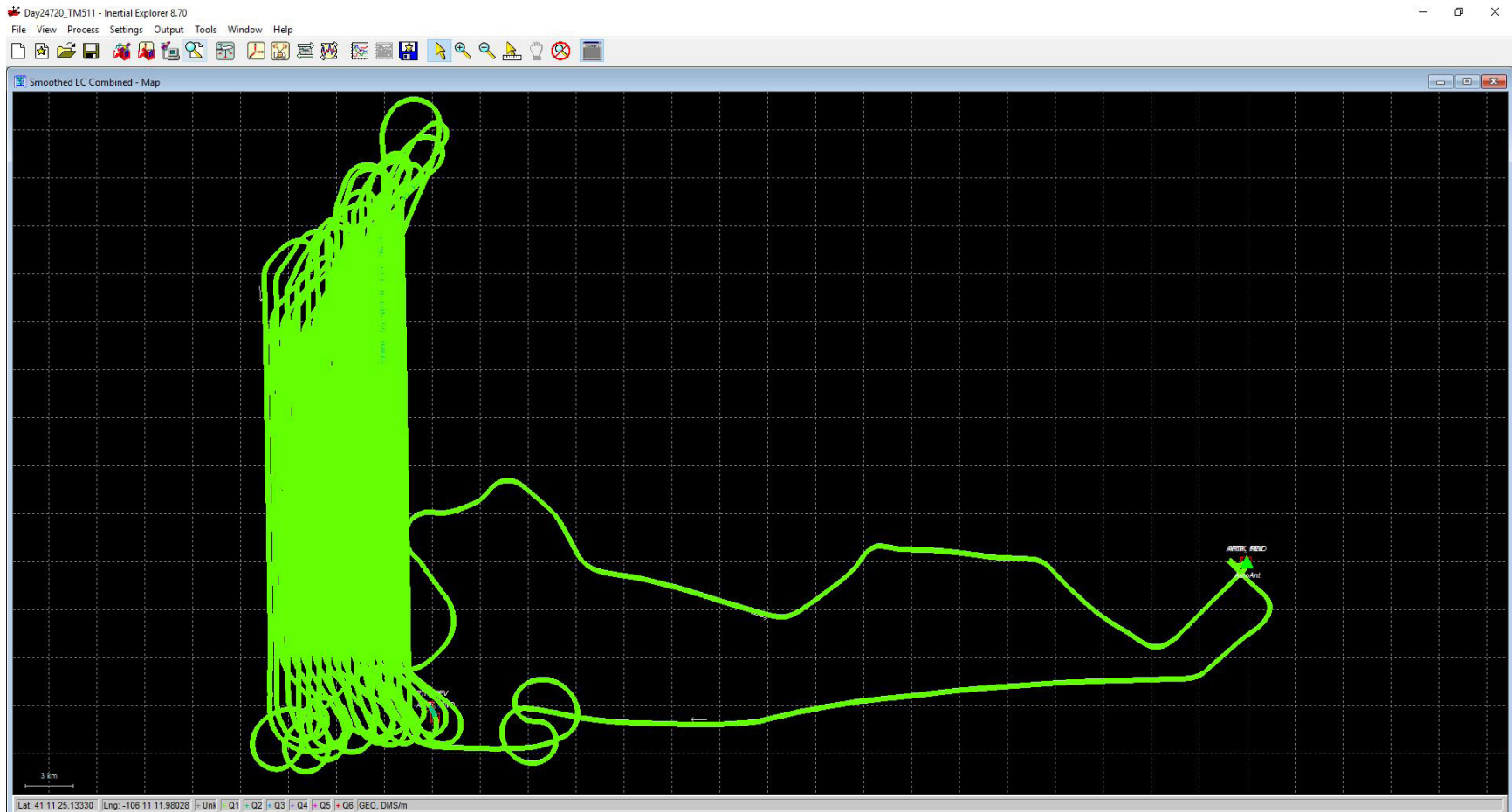
Day24620_TM557

PDOP Plot



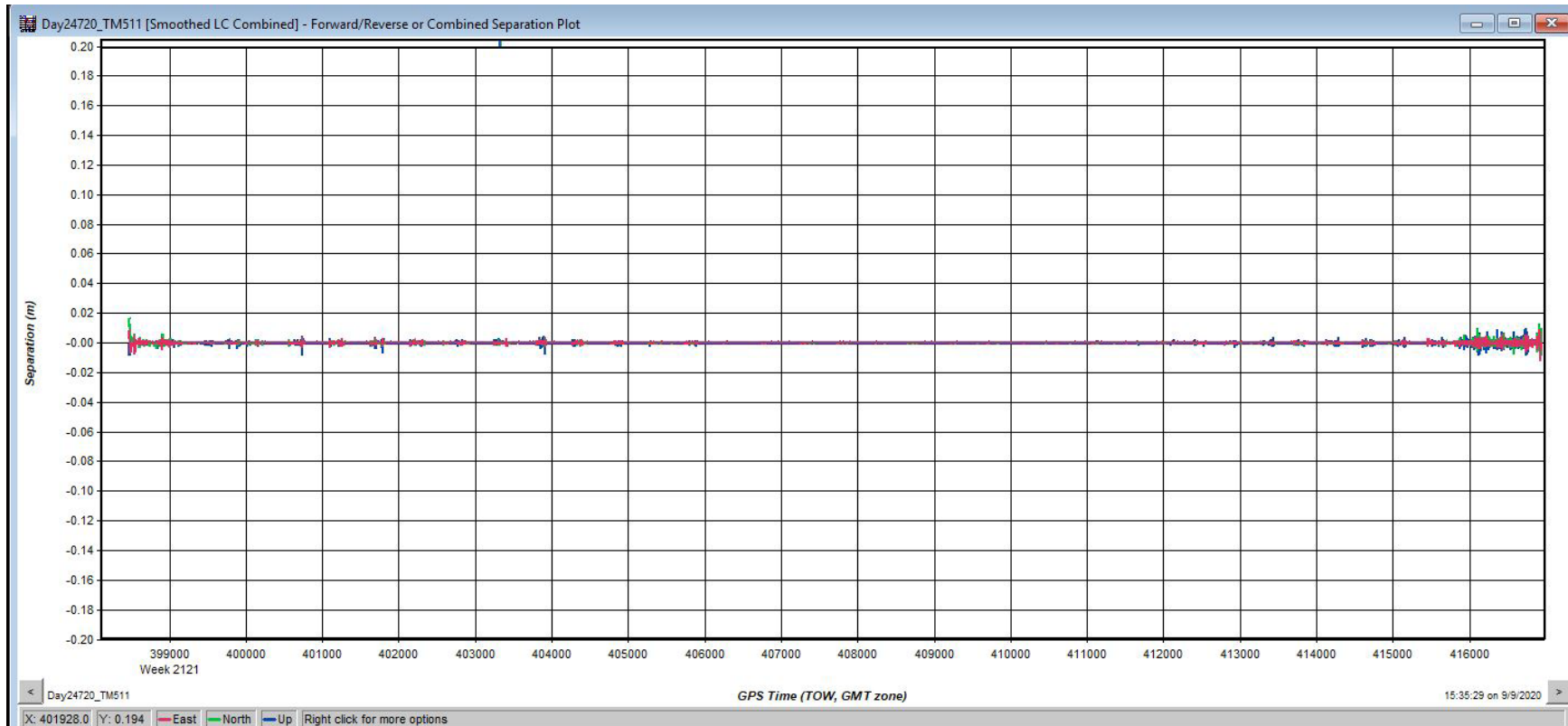
Day24720_TM511

Trajectory



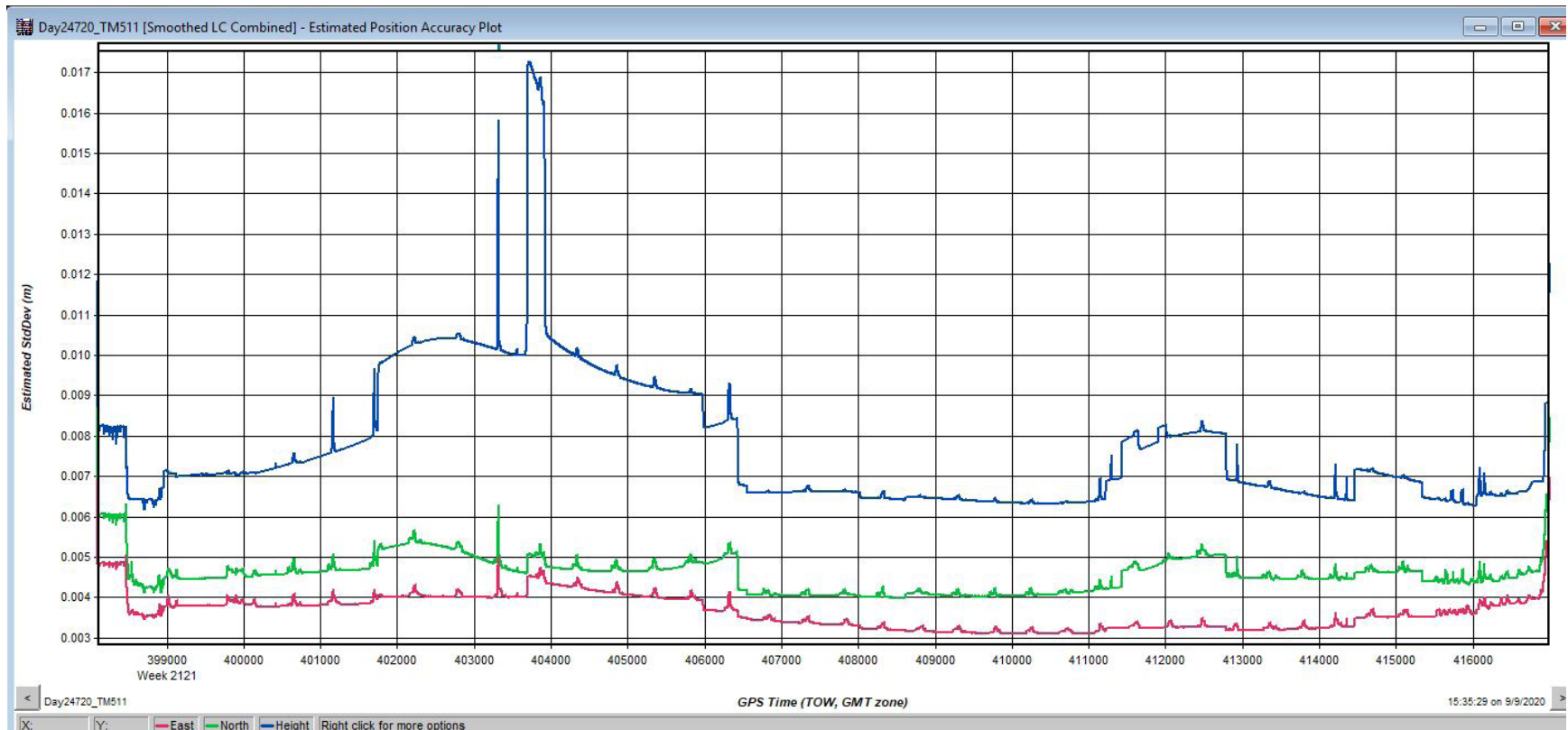
Day24720_TM511

Forward/Reverse or Combined Separation Plot



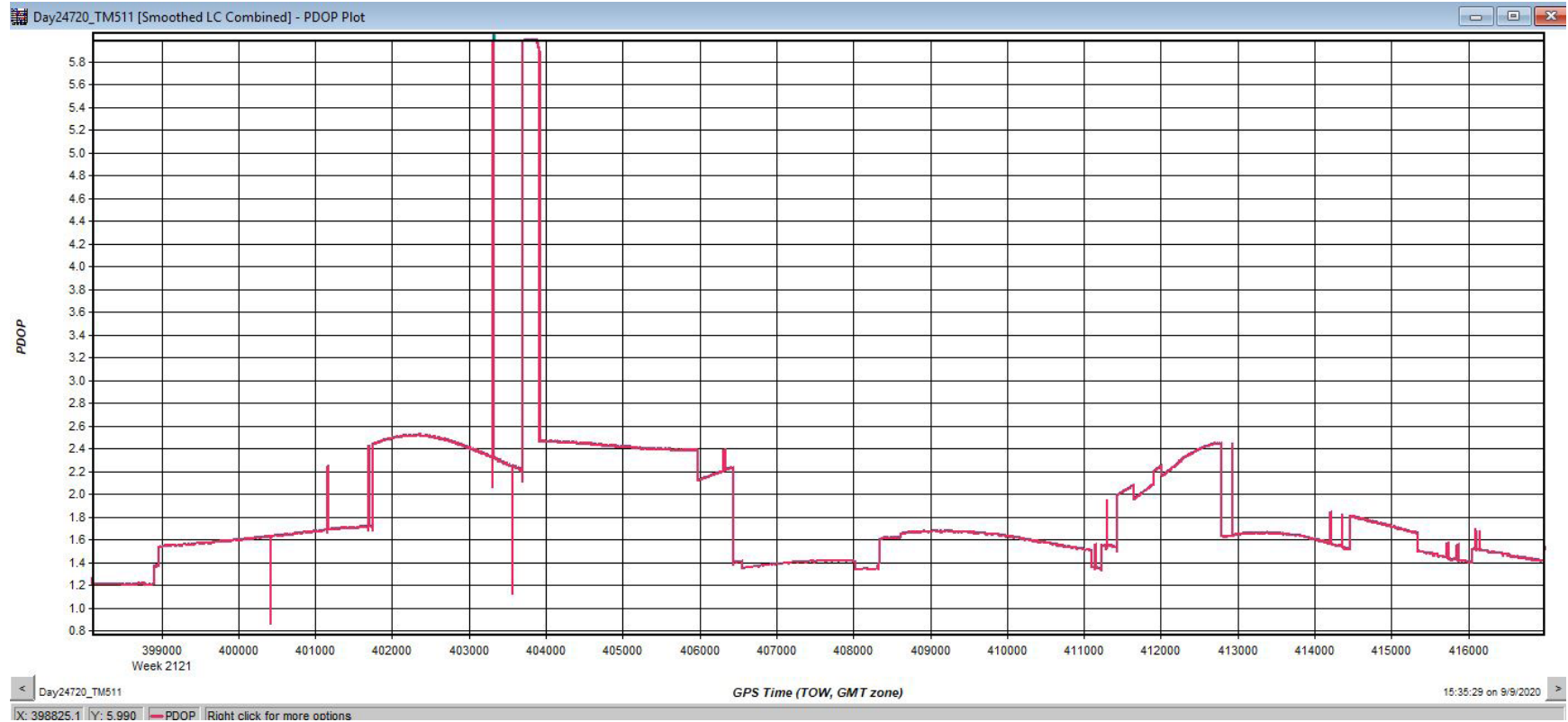
Day24720_TM511

Estimated Position Accuracy



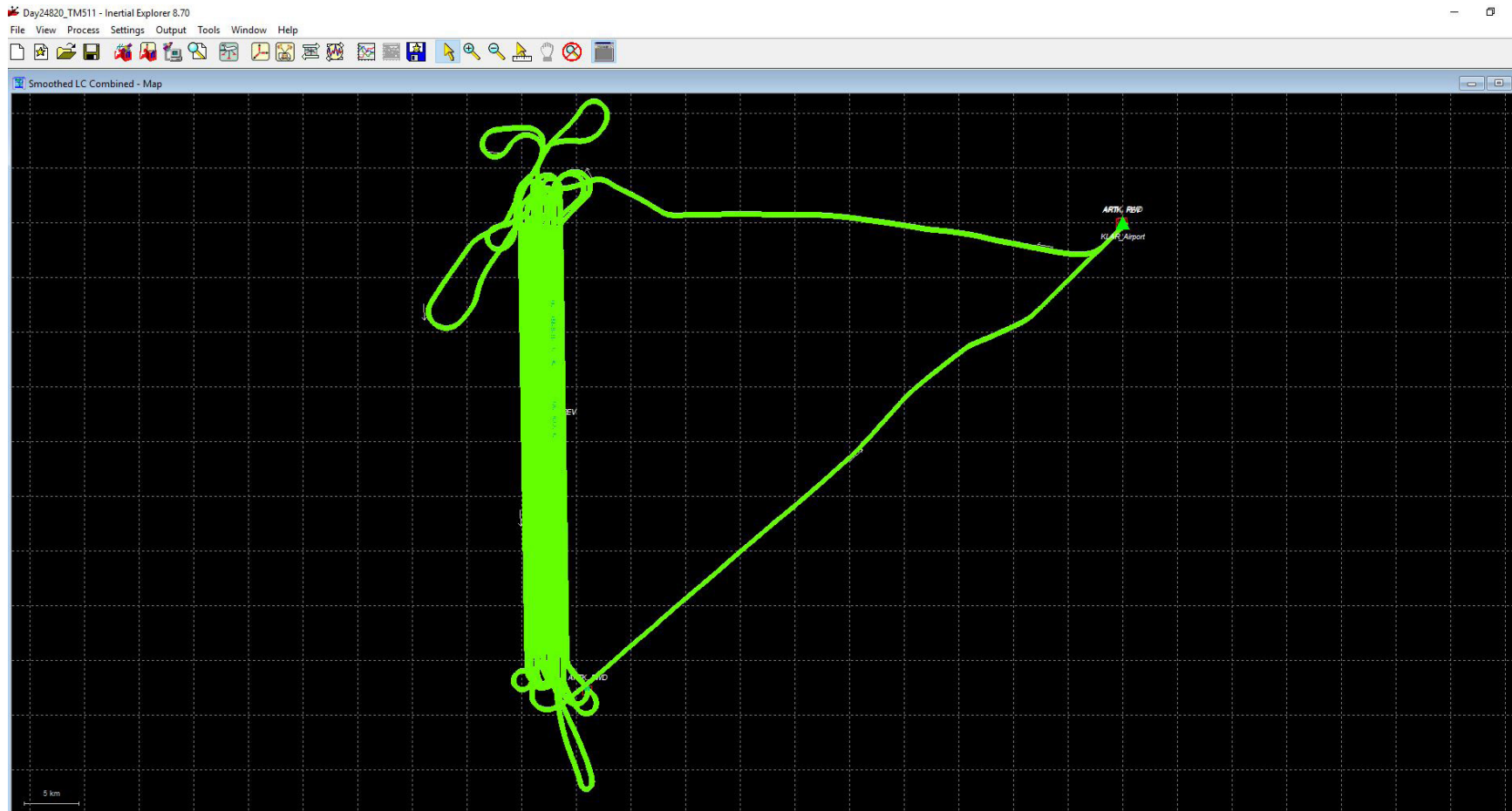
Day24720_TM511

PDOP Plot



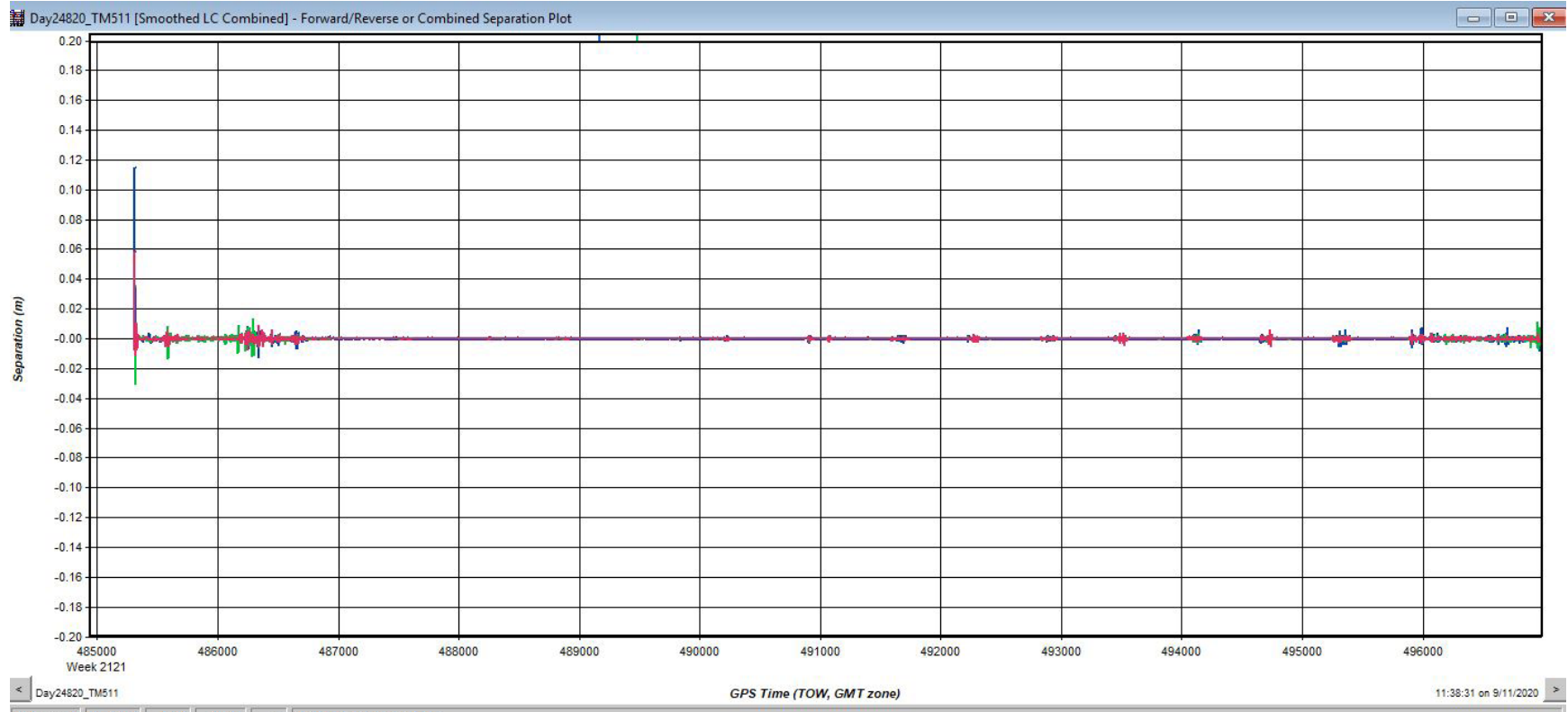
Day24820_TM511

Trajectory



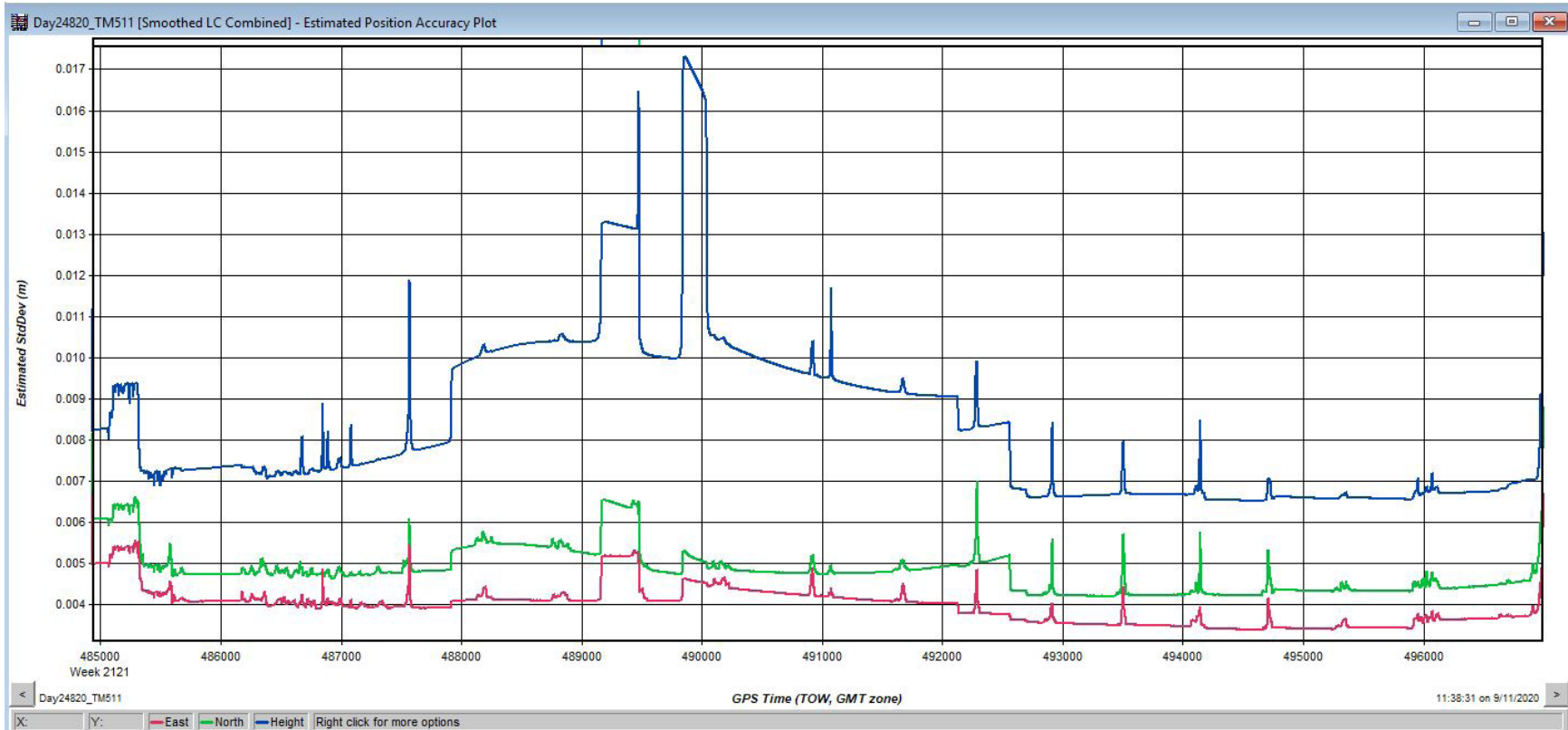
Day24820_TM511

Forward/Reverse or Combined Separation Plot



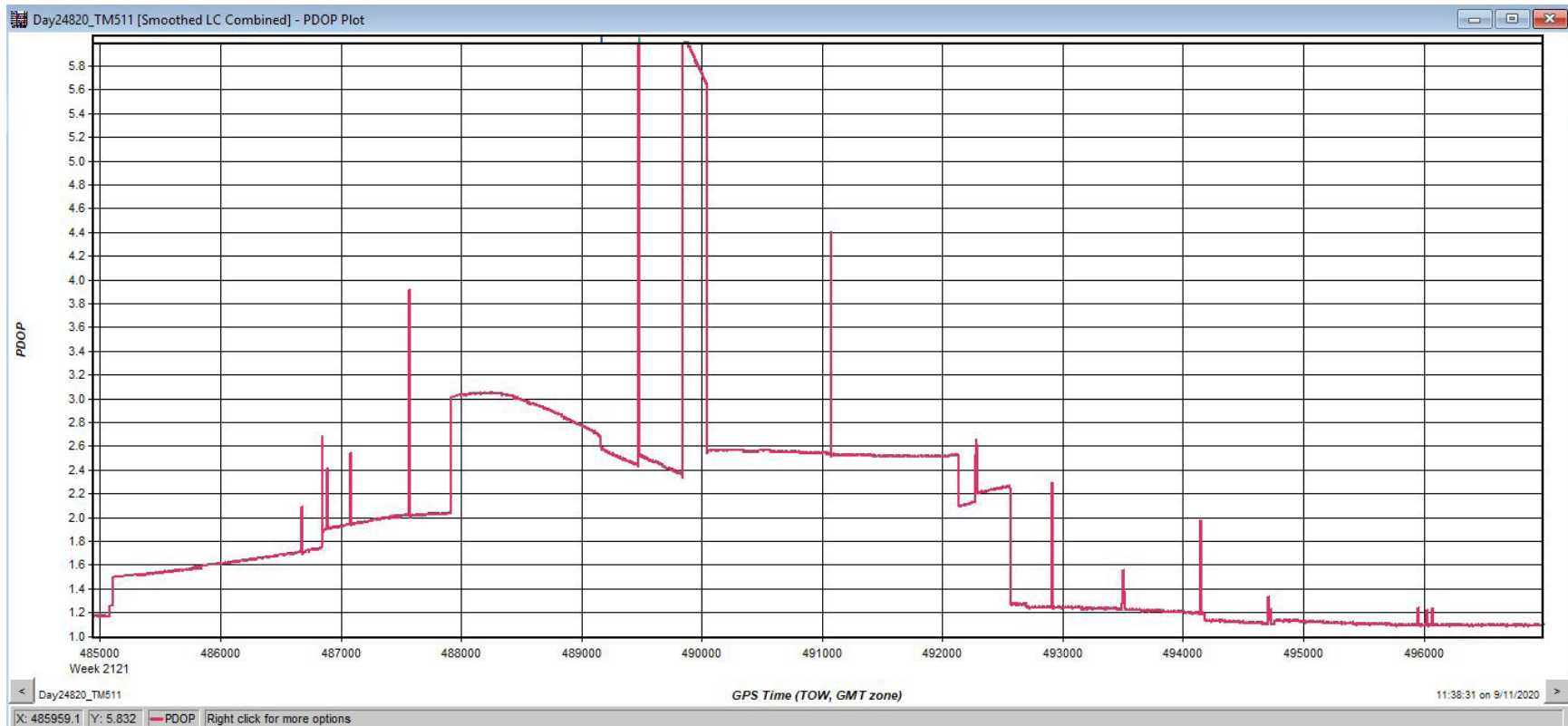
Day24820_TM511

Estimated Position Accuracy



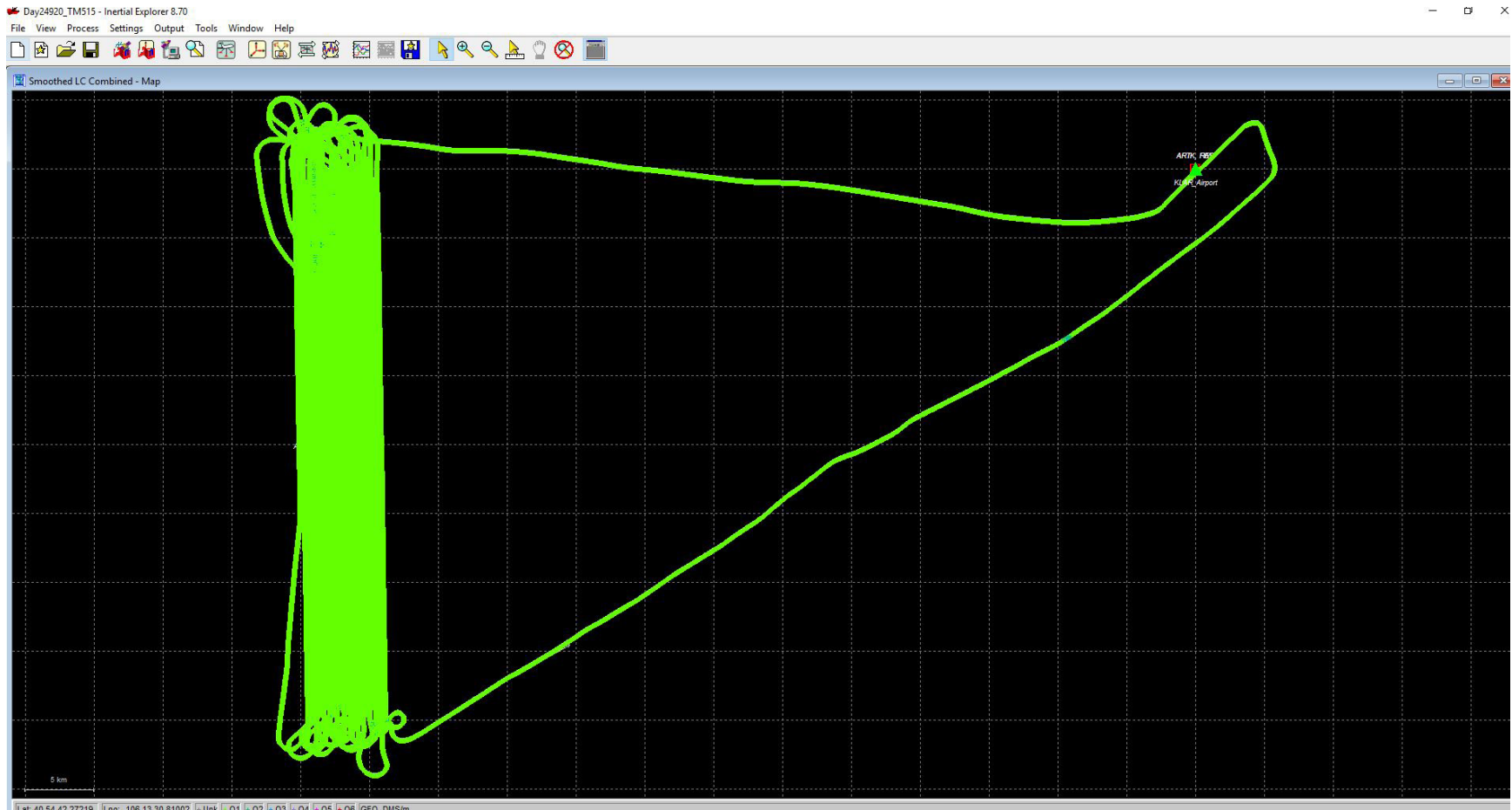
Day24820_TM511

PDOP Plot



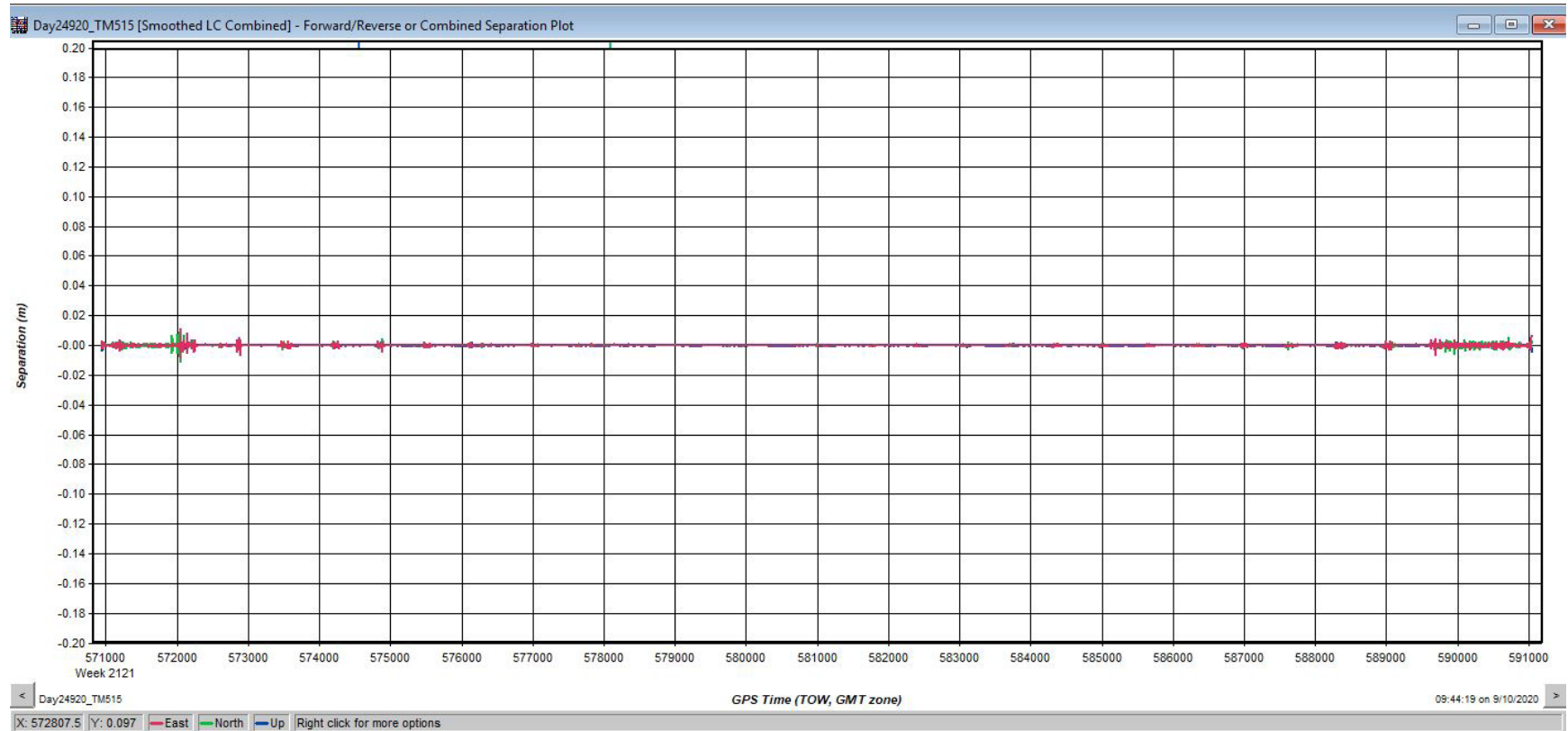
Day24920_TM515

Trajectory



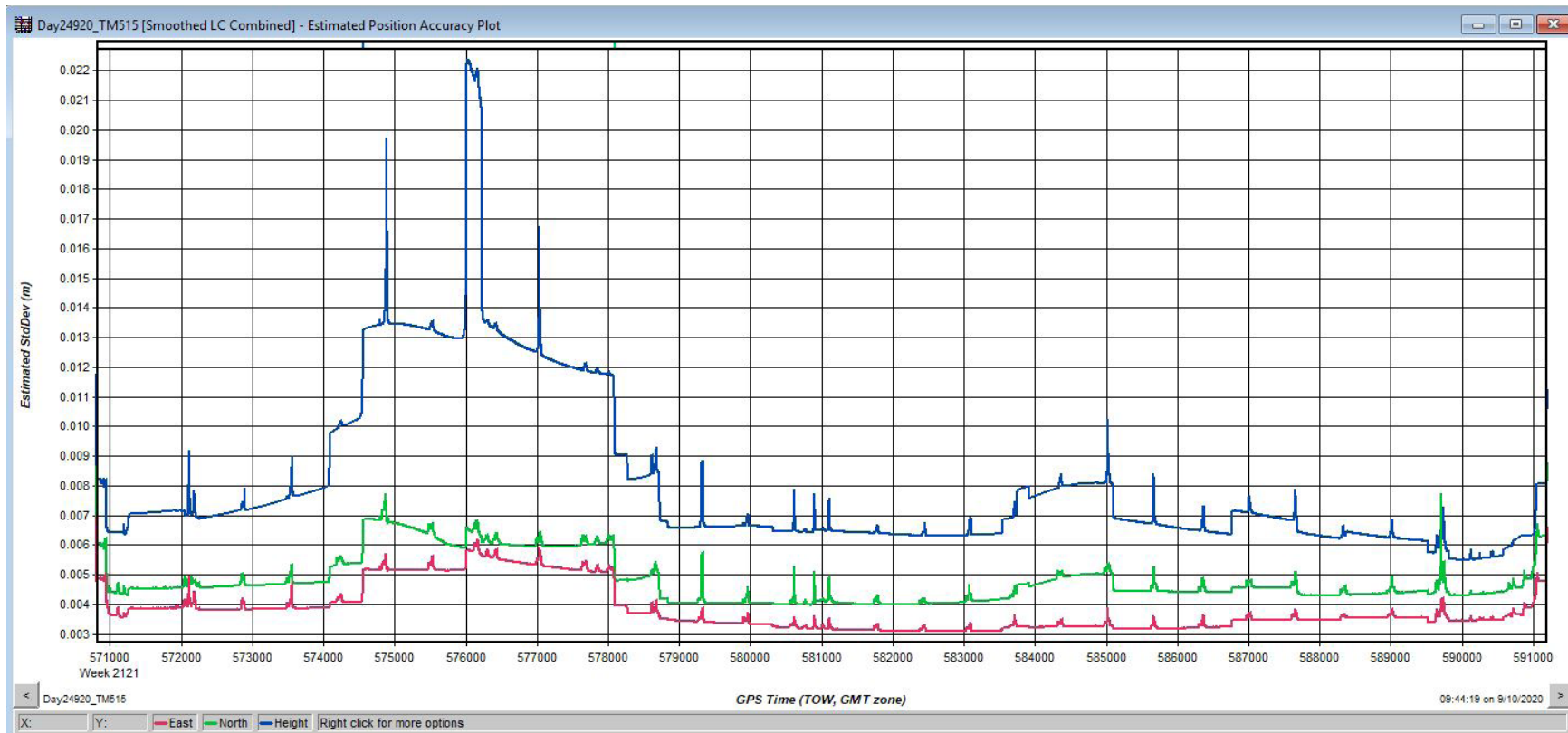
