LIDAR REPORT

MISSISSIPPI AND ALABAMA COASTAL MAPPING

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT

CONTRACTOR: R&M CONSULTANTS, INC.
CONTRACT NO. W91278-04-D-0001/0003
EN PROJECT NO. C-05-054

Prepared By:
WOOLPERT, INC.
PROJECT NO. 64557

November 2005

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Section 1

SECTION 1: OVERVIEW

Introduction

The U.S. Army Corps of Engineers has a contract task order in place with Woolpert, Inc., through R&M Consultants, for the collection of GPS ground survey and airborne Light Detection and Ranging (LiDAR) for selected areas along the gulf coast of Alabama, Mississippi, and Louisiana. The U.S. Army Corps of Engineers requests permission to allow our contractor to perform the overflight/data acquisition where required as part of this tasking. The data is used to support the Corps mission in debris removal, 3D Modeling, Flood Study Analysis, etc. in coordination with, and in support of, other federal government agencies.

The Mississippi and Alabama Coastal Mapping project calls for the following:

- ✓ The LiDAR DEM was delivered as "first return", "last return", "bare earth", and "water" delivery in ASCII format.
- ✓ The LiDAR Intensity imagery was delivered in TIFF format (with associated world file) and MrSID format.

This report contains a review of the project requirements and detailed information for LiDAR data acquisition and quality control (QC) including:

- ✓ Documentation specifying altitude, airspeed, scan angle, scan rate, LiDAR pulse rates, and other flight and equipment information deemed appropriate

- ✓ A chart of position dilution of precision (PDOP)

- ✓ A LiDAR System Data Report

- ✓ A LiDAR Data Acquisition report

- ✓ A report for the airborne global positioning system (ABGPS) survey performed during the LiDAR mission

- ✓ A system calibration report

Project Area

The project area encompasses approximately 740 square miles of Hancock, Harrison, Jackson counties in Mississippi, and Mobile County in Alabama. The limits are from the land water interface (shoreline) to the north Right of Way of Interstate 10.

Project Requirements

General standards for the LiDAR mission include:

- ✓ High density LiDAR data acquisition within the project limits (see Figure A, Project Boundary/LiDAR Coverage) at a sufficient altitude and 1 meter average density to support digital terrain model (DTM) development with a vertical accuracy of 15 centimeters (NSSDA $RMSE_Z$) in flat and open areas (i.e. low grass, plowed fields, lawn, golf courses).

- ✓ Avoid inclement weather for flight missions.

- ✓ Choose a flight path that provides satisfactory coverage of the study area, including both parallel and enough cross flight lines to allow for proper quality control.

- ✓ Document flight mission date, time, flight altitude, airspeed, scan angle, scan rate, laser pulse rates and other information deemed pertinent.

Section 2

SECTION 2: LIDAR DATA ACQUISITION

This section provides an overview of the LiDAR acquisition methodology employed by Woolpert Inc. on the Mississippi and Alabama Coastal Mapping project. Typical LiDAR system parameters include:

- ✓ Altitude
- ✓ Airspeed
- ✓ Scan angle
- ✓ Scan rate
- ✓ Laser pulse repetition rate

Flight and equipment information is also included.

LiDAR Overview

LiDAR data was acquired across the project limits (see Figure A, Project Boundary/LiDAR Coverage) by Woolpert Inc for the USACE, Mobile District in September 2005 and October 2005 along the coastline of Hancock, Harrison, Jackson counties in Mississippi and Mobile County in Alabama from the land water interface (shoreline) to the north Right of Way of Interstate-10. The LiDAR DEM was delivered as "first return", "last return", "bare earth", and "water" delivery in ASCII format. The LiDAR Intensity imagery was delivered in TIFF format (with associated world file) and MrSID format. Contract Number: W91278-04-D-0001/0003 EN. Project Number: C-05-054. Contractor: R&M Consultants, Inc., Anchorage, AK. Subcontractor: Woolpert, Inc., Dayton, OH.

LiDAR Mission

The LiDAR data acquisition was executed in eight sessions, on September 19, September 20, September 21, October 3, October 4, October 5, October 8, October 9, 2005 using a Leica ALS50 LiDAR System. Specific details about the ALS50 system are included in Section 4 of this report.

The airborne GPS (ABGPS) base stations supporting the LiDAR acquisition was located in three areas, eastern area, central area, and western area, divided by mapping limit along coastline across Mississippi and Alabama. Dual Frequency data was logged continuously for the duration of each LiDAR flight mission at a one-second sampling rate. A table of control points for the LiDAR survey is included in Section 5 of this report.

The flight plan for LiDAR consisted of parallel flights in an east-west extent across eastern and central areas, and in a north-south extent across western area (see Figure B, LiDAR Flight Layout). One-hundred-fifteen (115) flight lines of LiDAR data were acquired in 8 sessions along the coast.

No significant problems were encountered during the LiDAR data acquisition phase of the project.

LiDAR Statistical Data

The LiDAR parameters are as follows:

Aircraft Speed:	130 knots indicated air speed
Flying Height:	3,000 feet above ground level
Scanner Field of View:	40 degrees
Scan Frequency:	36 Hertz
Pulse Repetition Rate:	52,300 Hertz

Data Acquisition Summary

Table 2.1 LiDAR Acquisition Log, Mississippi and Alabama Coastal Mapping Project.

Date	Julian Day	Lines	Base 1
9-19-05	26205	C16-C26	MOB Base 1
9-20-05	26305	A1-A18	Stennis
9-21-05	26405	A19-A44	Kiln
10-03-05	27605	B46-B78	MOB Base 2
10-04-05	27705	B1-B11, eastern B12-B24	Van RM 1
10-05-05	27805	Western B12-24, B25-B29, C15 (abort)	Van RM 1
10-08-05	28105	B30-B45, C10-C15	MOB Base 1
10-09-05	28205	C1-C9	MOB Base 2

Section 3

SECTION 3: PDOP INFORMATION

PDOP, the Positional Dilution of Precision, is a factor that describes the effects of satellite geometry on the accuracy of the airborne GPS solution. The geometric distribution of the satellites is measured relative to the locations of the receivers on the ground and in the aircraft. PDOP can be computed in advance, based on the approximate receiver locations and the predicted location of the satellite, which is called the satellite ephemeris.

Low PDOP numbers are preferable; the higher the PDOP number, the weaker the geometric quality of solution between the satellite, aircraft and reference receivers.

Woolpert's goal is to maintain a final PDOP of 2.5 or less during all LiDAR acquisition missions. Satellite geometry and the resultant PDOP levels are dynamic, changing with the position of the aircraft. Occasionally, one satellite in the network will drop below the horizon, breaking its connection to the receiver, and the PDOP level will spike above 2.5 momentarily. Small deviations of this type are accounted for during post-processing of the data through the use of Kalman filtering. If PDOP in the aircraft rises above 2.5 for a significant time period, the survey is usually stopped until the geometry improves.

The following table contains the average PDOP and distance separation between the aircraft and base station for each LiDAR acquisition mission.

Table 3.1. Mississippi and Alabama Coastal Mapping Project LiDAR Report, PDOP

Date	Base Station	PDOP	Dist. Separation, KM
9-19-05	MOB Base 1	2.2	35
9-20-05	Stennis	2.5	20
9-21-05	Kiln	2.4	30
10-03-05	MOB Base 2	2.4	30
10-04-05	Van RM 1	2.3	35
10-05-05	Van RM 1	2.5	35
10-08-05	MOB Base 1	2.3	45
10-09-05	MOB Base 2	2.2	30

Section 4

SECTION 4: LIDAR SYSTEM DATA REPORT

The LiDAR data was acquired using an ALS50 onboard a Cessna T404. The ALS50 LiDAR system, developed by Leica Geosystems of Boston, Massachusetts, includes the simultaneous first, intermediate and last pulse data capture module, the extended altitude range module, and the target signal intensity capture module. The system software is operated on a P-400 Diagnostic System Laptop Computer aboard the aircraft.

The ALS50 LiDAR System has the following specifications:

Nominal	
Operating Altitude	400 – 3,000 meters
Elevation accuracy	15cm single shot
Range Resolution	1 cm
Scan angle	Variable from 0 to 75°
Swath width	Variable from 0 to 1.5 X altitude
Angle resolution	0.01°
Scan frequency	Variable based on scan angle
Horizontal Accuracy	Better than 1/2000 X altitude
Supported GPS receivers	Ashtech Z12, Trimble 7400, Novatel Millenium
Laser repetition rate	58 kHz
Beam divergence	0.3 mrads
Laser classification	Class IV laser product (FDA CFR 21)
Eye safe range	400m single shot depending on laser repetition rate
Power requirements	28 VDC @ 25A
Operating temperature	10-35°C
Humidity	0-95% non-condensing

Figure C-1 and C-8 contain images of the LiDAR flight logs.

Section 5

SECTION 5: REPORT FOR AIRBORNE GPS SURVEY DURING LIDAR MISSION

Introduction

Woolpert performed ABGPS surveying during the LiDAR mission to derive the flight trajectory at a 1-second interval. ABGPS is a critical factor in LiDAR data collection. As such, we spent considerable time developing flight windows around the satellite constellation. We also developed multiple base stations to provide redundancy and to reduce ionospheric and atmospheric errors due to distance separation between the aircraft and the base stations.

At a minimum, two base stations were in operation for every LiDAR acquisition session, operating at a 1-second sampling rate.

To provide a common base line with the aerial photography, all base stations were located over photography control points (see Ground Control Report). Final adjusted control point values were used to process the LiDAR data. Using the same reference system for LiDAR and photography helps provide close correlation between photography and LiDAR. The survey report includes extensive data about the procedures and results for the ground control survey.

As a continuing quality control measure, data was downloaded each evening in the field to verify a strong GPS solution and then refined in-house to determine final trajectories.

A base-station control survey was performed to provide uniformity and to ensure consistency between the ground control and Airborne GPS. All ground control surveys were performed to achieve accuracies which meets criteria for LiDAR Mapping outlined in the "Guidelines and Specifications for Flood Hazard Mapping Partners" as published in February 2002.

Project Team

Woolpert Inc survey and flight crews were responsible for the successful completion of this LiDAR project. The airborne GPS survey was conducted with exceptional coordination between the Woolpert survey crews and the flight crews.

Weather

LiDAR acquisition occurred when the cloud ceiling was at least 5,500 feet above ground level (AGL) and there was no rain or thick haze (visibility less than 4 miles).

Datum Reference

The datums used for this project include the North American Datum of 1983 High Accuracy Reference Network (NAD83/HARN) and the North American Vertical Datum (NAVD88). The coordinates are based on the UTM, zone 16, and the units of measure are in meter. LiDAR points are later translated into Geographic NAD83/HARN horizontal and NAVD88 vertical in the units of meters.

Field Work

The Woolpert flight and survey crews coordinated twice daily to review weather, flight schedules and GPS base station locations. Flights were generally performed in sequence, except when outside factors interfered, such as controlled burns or localized clouds. Once the day's schedule was determined, field crews set receivers in relation to the appropriate base stations. Flight and ground crews were in constant communication during data acquisition sessions through air-to-ground radios; if ground crews saw developing problems, such as high PDOP levels, they would alert the flight crew.

At the close of each day's data acquisition session, the flight and ground crews would meet at the field office to download data from receivers, recharge batteries, process and quality check the data, and prepare data backups. By the end of each day, the field crews were ready for the next day and the first-level quality control was complete. LiDAR data was also downloaded and initial processing steps were completed to check for any voids in the data. For example, if the plane encounters windy conditions, gaps in data between flight lines may result.

Airborne Control Stations

Seven (7) NGS monumental control points was used as a base-station during the LiDAR survey.

Station	Ellipsoid Height(meters)	Latitude (deg min sec)	Longitude (Deg min sec)
Kiln	-13.007	N30 25 08.90571	W 089 27 01.30237
Stennis	-22.581	N 30 22 23.16202	W 089 27 10.92706
Van RM 1	9.436	N 30 35 22.43950	W 088 43 18.15487
Bridge Reset	-24.699	N 30 24 38.14109	W 088 50 29.88759
MOB Base 1	37.326	N 30 40 55.11650	W 088 14 56.15580
MOB Base 2	37.201	N 30 40 55.09518	W 088 14 57.98743
CODEN	-24.160	N 30 23 02.27242	W 088 14 26.13402

Equipment

Woolpert owns all the equipment used for the ground control and ABGPS missions. Two base-station units were mobilized every day during the LiDAR mission, and were operated by a member of the Woolpert survey crew. Each base-station setup consisted of one Trimble Navigation R7 dual frequency geodetic receiver with Zephyr geodetic antenna, one 2-meter fixed-height tripod, and essential battery power and cabling. The aircraft is configured with a Novatel Millennium 12-channel, dual frequency GPS receiver to support LiDAR acquisition missions.

