Herbert Hoover Dike, Florida
LiDAR Report

Florida Division of Emergency Management (FDEM)

Prepared by:

Merrick & Company
2450 South Peoria Street
Aurora, CO 80014
Phone: (303) 751-0741
Fax: (303) 745-0964

EXECUTIVE SUMMARY

In the summer of 2007, Merrick & Company was contracted by the Florida Division of Emergency Management to execute a LiDAR (Light Detection And Ranging) survey for the project area around Lake Okeechobee Florida, located in the Southeastern part of Florida. The purpose of the project is to produce accurate, high-resolution data for planning, analysis, and for use with other data sets. Merrick & Company obtained LiDAR data over approximately 2289 square miles covering part of the following counties, Palm Beach, Martin, Okeechobee, Glades, Hendry, Highlands and Broward. The LiDAR data has been processed to result in a data set that is suitable for the future generation of 1-foot contours.

CONTRACT INFORMATION

Questions regarding this report should be addressed to:

Mr. Kenny Legleiter
Project Manager
Merrick & Company
2450 South Peoria Street
Aurora, CO 80014
303-353-3837
kenny.legleiter@merrick.com

Project Completion Report for Herbert Hoover Dike.

The contents of this report summarize the methods used to establish the GPS base station network, perform the LiDAR data collection and post-processing as well as the results of these methods for Herbert Hoover Dike Florida.

LiDAR System and Flight Report

Two LiDAR aircrafts, a Cessna 402C (N4661N-SN53) and a Cessna 402C (N274MR-SN35), flew the LiDAR data collection. The Cessna 402C (N4661N) flew between the dates of Sept. 8, 2007 and November 10, 2007 and the Cessna 402C (N274MR) flew between the dates of October 13, 2007 and December 19, 2007. The West Palm Beach International Airport (KPBI) was used as the airfield of operations. Some of the short flying times are due to clouds accumulating during the flight mission, forcing the aircraft to land. The LiDAR system in both planes is capable of multiple returns (4). The flight operator staff included Shaun Smith, Chris Guy, John Buckner, all employees of Merrick and Company.

Mission Parameters for the Cessna 402C (N4661N-SN53) High Altitude

LiDAR Sensor	Leica Geosystems ALS50 Phase 2Plus
Nominal Ground Sample Distance	0.95 meters
Average Altitude	9,500 Feet MSL
Average Airspeed	~108 Knots
Scan Rate	25.8 Hertz
Scan FOV (scan angle)	30˚
Pulse Rate	86,100 Hertz
Planned Flight Line Overlap	10%

Mission Parameters for the Cessna 402C (N4661N-SN53) Low Altitude

LiDAR Sensor	Leica Geosystems ALS50 Phase 2Plus
Nominal Ground Sample Distance	0.64 meters
Average Altitude	4,500 Feet MSL
Average Airspeed	~165 Knots
Scan Rate	36.9 Hertz
Scan FOV (scan angle)	60˚
Pulse Rate	145,300 Hertz
Planned Flight Line Overlap	55%

Mission Parameters for the Cessna 402C (N274MR-SN35)

LiDAR Sensor	Leica Geosystems ALS50 Phase 1
Nominal Ground Sample Distance	1.00 meter
Average Altitude	4,500 Feet MSL
Average Airspeed	~165 Knots
Scan Rate	23 Hertz
Scan FOV (scan angle)	60˚
Pulse Rate	59,800 Hertz
Planned Flight Line Overlap	55%

The scan field of view was altered during acquisition because of weather delays. To be able to complete the project as soon as possible with the cloud levels so low, we had to have alternative flight plans to get something done on cloudy days. The solution to this was lower and wider to keep our swath width and GSD the same as a higher, narrow flight. To wait for clear skies and fly high and narrow would have taken many more months to complete, thereby delaying delivering of the products. To fly low (under the clouds) and narrow would have added many more flight lines and cost much more time and money. With the limited vegetation (excluding the sugar cane), penetration of a wider FOV was not an issue. A 60 degree FOV is only 30 degrees off of nadir. Keep in mind, we could not penetrate most sugar cane even at a 0 degree/nadir FOV, so the wider FOV didn't have any impact on the accuracy or the number of bare-ground LiDAR returns in sugar cane.

Flight Mission Date and Times

Mission	Date	Aircraft	Start Time	End Time	Length Time
070908A	**Sept. 08, 2007**	**SN53**	**565066 GPS sec. 12:57:46 GMT**	**572537GPS sec. 15:02:17 GMT**	**7471 sec. 02:04:31**
070913A	**Sept. 13, 2007**	**SN53**	**394048 GPS sec. 13:27:28 GMT**	**409264 GPS sec. 17:41:04 GMT**	**15216 sec. 04:13:36**
070914A	**Sept. 14, 2007**	**SN53**	**480516 GPS sec. 13:28:36 GMT**	**487193 GPS sec. 15:19:53 GMT**	**6677 sec. 01:51:17**
070916A	**Sept. 16, 2007**	**SN53**	**48504 GPS sec. 13:28:24 GMT**	**55212 GPS sec. 15:20:12 GMT**	**6708 sec. 01:51:48**
070917A	**Sept. 17, 2007**	**SN53**	**133626 GPS sec. 13:07:06 GMT**	**143531 GPS sec. 15:52:11 GMT**	**9905 sec. 02:45:05**
070918A	**Sept. 18, 2007**	**SN53**	**218900 GPS sec. 12:48:20 GMT**	**227373 GPS sec. 15:09:33 GMT**	**8473 sec. 02:21:13**
071013A	**Oct. 13, 2007**	**SN35**	**565714 GPS sec. 13:08:34 GMT**	**575847 GPS sec. 15:57:27 GMT**	**10134 sec. 02:48:54**
071014A	**Oct. 14, 2007**	**SN35**	**43083 GPS sec. 11:58:03 GMT**	**55807 GPS sec. 15:30:07 GMT**	**12724 sec. 03:32:04**
071018A	**Oct. 18, 2007**	**SN35**	**389220 GPS sec. 12:07:00 GMT**	**400850 GPS sec. 15:20:50 GMT**	**11630 sec. 03:13:50**
071019A	**Oct. 19, 2007**	**SN35**	**476494 GPS sec. 12:21:34 GMT**	**485055 GPS sec. 14:44:15 GMT**	**8562 sec. 02:22:42**
071023A	**Oct. 23, 2007**	**SN35**	**221936 GPS sec.**	**228685 GPS sec.**	**6749 sec.**

			13:38:56GMT	15:31:25 GMT	01:52:29
071103A	Nov. 03, 2007	SN35	571224 GPS sec. 14:40:24 GMT	581962 GPS sec. 17:39:22 GMT	10738 sec. 02:58:58
071104A	Nov. 04, 2007	SN35	51792 GPS sec. 14:23:12 GMT	64453 GPS sec. 17:54:13 GMT	12661 sec. 03:31:01
071105A	Nov. 05, 2007	SN35	135774 GPS sec. 13:42:54 GMT	148543 GPS sec. 17:15:43 GMT	12770 sec. 03:32:50
071105A	Nov. 05, 2007	SN53	135750 GPS sec. 13:42:30 GMT	149913 GPS sec. 17:38:33 GMT	14163 sec. 03:56:03
071106A	Nov. 06, 2007	SN35	217116 GPS sec. 12:18:36 GMT	232497 GPS sec. 16:34:57 GMT	15381 sec. 04:16:21
071106A	Nov. 06, 2007	SN53	222545 GPS sec. 13:49:05 GMT	234663 GPS sec. 17:11:03 GMT	12118 sec. 03:21:58
071107A	Nov. 07, 2007	SN35	305911 GPS sec. 12:58:31 GMT	321607 GPS sec. 17:20:07 GMT	15696 sec. 04:21:36
071107A	Nov. 07, 2007	SN53	305846 GPS sec. 12:57:26 GMT	325609 GPS sec. 18:26:49 GMT	19763 sec. 05:29:23
071109A	Nov. 09, 2007	SN53	480168 GPS sec. 13:22:48 GMT	497879 GPS sec. 18:17:59 GMT	1771 sec. 04:55:11
071109B	Nov. 09, 2007	SN53	501936 GPS sec. 19:25:36 GMT	516350 GPS sec. 23:25:50 GMT	14414 sec. 04:00:14
071110A	Nov. 10, 2007	SN35	568462 GPS sec. 13:54:22 GMT	583925 GPS sec. 18:12:05 GMT	15463 sec. 04:17:43
071110B	Nov. 10, 2007	SN35	588132 GPS sec. 19:22:12 GMT	593718 GPS sec. 20:55:18 GMT	5586 sec. 01:33:06
071110A	Nov. 10, 2007	SN53	567501 GPS sec. 13:38:21 GMT	585810 GPS sec. 18:43:30 GMT	18309 sec. 05:05:09
071212A	Dec. 12, 2007	SN35	310977 GPS sec. 14:22:57 GMT	318893 GPS sec. 16:34:53 GMT	7916 sec. 02:11:56
071217A	Dec. 17, 2007	SN35	141076 GPS sec. 15:11:16 GMT	159155 GPS sec. 20:12:35 GMT	18080 sec. 05:01:20
071217B	Dec. 17, 2007	SN35	161828 GPS sec. 20:57:08 GMT	182302 GPS sec. 02:38:22 GMT	20474 sec. 05:41:14
071219A	Dec. 19, 2007	SN35	310658 GPS sec. 14:17:38 GMT	320000 GPS sec. 16:53:20 GMT	9342 sec. 02:35:42
071219B	Dec. 19, 2007	SN35	322974 GPS sec. 17:42:54 GMT	334591 GPS sec. 20:56:31 GMT	11617 sec. 03:13:37

Field Work / Procedures

Multiple ground Airborne GPS Base Stations, for the LiDAR data collection, were set up every mission. One base GPS receiver located at the airport was operational every day. Multiple ground GPS receivers were placed within the job boundary and under or close to the flight lines for that day. Pre-flight checks such as cleaning the sensor head glass are performed. A five minute INS initialization is conducted on the ground, with the aircraft engines running, prior to flight, to establish fine-alignment of the INS. GPS ambiguities are resolved by flying within ten kilometers of the base stations. During the data collection, the operator recorded information on log sheets which includes weather conditions, LiDAR operation parameters, and flight line statistics. Near the end of the mission, GPS ambiguities were again resolved by flying within ten kilometers of the base stations to aid in post-processing. Data was sent back to the main office and preliminary data processing was performed for quality control of

GPS data and to ensure sufficient overlap between flight lines. Any problematic data could then be reflown immediately as required. Final data processing was completed in the Aurora, Colorado office.

Planned Flight Diagrams

See Below.

Diagram 1 planned flight Lines for Herbert_Hoover_Dike

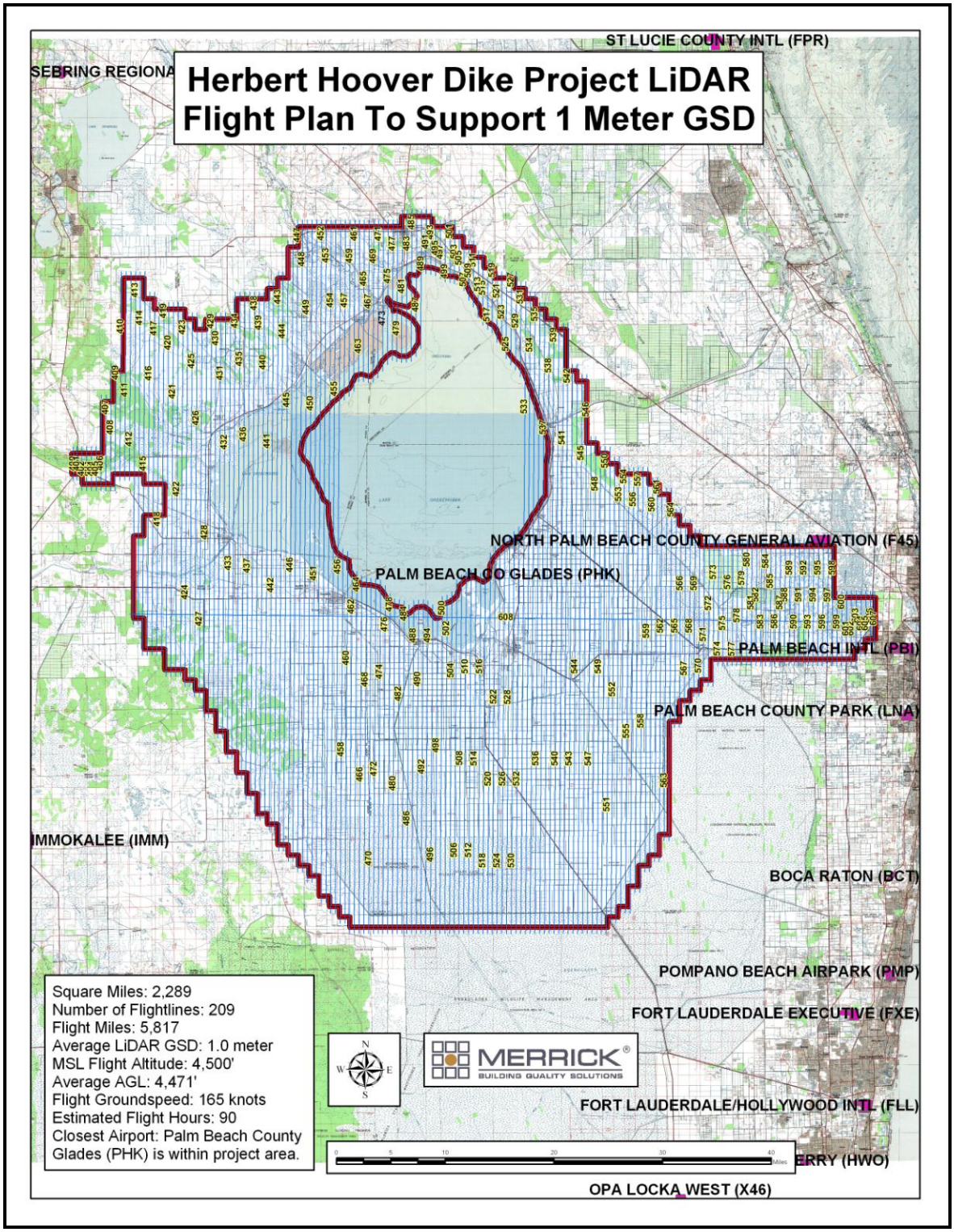
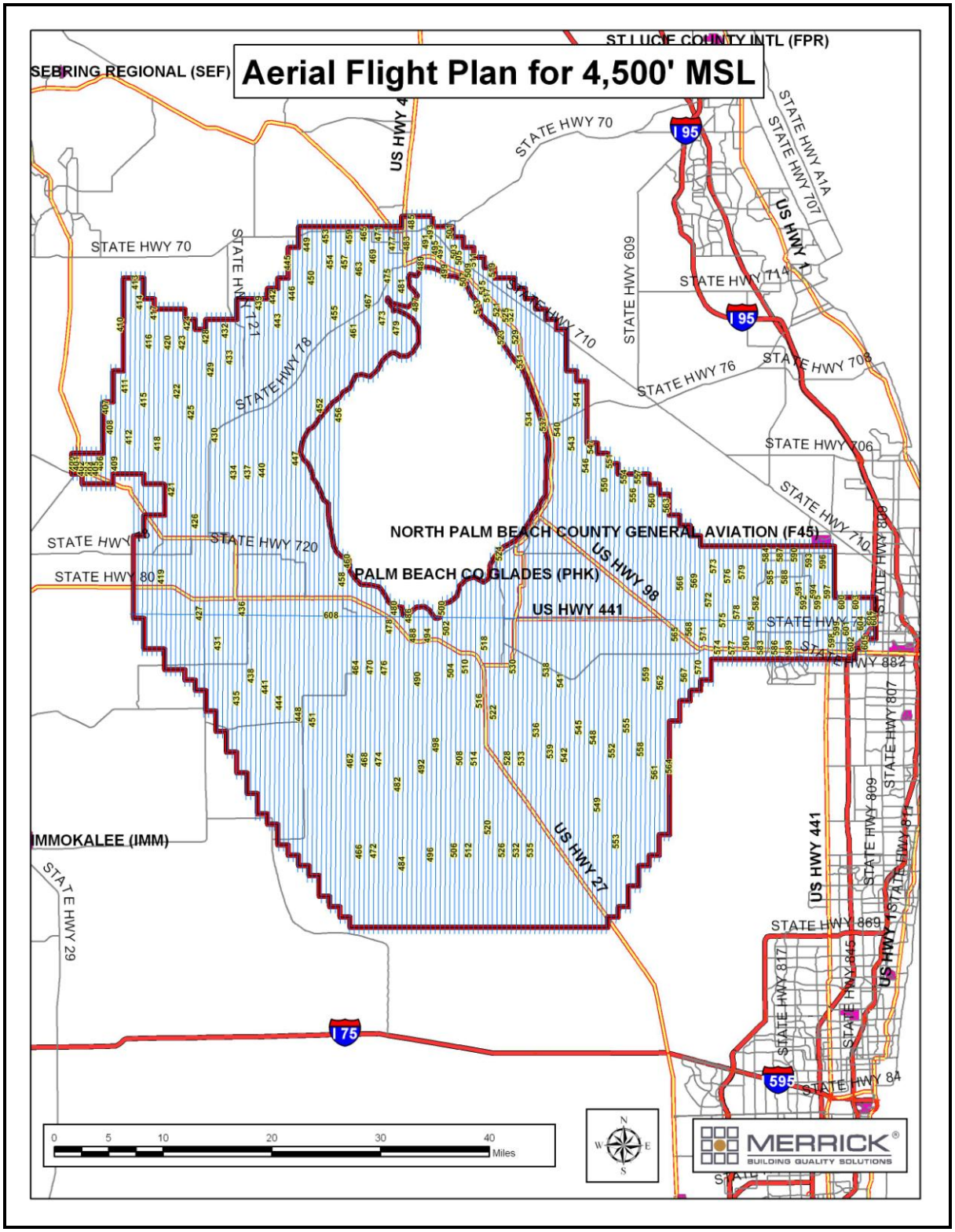
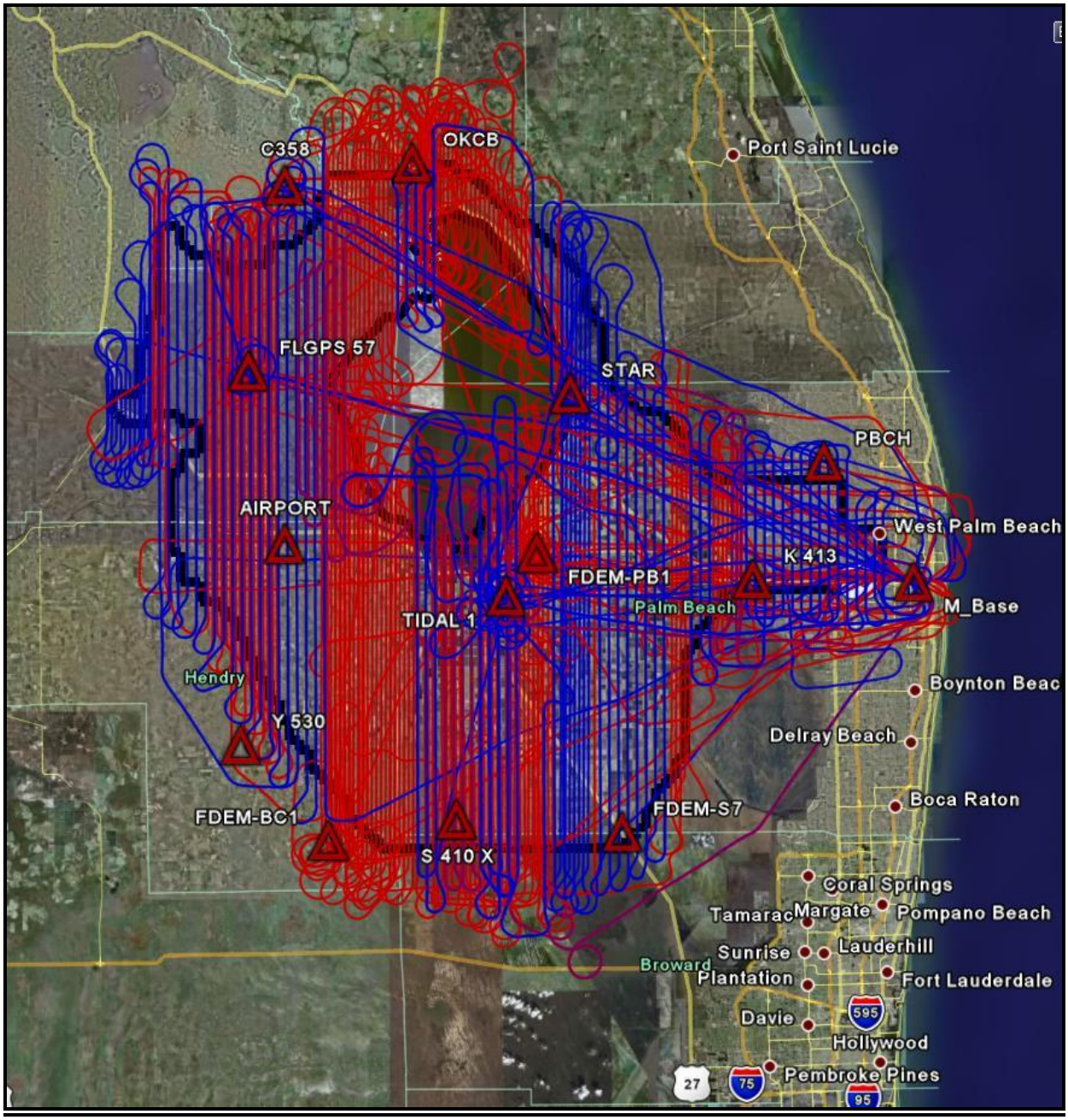


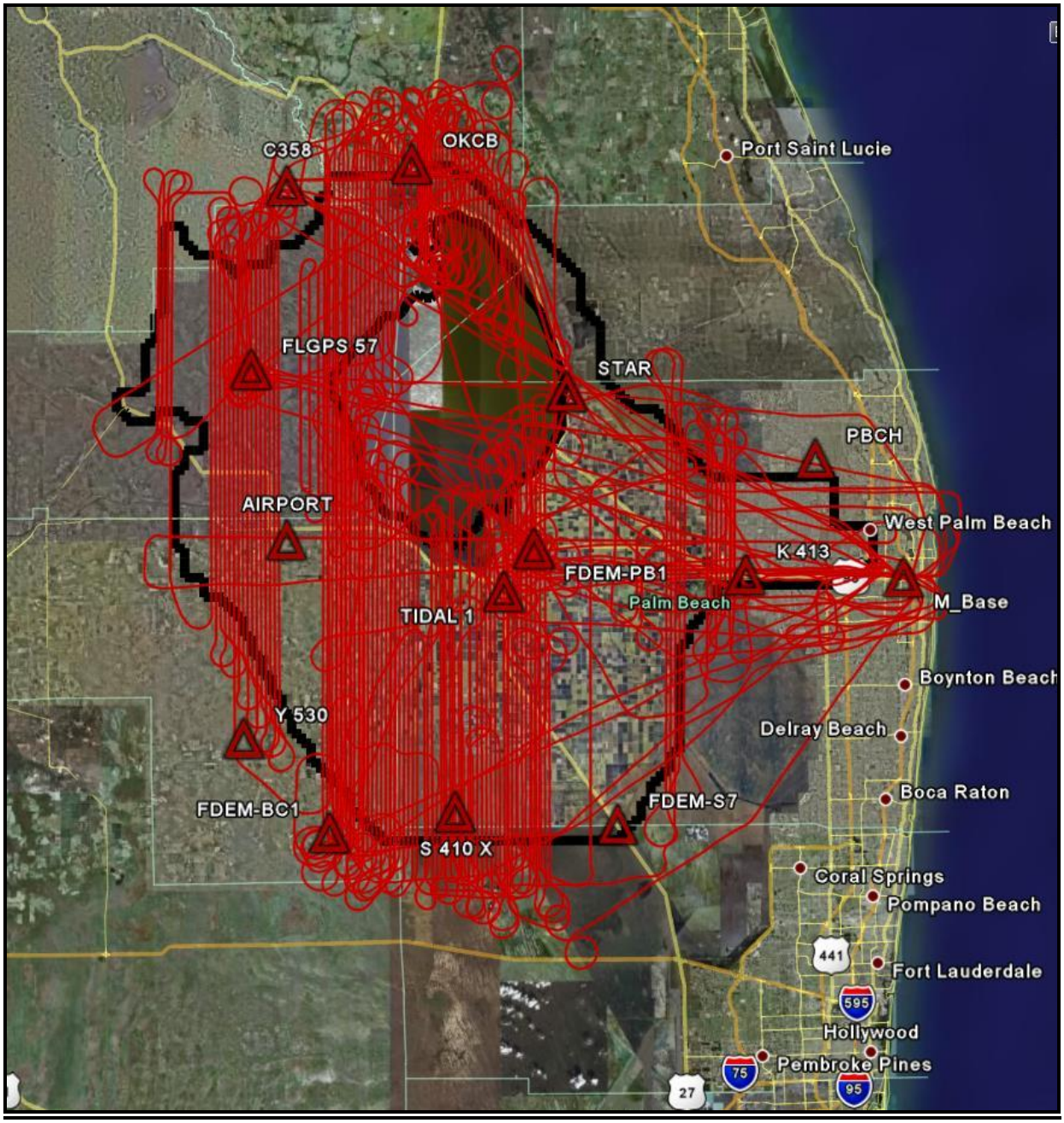
Diagram 2 planned flight Lines for Herbert Hoover Dike



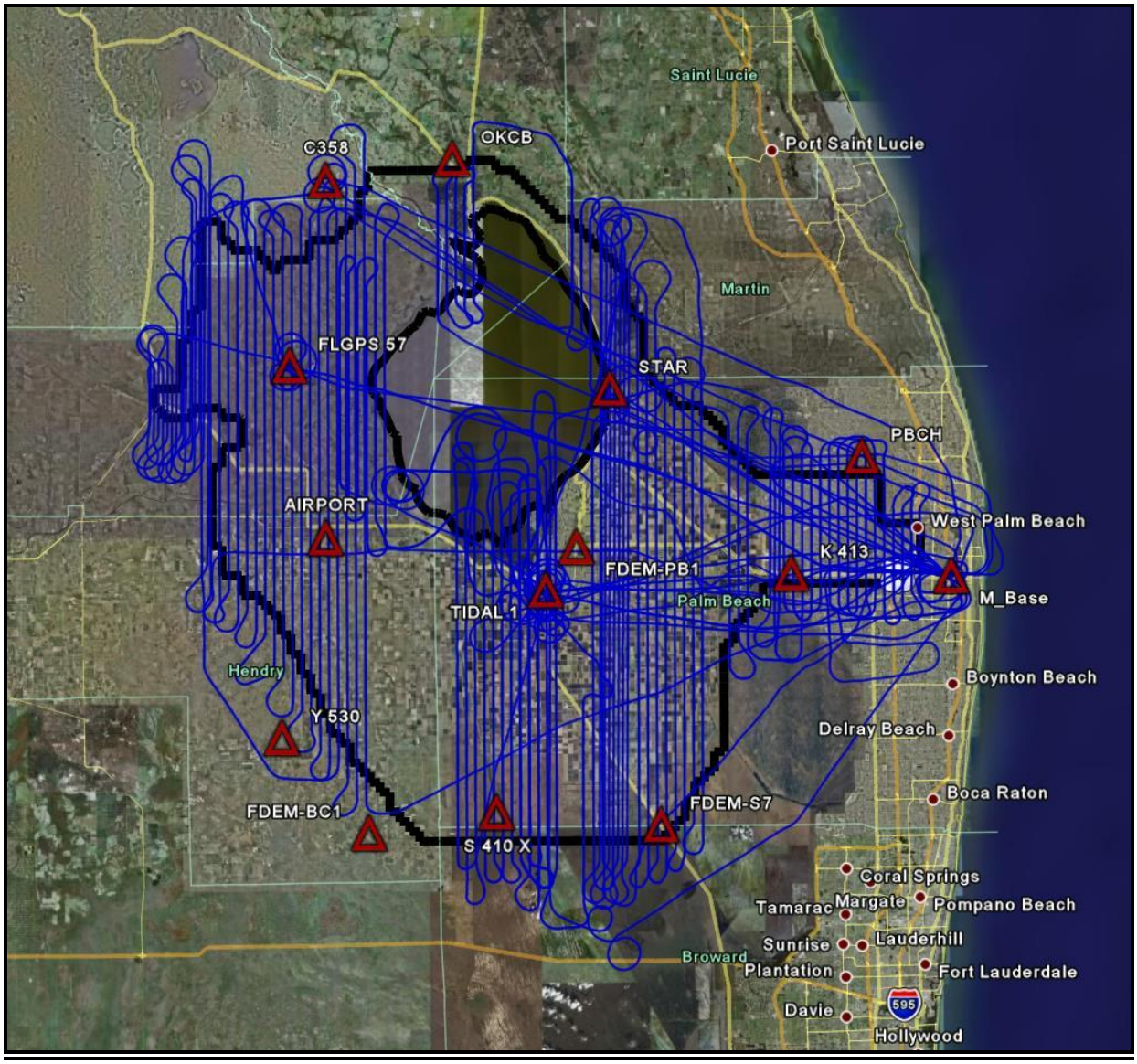
Actual flight lines with GPS base station locations shown for all aircraft