Day24920_TM515

Forward/Reverse or Combined Separation Plot



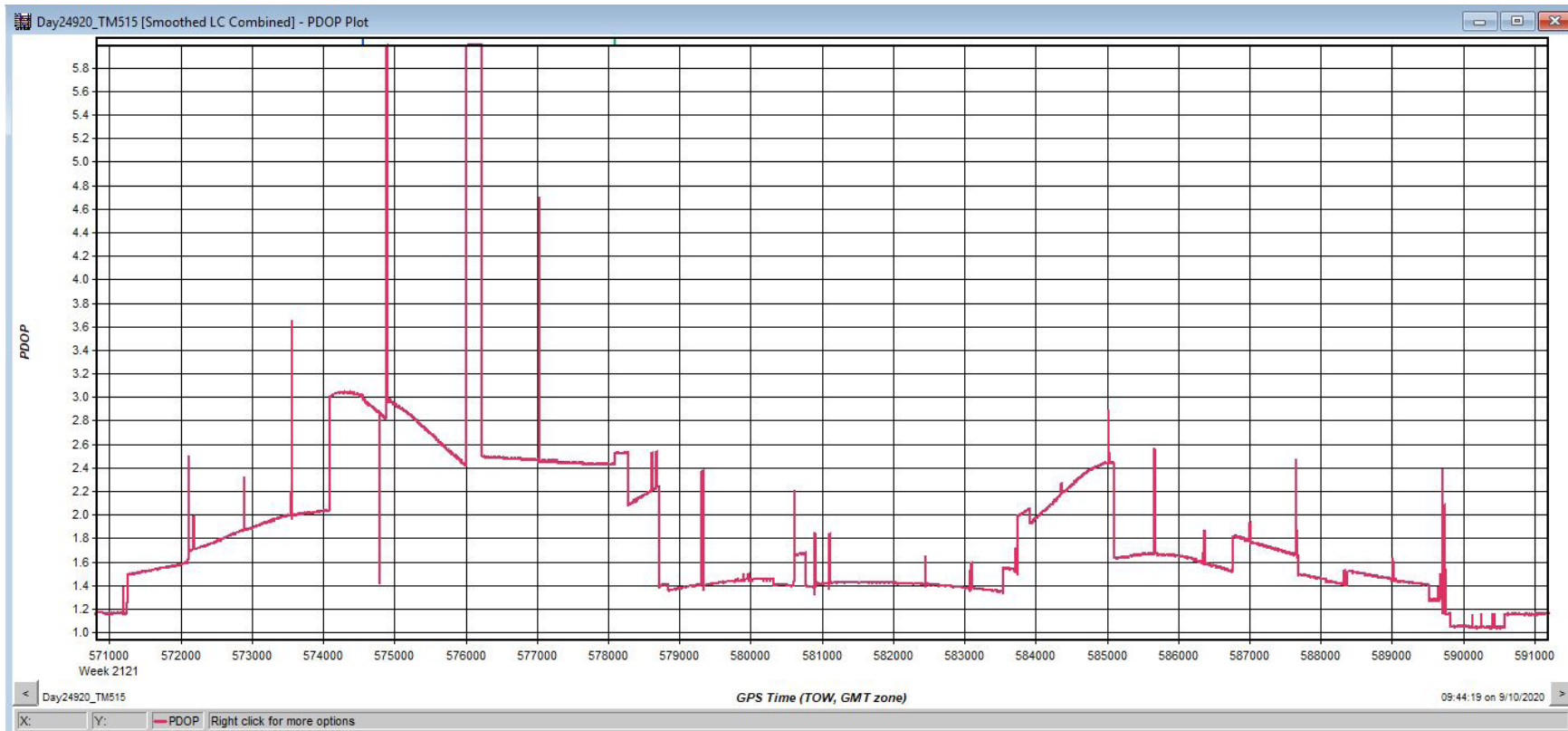
Day24920_TM515

Estimated Position Accuracy



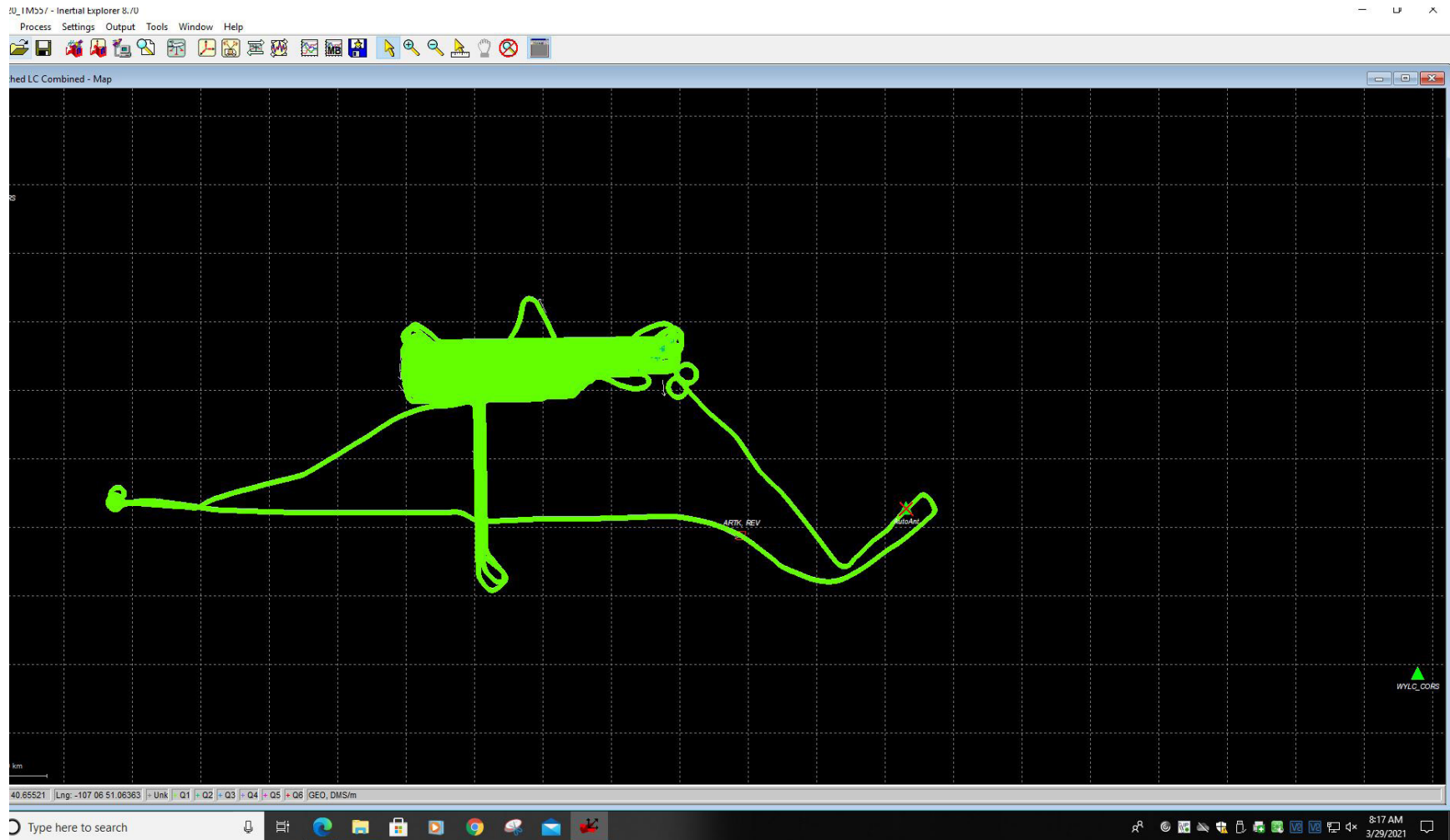
Day24920_TM515

PDOP Plot



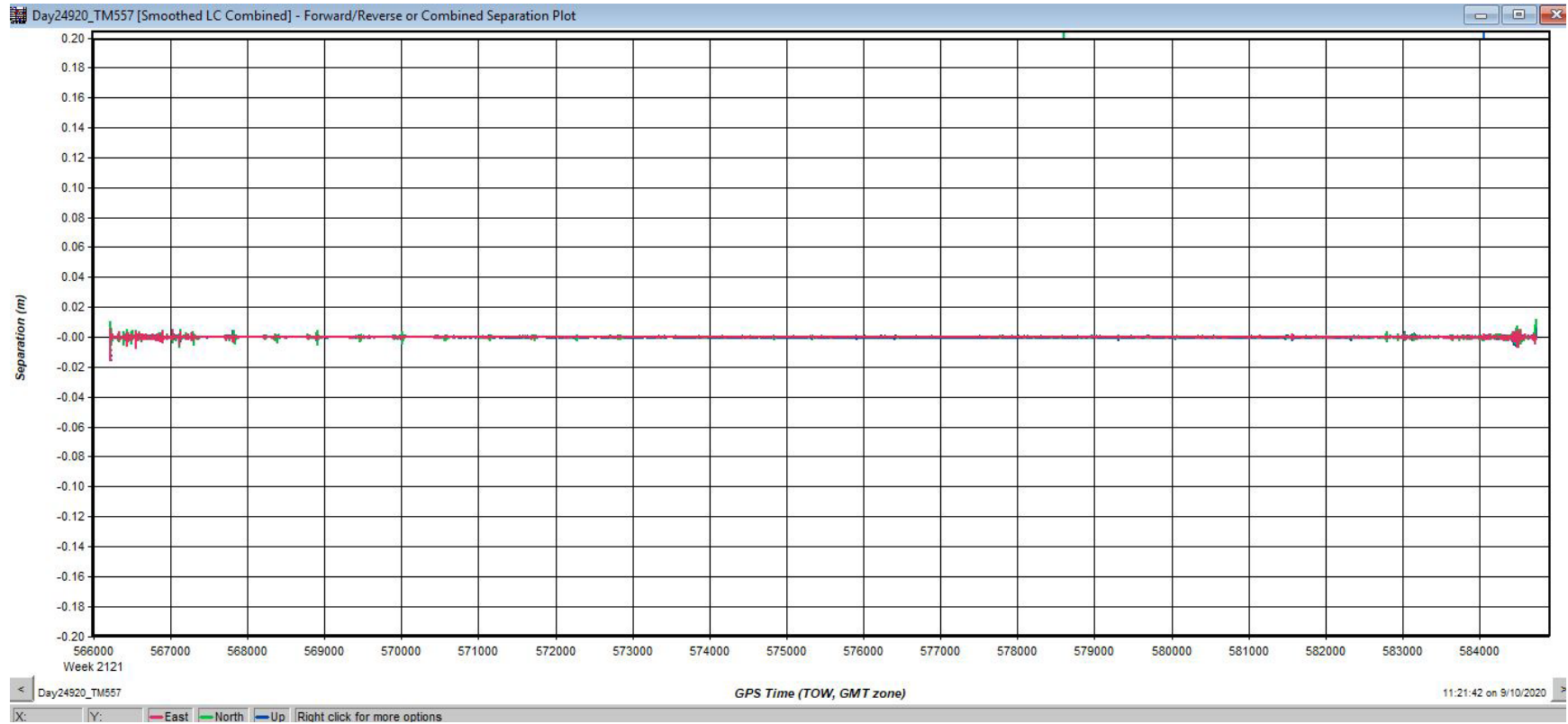
Day24920_TM557

Trajectory



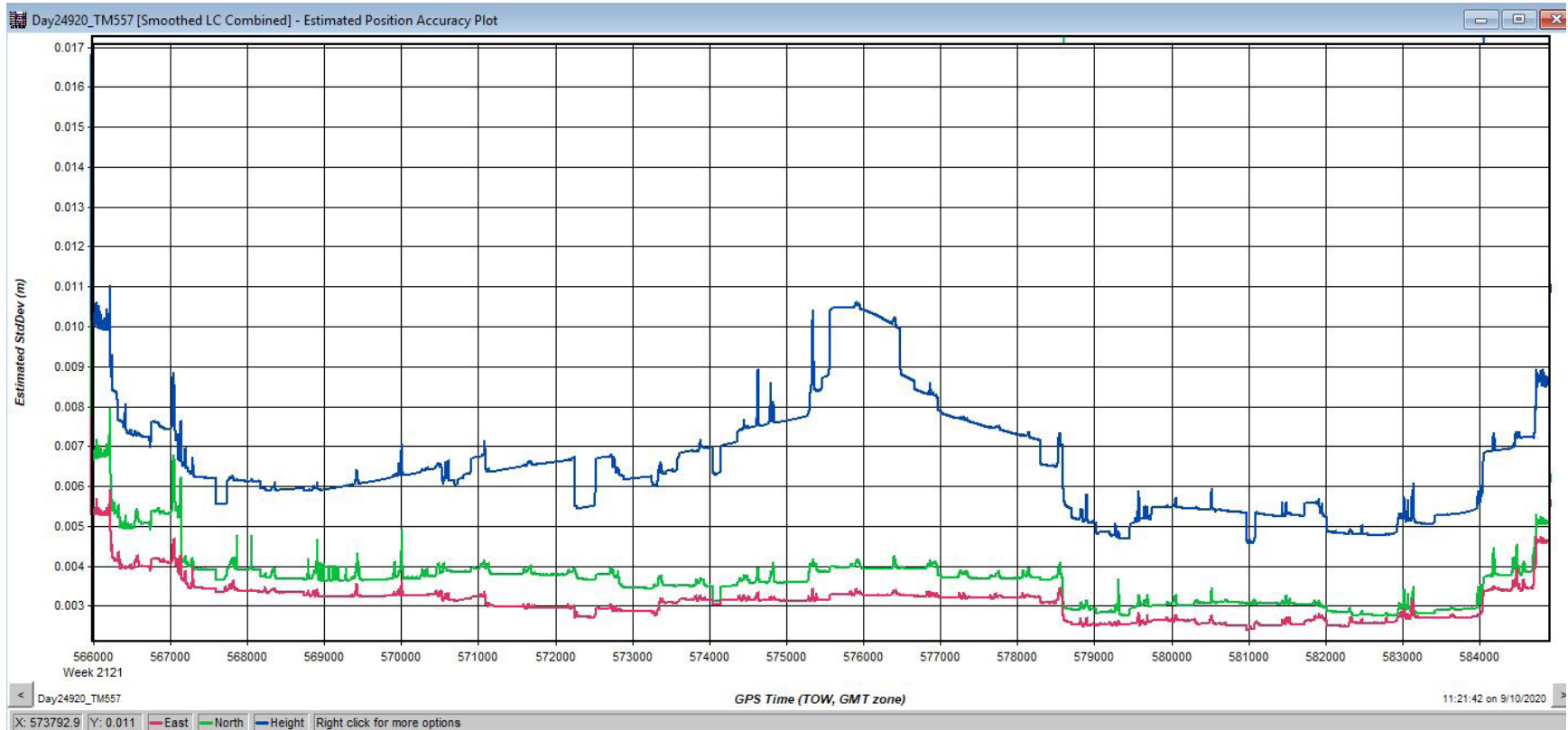
Day24920_TM557

Forward/Reverse or Combined Separation Plot



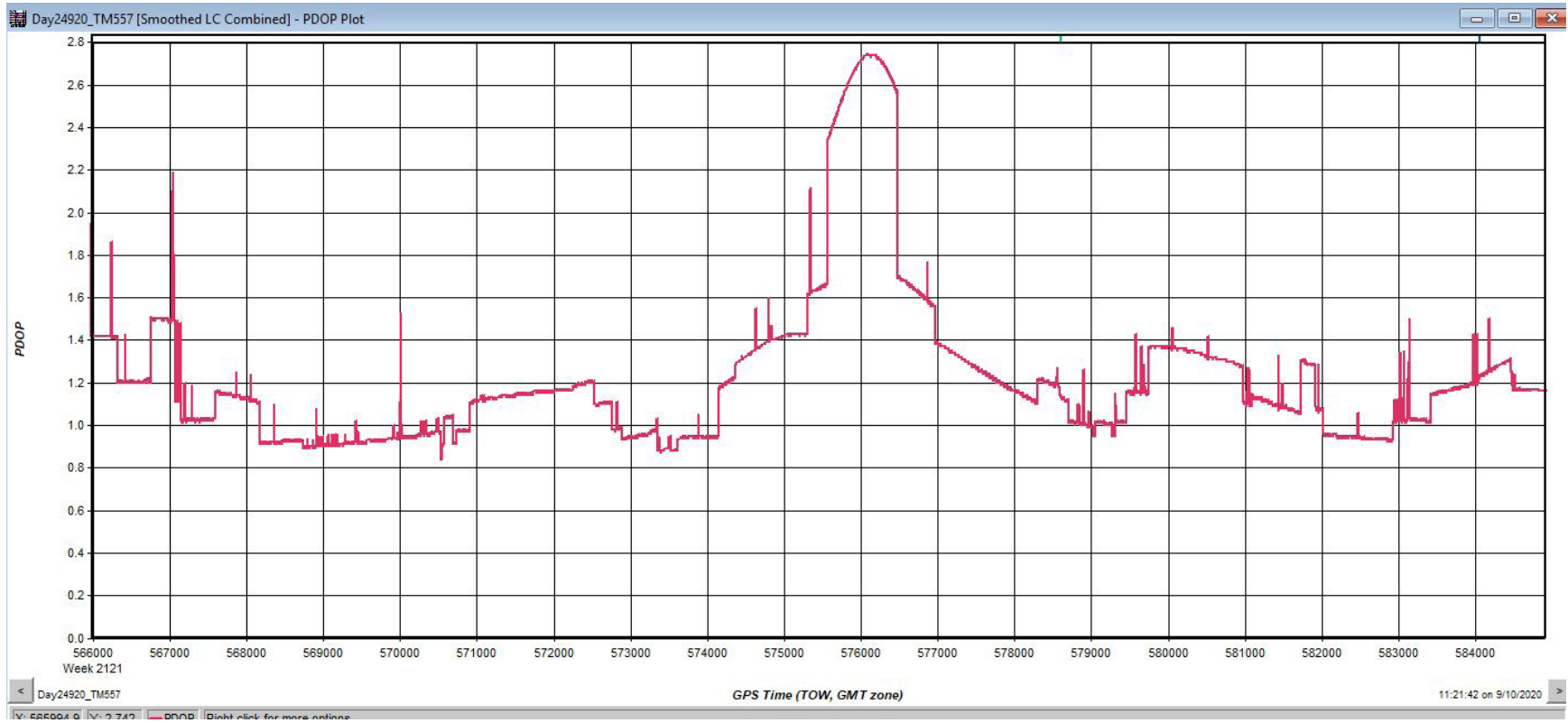
Day24920_TM557

Estimated Position Accuracy



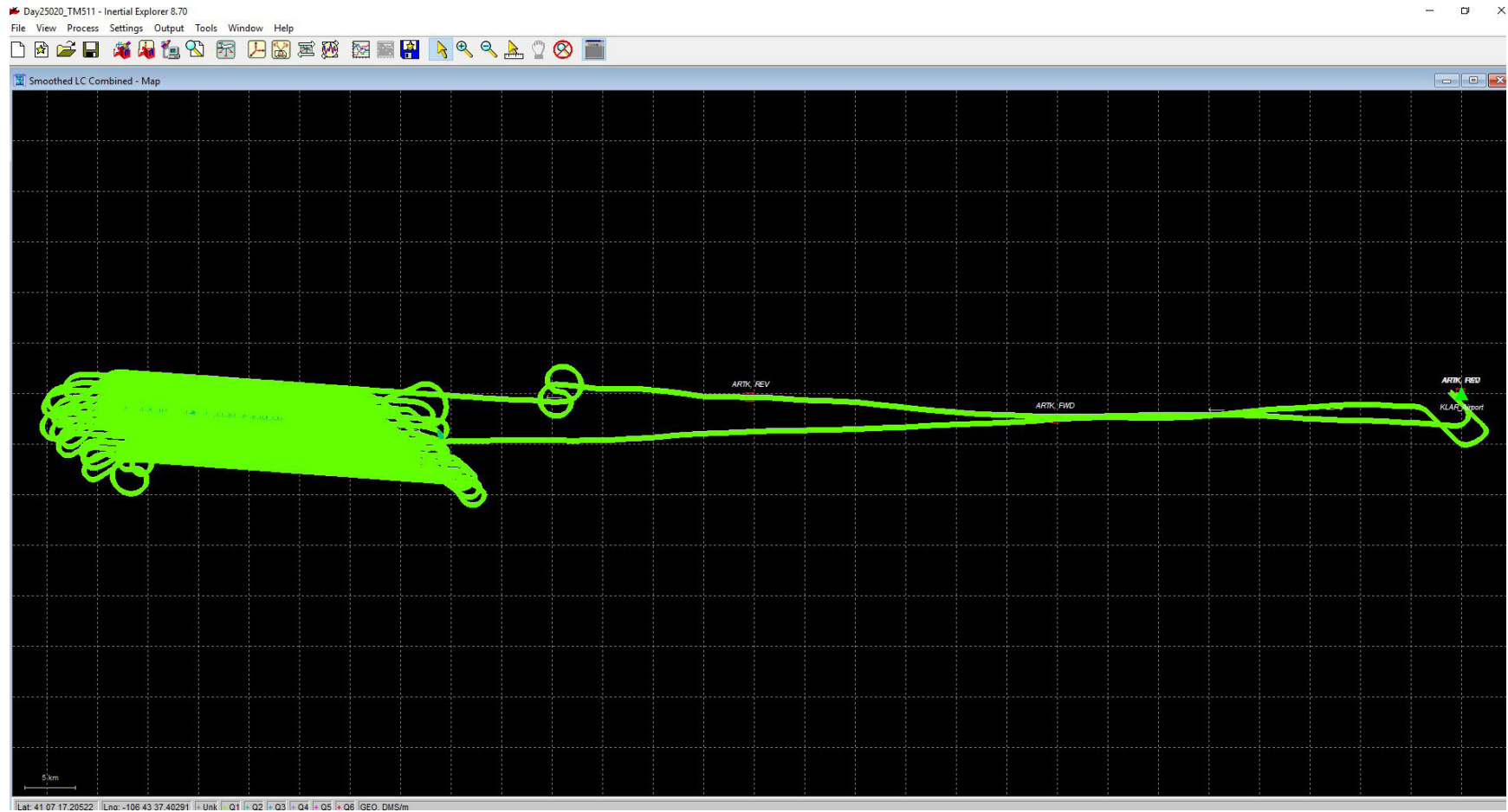
Day24920_TM557

PDOP Plot



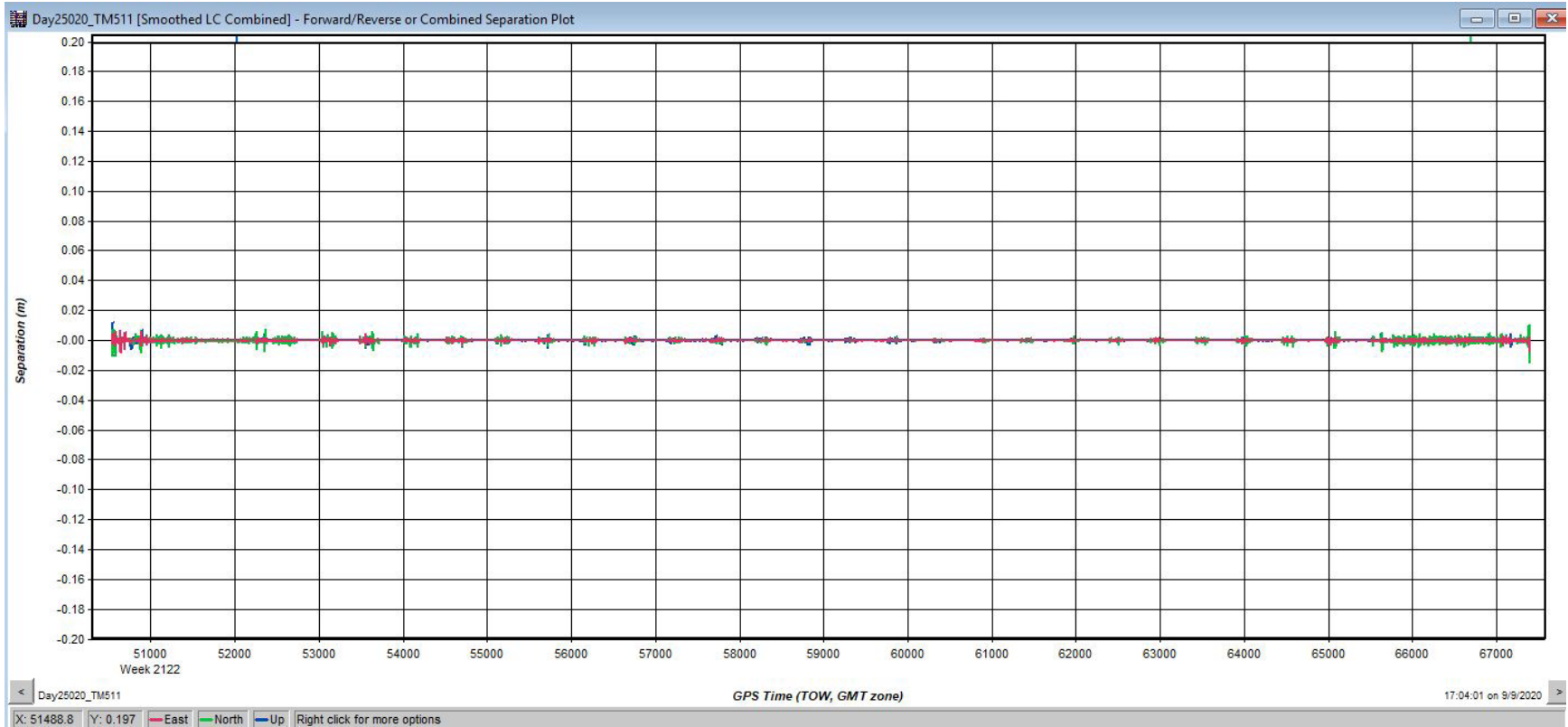
Day25020_TM511

Trajectory



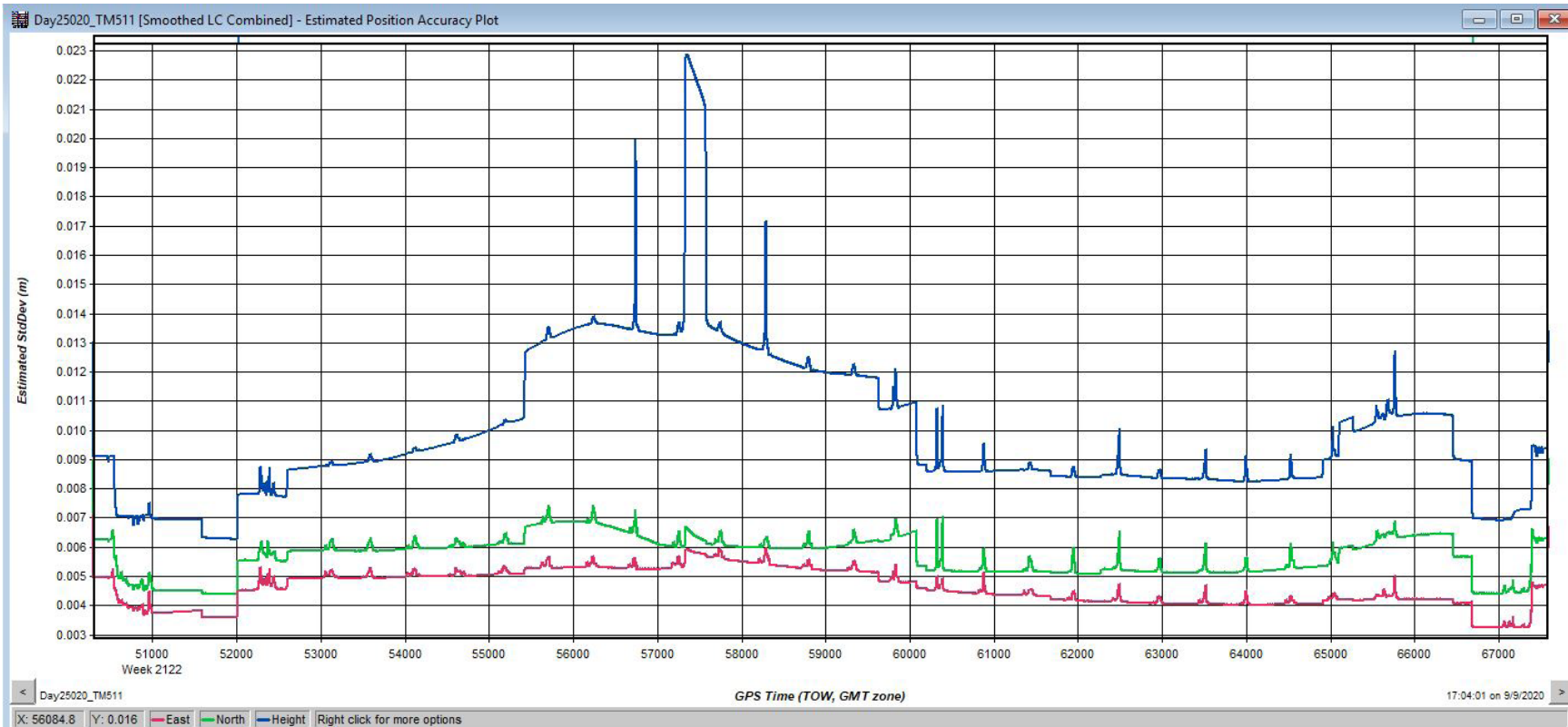
Day25020_TM511

Forward/Reverse or Combined Separation Plot



Day25020_TM511

Estimated Position Accuracy



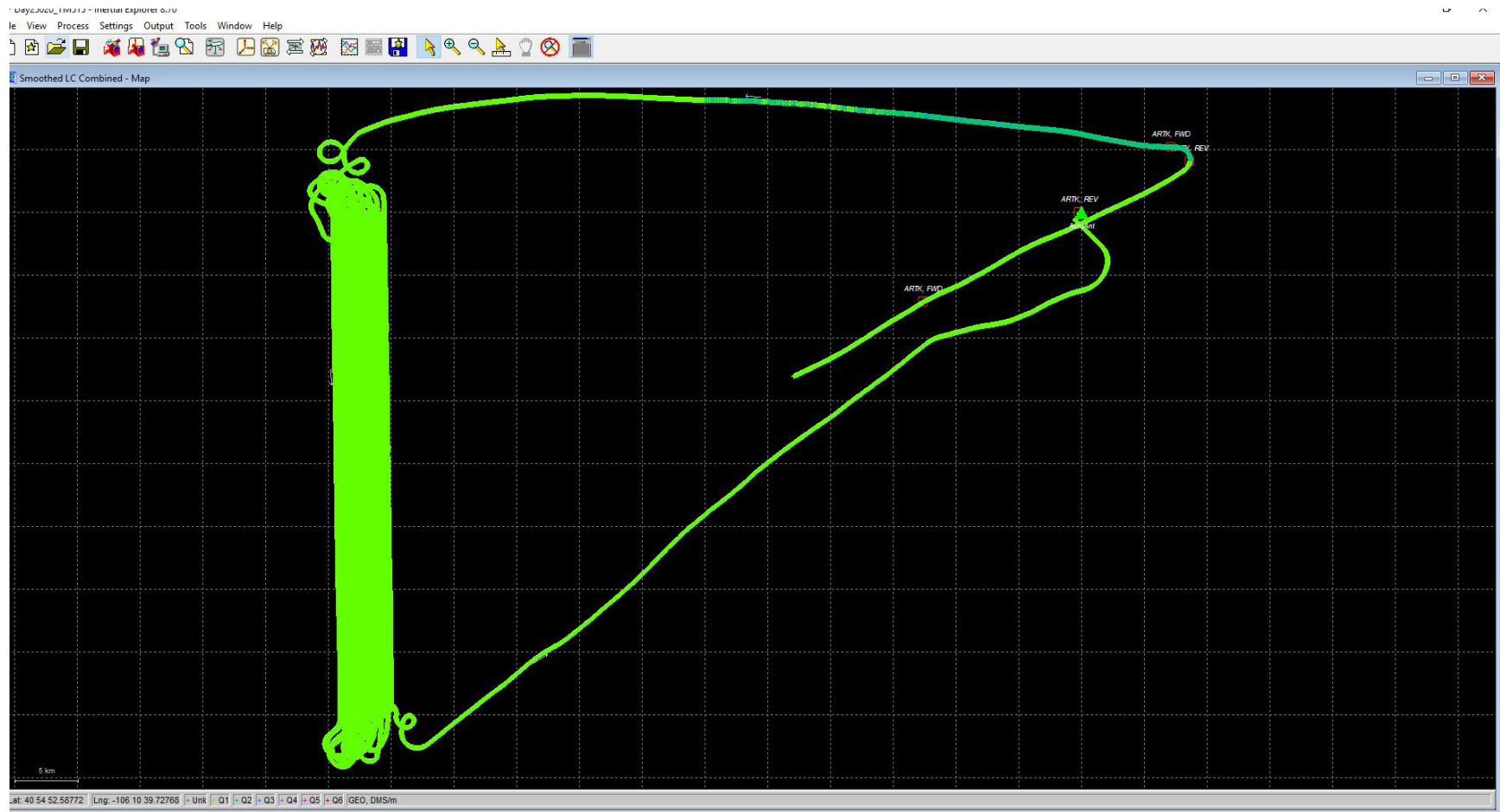
