Dewberry

PROJECT REPORT

For the

USGS San Francisco Coastal LiDAR – ARRA LiDAR

USGS Contract:

G10PC00013

Task Order Number:

G10PD00524

Prepared for:
USGS

Prepared by:
Dewberry
8401 Arlington Blvd.
Fairfax, Virginia 22031

Report Date: March 4, 2011

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Executive Summary

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the USGS San Francisco Coastal LiDAR project area.

The LiDAR data were processed to a bare-earth digital terrain model (DTM). Detailed breaklines and bare-earth DEMs were produced for the project area. Data was formatted according to tiles with each tile covering an area of 1500 m by 1500 m. A total of 712 tiles were produced for the project encompassing an area of approximately 610 sq. miles.

The Project Team

Dewberry served as the prime contractor for the project. In addition to project management, Dewberry was responsible for breakline production, Digital Elevation Model (DEM), quality assurance, and the final LAS classification of the data.

Dewberry contracted McGee Survey Consulting to complete ground surveying for the project and deliver surveyed checkpoints. Their task was to acquire surveyed checkpoints for the project to use in independent testing of the vertical accuracy of the LiDAR-derived surface model. They also verified the GPS base station coordinates used during LiDAR data acquisition to ensure that the base station coordinates were accurate. Note that a separate Survey Report was created for this portion of the project.

Terrapoint completed LiDAR data acquisition, data calibration, and initial LAS classification for approximately 610 square miles covering the project area.

Survey Area

The project area addressed by this report falls within the California Counties of Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, and Santa Clara.

Date of Survey

The LiDAR aerial acquisition was conducted from June 11, 2010 thru November 07, 2010.

Datum Reference

Data produced for the project were delivered in the following reference system.

Horizontal Datum: The horizontal datum for the project is North American Datum of 1983 (NAD 83)
Vertical Datum: The Vertical datum for the project is North American Vertical Datum of 1988 (NAVD88)
Coordinate System: UTM Zone 10 North
Units: Horizontal units are in meters, Vertical units are in meters.
Geiod Model: Geoid09.

LiDAR Vertical Accuracy

For the USGS San Francisco Coastal LiDAR Project, the tested $RMSE_z$ for all checkpoints equaled **0.07 m** compared with the 0.09 m specification; and the FVA computed using $RMSE_z$ x 1.9600 was equal to **0.13 m**, compared with the 0.15 m specification.

For the USGS San Francisco Coastal LiDAR Project, the tested CVA computed using the 95^{th} percentile was equal to **0.14 m,** compared with the 0.363 m specification.

Project Deliverables

The deliverables for the project are listed below.

1. Raw Point Cloud Data (Swaths)
2. Classified Point Cloud Data (Tiled)
3. Bare Earth Surface (Raster DEM – IMG Format)
4. Control & Accuracy Checkpoint Report & Points
5. Metadata
6. Project Report (Acquisition, Processing, QC)
7. Project Extents Derived from LiDAR Deliverable
8. Breakline Data (File GDB)

1 Project Tiling Footprint

Seven hundred and twelve (712 tiles were delivered for the project. Each tile's extent is 1500 meters by 1500 meters.

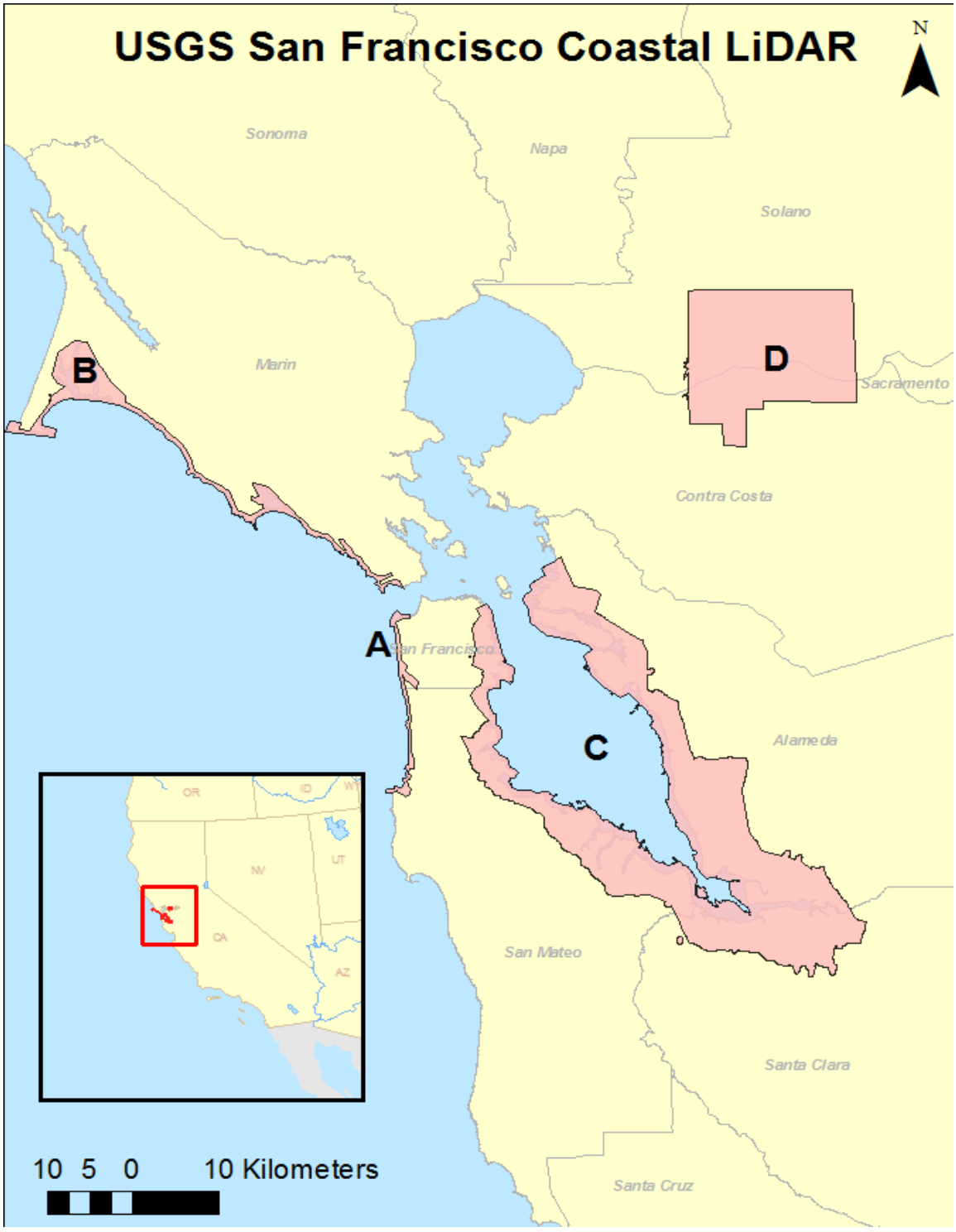

Figure 1: Project Map

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2 LiDAR Acquisition Report

LiDAR ACQUISTION REPORT

For

USGS GEOSPATIAL PRODUCTION AND SERVICES CONTACT 2
USGS CONTRACT#: G10PC00013
TASK ORDER NUMBER: G10PD00524
TASK ORDER NAME: San Francisco Coastal LiDAR – ARRA Lidar

Prepared by:
Dewberry
8401 Arlington Boulevard
Fairfax, Virginia 22031
www.dewberry.com

Report Date
March 4, 2011

Overview

This project provides high accuracy, calibrated multiple return LiDAR for approximately 610 square miles that includes the California Counties of Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, and Santa Clara.

The LiDAR data was acquired by Terrapoint USA. This report covers the acquisition activities for the entire project and contains information submitted from both subcontractors.

LiDAR data is remotely sensed high-resolution elevation data collected by an airborne collection platform. By positioning laser range finding with the use of 1 second GPS with 100 Hz inertial measurement unit corrections; LiDAR instruments are able to make highly detailed geospatial elevation products of the ground, man-made structures and vegetation.

This report covers the mission parameters, QA/QC steps, control information and other pertinent details of the LiDAR acquisition task.

Project Area

Terrapoint was responsible for providing LiDAR acquisition, calibration and delivery of partially classified LiDAR data files to Dewberry for their assigned areas. Dewberry will then perform all final data post-processing and classification steps to develop the requisite deliverables. This will include final LiDAR classification, breakline development and the development of "hydro-flattened" DEM products. Dewberry will also perform all requisite survey activities for this task order.

The project map on the following page illustrates project extents as well as the counties assigned to Terrapoint (shown in pink). The total project area is approximately 612 square miles.

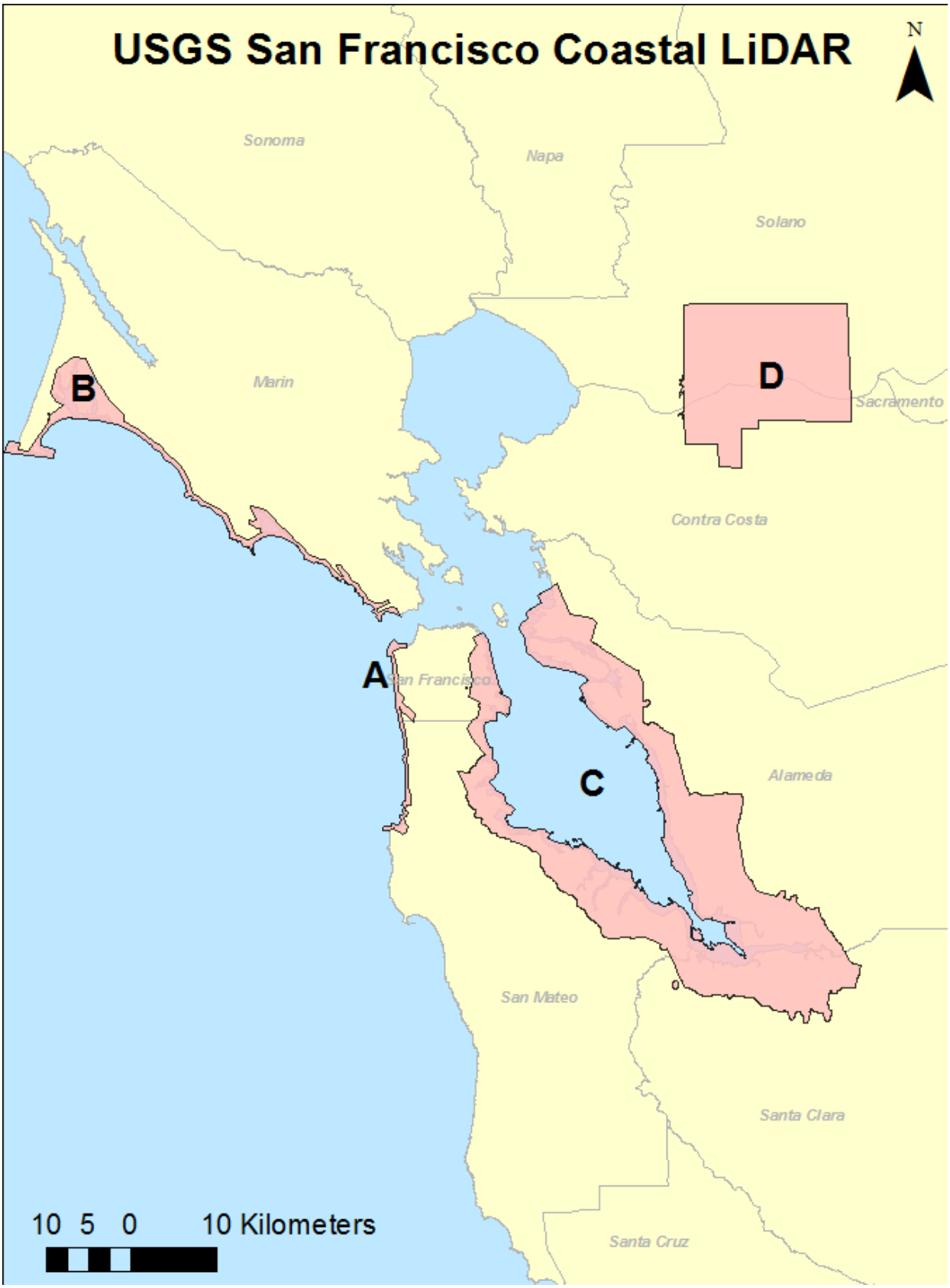


Figure 1: Project Boundary

Acquisition Equipment

One Optech ALTM 3100EA LiDAR systems were utilized to collect the data. The 100 kHz LiDAR system is a state-of-the-art system that enables the combination of accuracy and rapid collection speed due to its high scanning rate.

Optech ALTM 3100EA System

Table 1 represents a list of the features and characteristics for the Optech ALTM 3100EA system:

CHARACTERISTIC	ALTM 3100EA
Manufacturer	Optech
Platform	Fixed-wing/Helicopter
Scan principle/pattern	Sawtooth, uniform across 96% of swath
Wavelength(s) (µm)	1.064
Scan angle θ (°)	Variable from 0º to +/- 25º
Pulse rate (kHz)	0 – 100
Scan rate (Hz)	70
Flying height *h* minimum-maximum (m)	80 – 3500
Swath width (m)	Variable from 0 to 0.93 x altitude (m)
Beam divergence (mrad)	Dual divergence 0.3 or 0.8
Laser footprint (m)	0.75 @ 1000 m *h* (typical)
Across track point spacing (m)	Variable
Along track point spacing (m)	Variable
Point density (points/ sq m)	Variable
Flying speed typical (km/h)	250
Area/h (sq km/h)	Varies
Net flying time max/typical (h)	Typical at 7 hours
No. of echoes per pulse	4 including last
Intensity recording	Yes
Cameras	LMSI -Rollei 22 mega pixel color/CIR; Terrapoint - None
Ground GPS receivers (dual–frequency)	Any geodetic grade
Airborne GPS receiver (dual–frequency)	Geodetic grade dual frequency
IMU Manufacturer	Litton
IMU Frequency (Hz)	200
Attitude precision roll, pitch/heading (°)	0.005 / 0.008
Laser classification	Class IV
Eyesafe range (m)	70 (in flight)
Power requirements	28 VDC @ 35 A (maximum)
Operating temperature (°C)	-10º to +35º
Humidity (%)	0 to 95 non-condensing
Sensor dimensions (cm)	16 (w) x 19 (d) x 57 (h)
Sensor weight (kg)	23
Sensor mount	Directly to floor or to adapter for existing camera mount
Control rack	Single rack
Control rack dimensions (cm)	65 (w) x 59 (d) x 49 (h)
Control rack weight (kg)	53
Data storage/acquisition duration	Removable hard-drive

Table 1: LiDAR Sensor Characteristics

LiDAR System Parameters
The table below shows the configuration used in the acquisition of this project.

Configuration Item	Parameter	units
Aircraft Speed	150	**knots**
Data Acquisition Height	1300	**m AGL**
Swath Width	765.22	**m**
Distance Between Flight Lines	344.35	**m**
Overlap	50	**%**
Scanner Field Of View	19.4	**+/- degrees**
Scan Cutoff	0	**Degrees**
Pulse Repetition Rate	70	**KHz**
Scan Frequency	38.7	**Hz**
Number of Returns Per Pulse	4	**Discrete returns**
Beam Divergence	0.3 mrad (1/e)	**Optech mRad or Narrow for Optech**
Flight Line Length	30km	**<X km**
Base Station Distance	35km	**<X km**
Resultant Raw Point Density	2	**pt/m2 with overlap**

Table 2: LiDAR System Parameters

Aircraft
A Piper Navaho aircraft, registered as FVTL was used to conduct the aerial survey. The Navaho is a fixed wing aircraft that have an endurance of approximately 6-7 hours.

Base Station and Control GPS Receivers
Ground based GPS stations also acquired consecutive GPS information for the duration of the flights. A combination of Sokkia GSR 2600 and NovAtel DL-4+ dual-frequency GPS receivers were used to support the airborne operations of this survey.

Acquisition Dates and Flight Lines
Table 3 shows the number of flight lines and dates of acquisition along with each mission's name and the sensor configuration used.

Mission Summary

Survey Block	Station	Mission Name	Calendar Date	Number of LiDAR Production Lines	LiDAR Hours
USGS SAN Francisco	1010601	o110162a	11-Jun	lidar 188-199 and 102-119	6.7
USGS SAN Francisco	1010602-	o110163a	12-Jun	lidar 150-163	5.3

Survey Block	Station	Mission Name	Calendar Date	Number of LiDAR Production Lines	LiDAR Hours
	1010603				
USGS SAN Francisco	1010602-1010603	o110164a	13-Jun	lidar 164-172	4
USGS SAN Francisco	1010602 and 1010604	o110173a	22-Jun	lidar 24 to 41	3.5
USGS SAN Francisco	1010602_1010604	o110175a	24-Jun	lidar 181 to 187 and 71 to 94	6.4
USGS SAN Francisco	1010604	o110177a	26-Jun	lidar 63 to 70	2.3
USGS SAN Francisco	1010605	o110178a	27-Jun	lidar 1 to 7 and 15 to 23 and 173 and 174	5.5
USGS SAN Francisco	1010605	o110179a	28-Jun	lidar 8 to 15 line 84	5
USGS SAN Francisco	1010604	o110180a	29-Jun	lidar 50 to 62	2.7
USGS SAN Francisco	1010604	o110181a	30-Jun	lidar 42 to 49	2.7
USGS SAN Francisco	1010602	o110292a	19-Oct	7500ft 11-14	2.6
USGS SAN Francisco	1010602	o110293a	20-Oct	7500ft 9-15 and 5	4.5
USGS SAN Francisco	1010602	o110305a	1-Nov	regular flying height 1-13 & 21 & 25	4
USGS SAN Francisco	1010602	o110306a	2-Nov	regular flying height 1-8 reflights 5-8 13-20	4
USGS SAN Francisco	1010601	o110162a	11-Jun	lidar 188-199 and 102-119	6.7
USGS SAN Francisco	1010602-1010603	o110163a	12-Jun	lidar 150-163	5.3
USGS SAN Francisco	1010602-1010603	o110164a	13-Jun	lidar 164-172	4
USGS SAN Francisco	1010602 and 1010604	o110173a	22-Jun	lidar 24 to 41	3.5
USGS SAN Francisco	1010602_1010604	o110175a	24-Jun	lidar 181 to 187 and 71 to 94	6.4
USGS SAN Francisco	1010604	o110177a	26-Jun	lidar 63 to 70	2.3
USGS SAN Francisco	1010605	o110178a	27-Jun	lidar 1 to 7 and 15 to 23 and 173 and 174	5.5
USGS SAN Francisco	1010605	o110179a	28-Jun	lidar 8 to 15 line 84	5
USGS SAN Francisco	1010604	o110180a	29-Jun	lidar 50 to 62	2.7
USGS SAN Francisco	1010604	o110181a	30-Jun	lidar 42 to 49	2.7
USGS SAN Francisco	1010602	o110292a	19-Oct	7500ft 11-14	2.6
USGS SAN Francisco	1010602	o110293a	20-Oct	7500ft 9-15 and 5	4.5
USGS SAN Francisco	1010602	o110305a	1-Nov	regular flying height 1-13 & 21 & 25	4
USGS SAN Francisco	1010602	o110306a	2-Nov	regular flying height 1-8 reflights 5-8 13-20	4
USGS SAN Francisco	1010601	o110162a	11-Jun	lidar 188-199 and 102-119	6.7
USGS SAN Francisco	1010602-1010603	o110163a	12-Jun	lidar 150-163	5.3
USGS SAN Francisco	1010602-1010603	o110164a	13-Jun	lidar 164-172	4

Survey Block	Station	Mission Name	Calendar Date	Number of LiDAR Production Lines	LiDAR Hours
USGS SAN Francisco	1010602 and 1010604	o110173a	22-Jun	lidar 24 to 41	3.5
USGS SAN Francisco	1010602_ 1010604	o110175a	24-Jun	lidar 181 to 187 and 71 to 94	6.4
USGS SAN Francisco	1010604	o110177a	26-Jun	lidar 63 to 70	2.3
USGS SAN Francisco	1010605	o110178a	27-Jun	lidar 1 to 7 and 15 to 23 and 173 and 174	5.5
USGS SAN Francisco	1010605	o110179a	28-Jun	lidar 8 to 15 line 84	5
USGS SAN Francisco	1010604	o110180a	29-Jun	lidar 50 to 62	2.7
USGS SAN Francisco	1010604	o110181a	30-Jun	lidar 42 to 49	2.7
USGS SAN Francisco	1010602	o110292a	19-Oct	7500ft 11-14	2.6
USGS SAN Francisco	1010602	o110293a	20-Oct	7500ft 9-15 and 5	4.5
USGS SAN Francisco	1010602	o110305a	1-Nov	regular flying height 1-13 & 21 & 25	4
USGS SAN Francisco	1010602	o110306a	2-Nov	regular flying height 1-8 reflights 5-8 13-20	4

Table 3: Flight Lines and Acquisition Dates

A copy of the acquired flight lines is included in Appendix A and a copy of the flight logs is located in Appendix B.

Acquisition Specifications

The LiDAR data was collected using the specifications outlined in the "U.S. Geological Survey National Geospatial Program Base LiDAR Specifications, Version 13.

LiDAR collection parameters were as follows:

- LiDAR data was collected at a nominal pulse spacing (NPS) of 0.7 meters.
- The LiDAR was collected under cloud-and fog-free conditions
- Multiple return collection (first, last, and intermediate) and Intensity was collected
- The collection area was buffered by 140 meters

Flight Logs

Flight logs document the dates, flight crew, weather, flying height and times for each mission. The flight logs for the project are contained within Attachment A (Terrapoint).

Airborne GPS Positioning

Both Terrapoint and LMSI used either existing or newly established survey points to create a GPS network to control all flight missions and to support kinematic and static ground surveys used to quality control the data.

The projection and units used for all deliverables was as follows:

Horizontal Datum	NAD83 HARN
Vertical Datum	NAVD88
Projection	UTM
Zone	10 N
Units	Meters

The following subsections include the points established or utilized by each firm for these purposes.

Terrapoint Base Stations

Establishment of survey points to support the LiDAR data collection. Three existing published CGPS stations (CHAB, P181, P222) were observed in a GPS control network and used to establish three new points for the primary control for this site. 101U01, 101U02, 101U04, AY0887 and AY1499 were observed and used to control all flight missions and static ground surveys. The following are the final coordinates of the control points used in this project:

Station	Latitude (D M S)	Longitude (D M S)	H-Ell
1010601	37 30 52.26391	-122 29 41.86434	-16.6617
1010602	37 27 16.57733	-122 06 37.48309	-29.7404
1010603	37 39 48.24857	-122 07 23.10831	-23.1470
1010604	37 59 35.03464	-122 03 44.26783	-26.2030
1010605	37 59 49.29391	-122 45 33.01378	-26.2030

Geoid Model Used

All elevations were referenced to the GEOID09 model, published by the National Geodetic Survey (NGS), was used to reduce all ellipsoidal heights to orthometric.

Quality Control

Quality Control for Data Acquisition

The acquisition of overlapping calibration lines for every mission is key to the QC process since it helps identify any systematic issues in data acquisition or failures on the part of the GPS, IMU or other equipment that may not have been evident to the LiDAR operator during the mission.

Ground truth validation is used to assess the data quality and consistency over sample areas of the project. To facilitate a confident evaluation, existing survey control is used to validate the LiDAR data. Published survey control, where the orthometric height (elevation) has been determined by precise differential levelling or GPS observation, is deemed to be suitable.

The Field Project Manager performs kinematic post-processing of the aircraft GPS data in conjunction with the data collected at the Reference Station. Double difference phase processing of the GPS data is used to achieve the greatest accuracy. The GPS position accuracy is assessed by comparison of forward and reverse processing solutions and a review of the computational statistics. Any data anomalies are identified and the necessary corrective actions are implemented prior to the next mission.

System Logger – Power Up Health Checks

The system logging software performs automatic system and subsystem tests on power-up to verify proper functionality of the entire data acquisition system. Any anomalies are immediately investigated and corrected by the LiDAR operator if possible. Any persistent problems are referred to the engineering staff, which can usually resolve the issue by telephone and/or email. In the unlikely event that these steps do not resolve the problem, a trained engineer is immediately dispatched to the project site with the appropriate test equipment and spare parts needed to repair the system.

System Logger – Real Time Acquisition Checks

The system logging software continuously monitors the health and performance of all subsystems. Any anomalies are recorded in the System Log and reported to the LiDAR operator for resolution. If the operator is unable to correct the problem, the engineering staffs are immediately notified. They provide the operator with instructions or on-site assistance as needed to resolve the problem.

If any aspect of the data does not appear to be acceptable, the operator will review system settings to determine if an adjustment could improve the data quality. Navigation aids are provided to alert both the pilot and operator to any line following errors that could potentially compromise the data integrity. The pilot and operator review the data and determine whether an immediate re-flight of the line is required.

Post Acquisition Data Check

After the mission is completed, raw LiDAR and imagery data on the removable disk drive is transferred to the Field PC at the field operations staging area. An automated QA/QC program scans the System Log as well as the raw data files to detect potential errors. Any problems

identified are reported to the operator for further analysis. Data is also retrieved from all GPS Reference Stations, which were active during the mission and transferred to the Field PC. The GPS data is processed and tested for internal consistency and overall quality. Any errors or limit violations are reported to the operator for more detailed evaluation.

Data Viewer Analysis

The Field Project Manager utilizes a data viewer installed on the Field PC to review selected portions of the acquired LiDAR and imagery data, this permits a more thorough and detailed analysis of the data corrupted files or problems in the data itself are noted. If the data indicates improper settings or operation of the LiDAR sensor and camera, the Field Project Manager determines the appropriate corrective actions needed prior to the next mission.

Data Backup with Redundancy

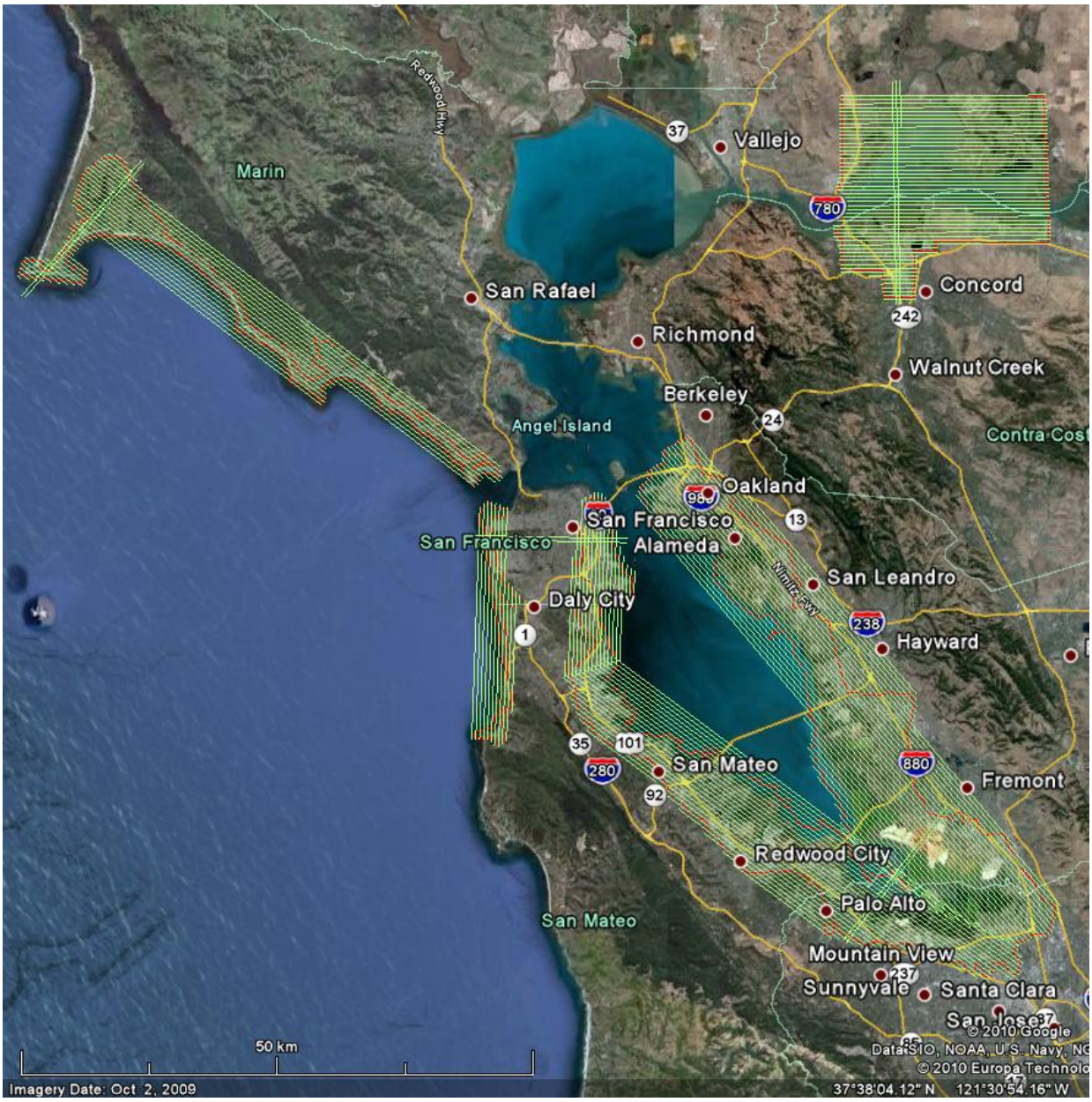
All LiDAR, imagery and GPS data is copied from the Field PC onto two separate removable hard drives: one for transfer to Calibration, and one for local backup. Each hard drive is reviewed to ensure data completeness and readability.

Conclusion

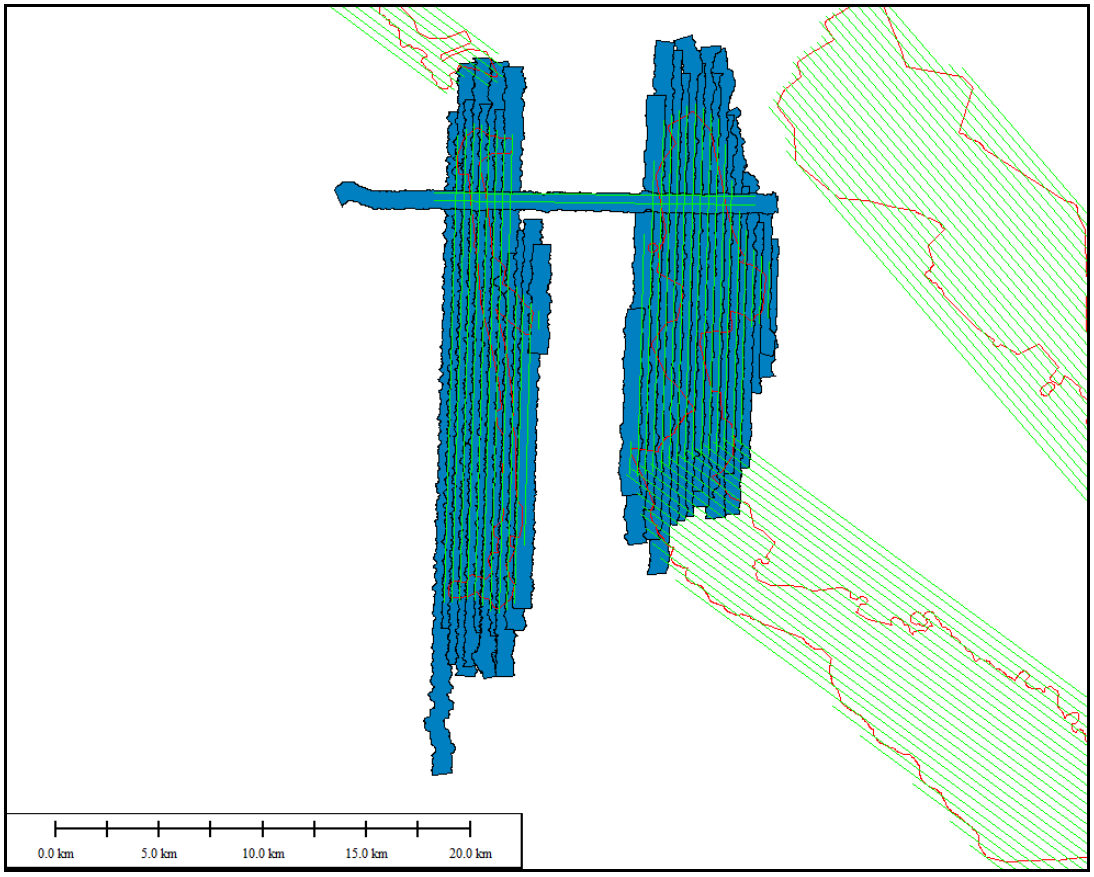
The LiDAR data products collected for the project meet or exceed the requirements set out in the task order statement of work and specifications.

