STARR
Strategic Alliance
for Risk Reduction

Cuming
Post-Flight Aerial Acquisition
Report

August 2011

Post-Flight Aerial Acquisition and Calibration Report

FEMA REGION 7
Cuming County, Nebraska

August 2011

Contents

1. Overview

1.1. Contact Information

Questions regarding the technical aspects of this report should be addressed to:

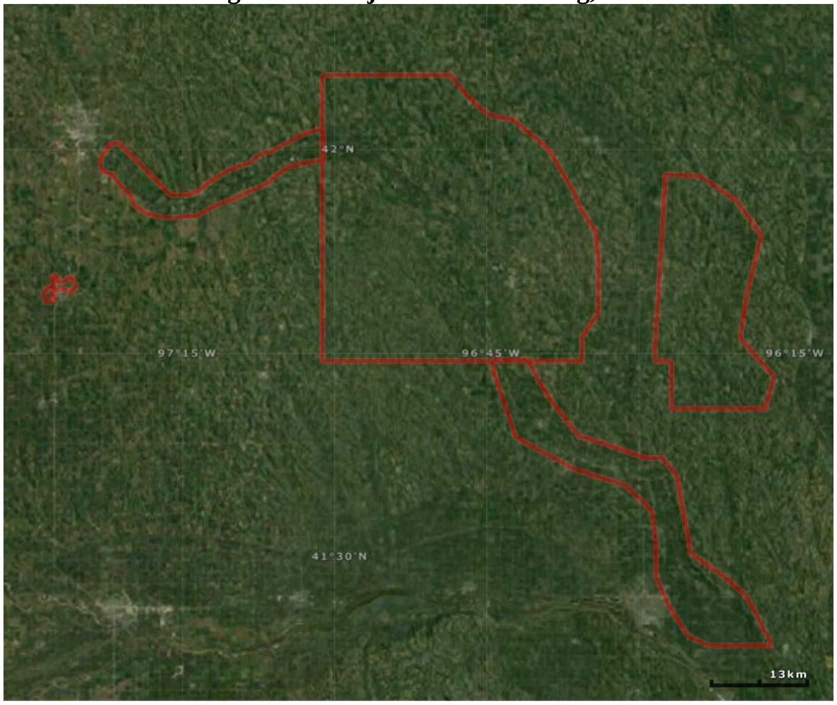
AeroMetric, Inc.
4020 Technology Parkway
Sheboygan, WI 53081

Attn: Robert Merry (Geomatics Manager)
Telephone: 920-457-3631
FAX: 920-457-0410
Email: rmerry@aerometric.com

1.2. Purpose and Location

AeroMetric, Inc acquired highly accurate Light Detection and Ranging (LiDAR) data for an area that comprised of approximately 800 square miles of Cuming County and surrounding counties in Nebraska for STARR as a part of FEMAs RiskMAP program.   A graphic of the location is provided in Figure 1.1.

Figure 1.1 Project Area – Cuming,NE



2. Acquisition

2.1. System Specifications

The LiDAR system specifications are provided in Table 2.1. There are five Cuming areas, Two areas paralleling the Elkhorn River were collected to the Highest Specification Level and the remaining three areas were collected to the High Specification Level.

Table 2.1 LiDAR System Specifications

High FEMA Specification Level
(4 Foot Equivalent Contour Accuracy)
Height – 2400 meters
Laser Pulse Rate – 50 kHz
Mirror Scan Frequency – 23 Hz
Scan Angle (+/-) 22°
Side Lap – 30%
Ground Speed – 160 knots
Nominal Point Spacing – 1.7 meter

Highest FEMA Specification Level
(2 Foot Equivalent Contour Accuracy)
Flying Height – 1700 meters
Laser Pulse Rate – 70 kHz
Mirror Scan Frequency – 37 Hz
Scan Angle (+/-) 17°
Side Lap – 50%
Ground Speed – 160 knots
Nominal Point Spacing – 0.78 meter

2.2. Base Station Information

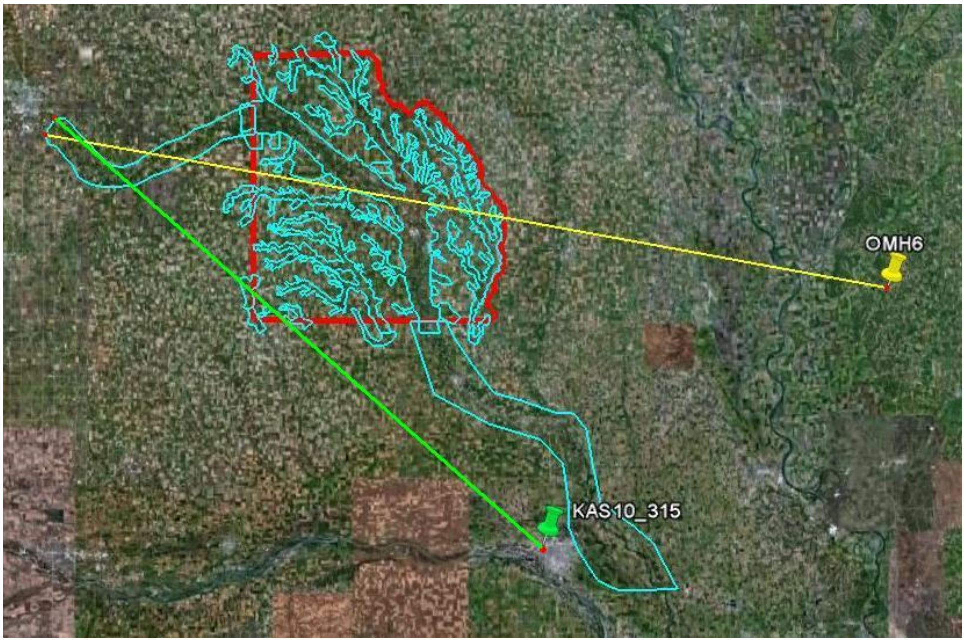
Table 2.2 provides the base stations locations that were used during the seven mission flights.

Table 2.2 Base Station Locations

POINT ID	LAT	LONG	HEIGHT (M)
KAS10_315	41 26 57.60685	96 30 55.00502	365.58
OMH6	41 46 42.57607	95 54 41.34132	398.356

Figure 2.1 provides a graphic representation of the location. In this graphic, the Green Stick Pin represents Base Station KAS10_315 that was utilized by 6 of the 7 flight missions. The maximum extent of the collection area was approximately 94.5k from Base Station KAS10_315, as represented by the green line. The Yellow Stick Pin represents Base Station OMH6 that was utilized by 1 of the 7 flight missions. The maximum extent of the collection area was approximately 125k from Base Station OMH6, as represented by the yellow line. Shapefiles of the Base Stations can be found in the Control.zip file attached to this report.

Figure 2.1 Base Station Locations



2.3. Time Period

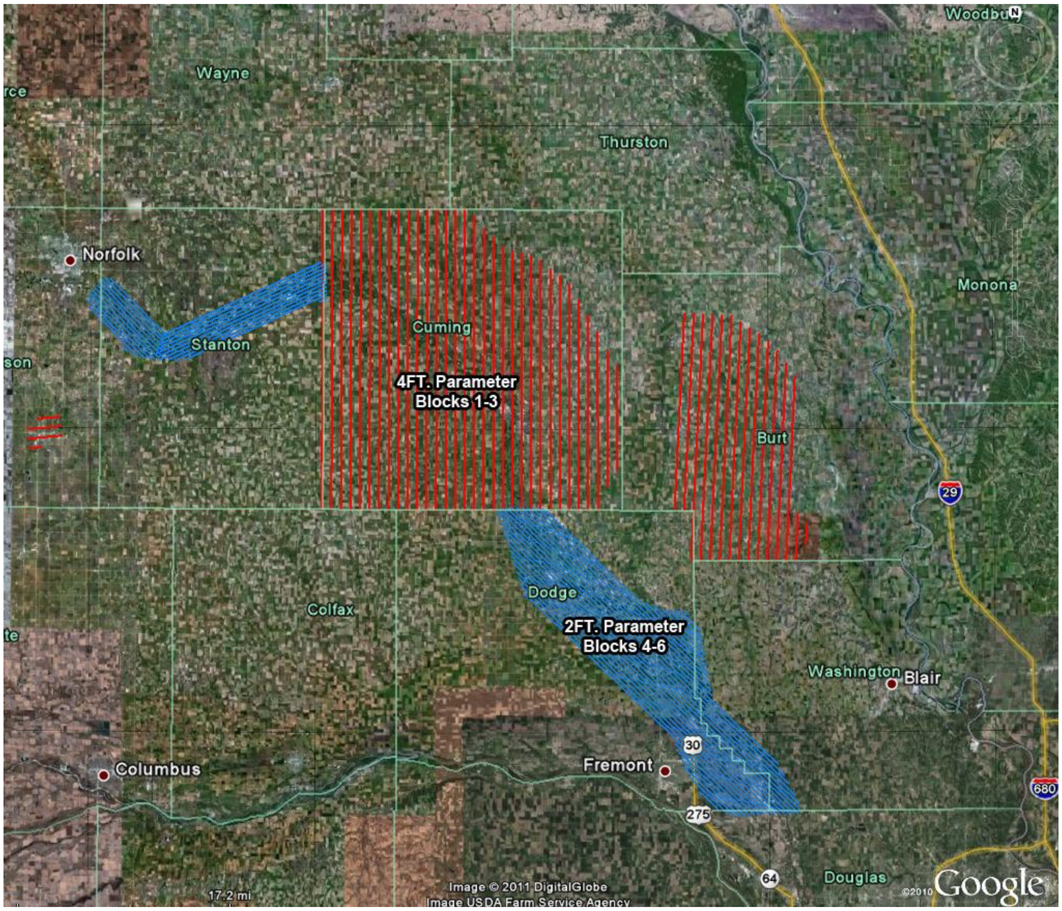
LiDAR data acquisition was completed between November 18, 2010 and December 6, 2010. A total of 7 flight missions were required to cover the project area. Missions 111810A and 112310A were flown but sections of the information from the flights were not used for the project. Information on these missions is provided in Table 2.3.

Table 2.3 Airborne LiDAR Acquisition Flight Summary

Acquisition Date, Mission, and Time	20101118 KAS10_315A 10:40-13:50 CST
	20101118 KAS10_315B 15:55-19:34 CST
	20101119 KAS10_315A 18:16-22:02 CST
	20101123A KAS10_315A 8:51-12:52 CST
	20101123B KAS10_315A 15:14-19:23 CST
	20101125 KAS10_315A 7:44-11:25 CST
	20101206 KAS10_315A 18:23-22:07 CST
Area of Acquisition	800 square miles
Aircraft	Twin Engine Fixed Wing
Planned Altitude	Blocks 1-3 2,400 meters AGL; Blocks 4-6 1,700 meters AGL
Planned Airspeed	160 knots
Planned Number of Flight Lines	Block 1 - 4 lines; Block 2 - 32 lines; Block 3 – 15 Lines
	Block 4 - 35 lines; Block 5 - 11 lines; Block 6 -12 Lines
Flight Line Spacing	Blocks 1 -3 450 meters; Blocks 4-6 1220 meters
Flight Line Coverage	2920 meters
Sidelap	Blocks 1-3 30%; Blocks 4-6 50%
System PRF	Blocks 1-3 50 kHz; Blocks 4-6 70 kHz
Mirror Scan Half Angle	Blocks 1-3 22°; Blocks 4-6 17°
Mirror Scan Rate	Blocks 1-3 23 Hz; Blocks 4-6 37 Hz
Nominal Point Density	Blocks 1-3 0.31ppm^2; Blocks 4-6 1.64 ppm^2
Datum	NAD83(HARN)
	NAVD88 via Geoid09
Projection and Units	Universal Transverse Mercator (UTM 14N)

Figure 2.2 depicts the flightlines for each area of the project. Shapefiles of the flightline swath can be found in the Coverage.zip file attached to this report.

Figure 2.2 LiDAR Flight Line Layout Map



2.4. PDOP

The maximum planned PDOP for the LiDAR collection was set at ≤ 3.0. The PDOP plots are provided in Figures 2.3-2.9. Two different versions of software were utilized for the GPS and POS processing. Both software versions are provided by the manufacture APPLANIX, but the reporting of the data is different. The graphs provided show the same information but are represented in different formats