Data Processing

All initial airborne data was processed using the Waypoint Consulting, Inc. GrafNav^{TM} software. Data was gathered and processed at a one-second data capture rate. All data was recorded at an elevation mask of 10 degrees.

Airborne GPS Data

GPS base station log sheets are included in Ground Control Survey Report.

Section 6

SECTION 6: DATA PROCESSING AND QUALITY CONTROL

LiDAR Data Processing

In this process, Woolpert employed GPS differential processing and Kalman filtering techniques to derive an aircraft trajectory solution at 0.5-second intervals for each base station within the project limits. Statistics for each solution (base station) were generated and studied for quality. The goal for each solution is to have:

- maintained satellite lock throughout the session
- position standard deviation of less than 5 centimeters
- low ionospheric noise
- few or no cycle slips
- a fixed integer ambiguity solution throughout the trajectory
- a maximum number of satellites for a given constellation
- a low (2.5 or less) Position Dilution of Precision (PDOP)

Often times a solution for a given base station will meet all of the above parameters in certain portions of the trajectory while the other base station might meet the above conditions in different portions of the trajectory solution. In this case, further processing was done to form different combinations of base station solutions and/or satellites to arrive at the optimal trajectory.

When the calibration, data acquisition, and GPS processing phases were complete, the formal data reduction process began. Woolpert LiDAR specialists:

- ✓ Studied individual flight lines and how these lines match adjacent flight lines to ensure the accuracy meets expectations.

- ✓ Identified and removed systematic error locally (by flight) which is not possible if the lines are combined into a block. This is sometimes the case when a satellite loss of lock occurs during a flight and the GPS solution fixes on the wrong integer ambiguity.

- ✓ Adjusted any small residual error (due to system noise) between flight lines and across all flight lines to survey ground control (or existing mapping if available).

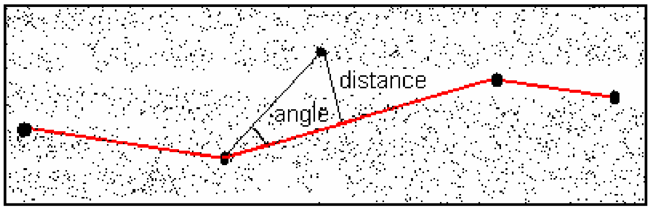
- ✓ Clipped the overlap region of each flight line to obtain a single homogenous coverage across the project area. This eliminated redundant, overlapping point data that could overwhelm terrain modeling software packages.

- ✓ Processed individual flight lines to derive “Point Cloud.”

  Given the airborne GPS aircraft trajectory and the raw LiDAR data subdivided by flight lines, we used manufacturer software to reduce raw information to a LiDAR point cloud on the ground. Woolpert has developed proprietary software to generate parameter files, allowing the manufacturer’s software to process a block; this allows us to batch process any number of flight lines. As part of this process, outliers in the data are removed. Typical outlying data points are a result of returns from clouds.

- ✓ Classified the point cloud data into ground and non-ground points

The classification algorithm classifies ground points by iteratively building a triangulated surface model. The routine starts by selecting some local low points as sure hits on the ground then builds an initial Triangulated Irregular Network (TIN) from selected low points. The routine then starts developing the ground model upward by iteratively adding new laser points to it. Each added point makes the model follow the ground surface more closely. Two iteration parameters, iteration angle and iteration distance, determine how close a point must be to a triangle plane so that the point can be accepted to the ground model. **Iteration angle** is the maximum angle between points, its projection on triangle plane and closest triangle vertex. **Iteration distance** parameter makes sure that the iteration does not make big jumps upwards when triangles are large. This helps to keep low buildings out of the ground model.



The vegetation and buildings are removed to obtain bare-earth. Even in areas covered by dense vegetation, ground points are correctly classified.

- ✓ Filtered the bare-earth data to remove small undulations.

Small random errors exist in the data due to electronic noise within the system. These errors manifest themselves as small undulations in the data. Woolpert developed a software application based on a Laplacian of Gaussian (LOG) operator modified to fit LiDAR data and remove small undulations. The filter controls accuracy by an elevation tolerance setting to meet a given accuracy threshold. The tolerance determines the maximum allowable elevation change of laser points. We developed a data structure suitable for LiDAR so that the searching routine is very fast [O(1)] computational complexity] making this algorithm quite efficient.

- ✓ Edge matched individual flight lines, generated statistics on the fit, and clipped the flight lines to butt match each other.

The next step in our process is to clip individual flight lines such that adjacent flight lines butt match and a homogenous LiDAR coverage is provided across the entire mapping limit, without overlap. A software routine was developed to follow the overlap region between two adjacent flight lines and place a “cut line” in the middle of the overlap region. The software will also generate statistics along each seamline as to how well each flight matches with its neighbor in flight.

If all flights are consistent within the mapping specifications, cross flight and ground control data is imported and studied for fit. As a QC measure, Woolpert has developed software to generate accuracy statistical reports by comparison among LiDAR points, ground control, and TINs generated by LiDAR points. The absolute accuracy is determined by comparison with ground control. Statistical analysis is then performed on the fit between the LiDAR data and the ground control. Based on the statistical analysis, the LiDAR data is then adjusted in relation to the ground control.

- ✓ Water removal and data QC.

This step requires LiDAR technicians visually go through all tiles to remove points on water from ground layer to water layer, and to remove any bridges and buildings remaining in ground layer to default layer.

✓ Generate LiDAR intensity images.

LiDAR intensity images in GeoTIFF format are generated from all layers of LiDAR points in tile sized pieces. A MrSID image is made from TIFF images.

✓ Translated the Data Into the Appropriate Map Projection

Once all of the data has been reduced and quality controlled, the bare-earth data is translated into the final map projection. Note that the airborne GPS aircraft trajectory is processed in the target datums in relation to the orthometric height. Woolpert used National Geodetic Survey's GEOID03 software to derive the orthometric height.

The raw LiDAR point cloud data is derived in UTM coordinates. All subsequent processing is carried out in this projection to avoid introducing errors associated with and moving across larger scale map projection zones. The data is translated into the target map projection through the Tralaine software package, a coordinate system converter. The entire transformation is generally setup and run in a batch mode.

As a quality control step, the orthometric heights are compared against ground survey results. In our experience, GEOID03 is sometimes inaccurate in certain areas of the country. If a problem is detected, we will have to acquire additional ground control that will allow us to calculate our own transformation by determining the rotation matrix.

Section 7

SECTION 7: ALS50 SYSTEM CALIBRATION REPORT

Introduction

This Woolpert ALS50 LiDAR System Calibration Report shall be used to represent confirmation of the LiDAR system specifications, performance, and requirements. The system functionality, elevation, and horizontal accuracy performance shall be demonstrated for calibration purposes.

This report contains various test results and information pertaining to the system. It should be noted that all numbers shown in this report are in **meters** unless otherwise stated. All coordinates stated in the report are in the WGS84 coordinate system with ellipsoidal elevation.

System Model Number:	ALS50
Client Name:	U.S. Army Corps of Engineers, Mobile District
Calibration Date	October 18, 2005
Report Prepared By:	Qian Xiao

System Specifications and Requirements

The ALS50 LiDAR system, built by Leica Geosystems for Woolpert Inc, has the following specifications:

Nominal	
Operating Altitude	400 – 3,000 meters
Elevation accuracy	15cm single shot
Range Resolution	1 cm
Scan angle	Variable from 0 to 75°
Swath width	Variable from 0 to 1.5 X altitude
Angle resolution	0.01°
Scan frequency	Variable based on scan angle
Horizontal Accuracy	Better than 1/2000 X altitude
Supported GPS receivers	Ashtech Z12, Trimble 7400, Novatel Millenium
Laser repetition rate	58 kHz
Beam divergence	0.3 mrads
Laser classification	Class IV laser product (FDA CFR 21)
Eye safe range	400m single shot depending on laser repetition rate
Power requirements	28 VDC @ 25A
Operating temperature	10-35°C
Humidity	0-95% non-condensing

On Site Antenna Offsets and Location

Aircraft GPS Antenna

The following measurements were calculated for Woolpert's aircraft N404CP equipped with LiDAR. The POS/AV and ALS50 processing numbers were calculated from internal measurements completed in Leica's lab, and the positioning of the GPS antenna on the aircraft was field surveyed by Woolpert using a total station.

Reference Point to GPS Antenna	
X	**0.646 m**
Y	**0.014 m**
Z	**-1.304 m**

The following measurements were calculated in the lab at Leica and will remain constant.

User to IMU Lever Arm (POS/AV)	
X	**-0.269 m**
Y	**0.139 m**
Z	**-0.017 m**

Base Station GPS Antenna

Monument Description:	
GPS Receiver Type: Trimble 4700 Antenna Type: Trimble	Epoch Interval: 1 sec Elevation Mask: 10 degrees Observation Type: Static
Station Names used in processing the acceptance data: #1: COLB N 39 57 35.11261 Lat. W 083 02 44.74737 Long. 186.57 Ellipsoidal. HI. #2: Woolpert N 39 45 56.36709 Lat. W 84 11 12.26236 Long. 194.775 Ellipsoidal. HI.	

Flight Calibration Methodology

Data Collection

To accomplish the formal calibration, Woolpert has established calibration ranges consisting of an airport runway, buildings, and parking lots. The calibration range has been ground surveyed to an accuracy of better than 1 cm. Four flight lines with two different altitude and opposing headings (see figure 7-3) are required in order to capture pitch, roll, heading (see figure 7-1) and torsion errors (see figure 7-2).

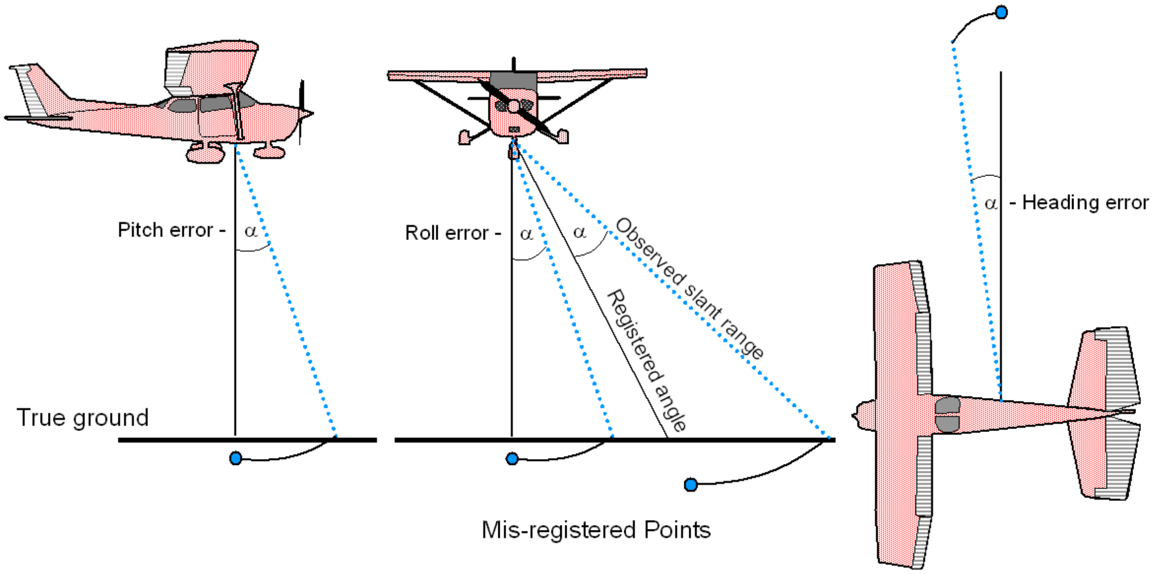


Figure 7-1: Misalignment Errors.

