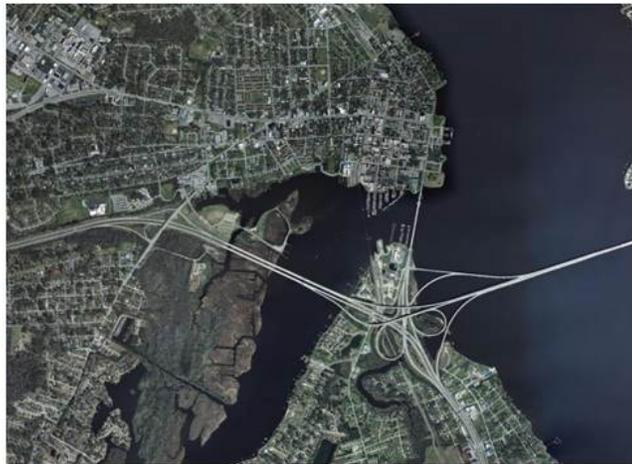


# North Carolina Coastal Orthoimagery 2012 Final Report



**Prepared for:**

**The North Carolina 911 Board**

**Prepared by:**

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**September 2013**

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## **Project Background**

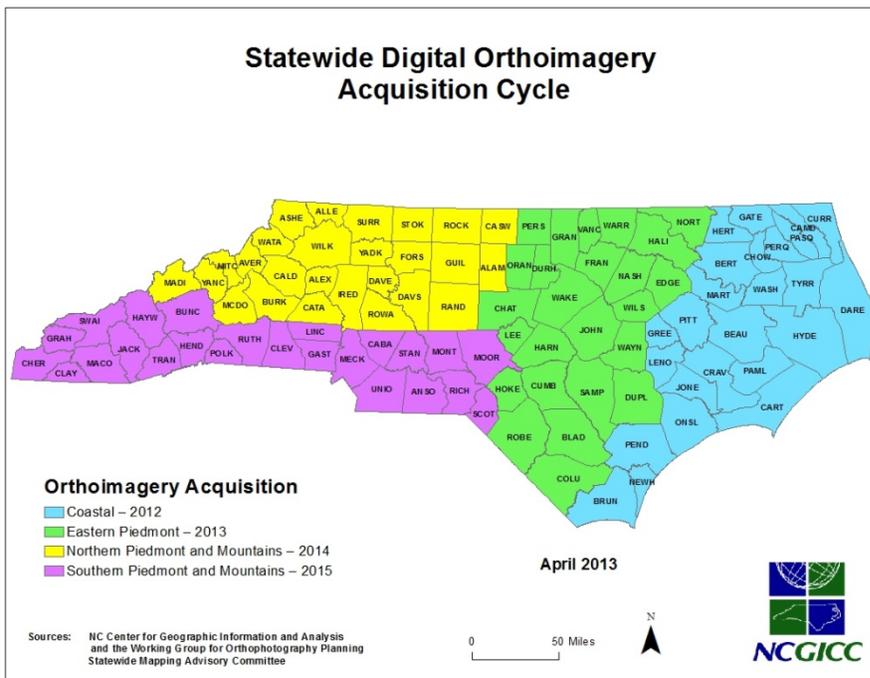
Digital aerial imagery is the most fundamental dataset for use with geographic information systems in local, state, and federal government and in numerous private and non-profit organizations. The 2010 Statewide Orthoimagery project confirmed that imagery is used by Public Safety Answering Points (PSAP) for visual reference and for accurate street mapping, by counties to map property boundaries and infrastructure, and by a range of users to display land use and impervious surfaces.

Orthoimagery is used in search and rescue operations, by the state emergency management office for emergency response planning and development of hazard mitigation plans, and by the floodplain program to develop flood insurance maps; it is used by the NC Department of Agriculture and Consumers Services for bio-emergency planning operations; it is used by the NC Department of Transportation (NCDOT) for highway mapping and planning; and by numerous other state and federal organizations to get a clear, current, and accurate picture of the landscape. In addition, other groups, such as the timber industry, utilities, and conservation organizations use aerial imagery to meet their information needs. The North Carolina Geographic Information Coordinating Council recognizes orthoimagery as a priority dataset, and the GIS Study, requested by the General Assembly and conducted by the NC Office of State Budget and Management, recommended funding of orthoimagery as a key dataset for multiple benefits.

Since the 2010 delivery, the Statewide Orthoimagery Program was established to implement a four-year cycle of orthoimagery acquisition based on the Business Plan for Orthoimagery in North Carolina and its recommended annual approach (See Figure 1). This plan was adopted by the NC 911 Board as the path forward to update the 2010 orthoimagery by acquiring new data for one-fourth of the state per year over four years. Phase 1 (Coastal Orthoimagery 2012) covering the North Carolina coastal plain was funded in July 2011 and all 25 counties were delivered to Primary PSAPs in the first quarter of 2013. The Coastal Orthoimagery 2012 project is the subject of this report.

### **1. Goals and Objectives**

The purpose of the Coastal Orthoimagery 2012 project was to acquire and deliver high resolution imagery to Primary PSAPs emergency operation centers in 25 counties in eastern coastal North Carolina to support accurate, timely and effective placement of 911 calls in correct locations (see Table 1). The technical framework for this project was to deliver an advanced technology solution for data sharing and accessibility to current imagery resources by 911 operations, individual counties, and North Carolina's citizens. That solution, and the ultimate deliverable for this project, culminated in the distribution of data to 911 PSAPs and county recipients and the means to access the data online.



**Figure 1: Statewide Orthoimagery by County, North Carolina**

Beaufort	Hertford	Perquimans
Bertie	Hyde	Pitt
Brunswick	Jones	Tyrrell
Carteret	Lenoir	Washington
Chowan	Martin	Ahoskie Police Department
Craven	New Hanover	Havelock Police Department
Currituck	Onslow	City of Jacksonville
Dare	Pamlico	Murfreesboro Police Department
Gates	Pasquotank/Camden	New Bern Emergency Communications
Greene	Pender	

**Table 1: Locations of Primary PSAP Client**

The project was built on the methodology and success of the Statewide Orthoimagery 2010 project and engaged, directly and indirectly, the best available technical expertise in public agencies and private service providers, and continues to rely on the services of the NC OneMap

Geospatial Portal. Phase 1, as well as the statewide program, is defined and rooted in the following core principles and/or recommendations implemented from 2010:

- 1) Provide all North Carolinians equivalent, up-to-date base imagery that supports detailed mapping of streets and building locations, as well as accurate mapping of property boundaries.
- 2) Provide comprehensive, consistent, high quality imagery that is seamless across county boundaries and city limits.
- 3) Give 911 call dispatchers confidence in the images and maps displayed in PSAPs across the state.
- 4) Create a statewide geospatial building block for the next generation of 911.
- 5) Realize the full potential of the NC OneMap Geospatial Portal for organizing and providing access to statewide, high-resolution imagery.
- 6) Support employment and income in North Carolina through state-licensed contractors and domestic data processing operations.
- 7) To adhere to the North Carolina Technical Specifications for Digital Orthophoto Base Mapping (State Standard) adopted October 1, 2009 (<http://www.secretary.state.nc.us/land/ThePage.aspx>)
- 8) To accomplish the Project Team’s objective of delivering the highest quality deliverable and rely on the Project Team to administer a proactive approach to project delivery rather than engage in reactive measures to quality issues
- 9) To perform oversight by requiring multiple deliverables of core attachment deliverables of compliance documentation as follows:
  1. Flight and Control Plan
  2. Ground Control Survey Report
  3. Imagery Acquisition Compliance Report
  4. Exploitation Image Post Processing Report
  5. Airborne GPS-IMU Post Processing & Aerotriangulation Report
  6. Orthoimagery Delivery Report
  7. Orthoimagery Quality Review Report
  8. Final Report and Lessons Learned
- 10) To provide a central means of project communication and collaboration through the Microsoft Online SharePoint Portal.
- 11) To institute a four-tiered approach to quality review defined as Level 1 (contractor delivery of a product signed and sealed to be in compliance with the State Standard); Level 2 (quality review by NCDOT); Level 3 (quality review by CGIA); and Level 4 (quality review and oversight by the PSAP and county end-user community).
- 12) To complete a full circle lifecycle for quality review (prior to product delivery), issues tracking, and resolution through the use of a central online interface and standard issues documentation.
- 13) To deliver a product that represents the truest depiction of the highest quality imagery.

## **1.1. Achievements**

The Coastal Orthoimagery 2012 project achieved all of its objectives. In summary, imagery of the highest quality was delivered on time and within budget to Primary PSAPs and county representatives in 25 counties in the coastal plain. The state project team consisting of CGIA, NCDOT, NC Department of Public Safety-Geodetic Survey (NCGS), and the NC Department of the Secretary of State-Land Records Management Section worked closely throughout the project to address technical and policy issues and provide oversight to the four private contractors assigned to the project.

Local stakeholders were actively involved in the quality assurance/quality control process yielding a better product with minimal follow up issues. The quality control process took advantage of a cloud-based solution for interactive review of imagery and made the review process more efficient than traditional methods. The orthoimagery was successfully loaded onto the NC OneMap Geospatial Portal, enabling free and quick access by public and private sector users.

## **1.2. Deliverables**

### **1.2.1. Products and Services Delivered**

#### Technical

- 1) Orthoimagery, true color with 0.5-foot resolution in 5,000 by 5,000 foot tiles (equivalent to a mapping scale of 1 inch – 200 feet) in GeoTIFF, MrSID (20:1 compression ratio), and 100:1 compression ratio) format to 29 county and municipal Primary PSAPs
- 2) Project metadata in txt, HTML, and XML per format per county
- 3) Continuous Operating Reference Station (CORS) network report
- 4) NC OneMap Geospatial Portal Image Services and applicable data
- 5) Outreach workshops
- 6) A functional and operable online QC application
- 7) 60-day local review and client satisfaction period
- 8) A minimum of 60% coverage area visual QC that confirms a product free of degradation and most resembles the truest representation of the highest quality imagery

#### Reports and Requirements Documentation

- 1) Weekly contractors' status reports
- 2) Monthly invoicing and accomplishments
- 3) Distribution schedules

- 4) Documentation providing permissions, limitations, and any restrictions regarding collection and use of orthoimagery comprising military properties within the Scope of the Project
- 5) Eight core project compliance documentation deliverables
- 6) Final Report and Contractors' Lessons Learned Reports
- 7) Guidelines for orthorectification specifications and procedures
- 8) NCGS horizontal quality review reports
- 9) 60-day local review and client satisfaction period customer surveys

## **2. Schedule and Milestones**

The project schedule covered 110 weeks from August 1, 2011 through August 31, 2013, defined by six blocks of core phases including four months of Qualifications-Based Selection (QBS), two months of Project Planning, two months of Acquisition, four months of Post Processing, four months of quality review, two months of post-delivery review, NC OneMap implementation, and closeout.

Table 2 represents the components of the project. The project team established planned start and finish dates early in the project for these milestones. Actual finish dates were recorded when milestones were completed.