PDOP Plots

Figure 2.3 – KAS10_315_111810A

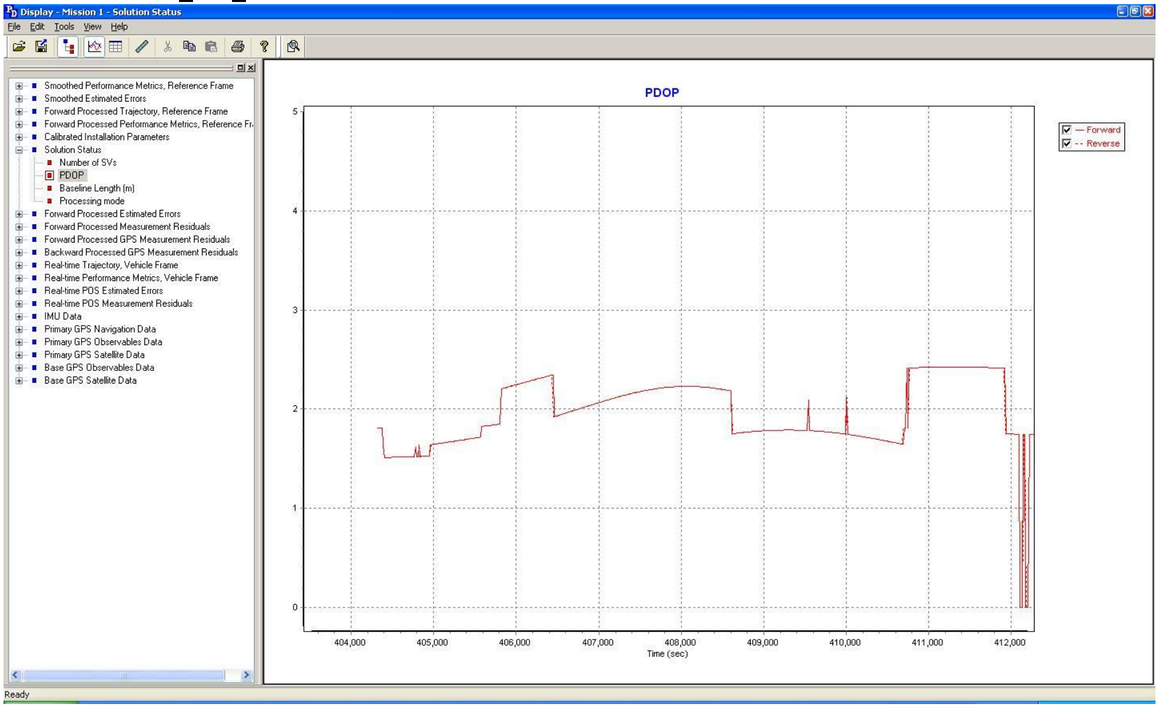


Figure 2.4 – KAS10_315_111810B

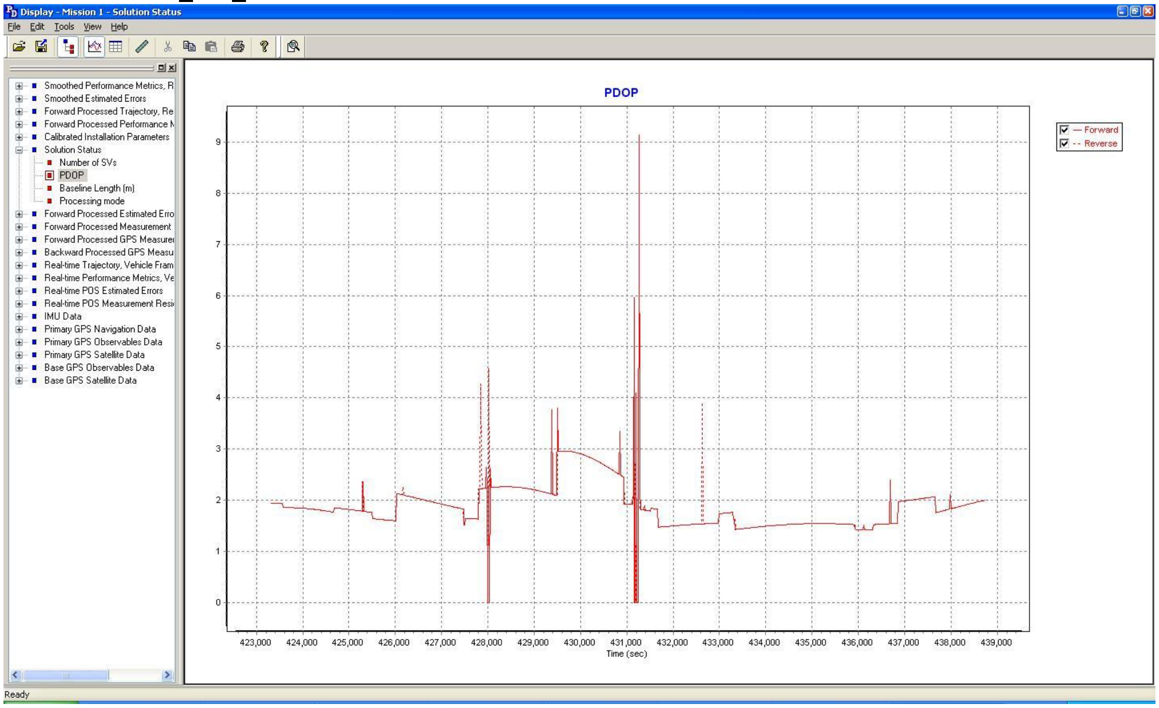


Figure 2.5 – KAS10_315_111910B

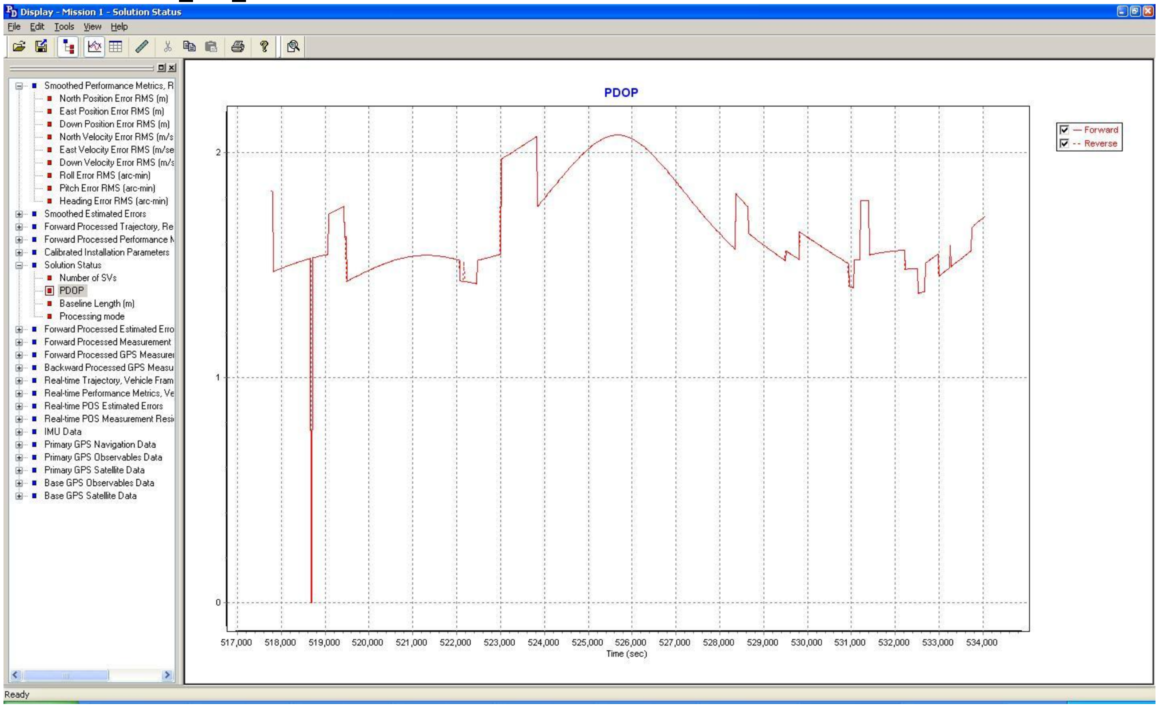


Figure 2.6 – KAS10_315_112310A

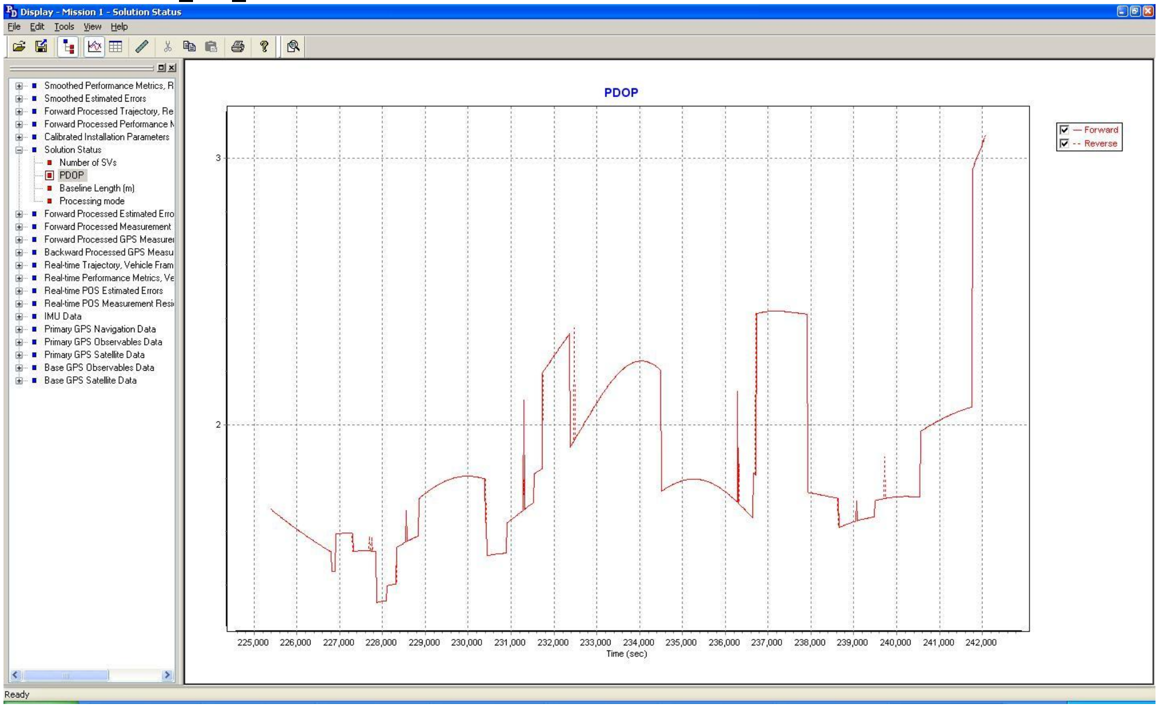


Figure 2.7 – KAS10_315_112310B

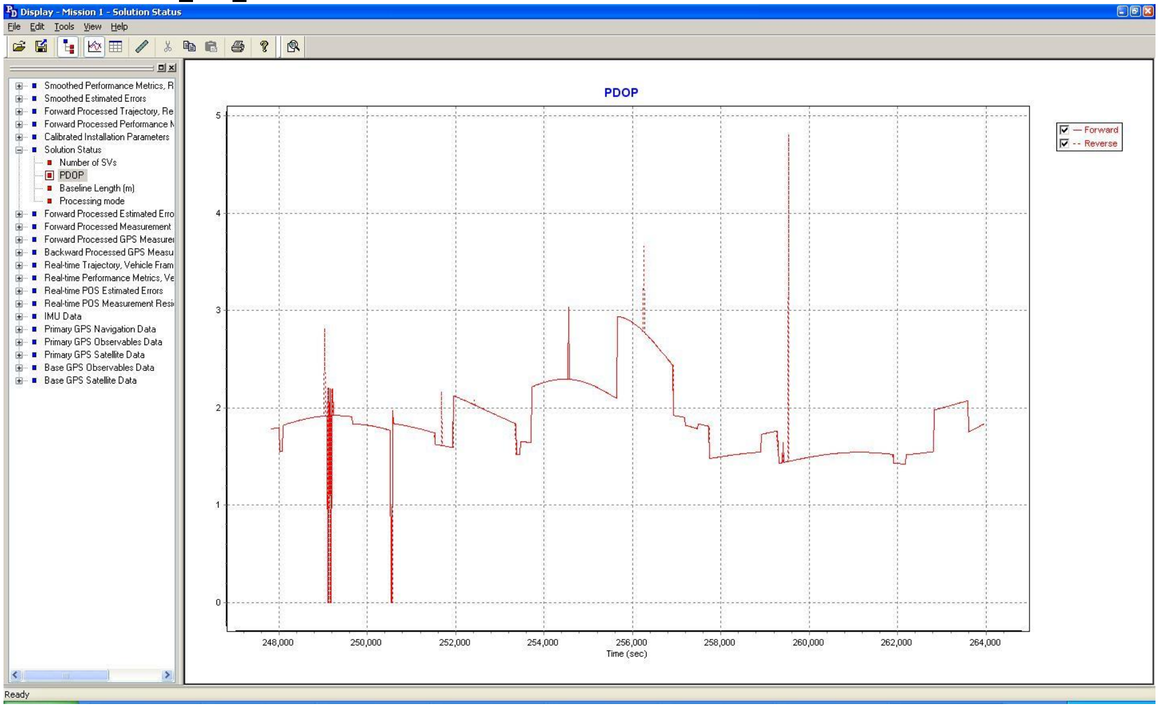


Figure 2.8 – KAS10_315_112510

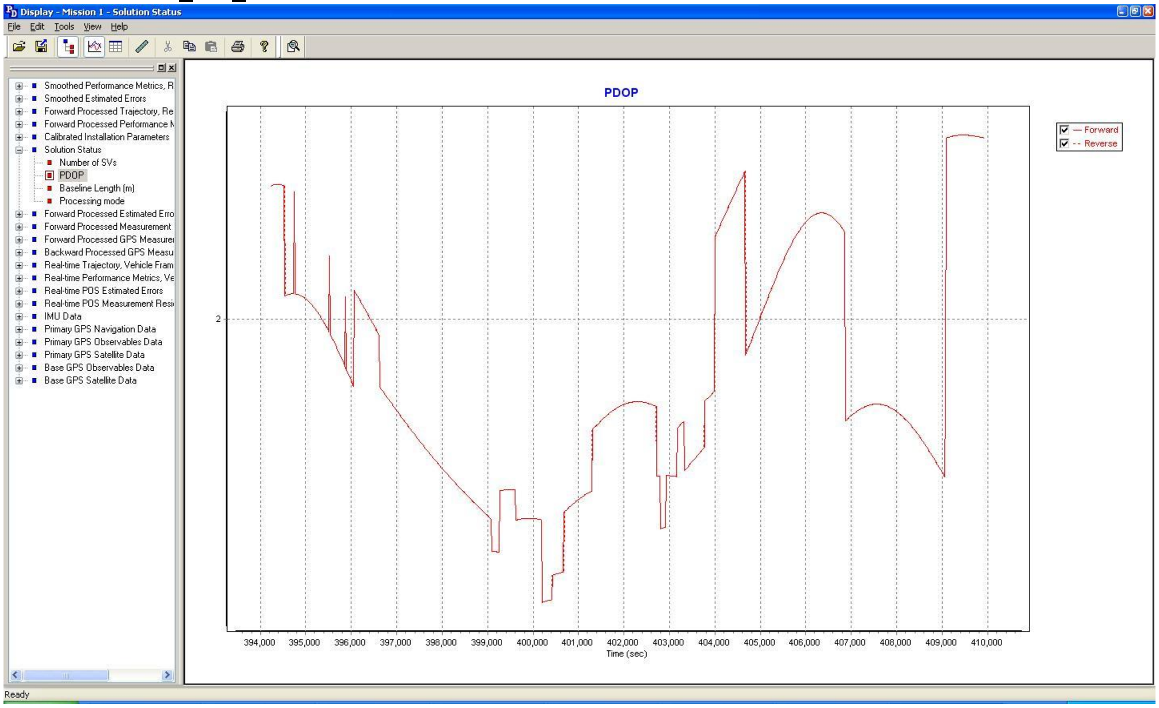
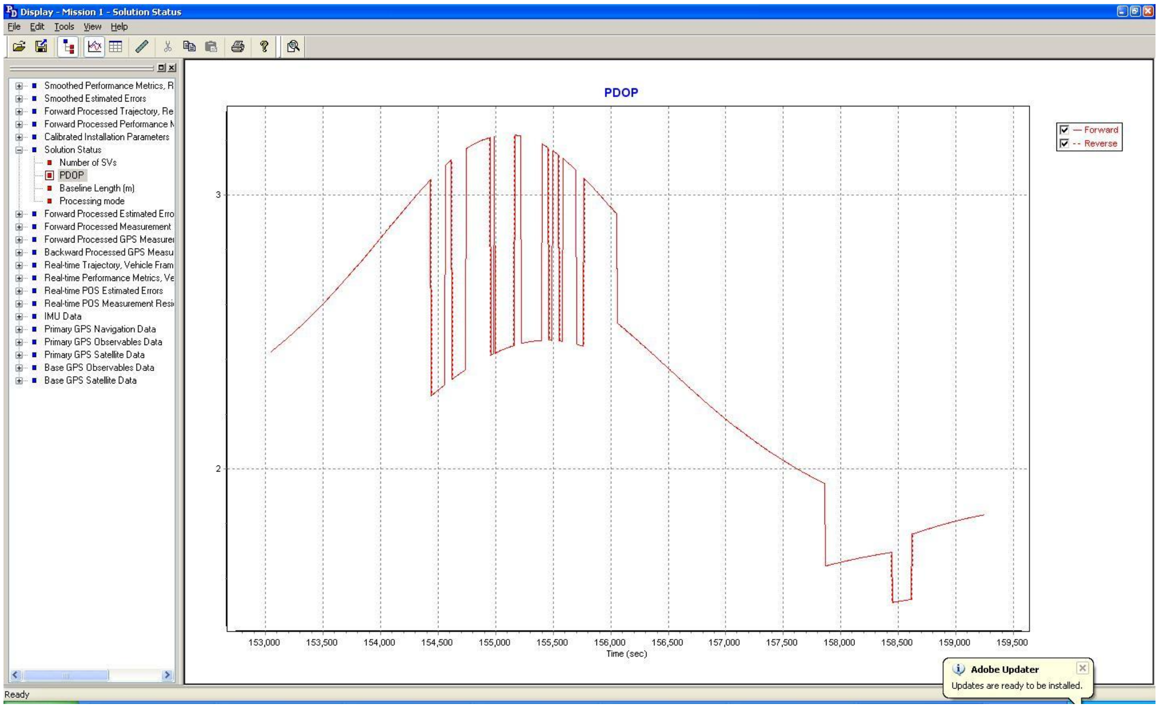


Figure 2.9 - L120610



Updates are ready to be installed.

3. Processing Summary

3.1. Airborne GPS

Applanix - POSGPS

Utilizing carrier phase ambiguity resolution on the fly (i.e., without initialization), the solution to sub-decimeter kinematic positioning without the operational constraint of static initialization as used in semi-kinematic or stop-and-go positioning was utilized for the airborne GPS post-processing.

The processing technique used by Applanix, Inc. for achieving the desired accuracy is Kinematic Ambiguity Resolution (KAR). KAR searches for ambiguities and uses a special method to evaluate the relative quality of each intersection (RMS). The quality indicator is used to evaluate the accuracy of the solution for each processing computation. In addition to the quality indicator, the software will compute separation plots (Figures 3.1-3.7) between any two solutions, which will ultimately determine the acceptance of the airborne GPS post processing.

