Acquisition and analysis of high spatial resolution orthoimagery for the Great Smoky Mountain National Park and the Chattahoochee National Forest

PROJECT COMPLETION REPORT

September 15, 2011

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AREAL EXTENT OF THE COLLECTION

Georgia—Lumpkin, White, Dawson, Towns, Fannin, Union; Tennessee—Sevier, Blount, Cocke; North Carolina—Swain, Haywood
1916 Sq. mi.; Chattahoochee National Forest and Great Smokey Mountain National Forest

NUMBER AND TYPES OF JOBS CREATED OR RETAINED AND LABOR HOURS

Gainesville State College –
University of Georgia –
Photo Science Geospatial Solutions -

Signature of Collaborators for the Completion of the Project and the Final Project Report

The final project report is accurate to the best of our knowledge and belief. The accompanying data are prepared adhering to the funding agency's (USGS) guidelines in the best possible manner.

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(Dr. Sudhanshu Sekhar Panda)—Principal Investigator Date

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(Dr. Jitendra Bal Sharma)—Co-Principal Investigator Date

_____ _____

(Dr. Marguerite Madden)—Co-Principal Investigator Date

_____ _____

(Dr. Thomas Jordan)—Co-Principal Investigator Date

_____ _____

(Mr. Jeffery Simmons)—Collaborator Date

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EXECUTIVE SUMMARY

Department of United States Geological Survey (USGS), Gainesville State College (GSC), University of Georgia (UGA), and Photo Science Geospatial Solutions (PSI) collaborated to acquire high spatial resolution (30 cm) leaf-off multispectral ortho-imagery for both the Chattahoochee National Forest (CNF) and the Great Smoky Mountain National Park (GRSM) to allow for the distribution of digital aerial imagery of these two very crucial ecosystems through USGS's National Map portal (http://nationalmap.gov/). The near-term objective of this project was to acquire high spatial resolution (30 cm) leaf-off multispectral ortho-imagery for both ecosystems and make them available to end-users for future applications towards their preservation.

This ortho-imagery would be used to pilot several applications that are crucial for natural resource managers of the CNF and the GRSM, which are two distinct and yet related ecosystems in the Southern Appalachian Mountains. The preservation and management of these wildernesses is predicated upon a detailed spatial inventory of its vegetation species and health, hydrology, infestations, fire fuel loading, and land cover changes over time. Institute for Environmental Spatial Analysis (IESA) of GSC and The Center for Remote Sensing and Mapping Science (CRMS) of UGA have conducted several natural resource management studies in CNF and GRSM ecosystems, respectively. Their experience through these works suggested deficiency in very high resolution multiband orthoimagery and LIDAR data for both areas. This project would fill some major gaps in such future advanced ecosystem management researches. The fusion of these two types of high resolution data and its analysis using advanced image processing techniques would yield a rich array of insights into the physical state of the ecosystems and their health.

Through this project, leaf-off CIR multispectral imagery at a high spatial resolution (30 cm) that is acquired for both ecosystems. LIDAR data was also acquired for the Tennessee portion of the GRSM as part of the sister project to this one. It is also anticipated that LIDAR data will be available for rest part of these ecosystems via other Federal initiatives. National Agricultural Imagery Program (NAIP) initiative provides imageries for leaf-on conditions for both ecosystems. With the completion of this project, now both ecosystems have all possible high quality digital data which would help natural resource managers and other end-users to conduct various studies like to ascertain tree species/health, pest infestations and deciduous stands, mapping the understory vegetation and evergreen stands.

Commercial provider PSI collaborated with the project team in acquiring the ortho-imagery for a selected contiguous portion of the CNF and all of GRSM as mentioned in the report later. This data was processed by PSI and students at GSC and UGA. The complete data processing methods are provided in the report later. After the completion of the data processing, Quality Assurance/Quality Control (QA/QC) was completed on the orthoimagery. A comprehensive metadata file was created for the processed orthoimageries to support end-users.

The team of faculty/scientists from GSC and UGA, personnel from PSI, and graduate/ undergraduate students from both institutions worked towards the completion of the project were well qualified and experienced to perform this job in a very capable manner. Several prototype documents were developed for the projects, which can be used for future orthoimagery acquisition projects by federal or other agencies. They are provided as Appendices in the report later. Several other organizations, such as County agencies, Chattahoochee-Oconee National Forest Department, Upper Chattahoochee River Keeper, Georgia Mountain Regional Development Center, and the Metropolitan North Georgia Water Planning District have shown

tremendous interest in using the orthoimagery data created through this project. The unique environmental geospatial technology programs in both schools (UGA and GSC) will certainly get tremendous help from this orthoimagery data and will help to grow and sustain the utilization of the data collected in innovative projects.

BACKGROUND

Digital orthoimagery is one of the basic geospatial data framework themes collected, archived, and disseminated by the United States Geological Survey (USGS) through its addition to *The National Map*. Digital orthoimagery production has become very common due to the development of powerful computing systems with sufficient resources, easier acquisition and increased generation of digital data, development of many commercial ortho-image production systems, and new application areas, particularly in connection with geospatial mapping (Baltsavias, 1996). Some of the most important geospatial mapping applications of ortho-imagery relevant to the Northeast Georgia Mountains and forest and Great Smoky Mountains ecosystems are: 1) high-accuracy land cover classification, 2) wild land fire behavior, 3) invasive species delineation in forest land, 4) climate data analysis with biomass mapping, 5) floodplain mapping and modeling, 6) unpaved trails mapping in forest land, 7) forest resources estimation and wild life habitat suitability modeling, 8) modeling of landforms, habitat, vegetation, and hydrology, and 9) decision support system development for watershed management.

USGS has devised priority areas of interest in the United States (US) that include sensitive landscapes and environments designated as Priority Ecosystems. Northeast Georgia includes most of the Chattahoochee National Forest (CNF) and its Southern reaches include the Lake Sidney Lanier watershed. This area is designated as a high priority hazards area by the USGS. Additionally, the area falls under moderate to high flood priority (Figure 1), highest landslide priority (Figure 2), moderate earthquake priority (Figure 3), low hurricane priority (Figure 4), and including a few spatial locations under wildfire priority (Figure 5). Similarly, the Great Smoky Mountains National Park (GRSM) has also been designated by USGS as a priority ecosystem. The GRSM is also considered by USGS as high flood priority (Figure 1), high landslide priority (Figure 2), moderate earthquake priority (Figure 3), and severe wildfire priority (Figure 5) area. The Lake Sidney Lanier watershed, which has been in the news lately due to water scarcity, is the primary watershed for the Atlanta region and is of immense economic importance to Georgia. Therefore, management of these vulnerable high priority ecosystems is not only one of the goals of federal agencies like USGS but also of all responsible citizens.

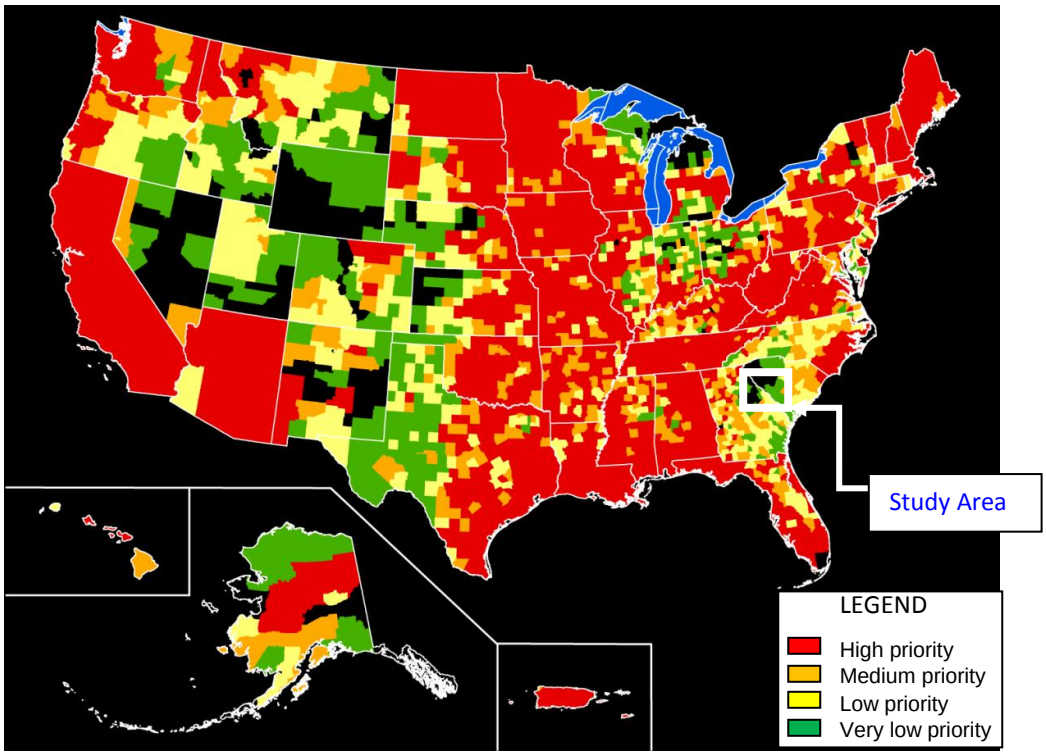

Figure 1: Flood priority zoning map of US (Source: http://www.usgs.gov/hazards/floods/)

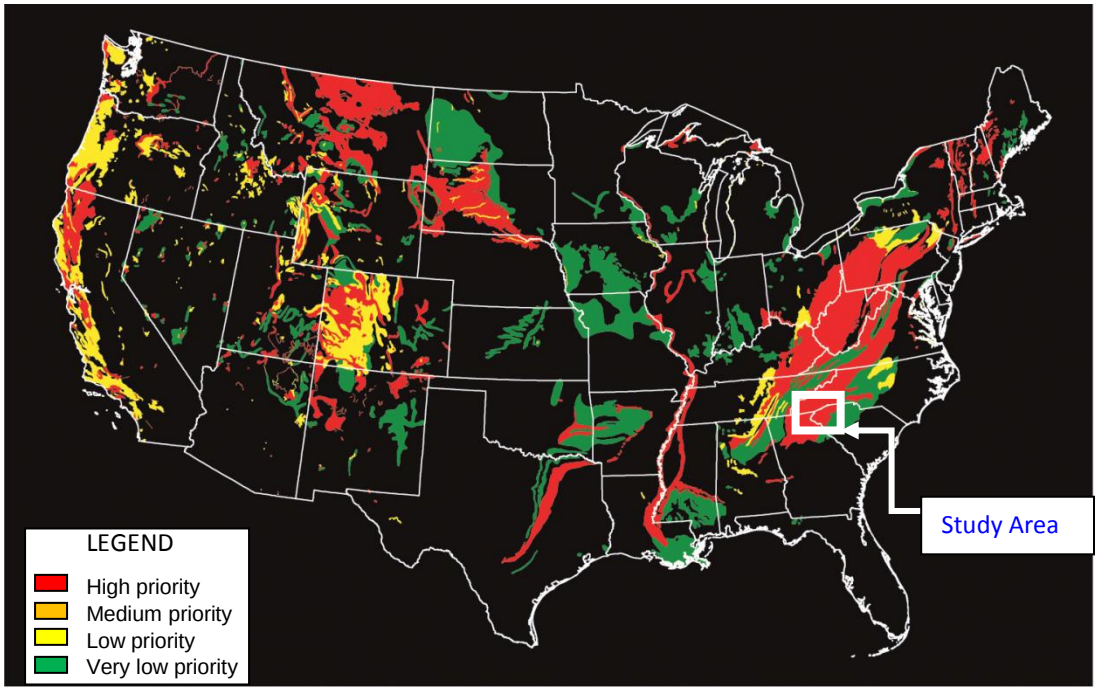

Figure 2: Landslide priority zoning map of US (Source: http://www.usgs.gov/hazards/landslides/)

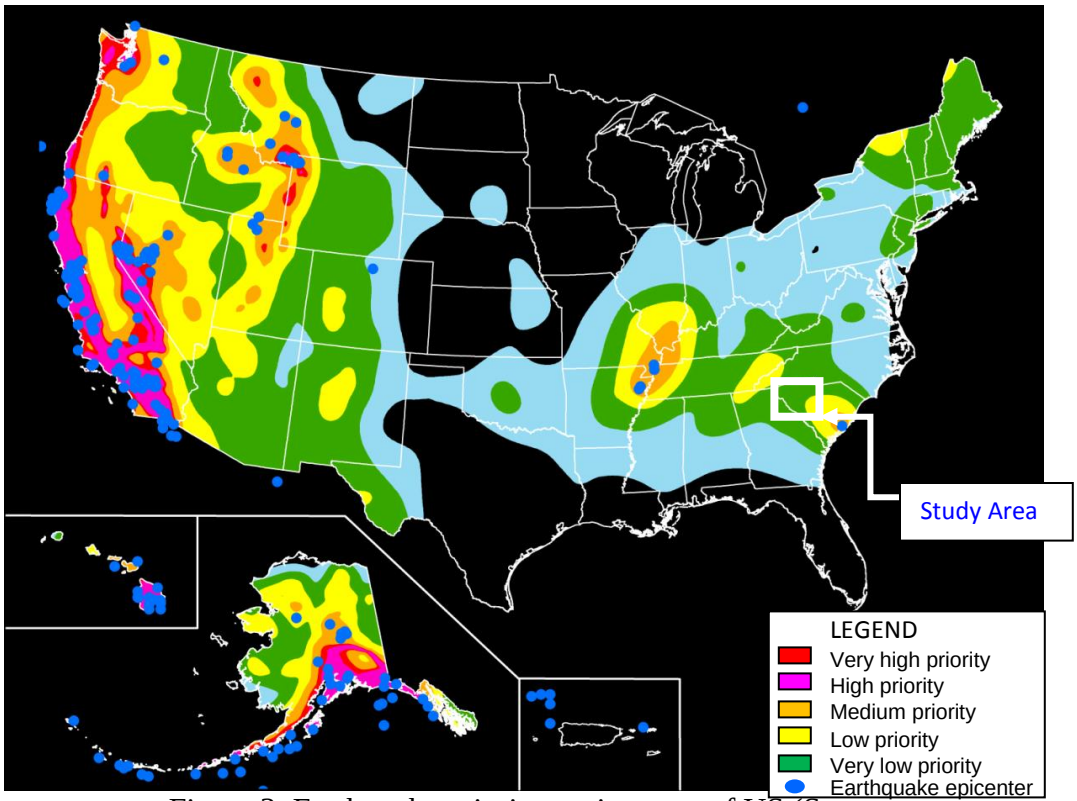

Figure 3: Earthquake priority zoning map of US (Source: http://www.usgs.gov/hazards/earthquakes/)

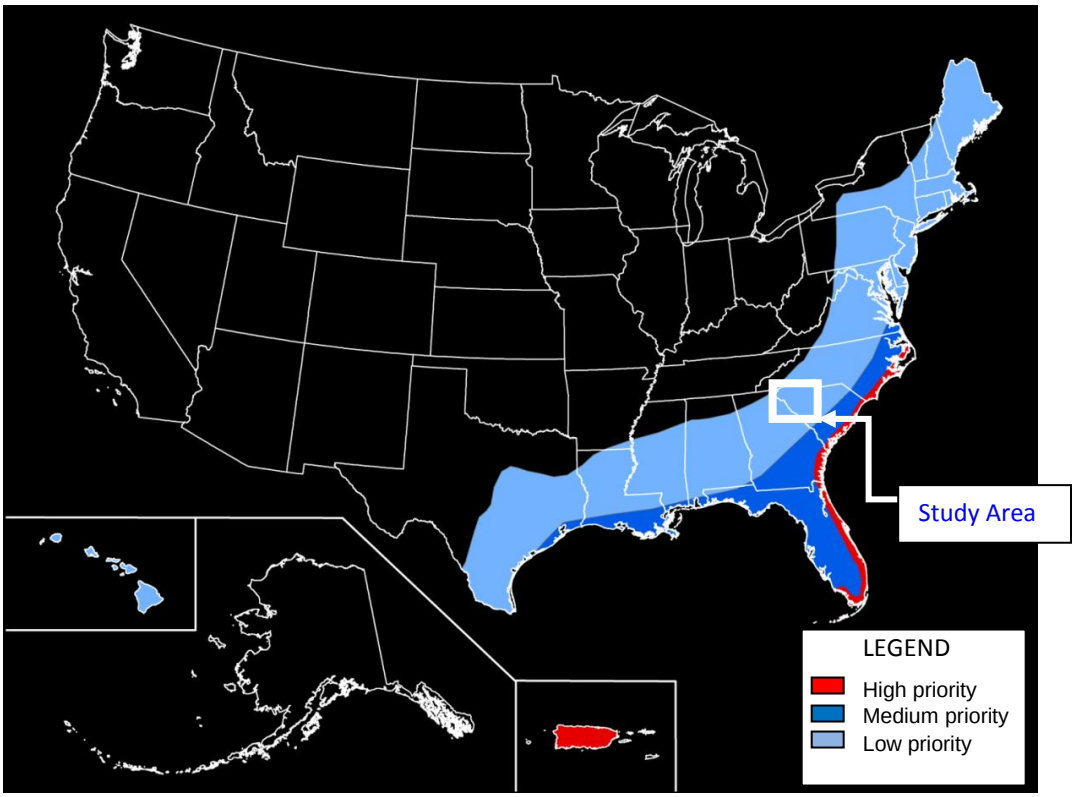

Figure 4: Hurricane priority zoning map of US (Source: http://www.usgs.gov/hazards/hurricanes/)

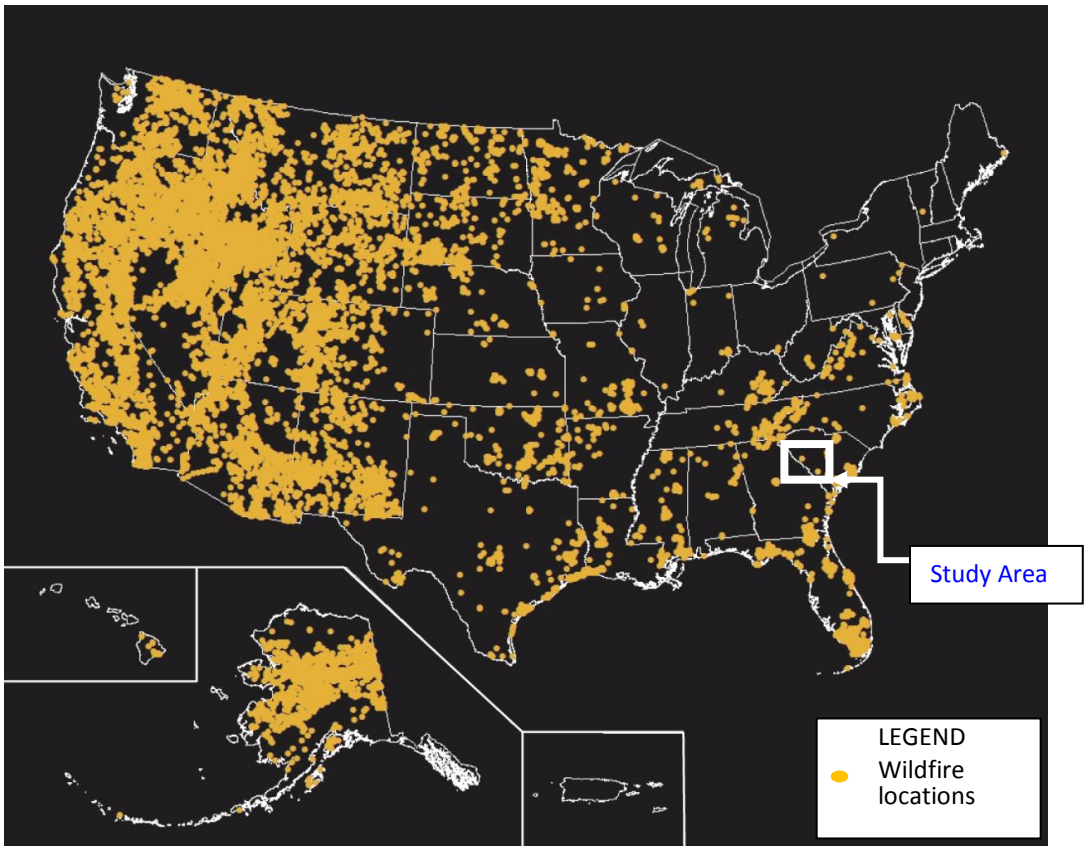

Figure 5: Wildfire priority zoning map of US (Source: http://www.usgs.gov/hazards/wildfires/)

Leaf-on condition orthoimagery (Visible and Infrared bands) of 1 m resolution for the study area (CNF and GRSM) is available for 2010 and will be available for later years in the leaf-on period as well through the United States Department of Agriculture (USDA)'s National Agriculture Imagery Program (NAIP). NAIP acquires images during the agricultural growing season or leaf-on period for the continental US. The images are obtained normally between the middle of April and the middle of September when most of the traditional row crops are grown and area available after geometric and radiometric rectifications (Hoffman et al., 2008). High-resolution orthoimagery of leaf-off condition is very essential for the studies mentioned in the previous paragraph and presently they do not exist for this study area. As mentioned in the executive summary, both vulnerable ecosystems will have a complete set of digital data (imagery) with the completion of this project and with the availability of LIDAR data through other federal or commercial sources.