Coastal Orthoimagery 2012 Final Report – September 2013

Item	Planned Start	Planned Finish	Actual Finish/Percent Complete
<b>Flight Planning</b>	<b>1/26/2012</b>	<b>2/15/2012</b>	
Attachment C: Flight and Control Plan	1/26/2012	2/3/2012	2/17/2012
Control Surveys and Attachment C-1: Control Surveys Report	1/26/2012	2/24/2012	9/7/2012
Continuously Operating Reference Stations (CORS) GPS Upgrades	10/15/2011	2/15/2012	2/8/2012
Validation Range	10/15/2011	2/15/2012	1/31/2012
Real-Time Network (RTN) GPS Maintenance	10/15/2011	2/15/2012	2/7/2012
<b>Acquisition</b>	<b>2/15/2012</b>	<b>4/30/2012</b>	
Acquisition(25 Counties)	2/15/2012	3/30/2012	3/30/2012
Attachment D: Imagery Acquisition Compliance Report	3/15/2012	5/1/2012	8/3/2012
Attachment E: Exploitation Image Post Processing Report	3/15/2012	5/1/2012	7/31/2012
Attachment F: Airborne GPS-IMU Post Processing Report	3/15/2012	5/1/2012	8/9/2012
<b>Aerotriangulation and Ortho Generation</b>	<b>4/1/2012</b>	<b>7/31/2012</b>	
Attachment G: Aerotriangulation Report	4/28/2012	6/22/02012	8/3/2012
<b>Product Delivery and Data Acceptance</b>	<b>7/15/2012</b>	<b>12/23/2012</b>	
County GeoTIFF/Image Services Delivery	8/3/2012	9/28/2012	9/19/2012
<b>Quality Review Resolutions</b>	<b>8/15/2012</b>	<b>5/31/2013</b>	
Vendor Level 2-4 Review (including resolutions acceptance)	8/7/2012	12/9/2012	12/14/2012
Final County GeoTIFF Media Delivery (including validation)	9/21/2012	12/21/2012	2/13/2013
Geodetic Horizontal Quality Review	9/21/2012	12/21/2012	2/1/2013
Product Packaging	12/1/2012	1/11/2013	2/11/2013
Product Delivery to PSAPs	1/1/2013	2/1/2013	2/15/2013
Post Delivery Level 4 County Review	3/1/2013	5/1/2013	5/15/2013

Final 60 day Re-submittal	6/1/2013	6/30/2013	5/30/2013
Implementation of NC OneMap GeoPortal	4/1/2013	5/1/2013	6/3/2013
<b>VOICE QC Application</b>	<b>2/26/2012</b>	<b>5/31/2013</b>	
Implement VOICE Visual Application	3/1/2012	3/1/2012	3/15/2012
Implement VOICE QC Application	7/1/2012	7/1/2012	7/31/2012
<b>Closeout</b>	<b>6/1/2013</b>	<b>7/31/2013</b>	
Final Outstanding Data Submittal	6/1/2013	7/31/2013	7/31/2013
Attachment J: Final Report	6/1/2013	7/31/2013	6/23/2013
Lessons Learned Report	6/1/2013	7/31/2013	7/31/2013

**Table 2: Project Milestones**

### 3. Project Scope and Management

#### 3.1. Responsibilities

This collaborative project took advantage of strategic resources from statewide 911 management and operations, the core collaboration project team, state standards and specifications, state technical services, the statewide GIS coordination structure, and ongoing statewide initiatives. The following are the specific project responsibilities shared and distributed among the six core members of the project collaboration team. Figure 2 is the project organization chart.

#### **NC 911 Board**

The NC 911 Board is the client for the orthoimagery product. The Board requires a consistent, accurate, high quality product for distribution to PSAPs across the study area. It provided guidance to CGIA through the planning, implementation, and delivery stages of the project. The 911 Board received quarterly briefings and monthly status updates on the project and provides feedback to the project team as needed.

#### **NC Center for Geographic Information and Analysis (CGIA)**

CGIA performed services including Qualifications-Based Selection processes, project administration, invoicing, quality control, product delivery, houses the NC OneMap Geospatial Portal and specifies the detailed requirements for information technology upgrades in the NC OneMap framework. CGIA performed outreach by communicating with counties and cities, contractors, state agencies, federal partners, and the public to explain the products and

benefits of the program, perform quality review of 5% of the project study area, insure compliance with DOD national security, and serves as project manager for a collaboration of state agencies under contract to the Office of Information Technology Services (ITS). These included the NC Department of Public Safety-NC Geodetic Survey (NCGS), the NC Department of Transportation (NCDOT) Photogrammetry Unit, and four private sector contractors. In addition, CGIA solicited guidance and recommendations from the Department of the Secretary of State and the Working Group for Orthophotography Planning within the Statewide Mapping Advisory Committee.

#### **NC Department of Transportation (NCDOT) Photogrammetry Unit**

NCDOT performed technical and advisory services. NCDOT has expertise and experience in managing orthoimagery acquisition, utilizing software for evaluating photogrammetric deliverables, performing oversight, developing, evaluating, and approving compliance documentation, and managing and performing visual quality control of up to 30% of the study area. NCDOT served as the core responsible party for insuring compliance of photogrammetry specifications.

#### **NC Department of Public Safety-NC Geodetic Survey (NCGS)**

NCGS performed technical advisory services for survey control, establishing field network systems, performing field maintenance, and for managing independent field quality control through a QBS process. NCGS has expertise and experience in managing photogrammetric deliverables, performing oversight, developing, evaluating, and approving compliance documentation, and managing and performing field quality control. NCGS served as the core responsible party for upgrading and maintaining the Continuously Operating Reference Station (CORS) network for GPS in North Carolina, maintaining the aerial camera validation range located in Surry County, setting survey control standards, and administering compliance for horizontal quality control.

#### **NC Department of the Secretary of State**

The Department of the Secretary of State (NCSOS) is the author of the *North Carolina Technical Specifications for Digital Orthophoto Base Mapping (the Standard)*, the state standard for orthoimagery acquisition. This standard was used as a foundational component of the statewide effort to ensure accuracy and consistency in the final product delivered to the PSAP community and other users. NCSOS served as the core responsible party for administering compliance to the orthophoto standards that serve as the fundamental framework of specifications for the acquisition contractors.

#### **NC Primary Public Safety Answering Points**

The Primary Public Safety Answering Points (PSAPs) and the local government representatives were critical to the successful completion of the project. These collaborators are the local experts for their geographic area. PSAP and county representative performed early quality

review and submit issues for resolution, receive final delivery of the orthoimagery product from CGIA, and perform final 60-day review of the orthoimagery products.

**Photogrammetric Services Contractors**

Private contractors, managed by CGIA with support from collaborating members of the state project team, performed aerial imagery acquisition and processing of 25 counties. The four primary contractors were: Atlas Geographic Data, Photo Science, Spatial Data Consultants, and Surdex. The contractors submitted initial orthoimagery products to the online quality control software application by county that meet *North Carolina Technical Specifications for Digital Orthophoto Base Mapping*. The contractors prepared and delivered a number of reports/documentation including Flight Planning, Survey Control, Imagery Acquisition Compliance, Exploitation Image Post Processing, Airborne GPS Post Processing, Aerotriangulation, and Orthoimagery Delivery, and Quality Review Resolutions, delivered metadata and other interim products, and resolved issues identified from the project team and client end-users during the quality review process.

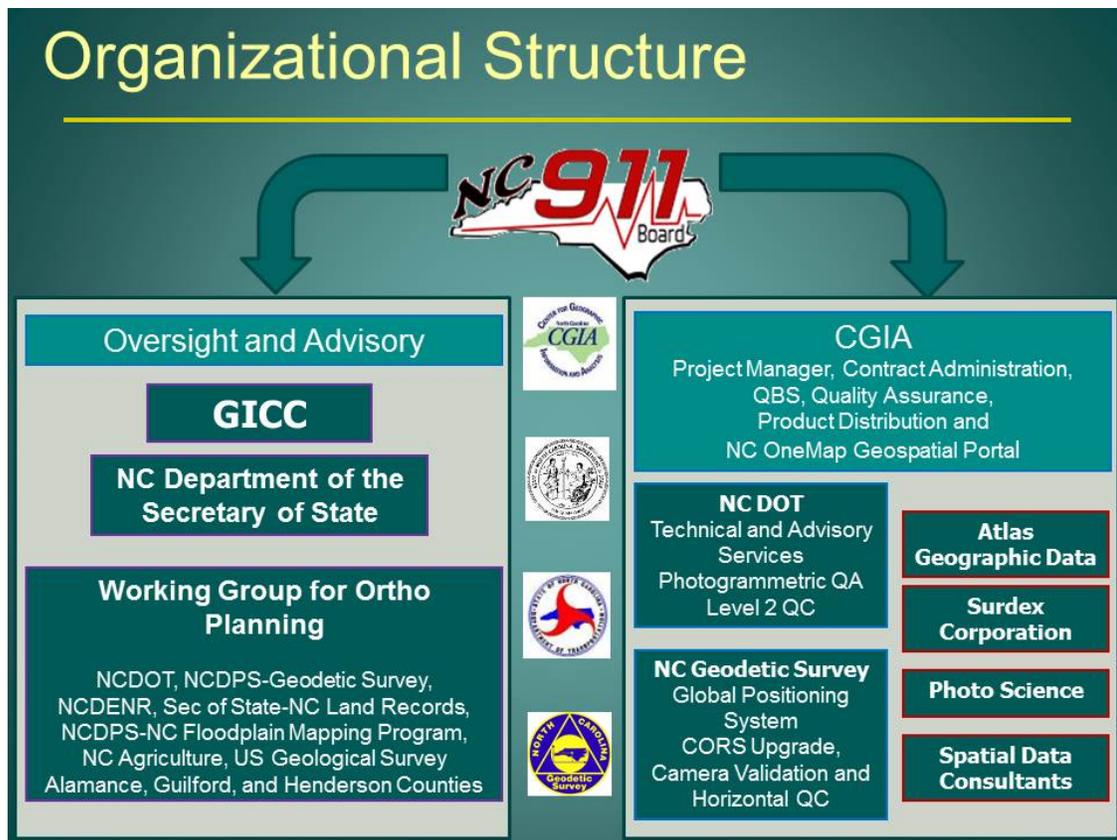
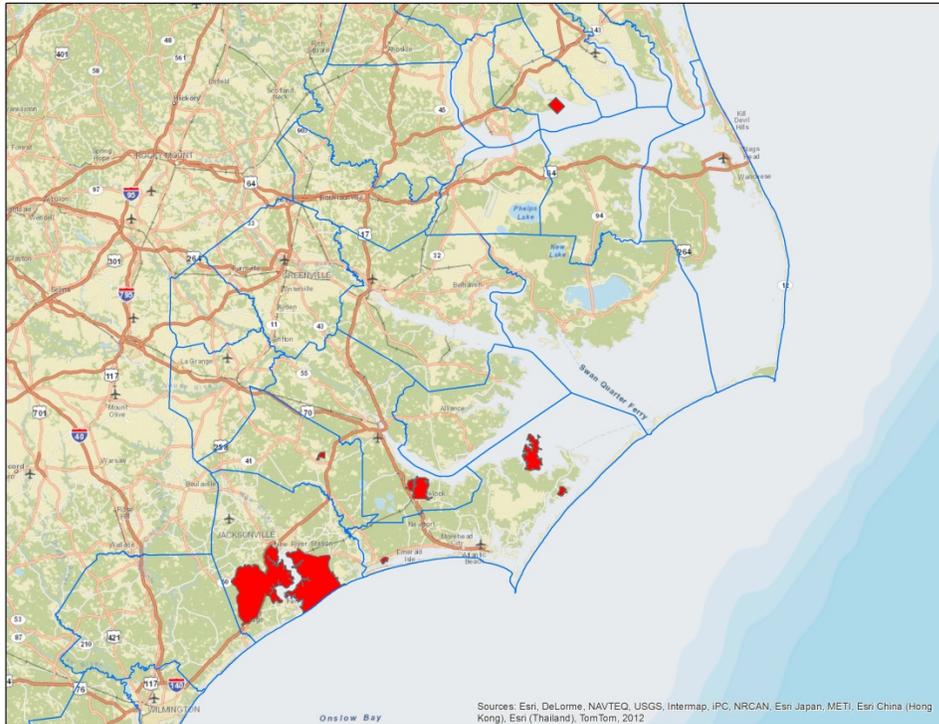