Day25020_TM511

PDOP Plot



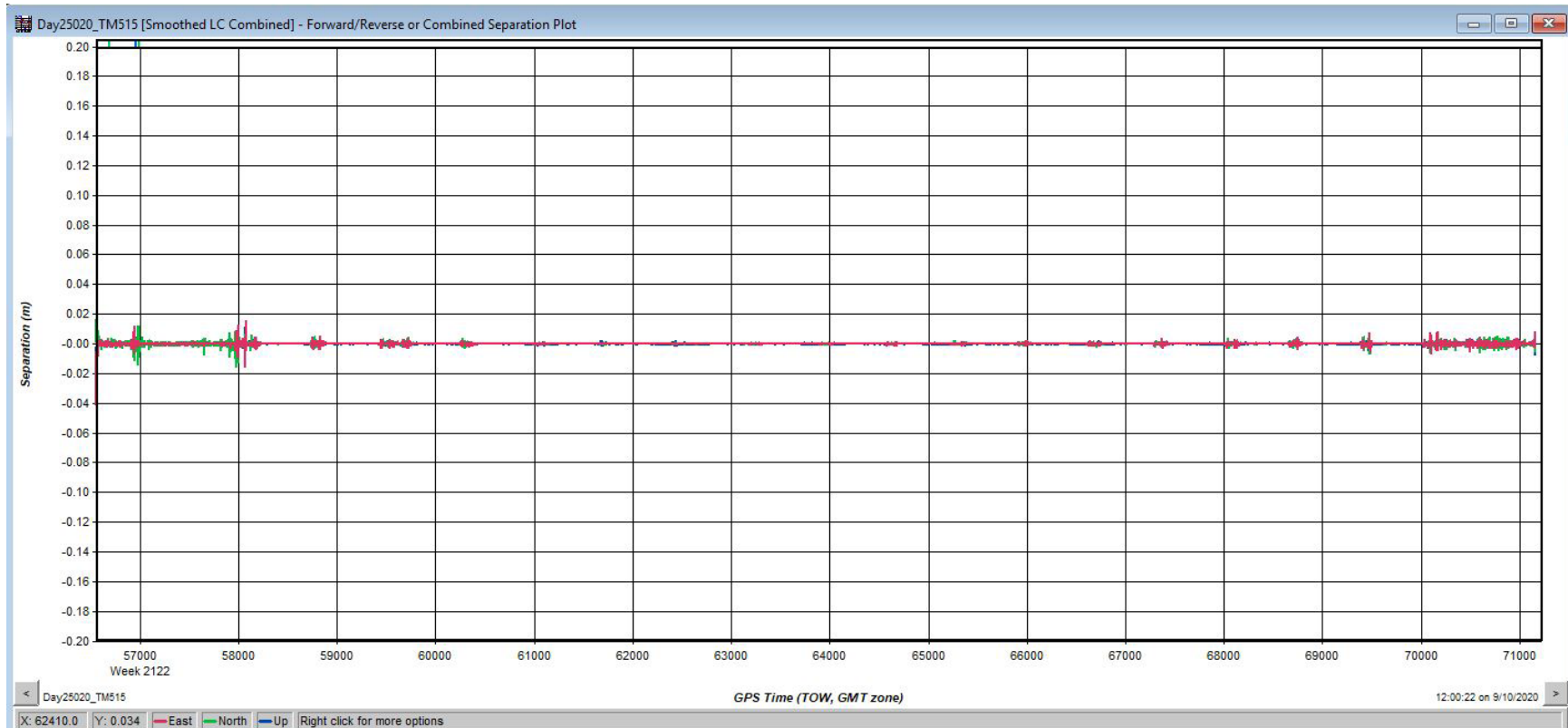
Day25020_TM515

Trajectory



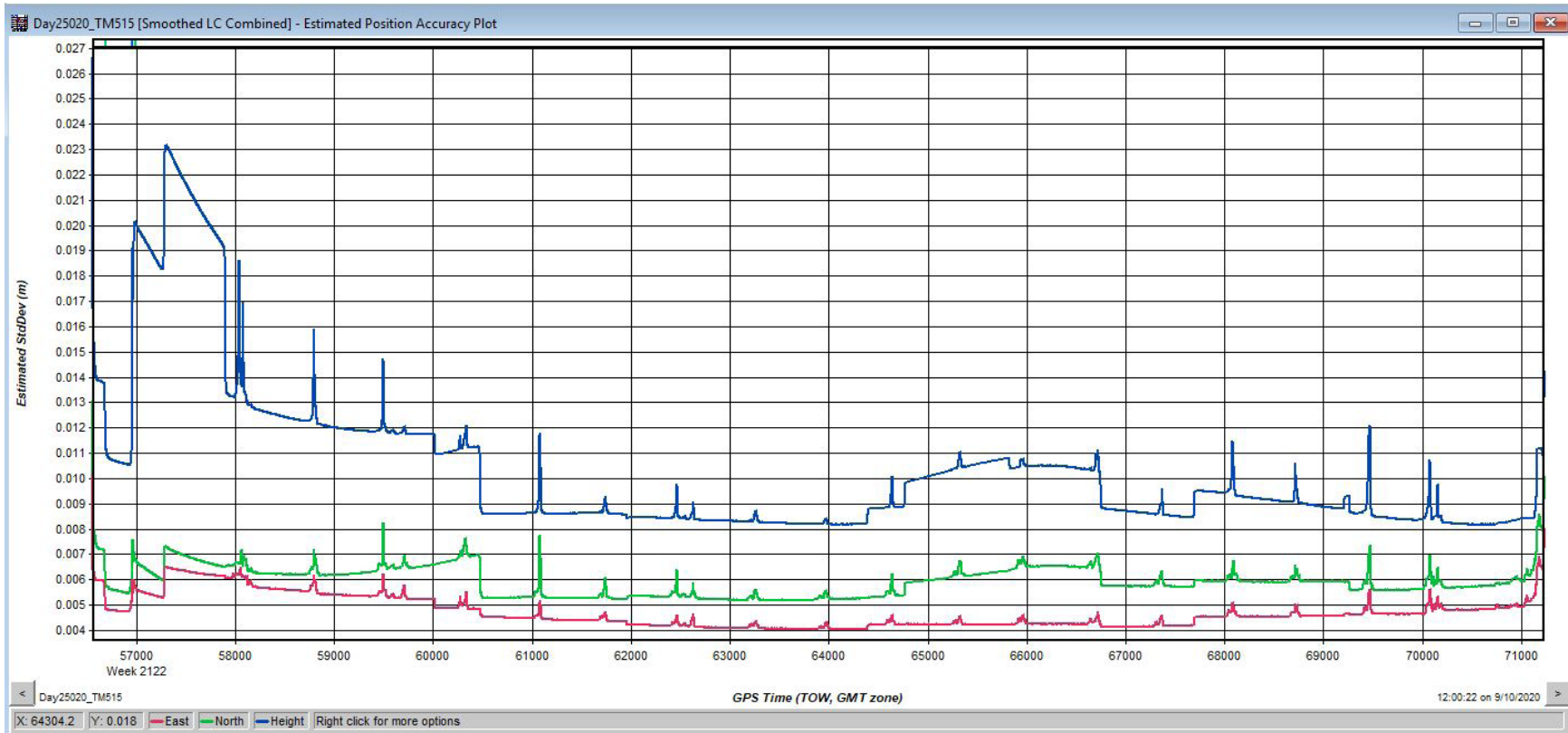
Day25020_TM515

Forward/Reverse or Combined Separation Plot



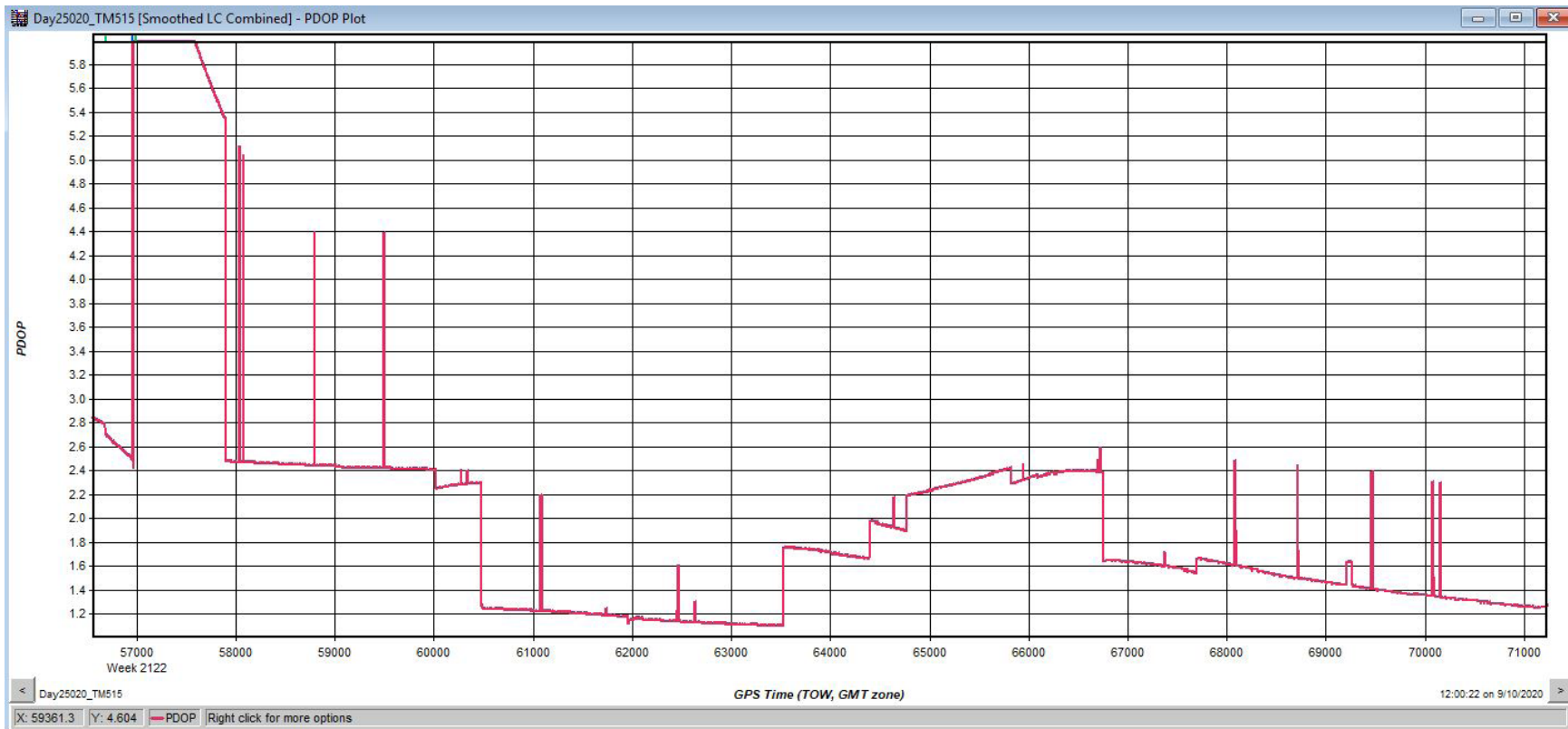
Day25020_TM515

Estimated Position Accuracy



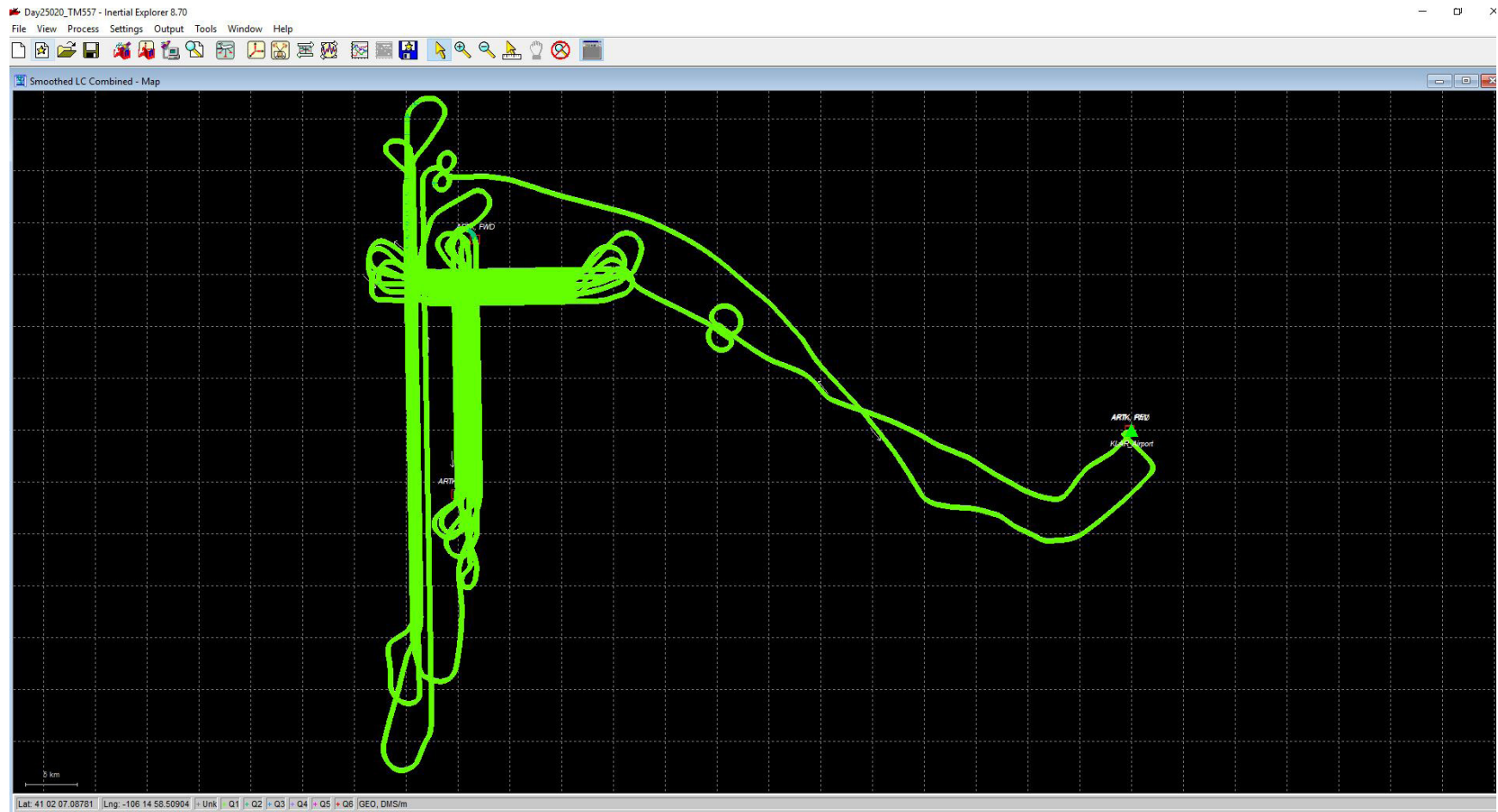
Day25020_TM515

PDOP Plot



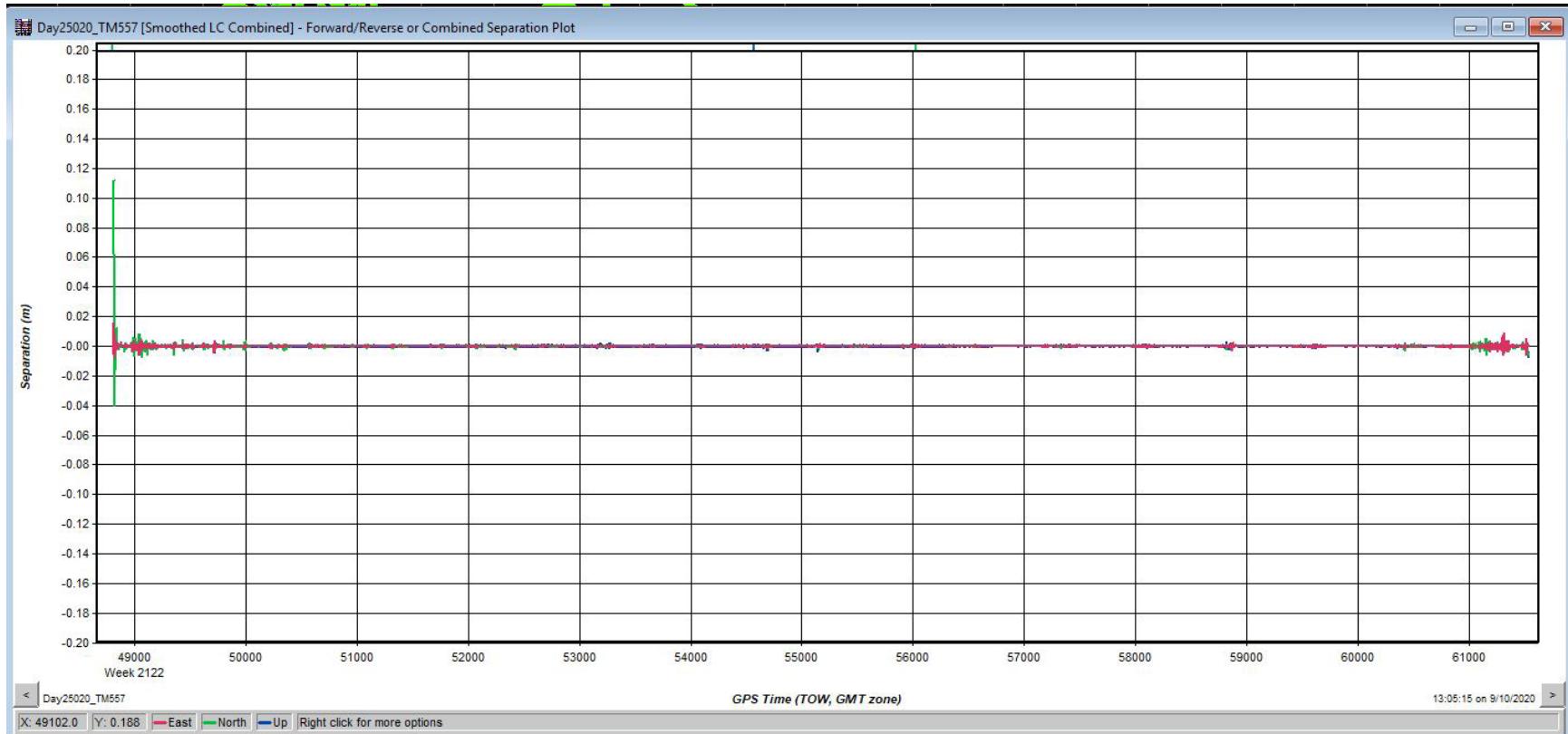
Day25020_TM557

Trajectory



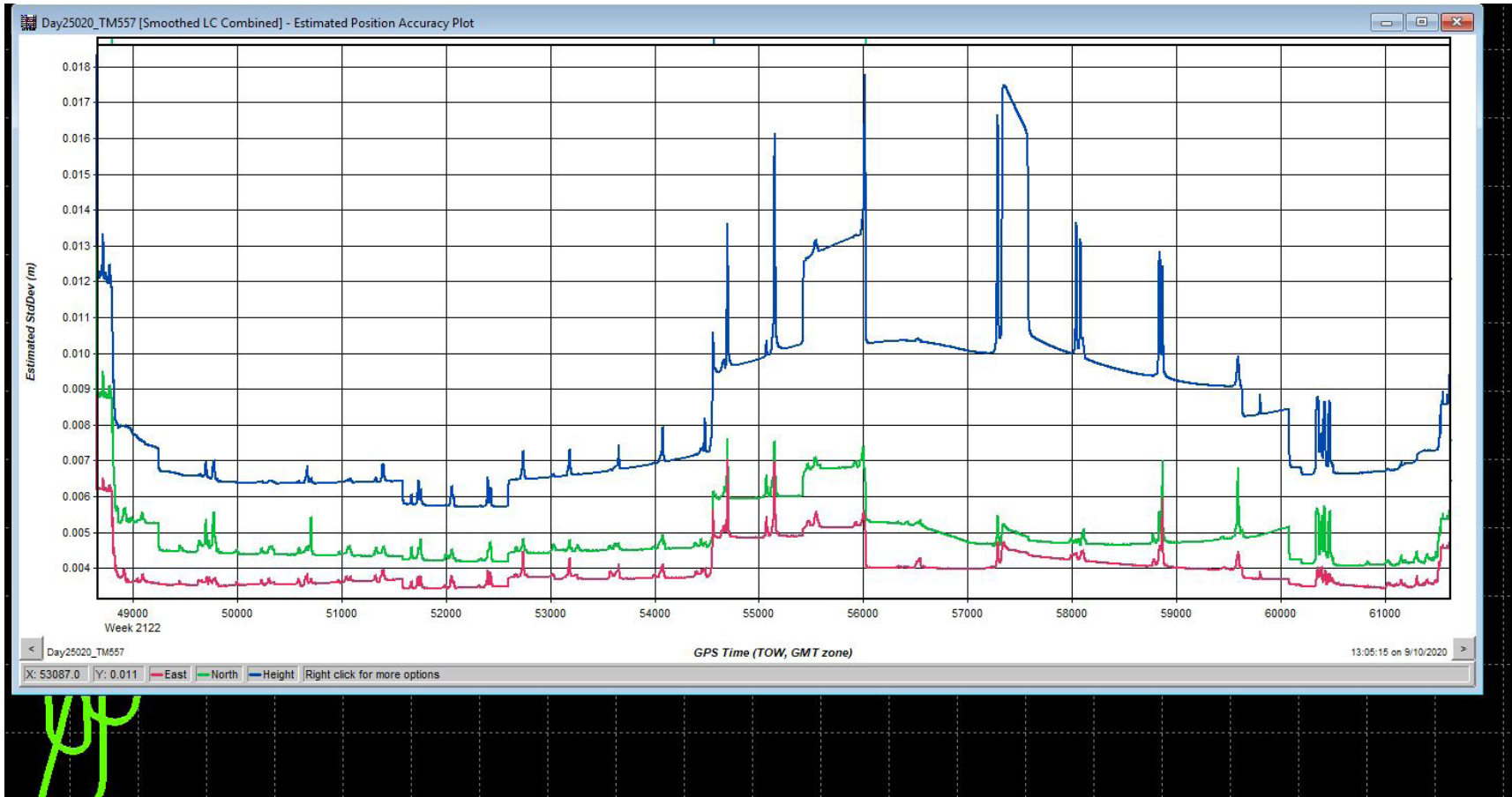
Day25020_TM557

Forward/Reverse or Combined Separation Plot



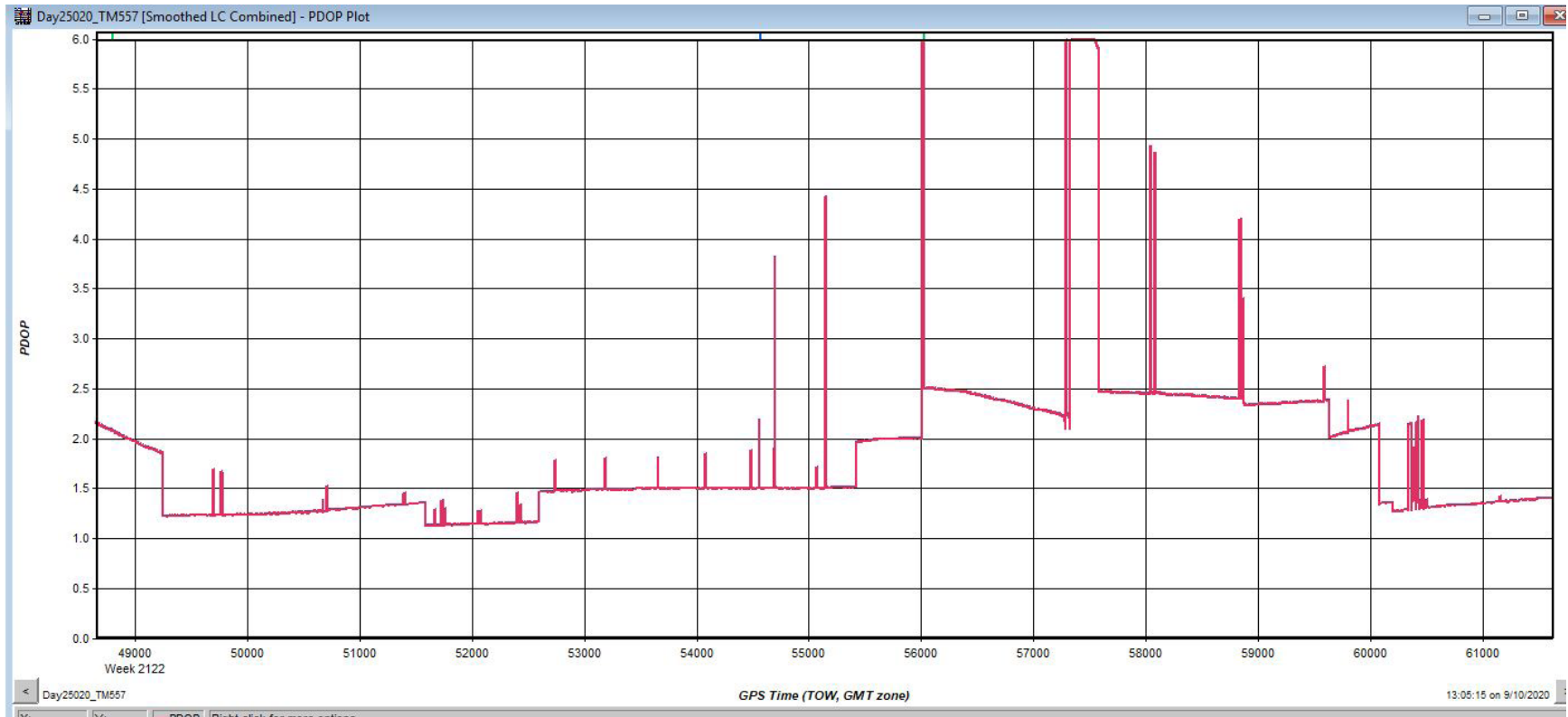
Day25020_TM557

Estimated Position Accuracy



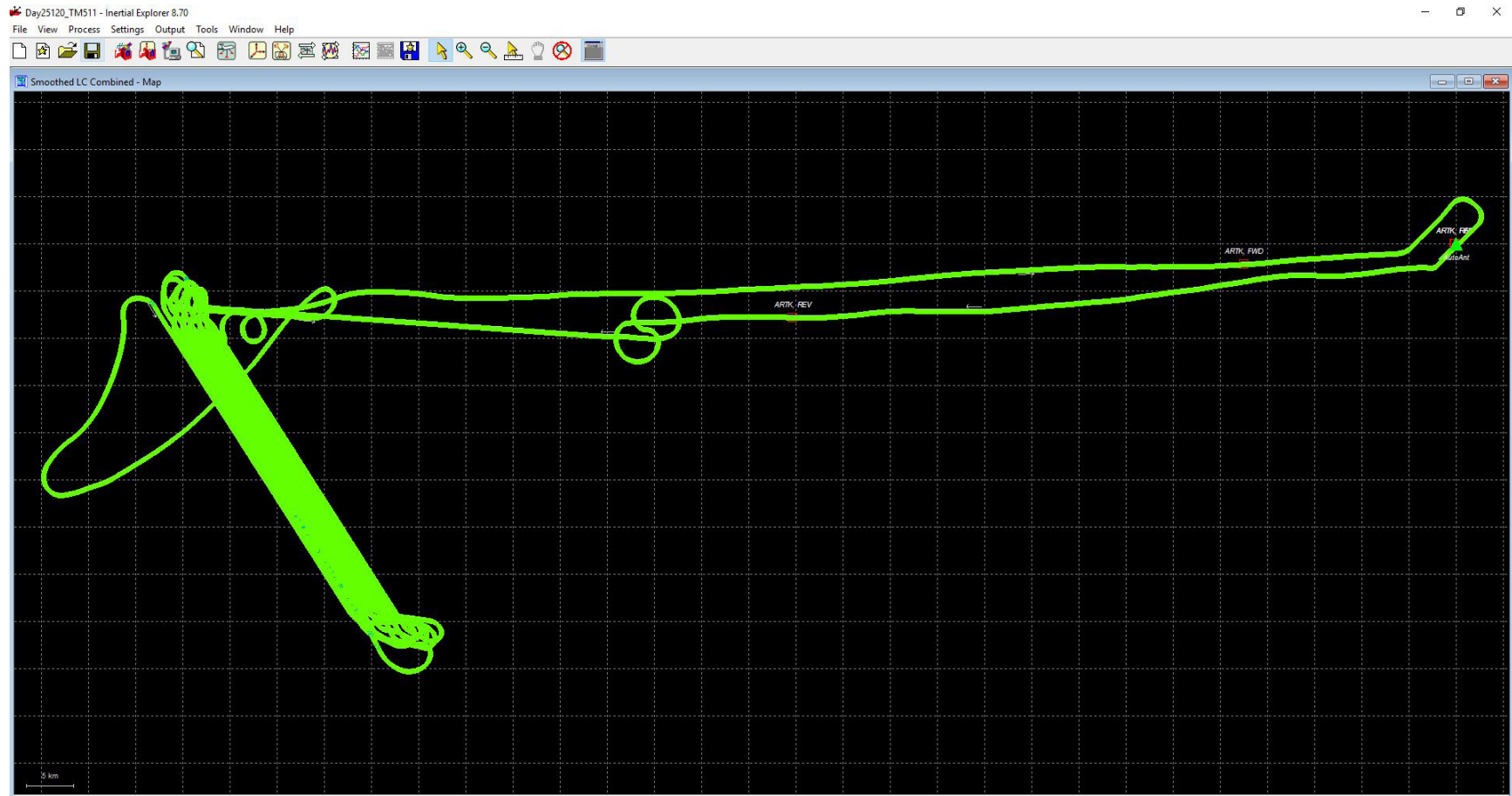
Day25020_TM557

PDOP Plot



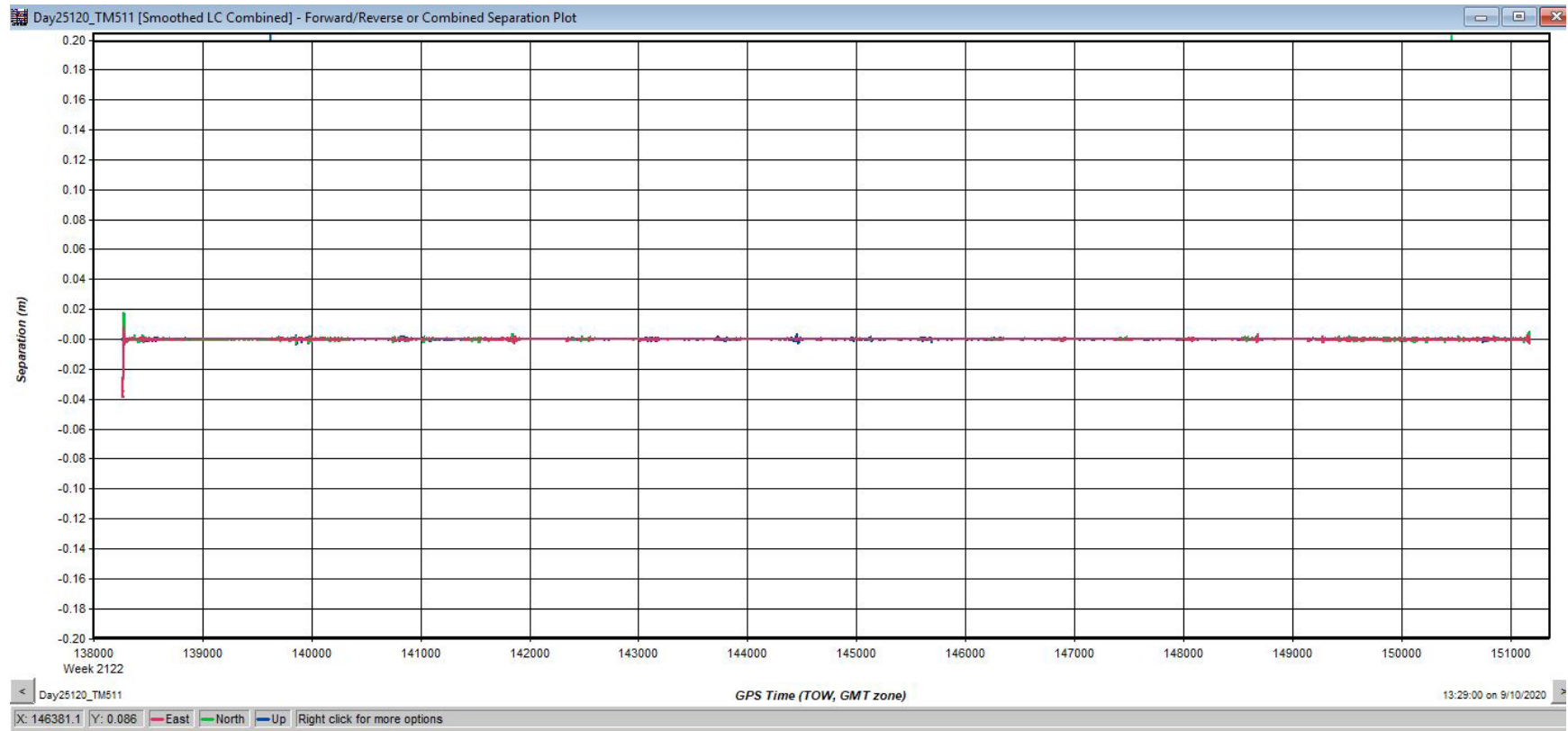
Day25120_TM511

Trajectory



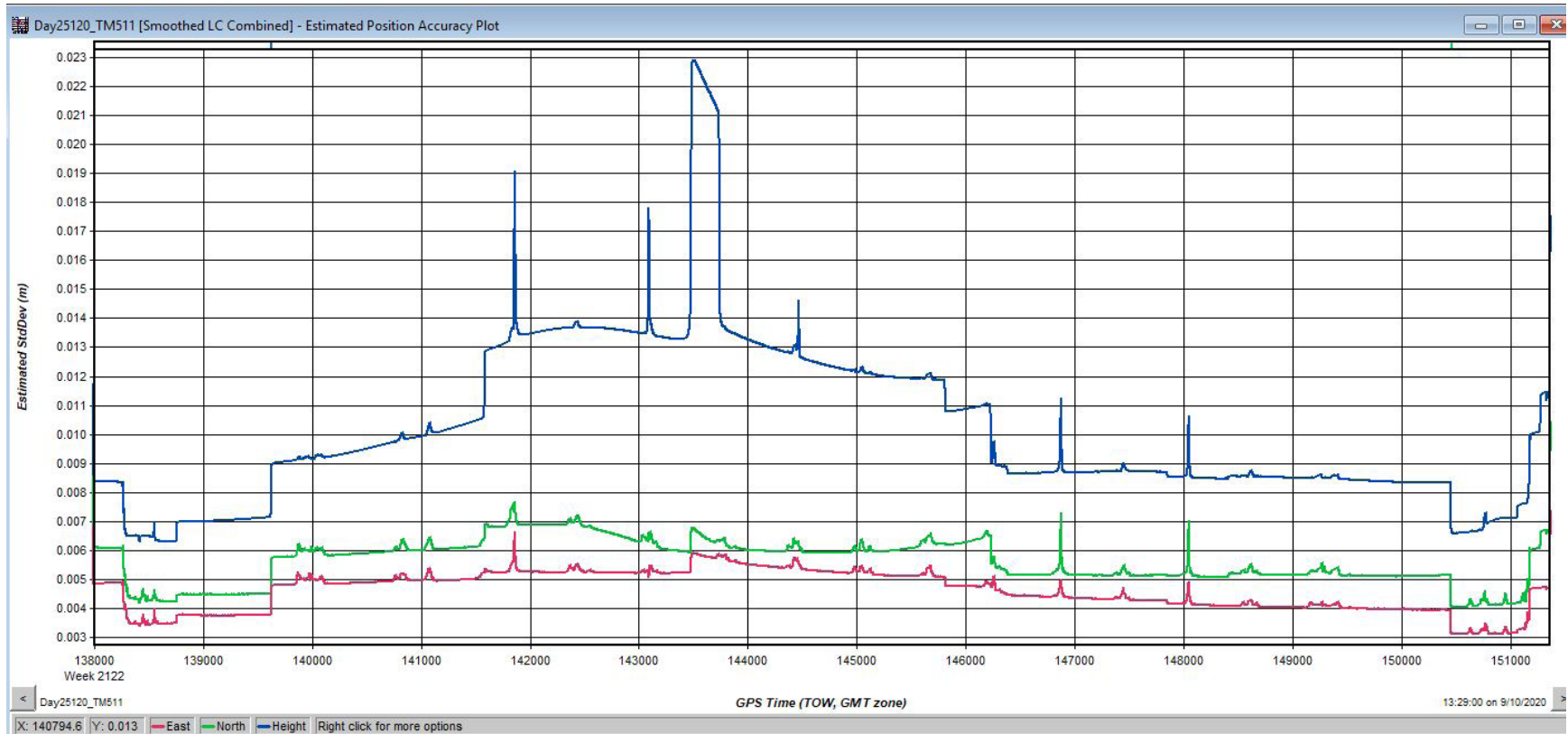
Day25120_TM511