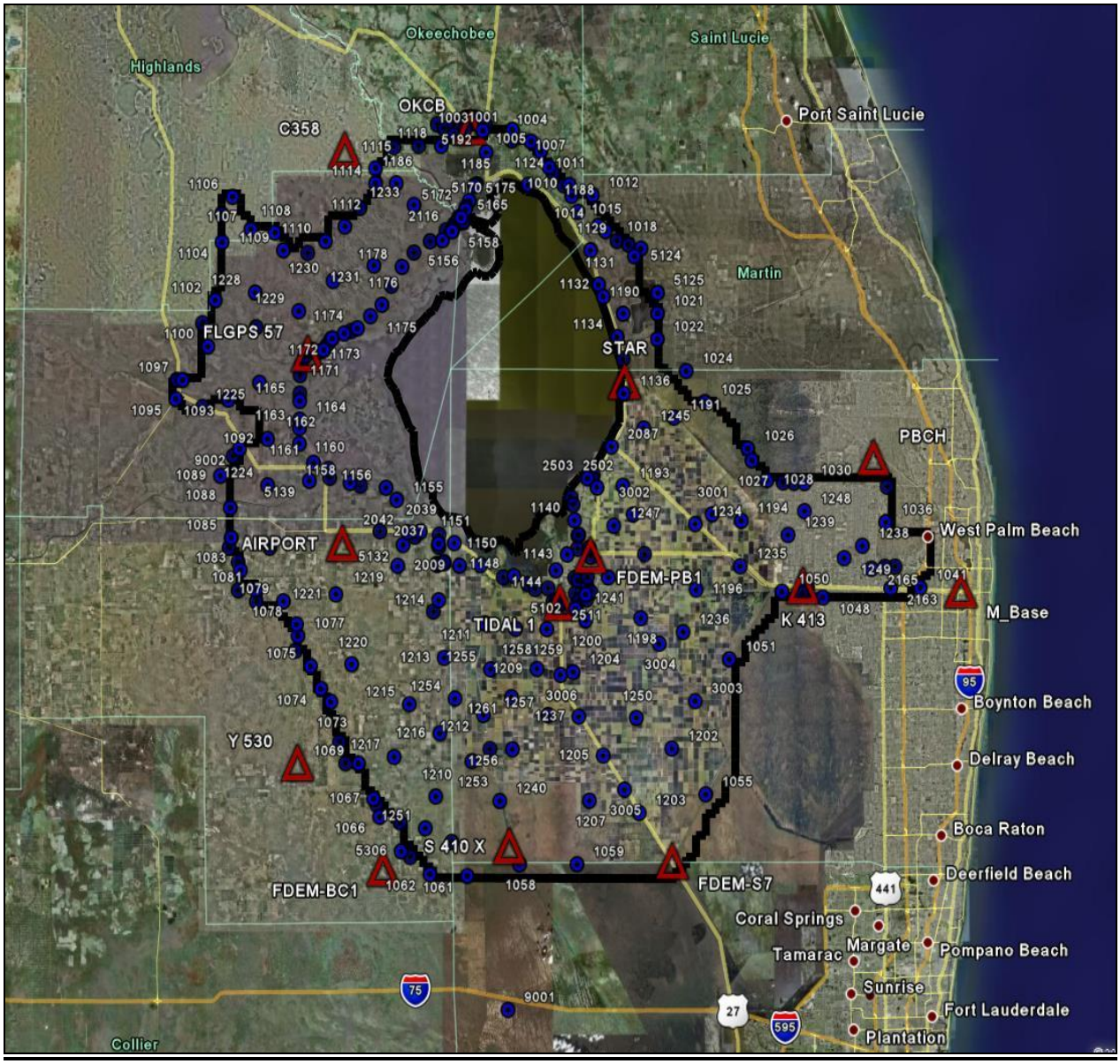
Actual flight lines with GPS base station locations for SN35 aircraft



Actual flight lines with GPS base station locations shown for SN53 aircraft



Ground control points with GPS base station locations



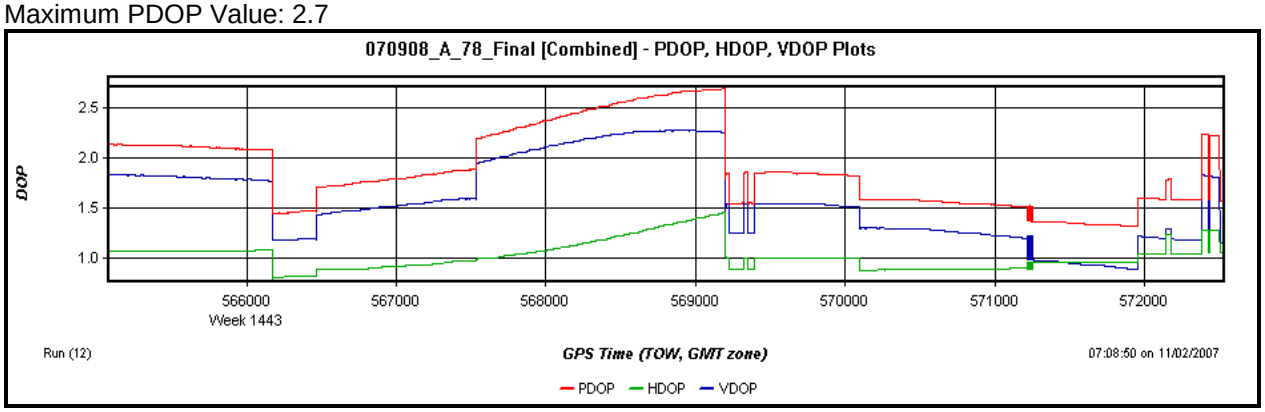
The LiDAR data was collected in a random method with a maximum point spacing of 4-ft in unobscured areas. An unobscured area is defined as areas without buildings, vegetation, or orther surface features that would hinder the LiDAR system in achieving the required density for bare-earth postings. The average ground sample distance for any of the lifts (acquisition flights) never exceeded 4-ft. The ortho DEM has the same vertical and horizontal accuracy as the LiDAR data.

LiDAR Data Processing

The airborne GPS data was post-processed using Waypoint's GravNAV software version 4.2 and 7.8. A fixed-bias carrier phase solution was computed in both the forward and reverse chronological directions. Whenever practical, LiDAR acquisition was limited to periods when the PDOP (Positional Dilution Of Precision) was less than 4.0. PDOP indicates satellite geometry relating to position. Generally PDOP's of 4.0 or less result in a good solution, however PDOP's between 4.0 and 5.0 can still yield good results most of the time. PDOP's over 6.0 are of questionable results and PDOP's of over 7.0 usually result in a poor solution. HDOP stands for Horizontal Dilution Of Precision and VDOP stands for Vertical Dilution Of Precision. Other quality control checks used for the GPS include analyzing the combined separation of the forward and reverse GPS processing from one base station and the results of the combined separation when processed from two different base stations. Basically this is the difference between the two trajectories. Also analysis of the number of satellites present during the flight and during data collection time periods.
The GPS trajectory was combined with the raw IMU data and post-processed using POSPac version 4.2. The smoothed best estimated trajectory (SBET) and refined attitude data are then utilized in the ALS Post Processor to compute the laser point-positions – the trajectory is combined with the attitude data and laser range measurements to produce the 3-dimensional coordinates of the mass points. Up to four return values are produced within the ALS Post Processor software for each pulse which ensures the greatest chance of ground returns in a heavily forested area.
Laser point classification was completed using Merrick Advanced Remote Sensing (MARS) LiDAR processing and modeling software. Several algorithms are used when comparing points to determine the best automatic ground solution. Each filter is built based on the projects terrain and land cover to provide a surface that is 90% free of anomalies and artifacts. After the auto filter has been completed the data is then reviewed by an operator utilizing MARS to remove any other anomalies or artifacts not resolved by the automated filter process. During these final steps the operator also verifies that the data set is consistent and complete with no data voids.
See Processing Summary Information Below.

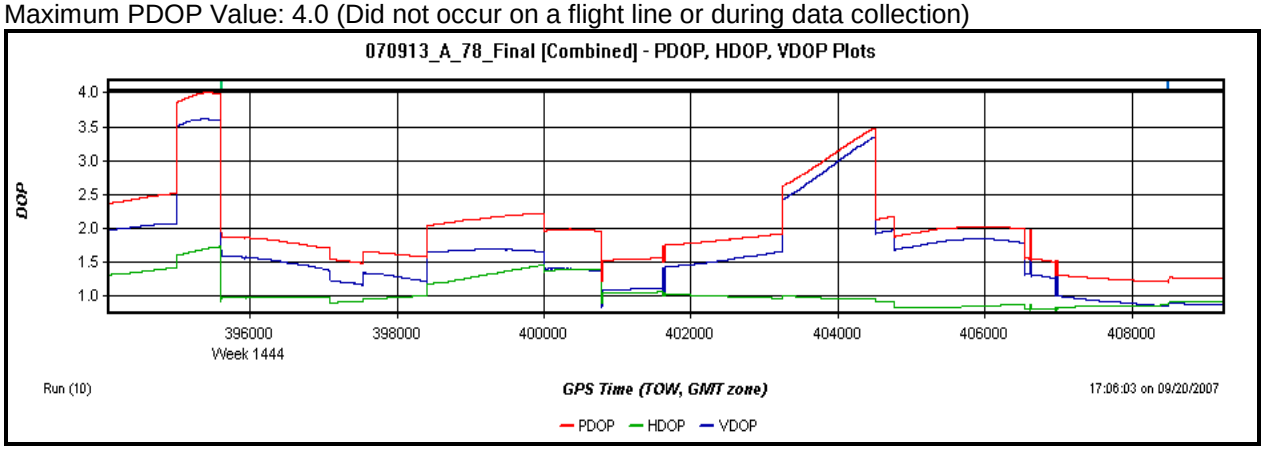
Processing Summary Information for mission 070908_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 7472
Measurement RMS Values: L1 Phase = 0.0368 (m)
Maximum PDOP Value: 2.7



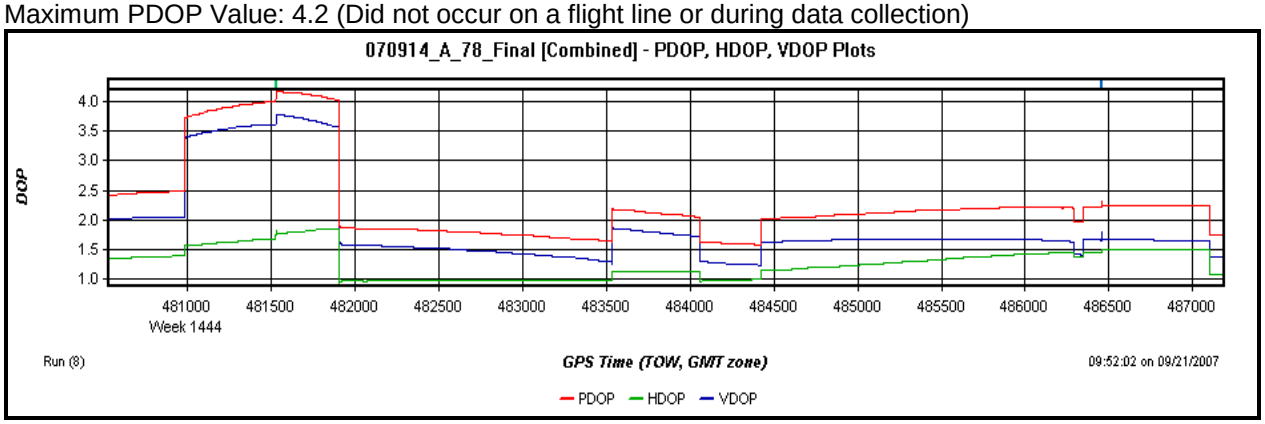
Processing Summary Information for mission 070913_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 15217
Measurement RMS Values: L1 Phase = 0.0246 (m)
Maximum PDOP Value: 4.0 (Did not occur on a flight line or during data collection)



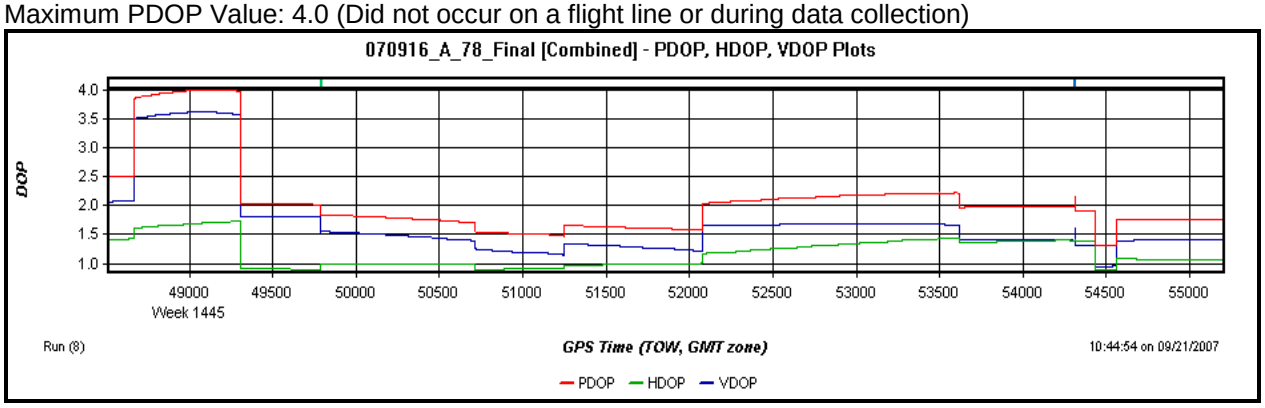
Processing Summary Information for mission 070914_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 6678
Measurement RMS Values: L1 Phase = 0.0204 (m)
Maximum PDOP Value: 4.2 (Did not occur on a flight line or during data collection)



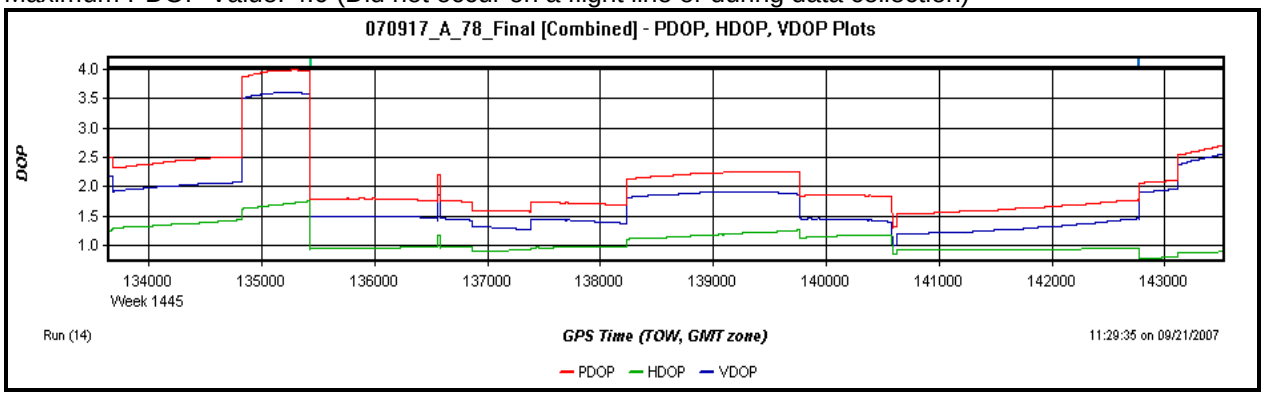
Processing Summary Information for mission 070916_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 6709
Measurement RMS Values: L1 Phase = 0.0262 (m)
Maximum PDOP Value: 4.0 (Did not occur on a flight line or during data collection)



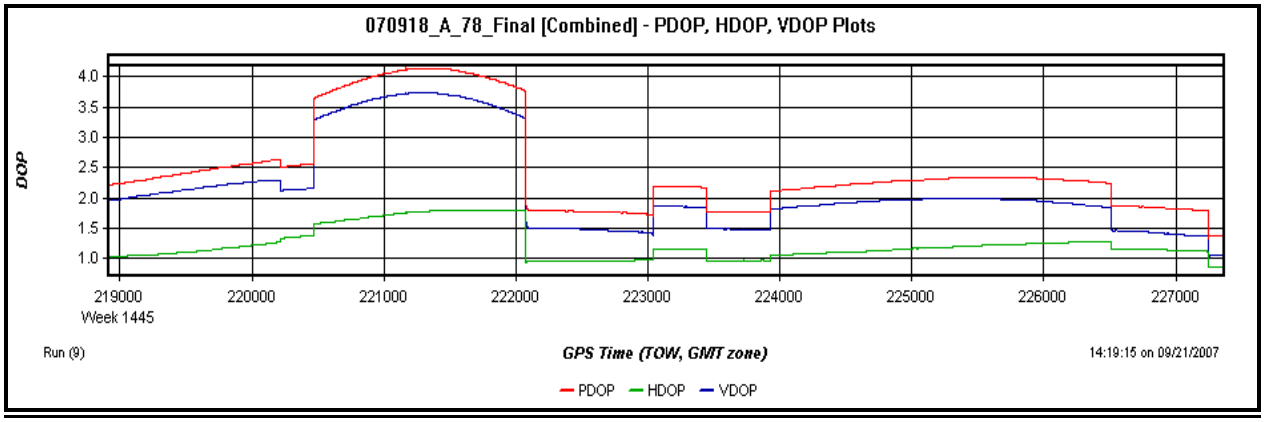
Processing Summary Information for mission 070917_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 9906
Measurement RMS Values: L1 Phase = 0.0251 (m)
Maximum PDOP Value: 4.0 (Did not occur on a flight line or during data collection)



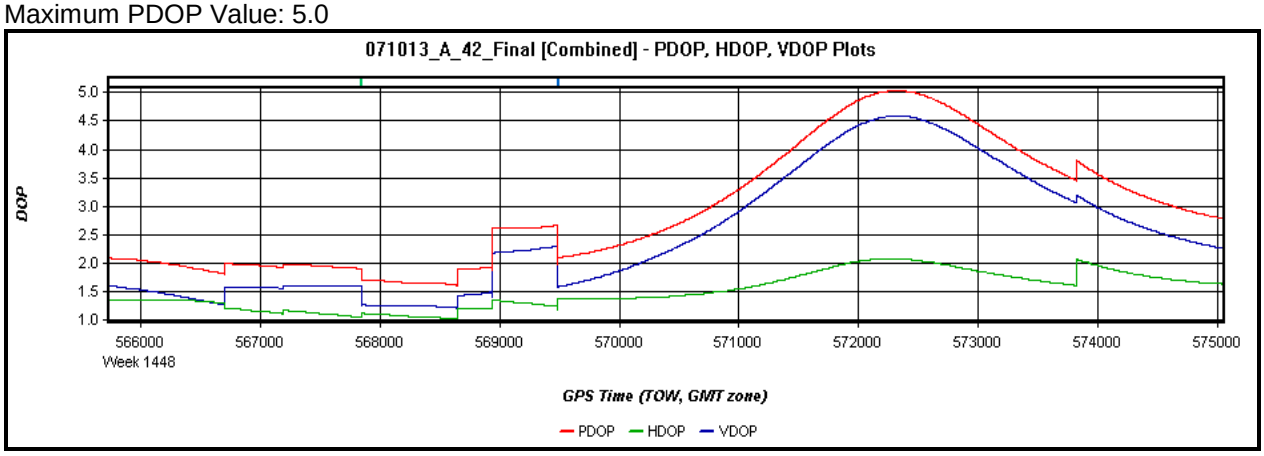
Processing Summary Information for mission 070918_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 8474
Measurement RMS Values: L1 Phase = 0.0272 (m)
Maximum PDOP Value: 4.1



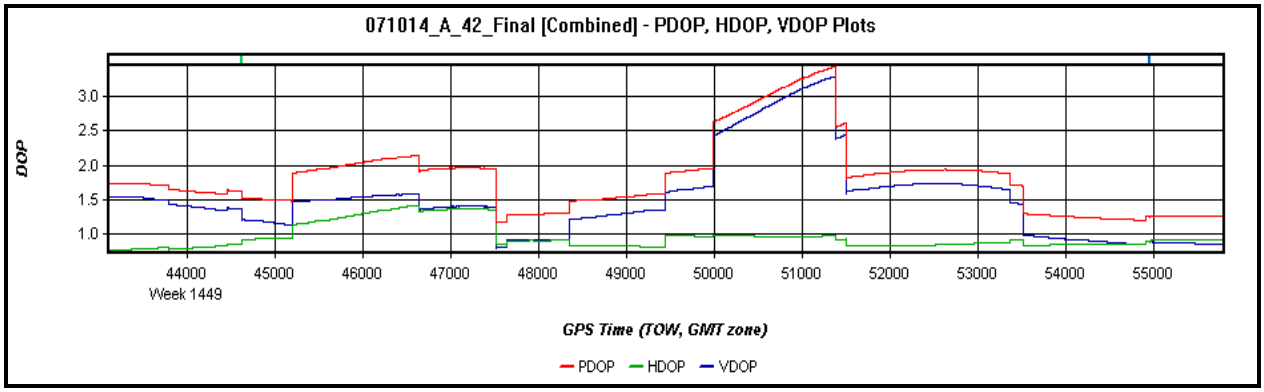
Processing Summary Information for mission 071013_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 20269
Measurement RMS Values: L1 Phase = 0.0232 (m)
Maximum PDOP Value: 5.0



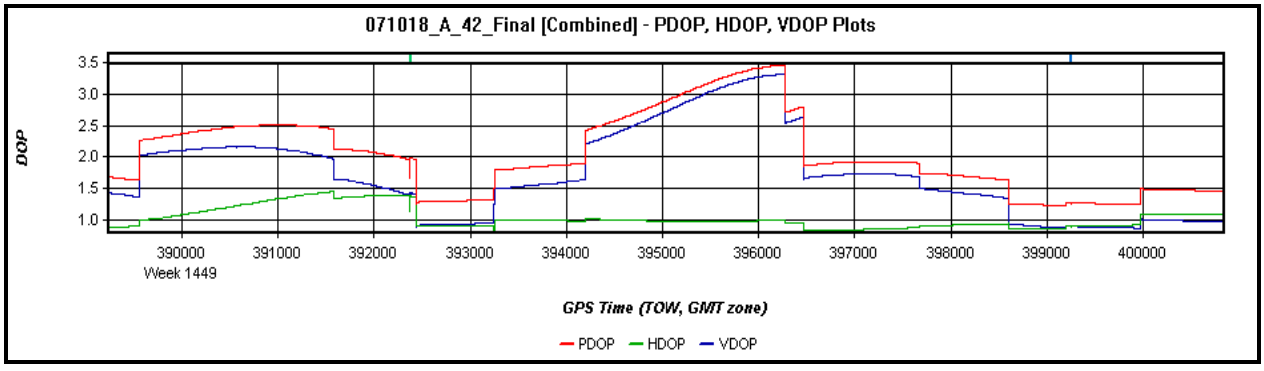
Processing Summary Information for mission 071014_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 25449
Measurement RMS Values: L1 Phase = 0.0252 (m)
Maximum PDOP Value: 3.4



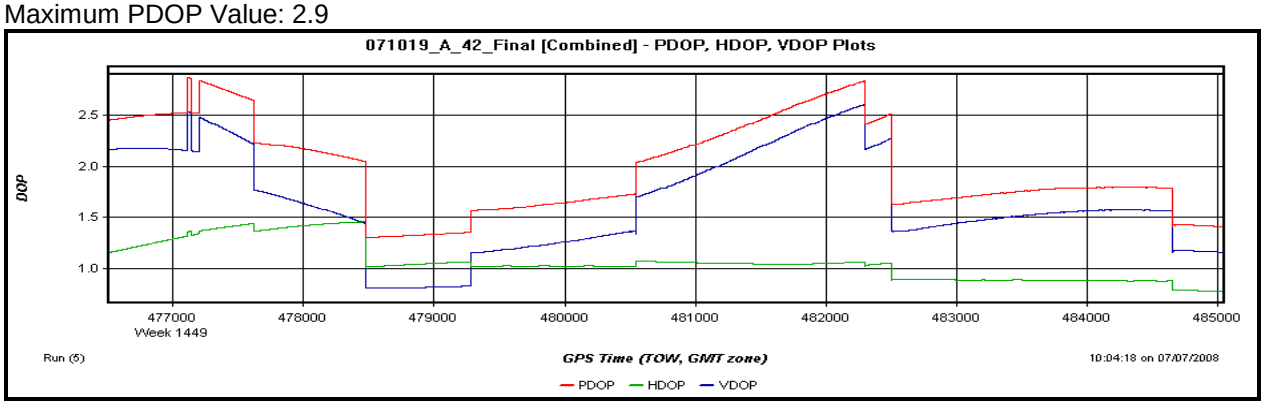
Processing Summary Information for mission 071018_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 23261
Measurement RMS Values: L1 Phase = 0.0246 (m)
Maximum PDOP Value: 3.5



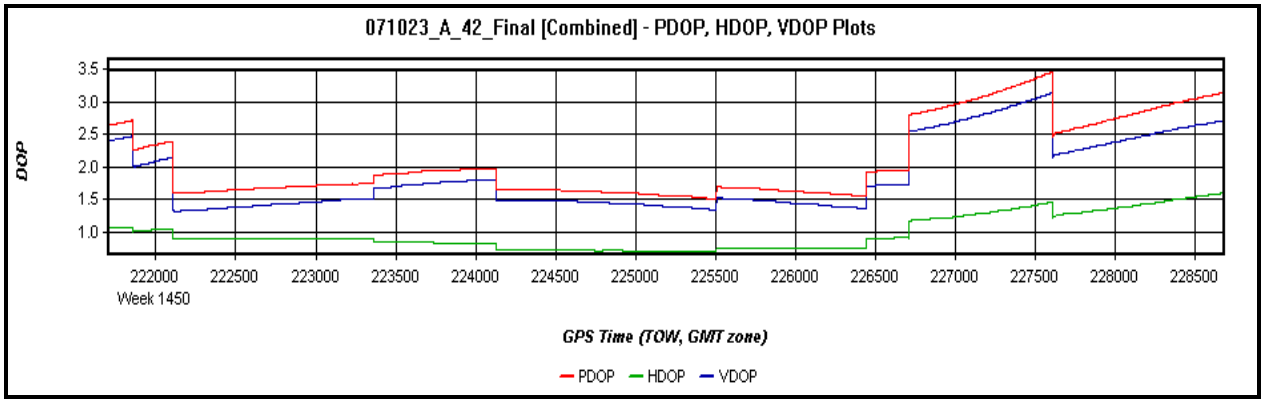
Processing Summary Information for mission 071019_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 17124
Measurement RMS Values: L1 Phase = 0.0259 (m)
Maximum PDOP Value: 2.9



