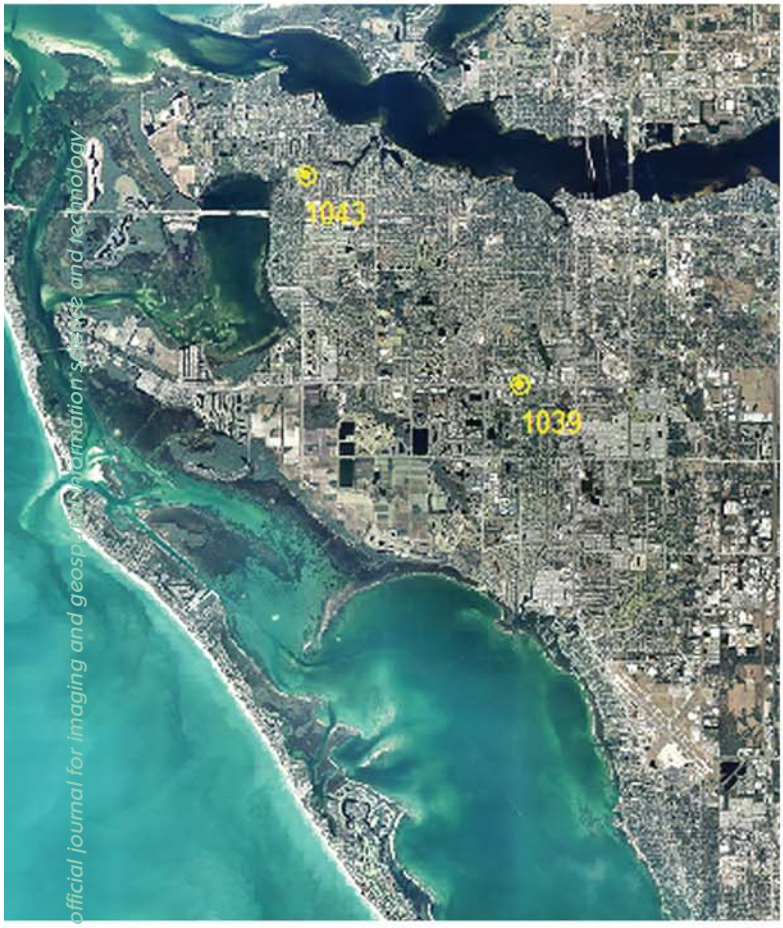
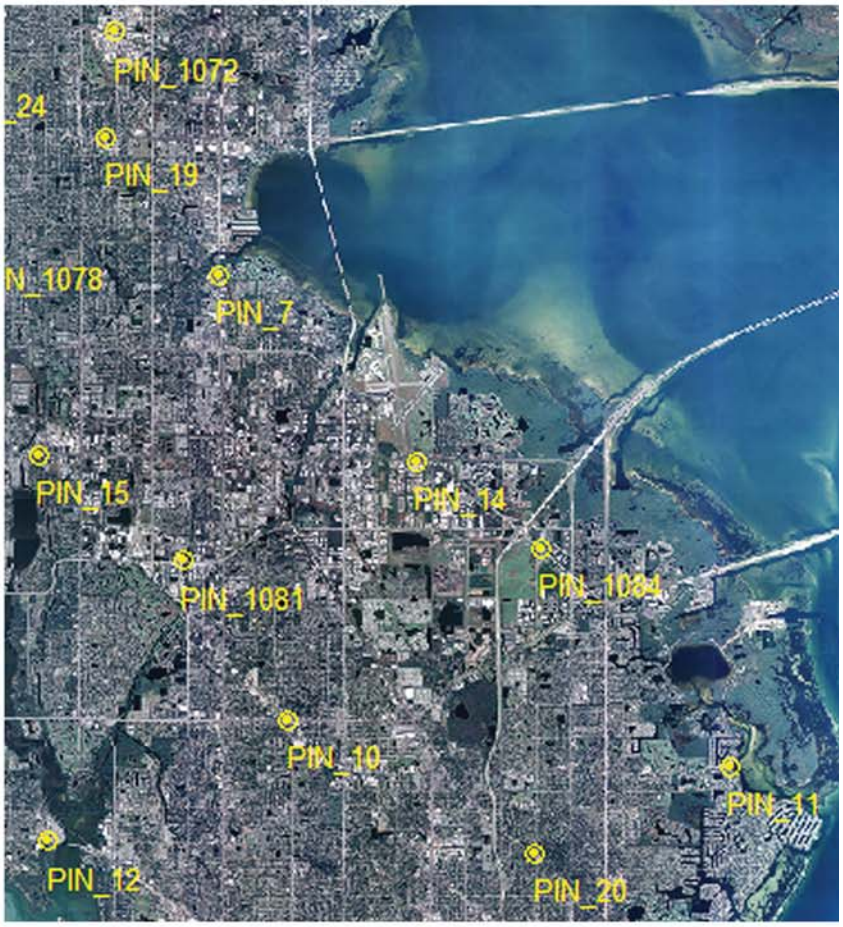
PE&RS

October 2010 Volume 76, Number 10





The official journal for imaging and geospatial information science and technology

Photogrammetric Engineering & Remote Sensing

This month's cover shows large-scale orthophotos with QC checkpoints

of large- and small-area collections.