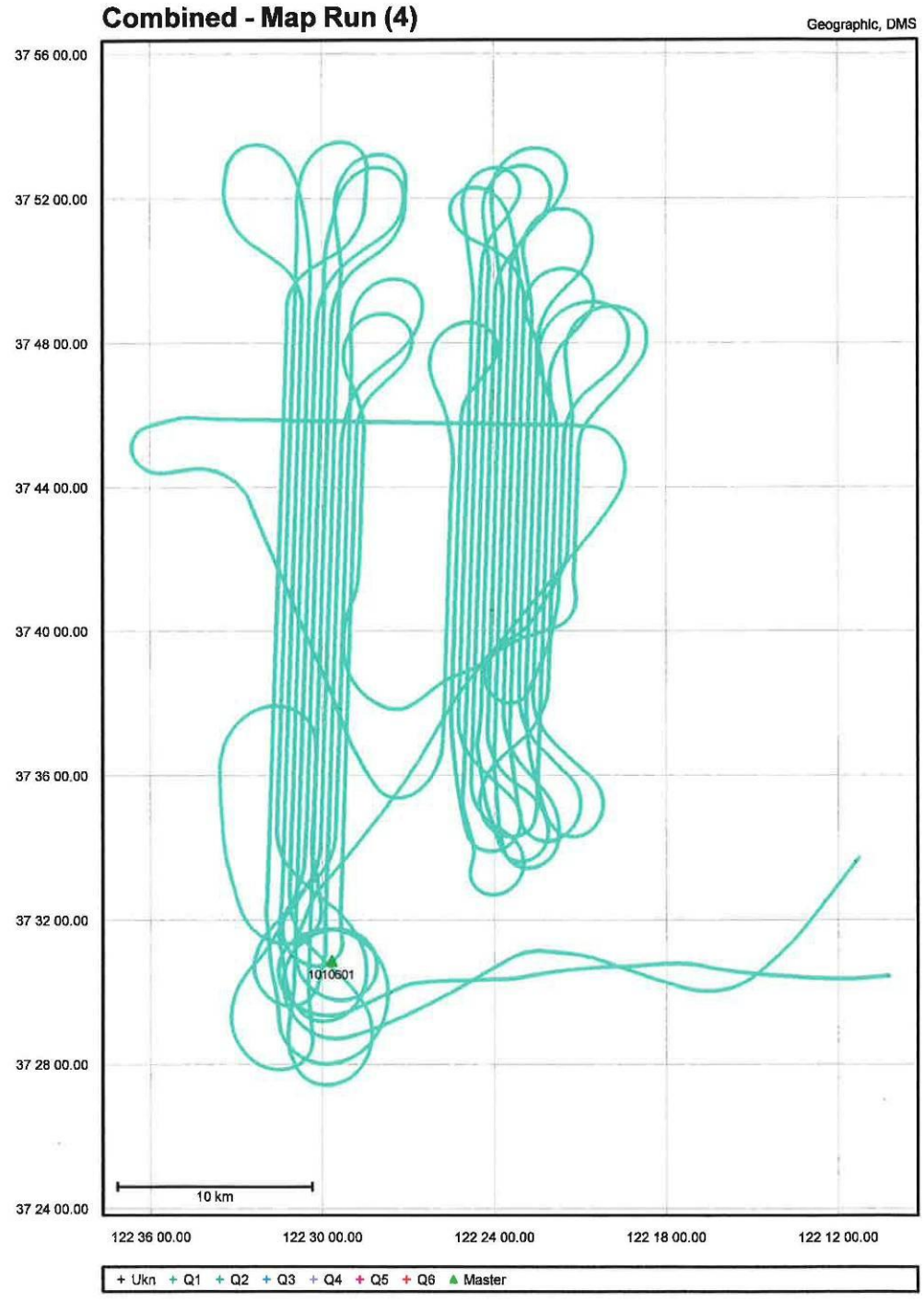
Appendix A Terrapoint As-Flown Flightlines

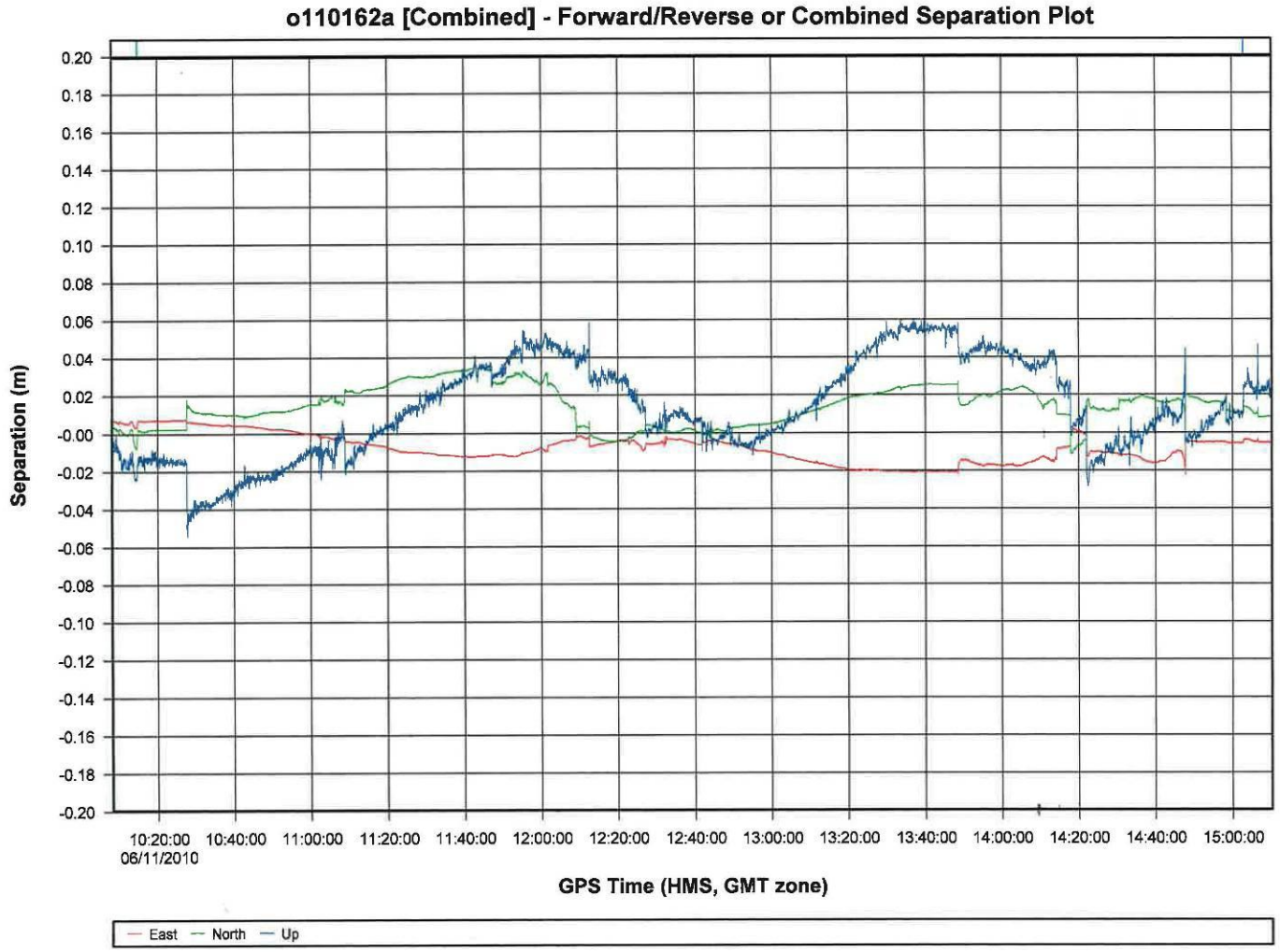
Please note that the actual flight lines include production lines. The colors in the image below represent different missions. The accompanying digital file has the individual mission identified in the database file.



Appendix B Terrapoint Flight Logs




Combined - Map Run (4)
Geographic, DMS
37 56 00.00
37 52 00.00
37 48 00.00
37 44 00.00
37 40 00.00
37 36 00.00
37 32 00.00
37 28 00.00
37 24 00.00
1010501
10 km
122 36 00.00
122 30 00.00
122 24 00.00
122 18 00.00
122 12 00.00
Ukn Q1 Q2 Q3 Q4 Q5 Q6 Master


o110162a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
10:20:00 06/11/2010
10:40:00
11:00:00
11:20:00
11:40:00
12:00:00
12:20:00
12:40:00
13:00:00
13:20:00
13:40:00
14:00:00
14:20:00
14:40:00
15:00:00
GPS Time (HMS, GMT zone)
East
North
Up

Project #	10106U	Session	0110162a

Flight Log

Terrapoint

Date	JUNE 11	Julian Day	162
Project	SAN FRANCISCO	Aircraft	NAVAJO
Staging	OAKLAND	Call Sign	C-FVTL
Survey Block	SF FAST/WEST	Pilot	MATHEW
Lines Complete	188-199, 102-114	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 15 Outside Pressure @ TO: 2998

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs)	Takeoff	(120L) x (Total flt hrs)
2:30	2:45	
Engine Off (Hobbs)	Landing	FBO $ / Litre
8:27	8:17	
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300m	19.2
Ground Speed	Mirror Scan Rate
150 KTS	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71 KHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	9:40	9:44
KAR Base	10:12	10:18
KAR Base	14:59	15:04
Post Mission	15:18	15:23

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
188		2	10:19	10:26			
189		182	10:31	10:37			
190		2	10:42	10:48			
191		182	10:53	10:59			
192		2	11:05	11:22			
193		182	11:15	11:22			
194		2	11:27		11:29		~~TRACK~~ TRAFFIC
194		182	11:33	11:39			
195		182	11:44	11:50			
196		2	11:54	11:59			

Project #	10106U	Session	011C162a

Flight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
197		182	12:04	12:09			
198		2	12:09	12:17			
199		182	12:30	12:22			
119		2	12:25	12:28			
118		189	12:32	12:37			
117		2	12:40	12:42			
116		189	12:45	RUN			
115		2	12:50	12:54			
114		189	12:57	13:01			
113		2	13:05	13:09			
112		182	13:13	13:18			
111		2	13:22	13:25			
110		189	13:29	13:34			
109		2	13:39 Risr	13 stored			
108		182	13:47	13:52			
107		2	13:58	14:01			
106		182	14:05	14:10			
105		2	14:14	14:20			
104		182	14:23	14:28			
103		2	14:31	14:35			
102		182	14:39	14:50			
CROSS			14:48	14:53			

GPS Base Log Sheet

Terrapoint

Station ID:	1010601	Project #:	10106U	Missions:	0110162a

Project Name:	USGS San Fran	Calender Date:	June 10/200	Julian Day	162
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					

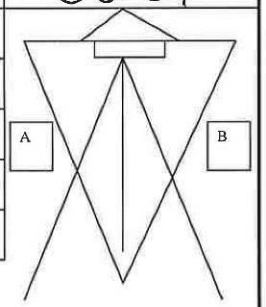
Monument is: ☐ Flush with ground ☑ Above ground 1 cm ☐ Below ground _____ cm

Location & Access: Half Moon Bay Airport.

Obstructions & Additional Notes

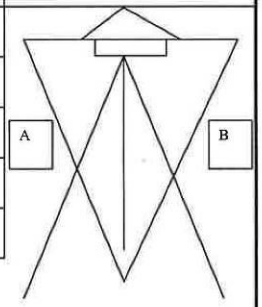
GPS Observation - MAIN

Rx Make / Model	GSR2600	Serial #	0002	
Ant Make / Model	SK600	Serial #	0027	
Operator	AC			
Session Time (GPS)	Start	23 46 00		
	End	21 12 00		
Slant Ht Before:	A: 1.597	B: 1.597		
Slant Ht After:	A:	B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



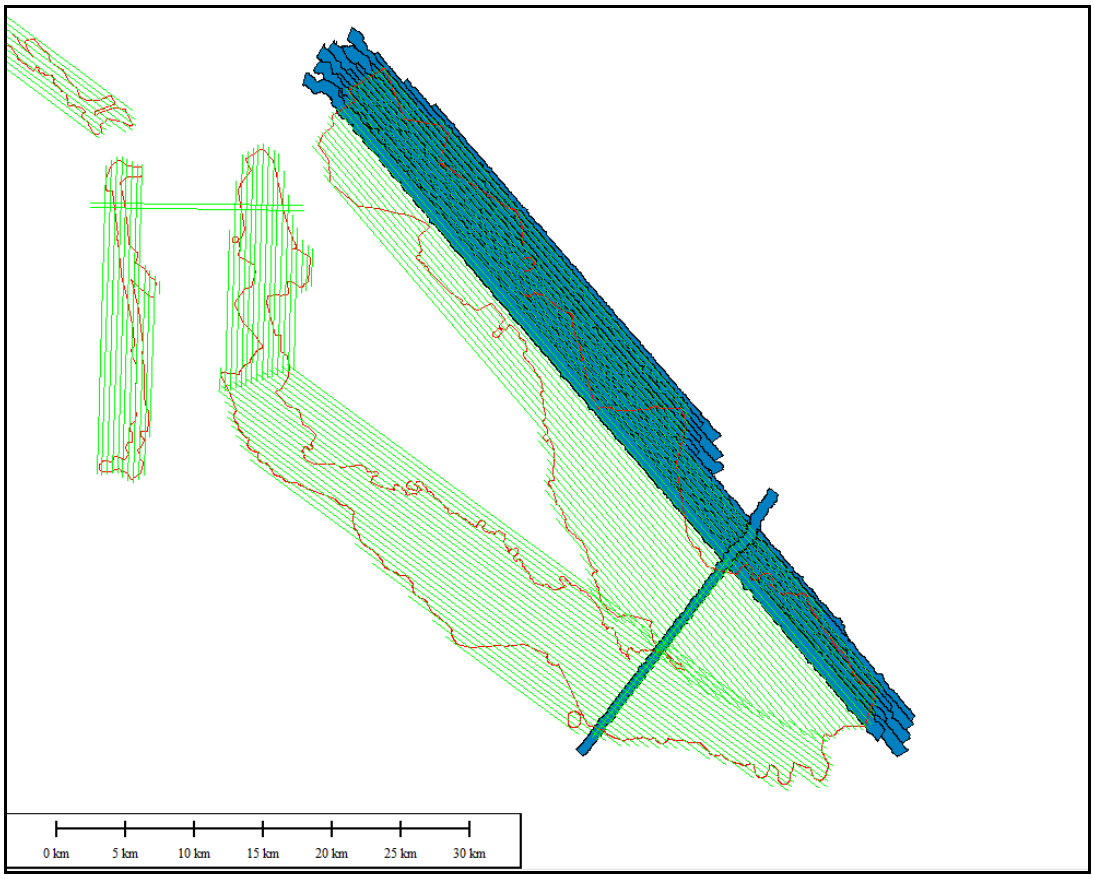
GPS Observation - Back-Up

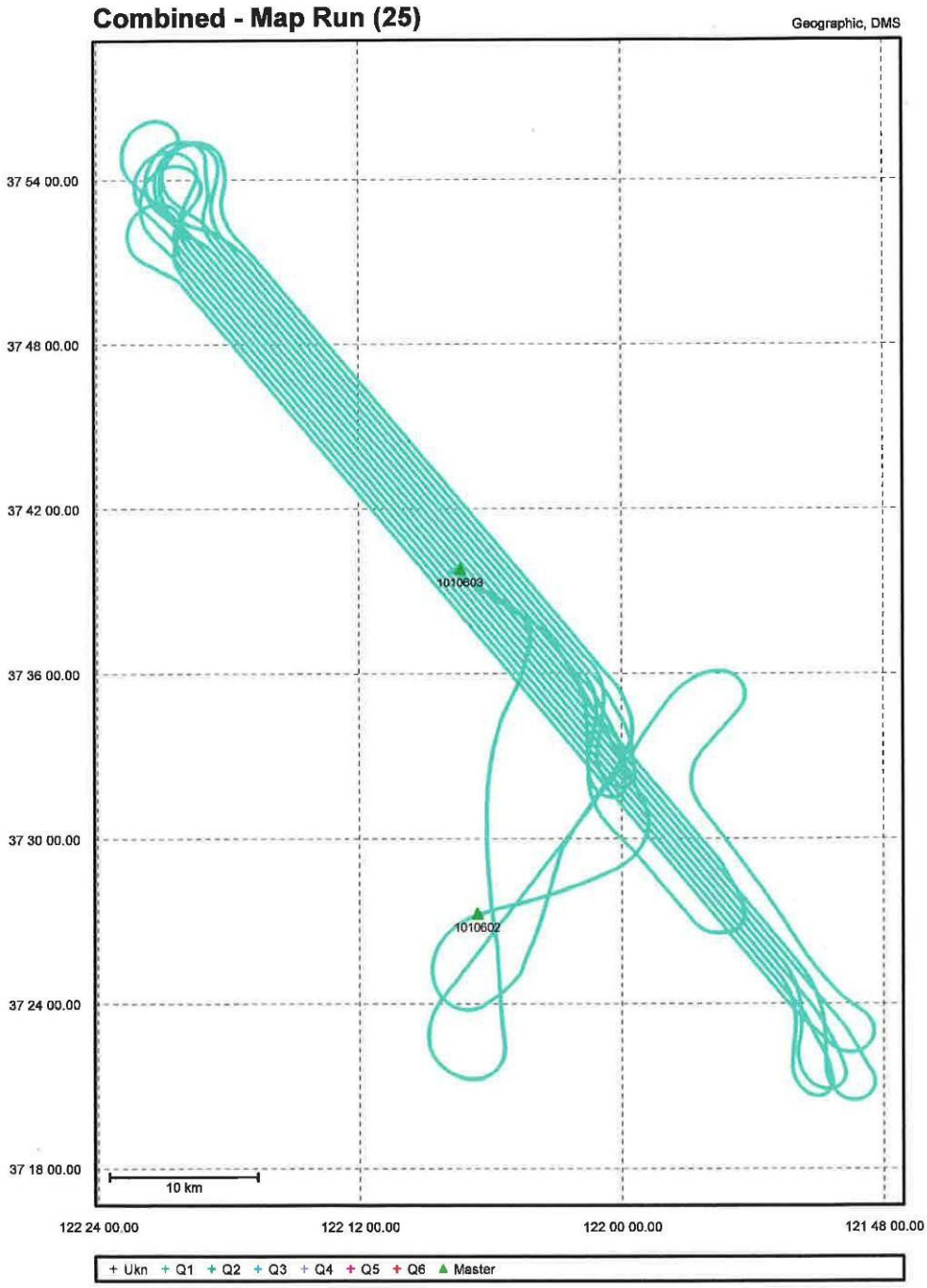
Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS)	Start			
	End			
Slant Ht Before:	A:	B:		
Slant Ht After:	A:	B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				

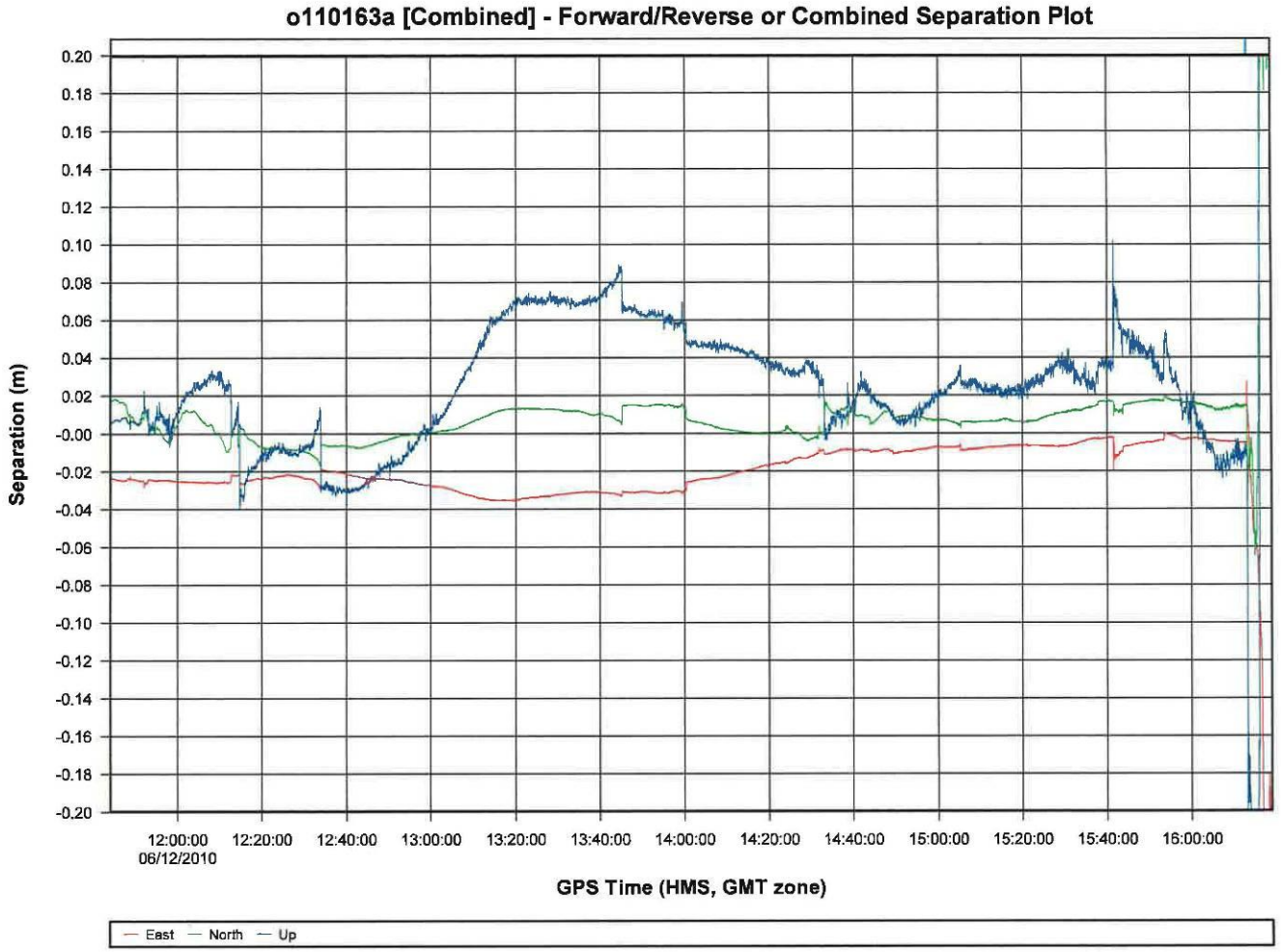


Mission: o110163a

2010 06 12




Combined - Map Run (25)
Geographic, DMS
37 54 00.00
37 48 00.00
37 42 00.00
37 36 00.00
37 30 00.00
37 24 00.00
37 18 00.00
1010603
1010602
10 km
122 24 00.00
122 12 00.00
122 00 00.00
121 48 00.00
Ukn Q1 Q2 Q3 Q4 Q5 Q6 Master


o110163a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
12:00:00
06/12/2010
12:20:00
12:40:00
13:00:00
13:20:00
13:40:00
14:00:00
14:20:00
14:40:00
15:00:00
15:20:00
15:40:00
16:00:00
GPS Time (HMS, GMT zone)
East
North
Up

Project #	101060	Session	0110163a

Flight Log

Terrapoint

Date	JUNE 12	Julian Day	163
Project	SAN FRANCISCO	Aircraft	NAVAJO
Staging	HAYWARD	Call Sign	C-FUTL
Survey Block	ALAMEDA	Pilot	MATTHEW
Lines Complete	150 - 163	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	01
System #	1
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 15 Outside Pressure @ TO: 2991

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs) 4:15	Takeoff 4:45	(120L) x (Total flt hrs)
Engine Off (Hobbs) 9:29	Landing 9:20	FBO $ / Litre
Total hrs (Hobbs) 5.3 hr.	Total hrs	Approx. Fuel Cost

Mission Plan	
Flying Height AGL 1300 M	Scan Angle (Optech) 19.2
Ground Speed 150 KTS	Mirror Scan Rate 38.7
First/Last/Alternating Return	Laser Pulse Rate 71 KHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	11:43	11:48
KAR Base		
KAR Base		
Post Mission	16:20	16:25

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Outout (Watts):
			Start	End	Time	NM to End	
150		320	12:09	12:17			
151		140	12:23	12:30			
152		320	12:35	12:44			
153		140	12:47	12:55			
154		320	13:00	13:09			
155		140	13:13	13:21			
156		320	13:27	13:39			13:26 ERROR 214 NAV DATA LOST
157		140	13:44	13:58			
158		320	14:03	14:17			
159		140	14:21	14:35			

Proje .#	101060	Session	6110163a

. light Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
160		160	14:40	14:54			
161		140	14:59	15:12			
162		320	15:17	15:30			
163		140	15:34	15:48			
Cross			15:59	16:04			

GPS Base Log Sheet

Terrapoint

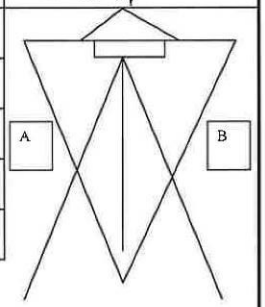
Station ID:	1010602	Project #:	10106V	Missions:	0110163a

Project Name:	USGS San Fran	Calender Date:	June 11 2010	Julian Day	162-163
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monitument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access: Palo Alto airport					

Obstructions & Additional Notes

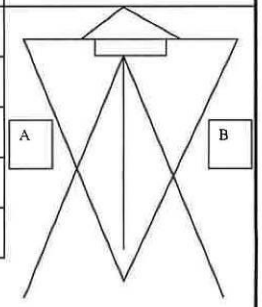
GPS Observation - MAIN

Rx Make / Model	DL4 Novatel	Serial #	0003	
Ant Make / Model	SK600	Serial #	0011	
Operator	TC			
Session Time (GPS) Start	20 07 11			
Session Time (GPS) End	19 57 00			
Slant Ht Before: A:	1.505	B:	1.505	
Slant Ht After: A:	1.505	B:	1.505	
Correction				
Phase Center		☒ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Observation - Back-Up

Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant Ht Before: A:		B:		
Slant Ht After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Base Log Sheet

Terrapoint

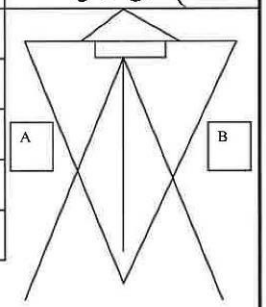
Station ID:	101060_03	Project #:	101060	Missions:	o110163a

Project Name:		Calender Date:	JUNE 12	Julian Day	163
Approx. Coordinates WGS 84	N	37 39 48.23	W	122 07 23.12	
Description of Mark (Take Photos)					
Monument is: ☐ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

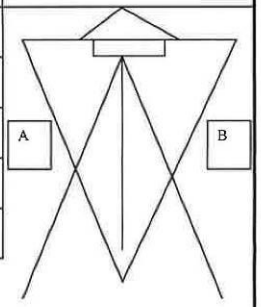
GPS Observation - MAIN

Rx Make / Model	GSL 2600	Serial #	0022
Ant Make / Model	NOVATEL 702	Serial #	0004
Operator	SCOTT		
Session Time (GPS) Start	11:30		
Session Time (GPS) End	16:41		
Slant HI Before: A:	.910 m	B:	.910 m
Slant HI After: A:	.910 m	B:	.910 m
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			



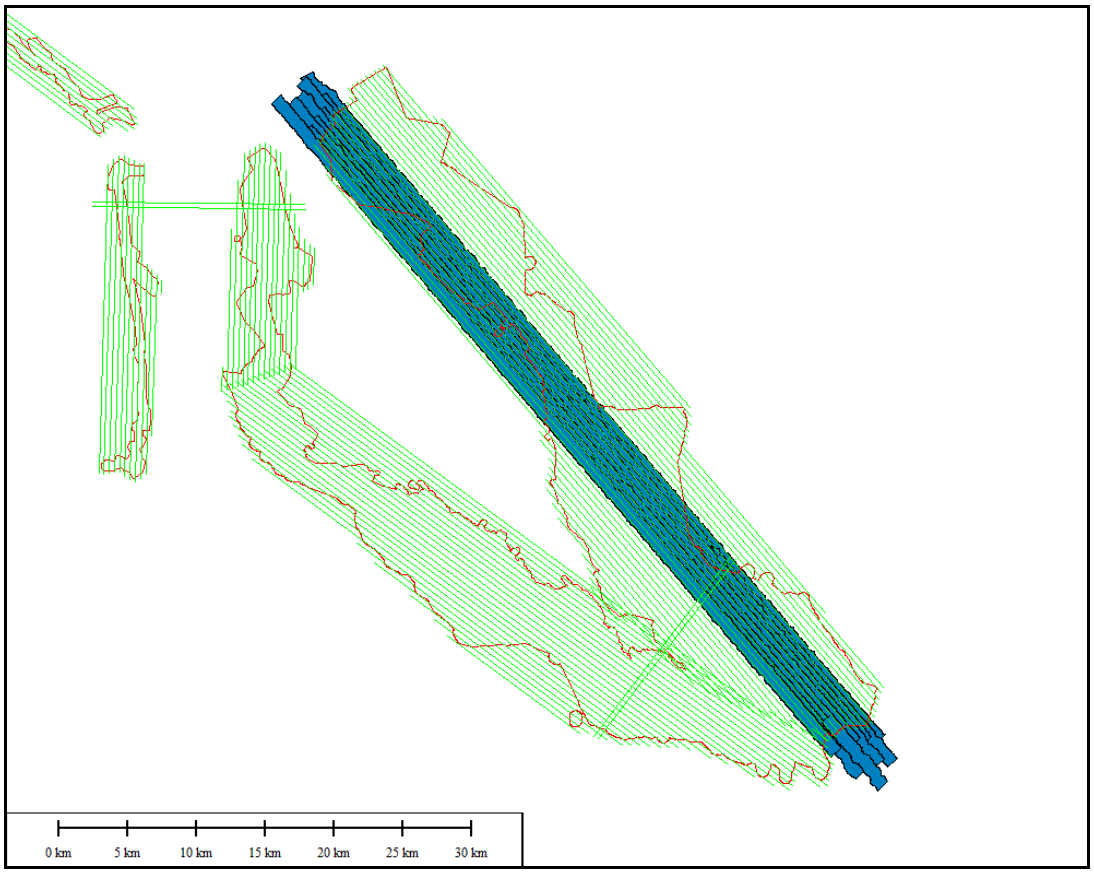
GPS Observation - Back-Up

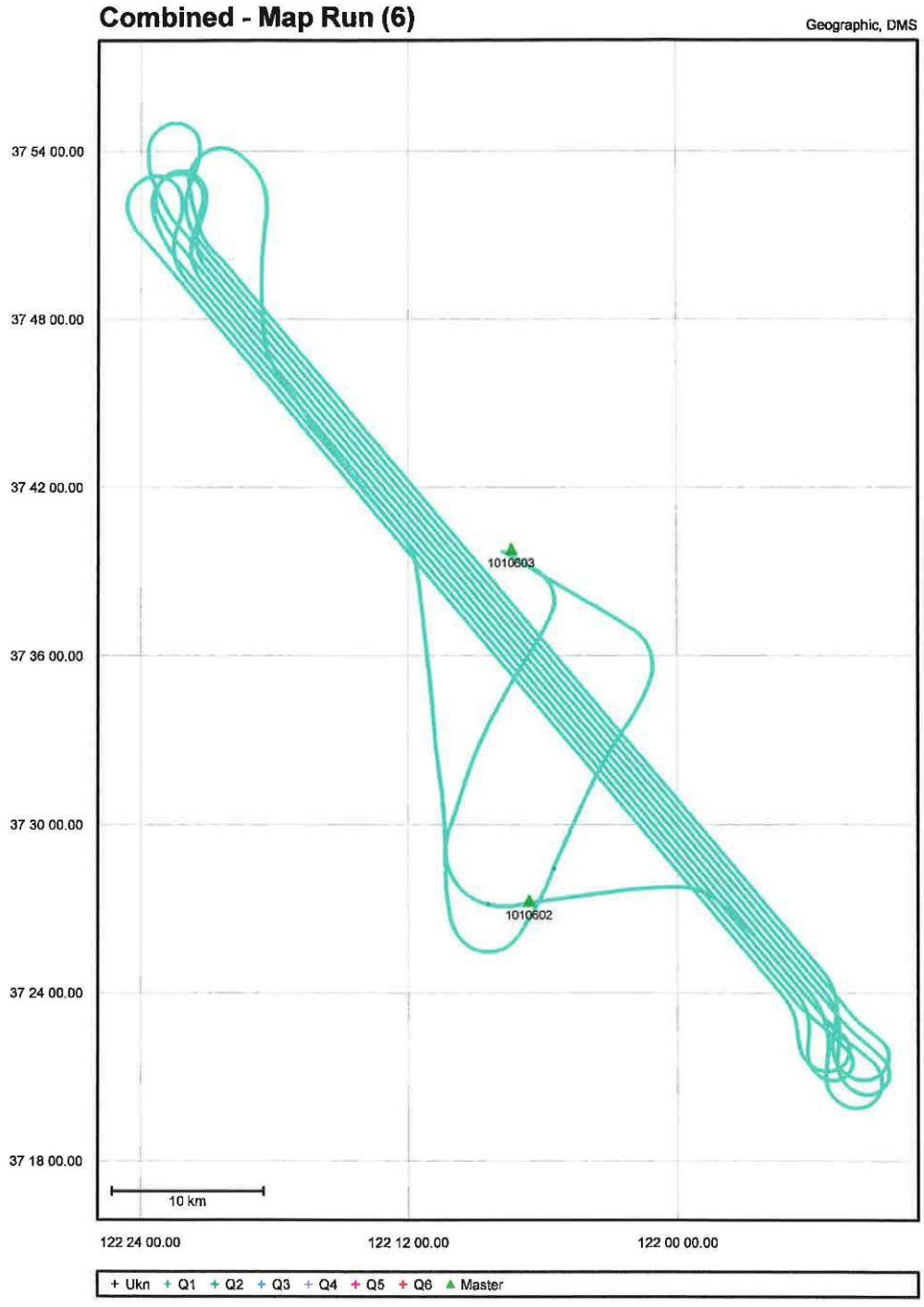
Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant HI Before: A:		B:	
Slant HI After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			

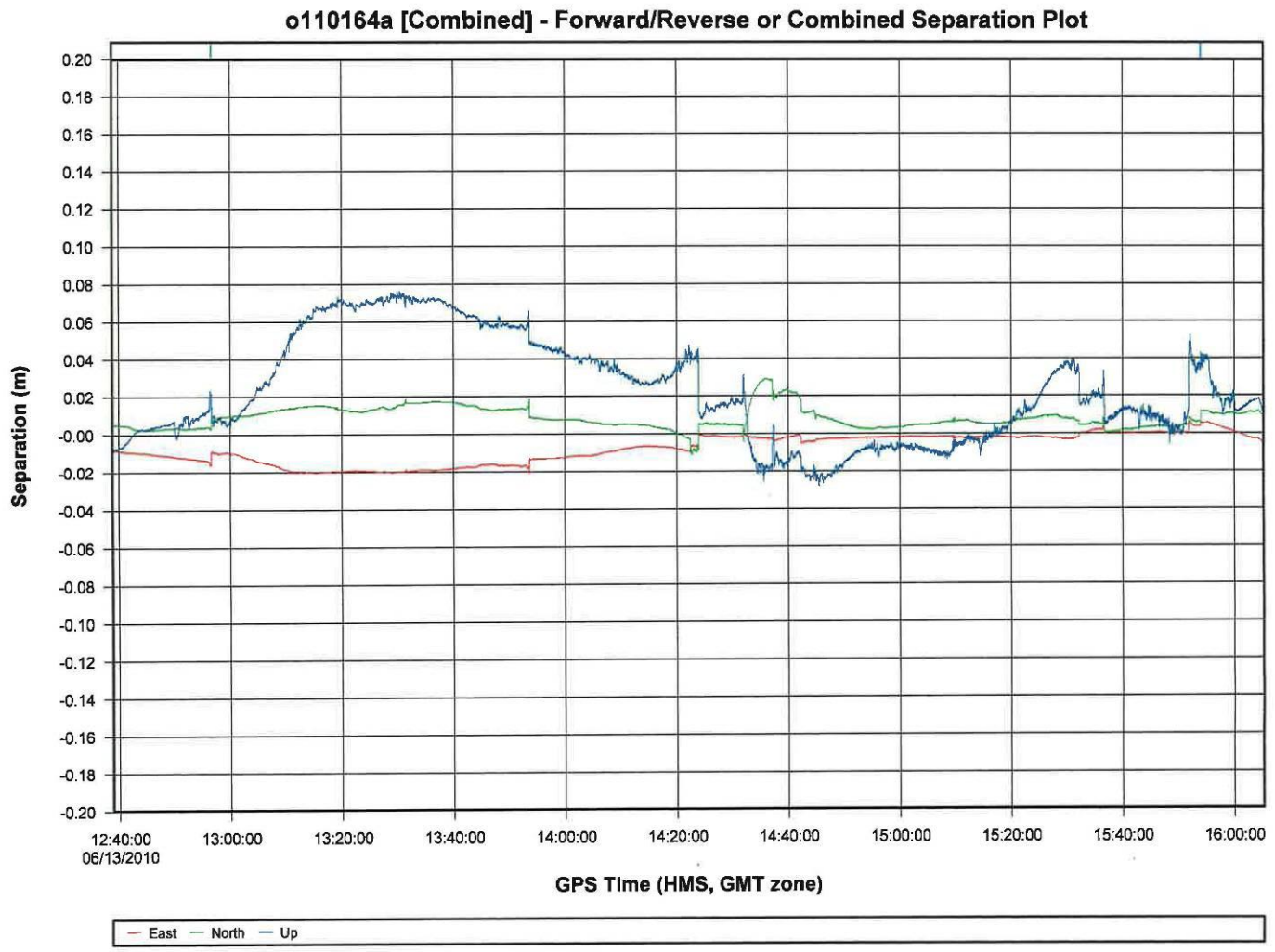


Mission: o110164a

2010 06 13




Combined - Map Run (6)
Geographic, DMS
37 54 00.00
37 48 00.00
37 42 00.00
37 36 00.00
37 30 00.00
37 24 00.00
37 18 00.00
1010603
1010602
10 km
122 24 00.00
122 12 00.00
122 00 00.00
+ Ukn + Q1 + Q2 + Q3 + Q4 + Q5 + Q6 ▲ Master


o110164a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
12:40:00
06/13/2010
13:00:00
13:20:00
13:40:00
14:00:00
14:20:00
14:40:00
15:00:00
15:20:00
15:40:00
16:00:00
GPS Time (HMS, GMT zone)
East
North
Up