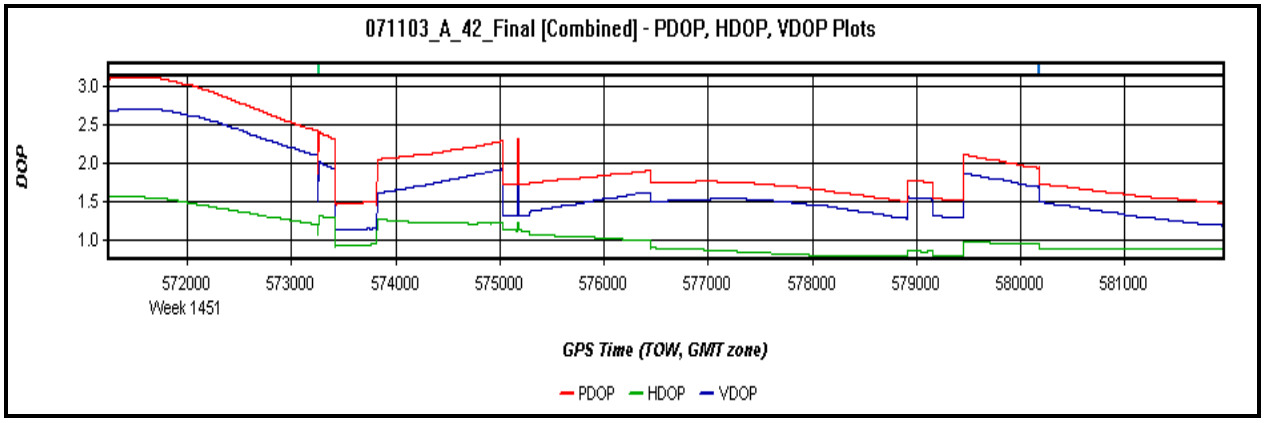
Processing Summary Information for mission 071023_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 14081
Measurement RMS Values: L1 Phase = 0.0268 (m)
Maximum PDOP Value: 3.5



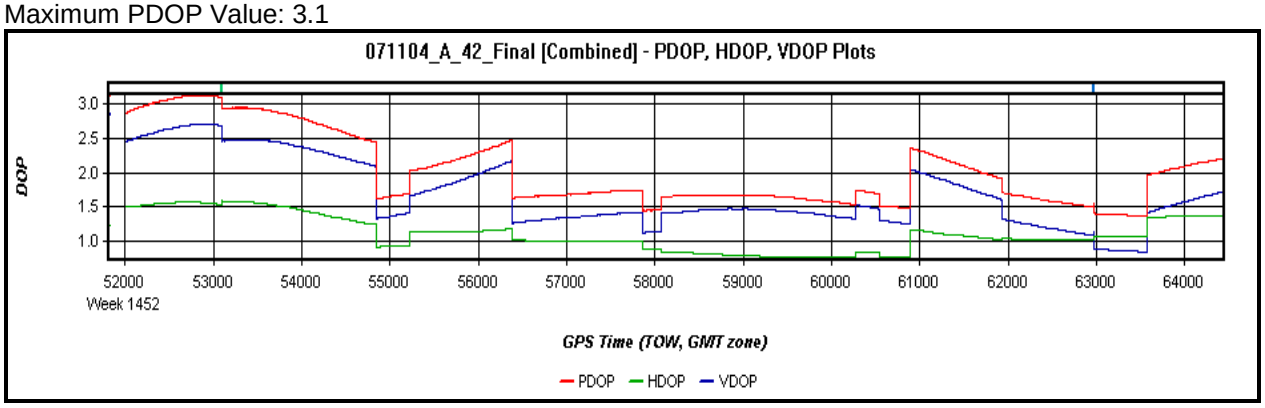
Processing Summary Information for mission 071103_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 21476
Measurement RMS Values: L1 Phase = 0.0169 (m)
Maximum PDOP Value: 3.1



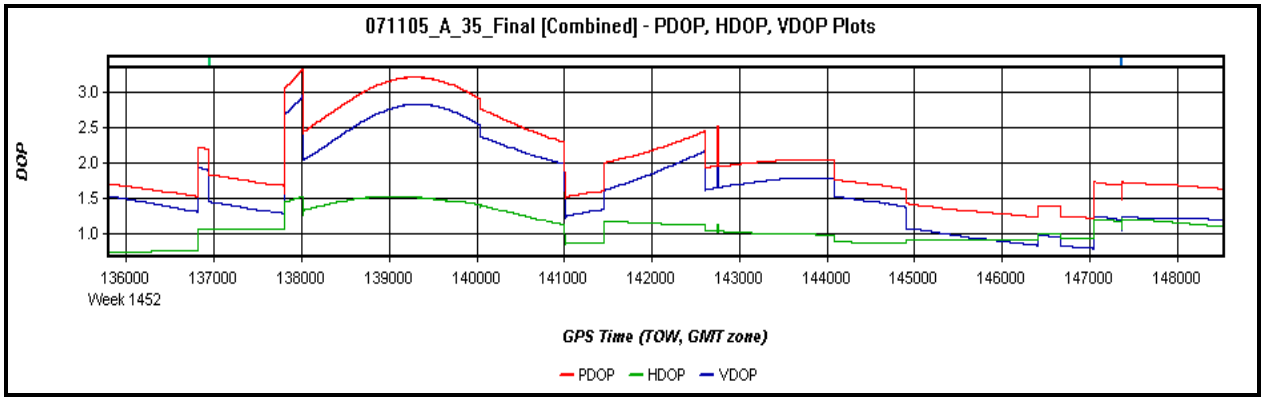
Processing Summary Information for mission 071104_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 24974
Measurement RMS Values: L1 Phase = 0.0157 (m)
Maximum PDOP Value: 3.1



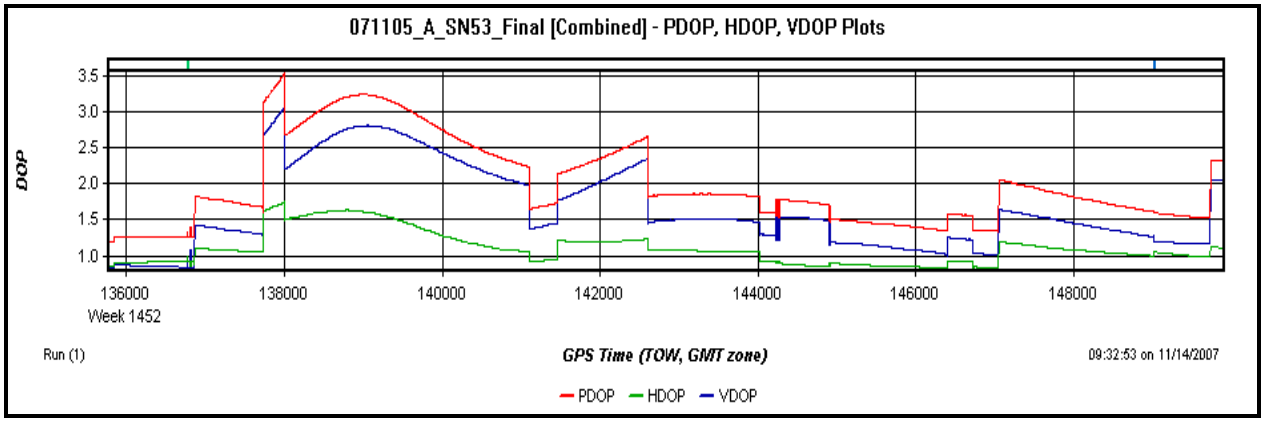
Processing Summary Information for mission 071105_A

Solution Type: Combined Fwd/Rev
Number of Epochs: 25540
Measurement RMS Values: L1 Phase = 0.0159 (m)
Maximum PDOP Value: 3.3



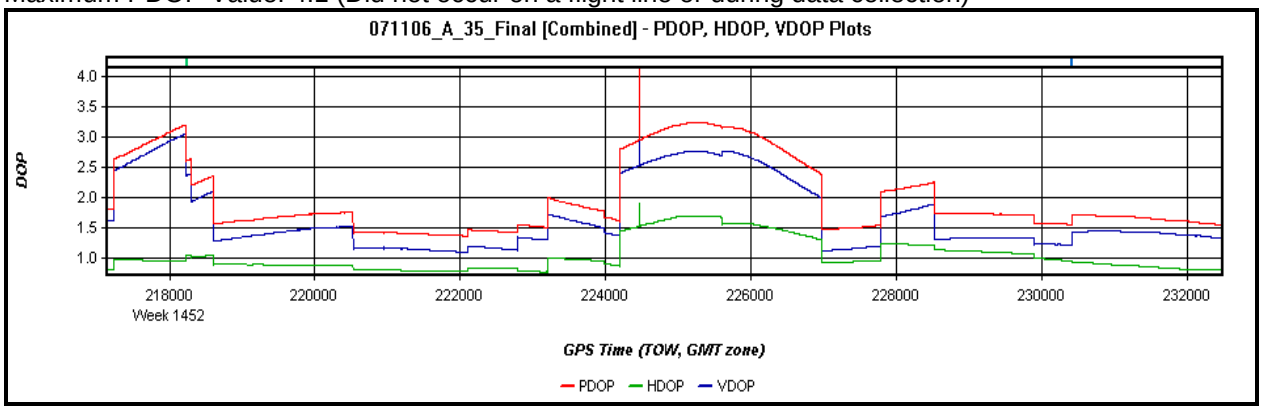
Processing Summary Information for mission 071105_A_SN53

Solution Type: Combined Fwd/Rev
Number of Epochs: 14164
Measurement RMS Values: L1 Phase = 0.0144 (m)
Maximum PDOP Value: 3.5



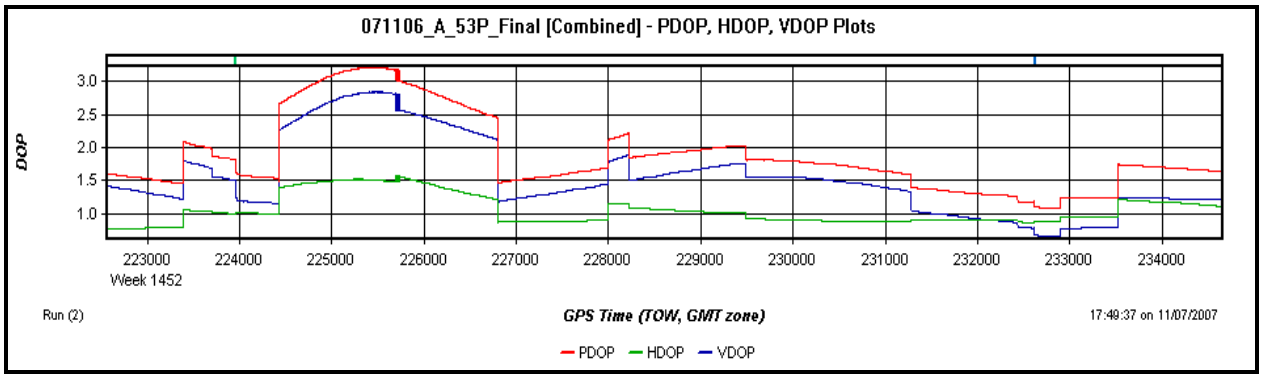
Processing Summary Information for mission 071106_A_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 30763
Measurement RMS Values: L1 Phase = 0.0187 (m)
Maximum PDOP Value: 4.1 (Did not occur on a flight line or during data collection)



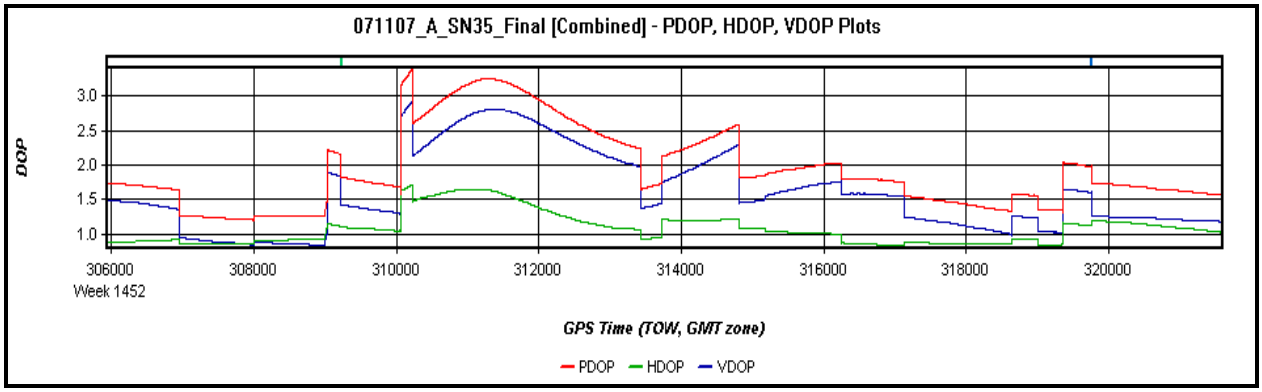
Processing Summary Information for mission 071106_A_SN53

Solution Type: Combined Fwd/Rev
Number of Epochs: 12119
Measurement RMS Values: L1 Phase = 0.0161 (m)
Maximum PDOP Value: 3.2



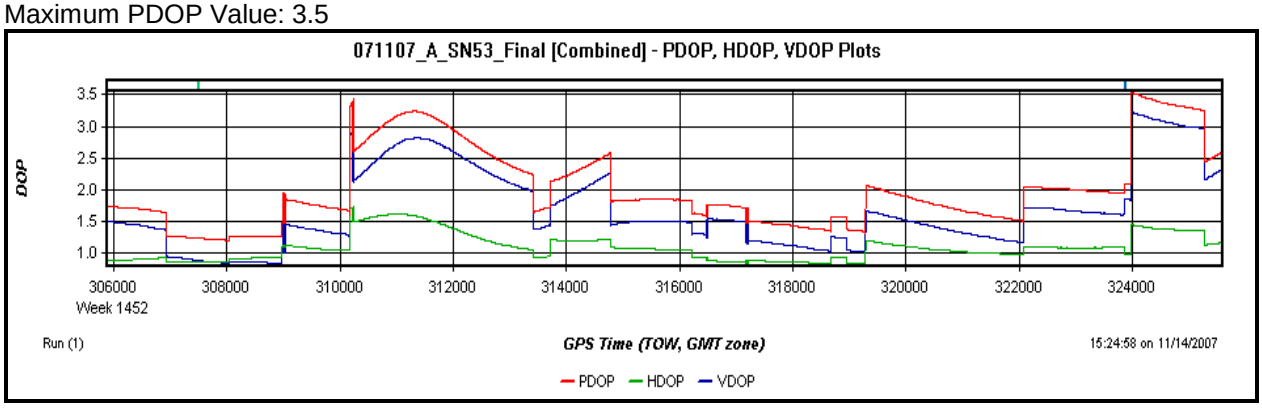
Processing Summary Information for mission 071107_A_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 31393
Measurement RMS Values: L1 Phase = 0.0191 (m)
Maximum PDOP Value: 3.4



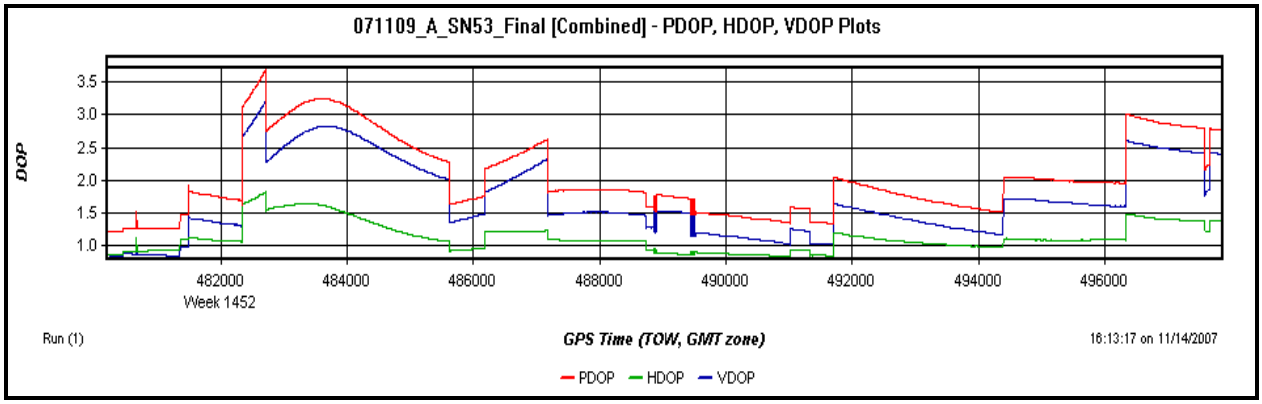
Processing Summary Information for mission 071107_A_SN53

Solution Type: Combined Fwd/Rev
Number of Epochs: 19764
Measurement RMS Values: L1 Phase = 0.0146 (m)
Maximum PDOP Value: 3.5



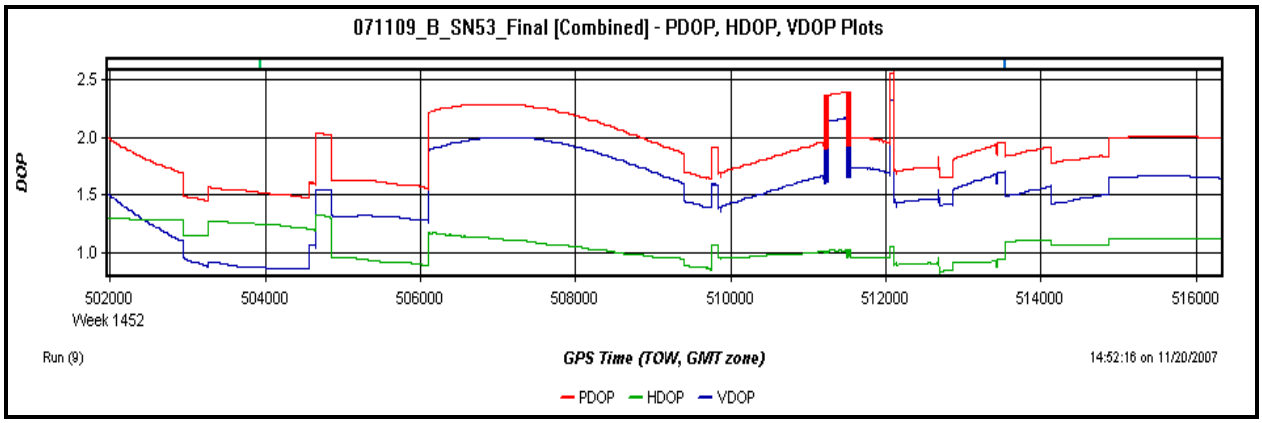
Processing Summary Information for mission 071109_A_SN53

Solution Type: Combined Fwd/Rev
Number of Epochs: 17712
Measurement RMS Values: L1 Phase: 0.0206 (m)
Maximum PDOP Value: 3.7



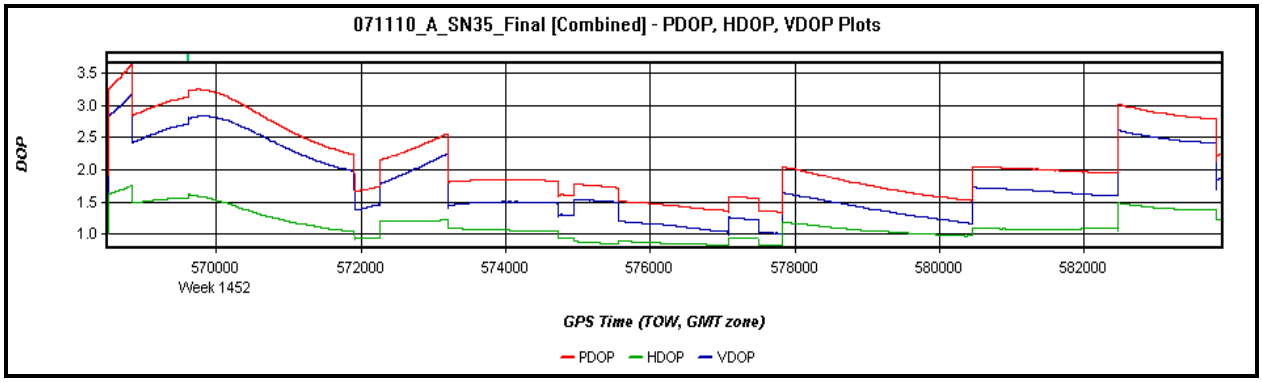
Processing Summary Information for mission 071109_B_SN53

Solution Type: Combined Fwd/Rev
Number of Epochs: 14415
Measurement RMS Values: L1 Phase = 0.0155 (m)
Maximum PDOP Value: 2.6



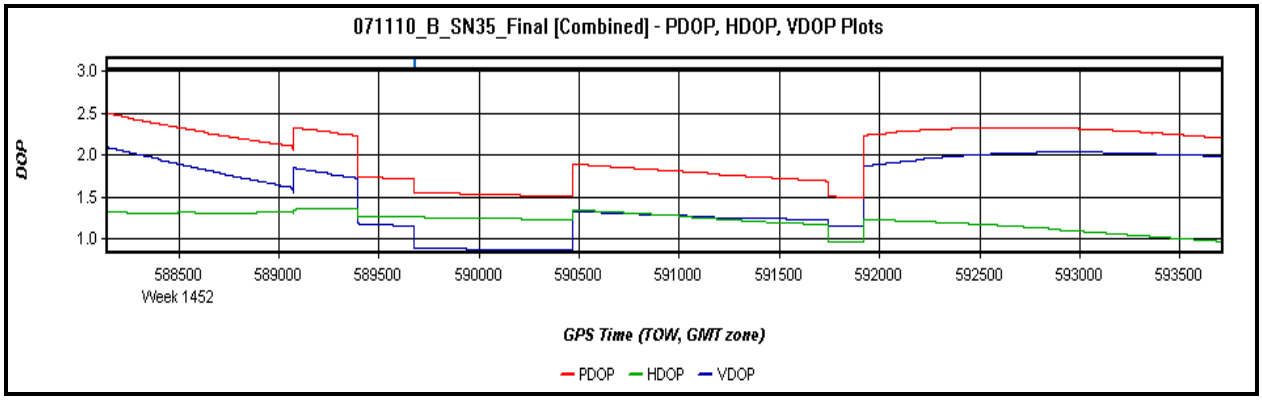
Processing Summary Information for mission 071110_A_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 30927
Measurement RMS Values: L1 Phase = 0.0153 (m)
Maximum PDOP Value: 3.6



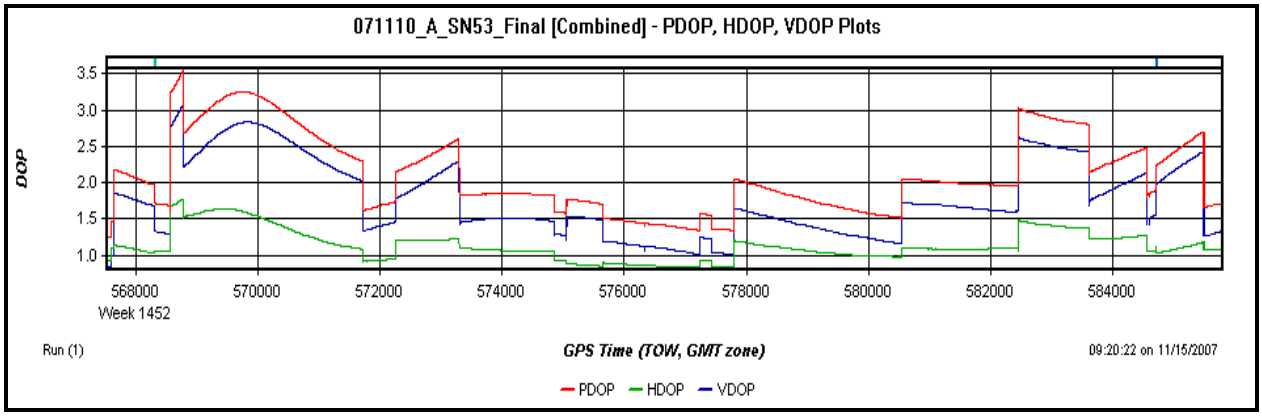
Processing Summary Information for mission 071110_B_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 11172
Measurement RMS Values: L1 Phase = 0.0180 (m)
Maximum PDOP Value: 2.5



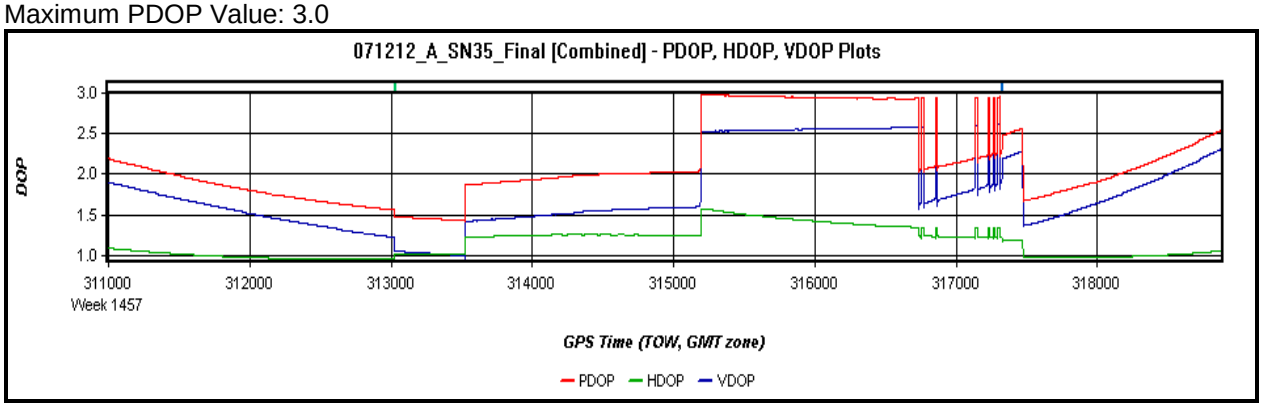
Processing Summary Information for mission 071110_A_SN53

Solution Type: Combined Fwd/Rev
Number of Epochs: 18310
Measurement RMS Values: L1 Phase = 0.0147 (m)
Maximum PDOP Value: 3.5



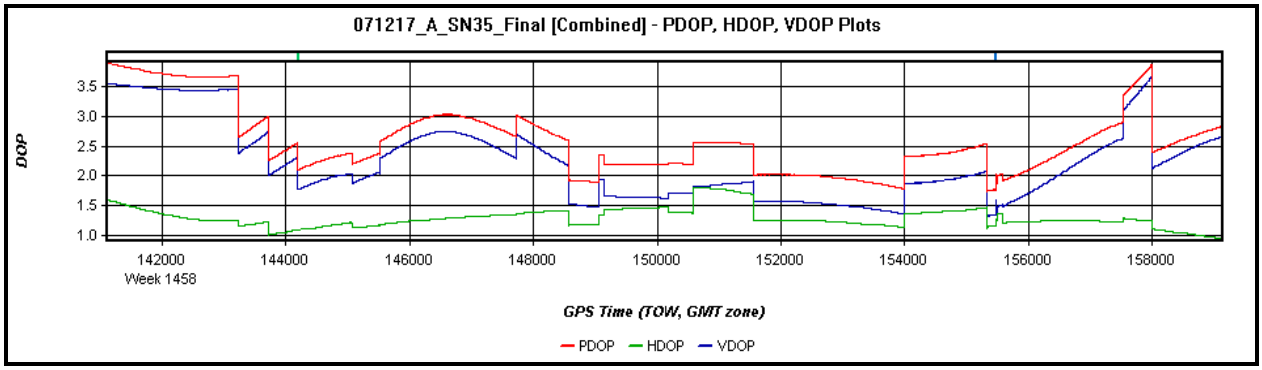
Processing Summary Information for mission 071212_A_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 15832
Measurement RMS Values: L1 Phase = 0.0196 (m)
Maximum PDOP Value: 3.0