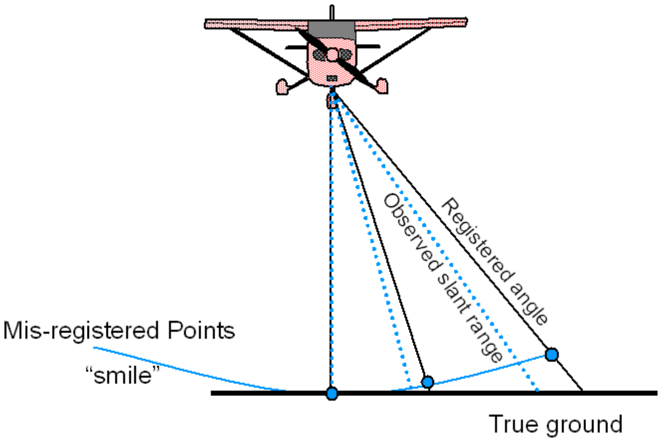


Figure 7-2: Torsion Error

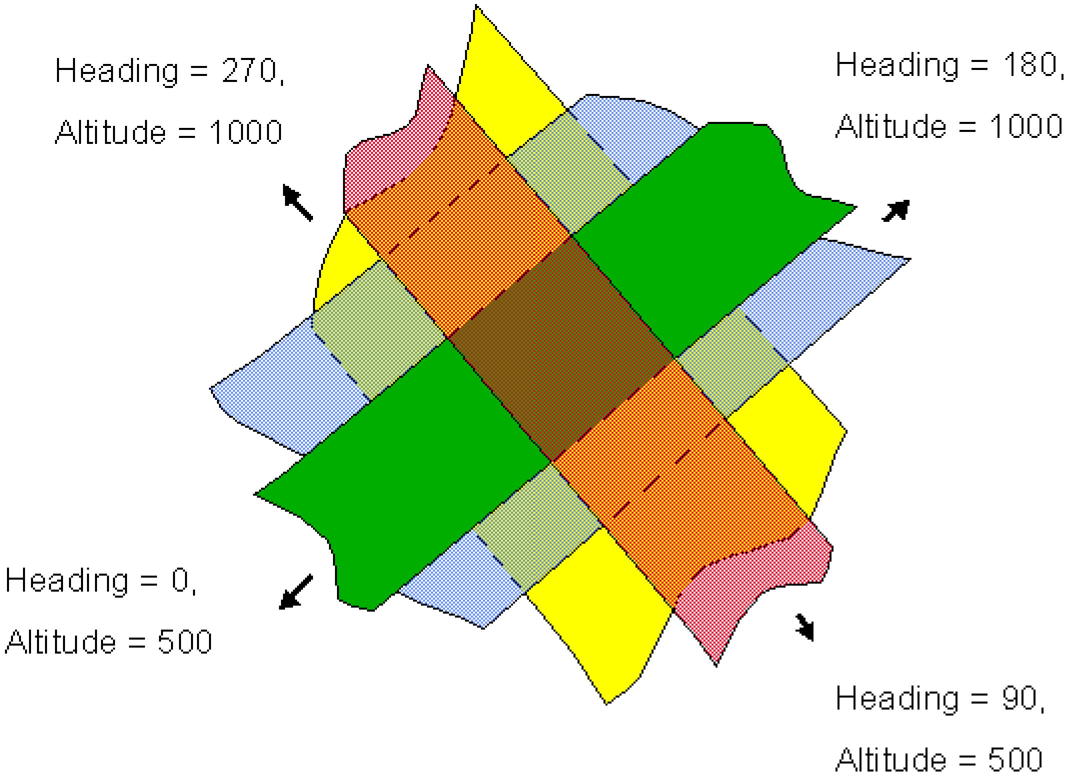


Figure 7-3: Optimal Flight Pattern for Calibration

Intensity Images

Four images from LiDAR intensity reflectance are generated in order to pick up tie points (see figure 7-4). A least square adjustment (LSA) is performed using AutoBoresighting software provided by system manufacturer. Pitch, roll, heading, and torsion errors are calculated by LSA.

Figure 7-4: Ortho photo generated from LiDAR intensity reflectance.

Ground Control Points

Ground control points were collected along and across an airport runway. A total of 116 runway points were surveyed. The LiDAR collects scan data over the control points and the data is then used to determine the absolute Z accuracy of the system. The distribution of the runway points can be found in Figure 7.5.

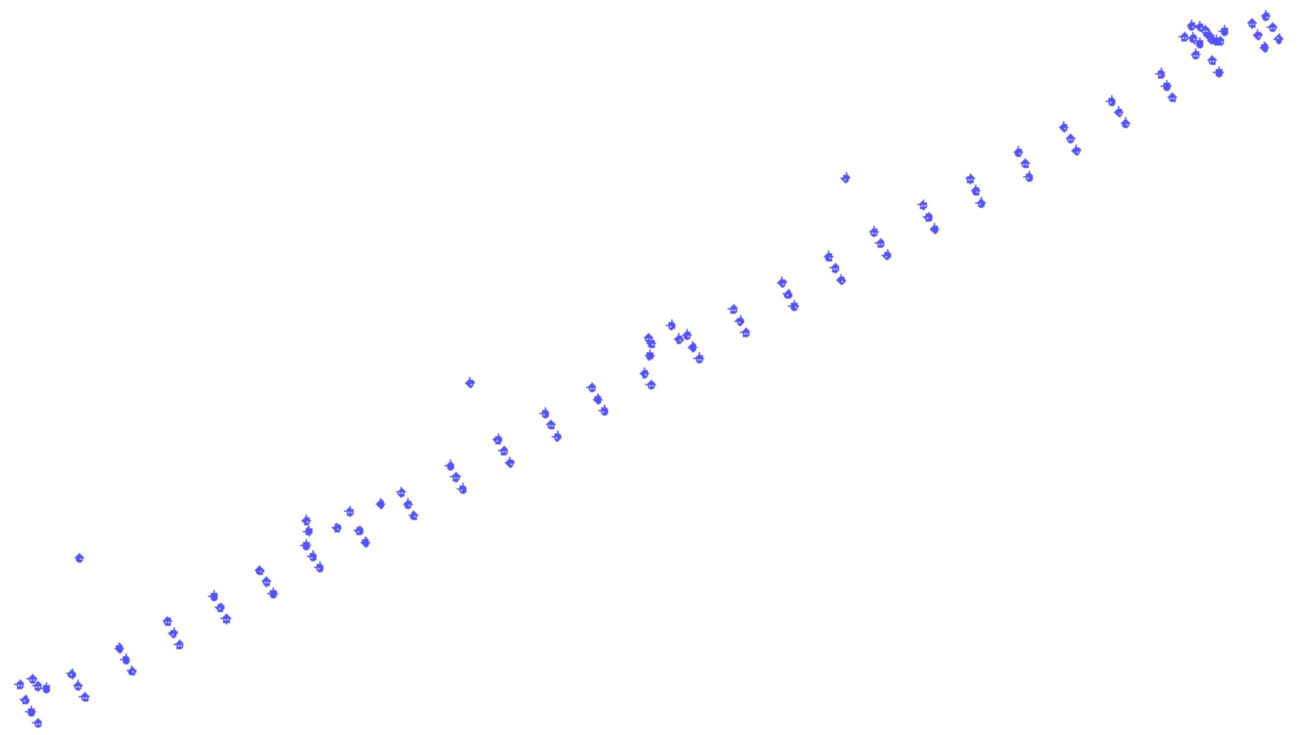


Figure 7-5: Ground control points on the runway

Flight over Ground Control Points

Flight lines, flown parallel and perpendicular to the runway control points, were used to determine the elevation (Z) error of the LiDAR data as well as pitch, roll, heading, and torsion can be seen in Figure 7-6. Each day the runway was flown, multiple overlapping strips were performed to assure that most control points were covered and to increase the likelihood that a laser point would strike within 0.5 meters of a control point.

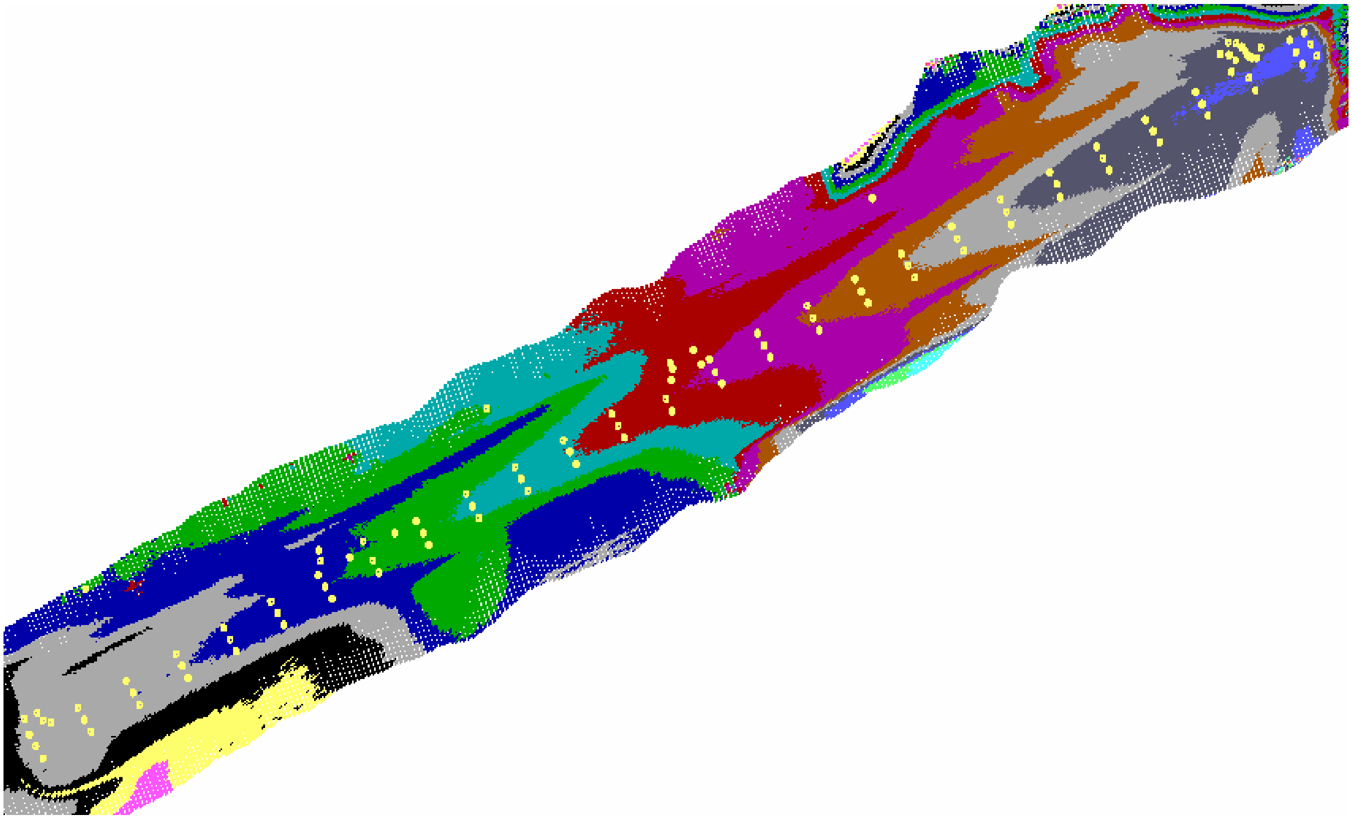


Figure 7-6: One flight line parallel to the runway ground control points. The flight line is color coded at one-meter elevation intervals. The LiDAR data was collected at about 500 meters AGL.

CALIBRATION RESULTS

Calibration Flight Summary

The following report summarizes the results of the calibration flights and error analysis.

Table 1 indicates the analysis of the LiDAR data when compared with ground truth data. The LiDAR specification stipulates that position accuracy should have a one-sigma (σ) value of 1/2000 times altitude (68% of all the values considered must be equal to or less than the σ-value). The elevation accuracy should have a one-sigma (σ) value of 15 cm.

Table 1. LiDAR Performance Accuracy

Flight	Base Station Used	Calibration Attribute	Standard Deviation	Mean Difference from Target	RMS	# of Points Evaluated	Elevation Flown (m AGL)
Day 29105	COLB	Elevation	0.015 m	-0.002 m	0.015	990387	900

Note: For Z calculations, all points are compared against existing DTM.

The error analysis between the ground truth elevation points and the LiDAR data can be seen in Table 1. The results of this analysis produced better elevation accuracy than one-sigma (σ) value of 15 cm. All comparisons fell within the required specifications.

Besides calibration over Woolpert calibration site, on-site calibration using data acquired for project was performed to calibrate pitch, roll, heading, and latency in a relative orientation way. This kind of calibration is employed to ensure relative accuracy.

Intensity based range correction was performed over a site with various surface types and known elevations. An intensity based range correction table was calculated based on statistics of measurements. This table was used for point cloud reduction.