The upper two images show orthophoto mosaics of Southwest Florida coastal counties, courtesy of Photo Science. The lower three images show a small-area collection conducted by a new helicopter-mounted camera system, courtesy of Merrick. In both cases, orthophotos were verified using checkpoint data, the labeled dots, in Accuracy Analyst™. Photo Science used the tool for verifying final products. Merrick used the tool for calibrating and verifying products from a new imaging system. Accuracy Analyst is the first software product from Spatial Information Solution (SIS) of Starkville, Mississippi. The software replaces lengthy and inconsistent manual methods of accuracy verification; it also streamlines related tasks currently conducted using a wide assortment of non-integrated tools. It provides capabilities for integrating, automating, and streamlining workflow for consistent and standardized approaches for planning and using checkpoints, verifying and documenting orthophoto geolocation accuracy, and enhancing quality control and assurance practices. These capabilities are being deployed by data producers and customers to provide a shared analytic solution for improving the delivery, review, feedback and acceptance of next generation mapping products.

For additional information, contact Spatial Information Solutions (info@spatialis.com) or visit the website at http://www.spatialis.com.

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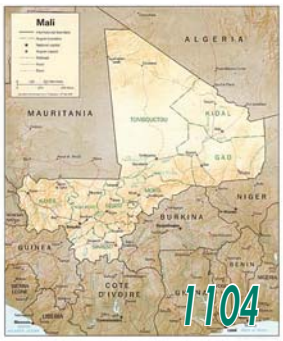

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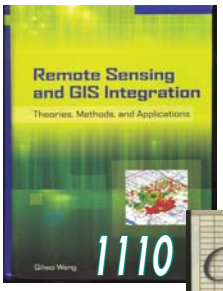

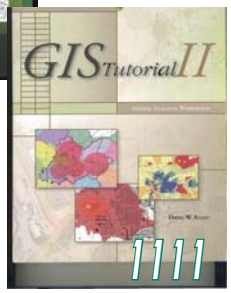

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Integrated Technologies for Orthophoto Accuracy Verification and Review

By Charles G. O'Hara, Tina Cary, and Karen Schuckman

"The Floodplain Mapping Program and the Department of Transportation have already indicated that the reports automatically created by Accuracy Analyst™ are acceptable...In other words, the use of this single package let us deliver more analytical results than we could manually, all in a standardized report that meets agencies' needs, while at the same time simplifying the process."

Orthophoto Accuracy Verification and Review

Need and Status: The National Digital Orthophoto Programs (NDOP) make use of data from the National Agriculture Imagery Program (NAIP) of the U.S. Department of Agriculture, the USGS National Orthoimagery Program, the National Digital Elevation Program (NDEP), Homeland Security (133 Urban Areas), the Federal Emergency Management Agency (FEMA) Flood Map Modernization Program, the Census Bureau MAF/TIGER Modernization Program, and many other state and local mapping programs.

Rapid growth in mapping for a wide range of applications drives demand for the acquisition and broad use of high-accuracy orthophotos. Whether for agriculture and resource management, emergency 911, asset and infrastructure management, internet and mobile mapping, or purely for base map updates, the production of accurate and up-to-date orthophotos for map content is growing at a similarly rapid pace. At scales from local to national, producing and verifying accurate and up-to-date orthophotos has relevance to a great number of experts and consumers.

Traditional methods of verifying spatial accuracy and performing quality control/quality assurance (QA/QC) require days of labor, and employ a sequence of procedures cobbled together from a hodgepodge of software tools; procedures vary from organization to organization and the results vary from person to person and company to company.

New Solution: Spatial Information Solutions (SIS) of Starkville, Mississippi, identified an opportunity created by the growing demand and industry need and developed a simple-to-use software tool that quickly verifies orthophoto accuracy using industry-approved methods and generates detailed statistics and informative reports. Benefits of *Accuracy Analyst*™ are being reaped by all participants in the North Carolina statewide 6" (15cm) orthophoto mapping project by providing a consistent, standardized verification tool for orthophoto quality control and assurance.

