



Connecticut River Project Report

For Contract

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PROJECT APPROACH

Project Name and Location

Connecticut River, CT, MA

Dates of Data Acquisition

Connecticut Project Area

May 8, 2004
May 11, 2004
May 12, 2004
May 15, 2004
May 20, 2004
June 4, 2004
June 7, 2004
June 8, 2004
June 16, 2004

Massachusetts Project Area

May 13, 2004
May 14, 2004
June 4, 2004
June 7, 2004
June 8, 2004
June 9, 2004
June 11, 2004
June 12, 2004
June 23, 2004
June 30, 2004
July 1, 2004
July 3, 2004

Dates of Data Processing

June, 2004 through September, 2004 – CT

September through October, 2004 – MA

October 2004 through March 2005 – CT and MA contour generation

General

Spectrum Mapping was tasked by ENSR International to collect LIDAR data and digital ortho imagery to generate breaklines and bare earth DEM to support 2-foot contour intervals in accordance with FEMA Appendix A. The project area for Connecticut River floodplain was approximately 267 square miles. 143 square miles in Massachusetts, which includes Hampden County, and 124 square miles in Connecticut, which includes Middlesex, Hartford and New London Counties. The Spectrum aircraft was equipped with the RAMS system, including a 26 Khz Laser, an inertial measurement unit (IMU), and a dual frequency GPS receiver and antenna. The RAMS sensor system also includes a RAMS 4K X 4K color digital camera mounted to the LIDAR unit.

Project Area

Spectrum ensures that the geographic extent of the project area is collected using the correct mission profiles for the desired products. This is accomplished using TRACK'AIR, a digital mission-planning tool.

Mission planning consists of several steps that ensure proper flight preparation. First and foremost the project boundary for the site is acquired from our customer and imported into our flight planning software. Following this, available information such as elevation data, vegetation coverage and cultural feature extents are reviewed and general assessments are made by our Photogrammetrists to determine proper LIDAR system settings, such as FOV (field of view) and GSD (ground sample distance). All LIDAR and image flight lines are flown with a minimum of 30% side overlap. Having set the previous parameters, the flight plan is prepared in digital form using our proprietary software. The existing elevation data is then imported and queried to calculate the flight altitudes for each flight line. Once flight planning is complete, waypoints in latitude/longitude and ellipsoid height are output to our flight management system.

GPS differential correction is required for our process. GPS planning software is used to predict PDOP (positional dilution of precision ... i.e. GPS quality) greater than 3.0. Should this condition occur, laser data acquisition is suspended until the satellite geometry improves. Spectrum's base stations are full wave, dual frequency, GPS receivers that record data at a rate of 1 second. All base station data is recorded to 1GB flash memory cards for immediate use after the mission.

Acquisition Systems

Spectrum Mapping employs a medium-format digital camera to capture color imagery concurrently with the laser data. This imagery was used in a stereo and ortho mono editing environment to control the quality of the terrain model generated by the RAMS™ LIDAR system, and to generate breaklines to conform to hydrologic modeling requirements. Use of the integrated LIDAR/Camera system provides a direct path to mapping output products, as the imagery is controlled using the same Airborne GPS/Inertial Measurement system used for the LIDAR sensor. Flight data was logged digitally to a 150Gb removable hard drive array on board the aircraft. GPS base station data was logged to flash memory cards. This allowed for rapid file transfer since tape systems have been eliminated from the process. Drives were downloaded daily, processed, and archived immediately following collection, yielding basic laser and image data within hours of data collection. Field checks of the data were performed each day to ensure complete coverage of the area flown that day for both laser and imagery data.

Data Acquisition

Our flight crew, comprised of a pilot and a system operator, mobilized to the project site ferrying all equipment and digital information required. Recovery of GPS base stations and coordination with the project ground control team were completed to identify correct base station and calibration site information.

A calibration site was established before the project commenced. Before each mission, the pilot will acquire data over this location. This calibration site consisted of a small area with existing control placed by GPS methods. Points are typically photo identifiable so they can be located in the digital imagery as well.

The flight crew was guided by a GPS controlled flight management system, which displays the flight plan; including altitude, heading, cross track deviation and PDOP. The system operator monitors flight management data in addition to laser information, and a real-time view of the digital imagery. During flight the crew monitors all functions in system operation and guidance ensuring a successful mission.

Ground Survey

Spectrum utilized airborne GPS methods for the production of this project. ENSR International provided survey control support as required and horizontal and vertical checkpoint surveys as needed for quality control.

GPS/IMU Processing

Position and orientation data must be processed first in order to resolve laser data, rectify imagery data, and verify flight coverage. All aircraft trajectory and exterior orientation parameters for imagery are generated during this process. Both horizontal and vertical project coordinate computations are accomplished at this stage. This processing takes approximately two times the actual flight time of the mission.

Raw Laser Data Processing

Laser data is then processed to resolve the range finder, scan angle, and position and orientation system data, using Spectrum's post-processor software. All returns are sorted to best reflect the vegetated and bare earth surfaces. Data are transformed from raw binary format to an LAS file format for filtering and custom projection. The most current NGS models are an integral part of the post-processing software, with custom projection options available.

Laser data are thinned for quick projection of swath coverage. Image footprints are then superimposed to assess all aspects of data collection. Spectrum's LIDIMAGE™ software is also used at this stage for a rudimentary test of the data validity. LIDIMAGE™ is a fast-generating bitmap utility for rapid viewing of the DEM data. Any seams, holes, or other unwanted artifacts could be quickly identified for potential re-flight areas.

Image Processing

Imagery is processed from its proprietary storage format to a raw binary format and then automatically radiometrically balanced for contrast. During this stage, image header information will be generated containing exposure number, position (x/y/z), and orientation (omega/phi/kappa). A header format will be generated to support batch processing of all frames, which automatically prepares the files for quality assurance testing and 3-D (stereo) editing. Spectrum utilizes Z/I Imaging's ORTHOPRO products for automated tone balancing and orthorectification.

Bare Earth Data Filtering

The LIDAR system collects elevation and position information from all reflective surfaces. The task is to identify and remove those features that do not describe the bare earth.

Spectrum houses all laser points in a database LAS (format) that retains information about flight day and time, return number, laser scan angle, and other proprietary information. This data is displayed and manipulated using our proprietary tools and software. The database is reviewed and areas of like characteristics are delineated and flagged. A laser processing group, will determine which type of filtering technique(s) need to be applied to each type of area, to best portray a bare earth surface. Factors that affect this decision are slope, vegetation and cultural features. Each project has unique characteristics that can only be assessed after the data is collected. The data is flagged in the LAS format and as part of the QC process with the imagery, reviewed to ensure correct surface depiction.

Data voids may occur from several different causes, including the following:

Natural

- LIDAR pulses may be naturally absorbed by water bodies or areas recently covered with asphalt. Such voids are normally considered to be unavoidable.

Operational

- The LIDAR system may have malfunctioned for some reason.
- Heavy winds, flight navigation system (FNS) error or pilot error may have caused "holidays" between flight lines.

Procedural

- Data points may be un-intentionally removed as part of the bare-earth post-processing to delete points that impinged on the tops of manmade structures or failed to penetrate dense vegetation.

Data voids caused by removal of LIDAR data points on manmade structures are acceptable.

As part of the field QC process, data voids caused operational constraints are re-collected if required. No data voids were identified in this project.

Artifacts are regions of anomalous elevations or oscillations and ripples within the DEM data resulting from systematic errors, environmental conditions, or incomplete post-processing. Spectrum utilizing both the imagery and software tools ensures that artifacts are properly modeled (removed or edited with breaklines) so that they do not influence the resulting surface.

Quality Assurance

A rigorous quality assurance program insures that the final data products meet all requirements prior to delivery to the customer. Quality Assurance / Quality Control is embedded into the overall data acquisition and processing steps we use. Quality assurance is inherent in developing the project plan, acquisition, verifying data and processing, and assuring that the final products meet all FEMA requirements in accordance with the contract. Spectrum Mapping's quality assurance procedures follow the "FEMA Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying" for use of LIDAR mapping technology.

DATA PROCESSING PROCEDURES

Data Processing Procedures

Data was delivered to Spectrum Mapping's Albuquerque office from the field on external hard drives. The data is cataloged and copied onto the processing computer disk drives. The data is then re-verified for coverage and quality. The data is then ready for calibration. Once the data is calibrated it is sent to the Denver office on external hard drives for post processing. The first step in the LIDAR data processing is to produce the x, y, and z laser returns using Spectrum's proprietary LIDAR data processing software. The next step in the laser data processing is to combine the flight lines in a merge process that eliminates any redundant points. In this step the data is also cropped into more manageable units that correspond to customer's specified data file boundaries or file size limitations. Noise or anomalous returns are usually filtered from all data during this processing step.

In order to produce the bare earth DEM's, vegetation removal is performed on the last return elevation point data by identifying the laser returns from above ground vegetation. This proprietary algorithm is capable of removing between 90-95% of the trees and most other prominent above ground vegetation from the data.

The next step in the post-processing of the DEM data is to perform the ellipsoid to orthometric height conversion using the National Geodetic Survey (NGS) Geoid Model, GEOID99. All elevation data was processed in this way on a point-by-point basis. The data is then brought into ArcGIS 8.2 and converted into a hillshade. This allows for better quality control. If additional editing is required, the tile with artifacts will go back to the manual vegetation removal step.

The final step was to assemble the bare earth DEM into the correct customer specified delivery format. The coordinate system is State Plane, Mass inland and CT. Horizontal reference is NAD83. Vertical control reference datum is NAVD88. Units of measurement are in US Survey Feet. All the variably-spaced x, y, z DEM points data were converted to ASCII comma delimited point files.

Editing Methodologies

Step 1: The raw data set is converted into gray shade tiff images and imported into Arcmap. The editor will then review the entire project area and determine a 1k x 1k tile (or a group of 1k x 1k tiles) that is representative of the extreme topographies in the project area. These areas should be based on features that are susceptible to filter erosion. (i.e. mountain ridgelines or peaks, roads or rail beds, levees/dikes, mine pits, canyon ledges) and any other abrupt changes in land topography.

Step 2: The editor will use this tile (or set of tiles) as a test area to determine the proper settings for the vegetation filter iterations. These settings should remove the maximum amount of vegetation spikes without degrading the above mentioned land features. The editor will implement the 'Plainer Fit' filter for all vegetation removal. This filter creates an average 'ground surface' based on the lower points (presumed to be ground) of an area and removes the points above this surface.

Step 3: Once the editor has determined the optimal settings for the test area, the settings will be implemented on the entire data set. Gray shade tiffs are then created and imported into the Arcmap project. Using a 1.5k x 1.5k viewing window, the editor will view the two image sets; edited and unedited, to see if any land features have been inadvertently removed. While the editor is reviewing their edits they will also create polygons that define areas in which further vegetation removal is required.

Step 4: After the polygons have been drawn around the remaining vegetation, the editor will only implement edits within those polygon boundaries. This allows for more aggressive inputs in the plainer fit filter because all of the edits are targeted on specific areas of vegetation. A final set of gray shades is created for final review. The processor will flag specific areas that require manual edits.

Step 5: Manual edits. The manual editor will use the actual points and imagery data to remove any remaining vegetation or artifacts. This is done by using Spectrum Mapping's LIDMASS software. The software allows the technician to view the data in 2D as well as 3D. The imagery collected during the acquisition is used as a QC tool to help correctly identify vegetation or other artifacts.

Image Orthorectification Processing Procedures

Spectrum performs a differential rectification on a pixel-by-pixel basis to remove image displacement due to topographic relief and aircraft attitude. Bilinear resampling techniques will be used during image orthorectification.

Position and orientation data from the AGPS and IMU must be processed first in order to verify flight coverage, resolve LIDAR data (used for accurate surface representation), and rectify imagery data. All aircraft trajectory and exterior orientation parameters for imagery are generated during this process.

Zeiss-Intergraph software is used throughout the process to ensure consistent results, and the exclusive use of a native digital image eliminates film scanning and the attendant image degradations that can occur when working with film media. The resulting products, generated from highly automated software applications processes, are individual ortho-photographically correct images, ready for the next step in the process.

The orthos are then mosaicked and color balanced together removing the frame-to-frame seam lines. This process creates a uniform radiometric appearance across the complete project area, eliminating inconsistencies in tone and density between individual orthophotos.

Breakline and Contour Generation

Breaklines are defined as linear features that describe a change in the slope, smoothness or continuity of surface. Breaklines are added to enforce the topology for the generation of contours from digital elevation models. Utilizing breaklines will enforce the hydrology in the generation of contour maps.

Spectrum utilized a combination of 2D data compilation and 3D stereo compilation for the generation of topographic breaklines. The 2D data compilation, from the digital camera ortho image data, combined with the bare earth LIDAR DEM data, produces an accurate planimetric representation of streams, rivers, and impediments to water flow. The 2D data is attributed from the interpolated bare earth LIDAR DEM surface with the associated elevation creating a "2 1/2 D" vector data set in a cost effective manner. Since Spectrum acquires aerial digital image mapping data concurrently with the LIDAR data acquisition, the spatial accuracy of both data sets is the same; as both utilize the same airborne GPS and IMU solution for positional determination. This process removes any potential errors in differing spatial and temporal accuracies of the topographic and image data sets and allows for a more accurate depiction of the surface topology.

Stereo compilation is used to supplement the LIDAR surface model in areas where laser returns may have been reduced due to water bodies (i.e. swamps/ marshland) and to spot check both the topographic breakline and bare earth DEM surface data.

This dual track approach ensures breakline map data accuracy by using the traditional stereo visual quality control combined with the cost-effective generation and editing of 2D ortho image derived breaklines.

The resultant combination of LIDAR DEM and breakline data known as Digital Terrain Model (DTM) data will represent the bare earth surface and meet FEMA and National Map Accuracy Standards (NMAS) for the 2-foot contour accuracy specifications. All DTM, contour data is GIS ready; meaning all polygons will be closed; all lines are continuous with no overshoots, undershoots or breaks. Intersection polygons are clearly defined and lines and polygons are not broken at map grid boundaries in the data.

All contours are generated from the bare earth DEM and breakline data using TerraModel software.

Deliverable DEM Data Format

Data Deliverables:

- Ground Surface DEM
- Breaklines
- 2-foot Contours
- 1ft GSD color ortho imagery

Data Format:

- Ground Surface DEM, Variably spaced, comma delimited ASCII point files
- 2 ft contours, ESRI Shape files
- Digital Imagery, Geo-tiff with tiff world files
- Breaklines, edge of water and drainage features, ESRI Shape files

Map Coordinate System and Datum:

Massachusetts Mainland and Connecticut State Plane, NAD83, NAVD88, US Survey Feet.

GEOID Used:

Geoid 99

Quality Control Procedures

Spectrum has many control procedures in place to provide quality assurance through each step of data processing.

- Step 1 - Spectrum verifies project boundaries and data deliverables with customer prior to flight
- Step 2 - QA of data after collection to verify complete coverage, data then goes to calibration
- Step 3 - QA of data after calibration to verify solution before data processing
- Step 4 - QA/QC of automated vegetation filter iterations; data may go through many different iterations of automated filters, data then goes to manual editing.
- Step 5 - QA/QC of manual edits by using imagery as background to help identify surface features.
- Step 6 - QA/QC of final deliverables. All rectified image data are projected to the contoured surface and reviewed for registration, DTM surface error, contour quality, contour edge matching, image sheer, mosaic seam and radiometric quality, and other data artifacts. All LIDAR DEM data are converted into hillshades and reviewed for artifact removal, proper datum and coordinate systems, data voids or anomalies, and edge matching.
- Step 7 - Delivery media are verified and checked for completeness before delivery.

PROJECT SUMMARY

Project Summary

Spectrum Mapping collected approximately 243 square miles of data for Connecticut River floodplain project area. This data was collected between May 8, 2004 and July 3, 2004. The main problems during collection were due to the inclement weather. The imagery cannot be collected when clouds obscure the surface.

There were no problems encountered during the post processing of this project except schedule. This area had far more vegetation than anticipated which in turn took longer to manually edit the tiles.