Final Calibration Parameters

The following numbers were derived by Leica through lab calibration, and from data acquired on Woolpert's LiDAR calibration site as well as from data for the project.

Parameter	Value	Format
Lab fixed parameters		
Range 1 Correction	2.400 m	0.000
Range 2 Correction	2.400 m	0.000
Encoder Latency	0.00 mcr sec	0.00
Ticks Per Revolution	8401818 ticks	0000000
Attitude		
*Roll (radian)	0.041013671	0.0000
*Pitch (radian)	-0.002854899	0.0000
*Heading (radian)	0.001416112	0.0000
*Scan angle correct	-12613 ticks	00000
Mechanic		
*Torsion (no unit)	-85000 units	0000

* Value calibrated on site from calibration data

Based on the analysis of the LiDAR data the accuracy of the system meets the required specifications.

Approved By:			
Title	**Name**	**Signature**	**Date**
LiDAR Specialist	**Qian Xiao**		**November 4, 2005**

Figure A

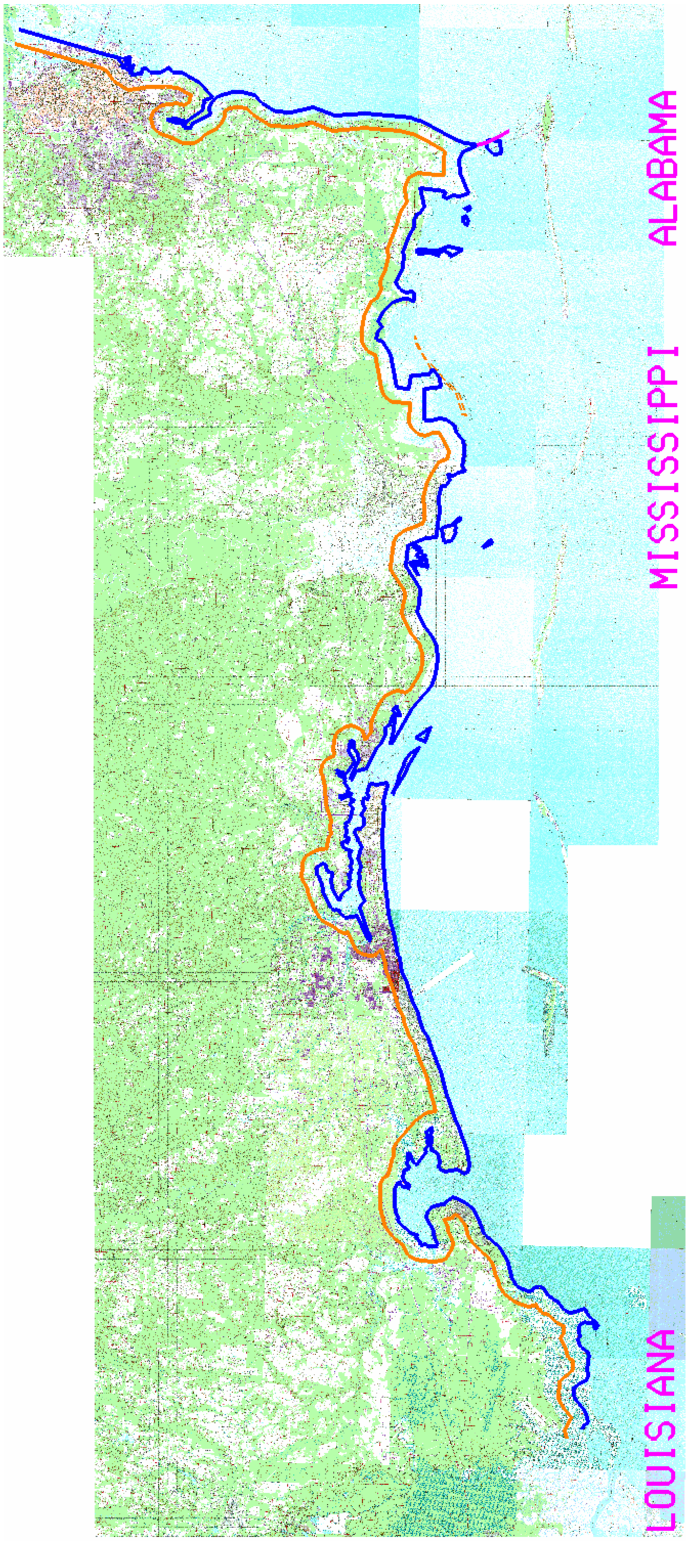


Figure A – Project Boundary/LiDAR Coverage

Figure B

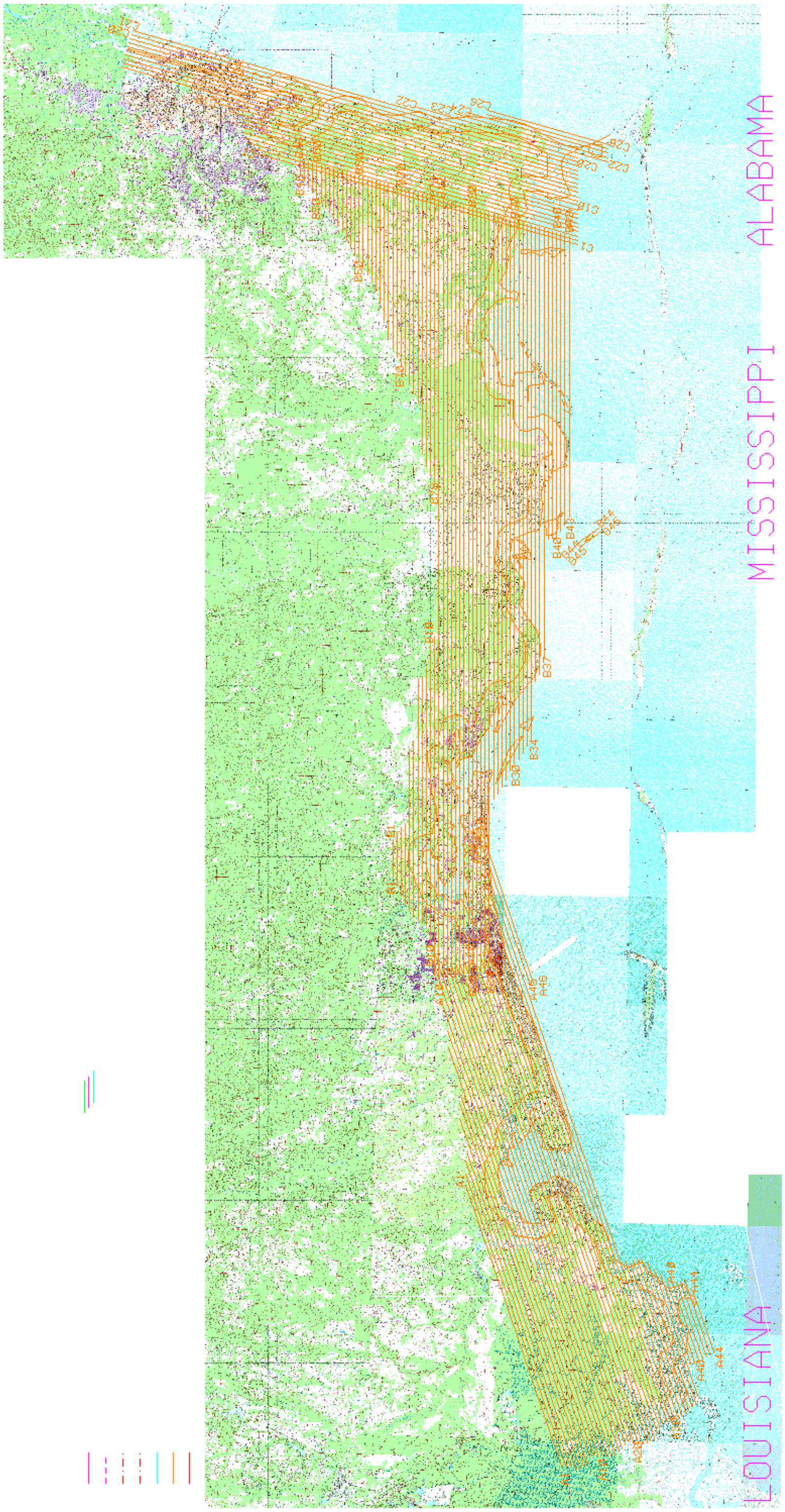
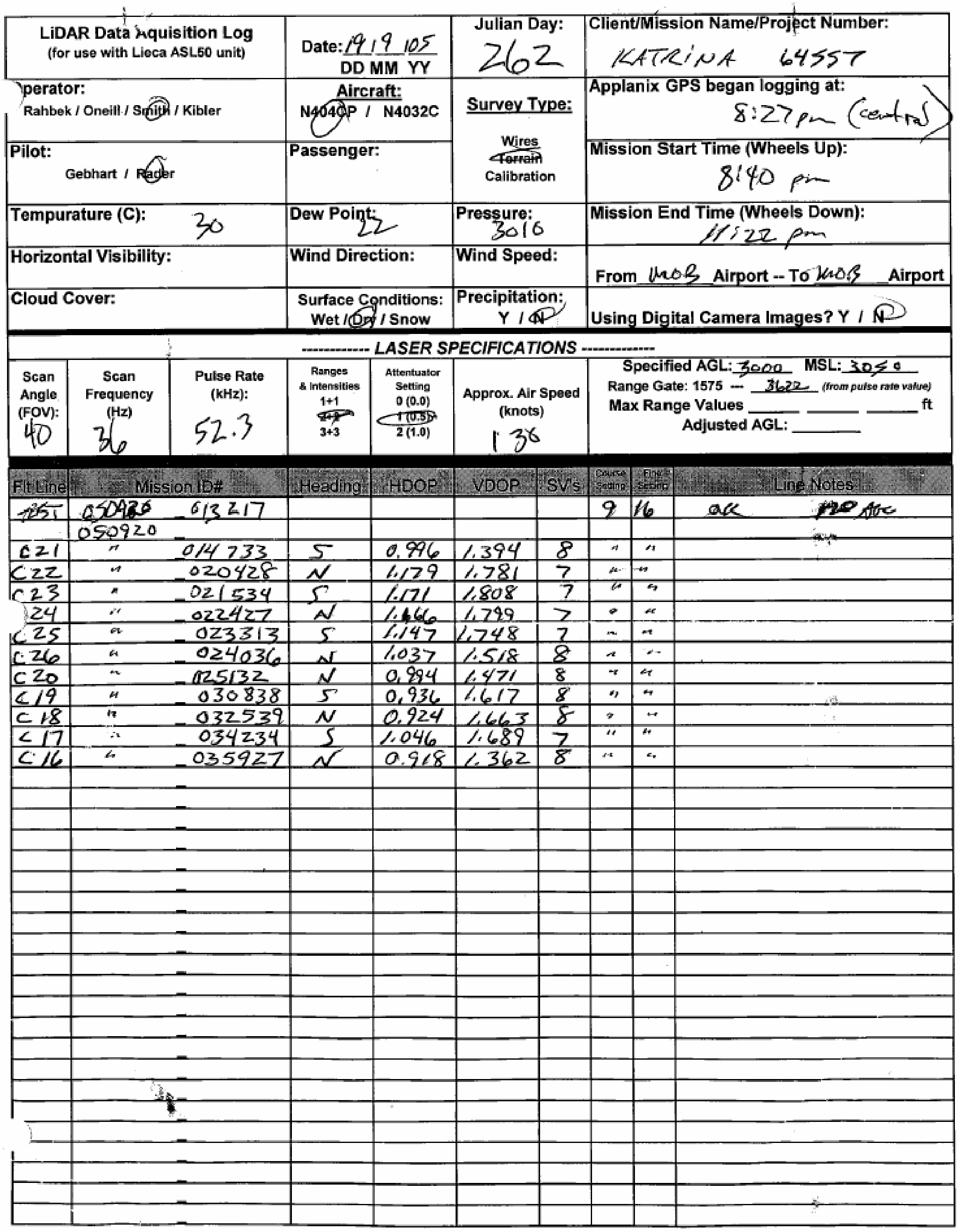