Forward/Reverse or Combined Separation Plot



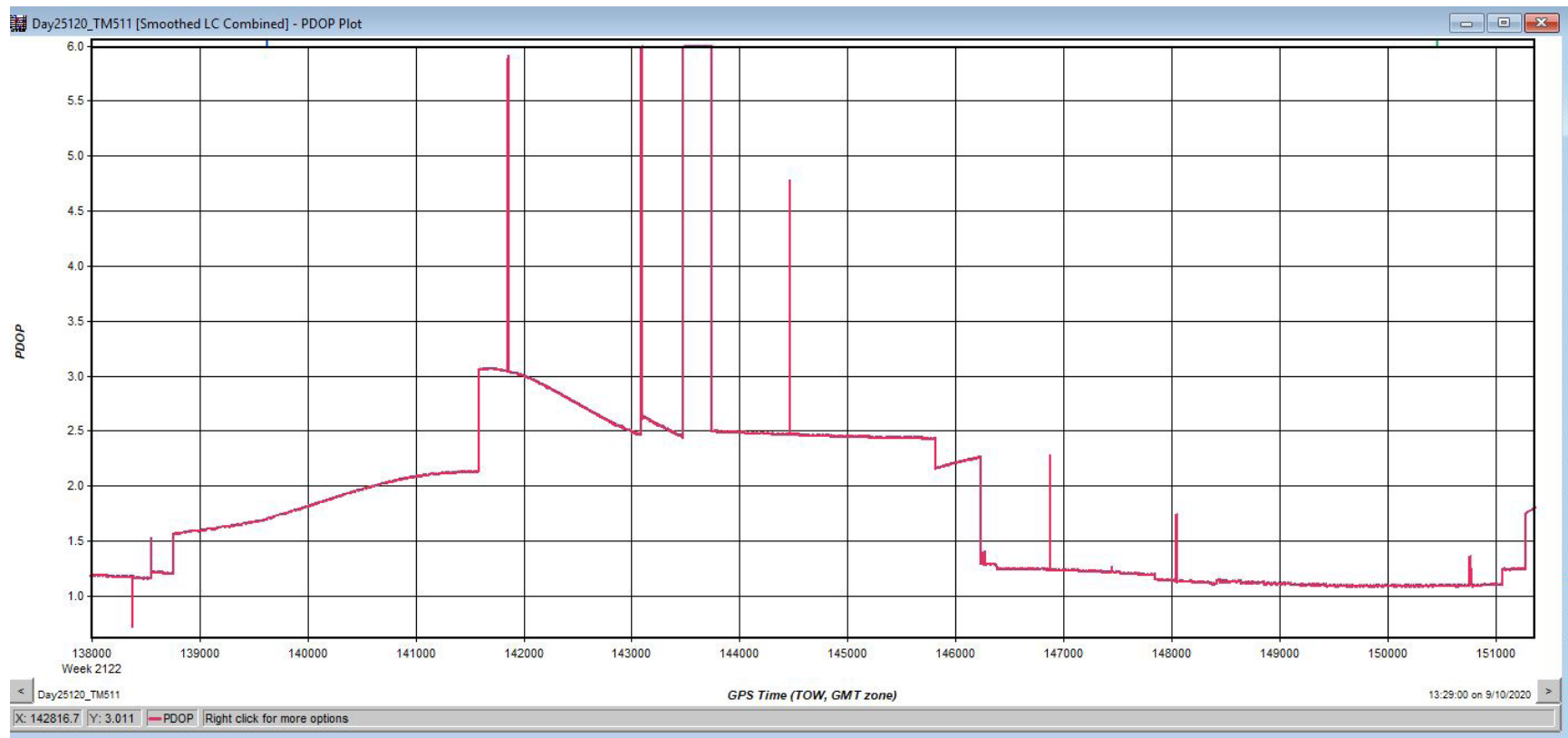
Day25120_TM511

Estimated Position Accuracy



Day25120_TM511

PDOP Plot



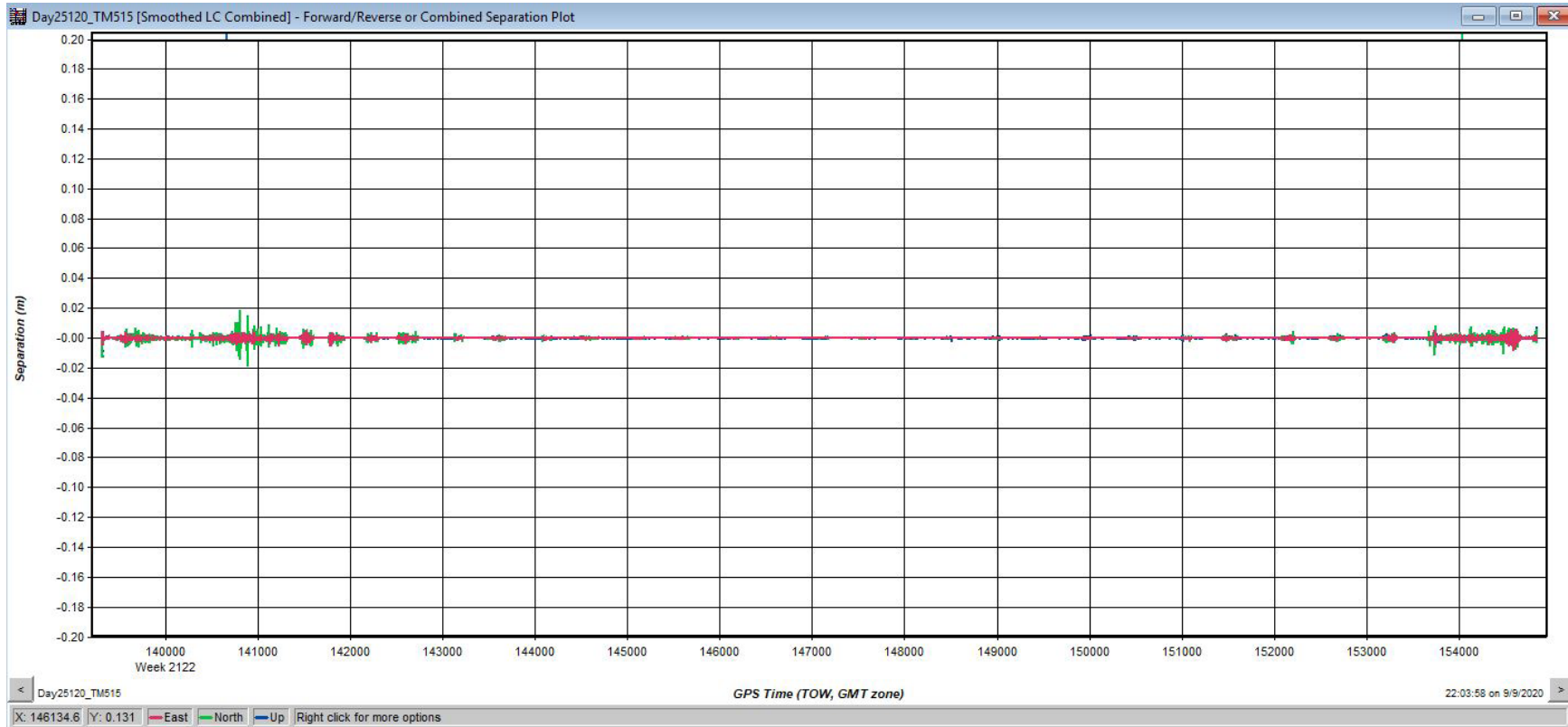
Day25120_TM515

Trajectory



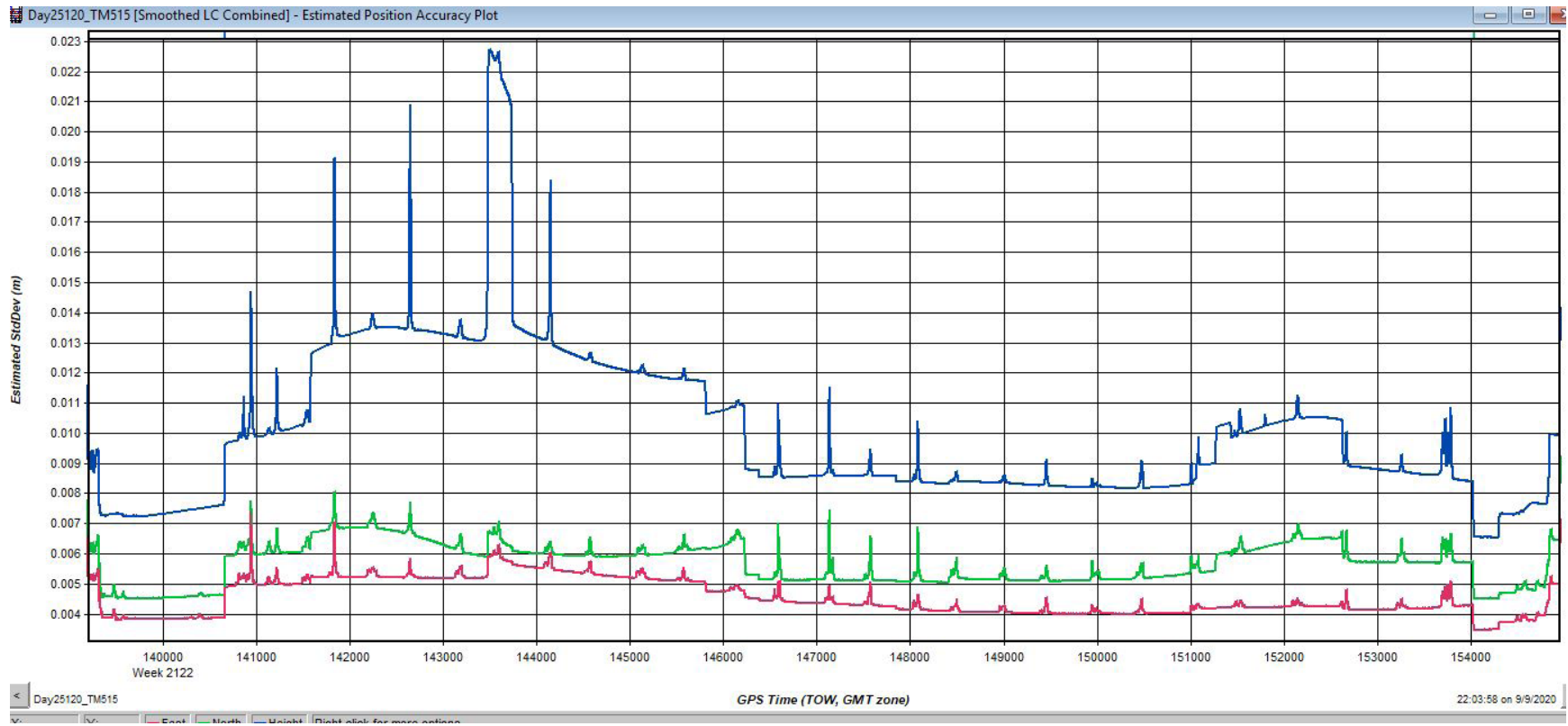
Day25120_TM515

Forward/Reverse or Combined Separation Plot



Day25120_TM515

Estimated Position Accuracy



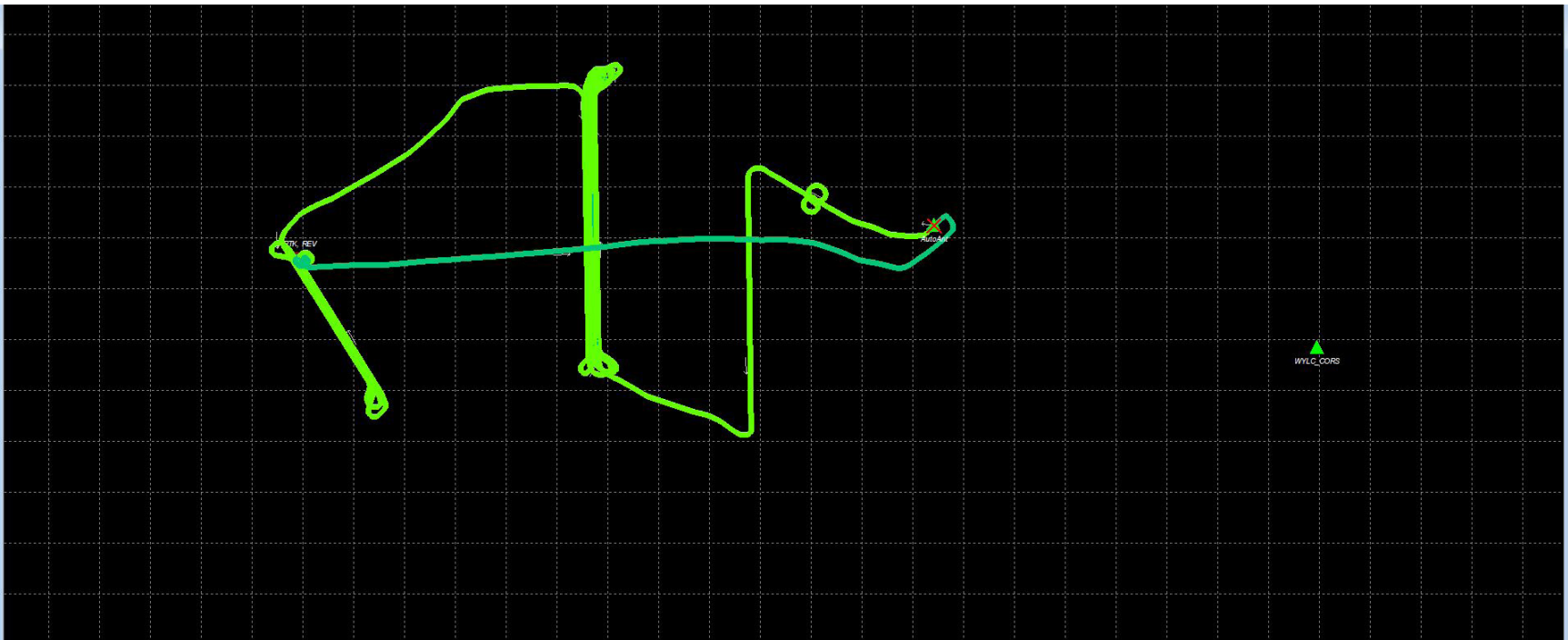
Day25120_TM515

PDOP Plot



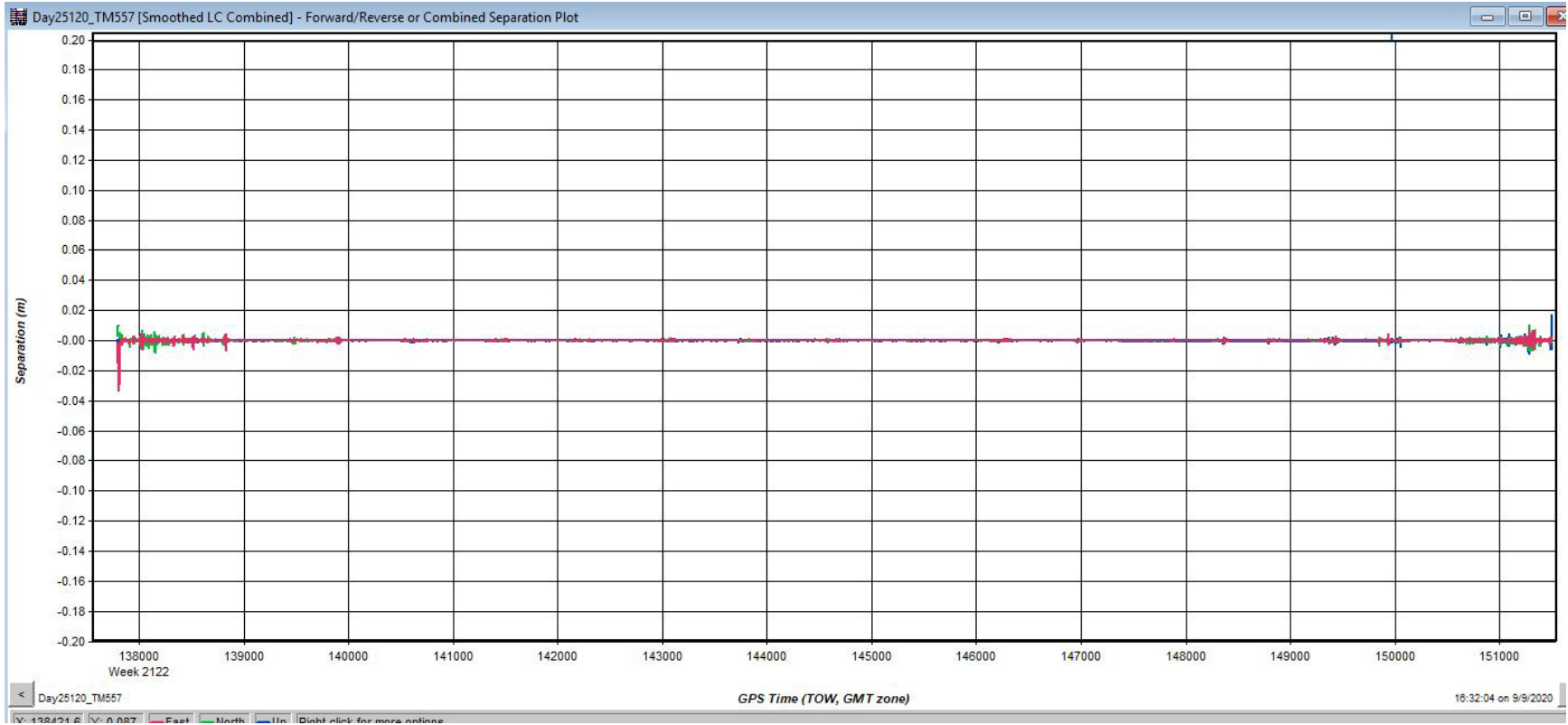
Day25120_TM557

Trajectory



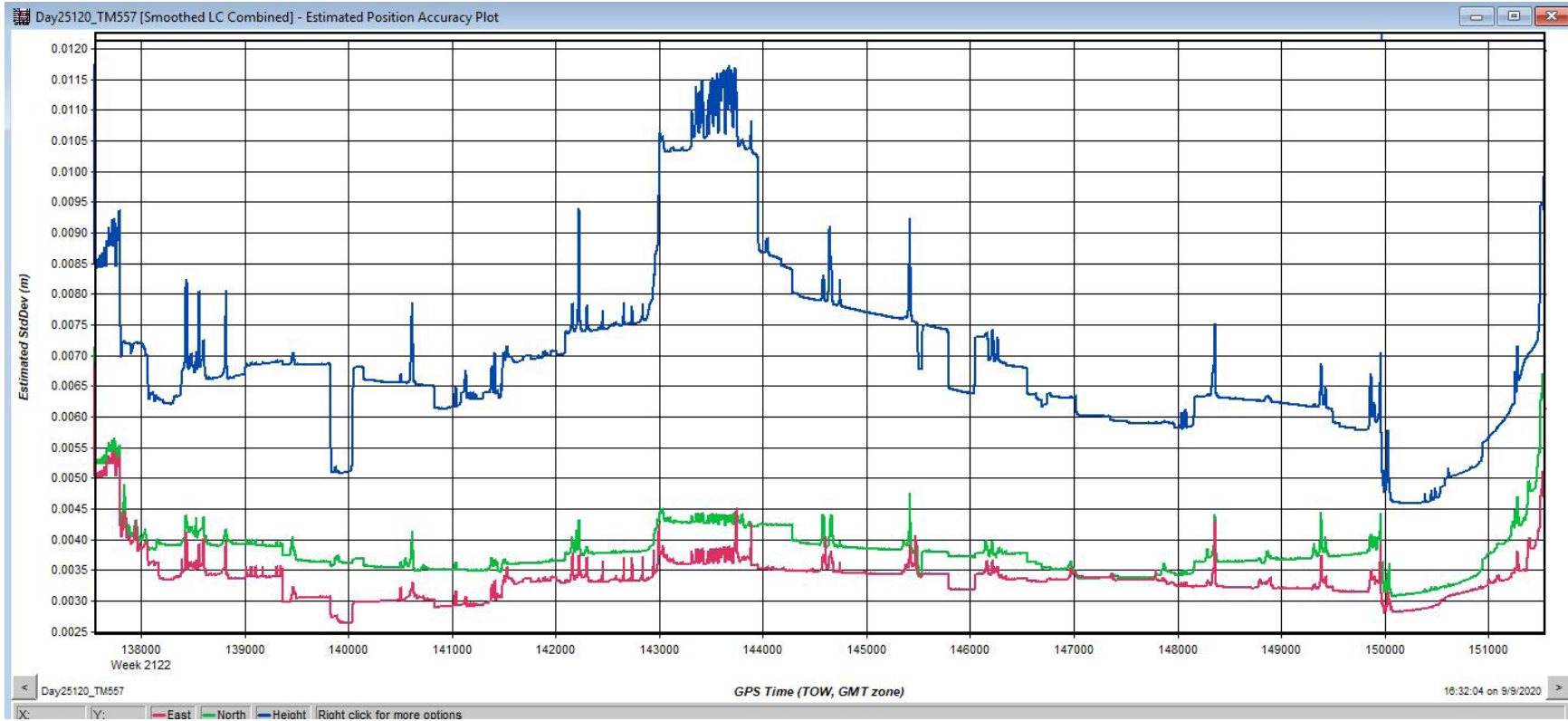
Day25120_TM557

Forward/Reverse or Combined Separation Plot



Day25120_TM557

Estimated Position Accuracy



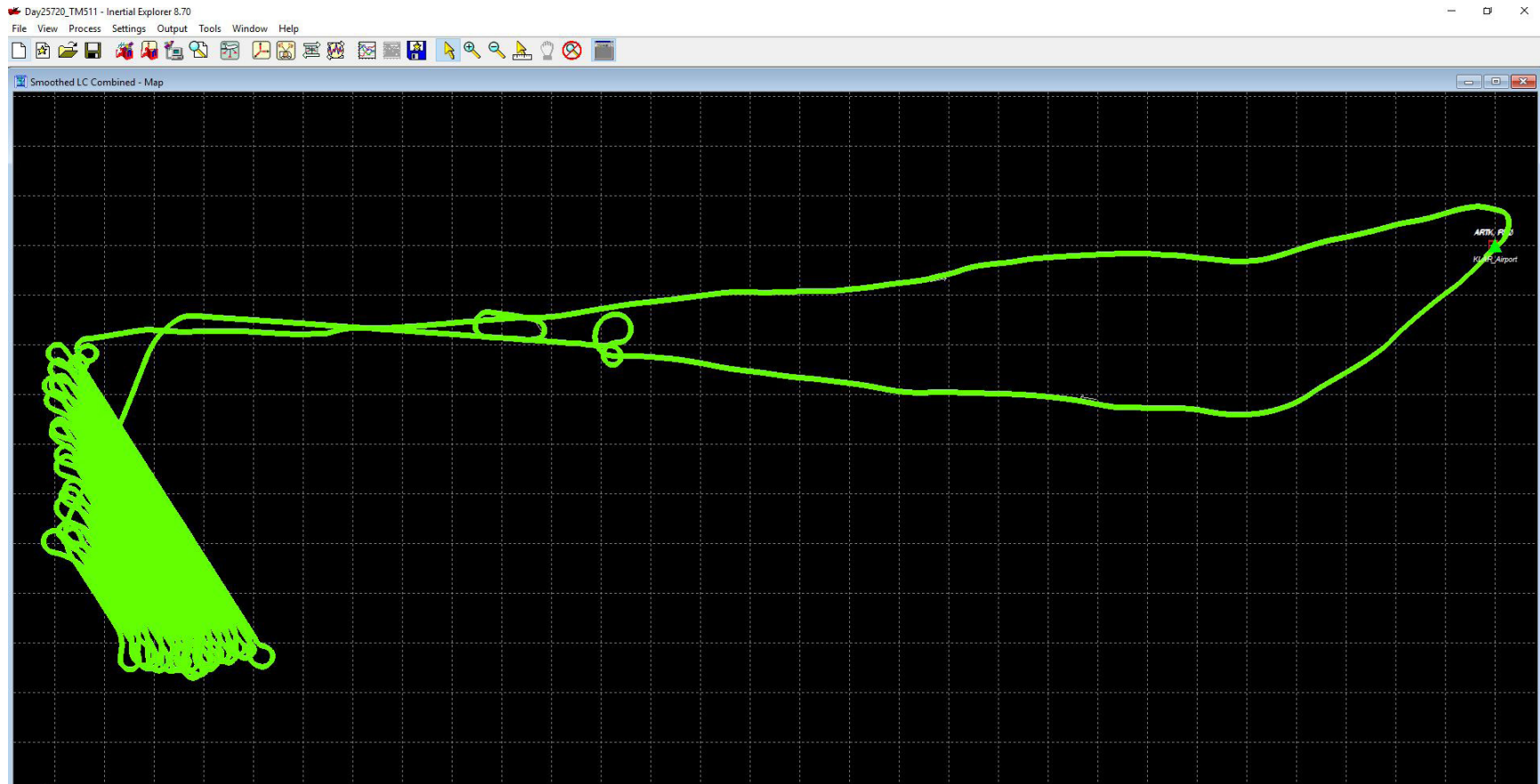
Day25120_TM557

PDOP Plot



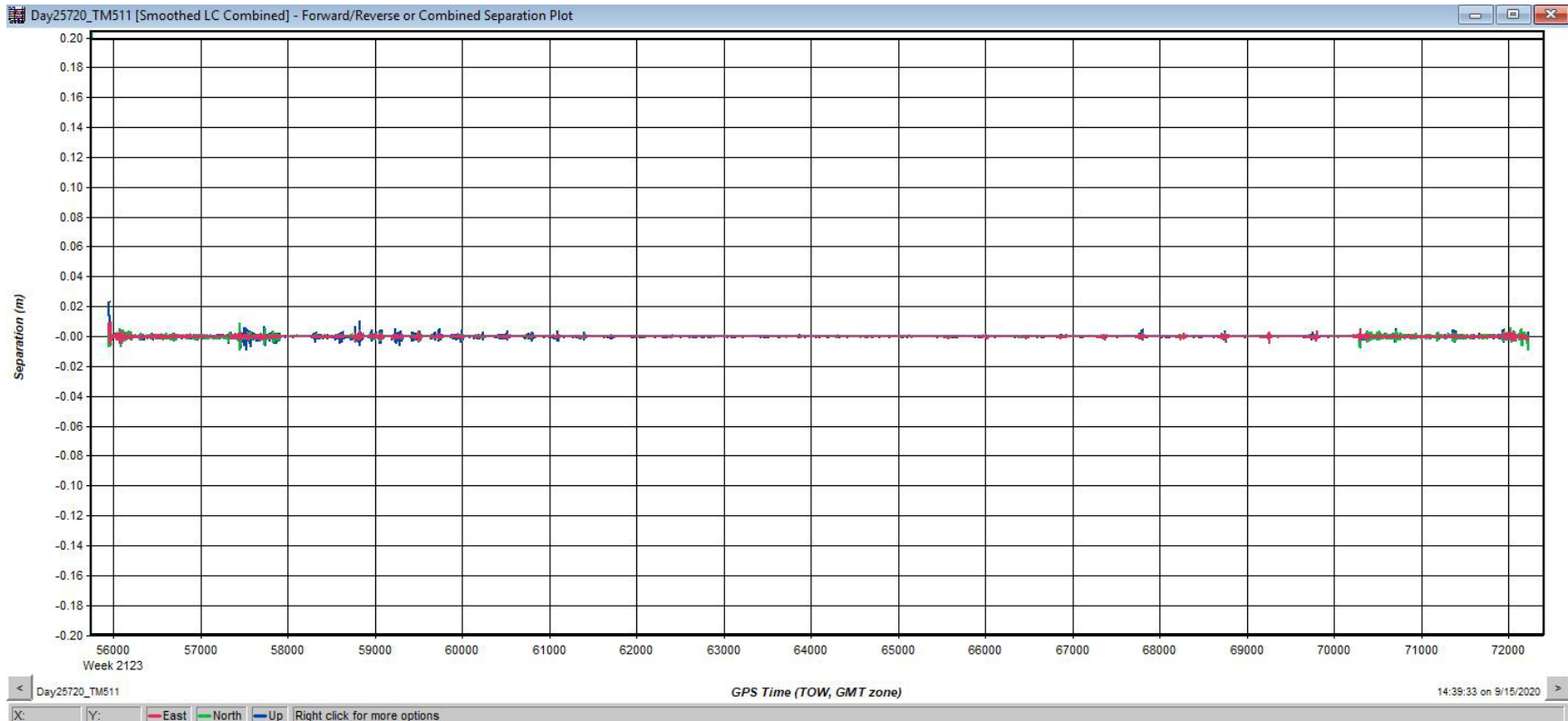
Day25720_TM511

Trajectory



