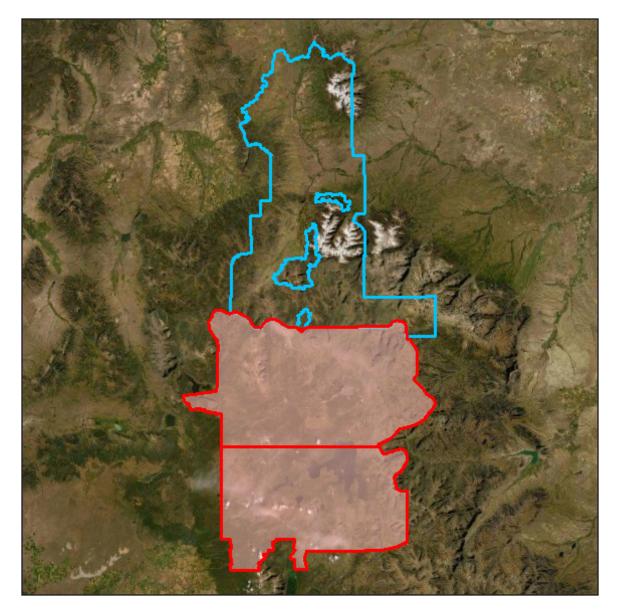
WY Yellowstone NP 2020 D20

Lidar Mapping Report Work Unit WY YellowstoneNP 2 2020 - 218553

May 2021





 Contract #
 G16PC00022

 Task Order #
 140G0220F0199



ContractorWoolpertProject #81200

Table of Contents

	w1
About	
Purpose	1
Specific	ations
Spatial	Reference1
Task Or	der Deliverables4
2. Acquisit	ion7
Flight Pl	anning7
Lidar Se	nsor Information7
Lidar Se	nsor Settings9
Timeline	
GNSS a	nd IMU Equipment9
Acquisi	ion Quality Assurance
3. Process	ng12
Process	ing Summary12
GPS-IM	J Trajectory Processing12
Coome	tric Calibration
Geome	
	Accuracy: Interswath (Overlap) Consistency
Relative	
Relative Relative	Accuracy: Interswath (Overlap) Consistency
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Relative Relative Lidar Do Hydrola Digital B	Accuracy: Interswath (Overlap) Consistency
Relative Relative Lidar Do Hydrolo Digital B Intensity	Accuracy: Interswath (Overlap) Consistency
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Relative Relative Lidar Do Hydrolo Digital B Intensity Metado	Accuracy: Interswath (Overlap) Consistency
Relative Relative Lidar Do Hydrolo Digital B Intensity Metado 4. Accura Horizon	e Accuracy: Interswath (Overlap) Consistency

Table of Contents

List of Figures

Figure 1-1. Project Area	2
Figure 1-2. Project Area - 218553	3
Figure 2-1. Flight Coverage	10
Figure 3-1. Interswath Testing Locations	15
Figure 3-2. Intraswath Testing Locations	17

List of Tables

able 1-1. Spatial Reference System	1
able 1-2. Deliverables	5
able 2-1. Acquisition Requirements	7
able 2-2. Leica Terrain Mapper Sensor Info	8
able 2-3. Lidar Sensor Settings	9
able 2-4. GNSS Base Stations 1	1
able 3-1. Interswath Results 1	4
able 3-2. Intraswath Results 1	6
able 3-3. Classified Point Breakdown 1	8
able 4-1. Classified Point Cloud Vertical Accuracy	21
able 4-2. DEM Accuracy2	22

Appendix Documents

Appendix 1: Sensor Calibration Report	A1-1
Appendix 2: Flight Logs	A2-1
Appendix 3: GPS / IMU Graphics	A3-1

1. Overview

About

This project contains a comprehensive outline of the 140G0220F0199 WY Yellowstone NP2020 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 QL2 and QL1 data over two areas of interest covering approximately 6,549 square miles in Yellowstone National Park and Park County, Montana (Figure 1-1).

This report encompasses the Work Unit 218553 area of interest (Figure 1-2). This AOI totals approximately 2,197 square miles and includes the following counties:

Wyoming

Montana

- Park
- Teton

Gallatin

Park

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 Assessment and Planning (MAP) program.

Specifications

Data for this task order was acquired and produced to meet USGS Lidar Base Specification 2020 revision 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.

Horizontal	EPSG Code	6341
	Datum	NAD83 (2011)
	Projection	UTM Zone 12
	Units	Meters
Vertical	Datum	NAVD88
	Geoid	GEOID18
	Units	Meters
	Height Type	Orthometric

Figure 1-1. Project Area

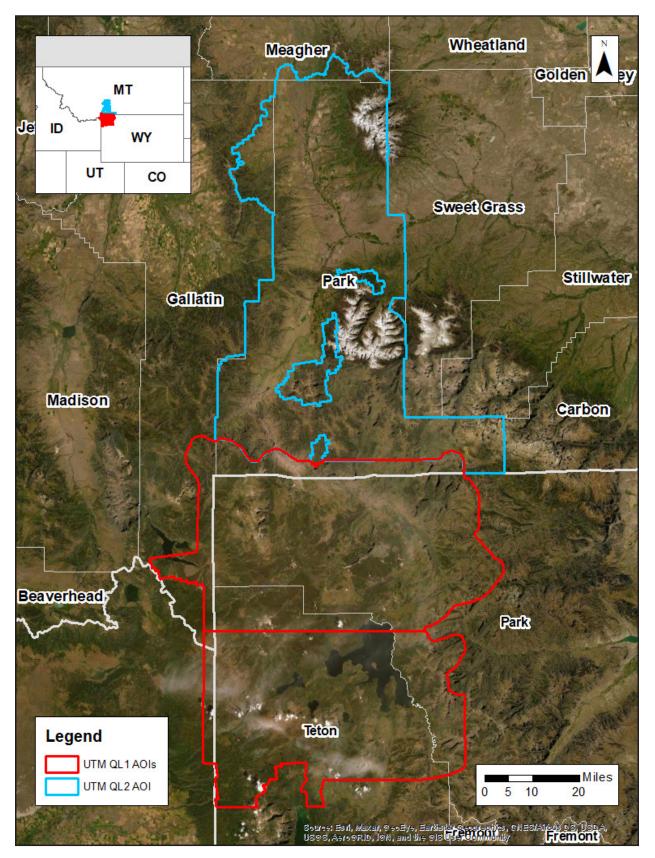
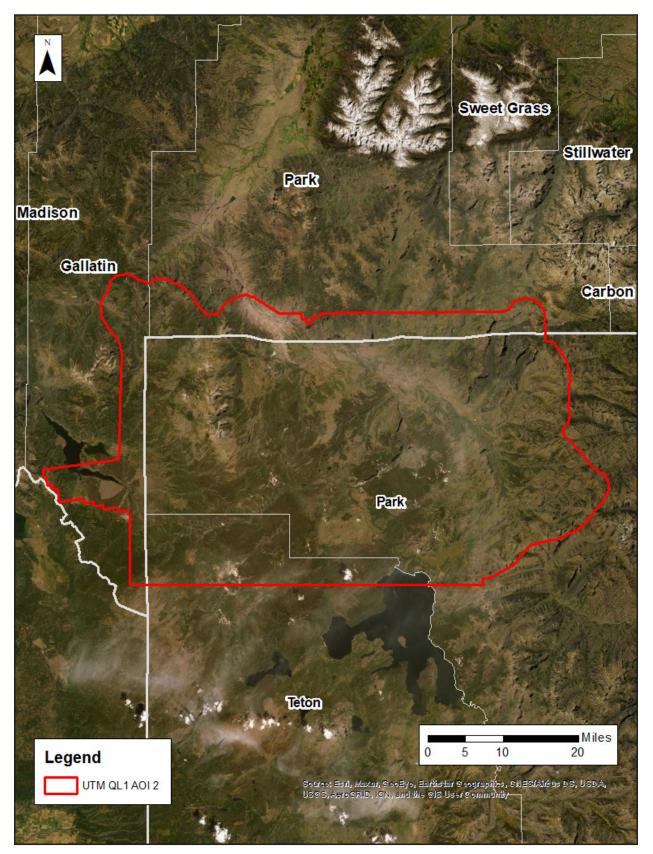


Figure 1-2. Project Area - 218553



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 f 500-meter x 500-meters. Tile names are derived from the US National Grid.

Example: 12TVP920865

This delivery's tiled dataset contains a total of 23,105 tiles. Some tiles were excluded from the dataset as they fell over water bodies.

Excluded tiles:

Classified Point Cloud (42): Intensity Imagery (55):

- 12TWQ465320
- 12TWQ530320
- 12TWQ480320
- 12TWQ485320 •
- 12TWQ530325 ٠
- 12TWQ490320 •
- 12TWQ510320 ٠
- 12TWQ505320
- 12TWQ515320
- 12TWQ495320 ٠
- 12TWQ475320
- 12TWQ520320 ٠
- 12TWQ525320
- •
- 12TWQ535320
- ٠ 12TWQ500320
- 12TWQ470320 •
- 12TWQ500330 •
- 12TWQ510325
- 12TWQ490335
- 12TWQ535325 ٠ •
- 12TVQ805550
- 12TWQ485325 •
- 12TWQ485330
- 12TWQ480325 •
- 12TWQ490330 •
- 12TVQ800550 •
- 12TWQ505330
- 12TWQ500325
- 12TVQ830545
- 12TVQ800555 •
- 12TVQ855540
- 12TVQ820545 ٠
- 12TVQ835545
- 12TWQ495335 •
- 12TVQ825545

Lidar Mapping Report

12TWQ535330

continued

12TVQ795555 • 12TWQ500330 • 12TWQ510325 12TWQ490335 •

- 12TWQ535325 •
- 12TVQ805550 •
- 12TWQ485325 •
- 12TWQ485330
- 12TWQ555320 •
- 12TWQ480325 •
- 12TWQ490330
- 12TVQ800550
- 12TVQ805560
- 12TWQ505330 •
- 12TWQ545325
- 12TWQ500325
- ٠ 12TWQ540320
- 12TWQ550325
- 12TVQ830545
- 12TVQ800555 ٠
- 12TVQ855540
- 12TWQ545310 ٠
- 12TWQ545320
- 12TVQ820545
- 12TVQ810560 •
- 12TVQ835545 •
- 12TWQ495335
- 12TVQ795560
- 12TVQ825545 •
- 12TWQ550320 ٠
- 12TWQ535330
- 12TWQ505325
- 12TWQ515325
- 12TWQ545330 •
- 12TVQ805555 •
- 12TWQ490325

continued

4

Max. Height Separation Rasters (56)

- 12TVQ795555
- 12TWQ500330 ٠
- 12TWQ510325
- 12TWQ490335 •
- 12TWQ535325 •
- •
- 12TWQ465320
- 12TVQ805550
- 12TWQ530320
- 12TWQ485325 •
- 12TWQ485330 •
- 12TWQ555320
- 12TWQ540325
- 12TWQ480325
- 12TWQ490330 •
- 12TWQ480320
- 12TWQ485320
- 12TVQ800550
- 12TVQ805560

12TWQ505330

12TWQ530325

12TWQ545325

12TWQ500325

12TWQ490320

12TWQ540320

12TWQ510320

12TWQ550325

12TWQ505320

12TVQ830545

12TVQ800555

12TVQ855540

12TWQ515320

12TWQ495320

12TWQ545310

12TWQ545320

12TVQ820545

12TWQ475320

continued

May 2021

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Classified Point Cloud (42) *continued*:

- 12TWQ505325
- 12TWQ515325
- 12TVQ805555
- 12TWQ490325
- 12TWQ495325
- 12TVQ825550

Intensity Imagery (55) *continued*:

- 12TWQ495325
- 12TVQ800560
- 12TVQ825550
- 12TWQ465320
- 12TWQ530320
- 12TWQ480320
- 12TWQ485320
- 12TWQ530325
- 12TWQ490320
- 12TWQ510320
- 12TWQ505320
- 12TWQ515320
- 12TWQ495320
- 12TWQ475320
- 12TWQ520320
- 12TWQ525320
- 12TWQ535320
- 12TWQ500320
- 12TWQ470320

Max. Height Separation Rasters (56) *continued*:

- 12TWQ520320
- 12TWQ525320
- 12TVQ810560
- 12TVQ835545
- 12TWQ495335
- 12TVQ795560
- 12TVQ825545
- 12TWQ550320
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- 12TWQ500320
- 12TVQ805555
- 12TWQ490325
- 12TWQ470320
- 12TWQ495325
- 12TVQ800560
- 12TVQ825550

Table 1-2. Deliverables

Lidar Data	
Classified lidar point cloud data	Tiles in LAS v1.4 format Classes • 1 – Processed, not Classified • 2 – Ground • 7 – Noise • 9 – Water • 17 – Bridge Decks • 18 – High Noise • 20 – Ignored Ground
Breaklines used for hydro- flattening	 Lake and River features as feature classes in an Esri file geodatabase 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, 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

Table 1-2: Deliverables (continued)

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	
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	 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	During period of annual minimal water level and minimal snow in the fall 2020 leaf-off window running through November 15, 2020	
Data Voids	 Not allowed except 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 Cloud and fog-free between the aircraft and ground Ground Snow free No unusual flooding or inundation, except in cases where the goal of the collection is to map the inundation Vegetation Leaf-off is preferred Time of Day Time of day is not of concern 	

Flight plans were created using Leica MissionPro software.

Lidar Sensor Information

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

• Leica TerrainMapper - serial numbers 511, 515, 557

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	• 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 	 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	Blocks 1-4
Max. Number of Returns	15
Nominal Point Spacing	0.35 m
Nominal Point Density	8 ppsm
Flying Height Above Ground Level	2,133 m
Flight Speed	150 knots
Scan Angle	40°
Scan Rate Used	1,580 Hz
Pulse Rate Used	150 kHz
Multi-Pulse in Air	Enabled
Swath Width	1,553 m
Swath Overlap	25%

Timeline

Lidar data was collected from September 25, 2020 through October 10, 2020. A total of 305 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 2-3 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

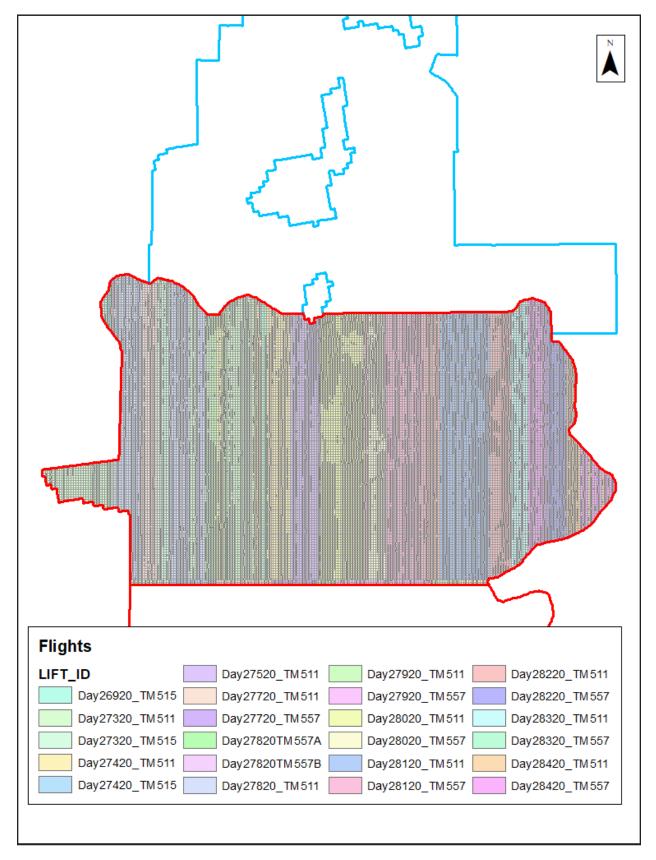


Table 2-4. GNSS Base Stations

Station Name	Longitude (DMS)	Latitude (DMS)	Ellipsoid Height L1 Phase Center (Meters)
MTSU_CORS	45° 39' 40.37685"	111° 2' 42.00897"	1495.554

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 $(4 \times ANPS)^2$ exhibited data coverage gaps.

Woolpert received Notice to Proceed for the project on July 30, 2020 and mobilized to the project area on September 8, 2020. As of September 8, there was both wildfire smoke and snow in the project area. Wildfires continued to burn outside of Yellowstone National Park throughout the month of October, but flight crews were able to adjust mission locations daily to avoid smoke haze.

Significant snowfall September 26-28, 2020 resulted in snow on the north faces of peaks that would persist until 2021. Woolpert continued with acquisition with approval from the USGS to classify snowy peaks as Class 21-Snow. October 24 through October 26, 2020 a strong cold front brought 16+ inches of snow and record cold temperatures. The snow persisted through the rest of the month and effectively ended the fall 2020 acquisition season. The Ground control survey was 100% complete at this time. Data acquisition was 98% complete.

On October 26, 2020 Woolpert's Quality Control noted a few small data voids on vertical cliffs of the tallest peaks. Woolpert recommended to USGS the acquisition of cross-flight data over these areas in spring 2021 to capture the peaks from different angles. Woolpert also recommended to USGS the processing of all data collected to date, with the cross-flight data acquired in 2021 to be processed separately and delivered as a data patch. USGS approved both of these recommendations in November 2020.

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 v2020 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)
-0.080	0.065	0.017
-0.035	0.060	0.019
-0.105	0.045	0.017
-0.120	0.055	0.014
-0.070	0.080	0.019
-0.040	0.097	0.026
-0.070	0.115	0.026
-0.077	0.060	0.021
-0.105	0.040	0.032
-0.085	0.040	0.028
-0.030	0.150	0.017
-0.240	0.040	0.022
-0.050	0.043	0.014
-0.090	0.030	0.018
-0.085	0.053	0.013
-0.040	0.063	0.017
-0.046	0.010	0.019
-0.065	0.025	0.016
-0.041	0.057	0.012
-0.110	0.067	0.023
-0.080	0.120	0.019
-0.060	0.070	0.015
-0.080	0.075	0.022
-0.090	0.035	0.022
-0.090	0.055	0.027
-0.080	0.045	0.025

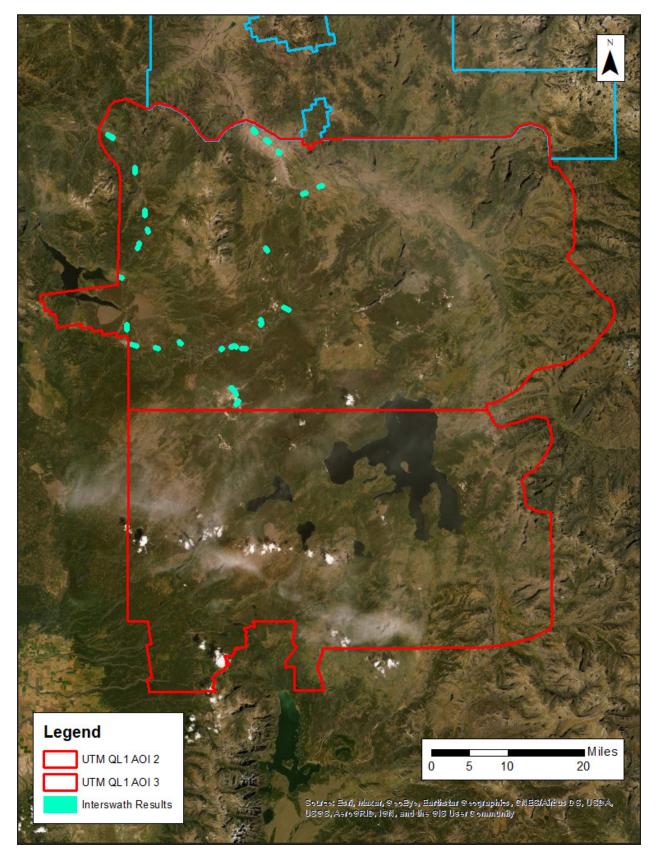


Figure 3-1. Interswath Testing Locations

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 v2020 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.

Minimum (m)	Maximum (m)	RMSDz (m)
-0.051	0.071	0.019
-0.073	0.025	0.030
-0.013	0.010	0.009
-0.057	0.057	0.018

Table 3-2. Intraswath Results

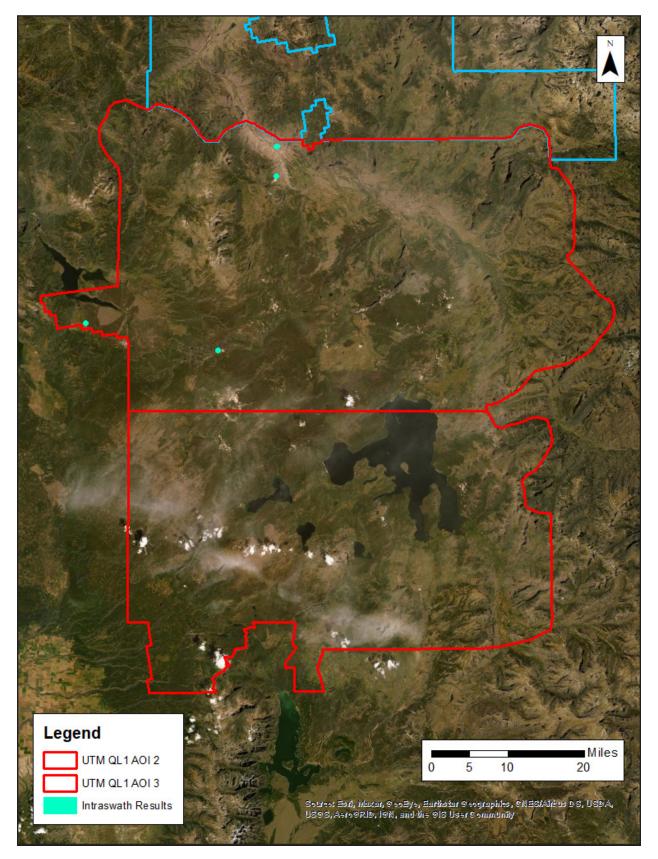


Figure 3-2. Intraswath Testing Locations

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.

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

Table 3-3. Classified Point Breakdown

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

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 0.158 cm RMSEx / RMSEy Horizontal Accuracy Class which equates to Positional Horizontal Accuracy = +/- 0.388 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 RMSEz 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.

	Result	Points Used
NVA	0.034 m RMSEz 0.067 m at 95% CL	24
VVA	0.114 at 95th Percentile	12

Table 4-1. Classified Point Cloud Vertical Accuracy

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 RMSEz 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	0.035 m RMSEz 0.0686 m at 95% CL	24
VVA	0.071 at 95th Percentile	12

Appendix 1: Sensor Calibration Report

- 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



Leica Geosystems AG Heinrich-Wild-Strasse CH-9435 Heerbrugg Schweiz www.leica-geosystems.com

1. System Components

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

3. Inspectors

Name Position	Bernhard Riedl Production Manager	15.11.2018	Rich Renhard
Name Position	Robert Bosch Support Engineer	23.05.2019	Xu Wang
Name Position	Michael Vetter Support Engineer	03.07.2019	h.300

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 Φ κ	-0.138877 0.130994 -0.006412	degree degree degree
Boresight		Value	Unit
	Θ Φ	0.001052 -0.001885	degree degree
Receiver 1		Value	Unit
Range	∆ Offset	0.000000	meters
Wedge 0		Value	Unit
Wedge Wedge Position Position Correction	Δ Alpha Δ Offset Χ Υ	0.001241 -0.426898 -0.019523 0.007883	degree degree degree degree
Mount	Roll	-0.020901	degree
Rotation Axis	Pitch Roll Pitch	0.107683 0.103712 0.124140	degree degree degree
Wedge 1		Value	Unit
Wedge Wedge Position Position Correction Mount	Δ Alpha Δ Offset Χ Υ Roll	-0.009545 0.412993 0.004000 0.011085 0.102859	degree degree degree degree degree
Mount	Pitch Speed Pitch	0.025756 1.50E-06	degree degree/rps ²
Rotation Axis	Roll Pitch	0.114811 -0.080531	degree degree
LiDAR Geometric Calibration File			
HYPERION_GEOMETRY_LIDARUNIT-5511	-C-855570-DATETIME-201810)23-153458.XM	ЛL
	Date	23.10.2018	
LiDAR Misalingment Flight LiDAR Misalingment Update Completed	Date 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

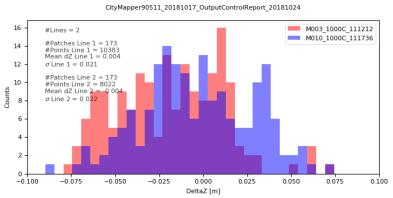
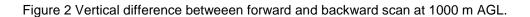


Figure 1 Vertical distance to ground control points at 1000 m AGL.