Figure B–LiDAR Coverage

Figure C



LiDAR Data Aquisition Log (for use with Lieca ASL50 unit)	Date: 19/9/05 DD MM YY	Julian Day: 262	Client/Mission Name/Project Number: KATRINA 64557
Operator: Rahbek / Oneill / [✓ Smith] / Kibler	Aircraft: [✓ N404CP] / N4032C	Survey Type: Wires ~~Terrain~~ Calibration	Applanix GPS began logging at: 8:27 pm (central)
Pilot: Gebhart / [✓ Rader]	Passenger:		Mission Start Time (Wheels Up): 8:40 pm
Tempurature (C): 30	Dew Point: 22	Pressure: 3016	Mission End Time (Wheels Down): 11:22 pm
Horizontal Visibility:	Wind Direction:	Wind Speed:	From MOB Airport -- To MOB Airport
Cloud Cover:	Surface Conditions: Wet / [✓ Dry] / Snow	Precipitation: Y / [✓ N]	Using Digital Camera Images? Y / [✓ N]

------------ *LASER SPECIFICATIONS* -------------

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & Intensities	Attentuator Setting	Approx. Air Speed (knots)	
40	36	52.3	1+1 ~~2+2~~ 3+3	0 (0.0) [✓ ~~1 (0.5)~~] 2 (1.0)	136	Specified AGL: 3000 MSL: 3050 Range Gate: 1575 --- 3622 *(from pulse rate value)* Max Range Values ______ ______ ______ ft Adjusted AGL: ________

Flt Line	Mission ID#	Heading	HDOP	VDOP	SV's	Course Setting	Fine Setting	Line Notes
~~[illegible]~~	~~050920~~ _613217					9	16	ok [illegible]
	050920 _							
C21	" 014733	S	0.996	1.394	8	"	"	
C22	" _020428	N	1.179	1.781	7	"	"	
C23	" _021534	S	1.171	1.808	7	"	"	
24	" _022427	N	1.666	1.799	7	"	"	
C25	" _023313	S	1.147	1.748	7	"	"	
C26	" _024036	N	1.037	1.518	8	"	"	
C20	" _025132	N	0.994	1.471	8	"	"	
C19	" _030838	S	0.936	1.617	8	"	"	
C18	" _032539	N	0.924	1.663	8	"	"	
C17	" _034234	S	1.046	1.689	7	"	"	
C16	" _035927	N	0.918	1.362	8	"	"	
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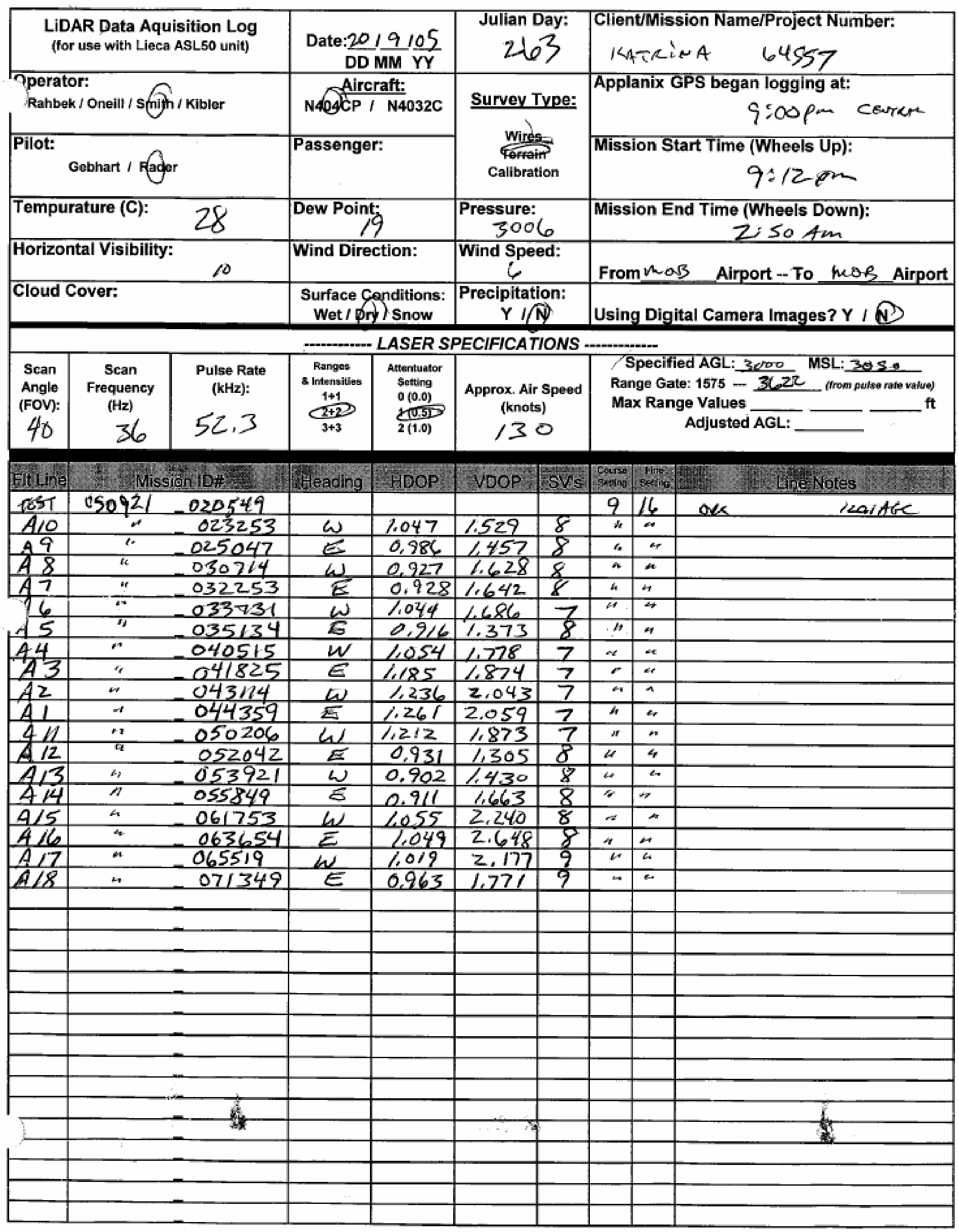
Figure C.1 – LiDAR Flight Log



LiDAR Data Aquisition Log
(for use with Lieca ASL50 unit)

Date: 20 / 9 / 05
DD MM YY

Julian Day: 263

Client/Mission Name/Project Number: KATRINA 64557

Operator: Rahbek / Oneill / [✓ Smith] / Kibler

Aircraft: [✓ N404CP] / N4032C

Survey Type: Wires / ~~Terrain~~ / Calibration

Applanix GPS began logging at: 9:00pm CENTRAL

Pilot: Gebhart / [✓ Rader]

Passenger:

Mission Start Time (Wheels Up): 9:12pm

Tempurature (C): 28

Dew Point: 19

Pressure: 3006

Mission End Time (Wheels Down): 2:50 Am

Horizontal Visibility: 10

Wind Direction:

Wind Speed: 6

From MOB Airport -- To MOB Airport

Cloud Cover:

Surface Conditions: Wet / [✓ Dry] / Snow

Precipitation: Y / [✓ N]

Using Digital Camera Images? Y / [✓ N]

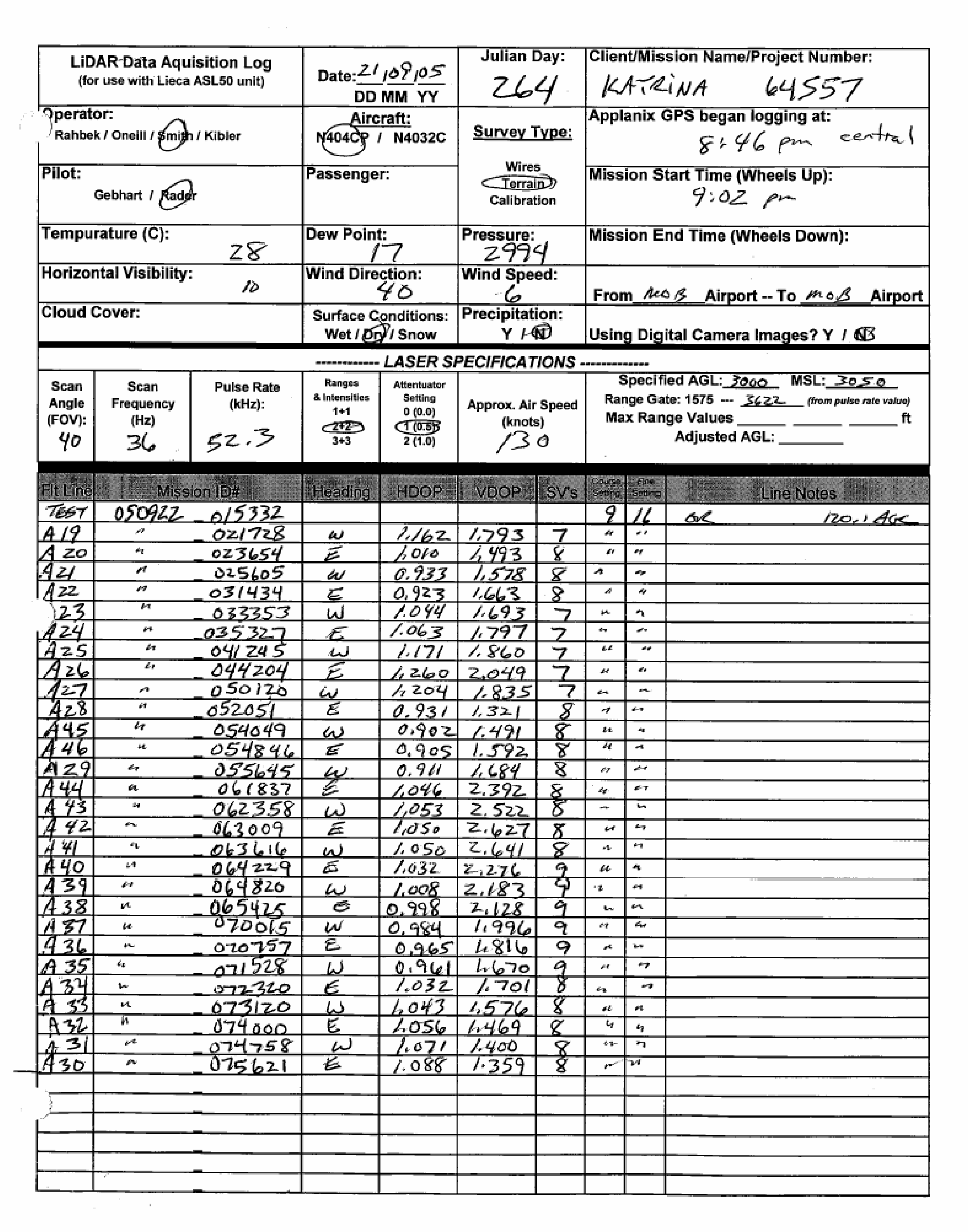
------------ *LASER SPECIFICATIONS* -------------

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & Intensities	Attentuator Setting	Approx. Air Speed (knots)
40	36	52.3	1+1 [✓ 2+2] 3+3	0 (0.0) [✓ 1 (0.5)] 2 (1.0)	130

Specified AGL: 3000 MSL: 3050
Range Gate: 1575 --- 3622 *(from pulse rate value)*
Max Range Values ______ ______ ______ ft
Adjusted AGL: ________

Flt Line	Mission ID#	Heading	HDOP	VDOP	SV's	Course Setting	Fine Setting	Line Notes
TEST	050921_020549					9	16	OK 1201AGC
A10	" _023253	W	1.047	1.529	8	"	"	
A9	" _025047	E	0.986	1.457	8	"	"	
A8	" _030714	W	0.927	1.628	8	"	"	
A7	" _032253	E	0.928	1.642	8	"	"	
A6	" _033731	W	1.044	1.686	7	"	"	
A5	" _035134	E	0.916	1.373	8	"	"	
A4	" _040515	W	1.054	1.778	7	"	"	
A3	" _041825	E	1.185	1.874	7	"	"	
A2	" _043114	W	1.236	2.043	7	"	"	
A1	" _044359	E	1.261	2.059	7	"	"	
A11	" _050206	W	1.212	1.873	7	"	"	
A12	" _052042	E	0.931	1.305	8	"	"	
A13	" _053921	W	0.902	1.430	8	"	"	
A14	" _055849	E	0.911	1.663	8	"	"	
A15	" _061753	W	1.055	2.240	8	"	"	
A16	" _063654	E	1.049	2.648	8	"	"	
A17	" _065519	W	1.019	2.177	9	"	"	
A18	" _071349	E	0.963	1.771	9	"	"	

Figure C.2 – LiDAR Flight Log



LiDAR Data Aquisition Log
(for use with Lieca ASL50 unit)