Figure 2: Project Collaboration Team

### **3.2. Dependencies**

The primary dependency for this project was the limited number of days of suitable conditions for flying and acquiring aerial images. Image acquisition requires clear skies, sun angle not under 33 degrees to limit shadow length, and deciduous trees free of spring foliage. Flights began in early February and ended in March. These specifications are fundamental to the state standard in addition to the specifications defined in the eight core compliance documents defined in section 4.6.4.

The other primary dependencies were the restrictions placed on the project team and its contractors by military installations and ranges in eastern North Carolina's special use airspace. Special use airspaces are extensive along the coast, but the project received permission to penetrate airspace over all land (all airspace) on the coast. This was a benchmark achievement relative to the 2010 project when access was denied to the Harvey Point area in Perquimans County. In addition, restrictions on public release were relaxed for Sunny Point, Dare Bombing Range, and Leland Exchange. Finally, image degradation of key Coast Guard locations was relaxed relative to 2010. The project did recognize the same exclusion restrictions, observed in 2010 for all Marine Corps sites as well as the immediate boundary of Harvey Point (Figure 3). For the Marine Corps, contractors could penetrate airspace, but were instructed to disengage sensors at the intersecting installation boundary thus eliminating any acquisition inside the boundary. At Harvey Point, sensors were allowed to engage, but the resulting imagery was not published for public use.



**Figure 3: Areas of Military Exclusion**

## **4. Communications**

The Project Team followed a communication plan that took advantage of the coordination structure of the NC Geographic Information Coordinating Council (GICC), the NC OneMap website, other technical projects with state partners, and outreach to professional organizations. The project team had a special focus on interaction with the military branches in the project area. All of the service branches have a presence in the region

### **4.1. Project Team Meetings**

Acquisition contractors' status calls in and Project Team meetings were scheduled for each Wednesday at CGIA. The agenda for each meeting included a vendor roundtable summarizing their weekly status report followed by an internal meeting of the state project team.

### **4.2. Military Coordination**

Military officials in eastern North Carolina were contacted for permission to acquire imagery over their installations and restricted areas and publish the imagery for public use. Upon project award, CGIA sought and confirmed points of contact for each of the military branches

with property in the 25-county study area. CGIA coordinated this communication with Mr. John Nicholson, the Governor’s Military Liaison. Project goals, schedule, and contractor points of contact were provided to the relevant points of contact in each of the military branches. Contractors provided information on flight crews, aircraft identification, survey crews, and other details leading to imagery acquisition over the installations and restricted areas.

### **4.3. GIS Coordination Structure**

This project engaged the GIS coordination structure in North Carolina to assure that products and services met the needs of the primary users (local 911 and GIS operations) and added value to the work of a wide range of GIS stakeholders. The coordination structure is well established, and its many members are active, willing and able to offer technical and other advice, communicate preferences, and highlight the benefits of the project.

#### **4.3.1. GICC Committees**

The Statewide Mapping Advisory Committee’s Working Group for Orthophotography Planning met quarterly and served as a technical advisory group. CGIA serves as staff to this group and coordinated work with the group by providing updates on the 2012 project.

The GICC has representation from private businesses, nongovernmental organizations, local governments, state agencies, federal government, and the university system. The project reported at each quarterly meeting of the GICC and reported to several of the Council’s subcommittees including the Statewide Mapping Advisory Committee, the State Government GIS Users Committee, the Federal Interagency Committee, the Management and Operations Committee, and the Local Government Committee as requested.

### **4.4. NC OneMap Website**

The Project Team maintained a folder and web pages on the [www.nconemap.com](http://www.nconemap.com) website. Individual pages were maintained for information regarding the overall Statewide Program, the Statewide 2010 project and the Coastal Orthoimagery project. Content included project overview, detailed description, frequently asked questions, project status, and resources, and links to resources such as the orthoimagery standard and the business plan for orthoimagery. CGIA notified local GIS contacts about the establishment of the project pages and about release of the new imagery in the Geospatial Portal. The NC OneMap Geospatial Portal also offers data download for GIS datasets, image services for 2010 and 2012, data discovery, and various resources for GIS users.

#### **4.5. Outreach to Professional Organizations and Other Data Users**

With the purpose of reaching users of orthoimagery who will benefit from the project, CGIA and the Project Team participated in meetings of professional organizations to convey the scope, approach, and benefits of the project. The team presented project explanations and updates to organizations that included the NC Eastern ArcGIS Users Group and three events of the NC Property Mappers Association. CGIA established one point of contact each for all Primary PSAPs and County GIS Coordinators. This served two purposes: (1) to serve as a means of communication throughout the project lifecycle and (2) to serve as imagery QC lead for the online QC application used by the project. CGIA provided regular monthly presentation slides to the Executive Director of the NC 911 Board and presented to the Board on a quarterly basis. The Land Records Management Section in the Department of the Secretary of State as well as the NC Geodetic Survey presented on the project at a large number of events. Other forums included the NC GIS Conference in February 2013. Finally, CGIA also presented a paper on web integrated QC tools at the Esri International User Conference in July 2013.

#### **4.6. Project Reports**

The project team was responsible for maintaining three levels of reporting progress on a regular basis to the Executive Director of the NC 911 Board as well as maintaining a suite of compliance documentation as follows:

##### **4.6.1. Reporting for Weekly Submission of Project Status to CGIA**

CGIA required weekly progress reports from the private sector contractors assigned to the project. These were distributed to the Project Team every Wednesday morning for review prior to the weekly status meeting that afternoon.

##### **4.6.2. Reporting Monthly Invoices and Invoice Accountability Status to the NC 911 Board**

CGIA received monthly status report and invoices from the vendors and submitted them to the NC 911 Board. The reports included the following:

1. Accomplishments for the month
2. Status of major tasks
3. Expenditures for the month and cumulative expenditures and balance for the project
4. Detailed accountability documentation that serves the purpose of justification for all expenditures.

#### **4.6.3. Monthly and Quarterly Presentations Submitted to the Executive Director of the NC 911 Board**

CGIA provided regular monthly update slides to the NC 911 Board and attended and presented at those meetings quarterly.

#### **4.6.4. Project Milestone Compliance Reporting**

To achieve the Project Team's objective of administering a proactive approach to quality, contracted requirements were implemented for the delivery of core attachment deliverables of compliance documentation as follows either per study area, per AT block, or per county for a total of 128 reports.

1. *Flight and Control Plan*
2. *Ground Control Survey Report*
3. *Imagery Acquisition Compliance Report*
4. *Exploitation Image Post Processing Report*
5. *Airborne GPS-IMU Post Processing Report*
6. *Aerotriangulation Report*
7. *Orthoimagery Delivery Report*
8. *Orthoimagery Quality Review Report*
9. *Final Report and Lessons Learned*

## **5. Procurement**

The magnitude of this project required engagement of four private photogrammetric services contractors for specific expertise in photogrammetry as well as the engagement of a software vendor to develop customizations to NC OneMap. All other contracted services were handled through agreements with state agencies. The large amount of acquired and processed data required investment in information technology to support and improve public access to the new imagery.

### **5.1. Contracted Services**

CGIA performed a QBS process for professional services to perform image acquisition and processing. Ultimately four contractors were procured for photogrammetric services including Atlas Geographic Data, Photo Science, Spatial Data Consultants, and Surdex Corporation.

NCGS conducted a separate QBS yielding three contractors to assist the Geodetic Survey in horizontal quality control. Those contractors were: Concord Engineering and Surveying, Joyner Keeny, and Woolpert.

## **5.2. NCDOT Photogrammetry Unit**

The NCDOT Photogrammetry Unit provided expert support to the project team in the area of photogrammetry. Specifically, NCDOT performed the following tasks:

1. Developed a tile review schema that supports a 25% NCDOT, 5% CGIA, and a 25% County quality review of the study area
2. Performed an orthoimagery tile quality review for image anomalies with a limit of three anomalies per tile (before rejecting that tile)
3. Evaluated anomalies and submit the results to CGIA
4. Performed a visual and quantitative comparison of orthoimagery tiles with exploitation images
5. Verified corrections to failed tiles provided by CGIA
6. Prepared an Orthoimagery Summary Evaluation Report for each county
7. Developed MrSID 20:1 compression image format for each tile for a county and developed 100:1 compression MrSID mosaic format for each county
8. Supported QBS selection process conducted by CGIA leading to qualification of vendors and selection of final set of contractors for imagery acquisition
9. Provided ongoing assistance to CGIA as part of project management and oversight activities

## **5.3. NC Department of Public Safety-NCGS**

The NC Geodetic Survey provided expert support to the project team in the areas of surveying, GPS, and horizontal quality control. Specifically, NCGS performed the following tasks:

1. Performed pre-flight geodetic control maintenance and updates to facilitate flight acquisition
2. Conducted QBS process to qualify vendors for horizontal quality control tasks
3. Performed field quality control review and evaluated visual quality review and provided recommendations
4. Supported QBS selection process conducted by CGIA leading to qualification of vendors and selection of final set of contractors for imagery acquisition.
5. Provided ongoing assistance to CGIA to support project management and oversight activities

## **5.4. Esri**

Esri was contracted to deliver customization and upgrade services to the NC OneMap Geospatial Portal. These services included new customizations providing the ability to preview and download imagery from multiple calendar years; allow up to 40 square miles of imagery to

be downloaded at one time; and house time-enabled orthoimagery developed for the Statewide Orthoimagery Program.

### **5.5. NC OneMap IT Infrastructure / Hosting Services**

CGIA completed a Technical Architecture System Design with assistance from ITS, and based on the plan, procured new redundant and failover servers in the ITS Western Data Center hosted by ITS Hosting Services for storing and serving 2010 and 2012 orthoimagery, respectively.