GPS Separation Plots

Figure 3.1 – KAS10_315_111810A

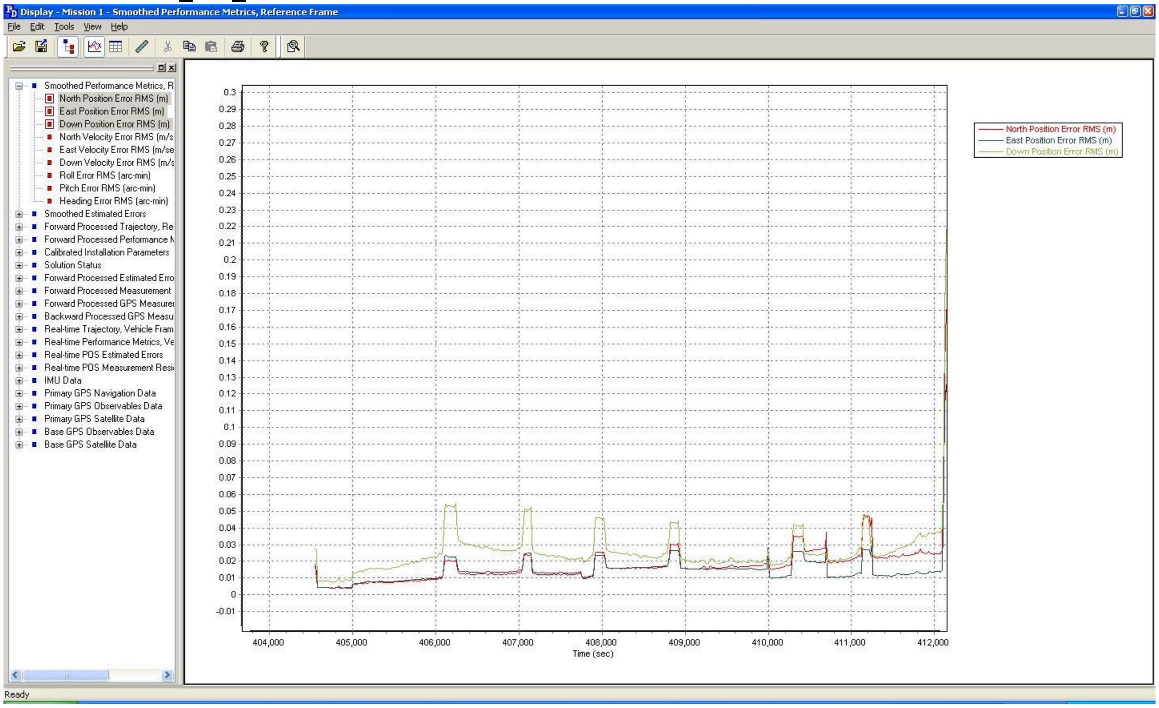


Figure 3.2 – KAS10_315_111810B

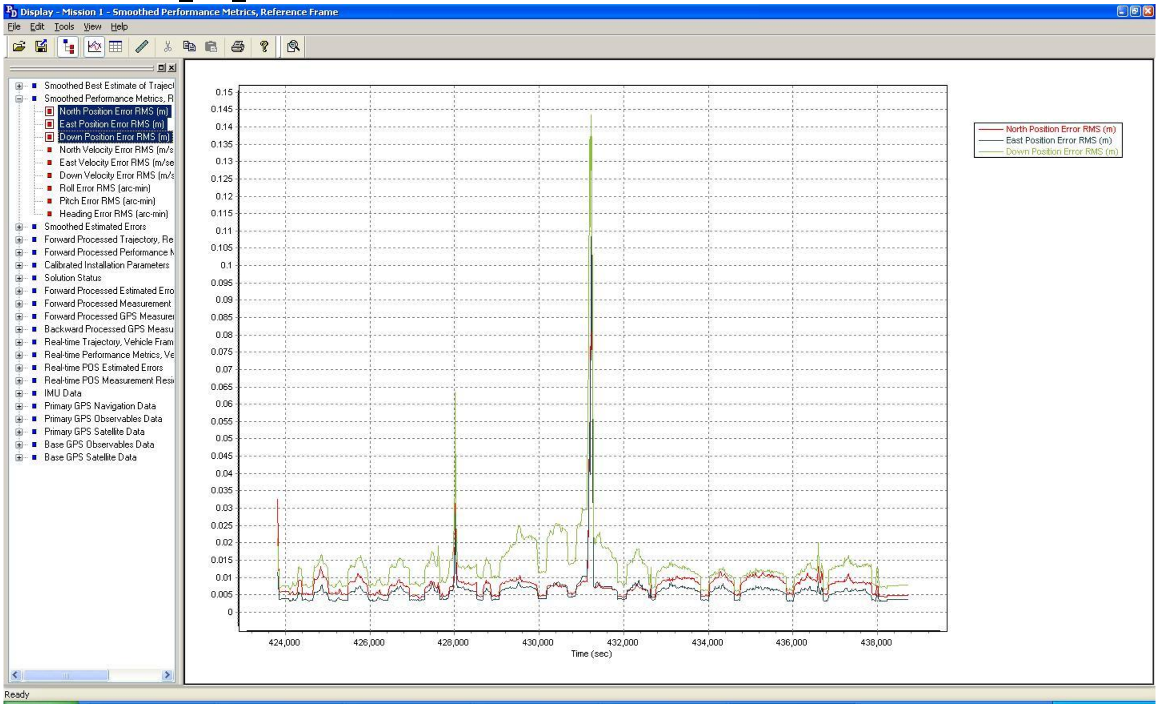


Figure 3.3 – KAS10_315_111910B

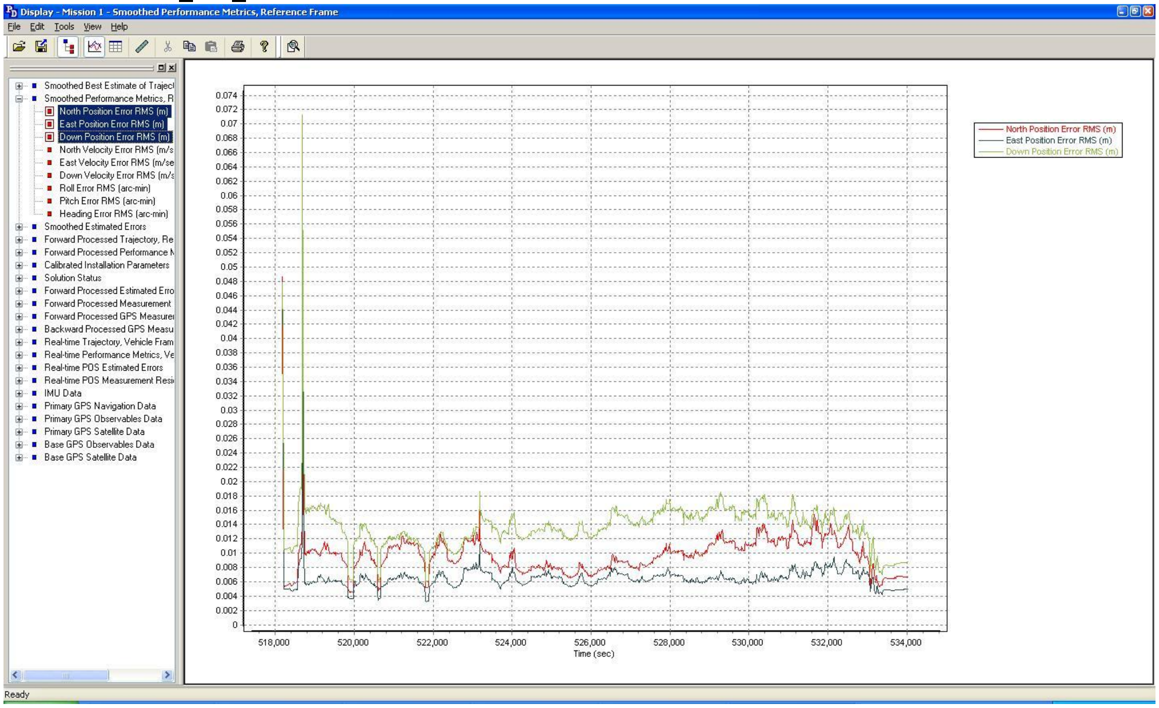


Figure 3.4 – KAS10_315_112310A

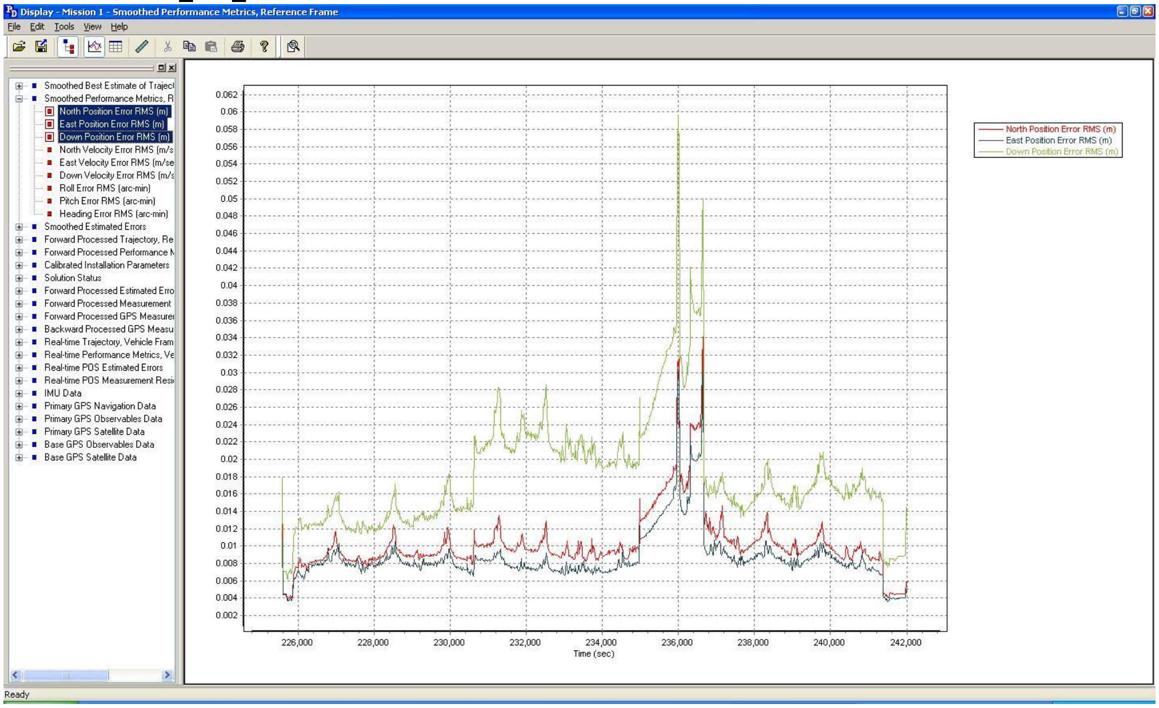


Figure 3.5 – KAS10_315_112310B

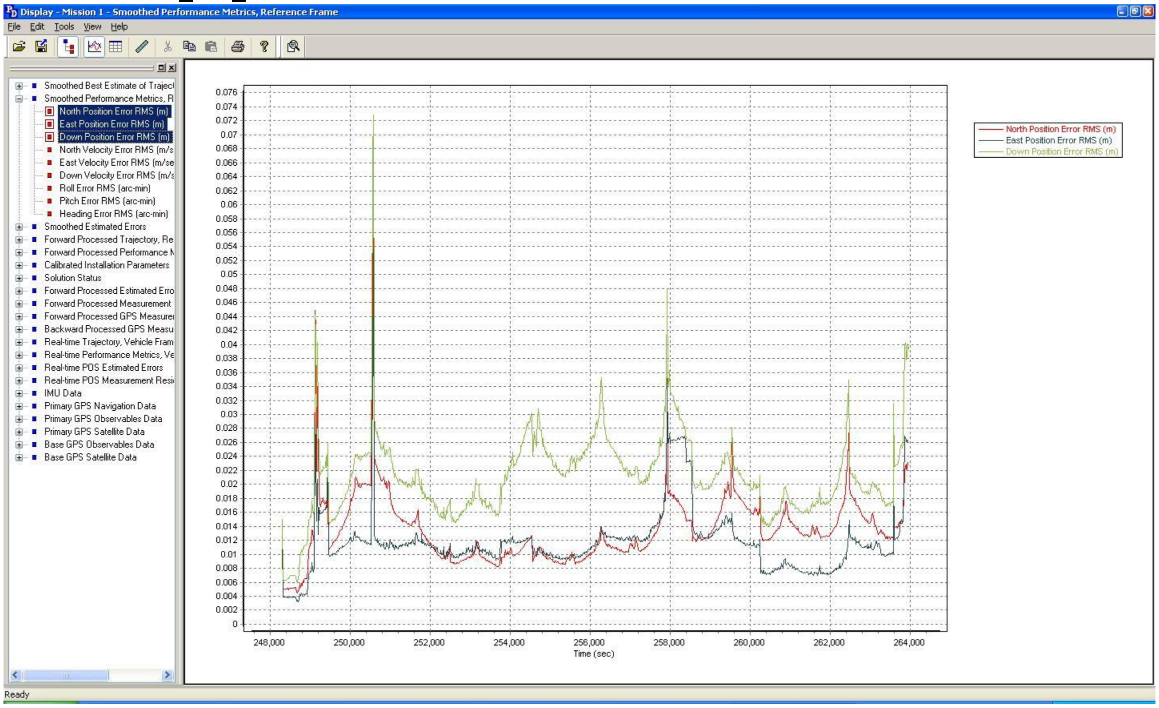


Figure 3.6 – KAS10_315_112510

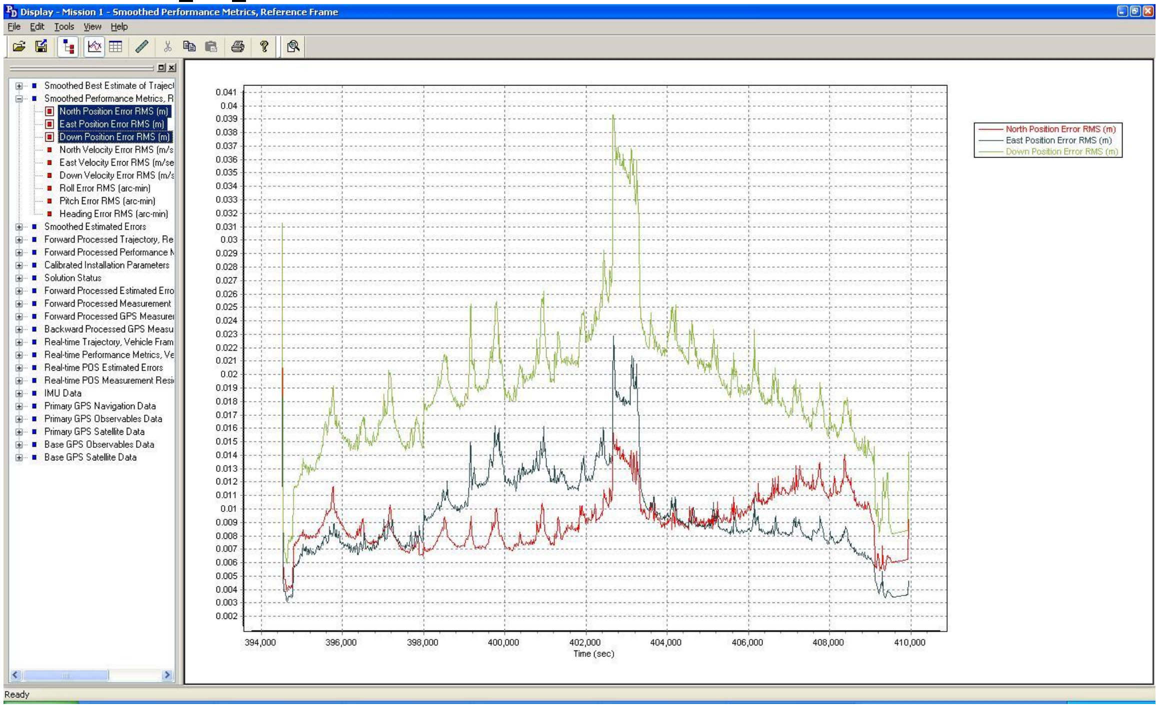
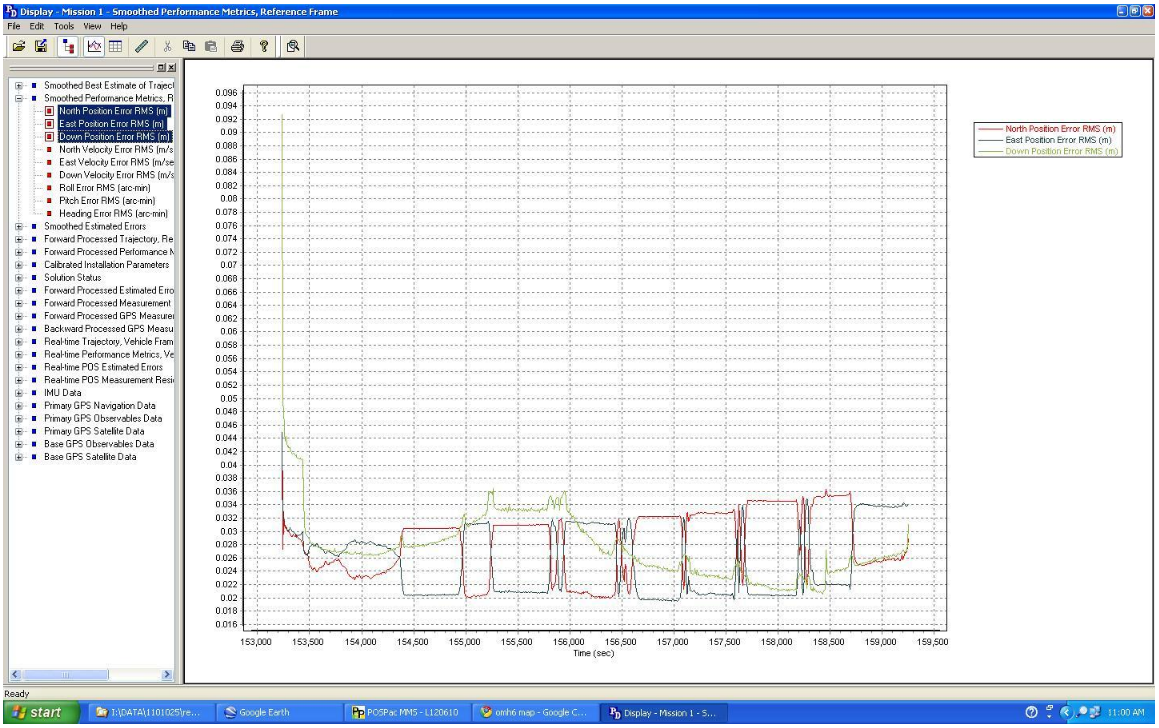


Figure 3.7 – L120610



Inertial Data

The post-processing of inertial and aiding sensor data (i.e. airborne GPS post processed data) is to compute an optimally blended navigation solution. The Kalman filter-based aided inertial navigation algorithm generates an accurate (in the sense of least-square error) navigation solution that will retain the best characteristics of the processed input data. An example of inertial/GPS sensor blending is the following: inertial data is smooth in the short term. However, a free-inertial navigation solution has errors that grow without bound with time. A GPS navigation solution exhibits short-term noise but has errors that are bounded. This optimally blended navigation solution will retain the best features of both, i.e. the blended navigation solution has errors that are smooth and bounded. The GPS Elevation Plots are presented in Figures 3.8 – 3.14.