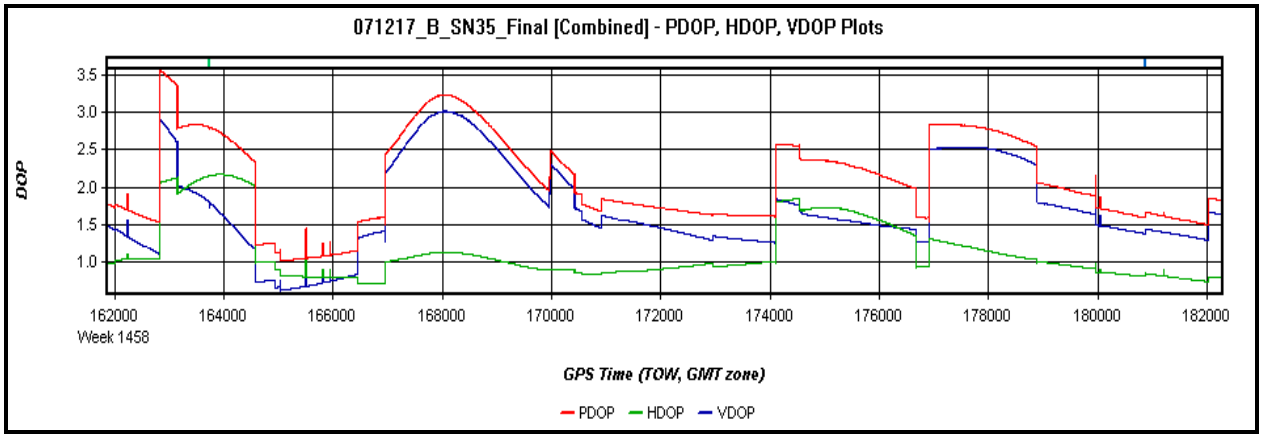
Processing Summary Information for mission 071217_A_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 36160
Measurement RMS Values: L1 Phase = 0.0178 (m)
Maximum PDOP Value: 3.9



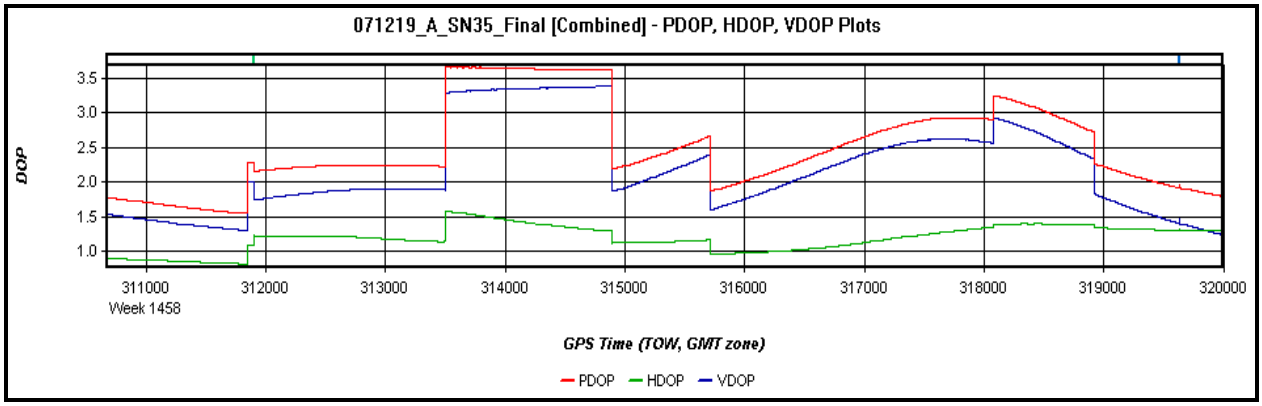
Processing Summary Information for mission 071217_B_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 40948
Measurement RMS Values: L1 Phase = 0.0153 (m)
Maximum PDOP Value: 3.6



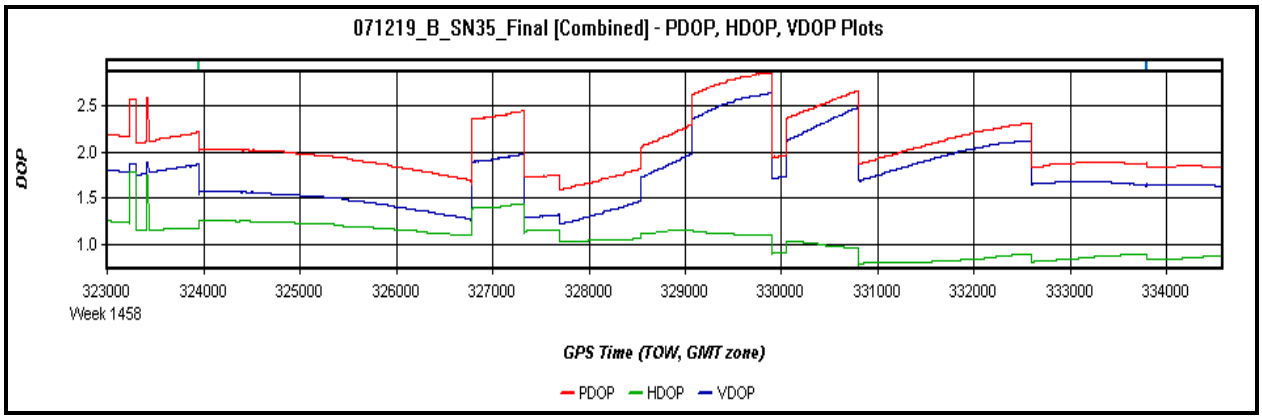
Processing Summary Information for mission 071219_A_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 18685
Measurement RMS Values: L1 Phase = 0.0157 (m)
Maximum PDOP Value: 3.7



Processing Summary Information for mission 071219_B_SN35

Solution Type: Combined Fwd/Rev
Number of Epochs: 23235
Measurement RMS Values: L1 Phase = 0.0175 (m)
Maximum PDOP Value: 2.9



GROUND CONTROL REPORT / CHECK POINT SURVEY RESULTS

GPS Controls

Multiple Ground GPS Base Stations, for the LiDAR data collection, were set up every mission. One base GPS receiver located at the airport was operational every day. Multiple ground GPS receivers were placed within the job boundary and under the flight lines or close to the flight lines for that day. All ground GPS Base Stations were free from obstructions with a clear and open view of the sky. Distance between ground GPS Base Stations is approximately 20 miles or less. See spreadsheet below for Ground GPS Base Station information. The spreadsheet below also shows the NGS (National Geodetic Survey) and CORS (Continually Operating Reference Stations) stations used as horizontal and vertical Control.

Project: Herbert Hoover Dike Florida
Job#: 02015609
Date: Sept 2007

Coordinate System: Florida State Plane
Zone: Florida East Zone
Datum: NAD83(HARN) (North America Datum 1983 adjustment of 1999)
Vertical Datum: NAVD88 using Geoid 2003 for Ellipsoid Heights
Units: US Survey Feet (Also Meters for Heights)

PT#	GEODETIC NAD83(1999)		ELLIPSOID	ELLIPSOID	DESCRIPTION
NAME	LATITUDE	LONGITUDE	HEIGHT	HEIGHT	
	NORTH	WEST	GEOID03	GEOID03	
	DEG MIN SEC	DEG MIN SEC	METERS	US FEET	
FLGPS_57	26°58'40.50800"N	81°06'39.55349"W	-20.390	-66.90	NGS FLGPS 57
K 413	26°41'04.28231"N	80°19'51.83212"W	-21.068	-69.12	NGS K 413
Y 530	26°27'32.60151"N	81°07'28.89820"W	-17.346	-56.91	NGS Y 530
TIDAL_1	26°39'48.66428"N	80°42'44.93607"W	-18.885	-61.96	NGS TIDAL 1
AIRPORT	26°44'15.66910"N	81°03'17.87454"W	-19.002	-62.34	NGS AIRPORT
OKCB	27°15'57.71572"N	80°51'19.18212"W	-13.646	-44.77	CORS OKCB (Phase Center)
PBCH	26°50'46.63828"N	80°13'09.30062"W	-15.200	-49.87	CORS PBCH (Phase Center)
M_Base	26°40'43.72332"N	80°04'56.26391"W	-16.977	-55.70	Airport Base 0n Roof
FDEM_BC1	26°19'33.46853"N	80°59'23.15546"W	-19.088	-62.62	ALUM DISC 3501
FDEM_PB1	26°43'24.17452"N	80°39'52.62600"W	-21.415	-70.26	ALUM DISC 3501
FDEM_S7	26°20'08.08252"N	80°32'10.72184"W	-16.938	-55.57	ALUM DISC 3501
S_410X	26°21'16.72086"N	80°47'29.55230"W	-19.205	-63.01	NGS S 410 X
C358	27°14'11.06461"N	81°03'14.29931"W	-16.538	-54.26	BRASS DISC
STAR	26°56'37.37676"N	80°36'40.71676"W	-15.379	-50.46	STEEL ROD

PT#	SP NAD83(1999) Florida East		NAVD88	NAVD88	DESCRIPTION
NAME	NORTHING	EASTING	ELEVATION	ELEVATION	
	Y	X	Z	Z	
	US FEET	US FEET	METERS	US FEET	

FLGPS_57	961160.73	620020.03	4.57	14.99	NGS FLGPS 57
K 413	855068.66	874592.70	4.58	15.04	NGS K 413
Y 530	772562.09	615371.38	7.28	23.90	NGS Y 530
TIDAL_1	846966.65	750065.36	6.11	20.06	NGS TIDAL 1
AIRPORT	873824.21	638227.59	5.59	18.34	NGS AIRPORT
OKCB	1065904.89	703163.25	12.94	42.46	CORS OKCB (Phase Center)
PBCH	914080.24	910743.56	11.29	37.03	CORS PBCH (Phase Center)
M_Base	853497.81	955841.22	9.32	30.58	Airport Base 0n Roof
FDEM_BC1	724166.59	659518.89	5.72	18.78	ALUM DISC 3501
FDEM_PB1	868765.00	765639.83	3.74	12.26	ALUM DISC 3501
FDEM_S7	727933.86	808030.92	7.99	26.20	ALUM DISC 3501
S_410X	734646.41	724427.85	5.60	18.36	NGS S 410 X
C358	1055112.11	638629.22	9.47	31.07	BRASS DISC
STAR	948906.48	782795.21	10.63	34.89	STEEL ROD

Ground Control Parameters

Horizontal: The horizontal datum for the project is the Florida State Plane, East Zone, North American Datum of 1983/High Accuracy Reference Network (NAD83/HARN), NAD83 uses the GRS80 ellipsoid Florida HARN = adjustment on 1999.

Vertical Datum: The Vertical datum for the project is North American Vertical Datum of 1988 (NAVD88).

Geiod Model: Geoid03 (Geoid 03 will be used to convert ellipsoid heights to orthometric heights).

Units: Horizontal units are in US Survey Feet, Vertical units are in US Survey Feet.

Ground Survey Control Report

The following listing shows the newly established GPS ground control, collected for LiDAR check points. The new ground control points (check points) were established and surveyed by Gustin, Cothern & Tucker, Inc., Surveyors and Engineers, located in Niceville Florida, and Merrick and Company surveyors.

Project: HHD Florida
Job#: 02015609
Date: Dec. 2007

Coordinate System: US State Plane 1983(1999)
Zone: Florida East
Project Datum: NAD83(1999)
Vertical Datum: NAVD88 (GEOID2003)
Units: USFeet

PT#	**SP NAD83(1999) Florida East**		**NAVD88**
Name	**Northing**	**Easting**	**Elevation**
	Y	**X**	**Z**
	USFeet	**USFeet**	**USFeet**

2037	874355.57	687892.02	17.41
2039	879844.23	678515.64	16.03
2041	877555.81	675669.07	16.76
2042	879451.32	672227.02	16.85
2044	879924.33	657809.08	19.17
2087	919237.66	776460.91	15.87
2114	1039969.88	706883.82	25.59
2163	854542.01	920021.03	17.28
2164	864604.21	922214.16	19.47
2165	863580.02	910099.68	18.32
2500	906325.88	767221.16	17.42
2501	904436.35	766816.07	12.46
2502	900439.92	769142.73	13.63
2503	904657.06	764278.17	16.04
2504	905666.60	764837.87	36.84
2505	892478.93	756930.04	14.13
2506	878229.88	759513.89	12.68
2507	868602.44	765911.57	13.41
2508	859191.57	764383.23	13.50
2509	855087.19	764144.49	15.75
2510	852232.93	766189.46	11.57
2511	851173.37	763484.39	12.08
2512	848882.57	763991.56	12.22
2513	848402.28	760372.95	11.77
2514	847314.56	749935.17	18.08
2515	846182.42	749651.04	13.66
2516	846578.95	749023.21	14.36
2517	847030.99	747977.44	12.07
2518	847812.32	746738.21	12.01
2519	848499.60	748424.61	15.72
2520	851679.53	758219.84	13.94
2521	857652.30	759397.73	15.16
2116	1019408.53	694726.46	17.37
CP1001	1065258.28	725083.58	30.69
CP1002	1060281.86	724888.21	29.37
CP1003	1064872.51	709898.45	26.80
CP1004	1059872.75	734609.07	32.88
CP1005	1055389.25	739602.59	32.38
CP1007	1048061.71	743973.99	28.63
CP1008	1045680.84	745996.92	37.34
CP1009	1039698.90	751604.77	28.16
CP1010	1034769.76	755601.69	26.99
CP1011	1039844.69	754418.79	29.05
CP1012	1035205.05	766283.09	30.53
CP1014	1020999.30	769436.71	30.78
CP1015	1018646.31	773054.02	29.06
CP1016	1014108.17	778942.19	28.77
CP1017	1012369.24	784875.55	29.79

CP1018	1010593.37	791317.52	31.50
CP1021	980690.22	799938.66	24.56
CP1022	968847.77	799871.15	26.03
CP1024	954236.38	814683.97	24.75
CP1025	939904.70	824312.94	25.97
CP1026	918680.97	846377.79	21.81
CP1027	913133.59	848598.35	21.49
CP1028	904160.15	856282.38	22.10
CP1029	903131.65	864643.45	23.67
CP1030	902926.01	875529.87	21.03
CP1035	901333.64	917967.48	20.37
CP1036	884937.21	917328.96	20.44
CP1041	854964.76	935193.78	15.84
CP1048	850210.66	885192.94	17.73
CP1049	852206.62	874562.58	24.41
CP1050	852803.79	864165.18	22.85
CP1051	821573.66	837274.68	15.19
CP1055	759382.88	825382.82	20.08
CP1058	726741.24	729879.82	16.58
CP1059	726949.39	759439.06	16.43
CP1061	721271.44	703065.90	12.87
CP1062	722042.58	683855.75	14.99
CP1063	729951.62	673779.70	16.42
CP1065	745850.24	668483.07	18.26
CP1066	748431.97	657966.96	26.56
CP1067	756697.89	654877.57	20.85
CP1069	772944.16	647042.71	25.86
CP1070	772976.47	640394.12	26.48
CP1071	782840.68	637242.52	25.52
CP1073	801277.72	632807.96	27.21
CP1074	807251.40	627657.72	27.10
CP1075	817690.25	622309.44	27.76
CP1076	824769.37	614542.19	28.80
CP1077	831606.43	615752.21	26.22
CP1078	836916.20	615039.85	25.76
CP1079	847494.90	608196.74	26.55
CP1080	847296.22	594292.13	27.23
CP1081	852682.48	594157.63	25.22
CP1082	852477.55	584843.02	27.11
CP1083	861698.15	586025.87	21.83
CP1084	865631.12	584754.27	21.47
CP1085	876751.05	581159.87	20.10
CP1086	872053.70	580166.65	21.26
CP1088	890552.00	580676.13	17.01
CP1089	905246.65	575552.82	21.50
CP1090	914367.57	582101.19	24.45
CP1091a	917679.23	585380.69	23.29
CP1092	922338.72	599767.98	19.74
CP1093	940388.98	579483.45	24.99

CP1094	937012.71	566230.06	34.94
CP1095	940608.85	552342.21	41.36
CP1096	949456.55	552818.80	42.27
CP1097	949423.08	555751.70	39.92
CP1100	964884.78	568772.90	37.41
CP1101	975650.78	565949.93	38.47
CP1102	986257.64	572514.20	36.38
CP1104	1013139.89	575793.99	36.01
CP1105	1026209.16	575580.39	32.73
CP1106	1034046.14	581110.75	34.99
CP1107	1019126.06	590670.04	34.28
CP1108	1017521.28	603000.60	27.78
CP1109	1009356.14	607542.65	28.76
CP1110	1013662.03	629140.22	25.94
CP1111	1008215.69	620020.83	26.32
CP1112	1020433.71	639137.68	23.40
CP1113	1028979.18	646888.77	25.49
CP1114	1040350.51	654822.50	26.08
CP1115	1047308.49	654751.57	30.25
CP1116	1057156.70	664170.71	28.13
CP1117	1057738.74	676910.45	29.84
CP1118	1057738.43	688553.78	29.53
CP1124	1039882.62	733246.83	27.05
CP1129	1009713.74	765444.13	20.72
CP1131	993850.53	769662.71	20.63
CP1132	988314.97	772082.33	17.45
CP1134	969815.95	779230.97	19.22
CP1135	959705.75	782294.11	19.27
CP1136	943700.74	782633.83	17.76
CP1139	895887.93	755886.91	14.75
CP1140	885318.87	757643.65	11.80
CP1141	878650.57	759823.81	12.06
CP1142	872282.93	759289.66	14.42
CP1143	869609.12	753974.53	12.30
CP1144	862242.23	748203.67	18.33
CP1145	853937.03	744161.31	39.92
CP1146	853651.57	737613.64	17.39
CP1147	855915.41	733754.04	16.93
CP1148	859540.65	726631.89	16.55
CP1149	858980.07	721150.02	16.22
CP1150	864564.83	709553.48	15.46
CP1151	874651.84	695980.27	17.49
CP1152	878432.90	688143.64	17.14
CP1155	894452.81	666315.46	16.45
CP1156	899939.46	660869.71	14.35
CP1157	900924.69	647654.79	15.25
CP1158	902166.57	642363.43	13.64
CP1159	904468.92	631899.90	15.93
CP1160	908541.73	631218.22	15.59

CP1161	911385.68	623484.82	14.51
CP1162	920179.44	616183.82	17.87
CP1163	927412.00	616206.89	18.98
CP1164	931232.73	616229.23	17.21
CP1165	939854.53	616283.98	24.11
CP1166	943263.70	616302.48	21.59
CP1167	951806.46	616360.96	21.07
CP1168	956070.89	616928.23	23.11
CP1169	960411.08	618987.36	16.28
CP1170	963389.38	622882.16	16.05
CP1171	963373.31	628519.87	16.48
CP1172	968753.75	632925.94	16.67
CP1173	971061.12	639004.01	17.13
CP1174	973391.82	645821.22	15.42
CP1175	979014.25	652502.93	17.93
CP1176	984312.99	658348.21	17.24
CP1177	993127.90	663187.57	29.66
CP1178	1001822.82	668623.80	19.49
CP1179	1008428.44	674699.79	20.54
CP1180	1013652.34	683007.18	20.71
CP1182	1021427.88	695468.86	19.06
CP1185	1039346.09	705688.65	20.63
CP1186	1040397.36	665467.52	23.63
CP1188	1027423.64	759023.53	25.57
CP1190	980529.65	782321.84	19.25
CP1191	932724.78	808552.26	16.35
CP1193	901255.55	782416.74	16.20
CP1194	885397.61	843200.00	13.29
CP1196	853658.91	820127.68	12.23
CP1197	869883.55	793646.95	13.59
CP1198	840390.84	791784.00	19.44
CP1200	839271.24	763476.63	14.08
CP1202	780406.05	807915.53	11.87
CP1203	750752.21	791243.89	13.51
CP1204	815473.83	757145.68	11.15
CP1205	777067.36	772743.85	13.23
CP1207	756260.95	765681.95	10.96
CP1209	816856.36	738653.16	13.96
CP1210	757883.05	686803.15	18.48
CP1211	837800.83	711837.17	14.64
CP1212	795568.39	711200.87	16.83
CP1213	821772.54	690922.89	14.83
CP1214	848267.34	688080.89	14.92
CP1215	800323.47	673130.39	16.28
CP1216	787011.75	688854.08	12.36
CP1217	776017.88	665413.44	19.17
CP1219	864027.39	666956.03	18.70
CP1220	818689.65	643421.73	22.39
CP1221	850808.58	635234.02	21.56

CP1224	900952.87	599882.47	16.57
CP1225	948146.69	595521.88	31.98
CP1228	989839.04	593057.70	30.31
CP1229	981282.53	615593.95	23.16
CP1230	995269.15	633195.29	23.00
CP1231	1002402.06	654192.97	30.80
CP1233	1030402.75	674621.99	25.58
CP1234	883812.77	819573.01	17.49
CP1235	864437.61	842732.14	14.98
CP1236	834094.97	813526.16	11.08
CP1237	795016.75	760130.06	13.13
CP1238	874044.36	905364.29	19.23
CP1239	878958.33	867185.72	18.30
CP1240	755950.55	719710.41	21.58
CP1241	859120.01	775066.58	14.67
CP1242	872209.22	601061.44	21.30
CP1243	737002.68	695068.24	19.44
CP1244	973814.49	593706.12	25.51
CP1245	927728.14	793052.52	11.72
CP1247	882842.44	777786.51	11.03
CP1248	889916.01	875620.89	21.11
CP1249	868340.57	896037.87	19.83
CP1250	794502.28	789649.51	12.99
CP1251	743234.86	681500.06	23.39
CP1253	774241.13	705340.22	16.85
CP1254	803028.94	696586.17	12.98
CP1255	816609.78	714784.92	11.06
CP1256	779808.06	726138.76	12.10
CP1257	795643.40	744331.07	10.78
CP1258	835263.97	727693.32	10.87
CP1259	835235.61	743648.87	12.42
CP1261	803842.32	725566.82	11.02
CP1301-PA1	864632.26	687363.81	13.50
CP1302-PA1	865368.37	690807.59	12.01
CP1304-PA1	872884.64	688067.17	16.12
CP2000	865889.22	690738.15	10.46
CP2005	864982.70	687018.15	13.35
CP2009	864208.92	698696.28	11.87
FDEM_BC1	659518.89	724166.59	18.78
CP3001	888318.09	828219.19	10.03
CP3002	888119.99	787767.01	10.85
CP3003	802304.62	819837.73	15.04
CP3004	828640.02	801290.30	16.43
CP3005	761414.21	783740.80	13.95
CP3006	814141.12	750726.50	15.65
CP3008	779867.01	714597.94	21.13
CP3010	843074.38	685411.47	16.67
CP5101	847356.89	759271.25	9.96
CP5102	844484.63	758296.19	11.20

CP5104	872607.46	765148.29	10.52
CP5109	858816.06	757815.83	15.45
CP5124	1007038.43	787922.99	29.52
CP5125	990144.93	799882.82	31.26
CP5127	902978.15	870246.50	24.00
CP5129	855071.01	877269.60	15.91
CP5130	864381.18	917044.88	18.53
CP5132	873668.95	669689.83	18.47
CP5139	903085.67	621361.24	13.55
CP5147	962886.92	622198.93	16.45
CP5149	962672.25	626517.12	17.94
CP5150	965650.97	630243.27	16.45
CP5152	968309.35	632175.03	16.41
CP5155	972181.92	642592.34	17.08
CP5156	1014139.17	689334.47	17.68
CP5157	1018717.35	691128.89	19.41
CP5158	1018263.10	694322.57	17.94
CP5159	1021726.67	696024.70	16.81
CP5160	1022498.37	697131.74	21.61
CP5161	1022418.39	699136.00	19.27
CP5163	1022664.78	700231.47	19.21
CP5164	1023351.10	700240.30	18.73
CP5165	1024612.79	698829.07	21.98
CP5166	1024883.20	697722.28	19.12
CP5170	1028260.94	701188.62	14.50
CP5172	1029318.98	701335.61	19.15
CP5175	1032389.26	703037.06	18.90
CP5192	1054792.93	711534.90	23.47
CP5209	1067815.97	711151.20	27.06
CP5212	1070344.33	707525.85	30.96
CP5213	1070843.42	705357.13	33.29
CP5214	1068376.09	705363.61	30.98
CP5215	1070807.58	704080.16	31.68
CP5216	1068348.04	704079.25	32.48
CP5217	1070810.78	702493.23	33.57
CP5218	1068300.93	702506.99	32.61
CP5219	1070823.89	700914.13	33.77
CP5220	1065827.59	700944.13	30.83
CP5223	1067669.98	694905.29	33.10
CP5224	1062847.63	694875.64	31.94
CP5225	1067648.90	686381.81	31.57
CP5226	1065686.63	689940.91	30.53
CP5306	732541.66	669118.38	17.84
CP5313	754000.62	656433.55	19.69

LiDAR Control Report (LiDAR Accuracy / Validation Results)

The following listing shows the results of the LiDAR data compared to the GPS ground survey control data. The listing is sorted by the **Z Error** column showing, in ascending order, the vertical difference between the LiDAR points and the surveyed ground control points.