## **6. Project Workflow and Variations**

The purpose of this section is to present the primary project workflow approaches organized by logical periods of the project, to document the relevant variations in this project relative to the 2010 statewide effort, and to present future recommendations. The Statewide Orthoimagery Program consists of four mirrored phases each consistent in approach where each subsequent phase builds not only on the success of the previous phase but also on recommendations for improvement. The project term begins in July and proceeds through a two-year cycle ending in June. The project lifecycle is defined by six core blocks:

1. Phase Initiation
2. Planning and Design
3. Imagery Acquisition and Post Processing
4. Production
5. Implementation
6. Closeout

### **6.1. Project Phases**

#### ***Block 1: Phase Initiation (Jul 2011 – Jan 2012)***

The purpose of this block is to develop contracts with public and private sector project partners, and begin other administrative tasks in preparation for orthoimagery acquisition. Specific activities during this block include:

1. Develop statements of work, develop and execute contracts between CGIA and the NC 911 Board and with other public and private organizations.
2. Manage a QBS process for private sector contractors and issue purchase orders. Specifically the QBS process is defined by the following logical sequence of events:
  - a. Engage the project team to develop a Request for Qualifications (RFQ).
  - b. Conduct an information gathering session that consisted of over 50 interested firms, prior to release of the RFQ.

- c. Hold an open-bid for a period of 30 days including a question-and-answer period.
- d. Develop a pre-qualified selection of candidates based on unbiased review and collaboration by a panel of six state project team members.
- e. Conduct a pre-proposal workshop followed by submittal and review of cost proposals.
- f. Perform contract negotiations.
- g. Issue purchase orders.

### ***2010 Variations:***

Variations from the 2010 statewide project are not applicable since CGIA did not perform these tasks for the 2010 statewide project.

### ***Future Recommendations:***

1. Move the Project Open/Close at least a month earlier to facilitate a longer planning period.
2. Eliminate the information session as the amount of potential invitees is not practical and the session did not demonstrate a value-added contribution to the process.
3. Develop more specific RFQ guidelines for standard delivery structure as well as develop more quantitative selection criteria.
4. Develop a more quantified scoring template and/or guidelines for consistency.

### ***Block 2A: Planning and Design (Nov 2011 – Jul 2012)***

The purpose of this task is plan the technical details of the project, conduct workshops, initiate engagement with the military, finalize technical requirements, initiate outreach, implement the quality review application, and develop, engage, review, and approve quality compliance documentation.

Specific activities under this task include:

1. Pre-Flight: Manage contracts, generate and finalize work orders, validate digital sensors using NC's validation range and procedures, produce and review and finalize detailed flight plans, design and implement ground control points, select project datasets for county boundaries and the statewide tile grid, finalize metadata templates, design the visual quality control process, design the horizontal quality control process, design the data validation process, and set milestones.
2. Requirements Workshops: Conduct kickoff and planning workshops with all applicable parties including project partners, contractors, and the Geographic Information Coordinating Council, Working Group for Orthophotography Planning.

3. Quality Control Application: Develop requirements, develop system design and testing procedures, conduct testing, and release the Virtual Online Inspection, Checking, and Editing (VOICE) application secured through the acquisition vendor contract. See Section 6.2 for production details.
4. Outreach: Perform outreach and conduct training programs for PSAPs and local government points of contact to perform quality review during the Production stage. CGIA worked with the NC 911 Board to identify the appropriate contacts.

### *2010 Variations:*

#### 1. Boundaries

- a. In coastal communities, the method for determination of the tile deliverable was that the 2,000-foot buffer was placed on shoreline data. In several situations, this method was questioned because it was vague, where a “shoreline” terminated and where a county intersection rule would apply. In 2012, county boundaries were obtained by the NC Geodetic Survey that would serve the purpose of eliminating any coastal or sound question regarding jurisdiction. At the same time it would provide a 100% coverage area.
- b. In 2010, existing imagery from the National Oceanic and Atmospheric Administration (NOAA) was utilized to fill in gaps where imagery was not acquired in the sounds. In the event NOAA data did not exist, an alternative was developed where a NOAA tile would be copied and its coordinate altered to fill in gaps. It was the recommendation that the value for logistics to acquire large expanses as well as administer the storage capacity (150 GB) does not exceed the benefit which is to display background data for cartographic purposes. Therefore, in 2012, NOAA data for the open water in the sounds was not part of the delivery. However, contractors were required to acquire more imagery in the sounds compared to 2010.

#### 2. Communications:

It was the observation that the SharePoint site was underutilized until the 90-day review when it was used more intensively. SharePoint is a commercial software tool from Microsoft to allow for collaborative sharing of documents such as status and technical reports. It was the recommendation that a more defined SharePoint structure be developed as a means to provide extended access to data and documentation and as a documented source of data requirements. In 2012, Microsoft SharePoint Online was implemented and required for all submittals and exchanges of documentation and information between the project team as well as the contractors.

3. Planning and Design Documentation:

As noted in Sections 1 and 5, to achieve the Project Team’s objective of administering a proactive approach to quality, contracted requirements were implemented for the delivery of core attachment deliverables of compliance documentation. The compliance documentation would serve two purposes: (1) to provide either intent, compliance, or to report and summarize events; and (2) to provide recorded documentation for future reference. Two of those documents, Attachment C (*Flight and Control Plan*) and Attachment C-1 (*Ground Control Survey Report*) were implemented during Planning and Design. Attachment C included a new requirement to perform Nadir flights of 18 major bridge locations to reduce the level of outward lean of elevated structures due to camera’s central perspective geometry.

4. Procurement

In 2010, an independent third party contractor was utilized for various services including QC of 25% of the study area, MrSID development, and packaging. In 2012, services were acquired from NCDOT under contract to CGIA to perform advisory and technical services tasks throughout the project. NCDOT became a new, standing member of the Project Team. Engaging NCDOT in this manner resulted in a cost savings to the project and provided a critical anchor to administer the Program’s proactive approach to quality, and consolidated photogrammetric expertise and services into a single body.

5. Military

- a. In 2010, the project team recommended that a senior level point of contact (POC) should be identified for each branch of the military. These individuals should be contacted early in the project planning process. Discussion with each POC would confirm standard documentation for a consistent method, location, intent, and approval process. In 2012, POCs were identified early and contractors were required to submit fact sheets of relevant prime and sub-contractor personnel and equipment that would be used for orthoimagery acquisition in military airspace.
- b. The project team observed that the exclusion from publication of whole 5,000 by 5,000-foot tiles that intersect the boundaries of a military installation necessarily leaves out significant portions of civilian property. That has an impact on 911 call answering and response as well as local and regional planning. The solution of trimming tiles, or clipping, to installation boundaries brought the adjacent civilian land into view and provided a more beneficial outcome to users. However, the level of effort to clip the data, as well as perform follow-up created a significant amount of work for the project team in change management,

scheduling of follow-up data releases, logistics, server updates, and the increased potential for confusion by users of the data.

### ***2010 Variations:***

In 2012, clipping was performed by the vendor during raw imagery post-processing rather than exclude entire tiles. This served two purposes: (1) to recognize economies of scale where the contractor would clip that data as part of its internal processes; and (2) to confirm compliance of military requirements for not producing data within their installations.

In 2010, four areas of military strategic importance were recognized by the project that contained initial exclusion. With the exception of Harvey Point in Perquimans County, all areas were flown and data was collected. Harvey Point was identified as a no-fly zone which included a significant portion of Perquimans County.

In 2012, early coordination and outreach demonstrated only two areas of exclusion which were the sites under the jurisdiction of the Marine Corps as well as Harvey Point. However, with permission, Harvey Point data was acquired and the exclusion area was only limited by the installation boundary. This marked a significant achievement for the project.

### ***Future Recommendations:***

1. Initial military engagement occurred approximately four months prior to acquisition which resulted in increased pressure on flight planning operations as well as alternative contracting approaches. It is recommended that military engagement and establishing points of contact should begin at least six months prior to acquisition.
2. Validation Range testing of sensors should only be required when either a new contractor is selected or an incumbent contractor acquires a new sensor.

### ***Block 2B: Imagery Acquisition and Post Processing (Feb 2012 – Jul 2012)***

The purpose of this task is to acquire leaf-off imagery and to perform and document all post processing activities prior to product delivery for the Phase 1 area. The flying season is driven by sun angle and vegetation per the *North Carolina Technical Specifications for Digital Orthophoto Base Mapping*, the state standard. The goals are to minimize shadows and vegetative cover that would obscure infrastructure or other key objects on the ground.

Specific activities under this task include:

1. Conduct flights and acquire orthoimagery for the 25 Phase 1 counties, and verify that images captured meet state specifications.

2. Develop imagery specifications to facilitate consistent radiometric deliverables across varying land classifications and contractor study areas.
3. Perform all post processing activities required to develop a tile-based orthorectified product.
4. Deliver acceptance documentation for acquisition and all post processing submittals.

### *2010 Variations:*

The most significant variations from 2010 were the shift from global radiometric balancing tied to pilot specifications to an approach focused on local landcover and visual consistency within reason, the installment of proactive guidelines for radiometrics, the evaluation of derived compliance metrics, the delivery of a representative sample of exploitation images, and the delivery of standardized compliance documentation. The project team held two workshops during the period. The first workshop was held to evaluate and finalize exploitation imagery guidelines. The second workshop was conducted as a pre-orthoimagery delivery discussion regarding the order in which county imagery would be delivered and expectations for that delivery. The following provide a summary of the imagery guidelines.

#### Landcover Guidelines

The Project Team implemented a program for contractors to develop exploitation imagery samples of the five different landcover types below. Exploitation imagery is an early form of the imagery before all adjustments have been made leading to a final orthoimagery tile. The intent was to produce imagery that is representative of local conditions rather than engage in global radiometric (i.e., color) balancing. Contractors would submit samples, the project team would evaluate metrics derived from the samples, provide comments, and grant acceptance of the samples.

1. Urban Industrial
2. Rural/Farmland/Wooded
3. Coastal Beach/Marsh
4. Suburban/Residential
5. Swamp/Wetland

#### Exploitation Imagery Guidelines

The landcover evaluations yielded a document called “Exploitation Imagery Guidelines” which keyed on the concepts and specific guidelines for three inter-related areas of focus which are radiometrics, specifications and metrics, and data sharing described below.

1. Tier 1 Visual Consistency Within Reason Guidelines

This guideline defined that exploitation image post processing produces exploitation images that are visually consistent (within reason) across all study areas and meet the Tier 2 Primary Image Metric Guidelines.

Exploitation images should be visually consistent (within reason) with the representative Coastal 2012 five different land cover classes.

Exploitation images shall have sharp well-defined edges, with minimum noise, minimum visual artifacts, the absence of “black outlines”, and should not demonstrate a “haze” effect or kept to the absolute minimum when viewing at full (1:1) resolution.

2. Tier 2 Guidelines

Industry best practice derived metric guidelines for contrast, sharpening, luminosity, etc., are recommended to generate acceptable imagery. The deliverable shall meet the Tier 1 guidelines and must demonstrate the highest amount of image clarity and sharpening without introducing artifacts or false color. Meeting these quality requirements of image consistency, and clarity was the primary goal and objective of the project. Simply meeting the minimum recommended specifications without consideration of these qualitative goals was not acceptable. The Project Team provided explicit instructions for the quantity of data and methodology for data sharing and matching between contractors.