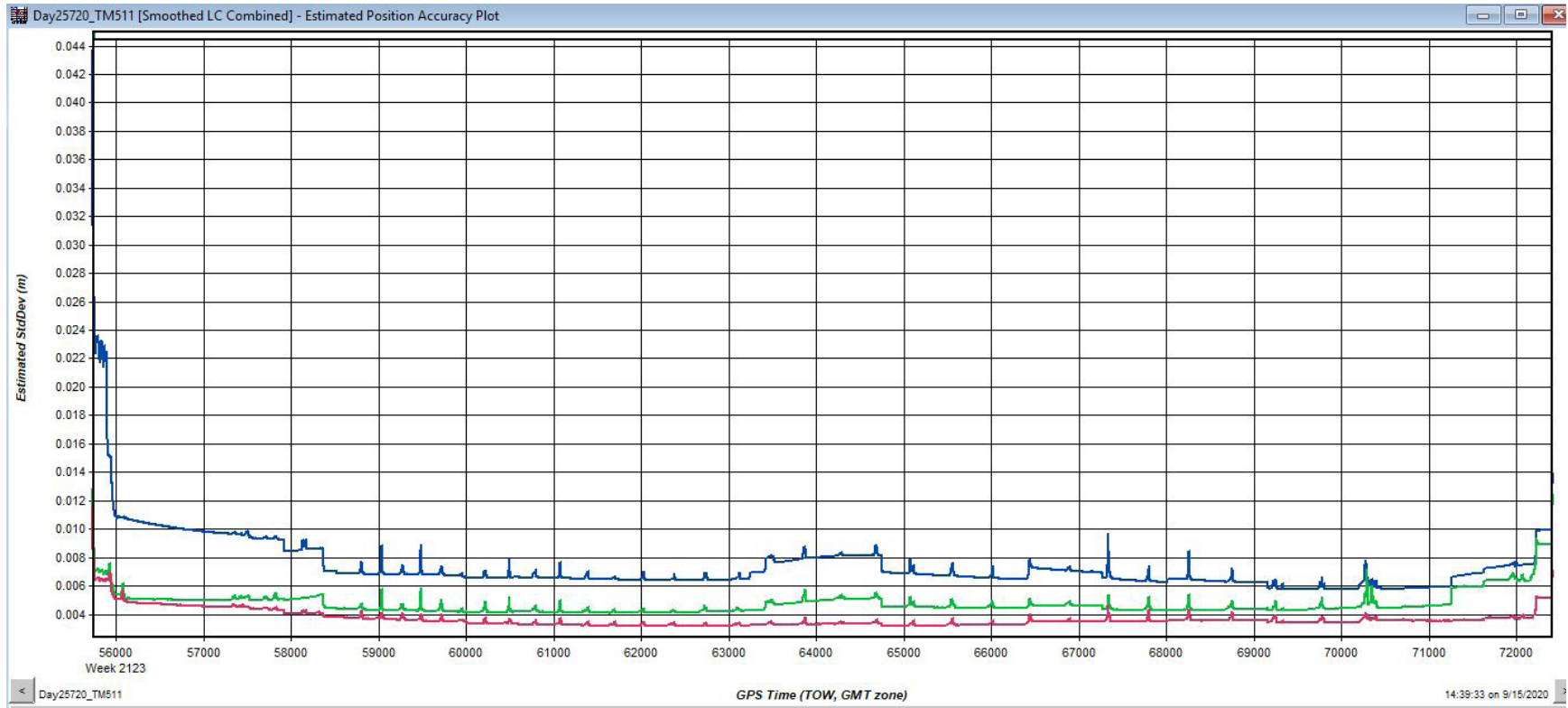
Day25720_TM511

Forward/Reverse or Combined Separation Plot



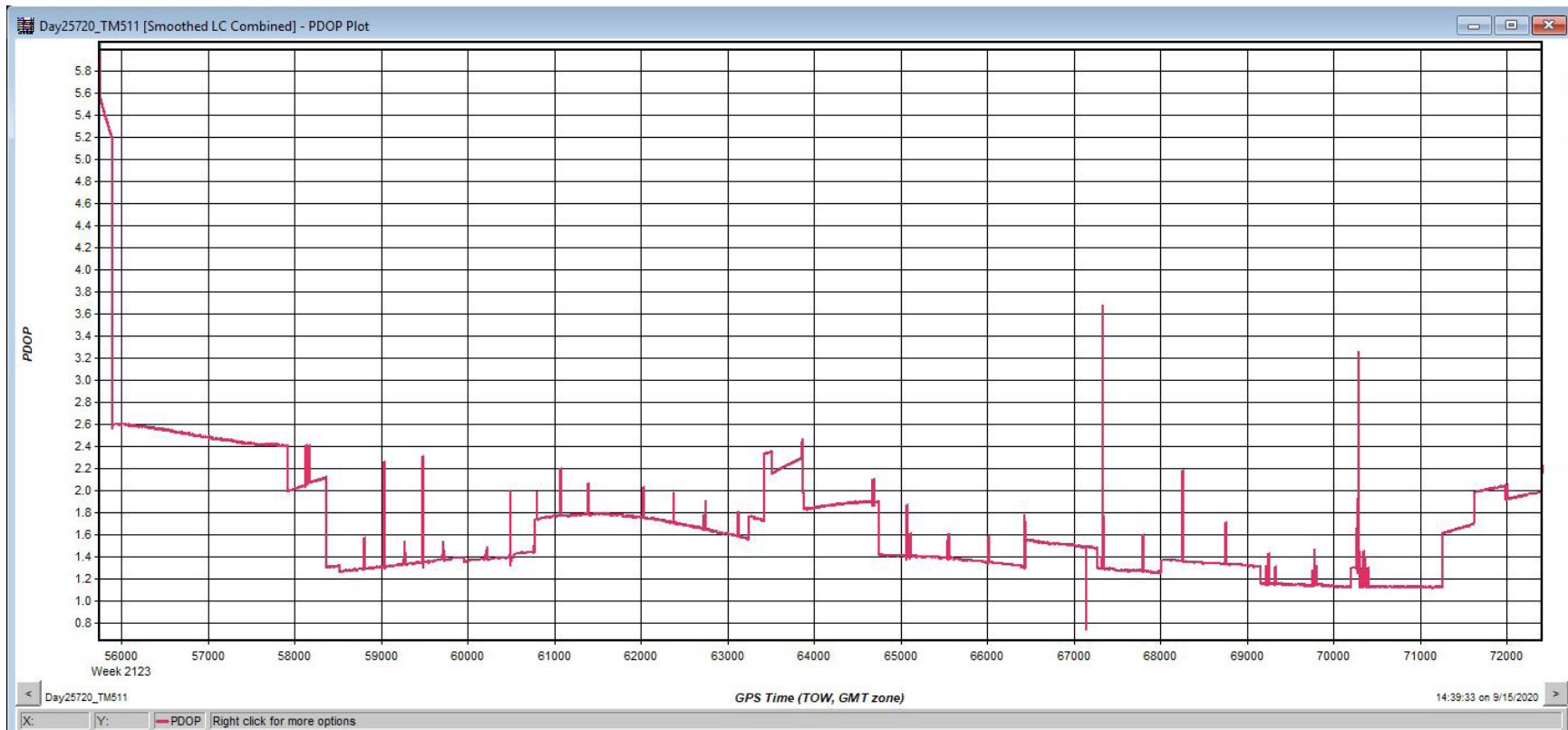
Day25720_TM511

Estimated Position Accuracy



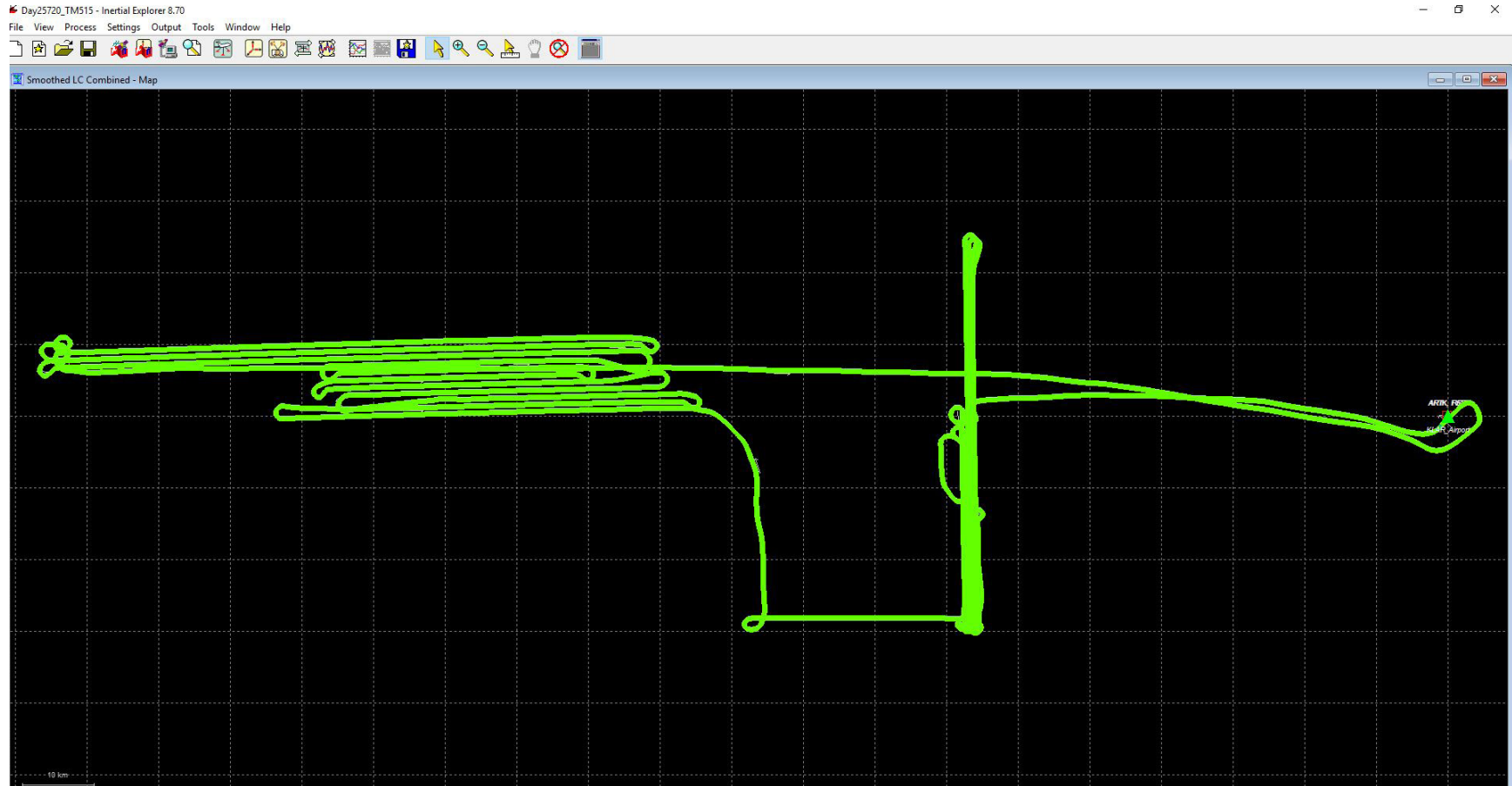
Day25720_TM511

PDOP Plot



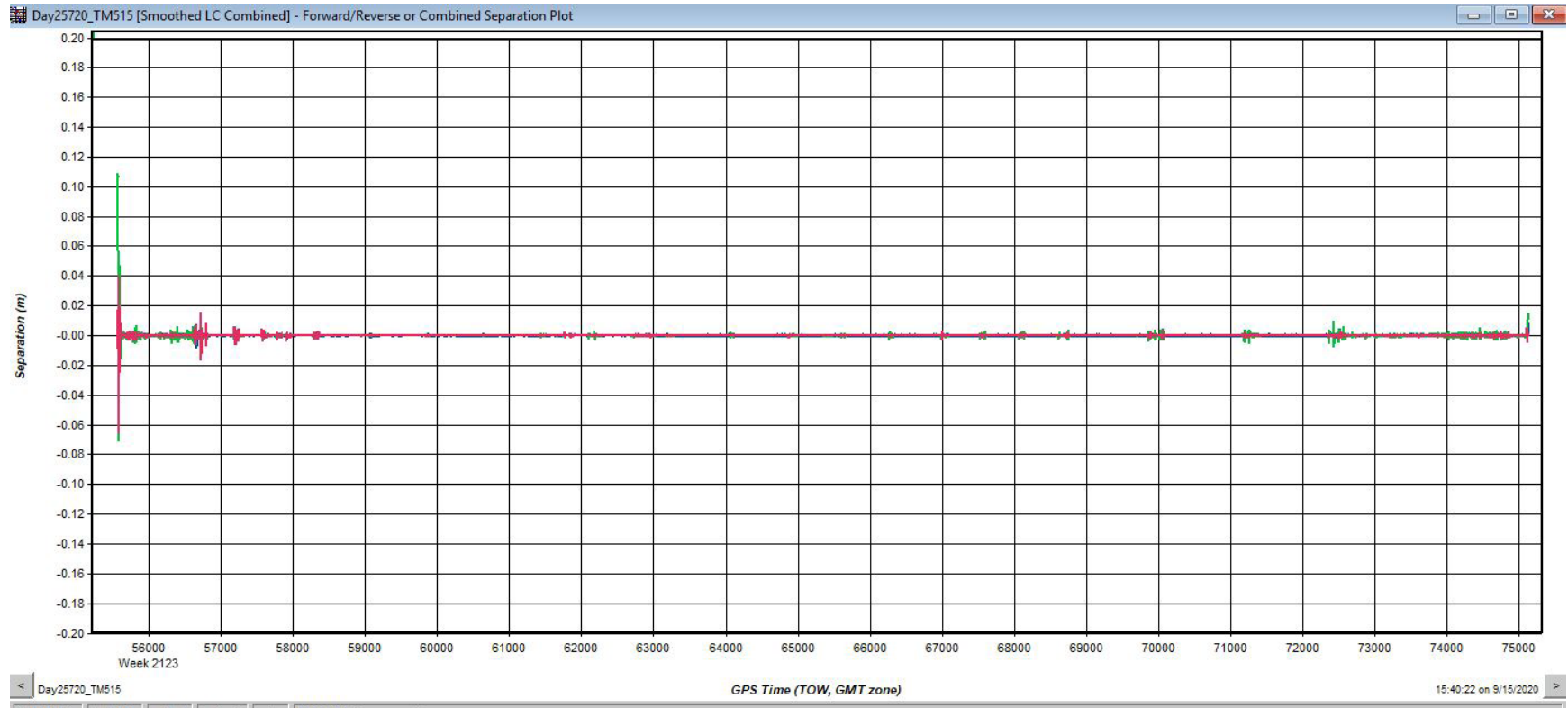
Day25720_TM515

Trajectory



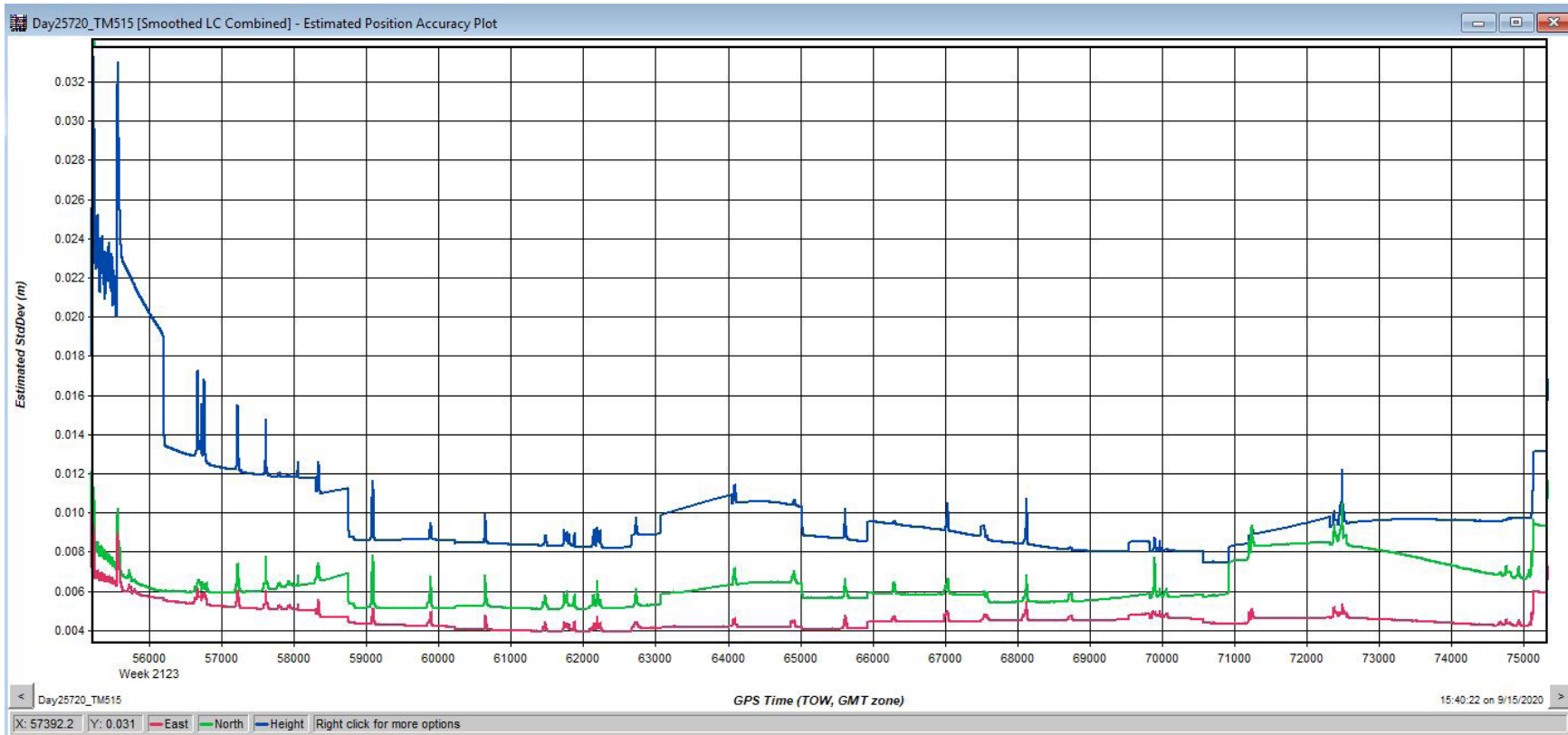
Day25720_TM515

Forward/Reverse or Combined Separation Plot



Day25720_TM515

Estimated Position Accuracy



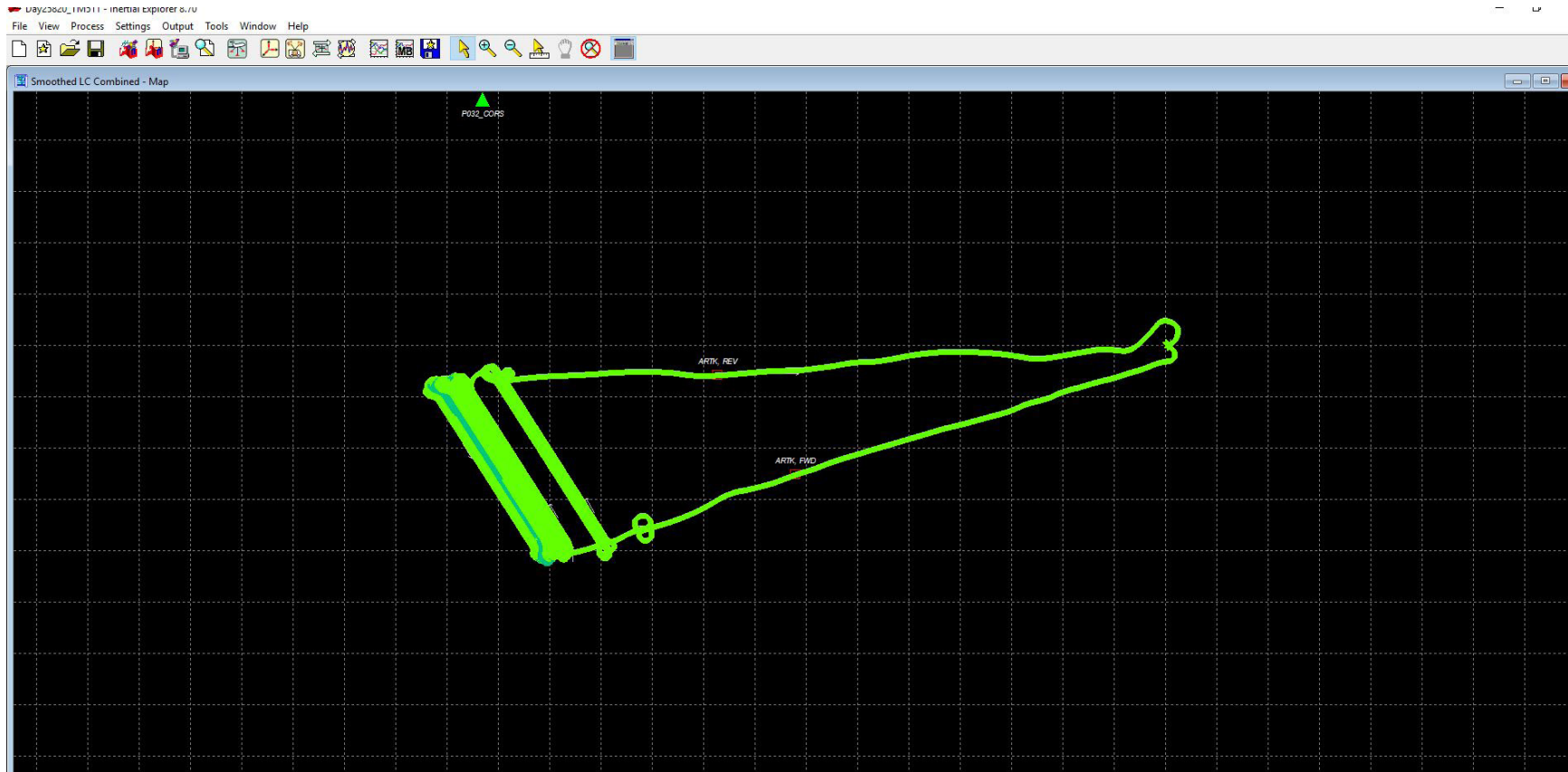
Day25720_TM515

PDOP Plot



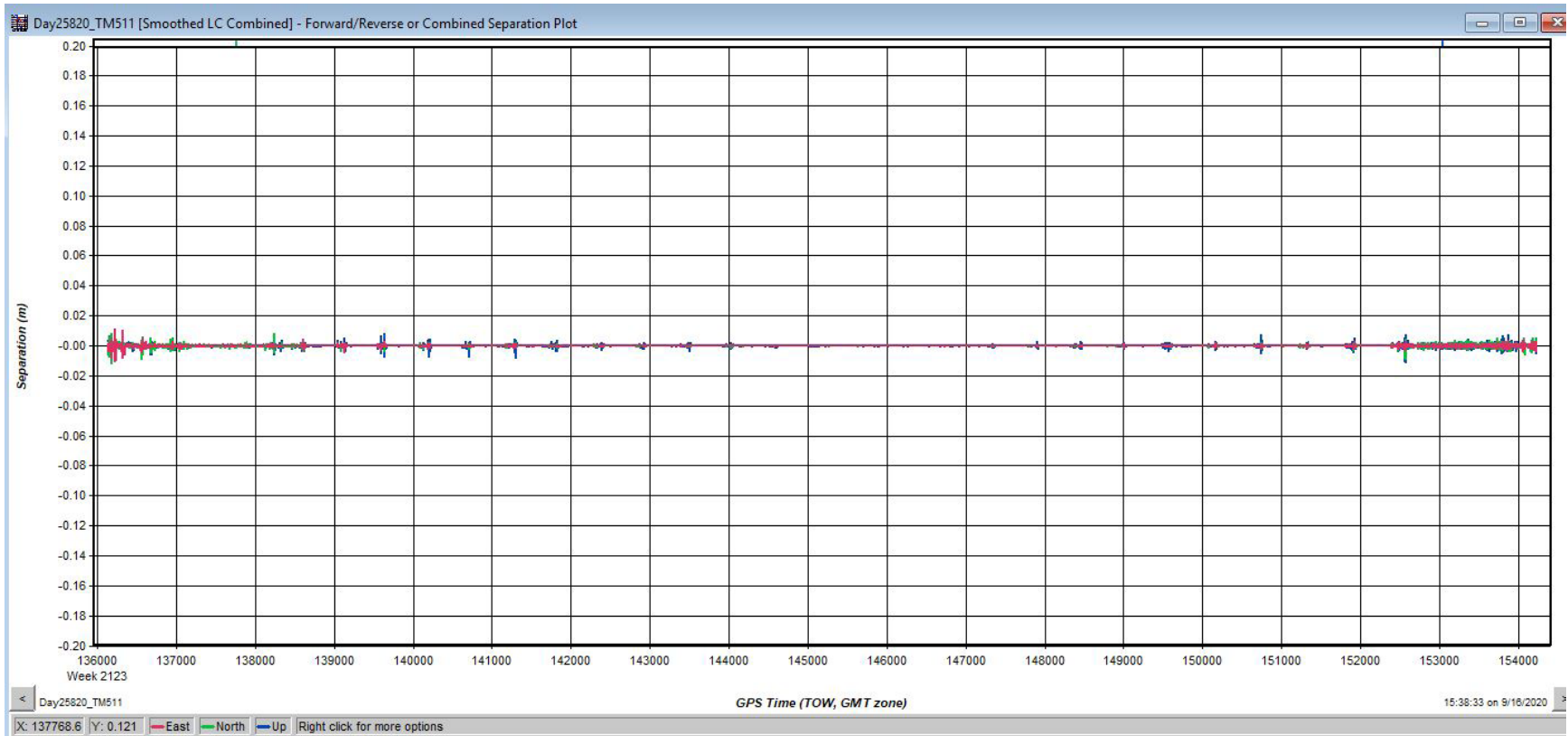
Day25820_TM511

Trajectory



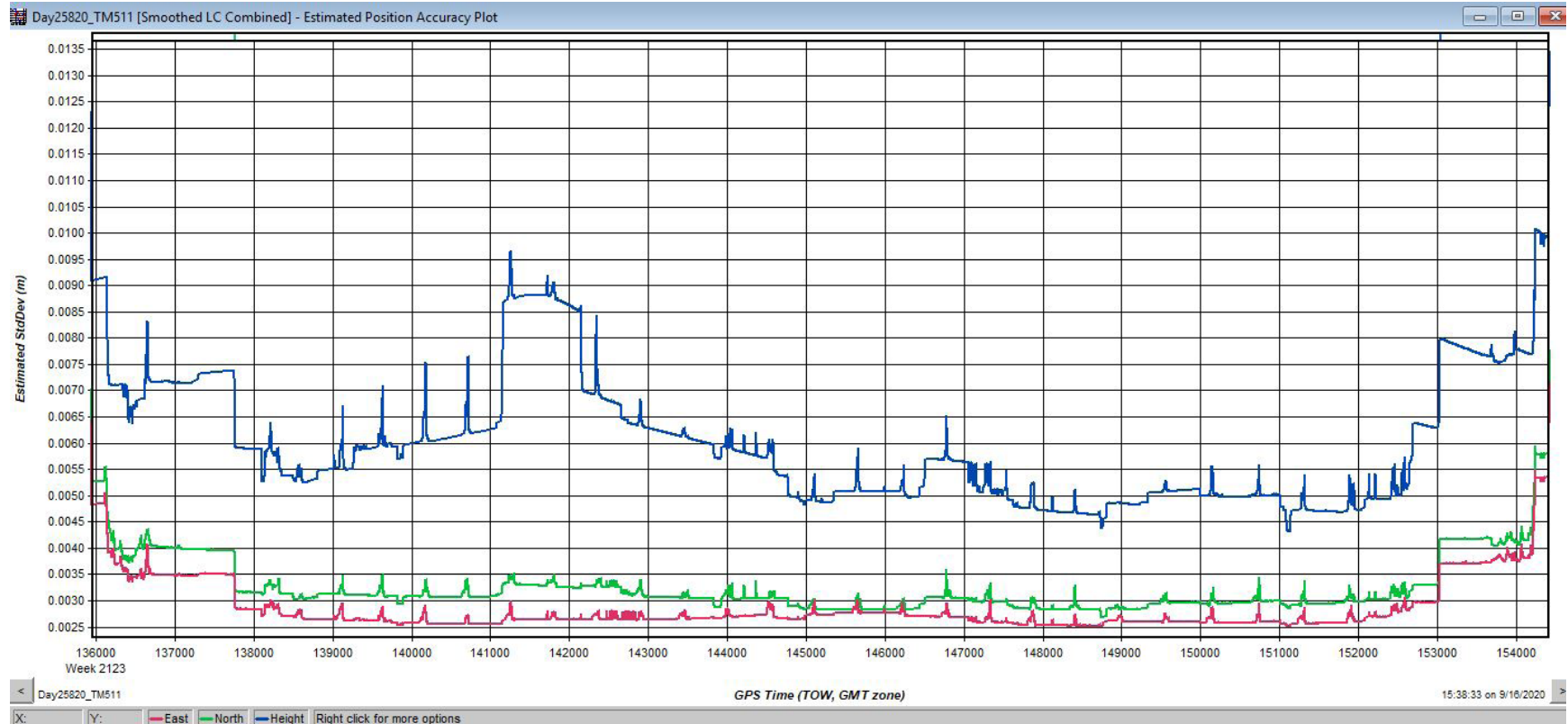
Day25820_TM511

Forward/Reverse or Combined Separation Plot



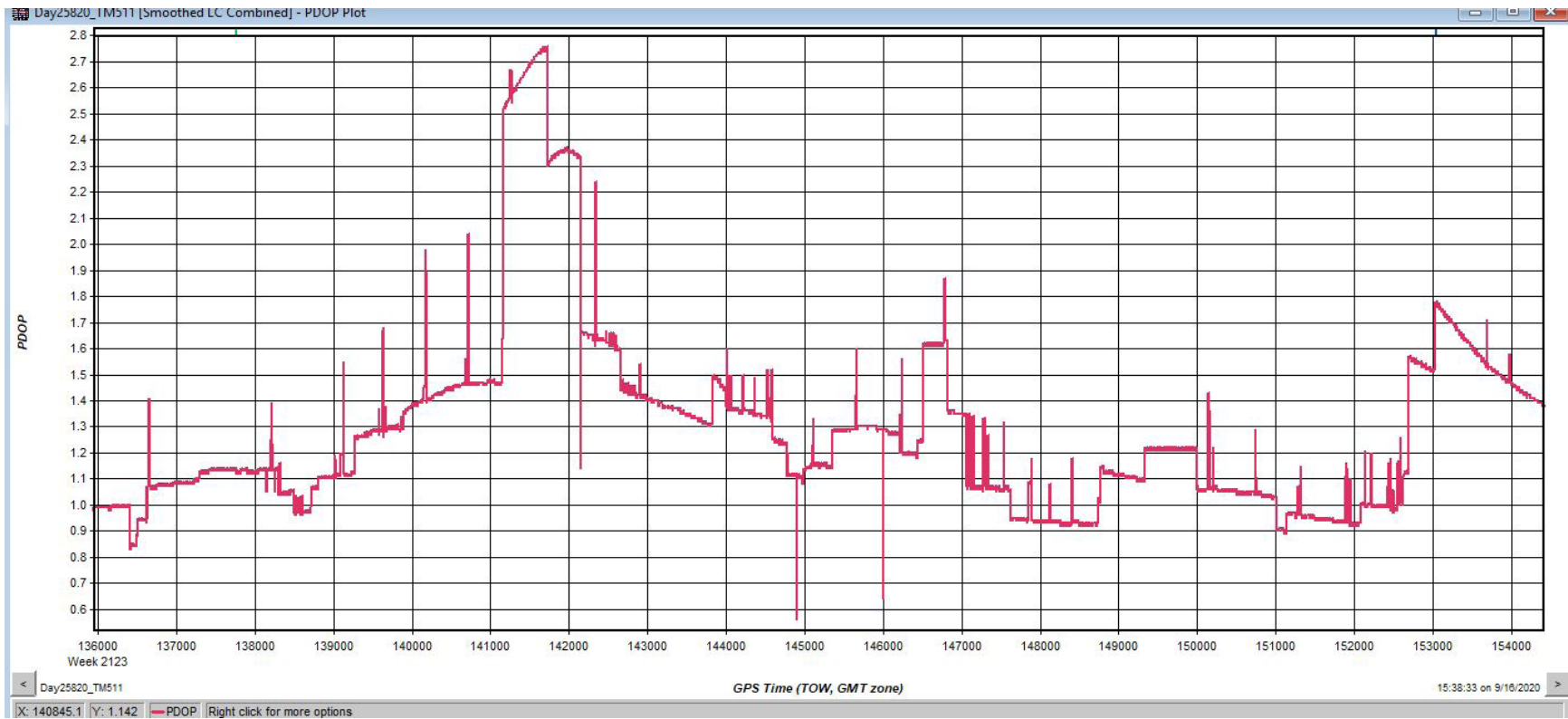
Day25820_TM511

Estimated Position Accuracy



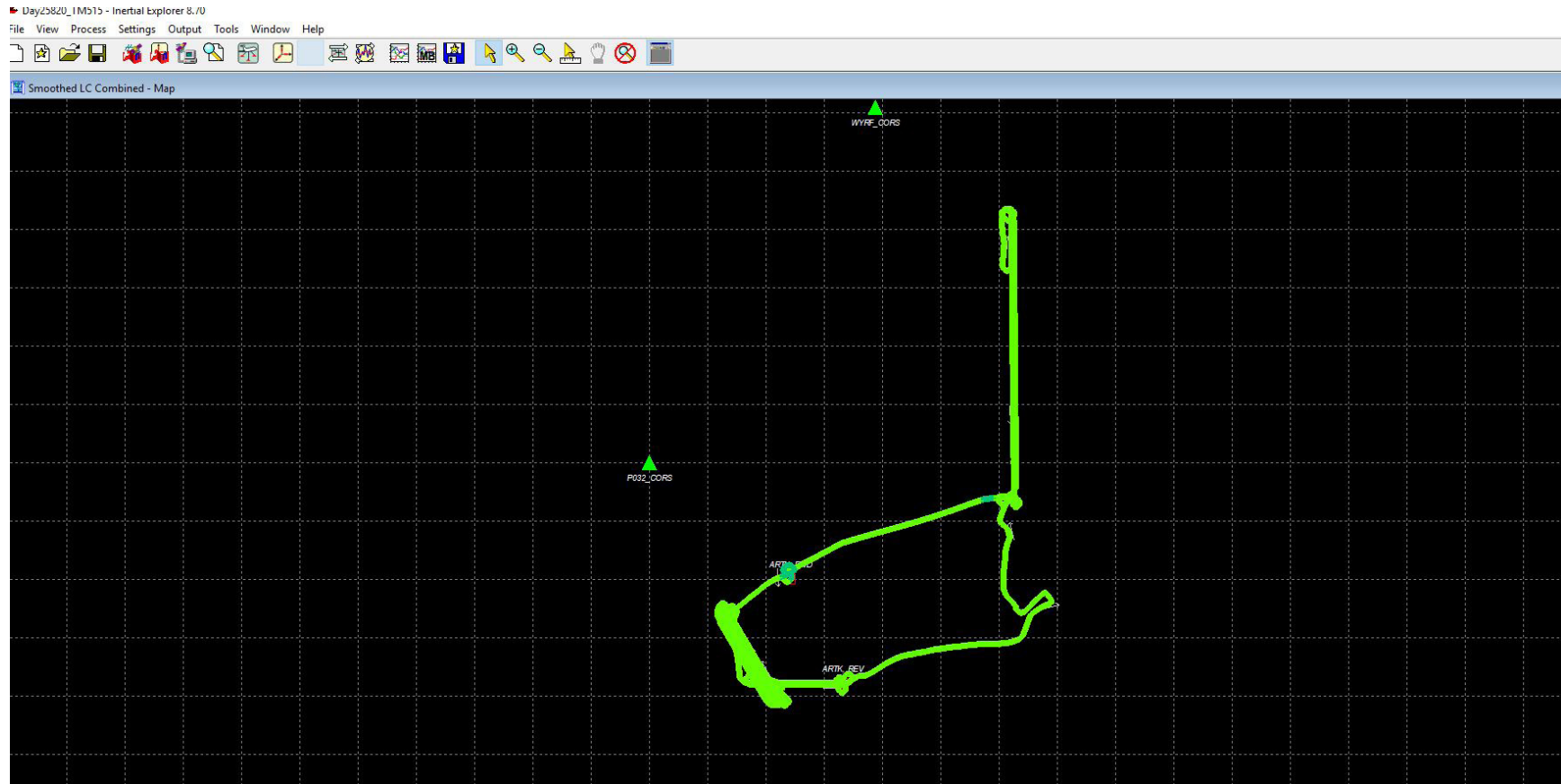