Date: 21/09/05
DD MM YY

Julian Day: 264

Client/Mission Name/Project Number: KATRINA 64557

Operator: Rahbek / Oneill / [✓ Smith] / Kibler

Aircraft: [✓ N404CP] / N4032C

Survey Type: Wires / [✓ Terrain] / Calibration

Applanix GPS began logging at: 8:46 pm central

Pilot: Gebhart / [✓ Rader]

Passenger:

Mission Start Time (Wheels Up): 9:02 pm

Tempurature (C): 28

Dew Point: 17

Pressure: 2994

Mission End Time (Wheels Down):

Horizontal Visibility: 10

Wind Direction: 40

Wind Speed: 6

From MOB Airport -- To MOB Airport

Cloud Cover:

Surface Conditions: Wet / [✓ Dry] / Snow

Precipitation: Y / [✓ N]

Using Digital Camera Images? Y / [✓ N]

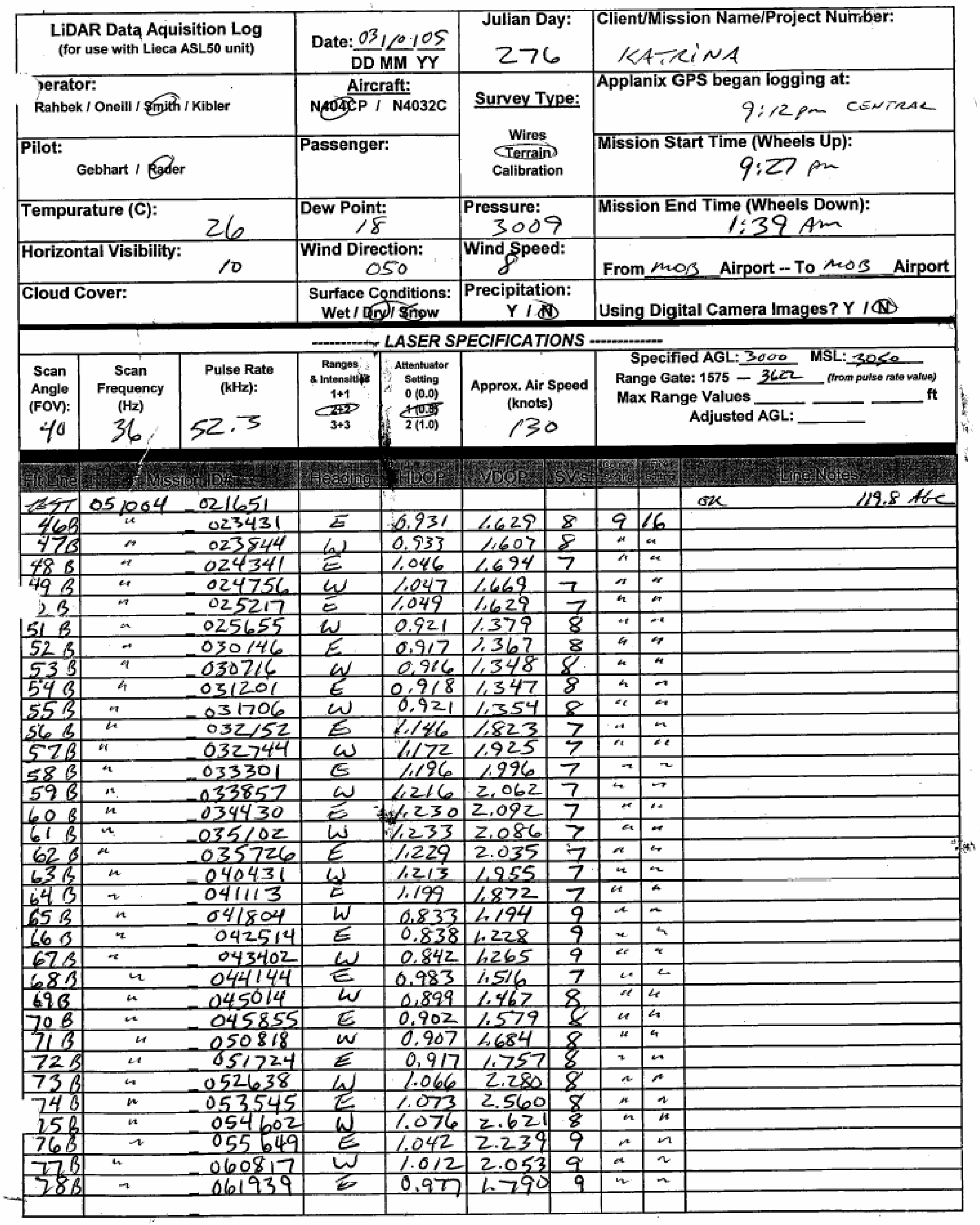
------------ ***LASER SPECIFICATIONS*** ------------

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & Intensities	Attentuator Setting	Approx. Air Speed (knots)
40	36	52.3	1+1 [✓ 2+2] 3+3	0 (0.0) [✓ 1 (0.5)] 2 (1.0)	130

Specified AGL: 3000 MSL: 3050
Range Gate: 1575 --- 3622 *(from pulse rate value)*
Max Range Values ______ ______ ______ ft
Adjusted AGL: ________

Flt Line	Mission ID#	Heading	HDOP	VDOP	SV's	Course Setting	Fine Setting	Line Notes
TEST	050922 _015332					9	16	OK 120.1 AGL
A19	" _021728	W	1.162	1,793	7	"	"	
A20	" _023654	E	1,010	1,493	8	"	"	
A21	" _025605	W	0.933	1,578	8	"	"	
A22	" _031434	E	0,923	1,663	8	"	"	
A23	" _033353	W	1.044	1,693	7	"	"	
A24	" _035327	E	1.063	1,797	7	"	"	
A25	" _041245	W	1.171	1.860	7	"	"	
A26	" _044204	E	1,260	2,049	7	"	"	
A27	" _050120	W	1,204	1.835	7	"	"	
A28	" _052051	E	0.931	1,321	8	"	"	
A45	" _054049	W	0,902	1.491	8	"	"	
A46	" _054846	E	0,905	1.592	8	"	"	
A29	" _055645	W	0.911	1,684	8	"	"	
A44	" _061837	E	1,046	2,392	8	"	"	
A43	" _062358	W	1,053	2.522	8	"	"	
A42	" _063009	E	1,050	2,627	8	"	"	
A41	" _063616	W	1.050	2,641	8	"	"	
A40	" _064229	E	1,032	2,276	9	"	"	
A39	" _064820	W	1,008	2,183	9	"	"	
A38	" _065425	E	0,998	2,128	9	"	"	
A37	" _070015	W	0,984	1,996	9	"	"	
A36	" _070757	E	0,965	1.816	9	"	"	
A35	" _071528	W	0,961	1.670	9	"	"	
A34	" _072320	E	1.032	1.701	8	"	"	
A33	" _073120	W	1,043	1,576	8	"	"	
A32	" _074000	E	1,056	1,469	8	"	"	
A31	" _074758	W	1.071	1.400	8	"	"	
A30	" _075621	E	1.088	1.359	8	"	"	
	_							
	_							
	_							
	_							
	_							
	_							
	_							

Figure C.3 – LiDAR Flight Log



LiDAR Data Aquisition Log
(for use with Lieca ASL50 unit)

Date: 03/10/05
DD MM YY

Julian Day: 276

Client/Mission Name/Project Number: KATRINA

erator: Rahbek / Oneill / [✓ Smith] / Kibler

Aircraft: [✓ N404CP] / N4032C

Survey Type: Wires / [✓ Terrain] / Calibration

Applanix GPS began logging at: 9:12 pm CENTRAL

Pilot: Gebhart / [✓ Rader]

Passenger:

Mission Start Time (Wheels Up): 9:27 pm

Tempurature (C): 26

Dew Point: 18

Pressure: 3009

Mission End Time (Wheels Down): 1:39 Am

Horizontal Visibility: 10

Wind Direction: 050

Wind Speed: 8

From MOB Airport -- To MOB Airport

Cloud Cover:

Surface Conditions: Wet / [✓ Dry] / Snow

Precipitation: Y / [✓ N]

Using Digital Camera Images? Y / [✓ N]

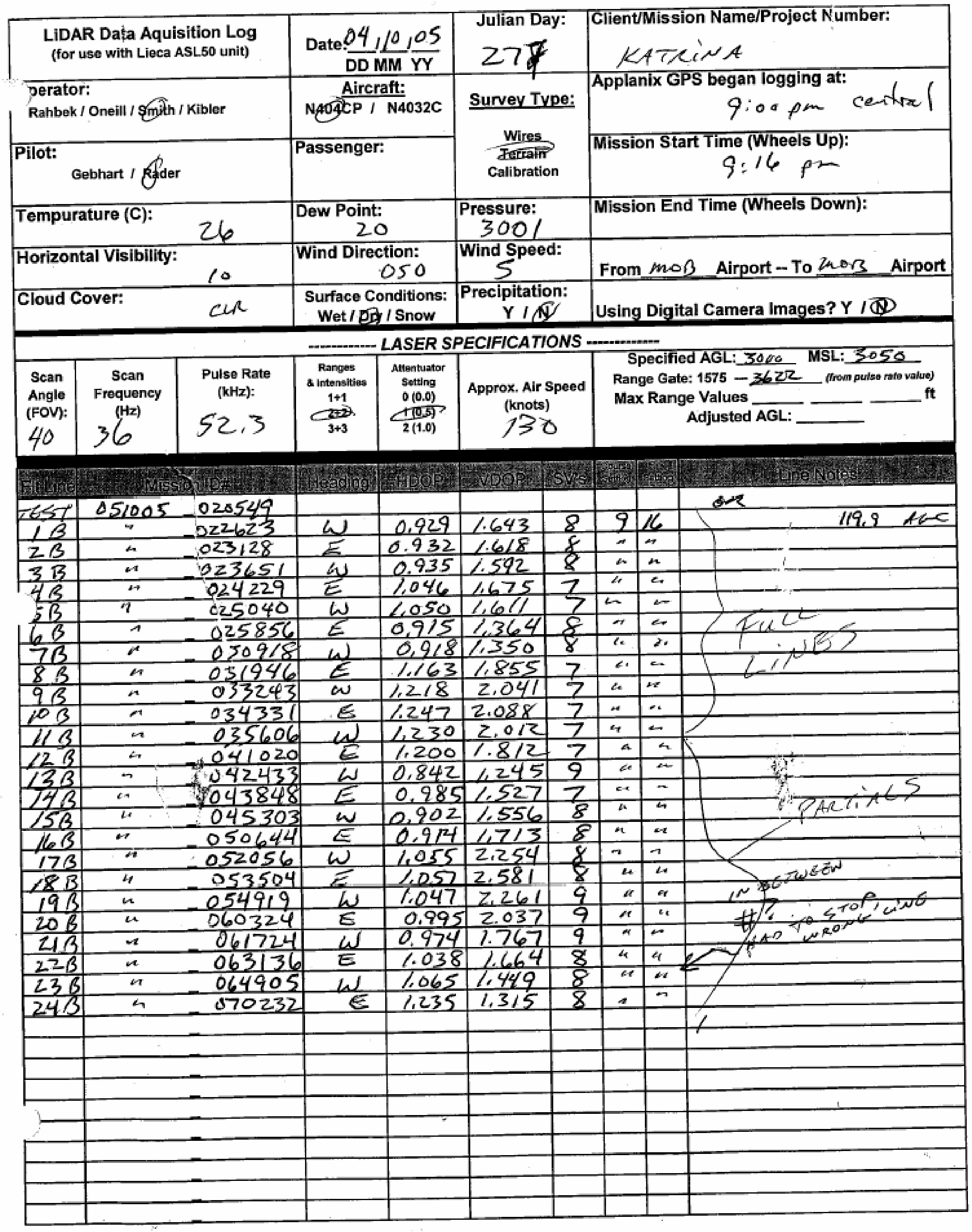
LASER SPECIFICATIONS

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & Intensities	Attenuator Setting	Approx. Air Speed (knots)
40	36	52.3	1+1 [✓ 2+2] 3+3	0 (0.0) [✓ 1 (0.5)] 2 (1.0)	130

Specified AGL: 3000 MSL: 3050
Range Gate: 1575 — 3622 (from pulse rate value)
Max Range Values ______ ______ ______ ft
Adjusted AGL: ________