The resultant processing generates the following data:

- Position: Latitude, Longitude, Altitude
- Velocity: North, East, and Down components
- 3-axis attitude: roll, pitch, true heading
- Acceleration: x, y, z components
- Angular rates: x, y, z components

GPS Altitude Plots

Figure 3.8 – KAS10_315_111810A

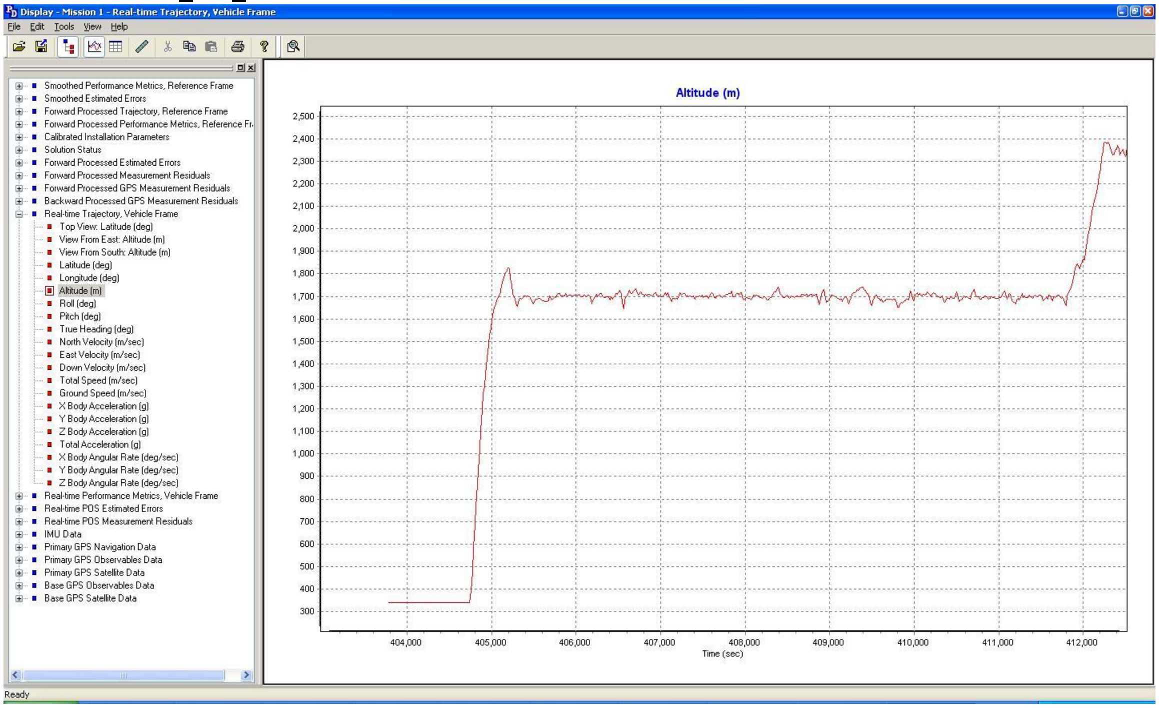


Figure 3.09 – KAS10_315_111810B

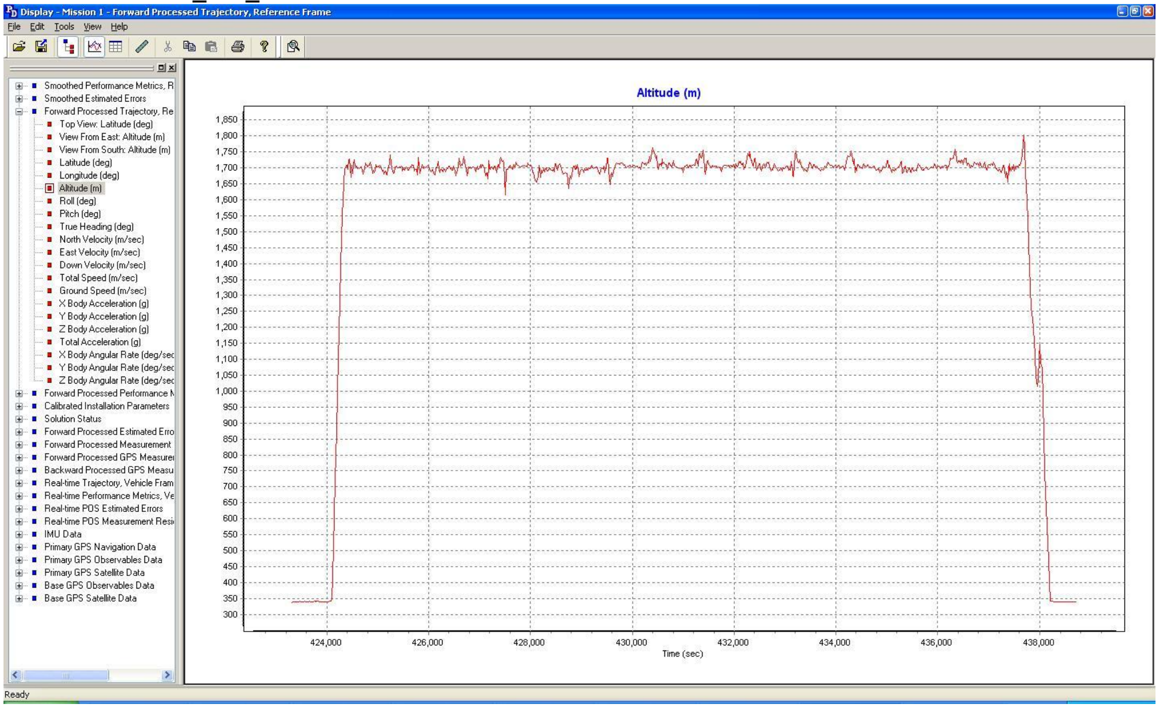


Figure 3.10 –KAS10_315_111910B

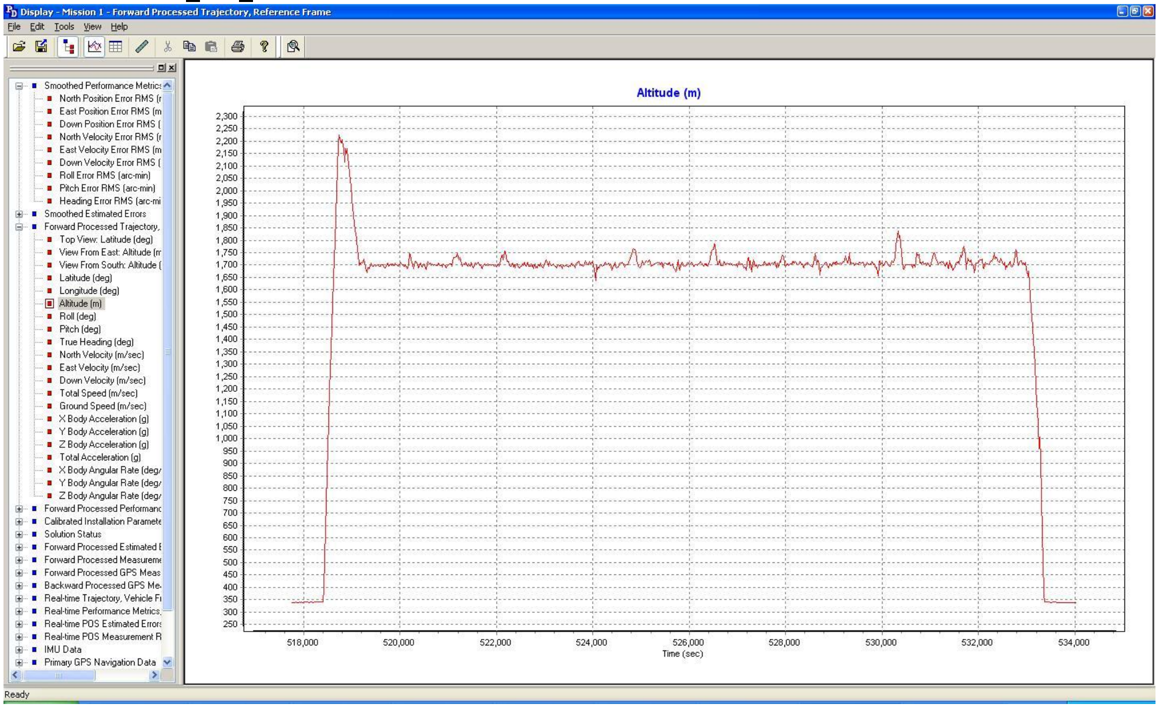


Figure 3.11 – KAS10_315_112310A

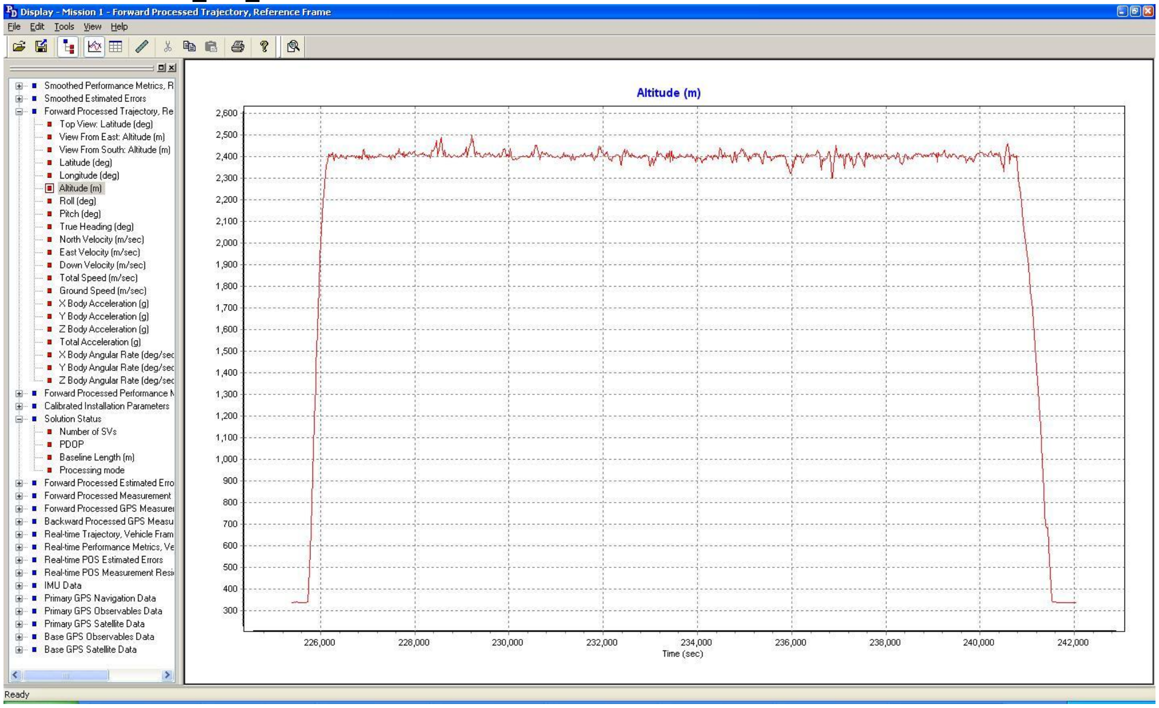


Figure 3.12 – KAS10_315_112310B

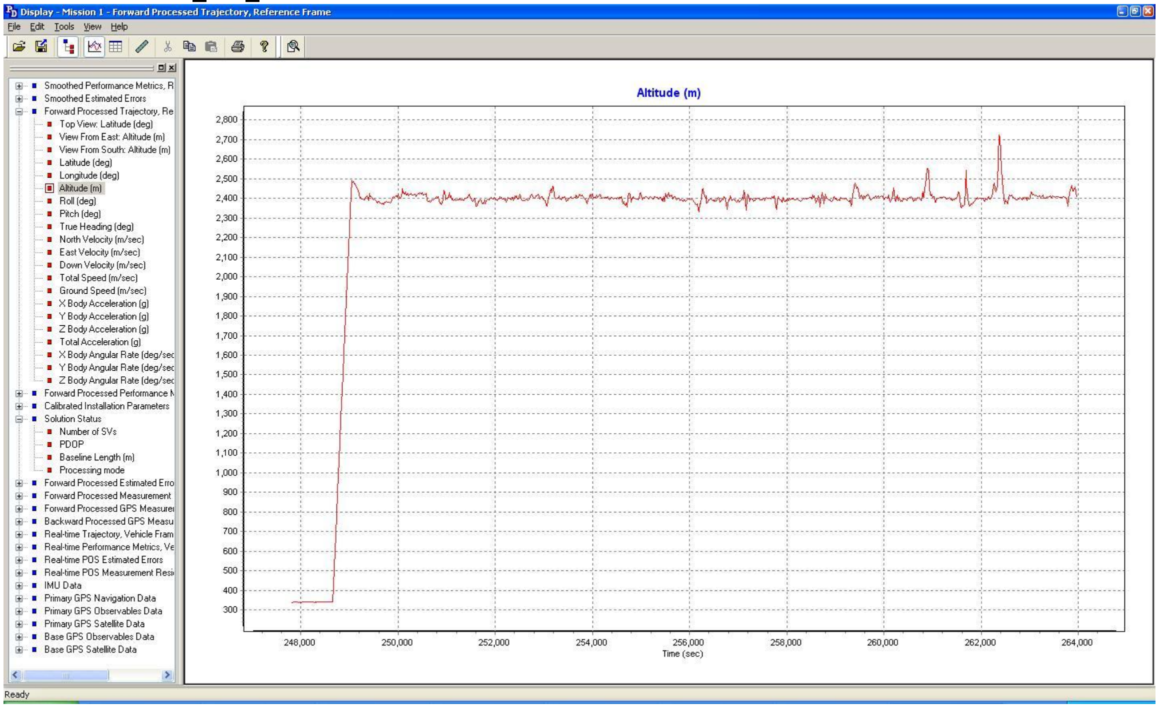


Figure 3.13 – KAS10_315_112510

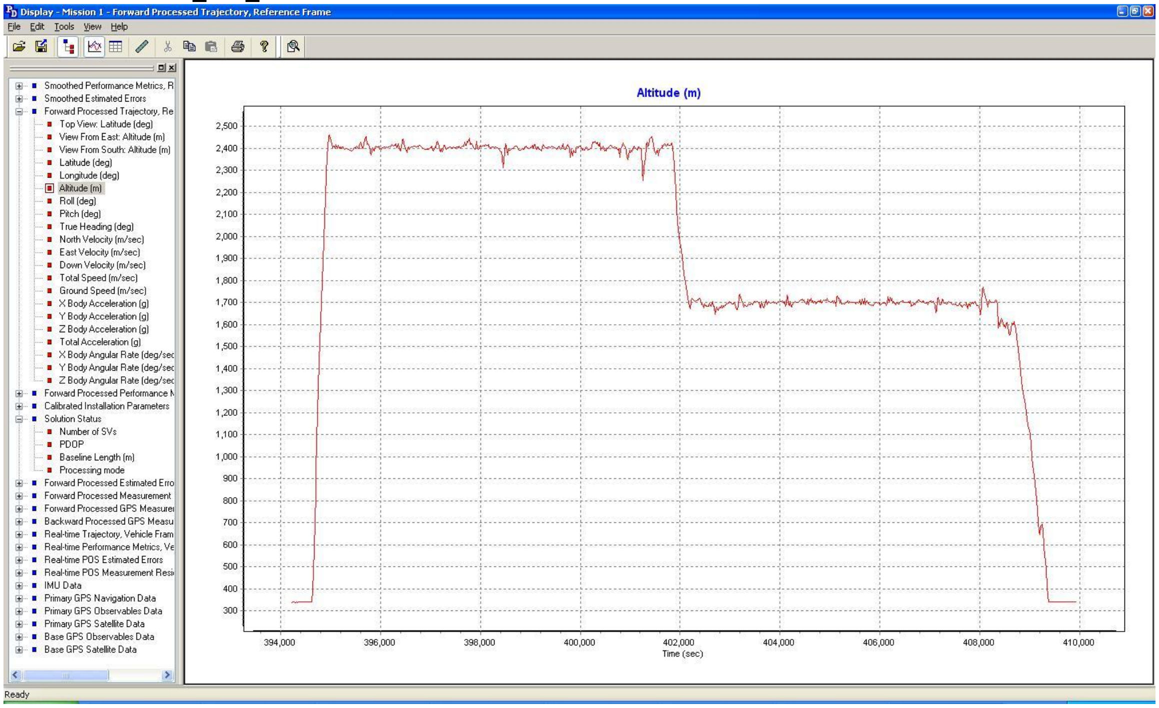
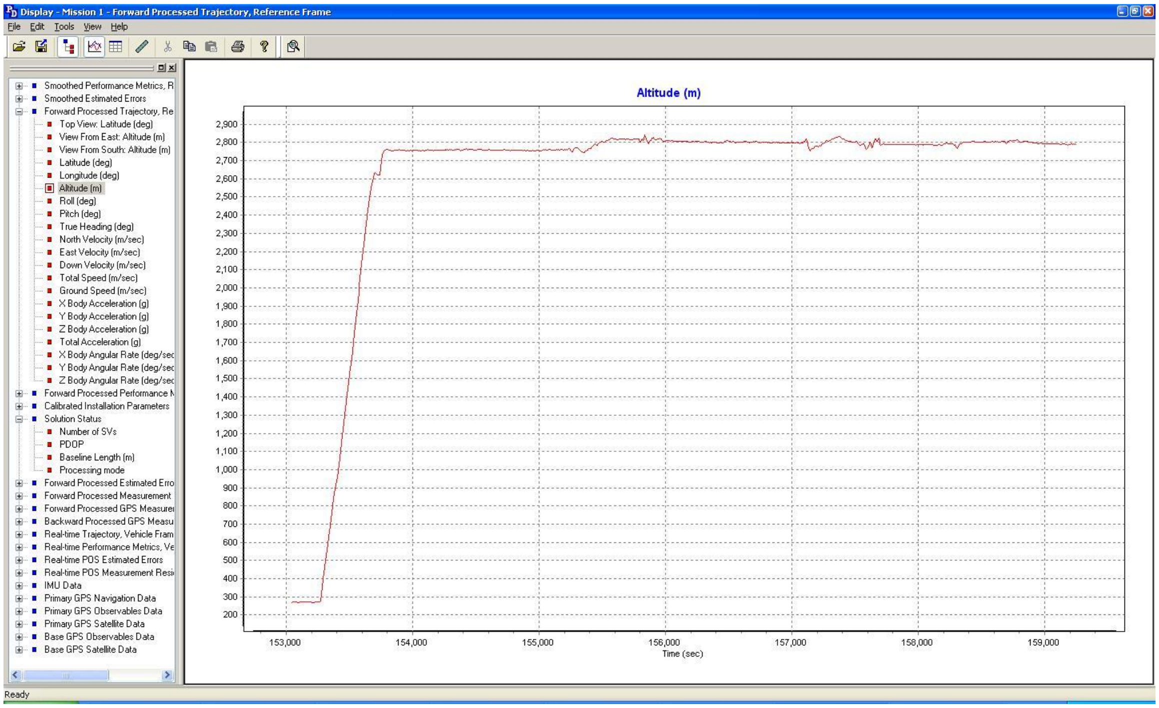


Figure 3.14 – L120610



The airborne GPS and blending of inertial and GPS post-processing were completed in multiple steps.