Organizations such as County agencies, Great Smoky Mountains National Park, Chattahoochee-Oconee National Forest Department, Upper Chattahoochee River Keeper, Georgia Mountain Regional Development Center, and the Metropolitan North Georgia Water Planning District, who deal with the development of the area, have a great need for geospatial products based on high resolution multispectral orthoimagery. Therefore, this project would serve their needs and the intended goals of promoting forest ecosystem preservation.

Orthoimagery Digital Data Description

According to Federal Geographic Data Committee (FGDC), digital orthoimagery is a georeferenced image prepared from a perspective aerial photograph or other remotely-sensed data in which displacement of objects due to sensor orientation and terrain relief have been removed (FGDC, 2011). Digital orthoimagery data has the geometric characteristics of a map and the image qualities of a photograph and are composed of an array of georeferenced (geometrically corrected) pixels that encode ground reflectance as a discrete value (FGDC, 2011). The digital orthoimageries acquired for this project are of 30 cm resolution and collected as aerial photograph, and processed to be available as a georeferenced image. According to FGDC (2011), many geographic features, including some in other framework data themes, can be interpreted and compiled from an orthoimagery and would support various application for the natural resources management.

OBJECTIVES

The main goal of the project was to collect, process, and disseminate high-resolution orthoimagery of the Chattahoochee National Forest and the Great Smoky Mountains National Park to United States Geological Survey department and to create or save jobs in return. The objectives to achieve that goal were i) to collect aerial image of 30 cm resolution through an expert company in accordance with the proposed guidelines provided in the RFP and ii) to perform QA/QC of the collected aerial imagery data to adhere to base orthoimagery specifications in the RFP.

STUDY AREA

As part of America's national forest system, the Chattahoochee National Forests represent the finest natural resources Georgia has to offer. These lands are rich in history and culture. CNF spreads across 18 North Georgia counties and covers around 750,000 acres. CNF serves as the headwaters of every major north Georgia river and home to abundant flora and fauna. According to locals of north Georgia, CNF stands as "testimony to the good of federal government, which took what was essentially a disaster area and turned it into Georgia's largest tourism asset and a great ecosystem (http://ngeorgia.com/naturally/cnf.html)." Since its inception in 1911, USDA is taking care of the forest range through several sustainable projects such as afforestation, introduction of wild animals, restoration projects for erosion prevention in rivers in the CNF, obstruction of invasive pests and species in the range, etc. However, a lot needs to be done to preserve this ecosystem with sustainable growth. Gainesville State College has a Memorandum of Understanding (MOU) with the Chattahoochee and Oconee National Forest Department to use geospatial technology including remote sensing for developing and working mini projects that would support the preservation of the CNF including its flora, fauna, water resources, and other natural resources. High resolution orthoimagery would support their preservation efforts and projects such as i) high-accuracy land cover classification, ii) wild land fire behavior, iii) invasive species delineation in forest land, iv) climate data analysis with biomass mapping, v) floodplain mapping and modeling, vi) unpaved trails mapping in forest land, vii) forest resources estimation and wild life habitat suitability modeling, viii) modeling of landforms, habitat, vegetation, and hydrology, ix) decision support system development for watershed management, and others.

The Great Smoky Mountains National Park (GRSM) is the most visited National Park in the US, (http://www.nps.gov/grsm/index.htm). The park straddles the border between North

Carolina and Tennessee upon a ridge of continuous forest. World renowned for its biodiversity, the park also contains numerous rare and endangered plant and animal life (Kaiser, 1999). The beauty of its ancient mountains and the quality of its remnants of Southern Appalachian mountain culture draws over 10 million visitors each year. Faced with concentrated areas of overuse by visitors, invasive insect pests such as the hemlock woody adelgid, atmospheric pollution, preserving this enriched ecosystem is of great necessity. Some of the projects the GRSM preservation group take up are i) vegetation typing at fine scales, including wetlands, small seeps, ii) canopy height in old growth as well as second growth, iii) reflectance for rock and boulder fields where many rare species are known, iv) soil litter depth for applications in wild land fire management, v) typing canopy openings by disturbance, i.e. wind throw, forest disease/insects, landslide, fire, etc., vi) species distributions, for those that signature well, vii) other applications for natural resources management, and viii) development of digital elevation model (DEM) through the extraction of 3D information using orthorectified stereo pairs.

Figure 6 shows the study area of 1916 sq. mi for which the orthoimageries were collected. It includes 1121 sq. mi. of contiguous forest land in northeast Georgia and 795 sq. mi. of the Great Smoky Mountains National Park forest range. Out of the total 1413 sq. mi. forest cover of Chattahoochee Oconee National Forest, 1121 sq. mi. of CNF was chosen due to its contiguity to help reduce the cost of data collection. The 795 sq. mi. of GRSM covers 373 sq. mi. in Tennessee and the rest 422 sq. mi. in North Carolina. The entire park is a contiguous entity and did not pose any such image acquisition problem.

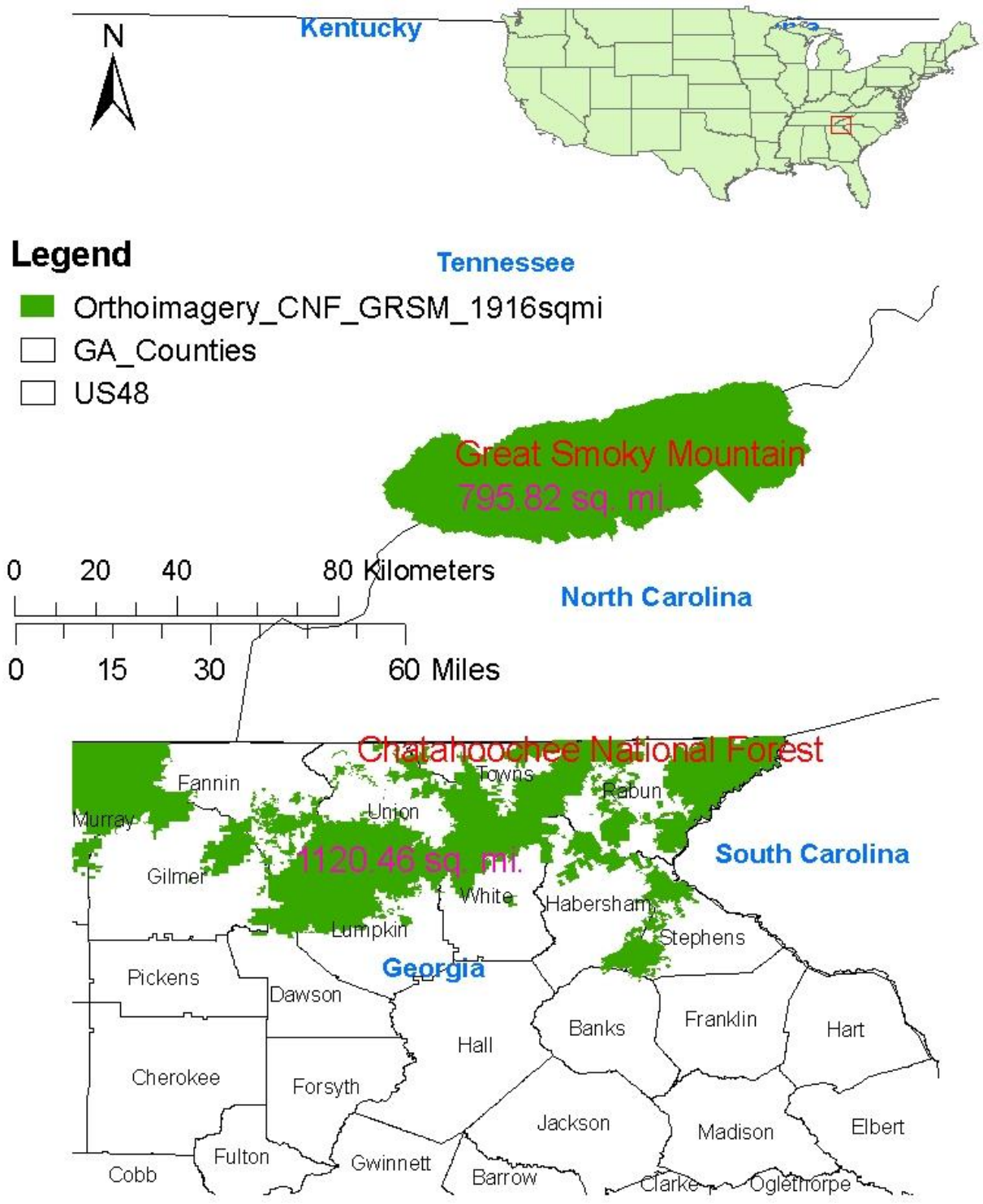

Figure 6: Study area (CNF and GRSM ecosystems) for the orthoimagery (30 cm) acquisition.

METHODOLOGY

Core Team Formation

A core team was formed along with project collaborators like GSC, UGA and PSI to accomplish the goal of this project. It included all the stakeholders of both CNF and GRSM including organizations such as County Agencies, Great Smoky Mountains National Park,, Chattahoochee-Oconee National Forest Department, Upper Chattahoochee River Keeper, Georgia Mountain Regional Development Center, and the Metropolitan North Georgia Water Planning District. These organizations along with the funding agency, USGS through its central and local (Atlanta) office time to time advised the collaborative partners in the smooth execution of the project. As mentioned in the competency section of the projects proposal earlier submitted to USGS, PIs and the PSI company were and are very well versed with orthoimagery acquisition and processing. PSI had worked with USGS in the past. Other agencies that advised the project team has tremendous knowledge in both ecosystems. They advised on the weather (snow fall and snow accumulations), leaf sprout times, and many other issues relating to the image acquisition with their firsthand knowledge of the field. Tom Remaley, Ecologist of Great Smoky Mountains National Park, especially was of great help in monitoring the snow and other weather conditions in the park.

Image Acquisition

PSI acquired 30 cm resolution four-band imagery with 400-580 nm (Blue), 500-650 nm (Green), 590-675 nm (Red), and 675-850 nm (NIR) band widths in accordance with the most current USGS specifications for digital imagery. The U.S. Department of the Interior, USGS, National Mapping Division, maintains the Content Standards for Digital Orthoimagery for the Federal Geographic Data Committee. According to the FGDC standard that is followed by USGS, the digital orthoimagery framework consists of two-dimensional, rectangular arrays of pixels, which correspond to ground areas called ground resolution cells. The pixels are arranged in horizontal rows and vertical columns with rows from top to bottom and the columns from left to right (FGDC, 2011). The multiband orthoimagery are stored as four-band GeoTIFF files with associated geographic location reference data (FGDC, 2011).

PSI utilized one of its three (3) Zeiss/Intergraph Digital Mapping Camera (DMC) units in conjunction with airborne GPS (ABGPS) and an Inertial Measurement Unit (IMU) to obtain 4 band imagery of the 1,916 sq. mi. study area following the USGS specifications as described above. The camera used four high-resolution 7K x 4K panchromatic cameras for individual band imagery collection. The Field of View (FOV) of the cameras was set at 69.3 degrees cross track and 42 degrees along track. The lens system in the camera was 4: x f = 120 mm/f: 4.0. The shutter and f-stop of the camera was continuously varying in a range of 1/50 – 1/300 sec f/4 – f/22. The on board storage capacity of the camera (FDS) was 1.7 TB or less than 4,400 images. The maximum frame rate was set at 2.1 sec/image. The radiometric resolution for all cameras was set at 12 bit. The operation envelope was set up to 8,000 m on non-pressurized condition. The weights of the camera, FDS, and T-AS Mount were 88, 87, 48 kg, respectively. The Zeiss/Intergraph Digital Mapping Camera (DMC) was used to acquire imageries with Above Ground Level specification for flight of 9,600 feet. This altitude ensured a greater than 30 centimeter ground pixel resolution as required by USGS. The DMC is a certified USGS digital aerial sensor. Therefore, it helped in adhering to the specifications of USGS for the image

acquisition. The final output image of the camera system provided a size of 7,680 x 13,824 pixels. A detailed DMC camera specification is provided in Appendix 1.

The image acquisition was conducted in leaf off conditions in a single season. The orthoimagery was acquired in the month of March 2010 for the entire 1916 sq. mi. of study area including both CNF and GRSM. In April 2011, LIDAR data was collected for a part of GRSM area (Tennessee portion) covering 373 sq. mi. to create DEM for supporting the orthoimagery data processing of the area. Snow accumulation on the ground hampered the LIDAR data collection for the area in 2010 and delayed the processing of the March 2010 acquired orthoimagery. Image acquisition in March 2010 ensured leaf-off conditions and also minimized long shadows that could affect image acquisition due to the mountainous terrain of our study area. Following procedure and specifications were followed while collecting/acquiring orthoimageries using the Zeiss/Intergraph Digital Mapping Camera.

- **Time of Day and Year:** Imagery was collected during minimal shadow conditions. Image collection was done when the sun angle was greater than 30-degrees**.** The project area did not have any significant development or high-rise buildings to create problems in image acquisition.
- **Collection Conditions:** Imagery was collected under conditions free from clouds and cloud shadows, smoke, haze, light streaks, snow, foliage, flooding, and excessive soil moisture. It was ensured that the images were obtained during the time deciduous trees are free of foliage (leaf-off condition).
- **Image Coverage**: The extent of image coverage over the project area was sufficient to ensure void areas do not exist within the 1500 m x 1500 m orthophoto tiles. Tiles, which met or exceeded the 300-m buffer was considered as full image tiles. A detailed description of tiling process is given later.
- **Calibration:** A factory issued calibration report for the Z/I DMC sensor used to collect the imagery. Appendix 2 contains the file description for the calibration process reports of both cameras (Zeiss 33 and 126), which is submitted as softcopy deliverables along with orthoimageries and the other deliverables. As stated earlier, the DMC is a USGS certified digital sensor.
- **Airborne GPS:** Camera position (latitude, longitude, and elevation) was recorded at the instant of collection with airborne GPS. Airborne GPS data was differentially corrected and organized as individual datasets grouped by flight line. Differentially corrected Airborne GPS positional data was stored on portable media, in a nonproprietary format acceptable to each organization. The horizontal root-mean-square error (RMSE) of the airborne GPS control data did not exceed 20cm. The vertical RMSE of the Airborne GPS control did not exceed 30cm. Table 1 contains an example of the RMSE and other correction report for the GPS control data for a single day. Appendix 3 contains the file description for the entire airborne GPS correction reports for the whole project, which is submitted as softcopy deliverables along with orthoimageries and the other deliverables.

Table 1: RMSE report of camera position with airborne GPS (Example of a Single day)

POS Export Utility
Copyright (C) 1997-2008 by Applanix Corporation [Sep 24 2009]
All rights reserved.

Parameter setup:
POSPROC SBET file: D:\Data\8114-001_Grt_Smk_Mtn\3-27-10B_126\3-27-10B_126\3-27-10B_126\Proc\sbet_3-27-10B_126.out
Camera mid-exposure event file: D:\Data\8114-001_Grt_Smk_Mtn\3-27-10B_126\3-27-10B_126\3-27-10B_126\Extract\event1_3-27-10B_126.dat
Event time shift: 0.000000 sec
Photo ID file:
Photo ID file format: 2 Fields (Time, Photo ID) Format
Offset between PHOTO ID and EVENT file times: 0.000000 sec
PHOTO ID time tolerance: 0.300000 sec
Mapping frame datum: NAD83 ; a = 6378137.000000; 1/f = 298.257222;
Coordinate transformation from WGS84 to mapping frame datum
dX = 0.984000; dY = -1.916000; dZ = -0.511000; f = 0.999999999017;
R1 = 0.000000127215; R2 = 0.000000045282; R3 = 0.000000055463;
sequence of the rotations: x,y,z,1
Mapping frame projection : TM;
central meridian = -87.000000 deg;
latitude of the grid origin = 0.000000 deg; grid scale factor = 0.999600:
false easting = 500000.000000 m; false northing = 0.000000 m;
Boresight values: tx = 0.0000 arc min, ty = 0.0000 arc min, tz = 0.0000 arc min.
Lever arm values: lx = 0.0000 m, ly = 0.0000 m, lz = 0.0000 m.

FL_FRAME,	TIME,	EAST SD,	NORTH SD,	HEIGHT SD
(Time in Sec,	Position SD in Meters)			
320_55	583281.40756	0.035	0.044	0.029
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320_51	583312.11381	0.035	0.044	0.030
320_50	583318.97434	0.035	0.045	0.030
320_49	583325.34677	0.035	0.044	0.029
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313_09	584282.92890	0.035	0.043	0.027
313_08	584289.81741	0.035	0.043	0.027
313_07	584296.90592	0.035	0.043	0.028
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****	585412.58783	0.036	0.045	0.037
****	585419.19230	0.036	0.045	0.037
****	585425.78479	0.036	0.045	0.038
****	585432.31728	0.036	0.045	0.038
****	586905.09588	0.028	0.048	0.030
****	587815.11884	0.036	0.047	0.039
****	587820.87927	0.036	0.046	0.040
****	587826.67170	0.036	0.046	0.040
****	587832.46812	0.036	0.046	0.040
****	587838.33255	0.036	0.046	0.040
****	587844.32099	0.036	0.046	0.040
****	587850.42544	0.036	0.047	0.040
****	587856.57389	0.036	0.047	0.040
****	587862.73835	0.036	0.047	0.041
****	587868.85478	0.036	0.047	0.041
****	587874.89123	0.036	0.047	0.043
****	588253.57109	0.038	0.046	0.039
****	588260.37959	0.038	0.046	0.039
****	588267.30010	0.038	0.046	0.039
****	588274.27661	0.038	0.046	0.039
****	588281.23713	0.038	0.046	0.039

****	588288.16164	0.038	0.046	0.039
****	588294.93814	0.038	0.046	0.039
****	588301.59063	0.038	0.046	0.039
****	588308.18312	0.038	0.046	0.039
****	588314.78760	0.038	0.046	0.040
****	588321.34809	0.038	0.046	0.039
328_30	588692.31538	0.037	0.048	0.037
328_31	588698.03580	0.037	0.048	0.038
328_32	588703.78022	0.037	0.049	0.041
328_33	588709.52065	0.046	0.052	0.065
328_34	588715.29308	0.049	0.053	0.071
328_35	588721.14950	0.049	0.053	0.071
328_36	588727.06994	0.050	0.052	0.071
328_37	588732.98638	0.050	0.052	0.072
328_38	588738.89481	0.050	0.052	0.073
328_39	588744.73523	0.051	0.052	0.073
328_40	588750.49166	0.052	0.053	0.075

- **Inertial Measurement Unit (IMU):** The Z/I DMC was equipped with both ABGPS and IMU capability. Therefore, in addition to the ABGPS data collection, the camera altitude at the moment of acquisition utilizing the IMU was recorded and they are shown in Tables 2-4. The IMU data was adjusted and organized as individual data sets grouped by corresponding flight lines. The RMSE of the adjusted IMU data did exceed 30cm. Table 1 and Appendix 3 contains information on the IMU data used in image acquisition.
- **Ground Control Points (GCPs)**: As referenced below under Datum and Coordinates, supplemental differentially corrected GPS ground controls were used to supplement the Airborne GPS positional adjustment and NGS control monumentation. They were stored on portable media, in a non-proprietary format and were mutually agreed by the USGS and the project team (GSC and UGA). Table 2 contains the coordinates of all GCPs used for image acquisition. The Supplemental Ground Control report that contains narrative, computations and field notes/photos for all points used in the supplemental ground control solution are provided in Appendix 4 as an example. The rest of the data are stored in the delivered hard drive.