Flt Line	Mission ID#		Heading	HDOP	VDOP	SV's	[illegible]	[illegible]	Line Notes
TEST	051004	021651							OK 119.8 Abc
46B	"	023431	E	0.931	1.629	8	9	16	
47B	"	023844	W	0.933	1.607	8	"	"	
48 B	"	024341	E	1.046	1.694	7	"	"	
49 B	"	024756	W	1.047	1.669	7	"	"	
2 B	"	025217	E	1.049	1.629	7	"	"	
51 B	"	025655	W	0.921	1.379	8	"	"	
52 B	"	030146	E	0.917	1.367	8	"	"	
53 B	"	030716	W	0.916	1.348	8	"	"	
54 B	"	031201	E	0.918	1.347	8	"	"	
55 B	"	031706	W	0.921	1.354	8	"	"	
56 B	"	032152	E	1.146	1.823	7	"	"	
57B	"	032744	W	1.172	1.925	7	"	"	
58 B	"	033301	E	1.196	1.996	7	"	"	
59 B	"	033857	W	1.216	2.062	7	"	"	
60 B	"	034430	E	1.230	2.092	7	"	"	
61 B	"	035102	W	1.233	2.086	7	"	"	
62 B	"	035726	E	1.229	2.035	7	"	"	
63B	"	040431	W	1.213	1.955	7	"	"	
64 B	"	041113	E	1.199	1.872	7	"	"	
65 B	"	041804	W	0.833	1.194	9	"	"	
66 B	"	042514	E	0.838	1.228	9	"	"	
67B	"	043402	W	0.842	1.265	9	"	"	
68B	"	044144	E	0.983	1.516	7	"	"	
69B	"	045014	W	0.899	1.467	8	"	"	
70 B	"	045855	E	0.902	1.579	8	"	"	
71 B	"	050818	W	0.907	1.684	8	"	"	
72B	"	051724	E	0.917	1.757	8	"	"	
73 B	"	052638	W	1.066	2.280	8	"	"	
74 B	"	053545	E	1.073	2.560	8	"	"	
75B	"	054602	W	1.076	2.621	8	"	"	
76B	"	055649	E	1.042	2.239	9	"	"	
77B	"	060817	W	1.012	2.053	9	"	"	
78B	"	061939	E	0.977	1.790	9	"	"	

Figure C.4 – LiDAR Flight Log



LiDAR Data Aquisition Log
(for use with Lieca ASL50 unit)

Date: 04 / 10 / 05
DD MM YY

Julian Day: 277

Client/Mission Name/Project Number: KATRINA

Operator: Rahbek / Oneill / [✓ Smith] / Kibler

Aircraft: [✓ N404CP] / N4032C

Survey Type: Wires / [✓ Terrain] / Calibration

Applanix GPS began logging at: 9:00 pm central

Pilot: Gebhart / [✓ Rader]

Passenger:

Mission Start Time (Wheels Up): 9:16 pm

Tempurature (C): 26

Dew Point: 20

Pressure: 3001

Mission End Time (Wheels Down):

Horizontal Visibility: 10

Wind Direction: 050

Wind Speed: 5

From MOB Airport -- To MOB Airport

Cloud Cover: CLR

Surface Conditions: Wet / [✓ Dry] / Snow

Precipitation: Y / [✓ N]

Using Digital Camera Images? Y / [✓ N]

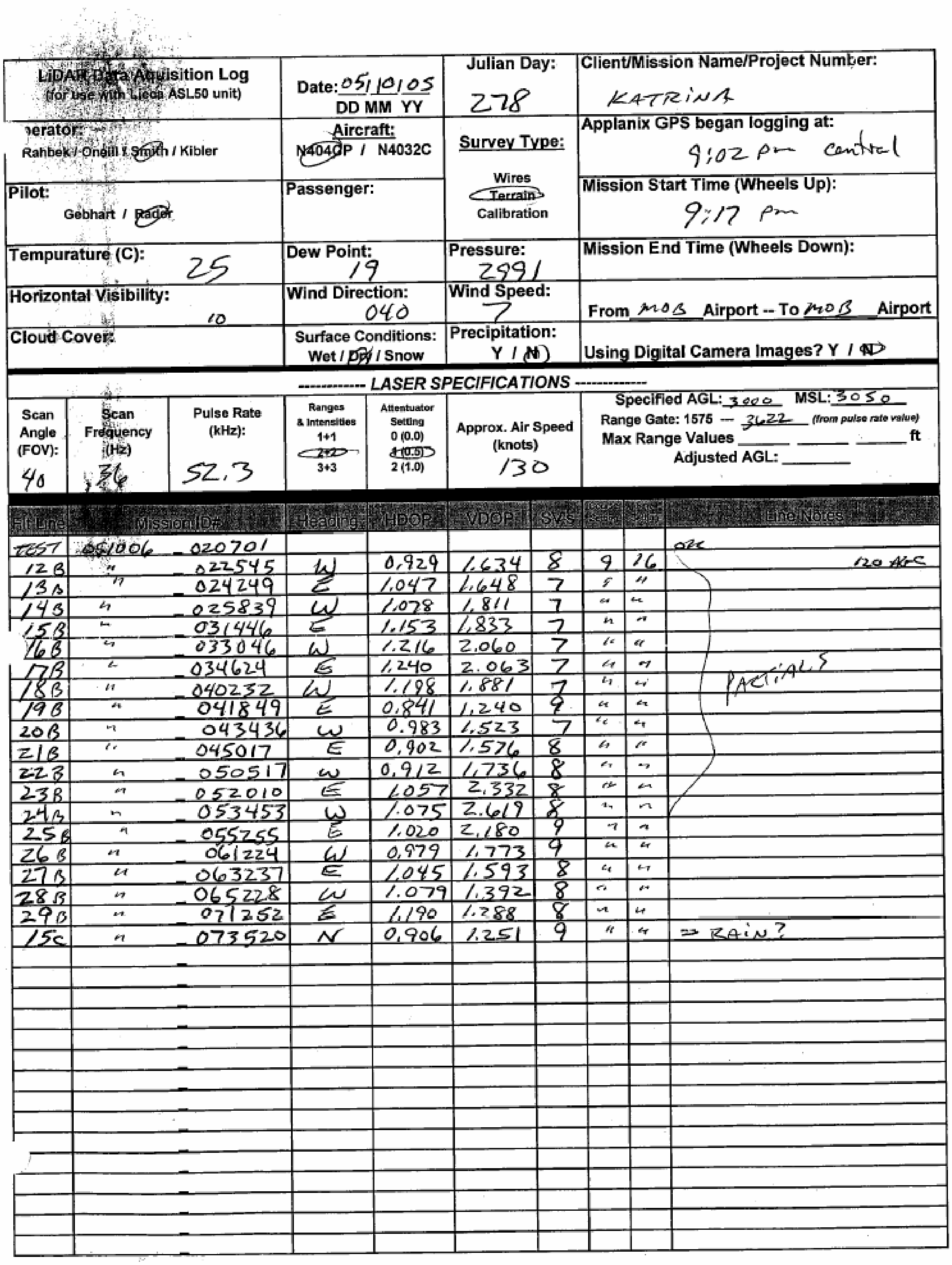
------------ *LASER SPECIFICATIONS* ------------

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & intensities	Attenuator Setting	Approx. Air Speed (knots)
40	36	52.3	1+1 [✓ 2+2] 3+3	0 (0.0) [✓ 1 (0.5)] 2 (1.0)	130

Specified AGL: 3000 MSL: 3050
Range Gate: 1575 — 3622 (from pulse rate value)
Max Range Values ______ ______ ______ ft
Adjusted AGL: ________

Flt Line	Mission ID#		Heading	HDOP	VDOP	SV's	[illegible]	[illegible]	Line Notes
TEST	051005	020549							[illegible]
1B	"	022623	W	0.929	1.643	8	9	16	119.9 AGC
2B	"	023128	E	0.932	1.618	8	"	"	FULL LINES
3B	"	023651	W	0.935	1.592	8	"	"	
4B	"	024229	E	1.046	1.675	7	"	"	
5B	"	025040	W	1.050	1.611	7	"	"	
6B	"	025856	E	0.915	1.364	8	"	"	
7B	"	030918	W	0.918	1.350	8	"	"	
8B	"	031946	E	1.163	1.855	7	"	"	
9B	"	033243	W	1.218	2.041	7	"	"	
10B	"	034331	E	1.247	2.088	7	"	"	
11B	"	035606	W	1.230	2.012	7	"	"	
12B	"	041020	E	1.200	1.812	7	"	"	PARTIALS
13B	"	042433	W	0.842	1.245	9	"	"	
14B	"	043848	E	0.985	1.527	7	"	"	
15B	"	045303	W	0.902	1.556	8	"	"	
16B	"	050644	E	0.914	1.713	8	"	"	
17B	"	052056	W	1.055	2.254	8	"	"	
18B	"	053504	E	1.057	2.581	8	"	"	IN BETWEEN
19B	"	054919	W	1.047	2.261	9	"	"	#'s HAD TO STOP, WRONG LINE
20B	"	060324	E	0.995	2.037	9	"	"	
21B	"	061724	W	0.974	1.767	9	"	"	
22B	"	063136	E	1.038	1.664	8	"	"	
23B	"	064905	W	1.065	1.449	8	"	"	
24B	"	070232	E	1.235	1.315	8	"	"	

Figure C.5 – LiDAR Flight Log



LiDAR Data Aquisition Log
(for use with Leica ASL50 unit)

Date: 05/10/05 (DD MM YY)

Julian Day: 278

Client/Mission Name/Project Number: KATRINA

Operator: Rahbek / Oneill / [✓ Smith] / Kibler

Aircraft: [✓ N404CP] / N4032C

Survey Type: Wires / [✓ Terrain] / Calibration

Applanix GPS began logging at: 9:02 pm central

Pilot: Gebhart / [✓ Rader]

Passenger:

Mission Start Time (Wheels Up): 9:17 pm

Tempurature (C): 25

Dew Point: 19

Pressure: 2991

Mission End Time (Wheels Down):

Horizontal Visibility: 10

Wind Direction: 040

Wind Speed: 7

From MOB Airport -- To MOB Airport

Cloud Cover:

Surface Conditions: Wet / [✓ Dry] / Snow

Precipitation: Y / [✓ N]

Using Digital Camera Images? Y / [✓ N]

------------ *LASER SPECIFICATIONS* ------------

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & Intensities	Attentuator Setting	Approx. Air Speed (knots)
40	36	52.3	1+1 [✓ 2+2] 3+3	0 (0.0) [✓ 1 (0.5)] 2 (1.0)	130

Specified AGL: 3000 MSL: 3050

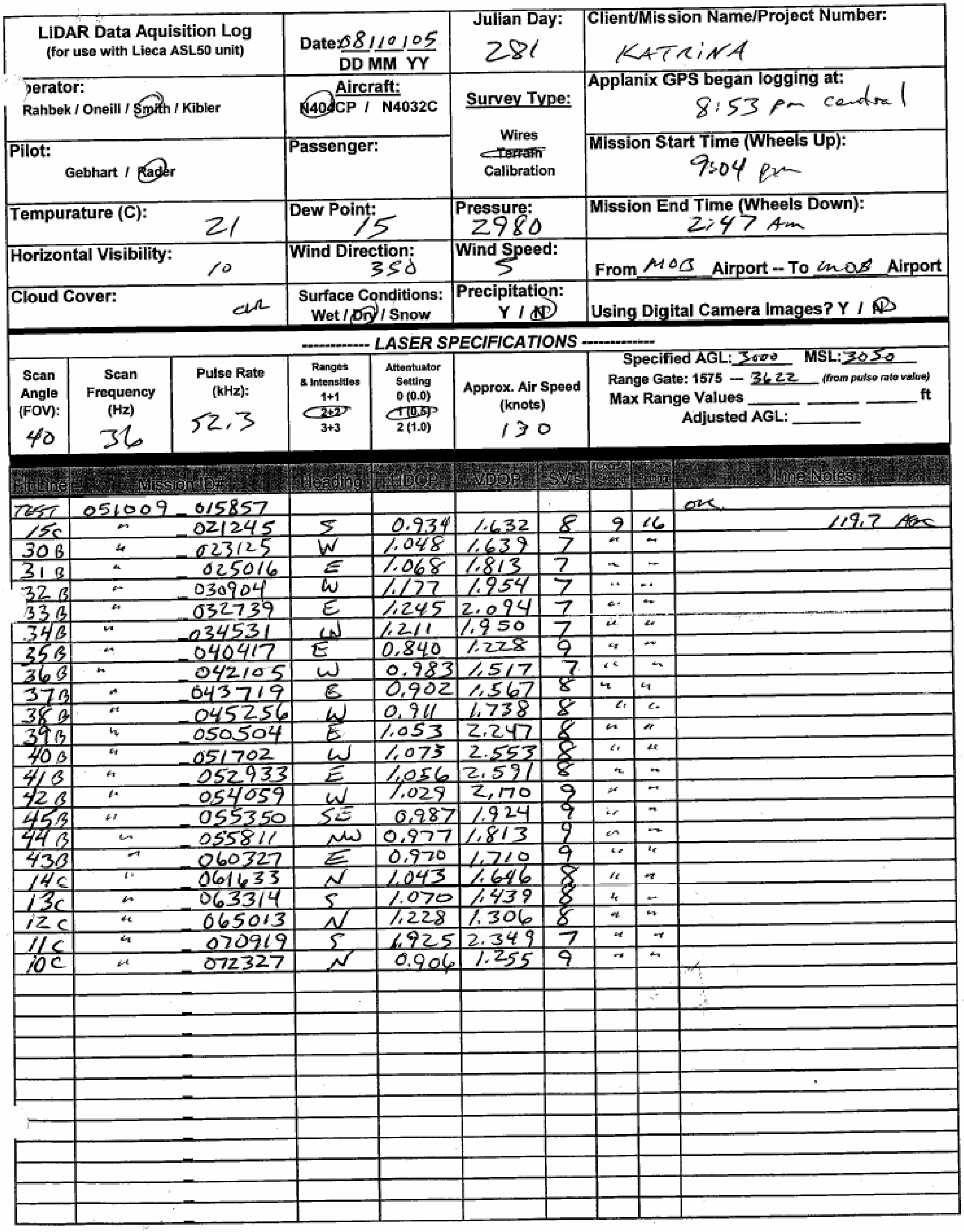
Range Gate: 1575 — 3622 (from pulse rate value)