Compliance Attachment Documents

The Project Team implemented deliverable requirements of four compliance documents that would serve two purposes: (1) to provide either intent, compliance, or to report and summarize events, and (2) to provide recorded documentation for future reference. NCDOT evaluations of all documentation were transmitted back to the contractors as Approved or Disapproved in the form of an Advisory Report.

1. Attachment D: Imagery Acquisition Compliance Report
2. Attachment E: Exploitation Image Post Processing Report
3. Attachment F: Airborne GPS-IMU Post Processing Report
4. Attachment G: Aerotriangulation Report

#### Nadir Approach

In 2010, in a few of the state's most urbanized city centers there were a few instances of building distortion or lean. A recommendation was that for highly urbanized areas (i.e., Charlotte, Raleigh) it could be beneficial to have additional or more densely packed flight lines over these areas to minimize off-nadir lean. In 2012, focus was applied to 18 strategic bridge locations where nadir imagery was required for flight planning. See the recommendation below for an applied approach to 2013.

#### Product Delivery Order

The Project Team held an Ortho Generation Workshop in June 2012 to discuss delivery requirements, expectations, and specifically to finalize a plan for the order of delivery of counties and tile assigned to them. The Project Team submitted a draft plan based on the progression of completed AT blocks and the counties that contractors are responsible for. The plan's premise was to deliver the tiles that define one "primary" county per contractor every week. Subsequent county deliveries would represent less than 100% to address redundant delivery for adjacent counties already delivered.

#### Exploitation Imagery Samples

The Project Team required that a representative sample of 5%-8% of exploitation imagery to evaluate: (1) compliance with the Tier 1 and Tier 2 guidelines, (2) to demonstrate a representative sample of final imagery deliverables and (3) as a source for comparing deliverables.

### *Future Recommendations:*

1. Exploitation Imagery Guidelines
  - a. Consensus from the Project Team as well as contractors was to develop a specific set of target images and guidelines for visual matching prior to acquisition. This would facilitate matching imagery specifications to already established targets.
  - b. For the project team to remove publication of specific or a range of specific metrics and rely more on approval of landcover guidelines evaluations and contractor data sharing.
  - c. For the project team to remove publication of specific instructions of the numbers of tiles that each contractor should provide to other contractors in areas of stereo overlap. Rely on contractors to conduct internal meetings and finalize acceptable metrics defined by Tier 1.

2. Compliance

- a. Combine Attachment F (Airborne GPS-IMU Post Processing Report) and Attachment G (Aerotriangulation Report) into single compliance document.
- b. Implement more timely image acquisition reporting for tilt, crab, and sun angle which will permit the state team to make re-flight decisions within a week of initial acquisition.

3. Nadir Approach

- a. In 2013, 11 urban locations were identified that would require the enhancements to flight plans to acquire nadir imagery in an attempt to reduce building lean.

4. Schedule

- a. Develop and secure the delivery order during acquisition or earlier to facilitate production schedules. The final delivery order sequence for each study area should be available and thereby included as part of Attachment C study area planning and be of benefit in the AT boundary delineation and sequencing. In this manner, the AT Block design and sequencing would more closely reconcile with the delivery order sequencing.
- b. Conduct the ortho generation meeting in May instead of June of the orthoimagery production year.

***Block 3: Production (Aug 2012 – Feb 2013)***

The purpose of this task is to complete a full circle quality review on the deliverable Tagged Image File Format (TIFF) product (including review, issues submittal, resolution, resolution submittal review, and signoff), to develop the secondary Multi-Resolution Seamless Image Database (MrSID) product after satisfactory signoff and delivery of the TIFF product, to implement ITS hosting services and procurement and initiate data loading onto NC OneMap, to perform packaging and initiate scheduling to facilitate delivery to PSAPs.

Specific activities under this task include:

1. Finalize and secure ITS hosting services and perform initial image data loading onto ITS servers.
2. Conduct Level 1 quality review by imagery processing contractors to assure that the imagery meets state specifications and is free of systematic error or systematic visual quality issues and to verify the quality and completeness of the product.
3. Conduct Level 2-4 quality review for 25 counties through the VOICE application, identify valid issues, and submit and receive revised imagery from imagery processing contractors.

4. Develop a MrSID format 20:1 compression file for each tile in the county and either a 50:1 or 100:1 compression format that represents an entire county mosaic. CGIIA will request feedback from PSAP and local government end-users to determine a desired compression format.
5. Package imagery products on portable disk drives to include delivery of final imagery in GeoTIFF format, MrSID compressed format, metadata, and other applicable documentation. This also includes the logistics to maintain master copies of the GeoTIFF tiles, MrSID tiles and mosaics, finalize metadata files, assemble neighbor imagery, and collect other applicable data relevant to the primary county.
6. Product Delivery: This task includes the distribution of data to each PSAP.
7. Procurement: Develop and procure agreement with Esri or other third-party contractors to facilitate customizations to NC OneMap and facilitate imagery loading.

### *2010 Variations:*

In 2012, the Production block demonstrated the most variations from 2010. These variations focused on a more contractual approach for delivery that focused on the Program's proactive approach to product delivery. The approach was driven by the need to eliminate regional systematic error and prolonged schedule delay. In addition, the Program required an approach to production that was rooted in the single handling of data as opposed to processing data several times. Closely related to this approach to production was the need to effectively manage packaging of redundant data. Finally, and without question, the most substantial variation from 2010 was the implementation of a QC review methodology defined by centralization and accessibility to imagery by an infinite number of end-users prior to delivery. The following is a summary of the proposed recommendations from 2010 coupled with the implemented measure in 2012.

1. Prior to release and acceptance, the contractors should be required to perform a macro level quality review to demonstrate adequate seamless color balancing across small scale regional areas. This will reduce the potential for systematic color issues to be sent back to the contractor.
  - *The Program implemented a contractual approach to product delivery referred to as Level 1 QC. This approach, put quite simply, is a requirement for contractors to "check their work" prior to delivery. Level 1 QC would precede a very rigid schedule of delivery defined by four counties per week every week until delivery was completed. Level 1 and product delivery would trigger the implementation of the concept of Level 2-Level 4 discussed in item 5 below.*

2. A number of observations were received across the state about small areas of localized blurriness that were later deemed to be issues related to the sensor (i.e., digital camera) used for the project. Investigating workarounds or upgrades to the sensor that could alleviate this issue should be investigated for future projects.
  - *The recommendation was observed and tied to production primarily because of the large volume of systematic error that resulted from this issue. The recommendation was rooted in the need to research the sensor. In 2012, it was realized that the underlying root of the problem was not the sensor but rather an approach to performing global color balancing. This approach, referred to as “dodging” was virtually eliminated in 2012 resulting in no demonstration of the issue in any reported QC check performed by the reviewers.*
3. The file format throughout the review process should be limited to GeoTIFF format, and MrSID generation should be held until all review resolutions have been completed. This will avoid multiple instances of file compression and the related file handling.
  - *In 2010 the production technique was revamped for handling and development of the MrSID product. In 2010, MrSID files were developed and shipped concurrently with the TIFF product and then QC was performed. In 2012, the MrSID product was not developed until all QC approvals were complete and the TIFF product was delivered as final.*
4. An alternative methodology to reduce “early” packaging should be considered where supporting documents such as reference data, reports, README files, metadata, etc., are not packaged on county drives until the primary image products have been accepted as ready for delivery.
  - *In 2010, deliveries were packaged by an independent contractor, shipped to CGIA where additional packaging would be performed as well as a QC of the delivered packaging. In 2012 the packaging workflow was revamped. The production workflow would be defined by the development of two 3TB “repository staging” drives that would house a single instance of all TIFF and MrSID products as well as single instances of all metadata, README files, compliance documentation, etc. Complex SQL validation routines were developed that would facilitate the automated packaging of county drives.*
  - *In addition, the approach to metadata was optimized where a single metadata record would be developed to record techniques for the creation of all file formats including TIFF, MrSID 20:1 compression, and MrSID mosaics. In 2010, three different metadata records were developed. CGIA would predefine the approaches in the metadata record, including its own and NCDOT’s approaches to the development of data. The metadata records*

*would be delivered to the contractors to complete documentation required by them.*

5. The concept of Level 1 QC was new to the Coastal 2012 project. The concept of a Level 2 and Level 3 QC review was performed in 2010. Level 2, a 25% QC review, was performed by an independent contractor and Level 3, a 5% review by CGIA, was performed after Level 2 was performed.
  - *In 2012, Level 2 review was streamlined by contracting with NCDOT to perform review concurrently with Level 3 review by CGIA, while adhering to a common and consistent approach to review standards. The Program would benefit, both in terms of production and cost, by engaging NCDOT for QC review as well as for Technical and Advisory Services.*
  - *In 2010 the concept of a Level 4 review (by the county end-user) was vaguely defined by a 90-day post-delivery method of inconsistent approaches to methods of review as well as receipt of review by CGIA. In 2012, the concept of Level 4 was introduced to occur concurrently with Level 2 and 3. This concept was driven by (1) a practical approach to performing end-user review and (2) the vision of the NC 911 Board to conduct QC prior to delivery to PSAP recipients.*
  
6. An advanced method of product review would reduce file and portable drive handling by the quality review parties. A recommendation is to either (1) load GeoTIFF files directly into an internal image service to facilitate data access for reviewers or (2) stage the GeoTIFFs on an internal image service maintained by the contractors.
  - *The most significant variation from 2010 was driven by this single requirement to conduct a productive and logistical means for quality review. In 2010, CGIA's vision was to implement advanced technology for serving imagery from a common platform rather than through inefficient storage on external hardware. This vision was fueled by the NC 911 Board's directive for early review. It was pursued through the addition of RFQ selection criteria to demonstrate qualifications for the development of an approach to image services. It was implemented through the application of a software application called VOICE discussed in detail in Section 6.*

#### ***Block 4: Implementation (Mar 2013 – May 2013)***

The purpose of this task is to implement release of data on NC OneMap and to evaluate each county's quality review (60-day evaluation period), and submit any final issues to orthoimagery acquisition contractors for resolution.

1. NC OneMap Implementation: CGIA will load the imagery into the NC OneMap database for public access as imagery services and as downloadable compressed imagery. The storage and maintenance will be continuous through the four cycles of quarter-state imagery acquisition.
2. 60-Day Evaluation: Each PSAP and county GIS office will review imagery quality during a period of 60 days. CGIA will evaluate county responses, submit issues to the processing contractor(s), and deliver resolutions as final.

### *2010 Variations:*

The 60-day evaluation period is a response to the 90-day evaluation period utilized in 2010. The most notable change is the implementation of VOICE discussed in Section 6.1 as a means for end-users to review imagery prior to distribution. The other closely related change is the awareness that this period is one of client satisfaction and detailed quality review of imagery should not be the focus.

### *Future Recommendations:*

CGIA and the NC 911 Board will monitor the effectiveness and response during the 60-day period from the 2012 project as well as the 2013 project to determine if the period is necessary as the Program continues into Phase 3.