Accuracy Analyst utilizes surveyed checkpoints in a streamlined workflow for rapid photo location of surveyed features. Offset between the surveyed location and the image location of checkpoints is used to quantify geolocational accuracy, assure contract compliance, and generate comprehensive reports. To complement the error analysis capabilities, this software has four modules that increase efficiency of the entire QA/QC process from start to finish: *CheckPoint Planner*, *PhotoBook*, *Report Generator* and *ReViewer*.

This software provides a common analytical framework among all project participants to plan projects, to complete internal product accuracy verification and quality control, and to deliver data with a common/shared analytic capability for enhanced delivery, review, and acceptance. Consolidating workflow practices saves labor hours, provides quantitative repeatable results, and provides a single tool in place of the current assortment of manual methods and un-integrated tools.

North Carolina Project

North Carolina is conducting a 6-inch digital aerial color orthophotography acquisition statewide as part of emergency 911 mapping updates. The project involves selecting many data contractors and sub-contractors to complete the acquisition and processing. All of the contractors are required to use similar camera systems, but system components and data production systems vary among the contractors.

The North Carolina Geodetic Survey (NCGS), a division of the Department of Environment and Natural Resources, is providing independent quality control for the statewide effort. One aspect of the quality control involved having all contractors acquire and process orthophotos over a camera

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validation range. NCGS used *Accuracy Analyst* and checkpoint data to rapidly qualify all contractors' acquisition platforms and to assure that the contractors' data production processes result in data that meet project specifications. Steven Kaufman, GISP (Certified GIS Professionals), GIS Manager at the NCGS, indicated that the manual procedures used previously required several different software packages and the new automated process reduces time and human error factors.

Another aspect of quality control is the collection of 30 checkpoints for each of North Carolina's 100 counties (Figure 1). Each county's checkpoint library will enable countywide orthophoto data to be verified using *Accuracy Analyst.* In this way, all of the verification reports will have the same information in the same format. Kaufman said, *"The Floodplain Mapping Program and the Department of Transportation have already indicated that the reports automatically created by Accuracy Analyst™ are acceptable."* He summarized by saying, *"In other words, the use of this single package let us deliver more analytical results than we could manually, all in a standardized report that meets agencies' needs, while at the same time simplifying the process."*

Accuracy Analyst *addresses this problem by providing standard and consistent approaches that are readily understood by all participants and may be adopted in a cost effective and efficient manner.*

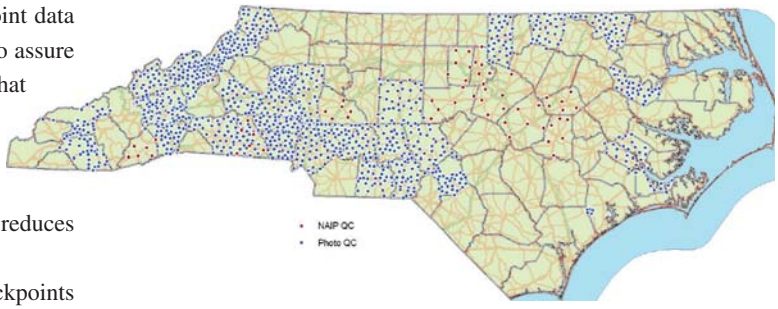

Figure 1. Early status map of NCGS checkpoints. (Courtesy of Steve Kaufman, NCGS)

Accuracy Analyst

Accuracy Analyst enables planning, collection, and use of ground control and checkpoint data for accuracy verification. *Survey CheckPoint Planner* (Figure 2) enables the use of existing imagery to identify locations for surveying ground control and checkpoints that may be identified in new image data. The tool enables planning locations, creating reports to direct the survey process, and using ancillary polygon, line, and point features for optimizing the process.

Flight lines and partial transparency of polygons of planned aerial photo footprints allow easy identification of areas of overlap. Identifying these areas for collection of control and checkpoints can result in better coordination with surveying teams and in better planning and col-