5.2.2 Difference of forward and backward scan of one line

Color	Limits [m]	Number of patches	Proportion of total number o patches [%]
	<=0.04	293823	93.48
	0.04-0.07	20386	6.49
	0.07-0.1	89	0.03
	>0.1	16	0.01
	>0.1		0.01



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 [%]
	<=0.04	32066	80.29
	0.04-0.07	7841	19.63
	0.07-0.1	21	0.05
	>0.1	12	0.03



Figure 3 Vertical difference betweeen 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

			Component
Camera Head Lens			CH82 NAT-D 2.8/80
Camera Model			
Focal Length			Distance [mm]
	С		83.00
Radial Symmetric Distorsion			Distance [mm]
	ko k1 k2		0.0000 0.0000 0.0000
Decentering Distortion	р1 Р2		Distance [mm] 0.0000 0.0000
Non-Orthogonality Distortion			Distance [mm]
Pixel Size (Height and Width)	b ₁ b ₂		0.0000 0.0000 Distance [mm]
	RGB NIR		0.0052 0.0120
Rows and Columns		Rows	Columns
	Active RGB Raw RGB Active NIR Raw NIR	7752 7788 3654 3366	10320 10336 4478 4500

6.2 Results of Geometric Calibration

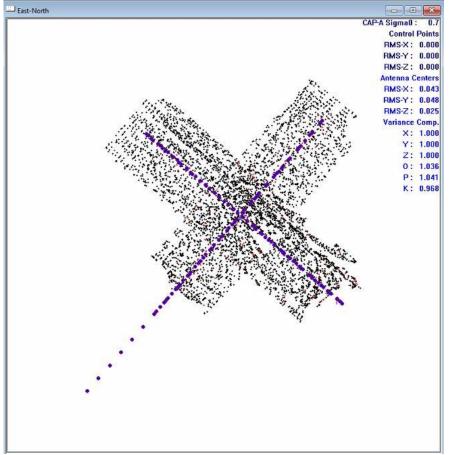
6.2.1 Calibration method for Green Reference Band

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:

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]
```

0.002

0.0007

Co-registration to green better than:

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

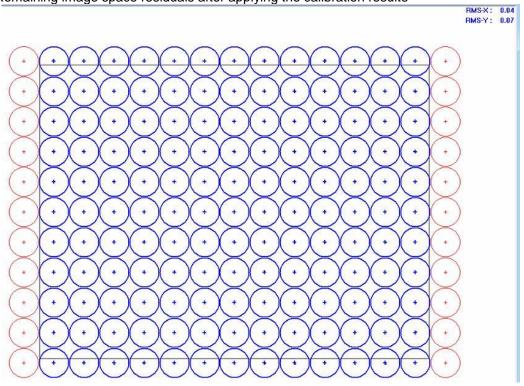
6.3 Estimation Results for Nadir Camera Head and Lens

		Component	Serial Number
Camera Head Lens View Direction in Pod Position		CH82 NAT-D 2.8/80 Nadir	82659 80254
IMU Misalignment		Angle [degree]	
	ω Φ κ	-0.00815 0.00028 -0.26654	
Principal Point		Distance [mm]	
	x y	0.0000 0.0000	
Focal Length		Distance [mm]	
	С	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
Misalingment Flight	Date	23.06.2019
Misalingment 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-L Calibration Certificate

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



Leica Geosystems AG Heinrich-Wild-Strasse CH-9435 Heerbrugg Schweiz www.leica-geosystems.com

1. System Components

Component	Туре	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			
		UN	12.12.2010	

3. Inspectors

Name Position	Bernhard Riedl Production Manager	12.12.2018	Rid Emlard
Name Position	Robert Bosch Support Engineer	12.12.2018	J. 3.00

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
	К	0.000504	degree
Boresight		Value	Unit
	Θ	0.015419	degree
	Φ	-0.001923	degree
Receiver 1		Value	Unit
Range	∆ Offset	0.000000	meters
Wedge 0		Value	Unit
Wedge	Δ Alpha	-0.043014	degree
Wedge Position	∆ Offset	0.442789	degree
Position Correction	Х	-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	∆ Alpha	-0.005517	degree
Wedge Position	∆ Offset	0.559649	degree
Position Correction	Х	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-551	6-C-855570-DATETIM	E-20181204-161828.XN	ΛL
	Date	04.12.2018	
LIDAD Missiliana and Elimber	Data		

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

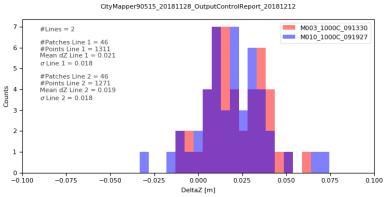
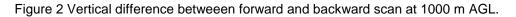


Figure 1 Vertical distance to ground control points at 1000 m AGL.

5.2.2 Difference of forward and backward scan of one line

	the second s	patches [%]
<=0.04	302593	99.75
0.04-0.07	716	0.24
0.07-0.1	17	0.01
>0.1	29	0.01
	0.04-0.07 0.07-0.1	0.04-0.07 716 0.07-0.1 17



5.2.3 Multi-line accuracy between two perpendicular lines

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

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.



Figure 3 Vertical difference betweeen 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	91557
Date	01 July 2020
Inspector	Ivan Belchev



Leica Geosystems AG Heinrich-Wild-Strasse CH-9435 Heerbrugg Schweiz www.leica-geosystems.com

1. System Components

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

2. Estimation Process

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

3. Inspectors

Name Position	Bernhard Riedl Production Manager	01.07.2020	Rud Renhard
Name Position	Ivan Belchev Workflow Specialist	01.07.2020	Utres
Name Position	Michael Vetter Support Engineer	01.07.2020	Vete blilad

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

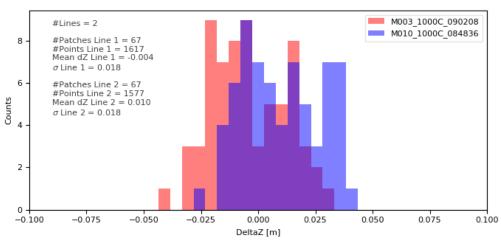
IMU Misalignment		Value	Unit
	ω	-0.063987	degree
	Φ	-0.049738	degree
	К	-0.005305	degree
Boresight		Value	Unit
	Θ	-0.001796	degree
	Φ	-0.003034	degree
Receiver 1		Value	Unit
Range	∆ Offset	0.000000	meters
Wedge 0		Value	Unit
Wedge	Δ Alpha	-0.045434	degree
Wedge Position	∆ Offset	0.352942	degree
Position Correction	Х	-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	∆ Offset	0.393122	degree
Position Correction	Х	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-2	0200625-085747.XM	ЛL
	Date	25.06.2020	
LiDAR Misalingment Flight	Date	-	
LiDAR Misalingment 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



TM-LN-91557_200623_OutputControlReport_200625

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 [%] 98.48	
	<=0.04	372019	98.48	
	0.04-0.07	5529	1.46	
	0.07-0.1	169	0.04	
	>0.1	33	0.01	



Figure 2 Vertical difference betweeen 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 [%]
	<=0.04	50354	99.33
	0.04-0.07	327	0.65
	0.07-0.1	6	0.01
	>0.1	6	0.01



Figure 3 Vertical difference betweeen 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

			Component
Camera Head Lens			CH82 NAT-D 2.8/80
Camera Model			
Focal Length			Distance [mm]
	С		83.00
Radial Symmetric Distorsion			Distance [mm]
	ko k1 k2		0.0000 0.0000 0.0000
Decentering Distortion	р1 р2		Distance [mm] 0.0000 0.0000
Non-Orthogonality Distortion			Distance [mm]
Pixel Size (Height and Width)	b ₁ b ₂		0.0000 0.0000 Distance [mm]
	RGB NIR		0.0052 0.0120
Rows and Columns		Rows	Columns
	Active RGB Raw RGB Active NIR Raw NIR	7752 7788 3654 3366	10320 10336 4478 4500

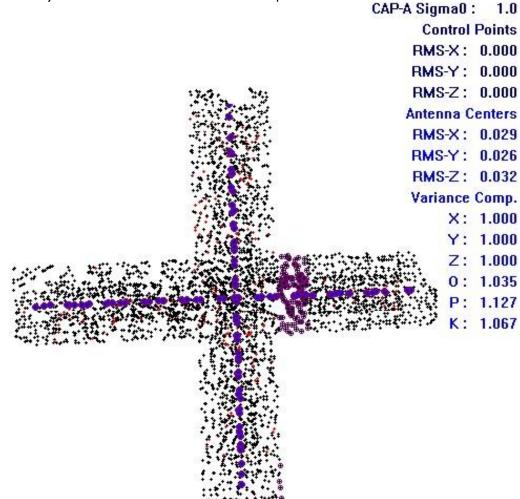
6.2 Results of Geometric Calibration

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:



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]

0.002

Co-registration to green better than:

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

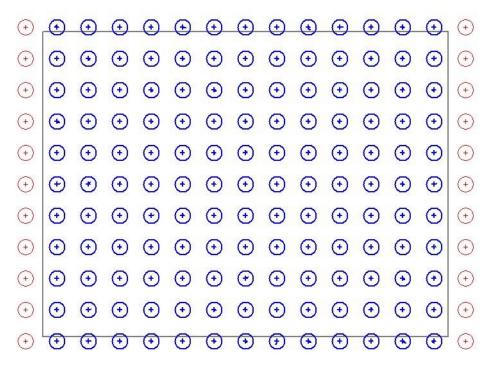
		Component	Serial Number
Camera Head Lens View Direction in Pod Position		CH82 NAT-D 2.8/80 Nadir	82673 80264
IMU Misalignment		Angle [degree]	
	ω Φ κ	0.03017 -0.01221 -0.25213	
Principal Point		Distance [mm]	
	x y	0.0000 0.0000	
Focal Length		Distance [mm]	
	С	83.00	
Geometric Calibration File			
RCD30_Geometry_CameraHead-8	32673798528_	_ensSystem-80264-	B-785423_DateTime-

20200629-142416.xml

Geometric Calibration Date	Date	29.06.2020
Radiometric Calibration Date	Date	30.01.2020
Misalingment Flight Misalingment Update Completed	Date 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

Project # 81200									uisitio		-0					
-				Project I	nfo								C	Date		
81200			Project	Name				U	nique ID		Flight	Date	UTC)	Day o	f Year	Flight
			Yellowsto	ne Block 1				Day2	69_90515_1		09,	/25/20	20	26	59	1
Cro	ew			Equij	oment						Time				Ai	rports
Pi	lot		Ai	rcraft Make	/ Mode	el / Tai	#		Hobbs St	art	Local	Start	UTCS	Start	De	parting
Gibi	ilaro			Cessna 404 1	itan - N	v7079F			2939.2	2	08:1	6:00	14:1	6:00		BZN
Oper	rator		Sei	nsor Make /	Model	/ Seria	al #		Hobbs E	nd	Loca	l End	UTC	End	Α	rriving
Kenr	nedy		Le	eica Terrain I	Napper	⁻ - 9051	.5		2940.6	5	09:3	8:00	15:3	8:00		BZN
						С	onditio	ons	-			·				
Wind Dir	(°)	Wind	Speed (kts)	Visibility	(mi)	Ceilin	ng (ft)	Clo	oud Cover	Temp	o. (°C)	Dew	Point	(°C)	Press	ure ("H
140			7	10					Clear	4	1		1		3	30.02
Air Spe	ed (kts)		Altitude	AGL (ft)	A	ltitude	MSL (ft	t)	Airfield El	evation	ı (ft)					
-	50		6,9				•			173	. ,					
			,				Setting	25	,			_	_	_	_	_
Point Spacir	ng (m)	Poin	t Density (pp	sm) Sc	an Ang	le/FOV		-	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Pov	ver (%)
0.35						10, 1 0 1	.,		150	()		1580	,,		10	
0.00									100	Ve	rify S-1		efore	Missio		Yes
Line #	Direct	ion	Start Time (UTC)	End Time (UTC)		me Line	Satel	lite	PDOP			Line No				105
1	S		14:41:00	14:43:00		02:00	17	7	1.3							
4	N		14:46:00	14:50:00		4:00	15		1.6							
2	S		14:53:00	14:56:00	-	03:00	17		1.2							
3	N		14:59:00	15:02:00	00:0	03:00	18	3	1.2							
5	S		15:11:00	15:15:00	00:0	04:00	18	3	1.2							
					<u> </u>											
										<u> </u>						
							_					_				
							Page 2	1		V	erify S-	Turns	After I	Vissio	n	Yes
dditional C	ommen	ts														

				Proie	ct Info								I	Date		
Project #			Project					U	nique ID		Flight	Date			f Year	Flight
81200			Yellowsto		1				73_90511_A		•	/29/20	. ,		73	A
	ew		10100310		uipmen	+		Duyz	/3_30311_/(Time	/25/20	20		-	rports
	lot		۸:				1 #		Hobbs St			Start		Start		-
				rcraft Ma		-										parting
	rika			Cessna 40					8049.8		09:2		15:2			<bzn< td=""></bzn<>
•	rator			nsor Mak					Hobbs E	-	Loca	-	UTC			rriving
Ry	van		Le	eica Terra	in Mappe				8055.9)	14:2	9:00	20:2	9:00	ŀ	 BZN
						C	Conditi	ons								
Wind Dir	۰(°) ۱	Nind	Speed (kts)	Visibil	ity (mi)	Ceilir	ng (ft)	Clo	oud Cover	Temp	o. (°C)	Dew	Point	(°C)	Press	ure ("H
200			3	-	.0				Clear	3	3		-1		3	3035
Air Spe	ed (kts)		Altitude	AGL (ft)		Altitude	MSL (ft)	Airfield Ele	vatior	n (ft)					
1	50				_		707			173						
						- /	Settin	ØS	,	-			_	_	_	_
Point Spaci	ng (m)	Doin	t Density (pp	sm)	Scan An	alo/EOV		-	n Frequency	/U)	Dulce	Rate	(LT-)	1.20	or Poy	ver (%)
0.35	15 (111)	rom		,5111)	Juli Al	40	()	Jta	150	(112)	ruise	1580	(K112)	Las	100	
0.35			2			40			150						_	-
	_	_			-					Ve	rify S-1	Furns E	Sefore	Missio	on	Yes
Line #	Direct	ion	Start Time	End Tin		ime	Sate	ellite	PDOP			Line N	otes/C	Comme	ents	
-		-	(UTC)	(UTC)	Or	n-Line			_			-				
95	S		15:25:00	15:28:0		:03:00		4	1.1							
97	S		15:45:00	15:49:0		:04:00	2		1.4							
96	N		15:52:00	15:55:0		:03:00		0	1.5							
94	S		15:57:00	16:00:0		:03:00		0	1.2							
93	N		16:03:00	16:06:0		:03:00		0	1.2							
92	S		16:09:00	16:11:0		:02:00	2		1.2	<u> </u>						
91 90	N S		16:15:00	16:18:0 16:23:0		:03:00 :03:00	2	0	1.2 1.2							
90 89	N N		16:20:00 16:25:00	16:23:0		:03:00	2		1.2							
88	S		16:31:00	16:28:0		:02:00	1	-	1.3							
87	N		16:36:00	16:38:0		:02:00	1		1.3							
86	S		16:41:00	16:43:0		:02:00		8	1.4							
85	N		16:46:00	16:48:0		:02:00		8	1.4							
84	S		16:50:00	16:53:0		:03:00		8	1.4							
83	N		16:55:00	16:58:0		:03:00		8	1.3							
82	S		17:00:00	17:02:0		:02:00		8	1.3							
81	N		17:06:00	17:07:0	0 00	:01:00	1	8	1.3							
80	S		17:10:00	17:11:0	0 00	:01:00	2	0	1.2							
79	N		17:14:00	17:16:0		:02:00		1	1.2							
30	N		17:27:00	17:41:0		:14:00		2	1							
31	S		17:44:00	17:57:0		:13:00	-	7	1.4							
45	N		18:03:00	18:17:0		:14:00	-	7	1.3			ne sno				
46	S		18:22:00	18:35:0		:13:00		9	1.2		sor	ne sno	w in tł	ne high	peaks	5
	N		18:38:00	18:51:0		:13:00		2	1							
47	· ·		18:54:00	19:07:0	0 00	:13:00	2	2	1							
47 48	S						Page				erify S-					Yes

					ect l	ert Lid							-	Date		
Ducie et #			Dustant		ect I	nto	1		uluur ID		El ala	Data			<u> </u>	
Project #			Project						nique ID		_		(UTC)	-		
81200			Yellowsto					Dayz	73_90515_1		-	/29/20	20	27		1
	ew					oment					Time	-				rports
	lot					/ Model / Ta			Hobbs St			Start	UTCS			parting
	ilaro					itan - N7079			2940.6		10:3		16:34			BZN
Ope	rator					Model / Seri			Hobbs E	nd	Loca	l End	UTC	End	A	rriving
Keni	nedy		Le	eica Ter	rain N	/lapper - 905			2946		16:0	3:00	22:03	3:00		BZN
							Conditio	ons								
Wind Dir	(°)	Wind	Speed (kts)	Visik	ility ((mi) Ceili	ng (ft)	Clo	oud Cover	Temp	o. (°C)	Dew	Point	(°C)	Press	ure ("H
180			3		10				Clear	1	1		2		3	30.34
Air Spe	ed (kts)	Altitude	AGL (ft)	Altitude	e MSL (ft)	Airfield El	evation	n (ft)					
15	50		6,9	98					4,4	473						
			,				Setting	s	,							
Point Spacir	ng (m)	Poir	nt Density (pp	sm)	Sca	an Angle/FO		-	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Pov	wer (%)
0.35	5 ()		7 \1"P			40			150	,		1580	,		100	
0.00						10			100	Ve	rify S-1		Refore	Missic	-	Yes
			Start Time	End T	me	Time					, 5					103
Line #	Direo	tion	(UTC)	UT		On-Line	Satel	lite	PDOP			Line N	otes/C	omme	ents	
20	Ν		17:10:00	17:24		00:14:00	20		1.3				dusting	-		
21	9	-	17:28:00	17:42		00:14:00	22		1		_		dusting	-		
22	N		17:45:00	18:00		00:15:00	17		1.5		-		dusting			
23	9	>	18:02:00	18:16	:00	00:14:00	17		1.3		Light	snow (dusting	s on n	orth e	na
1	9	:	18:23:00	18:34	.00	00:11:00	19		1.1		Start E	llock 3	6998	ΔGI 1	3074	MSI
2	N		18:37:00	18:47		00:11:00	22		1.1		Start L		, 0550	AGL, 1	5074	VIJL
3			18:50:00	19:01		00:11:00	22		1							
4	Ν	J	19:04:00	19:15	:00	00:11:00	18		1.2							
5	5	5	19:18:00	19:28	:00	00:10:00	20)	1.3							
6	N	J	19:34:00	19:47	:00	00:13:00	19		1.4							
7	5		19:52:00	20:04		00:12:00	22		1.2							
8	N		20:07:00	20:21		00:14:00	22		1.2	<u> </u>						
9 10	9		20:24:00	20:37		00:13:00	21		1.2 1.2							
10	N S		20:40:00 20:57:00	20:54		00:14:00 00:13:00	21 23		1.2							
11	N		20:37:00	21:10		00:13:00	23		1.1	<u> </u>						
		-														
						1	Page 1	L	1	V	erify S-	Turns	After N	Vissio	n	Yes
Additional C	omme	nts														