Project #	10106V	Session	0110164a

Flight Log

Terrapoint

Date	JUNE 13	Julian Day	164
Project	SAN FRANCISCO	Aircraft	NAVA50
Staging	HAYWARD	Call Sign	C-FVTL
Survey Block	ALAMEDA	Pilot	MATTHEW
Lines Complete	164-172	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 16 Outside Pressure @ TO: 2997

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs)	Takeoff	(120L) x (Total flt hrs)
5:25	5:40	
Engine Off (Hobbs)	Landing	FBO $ / Litre
9:12	9:02	
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost
4		

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300 m	19.2
Ground Speed	Mirror Scan Rate
150 KTS	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71 KHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	12:38	12:43
KAR Base		
KAR Base		
Post Mission	16:03	16:08

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
164		140	13:12	13:26			
165		320	13:29	13:43			
166		140	13:48	14:01			
167		320	14:06	14:19			ERROR 214 ERROR 207
168		140	14:23	14:36			
169		320	14:41	14:54			LATE START
170		140	14:58	15:11			
171		320	15:15	15:29			
172		140	15:32	15:46			
169		320	15:48	15:50			

GPS Base Log Sheet

Terrapoint

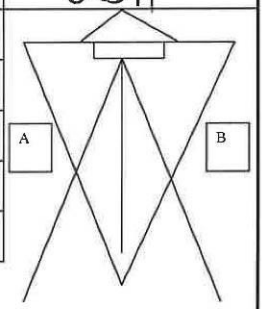
Station ID:	1010602	Project #:	10106V	Missions:	0110164a

Project Name:	USGS San Fran	Calender Date:	12 June 2010	Julian Day	163-164
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

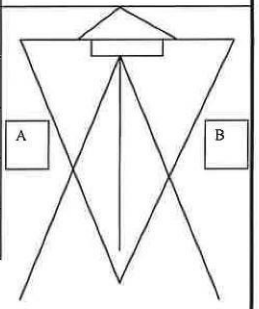
GPS Observation - MAIN

Rx Make / Model	DL4 Novate	Serial #	0003	
Ant Make / Model	SK600	Serial #	0011	
Operator	AC			
Session Time (GPS) Start	19 00 00			
Session Time (GPS) End	16 20 00			
Slant Ht Before: A:	1.505	B:	1.505	
Slant Ht After: A:	1.505	B:	1.505	
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Observation - Back-Up

Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant Ht Before: A:		B:		
Slant Ht After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Base Log Sheet

Terrapoint

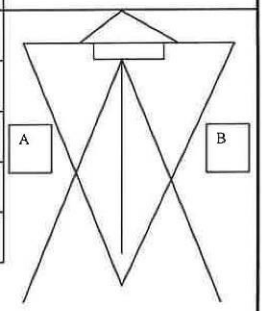
Station ID:	101061-03	Project #:	10106U	Missions:	0110164a

Project Name:	SANFRANCISCO	Calender Date:	JUNE 13	Julian Day	164
Approx. Coordinates WGS 84	N	37 39 48.23	W	122 07 23.09	
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

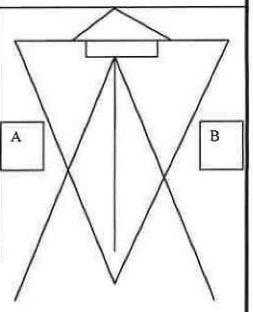
GPS Observation - MAIN

Rx Make / Model	OSR 2600	Serial #	0022
Ant Make / Model	NOVATEL 702	Serial #	
Operator	SCOTT		
Session Time (GPS) Start	12:10		
Session Time (GPS) End	16:23		
Slant Ht Before: A:	.910m	B:	.910m
Slant Ht After: A:	.910m	B:	.910m
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name	00221640.PDC		



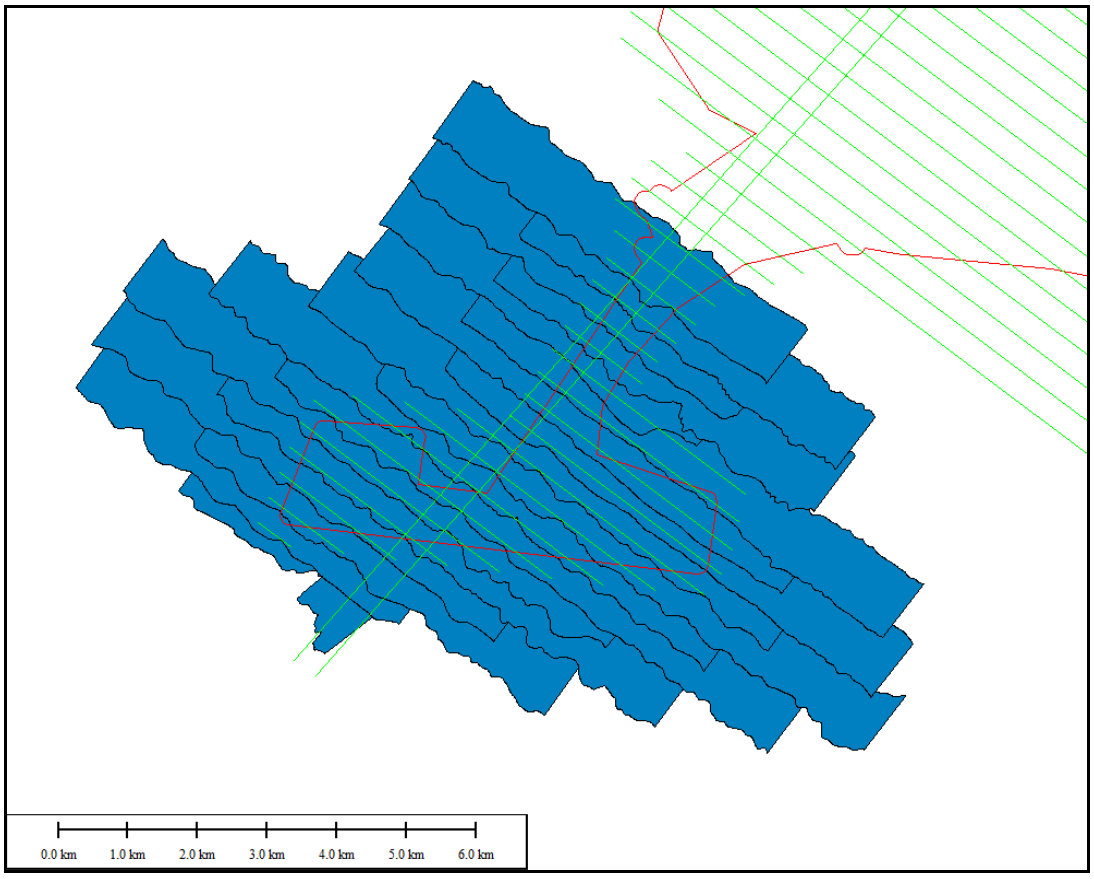
GPS Observation - Back-Up

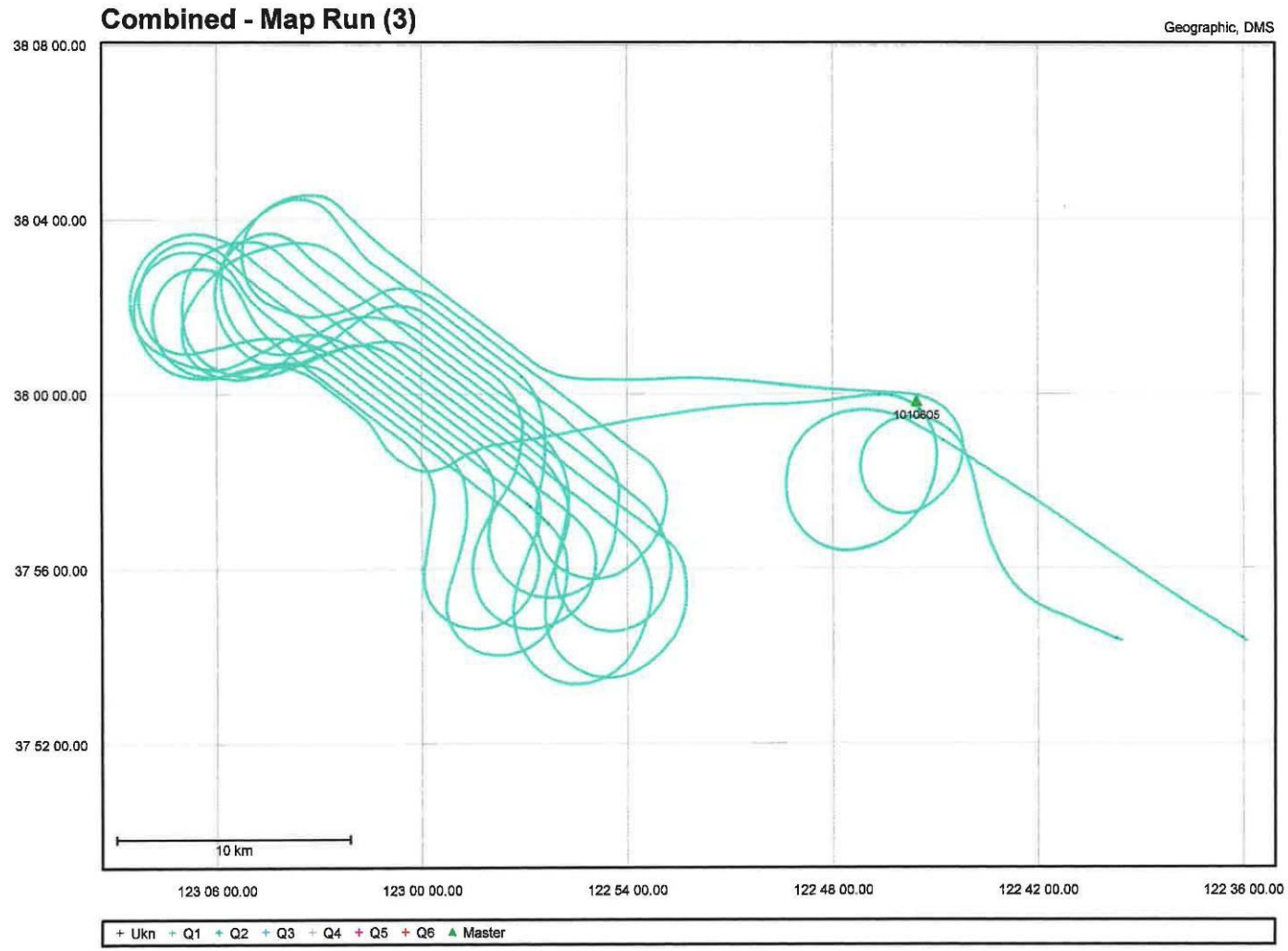
Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before: A:		B:	
Slant Ht After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			

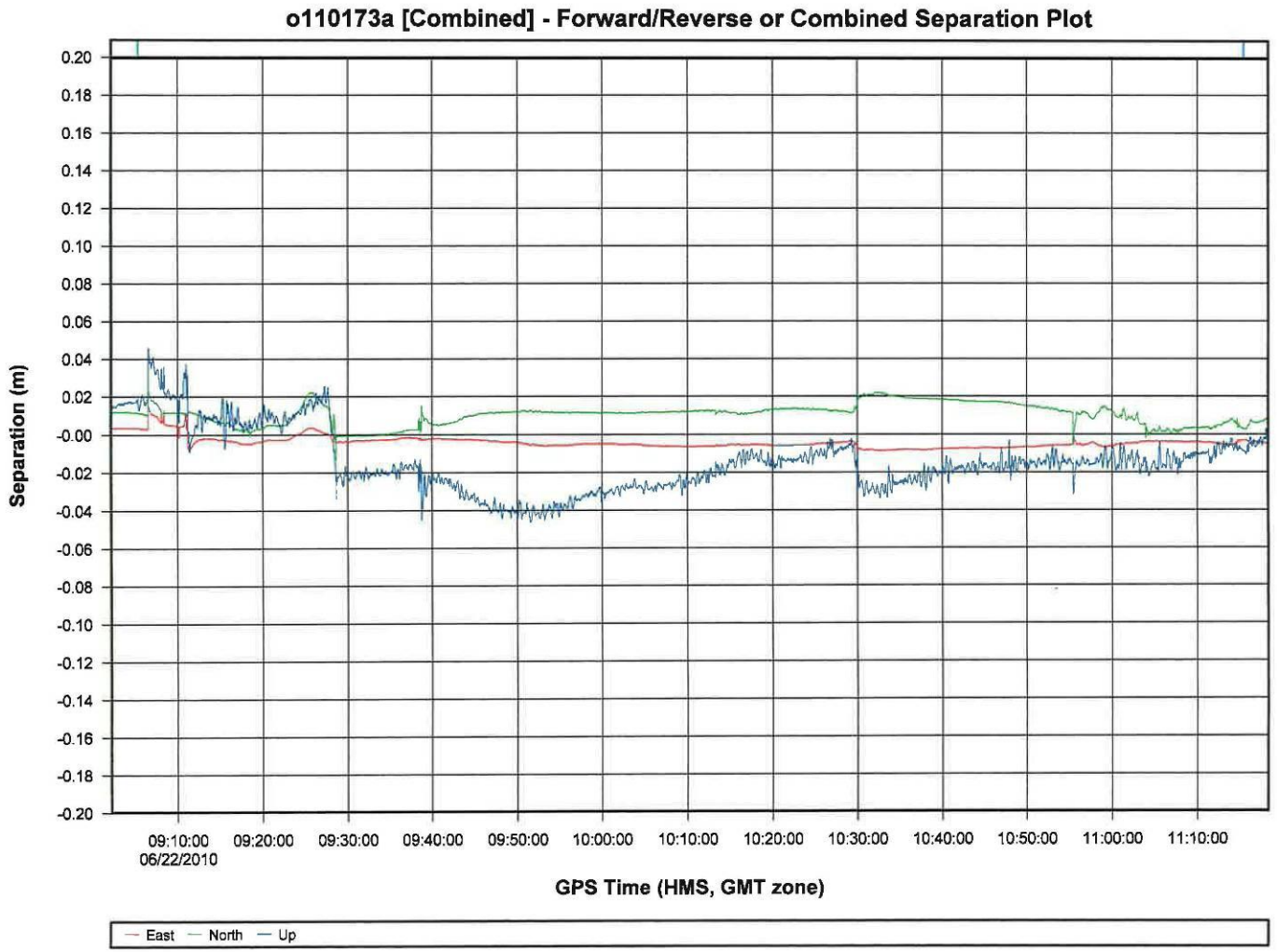


Mission: o110173a

2010 06 22




Combined - Map Run (3)
Geographic, DMS
38 08 00.00
38 04 00.00
38 00 00.00
37 56 00.00
37 52 00.00
1010605
10 km
123 06 00.00
123 00 00.00
122 54 00.00
122 48 00.00
122 42 00.00
122 36 00.00
Ukn Q1 Q2 Q3 Q4 Q5 Q6 Master


o110173a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
09:10:00
06/22/2010
09:20:00
09:30:00
09:40:00
09:50:00
10:00:00
10:10:00
10:20:00
10:30:00
10:40:00
10:50:00
11:00:00
11:10:00
GPS Time (HMS, GMT zone)
East
North
Up

Project #	10106U	Session	0110173a

Flight Log

Terrapoint

Date	JUNE 22	Julian Day	173
Project	SAN FRANCISCO	Aircraft	NAVAJO
Staging	HAYWARD	Call Sign	C-FVTL
Survey Block	BOLINAS	Pilot	PHILLIPE
Lines Complete	24-41	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO:
Outside Temp @ LA: 14
Outside Pressure @ TO:
Outside Pressure @ LA: 2999

Aircraft Block Time	☒ Times confirmed with pilot	
Engine On (Hobbs)	Takeoff	(120L) x (Total flt hrs)
1:18	1:48	
Engine Off (Hobbs)	Landing	FBO $ / Litre
4:48	4:30	
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost
3.5 hrs		

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300 m	19.2
Ground Speed	Mirror Scan Rate
150 KTS	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71 kHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	8:32	8:37
KAR Base	9:05	9:10
KAR Base	11:11	11:15
Post Mission	11:39	11:44

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
41		307	9:15	9:16			
40		127	9:20	9:22			
39		307	9:26	9:28			
38		127	9:32	9:34			
37		307	9:39	9:41			
36		127	9:45	9:47			
35		307	9:51	9:54			
34		127	9:59	10:01			
33		307	10:06	10:08			
32		127	10:13	10:18			

Proje[illegible] #	10106J	Session	0110173a

[illegible]ight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
31		307	10:21	10:23			
30		127	10:27	10:29			
29		307	10:34	10:35			
28		127	10:41	10:42			
27		307	10:47	10:48			
26		127	10:53	10:55			
25		307	11:00	11:01			
24		127	11:06	11:07			

2,

Page 2 of 2

GPS Base Log Sheet

Terrapoint

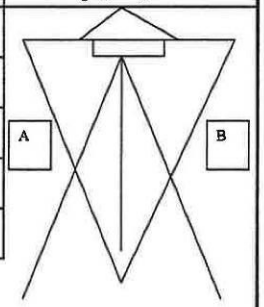
Station ID:	1010605	Project #:	10106U	Missions:	~~0106~~ 0110 1730

Project Name:	USGS San Fran	Calender Date:	June 21 2010	Julian Day	172-173
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

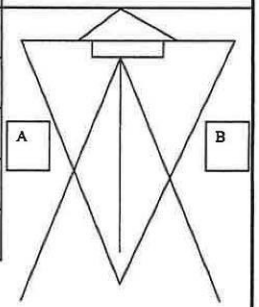
GPS Observation - MAIN

Rx Make / Model	GSR2600	Serial #	0026
Ant Make / Model	~~TPS~~ GPS702 Rev3	Serial #	0004
Operator	AC		
Session Time (GPS) Start	231200		
Session Time (GPS) End			
Slant Ht Before: A:	1.363	B:	
Slant Ht After: A:	1.363	B:	
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name			



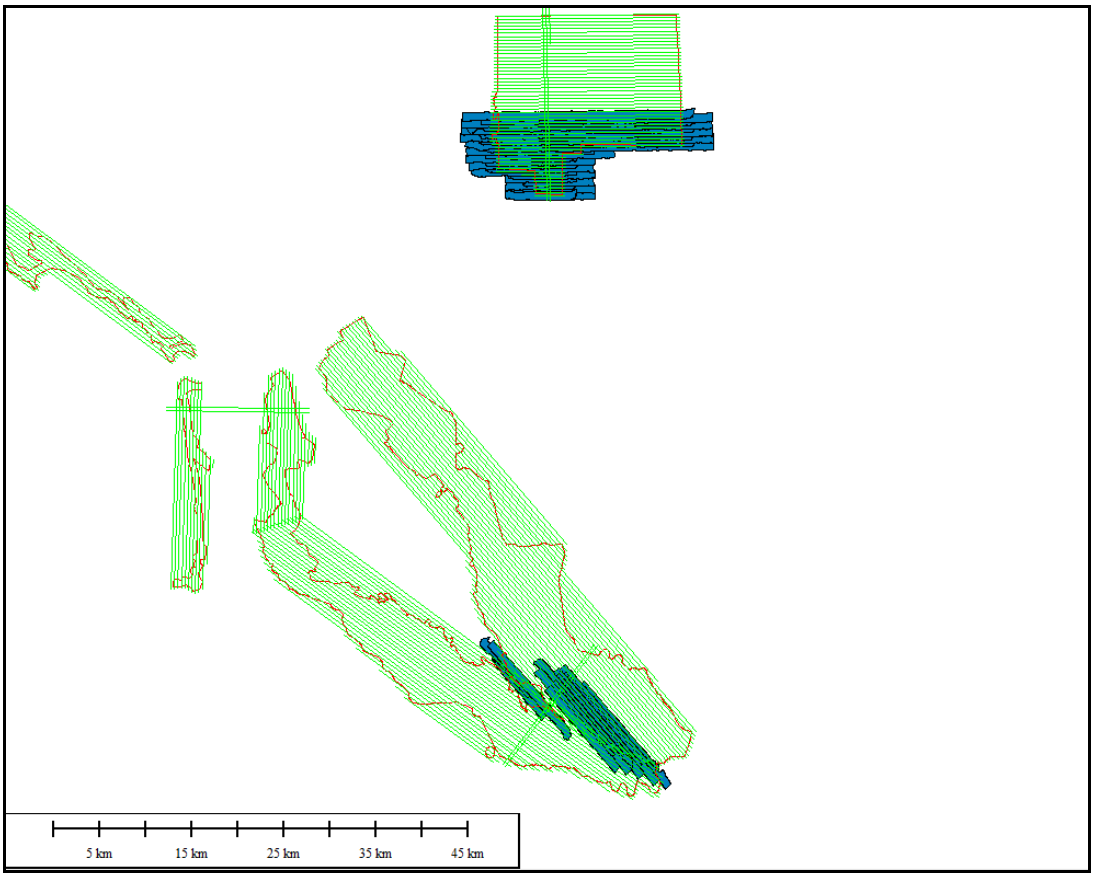
GPS Observation - Back-Up

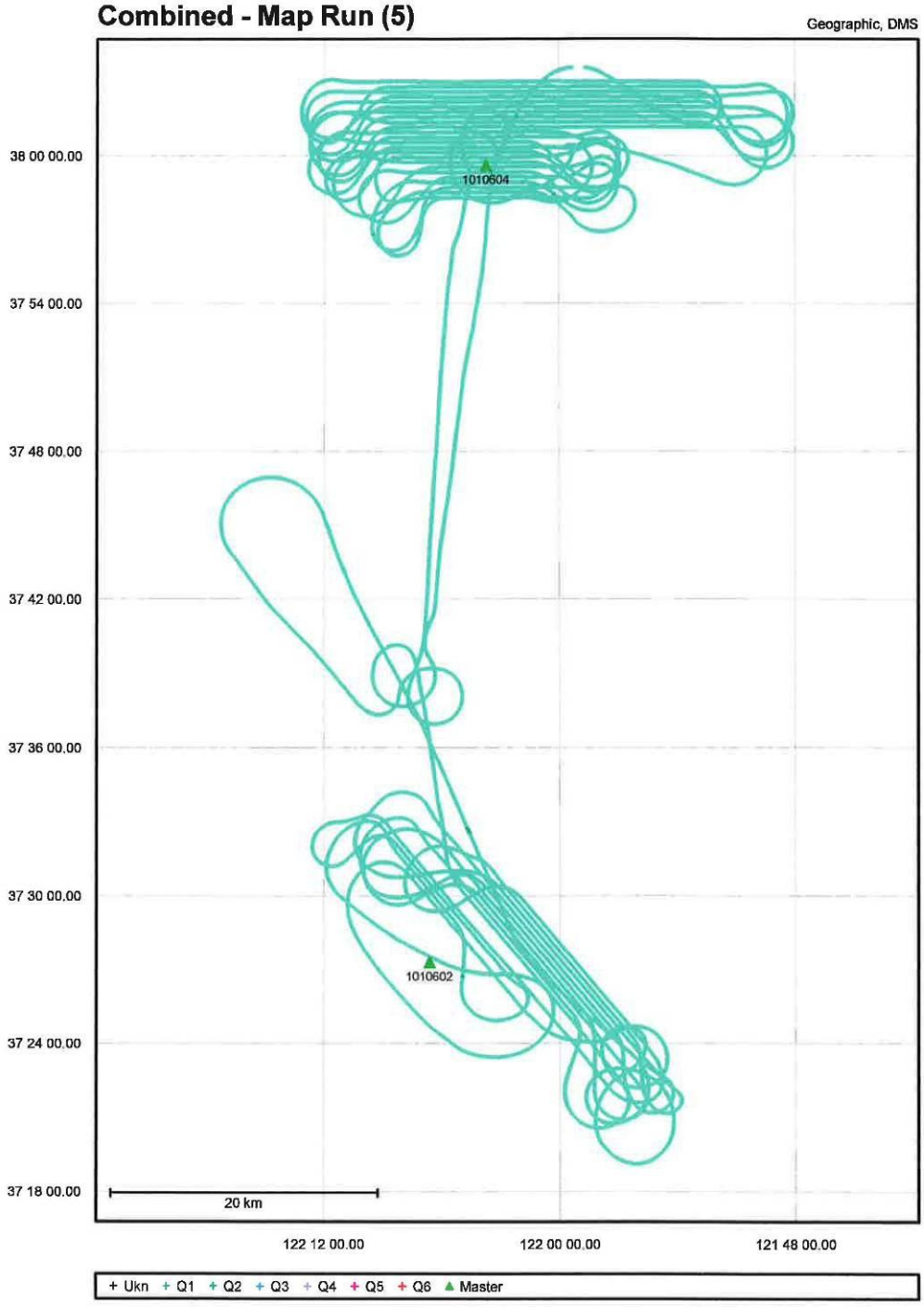
Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before: A:		B:	
Slant Ht After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			

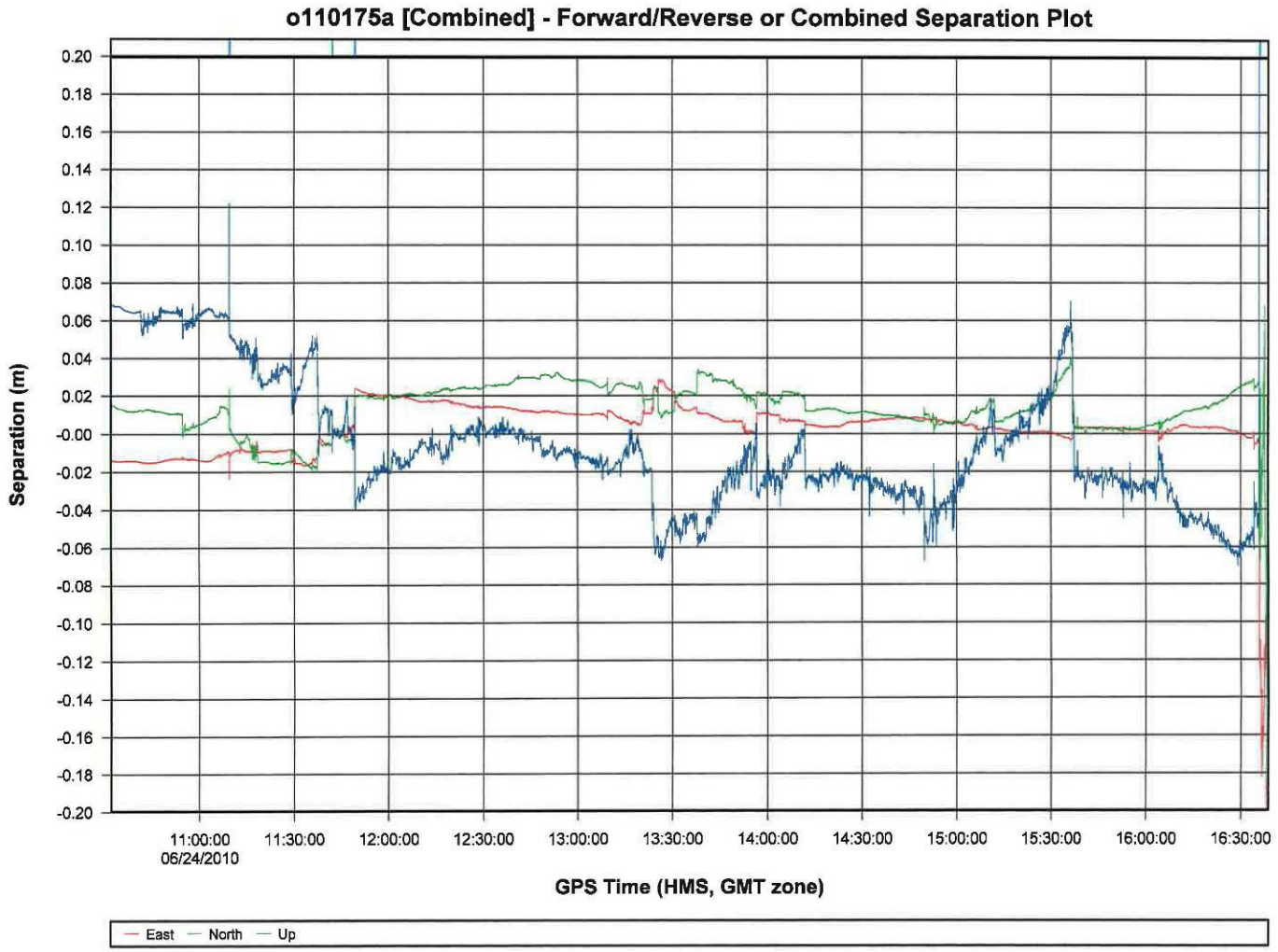


Mission: o110175a

2010 06 24




Combined - Map Run (5)
Geographic, DMS
38 00 00.00
37 54 00.00
37 48 00.00
37 42 00.00
37 36 00.00
37 30 00.00
37 24 00.00
37 18 00.00
1010604
1010602
20 km
122 12 00.00
122 00 00.00
121 48 00.00
+ Ukn + Q1 + Q2 + Q3 + Q4 + Q5 + Q6 ▲ Master


o110175a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
11:00:00
06/24/2010
11:30:00
12:00:00
12:30:00
13:00:00
13:30:00
14:00:00
14:30:00
15:00:00
15:30:00
16:00:00
16:30:00
GPS Time (HMS, GMT zone)
East
North
Up

Proje..#	10106U	Session	0110175a

..ight Log

Terrapoint

Date	JUNE 24	Julian Day	175
Project	SAN FRANCISCO	Aircraft	NAVAJO
Staging	CONCORD	Call Sign	C-FVTL
Survey Block	PORT CHICAGO	Pilot	PHILIPPE
Lines Complete	VARIOUS	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 14 Outside Pressure @ TO: 2993

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs)	Takeoff	(120L) x (Total flt hrs)
3:24	3:42	
Engine Off (Hobbs)	Landing	FBO $ / Litre
9:48	9:36	
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost
6.4hr.		

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300 m	19.2
Ground Speed	Mirror Scan Rate
150 KTS	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71 KHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	10:31	10:36
KAR Base	SEE FLIGHTLINES	
KAR Base		
Post Mission	16:39	16:44

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
KAR			10:53	10:57			HAYWARD AIRPORT
187		320	11:32	11:34			
186		140	11:46	11:48			
185		320	11:51	11:59			
173		320	12:06	12:09			STOPPED EARLY - CLOUDS
174		140	12:14	12:17			
175		320	12:20	12:24			
176		140	12:30	12:33			
177		320	12:37	12:41			
178		140	12:46	12:49			

Project #	410175a	Session	101060

Flight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
179		320	12:53	12:56			
180		140	13:01	13:04			
181		320	13:09	13:11			
KAR			13:15	13:19			HAYWARD
KAR			13:27	13:32			CONCORD
94		270	13:34	13:36			OUTSIDE OF TIDE
93		90	13:39	13:41			"
92		270	13:45	13:47			"
91		90	13:50	13:52			"
90		270	13:55	13:57			
89		90	14:00	14:02			
88		270	14:06	14:08			
87		90	14:11	14:13			
86		270	14:17	14:20			
85		90	14:22	14:25			
94		90	14:32	14:34			TIE FLIGHT
84		270	14:37	14:39			
83		90	14:43	14:45			
82		270	14:48	14:52			
81		90	14:50	14:58			
80		270	15:02	15:08			
79		90	15:11	15:17			

Project #	101060	Session	011017Sa

Flight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
78		270	15:20	15:25			
77		90	15:29	15:34			
76		270	15:38	15:43			
75		90	15:46	15:52			
74		270	15:55	16:01			
73		90	16:04	16:10			
72		270	16:13	16:19			
71		90	16:22	16:28			

Page 3 of 3

GPS Base Log Sheet

Terrapoint

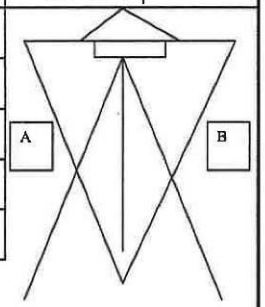
Station ID:	1010602	Project #:	10106V	Missions:	0160175a

Project Name:	USGS SanFran	Calender Date:	July 24 2010	Julian Day	175-175
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

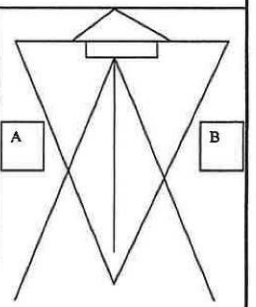
GPS Observation - MAIN

Rx Make / Model	DL4 Nov	Serial #	0003	
Ant Make / Model	SK600	Serial #	0011	
Operator	AC			
Session Time (GPS) Start	210600			
Session Time (GPS) End	210000			
Slant HI Before: A:	1.478	B:	1.478	
Slant HI After: A:	1.478	B:	1.478	
Correction				
Phase Center		☒ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Observation - Back-Up

Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant HI Before: A:		B:		
Slant HI After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Base Log Sheet

Terrapoint

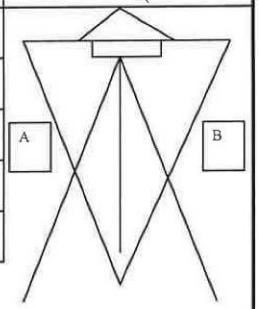
Station ID:	1010603	Project #:	10106U	Missions:	0110175a

Project Name:	SAN FRANCISCO	Calender Date:	JUNE 24	Julian Day	175
Approx. Coordinates WGS 84	N	37 39 48.32	W	122 07 23.19	
Description of Mark (Take Photos)					
Monitument is: ☑ Flush with ground	☐ Above ground _____ cm	☐ Below ground _____ cm			
Location & Access	HAYWARD AIRPORT				

Obstructions & Additional Notes

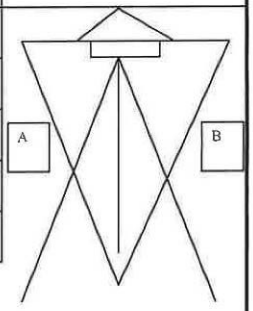
GPS Observation - MAIN

Rx Make / Model	GSR 2600	Serial #	0002
Ant Make / Model	SNA 600	Serial #	0127
Operator	SCOTT		
Session Time (GPS) Start	9:19		
Session Time (GPS) End	19:11		
Slant HI Before: A:	1.279	B:	1.279
Slant HI After: A:	1.279	B:	1.279
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name	00021750.PDC		



GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant HI Before: A:		B:	
Slant HI After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Base Log Sheet

Terrapoint

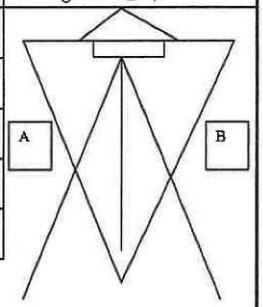
Station ID:	1010604	Project #:	101060	Missions:	0110175a

Project Name:	USGS San Fran	Calender Date:	Jan 24/2010	Julian Day	175
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is:	☒ Flush with ground	☐ Above ground _____ cm	☐ Below ground _____ cm		
Location & Access					

Obstructions & Additional Notes

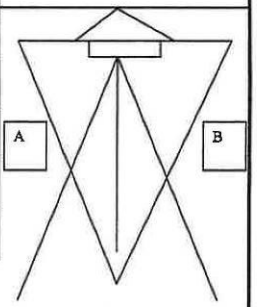
GPS Observation - MAIN

Rx Make / Model	GSR2600	Serial #	0022	
Ant Make / Model	SK600	Serial #	0009	
Operator	AC			
Session Time (GPS) Start	03 00 00			
Session Time (GPS) End	07 00 00			
Slant Ht Before: A:	1.375	B:	1.375	
Slant Ht After: A:	1.375	B:	1.375	
Correction				
Phase Center		☒ m ☐ in ☐ use GrafNav Profile		
Data File Name	00221750.jdc			