Post-Filter Control Report for Herbert_Hoover_Dike

Project File: MARSProjectHHD
Date: March 06: 2009
Vertical Accuracy Objective
Requirement Type: Accuracy(z)
Accuracy(z) Objective: 0.60
Confidence Level: 95%
Control Points in Report: 288
Elevation Calculation Method: Interpolated from TIN
Control Points with LiDAR Coverage: 256
Control Points with Required Accuracy (+/- 0.60): 248
Percent of Control Points with Required Accuracy (+/- 0.60): 96.88
Average Control Error Reported: -0.04
Maximum (highest) Control Error Reported: 0.82
Median Control Error Reported: -0.03
Minimum (lowest) Control Error Reported: -1.16
Standard deviation (sigma) of Z for sample: 0.29
RMSE of Z for sample (RMSE(z)): 0.29: PASS
FGDC/NSSDA Vertical Accuracy (Accuracy(z)): 0.57: PASS
NSSDA Achievable Contour Interval: 1.0
ASPRS Class 1 Achievable Contour Interval: 0.9
NMAS Achievable Contour Interval: 1.0

Control	Control Pt.	Control Pt.	Coverage	Control Pt.	from LiDAR	**Z Error**	Min Z	Median Z	Max Z
Point Id	X(East)	Y(North)		Z(Elev)	Z(Elev)				
	USFeet	USFeet		USFeet	USFeet	**USFeet**	USFeet	USFeet	USFeet
2116	694726.46	1019408.53	Yes	17.37	16.21	**-1.16**	16.18	16.20	16.25
2042	672227.02	879451.32	Yes	16.85	16.16	**-0.69**	16.10	16.16	16.20
2044	657809.08	879924.33	Yes	19.17	18.49	**-0.68**	18.42	18.49	18.65
1055	825382.82	759382.88	Yes	20.08	19.42	**-0.66**	18.82	19.47	19.66
3003	819837.73	802304.62	Yes	15.04	14.38	**-0.66**	14.37	14.38	14.41
2511	763484.39	851173.37	Yes	12.08	11.49	**-0.59**	11.36	11.53	11.60
1202	807915.53	780406.05	Yes	11.87	11.28	**-0.59**	10.77	11.31	11.34
3001	828219.19	888318.09	Yes	10.03	9.45	**-0.58**	9.33	9.58	9.66
2506	759513.89	878229.88	Yes	12.68	12.11	**-0.57**	12.04	12.19	12.25
1152	688143.64	878432.90	Yes	17.14	16.58	**-0.56**	16.51	16.62	16.67

1196	820127.68	853658.91	Yes	12.23	11.68	**-0.55**	11.57	11.66	11.71
2512	763991.56	848882.57	Yes	12.22	11.68	**-0.54**	11.00	11.41	11.90
1148	726631.89	859540.65	Yes	16.55	16.01	**-0.54**	15.87	15.96	16.04
2009	698696.28	864208.92	Yes	11.87	11.34	**-0.53**	11.04	11.33	11.39
1021	799938.66	980690.22	Yes	24.56	24.04	**-0.52**	23.94	23.97	24.10
1258	727693.32	835263.97	Yes	10.87	10.35	**-0.52**	10.10	10.17	10.42
3004	801290.30	828640.02	Yes	16.43	15.91	**-0.52**	15.55	15.93	15.98
2508	764383.23	859191.57	Yes	13.50	12.99	**-0.51**	12.97	12.98	13.20
1261	725566.82	803842.32	Yes	11.02	10.52	**-0.50**	10.48	10.52	10.55
2037	687892.02	874355.57	Yes	17.41	16.92	**-0.49**	16.74	16.90	16.98
2041	675669.07	877555.81	Yes	16.76	16.27	**-0.49**	16.15	16.29	16.88
2519	748424.61	848499.60	Yes	15.72	15.25	**-0.47**	14.81	15.05	15.57
1022	799871.15	968847.77	Yes	26.03	25.56	**-0.47**	25.50	25.55	25.71
1049	874562.58	852206.62	Yes	24.41	23.94	**-0.47**	23.77	24.35	24.50
1221	635234.02	850808.58	Yes	21.56	21.11	**-0.45**	21.05	21.41	21.56
1051	837274.68	821573.66	Yes	15.19	14.75	**-0.44**	14.39	14.74	14.83
1245	793052.52	927728.14	Yes	11.72	11.29	**-0.43**	7.42	11.94	11.99
1149	721150.02	858980.07	Yes	16.22	15.80	**-0.42**	15.49	15.72	15.89
3010	685411.47	843074.38	Yes	16.67	16.25	**-0.42**	16.23	16.29	16.31
1236	813526.16	834094.97	Yes	11.08	10.67	**-0.41**	10.66	10.68	10.71
1067	654877.57	756697.89	Yes	20.85	20.45	**-0.40**	20.26	20.40	20.50
1171	628519.87	963373.31	Yes	16.48	16.08	**-0.40**	16.04	16.14	16.20
1214	688080.89	848267.34	Yes	14.92	14.52	**-0.40**	14.37	14.63	14.68
1176	658348.21	984312.99	Yes	17.24	16.85	**-0.39**	16.74	16.78	17.01
1256	726138.76	779808.06	Yes	12.10	11.72	**-0.38**	11.55	11.72	12.00
5152	632175.03	968309.35	Yes	16.41	16.03	**-0.38**	15.99	16.08	16.32
1151	695980.27	874651.84	Yes	17.49	17.12	**-0.37**	17.03	17.13	17.21
1170	622882.16	963389.38	Yes	16.05	15.69	**-0.36**	15.49	15.87	15.88
5155	642592.34	972181.92	Yes	17.08	16.72	**-0.36**	16.51	16.73	17.02
1088	580676.13	890552.00	Yes	17.01	16.66	**-0.35**	16.60	16.71	16.76
5192	711534.90	1054792.93	Yes	23.47	23.12	**-0.35**	23.05	23.08	23.59
1209	738653.16	816856.36	Yes	13.96	13.62	**-0.34**	13.60	13.70	13.71
1113	646888.77	1028979.18	Yes	25.49	25.16	**-0.33**	25.13	25.27	25.27
1182	695468.86	1021427.88	Yes	19.06	18.74	**-0.32**	18.69	18.75	18.91
1157	647654.79	900924.69	Yes	15.25	14.94	**-0.31**	14.86	14.89	15.67
5160	697131.74	1022498.37	Yes	21.61	21.30	**-0.31**	21.14	21.25	21.82
5132	669689.83	873668.95	Yes	18.47	18.17	**-0.30**	18.06	18.20	18.30
2163	920021.03	854542.01	Yes	17.28	16.99	**-0.29**	16.90	16.94	17.16
5165	698829.07	1024612.79	Yes	21.98	21.69	**-0.29**	21.51	21.61	22.02
1025	824312.94	939904.70	Yes	25.97	25.69	**-0.28**	25.48	25.78	25.94
1175	652502.93	979014.25	Yes	17.93	17.66	**-0.27**	17.56	17.69	17.79

1145	744161.31	853937.03	Yes	39.92	39.66	**-0.26**	39.62	39.62	39.71
1107	590670.04	1019126.06	Yes	34.28	34.03	**-0.25**	33.79	33.95	34.04
1219	666956.03	864027.39	Yes	18.70	18.45	**-0.25**	18.05	18.30	18.49
1237	760130.06	795016.75	Yes	13.13	12.88	**-0.25**	12.53	12.99	13.52
5147	622198.93	962886.92	Yes	16.45	16.20	**-0.25**	15.97	16.07	16.66
2521	759397.73	857652.30	Yes	15.16	14.92	**-0.24**	14.81	14.89	15.03
1200	763476.63	839271.24	Yes	14.08	13.84	**-0.24**	13.75	13.94	14.30
5156	689334.47	1014139.17	Yes	17.68	17.44	**-0.24**	17.43	17.46	17.46
5157	691128.89	1018717.35	Yes	19.41	19.17	**-0.24**	18.88	19.04	19.29
1141	759823.81	878650.57	Yes	12.06	11.83	**-0.23**	11.52	11.57	12.00
1248	875620.89	889916.01	Yes	21.11	20.88	**-0.23**	20.70	20.91	21.01
2164	922214.16	864604.21	Yes	19.47	19.25	**-0.22**	19.24	19.26	19.28
2510	766189.46	852232.93	Yes	11.57	11.35	**-0.22**	11.32	11.38	11.52
1097	555751.70	949423.08	Yes	39.92	39.70	**-0.22**	39.43	39.76	39.76
1249	896037.87	868340.57	Yes	19.83	19.61	**-0.22**	19.59	19.61	19.64
2520	758219.84	851679.53	Yes	13.94	13.73	**-0.21**	13.62	13.62	13.81
1185	705688.65	1039346.09	Yes	20.63	20.42	**-0.21**	20.16	20.62	20.66
1215	673130.39	800323.47	Yes	16.28	16.07	**-0.21**	15.88	16.25	16.46
1230	633195.29	995269.15	Yes	23.00	22.80	**-0.20**	22.68	22.82	22.96
1240	719710.41	755950.55	Yes	21.58	21.38	**-0.20**	21.32	21.37	21.59
2516	749023.21	846578.95	Yes	14.36	14.17	**-0.19**	12.67	14.26	14.45
5101	759271.25	847356.89	Yes	9.96	9.77	**-0.19**	9.70	9.88	9.93
2502	769142.73	900439.92	Yes	13.63	13.45	**-0.18**	13.28	13.49	13.50
2509	764144.49	855087.19	Yes	15.75	15.57	**-0.18**	15.52	15.55	15.79
1158	642363.43	902166.57	Yes	13.64	13.46	**-0.18**	12.61	13.36	13.83
1003	709898.45	1064872.51	Yes	26.80	26.63	**-0.17**	26.50	26.63	26.70
5166	697722.28	1024883.20	Yes	19.12	18.95	**-0.17**	18.79	18.96	19.05
2501	766816.07	904436.35	Yes	12.46	12.30	**-0.16**	11.65	12.52	13.12
1085	581159.87	876751.05	Yes	20.10	19.94	**-0.16**	19.17	19.77	20.05
1142	759289.66	872282.93	Yes	14.42	14.26	**-0.16**	14.11	14.19	14.34
1146	737613.64	853651.57	Yes	17.39	17.23	**-0.16**	17.10	17.23	17.32
1225	595521.88	948146.69	Yes	31.98	31.82	**-0.16**	31.37	31.57	32.08
1001	725083.58	1065258.28	Yes	30.69	30.54	**-0.15**	30.23	30.43	30.67
1116	664170.71	1057156.70	Yes	28.13	27.98	**-0.15**	27.94	28.00	28.01
1048	885192.94	850210.66	Yes	17.73	17.59	**-0.14**	17.37	17.57	17.77
1156	660869.71	899939.46	Yes	14.35	14.21	**-0.14**	13.00	14.19	14.37
1160	631218.22	908541.73	Yes	15.59	15.45	**-0.14**	15.33	15.42	15.73
1194	843200.00	885397.61	Yes	13.29	13.15	**-0.14**	13.03	13.06	13.24
2165	910099.68	863580.02	Yes	18.32	18.19	**-0.13**	17.97	18.01	18.31
1250	789649.51	794502.28	Yes	12.99	12.86	**-0.13**	11.06	11.63	12.98
5170	701188.62	1028260.94	Yes	14.50	14.37	**-0.13**	14.34	14.40	14.65

1092	599767.98	922338.72	Yes	19.74	19.62	**-0.12**	19.47	19.59	20.21
1095	552342.21	940608.85	Yes	41.36	41.25	**-0.11**	41.15	41.33	41.42
1191	808552.26	932724.78	Yes	16.35	16.24	**-0.11**	16.10	16.18	16.32
1241	775066.58	859120.01	Yes	14.67	14.56	**-0.11**	14.46	14.63	14.80
5129	877269.60	855071.01	Yes	15.91	15.80	**-0.11**	15.55	15.69	15.82
5130	917044.88	864381.18	Yes	18.53	18.42	**-0.11**	18.38	18.48	18.64
5175	703037.06	1032389.26	Yes	18.90	18.79	**-0.11**	18.64	18.73	18.99
2503	764278.17	904657.06	Yes	16.04	15.94	**-0.10**	15.89	16.03	16.09
1027	848598.35	913133.59	Yes	21.49	21.39	**-0.10**	21.37	21.39	21.67
1129	765444.13	1009713.74	Yes	20.72	20.62	**-0.10**	20.39	20.71	20.77
2087	776460.91	919237.66	Yes	15.87	15.78	**-0.09**	15.68	15.68	15.91
1084	584754.27	865631.12	Yes	21.47	21.38	**-0.09**	21.26	21.38	21.39
1139	755886.91	895887.93	Yes	14.75	14.66	**-0.09**	14.18	14.57	14.73
1172	632925.94	968753.75	Yes	16.67	16.58	**-0.09**	16.35	16.91	17.07
1235	842732.14	864437.61	Yes	14.98	14.89	**-0.09**	14.66	14.84	14.97
1010	755601.69	1034769.76	Yes	26.99	26.91	**-0.08**	26.87	26.90	27.00
1014	769436.71	1020999.30	Yes	30.78	30.70	**-0.08**	30.50	30.60	30.79
1058	729879.82	726741.24	Yes	16.58	16.50	**-0.08**	16.21	16.45	16.54
1124	733246.83	1039882.62	Yes	27.05	26.97	**-0.08**	26.69	26.96	27.13
9002	585380.69	917679.23	Yes	23.29	23.22	**-0.07**	23.04	23.62	23.71
1094	566230.06	937012.71	Yes	34.94	34.87	**-0.07**	34.67	34.89	34.90
1118	688553.78	1057738.43	Yes	29.53	29.46	**-0.07**	29.21	29.54	29.65
1147	733754.04	855915.41	Yes	16.93	16.86	**-0.07**	16.85	16.91	16.92
1140	757643.65	885318.87	Yes	11.80	11.74	**-0.06**	11.65	11.75	11.98
1212	711200.87	795568.39	Yes	16.83	16.77	**-0.06**	16.73	16.78	16.95
1233	674621.99	1030402.75	Yes	25.58	25.52	**-0.06**	25.19	25.52	25.55
5124	787922.99	1007038.43	Yes	29.52	29.46	**-0.06**	29.37	29.47	29.55
1228	593057.70	989839.04	Yes	30.31	30.26	**-0.05**	29.86	30.26	30.36
1304	688067.17	872884.64	Yes	16.12	16.07	**-0.05**	16.00	16.18	16.23
5158	694322.57	1018263.10	Yes	17.94	17.89	**-0.05**	17.10	18.06	18.34
1012	766283.09	1035205.05	Yes	30.53	30.49	**-0.04**	30.43	30.47	30.66
1132	772082.33	988314.97	Yes	17.45	17.41	**-0.04**	17.30	17.42	17.62
1253	705340.22	774241.13	Yes	16.85	16.81	**-0.04**	16.70	16.80	16.87
1257	744331.07	795643.40	Yes	10.78	10.74	**-0.04**	10.72	10.72	10.85
5163	700231.47	1022664.78	Yes	19.21	19.17	**-0.04**	19.13	19.18	19.24
5172	701335.61	1029318.98	Yes	19.15	19.11	**-0.04**	19.11	19.12	19.18
1036	917328.96	884937.21	Yes	20.44	20.41	**-0.03**	20.19	20.35	20.48
2000	690738.15	865889.22	Yes	10.46	10.43	**-0.03**	10.29	10.44	10.52
1081	594157.63	852682.48	Yes	25.22	25.20	**-0.02**	25.10	25.20	25.39
1131	769662.71	993850.53	Yes	20.63	20.61	**-0.02**	20.37	20.39	20.79
1220	643421.73	818689.65	Yes	22.39	22.37	**-0.02**	21.92	22.41	22.46

1238	905364.29	874044.36	Yes	19.23	19.21	**-0.02**	19.10	19.26	19.46
1041	935193.78	854964.76	Yes	15.84	15.83	**-0.01**	15.75	15.77	15.85
1204	757145.68	815473.83	Yes	11.15	11.14	**-0.01**	10.48	11.39	11.41
5159	696024.70	1021726.67	Yes	16.81	16.80	**-0.01**	16.53	16.57	17.33
2504	764837.87	905666.60	Yes	36.84	36.84	**0.00**	36.63	36.87	37.04
1110	629140.22	1013662.03	Yes	25.94	25.94	**0.00**	25.70	26.06	26.22
1205	772743.85	777067.36	Yes	13.23	13.23	**0.00**	13.10	13.24	13.38
2005	687018.15	864982.70	Yes	13.35	13.35	**0.00**	13.02	13.38	13.60
5139	621361.24	903085.67	Yes	13.55	13.55	**0.00**	13.36	13.56	14.05
1017	784875.55	1012369.24	Yes	29.79	29.80	**0.01**	29.74	29.84	29.91
1105	575580.39	1026209.16	Yes	32.73	32.74	**0.01**	32.63	32.66	33.12
1167	616360.96	951806.46	Yes	21.07	21.08	**0.01**	21.05	21.08	21.08
1173	639004.01	971061.12	Yes	17.13	17.14	**0.01**	16.59	16.86	17.15
1178	668623.80	1001822.82	Yes	19.49	19.50	**0.01**	19.45	19.47	19.66
1255	714784.92	816609.78	Yes	11.06	11.07	**0.01**	10.94	11.06	11.13
5149	626517.12	962672.25	Yes	17.94	17.95	**0.01**	17.84	17.87	18.13
1076	614542.19	824769.37	Yes	28.80	28.82	**0.02**	28.68	28.72	28.96
3005	783740.80	761414.21	Yes	13.95	13.97	**0.02**	13.88	14.05	14.05
1159	631899.90	904468.92	Yes	15.93	15.96	**0.03**	15.65	15.81	16.07
1242	601061.44	872209.22	Yes	21.30	21.33	**0.03**	20.63	20.72	21.60
1108	603000.60	1017521.28	Yes	27.78	27.82	**0.04**	27.66	28.04	28.13
1211	711837.17	837800.83	Yes	14.64	14.68	**0.04**	14.58	14.67	14.74
2505	756930.04	892478.93	Yes	14.13	14.18	**0.05**	14.14	14.18	14.20
1096	552818.80	949456.55	Yes	42.27	42.32	**0.05**	42.29	42.32	42.36
1177	663187.57	993127.90	Yes	29.66	29.71	**0.05**	29.61	29.82	29.86
1197	793646.95	869883.55	Yes	13.59	13.64	**0.05**	13.41	13.55	13.89
1198	791784.00	840390.84	Yes	19.44	19.49	**0.05**	19.34	19.41	19.95
1302	690807.59	865368.37	Yes	12.01	12.06	**0.05**	10.20	12.20	12.25
1086	580166.65	872053.70	Yes	21.26	21.32	**0.06**	21.22	21.32	21.55
1164	616229.23	931232.73	Yes	17.21	17.27	**0.06**	17.19	17.38	17.55
1028	856282.38	904160.15	Yes	22.10	22.17	**0.07**	22.02	22.15	22.59
1161	623484.82	911385.68	Yes	14.51	14.58	**0.07**	14.35	14.61	14.76
1169	618987.36	960411.08	Yes	16.28	16.36	**0.08**	16.01	16.22	16.44
1231	654192.97	1002402.06	Yes	30.80	30.88	**0.08**	30.70	31.10	31.20
5164	700240.30	1023351.10	Yes	18.73	18.81	**0.08**	18.75	18.96	19.09
1030	875529.87	902926.01	Yes	21.03	21.13	**0.10**	21.01	21.13	21.23
1093	579483.45	940388.98	Yes	24.99	25.10	**0.11**	24.80	25.24	25.26
5161	699136.00	1022418.39	Yes	19.27	19.38	**0.11**	19.09	19.32	19.56
1004	734609.07	1059872.75	Yes	32.88	33.00	**0.12**	32.74	32.92	33.24
1143	753974.53	869609.12	Yes	12.30	12.42	**0.12**	12.39	12.44	12.53
1134	779230.97	969815.95	Yes	19.22	19.35	**0.13**	19.24	19.33	19.45

1166	616302.48	943263.70	Yes	21.59	21.72	**0.13**	21.66	21.73	21.76
1203	791243.89	750752.21	Yes	13.51	13.64	**0.13**	13.53	13.67	13.93
5104	765148.29	872607.46	Yes	10.52	10.65	**0.13**	10.61	10.73	10.82
5109	757815.83	858816.06	Yes	15.45	15.58	**0.13**	15.38	15.48	15.79
2507	765911.57	868602.44	Yes	13.41	13.55	**0.14**	13.49	13.57	13.67
5313	656433.55	754000.62	Yes	19.69	19.83	**0.14**	19.64	19.85	19.96
1073	632807.96	801277.72	Yes	27.21	27.36	**0.15**	27.22	27.41	27.80
1259	743648.87	835235.61	Yes	12.42	12.57	**0.15**	12.12	12.87	13.12
5102	758296.19	844484.63	Yes	11.20	11.35	**0.15**	10.92	11.26	11.62
5150	630243.27	965650.97	Yes	16.45	16.60	**0.15**	16.46	16.61	16.79
2039	678515.64	879844.23	Yes	16.03	16.19	**0.16**	16.07	16.15	16.26
1011	754418.79	1039844.69	Yes	29.05	29.21	**0.16**	29.19	29.22	29.29
1062	683855.75	722042.58	Yes	14.99	15.15	**0.16**	14.89	15.12	15.36
1065	668483.07	745850.24	Yes	18.26	18.42	**0.16**	18.29	18.42	18.44
1078	615039.85	836916.20	Yes	25.76	25.92	**0.16**	25.90	25.90	26.11
1102	572514.20	986257.64	Yes	36.38	36.54	**0.16**	36.52	36.59	36.60
1112	639137.68	1020433.71	Yes	23.40	23.56	**0.16**	23.45	23.54	24.01
1165	616283.98	939854.53	Yes	24.11	24.27	**0.16**	24.15	24.21	24.33
1217	665413.44	776017.88	Yes	19.17	19.33	**0.16**	19.30	19.33	19.58
3002	787767.01	888119.99	Yes	10.85	11.01	**0.16**	10.89	10.95	11.22
2517	747977.44	847030.99	Yes	12.07	12.24	**0.17**	12.12	12.31	12.45
1115	654751.57	1047308.49	Yes	30.25	30.42	**0.17**	30.21	30.45	30.51
1174	645821.22	973391.82	Yes	15.42	15.59	**0.17**	15.53	15.63	15.68
1244	593706.12	973814.49	Yes	25.51	25.68	**0.17**	25.57	25.66	25.71
2515	749651.04	846182.42	Yes	13.66	13.84	**0.18**	13.71	13.86	13.90
1009	751604.77	1039698.90	Yes	28.16	28.34	**0.18**	28.33	28.33	28.62
1035	917967.48	901333.64	Yes	20.37	20.55	**0.18**	20.43	20.50	20.59
1150	709553.48	864564.83	Yes	15.46	15.65	**0.19**	15.36	15.36	15.85
5127	870246.50	902978.15	Yes	24.00	24.19	**0.19**	23.78	24.24	24.45
3008	714597.94	779867.01	Yes	21.13	21.33	**0.20**	21.11	21.38	21.80
1008	745996.92	1045680.84	Yes	37.34	37.56	**0.22**	37.31	37.51	37.68
1180	683007.18	1013652.34	Yes	20.71	20.93	**0.22**	20.68	20.74	20.96
1239	867185.72	878958.33	Yes	18.30	18.52	**0.22**	18.41	18.57	18.83
1016	778942.19	1014108.17	Yes	28.77	29.00	**0.23**	28.96	29.01	29.16
1155	666315.46	894452.81	Yes	16.45	16.68	**0.23**	16.34	16.62	16.95
1301	687363.81	864632.26	Yes	13.50	13.73	**0.23**	12.75	13.71	13.86
1104	575793.99	1013139.89	Yes	36.01	36.25	**0.24**	35.88	36.43	36.59
1190	782321.84	980529.65	Yes	19.25	19.49	**0.24**	19.41	19.44	19.70
1007	743973.99	1048061.71	Yes	28.63	28.88	**0.25**	28.74	28.80	28.95
1015	773054.02	1018646.31	Yes	29.06	29.31	**0.25**	28.53	29.28	29.42
1077	615752.21	831606.43	Yes	26.22	26.47	**0.25**	26.37	26.50	26.54

1050	864165.18	852803.79	Yes	22.85	23.11	**0.26**	22.66	23.15	23.46
1109	607542.65	1009356.14	Yes	28.76	29.02	**0.26**	28.75	28.91	29.35
1213	690922.89	821772.54	Yes	14.83	15.09	**0.26**	15.08	15.09	15.10
1229	615593.95	981282.53	Yes	23.16	23.42	**0.26**	23.27	23.34	23.58
1061	703065.90	721271.44	Yes	12.87	13.14	**0.27**	12.93	13.08	13.21
1100	568772.90	964884.78	Yes	37.41	37.68	**0.27**	37.30	37.74	37.93
1114	654822.50	1040350.51	Yes	26.08	26.36	**0.28**	26.21	26.25	26.47
1254	696586.17	803028.94	Yes	12.98	13.26	**0.28**	13.15	13.32	13.53
1029	864643.45	903131.65	Yes	23.67	23.96	**0.29**	23.62	23.73	24.35
1136	782633.83	943700.74	Yes	17.76	18.05	**0.29**	17.99	18.23	18.23
1168	616928.23	956070.89	Yes	23.11	23.40	**0.29**	22.81	23.06	23.90
1002	724888.21	1060281.86	Yes	29.37	29.67	**0.30**	29.60	29.74	29.85
1163	616206.89	927412.00	Yes	18.98	19.28	**0.30**	19.07	19.56	19.62
1224	599882.47	900952.87	Yes	16.57	16.87	**0.30**	16.68	16.98	17.05
2518	746738.21	847812.32	Yes	12.01	12.32	**0.31**	12.27	12.35	12.38
1179	674699.79	1008428.44	Yes	20.54	20.85	**0.31**	20.23	20.92	21.04
2513	760372.95	848402.28	Yes	11.77	12.10	**0.33**	11.86	11.88	12.24
1074	627657.72	807251.40	Yes	27.10	27.43	**0.33**	26.89	27.09	27.54
1083	586025.87	861698.15	Yes	21.83	22.16	**0.33**	22.07	22.18	22.22
1117	676910.45	1057738.74	Yes	29.84	30.17	**0.33**	30.08	30.15	30.44
2514	749935.17	847314.56	Yes	18.08	18.42	**0.34**	18.30	18.57	18.61
1135	782294.11	959705.75	Yes	19.27	19.61	**0.34**	19.34	19.55	19.63
1210	686803.15	757883.05	Yes	18.48	18.82	**0.34**	17.94	18.82	19.00
1162	616183.82	920179.44	Yes	17.87	18.22	**0.35**	18.22	18.27	18.34
1188	759023.53	1027423.64	Yes	25.57	25.92	**0.35**	25.83	25.93	25.97
1059	759439.06	726949.39	Yes	16.43	16.79	**0.36**	16.78	16.90	17.11
1069	647042.71	772944.16	Yes	25.86	26.24	**0.38**	25.94	26.02	26.34
1193	782416.74	901255.55	Yes	16.20	16.58	**0.38**	16.51	16.54	16.60
1247	777786.51	882842.44	Yes	11.03	11.41	**0.38**	11.33	11.40	11.43
1243	695068.24	737002.68	Yes	19.44	19.83	**0.39**	19.78	19.85	20.07
1216	688854.08	787011.75	Yes	12.36	12.76	**0.40**	12.68	12.88	12.90
1186	665467.52	1040397.36	Yes	23.63	24.04	**0.41**	23.79	24.00	24.05
2500	767221.16	906325.88	Yes	17.42	17.85	**0.43**	17.75	17.84	17.86
1106	581110.75	1034046.14	Yes	34.99	35.43	**0.44**	35.37	35.40	35.80
1251	681500.06	743234.86	Yes	23.39	23.84	**0.45**	23.54	23.81	23.86
1144	748203.67	862242.23	Yes	18.33	18.80	**0.47**	18.66	18.78	18.98
1111	620020.83	1008215.69	Yes	26.32	26.82	**0.50**	26.65	26.81	26.85
1079	608196.74	847494.90	Yes	26.55	27.06	**0.51**	26.83	27.04	27.14
1207	765681.95	756260.95	Yes	10.96	11.56	**0.60**	9.30	11.01	12.24
1075	622309.44	817690.25	Yes	27.76	28.39	**0.63**	28.03	28.55	28.65
3006	750726.50	814141.12	Yes	15.65	16.47	**0.82**	16.15	16.23	16.60

1005	739602.59	1055389.25	No	32.38					
1018	791317.52	1010593.37	No	31.50					
1024	814683.97	954236.38	No	24.75					
1026	846377.79	918680.97	No	21.81					
1063	673779.70	729951.62	No	16.42					
1066	657966.96	748431.97	No	26.56					
1070	640394.12	772976.47	No	26.48					
1071	637242.52	782840.68	No	25.52					
1080	594292.13	847296.22	No	27.23					
1082	584843.02	852477.55	No	27.11					
1089	575552.82	905246.65	No	21.50					
1090	582101.19	914367.57	No	24.45					
1101	565949.93	975650.78	No	38.47					
9001	724166.59	659518.89	No	18.78					
5125	799882.82	990144.93	No	31.26					
5209	711151.20	1067815.97	No	27.06					
5212	707525.85	1070344.33	No	30.96					
5213	705357.13	1070843.42	No	33.29					
5214	705363.61	1068376.09	No	30.98					
5215	704080.16	1070807.58	No	31.68					
5216	704079.25	1068348.04	No	32.48					
5217	702493.23	1070810.78	No	33.57					
5218	702506.99	1068300.93	No	32.61					
5219	700914.13	1070823.89	No	33.77					
5220	700944.13	1065827.59	No	30.83					
5223	694905.29	1067669.98	No	33.10					
5224	694875.64	1062847.63	No	31.94					
5225	686381.81	1067648.90	No	31.57					
5226	689940.91	1065686.63	No	30.53					
5306	669118.38	732541.66	No	17.84					

LiDAR Control Report (LiDAR Accuracy and Validation Results for Bare Earth and Low Grass).

The following listing shows the results of the LiDAR data compared to the GPS ground survey control data collected on bare earth and low grass. The listing is sorted by the **Z Error** column showing, in ascending order, the vertical difference between the LiDAR points and the surveyed ground control points on bare earth and low grass.