				Pro	ject Ir	nfo								D	Date		
Project #			Project		•		_		U	nique ID		Flight	Date	(UTC)	Day of	f Year	Flight
81200			Yellowsto	ne Bloc	k 1					74 90511 A			/30/20		. 27		A
Cr	ew				Equip	ment			,			Time				Ai	rports
Pi	lot		Ai	rcraft N			l / Tai	#		Hobbs S	tart	Local	Start	UTCS	Start		parting
Ma	rika			Cessna			-			8055.	Э	09:3	9:00	15:39	9:00		KBZN
Ope	rator		Se	nsor M	ake / I	Model	/ Seria	al #		Hobbs E	nd	Loca	l End	UTC	End	A	rriving
•	an			eica Tei	-		-			8061.	2	13:1	8:00	19:18	8:00		KBZN
,								onditi	ons								
Wind Dir	(°)	Wind	Speed (kts)	Visi	bility (mi)		ng (ft)		oud Cover	Tem	o. (°C)	Dew	Point	(°C)	Press	sure ("H
120			3	-	10	-		0.17		Clear		2		-2	<u> </u>		3040
Air Spe	ed (kts)		Altitude	AGL (f		Al	titude	MSL (f	t)	Airfield El	evatior	n (ft)		_			
-	50				-,			182	-,		473	. (,					
								Settin	øs	.,			_	_	_	_	
oint Spacir	ng (m)	Poir	t Density (pr	osm)	Sca	n Angl			-	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Pov	wer (%)
0.35			8	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		4		()		150	()		1580	,		100	
0.55			Ű							150	Ve	rify S-1		Before	Missic	-	Yes
		_	Start Time	End 1	imo	Tin	10										103
Line #	Direc	tion	(UTC)	UT		On-L	-	Sate	llite	PDOP			Line N	otes/C	omme	ents	
54	S		14:51:00	(***	-,			2	2	1.3	Sen	sor cra	shed /	multip	le erro	ors/ se	e notes
_																	
54	S		15:39:00	15:52	2:00	00:13	3:00	2	3	1.2	a	ltitude	varies	slightly	/ betw	een al	l lines
55	N		15:55:00	16:09		00:14		2		1.1							
56	S		16:12:00	16:2		00:13		2		1.1							
57	N		16:28:00	16:42		00:14		2		1.1	<u> </u>						
58 59	S N		16:44:00 17:00:00	16:58 17:14		00:14		1		1.3 1.2							
60	S		17:16:00	17:14		00:12		1		1.2							
61	N		17:32:00	17:4		00:13		1		1.1							
62	S		17:47:00	18:00		00:13		1		1.3							
63	N		18:04:00	18:1		00:13		1	-	1.2							
64	S		18:19:00	18:32	2:00	00:13	3:00	1	8	1.2							
65	N		18:35:00	18:4		00:13		1	9	1							
66	S		18:50:00	19:03		00:13		1		1							
67	N		19:05:00	19:18	3:00	00:13	3:00	1	6	1.3							
								Deci	1			ouif - C	T.	A &	Aice!-	_	Var
								Page	T		V	erify S-	urns	Atter N	VIISSIO	n	Yes
dditional C				1								•			<u> </u>		
-			sensor crash						-								rrect MI se statio

				<u>Woolp</u>	ert	Lid	<u>ar A</u>	vcd	uisitio	n Lo	og					
				Project	Info								۵	Date		
Project #			Project	Name				U	nique ID		Flight	Date	(UTC)	Day o	f Year	Flight
81200			Yellowsto	ne Block 1				Day2	74_90515_1		09	/30/20	20	27	74	1
Cr	ew			Equi	pment						Time				Ai	rports
Pi	lot		Ai	rcraft Make	/ Mode	el / Tai	#		Hobbs S	tart	Local	Start	UTCS	Start	De	parting
Gib	ilaro			Cessna 404 1	Fitan - N	17079F	:		2946	5	08:4	0:00	14:4	0:00		BZN
Оре	rator		Sei	nsor Make /	Model	/ Seria	al #		Hobbs I	End	Loca	l End	UTC	End	Ar	riving
Ken	nedy		Le	eica Terrain I	Mapper	- 9051	L5		2951.	2	13:5	0:00	19:5	0:00		BZN
						C	Conditio	ons								
Wind Dir	(°)	Wind	Speed (kts)	Visibility	(mi)	Ceilir	ng (ft)	Clo	oud Cover	Tem	p. (°C)	Dew	Point	(°C)	Press	ure ("H
120			3	10					Clear		2		-2			30.4
Air Spe	ed (kts		Altitude	AGL (ft)	A	titude	MSL (f	t)	Airfield E	evatio	n (ft)					
	50		6,9				074			473	. ,					
			- ,0				Settin	gs	.,	-						
Point Spacir	ng (m)	Poin	t Density (pp	sm) Sc	an Angl			-	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Pov	ver (%)
0.35	-0 ()			, 50	4		. /		150	()		1580			100	
0.55					4	0			150	V	erify S-1		Refore	Missi		Yes
		_	Start Time	End Time	Tir	20		_			Jiny 5	i unito i		14113510		163
Line #	Direc	tion	(UTC)	(UTC)	On-l	-	Sate	lite	PDOP			Line N	otes/C	omme	ents	
13	S		15:55:00	16:09:00	00:1		22)	1.1		In	air re	start fo	or RCD	error	
14	N		16:12:00	16:26:00	00:1		22		1.1			i un re.		i neb	critici	
15	S		16:29:00	16:43:00	00:1		22		1.1							
16	N		16:46:00	17:00:00	00:1	4:00	19)	1.3							
17	S		17:03:00	17:17:00	00:1	4:00	18	3	1.2							
18	N		17:20:00	17:34:00	00:1		19		1.1							
19	S		17:37:00	17:51:00	00:1		15		1.5							
20	N		17:54:00	18:08:00	00:1		15		1.4							
21	S N		18:11:00 18:28:00	18:24:00 18:42:00	00:1		16		1.2 1							
22	S		18:45:00	18:58:00	00:1		18		1.1							
23	N		19:01:00	19:15:00	00:1		16		1.1							
								-								
										-						
							Page	1		V	'erify S-	Turns	After I	Vissio	n	Yes
dditional C	ommer	nts														

				Woolp		LIU		ACQ	uisitio		Jg					
				Project I	nfo									ate		
Project #			Project						nique ID				(UTC)	Day of	Year	Flight
81200		`	Yellowstone k					Day2	75_90511_A			/01/20	20	27	-	Α
Cr	ew			Equip	oment						Time					rports
Pi	lot		Ai	rcraft Make	/ Mode	l / Tai	#		Hobbs St		Local	Start	UTC S	Start	De	parting
Ni	со			Cessna 404 T	ïtan - N	404CP)		8061.2	2	09:0	5:00	15:05	5:00	ŀ	BZN
Оре	rator		Sei	nsor Make /	Model	/ Seria	al #		Hobbs E	ind	Loca	l End	UTC	End	Ar	riving
Ry	an		Le	eica Terrain N	Mapper	- 9051	.1		8066.	6	13:1	4:00	19:14	4:00	ŀ	(BZN
						С	onditi	ons								
Wind Dir	(°)	Wind	Speed (kts)	Visibility	(mi)	Ceilin	ng (ft)	Clo	oud Cover	Tem	p. (°C)	Dew	Point	(°C)	Press	ure ("H
0			0	10		20,	000		Broken		2		-2		3	3043
Air Spe	ed (kts)		Altitude	AGL (ft)	A	titude	MSL (f	t)	Airfield El	evatio	n (ft)					
1	50							-	4,4	473						
							Settin	gs								
Point Spacir	ng (m)	Poin	t Density (pp	sm) Sc	an Angl			-	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Pov	ver (%)
0.35	5	2.0	8	,	4(-	.,		150	/		1580	·/		100	
0.00			<u> </u>			5			100	Ve	erify S-1		Before	Missio		Yes
			Start Time	End Time	Tin	10										105
Line #	Direc	tion	(UTC)	(UTC)	On-L	-	Sate	llite	PDOP			Line N	otes/C	omme	nts	
68	S		15:05:00	15:17:00	00:12		2	1	1.2	a	ltitude	varies	slightly	, hetw	een al	llines
69	N		15:22:00	15:37:00	00:1		2		1.3	- u	intuac	varies	5116111	Jeen		
70	S		15:40:00	15:52:00	00:12		2		1.2							
71	N		15:56:00	16:10:00	00:14	4:00	2	3	1.3							
72	S		16:14:00	16:26:00	00:12		2	2	1.2							
73	N		16:30:00	16:44:00	00:14		2		1.1							
74	S		16:47:00	16:59:00	00:12		2		1.2							
75	N		17:04:00	17:17:00	00:13		2		1.1							
76 77	S N		17:21:00 17:37:00	17:33:00 17:51:00	00:12		20		1.3 1.5							
78	S		17:37:00	18:23:00	00:12		1	-	1.3							
70			10.11.00	10.23.00	00.11	2.00		,	1.5	<u> </u>						
												BLOCK	3/13,	,074 N	/ISL	
25	S		18:41:00	18:54:00	00:13	3:00	1	9	1		smok	e / reti	urns in	low to	mid 9	0's
26	N		19:00:00	19:14:00	00:14	4:00	1	7	1.2		smok	e / reti	urns in	low to	mid 9	0's
							Page	1		V	erify S-	Turns	After N	Aissior	า	Yes
dditional C	ommer	nts														

				Pro	oject lı	nfo								C	Date		
Project #			Project	Name	•		Τ		U	nique ID		Flight	Date	(UTC)	Day of	Year	Flight
81200			Yellowstone	Block 3	and 1			C	Day2	77_90511_A		10	/03/20	20	27	7	A
Cr	ew				Equip	ment			,			Time				Α	irports
	lot		Ai	rcraft I		/ Model /	Tail	#	_	Hobbs St		1	Start	UTCS	Start		eparting
	ico					itan - N40				8066.0		09:3		15:39			KBZN
	rator			0000110		Model / S		#		Hobbs E		Loca		UTC			rriving
						-					-		-				-
Ку	an		Le	eica re	rrain iv	lapper - S				8073.4	ł	15:3	2:00	21:32	2:00		KBZN
	(9)		6 1/1+)		/	.) 0		onditio		1.0	-	(80)	-	<u> </u>	(90)	_	/!!.
Wind Dir	· (°)	Wind	Speed (kts)	VISI	bility (mi) C	eiling		Clo	oud Cover		o. (°C)	Dew	Point	(°C)		sure ("H
130			6		10		20,0			Few		2		-2		_	3028
Air Spe	ed (kts)	Altitude	AGL (f	t)	Altit	ude l	MSL (ft)		Airfield El	evatior	n (ft)					
1	50		6,9	98			13,0	74		4,4	473						
							S	Setting	s								
oint Spacir	ng (m)	Poir	it Density (pp	sm)	Sca	n Angle/	FOV	(°)	Sca	n Frequency	(Hz)	Pulse	Rate	(kHz)	Lase	er Po	wer (%)
0.35			8			40				150			1580			10	0
											Ve	rify S-1	Furns E	Before	Missio	n	Yes
			Start Time	End 1	Гime	Time	Т				Ī	-					<u>.</u>
Line #	Direc	tion	(UTC)	(U1		On-Lin	е	Satelli	te	PDOP			Line N	otes/C	omme	nts	
27	S		15:39:00	. 15:5		00:13:0	00	21		1.1			BLOCH	(3 13	.074 N	1SL	
28	N	1	15:57:00	16:0		00:12:0		22		1.1					-	-	
29	S		16:13:00	16:2	5:00	00:12:0	0	21		1.1							
30	N	I	16:30:00	16:4	2:00	00:12:0	0	19		1.3							
31	S		16:46:00	16:5	8:00	00:12:0	00	19		1.2							
32	N	I	17:02:00	17:1	4:00	00:12:0	00	21		1.1							
33	S		17:18:00	17:3		00:12:0	-	20		1.1							
34	N		17:33:00	17:4		00:12:0	-	17		1.4							
35	S		17:48:00	17:5		00:11:0		17		1.3							
36	N		18:03:00	18:1		00:11:0		19		1.2							
37	S		18:17:00	18:2		00:10:0	-	22		1							
38	N S		18:31:00 18:45:00	18:4 18:5		00:10:0	_	20 21		1							
40	N N		18:59:00	19:1		00:10:0	-	21		1							
40	S		19:12:00	19:1		00:11:0		21		1.1							
42	N		19:27:00		8:00	00:11:0		22		1.2							
43	S		19:41:00		2:00	00:11:0		22		1.3							
														BLOCK	(1		
											a	ltitude	varies	slightly	/ betwo	een a	ll lines
19	N		20:11:00	20:2		00:13:0	-	20		1.3							
18	S		20:28:00	20:4		00:14:0		22		1.1							
17	N		20:45:00	20:5		00:13:0	_	24		1.1	L						
16	S		21:02:00	21:1		00:13:0	_	25		1							
15	N	I	21:18:00	21:3	2:00	00:14:0		26		1.1							
								Daga 1			<u> у</u>	erify S-	T	After	Aissian		Vaa
dditional C	0.000.000.000	**						Page 1			V	erny 3.	iuiiis		*1133101		Yes
uaitional C	ommei	its															

Crew I Pilot I Dar Perl I Operator I Fanning Vind Sp Wind Dir (°) Wind Sp 270 Vind Sp 270 Vind Sp Air Speed (kts) I 150 Point Sp 0.35 Point Sp Line # Direction 44 S 1 45 N 1 46 S 1 47 N 1	Sens Leic peed (kts) 0 4 Altitude A 6,998 Density (ppsr 8 tart Time (UTC) 16:54:00 17:08:00 17:22:00	NP Block 3 Equip raft Make / Reims 406 for Make / I ca Terrain M Visibility (10 AGL (ft) 8 m) Sca End Time (UTC) 17:04:00	Model / Tai Model / Tai N406SD Model / Seria Aapper - 9055 C mi) Ceilin 18, Altitude 13, Altitude 13, Man Angle/FOV 40	Day: al # 57 Conditions ng (ft) C 000 C MSL (ft) 074 Settings		Temp. (°C) 11 Temp. (°C) 11 evation (ft) 471 (Hz) Puls	0/03/202 il Start 54:00 al End 04:00 Dew E Rate (1580	UTC Start 16:54:00 UTC End 21:04:00 Point (°C) 4	277 A De A Pres	1 irports eparting KBZN KBZN Soure ("Hg 30.18
81200 \bigvee Y Pilot Operator Querator Querator Wind Dir (°) Wind Dir (°) Wind Space Querator Air Speced (kts) Querator Point Space (m) Point Space (m) Querator Querator Point Space (m) Querator	(ellowstone N Airc Sens Leio peed (kts) 0 0 0 Altitude A 6,998 Density (ppsr 8 tart Time (UTC) 16:54:00 1 17:08:00 1 17:22:00 0	NP Block 3 Equip raft Make / Reims 406 for Make / I ca Terrain M Visibility (10 AGL (ft) 8 m) Sca End Time (UTC) 17:04:00	/ Model / Tai - N406SD Model / Seria Aapper - 9055 (mi) Ceilin 18, Altitude 13, In Angle/FOV 40 Time On-Line	Day: I # al # 57 Conditions ng (ft) C 000 C MSL (ft) 074 Settings / (°) Sc	277_90557_1 Hobbs St 488.1 Hobbs E 494.2 Ioud Cover Clear Airfield Ele 4,4 T50	Temp. (°C) 11 Temp. (°C) 11 evation (ft) 471 (Hz) Puls	0/03/202 il Start 54:00 al End 04:00 Dew E Rate (1580	20 UTC Start 16:54:00 UTC End 21:04:00 Point (°C) 4 kHz) La	277 A De A Pres	1 irports eparting KBZN Arriving KBZN ssure ("Hg 30.18
Crew I Pilot I Dar Perl I Operator I Fanning Vind Sp Wind Dir (°) Wind Sp 270 Vind Sp 270 Vind Sp Air Speed (kts) I 150 Point Sp 0.35 Point Sp Line # Direction 44 S 1 45 N 1 46 S 1 47 N 1	Airc Sens Leic peed (kts) 0 0 4 Altitude A 6,998 Density (ppsr 8 tart Time (UTC) 16:54:00 17:08:00 17:22:00	Equip raft Make / Reims 406 for Make / I ca Terrain M Visibility (10 GL (ft) 8 m) Sca End Time (UTC) 17:04:00	/ Model / Tai - N406SD Model / Seria Aapper - 9055 (mi) Ceilin 18, Altitude 13, In Angle/FOV 40 Time On-Line	il # al # 57 Conditions ng (ft) C 000 e MSL (ft) 074 Settings / (°) Sc	Hobbs St 488.1 Hobbs E 494.2 Clear Clear Airfield Ela 4,4 An Frequency 150	Time art Loca 10: 10: 15: 15: Temp. (°C) 11 evation (ft) 471 (Hz) Puls	e Il Start 54:00 a I End 04:00 a Dew 56 E Rate (1580	UTC Start 16:54:00 UTC End 21:04:00 Point (°C) 4 kHz) La	A De A Pres aser Po	irports eparting KBZN Arriving KBZN SSURE ("Hg 30.18