1. The collected data was transferred from the field data collectors to the main computer. Data was saved under the project number and separated between LiDAR mission dates. Inside each mission date, a sub-directory was created with the aircraft's tail number and an A or B suffix was attached to record which mission of the day the data is associated with. Inside the tail number sub-directory, five sub-directories were also created: EO, GPS, IMU, PROC, and RAW.

2. The aircraft raw data (IMU and GPS data combined) was run through a data extractor program. This separated the IMU and GPS data. In addition to the extraction of data, it provided the analyst the first statistics on the overall flight. The program was POSPac (POS post-processing PACkage).

3. Executing POSGPS program to derive accurate GPS positions for all flights:

   Applanix POSGPS

   The software utilized for the data collected was PosGPS, a kinematic on-the-fly (OTF) processing software package. Post processing of the data is computed from each base station (Note: only base stations within the flying area were used) in both a forward and backward direction. This provides the analyst the ability to Quality Check (QC) the post processing, since different ambiguities are determined from different base stations and also with the same data from different directions.

   The trajectory separation program is designed to display the time of week that the airborne or roving antenna traveled, and compute the differences found between processing runs. Processed data can be compared between a forward/reverse solution from one base station, a reverse solution from one base station and a forward solution from the second base station, etc. For the Applanix POSGPS processing, this is considered the final QC check for the given mission. If wrong ambiguities were found with one or both runs, the analyst would see disagreements from the trajectory plot, and re-processing would continue until an agreement was determined.

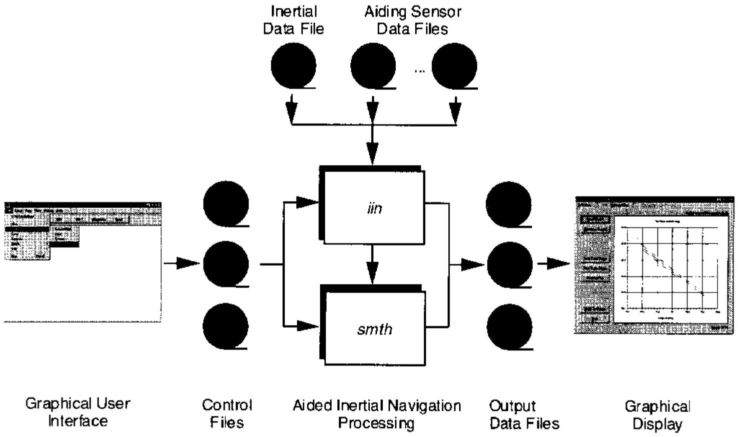
Once the analyst accepts a forward and reverse processing solution, the trajectory plot is analyzed and the combined solution is stored in a file format acceptable for the IMU post processor.

4. When the processed trajectory (either through POSGPS) data was accepted after quality control analysis, the combined solution is stored in a file format acceptable for the IMU post processor (i.e. POSProc). Shapefiles of the trajectories are found in the Coverage.zip attachment to this document.

5. Execute POSProc.

   POSProc comprises a set of individual processing interface tools. Figure 3.15 shows the organization of these tools that are a function of the POSProc processing components. These tools provide the functions described in the following paragraphs.

Figure 3.15 POSProc Processing Components



Integrated Inertial Navigation (*iin*) Module.

The name *iin* is a contraction of Integrated Inertial Navigation. *iin* reads inertial data and aiding data from data files specified in a processing environment file and computes the aided inertial navigation solution. The inertial data comes from a strapdown IMU. *iin* outputs the navigation data between start and end times at a data rate as specified in the environment file. *iin* also outputs Kalman filter data for analysis of estimation error statistics and smoother data that the smoothing program *smth* uses to improve the navigation solution accuracy.

iin implements a full strapdown inertial navigator that solves Newton's equation of motion on the earth using inertial data from a strapdown IMU. The inertial navigator implements coning and sculling compensation to handle potential problems caused by vibration of the IMU.

Smoother Module (*smth*)

smth is a companion processing module to *iin*. *smth* is comprised of two individual functions that run in sequence. *smth* first runs the *smoother function* and then runs the *navigation correction function*.

The *smth* smoother function performs backwards-in-time processing of the forwards-in-time blended navigation solution and Kalman filter data generated by *iin* to compute smoothed error estimates. *smth* implements a modified Bryson-Frazier smoothing algorithm specifically designed for use with the *iin* Kalman filter. The resulting smoothed strapdown navigator error estimates at a given time point are the optimal estimates based on all input data before and after the given time point. In this sense, *smth* makes use of all available information in the input data. *smth* writes the smoothed error estimates and their RMS estimation errors to output data files.

The *smth* navigation correction function implements a feedforward error correction mechanism similar to that in the *iin* strapdown navigation solution using the smoothed strapdown navigation errors. s*mth* reads in the smoothed error estimates and with these, corrects the strapdown navigation data. The resulting navigation solution is called a Best Estimate of Trajectory (BET), and is the best obtainable estimate of vehicle trajectory with the available inertial and aiding sensor data.

The above mentioned modules provide the analyst the following statistics to ensure that the most optimal solution was achieved: a log of the *iin* processing, the Kalman filter Measurement Residuals, Smoothed RMS Estimation Errors, and Smoothed Sensor Errors and RMS.

3.2. LIDAR Calibration

The purpose of the LiDAR system calibration is to refine the system parameters in order for the post-processing software to produce a “point cloud” that best fits the actual ground.

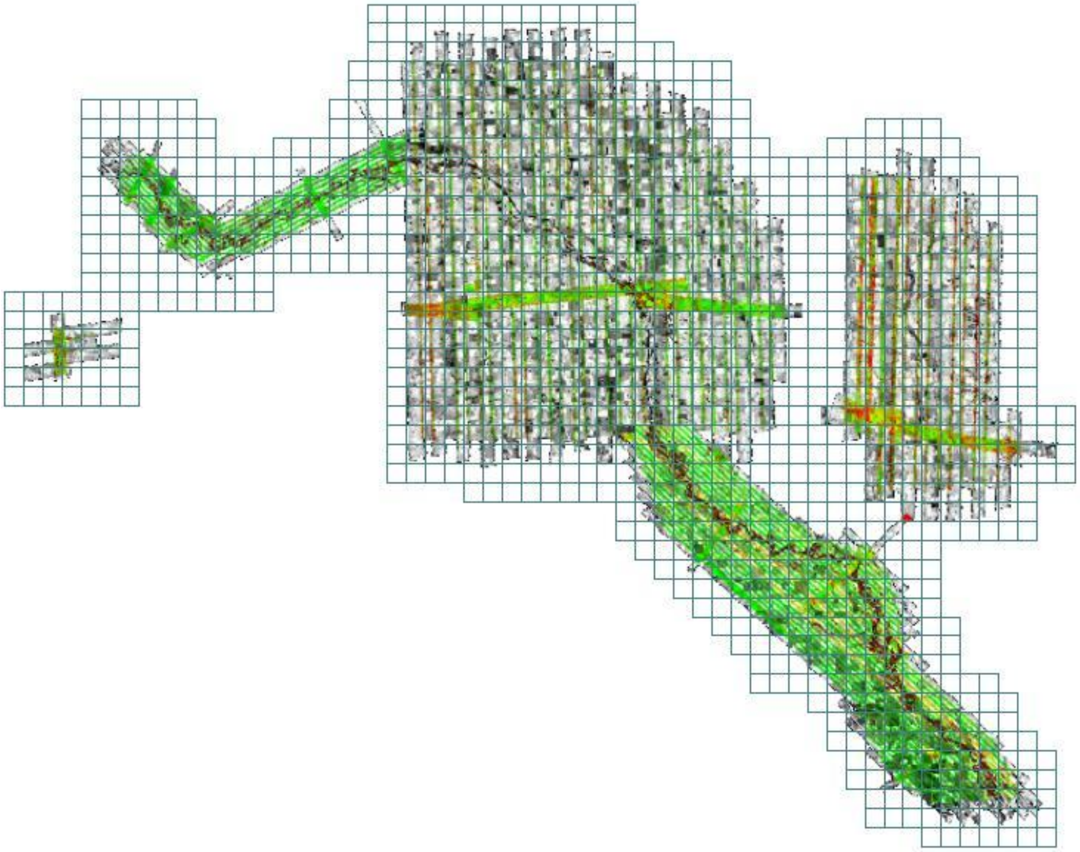
For each mission, LiDAR data for at least one cross flight is acquired over the mission’s acquisition site. The processed data of the cross flight is compared to the perpendicular flight lines using either the Optech proprietary software or TerraSolid's TerraMatch software to determine if any systematic errors are present. In this calibration, the data of individual flight lines are compared against each other and their systematic errors are corrected in the final processed data.

3.3. LIDAR Processing

The LAS files were then imported, verified, and parsed into manageable, tiled grids using GeoCue.

The first step after the data has been processed and calibrated is to perform a relative accuracy assessment on the flightline to flightline comparisons and also a data density test prior any further processing. To determine a proper accuracy assessment between flightlines, Aerometric uses GeoCue to create Orthos by elevation differences. The generated orthos have assigned elevation ranges that allow the technician to evaluate if the data passes the accuracy assessment and also determine if additional calibration efforts are needed based on the bias trends. Figure 3.16 is a screen capture of the elevation orthos where green indicates a flightline comparison of less than 5cm; yellow is 5-10 cm; orange is 10-15 cm, and red is greater than 15cm.

Figure 3.16 - DZ Raster Image



Summary

The GPS Quality for the Collection was very good and would be characterized as good to High as represented in the plots and information in Appendix A. The maximum horizontal variance for the project during the collection of mission lines was 9.5 centimeters. The maximum vertical variance for project collection was 21.5 centimeters, but it should be noted that this was not during the collection of the mission lines. The maximum vertical variance during collection of mission lines was 14.5 centimeters. These values are reflected in the plots in Appendix A.

Flight Log Overview

Post Spacing – 1 meter
AGL (Above Ground Level) average flying height – 4 ft Parameter 2400 meters; 2 ft Parameter 1700 meters
MSL (Mean Sea Level) average flying height – 4 ft Parameter 2900 meters; 2 ft Parameter 2200 Meters
Average Ground Speed – 160 knots
Field of View – 4 ft Parameter 40°; 2 ft Parameter 30°
Pulse Rate – 4 ft Parameter 50 kHz; 2 ft Parameter 70 kHz
Scan Rate – 4 ft Parameter 23 Hz; 2 ft Parameter 37 Hz
Side Lap (Average) – 4 ft Parameter 30%; 2 ft Parameter 50%

Flight logs are located in Appendix A of this document.

4. Data Verification

The data was verified using the ground control data collected by Compass Data, Inc. 52 Points were distributed throughout the project area and the points were compared to the Lidar data using TerraScan. TerraScan computes the vertical differences between the surveyed elevation and the LiDAR derived elevation for each point. Table 4.1 provides this vertical accuracy test. RMSE = 0.073 meters

The Fundamental Vertical Accuracy (FVA) was tested by Compass Data, Inc. This test consisted of 20 vertical checkpoints reported at the 95% confidence level RMSE. FVA= 0.140 meters

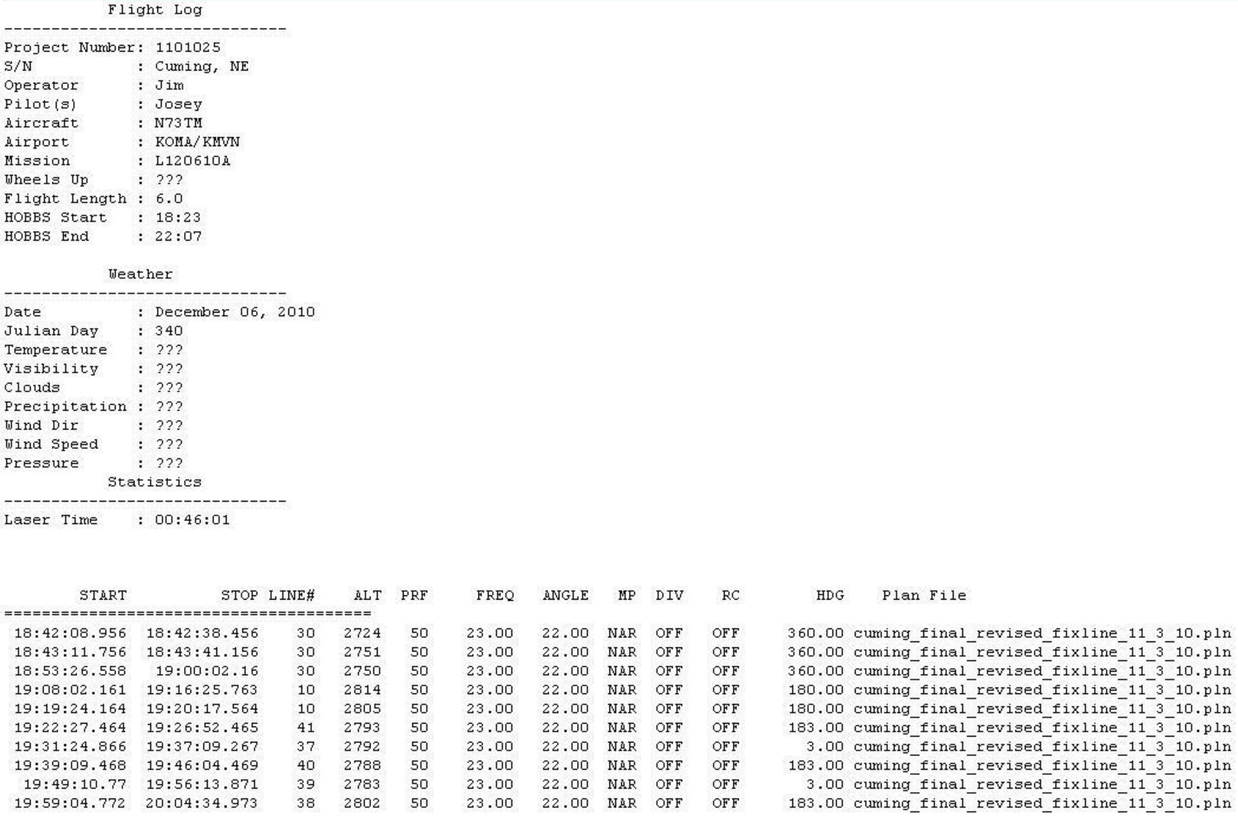
The Supplemental Vertical Accuracy (SVA) was tested by Compass Data, Inc. This test consisted of 20 vertical checkpoints reported at the 95th Percentile RMSE. CVA= 0.161 meters

Table 4-1 Vertical Accuracy Statistics

Control Point	**Easting** (UTM 14)	**Northing** (UTM 14)	**Actual Z** (M)	**LIDAR Z** (M)	**Difference Z** (M)
CMG101	635135.09	4651501.73	458.42	458.48	0.06
CMG102	635201.48	4648292.29	458.28	458.36	0.08
CMG103	644084.48	4644466.28	448.22	448.28	0.06
CMG104	644108.27	4642460.04	445.98	446.11	0.13
CMG105	655445.03	4650323.93	435.64	435.70	0.06
CMG106	655360.15	4647102.02	444.38	444.44	0.06
CMG107	663970.49	4653767.51	427.15	427.20	0.05
CMG108	664033.07	4650501.40	445.15	445.20	0.05
CMG109	665389.58	4660202.95	476.32	476.27	-0.05
CMG110	679906.10	4660494.14	441.01	441.02	0.01
CMG111	676824.37	4652377.35	442.82	442.81	-0.01
CMG112	692874.93	4652789.08	452.47	452.49	0.02
CMG113	665826.18	4642479.14	469.21	469.22	0.01
CMG114	681164.38	4642141.63	411.09	411.05	-0.04
CMG115	699583.73	4641648.68	447.11	447.08	-0.03
CMG116	666059.30	4632838.66	505.01	505.05	0.04
CMG117	682145.17	4633206.02	442.89	442.87	-0.02
CMG118	701406.57	4633638.33	418.75	418.74	-0.01
CMG119	666244.87	4624776.09	473.98	474.00	0.02
CMG120	682333.53	4625139.61	409.01	408.98	-0.03
CMG121	698424.14	4625516.46	432.52	432.54	0.02
CMG122	698424.50	4625517.56	432.54	432.49	-0.05
CMG123	688576.87	4622098.93	425.01	425.00	-0.01
CMG124	692999.27	4622158.34	403.23	403.23	0.00
CMG125	692854.24	4613328.18	398.08	398.00	-0.08
CMG126	699635.66	4613472.24	412.49	412.51	0.02
CMG127	708161.86	4606373.84	390.96	390.95	-0.01
CMG128	712122.29	4609723.96	373.07	373.04	-0.03
CMG129	711763.68	4595195.17	361.29	361.29	0.00
CMG130	715676.66	4596918.05	403.37	403.37	0.00
CMG131	718304.23	4592141.85	355.55	355.55	0.00
CMG132	718303.05	4592143.19	355.58	355.56	-0.02
CMG133	716318.41	4586764.49	355.85	355.80	-0.05
CMG134	725774.83	4586270.21	367.70	367.67	-0.03
CMG135	711007.02	4648410.71	407.05	407.16	0.11
CMG136	716635.99	4648575.37	378.30	378.27	-0.03
CMG137	711980.10	4641995.43	427.03	427.25	0.22
CMG138	723204.50	4642335.99	403.95	403.71	-0.24
CMG139	710708.09	4633885.01	403.14	403.22	0.08
CMG140	721079.73	4634197.11	418.33	418.24	-0.09
CMG141	710902.70	4624914.14	399.74	399.85	0.11
CMG142	722180.51	4625099.96	413.59	413.50	-0.09
CMG143	714267.66	4619465.10	404.06	404.12	0.06
CMG144	724869.82	4618961.90	388.20	388.02	-0.18
CMG145	716914.28	4638922.00	400.10	400.00	-0.10
CMG146	715594.28	4629214.61	418.84	418.85	0.01
CMG147	672131.60	4647445.01	425.06	425.07	0.01
CMG148	688241.45	4646220.31	430.56	430.54	-0.02
CMG149	672386.02	4637783.12	466.30	466.41	0.11
CMG150	691679.57	4638247.62	444.24	444.23	-0.01
CMG151	672594.18	4628134.75	455.36	455.38	0.02
CMG152	691898.56	4628576.93	405.46	405.44	-0.02