The contours and breaklines also took much longer than anticipated. Breaklines were drawn using the imagery and lidar for reference. The elevation was added to the breaklines using the lidar bare earth DEM. The 2-foot contours were then generated off of the collected breaklines and the bare earth DEM surface.

The data meets contract specifications for 2-foot contours of 0.50ft (15 cm). The combined DEM accuracy for CT and MA project areas was .483 feet RMSE. The DEM RMSE included a total of 48 control points.

LIDAR SYSTEM DATA REPORT

General System Acquisition Parameters

RAMS™ Digital Camera

Camera Array	4k X 4k pixel panchromatic, color,
Recording Rate Per Frame	less than 2.2 seconds
Camera FOV 50mm Lens	45 degrees fixed
50 mm Lens Calibration	less than 1 pixel RMSE full FOV
Camera FOV 90mm Lens	30 degrees fixed
90 mm Lens Calibration	less than 0.5 RMSE full FOV
Minimum Ground Projected Pixel Footprint	6 inches
Maximum Ground Projected Pixel Footprint	Unlimited (AGL dependent)
Image Geopositioning Accuracy	better than 1 foot RMSE absolute

RAMS™ System Specifications

Laser	
Laser Altitude	10,000 feet AGL Max
Laser Swath Width	7,250 feet Max
Laser Scan FOV	45 Degrees Max
Scan Rate	0-35 Hz (FOV dependent)
Laser Pulse Rate	100Hz-15kHz Max
Laser Returns	5 at 15kHz
Cross Track Spacing	0-25 feet
Along Track Spacing	3 feet minimum (Airspeed dependent)
Nominal X/Y Ground Sample Distance	10 feet
X, Y, Z Positional Accuracy	less than 1 foot RMSE absolute

Accuracy of the Topographic Surface Products

Green International Affiliates, Inc collected the 48 control points used below for the RMSE of the project areas. The RMSE below is combined for the Massachusetts and Connecticut project areas. The final RMSE is .483 feet vertical. This exceeds the FEMA Guidelines and Specifications for Flood Hazard Mapping.

This data meets the contract accuracy requirements of 15 cm (0.50 ft) (FEMA 2 ft contours) for the project. This data also meets FEMA's requirement of 18.5 cm (0.61 ft) for data supporting 2-foot contours. FEMA Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A, Section A.3.2 Vertical Accuracy Criteria.

1. To produce the RMSE, a TIN (triangular irregular network) was produced from the bare earth ASCII points.
2. Elevation differences were calculated between the TIN elevations and the independent control points provided.
3. The elevation differences are squared and the sum is averaged.
4. The RMSE is calculated by taking the square root of the Average minus the Error ² result.

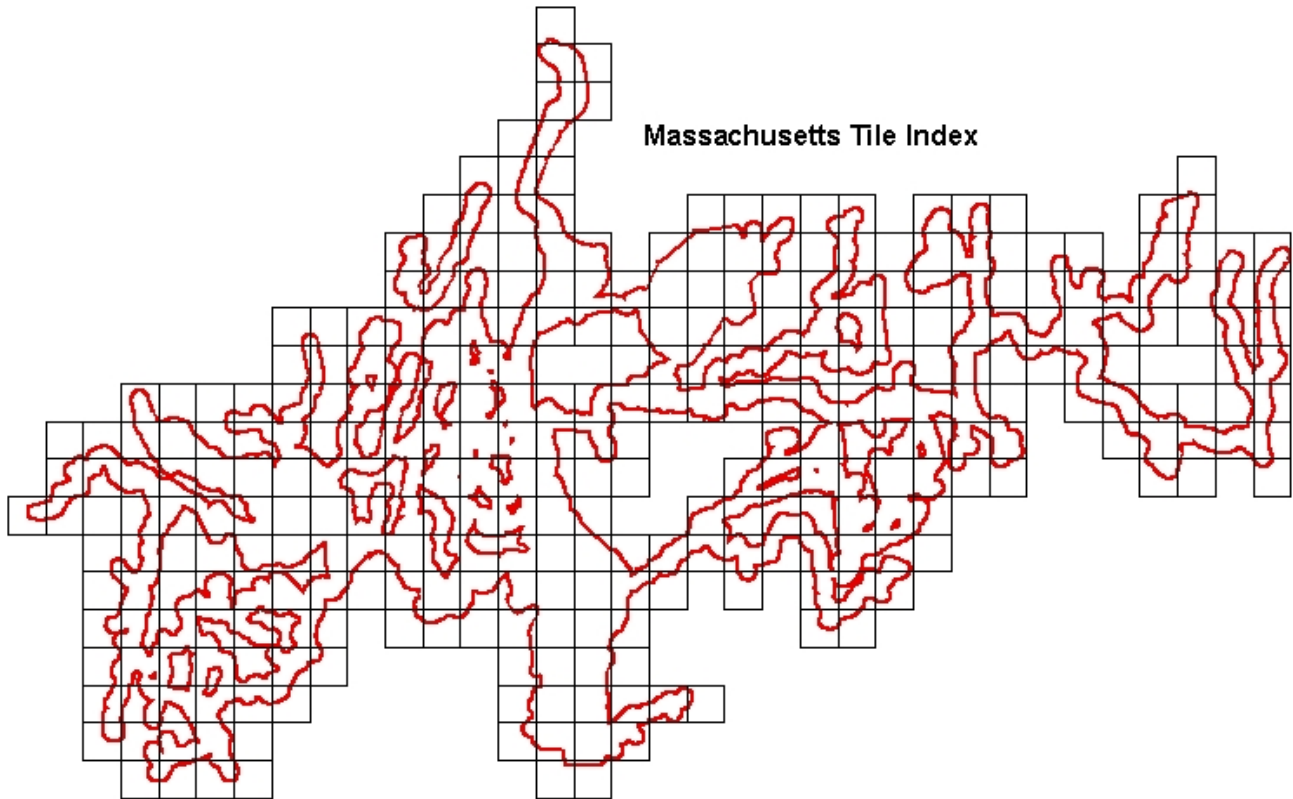
Please refer to Appendix A for all of the RMSE calculations.

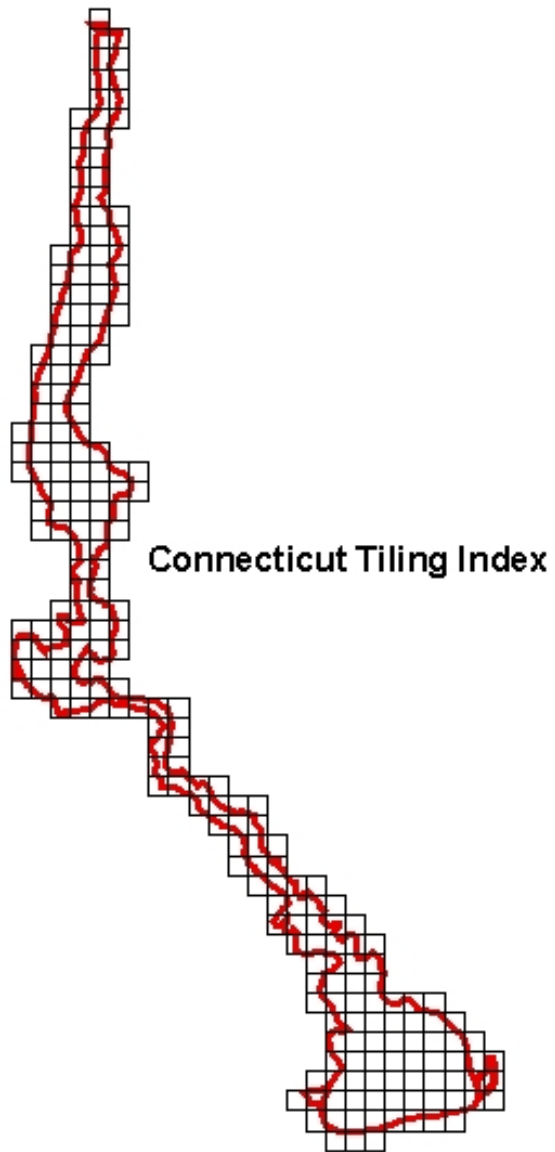
Control Point	Northing	Easting	Elevation ft	Lidar Elevation ft	Difference ft	Squared	Notes
1212	2889844.27	349444.34	90.04	89.14	-0.9008	0.8114	
229	2907506.19	355940.69	131.80	130.91	-0.8929	0.7973	
502	2907590.20	355930.00	129.29	128.43	-0.8645	0.7474	
184	2907399.76	355919.23	129.97	129.32	-0.6488	0.4209	
991203	843031.36	1022706.71	14.35	13.74	-0.610	0.3719	
991303	823283.70	1024837.70	32.60	31.99	-0.607	0.3678	
991001	890331.19	1032210.70	41.21	40.66	-0.549	0.3018	
991101	858662.19	1026428.27	80.27	79.73	-0.543	0.2947	
991301	823144.23	1025288.57	37.42	36.88	-0.540	0.2918	
701	2922735.26	358207.05	114.22	113.69	-0.5334	0.2845	
1210	2889796.90	349778.18	61.78	61.29	-0.4950	0.2450	
1410	2878485.47	352622.68	63.58	63.14	-0.4424	0.1957	
1411	2878454.67	352383.68	61.32	60.89	-0.4340	0.1884	
991703	723794.94	1077845.41	6.83	6.44	-0.392	0.1539	
992001	679192.91	1102663.78	49.74	49.37	-0.369	0.1361	
1510	2873667.35	351690.62	58.44	58.08	-0.3606	0.1300	
991503	780267.51	1037143.02	11.09	10.76	-0.334	0.1118	
991002	890213.50	1032336.72	34.72	34.39	-0.327	0.1066	
1901	2860347.34	360056.54	56.17	55.90	-0.2711	0.0735	
2312	2843143.68	353849.26	54.61	54.35	-0.2594	0.0673	
1910	2860559.98	360111.33	47.56	47.32	-0.2394	0.0573	
991801	724741.86	1077808.18	7.45	7.25	-0.201	0.0406	
991102	858590.04	1026254.50	91.28	91.09	-0.194	0.0375	
991701	724406.02	1077884.17	6.62	6.44	-0.185	0.0342	

991901	705016.67	1088699.31	6.87	6.69	-0.183	0.0335	
Control Point	Northing	Easting	Elevation ft	Lidar Elevation ft	Difference ft	Squared	Notes
991902	705068.86	1088633.19	8.20	8.03	-0.170	0.0288	
991501	780391.10	1037799.46	9.55	9.42	-0.134	0.0180	
702	2922545.56	357718.01	114.56	114.43	-0.1329	0.0177	
991201	843260.16	1022612.29	13.84	13.75	-0.087	0.0076	
1911	2860375.75	359979.18	55.17	55.09	-0.0800	0.0064	
991202	843674.95	1022801.07	14.17	14.14	-0.029	0.0008	
991708	762773.11	1045930.72	47.83	47.86	0.028	0.0008	
1513	2874682.92	352244.35	57.30	57.34	0.0353	0.0012	
991003	890024.69	1032365.69	31.96	32.02	0.061	0.0037	
991302	823178.80	1025130.46	33.90	34.04	0.137	0.0189	
2310	2843124.11	354245.87	52.05	52.21	0.1639	0.0269	
992002	679126.06	1102733.37	50.04	50.27	0.226	0.0513	
991803	724913.67	1078037.37	6.62	6.88	0.258	0.0664	
991103	858472.69	1026281.67	84.87	83.48	-1.390	1.9324	Point is in trees
148	2922733.15	357979.29	106.93	107.96	1.0253	1.0512	Point on grassy surface/possible survey
991709	762800.68	1045802.84	52.90	53.19	0.289	0.0836	
991702	723976.37	1077964.00	6.82	7.12	0.303	0.0916	
991502	780373.10	1037466.12	10.34	10.65	0.307	0.0943	
100	2922765.19	358220.92	111.90	112.23	0.3254	0.1059	
1401	2878012.96	352935.05	59.23	59.63	0.3960	0.1568	
991802	724459.56	1078091.47	6.82	7.22	0.397	0.1575	
1211	2889870.91	349877.42	62.56	62.97	0.4108	0.1688	
228	2907654.32	355896.98	123.57	124.46	0.8903	0.7926	
Total					-8.15	11.1838	
Avg. Error					-0.17	0.2330	
# Points / RMSE					48.00	0.4827	

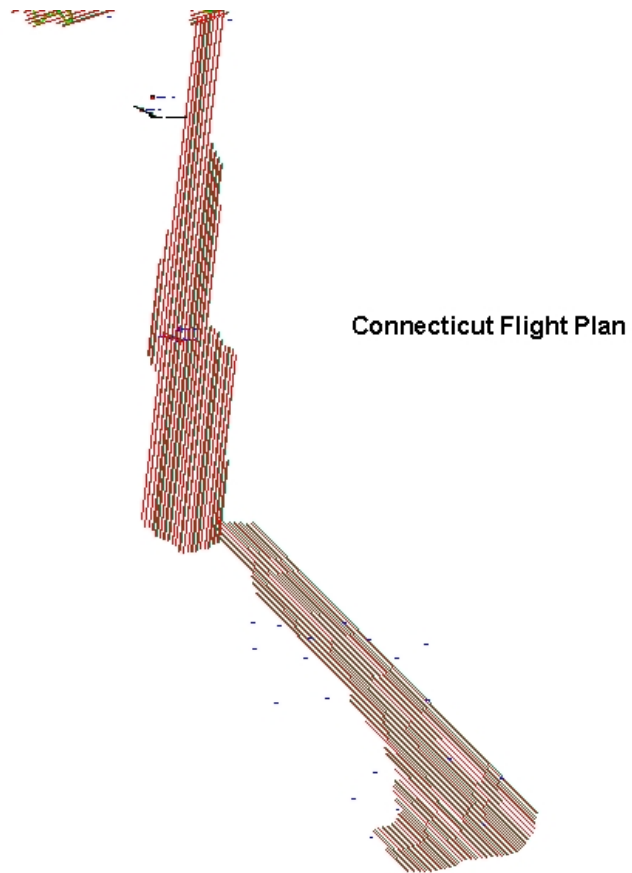
Tile Index

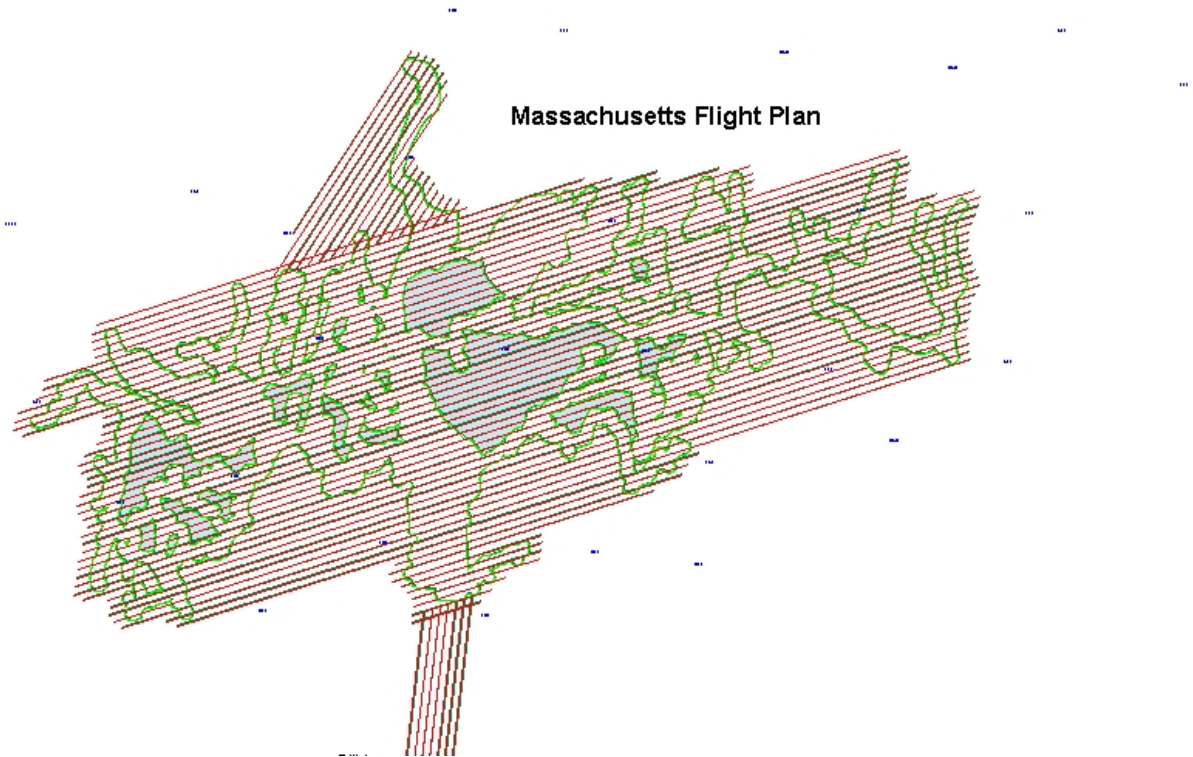
Below shows the tiling index for both the Connecticut and Massachusetts portion of the project area