Pilot Pilot Dar Perl Perl Operator Fanning Wind Dir (°) Wind Sp 270 Wind Sp 270 Wind Sp 270 Point Speed (kts) 150 Point Spacing (m) Point Space (m) Point D 0.35 St Line # Direction 44 S 1 45 N 1 46 S 1 47 N 1	Sens Leic peed (kts) 0 4 Altitude A 6,998 Density (ppsr 8 tart Time (UTC) 16:54:00 17:08:00 17:22:00	raft Make / Reims 406 For Make / I ca Terrain M Visibility (10 GL (ft) 8 m) Sca End Time (UTC) 17:04:00	/ Model / Tai - N406SD Model / Seria Aapper - 9055 (mi) Ceilin 18, Altitude 13, In Angle/FOV 40 Time On-Line	al # 57 Conditions ng (ft) C 000 MSL (ft) 074 Settings / (°) Sc	488.1 Hobbs E 494.2 Clear Airfield Eld 4,4 Airfield Eld 4,4	art Loca 10: nd Loc 15: Temp. (°C) 11 evation (ft) 471 (Hz) Puls	Il Start 54:00 54:00 0 al End 0 04:00 0 Berno 0 al End 0 04:00 0	16:54:00 UTC End 21:04:00 Point (°C) 4 kHz) Lá	Pres	eparting KBZN Arriving KBZN ssure ("Hg 30.18
Dar Perl Operator Operator Fanning Wind Dir (°) Wind Sp Wind Dir (°) Wind Sp Air Speed (kts) O 150 Point D Point Spacing (m) Point D O St Line # Direction St 44 S 1 446 S 1 446 S 1 447 N 1	Sens Leic peed (kts) 0 4 Altitude A 6,998 Density (ppsr 8 tart Time (UTC) 16:54:00 17:08:00 17:22:00	Reims 406 sor Make / I ca Terrain M Visibility (10 GL (ft) 8 m) Sca End Time (UTC) 17:04:00	i - N406SD Model / Seria Aapper - 9055 (mi) Ceilin 18, Altitude 13, Altitude 40 Time On-Line	al # 57 Conditions ng (ft) C 000 MSL (ft) 074 Settings / (°) Sc	488.1 Hobbs E 494.2 Clear Airfield Eld 4,4 Airfield Eld 4,4	10: nd Loc 15: Temp. (°C) 11 evation (ft) 471 (Hz) Puls	54:00 al End 04:00 Dew 6e Rate (1580	16:54:00 UTC End 21:04:00 Point (°C) 4 kHz) Lá	Pres Pres	KBZN Arriving KBZN ssure ("Hg 30.18 ower (%)
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Fanning Wind S Wind Dir (°) Wind S 270 Wind S 270 I Air Speed (kts) I 150 Point S Point Spacing (m) 0.35 Point C 0.35 St Line # Direction 44 S 1 45 N 1 46 S 1 47 N 1	Leic peed (kts) 0 0 4ltitude A 6,998 Density (ppsr 8 tart Time (UTC) 16:54:00 1 17:08:00 1 17:22:00 0	Ca Terrain M Visibility (10 GL (ft) 8 m) Sca End Time (UTC) 17:04:00	Aapper - 9055 Ceilin 18, Altitude 13, an Angle/FOV 40 Time On-Line	57 Conditions ng (ft) C 000 • MSL (ft) 074 074 Settings / (°) Sc	494.2 loud Cover Clear Airfield El 4,4 an Frequency 150	Temp. (°C) 11 evation (ft) 471 (Hz) Puls	04:00 Dew se Rate (1580	21:04:00 Point (°C) 4 kHz) Lá	Pres aser Po	KBZN ssure ("Hg 30.18 ower (%)
Wind Dir (°) Wind Sp 270 Wind Sp 270 I Air Speed (kts) I 150 Point Dir <dir< td=""> Point Spacing (m) 0.35 Point Dir<dir< td=""> Line # Direction St 44 S 1 45 N 1 46 S 1 47 N 1</dir<></dir<>	peed (kts) 0 Altitude A 6,998 Density (ppsr 8 tart Time (UTC) 16:54:00 17:08:00 17:22:00	Visibility (10 AGL (ft) 8 m) Sca End Time (UTC) 17:04:00	Ceilin 18, Altitude 13, In Angle/FOV 40 Time On-Line	Conditions ng (ft) C 000 MSL (ft) 074 Settings / (°) Sc	loud Cover Clear Airfield Ela 4,4 an Frequency 150	Temp. (°C) 11 evation (ft) 471 (Hz) Puls	Dew Be Rate (1580	Point (°C) 4 kHz) La	aser Po	sure ("Hg 30.18 wer (%)
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Point Spacing (m) Point D 0.35 Point D Line # Direction St 44 S 1 45 N 1 46 S 1 47 N 1	Density (ppsr 8 itart Time (UTC) 16:54:00 17:08:00 17:22:00	m) Sca End Time (UTC) 17:04:00	n Angle/FOV 40 Time On-Line	Settings / (°) Sc	an Frequency 150	(Hz) Puls	1580		10	00
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Line # Direction St 44 S 1 45 N 1 46 S 1 47 N 1	tart Time (UTC) 16:54:00 17:08:00 17:22:00	(UTC) 17:04:00	Time On-Line	Satellite	T	Verify S		efore Miss	-	
Line # Direction 44 S 1 45 N 1 46 S 1 47 N 1	(UTC) 16:54:00 17:08:00 17:22:00	(UTC) 17:04:00	On-Line	Satellite	PDOP	Verify S	-Turns B	efore Miss	ion	Vec
Line # Direction 44 S 1 45 N 1 46 S 1 47 N 1	(UTC) 16:54:00 17:08:00 17:22:00	(UTC) 17:04:00	On-Line	Satellite	PDOP					162
45 N 1 46 S 1 47 N 1	17:08:00 17:22:00						Line No	otes/Comn	nents	
46 S 1 47 N 1	17:22:00	17.10.00	00:10:00	21	1.1					
47 N 1		17:18:00	00:10:00	22	1.1					
		17:32:00	00:10:00	19	1.1					
48 <u>S</u> 1		17:50:00	00:12:00	17	1.3					
49 N 1		18:08:00 18:33:00	00:12:00 00:13:00	20 22	1.1	PROK		NE 48 AFTE		
49 N 1	18.20.00	10.55.00	00.15.00	22	1			NE 48 AFTE		
50 S 1	18:36:00	18:49:00	00:13:00	22	1			ORTED 18:		
		19:06:00	00:13:00	19	1.2					
	19:26:00	19:38:00	00:12:00	22	1.3	87% RI	TURN O	N NORTH	PART O	F LINE
		19:56:00	00:13:00	22	1.3					
		20:13:00	00:13:00	20	1.5					
		20:31:00 20:47:00	00:14:00 00:13:00	20 24	1.3					
		21:04:00	00:13:00	24	1.1					
Additional Comments				Page 1	I	Verify	S-Turns /	After Missi	on	Yes

					ect l			-	uisitio				D	ate		
Project #			Project					U	nique ID		Flight	Date	UTC)		Year	Flight
81200			Yellowsto		(1				78_90511_A			/04/20		278		A
	ew					ment		20172			Time	, . ,			-	rports
	lot		Δi			/ Model /	Tail #		Hobbs S	tart	1	Start	UTC S	tart		parting
	со				-	itan - N404			8073.4			8:00	15:08			(BZN
	rator					Model / S			Hobbs E		Loca		UTCI			riving
•	an					/lapper - 9			8079.2			3:00	19:53			(BZN
пу	an					napper - 9	Condi	tions	8079.	2	15.5	5.00	19.55	.00		
Wind Dir	(°)	Wind	Speed (kts)	Vicik	oility (mi) Co	eiling (ft)		oud Cover	Tom	p. (°C)	Dow	Point	(°C)	Drocc	ure ("H
	0	wina	0	VISI	10		ining (it)		Clear		р. (С) 4	Dew				3014
	/	,	-			A 1414		(61)					0			3014
Air Spe	-)	Altitude	AGL (IT)	Altitu	de MSL	(π)	Airfield El		n (π)					
1	50						<u> </u>		4,	473			_	_		
					_		Setti	-	_		- ·				_	1
Point Spacir	ng (m)	Poir	it Density (pp	sm)	Sca	n Angle/F	OV (°)	Sca	n Frequency	(Hz)	Pulse	Rate	(kHz)	Lase		wer (%)
0.35			8			40			150	-		1580			100	
	_					-	-		•	Ve	erify S-1	Furns E	Before I	Missior	า	Yes
Line #	Dire	tion	Start Time	End T		Time	Sat	ellite	PDOP			Line N	otes/Co	ommer	nts	
_			(UTC)	(UT	-	On-Line									<u> </u>	
7		5	15:08:00	15:20		00:12:0		21	1.2	a	ltitude	varies	slightly	betwe	en al	l lines
8	1	N 5	15:24:00 15:38:00	15:35 15:50		00:11:0 00:12:0		22 21	1.3 1.2							
10	1		15:56:00	16:10		00:12:0		21	1.2							
10			16:13:00	16:27		00:14:0		20	1.1							
12	N N		16:30:00	16:44		00:14:0		19	1.2							
13	9	5	16:48:00	17:01		00:13:0		20	1.2							
14	١	١	17:04:00	17:19	:00	00:15:0	0	21	1							
24	9	5	17:22:00	17:37		00:15:0		19	1.1							
25	1		17:41:00	17:55		00:14:0	_	17	1.3							
26		5	17:59:00	18:12		00:13:0		17	1.2							
27 28	1	N 5	18:16:00 18:32:00	18:29		00:13:0 00:14:0		20 20	1							
28		>	18:52:00	19:04		00:14:0		20	1.1							
32		5	19:07:00	19:21		00:14:0		20	1.1							
33		1	19:24:00	19:37		00:13:0		23	1							
34	9	5	19:41:00	19:53	:00	00:12:0	0	22	1.2							
							_									
	-						Page	e 1	<u>.</u>	V	erify S-	Turns	After N	lission		Yes
dditional C	omme	nts								-						J
	_															

				WO Pro	ject l	nfo								ſ	Date		
Project #	1		Project		•					nique ID		Elight	Date			f Voar	Flight
81200		v	ellowstone N			Л				78_91557_1			/04/20		-	78	1 1
	ew					ment			Dayz	/8_9199/_1		Time	04/20	20	21	-	irports
	lot		Δi	rcraft I			al / Tai	#		Hobbs St	art	Local	Start	UTC	Start		parting
	Perl		7.4		-	5 - N40	-	• ••		494.2		09:1		15:1		KBZN	
	rator		Sei	nsor M				al #		Hobbs E		Loca		UTC		rriving	
•	ning			eica Te	-		-			500.5		14:0		20:0		KBZN	
	0							onditi	ons								
Wind Di	· (°)	Wind	Speed (kts)	Visi	bility (mi)	-	ng (ft)		oud Cover	Tem	o. (°C)	Dew	Point	(°C)	Pres	sure ("H
270	.,		0		20			000		Clear		4		0	<u> </u>		30.14
Air Spe	ed (kts)		Altitude	AGL (f	t)	Α		MSL (f	t)	Airfield El	evatior	n (ft)		-			
-	50		6,9					074	- 1		471	···					
			,				,	Settin	gs	,				_	_	_	
Point Spaci	ng (m)	Poin	t Density (pp	sm)	Sca	n Ang			-	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Po	wer (%)
0.35			8				0			150	. ,		1580	. ,	10	0	
											Ve	rify S-1	Furns E	Before	Missio	on	Yes
			Start Time	End 1	Гime	Tir	ne										<u></u>
Line #	Direct	ion	(UTC)	(U1		On-		Sate	llite	PDOP			Line N	otes/C	Comme	ents	
58	S		15:13:00	15:2	7:00	00:1	4:00	23	3	1.2		HEAVY	SMOK	E. 98%	6 RETU	RNS V	VITH
59	N		15:31:00	15:4			4:00	20		1.3	DRC						OF 88%
60	S		15:48:00	16:0	2:00	00:1	4:00	2:	1	1.1	<u> </u>	Т	HEN B	ΑСК ΤΟ	D MID	90'S.	
1	N		16:09:00	16:2	0:00	00:1	1:00	20	0	1.1	STAF		СК 4. А	GL 6.9	98'.M	SL IS V	ARIABLE
2	S		16:25:00	16:3			1:00	19		1.2							
3	N		16:41:00	16:5		00:1	2:00	19	9	1.2							
4	S		16:58:00	17:1	0:00	00:1	2:00	20		1.1					"		
5	N		17:14:00					20	5	1.1							AL PAV BACK TC
													E. THE				
													W LO				
						<u> </u>					<u> </u>						
						<u> </u>											
						<u> </u>											
								Page	1	1	v	erify S-	Turns	After l	Missio	n	Yes
Additional C NU: 08:41N RROR NOT	IST WI	D:14:3	88MST F TO THE 28VE							O AT 17:15UT ON PAV WEN						2 DOV	VNLOAD

Network NP BLOCK 4 Day278_91557_2 10/04/2020 Seter at a colspan="4" state at a colsp	UTC Start I 18:35:00 UTC End 20:04:00 Point (°C) Pre 0	ear Flight # 2 Airports Departing KBZN Arriving KBZN ressure ("Hg 30.14		
Project # Project Name Unique ID Flight Date UT 81200 Yellowstone NP BLOCK 4 Day278_91557_2 10/04/2020 Crew Aircraft Make / Model / Tail # Hobbs Start Local Start U Pilot Aircraft Make / Model / Serial # Hobbs Start Local Start U Operator Sensor Make / Model / Serial # Hobbs End Local End L Fanning Leica Terrain Mapper - 9155 500.5 14:04:00 2 Visibility (mi) Ceiling (ft) Cloud Cover Temp. (°C) Dew Por 270 0 20 18,000 Clear 4 € Altitude AGL (ft) Altitude MSL (ft) Airfield Elevation (ft) Dew Por 150 158 150 6,998 30,074 4,471 158 158 158 Verify S-Tims Bef 0.35 8 18:37:00 00:12:00 19 1 RESTART BLOC 6 N 18:51:00 19:3:00 00:12:00 20 1.0 AND RET 6 N 18:51:00 19:3:00	20 278 UTC Start I 18:35:00 UTC End 20:04:00 Point (°C) Pre 0 I	2 Airports Departing KBZN Arriving KBZN		
Yellowstone NP BLOCK 4 Day278_91557_2 10/04/2020 Crew Time Pilot Aircraft Make / Model / Tail # Hobbs Start Local Start U Pilot Reims 406 - N4065D 494.2 12:35:00 1 Operator Sensor Make / Model / Serial # Hobbs End Local End L Fanning Leica Terrain Mapper - 91557 500.5 14:04:00 2 Conditions Visibility (mi) Ceiling (ft) Cloud Cover Temp. (°C) Dew Poo Airticke AGL (ft) Altitude MSL (ft) Airfield Elevation (ft) Airticke AGL (ft) Altitude MSL (ft) Airfield Elevation (ft) Airticke AGL (ft) Altitude MSL (ft) Airfield Elevation (ft) Settings Point Spacing (m) Point Density (ppsm) Scan Angle/FOV (°) Scan F	20 278 UTC Start I 18:35:00 UTC End 20:04:00 Point (°C) Pre 0 I	2 Airports Departing KBZN Arriving KBZN		
CrewTimePilotAircraft Make / Model / Tail #Hobbs StartLocal StartUDar PerlReims 406 - N406SD494.212:35:001OperatorSensor Make / Model / Serial #Hobbs EndLocal StartUOperatorSensor Make / Model / Serial #Hobbs EndLocal StartUFanningLeica Terrain Mapper - 91557500.514:04:002Wind Dir (°)Wind Speed (kts)Visibility (mi)Ceiling (ft)Cloud CoverTemp. (°C)Dew Po27002018,000Clear4 </td <td>UTC Start 18:35:00 20:04:00 70 70 70 70 70 70 70 70 70 70 70 70 7</td> <td>Departing KBZN Arriving KBZN ressure ("Hg</td>	UTC Start 18:35:00 20:04:00 70 70 70 70 70 70 70 70 70 70 70 70 7	Departing KBZN Arriving KBZN ressure ("Hg		
Holbs Start Local Start U Aircraft Make / Model / Tail # Hobbs Start Local Start U O Sensor Make / Model / Serial # Hobbs Start Local Start U O Contitue Temp. (°C) 13.07 Sensor Make / Model / Serial # U 13.07 Temp. (°C) 14.04.100 20 O 20 18.000 Clear Pom. (°C) Dew Pot Mind Dir (°) Minted KeL (ft) Altitude MSL (ft) Airfield Elevation (ft) Q O 20 13.07 Clear 4 Clear Q Point Spacing (m) Point Spacing (m) Start Time (UTC) Start Time (UTC) <th colspan="2" start="" start<="" td=""><td>18:35:00 UTC End 20:04:00 Point (°C) Pre 0</td><td>KBZN Arriving KBZN</td></th>	<td>18:35:00 UTC End 20:04:00 Point (°C) Pre 0</td> <td>KBZN Arriving KBZN</td>		18:35:00 UTC End 20:04:00 Point (°C) Pre 0	KBZN Arriving KBZN
Period - N40-500 4494.2 12:3:00 1 Operator Sensor Make / Model / Serial # Hobbs End Loca Ico 12:3:00 1 Genome (Randor	18:35:00 UTC End 20:04:00 Point (°C) Pre 0	KBZN Arriving KBZN		
Image: Second S	20:04:00 Point (°C) Pre 0	KBZN		