Table 2: Coordinates of Ground Control Points used in the image acquisition process (Only a subset of CNF area and all GRSM GCPs are shown here)

- CNF GCPs

Point_Id	Northing	Easting	Orth_heigh	Annotation
B-12	3858398	284899.1	470.841	DR AT EP\DR AT EP
B-13	3844638	280511.8	502.21	EP AT EP
B-14	3860404	271110.9	590.203	DR AT EP
B-15	3870948	300605.3	709.6	DR AT EP\DR AT EP
B-6	3857763	250296.8	661.452	EP AT EP
B-8	3868184	258501.9	647.177	DR AT EP
B-9	3853253	264674	584.135	NW CORNER OF STOP BAR
DAVIDSON	3856102	271299.8	661.616	NGS DISK SET IN CONCRETE
PP014	3830146	229527.2	441.437	EDGE RD AT EDGE RD
PP-016	3834525	289920.8	221.213	DR AT EP

QC-dd	3841715	267325.9	491.033	DR AT CHANGE IN ASPHALT
QC-ee	3836267	240769.2	495.739	CORNER OF STOP BAR
QC-g	3848847	239616.3	684.733	EP AT EP SHOULDER
QC-h	3853410	249063.1	816.084	CORNER OF PAINT STRIPE
QC-i	3866467	260718.8	808.555	DR AT EP
QC-j	3861142	273411.9	604.278	EP AT EP
QC-k	3854145	264412.3	604.056	DR AT EP
QC-m	3843944	280087.6	477.014	TIP OF TURN ARROW
QC-n	3856390	287630.5	485.436	DR AT EP\DR AT EP
QC-o	3869687	300512.8	626.544	ASPHALT SHOULDER AT EP

- GRSM GCPs

Point_Id	Northing	Easting	Orth_height	Annotations
HAYW	3933137	325459.2	838.225	NATIONAL CORS
NCBC	3917255	272296.1	594.761	NATIONAL CORS
NCMA	3964541	347352.1	590.809	NATIONAL CORS
PP11	3939770	294866.9	795.045	END OF FOG LINE AT BRIDGE
PP12	3930163	284897.6	748.408	CORNER CONC TROUT RUN
PP13	3943802	246713.1	549.021	CRNR OF PRKG STRIPE\MOVED FROM ORIG LOC
PP14	3937632	273762.1	1923.575	NORTHERN CORNER OF HANDICAP SYMBOL
PP15	3926760	278887.9	550.505	INSIDE INTRSX OF STRIPES
PP17	3928612	235052.3	513.082	TIP OF LEFT TURN ARROW
PP19	3939026	227313.7	271.042	SE CORNER OF STOP BAR
PP21	3947816	235002.6	670.148	INTRSX OF PVMNT CHG AT FOG LINE
PP22	3949461	244878.1	614.087	INTRSX OF DRIVE AT EP
PP23	3950833	254201.1	341.387	SW CORNER OF GRASS MEDIAN
PP25	3953560	269154.5	894.484	CORNER OF CONC PAD
PP26	3956553	277413.9	459.353	CORNER STOP BAR
PP27	3960065	290309.9	526.705	NW CORNER OF PARKING LOT
PP28	3959628	309718.3	475.526	EDGE OF PAVEMENT AT TANGENT POINT
PP29	3944526	314442.6	1183.679	CRNR ASPH DR AT GRAVEL RD\NORTH BLOCKED BY HILL
PP30	3932342	302275.9	1631.56	END OF YELLOW CL STRIPE
PP31	3947417	256467	412.274	VERTICAL POINT IN FIELD
PP32	3947515	265860.5	737.374	VERTICAL POINT IN PASTURE
PP33	3943503	280302.4	1538.095	INTRSX OF SIDEWALKS
PP34	3956635	282380.7	438.285	CORNER OF DRIVE
PP35	3944007	308306.1	847.736	SE CORNER OF WOODEN BRIDGE
PP36	3959265	300304.6	666.694	VERT PNT IN PARKING LOT\VERY HIGH TREES
PP37	3925052	250571.4	519.817	CORNER OF CONC BOAT RAMP
PP38	3924002	268689.2	591.43	CRNR ASPHALT DR
TN13	3979947	300900.9	391.231	NATIONAL CORS

TN15	3987753	250274.5	302.174	NATIONAL CORS
TN17	3967418	228501.9	311.753	NATIONAL CORS
TN26	3928240	170470.8	288.341	NATIONAL CORS

Figure 7 shows the flight path designed for the orthoimagery acquisition. Figure 8 shows the point exposure for flight path in both ecosystems of the study area. It is to be noted that eastern portion of CNF and the entire GRSM is under the UTM NAD 83 Zone 17 N geographic coordinate (Figure 7). The western portion of CNF is under the UTM NAD 83 Zone 16 N geographic coordinate (Figure 7). Tables 3-5 depict the flight line #, exposure, altitude (in ft), ALTIT_M (altitude in m), longitude, and latitude of flight exposures while collecting images of the study area in three different phases (CNF west, CNF east, and GRSM).

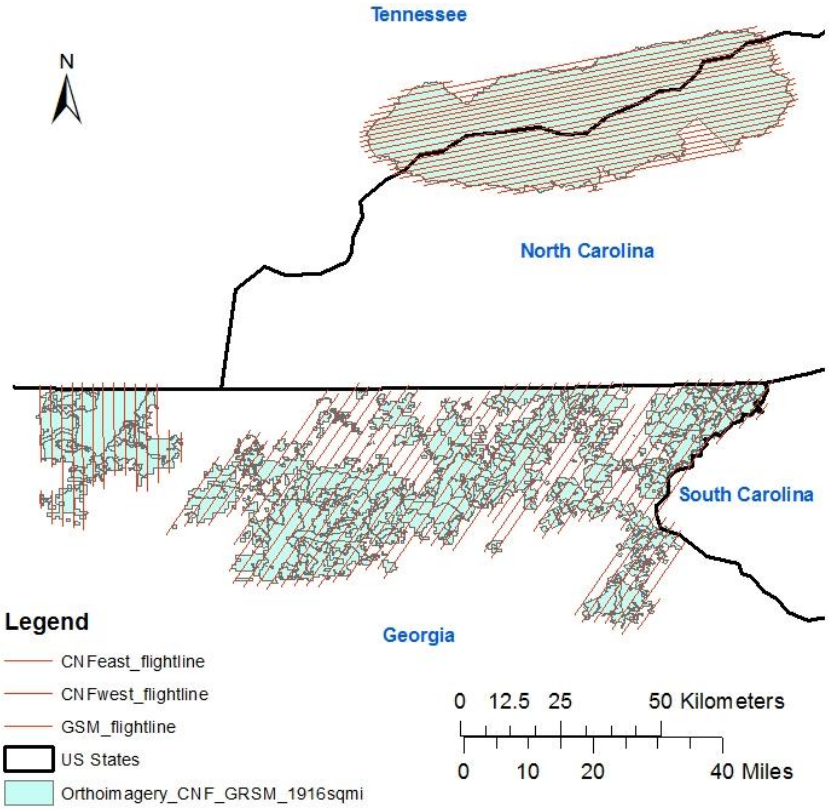

Figure 7: The designed Flight Path to acquire digital orthoimageries of study area (Source: PSI)

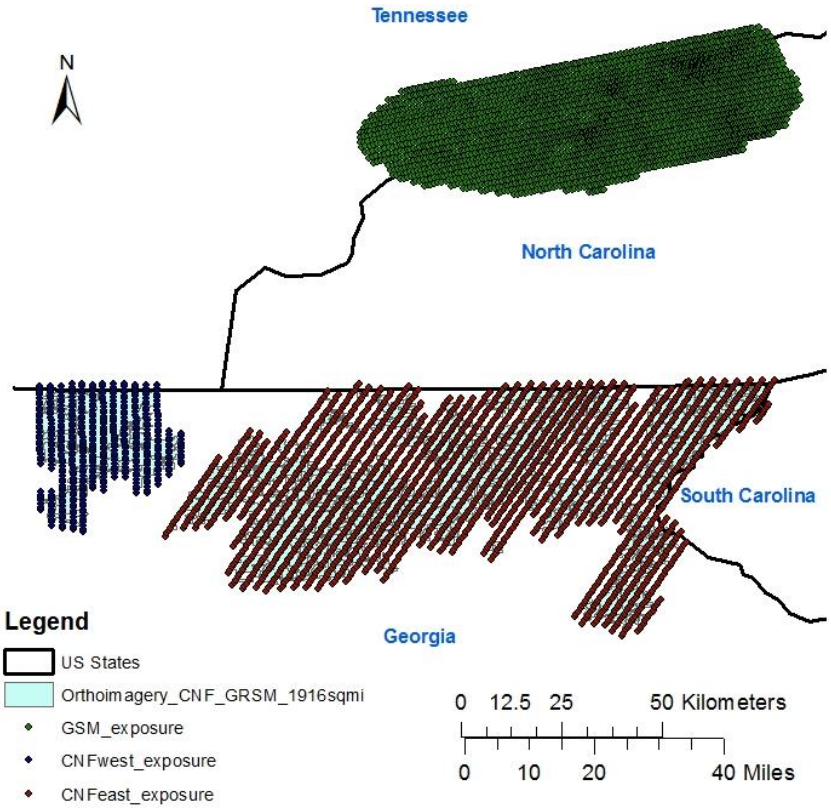

Figure 8: Designed flight path exposure points for digital orthoimagery acquisition (Source: PSI)

Table 3: The flight line exposure database for CNF west (UTM NAD 83 Zone 16 N)

PSID	FLIGHTLN	EXPOSURE	ALTITUDE	ALTIT_M	LON	LAT
2	201	1	9398	2865.00	-84.72737276	34.71971536
3	201	2	9398	2865.00	-84.72744727	34.72670639
4	201	3	9398	2865.00	-84.72752106	34.73362565
5	201	4	9398	2865.00	-84.72759354	34.74042666
6	201	5	9398	2865.00	-84.72766519	34.74713921
7	201	6	9398	2865.00	-84.72773564	34.75374866
8	201	7	9398	2865.00	-84.72780633	34.76038527
10	202	1	9398	2865.00	-84.72847974	34.82346559
11	202	2	9398	2865.00	-84.72855556	34.83056617
12	202	3	9398	2865.00	-84.72863126	34.83764672
13	202	4	9398	2865.00	-84.72870660	34.84469604
14	202	5	9398	2865.00	-84.72878099	34.85165262
15	202	6	9398	2865.00	-84.72885561	34.85864043
16	202	7	9398	2865.00	-84.72893071	34.86566341
17	202	8	9398	2865.00	-84.72900534	34.87264073
18	202	9	9398	2865.00	-84.72907770	34.87940896
19	202	10	9398	2865.00	-84.72915113	34.88626993
20	202	11	9398	2865.00	-84.72922695	34.89335990
21	202	12	9398	2865.00	-84.72930181	34.90035546

Note: Only 20 exposure points shown out of 496 points.

Table 4: The flight line exposure database for CNF east (UTM NAD 83 Zone 17 N)

PSID	FLIGHTLN	EXPOSURE	ALTITUDE	ALTIT_M	LON	LAT
2	301	1	10297	3139.00	-84.44998836	34.66169453
3	301	2	10297	3139.00	-84.44560921	34.66802728
4	301	3	10297	3139.00	-84.44127762	34.67429018
5	301	4	10297	3139.00	-84.43697989	34.68050289
6	301	5	10297	3139.00	-84.43271923	34.68666100
7	301	6	10297	3139.00	-84.42860162	34.69261134
8	301	7	10297	3139.00	-84.42448246	34.69856298
9	301	8	10297	3139.00	-84.42038858	34.70447707
10	301	9	10297	3139.00	-84.41613817	34.71061635
11	301	10	10297	3139.00	-84.41192925	34.71669447
12	301	11	10297	3139.00	-84.40774178	34.72274065
13	301	12	10297	3139.00	-84.40383732	34.72837734
14	301	13	10297	3139.00	-84.39995181	34.73398578
15	301	14	10297	3139.00	-84.39590192	34.73983049
16	301	15	10297	3139.00	-84.39173842	34.74583828
17	301	16	10297	3139.00	-84.38767993	34.75169325
18	301	17	10297	3139.00	-84.38360524	34.75757086
19	301	18	10297	3139.00	-84.37955737	34.76340890
20	301	19	10297	3139.00	-84.37556613	34.76916421
21	301	20	10297	3139.00	-84.37140691	34.77516079

Note: Only 20 exposure points shown out of 2684 points.

Table 5: The flight line exposure database for GRSM (UTM NAD 83 Zone 17 N)

PSID	FLIGHTLN	EXPOSURE	ALTITUDE	ALTIT_M	LON	LAT
2	101	1	8199	2499.40	-83.91975129	35.65355623
3	101	2	8199	2499.40	-83.91387642	35.65473676
4	101	3	8199	2499.40	-83.90787101	35.65594304
5	101	4	8199	2499.40	-83.90187144	35.65714800
6	101	5	8199	2499.40	-83.89603758	35.65831924
7	101	6	8199	2499.40	-83.88999188	35.65953279
8	101	7	8199	2499.40	-83.88353169	35.66082907
9	101	8	8199	2499.40	-83.87679100	35.66218126
10	101	9	8199	2499.40	-83.87023783	35.66349542
11	101	10	8199	2499.40	-83.86365437	35.66481531
12	101	11	8199	2499.40	-83.85699415	35.66615009
13	101	12	8199	2499.40	-83.85034227	35.66748285
14	101	13	8199	2499.40	-83.84398937	35.66875529
15	101	14	8199	2499.40	-83.83768594	35.67001748
16	101	15	8199	2499.40	-83.83142602	35.67127049
17	101	16	8199	2499.40	-83.82507598	35.67254126
18	101	17	8199	2499.40	-83.81872332	35.67381215
19	101	18	8199	2499.40	-83.81208527	35.67513978
20	101	19	8199	2499.40	-83.80528438	35.67649960

Note: Only 20 exposure points shown out of 3224 points.

The detailed flight line numbers and exposure station or strip numbers for this project is presented in the USGS Aerial Photography Supplemental Report format and provided as softcopy deliverables along with orthoimageries and the other deliverables.

The geographic extent of this project included a 300 meter buffer around the minimum bounding rectangle of the identified project area (Figure 6) as mentioned earlier. The orthoimagery was divided into total 3199 tiles. The tile extent and grid corroborated with the USGS specifications. There were 890, 1189, and 1120 tiles for the CNF west, CNF east, and GRSM portion of the study area. Figure 9 shows the detailed tiling of the study area as divided into 3 portions. Orthoimagery tiles did not contain any non-image data defined as photographic frame borders, fiducial marks, artifacts, and titling.

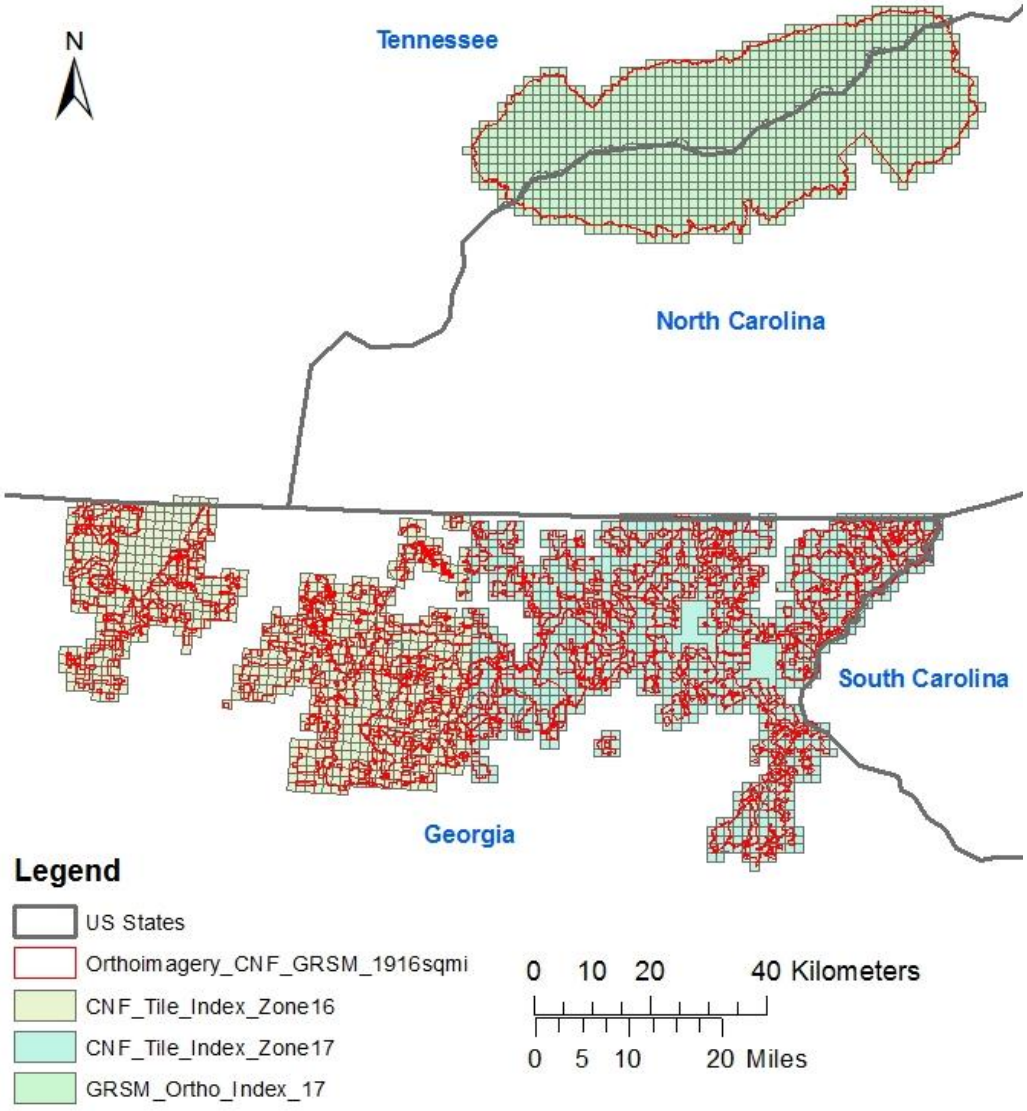

Figure 9: The tiles setting for the 1916 sq. mi. of the study area for orthoimagery acquisition.

Image Processing

The orthoimagery processing for orthorectification (geometric and radiometric correction) was conducted by Photo Science staffs, Student Research Assistants of GSC and

UGA with PI supervision. Following are the details of the orthoimagery data collection and processing procedures that were followed by the project team which was mandated by USGS specifications.

After the imageries were acquired, Photo Science conducted aerotriangulation to densify the base control network and the images were differentially rectified and converted to orthophotos using DEMS from several sources: 1) Western CNF used USGS 10-m NED data; 2) Eastern CNF used LiDAR-derived 3-m DEM; 3) The North Carolina portion of the GRSM used a 20-foot DEM derived from LiDAR collected as part of the NC Floodplain Mapping Program; and 4) the Tennessee Portion of GRSM used a 3-m DEM derived from LiDAR collected as part of this project. After creating the orthophotos from individual frames, it was necessary to mosaic the images and then cut them into tiles. For this process, initial seamlines were created by the PSI staffs using ImageStation OrthoPro (Intergraph Corporation, Huntsville, AL) software. Then, the seamlines were edited manually using ArcGIS 9.3 software by student assistants of both GSC and UGA. The protocol provided in Appendix 5a was developed by the project team to edit the seamlines. Screenshots are provided in the procedure shown in Appendix 5a. Also, another document was developed to support student assistants for seamline editing with extensive guidelines. The document containing the guideline is presented in Appendix 5b.

Based on the guidelines, seamlines were edited to confirm that the lines must cross perpendicularly over roads, rivers, and urban features in the imagery. If they do not cross perpendicularly over those land use features, there is a possibility that consecutive tiles would not match properly while mosaicking. Once all the seamlines were edited, they were checked by the PIs and the PSI staffs for any possible errors and they were updated.

- **Radiometry Balance.** The radiometric balances were conducted through these processes. The brightness and color values of the other chips were adjusted to match that of the principal chip while collecting the imageries. The seamlines between the overlapping chips was chosen to minimize tonal variations as discussed above. Localized adjustment of the brightness and color values was done to reduce radiometric differences between join areas. Adobe Photoshop CS3 and CS4 were used in this process. It was also made sure that the images (as a whole) had gradual changes in color balance across the project, if they exist. Abrupt tonal variations between tiles were adjusted using Adobe Photoshop software. Student assistants of both institutions with the supervision of the PIs and PSI staffs conducted these radiometric balances to the orthoimageries.
- **Edge-Matching.** All imageries were edge-matched to ensure that there were no mis-joins or edge-match issues due to excessive horizontal displacement along seamlines or at tile boundaries. No edge-tie displacement exceeded +/- 3 pixels.
- **Datums and Coordinates:** The high-resolution orthoimagery was projected in the North American Datum of 1983 (NAD83), using Universal Transverse Mercator (UTM) zone 17 for both GRSM and CNF representing the predominance of the project area with coordinates in meters although the western portion (Figure 9) of CNF was under 16 N zone. The vertical datum for this source dataset was North American Vertical Datum of 1988 (NAVD88). The project was controlled using the latest available NGS control adjustment as well as supplemental field control all of which were referenced to the NGS control monumentation.
- **Image Mosaicking**: full project orthoimagery was created by using multiple digital images ("chips") to produce the final product. All artifacts were minimized or eliminated by patching the area using chips from other imagery in order to produce a mosaic as

seamless/flawless as possible. The mosaiced imageries are provided in GeoTIFF format in an external hard drive.

Other QA/QC on Orthoimagery for Submission

After the image processing was completed and imageries are mosaiced together, the following quality control and quality assurances steps/procedures were followed.

- **Aerotriangulation data: Softcopy** Aerotriangulation (AT) techniques was used in the orthorectification process. The process consisted of a minimum of refined image coordinates and adjusted ground coordinates. A comprehensive AT report is provided as part of the deliverable and shown in Appendix 6. **Digital Orthorectified Image Datum**: Digital orthorectified images were referenced to North American Datum 1983, Universal Transverse Mercator (UTM) meters.
- **Digital Orthorectified Image Color:** Images were of four (4) bands consisting of red, green, and blue and near infrared stored in that order in BSQ format with the band widths of 400-580 nm (Blue), 500-650 nm (Green), 590-675 nm (Red), and 675-850 nm (NIR), respectively.
- **Spatial Resolution:** The spatial resolution was set to 30 cm ground sample distance (GSD). The orthoimagery was resampled from the original image or original capture, with resolution greater or less than the numbers, such as GSD of 30 cm and orthoimage resolution of 15 cm (max.) and 32 cm (min.).
- **Horizontal Accuracy:** All orthoimages had 95% (NSSDA Confidence Interval) of all well-defined points tested fall within the specified distance listed below of true ground, i.e., ground sample distance (GSD) of 30 cm and horizontal accuracy of 5.19 m. Table 6a and b contain the horizontal RMSE of each point in overall study area, CNF and GRSM portion, respectively. The horizontal RMSE for the CNF area was 0.08645 m and GRSM area was 0.25714 m. They were below the pixel resolution of orthoimagery.

Table 6a: Horizontal RMSE of each point in CNF portion of the study area (a subset of points shown but with overall average RMSE values.