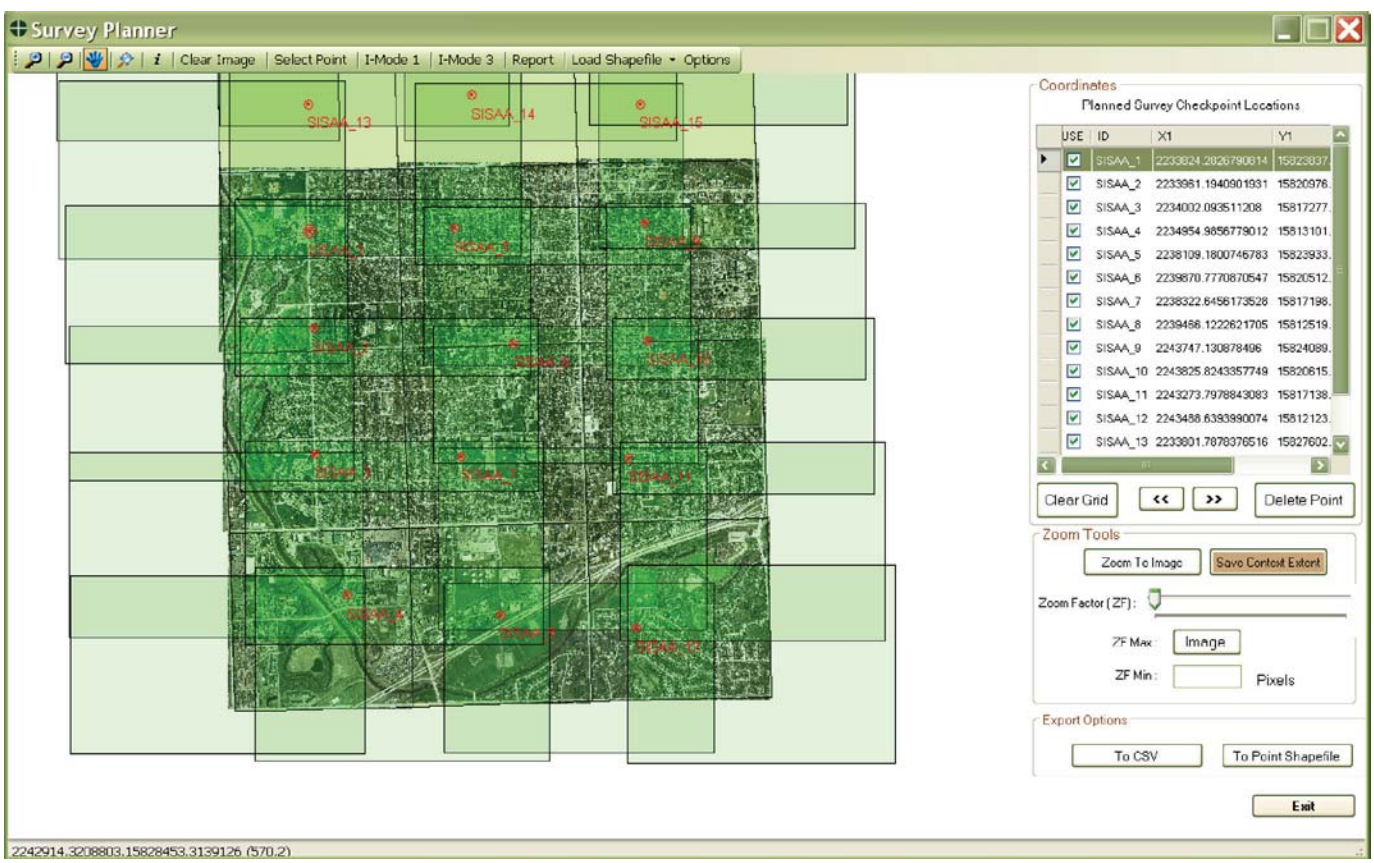

Figure 2. *Survey CheckPoint Planner* showing existing imagery and semi-transparent polygons of mock planned aerial image footprints. Additive transparency highlights areas of overlap useful to plan collecting survey locations most beneficial for data processing and accuracy testing and verification.

Figure 3. *PhotoBook* presents ground photos from the checkpoint library for the current location (SF3-32) for selection of surveyed locations used for offset error analytics.

"To fully implement a new model for delivery, review, feedback, and acceptance some amount of coordination and cooperation is needed among production managers, project managers, and their customers. This new set of methods will add value to the delivery process and will enable all parties to readily get 'on the same page' about the products."

lection of photopoints useful for testing and improving aerial triangulation, bundle adjustment, and final production accuracy verification.

Collecting and using checkpoints, developing industry-wide best practices, and extending the usefulness of checkpoints and survey data in general for mapping data verification is a major focus of continued enhancements in *Accuracy Analyst*.

An integrated *PhotoBook* shows ground photos of each survey checkpoint location, greatly enhancing the capabilities of analysts to rapidly pick the photo locations of surveyed checkpoint features in orthophotography. This tool (Figure 3) effectively presents survey locations to the user in a way that makes the selection of photo identifiable points quick and easy. The time to select photo-identifiable locations is reduced and operator uncertainty is eliminated. The contents for *PhotoBook* are easily managed, appended to add information, photos, and comments, and provide an extensible way to manage information and content useful for map data verification.

The analytic interface (Figure 4) enables analysts to select and zoom to the image area around a checkpoint of interest (SF3-36). The application displays coordinates and offsets in the data frame, complete accuracy statistics, and plots explaining circular error distribution as well as geographically varying error shown in the vector offset plot. Accompanying image chips (iChips) shown to the right are easily generated based on the context extent saved using the zoom factor slider bar interface. *PhotoBook* ground photos of survey locations have added speed and certainty to locating surveyed features in aerial images.