Day25820_TM511

PDOP Plot



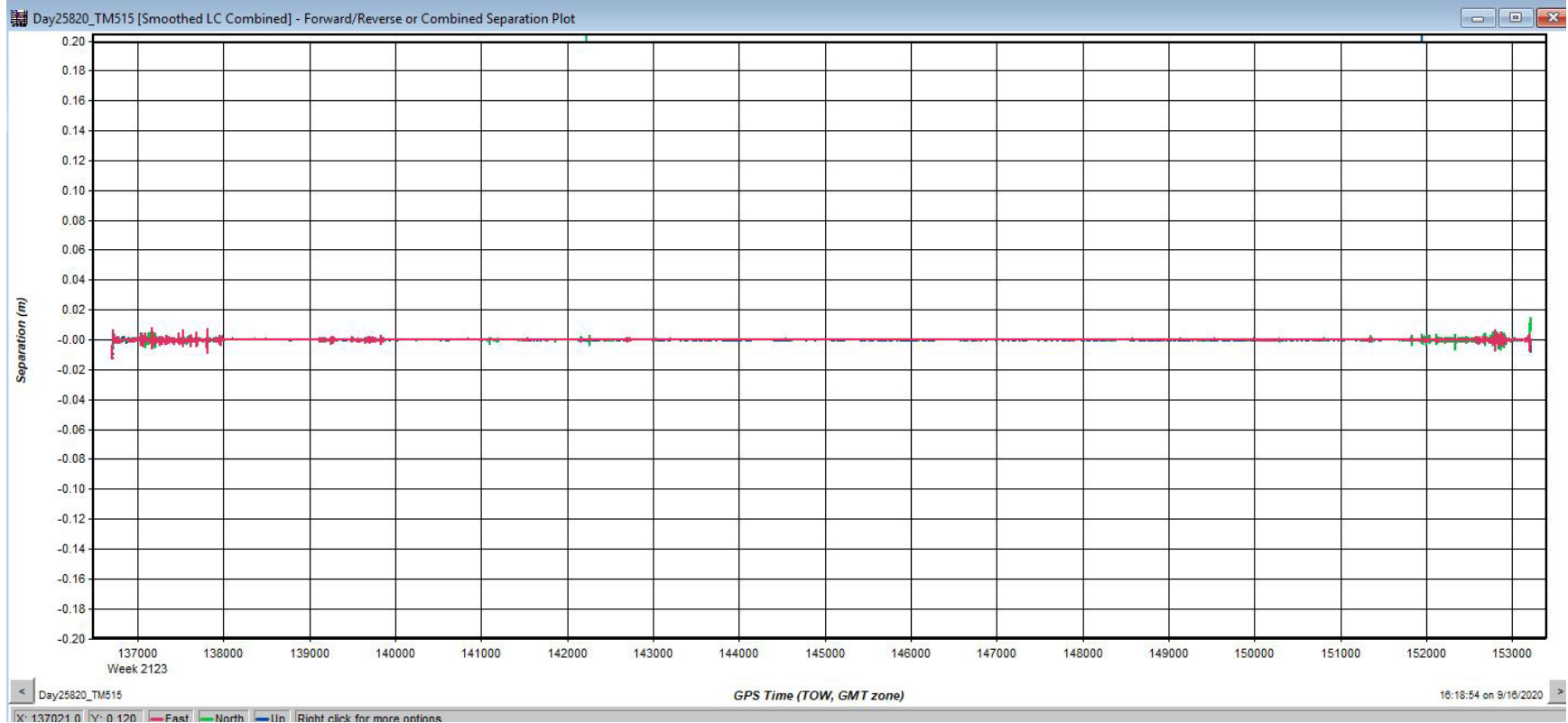
Day25820_TM515

Trajectory



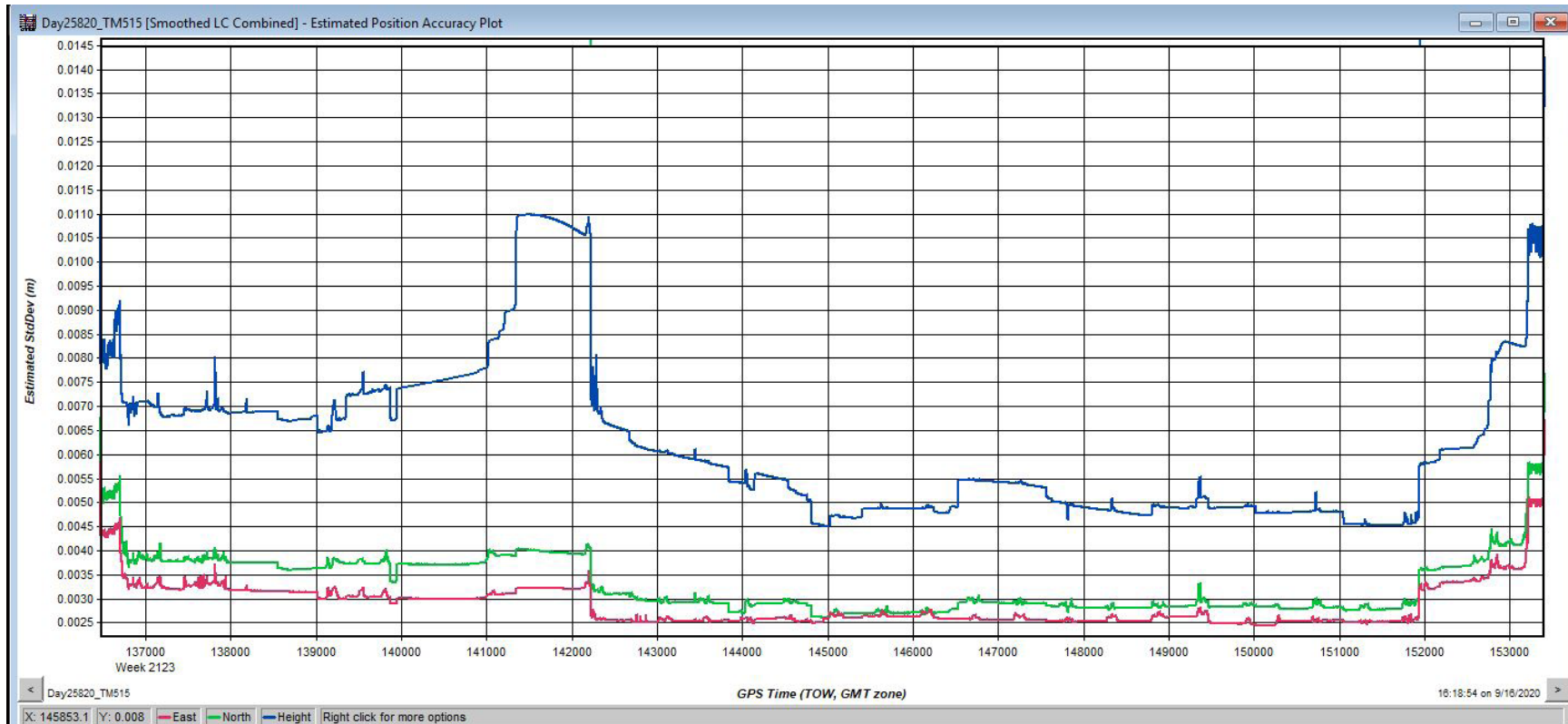
Day25820_TM515

Forward/Reverse or Combined Separation Plot



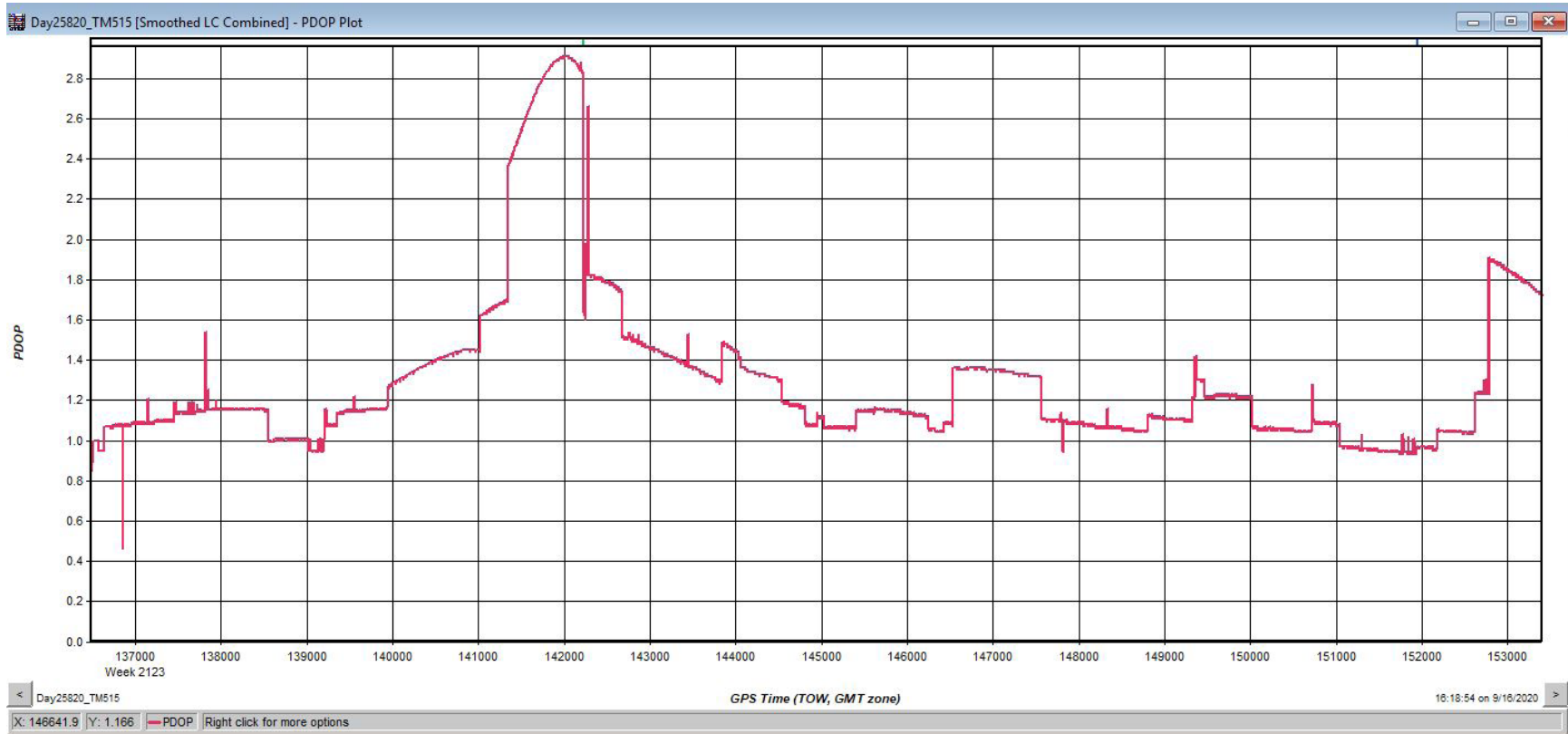
Day25820_TM515

Estimated Position Accuracy



Day25820_TM515

PDOP Plot



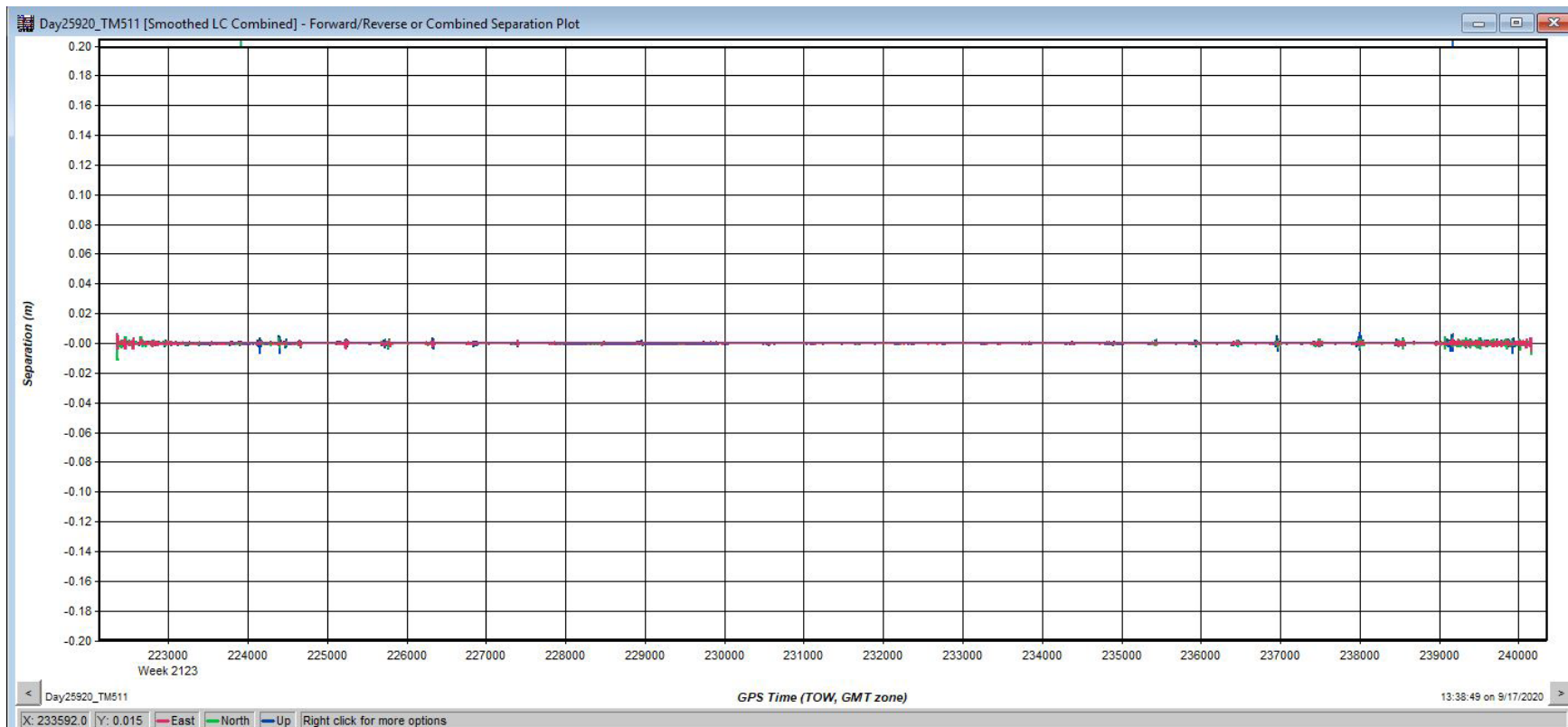
Day25920_TM511

Trajectory



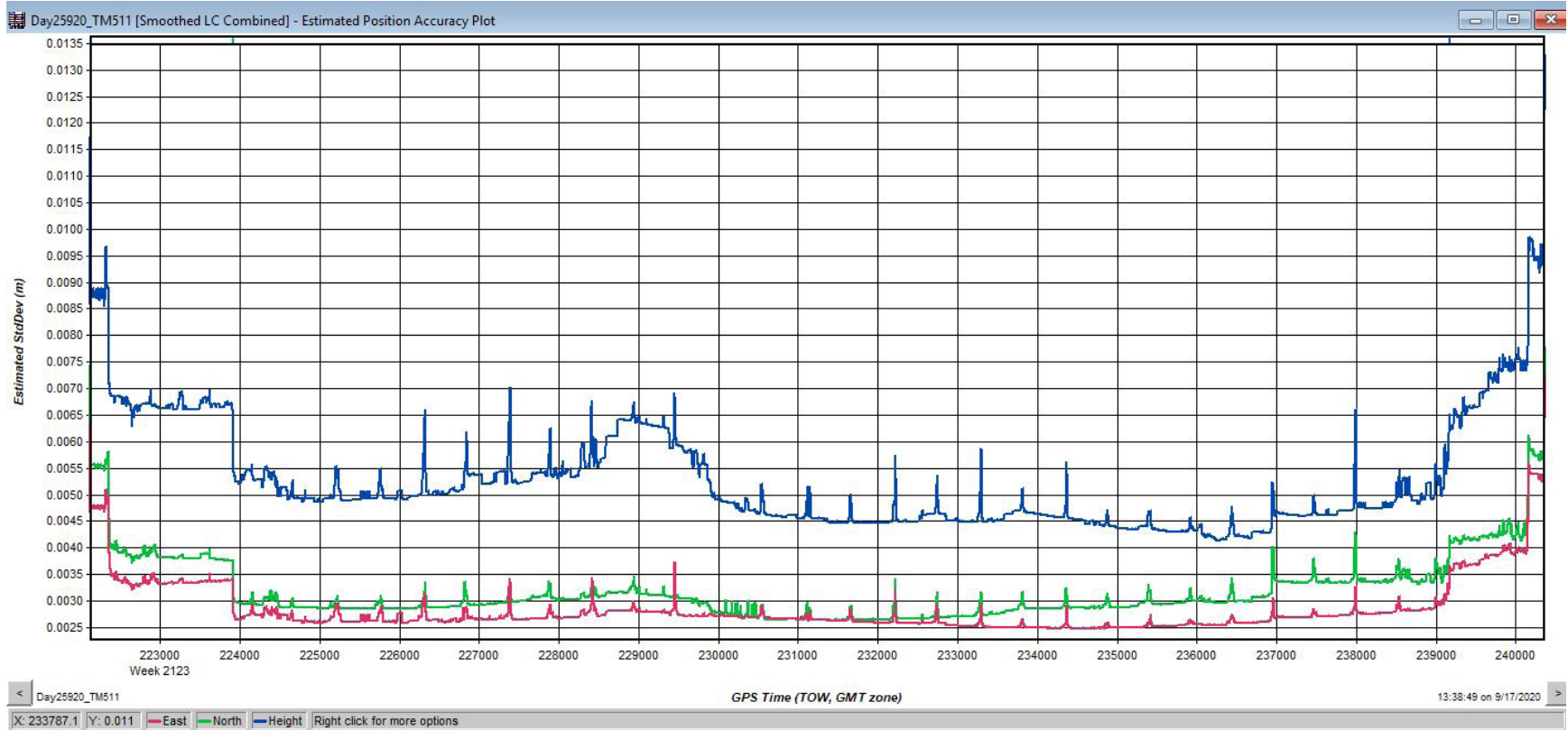
Day25920_TM511

Forward/Reverse or Combined Separation Plot



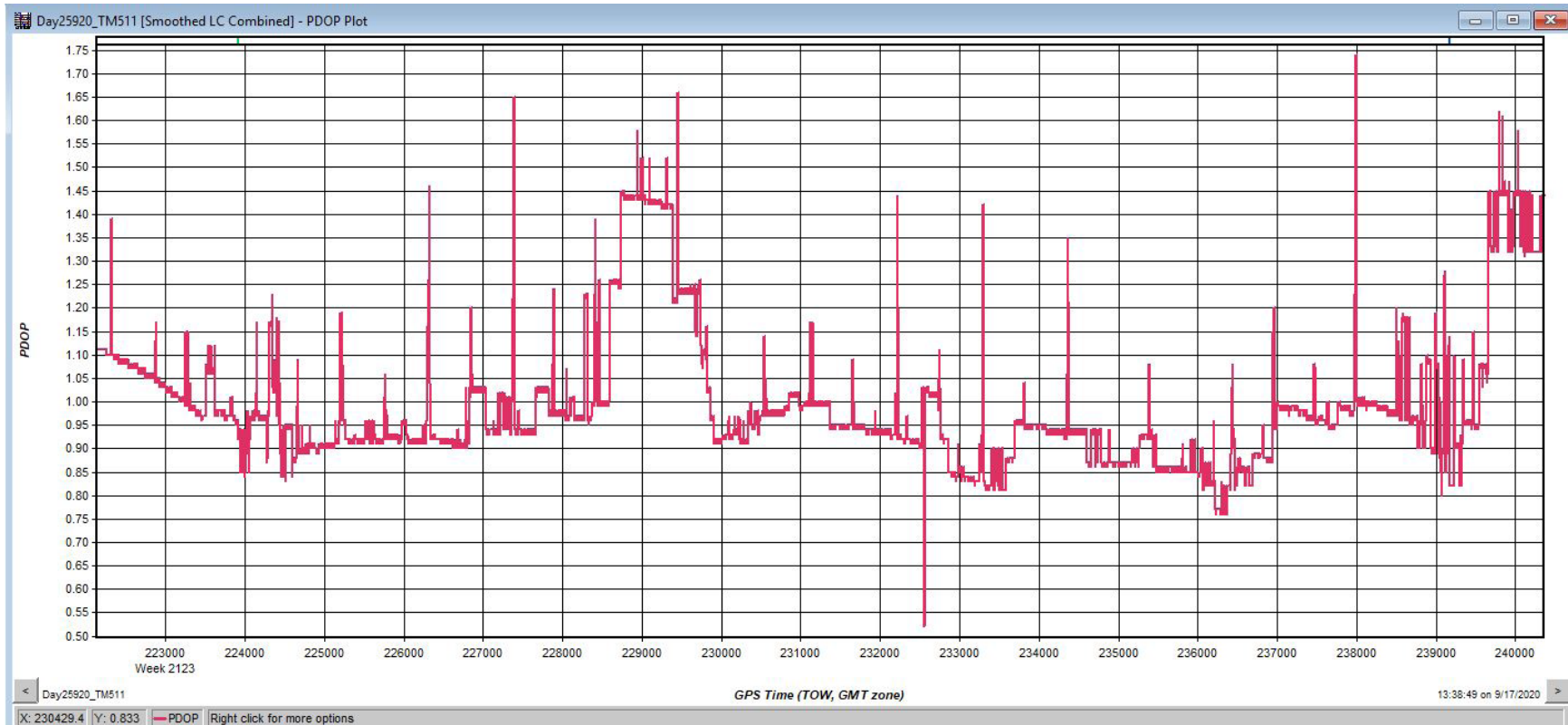
Day25920_TM511

Estimated Position Accuracy



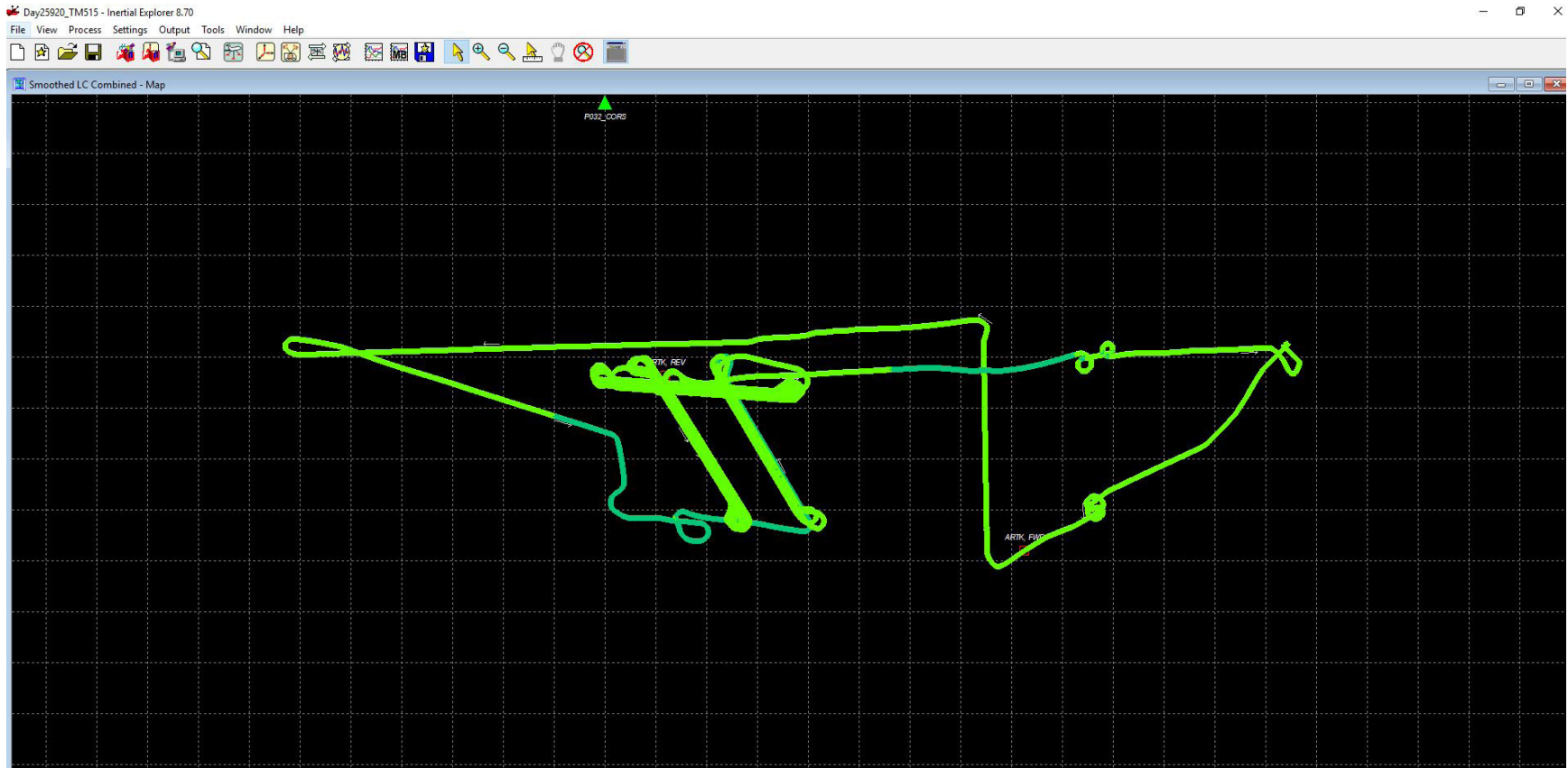
Day25920_TM511

PDOP Plot



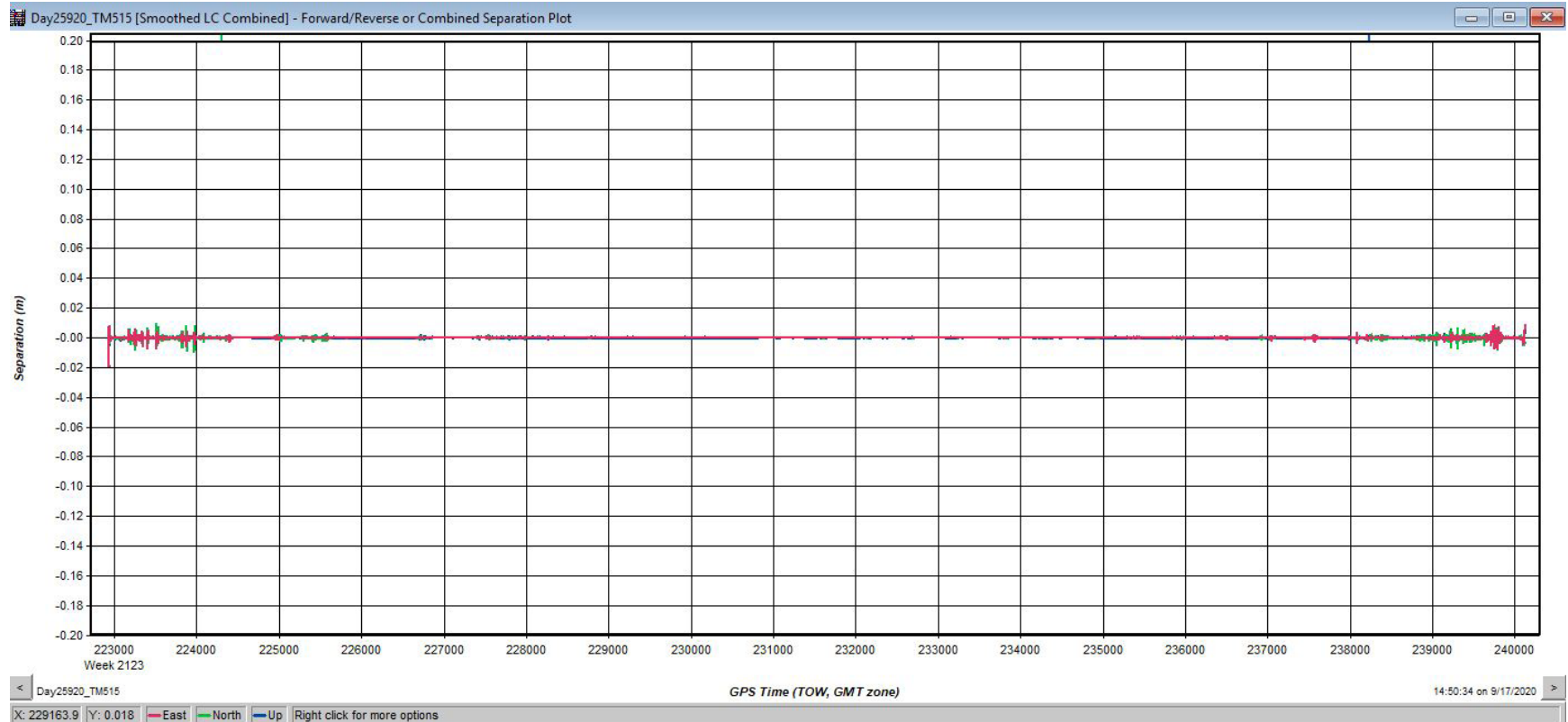
Day25920_TM515

Trajectory



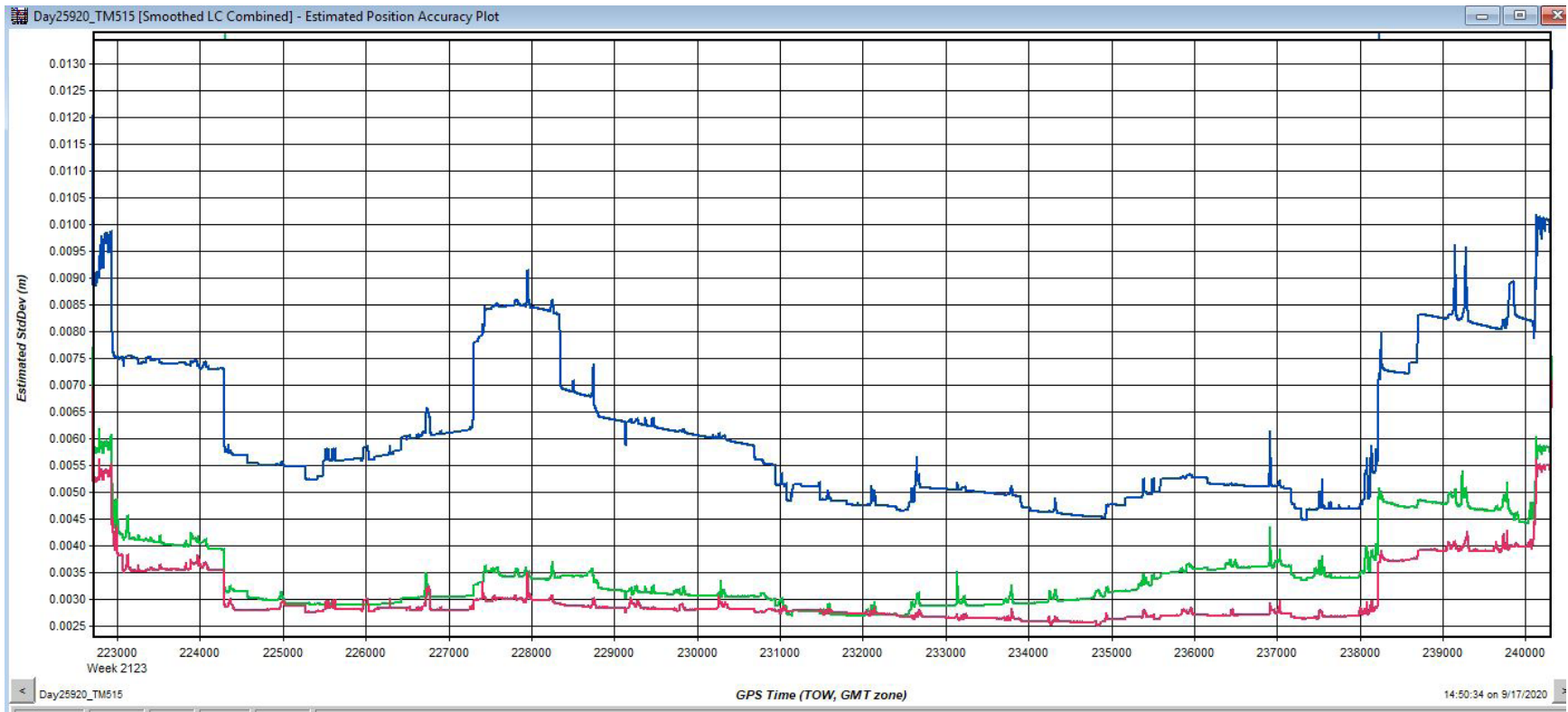
Day25920_TM515

Forward/Reverse or Combined Separation Plot