GPS Point #	Field Northing (Y)	Field Easting (X)	Ortho Northing (Y) - UTM	Ortho Easting (X) - UTM	Northing Difference	Northing Difference Squared	Easting Difference	Easting Difference Squared
B-12	3858397.694	284899.088	3,858,397.676	284,899.103	0.02	0.00032	-0.02	0.00023
B-13	3844638.478	280511.813	3,844,638.54	280,511.811	-0.06	0.00406	0.00	0.00000
B-14	3860404.15	271110.897	3,860,404.113	271,110.812	0.04	0.00135	0.09	0.00729
B-15	3870947.99	300605.273	3,870,947.818	300,605.416	0.17	0.02955	-0.14	0.02045
B-6	3857762.565	250296.763	3,857,762.565	250,296.766	0.00	0.00000	0.00	0.00001
B-8	3868184.211	258501.902	3,868,184.160	258,501.908	0.05	0.00260	-0.01	0.00004
B-9	3853253.444	264673.971	3,853,253.360	264,673.964	0.08	0.00706	0.01	0.00005
PP014	3830146.116	229527.182	3,830,146.100	229,527.161	0.02	0.00025	0.02	0.00046
PP-016	3834525.256	289920.792	3,834,525.259	289,920.779	0.00	0.00001	0.01	0.00018
QC-dd	3841715.488	267325.859	3,841,715.504	267,325.826	-0.02	0.00027	0.03	0.00112
QC-ee	3836266.732	240769.199	3,836,266.740	240,769.156	-0.01	0.00006	0.04	0.00187
QC-g	3848846.757	239616.25	3,848,846.827	239,616.245	-0.07	0.00491	0.00	0.00002

QC-h	3853410.441	249063.088	3,853,410.321	249,063.004	0.12	0.01438	0.08	0.00699
QC-i	3866467.018	260718.785	3,866,466.995	260,718.810	0.02	0.00051	-0.02	0.00060
QC-j	3861142.113	273411.85	3,861,142.132	273,411.862	-0.02	0.00034	-0.01	0.00014
QC-m	3843944.467	280087.641	3,843,944.464	280,087.627	0.00	0.00001	0.01	0.00019
QC-n	3856389.999	287630.474	3,856,390.050	287,630.489	-0.05	0.00257	-0.02	0.00024
QC-o	3869686.735	300512.796	3869686.636	300512.881	0.10	0.00972	-0.08	0.00716

Average	0.00467	0.00281
RMSE	0.06830	0.05300

Horizontal RMSE	**0.08645**
HMAS @ 95%	0.14963

Table 6b: Horizontal RMSE of each point in the GRSM portion of the study area (a subset of points shown but with overall average RMSE values).

GPS Point #	Field Northing (Y)	Field Easting (X)	Ortho Northing (Y) - UTM	Ortho Easting (X) - UTM	Northing Difference	Northing Difference Squared	Easting Difference	Easting Difference Squared
PP11	3939770	294866.9	3,939,770.096	294,866.856	-0.02	0.00028	0.00	0.00000
PP12	3930163	284897.6	3,930,162.89	284,897.602	-0.05	0.00280	0.04	0.00144
PP13	3943802	246713.1	3,943,801.841	246,713.142	0.04	0.00130	-0.03	0.00088
PP14	3937632	273762.1	3,937,632.021	273,762.025	-0.15	0.02103	0.09	0.00750
PP15	3926760	278887.9	3,926,759.899	278,887.935	-0.03	0.00063	-0.01	0.00009
PP17	3928612	235052.3	3,928,612.231	235,052.297	0.04	0.00176	0.00	0.00002
PP21	3947816	235002.6	3,947,816.058	235,002.543	0.00	0.00001	0.02	0.00040
PP22	3949461	244878.1	3,949,461.008	244,877.992	0.36	0.13206	0.12	0.01467
PP23	3950833	254201.1	3,950,833.212	254,201.060	-0.01	0.00005	0.01	0.00015
PP25	3953560	269154.5	3,953,559.657	269,154.478	-0.02	0.00026	0.00	0.00002
PP26	3956553	277413.9	3,956,553.307	277,413.898	0.07	0.00446	0.00	0.00000
PP28	3959628	309718.3	3,959,627.738	309,718.296	-0.03	0.00077	0.01	0.00006
PP29	3944526	314442.6	3,944,526.542	314,442.592	-0.08	0.00626	-0.04	0.00153
PP30	3932342	302275.9	3,932,341.203	302,275.492	0.72	0.51165	0.38	0.14524
PP33	3943503	280302.4	3,943,502.960	280,302.044	-0.05	0.00280	0.37	0.13374
PP34	3956635	282380.7	3,956,634.934	282,380.676	0.03	0.00073	0.03	0.00064
PP35	3944007	308306.1	3,944,006.997	308,305.801	0.20	0.04105	0.32	0.10524
PP37	3925052	250571.4	3,925,051.851	250,571.348	0.01	0.00004	0.03	0.00079
PP38	3924002	268689.2	3,924,001.933	268,689.242	-0.05	0.00279	-0.01	0.00003

Average	0.04574	0.02038
RMSE	0.21387	0.14276

Horizontal RMSE	0.25714
HMAS @ 95%	0.44507

- **Digital Orthorectified Image Format:** As mentioned earlier, orthoimages were prepared as final product for submission in uncompressed, untiled, ArcGIS readable, GeoTIFF file format, Version 1.8.2, (http://www.remotesensing.org/geotiff/spec/geotiffhome.html) with no internal tiling or overviews. Data was not compressed during ANY PHASE of the production process. The final GeoTIFF files included the following GeoTIFF tags and keys: ModelTiepointTag; ModelPixelScaleTag; **OR** ModelTransformation Tag; **AND** GTModelTypeGeoKey; GTRasterTypeGeoKey; ProjectedCSTypeGeoKey. Appendix 7 contains the image header information for the orthoimges. The associated world file header is also provided in Appendix 7.
- **Digital Orthorectified Image Tile Size:** Orthorectified GeoTIFF files represented "tiles" 1500 m X 1500 m cut at even 1500-m grid lines with no tile overedge. Corner coordinates were based on the UTM Grid and were evenly divisible by 1500 m. Tiles were accompanied by an index sheet and shape file suitable for loading into ArcGIS. The index sheet included tile boundary and filenames. The Index sheet collar included latitude/longitude reference coordinates.
- **Digital Orthorectified Image Characteristics:** Relative join (misalignment) of transportation features between adjacent image chips/tiles did not exceed 3 pixels. Orthophotos were tonally balanced to produce a uniform contrast and tone across the image tiles of the entire project.
- **Radiometic Resolution:** 4-Band Imagery. All imagery produced for this project contained both natural color and near-IR and had the bands saved in the order of Red, Green, Blue, and Infrared.
- **File Naming Convention:** The 1500m x 1500m ortho tile file name was derived from the southwest corner of each tile and was based on the U.S. National Grid. File names included Grid Zone Designation (GZD), 100,000 meter block designator and X and Y grid coordinates truncated to 100 meters.
- **Elevation data:** The elevation data was used in the orthorectification process is submitted in a common or non-proprietary format. Three sources of elevation data were used on the project; LiDAR (PSI for Tennessee portion of GRSM), LiDAR (From North Carolina), USGS NED Data for portion of the CNF project area and LiDAR data for remaining of CNF area provided by (PSI) (see Figure xxxx).
- **Horizontal Accuracy Testing**: GSC, UGA, and Photo Science performed a thorough horizontal test utilizing strategically located horizontal control locations throughout the project area. This test utilized supplemental field control completely independent of control used during data production.
- **Verification of Metadata**:
- Above all, QA/QC of the digital orthoimagery will be conducted by Photo Science personnel in collaboration with PI and Co-PI of the project that would involve students from GSC and UGA as interns with company. GSC and UGA recruited undergraduate and graduate students, respectively, to work on this project. Photo Science provided training in several sessions at PSI headquarters in Norcross, GA, and at the GSC and

UGA campuses. Audio and video links allowed students and staff members at each school to participate in the sessions held at remote locations. Following training, the students performed the QA/QC of the data that would be disseminated to USGS. PSI remained in contact with the schools to answer any questions and address problems that came up. They also performed the final correction and approval of any QA/QC issues identified by the student workers.

Appendix 8 contains a procedural framework for conducting the QA/QC for digital orthophotographs.

Metadata

Project and tile metadata describing the orthophoto production process are submitted as a product. The METADATA format is provided in Appendix 9. Federal Geographic Data Committee (FGDC) compliant metadata was created in extensible markup language (.xml) format for each 1500-m x 1500-m orthorectified tile. FGDC compliant metadata for orthoimagery tiles is delivered on portable hard drive media along with the associated images. Accompanying metadata was defined as complete after it was thoroughly checked against the FGDC metadata standards (http://www.fgdc.gov/metadata).

REFERENCES

Baltsavias, E.P. 1996. Digital ortho-images – a powerful tool for the extraction of spatial- and geo-information. ISPRS Journal of Photogrammetry and Remote Sensing, 51(2): 63-77).

FGDC, 2011. Content Standards for Digital Orthoimagery. FGDC-STD-008-1999. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/orthoimagery/orth_299.pdf. Accessed on August 2, 2011.

Hoffmann, R., Molander, C., & Bohn, T. 2008. NAIP 2008 summary briefing, Surdex Corporation. NAIP Coordination Meeting. http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=meet&topic=nai. Accessed on November 18, 2008.

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APPENDICES

APPENDIX 1:

DMC Specifications

The DMC camera (Figure 10) contains four high-resolution 7k x 4k large area CCD panchromatic chips and high-performance lenses that provide an optical resolution of 120 lp/mm at a maximum aperture of f/4. This results in a ground resolution of 7,680 pixels along track and 13,824 pixels across track. This width closely equates to traditional film camera equipped with a 6-inch lens. Figure 10 depicts the DMC camera in its gyro-stabilized mount.

The DMC camera is far superior to small format (4k x 4k) framing sensor technologies. Small format framing sensors do have stable interior geometry, rapid post-processing capabilities, and can process data in standard softcopy production systems. However, in addition to these capabilities, the technical design of the DMC enables significant additional advantage over small format sensors including:

Figure 10: Z/I Imaging's DMC frame-based cameras enable simultaneous image capture of both the color and color infrared imagery.

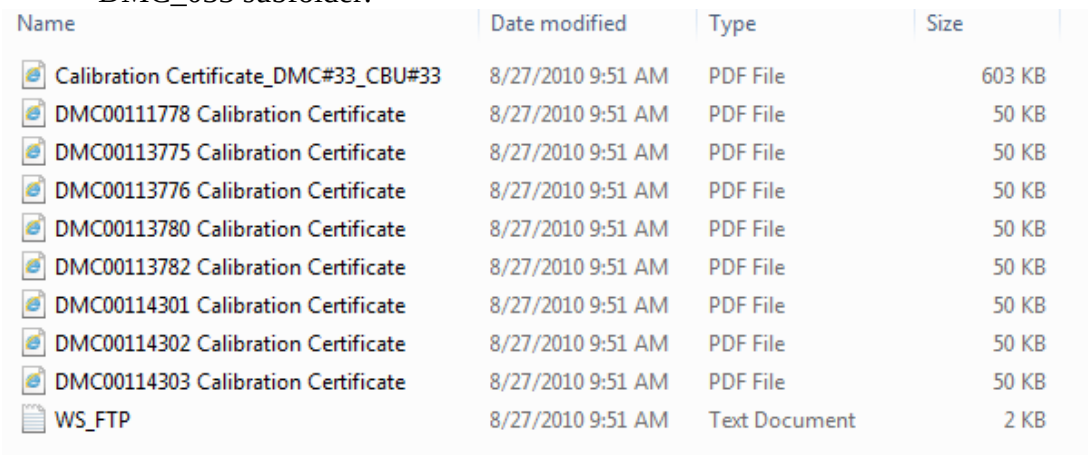
- Design as a direct replacement for aerial film cameras/scanners.
- Superior interior stability.
- Excellent radiometry.
- Stereo ground resolution as high as 5-centimeters.
- Electronic FMC.
- Suitability for all applications including high precision/large scale mapping and engineering applications.
- Precision manufacture of optical components.
- 120-millimeter focal length versus 55- to 80-millimeters of small frame systems.
- Greater than three times cross track FOV, minimizing the number of flight lines for image acquisition and decreasing down-stream orthophoto production requirements.
- Better geometry and less radial lens distortion as compared to medium format cameras.
- Simultaneous collection of panchromatic, true color, and near infrared bands.

APPENDIX 2:

Reports of the calibration process of both cameras (Zeiss 33 and 126):

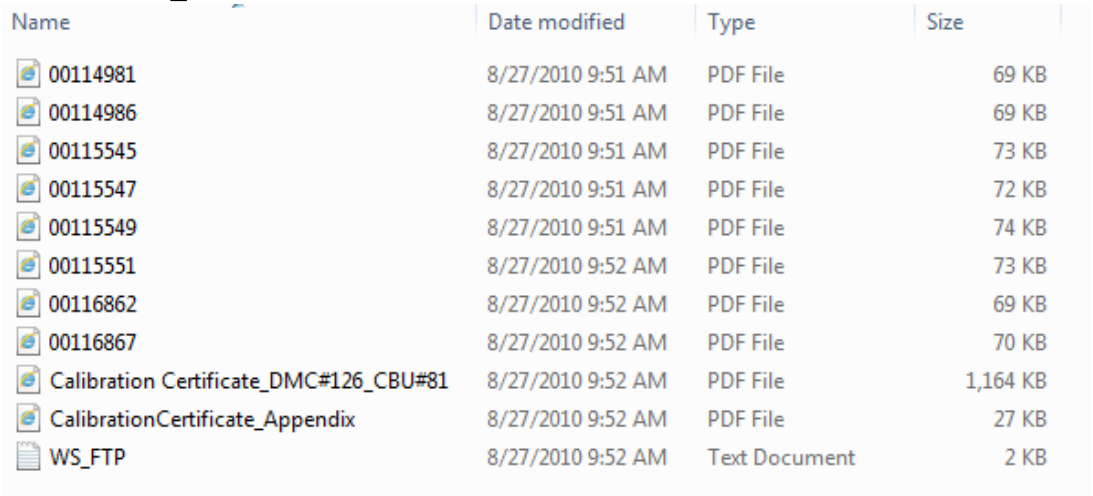
The Digital Mapping Camera calibration reports are provided as soft copy (*.PDF format) in the 'Camera_Calibration' folder of the external hard drive that accompanied the final report. The folder contains two subfolders 'DMC_033' and 'DMC_126' with individual report files inside them. Screenshots are provided to show the file names. Since the DMC contains multiple separate cameras for the panchromatic and spectral bands, each camera is calibrated separately.

- DMC_033 subfolder:



Name	Date modified	Type	Size
Calibration Certificate_DMC#33_CBU#33	8/27/2010 9:51 AM	PDF File	603 KB
DMC00111778 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
DMC00113775 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
DMC00113776 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
DMC00113780 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
DMC00113782 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
DMC00114301 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
DMC00114302 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
DMC00114303 Calibration Certificate	8/27/2010 9:51 AM	PDF File	50 KB
WS_FTP	8/27/2010 9:51 AM	Text Document	2 KB

- DMC_126 subfolder:



Name	Date modified	Type	Size
00114981	8/27/2010 9:51 AM	PDF File	69 KB
00114986	8/27/2010 9:51 AM	PDF File	69 KB
00115545	8/27/2010 9:51 AM	PDF File	73 KB
00115547	8/27/2010 9:51 AM	PDF File	72 KB
00115549	8/27/2010 9:51 AM	PDF File	74 KB
00115551	8/27/2010 9:52 AM	PDF File	73 KB
00116862	8/27/2010 9:52 AM	PDF File	69 KB
00116867	8/27/2010 9:52 AM	PDF File	70 KB
Calibration Certificate_DMC#126_CBU#81	8/27/2010 9:52 AM	PDF File	1,164 KB
CalibrationCertificate_Appendix	8/27/2010 9:52 AM	PDF File	27 KB
WS_FTP	8/27/2010 9:52 AM	Text Document	2 KB

APPENDIX 3:

Report of the airborne GPS correction information:

The airborne GPS correction reports are provided as soft copies in the 'Airborne_GPS' folder of the external hard drive that accompanied the final report. The folder contains eight subfolders '3-19-10B_DMC013', '3-20-10_DMC013', '3-24-10A_DMC013', '3-24-10A_DMC126', '3-24-10B_DMC013', '3-24-10B_DMC126', '3-27-10A_DMC126', and '3-27-10B_DMC126', with individual report files inside them. Screenshots are provided to show the file names.

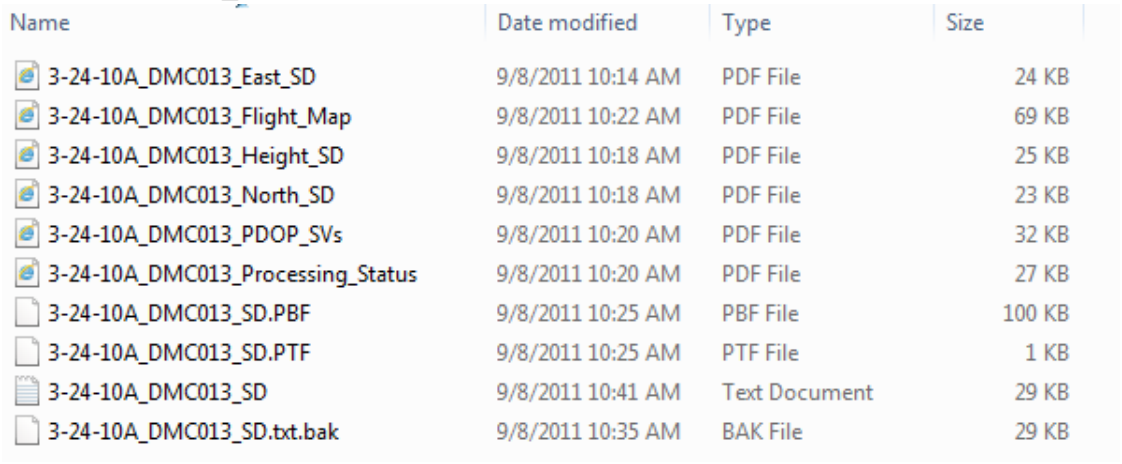
- 3-19-10B_DMC013 subfolder:

Name	Date modified	Type	Size
3-19-10B_DMC013_East_SD	9/8/2011 8:52 AM	PDF File	24 KB
3-19-10B_DMC013_Flight_Map	9/8/2011 8:59 AM	PDF File	53 KB
3-19-10B_DMC013_Height_SD	9/8/2011 8:53 AM	PDF File	23 KB
3-19-10B_DMC013_North_SD	9/8/2011 8:54 AM	PDF File	24 KB
3-19-10B_DMC013_PDOP_SVs	9/8/2011 8:55 AM	PDF File	32 KB
3-19-10B_DMC013_Processing_Status	9/8/2011 8:56 AM	PDF File	27 KB
3-19-10B_DMC013_SD.PBF	9/8/2011 9:06 AM	PBF File	116 KB
3-19-10B_DMC013_SD.PTF	9/8/2011 9:06 AM	PTF File	1 KB
3-19-10B_DMC013_SD	9/8/2011 10:08 AM	Text Document	8 KB
3-19-10B_DMC013_SD.txt.bak	9/8/2011 9:17 AM	BAK File	8 KB

- 3-20-10_DMC013 subfolder:

Name	Date modified	Type	Size
3-20-10_DMC013_East_SD	9/8/2011 9:36 AM	PDF File	22 KB
3-20-10_DMC013_Flight_Map	9/8/2011 9:41 AM	PDF File	57 KB
3-20-10_DMC013_Height_SD	9/8/2011 9:38 AM	PDF File	21 KB
3-20-10_DMC013_North_SD	9/8/2011 9:37 AM	PDF File	21 KB
3-20-10_DMC013_PDOP_SVs	9/8/2011 9:38 AM	PDF File	28 KB
3-20-10_DMC013_Processing_Status	9/8/2011 9:39 AM	PDF File	26 KB
3-20-10_DMC013_SD.PBF	9/8/2011 9:57 AM	PBF File	67 KB
3-20-10_DMC013_SD.PTF	9/8/2011 9:57 AM	PTF File	1 KB
3-20-10_DMC013_SD	9/8/2011 10:08 AM	Text Document	14 KB
3-20-10_DMC013_SD.txt.bak	9/8/2011 10:07 AM	BAK File	14 KB

- 3-24-10A_DMC013 subfolder:



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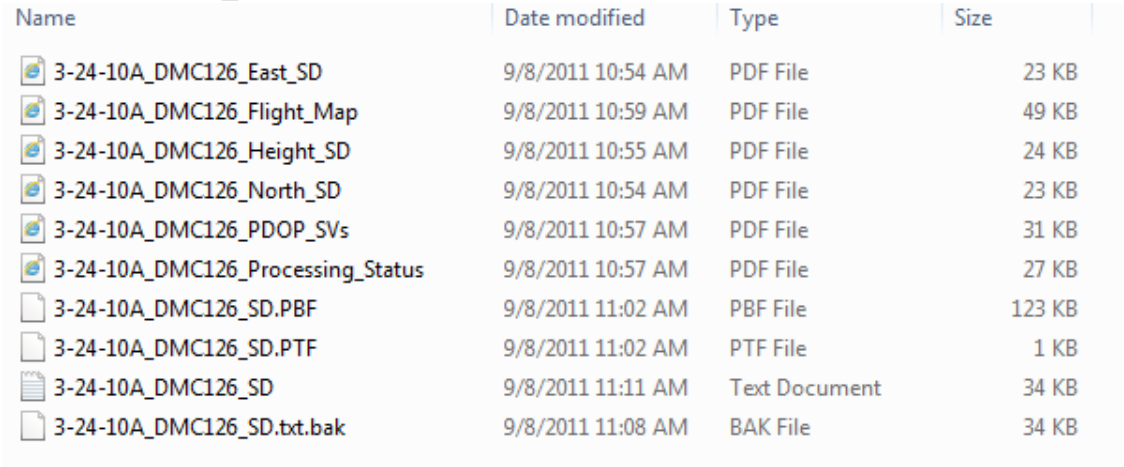
3-24-10A_DMC013_Height_SD	9/8/2011 10:18 AM	PDF File	25 KB
3-24-10A_DMC013_North_SD	9/8/2011 10:18 AM	PDF File	23 KB
3-24-10A_DMC013_PDOP_SVs	9/8/2011 10:20 AM	PDF File	32 KB
3-24-10A_DMC013_Processing_Status	9/8/2011 10:20 AM	PDF File	27 KB
3-24-10A_DMC013_SD.PBF	9/8/2011 10:25 AM	PBF File	100 KB
3-24-10A_DMC013_SD.PTF	9/8/2011 10:25 AM	PTF File	1 KB
3-24-10A_DMC013_SD	9/8/2011 10:41 AM	Text Document	29 KB
3-24-10A_DMC013_SD.txt.bak	9/8/2011 10:35 AM	BAK File	29 KB

- 3-24-10A_DMC126 subfolder:



Name	Date modified	Type	Size
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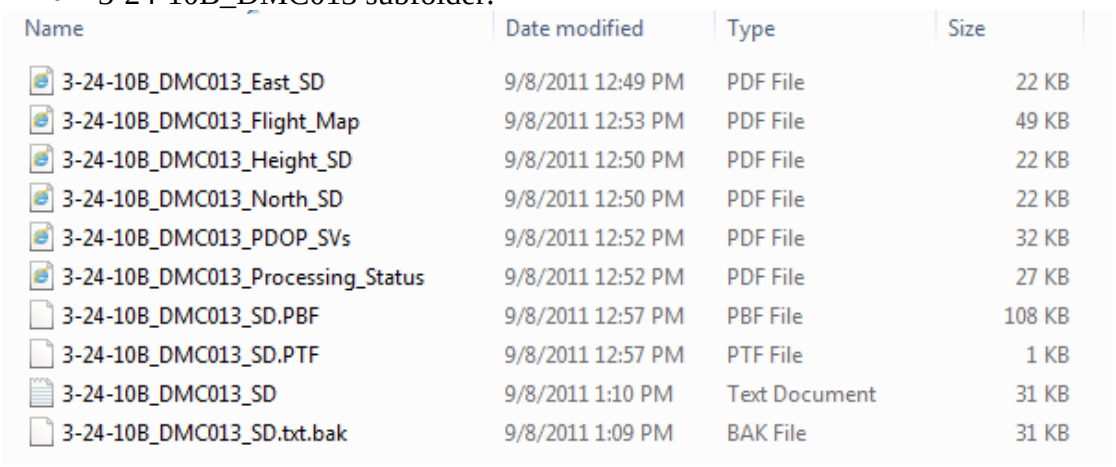
3-24-10A_DMC126_Flight_Map	9/8/2011 10:59 AM	PDF File	49 KB
3-24-10A_DMC126_Height_SD	9/8/2011 10:55 AM	PDF File	24 KB
3-24-10A_DMC126_North_SD	9/8/2011 10:54 AM	PDF File	23 KB
3-24-10A_DMC126_PDOP_SVs	9/8/2011 10:57 AM	PDF File	31 KB
3-24-10A_DMC126_Processing_Status	9/8/2011 10:57 AM	PDF File	27 KB
3-24-10A_DMC126_SD.PBF	9/8/2011 11:02 AM	PBF File	123 KB
3-24-10A_DMC126_SD.PTF	9/8/2011 11:02 AM	PTF File	1 KB
3-24-10A_DMC126_SD	9/8/2011 11:11 AM	Text Document	34 KB
3-24-10A_DMC126_SD.txt.bak	9/8/2011 11:08 AM	BAK File	34 KB

- 3-24-10B_DMC013 subfolder:



Name	Date modified	Type	Size
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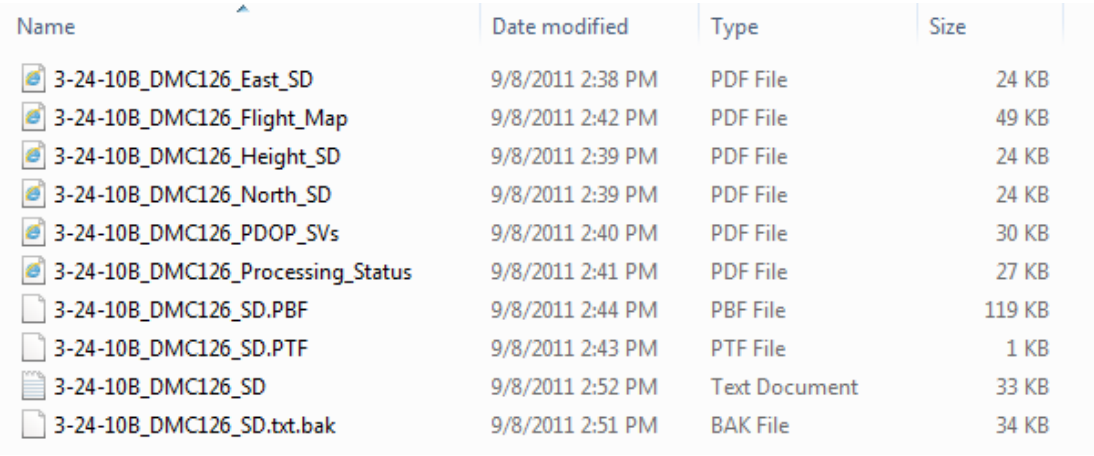
3-24-10B_DMC013_Height_SD	9/8/2011 12:50 PM	PDF File	22 KB
3-24-10B_DMC013_North_SD	9/8/2011 12:50 PM	PDF File	22 KB
3-24-10B_DMC013_PDOP_SVs	9/8/2011 12:52 PM	PDF File	32 KB
3-24-10B_DMC013_Processing_Status	9/8/2011 12:52 PM	PDF File	27 KB
3-24-10B_DMC013_SD.PBF	9/8/2011 12:57 PM	PBF File	108 KB
3-24-10B_DMC013_SD.PTF	9/8/2011 12:57 PM	PTF File	1 KB
3-24-10B_DMC013_SD	9/8/2011 1:10 PM	Text Document	31 KB
3-24-10B_DMC013_SD.txt.bak	9/8/2011 1:09 PM	BAK File	31 KB

- 3-24-10B_DMC126 subfolder:



Name	Date modified	Type	Size
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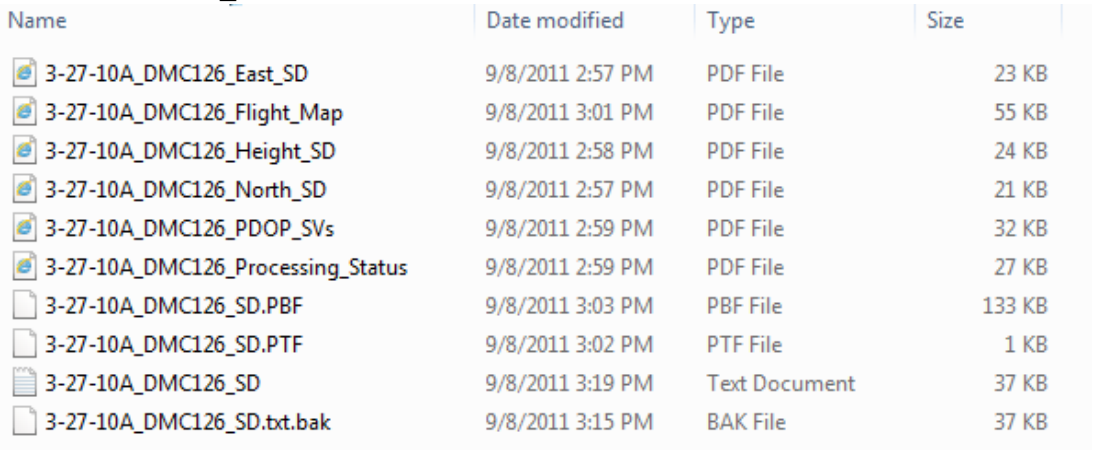
3-24-10B_DMC126_Height_SD	9/8/2011 2:39 PM	PDF File	24 KB
3-24-10B_DMC126_North_SD	9/8/2011 2:39 PM	PDF File	24 KB
3-24-10B_DMC126_PDOP_SVs	9/8/2011 2:40 PM	PDF File	30 KB
3-24-10B_DMC126_Processing_Status	9/8/2011 2:41 PM	PDF File	27 KB
3-24-10B_DMC126_SD.PBF	9/8/2011 2:44 PM	PBF File	119 KB
3-24-10B_DMC126_SD.PTF	9/8/2011 2:43 PM	PTF File	1 KB
3-24-10B_DMC126_SD	9/8/2011 2:52 PM	Text Document	33 KB
3-24-10B_DMC126_SD.txt.bak	9/8/2011 2:51 PM	BAK File	34 KB

- 3-27-10A_DMC126 subfolder:



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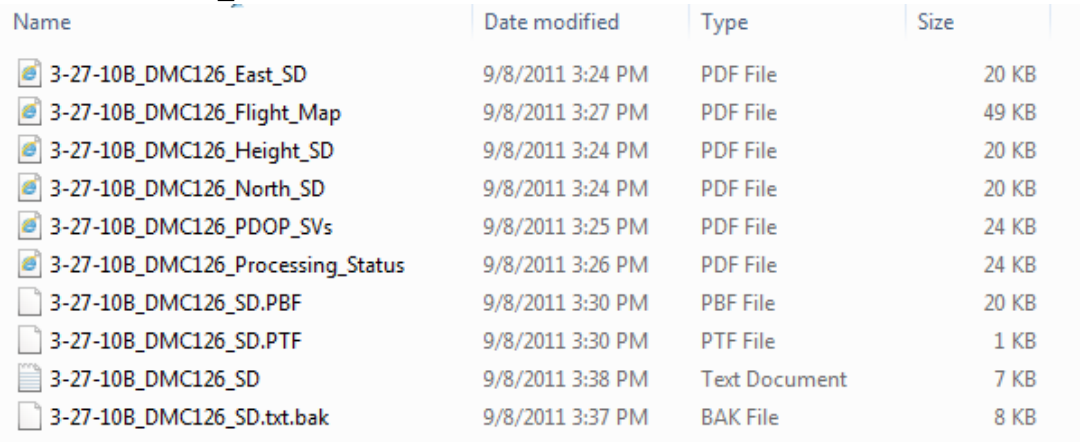
3-27-10A_DMC126_Height_SD	9/8/2011 2:58 PM	PDF File	24 KB
3-27-10A_DMC126_North_SD	9/8/2011 2:57 PM	PDF File	21 KB
3-27-10A_DMC126_PDOP_SVs	9/8/2011 2:59 PM	PDF File	32 KB
3-27-10A_DMC126_Processing_Status	9/8/2011 2:59 PM	PDF File	27 KB
3-27-10A_DMC126_SD.PBF	9/8/2011 3:03 PM	PBF File	133 KB
3-27-10A_DMC126_SD.PTF	9/8/2011 3:02 PM	PTF File	1 KB
3-27-10A_DMC126_SD	9/8/2011 3:19 PM	Text Document	37 KB
3-27-10A_DMC126_SD.txt.bak	9/8/2011 3:15 PM	BAK File	37 KB

- 3-27-10B_DMC126 subfolder:



Name	Date modified	Type	Size
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3-27-10B_DMC126_Flight_Map	9/8/2011 3:27 PM	PDF File	49 KB
3-27-10B_DMC126_Height_SD	9/8/2011 3:24 PM	PDF File	20 KB
3-27-10B_DMC126_North_SD	9/8/2011 3:24 PM	PDF File	20 KB
3-27-10B_DMC126_PDOP_SVs	9/8/2011 3:25 PM	PDF File	24 KB
3-27-10B_DMC126_Processing_Status	9/8/2011 3:26 PM	PDF File	24 KB
3-27-10B_DMC126_SD.PBF	9/8/2011 3:30 PM	PBF File	20 KB
3-27-10B_DMC126_SD.PTF	9/8/2011 3:30 PM	PTF File	1 KB
3-27-10B_DMC126_SD	9/8/2011 3:38 PM	Text Document	7 KB
3-27-10B_DMC126_SD.txt.bak	9/8/2011 3:37 PM	BAK File	8 KB

APPENDIX 4:

The Supplemental Ground Control report containing narrative, computations and field notes/photos for all points used in the supplemental ground control solution:

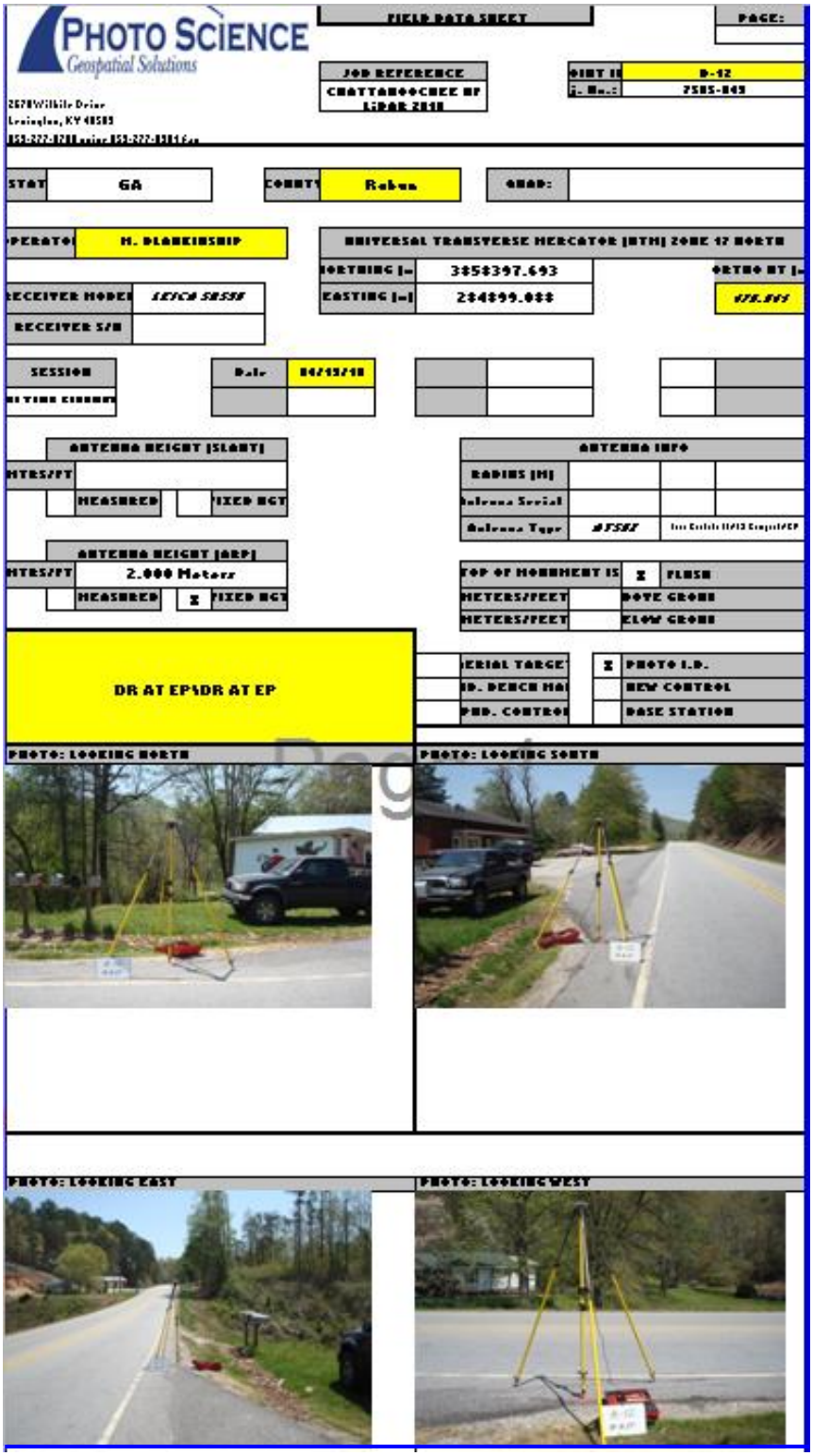
PHOTO SCIENCE
Geospatial Solutions

FIELD DATA SHEET

PAGE:

JOB REFERENCE
CHATTAHOOCHEE NF
LIDAR 2018

POINT ID: D-42
J. No.: 7585-843

STAT: GA

COUNTY: Rabun

QUAD:

OPERATOR: M. BLANKENSHIP

UNIVERSAL TRANSVERSE MERCATOR (UTM) ZONE 17 NORTH

NORTHING (m): 3858397.693

EASTING (m): 284899.088

ORTHO HT (m): 778.899

RECEIVER MODEL: LEICA GS18I

RECEIVER S/N:

SESSION

Date: 04/19/18

ANTENNA HEIGHT (SLANT)

MTRS/FT:

MEASURED

FIXED HGT

ANTENNA HEIGHT (ARP)

MTRS/FT: 2.000 Meters

MEASURED

X FIXED HGT

ANTENNA INFO

RADIUS (M):

Antenna Serial:

Antenna Type: AT502

TOP OF MONUMENT IS: X FLUSH

METERS/FEET: ABOVE GROUND

METERS/FEET: BELOW GROUND

DR AT EP\DR AT EP

X PHOTO I.D.

NEW CONTROL

BASE STATION

PHOTO: LOOKING NORTH

PHOTO: LOOKING SOUTH

PHOTO: LOOKING EAST

PHOTO: LOOKING WEST

The GCP reports as shown as an example of a single point are provided as soft copies in the ‘Ground_Control_Points >> Pictures ’ folder of the external hard drive that accompanied the final report. The folder contains two subfolders ‘CNF’and ‘GRSM’, with individual photo and report files inside them. Screenshots are provided to show the file names.

- CNF subfolder

Name	Date modified	Type	Size
B-1	8/11/2010 1:56 PM	Microsoft Office E...	4,646 KB
B-2	8/11/2010 3:15 PM	Microsoft Office E...	4,639 KB
B-3	8/12/2010 7:50 AM	Microsoft Office E...	11,221 KB
B-4	8/12/2010 7:53 AM	Microsoft Office E...	10,352 KB
B-5	8/12/2010 7:55 AM	Microsoft Office E...	11,397 KB
B-6	8/12/2010 7:52 AM	Microsoft Office E...	11,529 KB
B-7-East	1/14/2010 11:26 AM	JPEG image	1,038 KB
B-7-North	1/14/2010 11:26 AM	JPEG image	1,084 KB
B-7-South	1/14/2010 11:27 AM	JPEG image	1,041 KB
B-7-West	1/14/2010 11:27 AM	JPEG image	1,081 KB
B-8	8/12/2010 7:51 AM	Microsoft Office E...	11,389 KB
B-9	8/12/2010 7:56 AM	Microsoft Office E...	11,074 KB
B-10-East	1/13/2010 2:40 PM	JPEG image	1,058 KB
B-10-North	1/13/2010 2:39 PM	JPEG image	1,014 KB
B-10-South	1/13/2010 2:40 PM	JPEG image	949 KB
B-10-West	1/13/2010 2:40 PM	JPEG image	1,037 KB
B-11	8/12/2010 7:59 AM	Microsoft Office E...	10,961 KB
B-12	8/12/2010 8:01 AM	Microsoft Office E...	11,040 KB
B-13	8/12/2010 8:04 AM	Microsoft Office E...	10,590 KB
B-14	8/12/2010 8:00 AM	Microsoft Office E...	11,242 KB
B-15	8/12/2010 8:03 AM	Microsoft Office E...	11,461 KB
B-16	8/12/2010 8:02 AM	Microsoft Office E...	9,884 KB
B-17	8/12/2010 8:02 AM	Microsoft Office E...	4,387 KB
B-17-East	1/13/2010 12:18 PM	JPEG image	1,059 KB
B-17-North	1/13/2010 12:18 PM	JPEG image	973 KB
B-17-South	1/13/2010 12:18 PM	JPEG image	1,045 KB
B-17-West	1/13/2010 12:19 PM	JPEG image	955 KB
B-18-East	1/13/2010 10:37 AM	JPEG image	1,121 KB
B-18-North	1/13/2010 10:36 AM	JPEG image	1,101 KB
B-18-South	1/13/2010 10:37 AM	JPEG image	1,156 KB
B-18-West	1/13/2010 10:37 AM	JPEG image	1,209 KB