Vind Dir (°)Wind Speed (kts)Visibility (mi)Ceiling (ft)Cloud CoverTemp. (°C)Dew Po27002018,000Clear40Air Speed (kts)Altitude AGL (ft)Altitude MSL (ft)Airfield Elevation (ft)Airfield Elevation (ft)1506,99813,0744,4719Point Spacing (m)Point Density (ppsm)Scan Angle/FOV (°)Scan Frequency (Hz)Pulse Rate (kH0.358 40^{-1} 1501580Verify S-Turns BefeDirectionStart Time (UTC)End Time (UTC)SatellitePDOPLine Note5S18:35:0018:47:0000:12:00191RESTART BLOC6N18:51:0019:3:0000:12:00201.1AND REFL7S19:06:0019:18:0000:12:00201.21.28N19:21:0019:3:0000:12:00211.11.19S19:37:0019:48:0000:11:00221.21.2	Point (°C) Pre	ressure ("Hg		
Vind Dir (°)Wind Speed (kts)Visibility (mi)Ceiling (ft)Cloud CoverTemp. (°C)Dew Policy27002018,000Clear400Air Speed (kts)Altitude AGL (ft)Altitude MSL (ft)Airfield Elevation (ft)4001506,9913,0744,47190909090909090Point Spacing (m)Point Density (ppsm)Scan Argle/FOV (°)Scan Frequency (Hz)Pulse Rate (kH0.358840'150'1580'1580'Verify S-turns BefeStart Time (UTC)Time (UTC)SatellitePpDOPLine Note5\$18:35:0018:47:0000:12:00191RESTART BLOC6N18:51:0019:3:0000:12:00201.11AID AND REFL7\$19:06:0019:3:0000:12:00201.201.208N19:21:0019:3:0000:12:00211.111.119\$19:3:0019:4:0000:11:00221.201.20	0			
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SettingsSettingsPoint Spacing (m)Point Density (ppsm)Scan Angle/FOV (°)Scan Frequency (Hz)Pulse Rate (kH 0.35 8401501580Verify S-Turns BeforeUrrcionEnd Time (UTC)Time On-LinePDOPLine Note5S18:35:0018:47:0000:12:00191RESTART BLOC6N18:51:0019:03:0000:12:00201.1AND REFL7S19:06:0019:18:0000:12:00211.11.19S19:37:0019:48:0000:11:00221.21.2	(Hz) Laser P			
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$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		Power (%)		
Line # Direction Start Time (UTC) End Time (UTC) Time On-Line Satellite PDOP Line Note 5 S 18:35:00 18:47:00 00:12:00 19 1 RESTART BLOC 6 N 18:51:00 19:03:00 00:12:00 20 1.1 AND REFL 7 S 19:06:00 19:18:00 00:12:00 20 1.2 8 N 19:21:00 19:48:00 00:11:00 22 1.2		100		
Line # Direction Start Time (UTC) End Time (UTC) Time On-Line Satellite PDOP Line Note 5 S 18:35:00 18:47:00 00:12:00 19 1 RESTART BLOC 6 N 18:51:00 19:03:00 00:12:00 20 1.1 AND REFL 7 S 19:06:00 19:18:00 00:12:00 20 1.2 8 N 19:21:00 19:48:00 00:11:00 22 1.2		Yes		
5 S 18:35:00 18:47:00 00:12:00 19 1 RESTART BLOC 6 N 18:51:00 19:03:00 00:12:00 20 1.1 AND REFL 7 S 19:06:00 19:18:00 00:12:00 20 1.2 8 N 19:21:00 19:33:00 00:12:00 21 1.1 9 S 19:37:00 19:48:00 00:11:00 22 1.2	tes/Comments			
6 N 18:51:00 19:03:00 00:12:00 20 1.1 AND REFL 7 S 19:06:00 19:18:00 00:12:00 20 1.2 8 N 19:21:00 19:33:00 00:12:00 21 1.1 9 S 19:37:00 19:48:00 00:11:00 22 1.2		BOOT		
7 S 19:06:00 19:18:00 00:12:00 20 1.2 8 N 19:21:00 19:33:00 00:12:00 21 1.1 9 S 19:37:00 19:48:00 00:11:00 22 1.2	FLY OVER BASE.			
9 S 19:37:00 19:48:00 00:11:00 22 1.2				
10 N 19:52:00 20:04:00 00:12:00 21 1.3				
Image: set of the				
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Image: Constraint of the second se				
Page 1 Verify S-Turns Aft	Show NAtoria	Yes		
Additional Comments		103		
WU:08:41MST WD:14:38MST ALTITUDE (MSL): VARIABLE	arter Wilssion			

				Wo	olp	ert	Lid	ar A	\cq	uisiti	on	Log			<u></u>		
				Pro	ject l	nfo								0	Date		
Project #			Project						U	nique ID		Flight	: Date	(UTC)	Day o	f Year	Flight
81200		`	Yellowstone E	Blocks 3	B and 1	L			Day2	79_90511_	A	10	/05/20	20	27	'9	A
Cre	ew				Equip	ment						Time				Ai	rports
Pil	lot		Ai	rcraft I	Make ,	/ Mode	el / Tai	l #		Hobbs	Start	Local	Start	UTC S	Start	De	parting
Ni	со			Cessna	404 T	itan - N	1404CF)		807	9.2	10:0	7:00	16:0	7:00		KBZN
Ореі	rator		Sei	nsor M	ake /	Model	/ Seria	al #		Hobbs	s End	Loca	l End	UTC	End	Α	rriving
Ry	an		Le	eica Te	rrain N	/lapper	- 9051	11		808	4.5	14:0	3:00	20:0	3:00		KBZN
							C	Conditi	ons								
Wind Dir	(°)	Wind	Speed (kts)	Visi	bility ((mi)	Ceilir	ng (ft)	Clo	oud Cover	Те	mp. (°C)	Dew	/ Point	(°C)	Press	sure ("H
150			5		10		18,	000	S	cattered		9		0			3025
Air Spe	ed (kts)	Altitude	AGL (f	t)	A	titude	MSL (f	t)	Airfield	Elevat	ion (ft)					
-	50		6,9	-	-						4,473						
			,					Settin	gs								
oint Spacin	ng (m)	Poir	it Density (pp	sm)	Sca	an Ang			-	n Frequen	cy (Hz)	Pulse	Rate	(kHz)	Las	er Pov	wer (%)
0.35	57		8	,			0	.,		150			1580	. ,		10	
			-				-					Verify S-	Turns E	Before	Missic	-	Yes
Line #	Direo	tion	Start Time	End 1		Tir	-	Sate	llite	PDOP				otes/C			
			(UTC)	(U1		On-			-					-			
30	N		16:07:00	16:1		00:1		2		1.1	_						
31 32	S		16:22:00 16:37:00	16:3 16:4		00:1		2		1.3 1.2	_						
33	S		16:52:00	17:0		00:1		2		1.2							
34	N		17:08:00	17:1		00:1		2		1							
35	S	5	17:22:00	17:3		00:1		2		1.2							
36	Ν	1	17:38:00	17:4	9:00	00:1	1:00	2	0	1.1							
														BLOC			
44	N		18:06:00	18:1		00:0		2		1.1		Altitude	varies	slightly	y betw	een a	l lines
43	5		18:18:00	18:3		00:1		2		0.9	_						
35 36	N S		18:36:00 18:52:00	18:4 19:0		00:1		2		1	_						
37	N		19:08:00	19:0		00:1		1		1.2							
38	S		19:24:00	19:3		00:1		2		1.1							
21	N	J	19:50:00	19:5		00:0	4:00	2		1.2			refligh	nt north	ו 10 m	iles	
20	S	5	19:58:00	20:0	3:00	00:0	5:00	2	1	1.2			refligh	nt north	ו 10 m	iles	
								Page	1			Verify S	-Turns	After I	Vissio	n	Yes
dditional C	ommei	nts															

			Woo	lpert	Lid	ar A	cq	uisitio	n Lo	og					
			Proje	ct Info								0	Date		
Project #		Project	t Name				U	nique ID		Flight	Date	(UTC)	Day of	f Year	Flight #
81200		Yellowsto	ne Block	4			Day2	79_90515_1		10,	/05/20	20	27	'9	1
Crew			E	quipmen	t					Time				Aiı	ports
Pilot		Ai	rcraft Ma	ake / Mod	lel / Tai	1#		Hobbs St	art	Local	Start	UTCS	Start		parting
Gebhart			Cessna 4	04 Titan -	N7079F	:		2961.7	7	09:1	9:00	15:19	9:00		BZN
Operator		Se	nsor Mał	e / Mode	l / Seria	al #		Hobbs E	nd	Loca	End	UTC	End	Ar	riving
Kennedy				in Mappe	•			2966.8	3	14:2	6:00	20:2			BZN
, , ,						Conditio	ons		-						
Wind Dir (°)	Wind	Speed (kts)	Visihi	lity (mi)	-	ng (ft)		oud Cover	Temp	(°C)	Dew	Point	(°C)	Press	ure ("Hg
150		4		10	+	500		Broken	g		Den	0	(0)		0.25
Air Speed (k	(tc)		AGL (ft)	-		MSL (ft		Airfield Ele				0			0.25
					Annuae		.)			(11)					
150		6,5	998			C		4,4	473						
	<u> </u>		N			Setting	-	_	(11.)	D 1				-	10()
Point Spacing (m) Poir	nt Density (pp	osm)	Scan Ang		/ (˘)	Sca	n Frequency	(Hz)	Pulse	Rate	(KHZ)	Las		ver (%)
0.35					40		_	150			1580			100	
-				_					Ve	rify S-1	Furns E	Before	Missio	n	Yes
Line # Dir	rection	Start Time (UTC)	End Tir (UTC)		ime -Line	Satel	lite	PDOP			Line N	otes/C	comme	ents	
60	S	15:53:00	16:05:	00 00:	12:00	24	Ļ	1.1							
59	N	16:08:00	16:20:		12:00	22		1.1							
58	S	16:23:00	16:34:		11:00	21		1.3							
57	N	16:37:00	16:49:		12:00	21		1.2							
56	S N	16:51:00	17:03:0 17:19:0		12:00 13:00	21 22		1.2 1							
55 54	S	17:06:00 17:21:00	17:19:		12:00	22		1.2							
53	N	17:36:00	17:49:		13:00	20		1.2							
52	S	17:51:00	18:02:		11:00	18		1.2							
51	N	18:06:00	18:18:	00 00:	12:00	21		1							
50	S	18:20:00	18:32:	00 00:	12:00	24	ŀ	0.9							
49	N	18:34:00	18:46:		12:00	21		1.1							
48	S	18:49:00	19:00:		11:00	19		1.1							
47	N	19:02:00	19:15:		13:00	18		1.2							
46 45	S N	19:18:00 19:32:00	19:29:0 19:45:0		11:00 13:00	20 22		1.2 1.2							
			13.43.		13.00			1.2							
						Page 1	1		Ve	erify S-	Turns	After I	Missio	n	Yes

				ject Ir	ert Lid							ſ	Date		
Project #		Brojoci	t Name	ject ii	110			nique ID		Elight	Data	UTC)		f Voo	r Flight
•		Yellowstone		and 7				-			/06/20				
81200		renowstone					Jayz	80_90511_A		-	/06/20	020	Z	30	A
	ew			Equip		•				Time	<u>.</u>		<u>.</u>		irports
	lot	_		-	Model / Tai			Hobbs St			Start		Start	De	eparting
	ico				tan - N404CP			8084.5		08:5			8:00		KBZN
•	rator	_			Model / Seria			Hobbs E		Loca	-		End	Δ	rriving
Ry	/an	L	eica Ter	rain N	1apper - 9051			8091.2	2	14:5	2:00	20:5	2:00		KBZN
						Conditio	ns								
Wind Dir	·(°) Win	d Speed (kts)	Visi	bility (mi) Ceilir	ng (ft)	Clo	oud Cover	Temp	o. (°C)	Dew	/ Point	: (°C)	Pres	sure ("H
150		5		10				Clear	:	3		-2			3019
Air Spe	ed (kts)	Altitude	AGL (f	t)	Altitude	MSL (ft)		Airfield El	evatior	n (ft)					
1	50	6,9	998					4,4	173						
						Setting	s								
Point Spaci	ng (m) Po	int Density (pp	osm)	Sca	n Angle/FOV			n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Po	wer (%)
0.35		8			40			150			1580			10	00
									Ve	rify S-1	Furns E	Before	Missi	on	Yes
		Start Time	End T	ime	Time		_			-					
Line #	Direction	(UTC)	UT		On-Line	Satell	ite	PDOP			Line N	otes/C	Commo	ents	
39	S	14:58:00	15:13		00:13:00	25		1.1				BLOC			
40	N	15:14:00	15:27		00:13:00	24		1.1	a	ltitude	varies	slightl	y betw	een a	III lines
41	S	15:31:00	15:44		00:13:00	23		1.1							
42	N	15:47:00	16:00):00	00:13:00	22		1.1							
												BLOC	к 2		
1	S	16:08:00	16:22	1:00	00:13:00	20		1.2	alt	itude v	varies s			venn	all lines
2	N	16:24:00	16:3		00:13:00	20		1.2							
3	S	16:41:00	16:53		00:12:00	21		1.1							
4	N	16:56:00	17:09	9:00	00:13:00	22		1.1							
5	S	17:13:00	17:20	5:00	00:13:00	19		1.3							
6	N	17:29:00	17:42		00:13:00	18		1.3							
7	S	17:45:00	17:57		00:12:00	18		1.1							
8	N	18:01:00	18:13		00:12:00	18		1.1							
9	S	18:16:00	18:29		00:13:00	21		1							
10 11	N S	18:32:00 18:47:00	18:44 19:00		00:12:00 00:13:00	20 21		1							
11	N N	19:03:00	19:00		00:13:00	21		1.2							
13	S	19:18:00	19:33		00:13:00	23		1.1							
14	N	19:35:00	19:4		00:12:00	23		1.2							
15	S	19:50:00	20:03		00:13:00	21		1.2							
16	N	20:06:00	20:19	9:00	00:13:00	22		1.2							
17	S	20:22:00	20:3		00:13:00	22		1.2							
18	N	20:39:00	20:52	2:00	00:13:00	24		1.1							
						Page 1			V	erify S-	Turns	After	Missio	n	Yes
Additional C	omments														

				ject l	nfo								Date		
Project #		Project	Name				U	nique ID		Flight	Date	(UTC)	Day o	f Year	Flight
81200	Y	ellowstone NI	P BLOCI	<s &<="" 4="" td=""><td>. 2</td><td></td><td>Day2</td><td>80_91557_1</td><td></td><td>10</td><td>/06/20</td><td>20</td><td>28</td><td>30</td><td>1</td></s>	. 2		Day2	80_91557_1		10	/06/20	20	28	30	1
Crev	N			Equip	oment					Time				Α	irports
Pilo	t	Ai	rcraft N	/lake /	/ Model / Tai	il #		Hobbs St	tart	Local	Start	UTC	Start	De	parting
Dar Po	erl		Reim	ns F40	6 - N406SD			507.1		09:1	0:00	15:0	9:00		KBZN
Opera	tor	Se	nsor M	ake /	Model / Seria	al #		Hobbs E	nd	Loca	l End	UTC	End	Α	rriving
Fanni	ng	Le	eica Ter	rain N	/apper - 915	57		513.4		13:5	7:00	19:5	7:00		KBZN
					(Conditi	ons							•	
Wind Dir (°) Winc	l Speed (kts)	Visi	bility ((mi) Ceili	ng (ft)	Clo	oud Cover	Temp	o. (°C)	Dew	Point	: (°C)	Pres	sure ("H
150		5		50		000		Few		3		-2			30.19
Air Speed	d (kts)	Altitude	AGI (f		Altitude		t)	Airfield El	evation	- n (ft)		_			
150		6,9	-	•/		700	•/		471	. (,					
150	,	0,5	50		14,	Settin	ac	4,	+/ I		_	-	_	-	_
oint Spacing	(m) Doi:	nt Density (pp	sem)	500	an Angle/FO\		-	n Frequency	(Ц-)	Dulce	Rate	(20-)	Lac	or Do	wer (%)
			5111)	308	-	()	Sca		(112)	Pulse		(112)	LdS		
0.35		8			40			150	¥-		1580	ofers	N/:!-	10	H .
									ve	rify S-1		selore	WIISSIC	n	Yes
Line #	Direction	Start Time (UTC)	End T (UT		Time On-Line	Sate	llite	PDOP			Line N	otes/0	Comme	ents	
37	S	15:09:00	15:22		00:12:00	2		1.1				BLOC	К 4		
38	N	15:25:00	15:37		00:12:00	23		1.1	<u> </u>						
39	S	15:40:00	15:52		00:12:00	23		1.1							
40	<u>N</u> S	15:56:00 16:11:00	16:08 16:22		00:12:00	2:		1.1 1.1							
41 42	S	16:11:00	16:22		00:11:00	20		1.1							
43	S	16:42:00	16:53		00:11:00	2		1.1							
44	N	16:57:00	17:08		00:11:00	2		1			CON	TINUE		V	
														-	
67	S	17:19:00	17:22	1:00	00:02:00	18	8	1.3				BLOC	К4		
66	Ν	17:25:00	17:27		00:02:00	18	8	1.3							
65	S	17:30:00	17:32		00:02:00	18		1.3							
64	N	17:36:00	17:39	9:00	00:03:00	19	9	1.1				•	LL HA		
20	N	18:06:00	18:19	000	00:13:00	2:	1	1					O CON		
20	S	18:23:00	18:3		00:13:00	2		1		BLUCI	< Z. IVI3		TIODE	VARIA	DLE
22	N	18:39:00	18:5		00:12:00	19		1.1							
23	S	18:55:00	19:08		00:13:00	20		1.1							
24	N	19:11:00	19:24		00:13:00	20		1.2							
25	S	19:27:00	19:40	00:00	00:13:00	23	3	1.1							
26	Ν	19:44:00	19:57	7:00	00:13:00	2:	1	1.2							
						Page	1		v	erify S-	Turns	After	Missio	n	Yes