### *Block 5: Project Closeout (Jun 2013)*

The purpose of this task is to perform project management activities relevant to project closeout and procurement. This includes evaluation and acceptance of all deliverables including the following:

1. Lessons Learned Report
2. Outstanding Data Revisions
3. Final Project Report

### *Future Recommendations:*

Lessons learned reports should be due upon final delivery of orthoimagery and/or concurrent with delivery to the client rather than in the final months of the contract.

## **6.2. VOICE**

VOICE (Virtual Online Inspection Checking and Editing) is a GIS web-based tool that hosts imagery stored in the cloud. VOICE contains a suite of tools that facilitate QC of all imagery developed for the project. VOICE was developed as a response to 2010 recommendations to perform a more efficient means of quality review. VOICE satisfies the following objectives:

1. Satisfies the NC 911 Board’s requirement to provide end users the ability to review the product prior to delivery.
2. Provides secure access by end-user points of contract to review imagery as it is completed by contractors.
3. Stores imagery hosted in the cloud thus eliminating the need to deliver external drives that increase costs and scheduling.
4. Provides an effective solution for reviewing imagery seamlessly.

The premise of VOICE is to provide a central means for QC reviewers to evaluate and submit quality issues. The primary means to locate and evaluate imagery is through the use of “pick tiles”. Pick tiles are selected by NCDOT and CGIA as a subset of the full set of tiles for a county. A quantitative approach is used not only based on the importance of features, such as roads, urban areas, bridges, etc., but also where issues might exist between contractor study areas. Table 3 demonstrates the final issues statistics derived from VOICE.

County	Tiles Per County	Percent of Tiles Reviewed	Tiles that Had an Issue	Tiles That Passed Review	Submitted Issues
Beaufort (North)	628	34%	38	82%	45
Beaufort (South)	420	32%	47	65%	76
Bertie	818	37%	51	83%	64
Brunswick	1,092	33%	57	84%	66
Camden	322	30%	5	95%	5
Carteret	979	33%	65	80%	88
Chowan	240	35%	10	88%	16
Craven	845	32%	5	98%	10
Currituck	466	41%	6	97%	6
Dare	793	30%	26	89%	37
Gates	404	33%	16	88%	18
Greene	319	33%	5	95%	6
Hertford	436	33%	27	81%	33
Hyde	963	30%	6	98%	6
Jones	537	29%	9	94%	13
Lenoir	470	33%	12	92%	14
Martin	526	31%	26	84%	32
New Hanover	274	35%	23	76%	32
Onslow	782	36%	28	90%	46
Pamlico	489	33%	24	85%	36
Pasquotank	288	37%	12	89%	15
Pender	1,049	34%	50	86%	59
Perquimans	318	33%	6	94%	6
Pitt	742	38%	57	80%	80
Tyrrell	512	36%	12	93%	12
Washington	445	35%	15	90%	17
<b>Total</b>	<b>15,157</b>	<b>34%</b>	<b>638</b>	<b>88%</b>	<b>838</b>

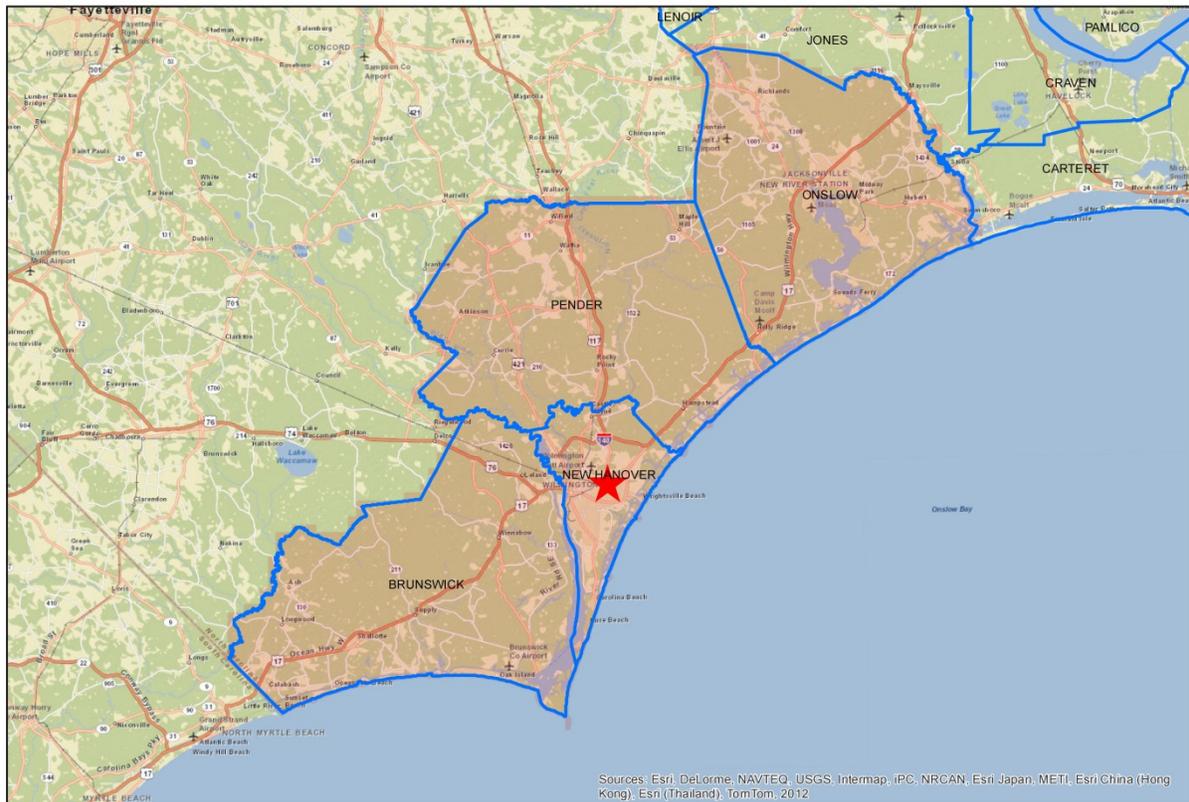
Table 3: Final VOICE Statistics

*Future Recommendations:*

VOICE proved to be a successful methodology and means to accomplish the project objectives. In addition, VOICE served to demonstrate the review of imagery as a concept rather than a simple application. The NC 911 Board has endorsed this concept as well as VOICE and it has been implemented in Phase 2 of the Program. Overall, there are two broad recommendations for the use of VOICE in Phase 2. The first is to provide an interface for contractors to respond to issues rather than track the progression of resolutions and approval through documentation. This single modification should reduce the paper flow dramatically. The second recommendation is to provide access to other sources of imagery, such as 2010 or 2012 for confirmation of perceived issues. Both of these recommendations are currently in place in Phase 2.

**6.3. Distribution of Products to Counties**

Each Primary PSAP received a portable disk drive with tiled orthoimagery in GeoTIFF and MrSID formats covering 100% of their applicable counties, mosaics of all counties bordering the primary counties, and other applicable information as defined in Section 1. The products were distributed in a set of four regional meetings across the coastal study area between January 29 and February 15, 2013. Each meeting included a cluster of 4-8 counties (Figures 4A-4D). Meetings included an overview, product details, technical notes, delivery of one portable drive per county, and a positive issuance of client satisfaction through the notice of a 60-day evaluation window described in Section 6.1 Block 4.



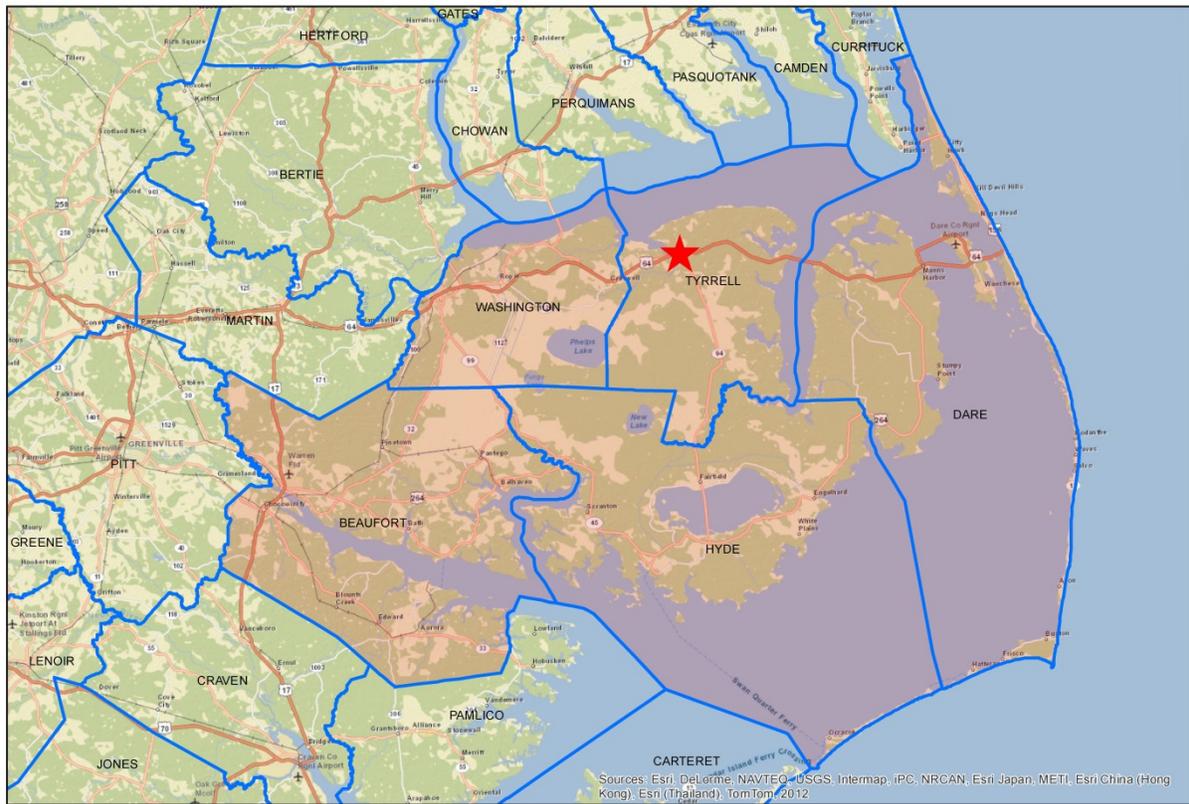
**Coastal Orthoimagery 2012  
Distribution Map  
Delivery 1 - Wilmington  
January 29, 2013**