Name	Date modified	Type	Size
B-18-West	1/13/2010 10:37 AM	JPEG image	1,209 KB
B-19	8/12/2010 8:05 AM	Microsoft Office E...	5,028 KB
B-19-East	1/12/2010 8:44 PM	JPEG image	1,193 KB
B-19-North	1/12/2010 8:43 PM	JPEG image	1,187 KB
B-19-South	1/12/2010 8:44 PM	JPEG image	1,152 KB
B-19-West	1/12/2010 8:44 PM	JPEG image	1,135 KB
B-20	8/12/2010 8:04 AM	Microsoft Office E...	4,671 KB
B-20-East	1/12/2010 5:50 PM	JPEG image	1,099 KB
B-20-North	1/12/2010 5:48 PM	JPEG image	1,082 KB
B-20-South	1/12/2010 5:50 PM	JPEG image	1,026 KB
B-20-West	1/12/2010 5:50 PM	JPEG image	1,106 KB
Cornport	8/12/2010 8:09 AM	Microsoft Office E...	10,526 KB
Davidson	8/12/2010 8:07 AM	Microsoft Office E...	10,822 KB
FAA_46A_A	8/11/2010 4:04 PM	Microsoft Office E...	331 KB
FAA_46A_B	8/12/2010 8:06 AM	Microsoft Office E...	5,358 KB
FRKN	8/11/2010 4:06 PM	Microsoft Office E...	331 KB
GABR	8/11/2010 4:06 PM	Microsoft Office E...	331 KB
NCMU	8/11/2010 4:07 PM	Microsoft Office E...	331 KB
PP-001	8/12/2010 8:15 AM	Microsoft Office E...	4,921 KB
PP-001-East	1/15/2010 3:48 PM	JPEG image	1,128 KB
PP-001-North	1/15/2010 3:48 PM	JPEG image	1,111 KB
PP-001-South	1/15/2010 3:49 PM	JPEG image	1,182 KB
PP-001-West	1/15/2010 3:49 PM	JPEG image	1,140 KB
PP-002	8/12/2010 8:12 AM	Microsoft Office E...	4,926 KB
PP-002-East	1/15/2010 3:19 PM	JPEG image	1,119 KB
PP-002-North	1/15/2010 3:19 PM	JPEG image	1,126 KB
PP-002-South	1/15/2010 3:19 PM	JPEG image	1,201 KB
PP-002-West	1/15/2010 3:20 PM	JPEG image	1,120 KB
PP-003	8/12/2010 8:15 AM	Microsoft Office E...	4,876 KB
PP-003-East	1/16/2010 11:05 AM	JPEG image	1,085 KB
PP-003-North	1/16/2010 11:04 AM	JPEG image	1,156 KB

Name	Date modified	Type	Size
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PP-003-West	1/16/2010 11:06 AM	JPEG image	1,122 KB
PP-004	8/12/2010 8:16 AM	Microsoft Office E...	4,697 KB
PP-004-East	1/16/2010 1:30 PM	JPEG image	1,018 KB
PP-004-North	1/16/2010 1:30 PM	JPEG image	1,130 KB
PP-004-South	1/16/2010 1:30 PM	JPEG image	1,040 KB
PP-004-West	1/16/2010 1:31 PM	JPEG image	1,152 KB
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PP-005-East	1/16/2010 12:44 PM	JPEG image	1,184 KB
PP-005-North	1/16/2010 12:43 PM	JPEG image	1,199 KB
PP-005-South	1/16/2010 12:44 PM	JPEG image	1,116 KB
PP-005-West	1/16/2010 12:44 PM	JPEG image	1,152 KB
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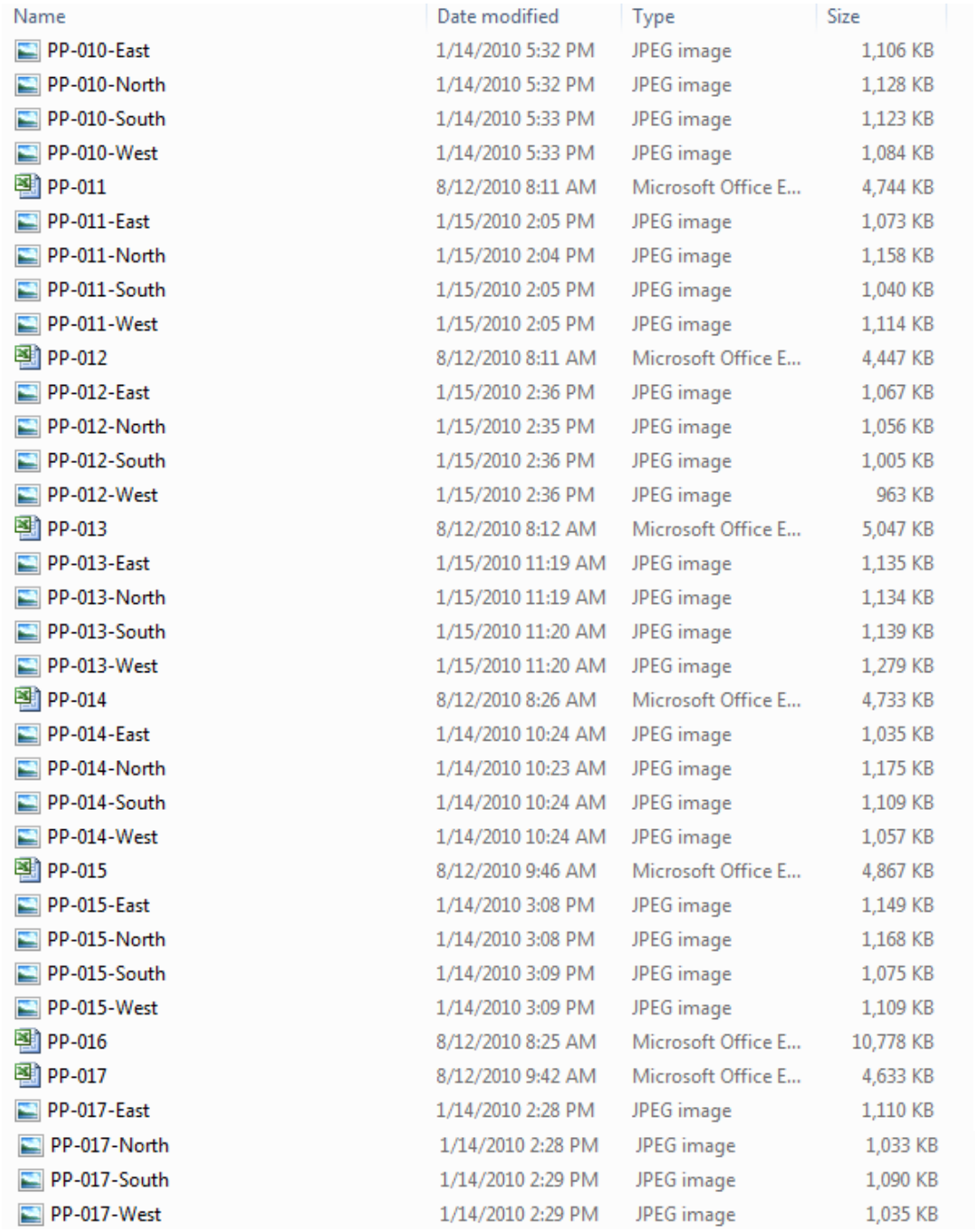
PP-006-East	1/16/2010 12:14 PM	JPEG image	1,099 KB
PP-006-North	1/16/2010 12:14 PM	JPEG image	1,140 KB
PP-006-South	1/16/2010 12:14 PM	JPEG image	1,159 KB
PP-006-West	1/16/2010 12:15 PM	JPEG image	1,163 KB
PP-007	8/12/2010 8:12 AM	Microsoft Office E...	4,847 KB
PP-007-East	1/15/2010 6:53 PM	JPEG image	1,141 KB
PP-007-North	1/15/2010 6:53 PM	JPEG image	1,145 KB
PP-007-South	1/15/2010 6:54 PM	JPEG image	1,081 KB
PP-007-West	1/15/2010 6:54 PM	JPEG image	1,121 KB
PP-008	8/12/2010 8:10 AM	Microsoft Office E...	4,814 KB
PP-008-East	1/15/2010 6:00 PM	JPEG image	1,083 KB
PP-008-North	1/15/2010 6:00 PM	JPEG image	1,168 KB
PP-008-South	1/15/2010 6:00 PM	JPEG image	1,058 KB
PP-008-West	1/15/2010 6:01 PM	JPEG image	1,146 KB
PP-009	8/12/2010 8:15 AM	Microsoft Office E...	4,998 KB
PP-009-East	1/15/2010 4:34 PM	JPEG image	1,187 KB
PP-009-North	1/15/2010 4:34 PM	JPEG image	1,122 KB
PP-009-South	1/15/2010 4:34 PM	JPEG image	1,118 KB
PP-009-West	1/15/2010 4:35 PM	JPEG image	1,212 KB



Name	Date modified	Type	Size
PP-010-East	1/14/2010 5:32 PM	JPEG image	1,106 KB
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PP-010-West	1/14/2010 5:33 PM	JPEG image	1,084 KB
PP-011	8/12/2010 8:11 AM	Microsoft Office E...	4,744 KB
PP-011-East	1/15/2010 2:05 PM	JPEG image	1,073 KB
PP-011-North	1/15/2010 2:04 PM	JPEG image	1,158 KB
PP-011-South	1/15/2010 2:05 PM	JPEG image	1,040 KB
PP-011-West	1/15/2010 2:05 PM	JPEG image	1,114 KB
PP-012	8/12/2010 8:11 AM	Microsoft Office E...	4,447 KB
PP-012-East	1/15/2010 2:36 PM	JPEG image	1,067 KB
PP-012-North	1/15/2010 2:35 PM	JPEG image	1,056 KB
PP-012-South	1/15/2010 2:36 PM	JPEG image	1,005 KB
PP-012-West	1/15/2010 2:36 PM	JPEG image	963 KB
PP-013	8/12/2010 8:12 AM	Microsoft Office E...	5,047 KB
PP-013-East	1/15/2010 11:19 AM	JPEG image	1,135 KB
PP-013-North	1/15/2010 11:19 AM	JPEG image	1,134 KB
PP-013-South	1/15/2010 11:20 AM	JPEG image	1,139 KB
PP-013-West	1/15/2010 11:20 AM	JPEG image	1,279 KB
PP-014	8/12/2010 8:26 AM	Microsoft Office E...	4,733 KB
PP-014-East	1/14/2010 10:24 AM	JPEG image	1,035 KB
PP-014-North	1/14/2010 10:23 AM	JPEG image	1,175 KB
PP-014-South	1/14/2010 10:24 AM	JPEG image	1,109 KB
PP-014-West	1/14/2010 10:24 AM	JPEG image	1,057 KB
PP-015	8/12/2010 9:46 AM	Microsoft Office E...	4,867 KB
PP-015-East	1/14/2010 3:08 PM	JPEG image	1,149 KB
PP-015-North	1/14/2010 3:08 PM	JPEG image	1,168 KB
PP-015-South	1/14/2010 3:09 PM	JPEG image	1,075 KB
PP-015-West	1/14/2010 3:09 PM	JPEG image	1,109 KB
PP-016	8/12/2010 8:25 AM	Microsoft Office E...	10,778 KB
PP-017	8/12/2010 9:42 AM	Microsoft Office E...	4,633 KB
PP-017-East	1/14/2010 2:28 PM	JPEG image	1,110 KB
PP-017-North	1/14/2010 2:28 PM	JPEG image	1,033 KB
PP-017-South	1/14/2010 2:29 PM	JPEG image	1,090 KB
PP-017-West	1/14/2010 2:29 PM	JPEG image	1,035 KB

- GRSM subfolder:

Name	Date modified	Type	Size
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PP-11_NORTH_2699	5/24/2010 12:31 PM	JPEG image	1,562 KB
PP-11_SOUTH_2700	5/24/2010 12:31 PM	JPEG image	1,547 KB
PP-11_WEST_2702	5/24/2010 12:32 PM	JPEG image	1,550 KB
PP-12_EAST_4323	5/24/2010 11:53 AM	JPEG image	812 KB
PP-12_HATCHERY_4320	5/24/2010 11:51 AM	JPEG image	738 KB
PP-12_HATHERY_4325	5/24/2010 11:53 AM	JPEG image	798 KB
PP-12_NORTH_4321	5/24/2010 11:52 AM	JPEG image	750 KB
PP-12_SOUTH_4322	5/24/2010 11:52 AM	JPEG image	795 KB
PP-12_WEST_4324	5/24/2010 11:53 AM	JPEG image	779 KB
PP-13_EAST_4269	5/22/2010 1:47 PM	JPEG image	744 KB
PP-13_NORTH_4267	5/22/2010 1:46 PM	JPEG image	807 KB
PP-13_SOUTH_4268	5/22/2010 1:47 PM	JPEG image	807 KB
PP-13_WEST_4270	5/22/2010 1:47 PM	JPEG image	804 KB
PP-14_EAST_4330	5/24/2010 5:40 PM	JPEG image	800 KB
PP-14_NORTH_4328	5/24/2010 5:40 PM	JPEG image	813 KB
PP-14_SOUTH_4329	5/24/2010 5:40 PM	JPEG image	762 KB
PP-14_WEST_4331	5/24/2010 5:41 PM	JPEG image	781 KB
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PP-15_NORTH_4312	5/24/2010 10:18 AM	JPEG image	743 KB
PP-15_SOUTH_4313	5/24/2010 10:18 AM	JPEG image	832 KB
PP-15_WEST_4315	5/24/2010 10:19 AM	JPEG image	743 KB
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PP-17_SOUTH_2631	5/21/2010 11:55 AM	JPEG image	1,517 KB
PP-17_WEST_2633	5/21/2010 11:56 AM	JPEG image	1,567 KB
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PP-19_NORTH_2661	5/22/2010 5:52 PM	JPEG image	1,536 KB
PP-19_SOUTH_2662	5/22/2010 5:53 PM	JPEG image	1,564 KB
PP-19_WEST_2664	5/22/2010 5:53 PM	JPEG image	1,546 KB
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Name	Date modified	Type	Size
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PP-21_WEST_2660	5/22/2010 4:40 PM	JPEG image	1,553 KB
PP-22_EAST_2653	5/22/2010 1:37 PM	JPEG image	1,522 KB
PP-22_NORTH_2651	5/22/2010 1:36 PM	JPEG image	1,543 KB
PP-22_SOUTH_2652	5/22/2010 1:37 PM	JPEG image	1,552 KB
PP-22_WEST_2654	5/22/2010 1:37 PM	JPEG image	1,560 KB
PP-23_EAST_2649	5/22/2010 12:02 PM	JPEG image	1,558 KB
PP-23_NORTH_2647	5/22/2010 12:01 PM	JPEG image	1,551 KB
PP-23_SOUTH_2648	5/22/2010 12:02 PM	JPEG image	1,572 KB
PP-23_WEST_2650	5/22/2010 12:02 PM	JPEG image	1,537 KB
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PP-25_SOUTH_2644	5/22/2010 9:35 AM	JPEG image	1,476 KB
PP-25_WEST_2646	5/22/2010 9:36 AM	JPEG image	1,519 KB
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PP-27_NORTH_2669	5/23/2010 10:03 AM	JPEG image	1,523 KB
PP-27_SOUTH_2670	5/23/2010 10:04 AM	JPEG image	1,545 KB
PP-27_WEST_2672	5/23/2010 10:05 AM	JPEG image	1,513 KB
PP-28_EAST_2683	5/23/2010 2:08 PM	JPEG image	1,537 KB
PP-28_EAST_2693	5/24/2010 8:44 AM	JPEG image	1,494 KB
PP-28_NORTH_2681	5/23/2010 2:07 PM	JPEG image	1,552 KB
PP-28_NORTH_2691	5/24/2010 8:44 AM	JPEG image	1,552 KB
PP-28_SOUTH_2682	5/23/2010 2:07 PM	JPEG image	1,519 KB
PP-28_SOUTH_2692	5/24/2010 8:44 AM	JPEG image	1,558 KB
PP-28_WEST_2684	5/23/2010 2:08 PM	JPEG image	1,517 KB
PP-28_WEST_2694	5/24/2010 8:45 AM	JPEG image	1,542 KB
PP-29__4300	5/23/2010 11:58 AM	JPEG image	756 KB

Name	Date modified	Type	Size
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PP-29__4302	5/23/2010 11:59 AM	JPEG image	699 KB
PP-29__4303	5/23/2010 11:59 AM	JPEG image	739 KB
PP-29_EAST_4298	5/23/2010 11:58 AM	JPEG image	781 KB
PP-29_NORTH_4296	5/23/2010 11:57 AM	JPEG image	801 KB
PP-29_SOUTH_4297	5/23/2010 11:58 AM	JPEG image	803 KB
PP-29_WEST_4299	5/23/2010 11:58 AM	JPEG image	825 KB
PP-30_EAST_2697	5/24/2010 10:55 AM	JPEG image	1,565 KB
PP-30_NORTH_2695	5/24/2010 10:54 AM	JPEG image	1,579 KB
PP-30_SOUTH_2696	5/24/2010 10:55 AM	JPEG image	1,550 KB
PP-30_WEST_2698	5/24/2010 10:56 AM	JPEG image	1,540 KB
PP-31_EAST_2721	5/25/2010 10:43 AM	JPEG image	1,561 KB
PP-31_NORTH_2719	5/25/2010 10:42 AM	JPEG image	1,588 KB
PP-31_SOUTH_2720	5/25/2010 10:43 AM	JPEG image	1,551 KB
PP-31_WEST_2722	5/25/2010 10:44 AM	JPEG image	1,564 KB
PP-32 SESSION END_4259	5/22/2010 11:08 AM	JPEG image	795 KB
PP-32_EAST_4249	5/22/2010 10:24 AM	JPEG image	815 KB
PP-32_NORTH_4247	5/22/2010 10:23 AM	JPEG image	823 KB
PP-32_SOUTH_4248	5/22/2010 10:23 AM	JPEG image	979 KB
PP-32_WEST_4250	5/22/2010 10:24 AM	JPEG image	821 KB
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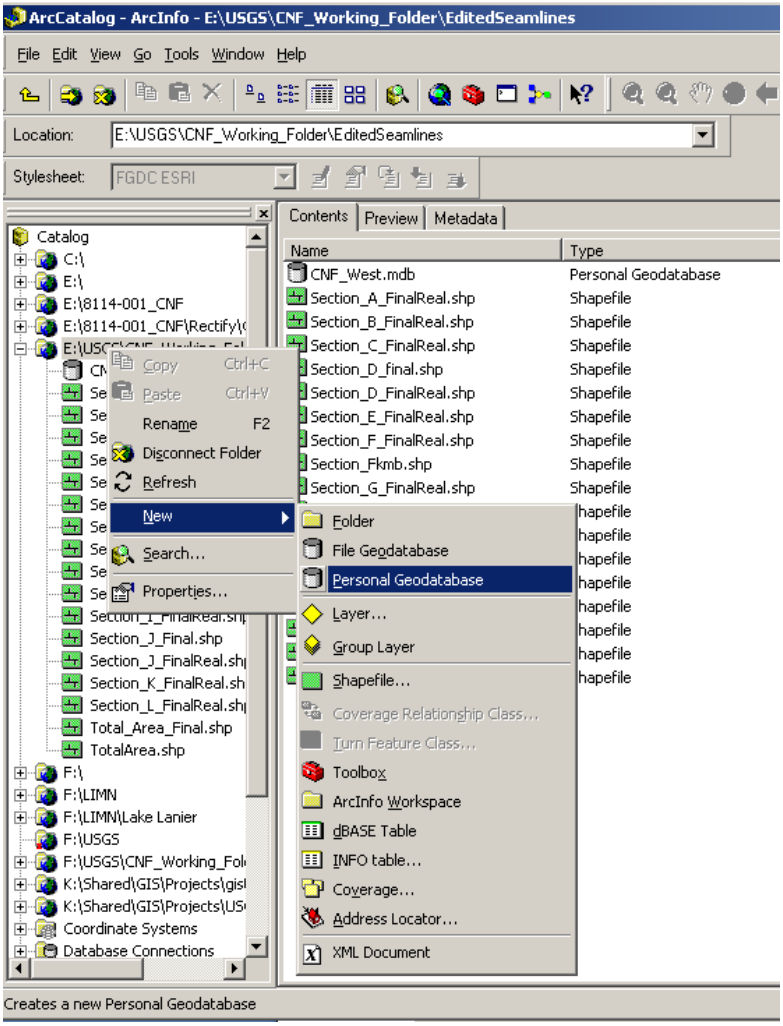
PP-33_NORTH_2703	5/24/2010 3:23 PM	JPEG image	1,541 KB
PP-33_SOUTH_2704	5/24/2010 3:23 PM	JPEG image	1,541 KB
PP-33_WEST_2706	5/24/2010 3:24 PM	JPEG image	1,553 KB
PP-34_EAST_2667	5/23/2010 8:15 AM	JPEG image	1,538 KB
PP-34_NORTH_2665	5/23/2010 8:15 AM	JPEG image	1,548 KB
PP-34_SOUTH_2666	5/23/2010 8:15 AM	JPEG image	1,538 KB
PP-34_WEST_2668	5/23/2010 8:16 AM	JPEG image	1,555 KB
PP-35_EAST_2687	5/23/2010 5:19 PM	JPEG image	1,531 KB
PP-35_NORTH_2685	5/23/2010 5:18 PM	JPEG image	1,546 KB
PP-35_SOUTH_2686	5/23/2010 5:19 PM	JPEG image	1,505 KB