Average dz	0.003
Minimum dz	-0.24
Maximum dz	0.22
Average magnitude	0.051
Root mean square	0.073
Std deviation	0.074

L120610A Condensed Flight Log

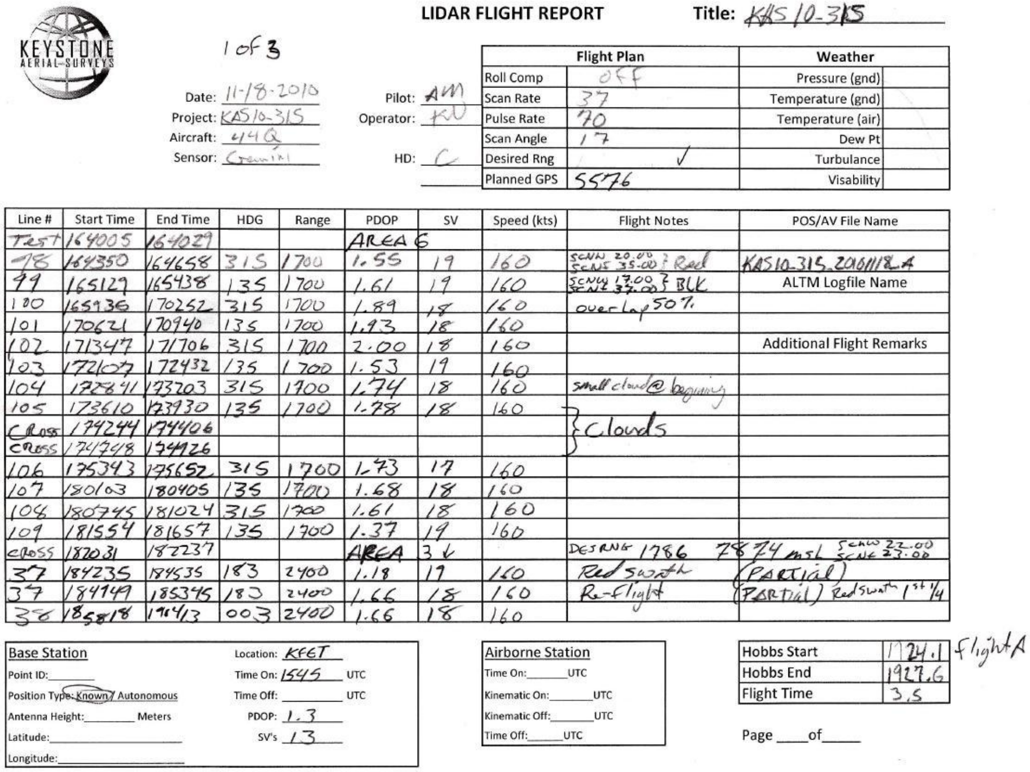


```
           Flight Log
------------------------------
Project Number: 1101025
S/N           : Cuming, NE
Operator      : Jim
Pilot(s)      : Josey
Aircraft      : N73TM
Airport       : KOMA/KMVN
Mission       : L120610A
Wheels Up     : ???
Flight Length : 6.0
HOBBS Start   : 18:23
HOBBS End     : 22:07

           Weather
------------------------------
Date          : December 06, 2010
Julian Day    : 340
Temperature   : ???
Visibility    : ???
Clouds        : ???
Precipitation : ???
Wind Dir      : ???
Wind Speed    : ???
Pressure      : ???
           Statistics
------------------------------
Laser Time    : 00:46:01


        START          STOP LINE#    ALT  PRF     FREQ   ANGLE   MP  DIV    RC        HDG    Plan File
=======================================
 18:42:08.956  18:42:38.456     30   2724   50    23.00   22.00  NAR  OFF   OFF     360.00 cuming_final_revised_fixline_11_3_10.pln
 18:43:11.756  18:43:41.156     30   2751   50    23.00   22.00  NAR  OFF   OFF     360.00 cuming_final_revised_fixline_11_3_10.pln
 18:53:26.558   19:00:02.16     30   2750   50    23.00   22.00  NAR  OFF   OFF     360.00 cuming_final_revised_fixline_11_3_10.pln
 19:08:02.161  19:16:25.763     10   2814   50    23.00   22.00  NAR  OFF   OFF     180.00 cuming_final_revised_fixline_11_3_10.pln
 19:19:24.164  19:20:17.564     10   2805   50    23.00   22.00  NAR  OFF   OFF     180.00 cuming_final_revised_fixline_11_3_10.pln
 19:22:27.464  19:26:52.465     41   2793   50    23.00   22.00  NAR  OFF   OFF     183.00 cuming_final_revised_fixline_11_3_10.pln
 19:31:24.866  19:37:09.267     37   2792   50    23.00   22.00  NAR  OFF   OFF       3.00 cuming_final_revised_fixline_11_3_10.pln
 19:39:09.468  19:46:04.469     40   2788   50    23.00   22.00  NAR  OFF   OFF     183.00 cuming_final_revised_fixline_11_3_10.pln
  19:49:10.77  19:56:13.871     39   2783   50    23.00   22.00  NAR  OFF   OFF       3.00 cuming_final_revised_fixline_11_3_10.pln
 19:59:04.772  20:04:34.973     38   2802   50    23.00   22.00  NAR  OFF   OFF     183.00 cuming_final_revised_fixline_11_3_10.pln
```

Flight Log 111810 Page 1



KEYSTONE AERIAL SURVEYS

LIDAR FLIGHT REPORT Title: KAS 10-315

1 of 3

Date: 11-18-2010
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini
Pilot: AM
Operator: KN
HD: C

Flight Plan		Weather	
Roll Comp	OFF	Pressure (gnd)	
Scan Rate	37	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	17	Dew Pt	
Desired Rng	✓	Turbulance	
Planned GPS	5576	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
Test	164005	164029			AREA 6				
78	164350	164658	315	1700	1.55	19	160	SCNW 20.00 SCNE 35.00 } Red	KAS10-315_20101118_A
99	165129	165438	135	1700	1.61	19	160	SCNW 17.00 SCNE 37.00 } BLK	ALTM Logfile Name
100	165936	170252	315	1700	1.89	18	160	overlap 50%	
101	170621	170940	135	1700	1.93	18	160		
102	171347	171706	315	1700	2.00	18	160		Additional Flight Remarks
103	172107	172432	135	1700	1.53	19	160		
104	172841	173203	315	1700	1.74	18	160	small cloud @ beginning	
105	173610	173930	135	1700	1.78	18	160	} Clouds	
CROSS	174244	174406							
CROSS	174748	174926							
106	175343	175652	315	1700	1.73	17	160		
107	180103	180405	135	1700	1.68	18	160		
108	180745	181024	315	1700	1.61	18	160		
109	181554	181657	135	1700	1.37	19	160		
CROSS	182031	182237			AREA	3 ↓		DESRNG 1786 7874 msl	SCNW 22.00 SCNE 23.00
37	184235	184535	183	2400	1.18	17	160	Red swath	(PARTIAL)
37	184149	185345	183	2400	1.66	18	160	Re-flight	(PARTIAL) Red swath 1st 1/4
38	185818	190413	003	2400	1.66	18	160		

Base Station
Point ID:
Position Type: [✓ Known] / Autonomous
Antenna Height: Meters
Latitude:
Longitude:
Location: KFET
Time On: 1545 UTC
Time Off: UTC
PDOP: 1.3
SV's 13

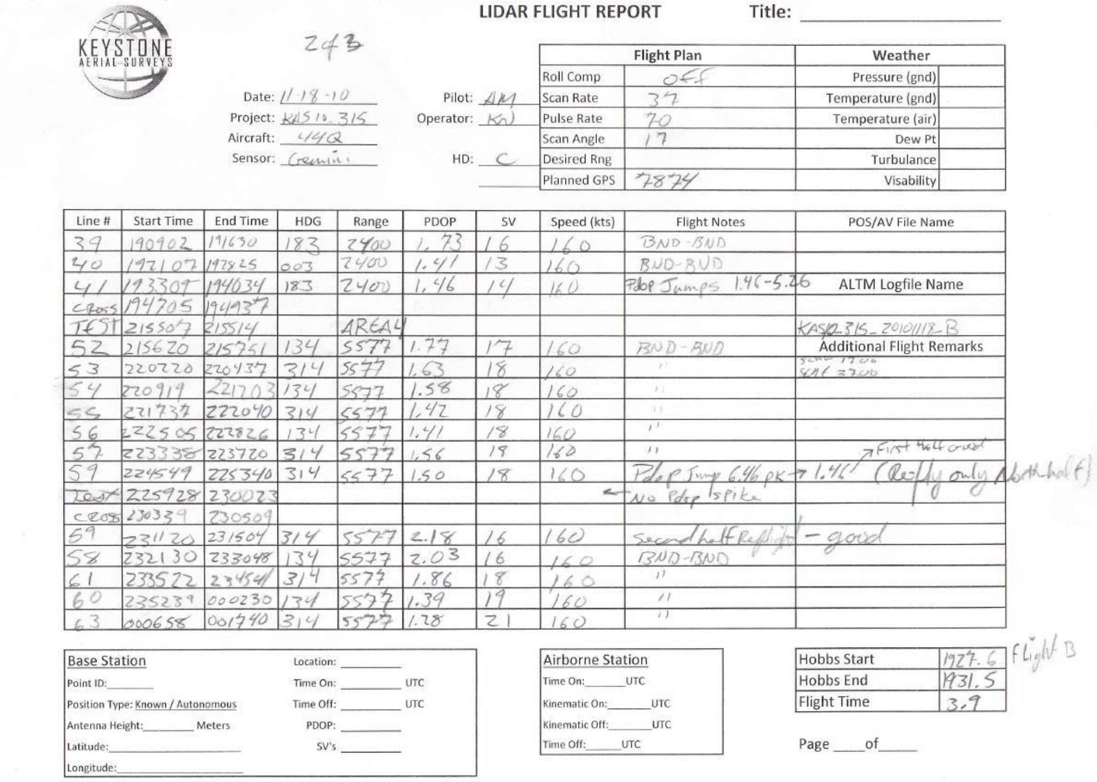
Airborne Station
Time On: UTC
Kinematic On: UTC
Kinematic Off: UTC
Time Off: UTC

Hobbs Start	1924.1
Hobbs End	1927.6
Flight Time	3.5

Flight A

Page ____of____

Flight Log 111810 Page 2



KEYSTONE AERIAL SURVEYS

LIDAR FLIGHT REPORT Title:

2 of 3

Date: 11-18-10
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini
Pilot: AM
Operator: KN
HD: C

Flight Plan		Weather	
Roll Comp	OFF	Pressure (gnd)	
Scan Rate	37	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	17	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	7874	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
39	190902	191630	183	2400	1.73	16	160	BND-BND	
40	192107	192825	003	2400	1.41	13	160	BND-BND	
41	193309	194034	183	2400	1.46	14	160	Pdop Jumps 1.46-5.26	ALTM Logfile Name
CROSS	194705	194937							
TEST	215507	215514		AREA 4					KAS10-315_20101118_B
52	215620	215751	134	5577	1.77	17	160	BND-BND	Additional Flight Remarks
53	220220	220437	314	5577	1.63	18	160	"	SCNW 17.00 SCNE 27.00
54	220919	221703	134	5577	1.58	18	160	"	
55	221737	222040	314	5577	1.42	18	160	"	
56	222505	222826	134	5577	1.41	18	160	"	
57	223338	223720	314	5577	1.56	18	160	"	First half good
59	224549	225340	314	5577	1.50	18	160	Pdop Jump 6.46 pk → 1.46	(Reflty only North half)
Test	225928	230023						← No Pdop spike	
CROSS	230339	230509							
59	231120	231504	314	5577	2.18	16	160	Second half Reflight	- good
58	232130	233048	134	5577	2.03	16	160	BND-BND	
61	233522	234541	314	5577	1.86	18	160	"	
60	235239	000230	134	5577	1.39	19	160	"	
63	000658	001740	314	5577	1.28	21	160	"	

Base Station
Point ID:
Position Type: Known / Autonomous
Antenna Height: Meters
Latitude:
Longitude:
Location:
Time On: UTC
Time Off: UTC
PDOP:
SV's

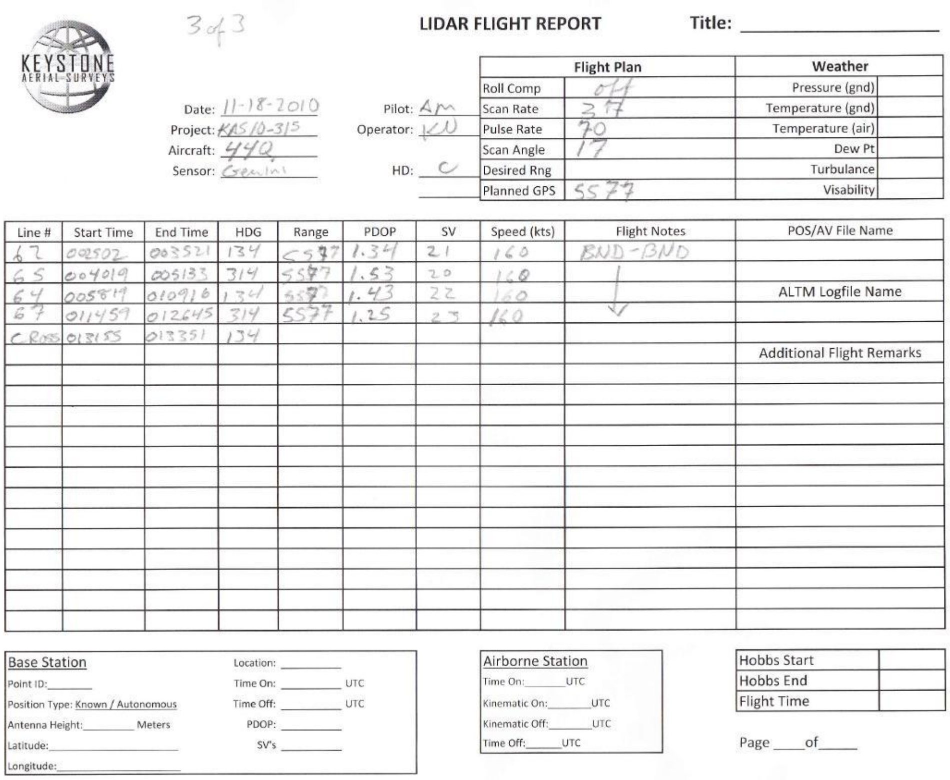
Airborne Station
Time On: UTC
Kinematic On: UTC
Kinematic Off: UTC
Time Off: UTC

Hobbs Start	1927.6
Hobbs End	1931.5
Flight Time	3.9

Flight B

Page ____of____

Flight Log 111810 Page 3



3 of 3

LIDAR FLIGHT REPORT **Title:** ____________________

KEYSTONE AERIAL SURVEYS

Date: 11-18-2010
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini

Pilot: AM
Operator: KN
HD: C

Flight Plan		Weather	
Roll Comp	off	Pressure (gnd)	
Scan Rate	37	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	17	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	5577	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes
62	002502	003521	134	5577	1.34	21	160	BND-BND
65	004019	005133	314	5577	1.53	20	160	↓
64	005819	010916	134	5577	1.43	22	160	
67	011459	012645	314	5577	1.25	23	160	
CROSS	013155	013351	134					