Report Generator delivers easy-to-comprehend, consistent, and fully documented PDF (Portable Document Format) reports (Figure 5). These reports include tabular, graphical, and statistical contents that are readily understood and are standards-based, complying with National Standard for Spatial Data Accuracy (NSSDA) accuracy verification requirements (Federal Geographic Data Committee 1998). Photo Science, a primary

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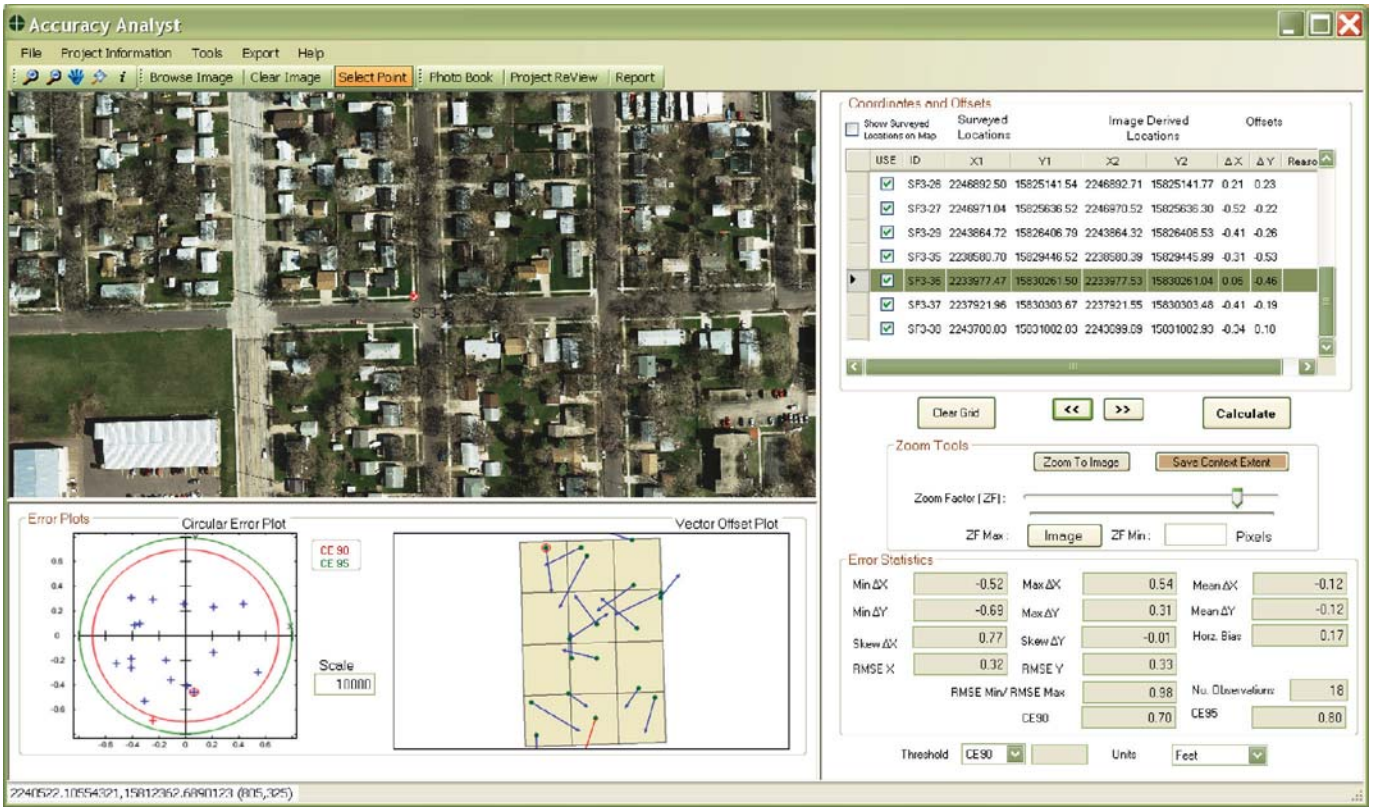