dditional Cor 490GB WI	mments U: 08:37MS	T WD:14:	24MST												

Flight Dat 10/07/2 Time Local Star 09:18:00 Local End 14:34:00	ate (UTC) D 7/2020	281 Art D	1 Airports
10/07/2 Time Local Star 09:18:00 Local End	7/2020 art UTC St 00 15:18:	281 Art D	1 Airports
Time Local Star 09:18:00 Local End	art UTC St 00 15:18:	A art D	irports
Local Star 09:18:00 Local End	0 15:18:	art D	-
09:18:00 Local End	0 15:18:	art D	-
09:18:00 Local End	0 15:18:		eparting
Local End			BZN
			Arriving
11.51.00			BZN
	20.34.		DEN
o. (°C) 🛛 De	Dew Point ('	C) Pres	ssure ("Hg
9	2		30.15
	Ζ		50.15
n (ft)			
			1
Pulse Rat			ower (%)
158			00
erify S-Turn	ns Before N	lission	Yes
Line	e Notes/Co	mments	
erify S-Turr	rns After M	ission	Yes
,	/erify S-Tu	/erify S-Turns After M	/erify S-Turns After Mission

					-					uisitio		-0					
					ject l	nfo									Date		
Project #			Project							nique ID			t Date				
81200		Y	ellowstone N			-			Day2	81_91557_1			/07/20	20	28	31	1
	ew					oment						Time					rports
	lot		Ai			/ Mode	-	#		Hobbs S			Start	UTC			parting
Dar	Perl			Rein	ns F40	6 - N40	6SD			513.4		09:1	.5:00	15:1	4:00		KBZN
Оре	rator					Model	-			Hobbs	End		l End		End	A	rriving
Fan	ning		Le	eica Tei	rrain N	Ларрег				519		13:1	.4:00	19:1	4:00		KBZN
							C	onditi	ons								
Wind Dir	(°)	Wind	Speed (kts)	Visi	bility ((mi)	Ceilir	ng (ft)	Clo	oud Cover	Tem	p. (°C)	Dew	Point	: (°C)	Press	sure ("H
170			3		10		18,	000		Clear		4		1		-	30.15
Air Spe	ed (kts)	Altitude	AGL (f	t)	Al	titude	MSL (t)	Airfield E	levatio	n (ft)					
1	50		6,9	98			13,	665		4	,471						
								Settin	gs								
Point Spacir	ng (m)	Poin	it Density (pp	osm)	Sca	an Angl	e/FOV	/ (°)	Sca	n Frequency	/ (Hz)	Pulse	e Rate	(kHz)	Las	er Pov	wer (%)
0.35			8			4(0			150			1580			10	0
											Ve	erify S-	Turns E	Before	Missi	on	Yes
Line #	Direc	tion	Start Time (UTC)	End 1 (U1		Tin On-L	-	Sate	llite	PDOP			Line N	otes/C	Commo	ents	
6	S	5	15:14:00	15:1	7:00	00:03	3:00	2	1	1.4	BLO	DCK1 (E	BLOCK	1 CON	1PLETE)(1366	55' MSL)
19	S		15:30:00	15:4		00:12			3	1.2			BLOCK				
27 28	N S		15:47:00 16:03:00	16:0 16:1		00:13		2		1.1 1.3		VAR	IABLE N	VISL FC	DK BLO	CKS 1	\$2
28	N		16:19:00	16:3		00:1		2		1.3							
30	S		16:34:00	16:4		00:13		1		1.2							
31	N	1	16:55:00	17:0		00:13		2		1							
32	S	;	17:12:00	17:2	5:00	00:13	3:00	1	5	1.4							
33	N		17:28:00	17:4		00:13		1		1.3							
34	S		17:44:00	17:5		00:13		1	-	1.2							
35	N S		18:00:00	18:1 18:2		00:13		1		1							
36 37	3		18:15:00 18:31:00	18:4		00:13			0 8	1.1							
38	S		18:46:00	18:5		00:12		1		1.1							
39	N		19:01:00	19:14		00:13			8	1.3							
													SCOU				
												REFLI	GHT LII			AL SN	OW
											-			REMA	1185.		
								<u> </u>			1						
								Daga	1			anifu C	T	After	Missia		Vee
dditional C	0.000 000 000	**						Page	T		v	erify S	-iurns	Aiter	1115510	11	Yes
889 GB	WU: 08		ST WD: 14:	04MST	MAII	NT HOB	BS: 54	60.3									

				wooip	bert	LIQ	ar A	٨Cq	uisitio		og					
				Project	Info								D	Date		
Project #			Project	Name				U	nique ID		Flight	Date	(UTC)	Day o	f Year	Flight
81200			Yellowsto	ne block 2				Day2	82_90511_A		10,	/08/20	20	28	32	А
Cr	ew			Equi	pment						Time				Ai	rports
Pi	lot		Ai	rcraft Make	/ Mod	el / Tai	l #		Hobbs S	tart	Local	Start	UTC S	Start	De	parting
Сог	mer			Cessna 404	Titan - N	N404CP)		8096.	5	09:4	1:00	15:41	1:00	ŀ	BZN
Оре	rator		Sei	nsor Make	/ Model	/ Seria	al #		Hobbs E	nd	Loca	l End	UTC	End	Ar	riving
Ry	an		Le	eica Terrain	Mapper	⁻ - 9051	.1		8101.4	4	13:0	3:00	19:03	3:00	ł	(BZN
						C	onditi	ons								
Wind Dir	(°)	Wind	Speed (kts)	Visibility	' (mi)	Ceilir	ng (ft)	Clo	oud Cover	Tem	p. (°C)	Dew	Point	(°C)	Press	ure ("H
0			0	5		20,	000		Few		7		1		-	2994
Air Spe	ed (kts)	Altitude	AGL (ft)	A	ltitude	MSL (f	t)	Airfield El	evatio	n (ft)					
1	50		6,9	98					4,4	473						
							Settin	gs								
Point Spacir	ng (m)	Poin	t Density (pp	sm) S	an Ang	le/FOV	′ (°)	Sca	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Pov	ver (%)
0.35			8		4	10			150			1580			100)
										Ve	erify S-1	Furns E	Before	Missic	on	Yes
Line #	Direc	tion	Start Time	End Time	Ti	me	Sate	11:40	PDOP			Line N	otes/C			
Line #	Direc	lion	(UTC)	(UTC)	On-	Line	Sale	mte	PDOP			Line N	oles/C	omme	ents	
40	S	5	15:41:00	15:54:00	_	.3:00	2		1.1	A	ltitude	varies	slightly	/ betw	een al	l lines
41	N		15:57:00	16:10:00	_	.3:00	24		1.1							
42	5		16:12:00	16:25:00	_	.3:00	2		1.3							
43	N S		16:28:00 16:43:00	16:40:00 16:56:00	_	.2:00	2		1.2 1.1							
61	N		17:00:00	17:13:00	_	.3:00	2		1.1							
62	S		17:16:00	17:29:00	_	3:00	2		1.3							
63	N		17:32:00	17:44:00	_	2:00	2		1.1							
64	S	;	17:47:00	18:01:00	00:1	4:00	1	9	1.2							
65	N		18:03:00	18:16:00	_	.3:00	24		0.9							
66	5		18:19:00	18:32:00	_	.3:00	2		1							
67 68	N		18:34:00 18:49:00	18:47:00 19:03:00		.3:00	19		1.2 1.1							
00		,	10.49.00	19.03.00	00.1	.4.00		5	1.1							
					+											
					-											
					+											
					+											
							Page	1		V	erify S-	Turns	After N	Aissio	n	Yes
dditional C	ommei	nts														

				Pro	ject Ir	nfo								[Date		
Project #			Project	: Name	-				U	nique ID		Flight	Date	(UTC)	Day o	f Yeai	r Flight
81200		Park	CO MT B4 / Y	'ellows	tone N	P B2			Day2	82 91557 1		10,	/08/20	20	28	32	1
Cr	ew				Equip	ment						Time				Α	irports
	lot		Ai			' Mode	l / Tai	#		Hobbs S	tart	Local	Start	UTC	Start		eparting
	Perl				-	5 - N406	-			519		09:2		15:2			KBZN
	rator		So			Model /		al #		Hobbs E	nd	Loca		UTC			rriving
· · ·						lapper				524.2	-	13:0	-	19:0			KBZN
Гdi	ning					lapper		onditi	0.000	524.2	-	15.0	0.00	19.0	0.00		NDZIN
Mind Di	. / 9 \	ام الم	Crossed (late)	Viai	h:1:4 /					and Courses	Tama	(°C)	Davi	Dalat	(%)	Dues	
Wind Di	.()	wind	Speed (kts)	VISI	bility (mi)		ng (ft)		oud Cover	-	o. (℃)	Dew	Point	(°C)		sure ("H
180			4		6			000		Few		4		-2			29.94
Air Spe	-)	Altitude	-	t)	Alt		MSL (f	t)	Airfield El		n (ft)					
1	50		10,	663				415		4,	471						
								Settin	gs								
Point Spaci	ng (m)	Poir	nt Density (pp	osm)	Sca	n Angle	e/FOV	/ (°)	Sca	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Po	wer (%)
0.7			2			40)			82			650			10	0
											Ve	rify S-1	Furns E	Before	Missio	on	Yes
			Start Time	End 1	Time	Tim	ne										
Line #	Dired	ction	(UTC)	דט)	.с)	On-L	ine	Sate	llite	PDOP			Line N	otes/C	comme	ents	
2	E		15:21:00	15:2	9:00	00:08	3:00	2	5	1.1		PITCH	5°-6° (DN WE	ST SID	E OF I	INE.
4	V	V	15:32:00	15:4	0:00	00:08	3:00	2	4	1.2	L	IGHT S	NOW	AND M	IOD PE	RMA	ROST
5	E	-	15:44:00	15:5	2:00	80:00	8:00	2	5	1.1		(P	F) ON I	EAST S	IDE OF	LINE	
6	V		15:56:00	16:0		00:08		2		1.1			5Kts+	-			INE
7	E		16:08:00	16:1		00:08		2		1.3			L5-L8:				
8	V		16:20:00	16:2		30:00		2		1.2	<u> </u>		8: LIGH				
9	E		16:31:00	16:3		30:00		2		1.2		L9-	L11: N	IANY S	MALL	LAKES	<i>.</i>
10 11	V E		16:43:00 16:56:00	16:5 17:0		80:00 80:00		2		1.1 1.2		۲° ۵	° PITCI				
11	V		17:08:00	17:10		30:00		2		1.2		5-0	FIIC	TVES	I SIDE	OF LI	1
15	E		17:20:00	17:2		00:00		2		1.2							
17	V		17:31:00	17:3		00:04		2		1.1		B4	PARK	CO M	г сом	PLETE	
81	9	5	17:44:00	17:5	6:00	00:12	2:00	1	9	1.2		BE	GIN YE	LLOWS	STONE	NP B	2
82	١	١	18:00:00	18:1		00:11	1:00	2	2	1	M	SL ALT	VARIES	S, POIN	IT DEN	ISITY=	8PPSM
83		5	18:14:00	18:2		00:10		2		1	SCA	N FREC	Q = 150)Hz, PL	JLSE R	ATE =	1580kH
84	N		18:28:00	18:3		00:07		1		1.2						_	
85		5	18:43:00	18:5		00:09		1		1.2					E CHO		TON
86	٩	N	18:56:00	19:0	b:00	00:10	J:00	1	8	1.2		IGHT S					ION
													NOR	IHEKN	SLOPE	-5.	
											+						
								<u> </u>			+						
								<u> </u>			1						
	8							Page	1		V	erify S-	Turns	After I	Missio	n	Yes
dditional C	omme	nts						0									
			WD: 13:4														

MAINT HOBBS: 5465.1.

							LID	ar /	٩Cd	uisiti	onl	og					
					ject l	nfo									Date		
Project #			Project							nique ID							Flight
81200		Ye	ellowstone Bl						Day2	83_90511_	<u>A</u>		/09/20	20	28		A
	ew					ment						Time					rports
	lot			rcraft N						Hobbs		_	Start	UTC			parting
	mer			Cessna						810		_	8:00	14:3			KBZN
Oper	rator			nsor Ma			-			Hobb		_	l End	UTC		A	rriving
Ry	an		Le	eica Ter	rain N	/lapper				810	6.9	12:5	7:00	18:5	7:00		KBZN
								onditi									
Wind Dir	(°)	Wind	Speed (kts)		bility (mi)		ng (ft)	Clo	oud Cover	Те	mp. (°C)	Dew	Point	(°C)	Press	sure ("H
140			7		0,010		18,	000		Few		1		-5			3000
Air Spe	ed (kts)		Altitude	AGL (ft	:)	A	titude	MSL (f	t)	Airfield	Elevat	ion (ft)					
15	50		6,9	98							4,473						
								Settin	gs								
Point Spacin	ng (m)	Poin	t Density (pp	sm)	Sca	n Ang	le/FOV	′ (°)	Sca	n Frequen	cy (Hz)	Pulse	e Rate	(kHz)	Las	er Pov	wer (%)
0.35			8			4	0			150			1580			10	0
												Verify S-	Turns E	Before	Missi	on	Yes
Line #	Direc	tion	Start Time (UTC)	End T (UT			ne Line	Sate	llite	PDOP			Line N	otes/C	Comme	ents	
69	S		17:24:00	17:37	-	00:1	3:00	2	2	1.1		Altit	ude va	ries be	tweer	all lin	es
70	N		17:40:00	17:53	3:00	00:1	3:00	2	0	1.2							
71	S		17:56:00	18:09			3:00	2		1							
72	N		18:13:00	18:25		00:1		2		1							
73 74	S N	_	18:28:00	18:41 18:57		00:1	3:00 3:00	2		1.1 1.2	_						
/4	IN		18:44:00	10.57	.00	00.1	5.00	2	0	1.2	_						
						<u> </u>					-						
						<u> </u>		<u> </u>			_						
											_						
						<u> </u>		<u> </u>									
						<u> </u>		<u> </u>			_						
								<u> </u>									
	<u> </u>					<u> </u>											
								Page	2			Verify S	Turns	After l	Missio	n	Yes
dditional C	ommen	ts															

				ject l	ert Lid	,	-1						Date		
Project #		Project		•			U	nique ID		Flight	Date		Day of	f Yea	r Flight
-	Park Co.	MT B1&B3 Y			P B1&B4	D		83_91557_1		•	/09/20		28		1
Crew					ment					Time				_	irports
Pilot		Ai			/ Model / Tai	#		Hobbs St	art	1	Start	UTC	Start		eparting
Dar Perl		, .			6 - N406SD		_	524.2			2:00		2:00		KBZN
Operator		Se			Model / Seria	al #		Hobbs E		Loca			End		Arriving
Fanning					Napper - 9155			529.1			0:00		0:00		KBZN
i dining				Taill		onditior	16	525.1		11.4	0.00	17.4	0.00		KDZIN
Wind Dir (°)	Wind	Speed (kts)	Vici	bility (ng (ft)		oud Cover	Tom	o. (°C)	Dew	Point	(°C)	Drog	sure ("H
140	vvind	7	V131	10		000	CIC	Few		1. (C)	Dew	-5	. (C)	Fies	30
				-				-		_		-5			50
Air Speed (k	tsj	Altitude		t)		MSL (ft)		Airfield El		ו (ת)					
150		11,	319			512		4,4	471			-	-	-	_
			•			Settings		_	/··		D · · ·				(0/)
Point Spacing (m) Poir	nt Density (pp	osm)	Sca	an Angle/FOV	/ (°)	Sca	n Frequency	(Hz)	Pulse	Rate	(KHZ)	Las		ower (%)
0.7		2		_	40			81			670				00
									Ve	erify S-1	Furns E	Before	Missic	on	Yes
Line # Dir	ection	Start Time (UTC)	End 1 (UT		Time On-Line	Satelli	te	PDOP			Line N	otes/0	Comme	ents	
49	Ν	14:42:00	14:49		00:07:00	22		1.1			PARK	CO B1	. (2PPS	M)	
50	S	14:53:00	15:00		00:07:00	23		1.2							
51	N	15:04:00	15:1		00:07:00	22		1.2							
52	S	15:15:00	15:22	2:00	00:07:00	23		1.1							
14	S	15:31:00	15:4	5.00	00:14:00	24		1.2		BF	GIN PA) B3 (21	PPSN	1)
	0											6,509			.,
58	S	15:58:00	16:1	1:00	00:13:00	22		1.2	l				NE NP E	· ·	
													Hz SCA		-
									<u> </u>				ATE; 69 F SPACI		AGL;
													E OFFX	NG;	
61	S	16:25:00	16:3	5:00	00:11:00	21		1.2		BE	GIN YE	LLOW	STONE	NP B	4
62	N	16:40:00	16:50		00:10:00	25		1.4					SL VAR		
63	S	16:54:00	17:04		00:10:00	24		1.2							
68	N	17:08:00	17:14		00:06:00	22		1.4			-		Y PERN		
69	S	17:17:00	17:23		00:06:00	21		1.3							
70 71	N S	17:26:00 17:34:00	17:32 17:40		00:06:00	22 20		1.1 1.2	<i>F</i>				LIGHT B4 CC		
/1	3	17.54.00	17.40	5.00	00.00.00	20		1.2		TELLC	70310		- D4 CC	VIVIFL	

Project # 81200 Crew Pilot Comer Operato Ryan		-	·	nfo								0	Date					
81200 Crew Pilot Comer Operato		-	Name			Project Info												
Crew Pilot Comer Operato		Vollowsto	Project Name L									Flight Date (UTC) Day of						
Pilot Comer Operato										10/10/2020			28	34	А			
Comer Operato									Time					Airport				
Operato		Ai	Aircraft Make / Model / Tail #							Local Start UTC			Start Departir		parting			