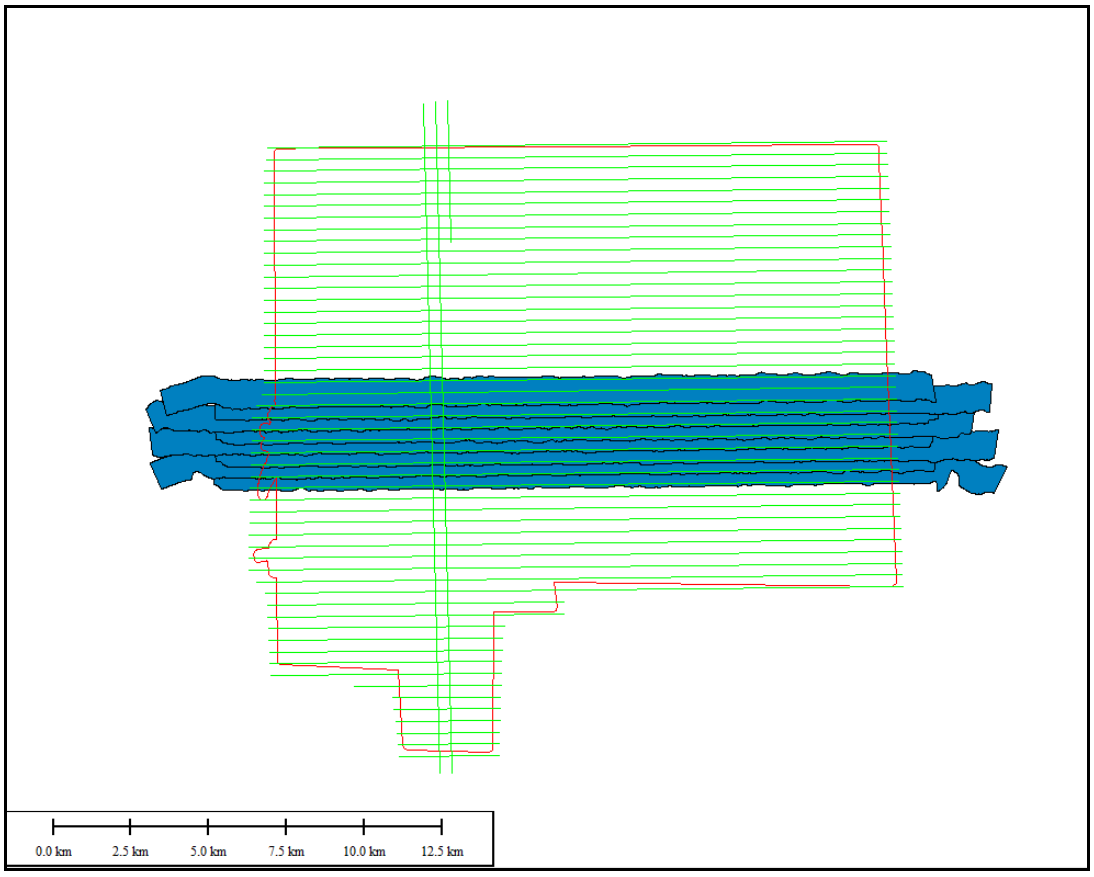
GPS Observation - Back-Up

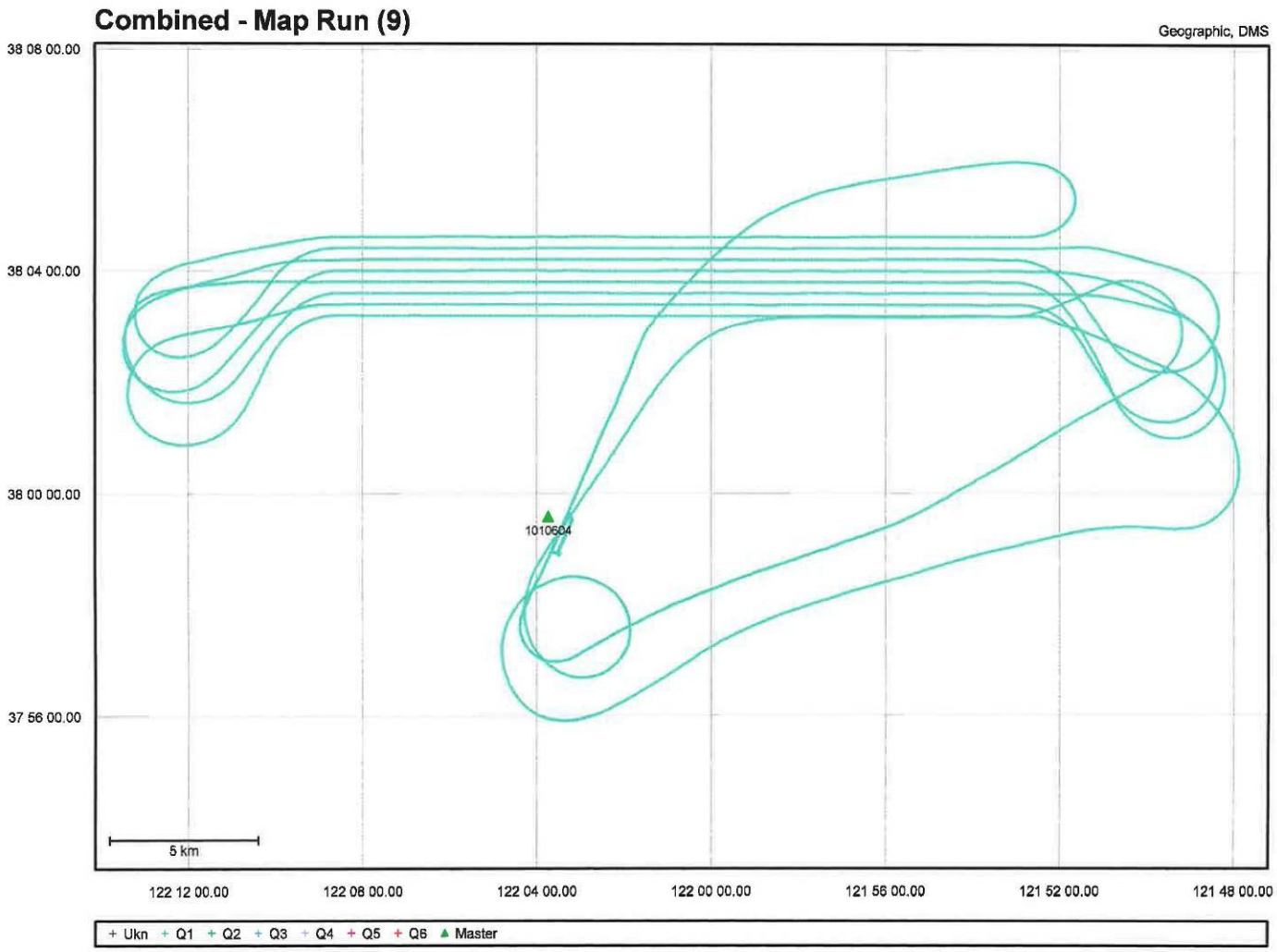
Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant Ht Before: A:		B:		
Slant Ht After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				

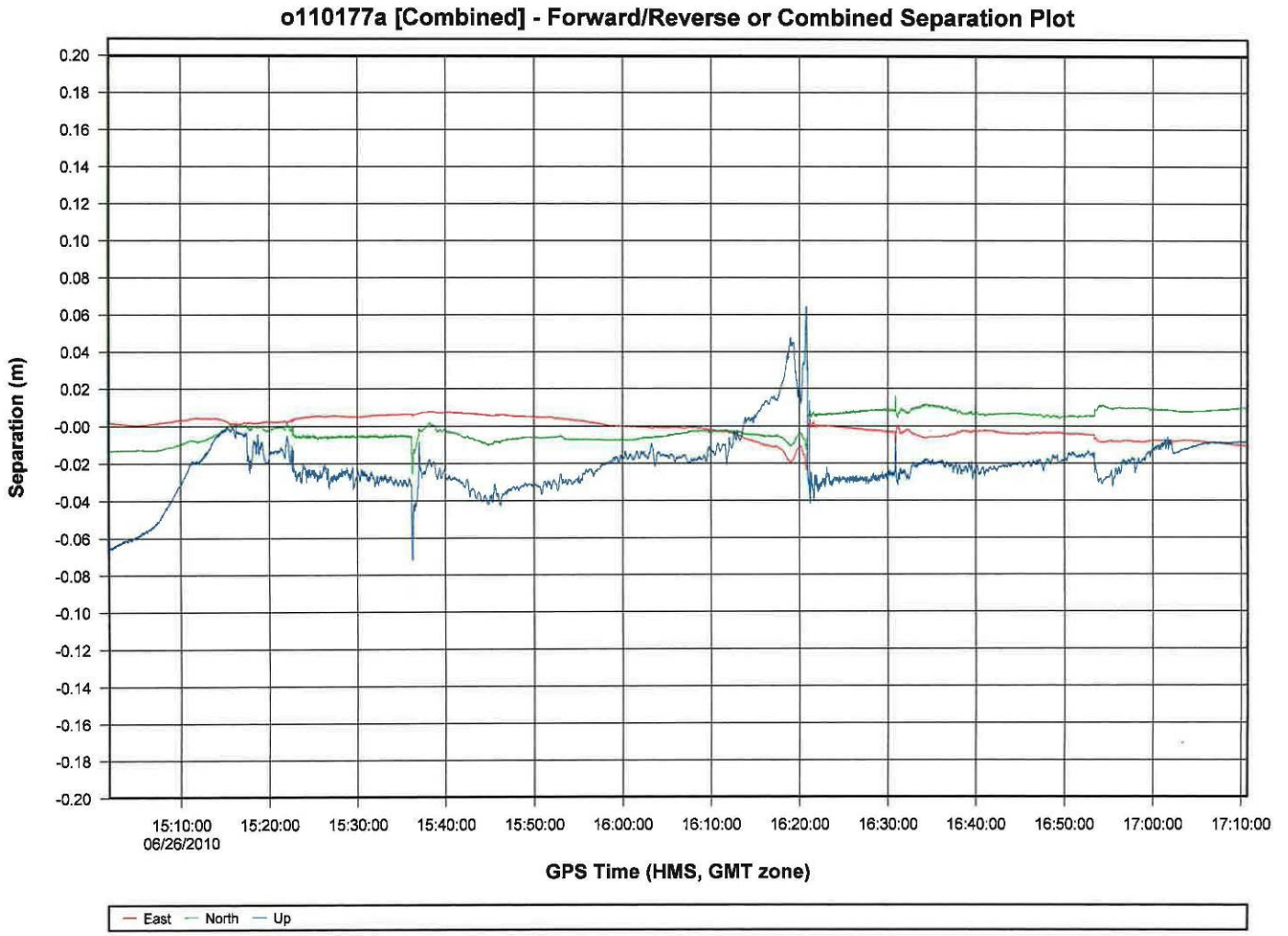


Mission: o110177a

2010 06 26




Combined - Map Run (9)
Geographic, DMS
38 08 00.00
38 04 00.00
38 00 00.00
37 56 00.00
1010604
5 km
122 12 00.00
122 08 00.00
122 04 00.00
122 00 00.00
121 56 00.00
121 52 00.00
121 48 00.00
Ukn Q1 Q2 Q3 Q4 Q5 Q6 Master


o110177a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
15:10:00
06/26/2010
15:20:00
15:30:00
15:40:00
15:50:00
16:00:00
16:10:00
16:20:00
16:30:00
16:40:00
16:50:00
17:00:00
17:10:00
GPS Time (HMS, GMT zone)
East
North
Up

Project #	101060	Session	0110177a

Flight Log

Terrapoint

Date	JUNE 26	Julian Day	177
Project	SAN FRANCISCO	Aircraft	NAV350
Staging	CONCORD	Call Sign	C-FVTZ
Survey Block	PORT CHICAGO	Pilot	PHILLIPE
Lines Complete	63-70	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO:
Outside Temp @ LA: 15
Outside Pressure @ TO:
Outside Pressure @ LA: 2996

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs)	Takeoff	(120L) x (Total flt hrs)
7:54	8:18	
Engine Off (Hobbs)	Landing	FBO $ / Litre
10:12	10:00	
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost
2.3hr.		

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300	19.2
Ground Speed	Mirror Scan Rate
150	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71 KHz

Static & KAR GPS // INS Alignment		
Time ☒GPS	Start	End
Pre Mission	15:05	15:10
KAR Base	15:32	15:37
KAR Base		
Post Mission	17:05	17:10

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
70		270	15:45	15:50			
69		90	15:54	16:00			
68		270	16:03	16:09			
67		90	16:12	16:18			
66		270	16:22	16:28			
65		90	16:31	16:37			
64		270	16:40	16:46			
63		90	16:49	16:55			

Page ___ of ___

GPS Base Log Sheet

Terrapoint

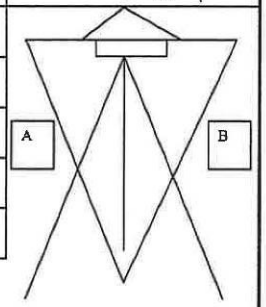
Station ID:	1010604	Project #:	10106U	Missions:	0110177a

Project Name:	USGS San Fran	Calender Date:	Jun 25 '10	Julian Day	177a
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☑ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

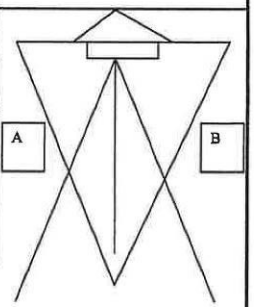
GPS Observation - MAIN

Rx Make / Model	GSR2600		Serial #	0022
Ant Make / Model	SK 600		Serial #	0009
Operator	AC			
Session Time (GPS) Start	03 57 00			
Session Time (GPS) End	17 20 00			
Slant Ht Before: A:	1.309	B:	1.309	
Slant Ht After: A:	1.309	B:	1.309	
Correction				
Phase Center		☑ m ☐ in ☐ use GrafNav Profile		
Data File Name				



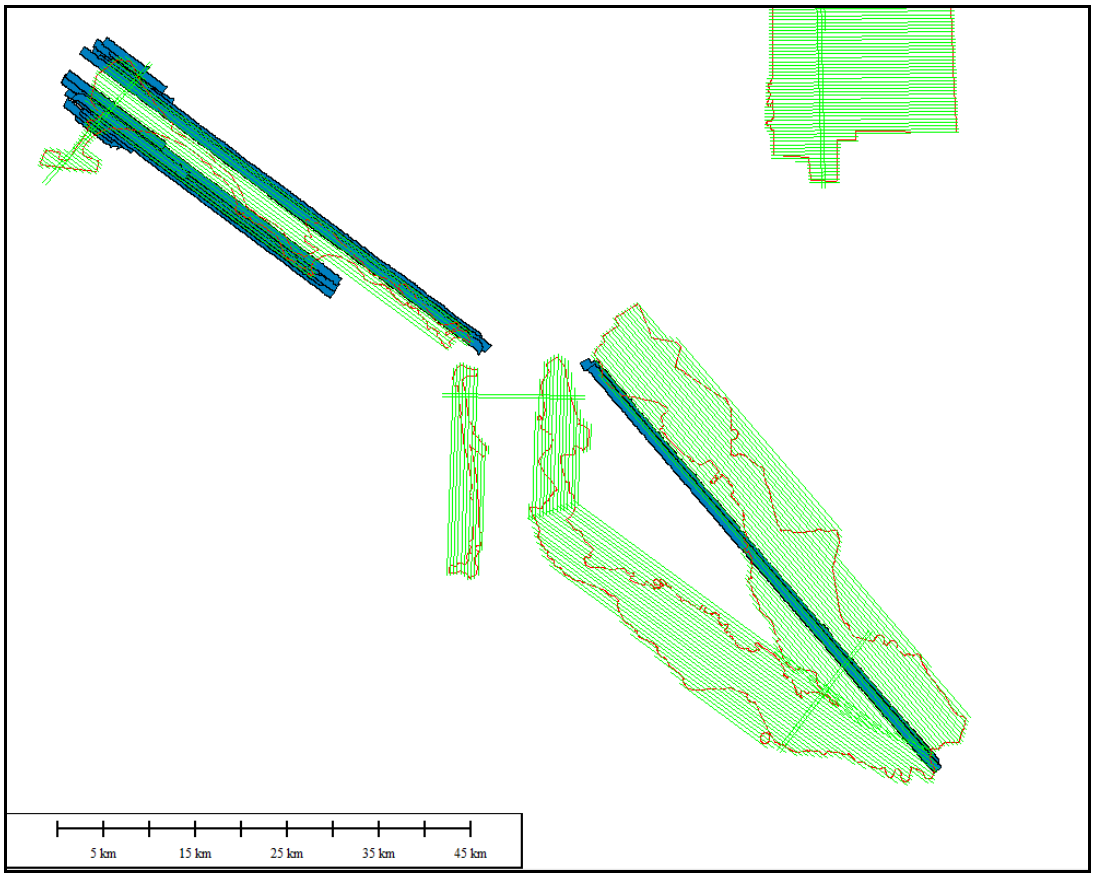
GPS Observation - Back-Up

Rx Make / Model			Serial #	
Ant Make / Model			Serial #	
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant Ht Before: A:		B:		
Slant Ht After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



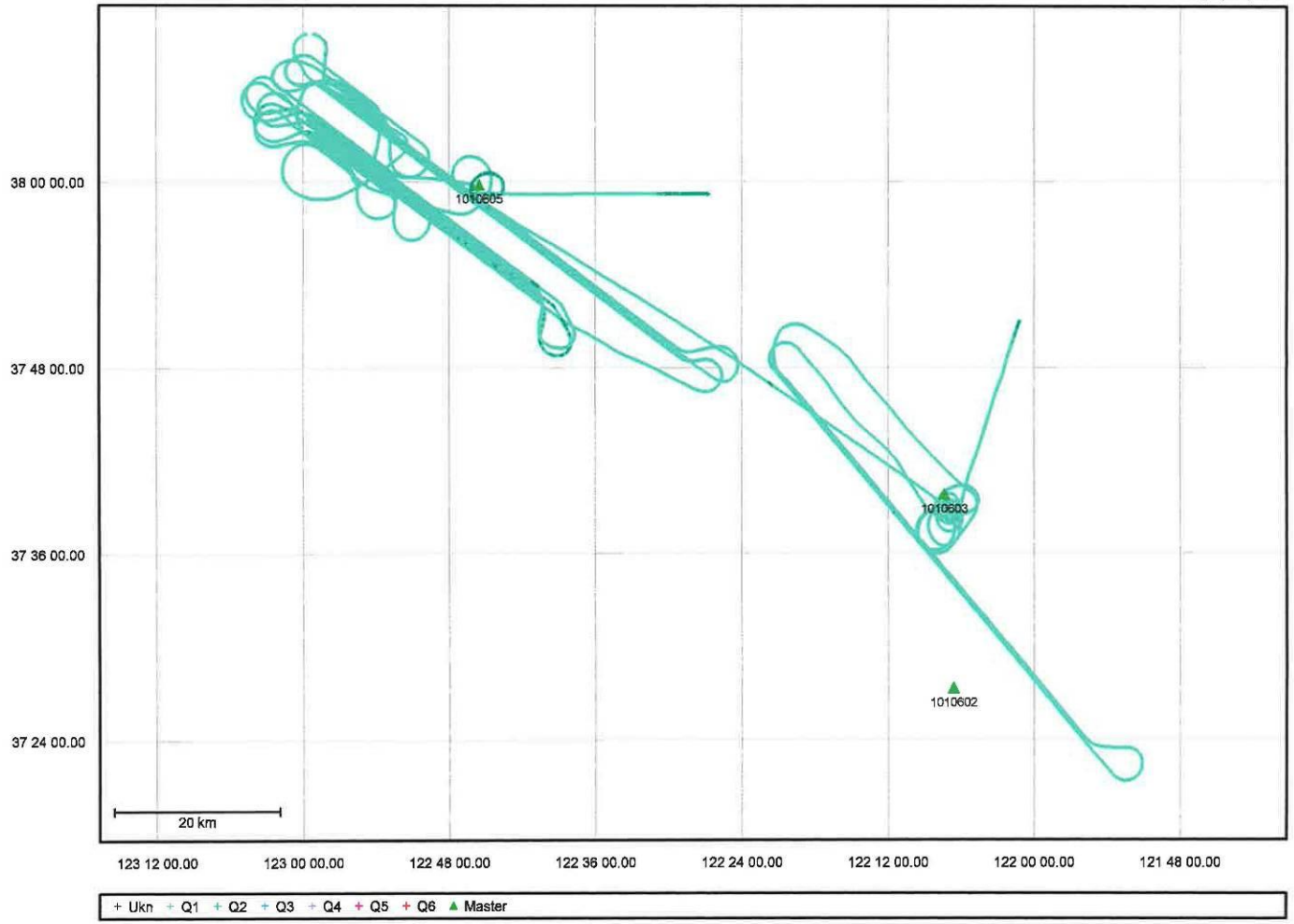
Mission: o110178a

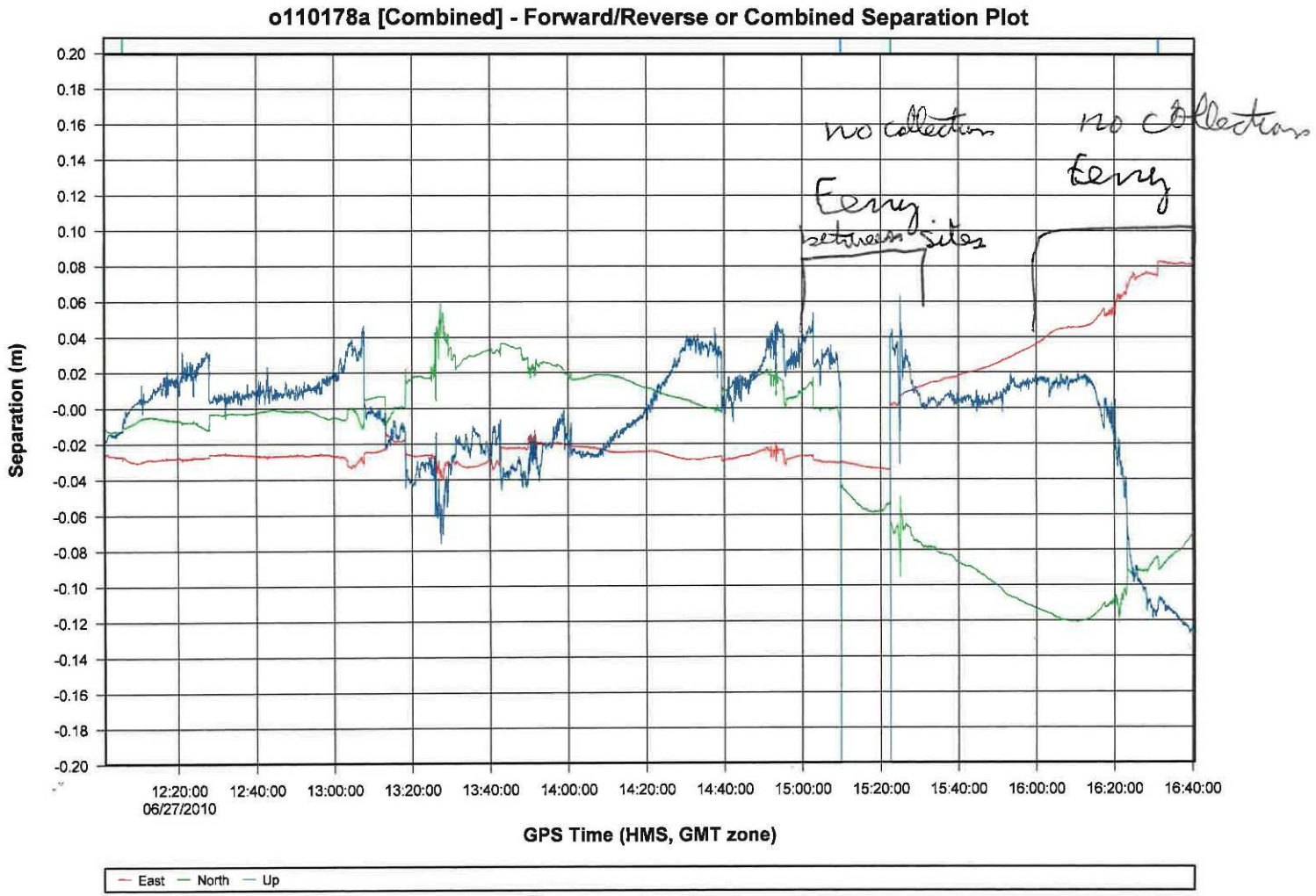
2010 06 27



Combined - Map Run (5)

Geographic, DMS




o110178a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
12:20:00 06/27/2010
12:40:00
13:00:00
13:20:00
13:40:00
14:00:00
14:20:00
14:40:00
15:00:00
15:20:00
15:40:00
16:00:00
16:20:00
16:40:00
GPS Time (HMS, GMT zone)
East
North
Up
no collection
Ferry
between sites
no collection
Ferry

Proje. #	10106U	Session	0110178a

.ight Log

Terrapoint

Date	JUNE-27	Julian Day	178
Project	SAN FRANCISCO	Aircraft	NAVAJO
Staging	CONCORD	Call Sign	C-FVTL
Survey Block		Pilot	PHILLIPE
Lines Complete	VARIOUS	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 14 Outside Pressure @ TO: 2983

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs)	Takeoff	(120L) x (Total flt hrs)
4:30	4:48	
Engine Off (Hobbs)	Landing	FBO $ / Litre
10:00	9:48	
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300M	19.2
Ground Speed	Mirror Scan Rate
150 KTS	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71 KHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	11:42	11:47
KAR Base	12:05	12:10
KAR Base	16:29	16:32
Post Mission	16:51	16:56

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
23		307	12:13				SHUTTERS CLOSED
~~MOTH~~		~~MOTH~~					
4		307	12:20	12:22			
3		127	12:27	12:28			
2		307	12:33	12:34			
1		127	12:38	12:40			
23		307	12:43	12:44			
22		127	12:48	12:49			
21		307	12:53	12:55			
5		127	12:57	13:09			

Project#	101060	Session	a110178a

. light Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
6		307	13:13	13:25			MAYBE SOME CLOUDS
7		127	13:29	13:41			CLOUDS IN THE SE
20		307	13:48	13:56			
19		127	14:00	14:07			
18		307	14:11	14:19			POOR ABOVE 4
17		127	14:22	14:30			SOME CLOUDS
16		307	14:34	14:42			
17		127	14:46	14:49			
18		307	14:53	14:57			
15		127	15:01	15:04			
KAR			15:06	15:10			BOLINAS
KAR			15:27	15:40			HAYWARD
173		140	15:52	16:05			
174		320	16:08	16:22			

GPS Base Log Sheet

Terrapoint

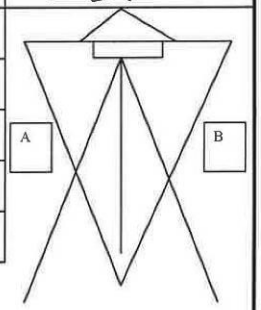
Station ID:	1010603	Project #:	101060	Missions:	1107789

Project Name:	SAN FRANCISCO	Calender Date:	JUNE 26	Julian Day	178
Approx. Coordinates WGS 84	N	37 39 48.31	W	122 07 23.20	
Description of Mark (Take Photos)					
Monument is: ☐ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access	HAYWARD AIRPORT				

Obstructions & Additional Notes

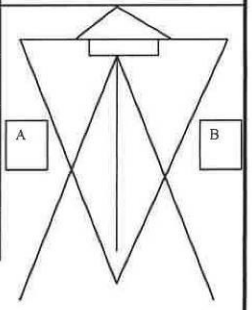
GPS Observation - MAIN

Rx Make / Model	GSR 2600	Serial #	0002	
Ant Make / Model	SK 600	Serial #	0027	
Operator	SCOTT			
Session Time (GPS) Start				
Session Time (GPS) End	18:20			
Slant HI Before: A:	1.278	B:	1.279	
Slant HI After: A:	1.279	B:	1.278	
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name	00021780.PDC			



GPS Observation - Back-Up

Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant HI Before: A:		B:		
Slant HI After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Base Log Sheet

Terrapoint

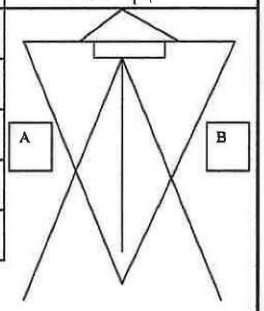
Station ID:	1010602	Project #:	10106U	Missions:	0110178a

Project Name:	USGS San Fran	Calender Date:	Jun 28/2010	Julian Day	177-178
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

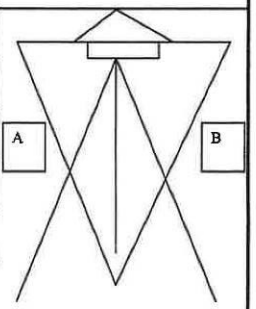
GPS Observation - MAIN

Rx Make / Model	DL4	Serial #	0003
Ant Make / Model	SK600	Serial #	0011
Operator	ASC		
Session Time (GPS) Start	20 01 00		
Session Time (GPS) End			
Slant Ht Before:	A: 1.478	B: 1.478	
Slant Ht After:	A: 1.478	B: 1.478	
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before:	A:	B:	
Slant Ht After:	A:	B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Base Log Sheet

Terrapoint

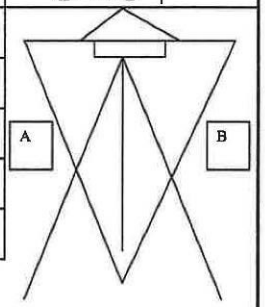
Station ID:	1010605	Project #:	10106	Missions:	0110178a

Project Name:	USGS San Fran	Calender Date:	June 26/2016	Julian Day	177-178
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

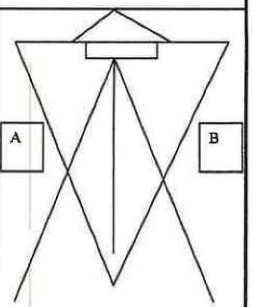
GPS Observation - MAIN

Rx Make / Model	GSR2600	Serial #	0026
Ant Make / Model	~~GPS 702 NOV~~ ~~S~~ 600 Rev3	Serial #	0004
Operator	AC		
Session Time (GPS) Start	223100		
Session Time (GPS) End	223800		
Slant Ht Before: A:	1.547	B:	1.547
Slant Ht After: A:	1.547	B:	1.547
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name			



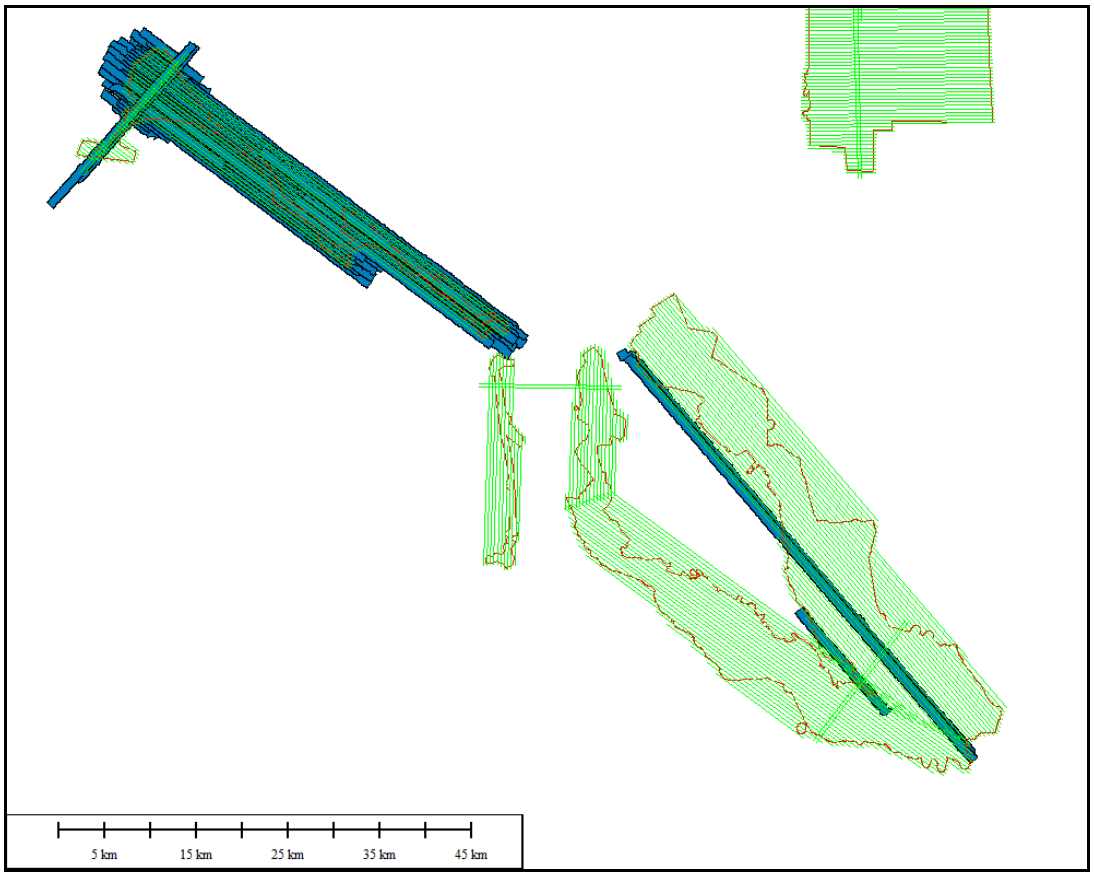
GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before: A:		B:	
Slant Ht After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			