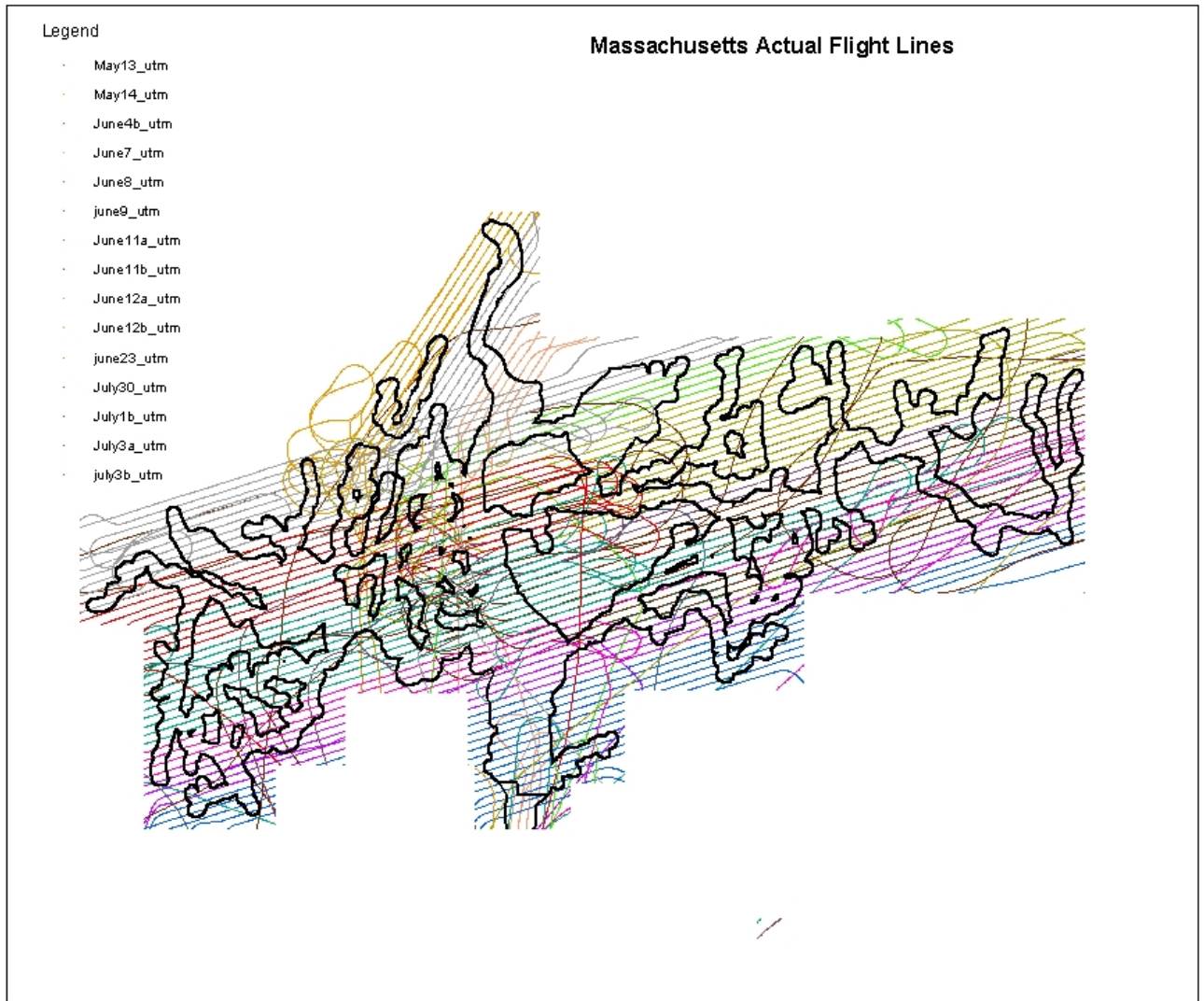


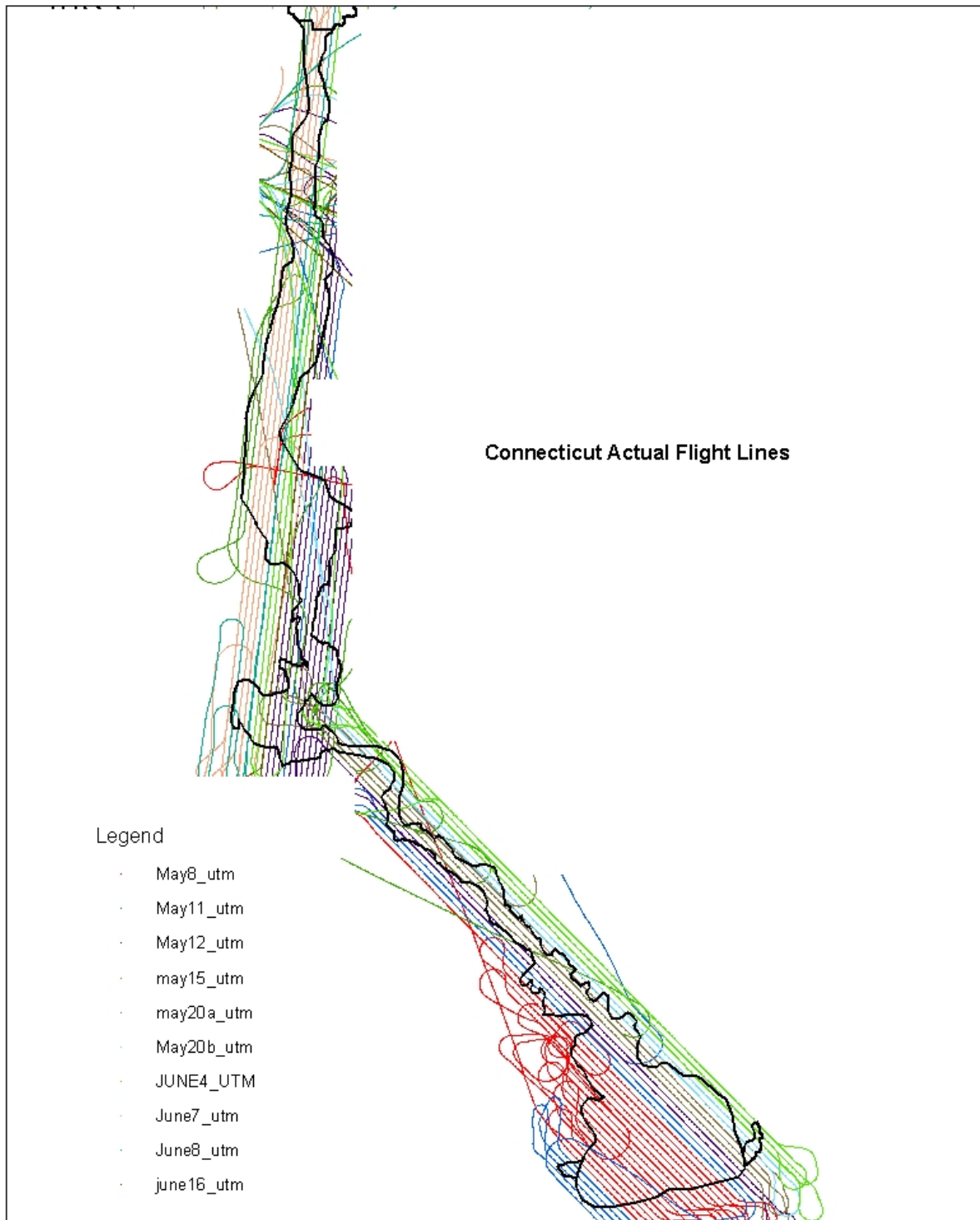
Planned Flight Lines





Actual Flight Lines





5/16/2005



FLIGHT REPORT

GPS Control

AC7670 SACS - This is a Secondary Airport Control Station.
 AC7670 DESIGNATION - BDL B
 AC7670 PID - AC7670
 AC7670 STATE/COUNTY- CT/HARTFORD
 AC7670 USGS QUAD - WINDSOR LOCKS (1984)

AC7670
 AC7670 *CURRENT SURVEY CONTROL

AC7670*	NAD 83 (1996)	-	41 57 00.32545 (N)	072 40 16.36405 (W)	ADJUSTED
AC7670*	NAVD 88	-	47.34 (meters)	155.3 (feet)	GPS OBS
AC7670	X	-	1,415,023.609 (meters)		COMP
AC7670	Y	-	-4,535,090.999 (meters)		COMP
AC7670	Z	-	4,241,494.757 (meters)		COMP
AC7670	LAPLACE CORR-		-2.73 (seconds)		DEFLEC99
AC7670	ELLIP HEIGHT-		18.30 (meters)	(06/04/02)	GPS OBS
AC7670	GEOID HEIGHT-		-29.07 (meters)		GEOID03

AC7670
 AC7670 HORZ ORDER - FIRST
 AC7670 ELLP ORDER - FOURTH CLASS I

AC7670
 AC7670 This mark is at Bradley Intl Airport (BDL)

AC7670
 AC7670 The horizontal coordinates were established by GPS observations
 AC7670 and adjusted by the National Geodetic Survey in May 2000.
 AC7670

AC7670 The orthometric height was determined by GPS observations and a
 AC7670 high-resolution geoid model.

AC7670
 AC7670 GPS derived orthometric heights for airport stations designated as
 AC7670 PACS or SACS are published to 2 decimal places. This maintains
 AC7670 centimeter relative accuracy between the PACS and SACS. It does
 AC7670 not indicate centimeter accuracy relative to other marks which are
 AC7670 part of the NAVD 88 network.

AC7670
 AC7670 Photographs are available for this station.

AC7670
 AC7670 The X, Y, and Z were computed from the position and ellipsoidal ht.
 AC7670

AC7670 The Laplace correction was computed from DEFLEC99 derived deflections.
 AC7670

AC7670 The ellipsoidal height was determined by GPS observations
 AC7670 and is referenced to NAD 83.

AC7670
 AC7670 The geoid height was determined by GEOID03.

AC7670;		North	East	Units	Scale	Factor	Converg.
AC7670;SPC CT	-	276,432.228	311,333.395	MT	1.00000952	+0 03	
08.1							
AC7670;UTM 18	-	4,646,857.849	693,021.043	MT	1.00005847	+1 33	
26.0							

AC7670
 AC7670! - Elev Factor x Scale Factor = Combined Factor

5/16/2005



AC7670!SPC CT - 0.99999713 x 1.00000952 = 1.00000665
AC7670!UTM 18 - 0.99999713 x 1.00005847 = 1.00005560

AC7670

AC7670

SUPERSEDED SURVEY CONTROL

AC7670

AC7670.No superseded survey control is available for this station.

AC7670

AC7670_U.S. NATIONAL GRID SPATIAL ADDRESS: 18TXM9302146858 (NAD 83)

AC7670_MARKER: DD = SURVEY DISK

AC7670_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT

AC7670_STAMPING: BDL B 1992

AC7670_MARK LOGO: NGS

AC7670_PROJECTION: FLUSH

AC7670_MAGNETIC: N = NO MAGNETIC MATERIAL

AC7670_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO

AC7670+STABILITY: SURFACE MOTION

AC7670_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR

AC7670+SATELLITE: SATELLITE OBSERVATIONS - September 25, 2000

AC7670

AC7670	HISTORY	- Date	Condition	Report By
AC7670	HISTORY	- 1992	MONUMENTED	NGS
AC7670	HISTORY	- 19991206	GOOD	WOOLPT
AC7670	HISTORY	- 20000925	GOOD	NGS

AC7670

AC7670

STATION DESCRIPTION

AC7670

AC7670'DESCRIBED BY NATIONAL GEODETIC SURVEY 1992 (GFS)

AC7670'THE STATION IS LOCATED AT THE BRADLEY INTERNATIONAL AIRPORT SOUTHEAST

AC7670'OF RUNWAY END 24. IT IS 95.3 FT (29.0 M) SOUTHEAST OF THE CENTERLINE

AC7670'OF THE TAXIWAY, 72.1 FT (22.0 M) NORTHEAST OF THE 6TH TAXIWAY LIGHT

AC7670'SOUTHWEST OF THE RUNWAY END, 45.5 FT (13.9 M) SOUTHEAST OF THE LINE

AC7670'EXTENDED OF THE HOLDBAR, 44.7 FT (13.6 M) SOUTHEAST OF THE 5TH TAXIWAY

AC7670'LIGHT FROM THE RUNWAY END, 26.8 FT (8.2 M) NORTHEAST OF A P-K NAIL AND

AC7670'WASHER SET IN THE SHOULDER OF THE TAXIWAY AND SOUTHEAST OF THE FAA

AC7670'ROAD TO THE APPROACH LIGHT LANE. THE STATION IS A STANDARD NOS DISK

AC7670'STAMPED BDL B 1992 SET IN THE TOP OF A 8-INCH CONCRETE POST WHICH IS

AC7670'FLUSH WITH THE GROUND.

AC7670

AC7670

STATION RECOVERY (1999)

AC7670

AC7670'RECOVERY NOTE BY WOOLPERT CONSULTANTS 1999 (WLP)

AC7670'THE STATION IS LOCATED APPROXIMATELY 9.0 KM (5.60 MI) WEST-SOUTHWEST

AC7670'FROM EAST WINDSOR, 5.7 KM (3.55 MI) WEST-NORTHWEST OF WINDSOR LOCKS,

AC7670'4.6 KM (2.85 MI) NORTH OF POQUONOCK, AT THE BRADLEY INTERNATIONAL

AC7670'AIRPORT. OWNERSHIP-- BRADLEY INTERNATIONAL AIRPORT, C/O STEVE KORTA

AC7670'AIRPORT MANAGER, BRADLEY INTERNATIONAL AIRPORT TERMINAL B, WINDSOR

AC7670'LOCKS CT 06096, PHONE NUMBER 860-292-2001, FAX NUMBER 860-292-2090.

AC7670'THIS STATION REQUIRES 24 HOUR NOTICE TO AIRPORT CONTACT FOR ACCESS.

AC7670'TO REACH THE STATION FROM THE JUNCTION OF INTERSTATE 91 (EXIT 40) AND

AC7670'STATE ROUTE 20, PROCEED WESTERLY 2.8 MI (4.5 KM) ALONG STATE ROUTE 20

AC7670'TO THE JUNCTION OF THE BRADLEY FIELD CONNECTOR. CONTINUE STRAIGHT

AC7670'ONTO THE BRADLEY FIELD CONNECTOR AND PROCEED NORTHEASTERLY 1.2 MI (1.9

AC7670'KM) TO THE MERGING OF THE CONNECTOR AND STATE ROUTE 401. CONTINUE

AC7670'NORTHEASTERLY 0.6 MI (1.0 KM) ALONG STATE ROUTE 401 TO THE JUNCTION OF

AC7670'A ROAD LEADING TO GATE 1 ON THE LEFT. TURN LEFT AND PROCEED

AC7670'NORTHWESTERLY 0.2 MI (0.3 KM) ALONG THE ROAD TO ANOTHER LEADING TO

AC7670'GATE 1. TURN LEFT AND PROCEED NORTH 0.05 MI (0.08 KM) TO GATE 1.