Max Range Values ______ ______ ______ ft

Adjusted AGL: ________

Flt Line	Mission ID#	Heading	HDOP	VDOP	SV's	[illegible]	[illegible]	Line Notes
TEST	051006_020701							OK
12B	" _022545	W	0.929	1.634	8	9	26	120 AGC
13B	" _024249	E	1.047	1.648	7	"	"	
14B	" _025839	W	1.078	1.811	7	"	"	
15B	" _031446	E	1.153	1.833	7	"	"	
16B	" _033046	W	1.216	2.060	7	"	"	
17B	" _034624	E	1.240	2.063	7	"	"	
18B	" _040232	W	1.198	1.881	7	"	"	PARTIALS
19B	" _041849	E	0.841	1.240	9	"	"	
20B	" _043436	W	0.983	1.523	7	"	"	
21B	" _045017	E	0.902	1.576	8	"	"	
22B	" _050517	W	0.912	1.736	8	"	"	
23B	" _052010	E	1.057	2.332	8	"	"	
24B	" _053453	W	1.075	2.619	8	"	"	
25B	" _055255	E	1.020	2.180	9	"	"	
26B	" _061224	W	0.979	1.773	9	"	"	
27B	" _063237	E	1.045	1.593	8	"	"	
28B	" _065228	W	1.079	1.392	8	"	"	
29B	" _071252	E	1.190	1.288	8	"	"	
15C	" _073520	N	0.906	1.251	9	"	"	⇒ RAIN?

Figure C.6 – LiDAR Flight Log



LiDAR Data Aquisition Log
(for use with Lieca ASL50 unit)

Date: 08/10/05
DD MM YY

Julian Day: 281

Client/Mission Name/Project Number: KATRINA

Operator: Rahbek / Oneill / [✓ Smith] / Kibler

Aircraft: [✓ N404CP] / N4032C

Survey Type: Wires / ~~Terrain~~ / Calibration

Applanix GPS began logging at: 8:53 pm central

Pilot: Gebhart / [✓ Rader]

Passenger:

Mission Start Time (Wheels Up): 9:04 pm

Tempurature (C): 21

Dew Point: 15

Pressure: 2980

Mission End Time (Wheels Down): 2:47 Am

Horizontal Visibility: 10

Wind Direction: 350

Wind Speed: 5

From MOB Airport -- To MOB Airport

Cloud Cover: clr

Surface Conditions: Wet / [✓ Dry] / Snow

Precipitation: Y / [✓ N]

Using Digital Camera Images? Y / [✓ N]

------------ LASER SPECIFICATIONS ------------

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & Intensities	Attentuator Setting	Approx. Air Speed (knots)
40	36	52.3	1+1 [✓ 2+2] 3+3	0 (0.0) [✓ 1 (0.5)] 2 (1.0)	130

Specified AGL: 3000 MSL: 3050
Range Gate: 1575 — 3622 (from pulse rate value)
Max Range Values ______ ______ ______ ft
Adjusted AGL: ________

Flt Line	Mission ID#	Heading	HDOP	VDOP	SV's	[illegible]	[illegible]	Line Notes
TEST	051009 _015857							ok.
15C	" _021245	S	0.934	1.632	8	9	16	119.7 Abc
30 B	" _023125	W	1.048	1.639	7	"	"	
31 B	" _025016	E	1.068	1.813	7	"	"	
32 B	" _030904	W	1.177	1.954	7	"	"	
33 B	" _032739	E	1.245	2.094	7	"	"	
34B	" _034531	W	1.211	1.950	7	"	"	
35B	" _040417	E	0.840	1.228	9	"	"	
36B	" _042105	W	0.983	1.517	7	"	"	
37B	" _043719	E	0.902	1.567	8	"	"	
38B	" _045256	W	0.911	1.738	8	"	"	
39B	" _050504	E	1.053	2.247	8	"	"	
40 B	" _051702	W	1.073	2.553	8	"	"	
41 B	" _052933	E	1.056	2.591	8	"	"	
42 B	" _054059	W	1.029	2.170	9	"	"	
45B	" _055350	SE	0.987	1.924	9	"	"	
44 B	" _055811	NW	0.977	1.813	9	"	"	
43B	" _060327	E	0.970	1.710	9	"	"	
14C	" _061633	N	1.043	1.646	8	"	"	
13C	" _063314	S	1.070	1.439	8	"	"	
12 C	" _065013	N	1.228	1.306	8	"	"	
11C	" _070919	S	1.925	2.349	7	"	"	
10C	" _072327	N	0.906	1.255	9	"	"	
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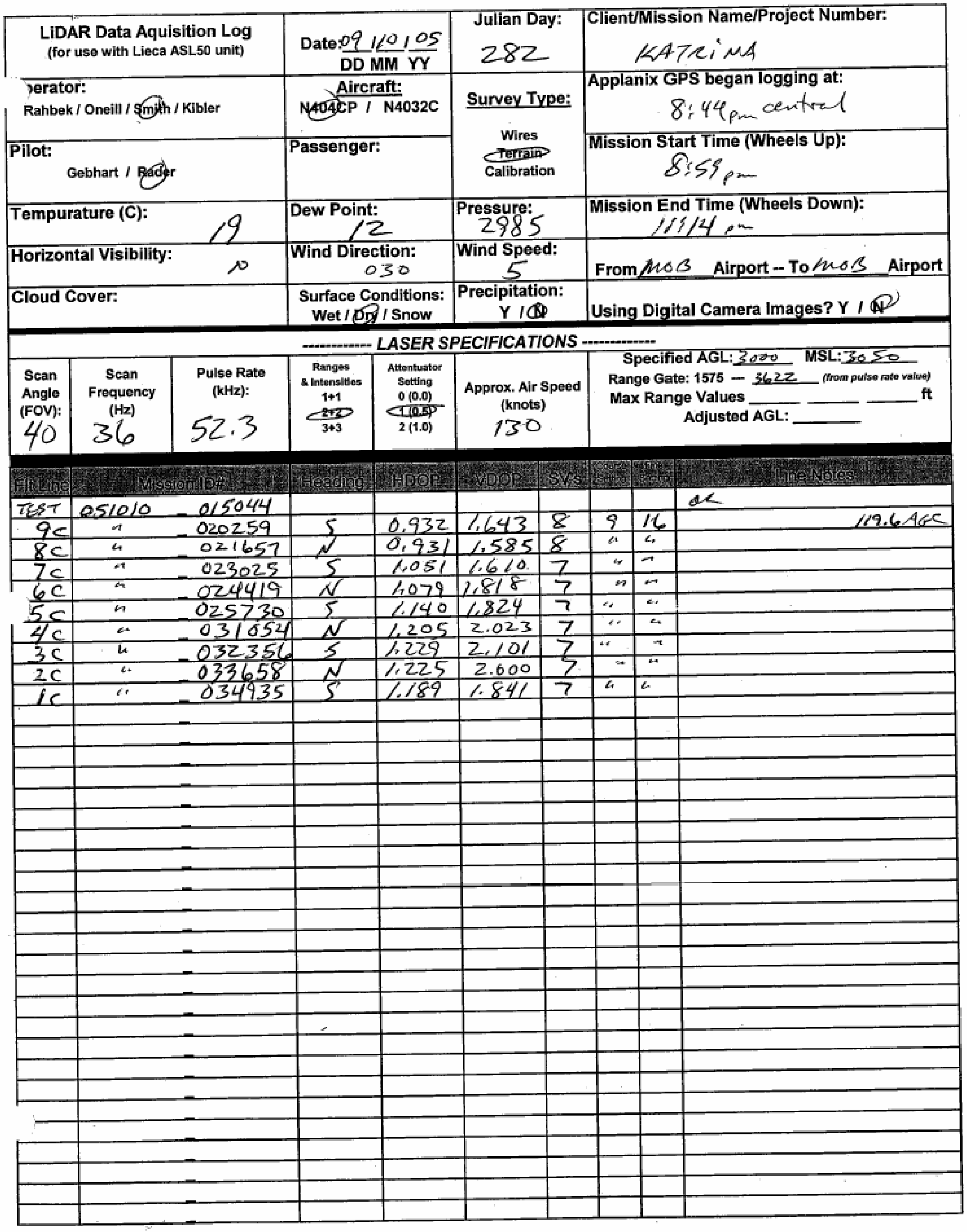
Figure C.7 – LiDAR Flight Log



LiDAR Data Aquisition Log
(for use with Lieca ASL50 unit)

Date: 09 / 10 / 05 DD MM YY

Julian Day: 282

Client/Mission Name/Project Number: KATRINA

perator: Rahbek / Oneill / [✓ Smith] / Kibler

Aircraft: [✓ N404CP] / N4032C

Survey Type: Wires [✓ Terrain] Calibration

Applanix GPS began logging at: 8:44 pm central

Pilot: Gebhart / [✓ Rader]

Passenger:

Mission Start Time (Wheels Up): 8:59 pm

Tempurature (C): 19

Dew Point: 12

Pressure: 2985

Mission End Time (Wheels Down): 11:14 pm

Horizontal Visibility: 10

Wind Direction: 030

Wind Speed: 5

From MOB Airport -- To MOB Airport

Cloud Cover:

Surface Conditions: Wet / [✓ Dry] / Snow

Precipitation: Y / [✓ N]

Using Digital Camera Images? Y / [✓ N]

------------- LASER SPECIFICATIONS -------------

Scan Angle (FOV):	Scan Frequency (Hz)	Pulse Rate (kHz):	Ranges & Intensities	Attentuator Setting	Approx. Air Speed (knots)	
40	36	52.3	1+1 [✓ 2+2] 3+3	0 (0.0) [✓ 1 (0.5)] 2 (1.0)	130	Specified AGL: 3000 MSL: 3050 Range Gate: 1575 — 3622 (from pulse rate value) Max Range Values ______ ______ ______ ft Adjusted AGL: ________

Flt Line	Mission ID#	Heading	HDOP	VDOP	SV's	[illegible]	[illegible]	Line Notes
TEST	051010 015044							ok
9c	" 020259	S	0.932	1.643	8	9	16	119.6 AGL
8c	" 021657	N	0.931	1.585	8	"	"	
7c	" 023025	S	1.051	1.610	7	"	"	
6c	" 024419	N	1.079	1.818	7	"	"	
5c	" 025730	S	1.140	1.824	7	"	"	
4c	" 031054	N	1.205	2.023	7	"	"	
3c	" 032356	S	1.229	2.101	7	"	"	
2c	" 033658	N	1.225	2.600	7	"	"	
1c	" 034935	S	1.189	1.841	7	"	"	

Figure C.8 – LiDAR Flight Log