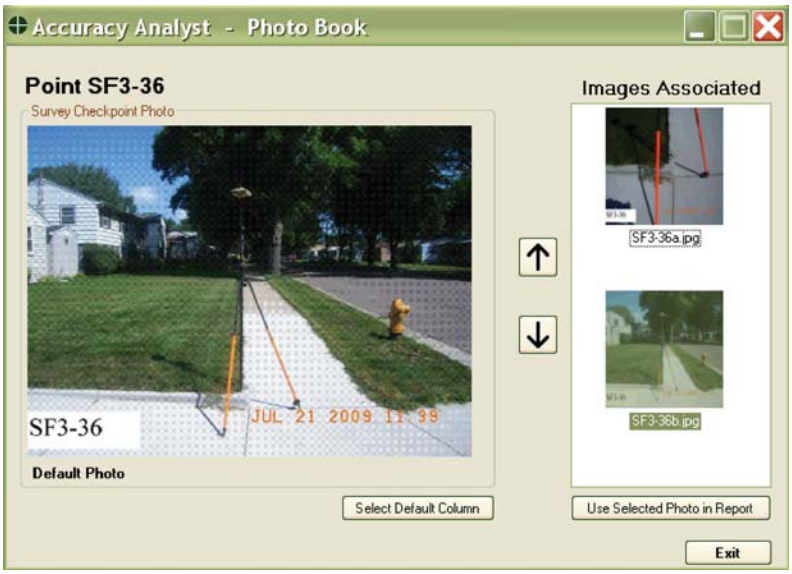

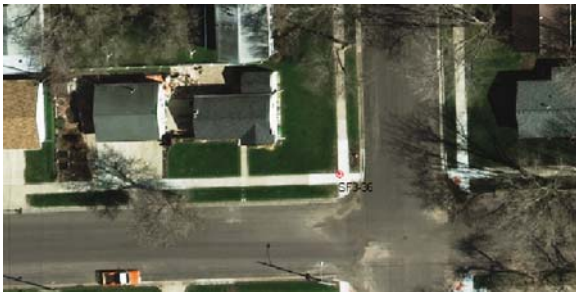

Figure 4. ***Accuracy Analyst*** **interface, iChips, and PhotoBook contents.**

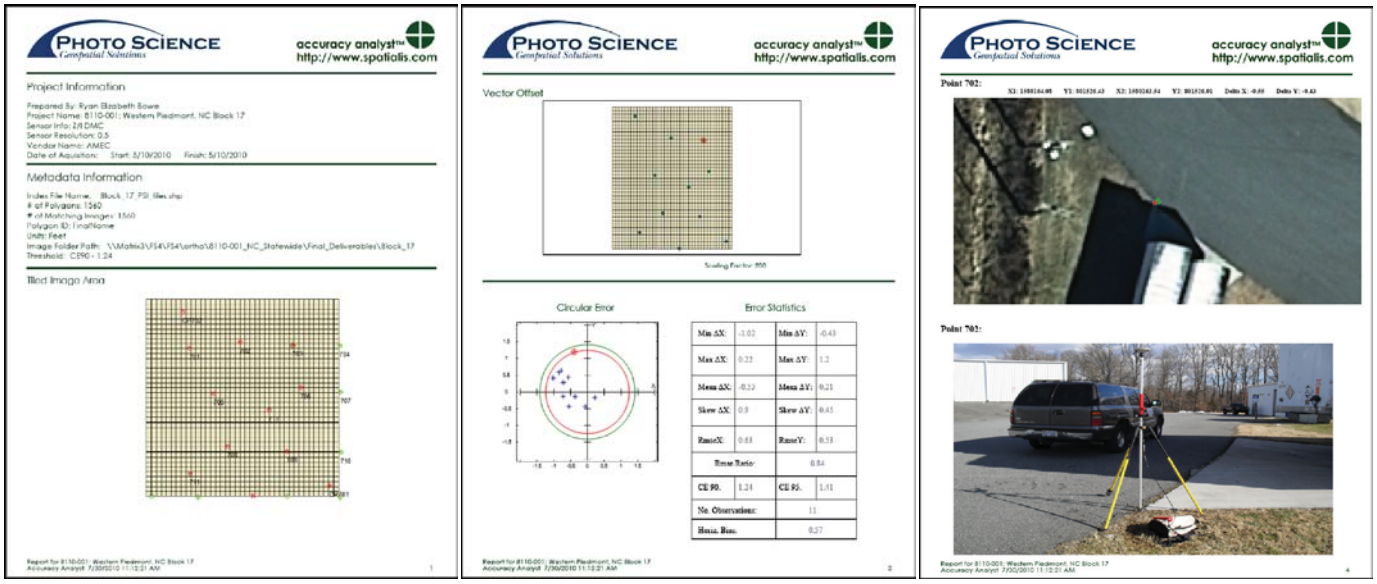

Figure 5. Report output for Block 17, Western Piedmont, NC. (Report Courtesy of Ryan Elizabeth Bowe, Photo Science)

data contractor on the North Carolina statewide mapping project, uses this software for data accuracy verification and reporting. Ryan Elizabeth Bowe, a GIS Technician for Photo Science, noted that the reports for the North Carolina project will help clearly verify that products meet accuracy and quality specifications for the project.