POS/AV File Name

ALTM Logfile Name

Additional Flight Remarks

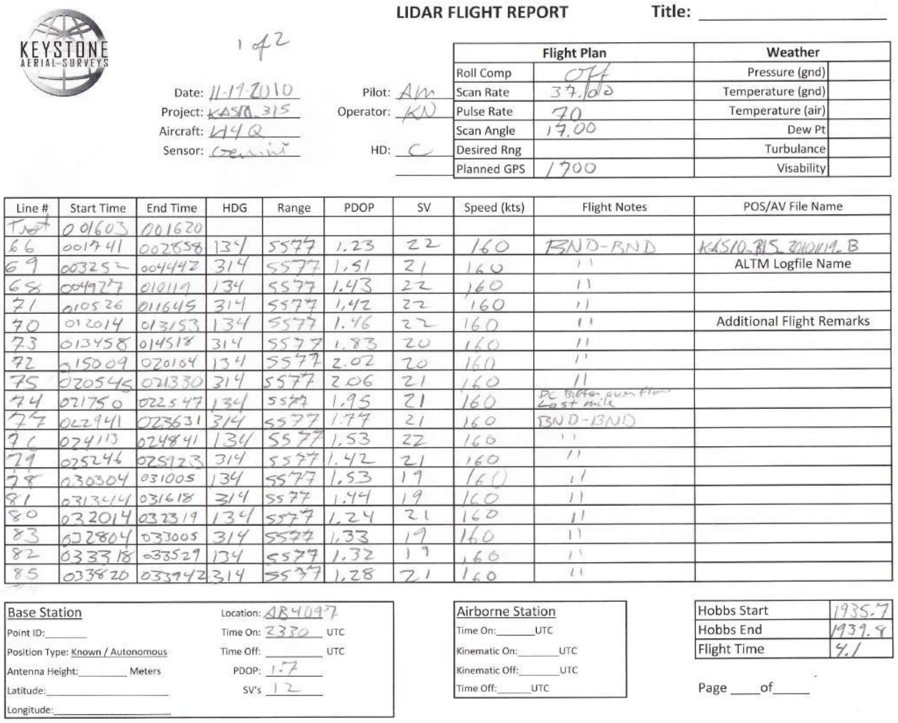
Base Station
Point ID:________
Position Type: Known / Autonomous
Antenna Height:_________ Meters
Latitude:______________________
Longitude:______________________
Location: __________
Time On: __________ UTC
Time Off: __________ UTC
PDOP: __________
SV's __________

Airborne Station
Time On:_______UTC
Kinematic On:_______UTC
Kinematic Off:_______UTC
Time Off:______UTC

Hobbs Start	
Hobbs End	
Flight Time	

Page ____of_____

Flight Log 111910 Page 1



LIDAR FLIGHT REPORT Title: ____________________

KEYSTONE AERIAL SURVEYS

1 of 2

Date: 11-19-2010
Project: KAS10_315
Aircraft: 44Q
Sensor: Gemini

Pilot: AM
Operator: KN
HD: C

Flight Plan		Weather	
Roll Comp	Off	Pressure (gnd)	
Scan Rate	37.00	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	17.00	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	1700	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
Test	001603	001620							
66	001741	002858	134	5577	1.23	22	160	BND-BND	KAS10_315_20101119_B
69	003252	004442	314	5577	1.51	21	160	"	ALTM Logfile Name
68	004927	010119	134	5577	1.43	22	160	"	
71	010526	011645	314	5577	1.42	22	160	"	
70	012014	013153	134	5577	1.46	22	160	"	Additional Flight Remarks
73	013458	014518	314	5577	1.83	20	160	"	
72	015009	020164	134	5577	2.02	20	160	"	
75	020545	021330	314	5577	2.06	21	160	"	
74	021750	022547	134	5577	1.95	21	160	PC Bitter pum flow Last mile	
77	022941	023631	314	5577	1.77	21	160	BND-BND	
76	024113	024841	134	5577	1.53	22	160	"	
79	025246	025923	314	5577	1.42	21	160	"	
78	030304	031005	134	5577	1.53	19	160	"	
81	031344	031618	314	5577	1.44	19	160	"	
80	032014	032319	134	5577	1.24	21	160	"	
83	032804	033005	314	5577	1.33	19	160	"	
82	033318	033529	134	5577	1.32	19	160	"	
85	033820	033942	314	5577	1.28	21	160	"	

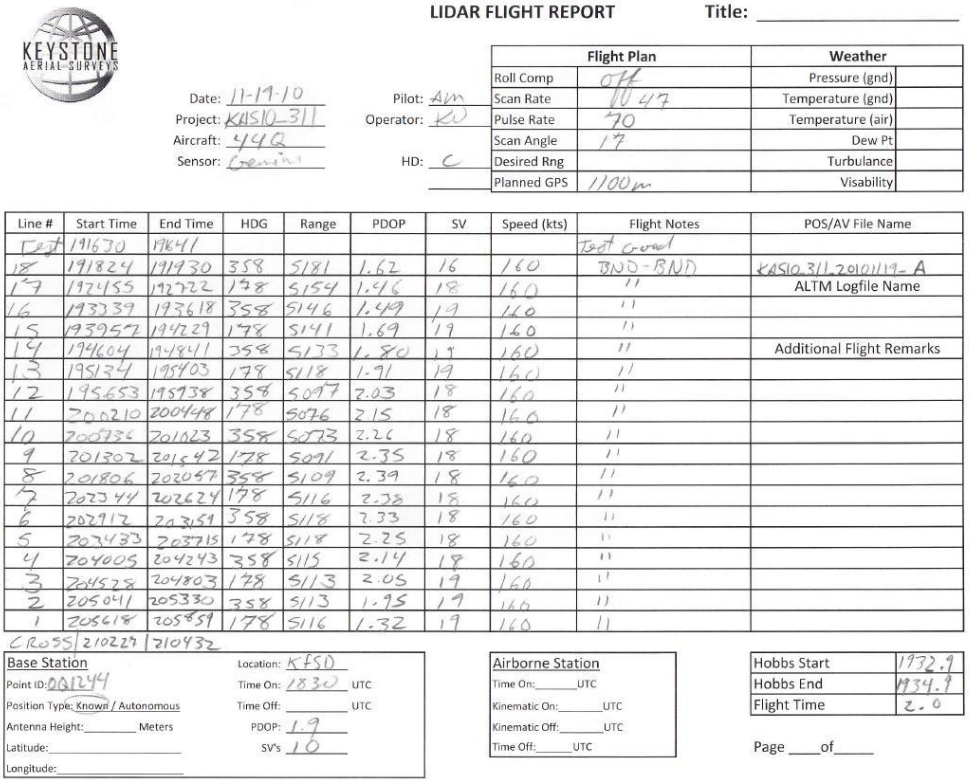
Base Station
Point ID:_______
Position Type: Known / Autonomous
Antenna Height:________ Meters
Latitude:____________________
Longitude:____________________
Location: AB4097
Time On: 2330 UTC
Time Off: __________ UTC
PDOP: 1.7
SV's 12

Airborne Station
Time On:______UTC
Kinematic On:_______UTC
Kinematic Off:_______UTC
Time Off:______UTC

Hobbs Start	1935.7
Hobbs End	1939.8
Flight Time	4.1

Page ____of_____

Flight Log 111910 Page 2



LIDAR FLIGHT REPORT Title: ____________________

KEYSTONE AERIAL SURVEYS

Date: 11-19-10
Project: KAS10_311
Aircraft: 44Q
Sensor: Gemini

Pilot: AM
Operator: KN
HD: C

Flight Plan		Weather	
Roll Comp	Off	Pressure (gnd)	
Scan Rate	40 47	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	17	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	1100m	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
Test	191630	19641						Test Good	
18	191824	191930	358	5181	1.62	16	160	BND-BND	KAS10_311_20101119_A
17	192455	192722	178	5154	1.46	18	160	"	ALTM Logfile Name
16	193339	193618	358	5146	1.49	19	160	"	
15	193957	194229	178	5141	1.69	19	160	"	
14	194604	194841	358	5133	1.80	19	160	"	Additional Flight Remarks
13	195134	195403	178	5118	1.91	19	160	"	
12	195653	195938	358	5097	2.03	18	160	"	
11	200210	200448	178	5076	2.15	18	160	"	
10	200736	201023	358	5073	2.26	18	160	"	
9	201302	201542	178	5091	2.35	18	160	"	
8	201806	202057	358	5109	2.39	18	160	"	
7	202344	202624	178	5116	2.38	18	160	"	
6	202912	203151	358	5118	2.33	18	160	"	
5	203433	203715	178	5118	2.25	18	160	"	
4	204005	204243	358	5115	2.14	18	160	"	
3	204528	204803	178	5113	2.05	19	160	"	
2	205041	205330	358	5113	1.95	19	160	"	
1	205618	205859	178	5116	1.32	19	160	"	

CROSS | 210227 | 210432

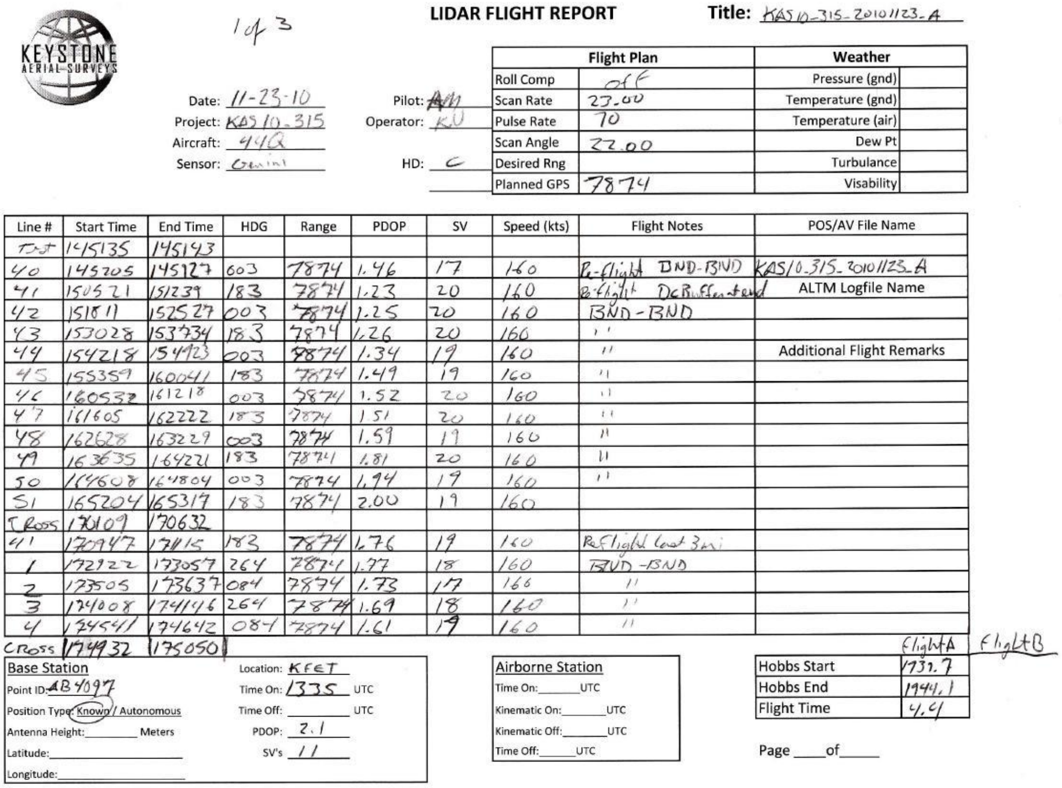
Base Station
Point ID: 0Q1244
Position Type: [✓ Known] / Autonomous
Antenna Height:________ Meters
Latitude:____________________
Longitude:____________________
Location: KFSD
Time On: 1830 UTC
Time Off: __________ UTC
PDOP: 1.9
SV's 10

Airborne Station
Time On:______UTC
Kinematic On:_______UTC
Kinematic Off:_______UTC
Time Off:______UTC

Hobbs Start	1932.9
Hobbs End	1934.9
Flight Time	2.0

Page ____of_____

Flight Log 112310 Page 1



1 of 3

LIDAR FLIGHT REPORT Title: KAS10-315-20101123-A

Date: 11-23-10
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini
Pilot: AM
Operator: KU
HD: C

Flight Plan		Weather	
Roll Comp	off	Pressure (gnd)	
Scan Rate	23.00	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	22.00	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	7874	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
Test	145135	145143							
40	145205	145127	003	7874	1.46	17	160	Re-flight BND-BND	KAS10-315-20101123-A
41	150521	151239	183	7874	1.23	20	160	Re-flight DeBuffered	ALTM Logfile Name
42	151811	152527	003	7874	1.25	20	160	BND-BND	
43	153028	153734	183	7874	1.26	20	160	"	
44	154218	154923	003	7874	1.34	19	160	"	Additional Flight Remarks
45	155359	160041	183	7874	1.49	19	160	"	
46	160532	161218	003	7874	1.52	20	160	"	
47	161605	162222	183	7874	1.51	20	160	"	
48	162628	163229	003	7874	1.59	19	160	"	
49	163635	164221	183	7874	1.81	20	160	"	
50	164608	164804	003	7874	1.94	19	160	"	
51	165204	165317	183	7874	2.00	19	160		
Cross	170109	170632							
41	170947	171115	183	7874	1.76	19	160	Reflight last 3mi	
1	172922	173057	264	7874	1.77	18	160	BND-BND	
2	173505	173637	084	7874	1.73	17	166	"	
3	174008	174146	264	7874	1.69	18	160	"	
4	174541	174642	084	7874	1.61	19	160	"	

Cross 174932 175050

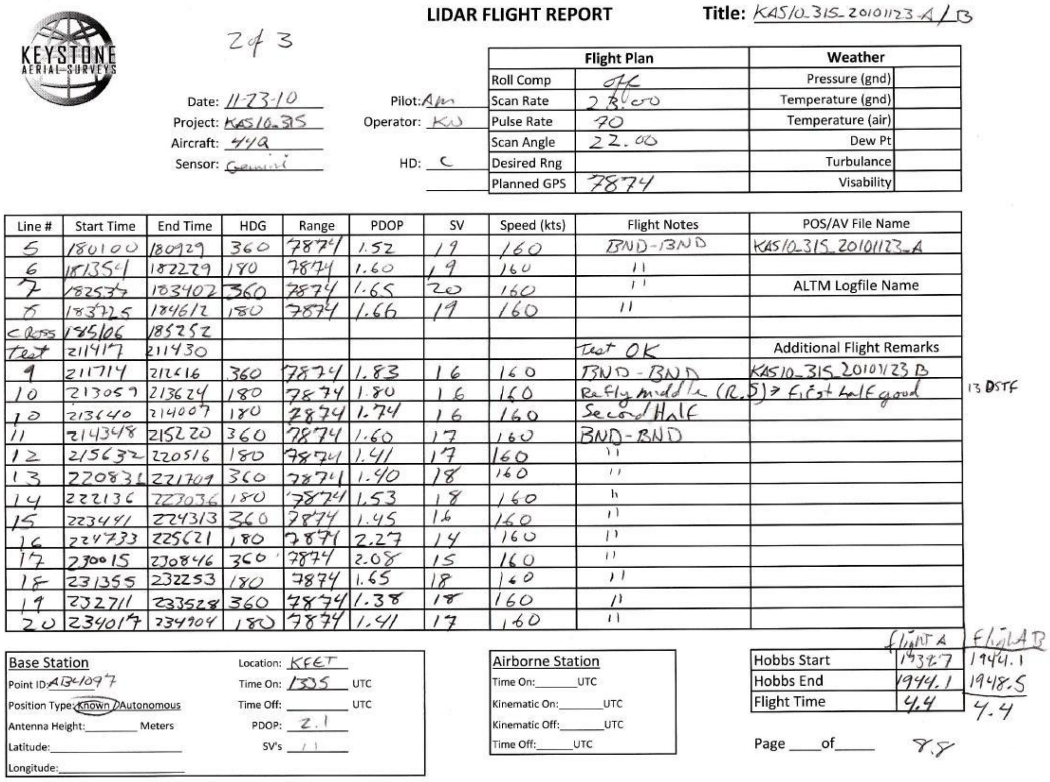
Base Station
Point ID: AB4097
Position Type: [✓ Known] / Autonomous
Antenna Height: ________ Meters
Latitude: ____________
Longitude: ____________
Location: KFET
Time On: 1335 UTC
Time Off: ________ UTC
PDOP: 2.1
SV's: 11

Airborne Station
Time On: ______UTC
Kinematic On: ______UTC
Kinematic Off: ______UTC
Time Off: ______UTC

	Flight A	Flight B
Hobbs Start	1937.7	
Hobbs End	1944.1	
Flight Time	4.4	

Page ____of_____

Flight Log 112310 Page2



2 of 3

LIDAR FLIGHT REPORT Title: KAS10-315-20101123-A / B

Date: 11-23-10
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini
Pilot: Am
Operator: KW
HD: C

Flight Plan		Weather	
Roll Comp	off	Pressure (gnd)	
Scan Rate	23.00	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	22.00	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	7874	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
5	180100	180929	360	7874	1.52	19	160	BND-BND	KAS10-315-20101123-A
6	181354	182229	180	7874	1.60	19	160	"	
7	182537	183402	360	7874	1.65	20	160	"	ALTM Logfile Name
8	183725	184612	180	7874	1.66	19	160	"	
Cross	185106	185252							
Test	211417	211430						Test OK	Additional Flight Remarks
9	211714	212616	360	7874	1.83	16	160	BND-BND	KAS10-315-20101123 B
10	213059	213624	180	7874	1.80	16	160	Refly middle (R.5) > First half good	
10	213640	214007	180	7874	1.74	16	160	Second Half	
11	214348	215220	360	7874	1.60	17	160	BND-BND	
12	215632	220516	180	7874	1.41	17	160	"	
13	220831	221709	360	7874	1.40	18	160	"	
14	222136	223036	180	7874	1.53	18	160	"	
15	223441	224313	360	7874	1.45	16	160	"	
16	224733	225621	180	7874	2.27	14	160	"	
17	230015	230846	360	7874	2.08	15	160	"	
18	231355	232253	180	7874	1.65	18	160	"	
19	232711	233528	360	7874	1.38	18	160	"	
20	234017	234904	180	7874	1.41	17	160	"	