AC7670'CONTINUE THROUGH THE GATE AND ONTO THE PERIMETER ROAD. PROCEED

5/16/2005



AC7670'WESTERLY 0.15 MI (0.24 KM) ALONG THE PERIMETER ROAD TO THE JUNCTION OF
AC7670'TAXIWAY CHARLIE. TURN RIGHT AND PROCEED NORTHEAST 0.4 MI (0.6 KM) TO
AC7670'THE APPROACH END OF RUNWAY 24 AND THE STATION ON THE RIGHT. THE
AC7670'STATION IS LOCATED SOUTHEAST OF THE HOLD LINE OF TAXIWAY C FOR RUNWAY
AC7670'24.

AC7670'THE STATION IS A BRONZE NOS HORIZONTAL CONTROL DISK STAMPED--BDL B
AC7670'1992-- SET IN THE TOP OF A 0.3 M (1.0 FT) DIAMETER CONCRETE MONUMENT.
AC7670'THE STATION IS LOCATED 21.9 M (71.9 FT) FROM TWY LIGHT NO 14-29 ON A
AC7670'MAGNETIC COMPASS AZIMUTH OF 30 DEGREES, 13.7 M (44.9 FT) FROM THE
AC7670'FIFTH TAXIWAY LIGHT FROM THE RUNWAY END ON A MAGNETIC COMPASS AZIMUTH
AC7670'OF 100 DEGREES, 8.2 M (26.9 FT) FROM THE PK NAIL WITH WASHER NUMBER 92
AC7670'SET IN TAXIWAY CHARLIE ON A MAGNETIC COMPASS AZIMUTH OF 76 DEGREES,
AC7670'6.1 M (20.0 FT) FROM THE CENTERLINE OF THE SERVICE ROAD ON A MAGNETIC
AC7670'COMPASS AZIMUTH OF 144 DEGREES. THIS STATION IS DESIGNATED AS A
AC7670'SECONDARY AIRPORT CONTROL STATION.

AC7670

AC7670

STATION RECOVERY (2000)

AC7670

AC7670'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (DGA)

AC7670'RECOVERED AS DESCRIBED.

AC7670'

AI5554 PACS - This is a Primary Airport Control Station.
 AI5554 DESIGNATION - BDL C
 AI5554 PID - AI5554
 AI5554 STATE/COUNTY- CT/HARTFORD
 AI5554 USGS QUAD - WINDSOR LOCKS (1984)

AI5554

*CURRENT SURVEY CONTROL

AI5554

AI5554*	NAD 83 (1996)	-	41 56 19.10654 (N)	072 41 03.20619 (W)	ADJUSTED
AI5554*	NAVD 88	-	51.84 (meters)	170.1 (feet)	GPS OBS

AI5554

AI5554	X	-	1,414,247.669 (meters)	COMP
AI5554	Y	-	-4,536,226.947 (meters)	COMP
AI5554	Z	-	4,240,551.847 (meters)	COMP
AI5554	LAPLACE CORR-		-2.99 (seconds)	DEFLEC99
AI5554	ELLIP HEIGHT-		22.80 (meters)	(06/04/02) GPS OBS
AI5554	GEOID HEIGHT-		-29.07 (meters)	GEOID03

AI5554

AI5554 HORZ ORDER - B

AI5554 ELLP ORDER - FOURTH CLASS I

AI5554

AI5554.This mark is at Bradley Intl Airport (BDL)

AI5554

AI5554.The horizontal coordinates were established by GPS observations

AI5554.and adjusted by the National Geodetic Survey in May 2000.

AI5554

AI5554.The orthometric height was determined by GPS observations and a

AI5554.high-resolution geoid model.

AI5554

AI5554.GPS derived orthometric heights for airport stations designated as

AI5554.PACS or SACS are published to 2 decimal places. This maintains

AI5554.centimeter relative accuracy between the PACS and SACS. It does

AI5554.not indicate centimeter accuracy relative to other marks which are

AI5554.part of the NAVD 88 network.

AI5554

AI5554.Photographs are available for this station.

AI5554

AI5554.The X, Y, and Z were computed from the position and ellipsoidal ht.

AI5554

AI5554.The Laplace correction was computed from DEFLEC99 derived deflections.

AI5554

AI5554.The ellipsoidal height was determined by GPS observations

AI5554.and is referenced to NAD 83.

AI5554

AI5554.The geoid height was determined by GEOID03.

AI5554

AI5554;		North	East	Units	Scale	Factor	Converg.
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AI5554;SPC CT	-	275,159.572	310,255.482	MT	1.00000808	+0 02	
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AI5554;UTM 18	-	4,645,557.263	691,976.872	MT	1.00005352	+1 32	
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53.5

AI5554

AI5554!		Elev Factor	x	Scale Factor	=	Combined Factor
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AI5554!SPC CT	-	0.99999642	x	1.00000808	=	1.00000450
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AI5554!UTM 18	-	0.99999642	x	1.00005352	=	1.00004994
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AI5554

AI5554 SUPERSEDED SURVEY CONTROL

AI5554

AI5554 ELLIP H (05/22/00) 22.79 (m) GP() 4

1

AI5554

AI5554.Superseded values are not recommended for survey control.

AI5554.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

AI5554.See file dsdata.txt to determine how the superseded data were derived.

AI5554

AI5554_U.S. NATIONAL GRID SPATIAL ADDRESS: 18TXM9197745557(NAD 83)

AI5554_MARKER: I = METAL ROD

AI5554_SETTING: 59 = STAINLESS STEEL ROD IN SLEEVE (10 FT.+)

AI5554_STAMPING: BDL C 1999

AI5554_MARK LOGO: NGS

AI5554_PROJECTION: FLUSH

AI5554_MAGNETIC: N = NO MAGNETIC MATERIAL

AI5554_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL

AI5554_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR

AI5554+SATELLITE: SATELLITE OBSERVATIONS - September 25, 2000

AI5554_ROD/PIPE-DEPTH: 31.1 meters

AI5554_SLEEVE-DEPTH : 1.00 meters

AI5554

AI5554	HISTORY	- Date	Condition	Report By
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AI5554	HISTORY	- 1999	MONUMENTED	WOOLPT
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AI5554	HISTORY	- 20000925	GOOD	NGS
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AI5554

AI5554 STATION DESCRIPTION

AI5554

AI5554'DESCRIBED BY WOOLPERT CONSULTANTS 1999 (ARL)

AI5554'THE STATION IS LOCATED APPROXIMATELY 9.0 KM (5.60 MI) WEST-SOUTHWEST

AI5554'FROM EAST WINDSOR, 5.7 KM (3.55 MI) WEST-NORTHWEST OF WINDSOR LOCKS,

AI5554'4.6 KM (2.85 MI) NORTH OF POQUONOCK, AT THE BRADLEY INTERNATIONAL

AI5554'AIRPORT. OWNERSHIP-- BRADLEY INTERNATIONAL AIRPORT, C/O STEVE KORTA

AI5554'AIRPORT MANAGER, BRADLEY INTERNATIONAL AIRPORT TERMINAL B, WINDSOR

AI5554'LOCKS CT 06096, PHONE NUMBER 860-292-2001, FAX NUMBER 860-292-2090.

AI5554'THIS STATION REQUIRES 24 HOUR NOTICE TO AIRPORT CONTACT FOR ACCESS.

AI5554'TO REACH THE STATION FROM THE JUNCTION OF INTERSTATE 91 (EXIT 40) AND

AI5554'STATE ROUTE 20, PROCEED WESTERLY 2.8 MI (4.5 KM) ALONG STATE ROUTE 20

AI5554'TO THE JUNCTION OF THE BRADLEY FIELD CONNECTOR. CONTINUE STRAIGHT

AI5554'ONTO THE BRADLEY FIELD CONNECTOR AND PROCEED NORTHEASTERLY 1.2 MI (1.9

AI5554'KM) TO THE MERGING OF THE CONNECTOR AND STATE ROUTE 401. CONTINUE

AI5554'NORTHEASTERLY 0.6 MI (1.0 KM) ALONG STATE ROUTE 401 TO THE JUNCTION OF

AI5554'A ROAD LEADING TO GATE C ON THE LEFT. TURN LEFT AND PROCEED

AI5554'NORTHWESTERLY 0.2 MI (0.3 KM) ALONG THE ROAD TO ANOTHER ROAD ON THE

AI5554'LEFT LEADING TO GATE C. TURN LEFT AND PROCEED NORTH 0.05 MI (0.08 KM)

AI5554'TO GATE C. PROCEED NORTH THROUGH THE GATE AND ONTO THE PERIMETER

AI5554'ROAD. PROCEED NORTHERLY ALONG THE PERIMETER ROAD 0.15 MI (0.24 KM) TO

AI5554'THE JUNCTION OF TAXIWAY CHARLIE. TURN RIGHT AND PROCEED 0.5 MI (0.8

AI5554'KM) ALONG TAXIWAY CHARLIE TO A SERVICE ROAD ON THE RIGHT, JUST PAST

AI5554'THE JUNCTION OF TAXIWAY KILO. TURN RIGHT AND PROCEED 0.05 MI (0.08

AI5554'KM) ALONG THE SERVICE ROAD TO THE TOP OF A BANK AND THE STATION ON THE

AI5554'RIGHT. THE STATION IS SET ONLINE WITH THE TAXIWAY LIGHT SOUTHWEST OF

AI5554'TAXIWAY KILO.

AI5554'THE STATION IS A PUNCH MARK ON THE TOP OF A 9/16-INCH STAINLESS STEEL

AI5554'ROD ENCASED IN A 1 M (3.3 FT) FINNED SLEEVE FILLED WITH NONTOXIC

AI5554'GREASE, DRIVEN TO A REFUSAL DEPTH OF 31.1 M, (102.0 FT) AND ENCASED IN

AI5554'A 5-INCH PVC PIPE WITH LOGO CAP STAMPED--BDL C 1999-- SET FLUSH WITH

AI5554'THE GROUND. THE STATION IS LOCATED 53.8 M (176.5 FT) FROM THE EDGE OF

AI5554'PAVEMENT ONLINE WITH THE TAXIWAY LIGHTS ON A MAGNETIC COMPASS AZIMUTH
 AI5554'OF 157 DEGREES, 49.7 M (163.1 FT) FROM THE SOUTHWEST CORNER OF THE
 AI5554'SOUTHERN SHACK ON A MAGNETIC COMPASS AZIMUTH OF 290 DEGREES, 39.6 M
 AI5554'(129.9 FT) FROM THE WEST CORNER OF THE CONCRETE PAD AT THE RPU ON A
 AI5554'MAGNETIC COMPASS AZIMUTH OF 20 DEGREES, 35.8 M (117.5 FT) FROM THE
 AI5554'EXTENDED CENTERLINE OF TAXIWAY K ON A MAGNETIC COMPASS AZIMUTH OF 240
 AI5554'DEGREES, 21.0 M (68.9 FT) FROM THE SOUTHERN CORNER OF THE CATCH BASIN
 AI5554'ON A MAGNETIC COMPASS AZIMUTH OF 190 DEGREES. THE STATION IS
 AI5554'DESIGNATED AS THE PRIMARY AIRPORT CONTROL STATION.

AI5554

STATION RECOVERY (2000)

AI5554

AI5554'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (DGA)

AI5554'RECOVERED IN GOOD CONDITION.

Ground Truth

GPS control monuments and the RMSE of their values.

PID	designation	SP NAD83 easting	SP NAD83 northing	navd88	monument correction	lidar surface diff	Squared
AI5568	CEF_B	373337.17	2892234.21	237.8		0.2907	0.08450649
MZ1405	A51	348946.25	2864962.78	157.77		0.309	0.095481
AI5567	CEF_A	376847.87	2897614.79	239.13	corrected from 4 cm below ground	-0.2881	0.08300161
AI5569	CEF C	374523.62	2902451.97	240.8		0.4553	0.20729809
AI5553	BAFA	327991.01	2882880.82	244.9		0.3066	0.09400356
AB3269	BAF AP STA C	327540.4	2889140.5	264.5		0.064	0.004096
MZ1794	BARNES RESET	325832.59	2885754.81	263		0.5077	0.25775929
MZ1129	Z39	427469.2	2885665.22	334.68		0.4844	0.23464336
Total						2.13	1.0608
Avg. Error						0.27	0.1326
# Points / RMSE						8.00	0.3641

GPS control was collected to establish control points at the Bradley International Airport calibration site. The survey work resulted in placing 5 ground photo panels CAL 1001 through 1005 at the calibration site.

Aerial Target	Grid Northing	Grid Easting	Elevation
1001	902033.28	1020995.95	167.01
1002	901760.75	1021462.44	167.78
1003	900747.97	1020547.65	166.39
1004	900702.81	1021371.76	165.79
1005	901402.17	1020628.27	168.34

Notes:

- 1- Coordinates are in US Survey Feet and reference the 1983 North American Datum (NAD83/96). Elevations are in US Survey Feet and reference North American Vertical Datum of 1988
- 2- (NAVD88)
- 3- Numbers and locations of Aerial Targets are taken from the Ortho Photo provided by Spectrum Mapping for Bradley International Airport.

GROUND CONTROL REPORT

Base Station Information

All base station information, notes, GPS station monument names and stability
Massachusetts:

PID - AC7670
Designation – BDL B
Projection – Flush
Stability – C – May hold, but of type commonly subject to surface motion.

Point AC7670 is located at the Bradley International Airport, CT. Point AC7670 is horizontal order first and fourth order class I ellipsoid order.

The station is located 21.9 m from TWY light number 14-29. 13.7 m from the fifth taxiway light from the runway end. 8.2 m from the PK nail with washer number 92 set in taxiway Charlie, and 6.1 m from the centerline of the service road.

AC7670 SACS - This is a Secondary Airport Control Station.

AC7670 DESIGNATION - BDL B

AC7670 PID - AC7670

AC7670 STATE/COUNTY- CT/HARTFORD

AC7670 USGS QUAD - WINDSOR LOCKS (1984)

AC7670

AC7670 *CURRENT SURVEY CONTROL

AC7670

AC7670* NAD 83(1996)- 41 57 00.32545(N) 072 40 16.36405(W) ADJUSTED

AC7670* NAVD 88 - 47.34 (meters) 155.3 (feet) GPS OBS

AC7670

AC7670 X - 1,415,023.609 (meters) COMP

AC7670 Y - -4,535,090.999 (meters) COMP

AC7670 Z - 4,241,494.757 (meters) COMP

AC7670 LAPLACE CORR- -2.73 (seconds) DEFLEC99

AC7670 ELLIP HEIGHT- 18.30 (meters) (06/04/02) GPS OBS

AC7670 GEOID HEIGHT- -29.07 (meters) GEOID03

AC7670

AC7670 HORZ ORDER - FIRST

AC7670 ELLP ORDER - FOURTH CLASS I

AC7670

AC7670.This mark is at Bradley Intl Airport (BDL)

AC7670

AC7670.The horizontal coordinates were established by GPS observations

AC7670.and adjusted by the National Geodetic Survey in May 2000.

AC7670

AC7670.The orthometric height was determined by GPS observations and a

AC7670.high-resolution geoid model.

AC7670

AC7670.GPS derived orthometric heights for airport stations designated as

AC7670.PACS or SACS are published to 2 decimal places. This maintains

AC7670.centimeter relative accuracy between the PACS and SACS. It does

AC7670.not indicate centimeter accuracy relative to other marks which are

AC7670.part of the NAVD 88 network.

AC7670

AC7670. Photographs are available for this station.

AC7670

AC7670. The X, Y, and Z were computed from the position and the ellipsoidal ht.

AC7670

AC7670. The Laplace correction was computed from DEFLEC99 derived deflections.

AC7670

AC7670. The ellipsoidal height was determined by GPS observations

AC7670. and is referenced to NAD 83.

AC7670

AC7670. The geoid height was determined by GEOID03.

AC7670

AC7670; North East Units Scale Factor Converg.

AC7670; SPC CT - 276,432.228 311,333.395 MT 1.00000952 +0 03 08.1

AC7670; UTM 18 - 4,646,857.849 693,021.043 MT 1.00005847 +1 33 26.0

AC7670

AC7670! - Elev Factor x Scale Factor = Combined Factor

AC7670! SPC CT - 0.99999713 x 1.00000952 = 1.00000665

AC7670! UTM 18 - 0.99999713 x 1.00005847 = 1.00005560

AC7670

AC7670 SUPERSEDED SURVEY CONTROL

AC7670

AC7670. No superseded survey control is available for this station.