-	r		Cessna 404 T	8106.9)	09:34:00 15:			34:00 KBZN									
Ryan	or	Sei	nsor Make /	Hobbs E	Local End UT			C End Arriving										
		Le	eica Terrain N	8110	11:03:00 17:			03:00 KBZN										
					С	onditi	ons											
Wind Dir (°)	Wind	Speed (kts)	Visibility	(mi)	Ceilin	ng (ft)	Clo	oud Cover	Temp	. (°C) Dew Poin			t (°C) Pressure ("H					
0		0	10		18,000			Few			-4		2		2980			
Air Speed (kts)		Altitude	AGL (ft)	Altitude		MSL (ft)		Airfield Elevation		n (ft)								
150		6,9	98		4,473													
						Settin	gs											
Point Spacing (m) Poir	t Density (pp	sm) Sca	′ (°)	Sca	n Frequency	(Hz)	Pulse	Rate	(kHz)	Las	er Pov	ver (%)					
0.35	-	8		40				150		1580				100				
									Ve	rify S-1	Turns E	Before	Missic	on	Yes			
Line # D	Direction	Start Time (UTC)	End Time (UTC)	Time On-Line		Satellite		PDOP				ne Notes/Comments						
87 S		15:34:00	15:44:00	00:10:00		22		1.1										
88	N	15:47:00	15:56:00	00:09:00		21		1.1										
89	89 S		16:11:00	00:10:00		18		1.3										
90			16:25:00	00:11:00		18		1.2										
98	S	16:28:00	16:37:00	00:09:00		19		1.2										
94 91	N S	16:40:00 16:53:00	16:50:00	00:10:00		19 16		1.1 1.4										
91	3	10.55.00	17:03:00	00.1	0.00	10)	1.4										
						<u> </u>												
1						Page	1		Ve	erify S-	Turns	After I	Vissio	n	Yes			
dditional Com	ments					-				-								

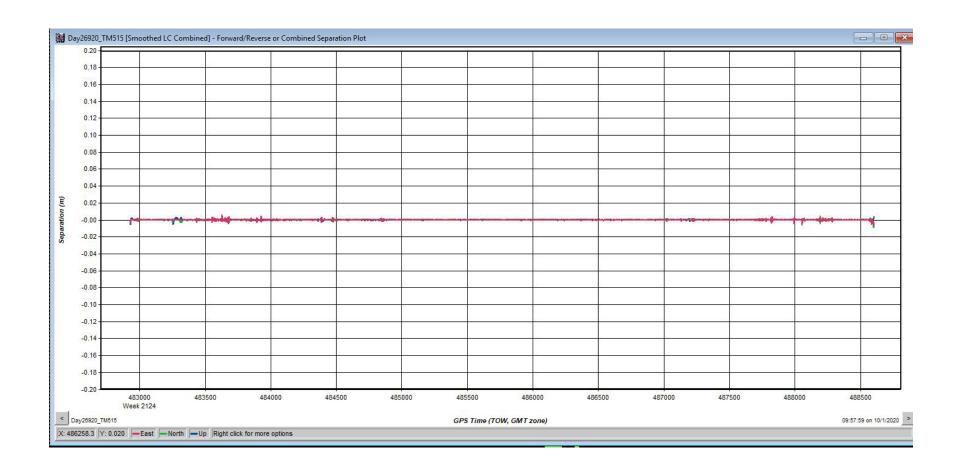
					-		LIU		ιcy	uisitic		56						
Project Info												Date						
Project #			Project							nique ID	Flight Date (UTC) Day of Year Flight 10/10/2020 284 1							
81200 Yellowstone NP BLOCK 2							Day284_91557_1						/10/20	23	_	1		
						pment					Time			Airport				
					aft Make / Model / Tail #					Hobbs S	Local Start UTC							
					Reims F406 - N406SD					529.				52:00 KBZN				
Operator			Sensor Make / Model / Serial # Leica Terrain Mapper - 91557							Hobbs				C End Arriving				
Fanr	ning		Le	eica Ter	rain N	/lapper				533.	6	11:2	8:00	17:2	8:00		KBZN	
	1.1.						-	onditi										
							ng (ft) Cloud Cover							: (°C)	Pressure ("			
270			0	10		18,0								-4			29.8	
Air Speed (kts)			Altitude AGL (ft)			A		MSL (f	t)	Airfield Elevation		n (ft)						
15	50		6,9	98				164		4	,471							
								Settin	-					-				
Point Spacin	g (m)				Scan Angle/FOV (°)				Scan Frequency (Hz)			Pulse Rate (kHz) Laser Powe						
0.35			8			4	10			150			1580			10		
								-			Ve	erify S-1	Furns E	Before	Missi	on	Yes	
Line #	Direc	ion Start Time End Tim (UTC) (UTC)			Time On-Line		Sate	llite	PDOP			Line Notes/Comments						
75	S		14:52:00	15:04			00:12:00		2	1.2		14,193' MSL						
	76 N		15:08:00	15:20			2:00			1.3								
	77 S		15:24:00	15:30			2:00	2		1.1								
78	78 N 79 S		15:40:00 15:56:00	15:52 16:02			1:00 1:00	21 18		1.2 1.3								
80 N		16:11:00	16:23			2:00	1		1.2			1	4,360	' MSI				
	00 IN 10.11.00		10.11.00			2.00				+			1,500					
101	101 S 16:		16:28:00	16:35:00		00:07:00		19		1.2		15,309' MSL						
100			16:39:00	16:42	16:42:00		00:03:00		9	1.1								
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97 N			16:54:00	16:57			00:03:00		6	1.4								
96 S 95 N			17:02:00 17:09:00	17:05		00:03:00		16 17		1.4								
93 S			17:16:00	17:20			00:04:00		, 7	1.4								
92 N		17:23:00	17:28:00		00:05:00		19		1.1	+		1	4,573	' MSL				
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Appendix 3: GPS / IMU Graphics

Day26920_TM515 Trajectory

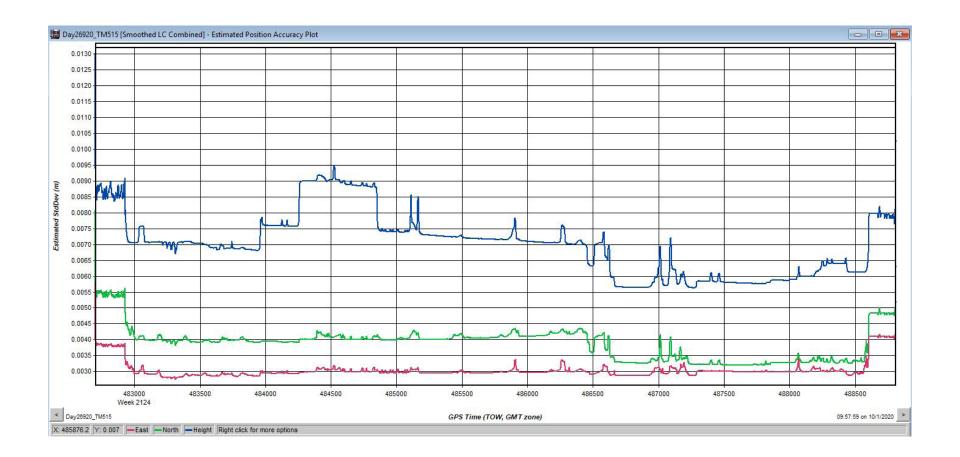
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Day26920_TM515

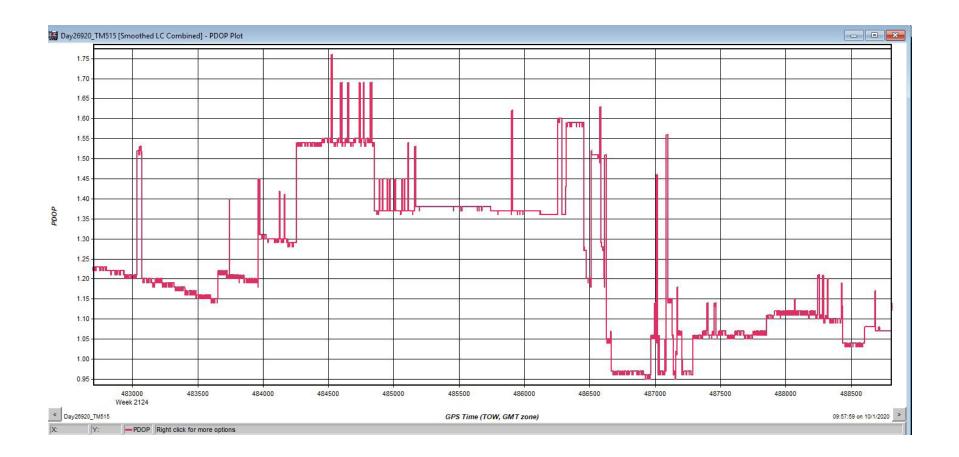


Day26920_TM515

Estimated Position Accuracy



Day26920_TM515 PDOP Plot

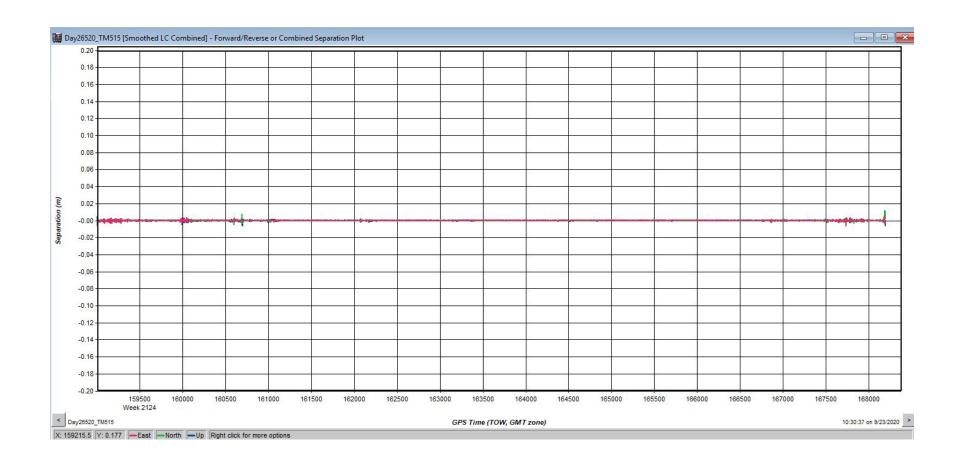


United States Geological Survey

Day27320_TM511 Trajectory

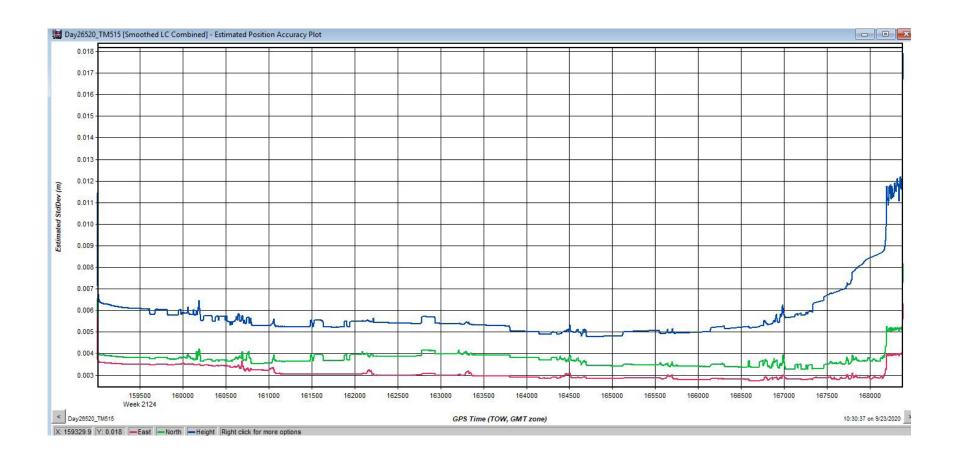
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Day27320_TM511



Day27320_TM511

Estimated Position Accuracy

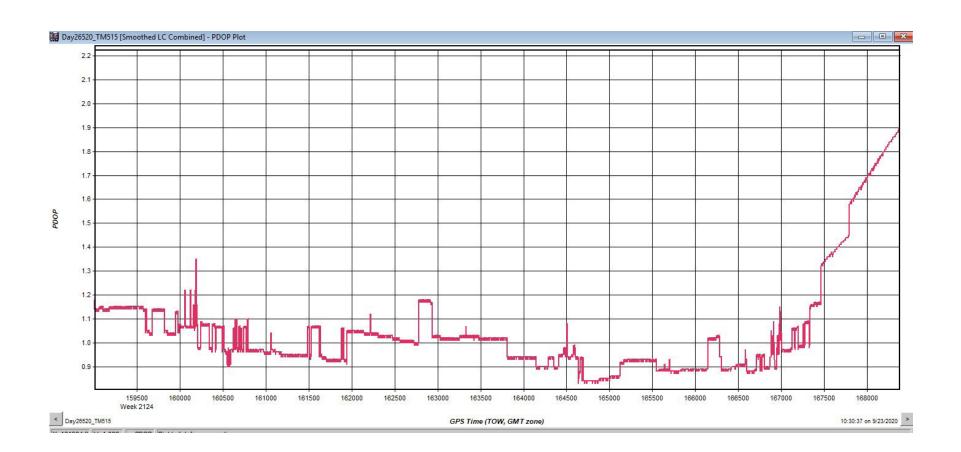


PDOP Plot

United States Geological Survey

Day27320_TM511

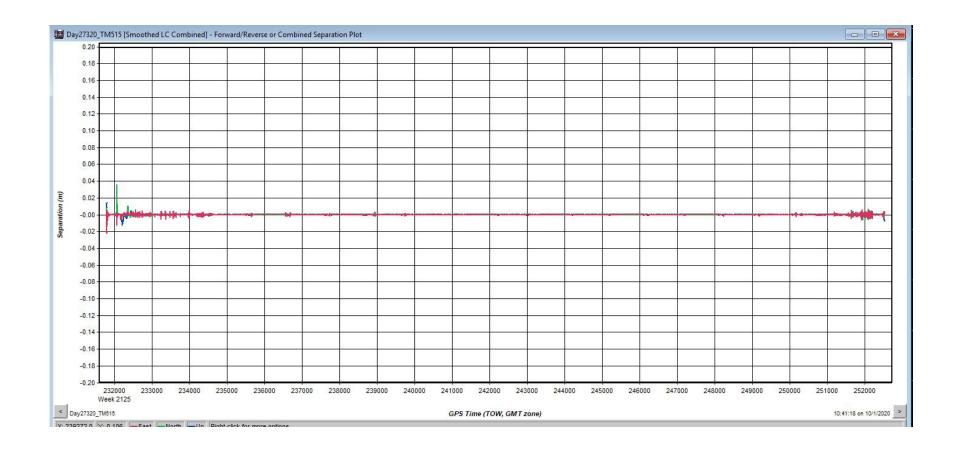
140G0220F0199 - WY Yellowstone NP 2 2020 D20



Day27320_TM515 Trajectory

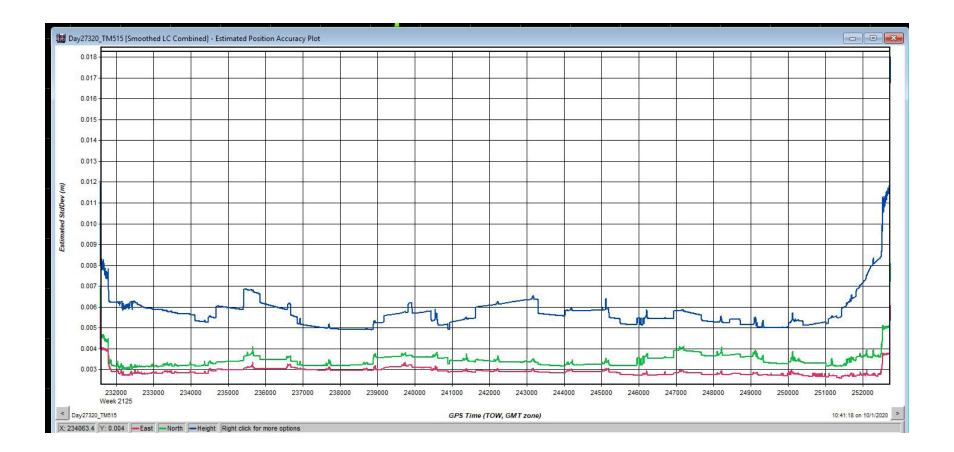
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Day27320_TM515

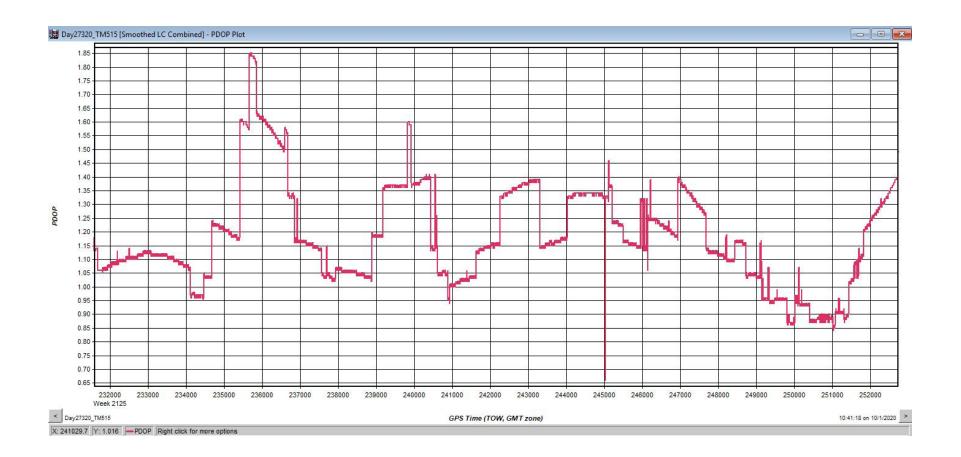


Day27320_TM515

Estimated Position Accuracy



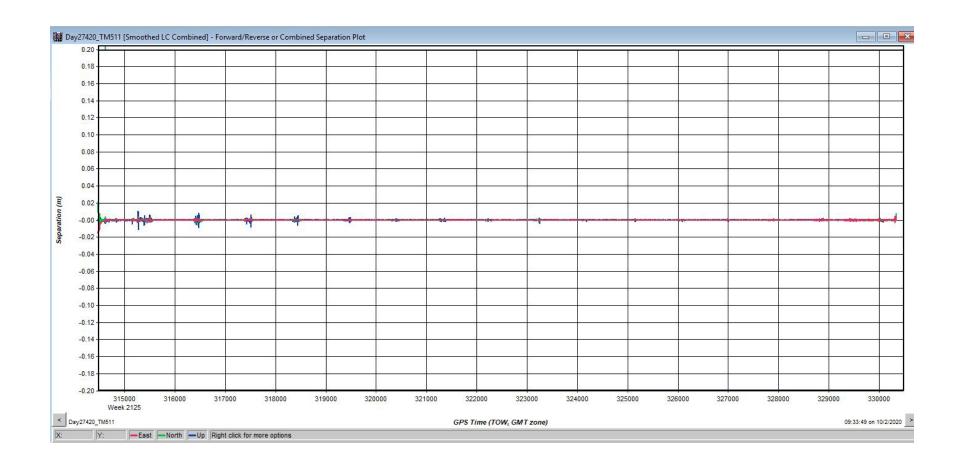
Day27320_TM515 PDOP Plot



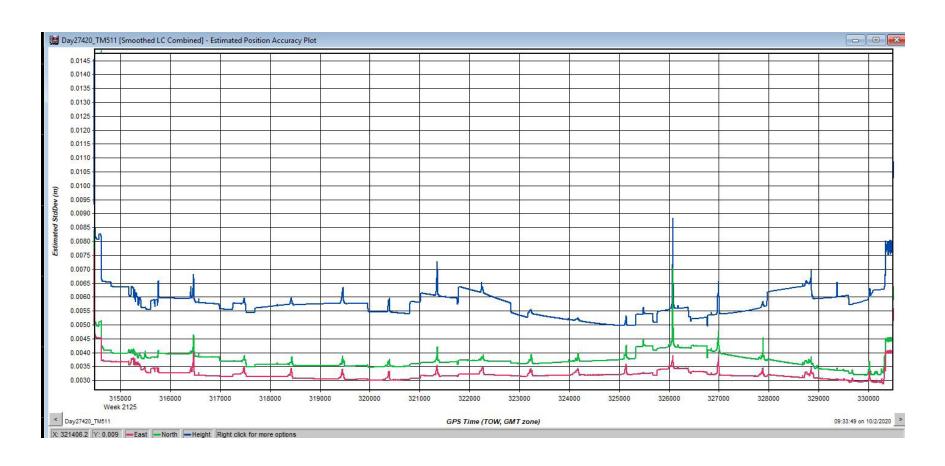
Day27420_TM511 Trajectory

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Day27420_TM511

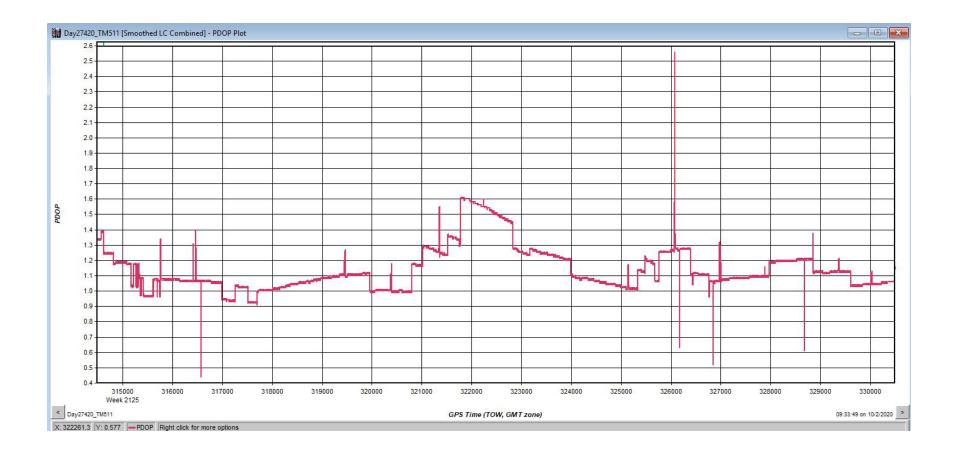


Day27420_TM511 Estimated Position Accuracy





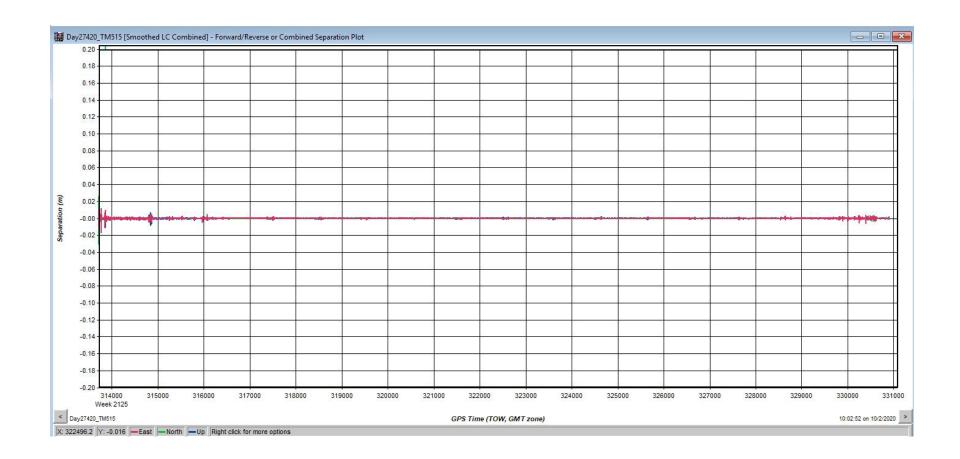
Day27420_TM511 PDOP Plot



Day27420_TM515 Trajectory

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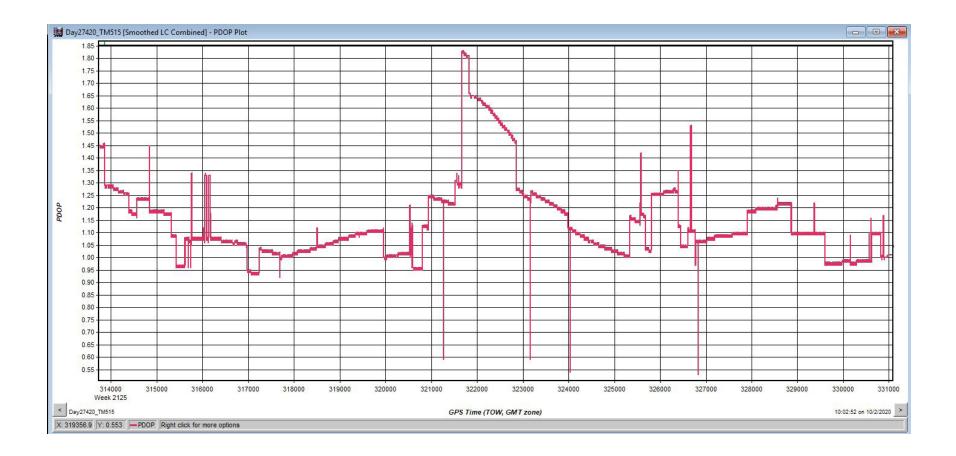
Day27420_TM515



Day27420_TM515 Estimated Position Accuracy

- - -Day27420_TM515 [Smoothed LC Combined] - Estimated Position Accuracy Plot 0.0155 0.0150 0.0145 0.0140 0.0135 0.0130 0.0125 0.0120 0.0115 0.0110 0.0105 nated StdDev (m) 0.0100 0.0095 0.0090 0.0085 stin 0.0080 0.0075 0.0070 0.0065 0.0060 **I** ~ 2 M 0.0055 ጎሰ 0.0050 0.0045 A 0.0040 44 0.0035 1 _____ 0.0030 314000 315000 316000 317000 318000 319000 320000 321000 322000 323000 324000 325000 326000 327000 328000 329000 330000 331000 Week 2125 < Day27420_TM515 10:02:52 on 10/2/2020 > GPS Time (TOW, GMT zone) X: 322416.7 Y: 0.004 -East North -Height Right click for more options

Day27420_TM515 PDOP Plot

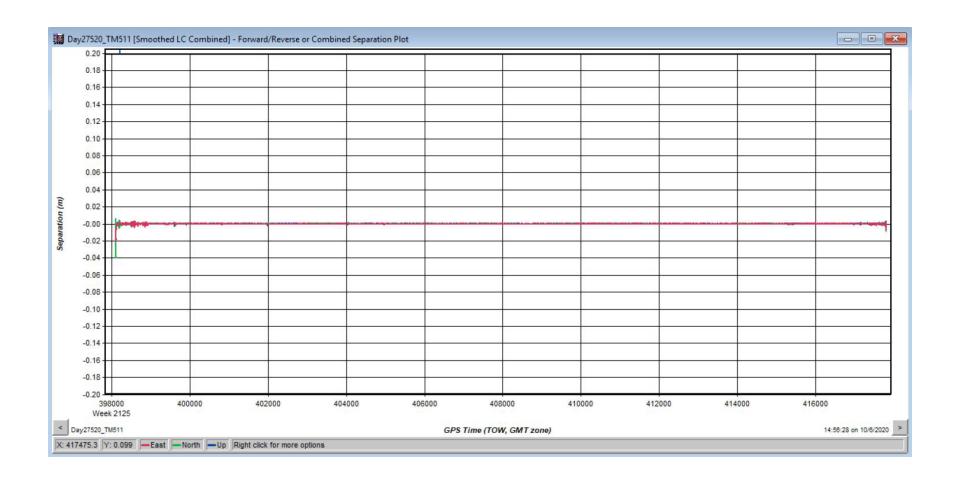


United States Geological Survey

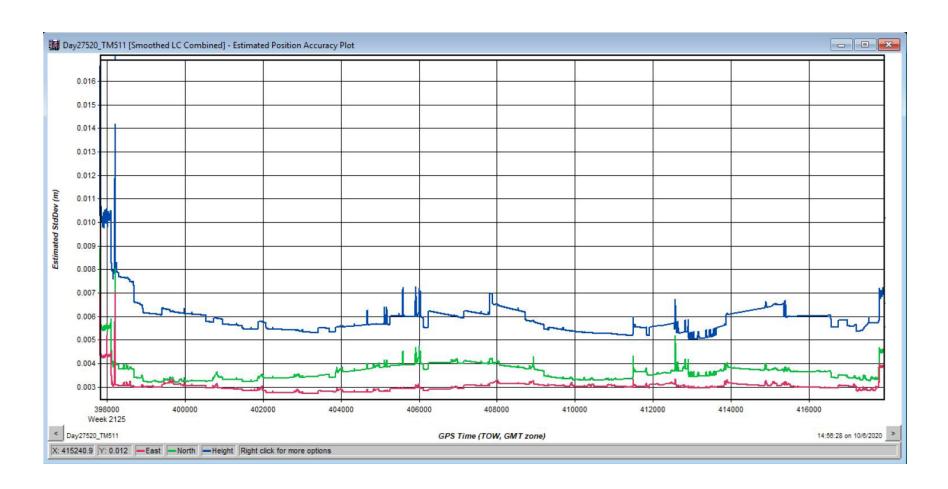
Day27520_TM511 Trajectory

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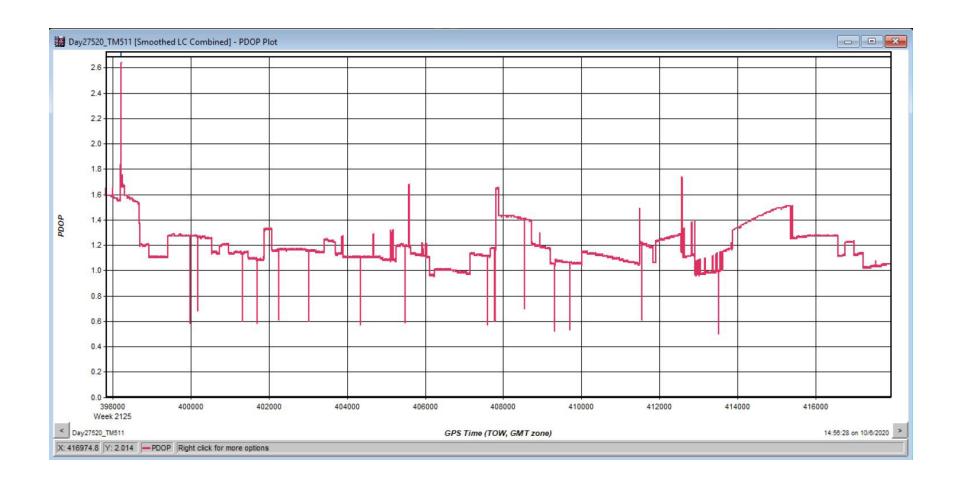
### Day27520_TM511



### Day27520_TM511 Estimated Position Accuracy



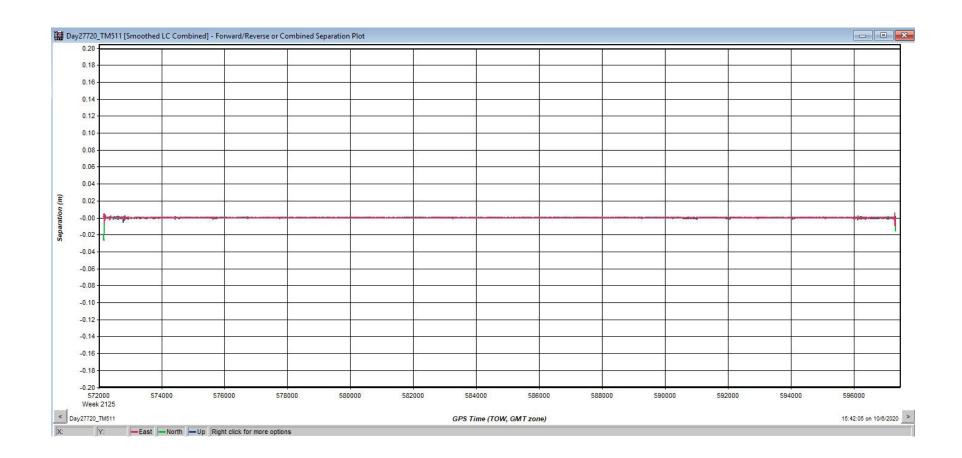
#### Day27520_TM511 PDOP Plot



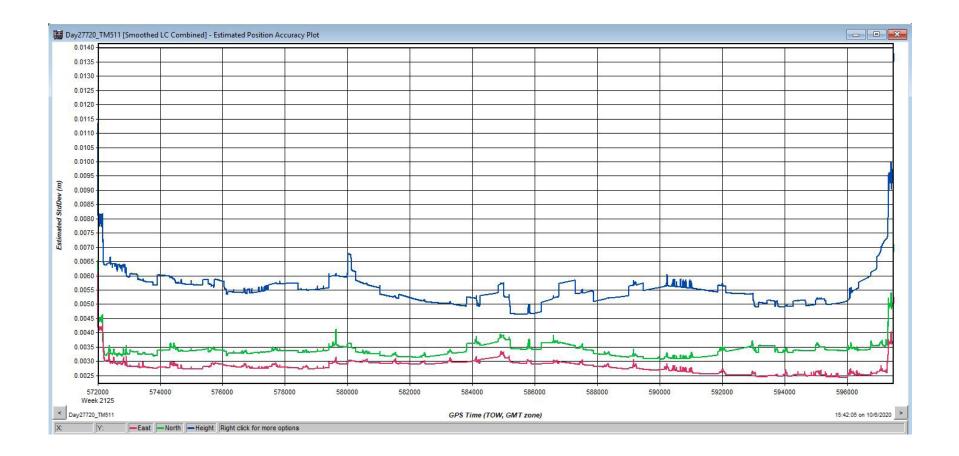
### Day27720_TM511 Trajectory

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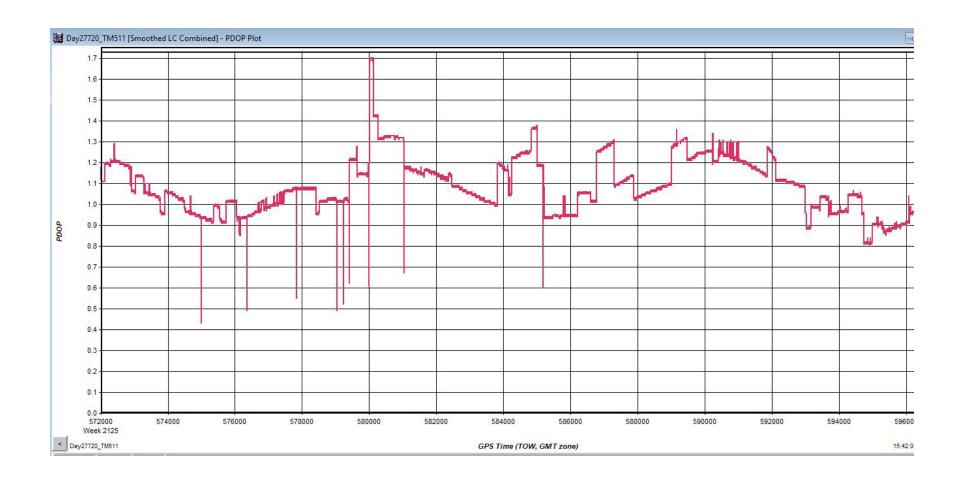
### Day27720_TM511



### Day27720_TM511 Estimated Position Accuracy



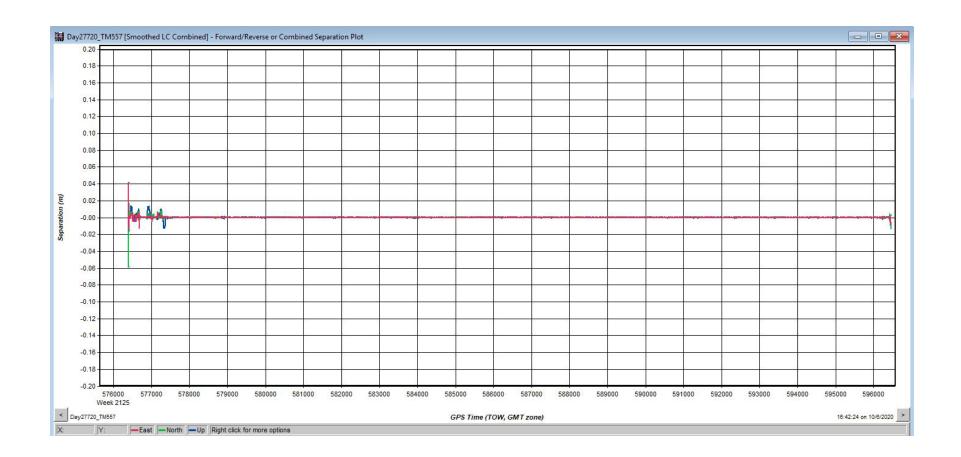
#### Day27720_TM511 PDOP Plot



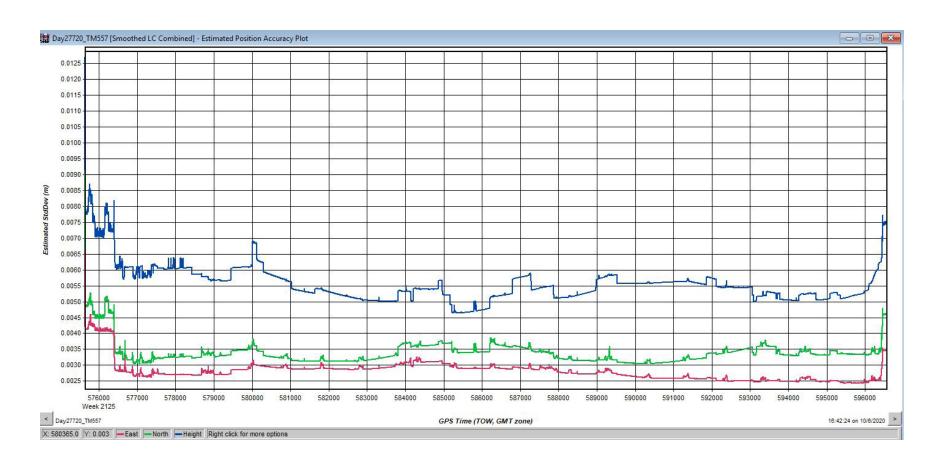
### Day27720_TM557 Trajectory

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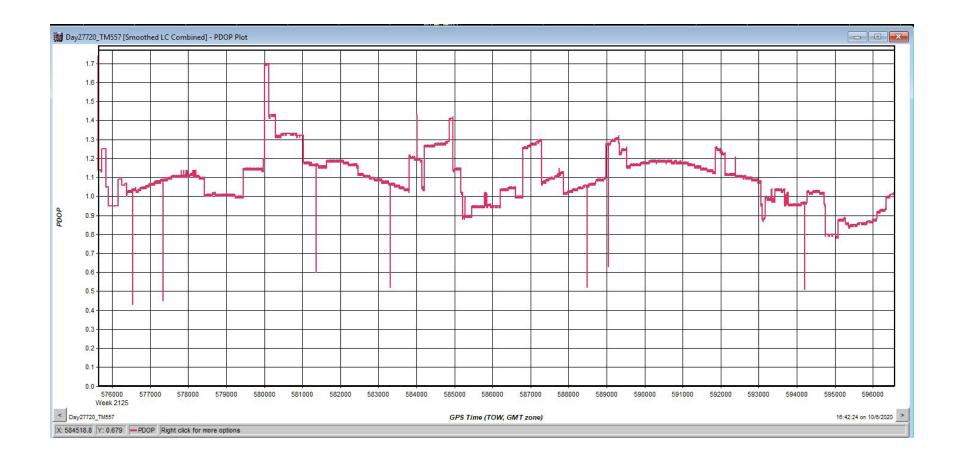
### Day27720_TM557



### Day27720_TM557 Estimated Position Accuracy



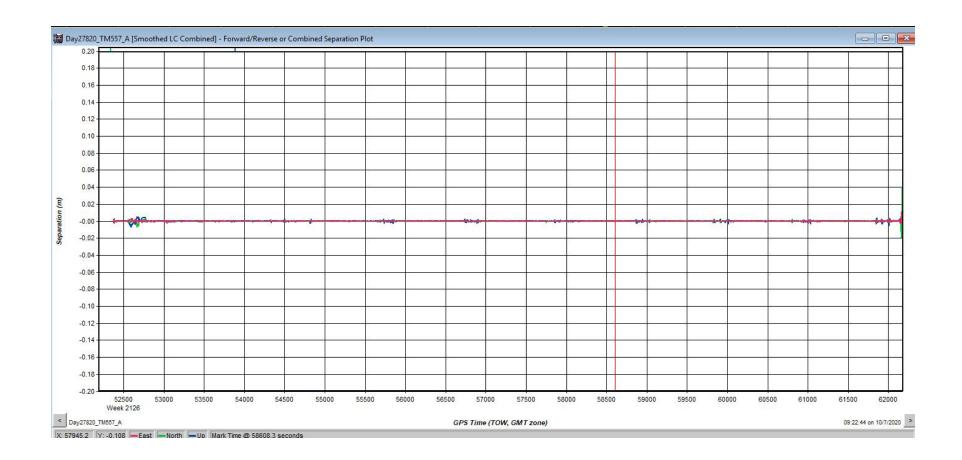
#### Day27720_TM557 PDOP Plot



### Day27820TM557A Trajectory

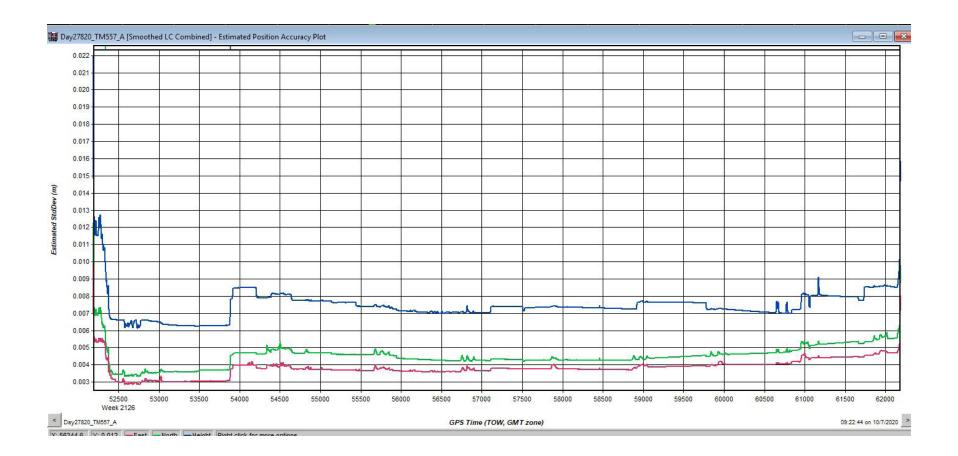
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### Day27820TM557A

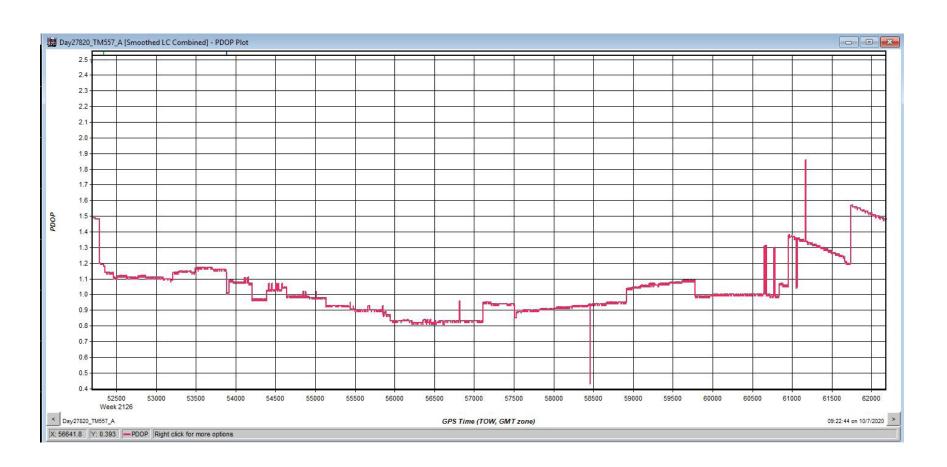


### Day27820TM557A

Estimated Position Accuracy



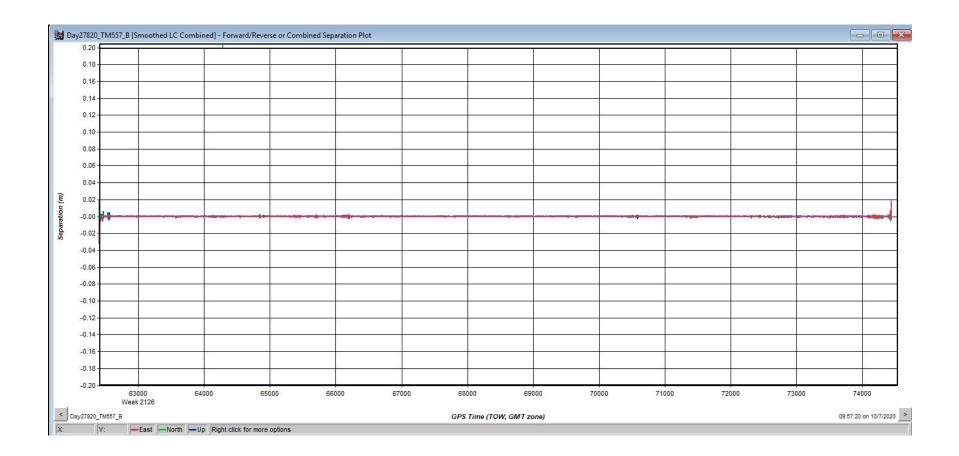
#### Day27820TM557A PDOP Plot



# Day27820TM557B Trajectory

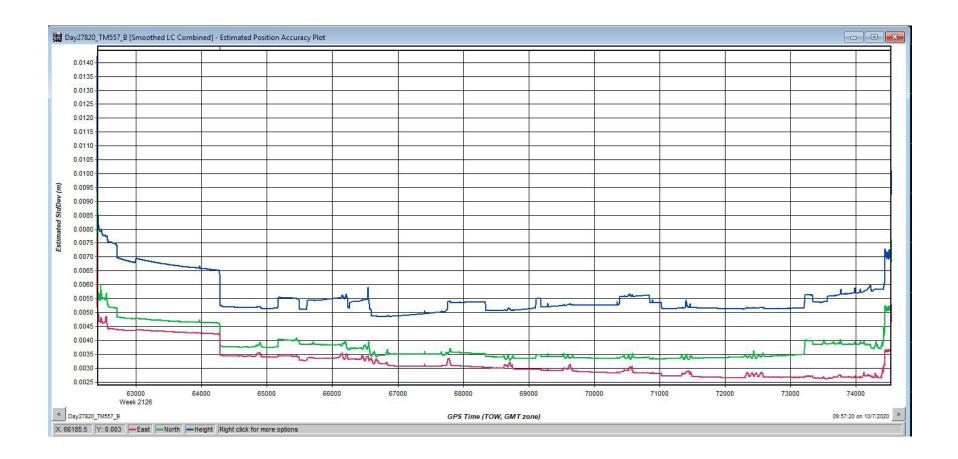
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#### Day27820TM557B



## Day27820TM557B

Estimated Position Accuracy



#### Day27820TM557B PDOP Plot

Day27820_TM557_B [Smoothed LC Combined] - PDOP Plot 1.40 1.35 1.30 1.25 1.20 1.15 1.10 1.05 1.00 . PDOP 0.95 den Mann-a 0.90 0.85 0.80 0.75 0.70 0.65 0.60 0.55 0.50 0.45 72000 73000 63000 64000 65000 66000 67000 68000 69000 70000 71000 74000 Week 2126 < Day27820_TM557_B 09:57:20 on 10/7/2020 > GPS Time (TOW, GMT zone) X: 65769.1 Y: 0.653 PDOP Right click for more options

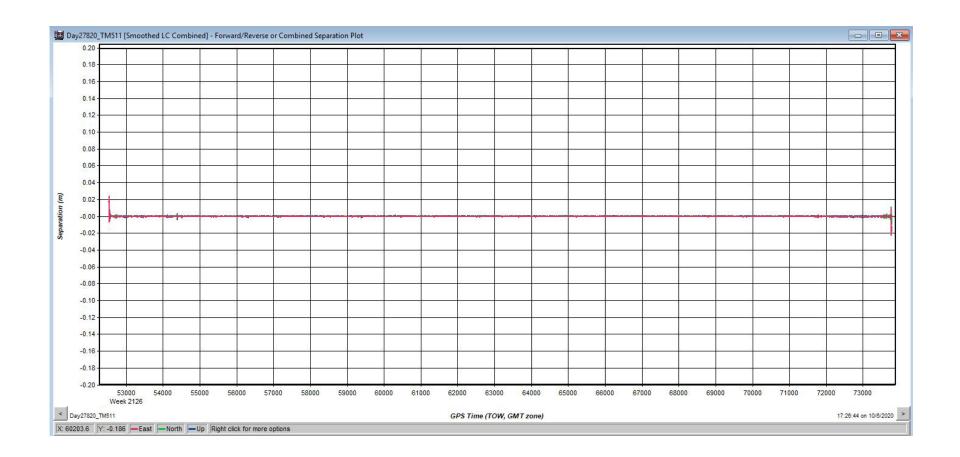
United States Geological Survey

# Day27820_TM511 Trajectory

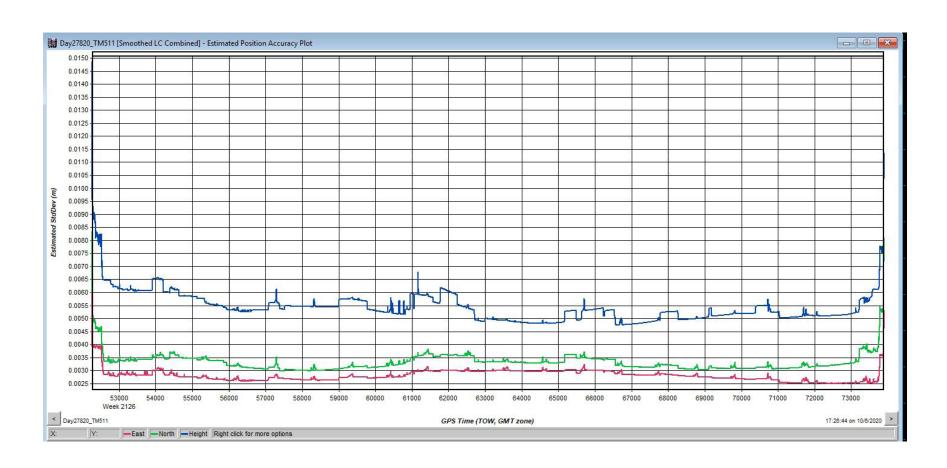
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Lidar Mapping Report - Appx. 3 GPS / IMU Graphics

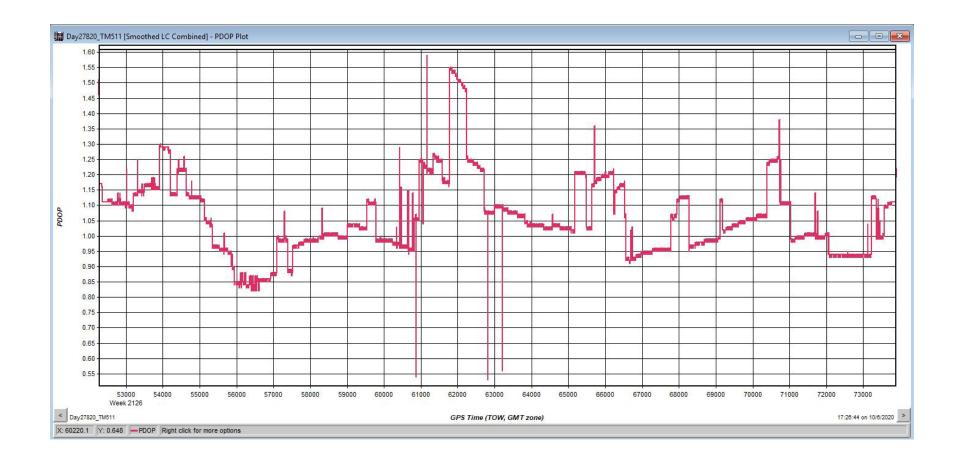
# Day27820_TM511



## Day27820_TM511 Estimated Position Accuracy



#### Day27820_TM511 PDOP Plot

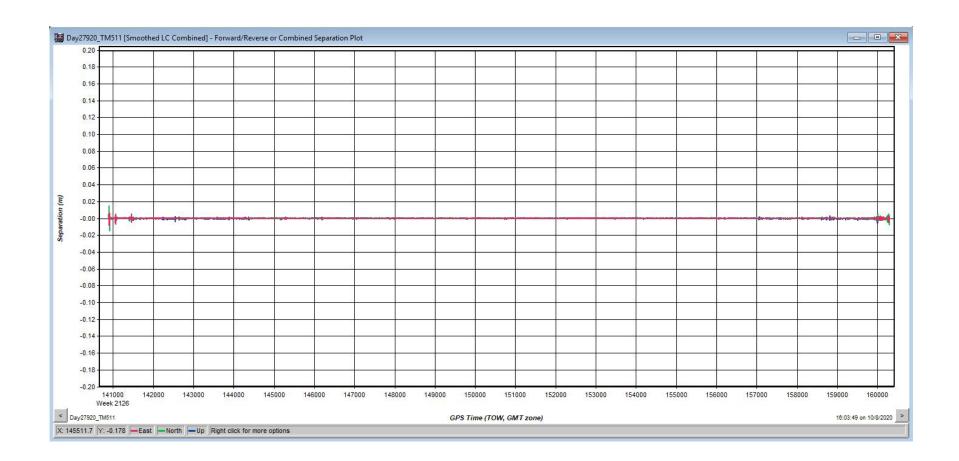


United States Geological Survey

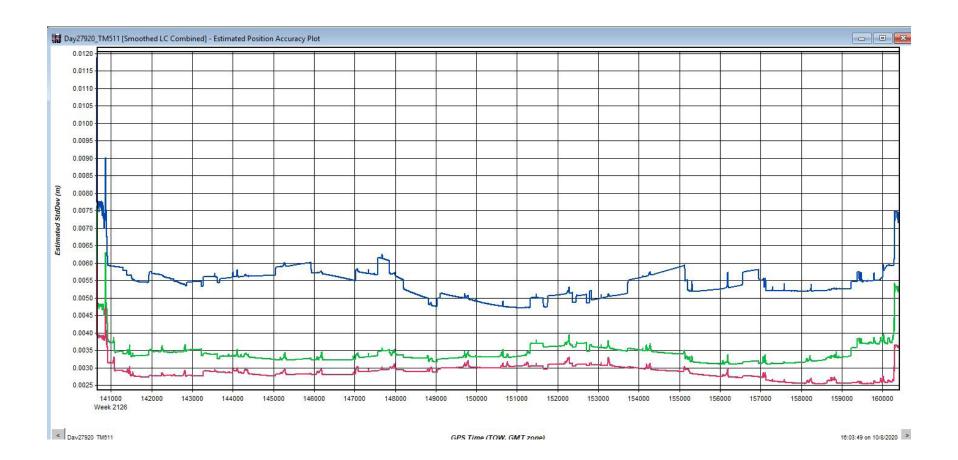
# Day27920_TM511 Trajectory

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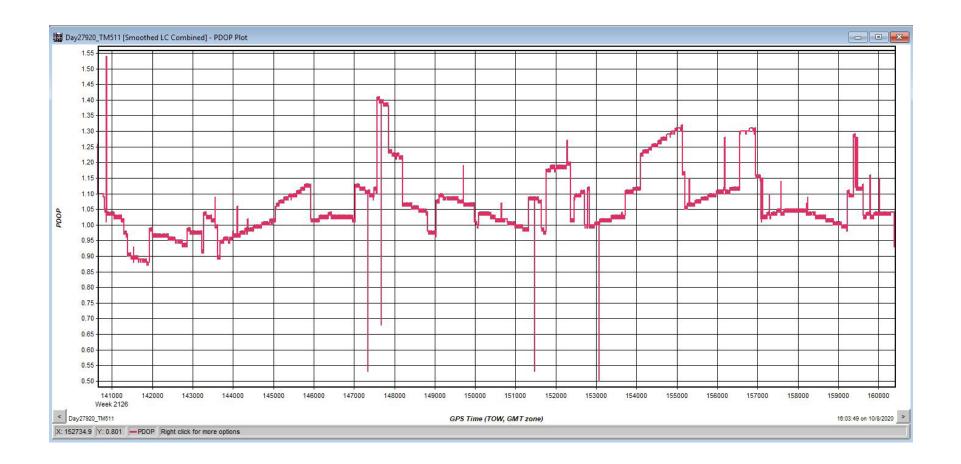
# Day27920_TM511



## Day27920_TM511 Estimated Position Accuracy



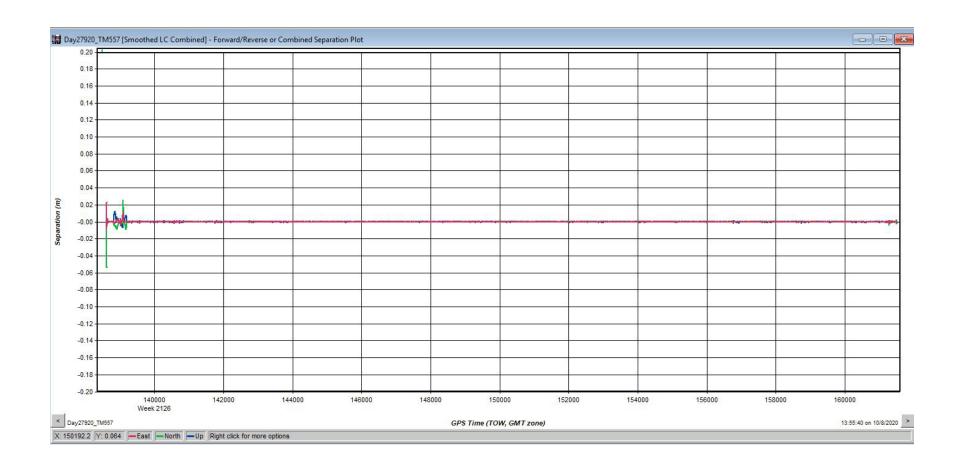
#### Day27920_TM511 PDOP Plot



# Day27920_TM557 Trajectory

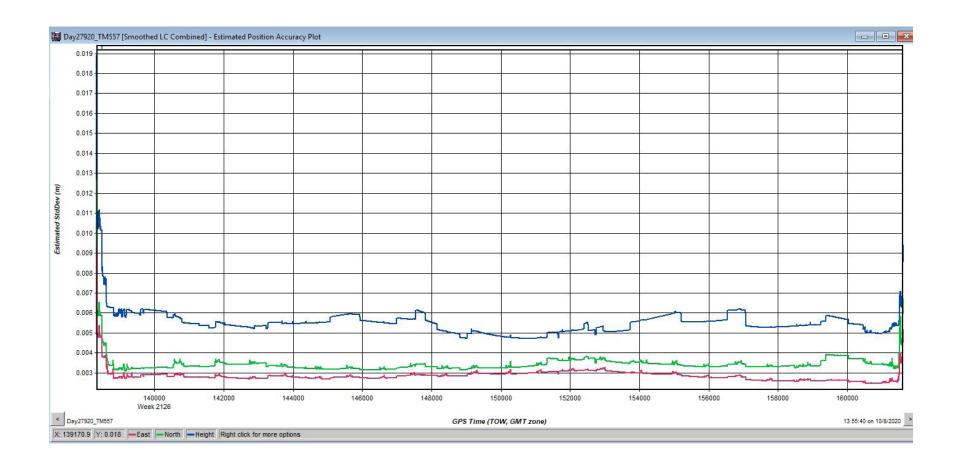
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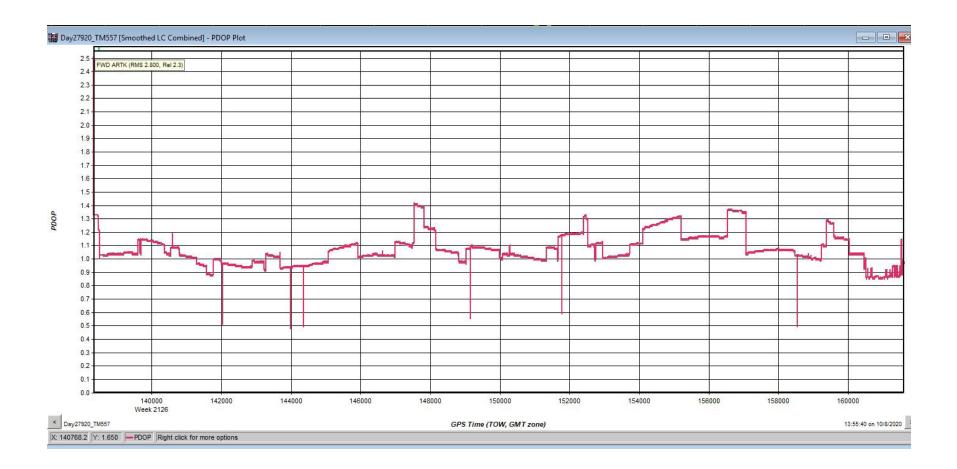


# Day27920_TM557

Estimated Position Accuracy



#### Day27920_TM557 PDOP Plot

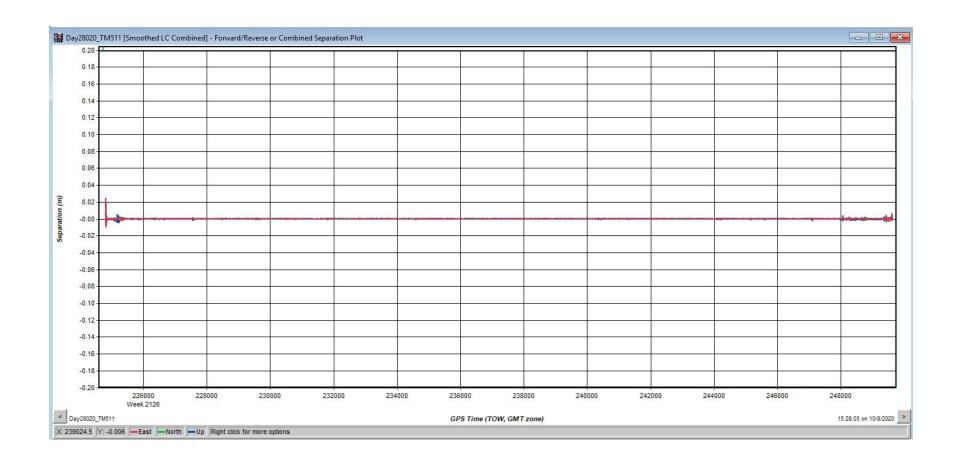


United States Geological Survey

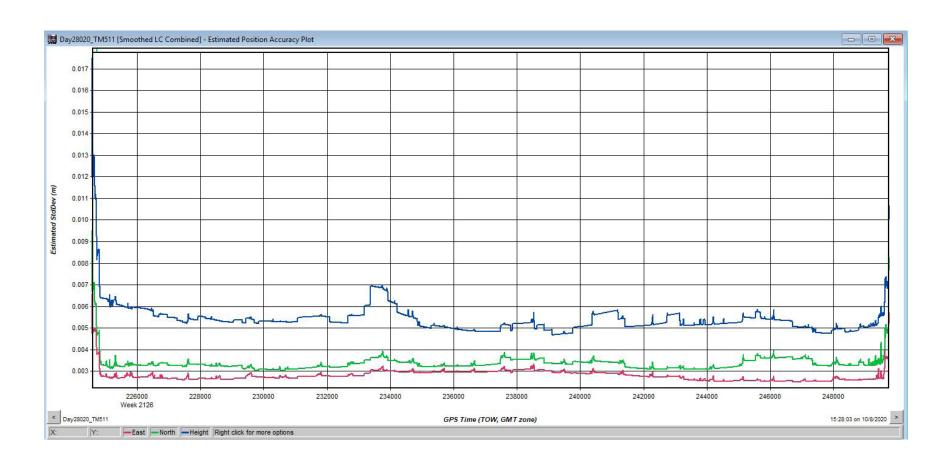
# Day28020_TM511 Trajectory

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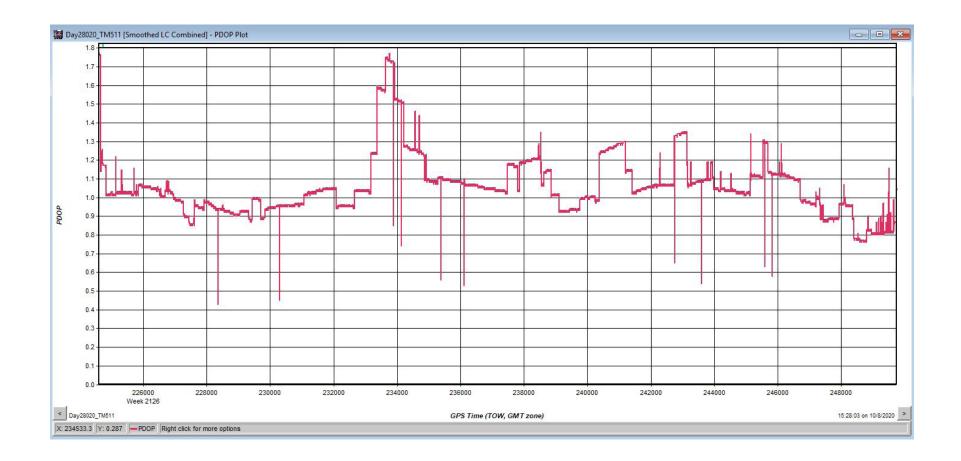
## Day28020_TM511



## Day28020_TM511 Estimated Position Accuracy



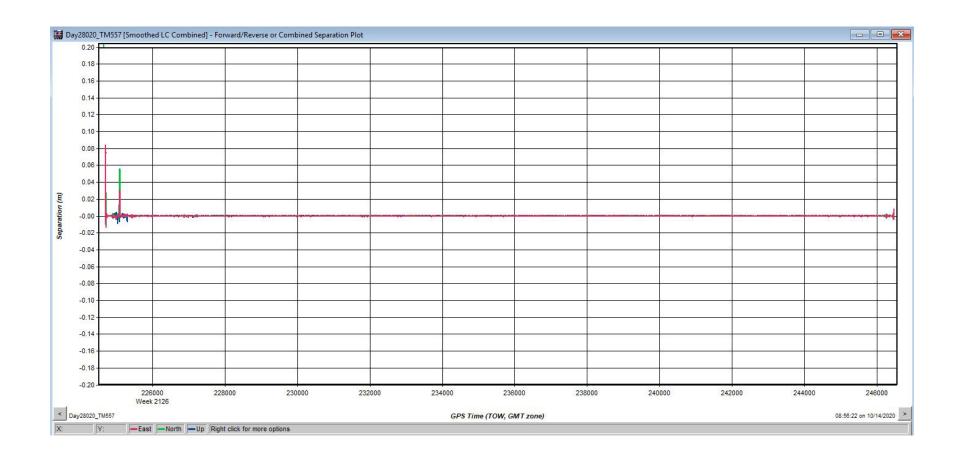
#### Day28020_TM511 PDOP Plot



# Day28020_TM557 Trajectory

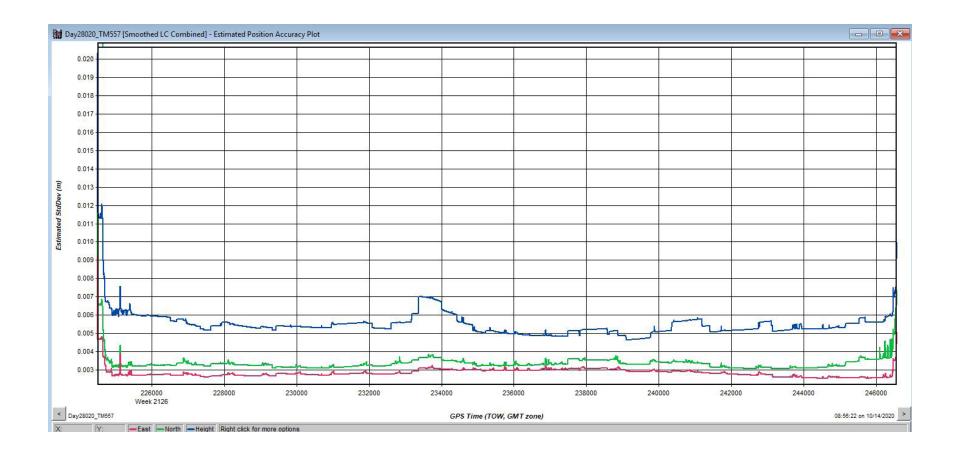
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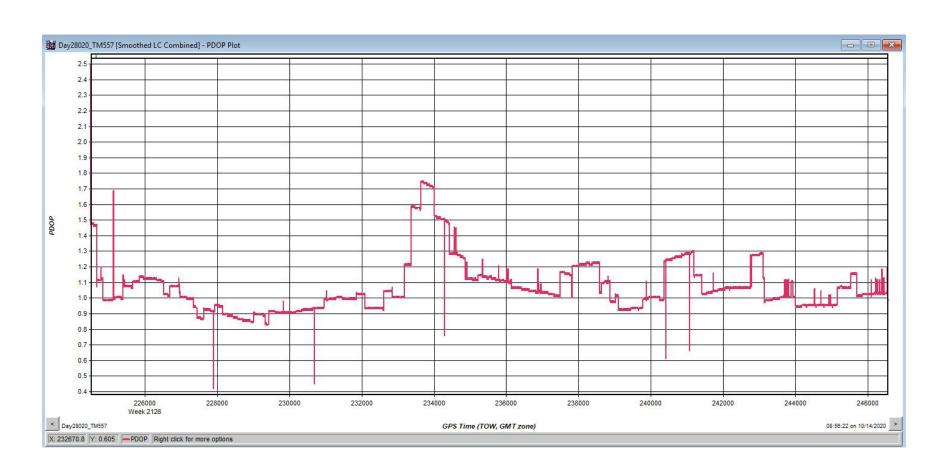


# Day28020_TM557

Estimated Position Accuracy



#### Day28020_TM557 PDOP Plot

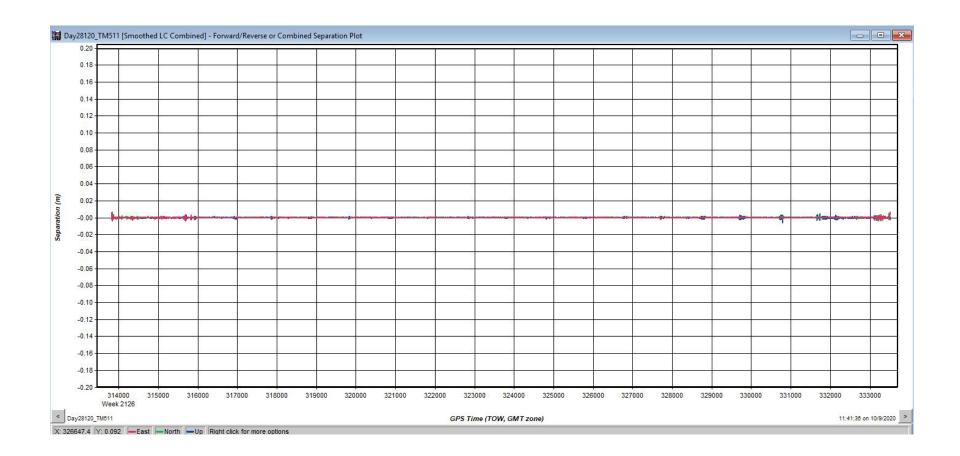


United States Geological Survey

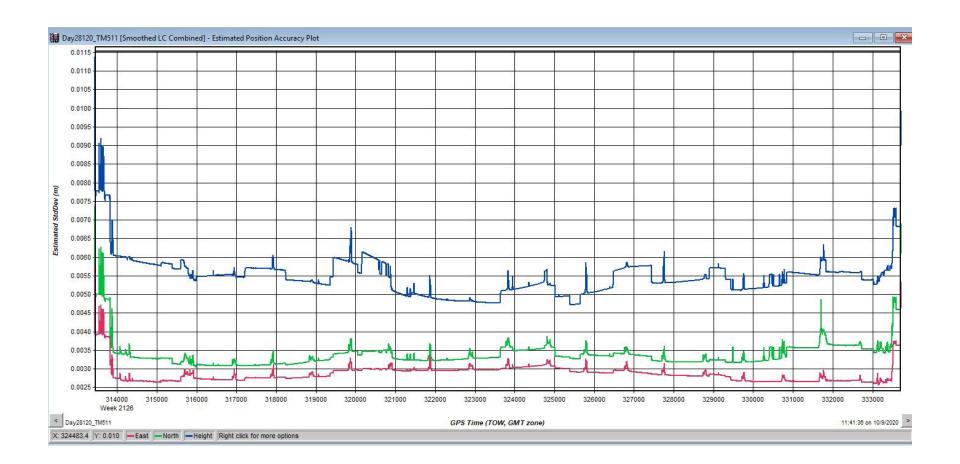
# Day28120_TM511 Trajectory

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## Day28120_TM511



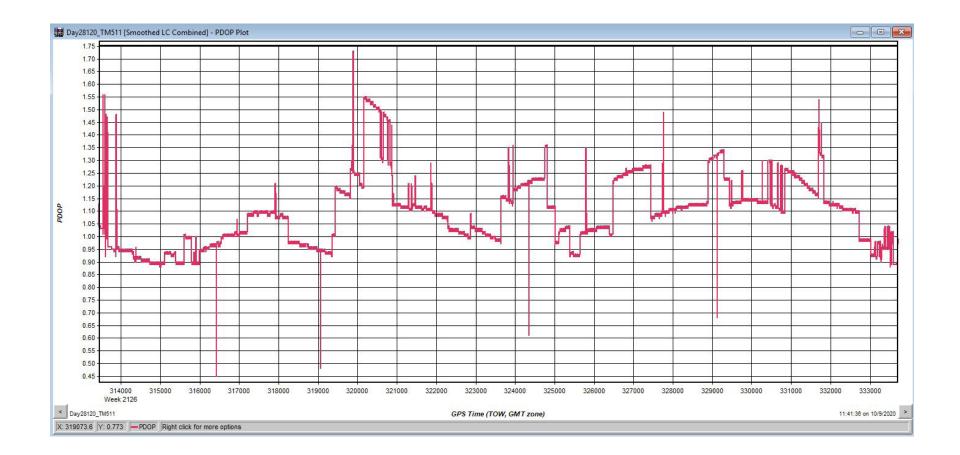
## Day28120_TM511 Estimated Position Accuracy



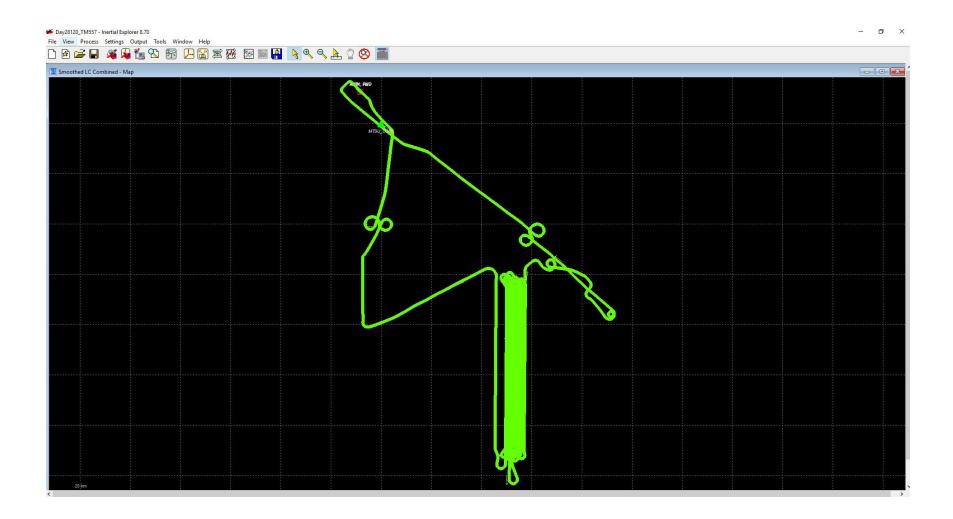
PDOP Plot

Day28120_TM511

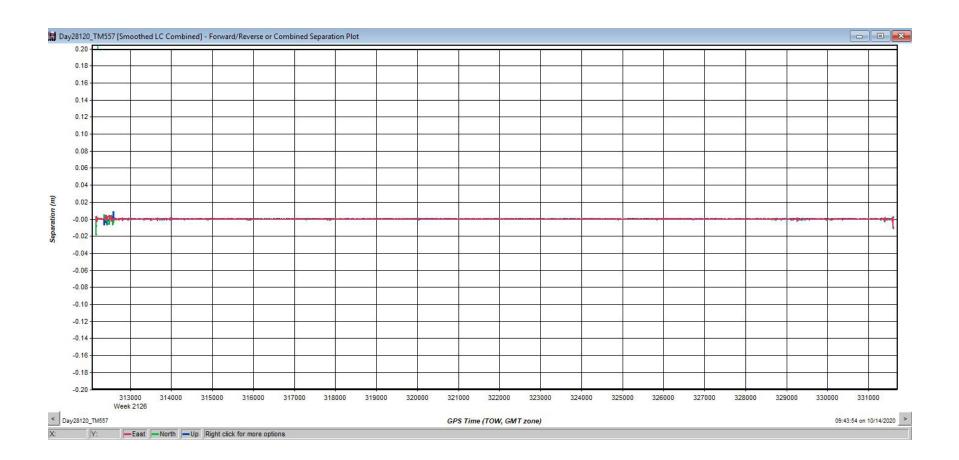




## Day28120_TM557 Trajectory

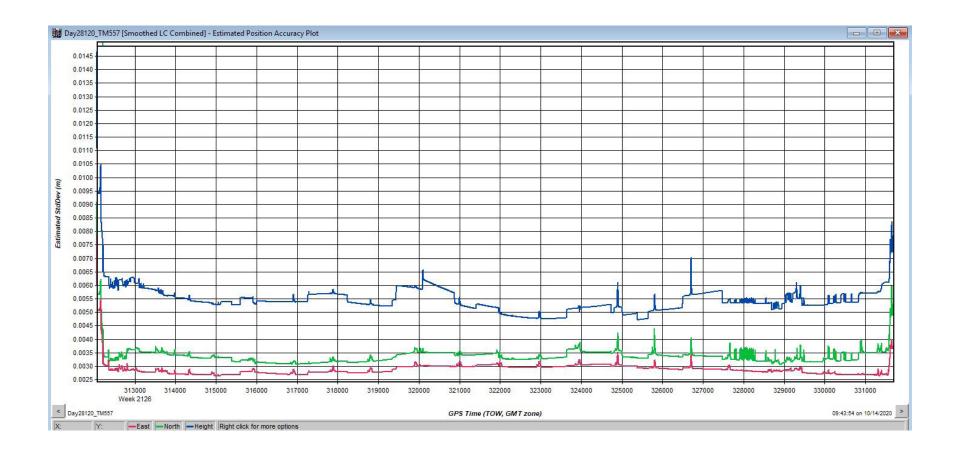


#### Day28120_TM557

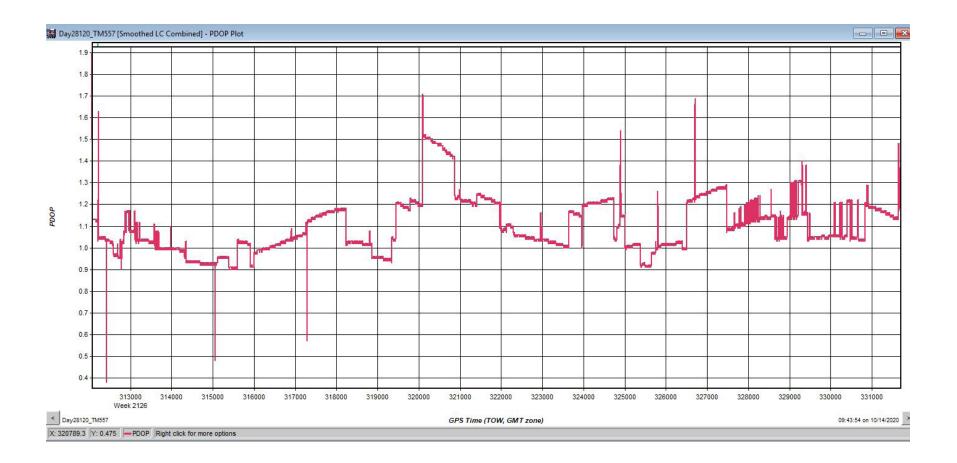


# Day28120_TM557

Estimated Position Accuracy



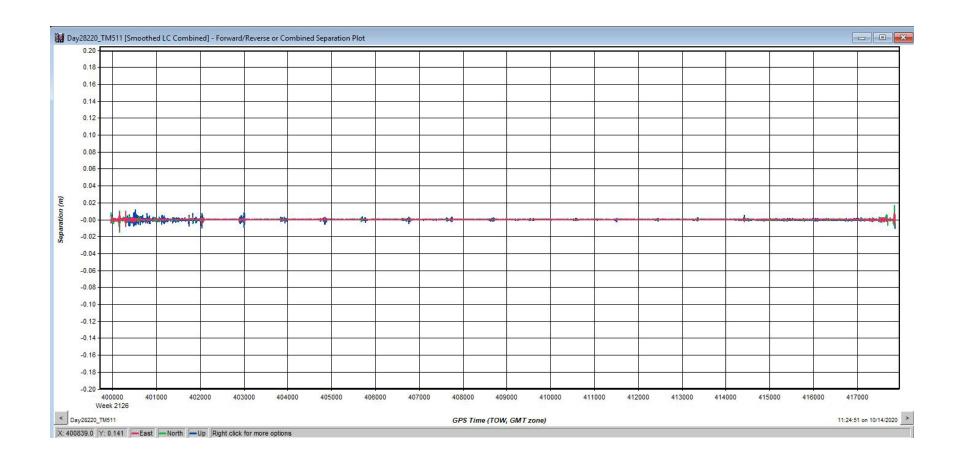
#### Day28120_TM557 PDOP Plot



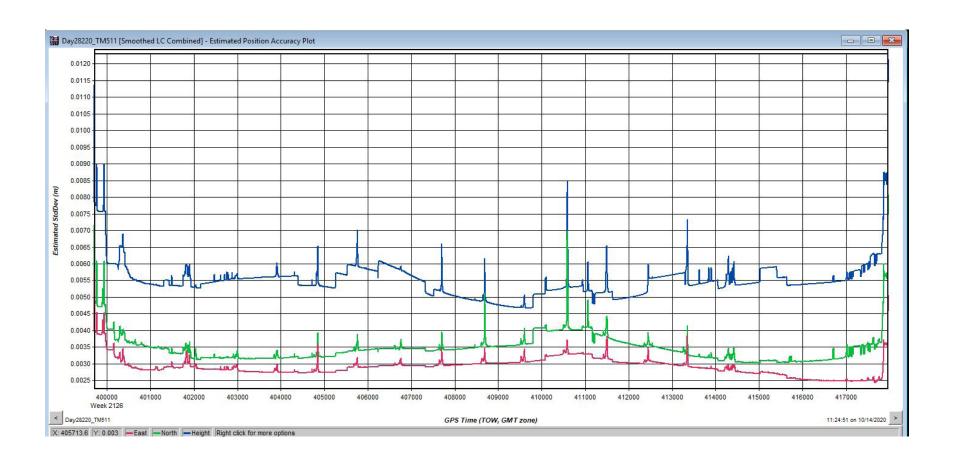
# Day28220_TM511 Trajectory

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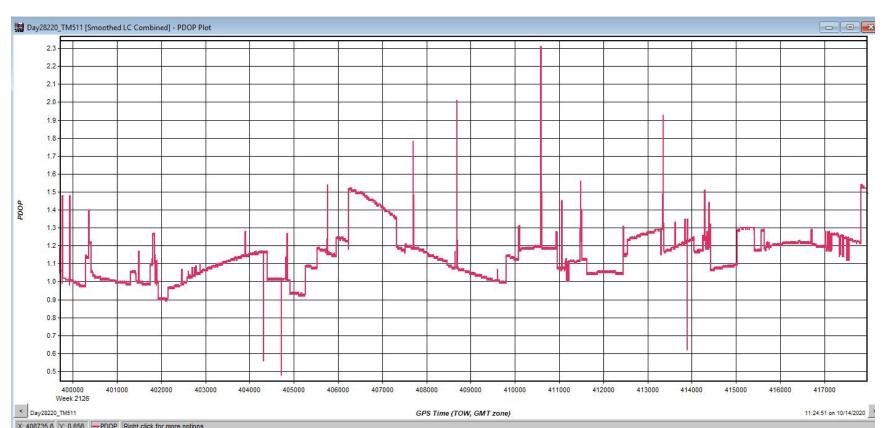
# Day28220_TM511



## Day28220_TM511 Estimated Position Accuracy



PDOP Plot



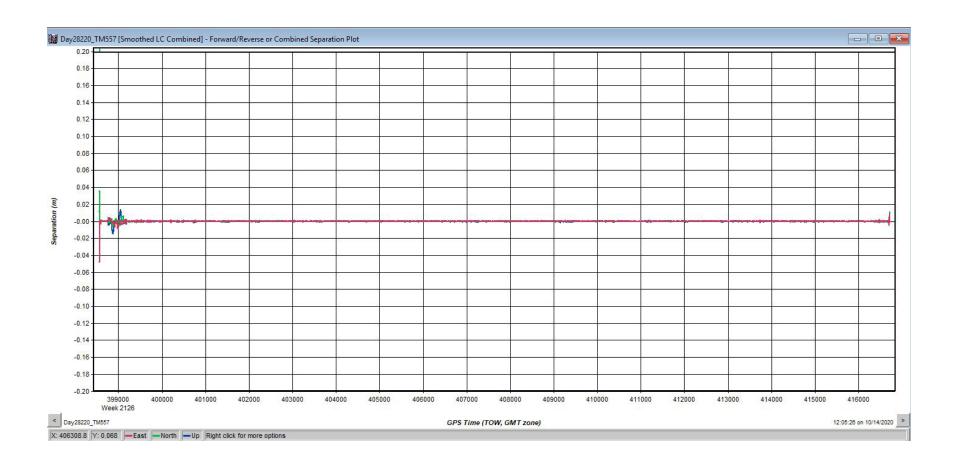


Day28220_TM511

# Day28220_TM557 Trajectory

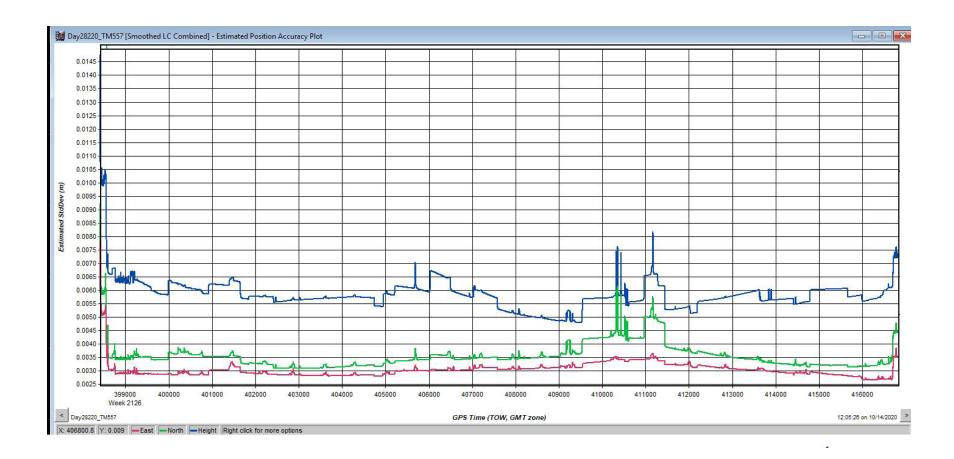
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## Day28220_TM557

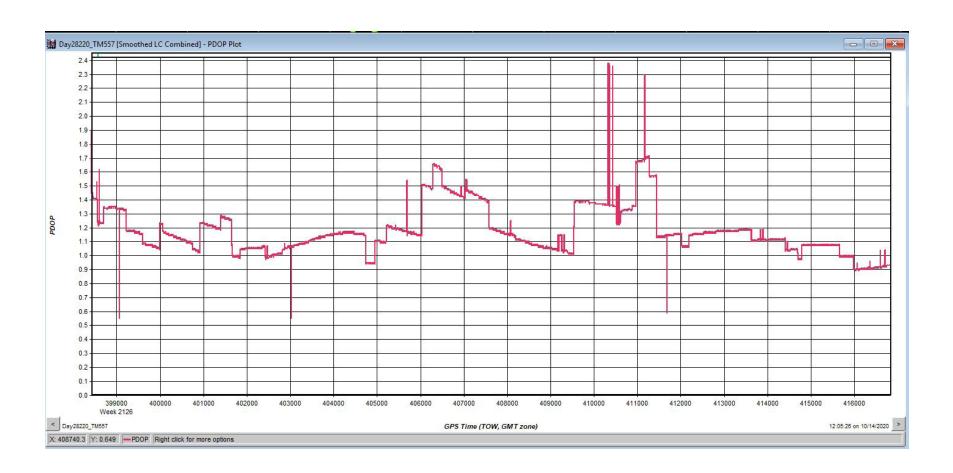


# Day28220_TM557

Estimated Position Accuracy



### Day28220_TM557 PDOP Plot

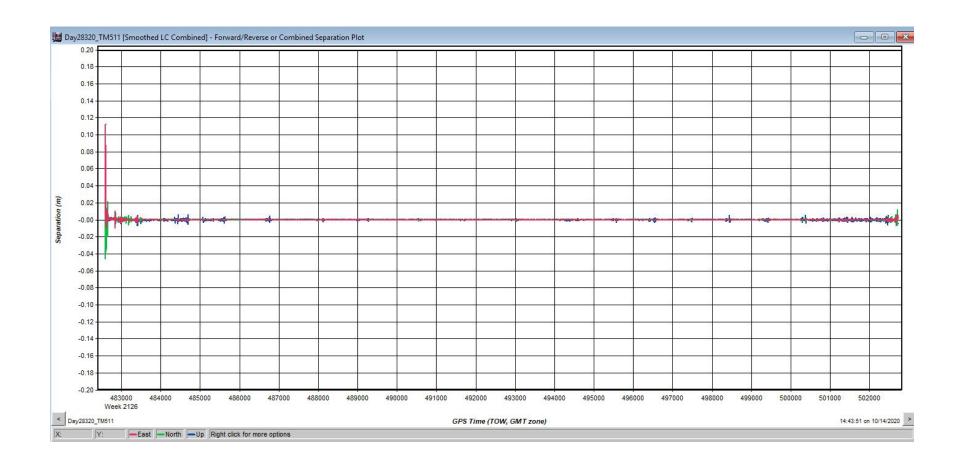


United States Geological Survey

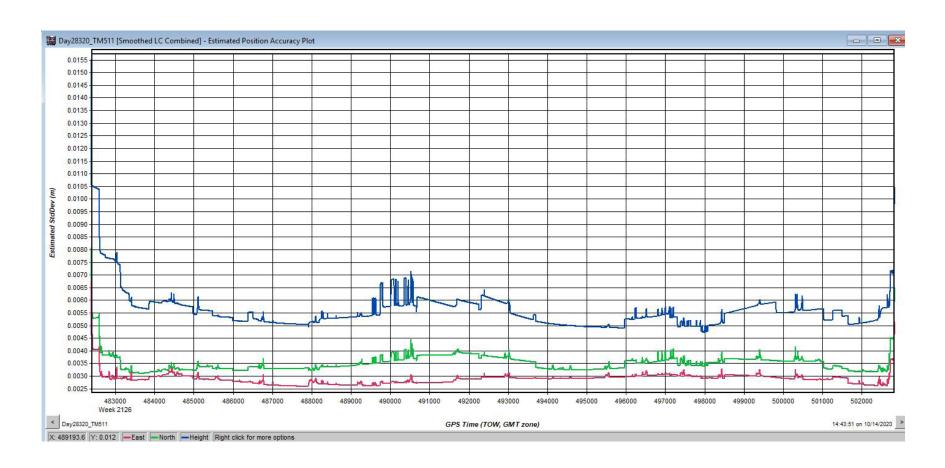
# Day28320_TM511 Trajectory

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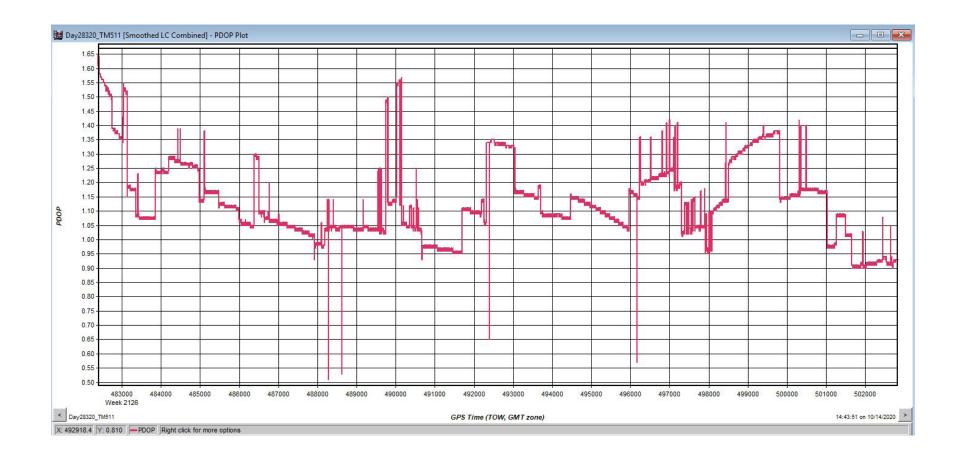
# Day28320_TM511



## Day28320_TM511 Estimated Position Accuracy



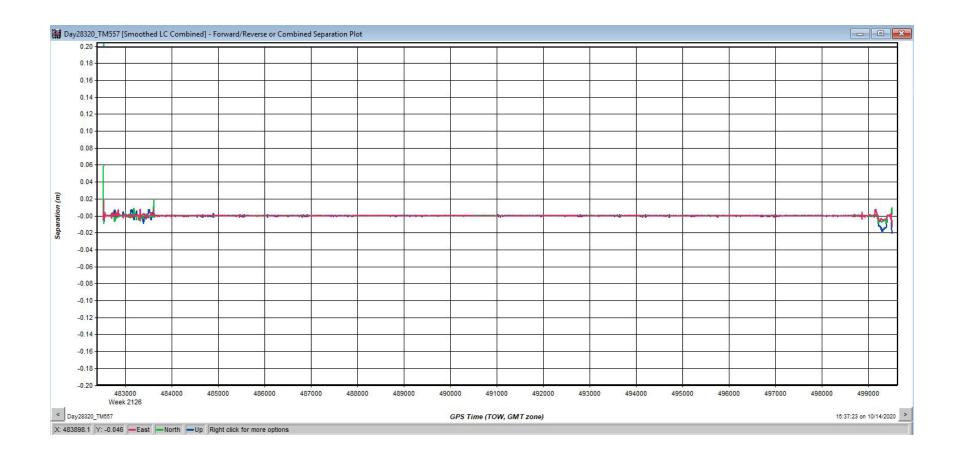
#### Day28320_TM511 PDOP Plot



## Day28320_TM557 Trajectory

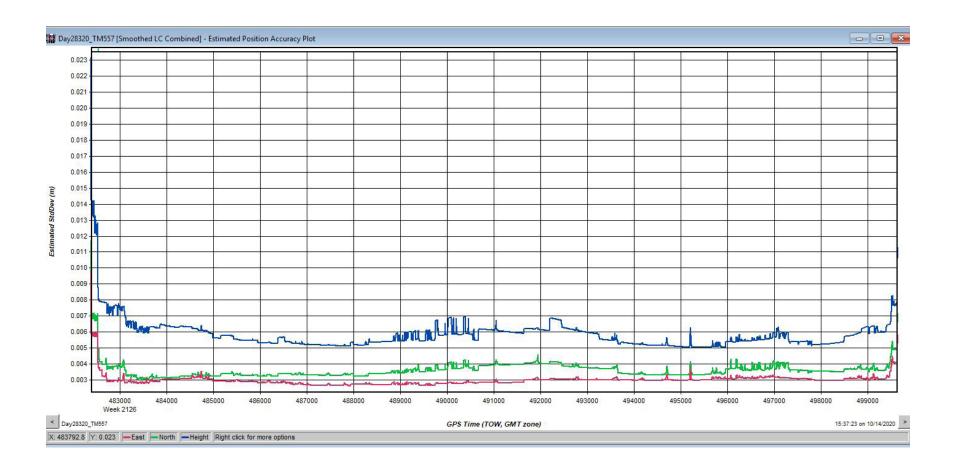


# Day28320_TM557

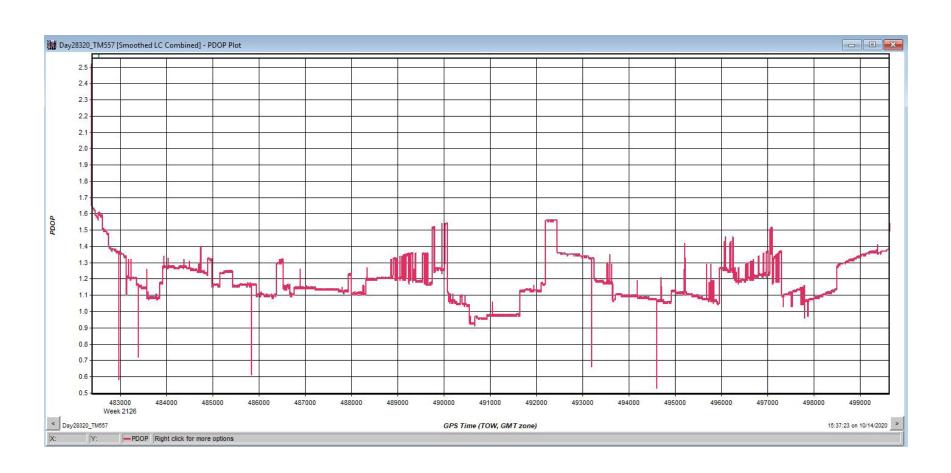


# Day28320_TM557

Estimated Position Accuracy



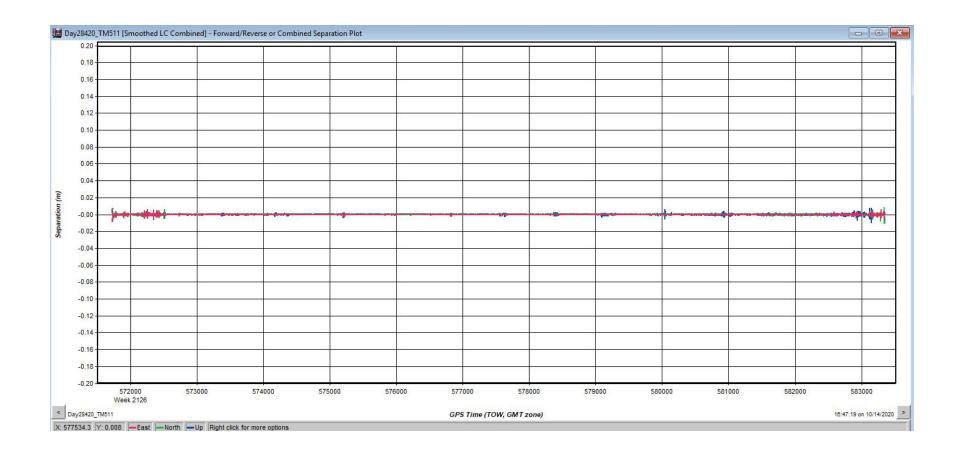
### Day28320_TM557 PDOP Plot



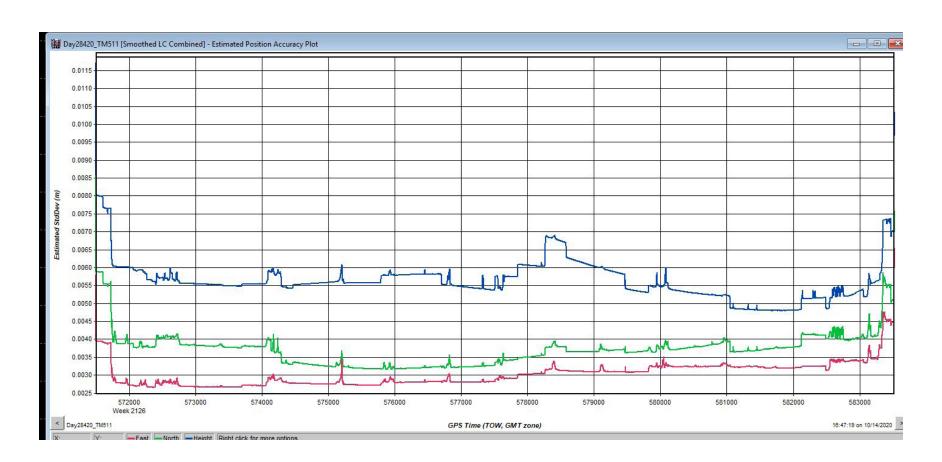
## Day28420_TM511 Trajectory



## Day28420_TM511



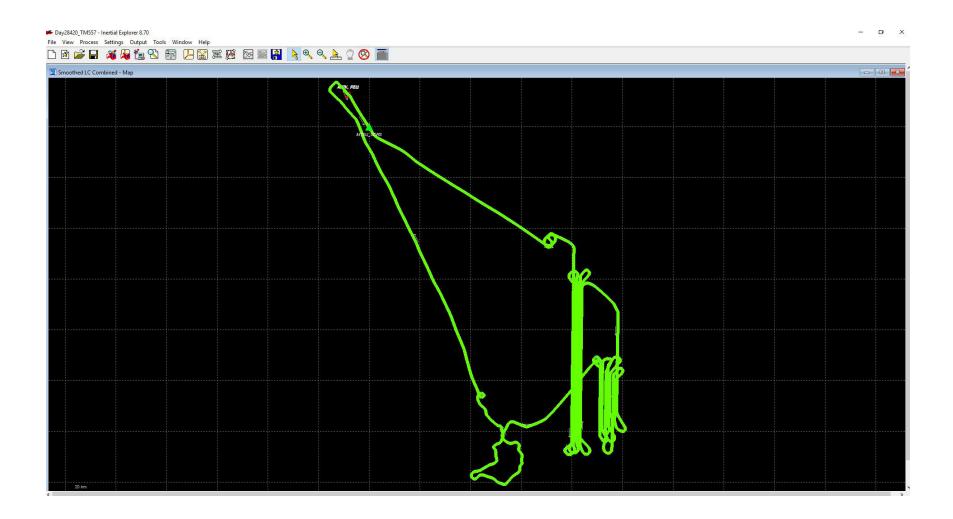
## Day28420_TM511 Estimated Position Accuracy



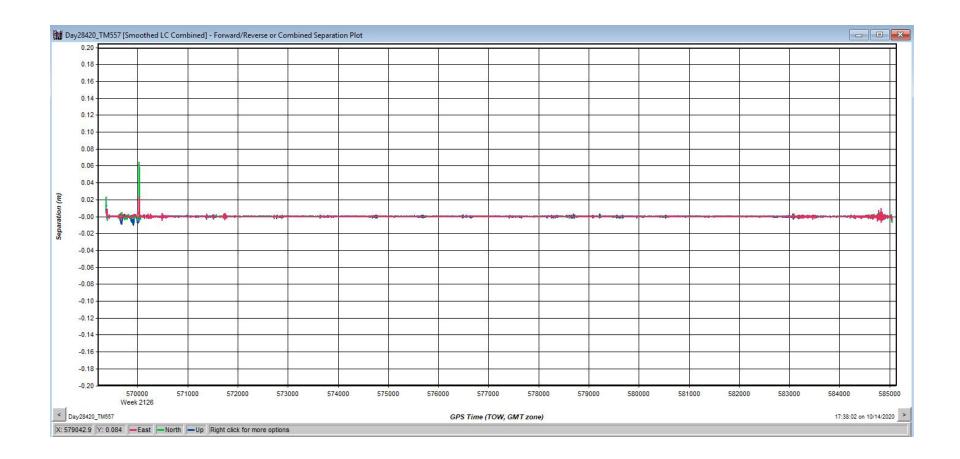
#### Day28420_TM511 PDOP Plot



## Day28420_TM557 Trajectory

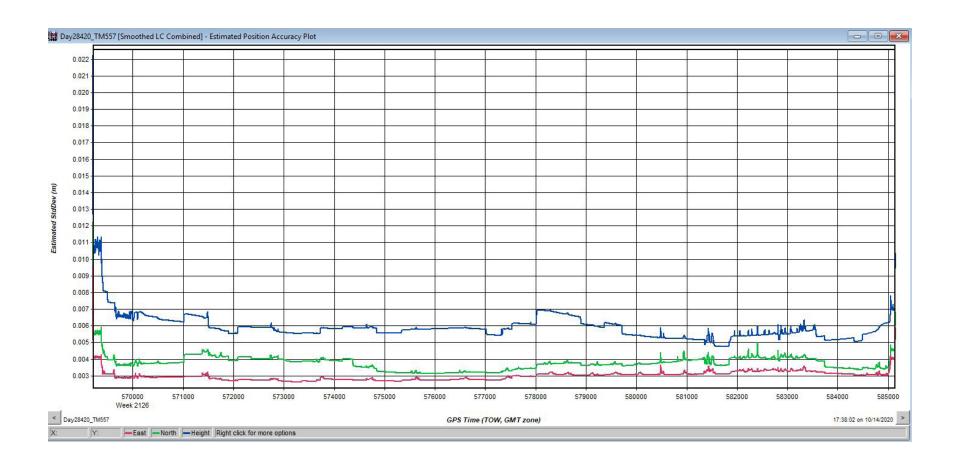


### Day28420_TM557



# Day28420_TM557

Estimated Position Accuracy



### Day28420_TM557 PDOP Plot

Day28420_TM557 [Smoothed LC Combined] - PDOP Plot 2.5 2.4 2.3 2.2 2.1 2.0 1.9 1.8 1.7 1.6 PDOP **F** 1.5 1.4 1.3 1.2 1----1.1 1.0 0.9 0.8 0.7 0.6 570000 Week 2126 571000 572000 573000 574000 575000 576000 577000 578000 579000 580000 581000 582000 583000 584000 585000 < Day28420_TM557 17:38:02 on 10/14/2020 > GPS Time (TOW, GMT zone) X: 577876.3 Y: 1.315 -PDOP Right click for more options