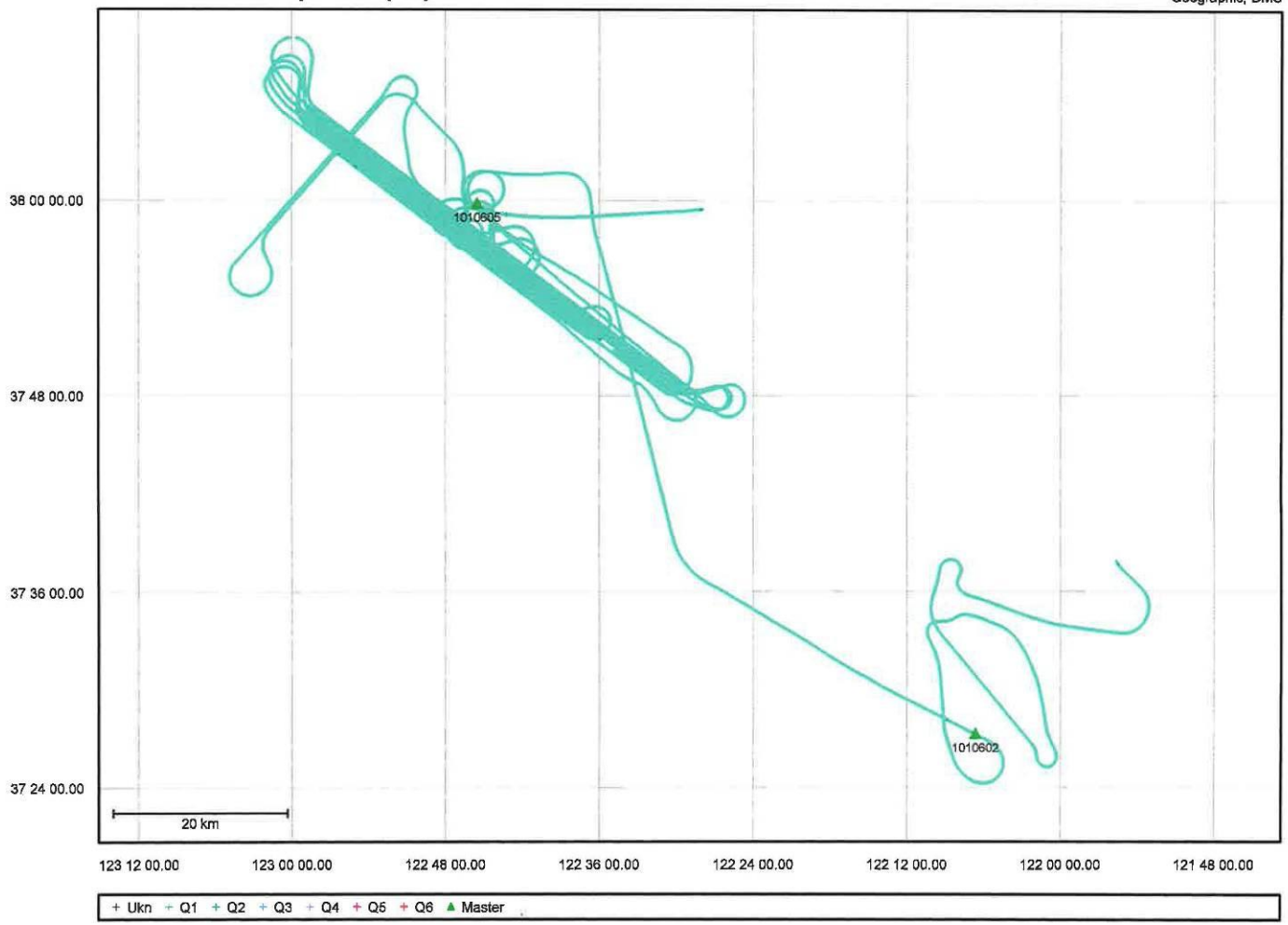
Mission: o110179a

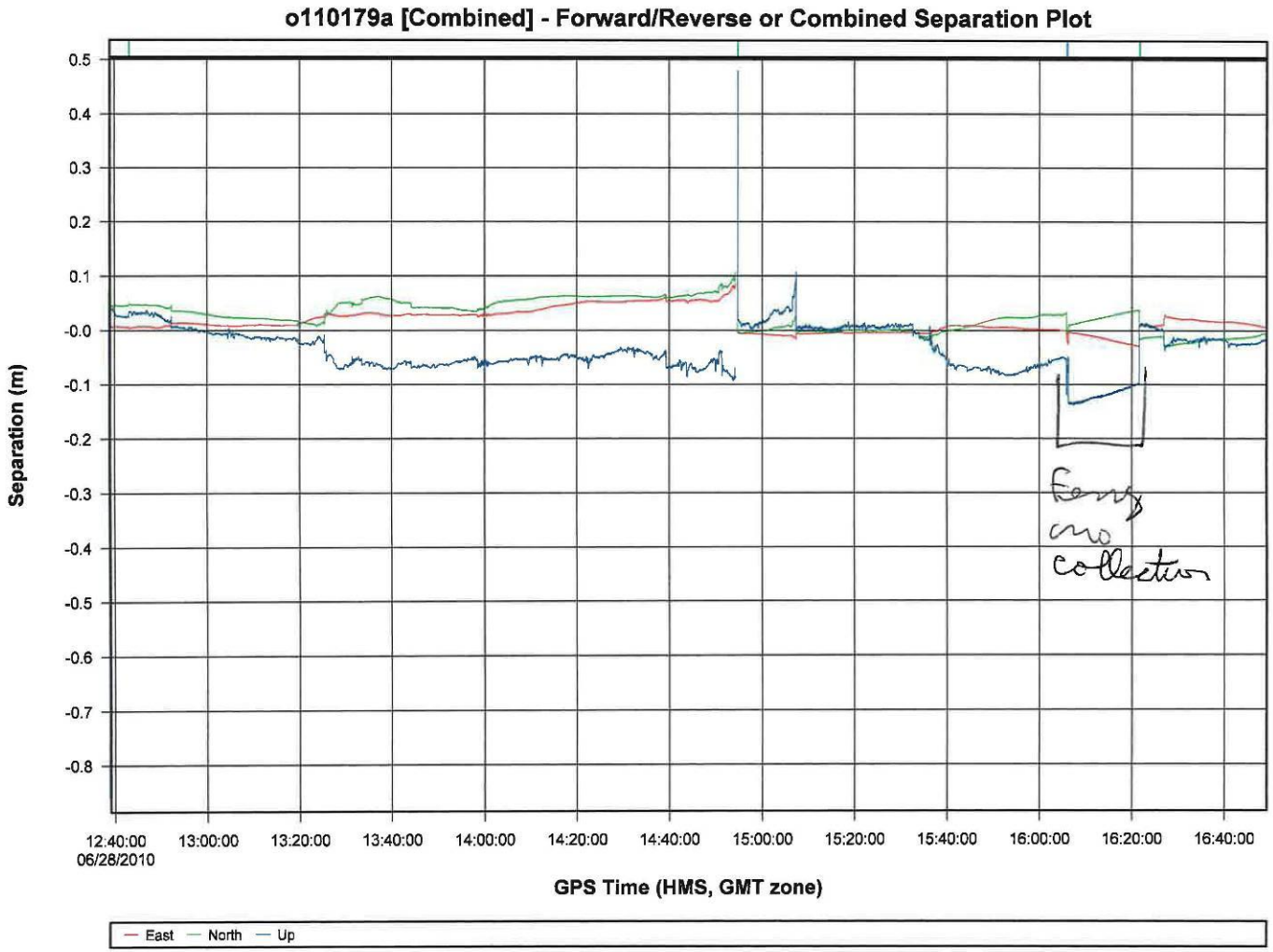
2010 06 28



Combined - Map Run (10)

Geographic, DMS




o110179a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.5
0.4
0.3
0.2
0.1
-0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
12:40:00
06/28/2010
13:00:00
13:20:00
13:40:00
14:00:00
14:20:00
14:40:00
15:00:00
15:20:00
15:40:00
16:00:00
16:20:00
16:40:00
GPS Time (HMS, GMT zone)
East
North
Up

Proje. #	10106U	Session	0110179a

.ight Log

Terrapoint

Date	JUNE 28	Julian Day	179
Project	SAN FRANCESCO	Aircraft	NAVASO
Staging	CONCORD	Call Sign	C-FVTL
Survey Block	POINT REYES	Pilot	PHIL
Lines Complete	VARIOUS	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 17 Outside Pressure @ TO: 2971

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs)	Takeoff	(120L) x (Total flt hrs)
5:12	5:30	
Engine Off (Hobbs)	Landing	FBO $ / Litre
10:12	10:00	
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300M	19.2
Ground Speed	Mirror Scan Rate
150	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71 kHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	12:20	12:25
KAR Base	12:43	12:47
KAR Base	15:56	16:02
Post Mission	17:03	17:08

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
8		307	12:47	12:52			
9		127	12:56	13:02			
10		307	13:05	13:11			
11		127	13:15	13:21			
12		307	13:24	13:30			
13		127	13:34	13:43			
14		307	13:46	13:54			
15		127	13:58	14:07			
7		307	14:17	14:18			PDOP ABOVE 4
9		127	14:22	14:29			

Project #	101060	Session	0110174a

Flight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
10		307	14:33	14:39			
11		127	14:42	14:48			
12		307	14:52	14:57			ERROR 207 & 214
13		127	15:01	15:07			
ICAR			15:15	15:20			BOZEMAN
CROSS		221	15:22	15:26			
CROSS		41	15:30	15:35			
8		127	15:40	15:48			
[illegible]		[illegible]					
ICAR			16:22	16:25			PALO ALTO
184		320	16:36	16:39			
[illegible]		[illegible]					

GPS Base Log Sheet

Terrapoint

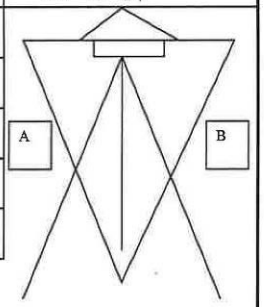
Station ID:	1010602	Project #:	10106V	Missions:	

Project Name:	USGS Sanfran	Calender Date:	27 Jan 2010	Julian Day	177-179
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monitument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

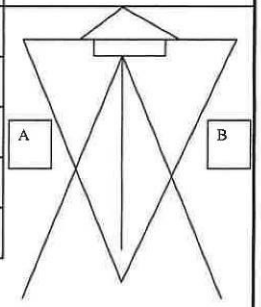
GPS Observation - MAIN

Rx Make / Model	DL4	Serial #	0003
Ant Make / Model	SK 600	Serial #	0011
Operator	AC		
Session Time (GPS) Start	~~AC~~ 200900		
Session Time (GPS) End			
Slant HI Before: A:	1.478	B:	1.478
Slant HI After: A:	1.478	B:	1.478
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant HI Before: A:		B:	
Slant HI After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Base Log Sheet

Terrapoint

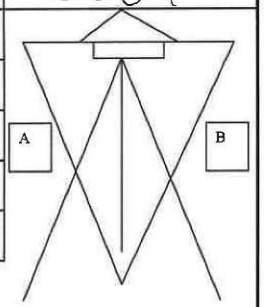
Station ID:	1010605	Project #:	10106V	Missions:	

Project Name:	USGS San Fran	Calender Date:	June 27 2010	Julian Day	178-179
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

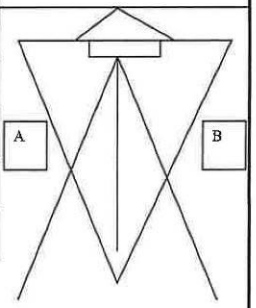
GPS Observation - MAIN

Rx Make / Model	GSR 2600	Serial #	0026
Ant Make / Model	GPS 702 Nov	Serial #	0004
Operator	AC		
Session Time (GPS) Start	224000		
Session Time (GPS) End			
Slant Ht Before: A:	1.547	B:	1.547
Slant Ht After: A:	1.547	B:	1.547
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before: A:		B:	
Slant Ht After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Base Log Sheet

Terrapoint

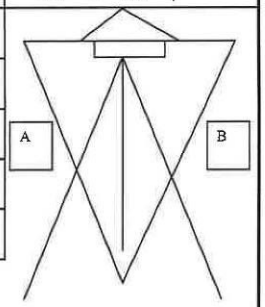
Station ID:	1010604	Project #:	10106U	Missions:	

Project Name:	USGS SanFran	Calender Date:	27 June 2010	Julian Day	178-~~179~~
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monitument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

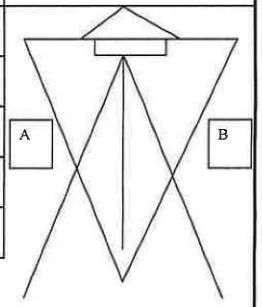
GPS Observation - MAIN

Rx Make / Model	GSR2600	Serial #	0022	
Ant Make / Model	SK 600	Serial #	0009	
Operator	AC			
Session Time (GPS) Start	02 50 00			
Session Time (GPS) End	17 30 00			
Slant HI Before: A:	1.373	B:	1.373	
Slant HI After: A:	1.373	B:	1.373	
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



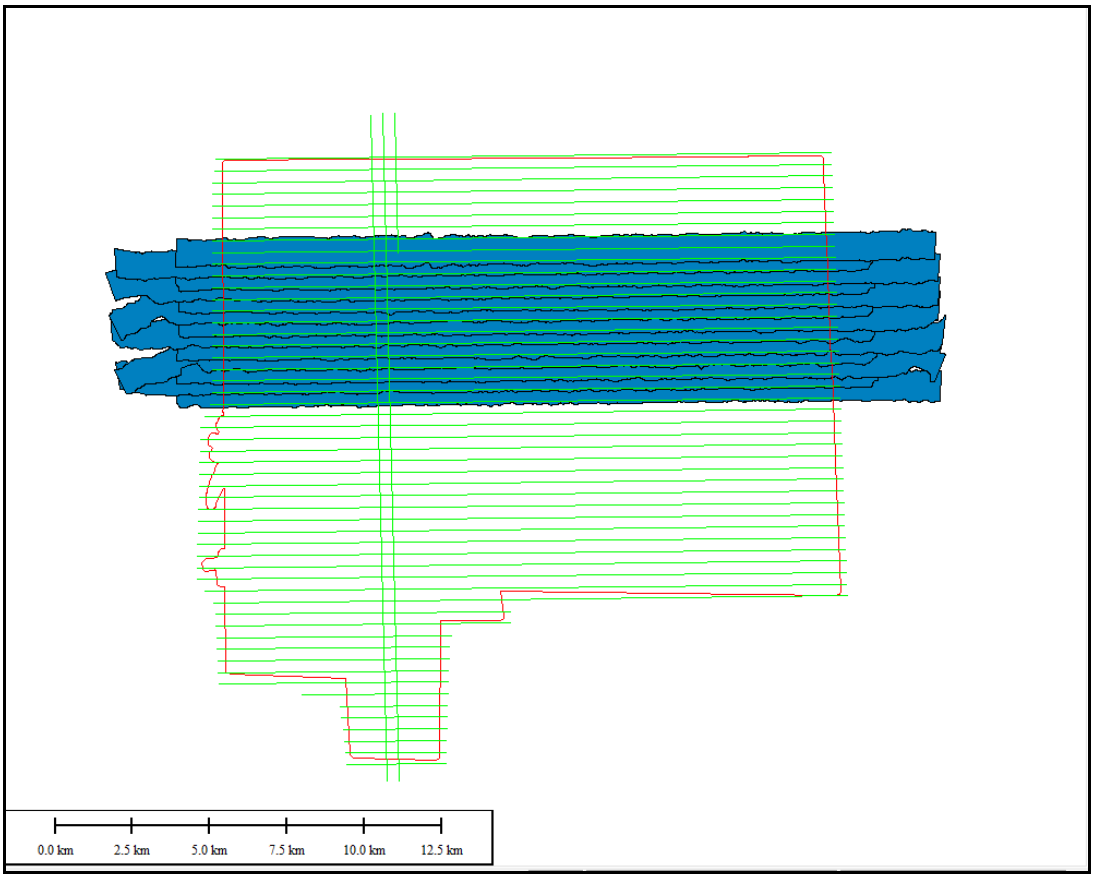
GPS Observation - Back-Up

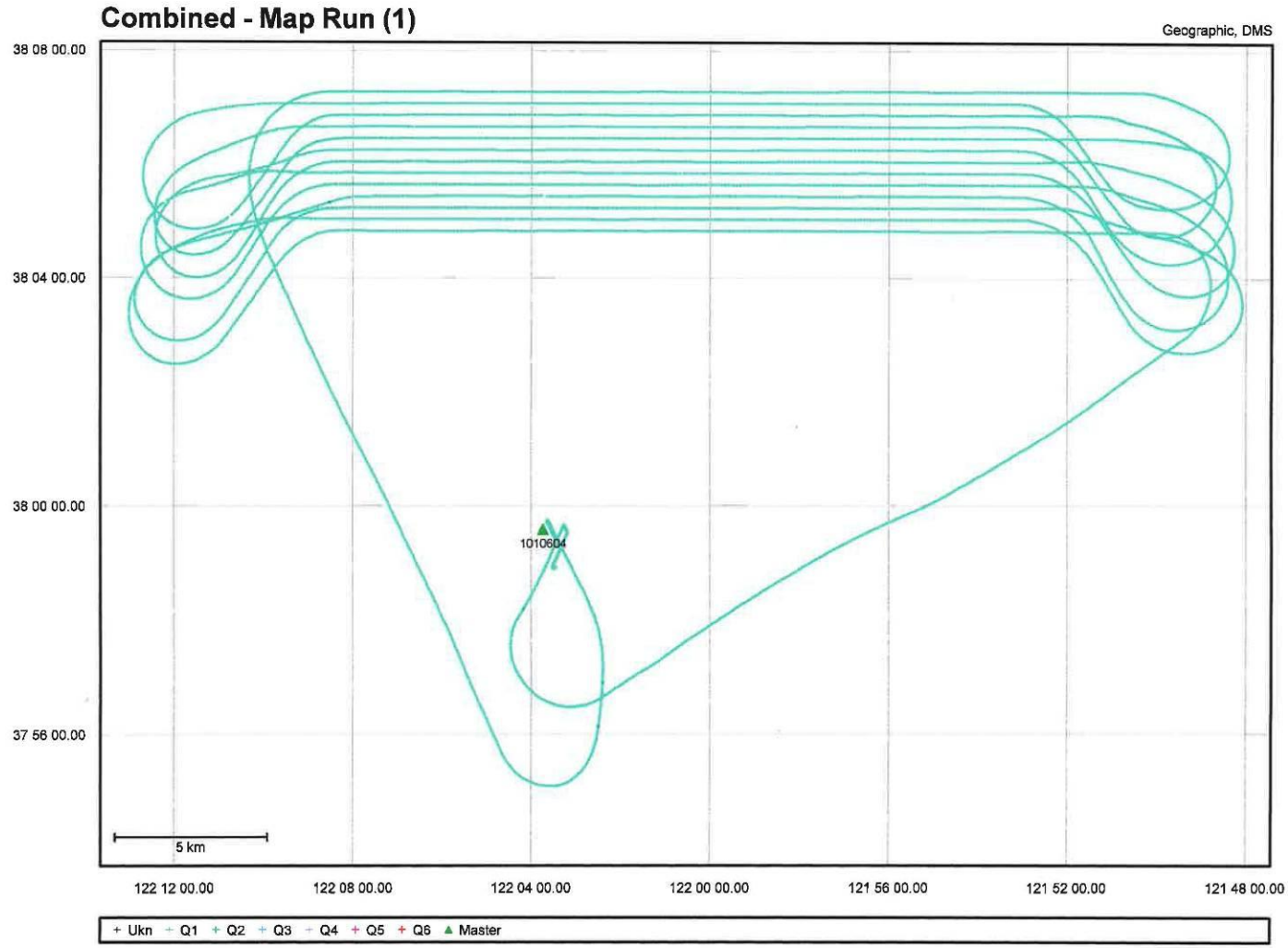
Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant HI Before: A:		B:		
Slant HI After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				

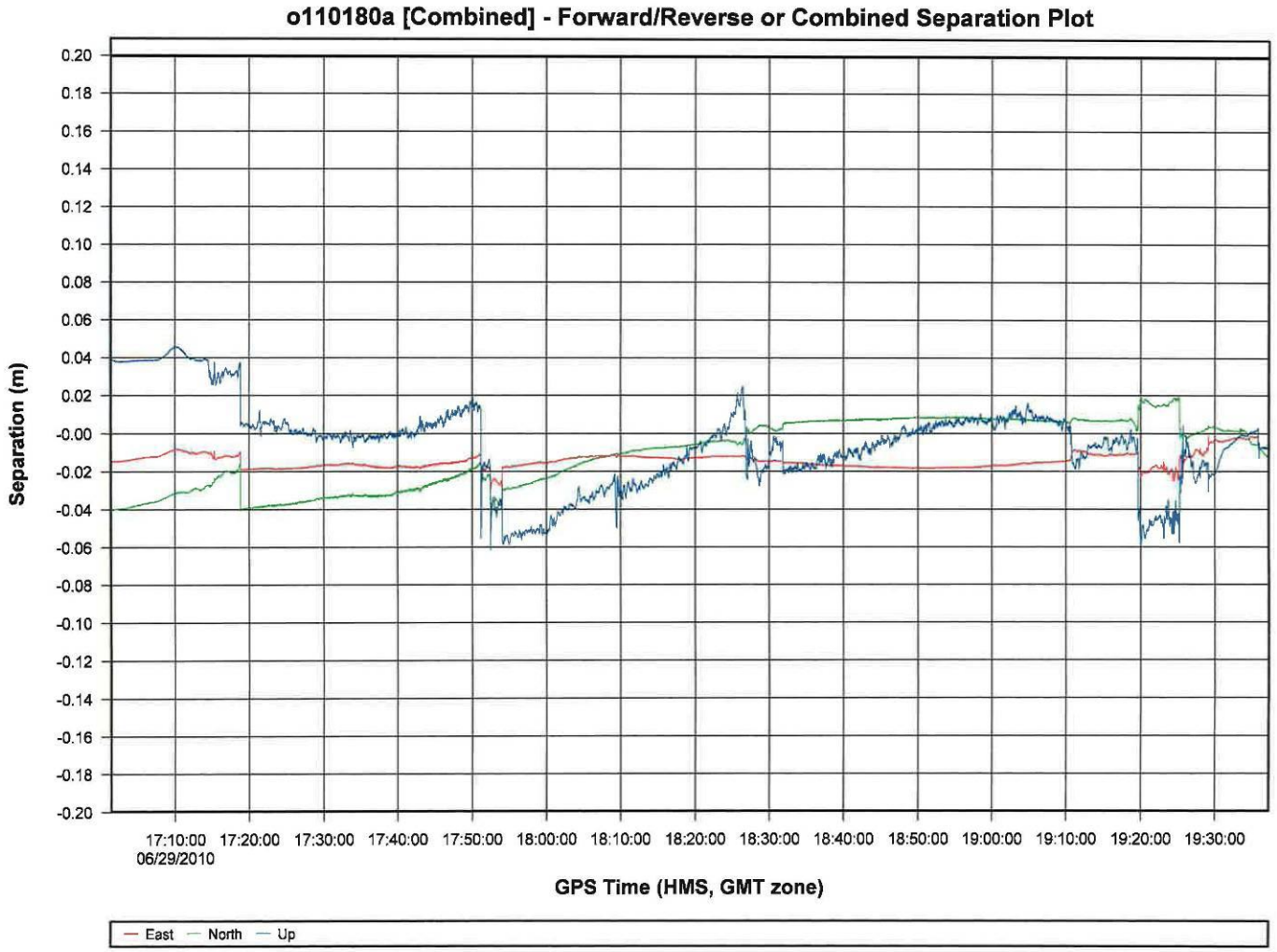


Mission: o110180a

2010 06 29




Combined - Map Run (1)
Geographic, DMS
38 08 00.00
38 04 00.00
38 00 00.00
37 56 00.00
1010604
5 km
122 12 00.00
122 08 00.00
122 04 00.00
122 00 00.00
121 56 00.00
121 52 00.00
121 48 00.00
Ukn Q1 Q2 Q3 Q4 Q5 Q6 Master


o110180a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
17:10:00 17:20:00 17:30:00 17:40:00 17:50:00 18:00:00 18:10:00 18:20:00 18:30:00 18:40:00 18:50:00 19:00:00 19:10:00 19:20:00 19:30:00
06/29/2010
GPS Time (HMS, GMT zone)
East North Up

Project #	10106U	Session	0110180a

Flight Log

Terrapoint

Date	JUNE 29	Julian Day	180
Project	SAN FRANCISCO	Aircraft	NAVAJO
Staging	CONCORD	Call Sign	C-FVTL
Survey Block	PORT CHICAGO	Pilot	PRELIPP
Lines Complete	50-62	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO:
Outside Temp @ LA: 23
Outside Pressure @ TO:
Outside Pressure @ LA: 2983

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs) 9:54	Takeoff 10:12	(120L) x (Total fit hrs)
Engine Off (Hobbs) 12:36	Landing 12:30	FBO $ / Litre
Total hrs (Hobbs)	Total hrs	Approx. Fuel Cost

Mission Plan	
Flying Height AGL 1300 m	Scan Angle (Optech) 19.2
Ground Speed 150 kts	Mirror Scan Rate 38.7
First/Last/Alternating Return	Laser Pulse Rate 71 kHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	17:02	17:08
KAR Base		
KAR Base		
Post Mission	19:32	19:37

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
62		270	17:24	17:30			
61		90	17:33	17:39			
60		270	17:42	17:48			
59		90	17:52	17:57			
58		270	18:01	18:06			
57		90	18:09	18:15			
56		270	18:18	18:24			
55		90	18:27	18:33			
54		270	18:36	18:42			
53		90	18:45	19:51			

Proje..#	101060	Session	20110180a

..ight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
52		270	18:54	19:00			
51		90	19:03	19:09			
50		270	19:12	19:18			

GPS Base Log Sheet

Terrapoint

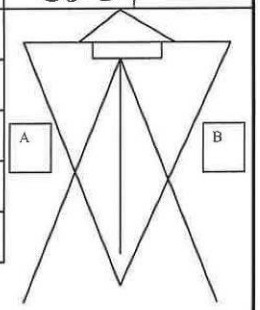
Station ID:	10108604	Project #:	10106	Missions:	01107804

Project Name:	SAN FRANCISCO	Calender Date:	JUNE 29	Julian Day	180
Approx. Coordinates WGS 84	N	37 [illegible]59 3511	W	122 03 44.37	
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access: BUCHANAN FIELD					

Obstructions & Additional Notes

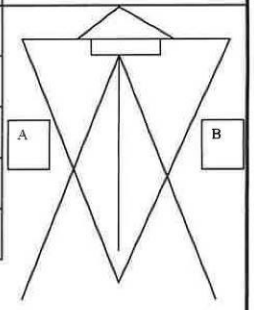
GPS Observation - MAIN

Rx Make / Model	GSR 2600	Serial #	0002	
Ant Make / Model	SK 600	Serial #	0027	
Operator	SCOTT			
Session Time (GPS) Start	16:35			
Session Time (GPS) End	19:50			
Slant Ht Before: A:	1.388	B:	1.389	
Slant Ht After: A:	1.389	B:	1.388	
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name	00021800.80			



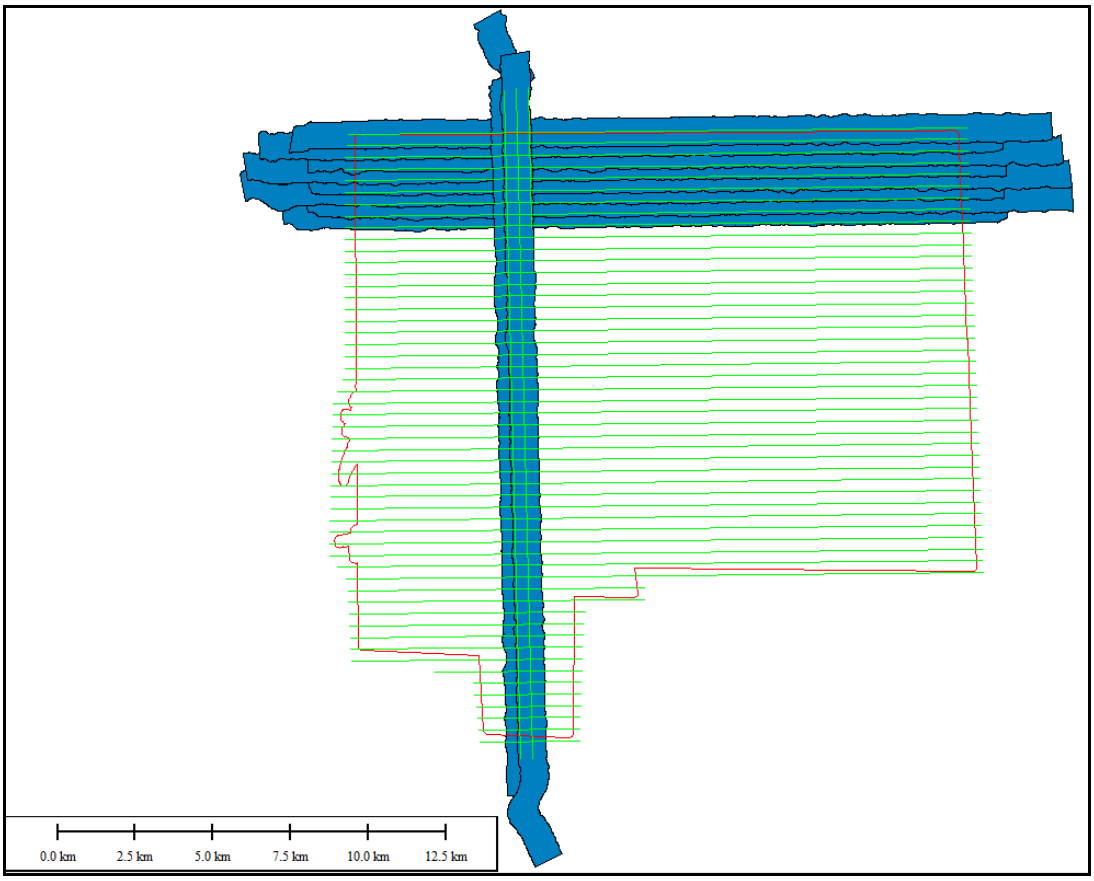
GPS Observation - Back-Up

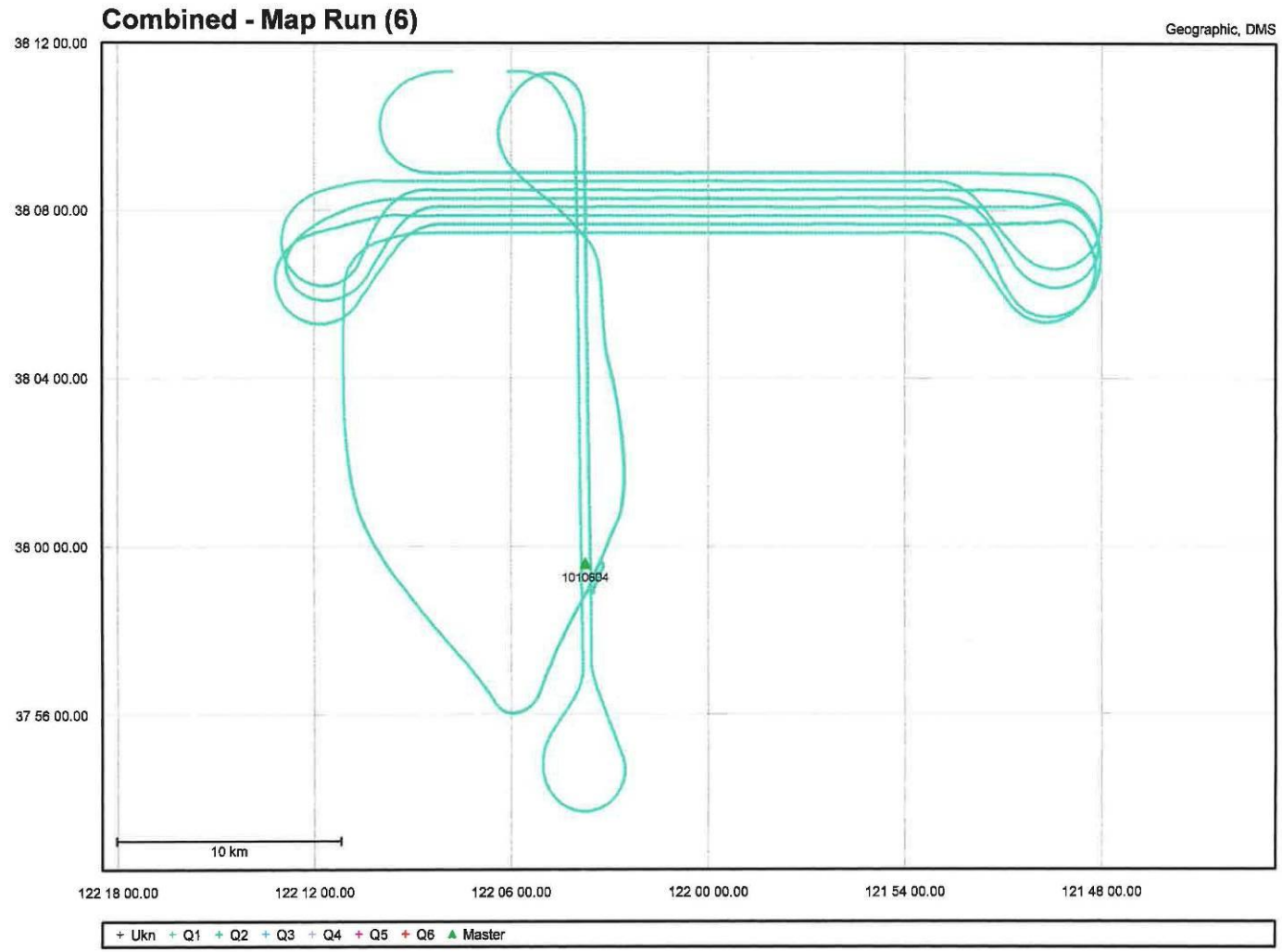
Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant Ht Before: A:		B:		
Slant Ht After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				

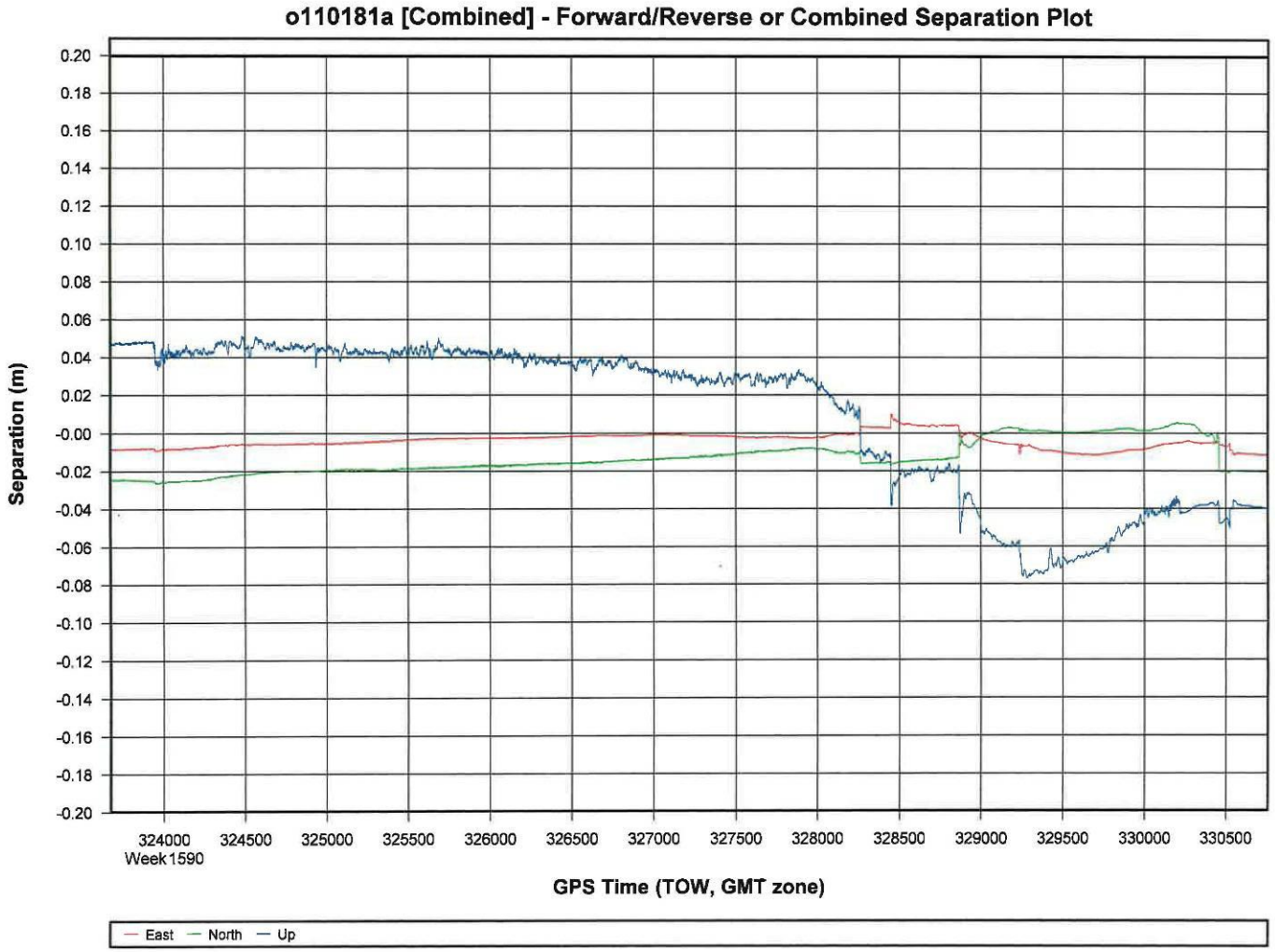


Mission: o110181a

2010 06 30




Combined - Map Run (6)
Geographic, DMS
38 12 00.00
38 08 00.00
38 04 00.00
38 00 00.00
37 56 00.00
1010604
10 km
122 18 00.00
122 12 00.00
122 06 00.00
122 00 00.00
121 54 00.00
121 48 00.00
Ukn Q1 Q2 Q3 Q4 Q5 Q6 Master


o110181a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
324000
Week 1590
324500
325000
325500
326000
326500
327000
327500
328000
328500
329000
329500
330000
330500
GPS Time (TOW, GMT zone)
East
North
Up