-  Delivery Location
-  Coastal County Boundary
-  Counties to be delivered

0 5 Miles  **Date: 1/9/2013**



**Figure 4A: Study Area 4 Cluster of Counties and Workshop Locations for Delivery of Orthoimagery to PSAPs, 2013**



**Coastal Orthoimagery 2012  
Distribution Map  
Delivery 2 - Columbia  
February 12, 2013**

 Delivery Location

 Coastal County Boundary  
 Counties to be delivered

0 5 Miles



Date: 1/9/2013



**Figure 4B: Study Area 2 Cluster of Counties and Workshop Locations for Delivery of Orthoimagery to PSAPs, 2013**

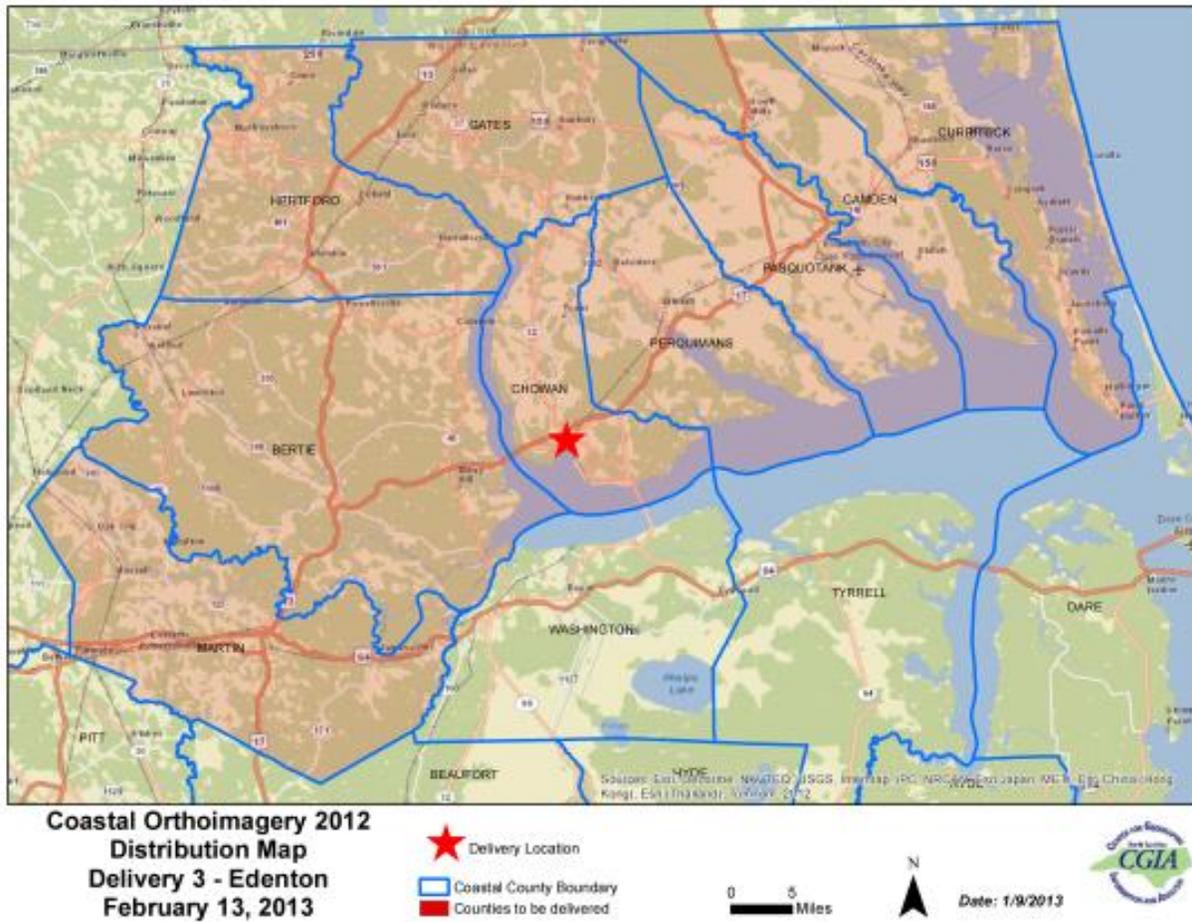
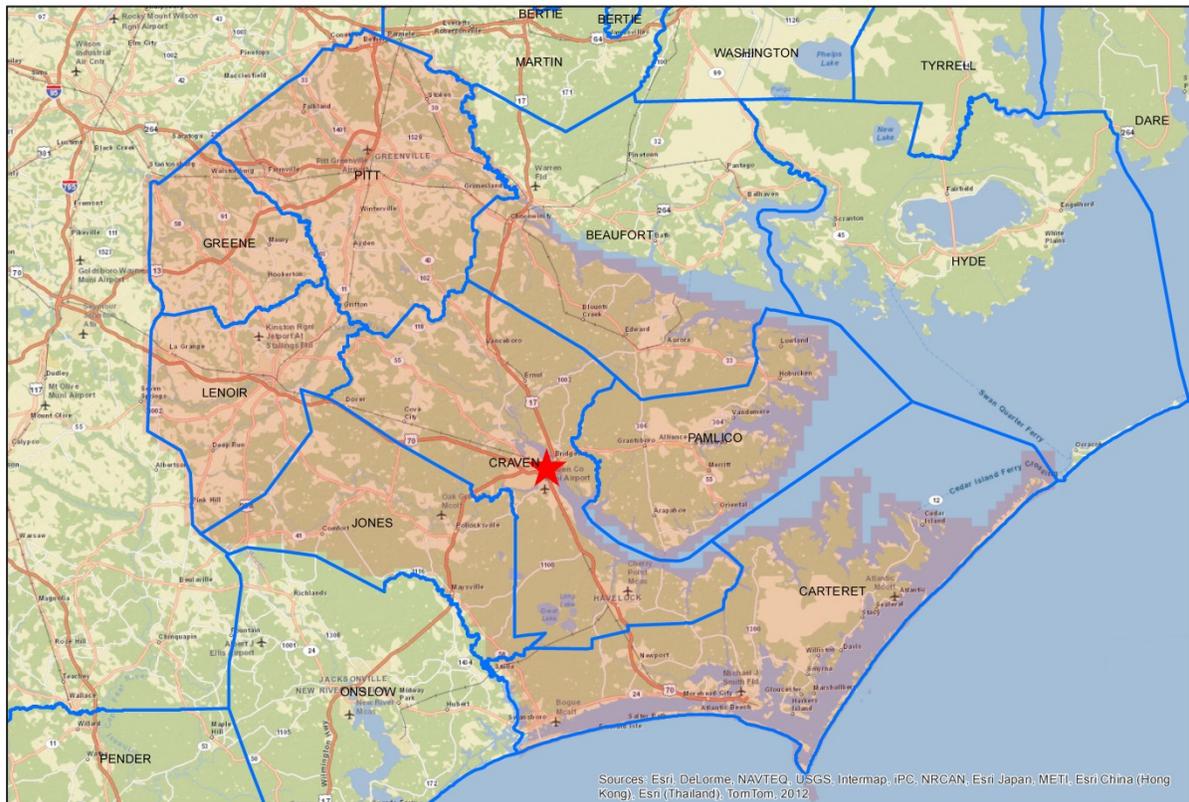


Figure 4C: Study Area 1 Cluster of Counties and Workshop Locations for Delivery of Orthoimagery to PSAPs, 2013



**Coastal Orthoimagery 2012  
Distribution Map  
Delivery 4 - New Bern  
February 15, 2013**

★ Delivery Location  
 □ Coastal County Boundary  
 ■ Counties to be delivered

0 5 Miles  Date: 1/9/2013



**Figure 4D: Study Area 3 Cluster of Counties and Workshop Locations for Delivery of Orthoimagery to PSAPs, 2013**

#### 6.4. Quality Review by PSAPs and Local GIS Operations

Following delivery, the project entered into a 60-day period where the end-user evaluated the imagery deliverable to insure customer satisfaction, confirm completeness, validate data integrity, and to improve the process for the NC 911 Board Coastal Orthoimagery 2012 project and subsequent phases. The 60-day period ended April 15, 2013 and no product issues were reported. This is a very positive statement regarding the quality of the product as well as a demonstration of the value of performing early QC review prior to delivery.

As was the case in 2010, one county CAD system could not support the MrSID Generation 3 format. CGIA responded by developing Generation 2 format for the entire county. In addition CGIA processed and delivered a higher resolution MrSID County Mosaic at 50:1 compression to seven counties.

### *2010 Variations:*

In 2010 a number of requests were to deliver a lower resolution 100:1 compression MrSID County Mosaic mainly to accommodate smaller file sizes. Specifically one instance was to accommodate disk space for mobile applications. CGIA responded in 2012 by delivering a 100:1 standard. As noted above, this request was reversed by seven counties.

### *Future Recommendations:*

CGIA will request from the Primary PSAP contacts a choice of either 100:1 or 50:1 compression mosaics prior to MrSID development. In addition, CGIA will work with the NC 911 Board to determine the feasibility of eliminating the 60-day period in future phases.

## **6.5. Sharing Products with State and Federal Partners**

CGIA will continue to work with its state and federal partners including USGS, through its Earth Resources Observation and Science (EROS) Data Center, the NC Division of Forest Resources, NCDOT, the NC Division of Coastal Management, and others to insure and satisfy the NC 911 Board's vision to provide imagery to agencies and citizens of North Carolina.

### *2010 Variations:*

CGIA recognized the NC Department of Cultural Resources (NCDRCR) as a strategic partner to assist in archiving the imagery as the Program progresses. The recommendation for the future is to contract with the NCDRCR to archive the 2010 data as each Phase is complete. In other words, as Phase 1 completes, archive the coastal counties from 2010.

## **6.6. Loading Data into NC OneMap Database/IT Solution**

Imagery and related geospatial data are hosted and served by the ITS enhanced information technology solution for NC OneMap. The files loaded to the server are TIFF with JPEG compression for the best combination of performance, file size, and versatility. The native format (GeoTIFF) tiles for Phase 1 totaled almost 6 TB of disk storage space. These files are not loaded on the server, but are retained by CGIA on portable disk drives. In order to satisfy the goal of the NC 911 Board to provide access to imagery to all citizens of North Carolina, the storage of data on ITS servers is critical. ITS maintains two servers located at the Eastern and Western Data Centers. The NC 911 Board has recognized storage and data retention as a fundamental cost requirement and funds the storage and backup through the portions of the schedule when data is live. At the closeout of the contract, those costs are retained by CGIA until the next phase at which time the data transitions from static to dynamic.

## 7. NC OneMap

The NC OneMap Geospatial Portal located at:

(<http://data.nconemap.com/geoport/catalog/main/home.page>) satisfies the vision of, and provides the technical means for, organizing and providing access to fast statewide, high-resolution imagery for all citizens of North Carolina. The NC OneMap information technology enhancements were focused on that objective, with priority on free, fast access to imagery services and downloadable files.