PP-35_WEST_2688	5/23/2010 5:19 PM	JPEG image	1,531 KB
PP-36__4292	5/23/2010 8:28 AM	JPEG image	592 KB
PP-36__4293	5/23/2010 8:28 AM	JPEG image	684 KB
PP-36__4294	5/23/2010 8:28 AM	JPEG image	510 KB
PP-36__4295	5/23/2010 8:28 AM	JPEG image	535 KB
PP-36_EAST_4286	5/23/2010 8:25 AM	JPEG image	673 KB
PP-36_NORTH_4284	5/23/2010 8:25 AM	JPEG image	645 KB
PP-36_SOUTH_4285	5/23/2010 8:25 AM	JPEG image	782 KB
PP-36_WEST_4287	5/23/2010 8:25 AM	JPEG image	684 KB
PP-37__2637	5/21/2010 8:55 PM	JPEG image	1,553 KB
PP-37_EAST_2641	5/21/2010 8:58 PM	JPEG image	1,565 KB
PP-37_NORTH_2634	5/21/2010 8:53 PM	JPEG image	1,514 KB
PP-37_NORTH_2638	5/21/2010 8:57 PM	JPEG image	1,508 KB
PP-37_SOUTH_2635	5/21/2010 8:54 PM	JPEG image	1,488 KB
PP-37_SOUTH_2639	5/21/2010 8:57 PM	JPEG image	1,551 KB
PP-37_WEST_2642	5/21/2010 8:58 PM	JPEG image	1,560 KB
PP-38__4308	5/24/2010 8:34 AM	JPEG image	712 KB
PP-38__4309	5/24/2010 8:34 AM	JPEG image	708 KB
PP-38__4310	5/24/2010 8:34 AM	JPEG image	765 KB
PP-38__4311	5/24/2010 8:35 AM	JPEG image	748 KB
PP-38_EAST_4306	5/24/2010 8:33 AM	JPEG image	639 KB
PP-38_NORTH_4304	5/24/2010 8:33 AM	JPEG image	778 KB
PP-38_SOUTH_4305	5/24/2010 8:33 AM	JPEG image	816 KB
PP-38_WEST_4307	5/24/2010 8:34 AM	JPEG image	793 KB

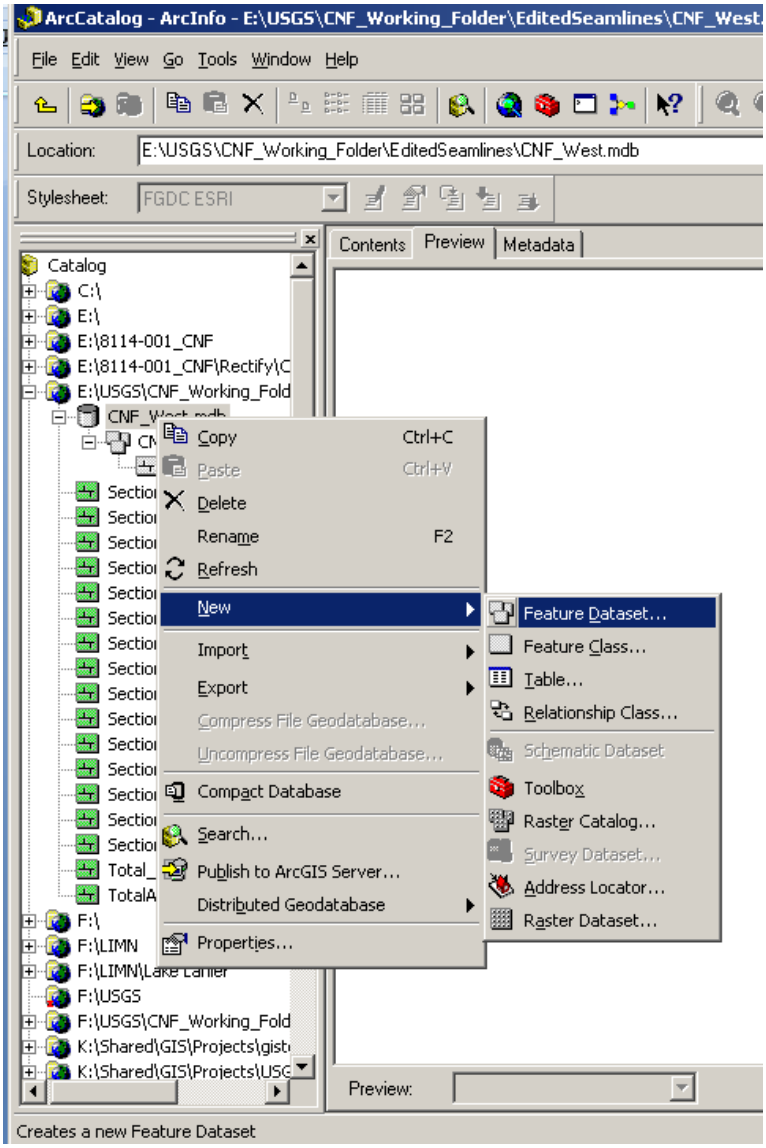
APPENDIX 5a:

Seamline Editing Protocol Using ArcGIS TOPOLOGY Features:

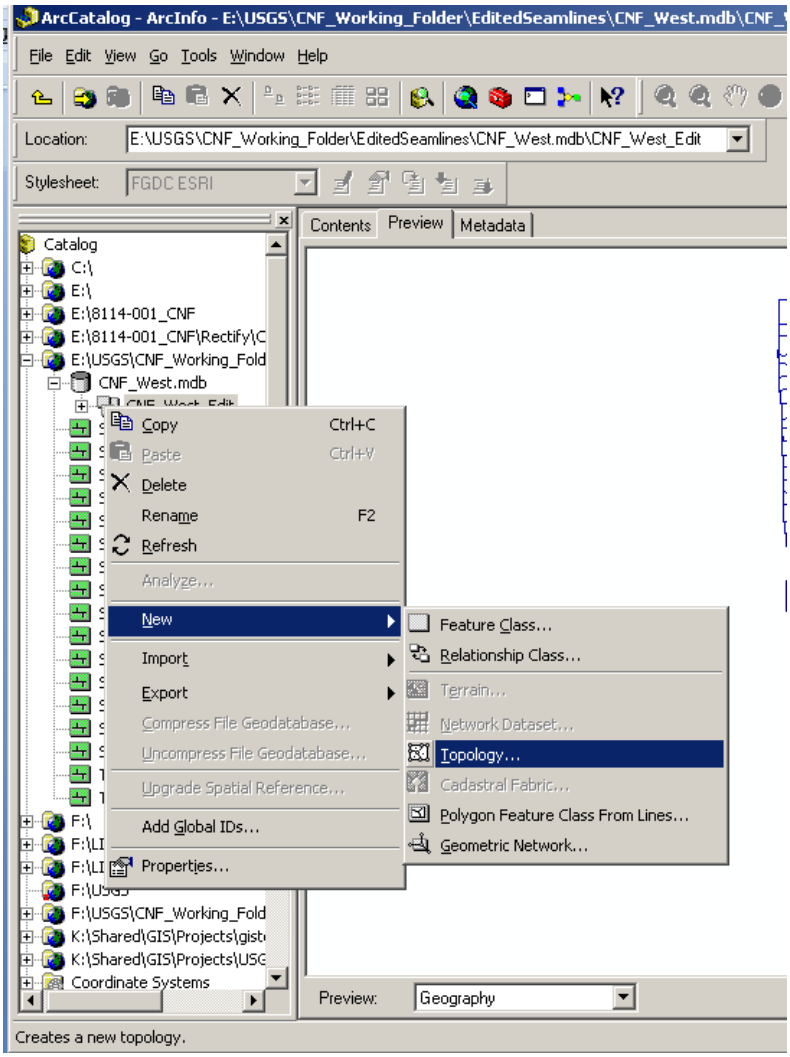
- Open ArcCatalog
- Move to your working folder
- Right-click the folder --> Click New --> Personal Geodatabase



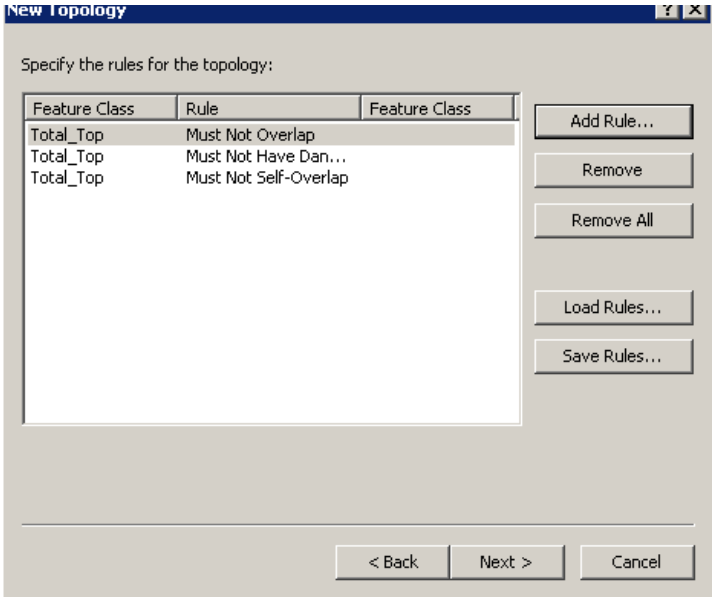
- Name Geodatabase i.e. CNF_West.mdb
- Right-click the GDB in the Table of Contents (TOC)
- Click New--> Feature Dataset



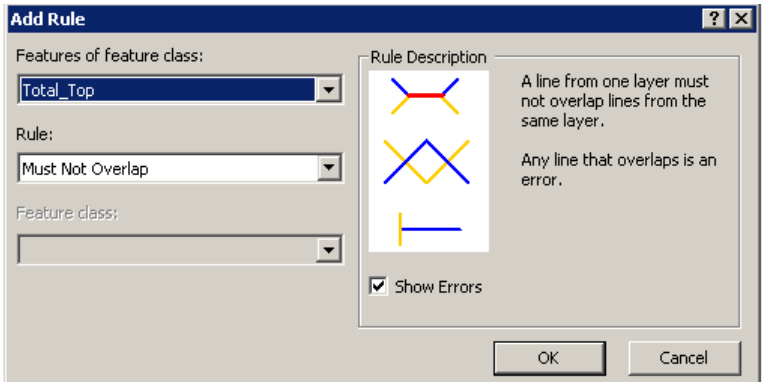
- Name the Dataset --> Click Next
- Import the coordinate system from the shapefile --> Click Next --> Next --> Finish
- Right-click the Dataset --> Click New --> Topology



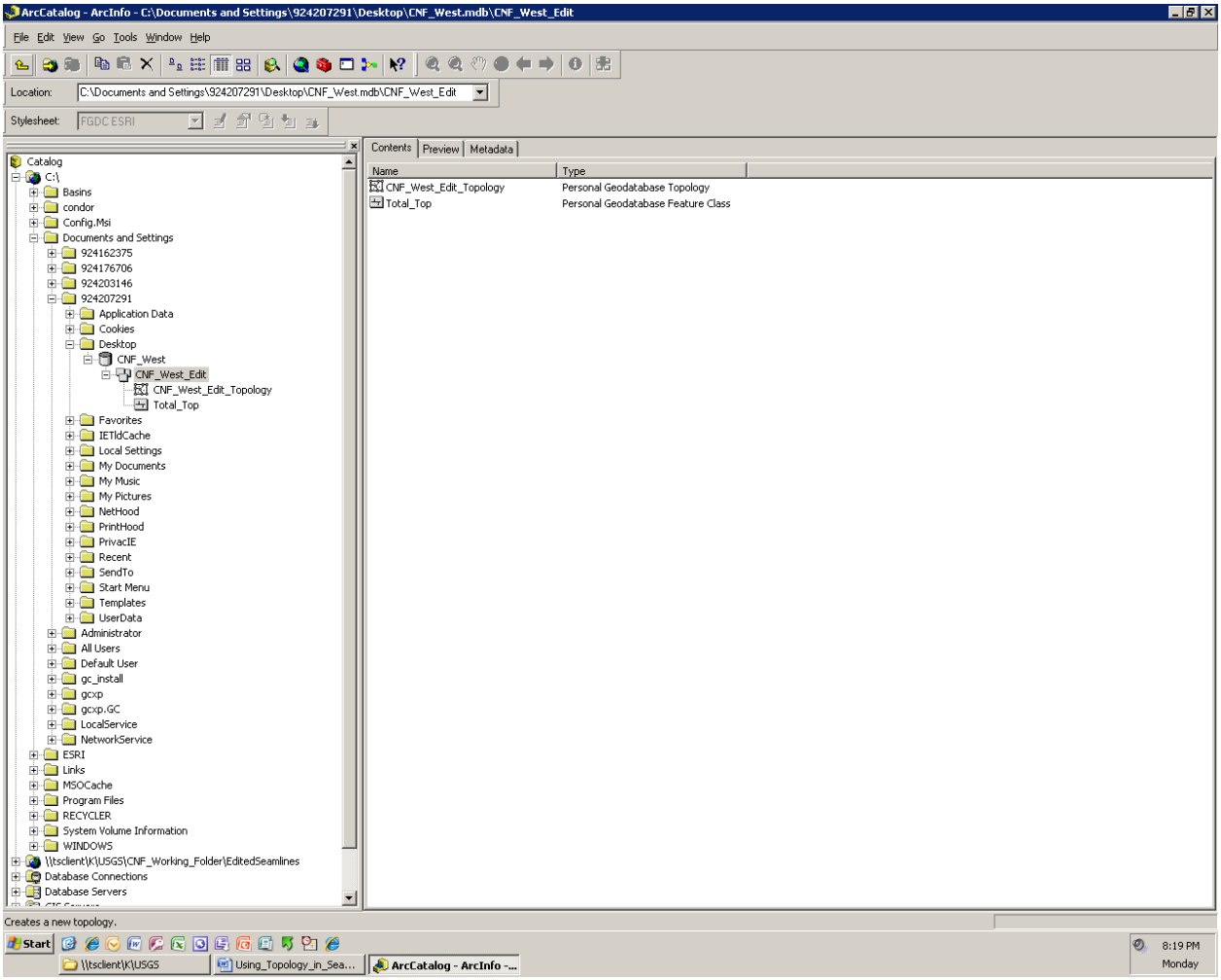
- The Topology Wizard will open --> Click Next
- Accept defaults --> Click Next
- Select the feature class --> Click Next
- Click Next again to accept ranking
- An empty new topology box will open --> Click Add Rule
- Select from the Rule dropdown box --> Must Not Overlap --> Click OK
- Repeat 14 and 15 with Must Not Have Dangles and Must Not Self-Overlap



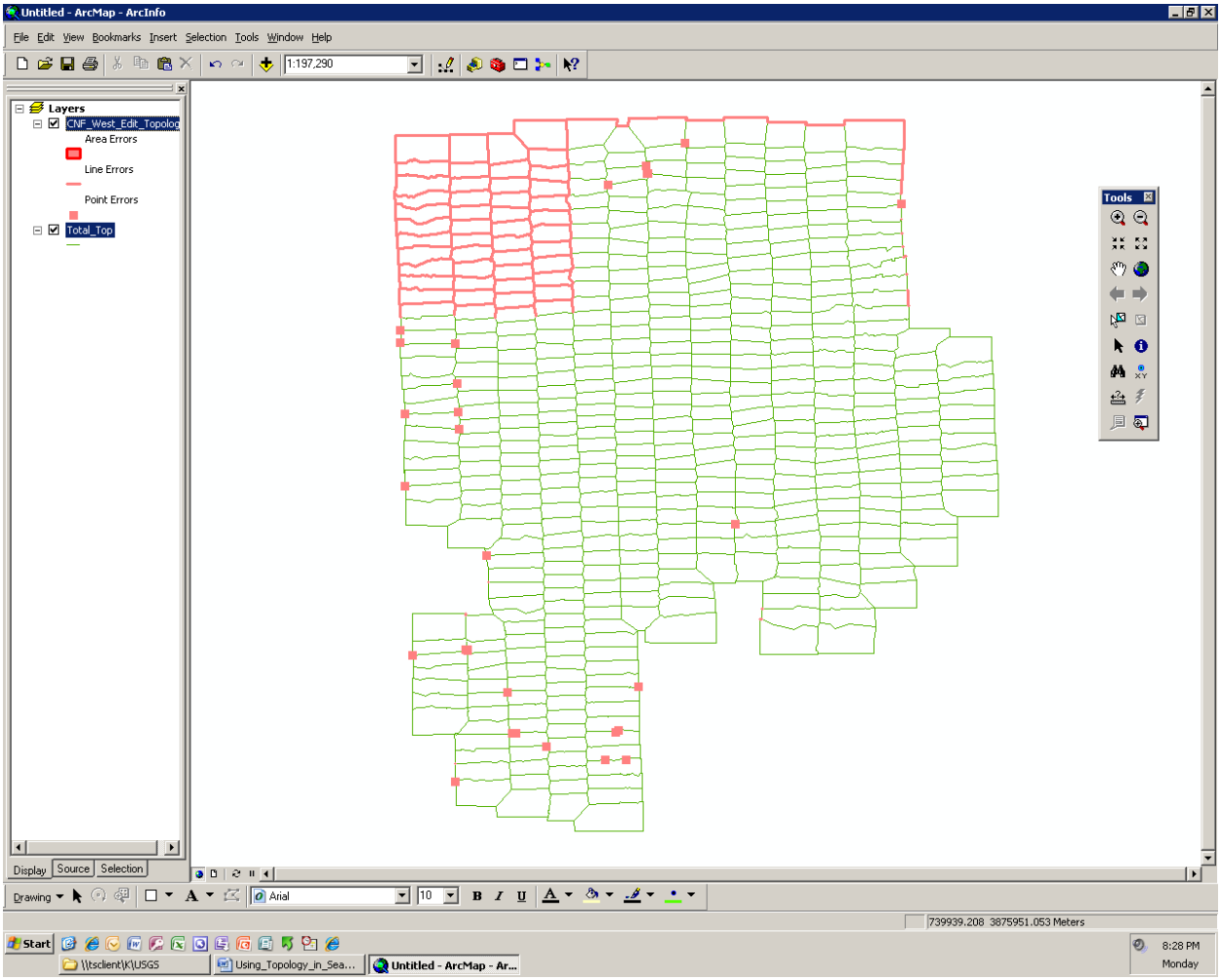
*Note that the Topology Wizard will give the explanation of the rule on the right of the box.



- Click Next --> Finish
- A box will ask if you want to validate Topology --> Click Yes
- A new topology is now created within the Geodatabase



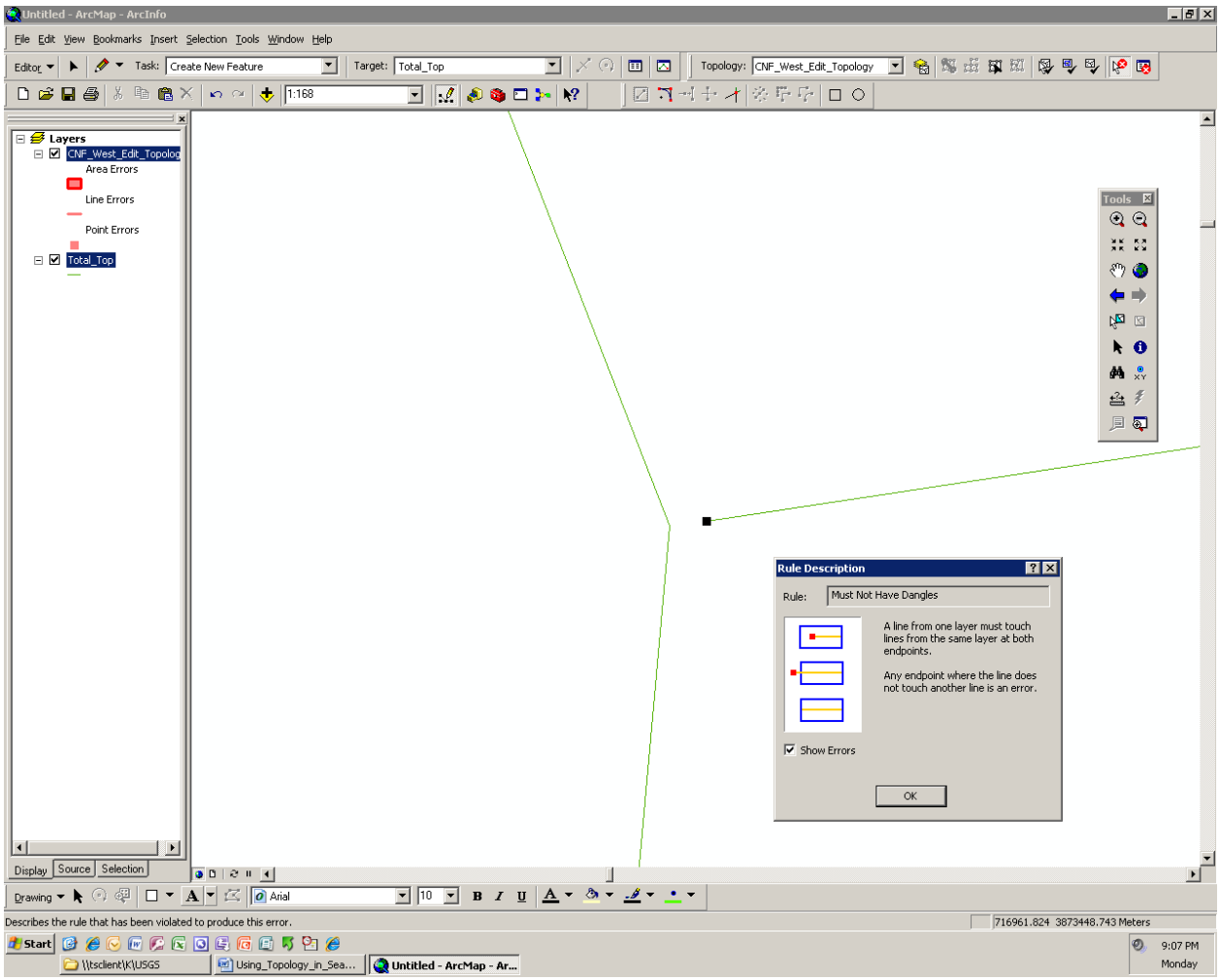
- Close ArcCatalog and open ArcMap
- Add the Feature Dataset



The map window shows the original feature class as well as the errors created by validating the topology rules applied earlier.