Project #	10106U	Session	011018la

Flight Log

Terrapoint

Date	JUNE 30	Julian Day	181
Project	SAN FRANCISCO	Aircraft	NAVAJO
Staging	CONCORD	Call Sign	6-FOXTROT
Survey Block	PORT OF OAKLAND	Pilot	MICHELLE
Lines Complete	42-49	Operator	SCOTT
		Observer	
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	
Shutter Speed	
Photo Freq.	
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 20 Outside Pressure @ TO: 2990

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs) 17:45	Takeoff 17:56	(120L) x (Total flt hrs)
Engine Off (Hobbs) 19:55	Landing 19:40	FBO $ / Litre
Total hrs (Hobbs) 2.2	Total hrs	Approx. Fuel Cost

Mission Plan	
Flying Height AGL 1300 M	Scan Angle (Optech) 19.2
Ground Speed 150 KTS	Mirror Scan Rate 38.7
First/Last/Alternating Return	Laser Pulse Rate 71 KHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	17:49	17:54
KAR Base		
KAR Base		
Post Mission	19:46	19:51

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
49		90	18:08	18:13			
48		270	18:18	18:23			
47		90	18:26	18:32			
46		270	18:36	18:42			
45		90	18:45	18:51			
44		270	18:55	19:00			
43		90	19:03	19:09			
42		270	19:12	19:18			
CROSS		179	19:21	19:26			
CROSS		359	19:29	19:36			

GPS Base Log Sheet

Terrapoint

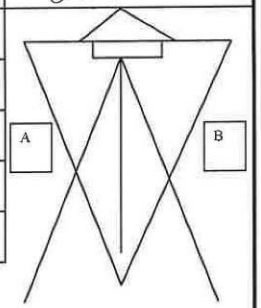
Station ID:		Project #:	10106U	Missions:	011018la

Project Name:	SAN FRANCISO	Calender Date:	JUNE 30	Julian Day	181
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☐ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access	BUCHANAN FIELD				

Obstructions & Additional Notes

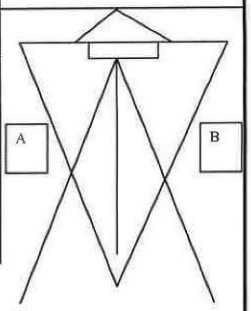
GPS Observation - MAIN

Rx Make / Model	NOVATEL DL4	Serial #	0003	
Ant Make / Model	SK 600	Serial #	0011	
Operator	SCOTT			
Session Time (GPS) Start				
Session Time (GPS) End	20:08			
Slant Ht Before: A:		B:		
Slant Ht After: A:	1.2112	B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name	00031810.DL			



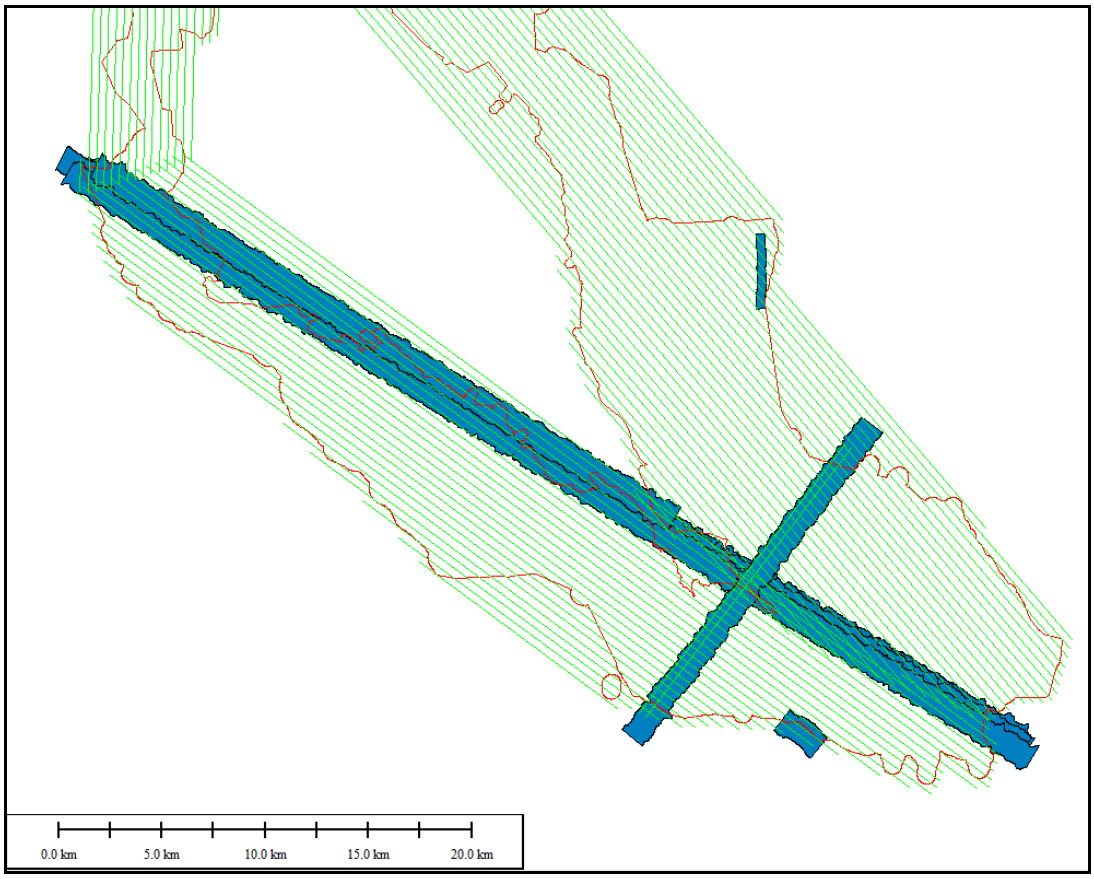
GPS Observation - Back-Up

Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant Ht Before: A:		B:		
Slant Ht After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				

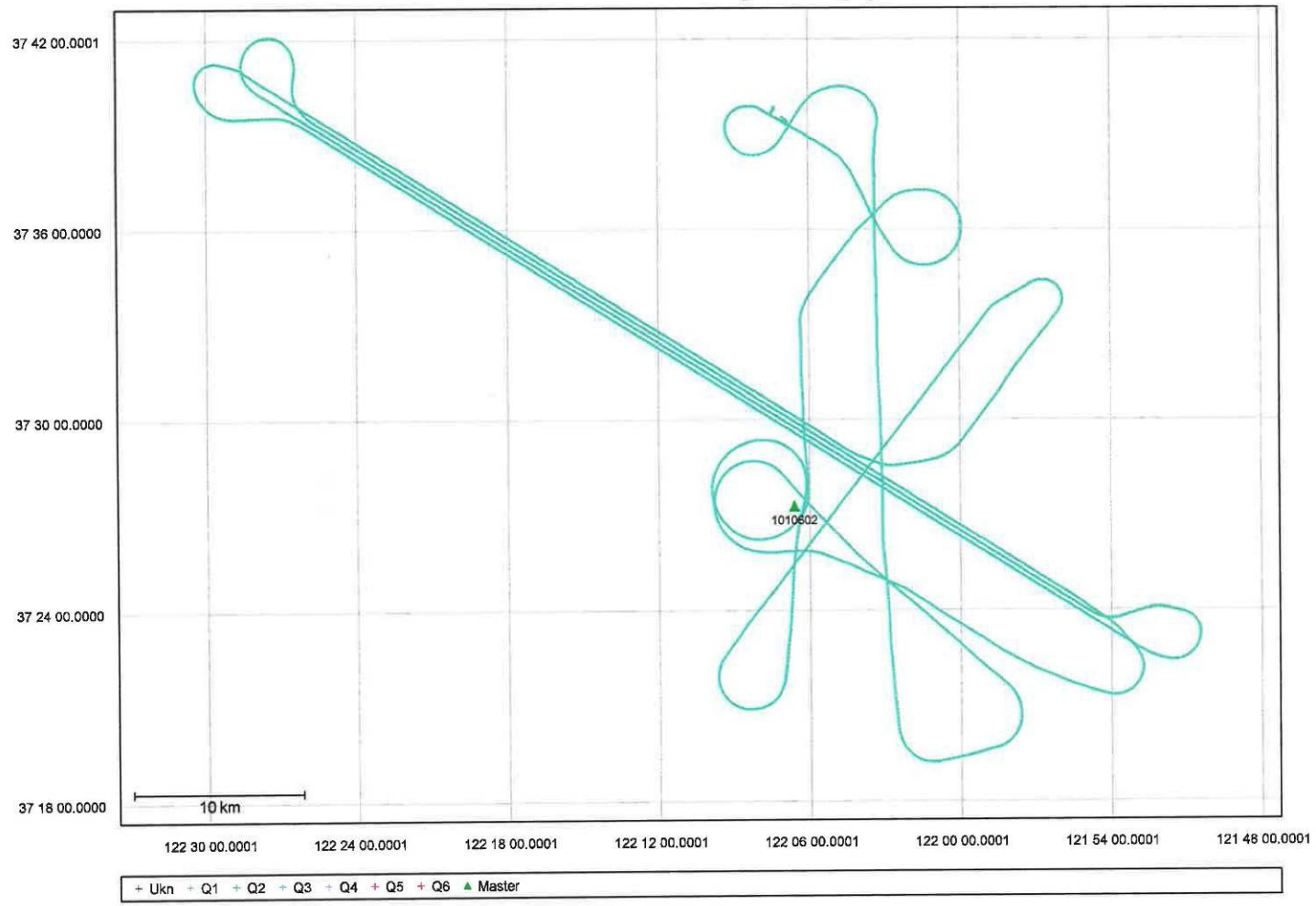


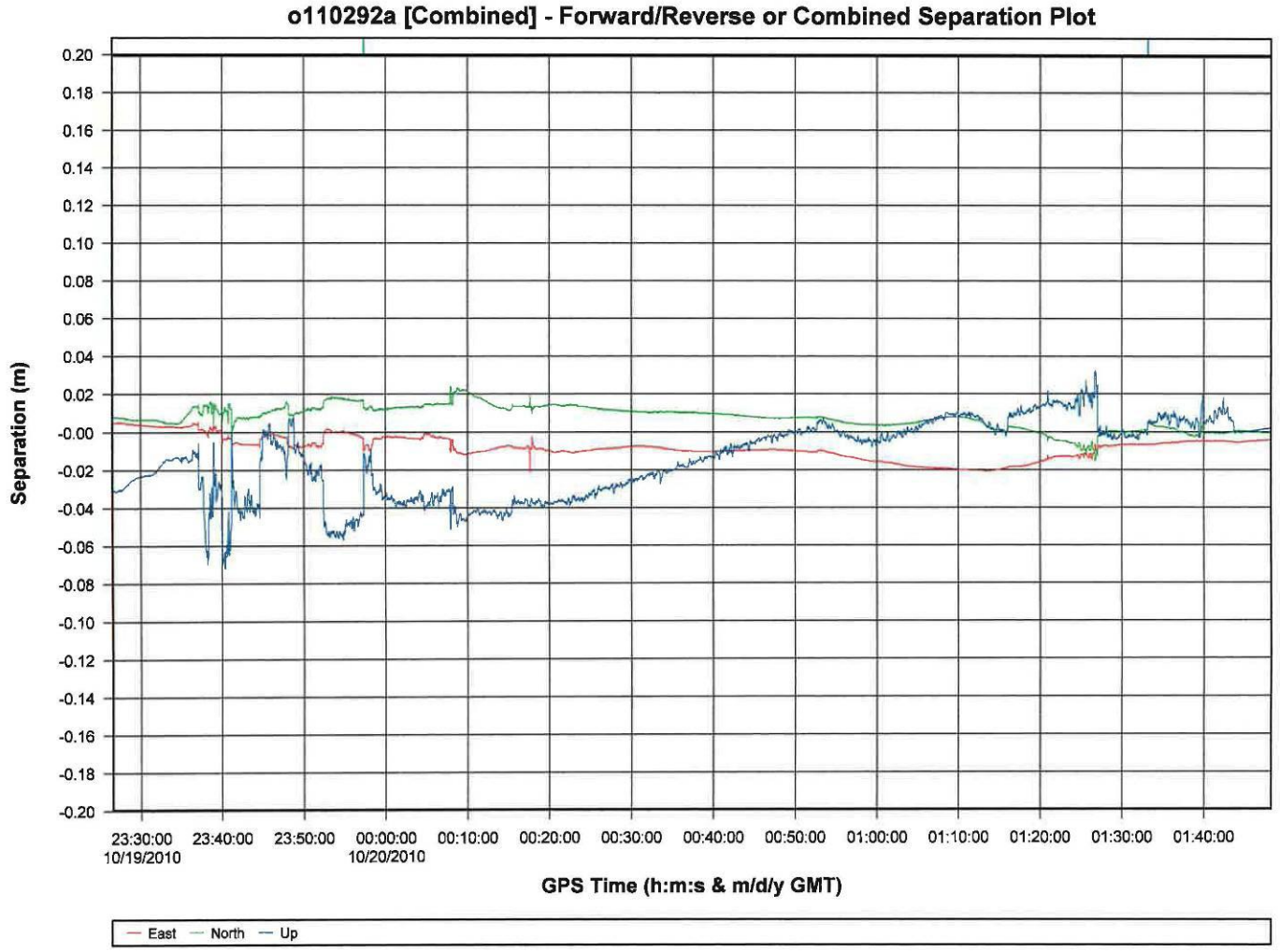
Mission: o110292a

2010 10 19



Combined - Map Run (2)




o110292a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
23:30:00 10/19/2010
23:40:00
23:50:00
00:00:00 10/20/2010
00:10:00
00:20:00
00:30:00
00:40:00
00:50:00
01:00:00
01:10:00
01:20:00
01:30:00
01:40:00
GPS Time (h:m:s & m/d/y GMT)
East
North
Up

Project # 101064 Session Kluane 01102[92]a Flight Log

Terrapoint

Date	Oct 19/10	Julian Day	292
Project	101064	Aircraft	Navajo
Staging	Kluane	Call Sign	C-FVFL
Survey Block	3/4	Pilot	Mathew H
Lines Complete	11-14, 45	Operator	Mathew
		Observer	Adrian C
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	NA
Shutter Speed	NA
Photo Freq.	NA
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 21° Outside Pressure @ TO: 2988

Outside Temp @ LA: 18° Outside Pressure @ LA: 2988

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs) 4:15	Ramp Out	Takeoff 4:37
Engine Off (Hobbs) 6.52	Ramp In	Landing 6:43
Total hrs (Hobbs) 2.6	Total hrs	Total hrs

Mission Plan	
Flying Height AGL 7500ft/2300m	Scan Angle (Optech) 15°
Ground Speed 125	Mirror Scan Rate 26
First/Last/Alternating Return	Laser Pulse Rate 50

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	4:11	4:34
KAR Base	4:55	5:00
KAR Base	6:26	6:33
Post Mission		

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time Start	GPS / UTC Time End	Flight Aborted Time	Flight Aborted NM to End	Photo Evens / Comments (Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):)
12		W	5:06	5:20			
13		E	5:24	5:39			
14		W	5:43	5:57			
11		E	6:01	6:10			
Calibration 1		S	6:18	6:23			Line 45
Calibrations		NA					Area.

Page ___ of ___

GPS Base Log Sheet

Palo Alto

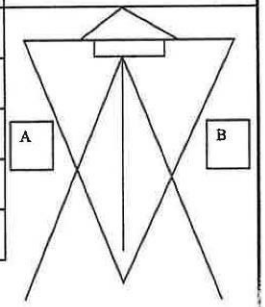
Station ID:	1010602	Project #:	101060	Missions:	0110292a

Project Name:	USGS San Fran	Calender Date:	19 Oct 2010	Julian Day	292
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

GPS Observation - MAIN

Rx Make / Model	GSR2600		Serial #	0022
Ant Make / Model	SK600		Serial #	0008
Operator	ASC			
Session Time (GPS)	Start	193000		
	End	171000		
Slant Ht Before:	A:	1.482	B:	1.482
Slant Ht After:	A:	1.482	B:	1.482
Correction				
Phase Center				

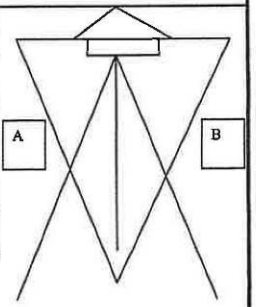


☒m ☐ in ☐ use GrafNav Profile

Data File Name	

GPS Observation - Back-Up

Rx Make / Model			Serial #	
Ant Make / Model			Serial #	
Operator				
Session Time (GPS)	Start			
	End			
Slant Ht Before:	A:		B:	
Slant Ht After:			B:	
Correction				
Phase Center				

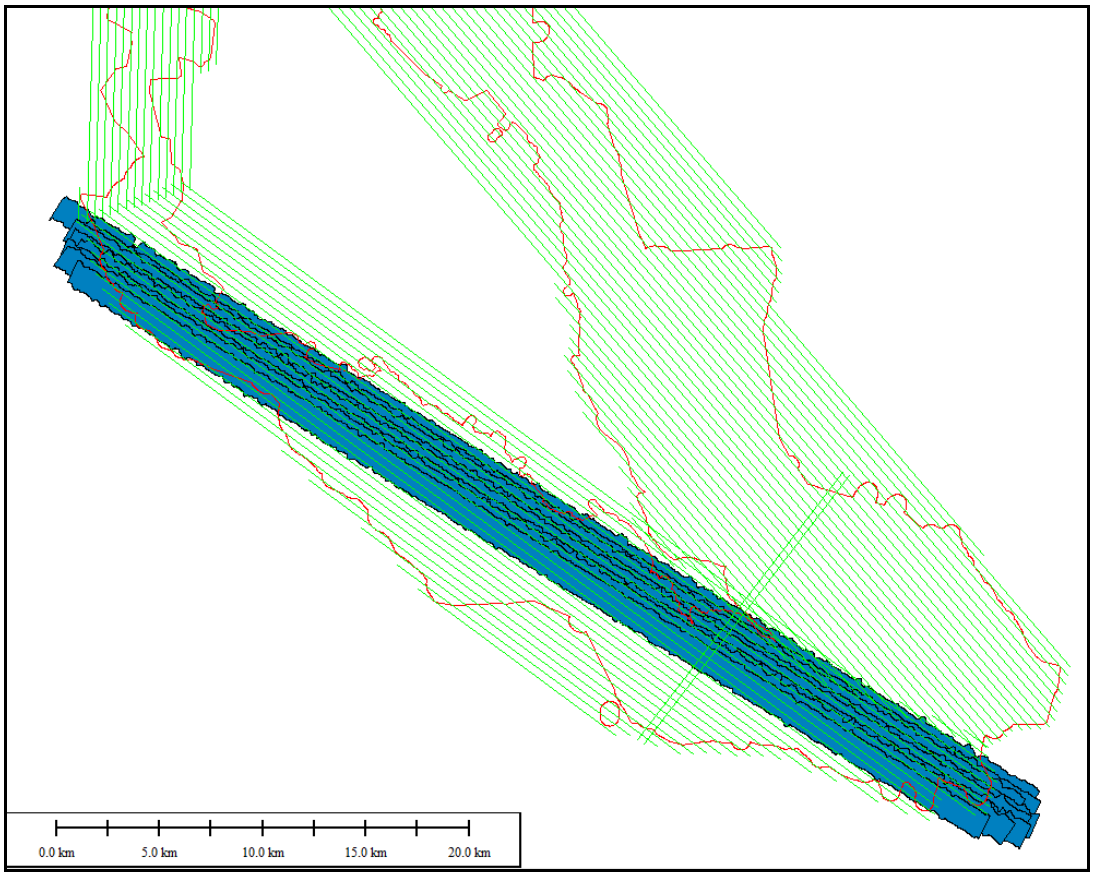


m ☐ in ☐ use GrafNav Profile

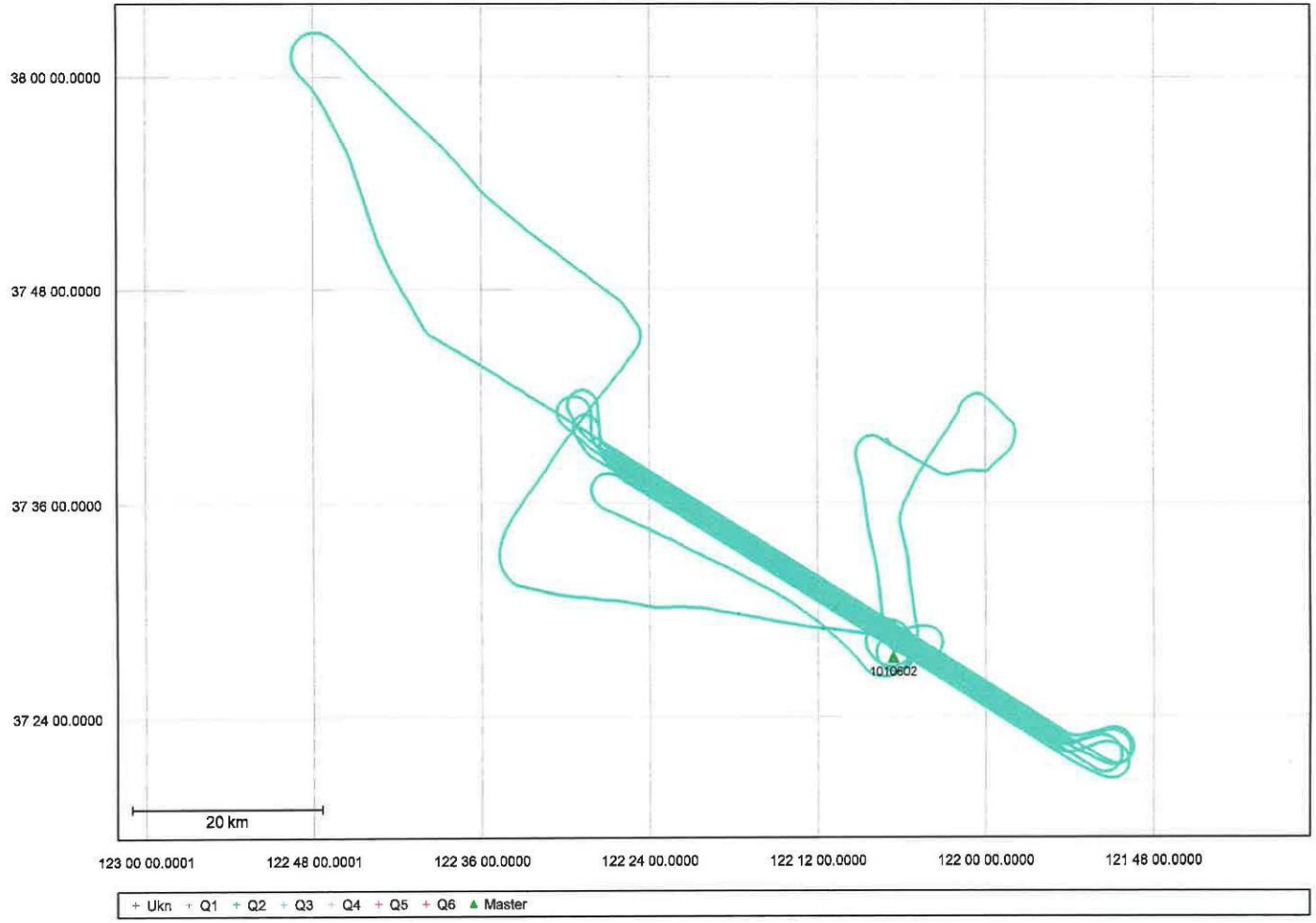
Data File Name	

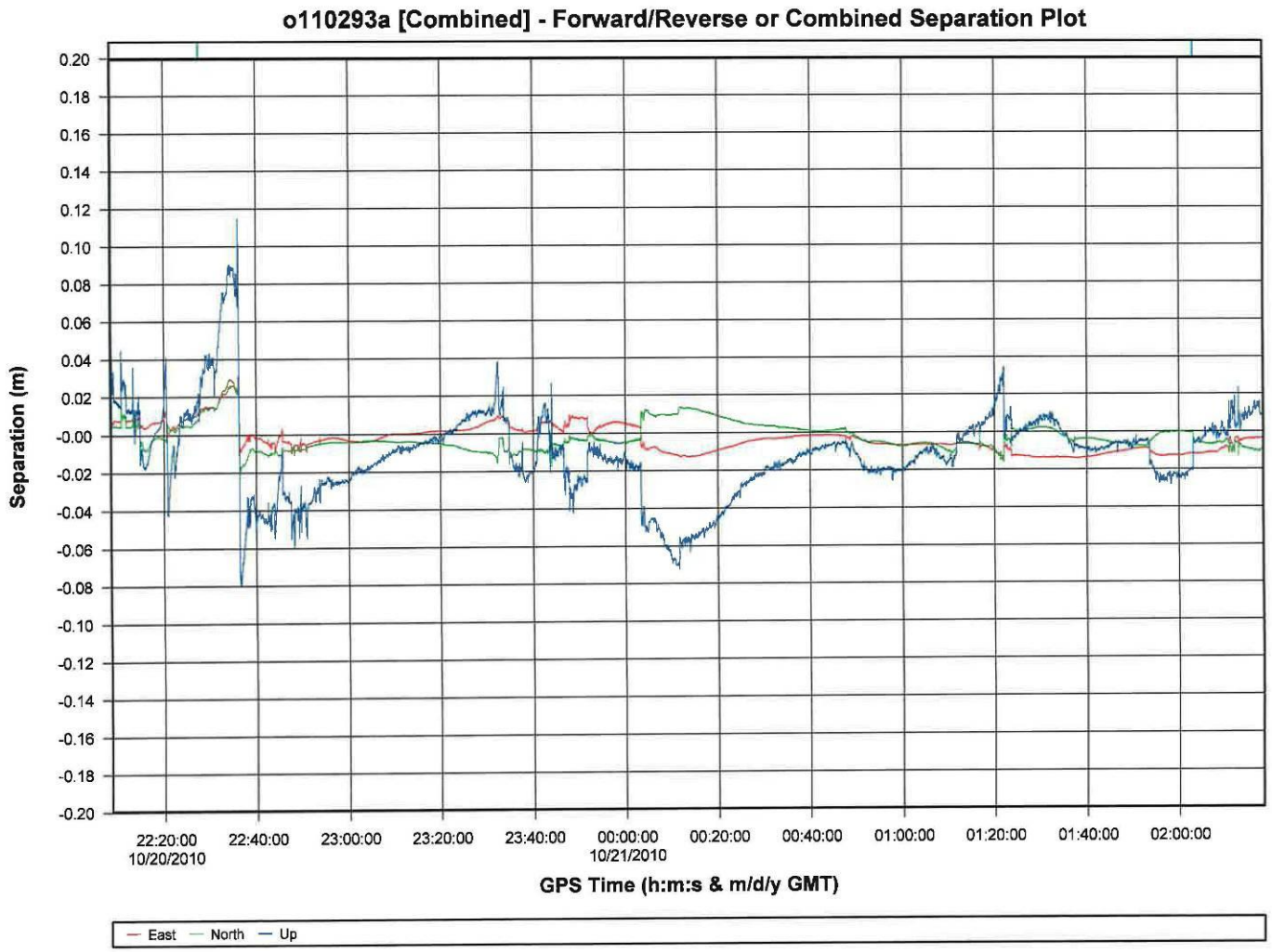
Mission: o110293a

2010 10 20



Combined - Map Run (1)




o110293a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
22:20:00 10/20/2010
22:40:00
23:00:00
23:20:00
23:40:00
00:00:00 10/21/2010
00:20:00
00:40:00
01:00:00
01:20:00
01:40:00
02:00:00
GPS Time (h:m:s & m/d/y GMT)
East
North
Up

Project #	10106U	Session	0110293a

Flight Log

Terrapoint

Date	Oct 20/10	Julian Day	293
Project	10106U	Aircraft	Navajo
Staging		Call Sign	C-FUTL
Survey Block		Pilot	Matthew H
Lines Complete	8-	Operator	Matt W
		Observer	Adrian C
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	NA
Shutter Speed	NA
Photo Freq.	NA
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 18° Outside Pressure @ TO: 2994

Outside Temp @ LA: Outside Pressure @ LA:

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs) 3:05	Ramp Out	Takeoff 3:21
Engine Off (Hobbs) 7:22	Ramp In	Landing 7:18
Total hrs (Hobbs)	Total hrs	Total hrs

Mission Plan	
Flying Height AGL 7500Ct /	Scan Angle (Optech) 15
Ground Speed 125 Kts	Mirror Scan Rate 25.5
First/Last/Alternating Return	Laser Pulse Rate 50 kHz

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	3:00	3:20
KAR Base	3:30	3:35
KAR Base	6:57	7:02
Post Mission		

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time Start	GPS / UTC Time End	Flight Aborted Time	Flight Aborted NM to End	Photo Evens / Comments (Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):)
5		~~E~~W	3:52		3:53	5(Approx)	Bolivas, orig plan. No Ranges
~~8~~	~~No Good.~~	E	4:15	4:30	→	Do not use	Flight Alternate A. Reduced
9		W	4:35	4:50			
10		E	4:55	5:10			
11		W	5:15	5:30			
12		E	5:35	5:50			
13		W	5:55	6:10			
14		E	6:15	6:28			Some Cloud Cover, may have drops
15		W	6:34	6:48			
							Clouds too heavy to Proceed

GPS Base Log Sheet

Terrapoint aerial services

Station ID:	Back up	Project #:	101001	Missions:	0110293

Project Name:		Calender Date:	Oct 20/10	Julian Day	293
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☐ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

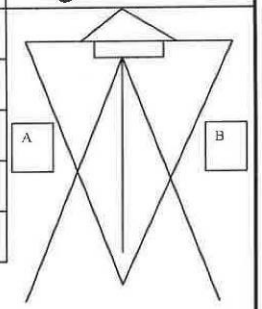
Obstructions & Additional Notes

Backup: Approx. Coordinates WGS 84

N
W

GPS Observation - MAIN

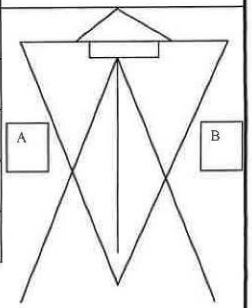
Rx Make / Model	GSR 2000		Serial #	0116
Ant Make / Model	SK600		Serial #	0007
Operator	Matt W			
Session Time (GPS)	Start	336800		
	End	354690		
Slant Ht Before:	A:	1.246	B:	1.246
Slant Ht After:	A:	1.246	B:	1.246
Correction				
Phase Center				
Data File Name	00162930.pdc			



☐ m ☐ in ☐ use GrafNav Profile

GPS Observation - Back-Up

Rx Make / Model			Serial #	
Ant Make / Model			Serial #	
Operator				
Session Time (GPS)	Start			
	End			
Slant Ht Before:	A:		B:	
Slant Ht After:	A:		B:	
Correction				
Phase Center				
Data File Name				



☐ m ☐ in ☐ use GrafNav Profile

GPS Base Log Sheet

Terrapoint

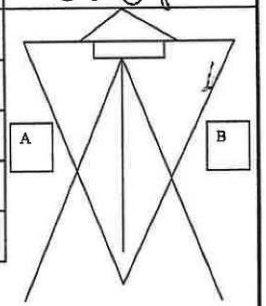
Station ID:	1010602	Project #:	10106U	Missions:	

Project Name:	USGS Sanfran	Calender Date:	20 Oct 2010	Julian Day	293
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

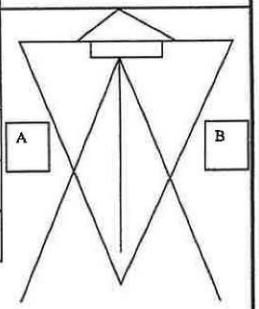
GPS Observation - MAIN

Rx Make / Model	GSR 2600	Serial #	0022
Ant Make / Model	SK600	Serial #	0008
Operator	ASC		
Session Time (GPS) Start	171100		
Session Time (GPS) End	043000		
Slant Ht Before: A:	1.982	B:	1.982
Slant Ht After: A:	1.982	B:	1.982
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name			



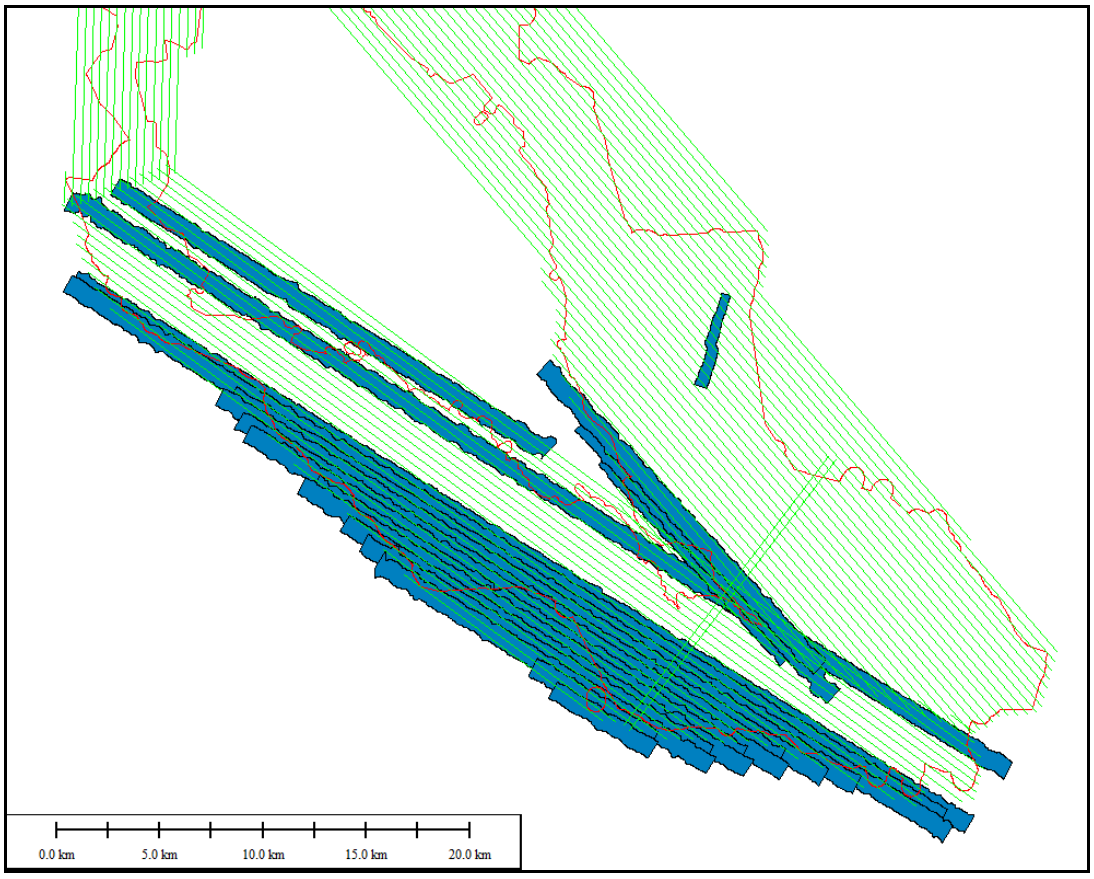
GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before: A:		B:	
Slant Ht After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			