AC7670

AC7670_U.S. NATIONAL GRID SPATIAL ADDRESS: 18TXM9302146858(NAD 83)

AC7670_MARKER: DD = SURVEY DISK

AC7670_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT

AC7670_STAMPING: BDL B 1992

AC7670_MARK LOGO: NGS

AC7670_PROJECTION: FLUSH

AC7670_MAGNETIC: N = NO MAGNETIC MATERIAL

AC7670_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO

AC7670+STABILITY: SURFACE MOTION

AC7670_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR

AC7670+SATELLITE: SATELLITE OBSERVATIONS - September 25, 2000

AC7670

AC7670 HISTORY - Date Condition Report By

AC7670 HISTORY - 1992 MONUMENTED NGS

AC7670 HISTORY - 19991206 GOOD WOOLPT

AC7670 HISTORY - 20000925 GOOD NGS

AC7670

AC7670 STATION DESCRIPTION

AC7670

AC7670'DESCRIBED BY NATIONAL GEODETIC SURVEY 1992 (GFS)

AC7670'THE STATION IS LOCATED AT THE BRADLEY INTERNATIONAL AIRPORT SOUTHEAST

AC7670'OF RUNWAY END 24. IT IS 95.3 FT (29.0 M) SOUTHEAST OF THE CENTERLINE

AC7670'OF THE TAXIWAY, 72.1 FT (22.0 M) NORTHEAST OF THE 6TH TAXIWAY LIGHT

AC7670'SOUTHWEST OF THE RUNWAY END, 45.5 FT (13.9 M) SOUTHEAST OF THE LINE

AC7670'EXTENDED OF THE HOLDBAR, 44.7 FT (13.6 M) SOUTHEAST OF THE 5TH TAXIWAY

AC7670'LIGHT FROM THE RUNWAY END, 26.8 FT (8.2 M) NORTHEAST OF A P-K NAIL AND

AC7670'WASHER SET IN THE SHOULDER OF THE TAXIWAY AND SOUTHEAST OF THE FAA

AC7670'ROAD TO THE APPROACH LIGHT LANE. THE STATION IS A STANDARD NOS DISK

AC7670'STAMPED BDL B 1992 SET IN THE TOP OF A 8-INCH CONCRETE POST WHICH IS

AC7670'FLUSH WITH THE GROUND.

AC7670

AC7670 STATION RECOVERY (1999)

AC7670

AC7670'RECOVERY NOTE BY WOOLPERT CONSULTANTS 1999 (WLP)

AC7670'THE STATION IS LOCATED APPROXIMATELY 9.0 KM (5.60 MI) WEST-SOUTHWEST
AC7670'FROM EAST WINDSOR, 5.7 KM (3.55 MI) WEST-NORTHWEST OF WINDSOR LOCKS,
AC7670'4.6 KM (2.85 MI) NORTH OF POQUONOCK, AT THE BRADLEY INTERNATIONAL
AC7670'AIRPORT. OWNERSHIP-- BRADLEY INTERNATIONAL AIRPORT, C/O STEVE KORTA
AC7670'AIRPORT MANAGER, BRADLEY INTERNATIONAL AIRPORT TERMINAL B, WINDSOR
AC7670'LOCKS CT 06096, PHONE NUMBER 860-292-2001, FAX NUMBER 860-292-2090.

AC7670'THIS STATION REQUIRES 24 HOUR NOTICE TO AIRPORT CONTACT FOR ACCESS.
AC7670'TO REACH THE STATION FROM THE JUNCTION OF INTERSTATE 91 (EXIT 40) AND
AC7670'STATE ROUTE 20, PROCEED WESTERLY 2.8 MI (4.5 KM) ALONG STATE ROUTE 20
AC7670'TO THE JUNCTION OF THE BRADLEY FIELD CONNECTOR. CONTINUE STRAIGHT
AC7670'ONTO THE BRADLEY FIELD CONNECTOR AND PROCEED NORTHEASTERLY 1.2 MI (1.9
AC7670'KM) TO THE MERGING OF THE CONNECTOR AND STATE ROUTE 401. CONTINUE
AC7670'NORTHEASTERLY 0.6 MI (1.0 KM) ALONG STATE ROUTE 401 TO THE JUNCTION OF
AC7670'A ROAD LEADING TO GATE 1 ON THE LEFT. TURN LEFT AND PROCEED
AC7670'NORTHWESTERLY 0.2 MI (0.3 KM) ALONG THE ROAD TO ANOTHER LEADING TO
AC7670'GATE 1. TURN LEFT AND PROCEED NORTH 0.05 MI (0.08 KM) TO GATE 1.
AC7670'CONTINUE THROUGH THE GATE AND ONTO THE PERIMETER ROAD. PROCEED
AC7670'WESTERLY 0.15 MI (0.24 KM) ALONG THE PERIMETER ROAD TO THE JUNCTION OF
AC7670'TAXIWAY CHARLIE. TURN RIGHT AND PROCEED NORTHEAST 0.4 MI (0.6 KM) TO
AC7670'THE APPROACH END OF RUNWAY 24 AND THE STATION ON THE RIGHT. THE
AC7670'STATION IS LOCATED SOUTHEAST OF THE HOLD LINE OF TAXIWAY C FOR RUNWAY
AC7670'24.

AC7670'THE STATION IS A BRONZE NOS HORIZONTAL CONTROL DISK STAMPED--BDL B
AC7670'1992-- SET IN THE TOP OF A 0.3 M (1.0 FT) DIAMETER CONCRETE MONUMENT.
AC7670'THE STATION IS LOCATED 21.9 M (71.9 FT) FROM TWY LIGHT NO 14-29 ON A
AC7670'MAGNETIC COMPASS AZIMUTH OF 30 DEGREES, 13.7 M (44.9 FT) FROM THE
AC7670'FIFTH TAXIWAY LIGHT FROM THE RUNWAY END ON A MAGNETIC COMPASS AZIMUTH
AC7670'OF 100 DEGREES, 8.2 M (26.9 FT) FROM THE PK NAIL WITH WASHER NUMBER 92
AC7670'SET IN TAXIWAY CHARLIE ON A MAGNETIC COMPASS AZIMUTH OF 76 DEGREES,
AC7670'6.1 M (20.0 FT) FROM THE CENTERLINE OF THE SERVICE ROAD ON A MAGNETIC
AC7670'COMPASS AZIMUTH OF 144 DEGREES. THIS STATION IS DESIGNATED AS A
AC7670'SECONDARY AIRPORT CONTROL STATION.

AC7670

AC7670 STATION RECOVERY (2000)

AC7670

AC7670'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (DGA)

AC7670'RECOVERED AS DESCRIBED.

AC7670'

PID - AI5554
 Designation – BDL C
 Projection – Flush
 Stability – B – Probably hold position/elevation well.

Point AI5554 is located at the Bradley International Airport, CT. Point AC7670 is horizontal order B and fourth order class I ellipsoid order. This is a primary airport control station.

The station is located 53.8 m from the edge of pavement oline with the taxiway lights, 49.7 m from the southwest corner of the southern shack, 39.6 m from the west corner of the concrete pad at the RPU, 35.8 m from the extended centerline of taxiway K, and 21.0 m from the southern corner of the catch basin.

AI5554 PACS - This is a Primary Airport Control Station.

AI5554 DESIGNATION - BDL C

AI5554 PID - AI5554

AI5554 STATE/COUNTY- CT/HARTFORD

AI5554 USGS QUAD - WINDSOR LOCKS (1984)

AI5554

AI5554 *CURRENT SURVEY CONTROL

AI5554

AI5554* NAD 83(1996)- 41 56 19.10654(N) 072 41 03.20619(W) ADJUSTED

AI5554* NAVD 88 - 51.84 (meters) 170.1 (feet) GPS OBS

AI5554

AI5554 X - 1,414,247.669 (meters) COMP

AI5554 Y - -4,536,226.947 (meters) COMP

AI5554 Z - 4,240,551.847 (meters) COMP

AI5554 LAPLACE CORR- -2.99 (seconds) DEFLEC99

AI5554 ELLIP HEIGHT- 22.80 (meters) (06/04/02) GPS OBS

AI5554 GEOID HEIGHT- -29.07 (meters) GEOID03

AI5554

AI5554 HORZ ORDER - B

AI5554 ELLP ORDER - FOURTH CLASS I

AI5554

AI5554.This mark is at Bradley Intl Airport (BDL)

AI5554

AI5554.The horizontal coordinates were established by GPS observations

AI5554.and adjusted by the National Geodetic Survey in May 2000.

AI5554

AI5554.The orthometric height was determined by GPS observations and a

AI5554.high-resolution geoid model.

AI5554

AI5554.GPS derived orthometric heights for airport stations designated as AI5554.PACS or SACS are published to 2 decimal places. This maintains AI5554.centimeter relative accuracy between the PACS and SACS. It does AI5554.not indicate centimeter accuracy relative to other marks which are AI5554.part of the NAVD 88 network.

AI5554

AI5554.Photographs are available for this station.

AI5554

AI5554.The X, Y, and Z were computed from the position and the ellipsoidal ht.

AI5554

AI5554.The Laplace correction was computed from DEFLEC99 derived deflections.

AI5554

AI5554.The ellipsoidal height was determined by GPS observations

AI5554.and is referenced to NAD 83.

AI5554

AI5554.The geoid height was determined by GEOID03.

AI5554

AI5554; North East Units Scale Factor Converg.

AI5554;SPC CT - 275,159.572 310,255.482 MT 1.00000808 +0 02 37.0

AI5554;UTM 18 - 4,645,557.263 691,976.872 MT 1.00005352 +1 32 53.5

AI5554

AI5554! - Elev Factor x Scale Factor = Combined Factor

AI5554!SPC CT - 0.99999642 x 1.00000808 = 1.00000450

AI5554!UTM 18 - 0.99999642 x 1.00005352 = 1.00004994

AI5554

AI5554 SUPERSEDED SURVEY CONTROL

AI5554

AI5554 ELLIP H (05/22/00) 22.79 (m) GP() 4 1

AI5554

AI5554.Superseded values are not recommended for survey control.

AI5554.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

AI5554.See file dsdata.txt to determine how the superseded data were derived.

AI5554

AI5554_U.S. NATIONAL GRID SPATIAL ADDRESS: 18TXM9197745557(NAD 83)

AI5554_MARKER: I = METAL ROD

AI5554_SETTING: 59 = STAINLESS STEEL ROD IN SLEEVE (10 FT.+)

AI5554_STAMPING: BDL C 1999

AI5554_MARK LOGO: NGS

AI5554_PROJECTION: FLUSH

AI5554_MAGNETIC: N = NO MAGNETIC MATERIAL

AI5554_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL

AI5554_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR

AI5554+SATELLITE: SATELLITE OBSERVATIONS - September 25, 2000

AI5554_ROD/PIPE-DEPTH: 31.1 meters

AI5554_SLEEVE-DEPTH : 1.00 meters

AI5554

AI5554 HISTORY - Date Condition Report By

AI5554 HISTORY - 1999 MONUMENTED WOOLPT

AI5554 HISTORY - 20000925 GOOD NGS

AI5554

AI5554 STATION DESCRIPTION

AI5554

AI5554'DESCRIBED BY WOOLPERT CONSULTANTS 1999 (ARL)

AI5554'THE STATION IS LOCATED APPROXIMATELY 9.0 KM (5.60 MI) WEST-SOUTHWEST

AI5554'FROM EAST WINDSOR, 5.7 KM (3.55 MI) WEST-NORTHWEST OF WINDSOR LOCKS,

AI5554'4.6 KM (2.85 MI) NORTH OF POQUONOCK, AT THE BRADLEY INTERNATIONAL

AI5554'AIRPORT. OWNERSHIP-- BRADLEY INTERNATIONAL AIRPORT, C/O STEVE KORTA

AI5554'AIRPORT MANAGER, BRADLEY INTERNATIONAL AIRPORT TERMINAL B, WINDSOR

AI5554'LOCKS CT 06096, PHONE NUMBER 860-292-2001, FAX NUMBER 860-292-2090.

AI5554'THIS STATION REQUIRES 24 HOUR NOTICE TO AIRPORT CONTACT FOR ACCESS.

AI5554'TO REACH THE STATION FROM THE JUNCTION OF INTERSTATE 91 (EXIT 40) AND

AI5554'STATE ROUTE 20, PROCEED WESTERLY 2.8 MI (4.5 KM) ALONG STATE ROUTE 20

AI5554'TO THE JUNCTION OF THE BRADLEY FIELD CONNECTOR. CONTINUE STRAIGHT

AI5554' ONTO THE BRADLEY FIELD CONNECTOR AND PROCEED NORTHEASTERLY 1.2 MI (1.9 AI5554' KM) TO THE MERGING OF THE CONNECTOR AND STATE ROUTE 401. CONTINUE AI5554' NORTHEASTERLY 0.6 MI (1.0 KM) ALONG STATE ROUTE 401 TO THE JUNCTION OF AI5554' A ROAD LEADING TO GATE C ON THE LEFT. TURN LEFT AND PROCEED AI5554' NORTHWESTERLY 0.2 MI (0.3 KM) ALONG THE ROAD TO ANOTHER ROAD ON THE AI5554' LEFT LEADING TO GATE C. TURN LEFT AND PROCEED NORTH 0.05 MI (0.08 KM) AI5554' TO GATE C. PROCEED NORTH THROUGH THE GATE AND ONTO THE PERIMETER AI5554' ROAD. PROCEED NORTHERLY ALONG THE PERIMETER ROAD 0.15 MI (0.24 KM) TO AI5554' THE JUNCTION OF TAXIWAY CHARLIE. TURN RIGHT AND PROCEED 0.5 MI (0.8 AI5554' KM) ALONG TAXIWAY CHARLIE TO A SERVICE ROAD ON THE RIGHT, JUST PAST AI5554' THE JUNCTION OF TAXIWAY KILO. TURN RIGHT AND PROCEED 0.05 MI (0.08 AI5554' KM) ALONG THE SERVICE ROAD TO THE TOP OF A BANK AND THE STATION ON THE AI5554' RIGHT. THE STATION IS SET ONLINE WITH THE TAXIWAY LIGHT SOUTHWEST OF AI5554' TAXIWAY KILO.

AI5554' THE STATION IS A PUNCH MARK ON THE TOP OF A 9/16-INCH STAINLESS STEEL AI5554' ROD ENCASED IN A 1 M (3.3 FT) FINNED SLEEVE FILLED WITH NONTOXIC AI5554' GREASE, DRIVEN TO A REFUSAL DEPTH OF 31.1 M, (102.0 FT) AND ENCASED IN AI5554' A 5-INCH PVC PIPE WITH LOGO CAP STAMPED--BDL C 1999-- SET FLUSH WITH AI5554' THE GROUND. THE STATION IS LOCATED 53.8 M (176.5 FT) FROM THE EDGE OF AI5554' PAVEMENT ONLINE WITH THE TAXIWAY LIGHTS ON A MAGNETIC COMPASS AZIMUTH AI5554' OF 157 DEGREES, 49.7 M (163.1 FT) FROM THE SOUTHWEST CORNER OF THE AI5554' SOUTHERN SHACK ON A MAGNETIC COMPASS AZIMUTH OF 290 DEGREES, 39.6 M AI5554' (129.9 FT) FROM THE WEST CORNER OF THE CONCRETE PAD AT THE RPU ON A AI5554' MAGNETIC COMPASS AZIMUTH OF 20 DEGREES, 35.8 M (117.5 FT) FROM THE AI5554' EXTENDED CENTERLINE OF TAXIWAY K ON A MAGNETIC COMPASS AZIMUTH OF 240 AI5554' DEGREES, 21.0 M (68.9 FT) FROM THE SOUTHERN CORNER OF THE CATCH BASIN AI5554' ON A MAGNETIC COMPASS AZIMUTH OF 190 DEGREES. THE STATION IS AI5554' DESIGNATED AS THE PRIMARY AIRPORT CONTROL STATION.