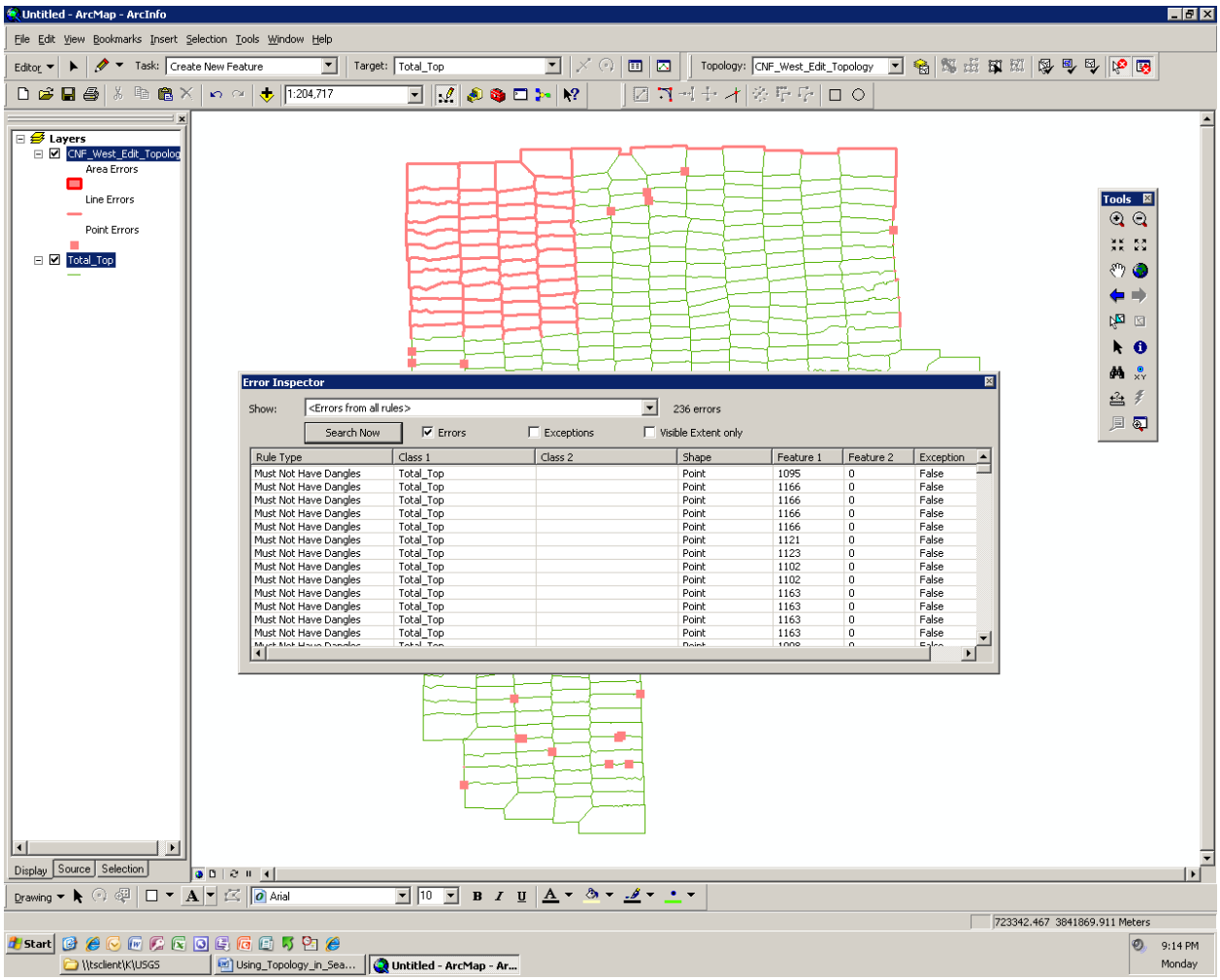
- Click View --> Toolbars and add the Advanced Editing, Editor, and Topology toolbars
- Start an editing session
- On the Topology toolbar click the Fix Topology Edit Tool

- Zoom into any error on the map and click with the Fix Topology Edit Tool
- Right click the highlighted error and click Rule Description to see the violated topology rule
- A box will display telling the error --> Click OK



- All errors can be seen simultaneously by using the Error Inspector Tool

- Click the Error Inspector Tool --> Uncheck Visible Extent --> Search Now



- Zoom to errors and correct using appropriate Editor, Advanced Editing, and Topology tools
- Validate Topology to ensure all errors are corrected
- Save Edits

APPENDIX 5b:

Guidelines for Editing Seamlines:

Items to avoid crossing:

- Roads
- Bridges
- Buildings
- Driveways
- Railroads
- Fences
- Retaining Walls
- Power Poles
- Water Bodies
- Major Power Lines
- Transmission Towers
- Antennas or Cell Towers

Items to utilize for hiding seamlines:

- Vegetation - Trees/Forest Areas
- Open Fields

General Notes:

- When crossing a linear feature such as a road, railroad, or driveway, cut across it at a perpendicular angle. If there is a displacement between the images this will create a nice clean offset making it easier to edit in Photoshop.
- Always have the ortho tile index referenced into your workspace while editing seamlines. Do not cross 'items to avoid' on or near a tile edge whenever possible.
- Try and stay in the centermost area of each image. Going further from the image center gives you more lean on the buildings, trees, etc, more distortion, and is less accurate.
- Make sure all seamlines are snapped to other seamlines at point intersections and each ortho image is contained in a closed polygon.

APPENDIX 6a:

Comprehensive aerotriangulation development procedure:

Aerial Triangulation Measurement

The measurement of the pass points, flight ties and control data was performed on Intergraph's ISAT, version 5.1, automated aerotriangulation system. Pass points were selected automatically using a sophisticated auto correlation algorithm.

AT Process Work Flow

SoftCopy Aerotriangulation is a computer process of densifying the ground control network from locations in a few of the digital images to numerous points in each digital image that is to be used in the mapping process. This process is dependent on the location and coordinate positions of the ABGPS and GPS photo control points as well as a precise camera calibration for the DMC camera used to capture the images.

A digital image of the aerial photography is utilized to compare and measure the coordinates of selected pass points, (min. 9 per image) with the exception of end images, which have a minimum of 6 per image. Pass points can be either dark spots on the ground, corner intersections of sidewalks, rocks, or road lines to name a few. As with conventional aerotriangulation, field survey points whether they are photo identification points or panels, are read the same way (digitized where you see them). The pass points and any photo control points are measured using the calibration statistics to adjust measurements for the specific camera characteristics. Computer routines (relative and absolute) provide analysis of all pass points, tie points, ABGPS and photo control points. Aerotriangulation constructs a detailed model of the position of each pass point and provides residuals at all photo control locations. Control points collected inaccurately in the field will result in an inefficient model and high residuals in the aerotriangulation process. General blunders can be identified from their high residuals. The end result is not only the referenced image, but also a coordinate listing of all of the points and corresponding residuals. Once all strips have been checked for completeness, the strips are assembled into a block where a second degree block adjustment is run along with the full least squares bundle adjustment. Once the last set of blunders and adjustments are complete, a final block bundle adjustment is run to produce the final solution.

The final adjustment of the block is accomplished by using a rigorous simultaneous least squares bundle adjustment. The general procedure is to remove all blunders from the data using automatic blunder detection. The bundle adjustment is then run with minimal ground control to test the photogrammetric measurements for consistency. Next, the full ground control data set, including the ABGPS data, is added to the adjustment. The horizontal control is then tightened and the effect on the vertical control and the photogrammetric residuals are inspected. The final adjustment makes sure that all of the measurements are in balance with each other and properly represent the actual conditions.

Aerial Triangulation Adjustment

The adjustment of the measurements was performed using a robust aerotriangulation software package on softcopy photogrammetric workstations. The final adjustment of the block was accomplished by using a rigorous simultaneous least squares bundle adjustment. The general procedure is to remove all blunders from the data using automatic blunder detection. The bundle adjustment is then run with minimal ground control to test the photogrammetric measurements for consistency. Next, the full ground control data set, including the ABGPS data, is added to

the adjustment holding the horizontal control very loose and the vertical control very tight. Since horizontal control errors can affect the vertical control but not vice-versa, we can detect errors in the vertical control. The horizontal control is then tightened and the effect on the vertical control and the photogrammetric residuals are inspected. The final adjustment makes sure that all of the measurements are in balance with each other and properly represent the actual conditions.

APPENDIX 6b:

Comprehensive aerotriangulation report of the project:

Report: (Example of Flight Line 301-Frame 30)
Rest are provided as digital file with the hard drive.

Photo-T Parameters and Results for Project 8114-001
PhotoT Triangulation Options

Adjustment Mode : Absolute
Precision Computation : Enabled
Error Detection : Disabled
Camera Calibration : Disabled
Self-Calibration : Disabled
Given EO/GPS : Enabled
Antenna Offsets : Disabled
GPS Shift/Drift Correction : Enabled
INS Shift/Drift Correction : Enabled

Parameters

Parameter	X/Omega	Y/Phi	Z/Kappa	XY
RMS Control	0.141	0.114	0.080	0.128
RMS Check				
RMS Limits	0.200	0.200	0.100	
Max Ground Residual	0.377	0.280	0.276	
Residual Limits	0.500	0.500	0.300	
Mean Std Dev Object	0.137	0.115	0.258	
RMS Photo Position	0.169	0.187	0.197	
RMS Photo Attitude	0.008	0.011	0.012	
Mean Std Dev Photo Position	0.147	0.160	0.091	
Mean Std Dev Photo Attitude	0.004	0.004	0.003	

Key Statistics

Sigma: 3.5 um
Number of iterations: 3
Degrees of Freedom: 114743

Solution Successful.

Current Count

Control Points Used: 38
Check Points Used: 0
Photos Used: 2636
Photos Not Used: 0
Image Points Used: 108004
Cameras used: (1).

Camera Id Lens Distortion
DMC Off

Project Settings

Linear Units: Meters
Angular Units: Degrees

Atm Refraction: Off
Earth Curvature: Off

Photo Statistics

Strip Id: 301 Photo Id: 301_30 Status: Used

Point Id	Status	Type	Class	Vx	Vy	V(xy)	# Rays	SVx	SVy	rx	ry	x-coord	y-coord
20218638	Measured		Pass	-0.7	1.0	1.2	3	0.5	-0.3	0.2	0.6	32.9	-50.7
20218808	Measured		Pass	-0.6	1.8	1.9	3	0.4	-0.6	0.2	0.6	31.5	-40.3
20218935	Measured		Pass	0.1	2.6	2.7	3	-0.1	-1.0	0.2	0.6	29.0	-17.1
20219199	Measured		Pass	0.1	1.8	1.8	3	-0.1	-0.7	0.2	0.6	27.7	5.0
20219271	Measured		Tie	-7.0	1.1	7.1	6	2.5	-0.4	0.6	0.7	34.2	24.6
20219319	Measured		Tie	-8.3	3.0	8.8	6	3.0	-1.0	0.6	0.7	33.8	24.8
20219516	Measured		Tie	24.6	-3.9	24.9	5	-8.9	1.4	0.6	0.6	34.8	66.8
20219546	Measured		Pass	-0.6	-0.4	0.7	3	0.4	0.1	0.2	0.6	36.1	67.2
20219646	Measured		Pass	-0.2	0.8	0.9	3	0.2	-0.3	0.1	0.6	34.3	-63.8
20219857	Measured		Pass	1.7	4.0	4.3	3	-1.2	-1.4	0.2	0.6	36.1	-46.7
20219961	Measured		Pass	-0.4	2.2	2.2	3	0.3	-0.8	0.2	0.6	37.2	1.2
20220053	Measured		Pass	0.4	2.0	2.1	3	-0.2	-0.7	0.2	0.6	38.3	10.7
20220351	Measured		Pass	-0.6	-0.1	0.6	3	0.4	0.0	0.2	0.6	39.7	66.1
20220397	Measured		Tie	18.2	-1.5	18.3	5	-6.6	0.5	0.6	0.6	37.0	66.4
20222357	Measured		Pass	0.0	-1.3	1.3	2	0.6	0.6	0.0	0.4	-8.1	-75.7
20222493	Measured		Pass	-0.1	-3.0	3.0	2	1.3	1.3	0.0	0.4	-6.5	-57.7
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20223098	Measured		Pass	0.0	-0.4	0.4	2	0.2	0.2	0.0	0.5	-4.2	15.1
20223425	Measured		Tie	-4.2	-5.9	7.3	4	1.5	2.5	0.6	0.5	-4.2	63.0
20223440	Measured		Tie	0.2	-4.3	4.3	4	-0.1	1.8	0.6	0.4	-6.8	65.1
20223652	Measured		Pass	0.0	-1.6	1.6	2	0.7	0.7	0.0	0.4	8.3	-79.9
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20224416	Measured		Pass	0.0	1.0	1.0	2	-0.4	-0.4	0.0	0.5	2.7	9.5
20224959	Measured		Pass	-0.1	-2.8	2.8	2	1.2	1.2	0.0	0.4	17.2	-81.2
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20225258	Measured		Pass	0.0	0.4	0.4	2	-0.2	-0.2	0.0	0.5	17.1	-38.4
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20225667	Measured		Pass	0.0	-0.1	0.1	2	0.0	0.0	0.0	0.5	16.5	7.4
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20226112	Measured		Pass	-0.1	1.4	1.4	3	0.0	-0.5	0.1	0.5	25.4	-76.2
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20227957	Measured		Pass	-1.0	2.8	3.0	3	0.7	-1.0	0.2	0.6	33.9	57.4

PP-012 Measured Control XYZ -1.7 2.0 2.6 3 0.8 -0.7 0.3 0.6 26.0 -41.9

APPENDIX 7:

Header file of Orthoimagery:

Output from Display Header
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Standard : : TIFF File
Format : : Uncompressed 24 bit RGB data
Pixels per Line : 5000
Number of Lines : 5000
Samples per pixel : 4
File bits per sample : 8
Actual bits per sample : 8
Minimum Value : 0
Maximum Value : 255
Untiled file
Number of overviews : 7
Overview sampling method: Averaged
Scanning device resolution : 0 : None Specified
Orientation : 4 : Row major order, origin at top left
NO scan line headers : non-scannable file
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Free vlt space (16-bit words) : 2000000000
Free packet space (16-bit words) : 2000000000
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Raster to World Matrix:
Units: Meters
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228000 , 3934500
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229499.999999942 , 3933000.00000093
228000 , 3933000.00000093
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Histogram packet Type=2, Subtype=9, Size=516, band id=5
Pixel Bits packet Type=2, Subtype=14, Size=4, bits per band=8, Unsigned
Geotiff_Information:
Version: 1

```
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      228000       3934500      0
    ModelPixelScaleTag (1,3):
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    GTRasterTypeGeoKey (Short,1): RasterPixelIsArea
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    GeogEllipsoidGeoKey (Short,1): Ellipse_GRS_1980
    ProjectedCSTypeGeoKey (Short,1): PCS_NAD83_UTM_zone_17N
    PCSCitationGeoKey (Ascii,58): "Universal Transverse Mercator; North American 1983;
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    ProjLinearUnitsGeoKey (Short,1): Linear_Meter
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    ProjNatOriginLatGeoKey (Double,1): 0
    ProjFalseEastingGeoKey (Double,1): 500000
    ProjFalseNorthingGeoKey (Double,1): 0
    ProjScaleAtNatOriginGeoKey (Double,1): 0.9996
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  End_Of_Geotiff.
PCS = 26917 (NAD83 / UTM zone 17N)
Projection = 16017 (UTM zone 17N)
Projection Method: CT_TransverseMercator
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Center        ( 228750.000,3933750.000)
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Orthoimagery WORLD File Header:
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APPENDIX 8:

QA/QC Procedures for Digital Orthos:

1) Reference edited seamline file and tile index file.
2) Reference orthos one tile at a time.
3) Follow the seamlines that fall within the tile at a zoom scale of 1=500.
4) Look for any linear feature offsets, tone or color mismatches, doubling effect, or other abnormalities along the seamline.
5) Draw a QC circle around any items found from #4.
6) Pan through the entire tile at a zoom scale of 1=1000.
7) Look for any blurring or stretches in the imagery. Look for warped or unnatural looking bridges, roads, buildings, etc.
8) Draw a QC circle around any item found from #7.
9) Continue on to the next ortho tile.

General Rule: It is better to have too many QC Circles than to miss something. If you have doubt whether something should be circled, place a circle anyway. The Photoshop editor can make that judgment and if it does not need corrected they can simply delete the QC circle and move on.

APPENDIX 9:

Example of METADATA structure of the orthoimageries:

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<abstract>This data set consists of 30 cm pixel resolution (approximately 1-foot), 4- Band Color Infrared (CIR) orthoimagery covering The Great Smoky Mountains National Park (GRSM) and Chattahoochee National Forest (CNF). This study area is approximately 1916 square miles and is included in the three states of Georgia, Tennessee, and North Carolina. An orthoimage is remotely sensed image data in which displacement of features in the image caused by terrain relief and sensor orientation has been mathematically removed. Orthoimagery combines the image characteristics of a photograph with the geometric qualities of a map. The design accuracy is estimated not to exceed 0.6-meter diagonal RMSE (0.424 m RMSE in X or Y). Each orthoimage provides 4-Band color infrared imagery over a 1500 by 1500-meters block (Tile) on the ground. There is no image overlap between adjacent Tiles. These data conform to the North American Datum of 1983 (NAD83) and the Universal Transverse Mercator Projection (UTM), zone 17N, though a few tiles in the western portion of the study area are projected to UTM Zone 16N. The data depict geographic features on the surface of the earth. This project was funded by American Recovery and Reinvestment Act (ARRA) funds.</abstract>
<purpose>This project generated high spatial resolution (30 cm) leaf-off multispectral orthoimagery for The Great Smoky Mountains National Park (GRSM) and Chattahoochee National Forest (CNF). This orthoimagery can be used to support the management of natural resources at the GRSM and the CNF, which represent distinct and yet related ecosystems in the Southern Appalachian Mountains range. This data set supports detailed analysis of surface hydrology and land cover, including vegetation inventories.</purpose>
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<cntper>Dr. Sudhanshu Sekhar Panda (GSC); Dr. J.B. Sharma (GSC); Dr. Marguerite Madden (UGA); Dr. Thomas Jordan (UGA, CRMS); Jeffery S. Simmons (PSI, Atlanta)</cntper>
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procedure ensures correct physical format and field values for tagged elements. Seamlines and tile edges are visually inspected. Seamline mismatches are not corrected unless the overall displacement exceeds one meter.</logic>

<complete>Orthoimages are visually inspected for completeness to ensure that no gaps or image misplacements exist within and between adjacent images. These images are derived by mosaicking multiple images to ensure complete coverage. Source imagery is cloud free. Photography was flown during leaf-off in deciduous vegetation regions. Coastal areas and international boundary regions may have areas without images (void areas) in parts of the coverage. These void areas have a radiometric value of either zero (black) or 128 (uniform gray).</complete>

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This data set was prepared from digital imagery taken in March 19 and 24, 2011 in the Western portion of the Chattahoochee National Forest. The digital imagery was collected using a Zeiss/Intergraph Digital Mapping Camera (DMC) to obtain Red, Green, Blue (RGB) and Color-InfraRed (CIR) from an Above Ground Level (AGL) of 9,600 feet for the 30 centimeter pixel resolution of the project area. The images were rectified and georeferenced to either a USGS 10 m DEM elevation model or elevation data obtained from LiDAR to create digital orthophoto files in GeoTIFF format. The National Elevation Dataset (NED) was used in areas on the CNF where no LiDAR data or suitable photogrammetric DEM existed. The GeoTIFF files were reviewed by the Gainesville State College, University of Georgia (UGA), and Photo Science Inc staff and used to prepare the MrSID format files.

The DMC images were aerotriangulated to support digital orthoimage production for the Chattahoochee National Forest (CNF) project area. Airborne GPS/IMU data and ground check point data were provided by Photo Science, Inc. The project was referenced to the North American Datum of 1983 (NAD83), Universal Transverse Mercator (UTM) meters, UTM Zone 17N horizontally and to the National Geodetic Vertical Datum of 1988 (NGVD88) vertically. Units were in meters. The project was controlled using the latest available NGS control adjustment as well as supplemental field control all of which was referenced to the NGS control monumentation. The DMC images, ABGPS/IMU data, and ground check point data were used as inputs to the Intergraph-AT softcopy program. The Intergraph-AT correlated image points and aerotriangulated the block of images to create exposure station exterior orientations. All ground points were manually measured on the imagery. These points were included in the aerotriangulation adjustments for absolute ground location verification.

Rectification was done using the aerotriangulation data, raw DMC images, the USGS DEM, and the updated CNF Ortho Elevation Model (OEM) data. These rectified images were used to generate seamlines which were then reviewed by the Gainesville State College and University of Georgia (UGA) Staff and edited. The rectified images were mosaicked, balanced, and cut into image tiles. These tiles were visually inspected and artifacts were removed as well as other edits performed. The final edited tiles were then cut to 1500 meters x 1500 meters tile index.

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