Project File: MARSProject
HHDBareEarthandLowGrass
Date: March 06 2009
Vertical Accuracy Objective
Requirement Type: Accuracy(z)
Accuracy(z) Objective: 0.60
Confidence Level: 95%
Control Points in Report: 193
Elevation Calculation Method: Interpolated from TIN
Control Points with LiDAR Coverage: 193
Control Points with Required Accuracy (+/- 0.60): 193
Percent of Control Points with Required Accuracy(+/-0.60):100.00
Average Control Error Reported: -0.02
Maximum (highest) Control Error Reported: 0.82
Median Control Error Reported: -0.02
Minimum (lowest) Control Error Reported: -0.84
Standard deviation (sigma) of Z for sample: 0.29
RMSE of Z for sample (RMSE(z)): 0.29:PASS
FGDC/NSSDA Vertical Accuracy (Accuracy(z)): 0.57: PASS
NSSDA Achievable Contour Interval: 1.0
ASPRS Class 1 Achievable Contour Interval: 0.9
NMAS Achievable Contour Interval: 1.0

Control	Control Pt.	Control Pt.	Coverage	Control Pt.	from LiDAR	**Z Error**	Min Z	Median Z	Max Z
Point Id	X(East)	Y(North)		Z(Elev)	Z(Elev)				
	USFeet	USFeet		USFeet	USFeet	**USFeet**	USFeet	USFeet	USFeet
CP1053	837287.09	777506.02	Yes	25.56	24.72	**-0.84**	24.67	24.70	24.74
CP1054	815818.71	743492.52	Yes	20.11	19.36	**-0.75**	19.32	19.36	19.39
CP1055	825382.82	759382.88	Yes	20.08	19.42	**-0.66**	18.82	19.47	19.66
CP3003	819837.73	802304.62	Yes	15.04	14.38	**-0.66**	14.37	14.38	14.41
CP1202	807915.53	780406.05	Yes	11.87	11.28	**-0.59**	10.77	11.31	11.34
CP3001	828219.19	888318.09	Yes	10.03	9.45	**-0.58**	9.33	9.58	9.66
CP1152	688143.64	878432.90	Yes	17.14	16.58	**-0.56**	16.51	16.62	16.67
CP1196	820127.68	853658.91	Yes	12.23	11.68	**-0.55**	11.57	11.66	11.71
CP1148	726631.89	859540.65	Yes	16.55	16.01	**-0.54**	15.87	15.96	16.04

CP2009	698696.28	864208.92	Yes	11.87	11.34	**-0.53**	11.04	11.33	11.39
CP1258	727693.32	835263.97	Yes	10.87	10.35	**-0.52**	10.10	10.17	10.42
CP3004	801290.30	828640.02	Yes	16.43	15.91	**-0.52**	15.55	15.93	15.98
CP1021	799938.66	980690.22	Yes	24.56	24.04	**-0.52**	23.94	23.97	24.10
CP1261	725566.82	803842.32	Yes	11.02	10.52	**-0.50**	10.48	10.52	10.55
CP1049	874562.58	852206.62	Yes	24.41	23.94	**-0.47**	23.77	24.35	24.50
CP1022	799871.15	968847.77	Yes	26.03	25.56	**-0.47**	25.50	25.55	25.71
CP1221	635234.02	850808.58	Yes	21.56	21.11	**-0.45**	21.05	21.41	21.56
CP1192	803485.88	905454.59	Yes	12.29	11.85	**-0.44**	11.73	11.85	12.12
CP1051	837274.68	821573.66	Yes	15.19	14.75	**-0.44**	14.39	14.74	14.83
CP1245	793052.52	927728.14	Yes	11.72	11.29	**-0.43**	7.42	11.94	11.99
CP1149	721150.02	858980.07	Yes	16.22	15.80	**-0.42**	15.49	15.72	15.89
CP3010	685411.47	843074.38	Yes	16.67	16.25	**-0.42**	16.23	16.29	16.31
CP1236	813526.16	834094.97	Yes	11.08	10.67	**-0.41**	10.66	10.68	10.71
CP1171	628519.87	963373.31	Yes	16.48	16.08	**-0.40**	16.04	16.14	16.20
CP1214	688080.89	848267.34	Yes	14.92	14.52	**-0.40**	14.37	14.63	14.68
CP1176	658348.21	984312.99	Yes	17.24	16.85	**-0.39**	16.74	16.78	17.01
CP1256	726138.76	779808.06	Yes	12.10	11.72	**-0.38**	11.55	11.72	12.00
CP1151	695980.27	874651.84	Yes	17.49	17.12	**-0.37**	17.03	17.13	17.21
CP1170	622882.16	963389.38	Yes	16.05	15.69	**-0.36**	15.49	15.87	15.88
CP1088	580676.13	890552.00	Yes	17.01	16.66	**-0.35**	16.60	16.71	16.76
CP1087	581133.47	885057.70	Yes	20.78	20.44	**-0.34**	20.15	20.63	20.80
CP1209	738653.16	816856.36	Yes	13.96	13.62	**-0.34**	13.60	13.70	13.71
CP1113	646888.77	1028979.18	Yes	25.49	25.16	**-0.33**	25.13	25.27	25.27
CP1182	695468.86	1021427.88	Yes	19.06	18.74	**-0.32**	18.69	18.75	18.91
CP1157	647654.79	900924.69	Yes	15.25	14.94	**-0.31**	14.86	14.89	15.67
CP1127	755017.11	1022985.35	Yes	19.62	19.34	**-0.28**	18.93	19.29	19.57
CP1025	824312.94	939904.70	Yes	25.97	25.69	**-0.28**	25.48	25.78	25.94
CP1175	652502.93	979014.25	Yes	17.93	17.66	**-0.27**	17.56	17.69	17.79
CP1145	744161.31	853937.03	Yes	39.92	39.66	**-0.26**	39.62	39.62	39.71
CP1219	666956.03	864027.39	Yes	18.70	18.45	**-0.25**	18.05	18.30	18.49
CP1107	590670.04	1019126.06	Yes	34.28	34.03	**-0.25**	33.79	33.95	34.04
CP1237	760130.06	795016.75	Yes	13.13	12.88	**-0.25**	12.53	12.99	13.52
CP1200	763476.63	839271.24	Yes	14.08	13.84	**-0.24**	13.75	13.94	14.30
CP1141	759823.81	878650.57	Yes	12.06	11.83	**-0.23**	11.52	11.57	12.00
CP1130	766920.74	1001832.55	Yes	16.04	15.81	**-0.23**	15.64	15.94	16.12
CP1248	875620.89	889916.01	Yes	21.11	20.88	**-0.23**	20.70	20.91	21.01
CP1249	896037.87	868340.57	Yes	19.83	19.61	**-0.22**	19.59	19.61	19.64
CP1097	555751.70	949423.08	Yes	39.92	39.70	**-0.22**	39.43	39.76	39.76
CP1185	705688.65	1039346.09	Yes	20.63	20.42	**-0.21**	20.16	20.62	20.66
CP1215	673130.39	800323.47	Yes	16.28	16.07	**-0.21**	15.88	16.25	16.46

CP1240	719710.41	755950.55	Yes	21.58	21.38	**-0.20**	21.32	21.37	21.59
CP1230	633195.29	995269.15	Yes	23.00	22.80	**-0.20**	22.68	22.82	22.96
CP1133	774613.28	981904.62	Yes	17.57	17.38	**-0.19**	17.35	17.47	17.48
CP1158	642363.43	902166.57	Yes	13.64	13.46	**-0.18**	12.61	13.36	13.83
CP1085	581159.87	876751.05	Yes	20.10	19.94	**-0.16**	19.17	19.77	20.05
CP1142	759289.66	872282.93	Yes	14.42	14.26	**-0.16**	14.11	14.19	14.34
CP1146	737613.64	853651.57	Yes	17.39	17.23	**-0.16**	17.10	17.23	17.32
CP1225	595521.88	948146.69	Yes	31.98	31.82	**-0.16**	31.37	31.57	32.08
CP1116	664170.71	1057156.70	Yes	28.13	27.98	**-0.15**	27.94	28.00	28.01
CP1156	660869.71	899939.46	Yes	14.35	14.21	**-0.14**	13.00	14.19	14.37
CP1048	885192.94	850210.66	Yes	17.73	17.59	**-0.14**	17.37	17.57	17.77
CP1194	843200.00	885397.61	Yes	13.29	13.15	**-0.14**	13.03	13.06	13.24
CP1160	631218.22	908541.73	Yes	15.59	15.45	**-0.14**	15.33	15.42	15.73
CP1250	789649.51	794502.28	Yes	12.99	12.86	**-0.13**	11.06	11.63	12.98
CP1092	599767.98	922338.72	Yes	19.74	19.62	**-0.12**	19.47	19.59	20.21
CP1126	748595.89	1029003.35	Yes	19.40	19.28	**-0.12**	19.11	19.39	20.23
CP1095	552342.21	940608.85	Yes	41.36	41.25	**-0.11**	41.15	41.33	41.42
CP1241	775066.58	859120.01	Yes	14.67	14.56	**-0.11**	14.46	14.63	14.80
CP1223	614133.56	874085.61	Yes	22.55	22.44	**-0.11**	22.23	22.29	22.64
CP1191	808552.26	932724.78	Yes	16.35	16.24	**-0.11**	16.10	16.18	16.32
CP1129	765444.13	1009713.74	Yes	20.72	20.62	**-0.10**	20.39	20.71	20.77
CP1027	848598.35	913133.59	Yes	21.49	21.39	**-0.10**	21.37	21.39	21.67
CP1235	842732.14	864437.61	Yes	14.98	14.89	**-0.09**	14.66	14.84	14.97
CP1172	632925.94	968753.75	Yes	16.67	16.58	**-0.09**	16.35	16.91	17.07
CP1139	755886.91	895887.93	Yes	14.75	14.66	**-0.09**	14.18	14.57	14.73
CP1014	769436.71	1020999.30	Yes	30.78	30.70	**-0.08**	30.50	30.60	30.79
CP1058	729879.82	726741.24	Yes	16.58	16.50	**-0.08**	16.21	16.45	16.54
CP1010	755601.69	1034769.76	Yes	26.99	26.91	**-0.08**	26.87	26.90	27.00
CP1124	733246.83	1039882.62	Yes	27.05	26.97	**-0.08**	26.69	26.96	27.13
CP1147	733754.04	855915.41	Yes	16.93	16.86	**-0.07**	16.85	16.91	16.92
CP1091a	585380.69	917679.23	Yes	23.29	23.22	**-0.07**	23.04	23.62	23.71
CP1118	688553.78	1057738.43	Yes	29.53	29.46	**-0.07**	29.21	29.54	29.65
CP1094	566230.06	937012.71	Yes	34.94	34.87	**-0.07**	34.67	34.89	34.90
CP1140	757643.65	885318.87	Yes	11.80	11.74	**-0.06**	11.65	11.75	11.98
CP1233	674621.99	1030402.75	Yes	25.58	25.52	**-0.06**	25.19	25.52	25.55
CP5124	787922.99	1007038.43	Yes	29.52	29.46	**-0.06**	29.37	29.47	29.55
CP1212	711200.87	795568.39	Yes	16.83	16.77	**-0.06**	16.73	16.78	16.95
CP1228	593057.70	989839.04	Yes	30.31	30.26	**-0.05**	29.86	30.26	30.36
CP1304-PA1	688067.17	872884.64	Yes	16.12	16.07	**-0.05**	16.00	16.18	16.23
CP1253	705340.22	774241.13	Yes	16.85	16.81	**-0.04**	16.70	16.80	16.87
CP1132	772082.33	988314.97	Yes	17.45	17.41	**-0.04**	17.30	17.42	17.62

CP1257	744331.07	795643.40	Yes	10.78	10.74	**-0.04**	10.72	10.72	10.85
CP2000	690738.15	865889.22	Yes	10.46	10.43	**-0.03**	10.29	10.44	10.52
CP1036	917328.96	884937.21	Yes	20.44	20.41	**-0.03**	20.19	20.35	20.48
CP1238	905364.29	874044.36	Yes	19.23	19.21	**-0.02**	19.10	19.26	19.46
CP1131	769662.71	993850.53	Yes	20.63	20.61	**-0.02**	20.37	20.39	20.79
CP1220	643421.73	818689.65	Yes	22.39	22.37	**-0.02**	21.92	22.41	22.46
CP1204	757145.68	815473.83	Yes	11.15	11.14	**-0.01**	10.48	11.39	11.41
CP1205	772743.85	777067.36	Yes	13.23	13.23	**0.00**	13.10	13.24	13.38
CP2005	687018.15	864982.70	Yes	13.35	13.35	**0.00**	13.02	13.38	13.60
CP1110	629140.22	1013662.03	Yes	25.94	25.94	**0.00**	25.70	26.06	26.22
CP1105	575580.39	1026209.16	Yes	32.73	32.74	**0.01**	32.63	32.66	33.12
CP1017	784875.55	1012369.24	Yes	29.79	29.80	**0.01**	29.74	29.84	29.91
CP1173	639004.01	971061.12	Yes	17.13	17.14	**0.01**	16.59	16.86	17.15
CP1167	616360.96	951806.46	Yes	21.07	21.08	**0.01**	21.05	21.08	21.08
CP1178	668623.80	1001822.82	Yes	19.49	19.50	**0.01**	19.45	19.47	19.66
CP1255	714784.92	816609.78	Yes	11.06	11.07	**0.01**	10.94	11.06	11.13
CP3005	783740.80	761414.21	Yes	13.95	13.97	**0.02**	13.88	14.05	14.05
CP1159	631899.90	904468.92	Yes	15.93	15.96	**0.03**	15.65	15.81	16.07
CP1242	601061.44	872209.22	Yes	21.30	21.33	**0.03**	20.63	20.72	21.60
CP1211	711837.17	837800.83	Yes	14.64	14.68	**0.04**	14.58	14.67	14.74
CP1108	603000.60	1017521.28	Yes	27.78	27.82	**0.04**	27.66	28.04	28.13
CP1198	791784.00	840390.84	Yes	19.44	19.49	**0.05**	19.34	19.41	19.95
CP1197	793646.95	869883.55	Yes	13.59	13.64	**0.05**	13.41	13.55	13.89
CP1177	663187.57	993127.90	Yes	29.66	29.71	**0.05**	29.61	29.82	29.86
CP1302-PA1	690807.59	865368.37	Yes	12.01	12.06	**0.05**	10.20	12.20	12.25
CP1096	552818.80	949456.55	Yes	42.27	42.32	**0.05**	42.29	42.32	42.36
CP1164	616229.23	931232.73	Yes	17.21	17.27	**0.06**	17.19	17.38	17.55
CP1086	580166.65	872053.70	Yes	21.26	21.32	**0.06**	21.22	21.32	21.55
CP1028	856282.38	904160.15	Yes	22.10	22.17	**0.07**	22.02	22.15	22.59
CP1161	623484.82	911385.68	Yes	14.51	14.58	**0.07**	14.35	14.61	14.76
CP1169	618987.36	960411.08	Yes	16.28	16.36	**0.08**	16.01	16.22	16.44
CP1231	654192.97	1002402.06	Yes	30.80	30.88	**0.08**	30.70	31.10	31.20
CP1030	875529.87	902926.01	Yes	21.03	21.13	**0.10**	21.01	21.13	21.23
CP1093	579483.45	940388.98	Yes	24.99	25.10	**0.11**	24.80	25.24	25.26
CP1143	753974.53	869609.12	Yes	12.30	12.42	**0.12**	12.39	12.44	12.53
CP1004	734609.07	1059872.75	Yes	32.88	33.00	**0.12**	32.74	32.92	33.24
CP1134	779230.97	969815.95	Yes	19.22	19.35	**0.13**	19.24	19.33	19.45
CP1166	616302.48	943263.70	Yes	21.59	21.72	**0.13**	21.66	21.73	21.76
CP1203	791243.89	750752.21	Yes	13.51	13.64	**0.13**	13.53	13.67	13.93
CP1073	632807.96	801277.72	Yes	27.21	27.36	**0.15**	27.22	27.41	27.80
CP1259	743648.87	835235.61	Yes	12.42	12.57	**0.15**	12.12	12.87	13.12

CP1011	754418.79	1039844.69	Yes	29.05	29.21	**0.16**	29.19	29.22	29.29
CP1112	639137.68	1020433.71	Yes	23.40	23.56	**0.16**	23.45	23.54	24.01
CP3002	787767.01	888119.99	Yes	10.85	11.01	**0.16**	10.89	10.95	11.22
CP1065	668483.07	745850.24	Yes	18.26	18.42	**0.16**	18.29	18.42	18.44
CP1165	616283.98	939854.53	Yes	24.11	24.27	**0.16**	24.15	24.21	24.33
CP1078	615039.85	836916.20	Yes	25.76	25.92	**0.16**	25.90	25.90	26.11
CP1217	665413.44	776017.88	Yes	19.17	19.33	**0.16**	19.30	19.33	19.58
CP1102	572514.20	986257.64	Yes	36.38	36.54	**0.16**	36.52	36.59	36.60
CP1174	645821.22	973391.82	Yes	15.42	15.59	**0.17**	15.53	15.63	15.68
CP1244	593706.12	973814.49	Yes	25.51	25.68	**0.17**	25.57	25.66	25.71
CP1035	917967.48	901333.64	Yes	20.37	20.55	**0.18**	20.43	20.50	20.59
CP1009	751604.77	1039698.90	Yes	28.16	28.34	**0.18**	28.33	28.33	28.62
CP1150	709553.48	864564.83	Yes	15.46	15.65	**0.19**	15.36	15.36	15.85
CP3008	714597.94	779867.01	Yes	21.13	21.33	**0.20**	21.11	21.38	21.80
CP1239	867185.72	878958.33	Yes	18.30	18.52	**0.22**	18.41	18.57	18.83
CP1180	683007.18	1013652.34	Yes	20.71	20.93	**0.22**	20.68	20.74	20.96
CP1057	777850.29	727137.47	Yes	13.97	14.19	**0.22**	13.98	14.15	14.19
CP1301-PA1	687363.81	864632.26	Yes	13.50	13.73	**0.23**	12.75	13.71	13.86
CP1016	778942.19	1014108.17	Yes	28.77	29.00	**0.23**	28.96	29.01	29.16
CP1155	666315.46	894452.81	Yes	16.45	16.68	**0.23**	16.34	16.62	16.95
CP1104	575793.99	1013139.89	Yes	36.01	36.25	**0.24**	35.88	36.43	36.59
CP1190	782321.84	980529.65	Yes	19.25	19.49	**0.24**	19.41	19.44	19.70
CP1007	743973.99	1048061.71	Yes	28.63	28.88	**0.25**	28.74	28.80	28.95
CP1015	773054.02	1018646.31	Yes	29.06	29.31	**0.25**	28.53	29.28	29.42
CP1077	615752.21	831606.43	Yes	26.22	26.47	**0.25**	26.37	26.50	26.54
CP1109	607542.65	1009356.14	Yes	28.76	29.02	**0.26**	28.75	28.91	29.35
CP1050	864165.18	852803.79	Yes	22.85	23.11	**0.26**	22.66	23.15	23.46
CP1229	615593.95	981282.53	Yes	23.16	23.42	**0.26**	23.27	23.34	23.58
CP1213	690922.89	821772.54	Yes	14.83	15.09	**0.26**	15.08	15.09	15.10
CP1100	568772.90	964884.78	Yes	37.41	37.68	**0.27**	37.30	37.74	37.93
CP1061	703065.90	721271.44	Yes	12.87	13.14	**0.27**	12.93	13.08	13.21
CP1254	696586.17	803028.94	Yes	12.98	13.26	**0.28**	13.15	13.32	13.53
CP1168	616928.23	956070.89	Yes	23.11	23.40	**0.29**	22.81	23.06	23.90
CP1029	864643.45	903131.65	Yes	23.67	23.96	**0.29**	23.62	23.73	24.35
CP1136	782633.83	943700.74	Yes	17.76	18.05	**0.29**	17.99	18.23	18.23
CP1002	724888.21	1060281.86	Yes	29.37	29.67	**0.30**	29.60	29.74	29.85
CP1224	599882.47	900952.87	Yes	16.57	16.87	**0.30**	16.68	16.98	17.05
CP1163	616206.89	927412.00	Yes	18.98	19.28	**0.30**	19.07	19.56	19.62
CP1179	674699.79	1008428.44	Yes	20.54	20.85	**0.31**	20.23	20.92	21.04
CP1074	627657.72	807251.40	Yes	27.10	27.43	**0.33**	26.89	27.09	27.54
CP1083	586025.87	861698.15	Yes	21.83	22.16	**0.33**	22.07	22.18	22.22

CP1117	676910.45	1057738.74	Yes	29.84	30.17	**0.33**	30.08	30.15	30.44
CP1135	782294.11	959705.75	Yes	19.27	19.61	**0.34**	19.34	19.55	19.63
CP1210	686803.15	757883.05	Yes	18.48	18.82	**0.34**	17.94	18.82	19.00
CP1162	616183.82	920179.44	Yes	17.87	18.22	**0.35**	18.22	18.27	18.34
CP1188	759023.53	1027423.64	Yes	25.57	25.92	**0.35**	25.83	25.93	25.97
CP1059	759439.06	726949.39	Yes	16.43	16.79	**0.36**	16.78	16.90	17.11
CP1193	782416.74	901255.55	Yes	16.20	16.58	**0.38**	16.51	16.54	16.60
CP1069	647042.71	772944.16	Yes	25.86	26.24	**0.38**	25.94	26.02	26.34
CP1247	777786.51	882842.44	Yes	11.03	11.41	**0.38**	11.33	11.40	11.43
CP1243	695068.24	737002.68	Yes	19.44	19.83	**0.39**	19.78	19.85	20.07
CP1216	688854.08	787011.75	Yes	12.36	12.76	**0.40**	12.68	12.88	12.90
CP1186	665467.52	1040397.36	Yes	23.63	24.04	**0.41**	23.79	24.00	24.05
CP1106	581110.75	1034046.14	Yes	34.99	35.43	**0.44**	35.37	35.40	35.80
CP1251	681500.06	743234.86	Yes	23.39	23.84	**0.45**	23.54	23.81	23.86
CP1144	748203.67	862242.23	Yes	18.33	18.80	**0.47**	18.66	18.78	18.98
CP1111	620020.83	1008215.69	Yes	26.32	26.82	**0.50**	26.65	26.81	26.85
CP1079	608196.74	847494.90	Yes	26.55	27.06	**0.51**	26.83	27.04	27.14
CP1207	765681.95	756260.95	Yes	10.96	11.56	**0.60**	9.30	11.01	12.24
CP1075	622309.44	817690.25	Yes	27.76	28.39	**0.63**	28.03	28.55	28.65
CP3006	750726.50	814141.12	Yes	15.65	16.47	**0.82**	16.15	16.23	16.60

LiDAR Control Report (LiDAR Accuracy and Validation Results for Brush.

The following listing shows the results of the LiDAR data compared to the GPS ground survey control data collected on brush areas. The listing is sorted by the **Z Error** column showing, in ascending order, the vertical difference between the LiDAR points and the surveyed ground control points in brush areas.

Project File:
MARSProjectHHDBrush
Date: March 06:2009
Vertical Accuracy Objective
Requirement Type: Accuracy(z)
Accuracy(z) Objective: 1.20
Confidence Level: 95%
Control Points in Report: 136
Elevation Calculation Method: Interpolated from TIN
Control Points with LiDAR Coverage: 124
Control Points with Required Accuracy (+/- 1.20): 101
Percent of Control Points with Required Accuracy (+/- 1.20): 81.45
Average Control Error Reported: 0.61
Maximum (highest) Control Error Reported: 3.36
Median Control Error Reported: 0.48
Minimum (lowest) Control Error Reported: -2.10
Standard deviation (sigma) of Z for sample: 0.76
RMSE of Z for sample (RMSE(z)): 0.97:FAIL
FGDC/NSSDA Vertical Accuracy (Accuracy(z)): 1.91: FAIL
NSSDA Achievable Contour Interval: 4.0
ASPRS Class 1 Achievable Contour Interval: 3.0
NMAS Achievable Contour Interval: 4.0

Control	Control Pt.	Control Pt.	Coverage	Control Pt.	from LiDAR	**Z Error**	Min Z	Median Z	Max Z
Point Id	X(East)	Y(North)		Z(Elev)	Z(Elev)				
	USFeet	USFeet		USFeet	USFeet	**USFeet**	USFeet	USFeet	USFeet
CP5509	703346.55	1042206.91	Yes	16.70	14.60	**-2.10**	12.35	16.66	16.75
CP5328	673208.08	805701.23	Yes	18.44	17.65	**-0.79**	15.31	17.76	17.87
CP5337	806806.73	852283.94	Yes	8.86	8.18	**-0.68**	8.09	8.21	8.37
2021	662246.36	781556.44	Yes	20.89	20.21	**-0.68**	19.99	20.27	20.44
CP5300	800608.45	940699.88	Yes	16.43	15.82	**-0.61**	15.79	15.82	15.83
CP5343	798090.02	901425.19	Yes	12.93	12.42	**-0.51**	12.24	12.48	12.58
CP5333	800312.59	738132.48	Yes	14.52	14.11	**-0.41**	13.46	13.89	14.35
CP1303-PA1	698697.42	864795.63	Yes	11.26	10.88	**-0.38**	9.97	10.83	10.92
CP1206	829680.69	911880.98	Yes	16.07	15.80	**-0.27**	15.77	15.82	15.87
CP1052	837191.60	793294.66	Yes	16.46	16.23	**-0.23**	16.12	16.73	16.91

CP1031	886746.72	904855.97	Yes	20.72	20.50	**-0.22**	20.48	20.52	20.63
2095	835344.74	890912.54	Yes	11.60	11.39	**-0.21**	11.28	11.34	11.71
CP1023	798161.32	952961.86	Yes	23.75	23.56	**-0.19**	23.14	23.59	23.68
CP1201	784251.87	810226.51	Yes	13.49	13.31	**-0.18**	13.17	13.65	13.67
2183	876094.43	892957.26	Yes	17.33	17.26	**-0.08**	17.25	17.25	17.27
CP1227	607603.78	961857.22	Yes	22.18	22.14	**-0.04**	22.08	22.15	22.21
CP5334	792716.67	782953.87	Yes	9.95	9.91	**-0.04**	9.86	9.97	10.06
2151	635427.21	863681.42	Yes	19.01	18.99	**-0.02**	18.96	19.01	19.53
CP1033	902570.75	901557.89	Yes	20.85	20.84	**-0.01**	20.71	20.73	20.97
2182	886307.69	894739.24	Yes	18.08	18.09	**0.01**	17.92	18.18	18.38
CP1098	565781.37	948770.74	Yes	36.90	36.93	**0.03**	36.83	36.87	37.03
CP5301	845791.79	834190.27	Yes	12.99	13.06	**0.07**	13.02	13.11	13.54
2168	888457.14	873682.86	Yes	17.56	17.63	**0.07**	17.48	17.89	17.99
CP1099	565673.11	956802.09	Yes	35.33	35.44	**0.11**	35.33	35.50	35.81
CP1199	814205.47	810380.90	Yes	14.15	14.28	**0.13**	13.97	14.44	15.14
2178	877312.64	862631.46	Yes	16.70	16.84	**0.14**	16.62	16.75	16.95
CP5313	656433.55	754000.62	Yes	19.69	19.83	**0.14**	19.64	19.85	19.96
2169	887985.25	864777.10	Yes	18.11	18.27	**0.15**	18.23	18.25	18.49
2139	623480.01	831816.40	Yes	23.90	24.06	**0.16**	23.99	24.08	24.28
2181	886209.54	888594.35	Yes	19.06	19.22	**0.16**	19.05	19.16	19.30
CP1252	694915.66	752522.77	Yes	15.18	15.36	**0.18**	15.35	15.36	15.44
2007	711408.22	793359.66	Yes	10.50	10.68	**0.18**	10.58	10.69	11.01
CP1226	573958.53	959094.22	Yes	29.58	29.76	**0.18**	29.76	29.78	29.83
2133	626657.82	912536.16	Yes	24.27	24.45	**0.18**	24.38	24.48	24.55
CP5340	730356.82	843120.90	Yes	11.58	11.77	**0.19**	11.49	12.11	12.30
CP5302	825480.11	759396.31	Yes	10.30	10.50	**0.20**	10.45	10.50	10.52
CP1208	742173.68	771790.46	Yes	13.14	13.36	**0.22**	13.20	13.36	13.43
2127	639052.51	971028.06	Yes	9.11	9.33	**0.22**	9.24	9.31	9.45
CP1232	662954.57	1016415.61	Yes	20.34	20.59	**0.25**	20.52	20.58	20.70
2155	629346.75	892201.06	Yes	11.75	12.01	**0.26**	11.96	11.99	12.10
CP5315	671554.30	763513.68	Yes	16.64	16.91	**0.27**	16.67	17.06	17.07
2177	877184.81	855407.94	Yes	14.90	15.18	**0.28**	15.05	15.10	15.26
2150	638643.72	855559.33	Yes	18.79	19.08	**0.29**	18.79	18.88	19.11
CP1037	938477.58	879855.16	Yes	19.38	19.67	**0.29**	19.52	19.66	19.69
CP1189	782722.62	1002385.29	Yes	26.22	26.51	**0.29**	26.50	26.53	26.54
CP5341	775093.50	869601.00	Yes	9.96	10.26	**0.30**	10.12	10.33	10.36
2089	818950.95	922602.73	Yes	12.95	13.25	**0.30**	13.20	13.24	13.27
2170	881829.89	863174.24	Yes	18.06	18.39	**0.34**	18.37	18.50	18.56
CP5310	687573.75	728821.25	Yes	13.67	14.02	**0.35**	13.95	13.95	14.51
2152	635322.92	874302.19	Yes	19.08	19.45	**0.37**	19.27	19.78	19.83
2112	704967.31	1040390.46	Yes	14.80	15.18	**0.38**	14.87	14.90	15.23