AI5554

AI5554 STATION RECOVERY (2000)

AI5554

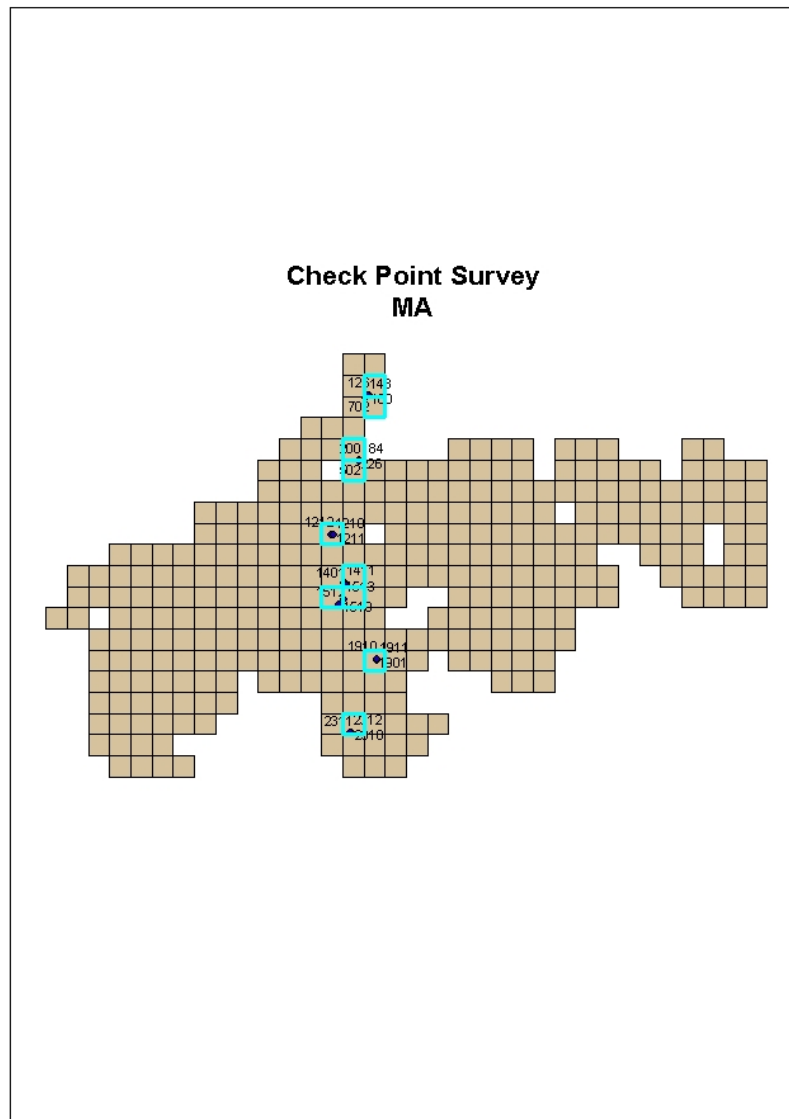
AI5554' RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (DGA)

AI5554' RECOVERED IN GOOD CONDITION.

Checkpoint Survey

Mass Notes: Coordinates are in US Survey Feet and reference the Mass. 1983 American Datum (NAD83/2001)

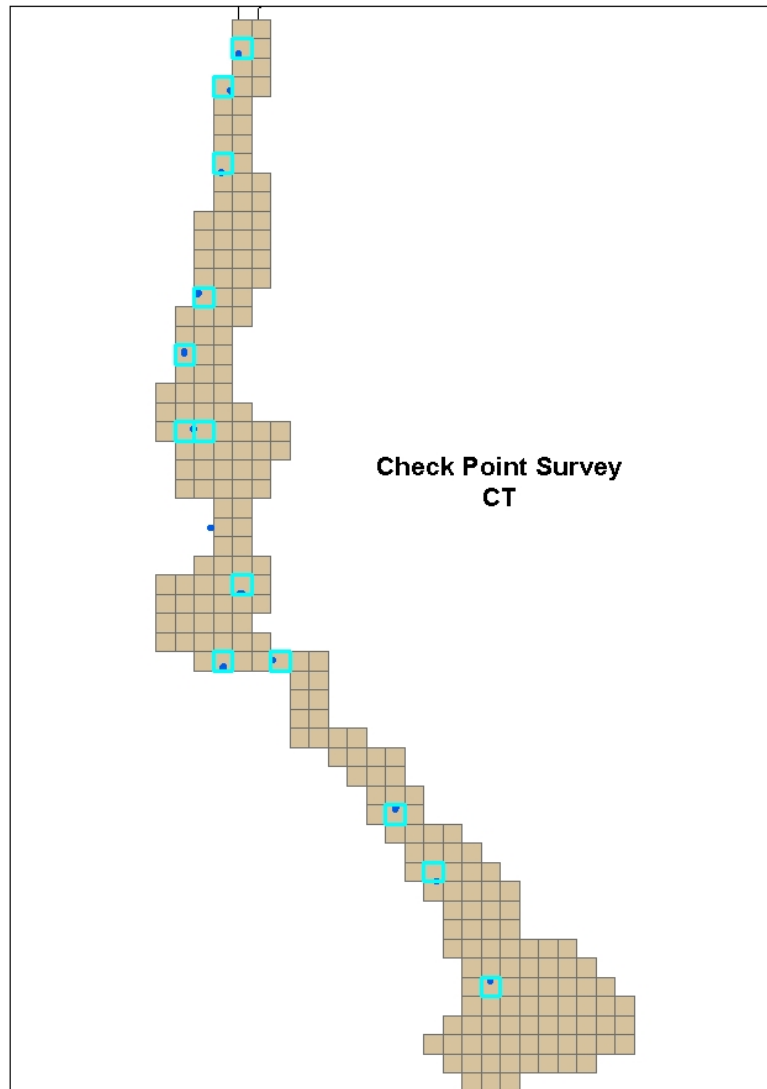
Elevations are in US Survey feet and reference North American Vertical Datum of 1988 (NAVD88). The picture below shows the area the MA check point survey was completed.



MA – Check Point Survey

Site #	ID	Type	Northing	Easting	Elevation
1	228	WOD	2907654.32	355896.98	123.57
	229	GRA	2907506.19	355940.69	131.80
	502	PAV	2907590.20	355930.00	129.29
	226	WOD-S	2907595.29	355865.69	124.46
	200	PAV-S	2907503.75	355892.66	131.16
	184	GRA-S	2907399.76	355919.23	129.97
2	161	WOD	2922391.82	357471.12	108.77
	701	PAV	2922735.26	358207.05	114.22
	702	GRA	2922545.56	357718.01	114.56
	100	PAV-S	2922765.19	358220.92	111.90
	126	GRA-S	2922898.14	358246.29	105.95
	148	WOD-S	2922733.15	357979.29	106.93
3	1211	WOD	2889870.91	349877.42	62.56
	1212	GRA	2889844.27	349444.34	90.04
	1210	PAV	2889796.90	349778.18	61.78
4	1410	WOD	2878485.47	352622.68	63.58
	1411	PAV	2878454.67	352383.68	61.32
	1401	GRA	2878012.96	352935.05	59.23
5	1510	PAV	2873667.35	351690.62	58.44
	1512	WOD	2873559.02	351180.61	55.75
	1513	GRA	2874682.92	352244.35	57.30
6	1901	GRA	2860347.34	360056.54	56.17
	1910	WOD	2860559.98	360111.33	47.56
	1911	PAV	2860375.75	359979.18	55.17
7	2310	GRA	2843124.11	354245.87	52.05
	2311	WOD	2843012.29	354249.40	60.03
	2312	PAV	2843143.68	353849.26	54.61

CT Notes: Coordinates are in US Survey Feet and reference the CT 1983 North American Datum (NAD83/2001). Elevations are in US Survey feet and reference North American Vertical Datum of 1988 (NAVD88). The picture below shows the area the checkpoint survey was conducted in CT.



CONN.

Site #	ID	Type	Northing	Easting	Elevation
8	99801	PAV	920980.34	1036880.16	123.95
	99802	GRA	921137.91	1036763.42	124.34
	99803	WOD	921236.96	1036878.03	127.04
9	99901	PAV	911423.01	1034876.33	102.31
	99902	GRA	911581.69	1034848.27	100.91
	99903	WOD	911680.95	1034728.85	102.16
10	991001	PAV	890331.19	1032210.70	41.21
	991002	GRA	890213.50	1032336.72	34.72
	991003	WOD	890024.69	1032365.69	31.96
11	991101	PAV	858662.19	1026428.27	80.27
	991102	GRA	858590.04	1026254.50	91.28
	991103	WOD	858472.69	1026281.67	84.87
12	991201	PAV	843260.16	1022612.29	13.84
	991202	GRA	843674.95	1022801.07	14.17
	991203	WOD	843031.36	1022706.71	14.35
13	991301	PAV	823144.23	1025288.57	37.42
	991302	GRA	823178.80	1025130.46	33.90
	991303	WOD	823283.70	1024837.70	32.60
14	991401	PAV	797455.98	1029671.24	146.13
	991402	GRA	797470.87	1029824.34	147.59
	991403	WOD	797407.96	1029567.46	137.45
15	991501	PAV	780391.10	1037799.46	9.55
	991502	GRA	780373.10	1037466.12	10.34
	991503	WOD	780267.51	1037143.02	11.09
16	991601	PAV	761108.90	1033115.02	172.12
	991602	GRA	761123.53	1032826.63	168.00
	991603	WOD	761018.00	1032818.44	167.83
17	991701	PAV	724406.02	1077884.17	6.62
	991702	GRA	723976.37	1077964.00	6.82
	991703	WOD	723794.94	1077845.41	6.83
17-S	991708	PAV-S	762773.11	1045930.72	47.83
	991709	GRA-S	762800.68	1045802.84	52.90
18	991801	PAV	724741.86	1077808.18	7.45

Site #	ID	Type	Northing	Easting	Elevation
	991802	GRA	724459.56	1078091.47	6.82
	991803	WOD	724913.67	1078037.37	6.62
19	991901	PAV	705016.67	1088699.31	6.87
	991902	GRA	705068.86	1088633.19	8.20
	991903	WOD	705093.71	1088575.15	10.50
20	992001	PAV	679192.91	1102663.78	49.74
	992002	GRA	679126.06	1102733.37	50.04
	992003	WOD	679325.32	1102800.50	44.94

5/16/2005



SYSTEM CALIBRATION REPORT

System Calibration

The Spectrum RAMS LIDAR system uses multiple layers of system calibration. The initial instrument calibration is accomplished during the system fabrication. All critical components (IMU, LIDAR, Camera, and Scanner) are optically aligned to a common optical bench using NIST traceable optical collimators and optical flats. This alignment is initially carried out to 2 arc seconds. In addition to the optical bench calibration, the LIDAR system is operated against a series of known targets to determine both scale factor and bias accuracy. All system timing is derived from GPS.

On any aircraft installation the critical factor is location of the GPS antenna and IMU positioning with respect to the RAMS optical reference. This is accomplished through a differential GPS survey. After installation in the aircraft, the system is then flown against a ground test range that was developed using high accuracy GPS points from a licensed surveyor. This range provides several hundred points that are used to statistically verify the in flight calibration.

One of the benefits of a LIDAR system is that the calibration of the system is verified each time two or more flight lines are combined. This is a result of taking measurements on a common point from multiple locations (i.e. the ground point is fixed and each flight line that sees this is a different instrument location). When multiple flight lines can be combined with no artifacts then the calibration of the system is validated in terms of range and angular accuracies. Our standard practice requires that at least one flight line within the project be flown in both directions for calibration verification of range and angular accuracy.

Another important area of quality control is edge matching. All edge matching discrepancies in LIDAR DEM data occur between two flight lines. Identification of edge matching discrepancies is performed by overlaying either the contour or the shaded relief model representation of the original DEM. If edge artifacts are found in the overlap area between two flight lines then this represents an edge discrepancy. The GPS / IMU data is then reevaluated to check for any possible errors in the post processing or a spike in the PDOP at the time of data acquisition. Usually this type of problem is resolved by reprocessing the GPS / IMU.

For accuracy verification, static survey points are collected, using static benchmarks where available. These survey points within the project boundary are selected to allow a statistical absolute elevation verification of the data. This data set is then statistically compared to the project LIDAR DEM data after the combination of flight lines to verify accuracy both horizontal and vertical. The RMSE (Root Mean Square Error) of the LIDAR DEM will be calculated using the ground GPS data to ensure that the vertical error is less than 0.15 m and the horizontal is less than 0.5 m.

GPS / Calibration Processing Summary

All GPS phase data was post-processed with continuous kinematic survey techniques using “On the Fly” (OTF) integer ambiguity resolution. The GPS data was processed with forward and reverse processing algorithms. The results from each process were combined to yield a single fixed integer phase differential solution of the aircraft trajectory. Plots of altitude and the forward and reverse GPS solution residuals (RMS and DOP) are attached for each day of flight. Spikes in the vertical component of these plots occur in turns and ferrying to and from collection sites, and do not affect the integrity of the solution. The RMS separation values (25%-75% weighting) for all flights are summarized below.

The Processing Summary provides statistics about the final solution. The processing summary includes details such as solution type, baseline distances, number of epochs in total, epochs not processed, and epochs with bad C/A code and L1 phase measurements.

Statistics such as RMS values of the C/A code, L1 phase, L1 Doppler measurements, quality number percentages, estimated position standard deviations calculated from the Kalman filtering, and percentages of epochs having double difference DOPs over 10, provide a quick, convenient method of assessing processed solutions. The forward/reverse separation RMS values for Easting (E), Northing(N), and Heighting (H) are listed, and the forward/reverse separation RMS values of E,N, and H for 25%-75% weighting.

The latter RMS values take into account the weighting of the forward/reverse combined solution only in the region of 25%-75% where the float solution has had time to converge to a lower value of error since the larger error values occur at the beginning of the processing direction. The same can be said for a Kinematic Ambiguity Resolution (KAR) fixed solution as well. The RMS values for the 25%-75% weighting of the combined solution are generally lower than the RMS values from the forward/reverse separation because if one solution has high error values, most of the weighting will go to the other processing direction.

The following is checked in the Processing Summary:

The forward/reverse separation RMS values of E, N, and H are generally low if a fixed integer solution has been obtained. The values should be less than 0.05 meters, but no greater than 0.10 meters.

The Quality Number Percentages should almost all be Quality 1. This number is typically close to 100%, with 1% in Quality 2 for a fixed integer solution.

Processing Summary Information

The processing summaries below are for every mission used in the CT River project. This GPS data includes all turns, where you could have higher quality numbers due to the unstable nature of a turn, and greater baseline distances.