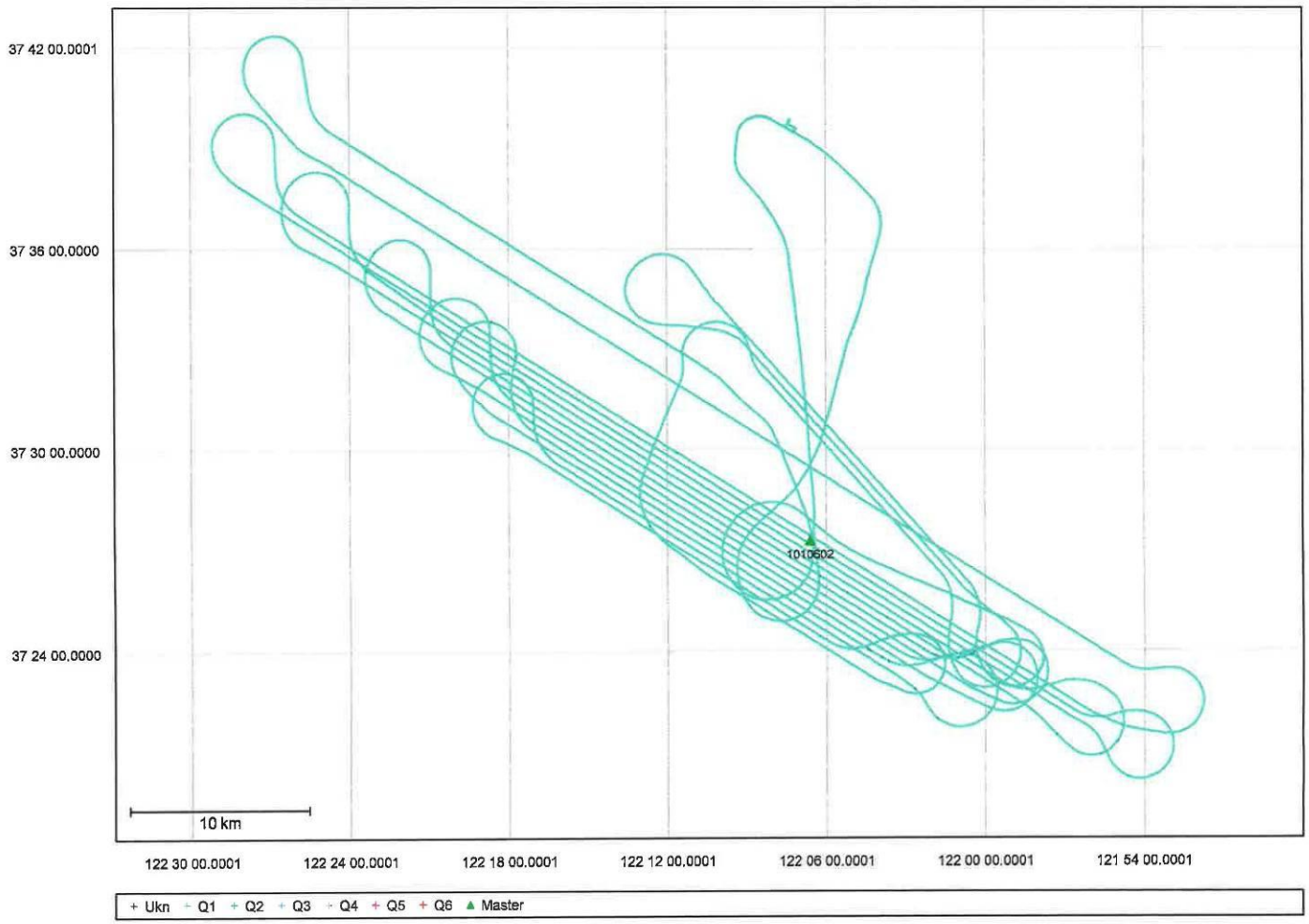


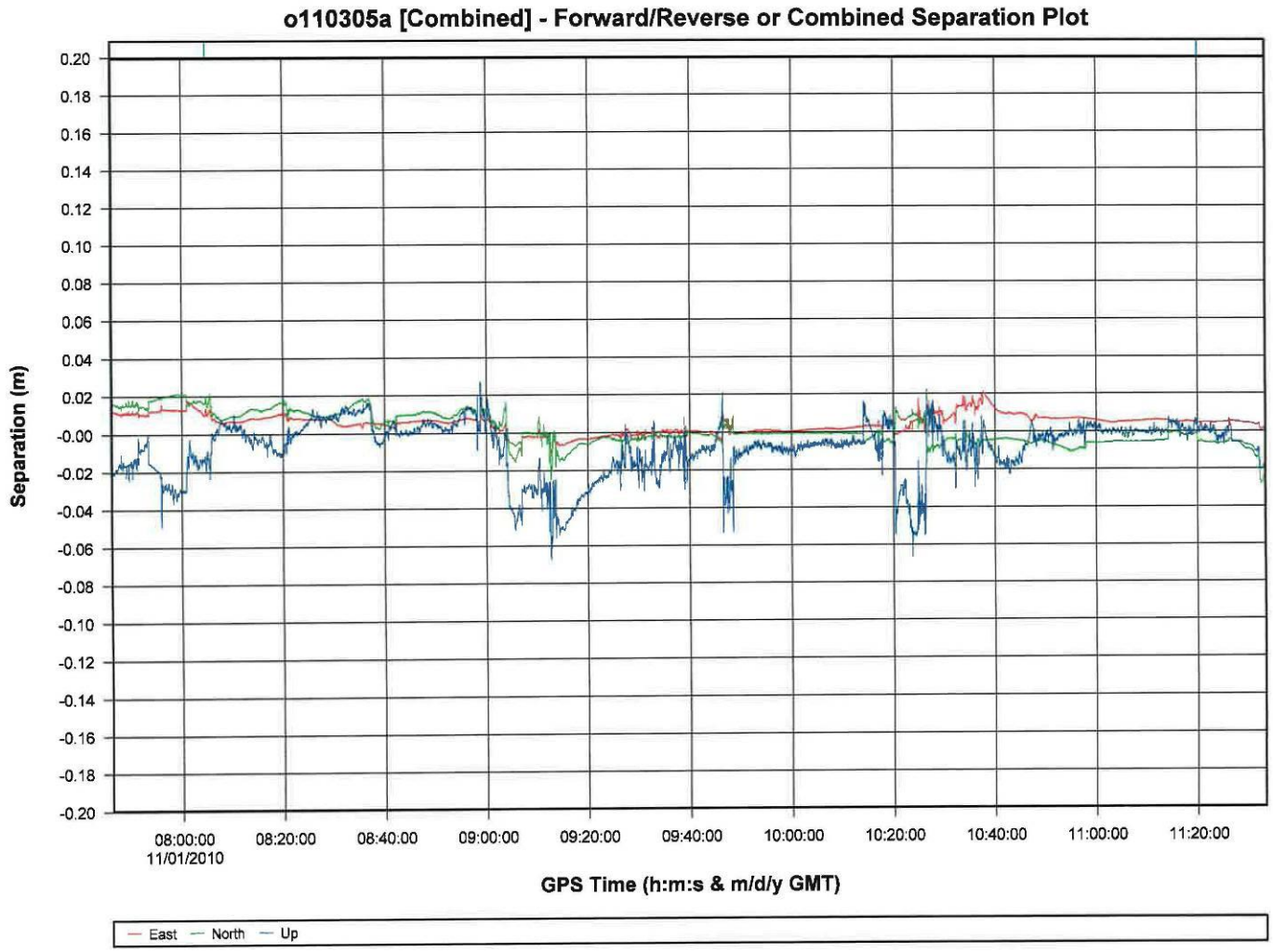
Mission: o110305a

2010 11 01



Combined - Map Run (1)




o110305a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
08:00:00
11/01/2010
08:20:00
08:40:00
09:00:00
09:20:00
09:40:00
10:00:00
10:20:00
10:40:00
11:00:00
11:20:00
GPS Time (h:m:s & m/d/y GMT)
East
North
Up

Project #	101866	Session	0161305a

Flight Log

Terrapoint

Date	Nov 1	Julian Day	305
Project	101866	Aircraft	Navajo
Staging		Call Sign	C-EVTL
Survey Block		Pilot	Matt H
Lines Complete		Operator	Matt W
		Observer	Adrian C
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	NA
Shutter Speed	NA
Photo Freq.	NA
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 12 Outside Pressure @ TO: 3027

Outside Temp @ LA: 12 Outside Pressure @ LA: 3028

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs) 12:32	Ramp Out	Takeoff 12:55
Engine Off (Hobbs) 4:35	Ramp In	Landing 4:25
Total hrs (Hobbs) 3hr 57m	Total hrs	Total hrs 3.5 hrs.

Mission Plan	
Flying Height AGL 1300	Scan Angle (Optech) 19.2
Ground Speed 150	Mirror Scan Rate 38.7
First/Last/Alternating Return	Laser Pulse Rate 71

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	12:32	12:55
KAR Base	1:00	1:05
KAR Base	4:14	4:19
Post Mission	4:25	4:37

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time Start	GPS / UTC Time End	Flight Aborted Time	Flight Aborted NM to End	Photo Evens / Comments (Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):)
25		W	1:07	1:12			plan A
21		E	1:16	1:28			
13		W	1:31	1:42			
12		E	1:46	1:57			
11		W	2:01	2:10			
10		E	2:16	2:23			
9		W	2:28	2:36			
8		E	2:40	2:47			
7		W	2:51	2:56			
6		E	3:00	3:06			

Project #	lolobe	Session	o11805a

Flight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
5		W	3:10	3:15			
4		E	3:20	3:24			
3		W	3:29	3:33			
2		E	3:34	3:41			
1		W	3:45	3:46			
11		E	3:51	3:54			Plan B
10		W	3:58	4:01			
9		E	4:05	4:09			
~~8~~		~~W~~					

GPS Base Log Sheet

Terrapoint

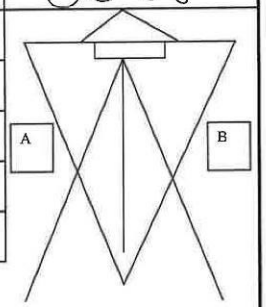
Station ID:	1010602	Project #:	10106U	Missions:	B\ 103050

Project Name:	USGS San Fran	Calender Date:	May 1 2010	Julian Day	3050
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

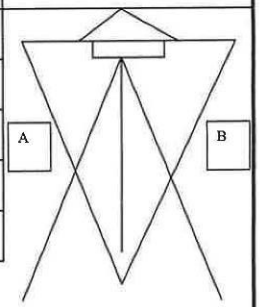
GPS Observation - MAIN

Rx Make / Model	GSR 2600	Serial #	0022
Ant Make / Model	SK 600	Serial #	0008
Operator	ASC		
Session Time (GPS) Start	230300		
Session Time (GPS) End	184600		
Slant Ht Before: A:	1.496	B:	1.496
Slant Ht After: A:	1.496	B:	1.496
Correction			
Phase Center	☒ m ☐ in ☐ use GrafNav Profile		
Data File Name			



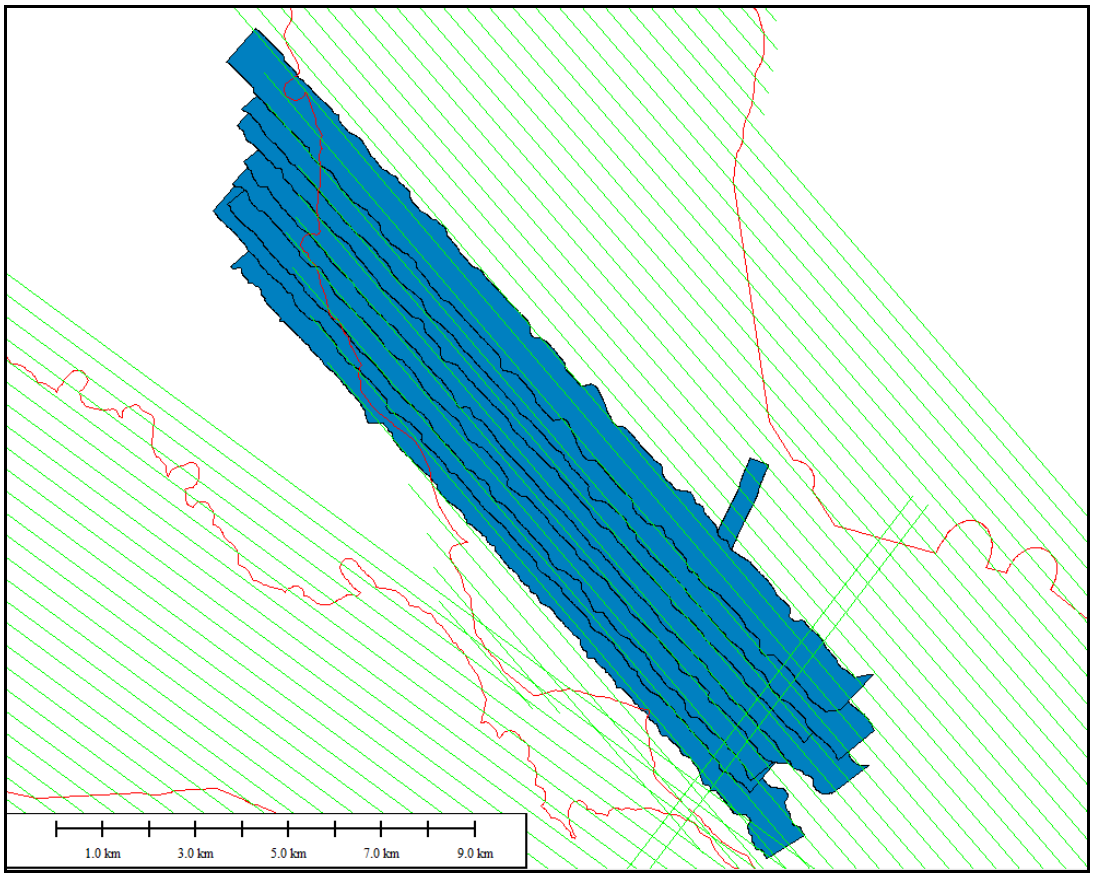
GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before: A:		B:	
Slant Ht After: A:		B:	
Correction			
Phase Center	☐ m ☐ in ☐ use GrafNav Profile		
Data File Name			

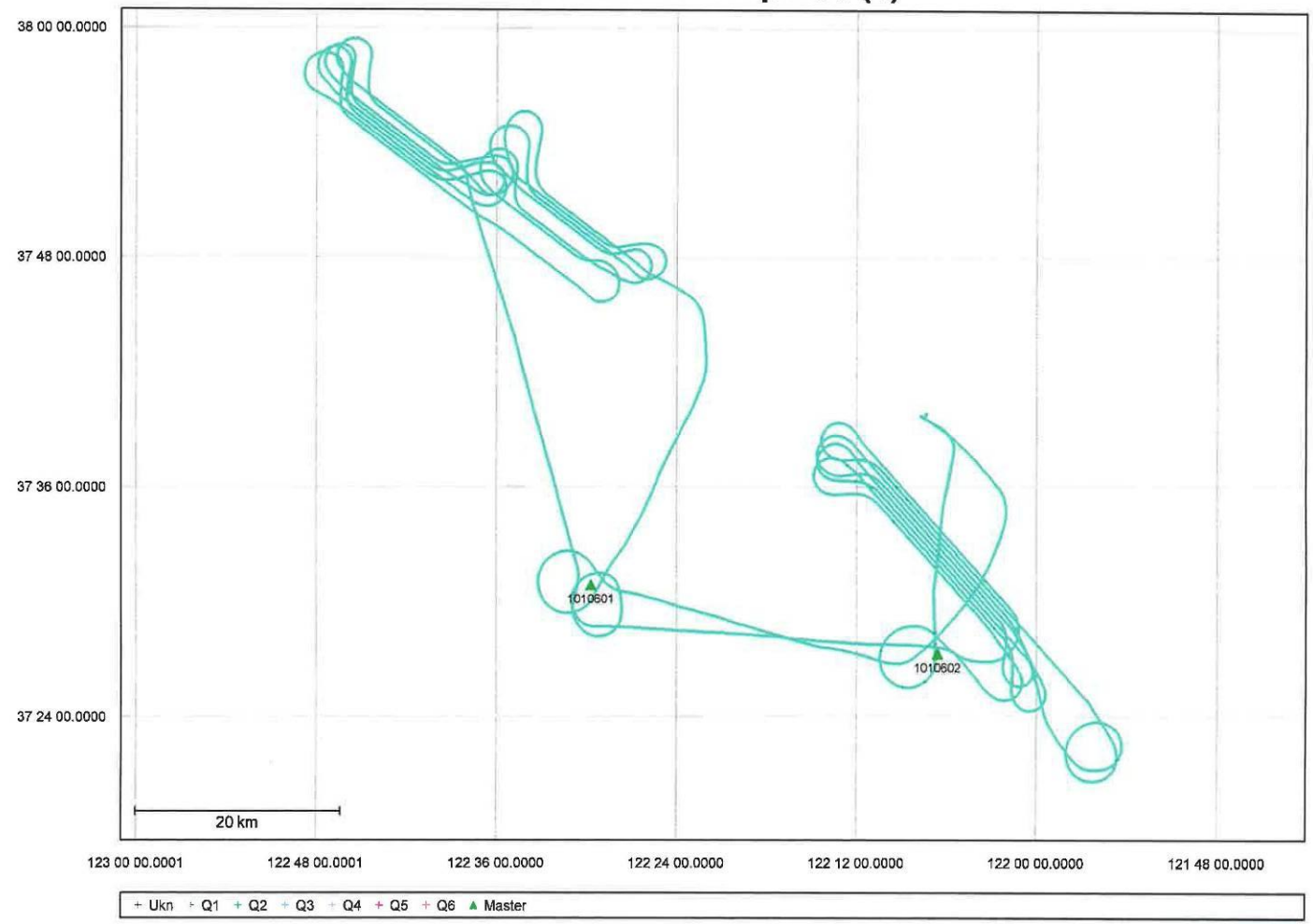


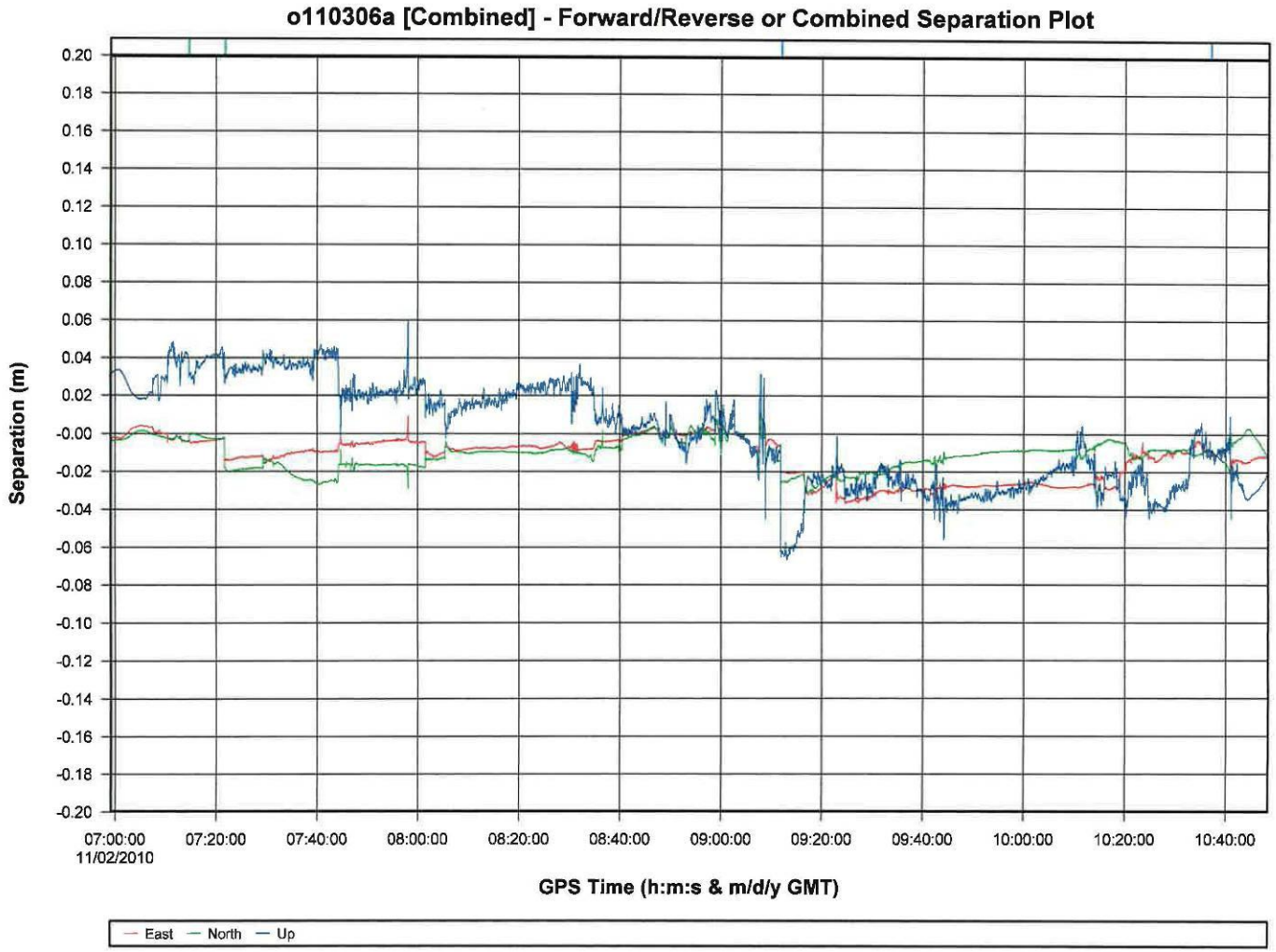
Mission: o110306a

2010 11 02



Combined - Map Run (1)




o110306a [Combined] - Forward/Reverse or Combined Separation Plot
Separation (m)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
-0.20
07:00:00
11/02/2010
07:20:00
07:40:00
08:00:00
08:20:00
08:40:00
09:00:00
09:20:00
09:40:00
10:00:00
10:20:00
10:40:00
GPS Time (h:m:s & m/d/y GMT)
East
North
Up

Project #	101064	Session	01103069	Flight Log

Terrapoint

Date	Nov 2	Julian Day	306
Project	101064	Aircraft	Navajo
Staging		Call Sign	C-FXTL
Survey Block		Pilot	Matt H
Lines Complete		Operator	Matt W
		Observer	Adrian C
Mission Objective			

ALMIS/Optech	
System #	
Laser Scanner	
Camera/Lens SN	NA
Shutter Speed	NA
Photo Freq.	NA
IMU	
GPS Rx	
Data Drive	

Additional Notes:

Outside Temp @ TO: 12 Outside Pressure @ TO: 3032

Outside Temp @ LA: 12 Outside Pressure @ LA: 3031

Aircraft Block Time ☐ Times confirmed with pilot		
Engine On (Hobbs)	Ramp Out	Takeoff
11:50		12:08
Engine Off (Hobbs)	Ramp In	Landing
3:50		3:43
Total hrs (Hobbs)	Total hrs	Total hrs
4 hrs.		3 hrs. 35 min

Mission Plan	
Flying Height AGL	Scan Angle (Optech)
1300	19.2
Ground Speed	Mirror Scan Rate
150	38.7
First/Last/Alternating Return	Laser Pulse Rate
	71

Static & KAR GPS // INS Alignment		
Time ☐GPS	Start	End
Pre Mission	11:43	12:08
KAR Base	PA 12:13 / Y/2m 12:20	PA 12:16 / Y/2m 12:25
KAR Base	PA 3:30 / Y/2m 2:07	PA 3:35 / Y/2m 2:17
Post Mission	3:43	

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time Start	GPS / UTC Time End	Flight Aborted Time	Flight Aborted NM to End	Photo Evens / Comments (Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):)
5		W	12:35	12:36			Original Flight Plan. Boolines
6		E	12:41	12:42			
7		W	12:46	12:48			
8		E	12:52	12:54			
12		W	12:58	1:00			Eastern Section
13		E	1:04	1:05			Eastern Section
20		W	1:12	1:14			
19		E	1:19	1:21			
18		W	1:25	1:27			
17		E	1:31	1:33			

Project #	101064	Session	0110306a

Flight Log

Terrapoint

Flight Plan Line #	LIDAR File Name	Flight Direction	GPS / UTC Time		Flight Aborted		Photo Evens / Comments Please periodically record: Outside Temp: Cabin Temp: Laser Temp: Output (Watts):
			Start	End	Time	NM to End	
16		W	1:38	1:40			
15		E	1:44	1:46			
13		W	1:50	1:52			
12		E	1:56	1:58			
8		W	2:23	2:27			Plan B
7		E	2:31	2:34			
6		W	2:39	2:43			
5		E	2:46	2:50			
4		W	2:54	2:58			
3		E	3:01	3:05			
2		W	3:17	3:21			
1		E	3:25	3:29			

GPS Base Log Sheet

Terrapoint

Station ID:	1010602	Project #:	10106U	Missions:	d110306a

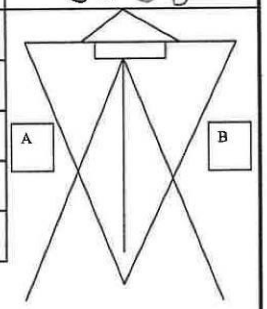
Project Name:	USGS San Fran	Calender Date:	Nov 12010	Julian Day	306
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monitument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

1840

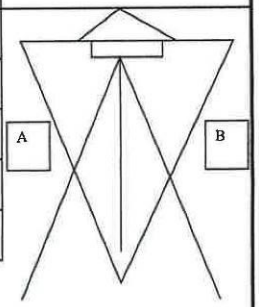
GPS Observation - MAIN

Rx Make / Model	GSR2600	Serial #	0022
Ant Make / Model	SK600	Serial #	0008
Operator	ASC		
Session Time (GPS) Start	164100		
Session Time (GPS) End	030600		
Slant Ht Before: A:	1.496	B:	1.496
Slant Ht After: A:	1.496	B:	1.496
Correction			
Phase Center		☒ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Observation - Back-Up

Rx Make / Model		Serial #	
Ant Make / Model		Serial #	
Operator			
Session Time (GPS) Start			
Session Time (GPS) End			
Slant Ht Before: A:		B:	
Slant Ht After: A:		B:	
Correction			
Phase Center		☐ m ☐ in ☐ use GrafNav Profile	
Data File Name			



GPS Base Log Sheet

Terrapoint

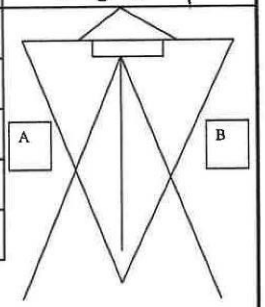
Station ID:	Half moon 101060 1	Project #:	L0106 U	Missions:	0110306a

Project Name:	USGS San Fram	Calender Date:	Nov 1200	Julian Day	306
Approx. Coordinates WGS 84	N		W		
Description of Mark (Take Photos)					
Monument is: ☒ Flush with ground ☐ Above ground _____ cm ☐ Below ground _____ cm					
Location & Access					

Obstructions & Additional Notes

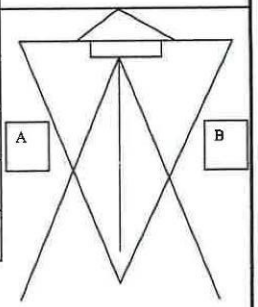
GPS Observation - MAIN

Rx Make / Model	GSR2600	Serial #	0076	
Ant Make / Model	SK600	Serial #	0009	
Operator	ASC			
Session Time (GPS) Start	174600			
Session Time (GPS) End	023700			
Slant Ht Before: A:	1.493	B:	1.493	
Slant Ht After: A:	1.493	B:	1.493	
Correction				
Phase Center		☒ m ☐ in ☐ use GrafNav Profile		
Data File Name				



GPS Observation - Back-Up

Rx Make / Model		Serial #		
Ant Make / Model		Serial #		
Operator				
Session Time (GPS) Start				
Session Time (GPS) End				
Slant Ht Before: A:		B:		
Slant Ht After: A:		B:		
Correction				
Phase Center		☐ m ☐ in ☐ use GrafNav Profile		
Data File Name				



Appendix C Terrapoint Geodetic Control Points

Survey Block	Station	Latitude (D M S Hem)	Longitude (D M S Hem)	Easting (m)	Northing (m)	H-Ell (m)	H-MSL (m)
USGS SAN Francisco	**1010601** _	37 30 52.26391 N	122 29 41.86434 W	544631.825	4152071.77	-16.6617	16.3482
USGS SAN Francisco	**1010602** _	37 27 16.57733 N	122 06 37.48309 W	578679.16	4145676.561	-29.7404	2.8724
USGS SAN Francisco	**1010603** _	37 39 48.24857 N	122 07 23.10831 W	577342.0783	4168831.542	-23.147	9.3084
USGS SAN Francisco	**1010604** _	37 59 35.03464 N	122 03 44.26783 W	582336.5029	4205460.353	-26.203	5.8901
USGS SAN Francisco	**1010605** _	37 59 49.29391 N	122 45 33.01378 W	521145.0563	4205512.416	50.361	82.751

3 LiDAR Processing & Qualitative Assessment

3.1 Data Classification and Editing

LiDAR mass points were produced to LAS 1.2 specifications, including the following LAS classification codes:

- Class 1 = Unclassified, and used for all other features that do not fit into the Classes 2, 7, 9, or 10, including vegetation, buildings, etc.
- Class 2 = Ground, includes accurate LiDAR points in overlapping flight lines
- Class 7 = Noise, low and high points
- Class 9 = Water, points located within collected breaklines
- Class 10 = Ignored Ground due to breakline proximity.

The data was processed using GeoCue and TerraScan software. The initial step is the setup of the GeoCue project, which is done by importing project defined tile boundary index encompassing the entire project areas. The acquired 3D laser point clouds, in LAS binary format, were imported into the GeoCue project and divided into file size optimized tiles. Once tiled, the laser points were classified using a proprietary routine in TerraScan. This routine removes any obvious outliers from the dataset following which the ground layer is extracted from the point cloud. The ground extraction process encompassed in this routine takes place by building an iterative surface model.

This surface model is generated using three main parameters: building size, iteration angle and iteration distance. The initial model is based on low points being selected by a "roaming window" with the assumption is that these are the ground points. The size of this roaming window is determined by the building size parameter. The low points are triangulated and the remaining points are evaluated and subsequently added to the model if they meet the iteration angle and distance constraints. This process is repeated until no additional points are added within iterations. A second critical parameter is the maximum terrain angle constraint, which determines the maximum terrain angle allowed within the classification model.

Once the data has been auto-classified the LAS format 1.0 format points are converted to LAS 1.2 Point Data Record Format 1 and converted to the required ASPRS classification scheme (1=Unclassified,2=ground,7=noise/flyers) from Terrapoint Proprietary classification scheme.

The following fields within the LAS files are populated to the following precision: GPS Time (0.000001 second precision), Easting (0.01 foot precision), Northing (0.01 foot precision), Elevation (0.01 foot precision), Intensity (integer value - 12 bit dynamic range), Number of Returns (integer - range of 1-4), Return number (integer range of 1-4), Scan Direction Flag (integer - range 0-1), Classification (integer), Scan Angle Rank (integer), Edge of flight line (integer, range 0-1), User bit field (integer - flight line information encoded). The LAS file also contains a Variable length record in the file header.

Dewberry utilizes a variety of software suites for data processing. The LAS dataset was received and imported into GeoCue task management software and retiled into 1500 m by 1500 m tiles for processing in Terrascan. Each tile was imported into Terrascan and a surface model was created to examine the ground classification. Dewberry analysts visually reviewed the ground surface model and corrected errors in the ground classification such as vegetation, buildings, and bridges that were present following

the initial processing conducted by Terrapoint. Dewberry analysts employ 3D visualization techniques to view the point cloud at multiple angles and in profile to ensure that non-ground points are removed from the ground classification. After the ground classification corrections were completed, the dataset was processed through a water classification routine that utilizes breaklines compiled by Dewberry to automatically classify hydro features. The water classification routine selects ground points within the breakline polygons and automatically classifies them as class 9, water. The final classification routine applied to the dataset selects ground points within a specified distance of the water breaklines and classifies them as class 10, ignored ground due to breakline proximity.

3.2 Qualitative Assessment

Dewberry qualitative assessment utilizes a combination of statistical analysis and interpretative methodology to assess the quality of the data for a bare-earth digital terrain model (DTM). This process looks for anomalies in the data and also identifies areas where man-made structures or vegetation points may not have been classified properly to produce a bare-earth model.

Within this review of the LiDAR data, two fundamental questions were addressed:

- Did the LiDAR system perform to specifications?
- Did the vegetation removal process yield desirable results for the intended bare-earth terrain product?

Mapping standards today address the quality of data by quantitative methods. If the data are tested and found to be within the desired accuracy standard, then the data set is typically accepted. Now with the proliferation of LiDAR, new issues arise due to the vast amount of data. Unlike photogrammetrically-derived DEMs where point spacing can be eight meters or more, LiDAR nominal point spacing for this project is 1 point per .7 square meters. The end result is that millions of elevation points are measured to a level of accuracy previously unseen for traditional elevation mapping technologies and vegetated areas are measured that would be nearly impossible to survey by other means. The downside is that with millions of points, the dataset is statistically bound to have some errors both in the measurement process and in the artifact removal process.

As previously stated, the quantitative analysis addresses the quality of the data based on absolute accuracy. This accuracy is directly tied to the comparison of the discreet measurement of the survey checkpoints and that of the interpolated value within the three closest LiDAR points that constitute the vertices of a three-dimensional triangular face of the TIN. Therefore, the end result is that only a small sample of the LiDAR data is actually tested. However there is an increased level of confidence with LiDAR data due to the relative accuracy. This relative accuracy in turn is based on how well one LiDAR point "fits" in comparison to the next contiguous LiDAR measurement. Once the absolute and relative accuracy has been ascertained, the next stage is to address the cleanliness of the data for a bare-earth DTM.

By using survey checkpoints to compare the data, the absolute accuracy is verified, but this also allows us to understand if the artifact removal process was performed correctly. To reiterate the quantitative approach, if the LiDAR sensor operated correctly over open terrain areas, then it most likely operated correctly over the vegetated areas. This does not mean that the entire bare-earth was measured; only that the elevations surveyed are most likely accurate (including elevations of treetops, rooftops, etc.). In the event that the LiDAR pulse filtered through the vegetation and was able to measure the true surface (as well as measurements on the surrounding vegetation) then the level of accuracy of the vegetation removal process can be tested as a by-product.