Day25920_TM515

Estimated Position Accuracy



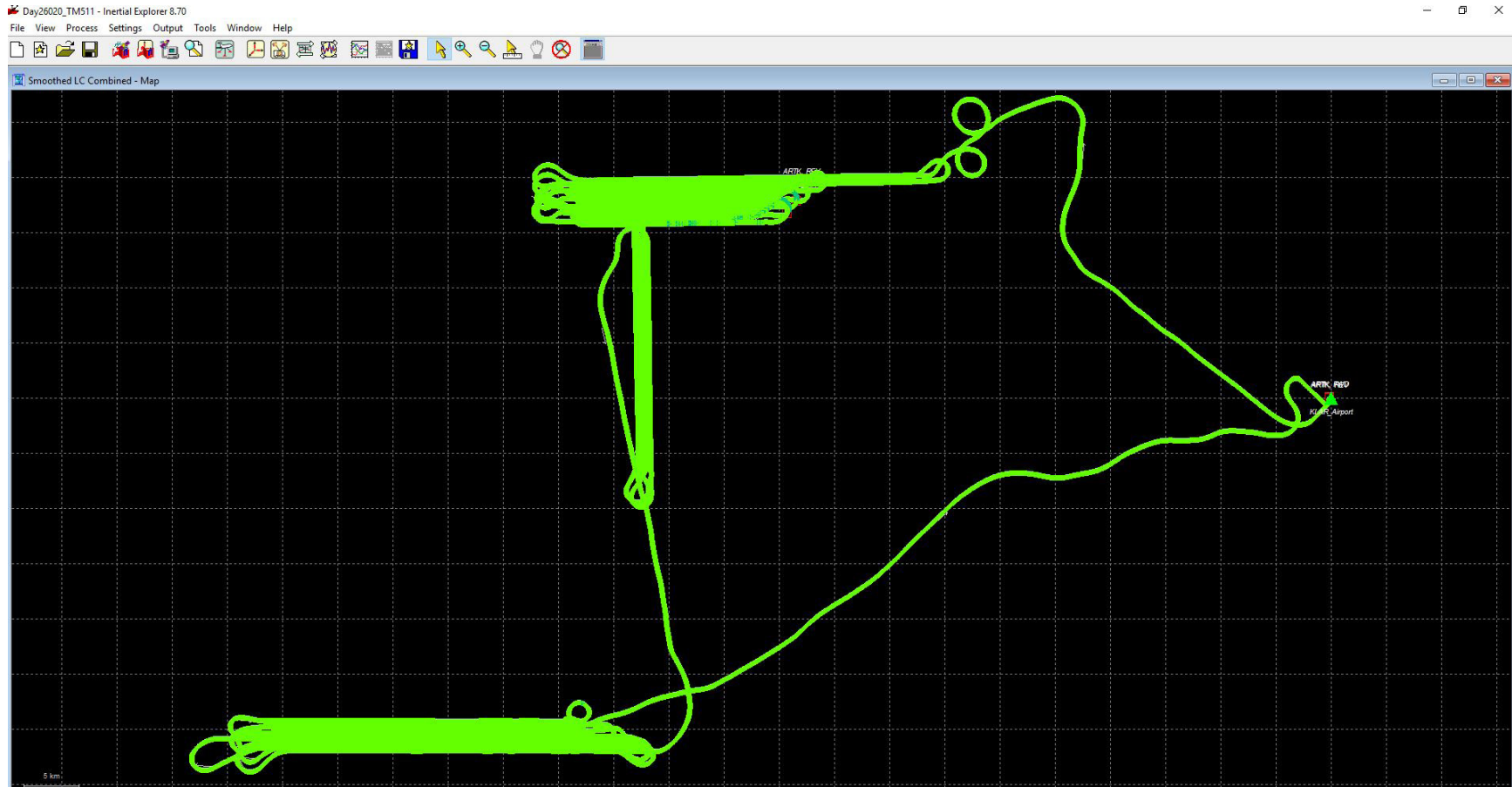
Day25920_TM515

PDOP Plot



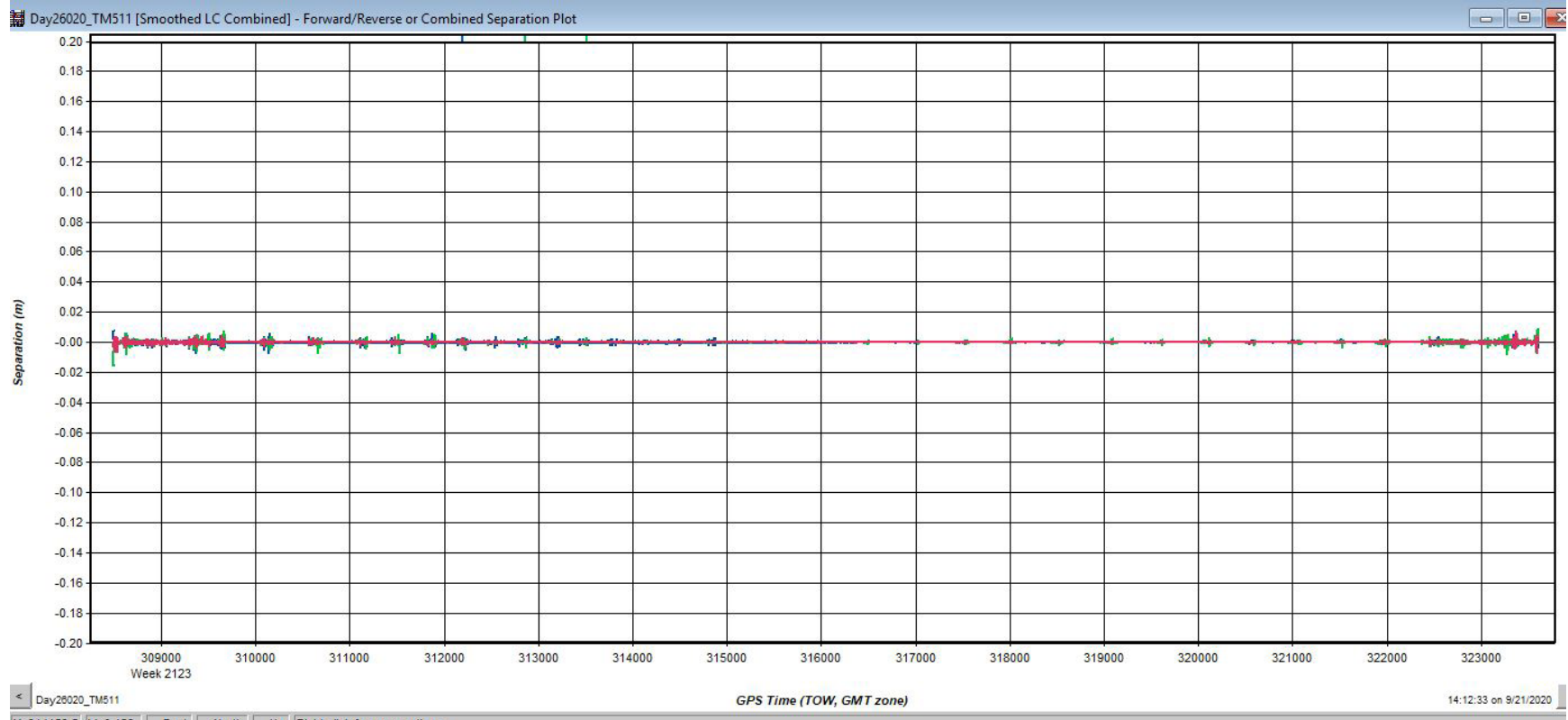
Day26020_TM511

Trajectory



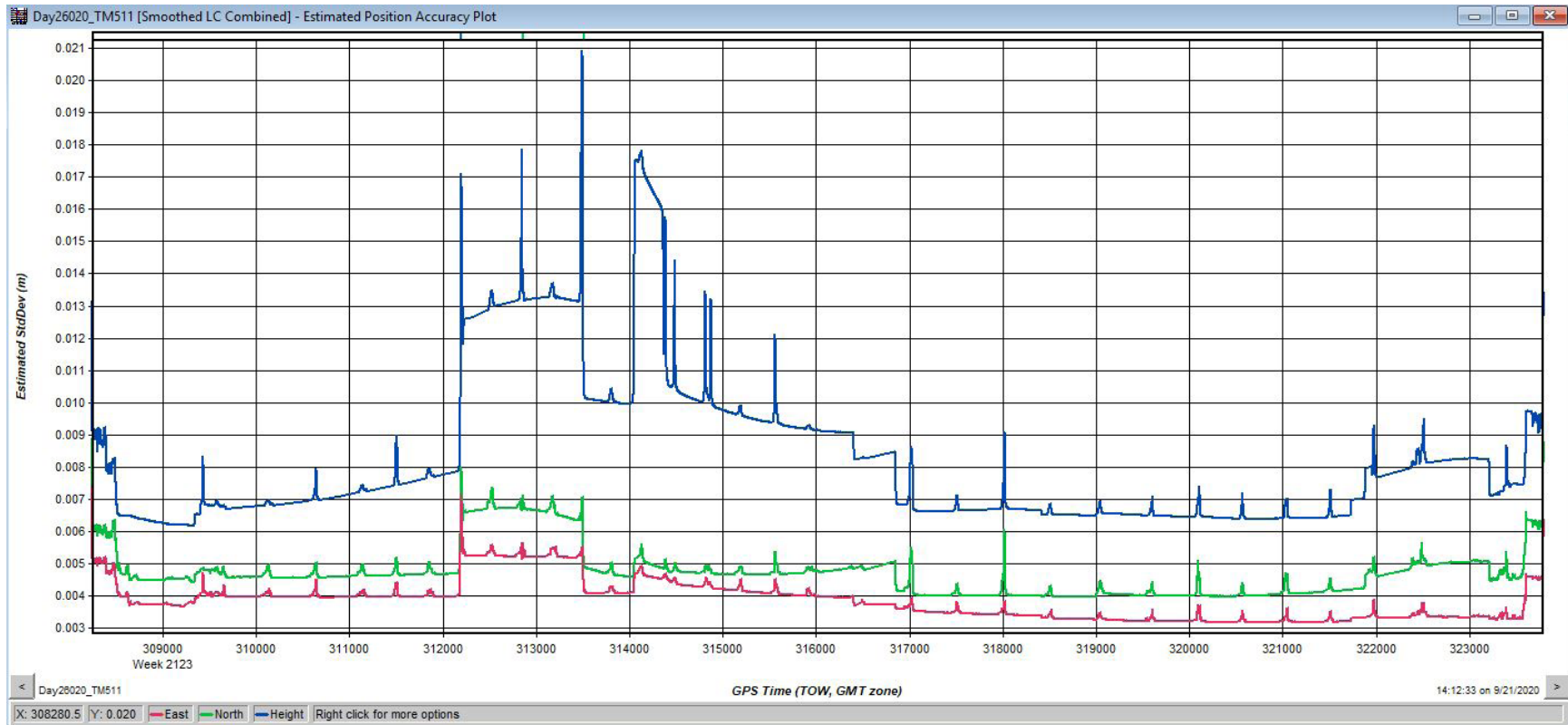
Day26020_TM511

Forward/Reverse or Combined Separation Plot



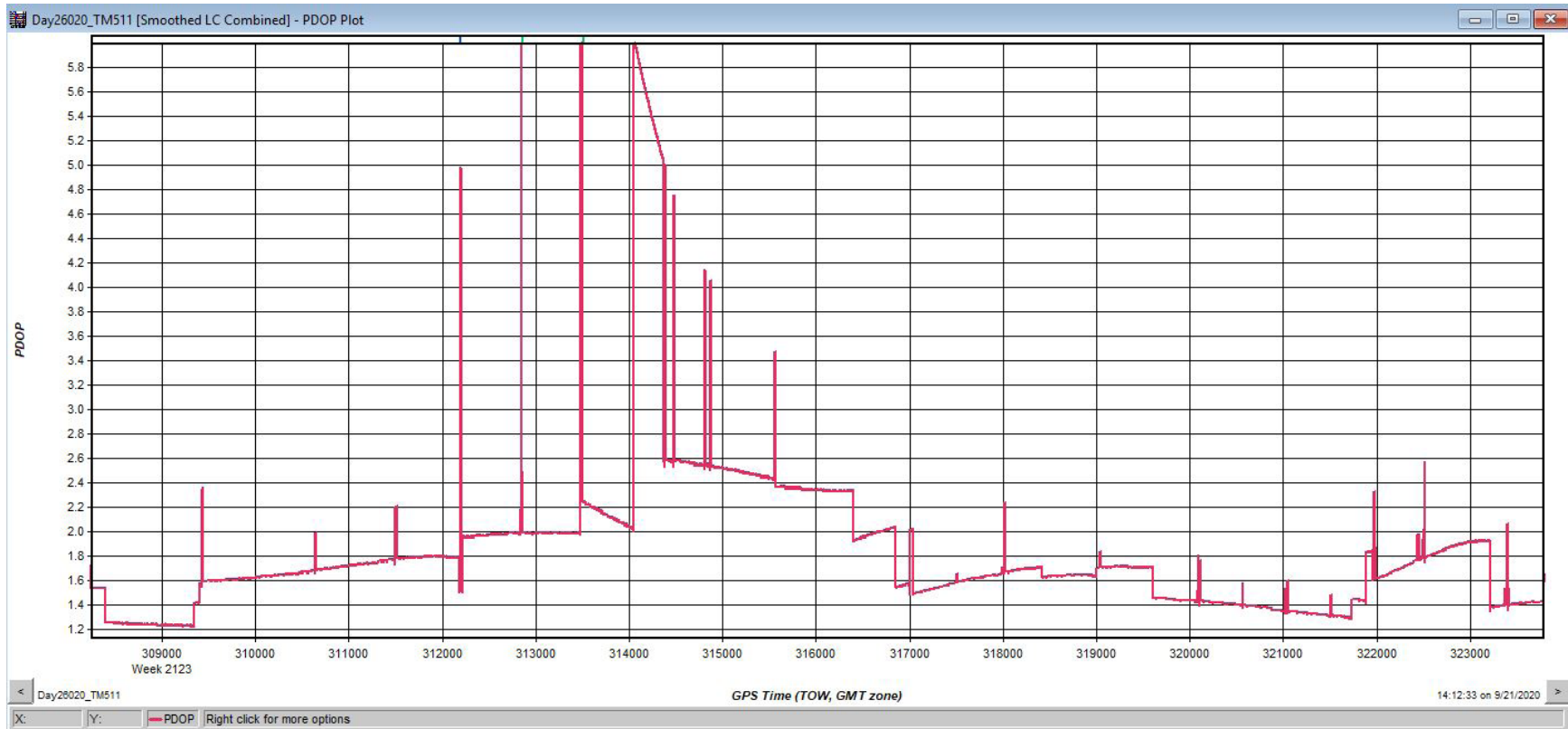
Day26020_TM511

Estimated Position Accuracy



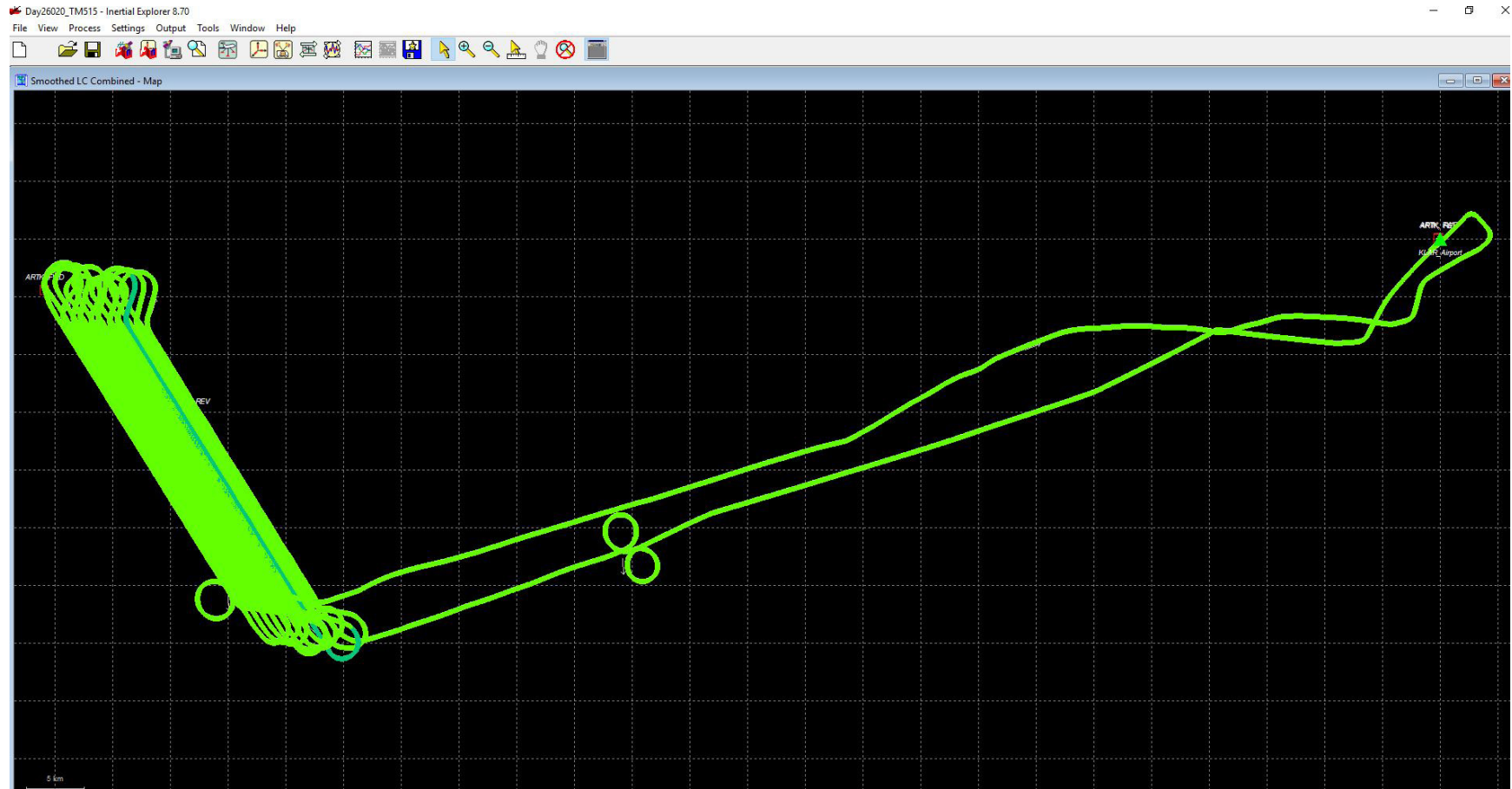
Day26020_TM511

PDOP Plot



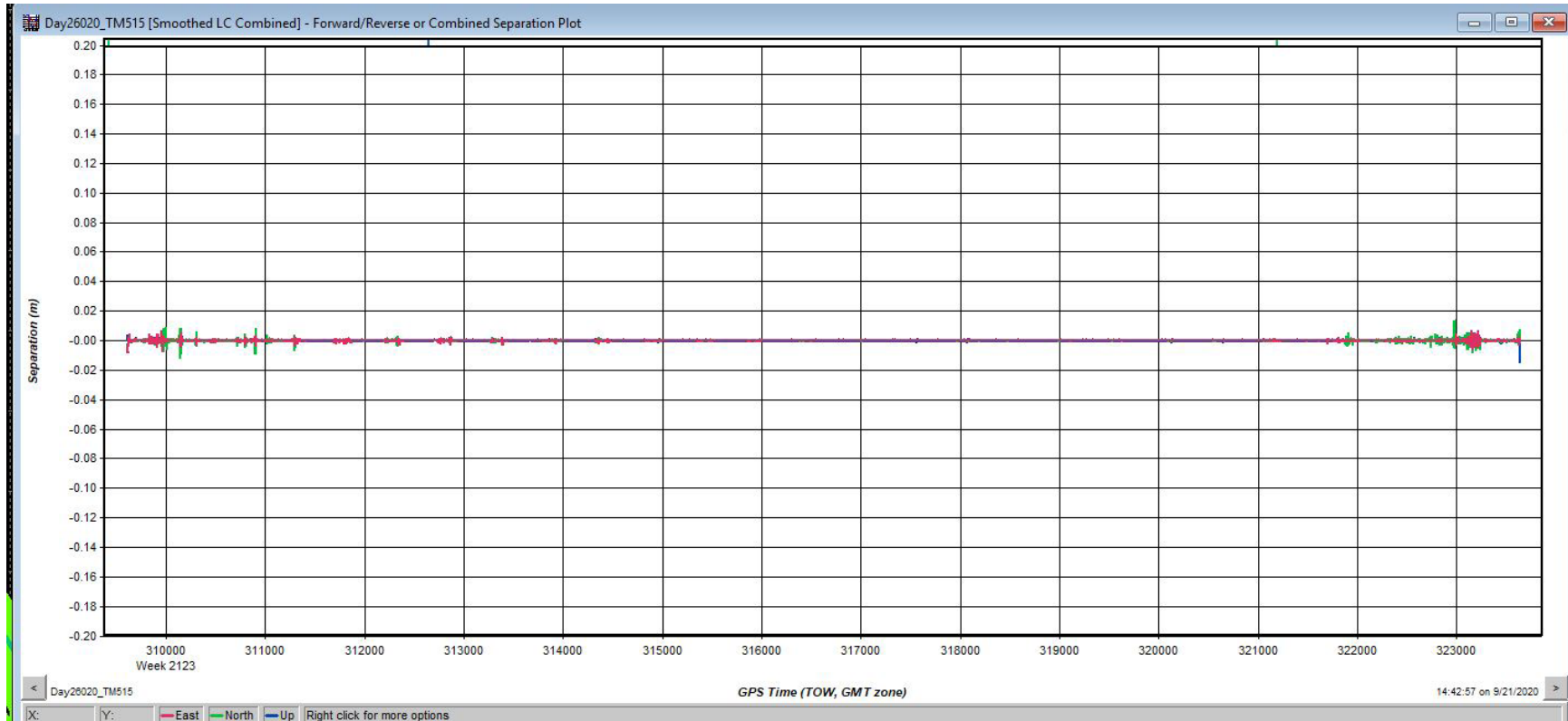
Day26020_TM515

Trajectory



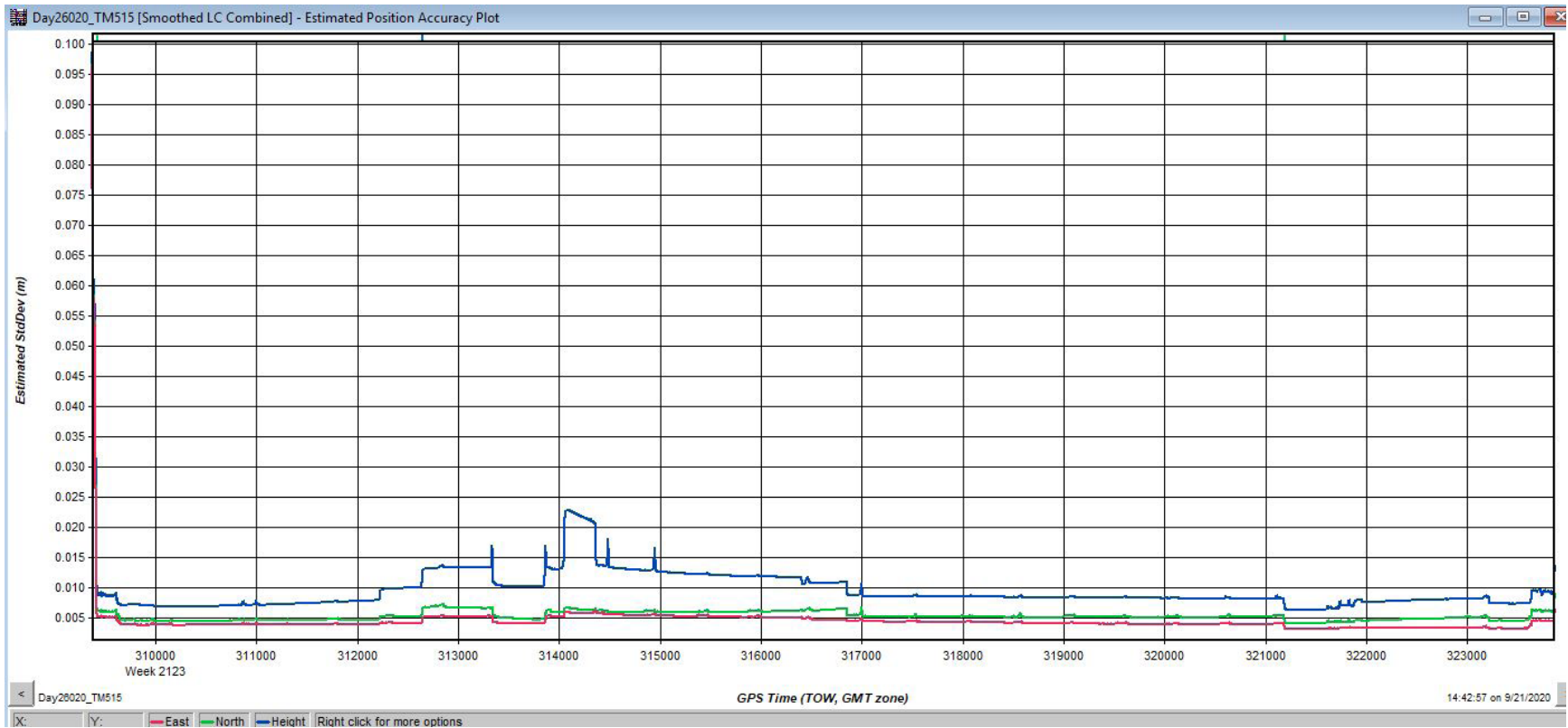
Day26020_TM515

Forward/Reverse or Combined Separation Plot



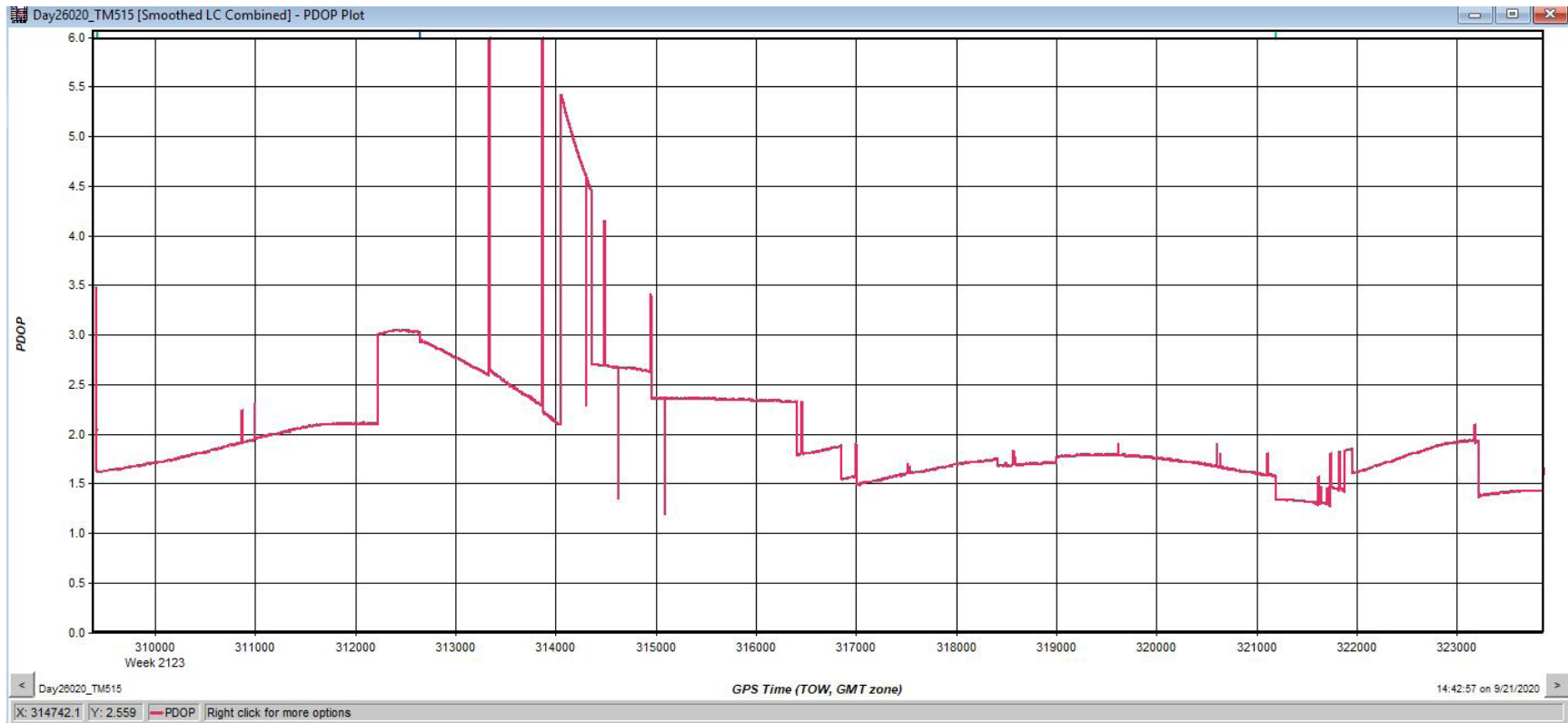
Day26020_TM515

Estimated Position Accuracy



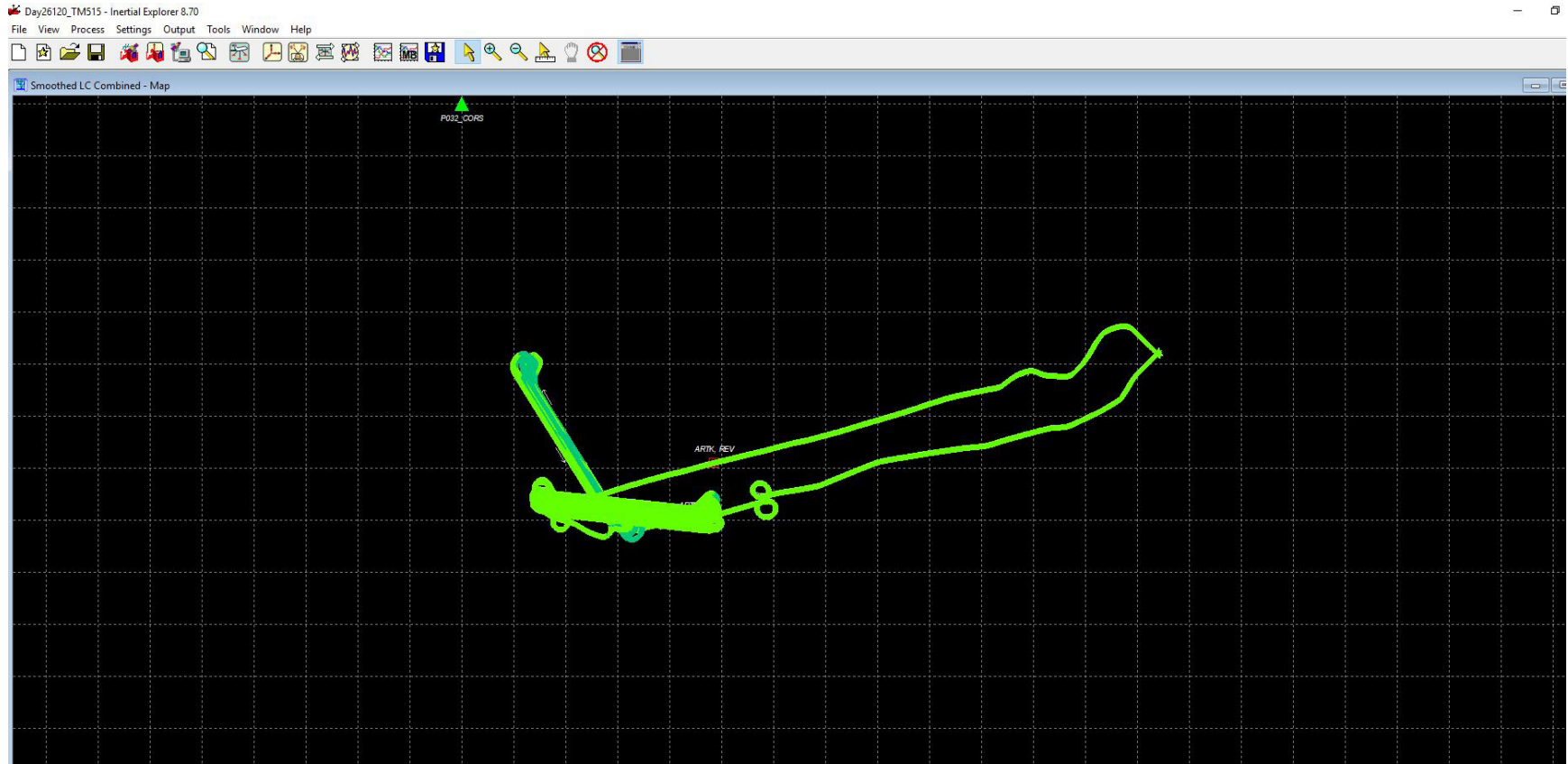
Day26020_TM515

PDOP Plot



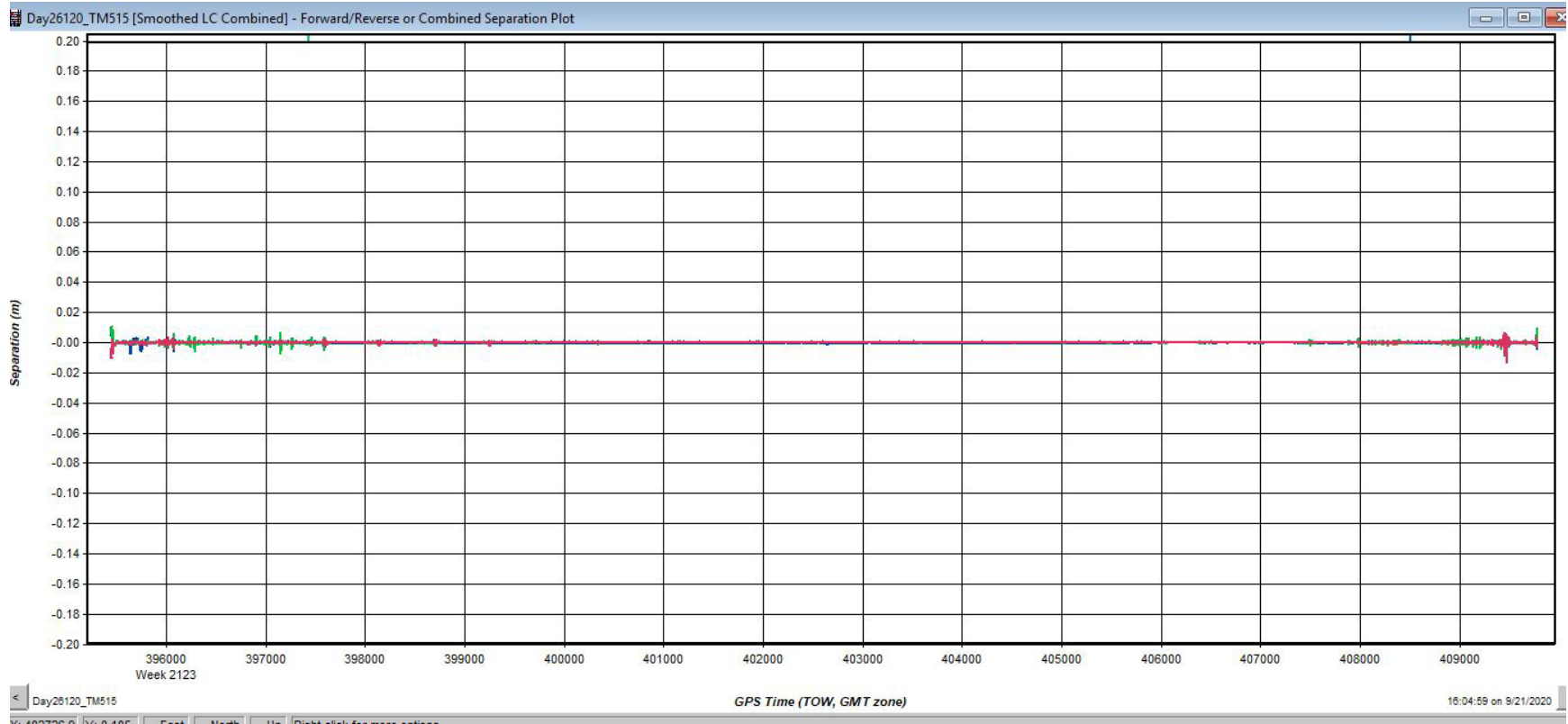