Reports are standardized, always having the same information in the same order. The first section includes

- project metadata,
- summary information about the image data,
- the index tile showing checkpoint locations,
- error plots for circular error and vector offsets, and
- full statistical reporting.

Subsequent sections of the report include a complete data table of locations and offsets, image chips of checkpoint locations, positions of the survey checkpoints and the photo identified locations, and the X and Y offsets.

ReViewer provides an interface (Figure 6) for standardizing quality control procedures as well as a mechanism for delivery, review, feedback, and acceptance of orthophoto projects. According to Chris Schnell, Imaging and Terrain Manager for Aero-Metric, the ability to send different parts of large area data blocks to different editors potentially at different office locations requires that edits and call-outs from multiple sources be readily consolidated into a single view for each block and summarized across large projects.

The Old Model – Disk Shipment: This new software overcomes current "disk shipment" industry delivery practices which include no standard methods, consistent platforms, or automated approaches for review, feedback, and acceptance. To fully implement a new model for delivery, review, feedback, and acceptance some amount of coordination and cooperation is needed among production managers, project managers, and their customers. This new set of methods will add value to the delivery process and will enable all parties to readily get "on the same page" about the products.

Comments and input from users enabled SIS to compile feedback, and subsequently release an incremental update of the software that delivers enhanced reviewing tools for placing user-identified call-outs (point locations) and capabilities to incorporate ancillary shapefiles for enhanced planning and review. A full set of options enables users to develop customized lists of call-outs that are easily selected from a form that opens each time a new review point is added to the session. Options may be saved as custom configuration files relevant to specific customers or project types. In addition, the tool supports distributed quality control through export of session call-outs as a comma separated value (CSV) file which may then be consolidated with other call-out lists from multiple sources and loaded to provide an overall view of all quality control issues for a given orthophoto data block.

Users and industry experts suggested that the development of these capabilities would provide a common analytical framework for data vendors to plan projects, enhance internal product accuracy verification and quality control, and deliver a common/shared analytic capability to customers and/or independent verification firms for enhanced delivery, review, and acceptance.

Shared Analytics

From earliest phases of a mapping project in which flight plans are generated and used to plan project survey control to final product delivery, the Accuracy Analyst Project file (AAP file) enables data and the AAP file to be used to support various workflow tasks and be shared for efficient use and completion of work. With the North Carolina project, the use of the technology by the customer and all major production contractors demonstrates that the benefits of the technology are compounded by the use of the tool across workflow tasks and more so when data, project files, and results are exchanged between project participants in a shared analytics mode.

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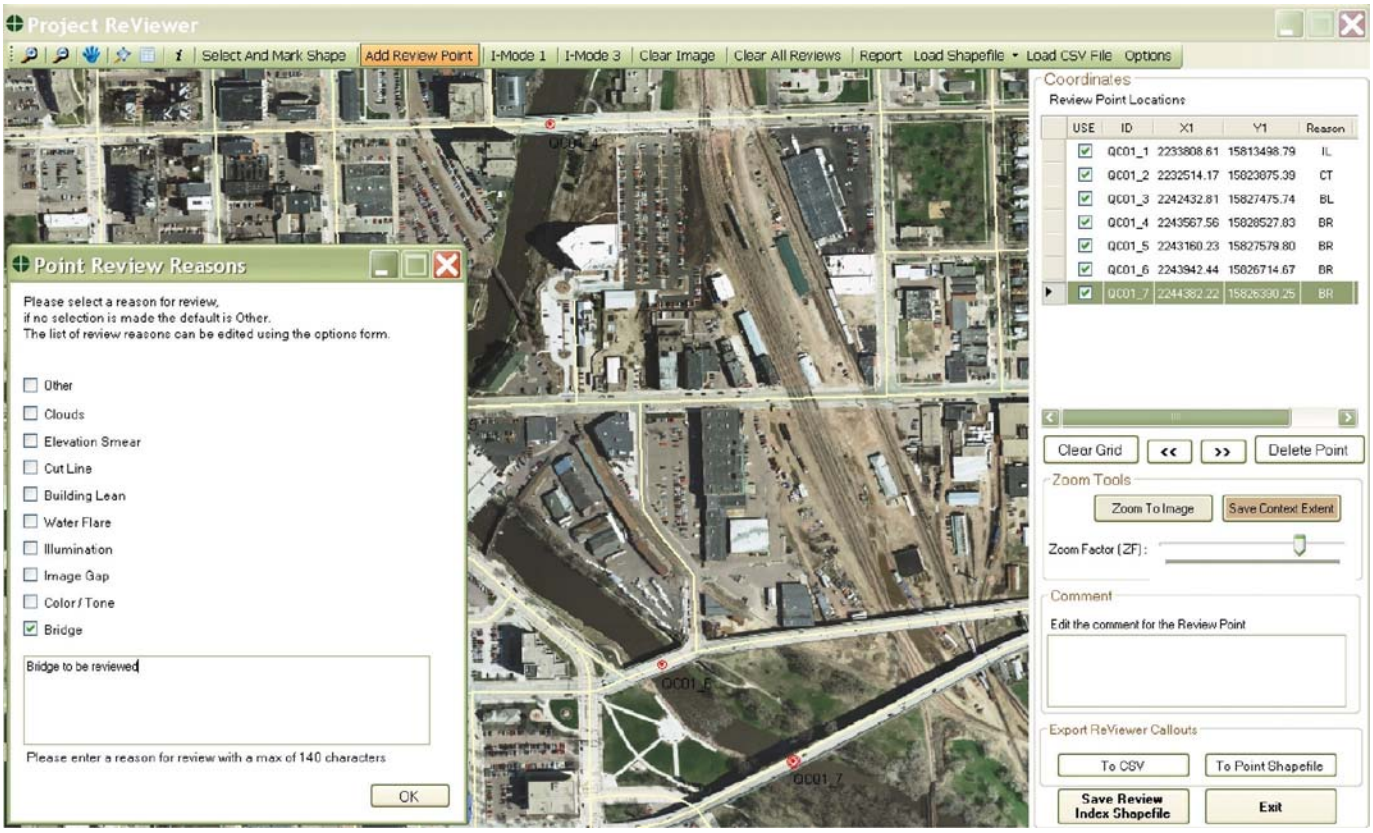