Program: GrafNav

Version: 6.03

Project: **June 4, 2004 mission 2**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 16423

No processed position: 8219

Missing Fwd or Rev: 1

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0206 (m)

C/A Code: 1.27 (m)

L1 Doppler: 0.026 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.013 (m)

North: 0.026 (m)

Height: 0.061 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8200 occurrences):

East: 0.008 (m)

North: 0.021 (m)

Height: 0.057 (m)

Quality Number Percentages:

Q 1: 100.0 %

Q 2: 0.0 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 92.3 %

0.10 - 0.30 m: 7.7 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 45.567 (km)

Minimum: 0.198 (km)

Average: 15.936 (km)

First Epoch: 0.201 (km)

Last Epoch: 0.201 (km)

Program: GrafNav
Version: 6.03
Project: **June 7, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 21116
No processed position: 10563
Missing Fwd or Rev: 1
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0229 (m)
C/A Code: 1.06 (m)
L1 Doppler: 0.026 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.023 (m)
North: 0.025 (m)
Height: 0.035 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (10548 occurrences):

East: 0.023 (m)
North: 0.024 (m)
Height: 0.027 (m)

Quality Number Percentages:

Q 1: 99.9 %
Q 2: 0.1 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 98.1 %
0.10 - 0.30 m: 1.9 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 47.328 (km)
Minimum: 0.208 (km)
Average: 19.962 (km)
First Epoch: 0.209 (km)
Last Epoch: 0.246 (km)

Program: GrafNav
Version: 6.03
Project: **June 8, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 19628
No processed position: 9814
Missing Fwd or Rev: 1
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0232 (m)
C/A Code: 1.09 (m)
L1 Doppler: 0.032 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.013 (m)
North: 0.030 (m)
Height: 0.029 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (9807 occurrences):

East: 0.011 (m)
North: 0.029 (m)
Height: 0.024 (m)

Quality Number Percentages:

Q 1: 99.6 %
Q 2: 0.4 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 84.7 %
0.10 - 0.30 m: 15.3 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 15.3 %

Baseline Distances:

Maximum: 48.046 (km)
Minimum: 0.214 (km)
Average: 21.514 (km)
First Epoch: 0.214 (km)
Last Epoch: 0.218 (km)

Program: GrafNav
Version: 6.03
Project: **June 9, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 17575
No processed position: 8790
Missing Fwd or Rev: 0
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0220 (m)
C/A Code: 1.11 (m)
L1 Doppler: 0.033 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.030 (m)
North: 0.026 (m)
Height: 0.089 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8779 occurrences):

East: 0.029 (m)
North: 0.026 (m)
Height: 0.089 (m)

Quality Number Percentages:

Q 1: 99.8 %
Q 2: 0.2 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 92.6 %
0.10 - 0.30 m: 7.4 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 7.4 %

Baseline Distances:

Maximum: 49.529 (km)
Minimum: 0.201 (km)
Average: 20.006 (km)
First Epoch: 0.201 (km)
Last Epoch: 0.223 (km)

Program: GrafNav
Version: 6.03
Project: **June 11, 2004 mission 1**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 23023
No processed position: 11513
Missing Fwd or Rev: 0
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0226 (m)
C/A Code: 1.17 (m)
L1 Doppler: 0.032 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.019 (m)
North: 0.034 (m)
Height: 0.035 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (11504 occurrences):

East: 0.019 (m)
North: 0.028 (m)
Height: 0.034 (m)

Quality Number Percentages:

Q 1: 99.8 %
Q 2: 0.2 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 94.6 %
0.10 - 0.30 m: 5.4 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 5.4 %

Baseline Distances:

Maximum: 40.766 (km)
Minimum: 0.197 (km)
Average: 17.804 (km)
First Epoch: 0.201 (km)
Last Epoch: 0.201 (km)

Program: GrafNav
Version: 6.03
Project: **June 11, 2004 mission 2**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 17650
No processed position: 8824
Missing Fwd or Rev: 0
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0193 (m)
C/A Code: 1.25 (m)
L1 Doppler: 0.026 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.012 (m)
North: 0.019 (m)
Height: 0.044 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8819 occurrences):

East: 0.011 (m)
North: 0.014 (m)
Height: 0.044 (m)

Quality Number Percentages:

Q 1: 99.6 %
Q 2: 0.4 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 58.6 %
0.10 - 0.30 m: 41.4 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 28.867 (km)
Minimum: 0.201 (km)
Average: 18.047 (km)
First Epoch: 0.201 (km)
Last Epoch: 0.228 (km)

Program: GrafNav
Version: 6.03
Project: **June 12, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 25114
No processed position: 12560
Missing Fwd or Rev: 1
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0222 (m)
C/A Code: 1.10 (m)
L1 Doppler: 0.030 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.029 (m)
North: 0.046 (m)
Height: 0.077 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (12542 occurrences):

East: 0.028 (m)
North: 0.044 (m)
Height: 0.075 (m)

Quality Number Percentages:

Q 1: 99.6 %
Q 2: 0.4 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 94.8 %
0.10 - 0.30 m: 5.1 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 5.1 %

Baseline Distances:

Maximum: 43.086 (km)
Minimum: 0.201 (km)
Average: 23.823 (km)
First Epoch: 0.201 (km)
Last Epoch: 0.243 (km)

Program: GrafNav
Version: 6.03
Project: **June 12, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 11687

No processed position: 5842

Missing Fwd or Rev: 0

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0172 (m)

C/A Code: 1.25 (m)

L1 Doppler: 0.026 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.034 (m)

North: 0.017 (m)

Height: 0.055 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (5836 occurrences):

East: 0.032 (m)

North: 0.012 (m)

Height: 0.047 (m)

Quality Number Percentages:

Q 1: 99.8 %
Q 2: 0.2 %
Q 3: 0.0 %
Q 4: 0.0 %
Q 5: 0.0 %
Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 91.3 %
0.10 - 0.30 m: 8.7 %
0.30 - 1.00 m: 0.0 %
1.00 - 5.00 m: 0.0 %
5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 43.288 (km)
Minimum: 0.242 (km)
Average: 17.222 (km)
First Epoch: 0.243 (km)

Last Epoch: 0.246 (km)

Program: GrafNav
Version: 6.03
Project: **June 16, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 10763

No processed position: 5384

Missing Fwd or Rev: 0

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0216 (m)

C/A Code: 1.15 (m)

L1 Doppler: 0.026 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.014 (m)

North: 0.029 (m)

Height: 0.049 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (5374 occurrences):

East: 0.012 (m)

North: 0.024 (m)

Height: 0.046 (m)

Quality Number Percentages:

Q 1: 89.3 %

Q 2: 3.0 %

Q 3: 6.5 %

Q 4: 1.2 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 89.2 %

0.10 - 0.30 m: 10.8 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 10.4 %

Baseline Distances:

Maximum: 45.257 (km)

Minimum: 0.242 (km)

Average: 11.676 (km)

First Epoch: 0.242 (km)

Last Epoch: 0.247 (km)

Program: POSGPS
Version: 4.10
Project: **June 23, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file:	31456
No processed position:	15732
Missing Fwd or Rev:	3
With bad C/A code:	0
With bad L1 Phase:	0

Measurement RMS Values:

L1 Phase:	0.0195 (m)
C/A Code:	0.69 (m)
L1 Doppler:	0.025 (m/s)

Fwd/Rev Separation RMS Values:

East:	0.040 (m)
North:	0.046 (m)
Height:	0.071 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (15708 occurrences):

East: 0.040 (m)

North: 0.046 (m)

Height: 0.071 (m)

Quality Number Percentages:

Q 1: 100.0 %

Q 2: 0.0 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 88.8 %

0.10 - 0.30 m: 11.2 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 53.585 (km)

Minimum: 0.177 (km)
Average: 25.132 (km)
First Epoch: 0.222 (km)
Last Epoch: 0.177 (km)

Program: GrafNav
Version: 6.03
Project: **May 11, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 17907
No processed position: 8955
Missing Fwd or Rev: 0
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0243 (m)
C/A Code: 1.03 (m)
L1 Doppler: 0.030 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.014 (m)
North: 0.039 (m)

Height: 0.026 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8947 occurrences):

East: 0.012 (m)

North: 0.037 (m)

Height: 0.026 (m)

Quality Number Percentages:

Q 1: 99.9 %

Q 2: 0.1 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 62.6 %

0.10 - 0.30 m: 37.4 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 9.1 %

Baseline Distances:

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Maximum: 83.919 (km)
Minimum: 0.210 (km)
Average: 41.833 (km)
First Epoch: 0.215 (km)
Last Epoch: 0.215 (km)

Program: GrafNav
Version: 6.03
Project: **May 12, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 23417
No processed position: 11708
Missing Fwd or Rev: 1
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0218 (m)
C/A Code: 1.14 (m)
L1 Doppler: 0.036 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.028 (m)

North: 0.043 (m)

Height: 0.063 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (11701 occurrences):

East: 0.027 (m)

North: 0.043 (m)

Height: 0.062 (m)

Quality Number Percentages:

Q 1: 99.9 %

Q 2: 0.1 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 96.8 %

0.10 - 0.30 m: 3.2 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 8.6 %

Baseline Distances:

Maximum: 85.994 (km)

Minimum: 0.202 (km)

Average: 29.119 (km)

First Epoch: 0.202 (km)

Last Epoch: 0.214 (km)

Program: GrafNav

Version: 6.03

Project: **May 13, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 22251

No processed position: 11125

Missing Fwd or Rev: 1

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0231 (m)

C/A Code: 1.11 (m)

L1 Doppler: 0.038 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.016 (m)

North: 0.042 (m)

Height: 0.061 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (11120 occurrences):

East: 0.015 (m)

North: 0.041 (m)

Height: 0.061 (m)

Quality Number Percentages:

Q 1: 99.9 %

Q 2: 0.1 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 92.7 %

0.10 - 0.30 m: 7.3 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 7.3 %

Baseline Distances:

Maximum: 45.855 (km)

Minimum: 0.209 (km)

Average: 16.264 (km)

First Epoch: 0.209 (km)

Last Epoch: 0.226 (km)

Program: GrafNav

Version: 6.03

Project: **May 14, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 16662

No processed position: 8333

Missing Fwd or Rev: 0

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0312 (m)

C/A Code: 1.01 (m)

L1 Doppler: 0.027 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.034 (m)

North: 0.039 (m)

Height: 0.071 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8326 occurrences):

East: 0.033 (m)

North: 0.028 (m)

Height: 0.066 (m)

Quality Number Percentages:

Q 1: 99.4 %

Q 2: 0.6 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 100.0 %

0.10 - 0.30 m: 0.0 %

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0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 45.848 (km)

Minimum: 0.210 (km)

Average: 25.110 (km)

First Epoch: 0.215 (km)

Last Epoch: 0.214 (km)

Program: GrafNav
Version: 6.03
Project: **May 15, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 16894

No processed position: 8447

Missing Fwd or Rev: 1

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0236 (m)

C/A Code: 1.11 (m)

L1 Doppler: 0.032 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.027 (m)

North: 0.020 (m)

Height: 0.062 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8442 occurrences):

East: 0.023 (m)

North: 0.017 (m)

Height: 0.059 (m)

Quality Number Percentages:

Q 1: 99.7 %

Q 2: 0.3 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 84.2 %

0.10 - 0.30 m: 15.8 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 12.1 %

Baseline Distances:

Maximum: 68.648 (km)

Minimum: 0.205 (km)

Average: 26.703 (km)

First Epoch: 0.205 (km)

Last Epoch: 0.227 (km)

Program: GrafNav
Version: 6.03
Project: **May 20, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 16710

No processed position: 8356

Missing Fwd or Rev: 0

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0214 (m)

C/A Code: 1.15 (m)

L1 Doppler: 0.039 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.030 (m)

North: 0.065 (m)

Height: 0.109 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (8350 occurrences):

East: 0.026 (m)

North: 0.045 (m)

Height: 0.108 (m)

Quality Number Percentages:

Q 1: 99.8 %

Q 2: 0.2 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 72.9 %

0.10 - 0.30 m: 27.1 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 11.0 %

Baseline Distances:

Maximum: 85.692 (km)

Minimum: 0.116 (km)

Average: 36.812 (km)

First Epoch: 0.116 (km)

Last Epoch: 0.258 (km)

Program: GrafNav

Version: 6.03

Project: **May 20, 2004 mission 2**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 11160

No processed position: 5582

Missing Fwd or Rev: 1

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0195 (m)

C/A Code: 1.21 (m)

L1 Doppler: 0.027 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.014 (m)

North: 0.016 (m)

Height: 0.040 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (5574 occurrences):

East: 0.013 (m)

North: 0.010 (m)

Height: 0.028 (m)

Quality Number Percentages:

Q 1: 99.9 %

Q 2: 0.1 %

Q 3: 0.0 %

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Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 89.4 %

0.10 - 0.30 m: 10.6 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 85.064 (km)

Minimum: 0.258 (km)

Average: 25.527 (km)

First Epoch: 0.258 (km)

Last Epoch: 0.258 (km)

Program: GrafNav
Version: 6.03
Project: **May 8, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 22613
No processed position: 11306
Missing Fwd or Rev: 0
With bad C/A code: 0
With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0243 (m)
C/A Code: 1.05 (m)
L1 Doppler: 0.027 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.011 (m)
North: 0.034 (m)
Height: 0.036 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (11304 occurrences):

East: 0.010 (m)
North: 0.032 (m)
Height: 0.033 (m)

Quality Number Percentages:

Q 1: 99.8 %

Q 2: 0.2 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 99.4 %

0.10 - 0.30 m: 0.6 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 65.523 (km)

Minimum: 0.150 (km)

Average: 39.291 (km)

First Epoch: 0.232 (km)

Last Epoch: 0.240 (km)

Program: GrafNav
Version: 6.03
Project: **July 1, 2004**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 9509

No processed position: 4752

Missing Fwd or Rev: 1

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0176 (m)

C/A Code: 0.70 (m)

L1 Doppler: 0.028 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.109 (m)

North: 0.073 (m)

Height: 0.137 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (3647 occurrences):

East: 0.019 (m)

North: 0.012 (m)

Height: 0.042 (m)

Quality Number Percentages:

Q 1: 99.9 %

Q 2: 0.1 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 91.1 %

0.10 - 0.30 m: 8.9 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 6.7 %

Baseline Distances:

Maximum: 54.482 (km)

Minimum: 0.202 (km)

Average: 24.224 (km)

First Epoch: 0.202 (km)

Last Epoch: 0.907 (km)

Version: 6.03

Project: **July 1, 2004 mission 2**

Solution Type: Combined Fwd/Rev

Number of Epochs:

Total in GPB file: 23698

No processed position: 11845

Missing Fwd or Rev: 1

With bad C/A code: 0

With bad L1 Phase: 0

Measurement RMS Values:

L1 Phase: 0.0238 (m)

C/A Code: 0.64 (m)

L1 Doppler: 0.026 (m/s)

Fwd/Rev Separation RMS Values:

East: 0.025 (m)

North: 0.014 (m)

Height: 0.050 (m)

Fwd/Rev Sep. RMS for 25%-75% weighting (11835 occurrences):

East: 0.024 (m)

North: 0.013 (m)

Height: 0.043 (m)

Quality Number Percentages:

Q 1: 99.7 %

Q 2: 0.3 %

Q 3: 0.0 %

Q 4: 0.0 %

Q 5: 0.0 %

Q 6: 0.0 %

Position Standard Deviation Percentages:

0.00 - 0.10 m: 85.4 %

0.10 - 0.30 m: 14.6 %

0.30 - 1.00 m: 0.0 %

1.00 - 5.00 m: 0.0 %

5.00 m + over: 0.0 %

Percentages of epochs with DD_DOP over 10.00:

DOP over Tol: 0.0 %

Baseline Distances:

Maximum: 54.686 (km)

Minimum: 0.220 (km)

Average: 26.981 (km)

First Epoch: 0.221 (km)

Last Epoch: 0.243 (km)

Calibration Accuracy

LIDAR, IMU, and GPS data were correlated using GPS time and processed using LIDAR post-processing software to determine the coordinate of each point on the ground. The RAMS LIDAR is able to receive up to three returns from each laser shot fired. This allows receipt of return data from multiple objects as the laser beam travels toward the ground. All returns have been corrected for atmospheric refraction and transmission delays. The resulting three-dimensional coordinates are compiled in an ASCII mass point file of x, y, z on the state plane projection. Initial evaluation of the LIDAR data included the comparison of the data from the flight lines to the survey performed at the calibration site at the respective airport. Five control points were set at various locations near the airport proper. The camera was used for boresighting. These same points were used in boresighting the camera as noted previously. The laser and camera were boresighted each day of flying.

Appendix A

RMSE calculations and iterations

Initial combined RMSE for CT and MA project areas. Total of 50 control points.