Day26120_TM515

Trajectory



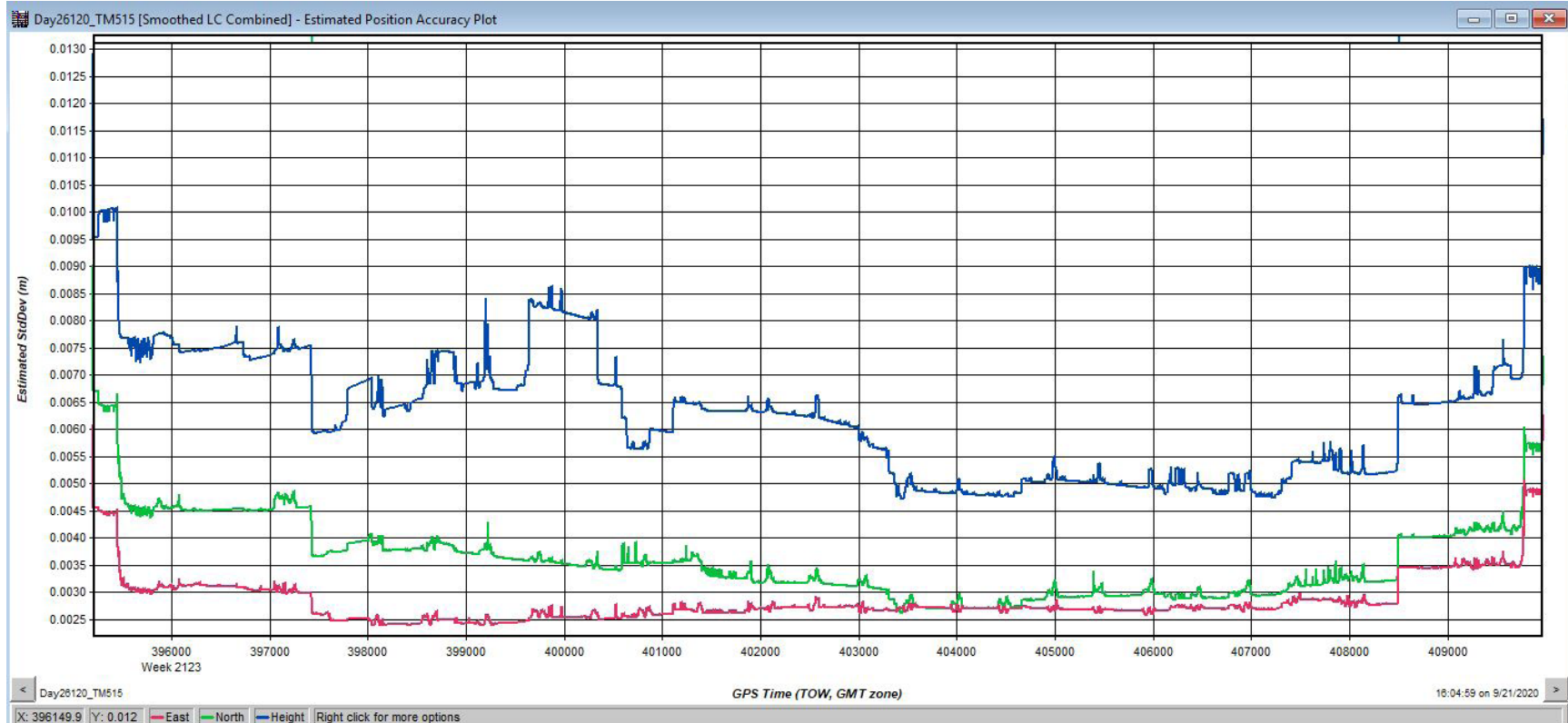
Day26120_TM515

Forward/Reverse or Combined Separation Plot



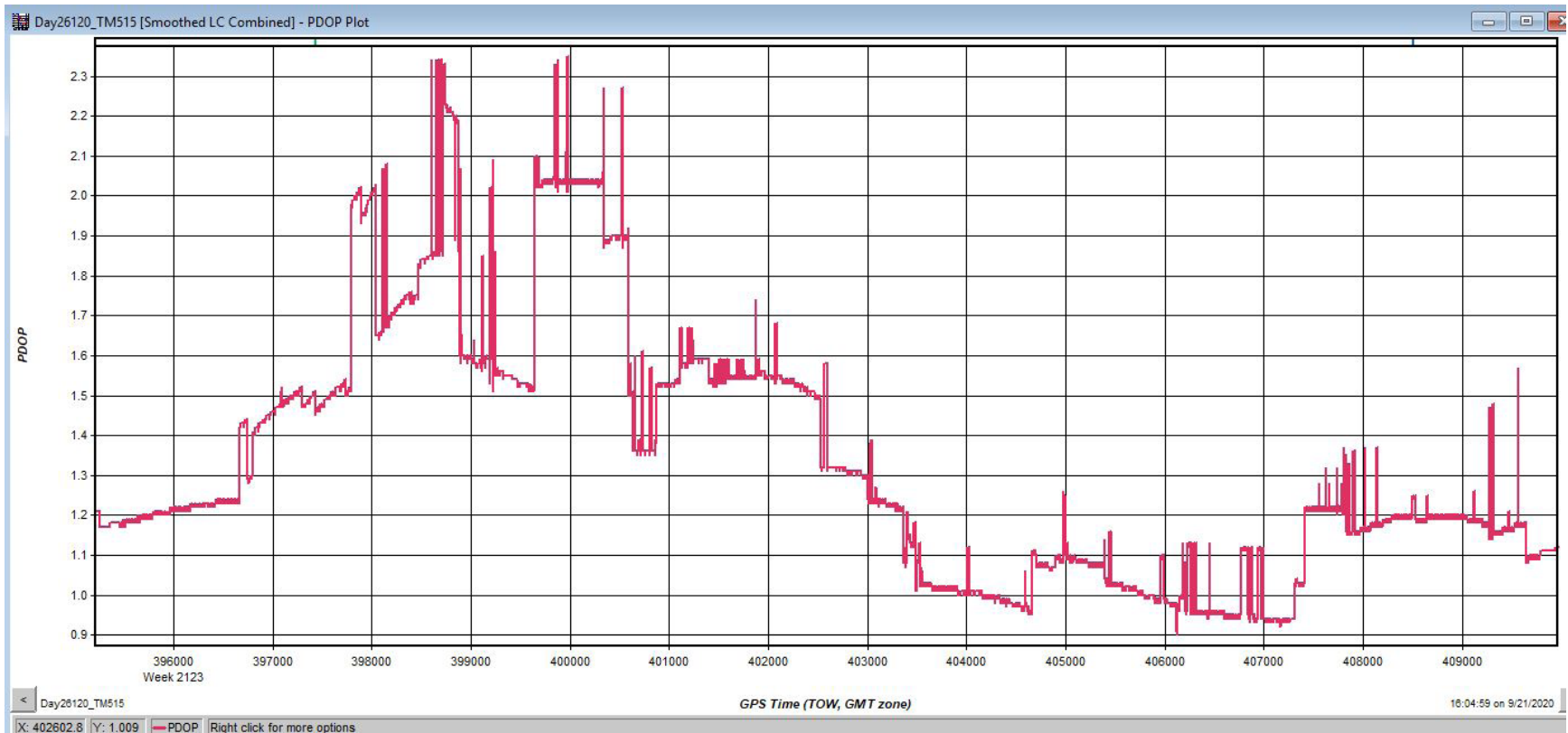
Day26120_TM515

Estimated Position Accuracy



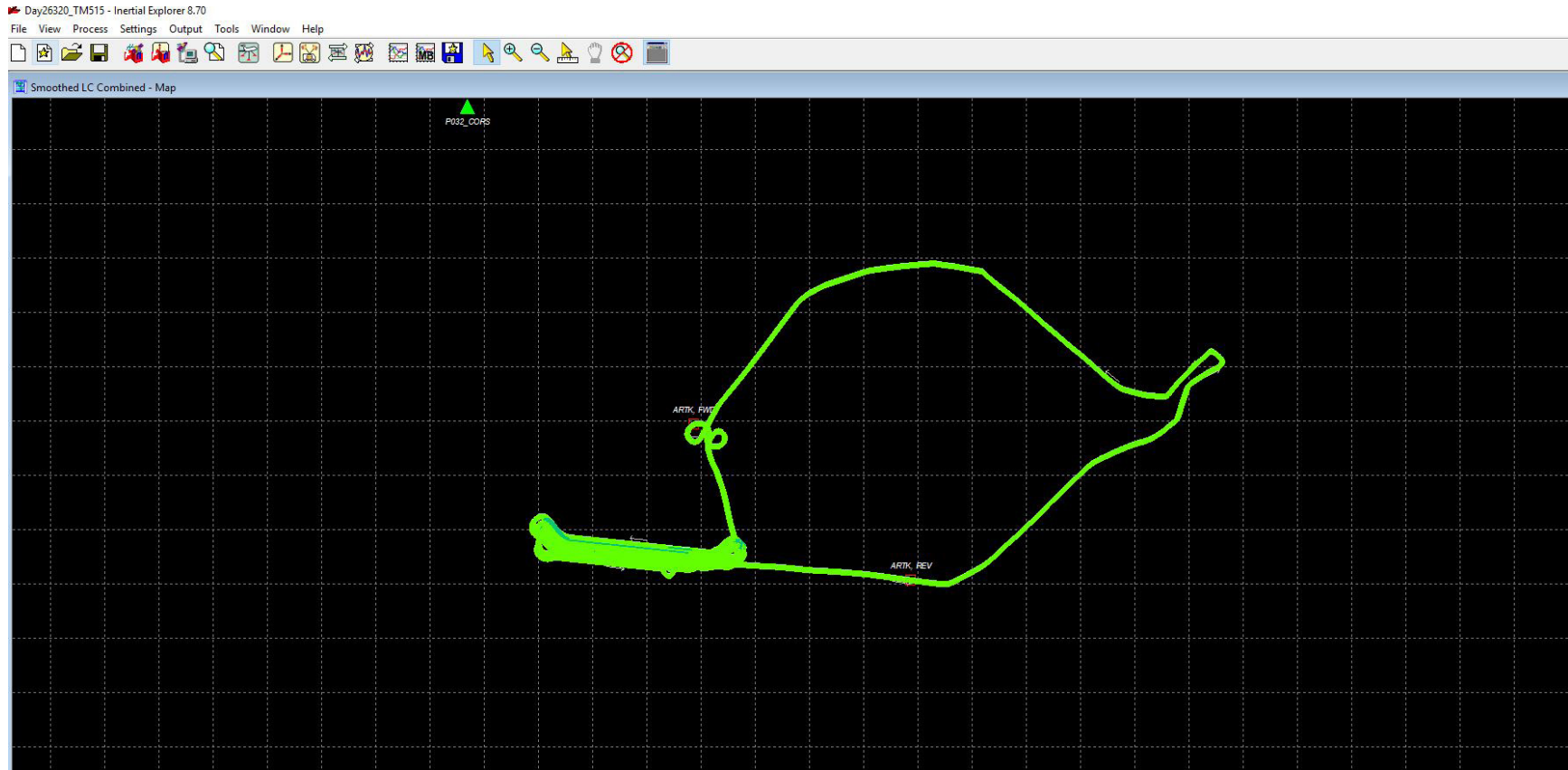
Day26120_TM515

PDOP Plot



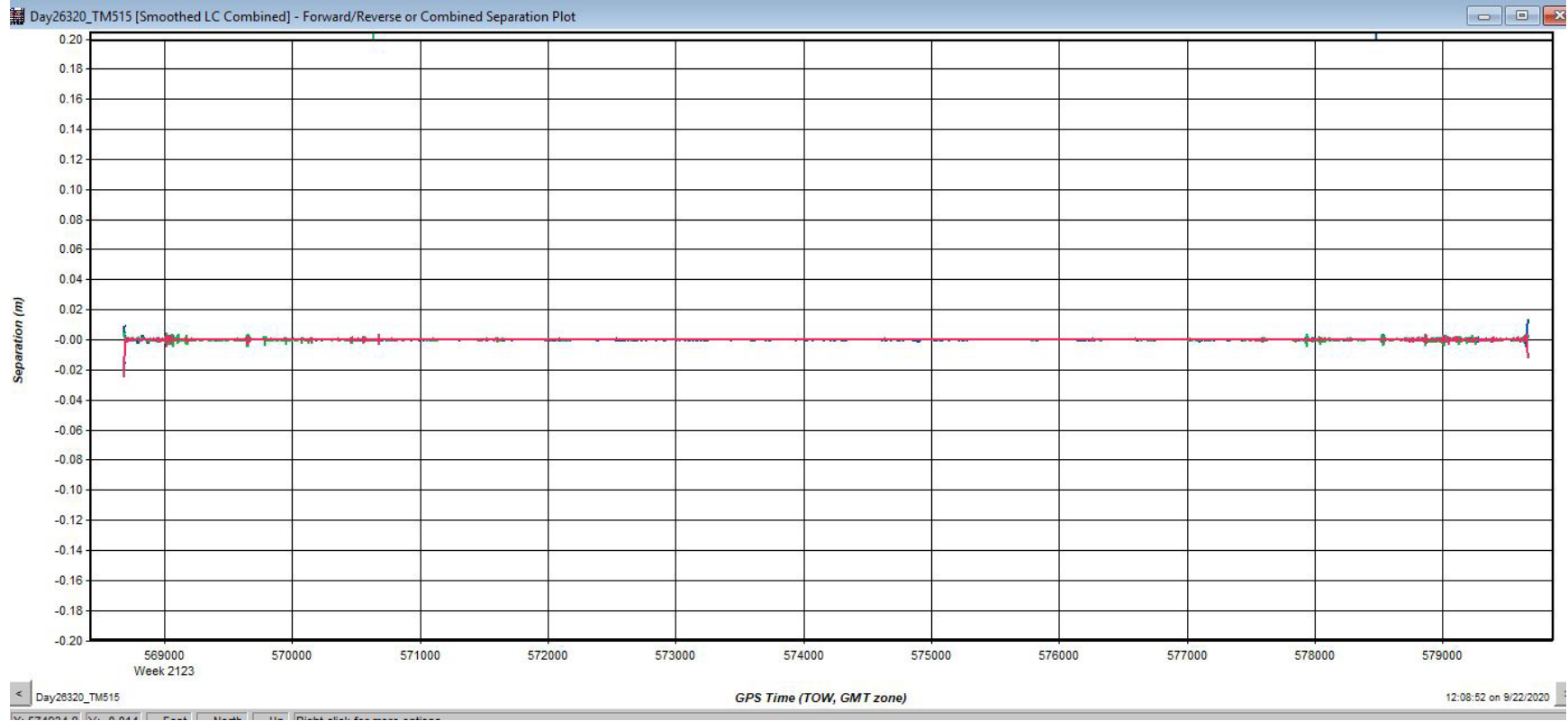
Day26320_TM515

Trajectory



Day26320_TM515

Forward/Reverse or Combined Separation Plot



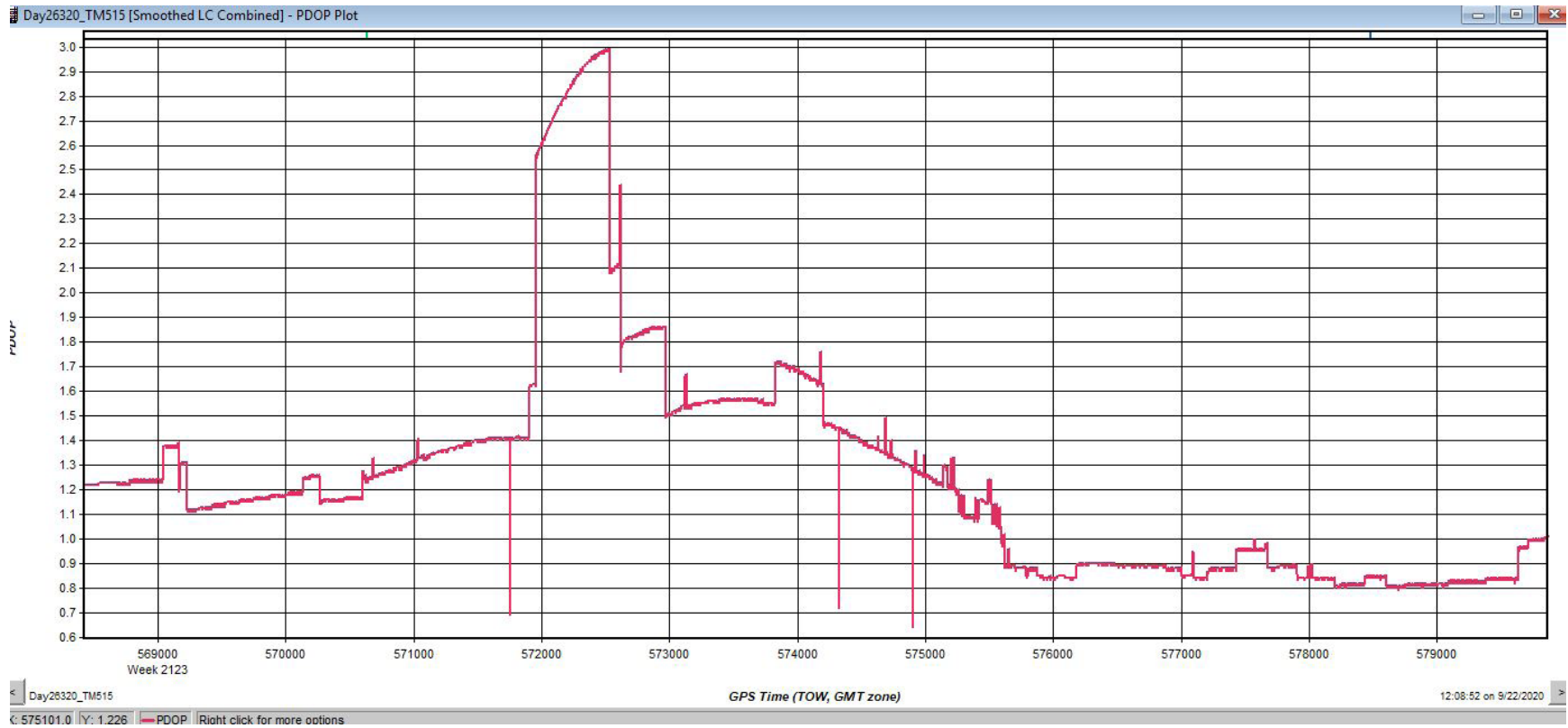
Day26320_TM515

Estimated Position Accuracy

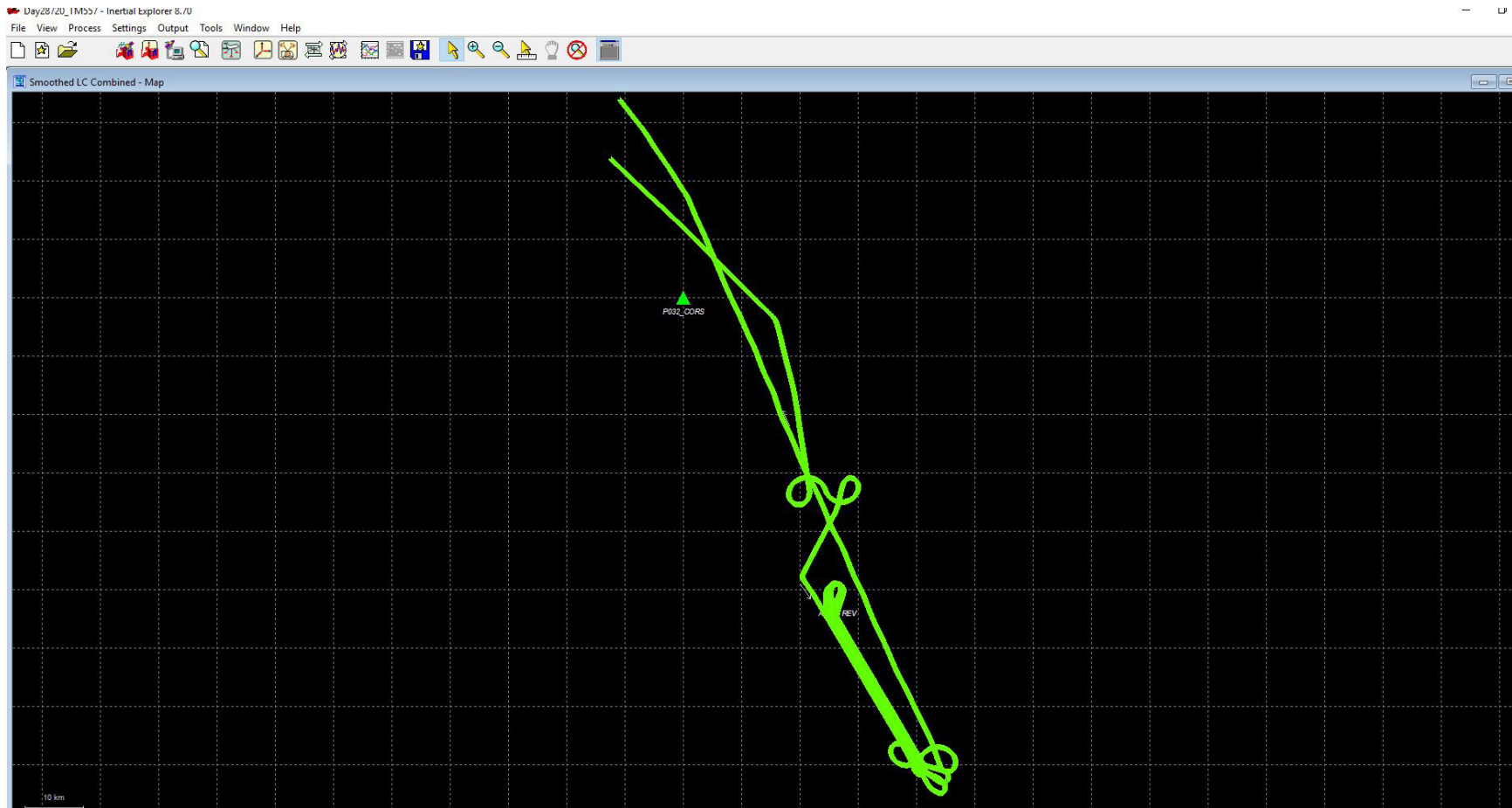


Day26320_TM515

PDOP Plot

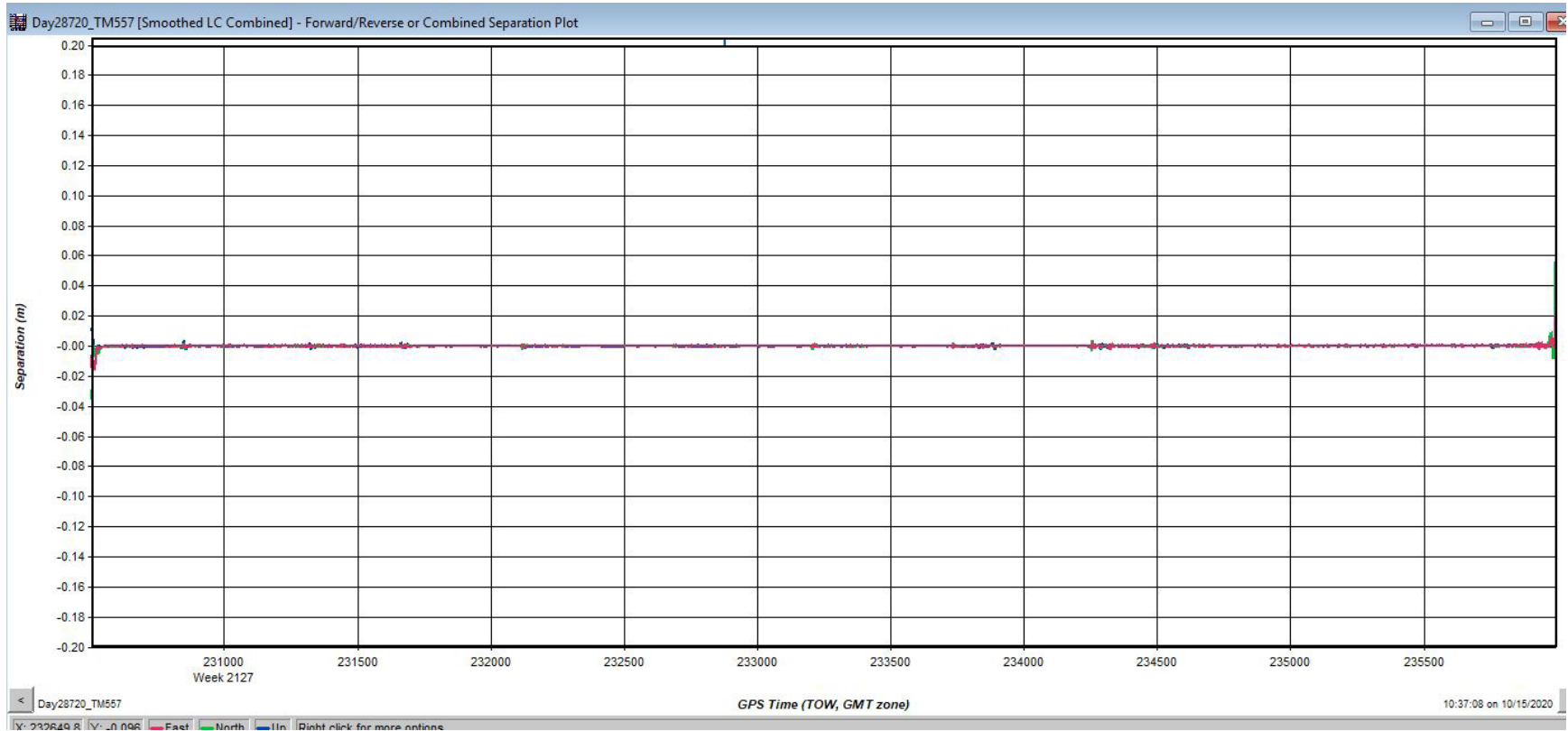


Day28720_TM515 Trajectory



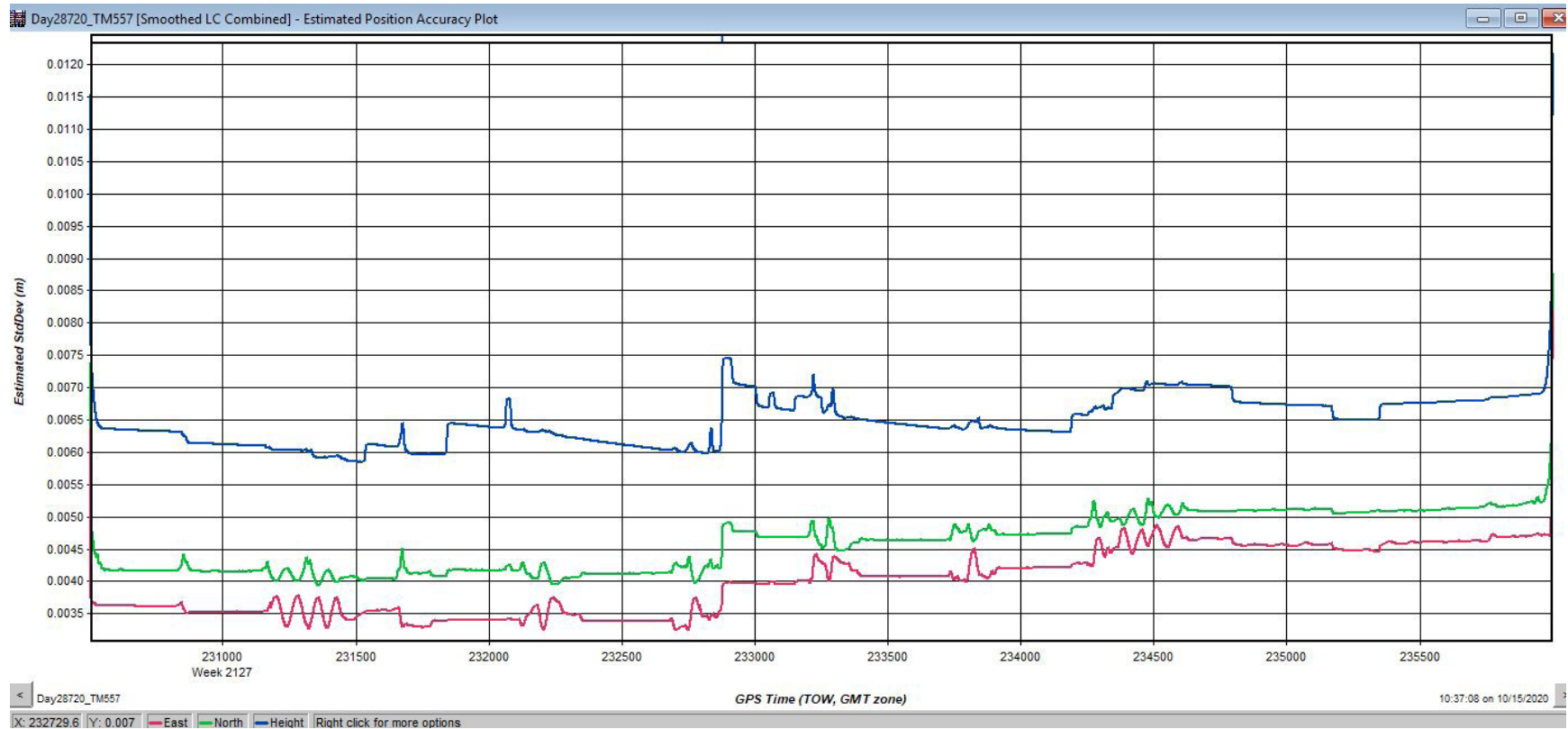
Day28720_TM515

Forward/Reverse or Combined Separation Plot



Day28720_TM515

Estimated Position Accuracy



Day28720_TM515

PDOP Plot