13 DSTF

Base Station
Point ID: AB4097
Position Type: [✓ Known] / Autonomous
Antenna Height: ________ Meters
Latitude: ____________
Longitude: ____________
Location: KFET
Time On: 1335 UTC
Time Off: ________ UTC
PDOP: 2.1
SV's: 11

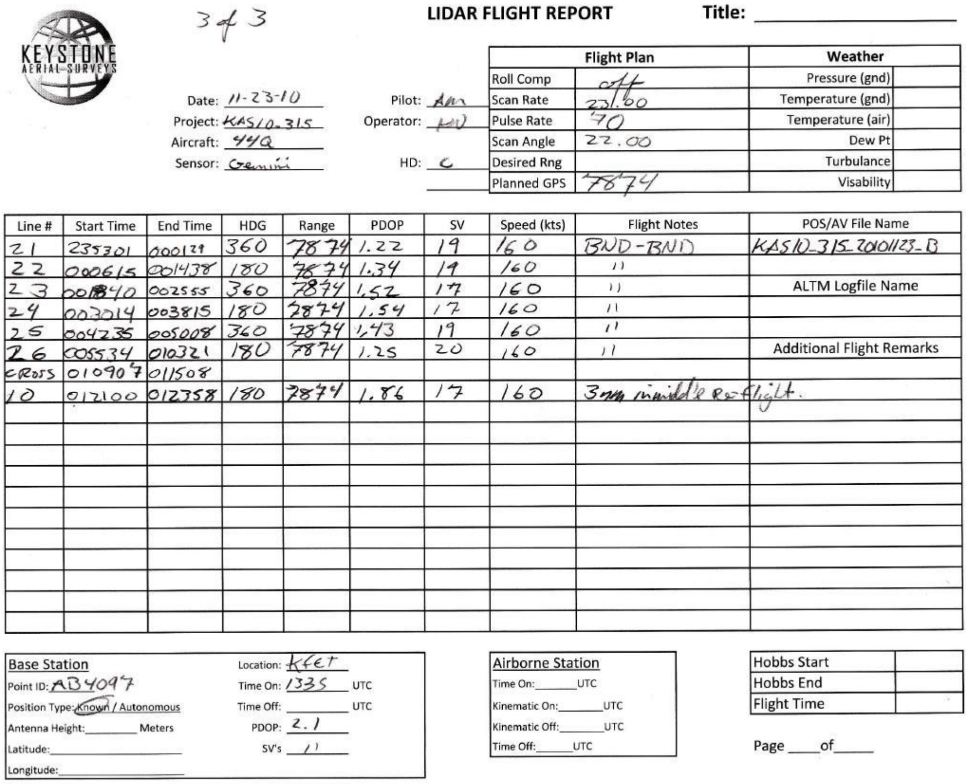
Airborne Station
Time On: ______UTC
Kinematic On: ______UTC
Kinematic Off: ______UTC
Time Off: ______UTC

	Flight A	Flight B
Hobbs Start	1937.7	1944.1
Hobbs End	1944.1	1948.5
Flight Time	4.4	4.4

Page ____of_____ 8.8

1

Flight Log 112310 Page 3



3 of 3

LIDAR FLIGHT REPORT Title: ____________

KEYSTONE AERIAL SURVEYS

Date: 11-23-10
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini

Pilot: AM
Operator: [illegible]
HD: C

Flight Plan		Weather	
Roll Comp	off	Pressure (gnd)	
Scan Rate	23.60	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	22.00	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	7874	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
21	235301	000129	360	7874	1.22	19	160	BND-BND	KAS10-315-20101123-B
22	000615	001438	180	7874	1.34	19	160	"	
23	001840	002555	360	7874	1.52	17	160	"	ALTM Logfile Name
24	003014	003815	180	7874	1.54	17	160	"	
25	004235	005008	360	7874	1.43	19	160	"	
26	005534	010321	180	7874	1.25	20	160	"	Additional Flight Remarks
CROSS	010907	011508							
10	012100	012358	180	7874	1.86	17	160	3nm middle Re-flight.	

Base Station

Point ID: AB4097
Position Type: [✓ Known] / Autonomous
Antenna Height: ________ Meters
Latitude: ____________________
Longitude: ____________________

Location: KFET
Time On: 1335 UTC
Time Off: ________ UTC
PDOP: 2.1
SV's 11

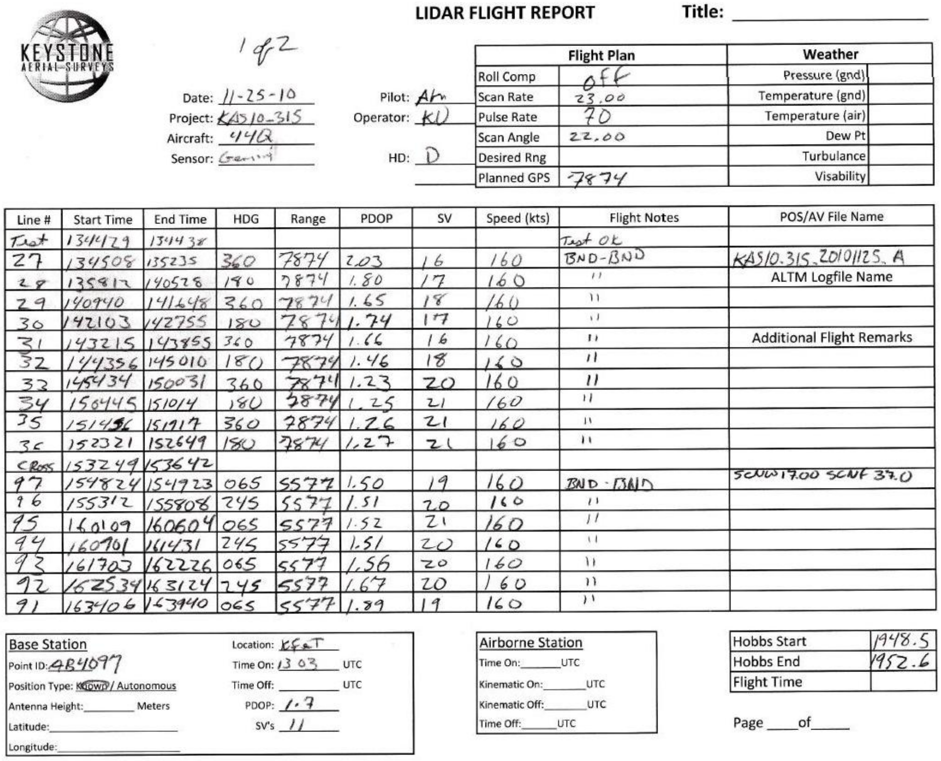
Airborne Station

Time On: ______ UTC
Kinematic On: ______ UTC
Kinematic Off: ______ UTC
Time Off: ______ UTC

Hobbs Start	
Hobbs End	
Flight Time	

Page ____ of _____

Flight Log 112510 Page 1



LIDAR FLIGHT REPORT Title: ____________________

1 of 2

Date: 11-25-10
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini

Pilot: AM
Operator: KU
HD: D

Flight Plan		Weather	
Roll Comp	off	Pressure (gnd)	
Scan Rate	23.00	Temperature (gnd)	
Pulse Rate	70	Temperature (air)	
Scan Angle	22.00	Dew Pt	
Desired Rng		Turbulance	
Planned GPS	7874	Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
Test	134429	134438						Test OK	
27	134508	135235	360	7874	2.03	16	160	BND-BND	KAS10.315_20101125_A
28	135812	140528	180	7874	1.80	17	160	"	ALTM Logfile Name
29	140940	141648	360	7874	1.65	18	160	"	
30	142103	142755	180	7874	1.74	17	160	"	
31	143215	143855	360	7874	1.66	16	160	"	Additional Flight Remarks
32	144356	145010	180	7874	1.46	18	160	"	
33	145434	150031	360	7874	1.23	20	160	"	
34	150445	151014	180	7874	1.25	21	160	"	
35	151456	151917	360	7874	1.26	21	160	"	
36	152321	152649	180	7874	1.27	21	160	"	
CROSS	153249	153642							
97	154824	154923	065	5577	1.50	19	160	BND-BND	SCNW 17.00 SCNF 37.0
96	155312	155808	245	5577	1.51	20	160	"	
95	160109	160604	065	5577	1.52	21	160	"	
94	160901	161431	245	5577	1.51	20	160	"	
93	161703	162226	065	5577	1.56	20	160	"	
92	162534	163124	245	5577	1.67	20	160	"	
91	163406	163940	065	5577	1.89	19	160	"	

Base Station
Point ID: 4B4097
Position Type: [✓ Known] / Autonomous
Antenna Height: ________ Meters
Latitude: ____________________
Longitude: ____________________
Location: KFAT
Time On: 13 03 UTC
Time Off: ________ UTC
PDOP: 1.7
SV's 11

Airborne Station
Time On: ______UTC
Kinematic On: _______UTC
Kinematic Off: _______UTC
Time Off: ______UTC

Hobbs Start	1948.5
Hobbs End	1952.6
Flight Time	

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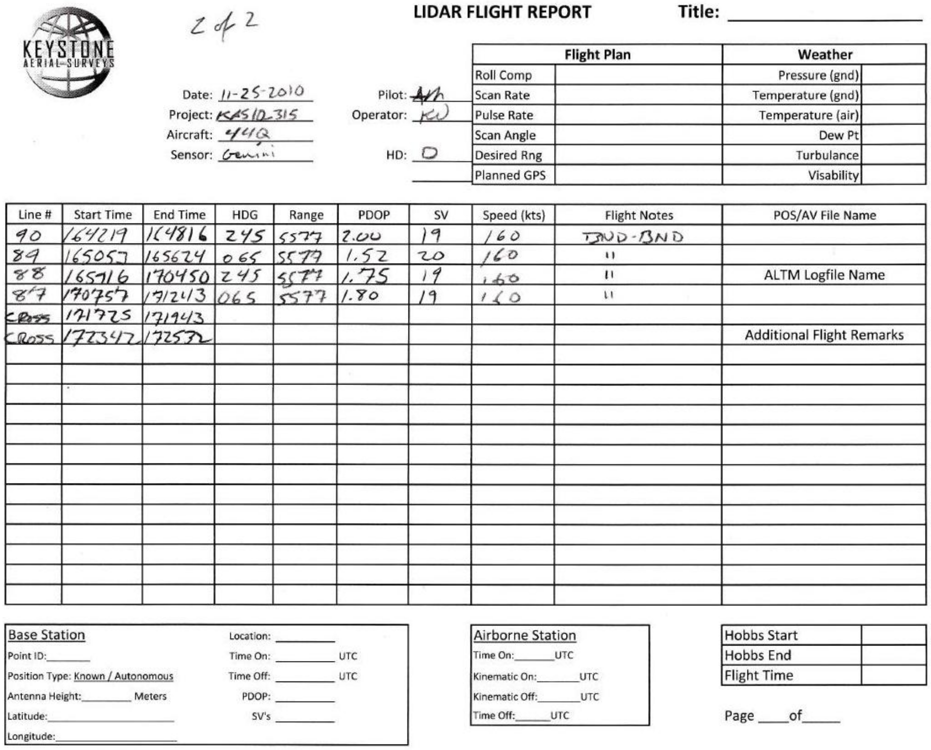
Flight Log 112510 Page 2



LIDAR FLIGHT REPORT Title: ____________________

2 of 2

Date: 11-25-2010
Project: KAS10-315
Aircraft: 44Q
Sensor: Gemini

Pilot: AM
Operator: KU
HD: D

Flight Plan		Weather	
Roll Comp		Pressure (gnd)	
Scan Rate		Temperature (gnd)	
Pulse Rate		Temperature (air)	
Scan Angle		Dew Pt	
Desired Rng		Turbulance	
Planned GPS		Visability	

Line #	Start Time	End Time	HDG	Range	PDOP	SV	Speed (kts)	Flight Notes	POS/AV File Name
90	164219	164816	245	5577	2.00	19	160	BND-BND	
89	165053	165624	065	5577	1.52	20	160	"	
88	165716	170450	245	5577	1.75	19	160	"	ALTM Logfile Name
87	170757	171243	065	5577	1.80	19	160	"	
CROSS	171725	171943							
CROSS	172347	172532							Additional Flight Remarks

Base Station
Point ID: _______
Position Type: Known / Autonomous
Antenna Height: ________ Meters
Latitude: ____________________
Longitude: ____________________
Location: ________
Time On: ________ UTC
Time Off: ________ UTC
PDOP: ________
SV's ________

Airborne Station
Time On: ______UTC
Kinematic On: _______UTC
Kinematic Off: _______UTC
Time Off: ______UTC

Hobbs Start	
Hobbs End	
Flight Time	

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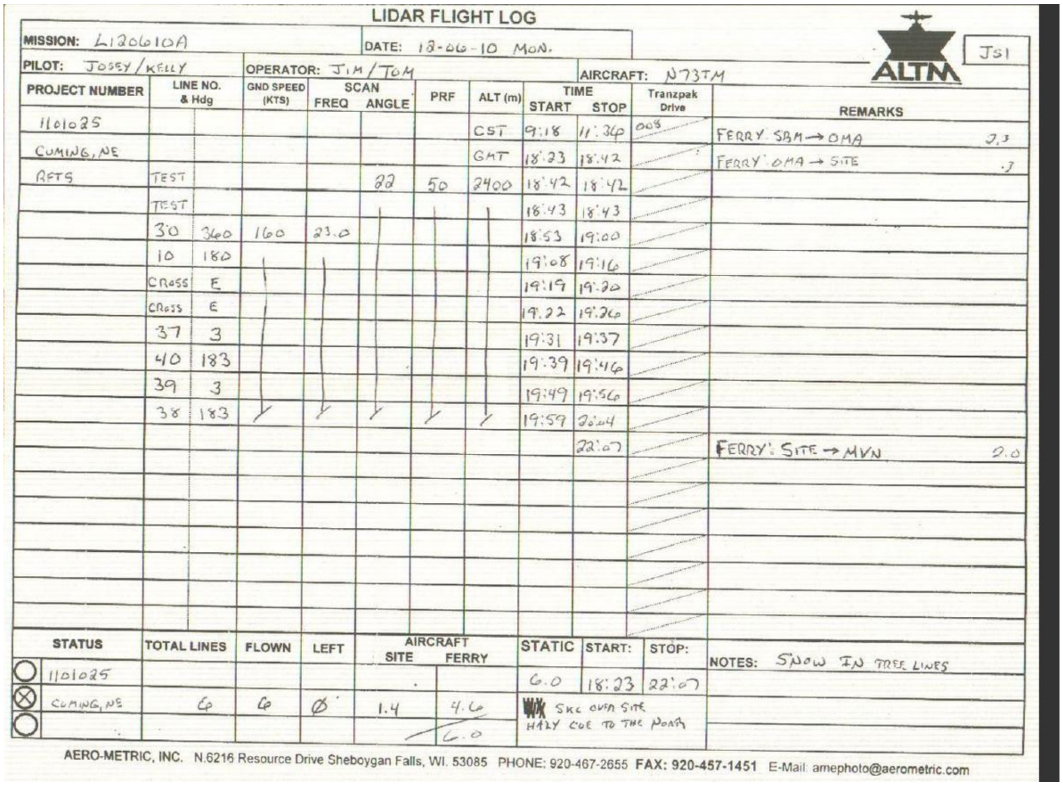
Flight Log L120610A



LIDAR FLIGHT LOG

JSI

ALTM

MISSION: L120610A

DATE: 12-06-10 MON.

PILOT: JOSEY / KELLY

OPERATOR: JIM / TOM

AIRCRAFT: N73TM

PROJECT NUMBER	LINE NO. & Hdg		GND SPEED (KTS)	SCAN FREQ	SCAN ANGLE	PRF	ALT (m)	TIME START	TIME STOP	Tranzpak Drive	REMARKS	
1101025							CST	9:18	11:36	008	FERRY SBM → OMA	2.3
CUMING, NE							GMT	18:23	18:42		FERRY OMA → SITE	.3
RFTS	TEST				22	50	2400	18:42	18:42			
	TEST							18:43	18:43			
	30	360	160	23.0				18:53	19:00			
	10	180						19:08	19:16			
	CROSS	E						19:19	19:20			
	CROSS	E						19:22	19:26			
	37	3						19:31	19:37			
	40	183						19:39	19:46			
	39	3						19:49	19:56			
	38	183						19:59	20:04			
									22:07		FERRY: SITE → MVN	2.0

STATUS	TOTAL LINES	FLOWN	LEFT	AIRCRAFT SITE	AIRCRAFT FERRY	STATIC	START:	STOP:
○ 1101025						6.0	18:23	22:07
⊗ CUMING, NE	6	6	0	1.4	4.6	WX SKC OVER SITE HAZY CDE TO THE NORTH		
○					6.0			

NOTES: SNOW IN TREE LINES

AERO-METRIC, INC. N.6216 Resource Drive Sheboygan Falls, WI. 53085 PHONE: 920-467-2655 **FAX: 920-457-1451** E-Mail: amephoto@aerometric.com