Control Point	Northing	Easting	Elevation ft	Lidar Elevation ft	Difference ft	Squared	Notes
1212	2889844.27	349444.34	90.04	89.14	-0.9008	0.8114	
229	2907506.19	355940.69	131.80	130.91	-0.8929	0.7973	
502	2907590.20	355930.00	129.29	128.43	-0.8645	0.7474	
184	2907399.76	355919.23	129.97	129.32	-0.6488	0.4209	
991203	843031.36	1022706.71	14.35	13.74	-0.610	0.3719	
991303	823283.70	1024837.70	32.60	31.99	-0.607	0.3678	
991001	890331.19	1032210.70	41.21	40.66	-0.549	0.3018	
991101	858662.19	1026428.27	80.27	79.73	-0.543	0.2947	
991301	823144.23	1025288.57	37.42	36.88	-0.540	0.2918	
701	2922735.26	358207.05	114.22	113.69	-0.5334	0.2845	
1210	2889796.90	349778.18	61.78	61.29	-0.4950	0.2450	
1410	2878485.47	352622.68	63.58	63.14	-0.4424	0.1957	
1411	2878454.67	352383.68	61.32	60.89	-0.4340	0.1884	
991703	723794.94	1077845.41	6.83	6.44	-0.392	0.1539	
992001	679192.91	1102663.78	49.74	49.37	-0.369	0.1361	
1510	2873667.35	351690.62	58.44	58.08	-0.3606	0.1300	
991503	780267.51	1037143.02	11.09	10.76	-0.334	0.1118	
991002	890213.50	1032336.72	34.72	34.39	-0.327	0.1066	
1901	2860347.34	360056.54	56.17	55.90	-0.2711	0.0735	
2312	2843143.68	353849.26	54.61	54.35	-0.2594	0.0673	
1910	2860559.98	360111.33	47.56	47.32	-0.2394	0.0573	
991801	724741.86	1077808.18	7.45	7.25	-0.201	0.0406	
991102	858590.04	1026254.50	91.28	91.09	-0.194	0.0375	
991701	724406.02	1077884.17	6.62	6.44	-0.185	0.0342	
991901	705016.67	1088699.31	6.87	6.69	-0.183	0.0335	
991902	705068.86	1088633.19	8.20	8.03	-0.170	0.0288	
991501	780391.10	1037799.46	9.55	9.42	-0.134	0.0180	
702	2922545.56	357718.01	114.56	114.43	-0.1329	0.0177	
991201	843260.16	1022612.29	13.84	13.75	-0.087	0.0076	
1911	2860375.75	359979.18	55.17	55.09	-0.0800	0.0064	
991202	843674.95	1022801.07	14.17	14.14	-0.029	0.0008	
991708	762773.11	1045930.72	47.83	47.86	0.028	0.0008	
1513	2874682.92	352244.35	57.30	57.34	0.0353	0.0012	
991003	890024.69	1032365.69	31.96	32.02	0.061	0.0037	
991302	823178.80	1025130.46	33.90	34.04	0.137	0.0189	
2310	2843124.11	354245.87	52.05	52.21	0.1639	0.0269	
992002	679126.06	1102733.37	50.04	50.27	0.226	0.0513	
991803	724913.67	1078037.37	6.62	6.88	0.258	0.0664	
991103	858472.69	1026281.67	84.87	83.48	-1.390	1.9324	Point is in trees
148	2922733.15	357979.29	106.93	107.96	1.0253	1.0512	Point on grassy surface/possible survey
991709	762800.68	1045802.84	52.90	53.19	0.289	0.0836	
991702	723976.37	1077964.00	6.82	7.12	0.303	0.0916	
991502	780373.10	1037466.12	10.34	10.65	0.307	0.0943	

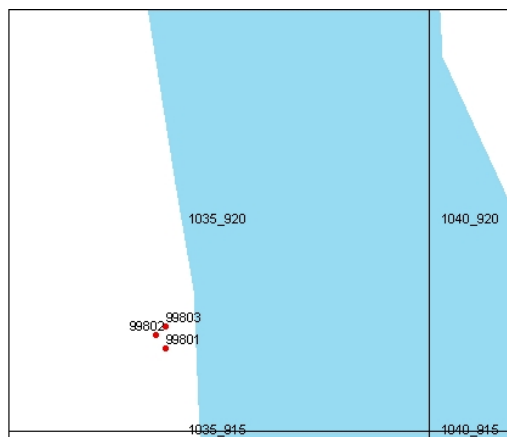
Control Point	Northing	Easting	Elevation ft	Lidar Elevation ft	Difference ft	Squared	Notes
100	2922765.19	358220.92	111.90	112.23	0.3254	0.1059	
1401	2878012.96	352935.05	59.23	59.63	0.3960	0.1568	
991802	724459.56	1078091.47	6.82	7.22	0.397	0.1575	
2311	2843012.29	354249.40	60.03	58.81	-1.2237	1.4974	Point is in trees, low pt density in the area
1512	2873559.02	351180.61	55.75	57.08	1.3303	1.7697	Point is in trees, low pt density in the area
1211	2889870.91	349877.42	62.56	62.97	0.4108	0.1688	
228	2907654.32	355896.98	123.57	124.46	0.8903	0.7926	
Total					-8.04	14.4510	
Avg. Error					-0.16	0.2890	
# Points / RMSE					50.00	0.5376	

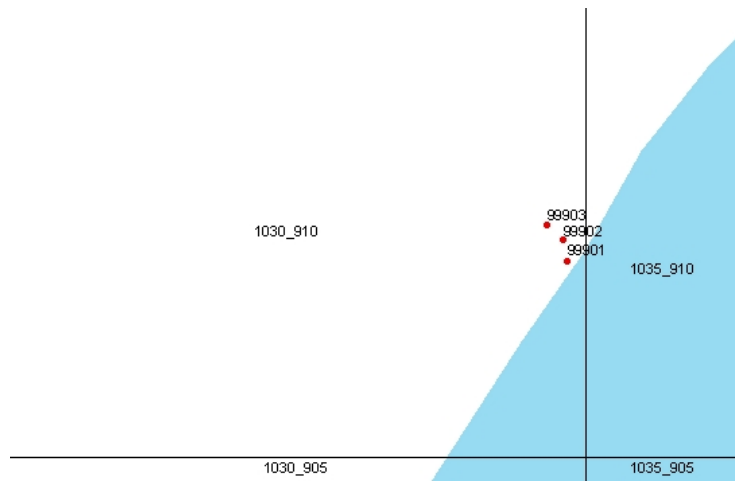
Points removed

2311	2843012.29	354249.40	60.03	58.81	-1.2237	1.4974	Point is in trees, low pt density in the area
1512	2873559.02	351180.61	55.75	57.08	1.3303	1.7697	Point is in trees, low pt density in the area

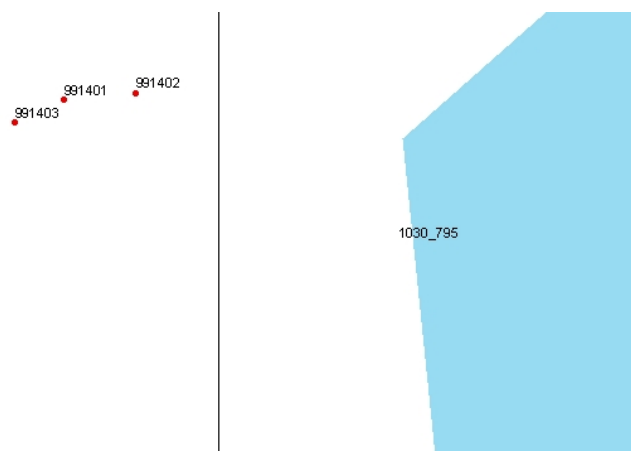
Checkpoints removed due to not being located inside the project area:

99801	920980.34	1036880.16	123.95
99802	921137.91	1036763.42	124.34
99803	921236.96	1036878.03	127.04
99901	911423.01	1034876.33	102.31
99902	911581.69	1034848.27	100.91
99903	911680.95	1034728.85	102.16
991401	797455.98	1029671.24	146.13
991402	797470.87	1029824.34	147.59
991403	797407.96	1029567.46	137.45
991601	761108.90	1033115.02	172.12
991602	761123.53	1032826.63	168.00
991603	761018.00	1032818.44	167.83

**Points 99801, 99802, 99803 located outside of the delivered blue project area**



Points 99901, 99902, 99903 located outside of the delivered blue project area



Points 991401, 991402, 991403 located outside of the delivered blue project area



Points 991601, 991602, 991603 located outside of the delivered blue project area

3 Points were removed due to being outliers (3-sigma level)

An excerpt from the FEMA Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A section A.8.3.1.

“ Outliers often occur as a result of the failure to achieve a true bare-earth surface from the vegetation removal process. A single outlier can override dozens or hundreds of accurate checkpoints, making the entire RMSE value appear to be poor. To deal with outliers, a criterion may be established to remove a small percentage of the total number of checkpoints surveyed that exhibit the largest discrepancies. Statisticians almost unanimously agree that errors exceeding the “3-sigma” level are outliers; the “3-sigma” level provides confidence at the 99.75 percent confidence level, enabling only the worst 0.25 percent of a dataset to be discarded as outliers.”

991903	705093.71	1088575.15	10.50	4.35	-6.1454	37.76594
992003	679325.32	1102800.50	44.94	50.17	5.2255	27.30585
226	2907595.29	355865.69	124.46	121.01	-3.4518	11.914923

5 Points removed due to point location

200	2907503.75	355892.66	131.16	130.12	-1.0367	1.0747
126	2922898.14	358246.29	105.95	107.19	1.2356	1.5267
161	2922391.82	357471.12	108.77	107.23	-1.5365	2.3608
2311	2843012.29	354249.40	60.03	58.81	-1.2237	1.4974
1512	2873559.02	351180.61	55.75	57.08	1.3303	1.7697



Point 126

This point is within 5 meters of a (breakline) sharp slope into the water. Points need to be clear of all breaklines in a 5-meter radius.

**Point 200**

This point is classified as pavement but is within 5 meters of a large tree. Points need to be unobstructed in a 5-meter radius.

**Point 161**

Was removed due to point location. The point is within 5 meters of a fairly steep drop off to the water.

**Point 2311 – total leaf coverage, minimal point density**

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Point 1512 – total leaf coverage, minimal point density

Final RMSE for combined areas. .482 feet RMSE

Control Point	Northing	Easting	Elevation ft	Lidar Elevation ft	Difference ft	Squared	Notes
1212	2889844.27	349444.34	90.04	89.14	-0.9008	0.8114	
229	2907506.19	355940.69	131.80	130.91	-0.8929	0.7973	
502	2907590.20	355930.00	129.29	128.43	-0.8645	0.7474	
184	2907399.76	355919.23	129.97	129.32	-0.6488	0.4209	
991203	843031.36	1022706.71	14.35	13.74	-0.610	0.3719	
991303	823283.70	1024837.70	32.60	31.99	-0.607	0.3678	
991001	890331.19	1032210.70	41.21	40.66	-0.549	0.3018	
991101	858662.19	1026428.27	80.27	79.73	-0.543	0.2947	
991301	823144.23	1025288.57	37.42	36.88	-0.540	0.2918	
701	2922735.26	358207.05	114.22	113.69	-0.5334	0.2845	
1210	2889796.90	349778.18	61.78	61.29	-0.4950	0.2450	
1410	2878485.47	352622.68	63.58	63.14	-0.4424	0.1957	
1411	2878454.67	352383.68	61.32	60.89	-0.4340	0.1884	
991703	723794.94	1077845.41	6.83	6.44	-0.392	0.1539	
992001	679192.91	1102663.78	49.74	49.37	-0.369	0.1361	
1510	2873667.35	351690.62	58.44	58.08	-0.3606	0.1300	
991503	780267.51	1037143.02	11.09	10.76	-0.334	0.1118	
991002	890213.50	1032336.72	34.72	34.39	-0.327	0.1066	
1901	2860347.34	360056.54	56.17	55.90	-0.2711	0.0735	
2312	2843143.68	353849.26	54.61	54.35	-0.2594	0.0673	
1910	2860559.98	360111.33	47.56	47.32	-0.2394	0.0573	
991801	724741.86	1077808.18	7.45	7.25	-0.201	0.0406	
991102	858590.04	1026254.50	91.28	91.09	-0.194	0.0375	
991701	724406.02	1077884.17	6.62	6.44	-0.185	0.0342	
991901	705016.67	1088699.31	6.87	6.69	-0.183	0.0335	
991902	705068.86	1088633.19	8.20	8.03	-0.170	0.0288	
991501	780391.10	1037799.46	9.55	9.42	-0.134	0.0180	
702	2922545.56	357718.01	114.56	114.43	-0.1329	0.0177	
991201	843260.16	1022612.29	13.84	13.75	-0.087	0.0076	
1911	2860375.75	359979.18	55.17	55.09	-0.0800	0.0064	
991202	843674.95	1022801.07	14.17	14.14	-0.029	0.0008	
991708	762773.11	1045930.72	47.83	47.86	0.028	0.0008	
1513	2874682.92	352244.35	57.30	57.34	0.0353	0.0012	
991003	890024.69	1032365.69	31.96	32.02	0.061	0.0037	
991302	823178.80	1025130.46	33.90	34.04	0.137	0.0189	
2310	2843124.11	354245.87	52.05	52.21	0.1639	0.0269	
992002	679126.06	1102733.37	50.04	50.27	0.226	0.0513	
991803	724913.67	1078037.37	6.62	6.88	0.258	0.0664	
991103	858472.69	1026281.67	84.87	83.48	-1.390	1.9324	Point is in trees
148	2922733.15	357979.29	106.93	107.96	1.0253	1.0512	Point on grassy surface/possible survey
991709	762800.68	1045802.84	52.90	53.19	0.289	0.0836	

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Control Point	Northing	Easting	Elevation ft	Lidar Elevation ft	Difference ft	Squared	Notes
991702	723976.37	1077964.00	6.82	7.12	0.303	0.0916	
991502	780373.10	1037466.12	10.34	10.65	0.307	0.0943	
100	2922765.19	358220.92	111.90	112.23	0.3254	0.1059	
1401	2878012.96	352935.05	59.23	59.63	0.3960	0.1568	
991802	724459.56	1078091.47	6.82	7.22	0.397	0.1575	
1211	2889870.91	349877.42	62.56	62.97	0.4108	0.1688	
228	2907654.32	355896.98	123.57	124.46	0.8903	0.7926	
Total					-8.15	11.1838	
Avg. Error					-0.17	0.2330	
# Points / RMSE					48.00	0.4827	

5/16/2005



Appendix B

Survey Report

Point locations of check point survey provided by Green International Affiliates, Inc.

Connecticut

SITE 8



POINT S8_WOD



POINT S8_VC1_PAV



POINT S8_VC2_GRA

SITE 9



Point S9VC1_PAV

5/16/2005



Point S9VC2_GRA



Point S9WOD

SITE 10



Point S10_CKWOD



Point S10_VC1_PAV



Point S10_VC2_GRA

SITE 11



POINT S11_CKWOD



POINT S11_VC1_PAV



POINT S11_VC2_GRA

SITE 12



POINT S12_CKWOD



POINT S12_VC1_PAV



POINT S12_VC2_GRA

SITE 13



POINT S13_CKWOD



POINT S13_VC1_PAV



POINT S13_VC2_GRA

SITE 14



POINT S14_CKWOD



POINT S14_VC1_PAV



POINT S14_VC2_GRA

SITE 15



POINT S15_CKWOD



POINT S15_VC1_PAV



POINT S15_VC2_GRA

SITE 16



POINT S16_CKWOD



POINT S16_VC1_PAV



POINT S16_VC2_GRA

SITE 17



POINT S17_CKWOD

5/16/2005



POINT S17_CKPAV



POINT S17_CKGRA

SITE 18



POINT S18_CKWOD



POINT S18_VC1_PAV



POINT S18_VC2_GRA

SITE 19



POINT S19_CKWOD



POINT S19_VC1_PAV



POINT S19_VC2_GRA

SITE 20



POINT S20_CKWOD



POINT S20_VC1_PAV

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POINT S20_VC2_GRA

MASS POINTS

SITE 5



POINT S5_CKWOD



POINT S5_PAV



POINT S5_GRA

SITE 7



POINT S7_CKWOD



POINT S7_VC1_PAV



POINT S7_VC2_GRA

SITE 12



POINT S12_CKWOD



POINT S12_PAV



POINT S12_GRA

SITE 14



POINT S14_WOD



POINT S14_PAV



POINT S14_GRA

SITE 15



POINT S15_WOD



POINT S15_PAV



POINT S15_GRA

SITE 19



POINT S19_WOD



POINT S19_PAV



POINT S19_VC1 (GRA)

SITE 23



POINT S23_WOD



POINT S23_PAV

5/16/2005



POINT S23_GRA