To fully address the data for overall accuracy and quality, the level of cleanliness (or removal of above-ground artifacts) is paramount. Since there are currently no effective automated testing procedures to measure cleanliness, Dewberry employs a combination of statistical and visualization processes. This includes creating pseudo image products such as LiDAR orthos produced from the intensity returns, Triangular Irregular Network (TIN)'s, Digital Elevation Models (DEM) and 3-dimensional models. By creating multiple images and using overlay techniques, not only can potential errors be found, but Dewberry can also find where the data meets and exceeds expectations. This report will present representative examples where the LiDAR and post processing had issues as well as examples of where the LiDAR performed well.

3.3 Analysis

Dewberry utilizes GeoCue software as the primary geospatial process management system. GeoCue is a three tier, multi-user architecture that uses .NET technology from Microsoft. .NET technology provides the real-time notification system that updates users with real-time project status, regardless of who makes changes to project entities. GeoCue uses database technology for sorting project metadata. Dewberry uses Microsoft SQL Server as the database of choice. Specific analysis is conducted in Terrascan and QT Modeler environments.

Following the completion of LiDAR point classification, the Dewberry qualitative assessment process flow for the USGS San Francisco Coastal LiDAR project incorporated the following reviews:

1. *Format:* The LAS files are verified to meet project specifications. The LAS files for the USGS San Francisco Coastal LiDAR project conform to the specifications outlined below.

- Format, Echos, Intensity
    - LAS format 1.2, point data record format 1
    - Point data record format 1
    - Multiple returns (echos) per pulse
    - Intensity values populated for each point
- ASPRS classification scheme
    - Class 1 – unclassified
    - Class 2 – ground
    - Class 7 – Noise
    - Class 9 – Water
    - Class 10 – Ignored Ground due to breakline proximity
- Projection
    - Datum – North American Datum 1983
    - Projected Coordinate System – UTM Zone 10 N
    - Units – Meters
    - Vertical Datum – North American Vertical Datum 1988, Geoid 09
    - Vertical Units - Meters
- LAS header information:
    - Class (Integer)
    - GPS Week Time (0.0001 seconds)
    - Easting (0.01 foot)

- Northing (0.01 foot)
- Elevation (0.01 foot)
- Echo Number (Integer 1 to 4)
- Echo (Integer 1 to 4)
- Intensity (8 bit integer)
- Flight Line (Integer)
- Scan Angle (Integer degree)

2. *Data density, data voids:* The LAS files are used to produce Digital Elevation Models using the commercial software package "QT Modeler" which creates a 3-dimensional data model derived from Class 2 (ground points) in the LAS files. Grid spacing is based on the project density deliverable requirement for un-obscured areas. For the USGS San Francisco Coastal LiDAR project it is stipulated that the minimum post spacing in un-obscured areas should be 1 point per 1 square meter.

    a. Acceptable voids (areas with no LiDAR returns in the LAS files) that are present in the majority of LiDAR projects include voids caused by bodies of water. These are considered to be acceptable voids.

3. *Bare earth quality:* Dewberry reviewed the cleanliness of the bare earth to ensure the ground has correct definition, meets the project requirements, there is correct classification of points, and there are less than 5% residual artifacts.

3.4 Conclusion

The dataset conforms to project specifications for format and header values. The spatial projection information and classification of points is correct. Calibration issues identified in the dataset have been corrected. Minor artifacts and areas of aggressive classification are isolated and have minimal impact on the usability of the dataset.

4 Survey Vertical Accuracy Checkpoints

PT. #	NORTHING	EASTING	ELEVS.
	UTM Zone 10N, NAVD 88 M		
POINT ID	**NORTHING (M)**	**EASTING (M)**	**ELEVATION (M)**
pt282	4176230.19	555284.12	8.75
pt331	4172832.81	571315.71	1.9
pt342	4154568.21	581949.4	4.07
pt341	4154417.52	581104.78	1.8
pt283	4176055.13	555601.85	14.57
pt281	4176457.43	555341.35	2.03
pt353	4150895.26	569312.26	2.6
pt343	4154358.21	581923.6	13.12
pt333	4172860.55	571413.53	3.49
pt351	4150915.03	569402.77	2.11

pt352	4150884.26	569424.46	2.94
pt332	4172832.91	571463.89	2.94
pt102	4205339.73	501832.68	33.21
pt103	4205304.96	501492.34	64.1
pt104	4205255.43	501799.24	40.96
pt101	4205389.08	501936.66	1.8
pt361	4161372.898	543952.658	4.6
pt362	4161313.186	544081.105	2.83
pt363	4161396.902	544282.148	4.72
pt211	4220127.133	578855.212	1.6
pt212	4220388.325	578755.33	1.36
pt213	4220123.641	578680.611	1.62

Table 4: USGS San Francisco Coastal LiDAR surveyed accuracy checkpoints

5 LiDAR Vertical Accuracy Statistics & Analysis

5.1 Background

Dewberry tests and reviews project data both quantitatively (for accuracy) and qualitatively (for usability).

For qualitative assessment (i.e. vertical accuracy assessment), twenty-one (21) check points were surveyed for the project and are located within open terrain, marsh, and urban land cover categories. The survey established test points grouped in sites. Each site contains three test points in three land categories defined as marshlands, bare earth or short grass, and asphalt surfaces. Marshland is defined as bare earth surface below high water. A few marsh points could only be located in marsh grasses or about a meter above the high water line. The points were fundamental test points with a few exceptions of grasses in the marshes. Most of the test points on asphalt are located at a contrasting painted feature (see photos) to assist in assessing the horizontal accuracies of the lidar mapping. The sites were chosen to provide distribution, access to the shoreline, land categories, security for the survey activities, and in most cases control nearby for recovery of NAVD88. A survey report was produced which details and validates how the survey was completed for this project.

5.2 Vertical Accuracy Test Procedures

FVA (Fundamental Vertical Accuracy) is determined with check points located only in land cover category (1), open terrain (grass, dirt, sand, and/or rocks), where there is a very high probability that the LiDAR sensor will have detected the bare-earth ground surface and where random errors are expected to follow a normal error distribution. The FVA determines how well the calibrated LiDAR sensor performed. With a normal error distribution, the vertical accuracy at the 95% confidence level is computed as the vertical root mean square error (RMSEz) of the checkpoints x 1.9600. For the USGS San Francisco Coastal LiDAR project, vertical accuracy must be 18 cm or less based on an RMSEz of 9.25 cm x 1.9600.

CVA (Consolidated Vertical Accuracy) is determined with all checkpoints in all land cover categories combined where there is a possibility that the LiDAR sensor and post-processing may yield elevation errors that do not follow a normal error distribution. CVA at the 95% confidence level equals the 95th

percentile error for all checkpoints in all land cover categories combined. The USGS San Francisco Coastal LiDAR Project CVA standard is 36.3 cm at the 95% confidence level. The CVA is accompanied by a listing of the 5% outliers that are larger than the 95th percentile used to compute the CVA; these are always the largest outliers that may depart from a normal error distribution. Here, $Accuracy_z$ differs from CVA because $Accuracy_z$ assumes elevation errors follow a normal error distribution where RMSE procedures are valid, whereas CVA assumes LiDAR errors may not follow a normal error distribution in vegetated categories, making the RMSE process invalid.

Checkpoints were surveyed only in open terrain or urban terrain and used jointly to test the vertical accuracy of the project. Only urban and open terrain points were surveyed as these locations are going to give the best indication as to whether or not the LiDAR sensor performed correctly. The survey checkpoints were tested using both the RMSEz and 95th percentile method.

The relevant testing criteria are summarized in Table 5.

Quantitative Criteria	Measure of Acceptability
Consolidated Vertical Accuracy (CVA) in all land cover categories combined = 95% confidence lever	36.3 cm (based on combined 95th percentile)
Consolidated Vertical Accuracy (CVA) in all land cover categories combined using RMSEz *1.9600	18 cm (based on RMSEz * 1.9600)

Table 5 – Acceptance Criteria

5.3 Vertical Accuracy Testing Steps

The primary QA/QC vertical accuracy testing steps used by Dewberry are summarized as follows:

1. Dewberry's team surveyed QA/QC vertical checkpoints in accordance with the project's specifications. Figure 2 shows the location of the checkpoints.
2. Next, Dewberry interpolated the bare-earth LiDAR DTM to provide the z-value for each of the 21 checkpoints.
3. Dewberry then computed the associated z-value differences between the interpolated z-value from the LiDAR data and the ground truth survey checkpoints and computed CVA values.
4. The data were analyzed by Dewberry to assess the accuracy of the data. The review process examined the various accuracy parameters as defined by the scope of work. The overall descriptive statistics of each dataset were computed to assess any trends or anomalies. This report provides tables, graphs and figures to summarize and illustrate data quality.

Figure 9 shows the location of the QA/QC checkpoints within the project area.

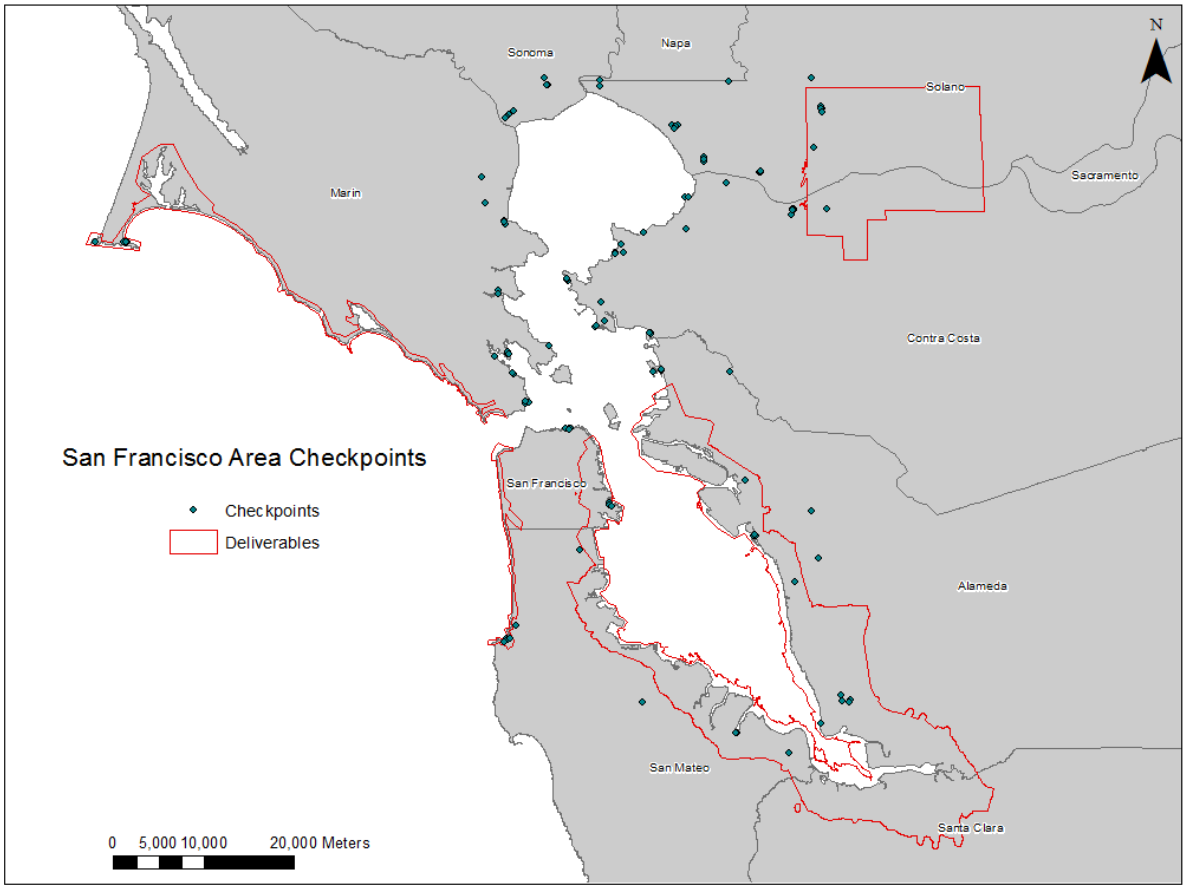


Figure 2: Location of QA/QC Checkpoints

5.4 Vertical Accuracy Results

Table 6 summarizes the tested vertical accuracy resulting from a comparison of the surveyed checkpoints to the elevation values present within the LiDAR LAS files.

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec= 18 cm	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec= 36.3 cm
Consolidated	21	11.76	9

Table 6 – FVA and CVA Vertical Accuracy at 95% Confidence Level

The $RMSE_z$ for all checkpoints (open terrain, marsh, and urban terrain) tested 6 cm, within the target criteria of 9.25 cm. Compared with the 18 cm specification, the FVA tested 11.7 cm at the 95% confidence level based on $RMSE_z$ x 1.9600.

Compared with the 36.3 cm specification, CVA for all checkpoints tested 9 cm at the 95% confidence level based on the 95th percentile.

Figure 10 illustrates the magnitude of the differences between the QA/QC checkpoints and LiDAR data. This shows that the majority of LiDAR elevations were within +/- 0.05 m of the checkpoints elevations.

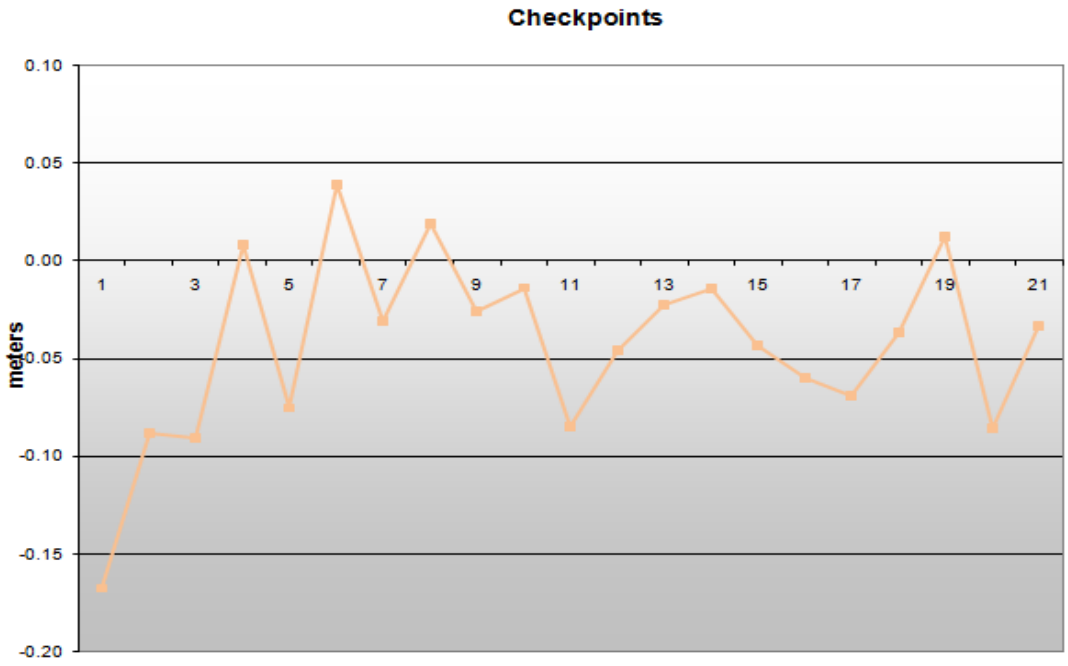


Figure 10 – Magnitude of Elevation Discrepancies

Table 7 provides overall descriptive statistics.

100 % of Totals	RMSE (m) Open Terrain Spec=0.0925 m	Mean (m)	Median (m)	Skew	Std Dev (m)	# of Points	Min (m)	Max (m)
Consolidated	0.06	-0.04	-0.04	-0.60	0.05	21	-0.17	0.04
Open Terrain	0.07	-0.06	-0.08	1.35	0.04	7	-0.09	0.02
Marsh	0.07	-0.04	-0.02	-1.86	0.06	7	-0.17	0.01
Urban	0.05	-0.03	-0.04	0.04	0.04	7	-0.09	0.04

Table 7: Overall Descriptive Statistics

5.5 Conclusion

Based on the vertical accuracy testing conducted by Dewberry, the LiDAR dataset for the USGS San Francisco Coastal LiDAR Project satisfies the project's pre-defined vertical accuracy criteria.

6 Breakline Production & Qualitative Assessment Report

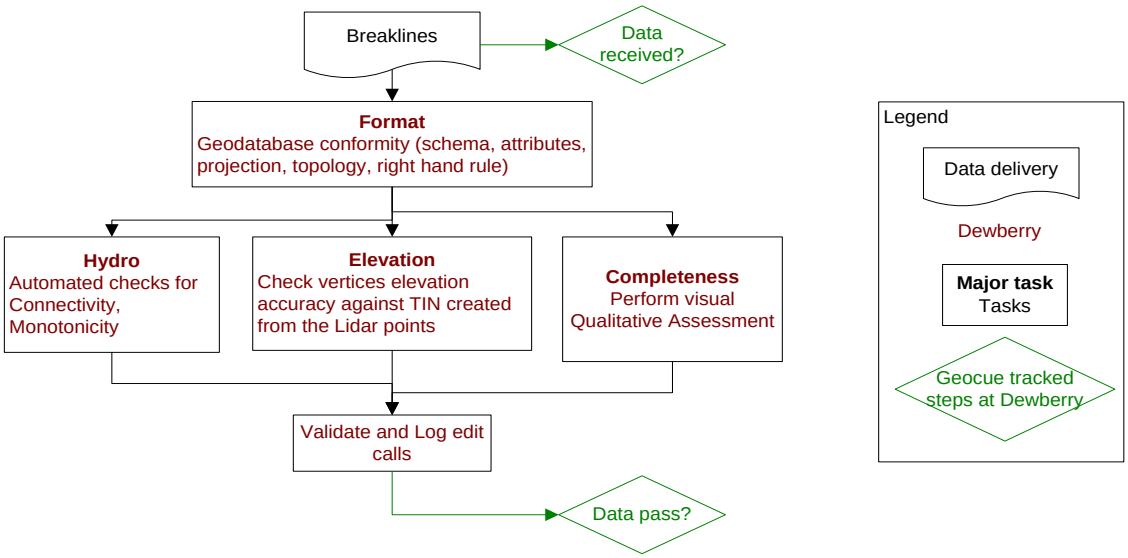
6.1 Breakline Production Methodology

Dewberry used GeoCue software to develop LiDAR stereo models of the USGS San Francisco Coastal LiDAR Project area so the LiDAR derived data could be viewed in 3-D stereo using Socet Set softcopy photogrammetric software. Using LiDARgrammetry procedures with LiDAR intensity imagery, Dewberry stereo-compiled the five types of hard breaklines in accordance with the project's Data Dictionary.

All drainage breaklines are monotonically enforced to show downhill flow. Water bodies are reviewed in stereo and the lowest elevation is applied to the entire waterbody. Tidally influenced features may not be entirely monotonic where affected by tidal differences between flight lines. Tidal differences between flight lines are not feathered but more accurately represent ground conditions by showing the abrupt changes that may occur in tidally influenced areas.

6.2 Breakline Qualitative Assessment

Dewberry completed breakline qualitative assessments according to a defined workflow. The following workflow diagram represents the steps taken by Dewberry to provide a thorough qualitative assessment of the breakline data.



6.3 Breakline Topology Rules

Automated checks are applied on hydro features to validate the 3D connectivity of the feature and the monotonicity of the hydrographic breaklines. Dewberry's major concern was that the hydrographic breaklines have a continuous flow downhill and that breaklines do not undulate. Error points are generated at each vertex not complying with the tested rules and these potential edit calls are then visually validated during the visual evaluation of the data. This step also helped validate that breakline vertices did not have excessive minimum or maximum elevations and that elevations are consistent with adjacent vertex elevations.

The next step is to compare the elevation of the breakline vertices against the elevation extracted from the ESRI Terrain built from the LiDAR ground points, keeping in mind that a discrepancy is expected because of the hydro-enforcement applied to the breaklines and because of the interpolated imagery used to acquire the breaklines. A given tolerance is used to validate if the elevations do not differ too much from the LiDAR.

Dewberry's final check for the breaklines was to perform a full qualitative analysis. Dewberry compared the breaklines against LiDAR intensity images to ensure breaklines were captured in the required locations. The quality control steps taken by Dewberry are outlined in the QA Checklist below.

6.4 Breakline QA/QC Checklist

Project Number/Description: TO G10PD00524 USGS San Francisco Coastal LiDAR

Date:_____03/04/2011____

Note: All three feature classes for San Francisco will be delivered as polygons. Boxes can be checked when done by right clicking on them and going to properties, and changing the default value to checked.

Overview

☒ All Feature Classes are present in GDB

☒ All features have been loaded into the geodatabase correctly. Ensure feature classes with subtypes are domained correctly.

☒ The breakline topology inside of the geodatabase has been validated. See Data Dictionary for specific rules

☒ Projection/coordinate system of GDB is accurate with project specifications

Perform Completeness check on breaklines using either intensity or ortho imagery

☒ Check entire dataset for missing features that were not captured, but should be to meet baseline specifications or for consistency (See Data Dictionary for specific collection rules). NHD data will be used to help evaluate completeness of collected hydrographic features. Features should be collected consistently across tile bounds within a dataset as well as be collected consistently between datasets.

☒ Check to make sure breaklines are compiled to correct tile grid boundary and there is full coverage without overlap

☒ Check to make sure breaklines are correctly edge-matched to adjoining datasets if applicable. Ensure breaklines from one dataset join breaklines from another dataset that are coded the same

and all connecting vertices between the two datasets match in X,Y, and Z (elevation). There should be no breaklines abruptly ending at dataset boundaries and no discrepancies of Z-elevation in overlapping vertices between datasets.

Compare Breakline Z elevations to LiDAR elevations

☒ Using a terrain created from LiDAR ground points and water points and GeoFIRM tools, drape breaklines on terrain to compare Z values. Breakline elevations should be at or below the elevations of the immediately surrounding terrain. Z value differences should generally be limited to within 1 FT. This should be performed before other breakline checks are completed.

Perform automated data checks using PLTS

The following data checks are performed utilizing ESRI's PLTS extension. These checks allow automated validation of 100% of the data. Error records can either be written to a table for future correction, or browsed for immediate correction. PLTS checks should always be performed on the full dataset.

☒ Perform "adjacent vertex elevation change check" on the Inland Ponds feature class (Elevation Difference Tolerance=.001 feet). This check will return Waterbodies whose vertices are not all identical. This tool is found under "Z Value Checks."

☒ Perform "unnecessary polygon boundaries check" on Tidal Waters, Inland Ponds, and Inland Streams feature classes. This tool is found under "Topology Checks."

☒ Perform "duplicate geometry check" on (tidal waters to tidal waters), (inland streams to inland streams), (inland ponds to inland ponds), (tidal waters to inland streams), (tidal waters to inland ponds), (inland ponds to inland streams). Attributes do not need to be checked during this tool. This tool is found under "Duplicate Geometry Checks."

☒ Perform "geometry on geometry check" on (tidal waters to inland streams), (tidal waters to inland ponds), (inland ponds to inland streams). Spatial relationship is contains, attributes do not need to be checked. This tool is found under "Feature on Feature Checks."

☒ Perform "polygon overlap/gap is sliver check" on (tidal waters to tidal waters), (inland streams to inland streams), (inland ponds to inland ponds), (tidal waters to inland streams), (tidal waters to inland ponds), (inland ponds to inland streams). Maximum Polygon Area is not required. This tool is found under "Feature on Feature Checks."

Perform Dewberry Proprietary Tool Checks

☒ Perform monotonicity check on inland streams features using "A3_checkMonotonicityStreamLines." This tool looks at line direction as well as elevation. Features in the output shapefile attributed with a "d" are correct monotonically, but were compiled from low elevation to high elevation. These errors can be ignored. Features in the output shapefile attributed with an "m" are not correct monotonically and need elevations to be corrected. Input features for this tool need to be in a geodatabase. Z tolerance is .01 feet. Polygons need to be exported as lines for the monotonicity tool.

☒ Perform connectivity check between (tidal waters to inland streams), (tidal waters to inland ponds), (inland ponds to inland streams) using the tool "07_CheckConnectivityForHydro." The input for this tool needs to be in a geodatabase. The output is a shapefile showing the location of overlapping vertices from the polygon features and polyline features that are at different Z-elevation. The unnecessary polygon boundary check must be run and all errors fixed prior to performing connectivity check. If there are exceptions to the polygon boundary rule then that feature class must be checked against itself, i.e. inland streams to inland streams.

Metadata

☒ Each XML file (1 per feature class) is error free as determined by the USGS MP tool

☒ Metadata content contains sufficient detail and all pertinent information regarding source materials, projections, datums, processing steps, etc. Content should be consistent across all feature classes.

Completion Comments: Complete – Approved

6.5 Data Dictionary

Dewberry®

LiDARgrammetry Data Dictionary & Stereo Compilation Rules

For the USGS San Francisco Coastal LiDAR –ARRA LiDAR Project

May 21, 2010

Table of Contents

HORIZONTAL AND VERTICAL DATUM

The horizontal datum shall be North American Datum of 1983 (Epoch 2009.00), Units in meters. The vertical datum shall be referenced to the North American Vertical Datum of 1988 (NAVD 88), Units in meters. Geoid09 shall be used to convert ellipsoidal heights to orthometric heights.

Coordinate System and Projection

All data shall be projected to UTM Zone 10N, Horizontal Units in meters and Vertical Units in meters.

Tidal Waters

Feature Dataset: BREAKLINES
Contains M Values: No
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: TIDAL_WATERS
Contains Z Values: Yes
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Feature Type: Polygon
Annotation Subclass: None

Description

This polygon feature class will outline the land / water interface at the time of LiDAR acquisition.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Definition	Capture Rules
TIDAL_WATERS	The coastal breakline will delineate the land water interface using LiDAR data as reference. In flight line boundary areas with tidal variation the coastal shoreline may show stair stepping as no feathering is allowed.	The feature shall be extracted at the apparent land/water interface, as determined by the LiDAR intensity data, to the extent of the tile boundaries. Differences caused by tidal variation are acceptable and breaklines delineated should reflect that change with no feathering. Breaklines must be captured at or just below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding LiDAR points. Acceptable variance in the negative direction will be defined for each project individually. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the

		water’s edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water. Breaklines shall snap and merge seamlessly with linear hydrographic features.

Inland Streams and Rivers

Feature Dataset: BREAKLINES
Contains M Values: No
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: STREAMS_AND_RIVERS
Contains Z Values: Yes
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Feature Type: Polygon
Annotation Subclass: None

Description

This polygon feature class will depict linear hydrographic features with a width greater than 100 feet.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Definition	Capture Rules
Streams and Rivers	Linear hydrographic features such as streams, rivers, canals, etc. with an average width greater than 100 feet in length. In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Other natural or manmade embankments will not qualify for this project.	Capture features showing dual line (one on each side of the feature). Average width shall be great than 100 feet to show as a double line. Each vertex placed should maintain vertical integrity and data is required to show "closed polygon". Generally both banks shall be collected to show consistent downhill flow. There are exceptions to this rule where a small branch or offshoot of the stream or river is present. The banks of the stream must be captured at the same elevation to ensure flatness of the water feature. If the elevation of the banks appears to be different see the task manager or PM for further guidance. Breaklines must be captured at or just below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding LiDAR points. Acceptable variance in the negative direction will be defined for each project individually. These instructions are only for docks or piers that follow the coastline or water's edge, not for

		docks or piers that extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water. Every effort should be made to avoid breaking a stream or river into segments. Dual line features shall break at road crossings (culverts). In areas where a bridge is present the dual line feature shall continue through the bridge. Islands: The double line stream shall be captured around an island if the features on either side of the island meet the criteria for capture. In this case a segmented polygon shall be used around the island in order to allow for the island feature to remain as a "hole" in the feature.

Inland Ponds and Lakes

Feature Dataset: BREAKLINES
Contains M Values: No
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: PONDS_AND_LAKES
Contains Z Values: Yes
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Feature Type: Polygon
Annotation Subclass: None

Description

This polygon feature class will depict closed water body features that are at a constant elevation.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Definition	Capture Rules
Ponds and Lakes	Land/Water boundaries of constant elevation water bodies such as lakes, reservoirs, ponds, etc. Features shall be defined as closed polygons and contain an elevation value that reflects the best estimate of the water elevation at the time of data capture. Water body features will be captured for features 2 acres in size or greater. "Donuts" will exist where there are islands within a closed water body feature greater than ½ acre in size.	Water bodies shall be captured as closed polygons with the water feature to the right. The compiler shall take care to ensure that the z-value remains consistent for all vertices placed on the water body. Breaklines must be captured at or just below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding LiDAR points. Acceptable variance in the negative direction will be defined for each project individually. An Island within a Closed Water Body Feature will also have a "donut polygon" compiled. These instructions are only for docks or piers that follow the coastline or water's edge, not for docks or piers that extend perpendicular from the land into the water. If it can be reasonably determined where the edge of water most probably falls, beneath the dock or

		pier, then the edge of water will be collected at the elevation of the water where it can be directly measured. If there is a clearly-indicated headwall or bulkhead adjacent to the dock or pier and it is evident that the waterline is most probably adjacent to the headwall or bulkhead, then the water line will follow the headwall or bulkhead at the elevation of the water where it can be directly measured. If there is no clear indication of the location of the water's edge beneath the dock or pier, then the edge of water will follow the outer edge of the dock or pier as it is adjacent to the water, at the measured elevation of the water.

Contact Information

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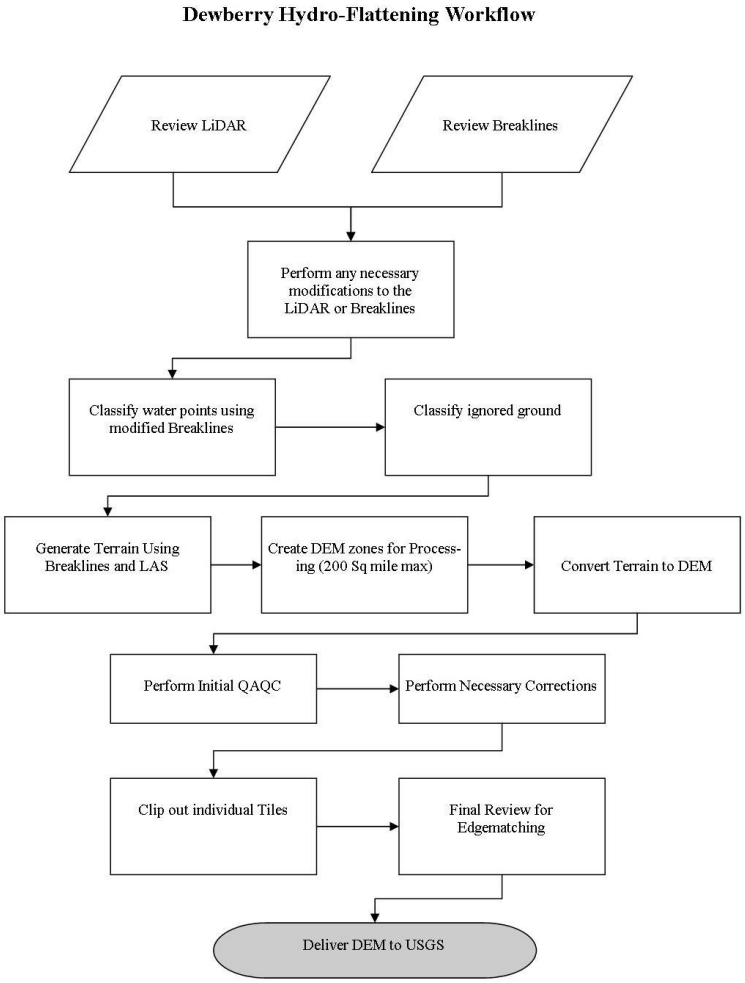
7 DEM Production & Qualitative Assessment

7.1 DEM Production Methodology

Dewberry's utilizes ESRI software and Global Mapper for the DEM production and QC process. ArcGIS software is used to generate the products and the QC is performed in both ArcGIS and Global Mapper.



1. Classify Water Points: LAS point falling within hydrographic breaklines shall be classified to ASPRS class 9 using TerraScan. Breaklines must be prepared correctly prior to performing this task.
2. Classify Ignored Ground Points: Classify points in close proximity to the breaklines from Ground to class 10 (Ignored Ground). Close proximity will be defined as ½ the nominal point spacing on either side of the breakline. Breaklines will be buffered using this specification and the subsequent file will need to be prepared in the same manner as the water breaklines for classification. This process will be performed after the water points have been classified and only run on remaining ground points.

3. Terrain Processing: A Terrain will be generated using the Breaklines and LAS data that has been imported into Arc as a Multipoint File. If the final DEMs are to be clipped to a project boundary that boundary will be used during the generation of the Terrain.
4. Create DEM Zones for Processing: Create DEM Zones that are buffered around the edges. Zones should be created in a logical manner to minimize the number of zones without creating zones too large for processing. Dewberry will make zones no larger than 200 square miles (taking into account that a DEM will fill in the entire extent not just where LiDAR is present). Once the first zone is created it must be verified against the tile grid to ensure that the cells line up perfectly with the tile grid edge.
5. Convert Terrain to Raster: Convert Terrain to raster using the DEM Zones created in step 6. In the environmental properties set the extents of the raster to the buffered Zone. For each subsequent zone, the first DEM will be utilized as the snap raster to ensure that zones consistently snap to one another.
6. Perform Initial QAQC on Zones: During the initial QA process anomalies will be identified and corrective polygons will be created.
7. Correct Issues on Zones: Corrections on zones will be performed following Dewberry's in-house correction process.
8. Extract Individual Tiles: Individual Tiles will be extracted from the zones utilizing the Dewberry created tool.
9. Final QA: Final QA will be performed on the dataset to ensure that tile boundaries are seamless.

7.2 DEM Qualitative Assessment

Dewberry performed a comprehensive qualitative assessment of the DEM deliverables to ensure that all tiled DEM products were delivered with the proper extents, were free of processing artifacts, and contained the proper referencing information. This process was performed in ArcGIS software with the use of a tool set Dewberry has developed to verify that the raster extents match those of the tile grid and contain the correct projection information. The DEM data was reviewed at a scale of 1:5000 to review for artifacts caused by the DEM generation process and to review the hydro-flattened features. To perform this review Dewberry creates HillShade models and overlays a partially transparent colorized elevation model to review for these issues. Upon completion of this review the DEM data is loaded into Global Mapper to ensure that all files are readable and that no artifacts exist between tiles.

7.3 DEM QA/QC Checklist

Project Number/Description: TO G10PD00524 USGS San Francisco Coastal LiDAR
Date:_____03/04/2011_____

Overview

☒ Correct number of files is delivered and all files are in ERDAS IMG format
☒ Verify Raster Extents
☒ Verify Projection/Coordinate System

Review

☒ Manually review bare-earth DEMs with a hillshade to check for issues with hydro-enforcement process or any general anomalies that may be present. Specifically, water should be flowing downhill, water features should NOT be floating above surrounding terrain and

bridges/box culverts should NOT be present in bare-earth DEM. Hydrologic breaklines should be overlaid during review of DEMs.

☒ Overlap points (in the event they are supplied to fill in gaps between adjacent flightlines) are not to be used to create the bare-earth DEMs

☒ DEM cell size is 2 meters

☒ Perform final overview in Global Mapper to ensure seamless product.

Metadata

☒ Project level DEM metadata XML file is error free as determined by the USGS MP tool

☒ Metadata content contains sufficient detail and all pertinent information regarding source materials, projections, datums, processing steps, etc.

Completion Comments: Complete - Approved