CP5332	653647.83	819408.08	Yes	19.22	19.62	**0.40**	19.30	19.64	19.84
2154	635371.47	879411.65	Yes	18.40	18.80	**0.40**	18.72	19.01	19.03
2132	624014.04	911322.41	Yes	12.95	13.36	**0.41**	13.21	13.32	13.54
2134	595129.86	908598.66	Yes	17.98	18.43	**0.44**	18.19	18.60	19.57
2158	630750.53	900807.66	Yes	14.77	15.22	**0.45**	15.07	15.15	15.68
2147	624873.76	847634.37	Yes	22.90	23.34	**0.45**	23.31	23.34	23.38
CP5326	673582.89	779113.49	Yes	14.40	14.85	**0.45**	14.76	14.84	14.91
2161	658266.31	897242.55	Yes	14.20	14.65	**0.45**	14.54	14.62	14.83
2119	674580.39	1008453.41	Yes	18.30	18.75	**0.45**	18.46	18.85	19.17
CP1103	575955.28	988505.21	Yes	33.07	33.52	**0.45**	33.06	33.23	33.63
2184	875533.71	887067.18	Yes	18.51	18.99	**0.48**	18.61	18.88	19.07
CP5503	628933.99	1013818.67	Yes	24.53	25.02	**0.49**	24.73	25.03	25.24
CP5510	688796.31	1037601.15	Yes	17.81	18.33	**0.52**	17.96	18.24	19.75
2142	632607.98	842634.92	Yes	20.88	21.40	**0.52**	21.23	21.63	21.79
2180	882815.26	879907.21	Yes	19.59	20.12	**0.53**	19.88	20.09	20.33
2137	554310.08	942074.21	Yes	41.78	42.35	**0.57**	42.06	42.47	42.57
CP5305	679076.99	736649.96	Yes	14.89	15.47	**0.58**	15.30	15.74	15.77
2123	655258.43	981548.83	Yes	13.35	13.94	**0.59**	13.14	13.90	14.03
CP5336	765583.62	749763.29	Yes	12.90	13.49	**0.59**	13.11	13.42	14.09
2046	641327.39	879909.25	Yes	16.69	17.30	**0.61**	17.02	17.34	17.62
CP5311	683729.17	732639.89	Yes	12.95	13.56	**0.61**	13.42	13.54	13.93
2129	617852.69	957799.88	Yes	11.18	11.80	**0.62**	11.57	11.85	11.89
CP5330	630243.98	818140.30	Yes	25.18	25.80	**0.62**	25.72	25.86	26.06
2023	662180.26	802855.26	Yes	18.90	19.54	**0.64**	18.99	19.41	19.78
CP5317	716973.01	769001.68	Yes	13.05	13.69	**0.64**	13.56	14.07	14.27
CP5495	626482.06	966516.75	Yes	14.04	14.68	**0.64**	14.20	14.88	14.91
CP5338	773700.79	831005.90	Yes	9.14	9.85	**0.71**	9.53	9.75	10.38
CP5319	646838.75	778701.50	Yes	23.14	23.85	**0.71**	23.64	24.14	24.31
CP5316	766271.97	786615.61	Yes	13.92	14.64	**0.72**	14.08	14.27	15.09
2029	683063.66	842713.75	Yes	13.15	13.90	**0.75**	13.28	13.90	13.96
CP5303	680919.77	743265.93	Yes	14.08	14.84	**0.76**	14.75	14.83	14.95
2179	881767.36	862059.78	Yes	14.72	15.50	**0.78**	14.82	14.93	15.73
2166	898287.42	863182.39	Yes	17.11	17.92	**0.81**	17.66	17.93	17.96
CP5497	620987.82	976667.70	Yes	19.18	20.00	**0.82**	19.69	20.57	20.71
2130	616393.39	943696.17	Yes	15.35	16.20	**0.84**	15.89	16.21	16.58
2138	614658.45	831671.38	Yes	24.04	24.89	**0.85**	24.55	24.76	25.35
2146	615385.46	847487.27	Yes	22.70	23.57	**0.87**	23.35	24.29	24.42
2128	625926.45	964836.58	Yes	14.16	15.04	**0.88**	14.82	14.92	15.58
2173	856556.15	869611.41	Yes	10.51	11.40	**0.89**	10.87	11.80	11.84
2148	634065.94	848391.97	Yes	19.35	20.29	**0.94**	19.81	20.14	20.61
CP5342	835322.28	869568.38	Yes	11.20	12.14	**0.94**	11.90	12.21	12.70

CP5513	691874.94	1033257.15	Yes	20.71	21.66	**0.95**	21.60	21.61	21.70
CP5508	677532.65	1025170.69	Yes	17.82	18.78	**0.96**	18.14	18.86	18.88
2026	674974.08	832311.72	Yes	16.46	17.42	**0.96**	17.08	17.59	17.61
2143	624972.78	842536.61	Yes	23.98	24.96	**0.98**	24.75	25.31	25.45
2115	694782.92	1019405.55	Yes	15.70	16.69	**0.99**	16.38	16.67	16.83
CP5501	620159.11	1003467.61	Yes	25.76	26.80	**1.04**	26.02	26.94	27.55
2172	861131.07	856201.20	Yes	11.28	12.42	**1.14**	12.32	12.37	12.44
CP5339	750363.51	832185.50	Yes	12.03	13.18	**1.15**	12.77	13.80	13.82
CP5511	690181.26	1035615.48	Yes	16.53	17.69	**1.16**	17.24	17.73	17.79
CP5507	680212.48	1022328.43	Yes	16.34	17.53	**1.19**	17.45	17.64	17.75
2140	635355.34	831748.40	Yes	21.36	22.61	**1.25**	22.22	22.65	22.89
CP5327	707607.35	811464.71	Yes	13.54	14.88	**1.34**	13.15	15.04	15.17
2167	885550.74	864514.58	Yes	18.08	19.50	**1.42**	19.41	19.74	20.11
2145	614969.97	842323.26	Yes	24.70	26.13	**1.43**	25.85	26.24	26.34
CP5331	641193.78	818485.56	Yes	22.45	23.98	**1.53**	23.80	24.07	24.12
2131	616275.25	924531.01	Yes	12.95	14.53	**1.58**	14.46	14.51	14.61
CP5309	690352.07	720821.33	Yes	15.42	17.01	**1.59**	15.17	16.81	17.07
CP5329	659684.14	806160.01	Yes	17.89	19.49	**1.60**	19.27	19.54	20.26
CP5304	678959.54	739693.35	Yes	14.79	16.49	**1.70**	15.89	16.46	16.78
CP5500	627044.09	1000715.93	Yes	22.56	24.28	**1.72**	23.43	23.54	24.62
CP5496	620377.29	973145.68	Yes	18.70	20.43	**1.73**	19.72	20.06	21.06
CP5502	629904.77	1006302.02	Yes	23.02	24.78	**1.76**	24.49	24.53	26.26
2171	874615.67	855073.25	Yes	15.19	16.98	**1.80**	16.42	17.02	17.08
2121	663489.10	993552.02	Yes	14.15	15.97	**1.83**	15.01	16.08	16.21
2025	661775.82	824280.21	Yes	16.47	18.35	**1.88**	18.28	18.34	18.37
CP5498	633954.57	981700.00	Yes	16.35	18.30	**1.95**	17.47	17.96	18.57
2019	659815.21	762918.63	Yes	19.96	21.92	**1.96**	21.81	21.94	22.09
CP5499	634566.21	990142.80	Yes	18.31	20.49	**2.18**	20.22	20.87	21.29
CP5318	662606.06	781715.22	Yes	18.44	20.63	**2.19**	20.52	20.58	20.93
CP5512	705072.42	1038565.12	Yes	12.97	15.18	**2.21**	10.33	15.74	15.77
CP5515	695908.35	1026578.32	Yes	17.79	20.50	**2.71**	18.19	21.35	21.98
CP5514	702508.20	1031596.15	Yes	15.06	18.42	**3.36**	16.92	18.34	18.75
CP5306	669118.38	732541.66	No	17.84					
CP5307	668954.85	720461.59	No	15.66					
CP5308	673023.02	720498.10	No	17.41					
CP5312	655452.39	726694.66	No	18.41					
CP5314	624247.28	763076.15	No	24.91					
CP5320	630750.92	777943.51	No	24.35					
CP5321	621795.92	772634.66	No	22.69					
CP5322	615258.41	780753.36	No	24.27					
CP5323	625843.59	784980.89	No	24.42					

CP5324	627805.76	784845.13	No	23.68					
CP5345	773168.10	1029294.10	No	29.19					
CP5506	628201.78	1015440.40	No	23.96					

LiDAR Control Report (LiDAR Accuracy and Validation Results for Sugarcane.

The following listing shows the results of the LiDAR data compared to the GPS ground survey control data collected on brush areas. The listing is sorted by the **Z Error** column showing, in ascending order, the vertical difference between the LiDAR points and the surveyed ground control points in sugarcane areas.

Project File: MARSProjectSugarcane
Date: October 17: 2008
Vertical Accuracy Objective
Requirement Type: Accuracy(z)
Accuracy(z) Objective: 1.20
Confidence Level: 95%
Control Points in Report: 133
Elevation Calculation Method: Interpolated from TIN
Control Points with LiDAR Coverage: 62
Control Points with Required Accuracy (+/- 1.20): 59
Percent of Control Points with Required Accuracy (+/- 1.20): 95.16
Average Control Error Reported: -0.10
Maximum (highest) Control Error Reported: 1.69
Median Control Error Reported: -0.20
Minimum (lowest) Control Error Reported: -1.34
Standard deviation (sigma) of Z for sample: 0.56
RMSE of Z for sample (RMSE(z)): 0.56: PASS
FGDC/NSSDA Vertical Accuracy (Accuracy(z)): 1.10: PASS
NSSDA Achievable Contour Interval: 2.0
ASPRS Class 1 Achievable Contour Interval: 2.0
NMAS Achievable Contour Interval: 2.0

Control	Control Pt.	Control Pt.	Coverage	Control Pt.	from LiDAR	**Z Error**	Min Z	Median Z	Max Z
Point Id	X(East)	Y(North)		Z(Elev)	Z(Elev)				
	USFeet	USFeet		USFeet	USFeet	**USFeet**	USFeet	USFeet	USFeet
2003	707699.16	822071.33	Yes	9.11	7.77	**-1.34**	7.77	7.77	7.77
2096	838337.02	893373.52	Yes	11.55	10.29	**-1.26**	10.29	10.29	10.29
2063	831220.85	834068.18	Yes	8.84	7.88	**-0.96**	7.88	7.88	7.88
2057	824999.06	839456.26	Yes	8.33	7.50	**-0.83**	7.50	7.50	7.50
CP5470	741410.85	811397.68	Yes	9.47	8.68	**-0.79**	8.68	8.68	8.68
CP5414	780489.81	877657.43	Yes	9.63	8.85	**-0.78**	8.85	8.85	8.85
102012	698598.50	864050.66	Yes	8.16	7.40	**-0.76**	7.40	7.40	7.40
CP5453	834804.26	780794.98	Yes	8.25	7.50	**-0.75**	7.50	7.50	7.50
CP5450	821205.08	791982.56	Yes	7.53	6.80	**-0.73**	6.80	6.80	6.80
2034	688243.62	866595.97	Yes	13.21	12.50	**-0.71**	12.50	12.50	12.50
CP5475	727656.45	843235.42	Yes	8.76	8.05	**-0.71**	8.05	8.05	8.05

2035	688236.63	866691.15	Yes	13.13	12.54	**-0.59**	12.54	12.54	12.54
102006	687292.88	864665.61	Yes	12.92	12.41	**-0.51**	12.41	12.41	12.41
CP5465	757695.50	779817.98	Yes	8.77	8.28	**-0.49**	8.28	8.28	8.28
2157	630677.90	900756.22	Yes	12.81	12.33	**-0.48**	12.33	12.33	12.33
2032	688202.93	848378.80	Yes	9.49	9.01	**-0.48**	9.01	9.01	9.01
CP5447	779305.15	791719.96	Yes	7.95	7.56	**-0.39**	7.56	7.56	7.56
CP5452	802715.94	777711.34	Yes	8.70	8.33	**-0.37**	8.33	8.33	8.33
CP5479	690883.29	821892.69	Yes	11.62	11.27	**-0.35**	11.27	11.27	11.27
2160	658335.44	897250.21	Yes	11.31	10.97	**-0.34**	10.97	10.97	10.97
CP5406	790511.67	901491.96	Yes	9.63	9.30	**-0.33**	9.30	9.30	9.30
CP5485	657682.00	879444.29	Yes	16.49	16.16	**-0.33**	16.16	16.16	16.16
2530	760611.63	830188.40	Yes	8.66	8.34	**-0.32**	8.34	8.34	8.34
2531	763240.34	833853.81	Yes	8.74	8.46	**-0.28**	8.46	8.46	8.46
2093	835203.10	885656.70	Yes	7.57	7.32	**-0.25**	7.32	7.32	7.32
2533	763842.74	841798.43	Yes	9.83	9.59	**-0.24**	9.59	9.59	9.59
102003	690729.85	865786.03	Yes	10.32	10.09	**-0.23**	9.10	10.15	10.15
CP5448	793466.75	791910.24	Yes	6.73	6.51	**-0.22**	6.51	6.51	6.51
CP5466	741787.42	779895.37	Yes	9.38	9.16	**-0.22**	9.16	9.16	9.16
CP5456	824797.67	759561.53	Yes	7.71	7.51	**-0.20**	7.51	7.51	7.51
2526	758051.50	830079.94	Yes	8.54	8.34	**-0.20**	8.34	8.34	8.34
CP5491	610913.22	927281.08	Yes	16.48	16.28	**-0.20**	16.28	16.28	16.28
CP5468	741674.29	795757.17	Yes	8.83	8.68	**-0.15**	8.68	8.68	8.68
CP5451	773006.04	777563.14	Yes	8.24	8.13	**-0.11**	8.13	8.13	8.13
2031	687830.42	848415.37	Yes	9.43	9.33	**-0.10**	9.33	9.33	9.33
CP5478	694097.25	797653.55	Yes	9.35	9.28	**-0.07**	9.28	9.28	9.28
CP5486	645909.46	879411.76	Yes	16.80	16.73	**-0.07**	16.73	16.73	16.73
2162	663374.09	890482.09	Yes	9.24	9.19	**-0.05**	9.19	9.19	9.19
CP5462	757968.46	764512.23	Yes	9.24	9.19	**-0.05**	9.19	9.19	9.19
CP5467	714807.33	779941.23	Yes	8.82	8.81	**-0.01**	8.81	8.81	8.81
102007	687335.23	864599.88	Yes	12.76	12.76	**0.00**	12.76	12.76	12.76
2156	629415.47	892161.70	Yes	9.58	9.80	**0.22**	9.80	9.80	9.80
2072	826600.50	789445.86	Yes	7.41	7.63	**0.22**	7.63	7.63	7.63
2529	760650.09	832494.00	Yes	8.74	8.97	**0.23**	8.97	8.97	8.97
2525	757987.71	827983.37	Yes	8.81	9.04	**0.23**	9.04	9.04	9.04
CP5473	709627.19	827412.42	Yes	9.27	9.54	**0.27**	9.54	9.54	9.54
CP5469	711328.64	795780.84	Yes	9.65	9.93	**0.28**	9.93	9.93	9.93
2080	842720.18	864183.61	Yes	6.12	6.42	**0.30**	6.42	6.42	6.42
2010	707079.63	811016.61	Yes	9.52	9.86	**0.34**	9.86	9.86	9.86
2532	763850.35	839323.60	Yes	9.23	9.59	**0.36**	9.59	9.59	9.59
CP5488	613612.50	879495.91	Yes	19.62	20.02	**0.40**	20.02	20.02	20.02
CP5477	694217.58	781618.64	Yes	8.97	9.37	**0.40**	9.37	9.37	9.37

CP5482	667026.60	864123.48	Yes	17.09	17.49	**0.40**	17.49	17.49	17.49
CP5492	591007.70	913479.10	Yes	17.66	18.15	**0.49**	18.15	18.15	18.15
CP5449	808071.03	791956.49	Yes	7.36	7.86	**0.50**	7.86	7.86	7.86
CP5446	763473.30	791699.93	Yes	7.90	8.49	**0.59**	8.49	8.49	8.49
2176	856380.80	859280.15	Yes	7.57	8.18	**0.61**	8.18	8.18	8.18
102008	687419.05	864520.85	Yes	12.15	12.76	**0.61**	12.76	12.76	12.76
2159	642324.15	901028.16	Yes	12.63	13.39	**0.76**	13.39	13.39	13.39
2527	758095.62	831869.92	Yes	8.15	9.10	**0.95**	9.10	9.10	9.10
2528	758111.77	832534.49	Yes	8.01	8.97	**0.96**	8.97	8.97	8.97
102010	698756.73	864296.76	Yes	7.81	9.50	**1.69**	9.50	9.50	9.50
2012	717226.95	816549.19	No	8.65					
2108	781992.87	802248.91	No	7.58					
2109	769183.58	802203.58	No	7.85					
2110	759366.67	802192.35	No	7.79					
2522	751292.18	819580.01	No	8.75					
2523	752514.87	819588.40	No	8.35					
2524	752636.56	822046.82	No	8.75					
102002	690642.55	865884.58	No	9.51					
102004	690840.02	865888.00	No	9.77					

LiDAR Control Report (LiDAR Accuracy and Validation Results for Urban.

The following listing shows the results of the LiDAR data compared to the GPS ground survey control data collected on brush areas. The listing is sorted by the **Z Error** column showing, in ascending order, the vertical difference between the LiDAR points and the surveyed ground control points in urban areas.

Project File: MARSProject1 *
Date: March 06: 2009
Vertical Accuracy Objective
Requirement Type: Accuracy(z)
Accuracy(z) Objective: 1.20
Confidence Level: 95%
Control Points in Report: 157
Elevation Calculation Method: Interpolated from TIN
Control Points with LiDAR Coverage: 157
Control Points with Required Accuracy (+/- 1.20): 154
Percent of Control Points with Required Accuracy (+/- 1.20): 98.09
Average Control Error Reported: -0.16
Maximum (highest) Control Error Reported: 0.43
Median Control Error Reported: -0.14
Minimum (lowest) Control Error Reported: -1.58
Standard deviation (sigma) of Z for sample: 0.30
RMSE of Z for sample (RMSE(z)): 0.33: PASS
FGDC/NSSDA Vertical Accuracy (Accuracy(z)): 0.66: PASS
NSSDA Achievable Contour Interval: 2.0
ASPRS Class 1 Achievable Contour Interval: 2.0
NMAS Achievable Contour Interval: 2.0

Control	Control Pt.	Control Pt.	Coverage	Control Pt.	from LiDAR	Z Error	Min Z	Median Z	Max Z
Point Id	X(East)	Y(North)		Z(Elev)	Z(Elev)				
	USFeet	USFeet		USFeet	USFeet	USFeet	USFeet	USFeet	USFeet
CP5184	706855.80	1046372.76	Yes	16.90	15.32	-1.58	15.16	15.44	15.45
CP5180	712260.63	1043391.95	Yes	14.10	12.74	-1.36	12.55	12.76	12.82
2116	694726.46	1019408.53	Yes	17.37	16.21	-1.16	16.18	16.20	16.25
CP1305-PA1	680196.25	874644.88	Yes	16.91	16.05	-0.86	15.87	15.98	16.21
CP5195	708572.64	1055615.93	Yes	28.63	27.93	-0.70	27.79	28.03	28.09
2042	672227.02	879451.32	Yes	16.85	16.16	-0.69	16.10	16.16	16.20
2044	657809.08	879924.33	Yes	19.17	18.49	-0.68	18.42	18.49	18.65
CP5168	700051.20	1027058.80	Yes	15.47	14.81	-0.66	14.65	14.81	15.27
CP5189	711337.59	1052563.74	Yes	25.28	24.64	-0.64	24.56	24.63	24.75
CP1181	692064.78	1015285.10	Yes	17.94	17.34	-0.60	17.22	17.41	17.55
2511	763484.39	851173.37	Yes	12.08	11.49	-0.59	11.36	11.53	11.60
2506	759513.89	878229.88	Yes	12.68	12.11	-0.57	12.04	12.19	12.25

2512	763991.56	848882.57	Yes	12.22	11.68	-0.54	11.00	11.41	11.90
CP5137	675890.30	883147.50	Yes	14.55	14.02	-0.53	13.98	14.21	14.28
2508	764383.23	859191.57	Yes	13.50	12.99	-0.51	12.97	12.98	13.20
CP5131	672138.74	873259.52	Yes	18.23	17.73	-0.50	17.61	17.70	17.77
CP5176	706779.59	1043336.76	Yes	15.82	15.33	-0.49	15.26	15.43	15.60
2041	675669.07	877555.81	Yes	16.76	16.27	-0.49	16.15	16.29	16.88
2519	748424.61	848499.60	Yes	15.72	15.25	-0.47	14.81	15.05	15.57
CP5134	671321.83	871508.06	Yes	21.21	20.77	-0.44	20.66	20.73	20.83
CP5187	711697.66	1050331.23	Yes	22.14	21.72	-0.42	21.60	21.75	21.78
CP5227	702090.27	1057736.80	Yes	30.30	29.91	-0.39	29.83	29.97	30.13
CP5152	632175.03	968309.35	Yes	16.41	16.03	-0.38	15.99	16.08	16.32
CP1154	667755.64	887786.57	Yes	15.19	14.82	-0.37	14.75	14.89	14.95
CP5155	642592.34	972181.92	Yes	17.08	16.72	-0.36	16.51	16.73	17.02
CP5193	711098.81	1055403.00	Yes	26.65	26.30	-0.35	25.69	26.12	26.41
CP5192	711534.90	1054792.93	Yes	23.47	23.12	-0.35	23.05	23.08	23.59
CP5154	639140.33	971181.66	Yes	17.04	16.69	-0.35	16.64	16.65	16.72
CP1246	899289.29	888543.17	Yes	19.11	18.76	-0.35	18.70	18.79	19.06
CP5188	711673.73	1052063.04	Yes	23.57	23.23	-0.34	23.06	23.32	23.57
CP5179	713590.75	1043064.92	Yes	14.05	13.71	-0.34	13.70	13.74	13.93
CP1040	935035.94	860126.83	Yes	16.46	16.12	-0.34	16.05	16.21	16.36
CP1032	894453.00	904519.54	Yes	21.65	21.32	-0.33	21.27	21.34	21.44
CP5229	698618.52	1057736.34	Yes	31.05	30.73	-0.32	30.29	30.51	31.03
CP5167	699442.57	1025209.76	Yes	18.36	18.04	-0.32	17.62	17.94	18.14
CP5135	684357.11	879650.07	Yes	14.83	14.51	-0.32	14.36	14.43	14.73
CP5160	697131.74	1022498.37	Yes	21.61	21.30	-0.31	21.14	21.25	21.82
CP5136	685623.08	879525.48	Yes	21.18	20.88	-0.30	20.84	20.85	20.95
CP5132	669689.83	873668.95	Yes	18.47	18.17	-0.30	18.06	18.20	18.30
CP5165	698829.07	1024612.79	Yes	21.98	21.69	-0.29	21.51	21.61	22.02
CP5133	674412.04	873549.98	Yes	18.02	17.73	-0.29	17.52	17.62	17.78
2163	920021.03	854542.01	Yes	17.28	16.99	-0.29	16.90	16.94	17.16
CP5185	708290.94	1048683.90	Yes	19.09	18.81	-0.28	18.63	18.88	18.88
CP5145	617779.88	959364.53	Yes	15.62	15.34	-0.28	15.10	15.25	15.95
CP5103	759650.50	849364.68	Yes	10.75	10.47	-0.28	10.39	10.48	10.86
CP1195	882035.21	877321.97	Yes	21.52	21.24	-0.28	20.85	21.21	21.30
CP5200	711381.17	1059311.95	Yes	27.21	26.94	-0.27	26.88	26.93	27.10
CP5182	711382.63	1046877.73	Yes	18.20	17.95	-0.25	17.45	18.34	18.52
CP5147	622198.93	962886.92	Yes	16.45	16.20	-0.25	15.97	16.07	16.66
CP1046	903744.36	850473.87	Yes	15.02	14.77	-0.25	14.66	14.83	14.87
CP5190	711260.22	1053618.28	Yes	25.67	25.43	-0.24	25.27	25.43	25.45
CP5157	691128.89	1018717.35	Yes	19.41	19.17	-0.24	18.88	19.04	19.29
CP5156	689334.47	1014139.17	Yes	17.68	17.44	-0.24	17.43	17.46	17.46

CP5151	631233.95	967128.88	Yes	16.91	16.67	-0.24	16.57	16.57	16.84
2521	759397.73	857652.30	Yes	15.16	14.92	-0.24	14.81	14.89	15.03
CP1042	930327.36	855075.31	Yes	16.35	16.13	-0.22	16.11	16.14	16.18
2510	766189.46	852232.93	Yes	11.57	11.35	-0.22	11.32	11.38	11.52
2164	922214.16	864604.21	Yes	19.47	19.25	-0.22	19.24	19.26	19.28
2520	758219.84	851679.53	Yes	13.94	13.73	-0.21	13.62	13.62	13.81
CP5231	703644.32	1055126.03	Yes	28.10	27.90	-0.20	27.87	28.26	28.37
CP5186	711512.56	1049596.69	Yes	18.84	18.64	-0.20	18.49	18.71	18.75
CP5183	710815.88	1047289.96	Yes	19.11	18.92	-0.19	18.79	19.03	19.06
CP5174	703200.31	1031521.96	Yes	16.64	16.45	-0.19	16.30	16.46	16.62
CP5101	759271.25	847356.89	Yes	9.96	9.77	-0.19	9.70	9.88	9.93
CP1153	681308.90	882835.25	Yes	23.63	23.44	-0.19	23.34	23.43	23.87
2516	749023.21	846578.95	Yes	14.36	14.17	-0.19	12.67	14.26	14.45
CP5199	709202.81	1058140.47	Yes	29.08	28.90	-0.18	28.71	28.74	29.59
CP5108	759375.06	860427.91	Yes	13.19	13.01	-0.18	12.82	13.00	13.11
CP1044	923269.86	850031.23	Yes	15.44	15.26	-0.18	15.24	15.30	15.74
CP1039	939833.74	860120.23	Yes	15.07	14.89	-0.18	14.81	14.95	15.17
2509	764144.49	855087.19	Yes	15.75	15.57	-0.18	15.52	15.55	15.79
2502	769142.73	900439.92	Yes	13.63	13.45	-0.18	13.28	13.49	13.50
CP5166	697722.28	1024883.20	Yes	19.12	18.95	-0.17	18.79	18.96	19.05
CP5118	774117.30	841567.21	Yes	14.01	13.84	-0.17	13.83	13.84	13.90
2501	766816.07	904436.35	Yes	12.46	12.30	-0.16	11.65	12.52	13.12
CP5173	702174.88	1030584.57	Yes	17.32	17.17	-0.15	17.01	17.31	17.42
CP5202	711365.05	1061001.65	Yes	26.83	26.69	-0.14	26.17	26.85	27.04
CP5178	712405.22	1042779.17	Yes	14.70	14.56	-0.14	14.11	14.72	14.89
CP5162	699058.95	1023494.85	Yes	19.92	19.78	-0.14	19.74	19.78	19.97
CP5170	701188.62	1028260.94	Yes	14.50	14.37	-0.13	14.34	14.40	14.65
2165	910099.68	863580.02	Yes	18.32	18.19	-0.13	17.97	18.01	18.31
CP5128	891777.57	895059.11	Yes	21.08	20.96	-0.12	20.66	20.89	21.01
CP1047	895626.38	850102.91	Yes	14.65	14.53	-0.12	14.45	14.58	14.64
CP5175	703037.06	1032389.26	Yes	18.90	18.79	-0.11	18.64	18.73	18.99
CP5130	917044.88	864381.18	Yes	18.53	18.42	-0.11	18.38	18.48	18.64
CP5129	877269.60	855071.01	Yes	15.91	15.80	-0.11	15.55	15.69	15.82
CP1120	710318.13	1059697.36	Yes	28.60	28.49	-0.11	28.33	28.37	28.80
CP5196	711803.47	1056893.26	Yes	25.78	25.68	-0.10	25.66	25.68	26.13
CP5169	700885.01	1027591.47	Yes	13.52	13.42	-0.10	13.36	13.47	13.48
CP5107	759722.06	851812.55	Yes	11.78	11.68	-0.10	11.51	11.77	11.80
2503	764278.17	904657.06	Yes	16.04	15.94	-0.10	15.89	16.03	16.09
CP5230	704095.48	1057687.44	Yes	29.37	29.28	-0.09	28.96	29.44	30.05
CP5205	710787.69	1063472.33	Yes	28.36	28.27	-0.09	28.08	28.15	28.49
CP5138	623127.22	902163.76	Yes	11.70	11.61	-0.09	11.47	11.64	12.02