Like 2010, the NC OneMap team contracted with Esri to develop customizations to the Geospatial Portal to serve two broad needs. The first was to upgrade tools to automate discovery and access to information. Specifically, the NC OneMap Geospatial Portal customizations included and/or accomplished the following:

1. preview and download imagery from multiple calendar years (Figure 5)
2. doubled the download area of interest from 20 square miles to 40 square miles
3. get instant map and image service status
4. browse collections from A to Z
5. perform type ahead searching
6. view the five most recent transactions
7. updated the instructional videos

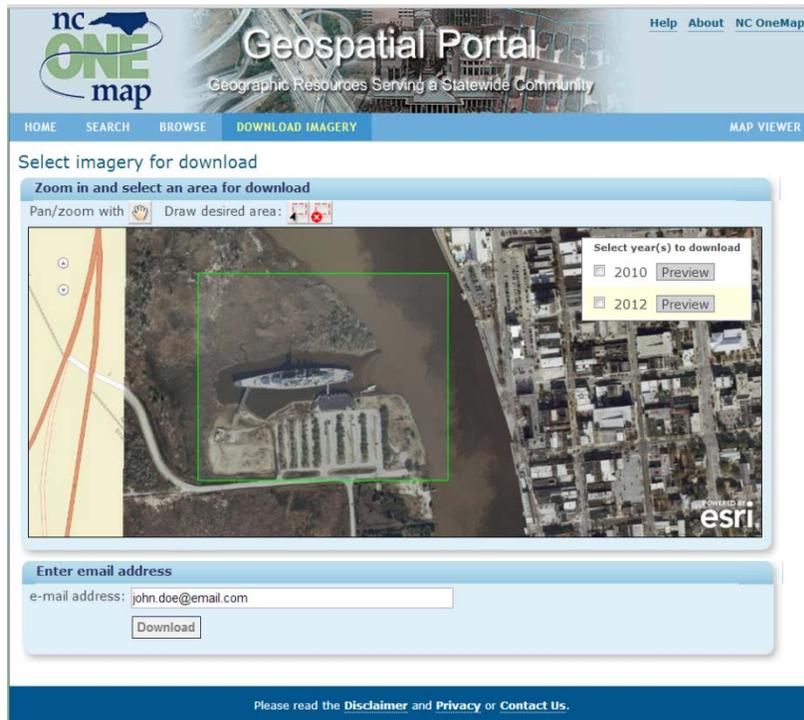


Figure 5: NC OneMap Geospatial Portal Download

The second customization was to update the inventory of high resolution imagery with 2012. As each successive phase of the Statewide Orthoimagery Program is completed, NC OneMap will continue to maintain the inventory of Program imagery. In 2012, NC OneMap also developed new technology that allows the end-user several options for how they view and access imagery. In the past, image services were available as standalone resources. In other words, the end-user was required to access only one year at a time. In 2012, the end-user still has options for selecting any given year, but now has additional options to load a single time-enabled image service and choose from all inventoried years during the range of 1995-2012. Figure 6 demonstrates the time-enabled technology available for viewing different years. In addition, the end-user may also load image services that will display the most recent source of imagery. For example, as the user moves out of the Coastal 2012 study area, the imagery will transition to 2010. For the technical end-user, these choices or image services can be found at [services.nconemap.com](http://services.nconemap.com).

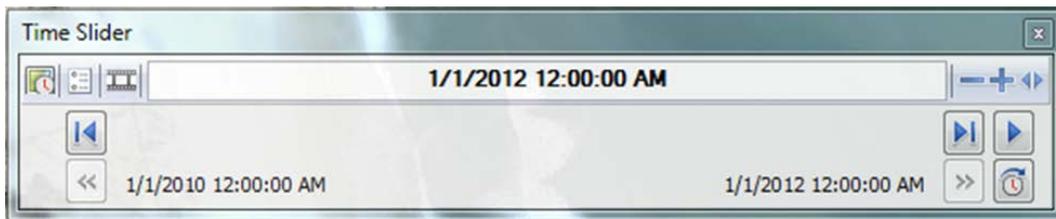


Figure 6: Time Enabled Imagery Toolbar

## 8. Summary

The Coastal Orthoimagery 2012 project established a firm foundation for the four-phase update of the 2010 statewide orthoimagery product. The project was led by a team of state agencies and supported by private sector contractors that produced orthoimagery to the statewide standard. The standard was approved by the Secretary of State, adopted by the Geographic Information Coordinating Council and endorsed by the NC 911 Board.

The project team delivered 15, 412 tiles of orthoimagery covering 13,583 square miles in the winter of 2013. This area included 29 PSAPs and encompassed 25 counties in the coastal plain. Almost 90% of the tiles passed the quality review process following review by the contractor, CGIA, NCDOT, and the PSAP and county GIS reviewers. The data was loaded into the NC OneMap data resource for widespread accessibility in the spring of 2013.

The project team performed an internal assessment of the project, yielding lessons learned and recommendations for improvement in the areas of project planning/management, engagement with military installations, image acquisition and processing, quality control, and NC OneMap implementation.

The Coastal Orthoimagery 2012 project was completed on time and under budget with a product that meets the needs of the PSAPs for current, consistent, accurate, and complete orthoimagery. The product has added benefits for many stakeholders beyond the 911 community.

## 9. Acknowledgements

This project achieved success as a result of the effective collaboration and teamwork among public agencies and private sector service providers. The project team would like to recognize the following participants for helping keep the project on task, on time, and within budget to the benefit of all.

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## 10. Appendix: Definitions

### Aerial Photography

Aerial photography is any photography taken from the air. Typically, aerial photographs are taken with specialized, high-quality, large format cameras that point down vertically from the aircraft to the ground below. Orthophotography is derived from overlapping vertical aerial photography. Digital cameras are becoming more prevalent than film cameras for projects in North Carolina.

### Aerial Triangulation

The primary purpose of aerial triangulation (AT) is to compensate for errors in ground positioning of the imagery. GPS positional data is processed against the stationary GPS base stations established throughout the project area. Also, data from the sensor (camera) is processed to provide the continuous orientation and position of the sensor throughout the flight of the aircraft. The orientation and position is used with the raw imagery data to produce a georeferenced image. The triangulation process involves multiple viewing angles and point matching to produce a network of image points. Ground control points are also integrated in the processing to produce imagery that fits the terrain within accuracy specifications.

### Continuously Operating Reference Station (CORS)

The National Geodetic Survey (NGS), an office of the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service, coordinates a network of continuously operating reference stations (CORS). Each CORS site provides Global Navigation Satellite System (GNSS - GPS and GLONASS) carrier phase and code range measurements in support of three-dimensional positioning activities throughout the United States and its territories. Surveyors, GIS/LIS professionals, engineers, scientists, and others can apply CORS data to position points at which GNSS data have been collected. The CORS system enables positioning accuracies that approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically.

### Datum

A set of constants specifying the coordinate system used for geodetic control, i.e., for calculating the coordinates of points on the Earth. This project uses the standard datum for orthoimagery in North Carolina: North America Datum (NAD) 1983 with the readjustment from 2007 (National Spatial Reference System (NSRS) 2007).

### Digital Orthoimagery (DOI)

Digital Orthoimagery is a remotely-sensed digital picture, stored in a raster data format. It is a geo-referenced image prepared from a vertical photograph or other remotely-sensed data in which displacement of objects due to sensor orientation and terrain relief have been removed.

### Digital Elevation Model (DEM)

Digital Elevation Model is a sample of ground elevations points used to model a land surface. It is a required element in the processing of digital orthoimagery based on the accurate identification of control points in the images whose ground positions are accurately known. North Carolina has statewide elevation datasets derived from Light Detection and Ranging (LIDAR) technology.

### Geographic Registration

Registration is the spatial referencing of an orthoimage to an area on the earth's surface. An image must be geographically registered in order to use it in a GIS as an overlay.

#### Global Positioning System (GPS)

A system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

#### Ground Control Point

Points of accurately known geographic location used to register imagery and other coverage data to ground position. In preparation for flights, white panels are placed in visible locations (ground control points) and their positions are surveyed and recorded. For quality control, aerial imagery contractors compare the geospatial location of the ground control points in the imagery to the recorded locations. Third party horizontal quality control may use the ground control points and other recorded reference points to check the accuracy of visible locations in the imagery.

#### Ground Sample Distance (GSD)

Ground sample distance is the area on the ground represented by each pixel in a digital orthoimage. The smaller the pixel, the more detail is visible in the image. North Carolina requires pixel of one-foot or smaller, and 6-inch and even 3-inch pixels are prevalent over urban areas. This project uses 6-inch GSD.

#### High Accuracy Reference Network (HARN)

The HARN is a statewide network of survey monuments measured to an extremely high level of accuracy with respect to, and as part of, a similar nationwide network of high-accuracy points. The positions of these monuments are established using Global Positioning System (GPS) and other sophisticated space-based measuring technologies. HARN is not expressed as part of the datum for this project (NAD 1983, NSRS2007).

#### Metadata

Metadata is information in standard format about the content, quality, and condition of a dataset. For imagery, metadata includes when and how images were captured from aircraft, processing, extent, contact information, and other items that inform users of the imagery products.

#### Multi-spectral

Digital orthoimagery collected in multiple bands, with each band corresponding to a portion of the spectrum. Various band combinations may be combined to assist in the identification of specific ground features, via automated image processing techniques.

#### Natural Color

Natural color is derived from three (red, green, blue) of the four digital bands captured by digital cameras. Commonly used for inventory analysis, cartographic verification, and data verification. Especially useful for showing man-made features, which typically occur in a wider range of colors than natural features.

#### Orthoimagery

An orthoimage is remotely sensed image data in which displacement of features in the image caused by terrain relief and sensor orientation have been mathematically removed. Orthoimagery combines the image characteristics of a photograph with the geometric qualities of a map. An orthoimage or orthophoto is an aerial photograph (or digital image) geometrically

corrected ("orthorectified") such that the scale is uniform: the photo has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthoimage can be used to measure true distances, because it is an accurate representation of the earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt. Orthoimagery is commonly used in the creation of a Geographic Information System (GIS). Software can display the orthoimage and enable an operator to digitize or place line work, text annotations or geographic symbols (such as hospitals, schools, and fire stations).

**Panchromatic**

A film type which renders imagery as gray scale. It generally provides the best resolution and least amount of storage space.

**Pixel**

A pixel is a two-dimensional picture element that is the smallest non-divisible element of a digital image. For this project, a pixel represents 6 inches on the ground, and each 5,000 by 5,000-foot tile has 10 million pixels.

**Positional Accuracy**

This refers to the variation that can exist between coordinates for a feature on the image to the actual location of that feature on the earth's surface.

**Public Safety Answering Point (PSAP)**

A public safety answering point is a call center responsible for answering calls to an emergency telephone number for police, firefighting, and ambulance services.

**Remote Sensing**

The process of collecting data about objects or landscape features without coming into direct physical contact with them.

**Scale**

Scale is the ratio of distances on a map to those same distances on the earth's surface. Ground resolution relates to mapping scale. For example, a map scale of 1 inch on the map = 200 feet on the ground is equivalent to an image ground resolution of 6 inches (pixel size). A scale of 1-to-400 is equivalent to 1-foot resolution. A scale of 1-to-100 is equivalent to 3-inch ground resolution.

**State Plane**

A coordinate system (grid) of plane rectangular (x, y) coordinates for pre-determined zones in each of the 50 states. Local governments in North Carolina use state plane with map units in feet.

**Tile**

Images are subdivided into smaller units to reduce the physical file size and the amount of computer processing required. Tiles usually cover a regular rectangular grid. The tile size for 6-inch resolution images in North Carolina is 5,000 feet by 5,000 feet.

Sources: NC Center for Geographic Information and Analysis; adapted from New York State Geographic Information System Clearinghouse; the Federal Geographic Data Committee glossary; USGS metadata records, and various project documents.