2087	776460.91	919237.66	Yes	15.87	15.78	-0.09	15.68	15.68	15.91
CP5194	709948.38	1055373.78	Yes	27.26	27.19	-0.07	27.03	27.10	27.32
CP5114A	759390.99	853846.54	Yes	16.39	16.32	-0.07	16.06	16.17	16.58
CP1125	742723.91	1034889.53	Yes	19.63	19.56	-0.07	19.46	19.50	20.10
CP5148	624851.88	963273.30	Yes	14.88	14.82	-0.06	14.62	14.74	14.93
CP1183	698931.52	1023870.01	Yes	22.54	22.48	-0.06	22.23	22.38	22.63
CP5158	694322.57	1018263.10	Yes	17.94	17.89	-0.05	17.10	18.06	18.34
CP5153	634540.72	969361.97	Yes	15.38	15.33	-0.05	15.27	15.38	15.81
CP5172	701335.61	1029318.98	Yes	19.15	19.11	-0.04	19.11	19.12	19.18
CP5163	700231.47	1022664.78	Yes	19.21	19.17	-0.04	19.13	19.18	19.24
CP5141	622248.29	907110.18	Yes	13.85	13.82	-0.03	13.60	13.63	13.92
CP5191	709695.17	1053104.74	Yes	24.89	24.87	-0.02	24.45	24.63	25.01
CP5110	761143.19	851188.99	Yes	11.37	11.35	-0.02	11.31	11.55	11.55
CP5159	696024.70	1021726.67	Yes	16.81	16.80	-0.01	16.53	16.57	17.33
CP5111	776398.40	848635.32	Yes	12.82	12.81	-0.01	12.70	12.80	12.83
CP1138	764968.79	905745.33	Yes	36.84	36.83	-0.01	36.74	36.97	37.15
CP1137	776348.34	919815.40	Yes	18.61	18.60	-0.01	18.57	18.62	18.71
CP5139	621361.24	903085.67	Yes	13.55	13.55	0.00	13.36	13.56	14.05
CP5105	763793.77	848626.79	Yes	13.40	13.40	0.00	13.11	13.39	13.44
2504	764837.87	905666.60	Yes	36.84	36.84	0.00	36.63	36.87	37.04
CP5149	626517.12	962672.25	Yes	17.94	17.95	0.01	17.84	17.87	18.13
CP5119	774990.36	857862.22	Yes	9.89	9.91	0.02	9.62	9.95	10.02
CP1121	716298.53	1061775.62	Yes	23.84	23.86	0.02	23.70	23.92	23.99
CP5181	711575.29	1045042.38	Yes	16.70	16.73	0.03	16.55	16.93	16.95
CP5146	612486.42	957097.99	Yes	18.06	18.09	0.03	17.72	18.13	18.13
CP1123	722280.09	1044562.23	Yes	40.03	40.06	0.03	40.02	40.06	40.09
CP5140	624504.47	908200.06	Yes	13.71	13.75	0.04	13.43	13.63	14.21
2505	756930.04	892478.93	Yes	14.13	14.18	0.05	14.14	14.18	14.20
CP5177	711326.72	1042890.89	Yes	15.25	15.33	0.08	15.12	15.15	15.39
CP5164	700240.30	1023351.10	Yes	18.73	18.81	0.08	18.75	18.96	19.09
CP1034	914104.72	903609.42	Yes	20.83	20.91	0.08	20.65	20.80	21.06
CP5198	711356.55	1057856.11	Yes	27.31	27.40	0.09	27.12	27.41	27.53
CP5142	627409.29	910870.85	Yes	19.89	19.98	0.09	19.65	19.82	20.28
CP5112	764565.59	859032.04	Yes	15.53	15.62	0.09	15.48	15.52	15.70
CP5143	627871.81	908624.21	Yes	16.14	16.24	0.10	15.79	16.09	16.31
CP5106	758554.93	851826.92	Yes	14.54	14.64	0.10	14.23	14.64	14.71
CP1184	702633.80	1031624.33	Yes	19.41	19.51	0.10	19.24	19.44	19.62
CP5204	711176.12	1062233.49	Yes	26.55	26.66	0.11	26.39	26.66	26.80
CP5161	699136.00	1022418.39	Yes	19.27	19.38	0.11	19.09	19.32	19.56
CP5201	709885.15	1059223.84	Yes	28.26	28.39	0.13	28.07	28.25	28.80
CP5109	757815.83	858816.06	Yes	15.45	15.58	0.13	15.38	15.48	15.79

CP5104	765148.29	872607.46	Yes	10.52	10.65	0.13	10.61	10.73	10.82
2507	765911.57	868602.44	Yes	13.41	13.55	0.14	13.49	13.57	13.67
CP5150	630243.27	965650.97	Yes	16.45	16.60	0.15	16.46	16.61	16.79
CP5144	614352.16	957094.71	Yes	17.98	18.13	0.15	17.90	17.94	18.25
CP5102	758296.19	844484.63	Yes	11.20	11.35	0.15	10.92	11.26	11.62
CP1122	711346.09	1041097.82	Yes	18.93	19.09	0.16	18.90	18.90	19.15
2039	678515.64	879844.23	Yes	16.03	16.19	0.16	16.07	16.15	16.26
CP5197	709945.11	1056502.89	Yes	28.29	28.46	0.17	27.93	28.24	28.53
CP5114B	761357.34	854002.15	Yes	12.35	12.52	0.17	12.39	12.47	12.69
2517	747977.44	847030.99	Yes	12.07	12.24	0.17	12.12	12.31	12.45
2515	749651.04	846182.42	Yes	13.66	13.84	0.18	13.71	13.86	13.90
CP5127	870246.50	902978.15	Yes	24.00	24.19	0.19	23.78	24.24	24.45
CP5117	759316.88	856511.87	Yes	14.47	14.66	0.19	14.48	14.79	15.01
CP5171	700994.72	1028790.94	Yes	17.68	17.90	0.22	17.53	17.71	18.20
CP5113	769136.70	852403.68	Yes	14.10	14.37	0.27	14.11	14.19	14.71
CP5116	766937.39	853769.84	Yes	12.98	13.28	0.30	12.66	13.39	13.61
CP5115	763969.17	853767.02	Yes	13.03	13.34	0.31	13.15	13.50	13.57
2518	746738.21	847812.32	Yes	12.01	12.32	0.31	12.27	12.35	12.38
2513	760372.95	848402.28	Yes	11.77	12.10	0.33	11.86	11.88	12.24
2514	749935.17	847314.56	Yes	18.08	18.42	0.34	18.30	18.57	18.61
CP1119	699841.43	1059721.23	Yes	31.08	31.51	0.43	30.99	31.62	31.71
2500	767221.16	906325.88	Yes	17.42	17.85	0.43	17.75	17.84	17.86

LiDAR CALIBRATION

Introduction

A LiDAR calibration or 'boresight' is performed on every mission to determine and eliminate systemic biases that occur within the hardware of the Leica ALS50 laser scanning system, the inertial measurement unit (IMU), and because of environmental conditions which affect the refraction of light. The systemic biases that are corrected for include roll, pitch, and heading.

Calibration Procedures

In order to correct the error in the data, misalignments of features in the overlap areas of the LiDAR flightlines must be detected and measured. At some point within the mission, a specific flight pattern must be flown which shows all the misalignments that can be present. Typically, Merrick flies a pattern of at least three opposing direction and overlapping lines, three of which provide all the information required to calibrate the system.

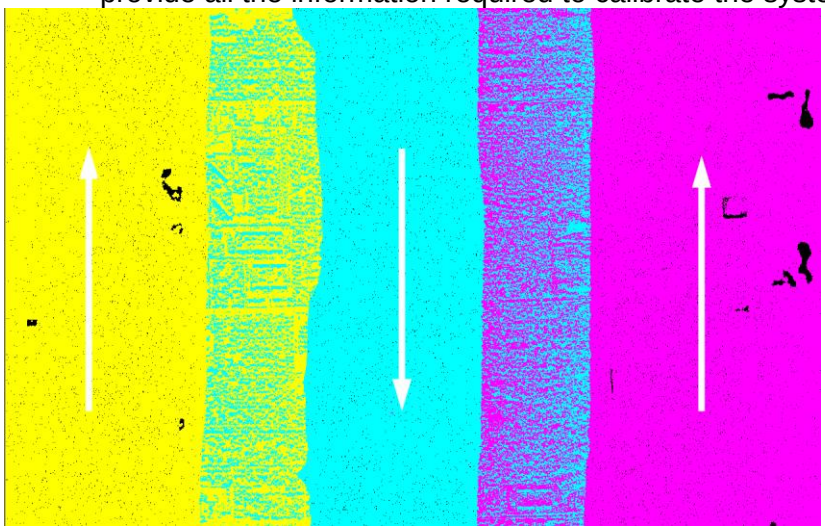


Figure 1: Flight pattern required for calibration

Correcting for Pitch and Heading Biases

There are many settings in the ALS40/50 post processor that can be used to manipulate the data; six are used for boresighting. They are roll, pitch, heading, torsion, range and atmospheric correction. The order in which each is evaluated is not very important and may be left to the discretion of the operator. For this discussion, pitch and heading will be evaluated first. It is important to remember that combinations of error can be very confusing, and this is especially true with pitch and heading. They affect the data in similar ways, so error attributed to pitch may be better blamed on heading and vice versa. To see a pitch/heading error, one must use the profile tool to cut along the flight path at a pitched roof or any elevation feature that is parallel to the flight path. View the data by elevation to locate these scenarios.

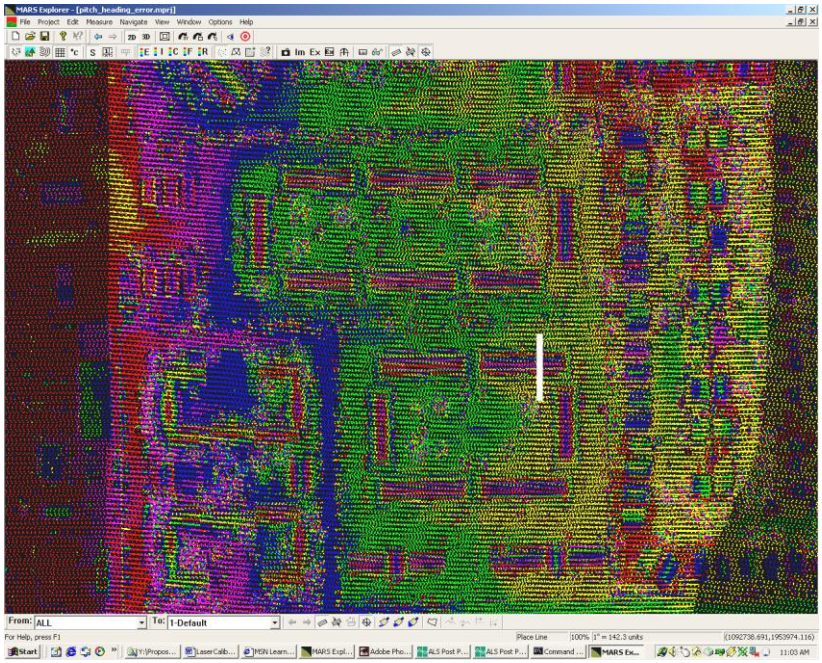


Figure 2: Orthographic view with profile line

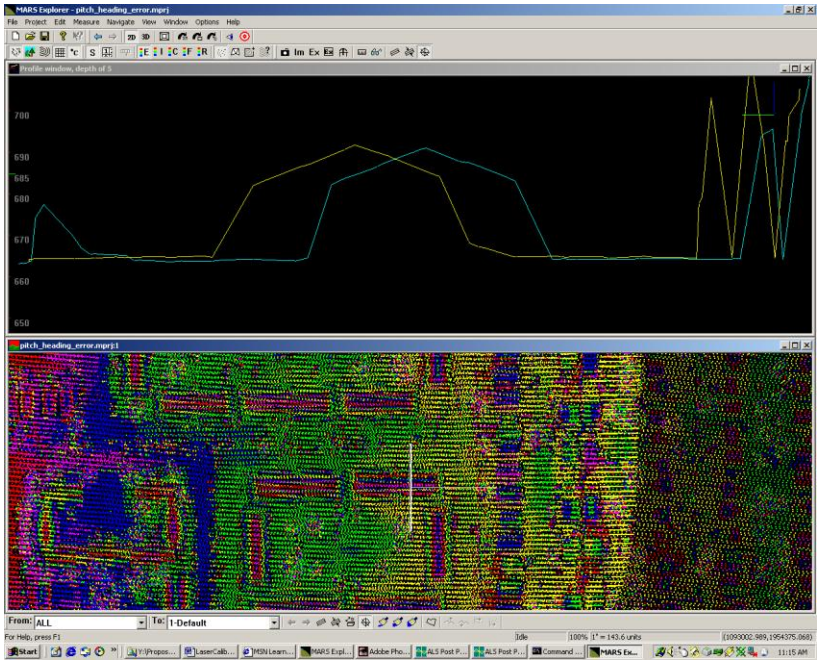


Figure 3: Profile view of misalignment

The profile line in figures 2 and 3 has an additional thin line perpendicular to the cut that shows the direction of the view. In this case, the line is pointing to the right, or east. In the profile window, we are looking through two separate TINs, so there are two lines showing the location of the same building. The yellow line is from the flight line on the left (flown north); the light blue line is from the flight line in the middle (flown south).

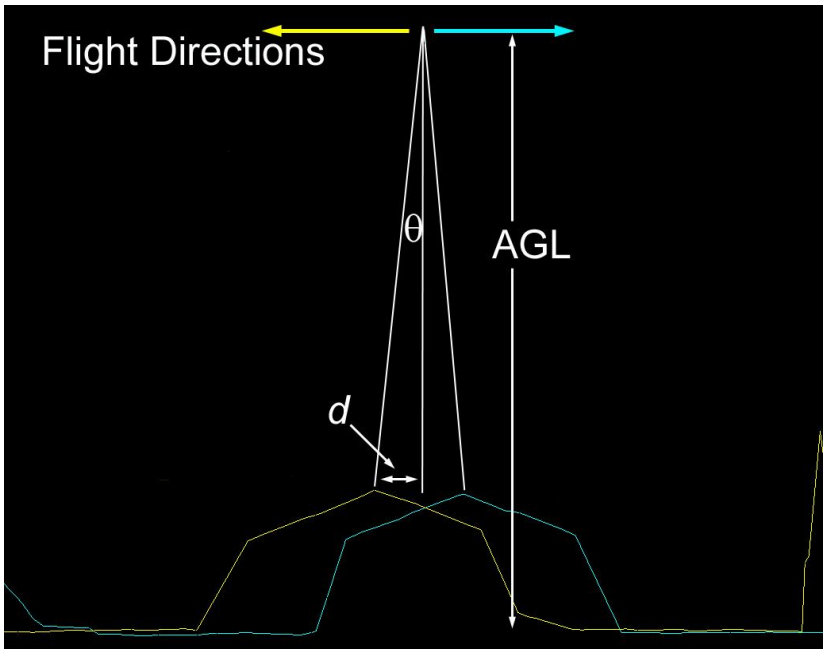


Figure 4: Adjusting pitch

The top arrows represent each respective flight direction. We are looking east, the yellow flight line was flown north, and the blue line is flown south. Adjusting pitch changes the relationship between the pitch from the IMU and the actual pitch of the plane. Increasing pitch sends the nose of the plane up and the data ahead in the flight direction. Lowering pitch does the opposite. In this example, pitch needs to decrease in order to bring these two roof lines together. The angle thetą must be expressed in radians. The formula to arrive at this angle is…

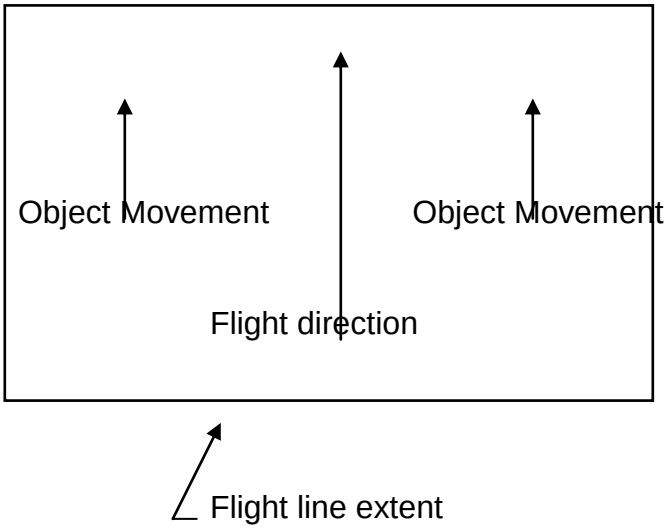
$$\theta = \frac{\arctan\left(\frac{d}{AGL}\right)}{57.2958}$$

where *d* is the distance from nadir (directly under the plane) to the peak of the roof and AGL is the 'above ground level' of the plane. The conversion from degrees to radians is one radian equals 57.2958 degrees. This number is then subtracted from the pitch value that was used to create the data.

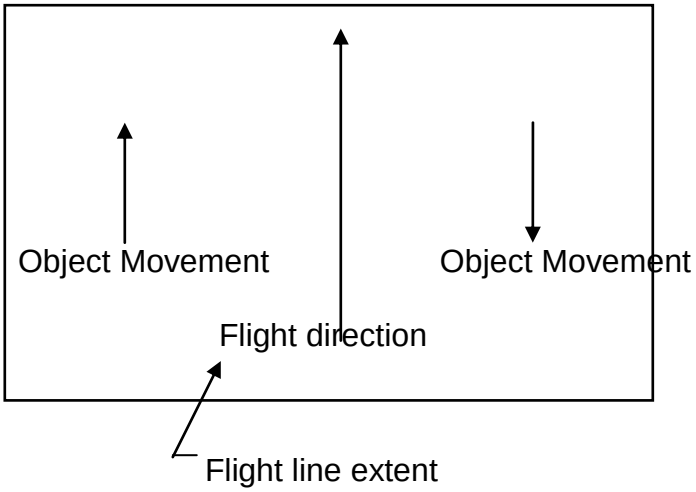
The next issue to resolve, before actually changing the pitch value, is to determine if this shift is at all due to an incorrect heading value, since heading will move data in the direction of flight also. The difference is that heading rotates the data, meaning that when heading is changed, objects on opposite sides of the swath move in opposite directions.

Figures 5 and 6: Pitch and Heading movement

Pitch increases, objects throughout the data move forward.



Heading increases, objects move clockwise.



When heading changes, objects on the sides of the flight line move in opposite directions. If heading is increased, objects in the flight line move in a clockwise direction. If heading is decreased, objects move in a counter-clockwise direction.

To find out if heading is correct, a similar profile line must be made in the overlap area between the middle flight line and the one to the east, or right side. If the distance *d* (see figure 4) is different on the right verses the left, then heading is partially responsible for the error. If the distance *d* is the same on both sides then heading *or* pitch is fully responsible.

Correcting for the Roll Bias

The purpose of a 'truth survey' is to evaluate roll and to ensure that the surface is accurate vertically. This survey is typically done in a localized area and the purpose is to provide a truth reference to every mission and to help in the calibration effort. Since every mission's data must be compared to this survey, it makes sense for this survey to be done at a place where the plane will be for every mission, i.e., the airport. The survey is done along a taxiway or runway, and the calibration flight lines are flown perpendicular to it, which makes it perfect for evaluating roll.

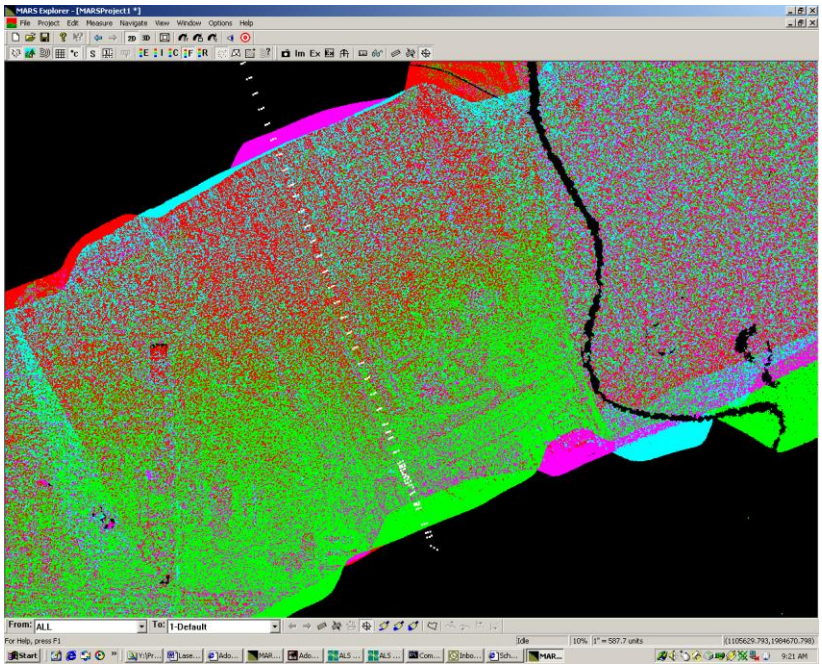


Figure 7: The truth survey

The white dots represent the survey, and four flight lines, two from the beginning of the mission and two from the end, have been flown. Each pair of flight lines was flown in opposite directions, and in this case the red and blue lines were flown east and the green and magenta lines were flown west. The first step is to make a profile line across the survey. It is important to create this cut on one side of the taxiway so as to avoid cutting through and over the crown. Once the profile is created, exaggeration of the elevation by 100 times is necessary to see the pattern. (figure 8)

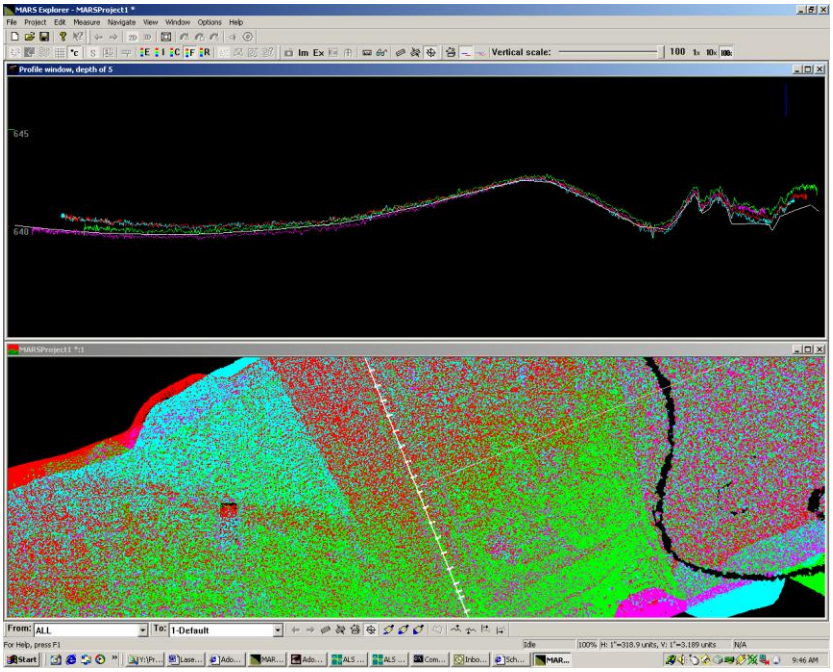


Figure 8: Profile view of calibration flight lines

Even without zooming in, a pattern is already apparent. The two east flown lines, red and blue, are high on the left compared to the west flown lines, and low on the right. Since the profile line was created with the view eastward, it is easiest to think about what the east lines are doing. The east lines are low on the right, which means the relationship between the IMU and the right wing of the plane must be adjusted up. As in heading adjustments, sending the data in a clockwise direction is positive. If the axis of the clock is the tail/nose axis of the plane, then it is obvious this data must go in a counter clock-wise, or negative direction. The method for determining the magnitude of the adjustment is similar to determining the magnitude of the adjustment for the pitch. The only difference is how the triangles are drawn in relationship to the data. (figures 9 and 10)

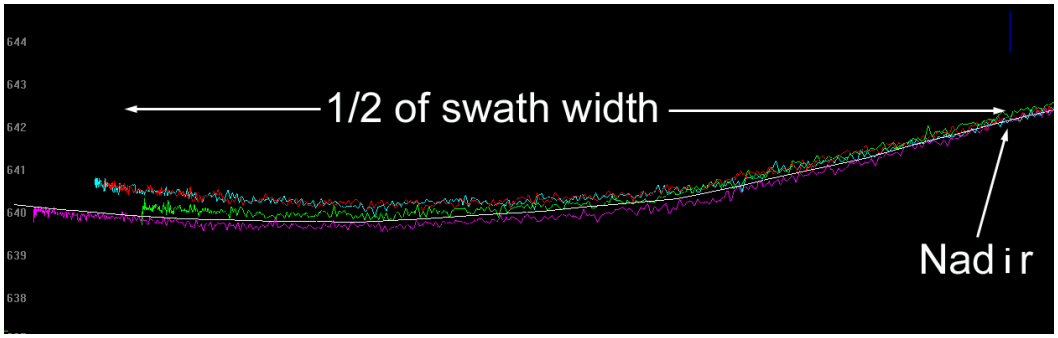


Figure 9: Half of calibration profile

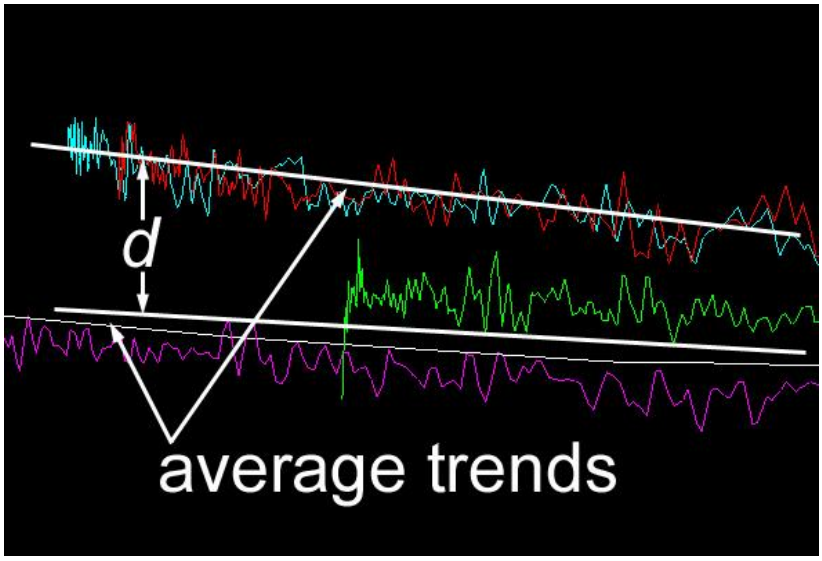


Figure 10: Differences in average roll trends

The important measurements for this formula are the distance from nadir to the edge of the swath, or ½ swath width, and d, the distance from the two average trend lines for each group. Since any adjustments made to roll effect both east and west lines, we are really interested in ½ d; this will give the value that will bring both sets of lines together. The formula is:

$$\theta = \frac{\arctan\left(\frac{d/2}{EdgeToNadir}\right)}{57.2958}$$

Correcting the Final Elevation

The next step is to ensure that all missions have the same vertical offset. Two techniques are used to achieve this. The first is to compare all calibration flight lines and shift the missions appropriately. The second is to fly an extra 'cross flight' which touches all flight lines in the project. Each mission's vertical differences can then be analyzed and corrected. However, the result of this exercise is only proof of a high level of relative accuracy. Since many of the calibration techniques affect elevation, project wide GPS control must be utilized to place the surface in the correct location. This can be achieved by utilizing the elevation offset control in the post processor or by shifting the data appropriately in MARS. The control network may be pre-existing or collected by a licensed surveyor. This is always the last step and is the only way to achieve the high absolute accuracy that is the overall goal.