Figure 6. Interface for *ReViewer* showing a zoomed-in view of orthophoto data, use of the "Add Review Point," and the form for Point Review Reasons which allows the QC analyst to easily insert a point for a desired call-out type as well as comments for the specific point of interest.

Whether for local, statewide, or national efforts, the participants in a mapping project typically include one or more data customers, production contractors, sub-contractors, and verification contractors. Each participant has a different role to play in a project and each role can benefit from the shared analytic capabilities of a flexible accuracy verification and quality control and assurance tool.

Data Customers order and contract for aerial image data and orthorectified image products. Planning the data acquisition project and developing specifications and requirements, implementing qualifications for contractors, and determining the number of and requirements for contractors are responsibilities of the customer. The services and support of a verification contractor can be vital to ensuring that projects deliver the best data possible. The customer may employ this software to plan, acquire, and use checkpoint libraries for data verification. Further, the tool may be used to qualify data contractor systems, processes, and products. The customer may develop project specifications that require standardized verification and QC results to be provided with data products to the customer as well as to a verification contractor.

Production Contractors collect and process data and are responsible for creating final products. Production contractors plan their data acquisition including flight planning, field surveying, and coordinating and directing the orderly work of any sub-contractors they may engage. Each production contractor may have significantly different internal workflows and methods for planning, production, data verification, and quality control of final products. Production contractors using this software can standardize planning, collection, and use of control and checkpoint data and the generation of reports for all contractors and their sub-contractors.

Delivering Accuracy Analyst project (AAP) files with data and products is a core component of using the tool in a shared analytic mode. Providing AAP files along with data can enable rapid cross-verification and a common understanding between contractor and subcontractor as well as with the customer and verification contractor about delivery products, documentation, and verification protocols; this common understanding results in an improved pathway to data acceptance and payment.

Sub-Contractors work under the direction of production contractors to collect and process data consistent with overall project requirements and specifications. The quality and accuracy of the final products delivered to the customer remain the responsibility of the prime production contractor. Sub-contractors may use this software to ensure that their products meet project requirements and to provide a smooth hand off of data to the prime production contractors for whom they work. Standard methods and practices as well as consistent approaches for reporting and exchange can only help sub-contractors to fulfill their role in a major mapping project.

Verification Contractors work for the customer and with production contractors to coordinate data production and delivery, verify that data and products meet specifications, and provide overall assurance and documentation of the finished products. They may also work with the customer in early planning phases to develop specifications and requirements; to assess likely number of contractors needed; and to implement methods and approaches to ensure contractors' qualifications and procedures for data verification, data review, feedback, and acceptance. Verification contractors may leverage this technology to standardize and streamline all aspects of the verification workflow, coordinating delivery of data along with shared analytics capability to review producer's reported accuracy and any QC call-outs or features that are by standard practice highlighted for review in the delivery. Given an AAP file with each delivery, and data structured and standardized, the verification contractor may work closely with the customer to review vendor accuracy, substitute the customer's independent checkpoints and efficiently cross-verify the data for greatly enhanced certainty about the accuracy and quality of products as well as reduced time to make delivered products available to end users.

Shared Analytics among all participants in a mapping project facilitates orderly planning, verification, quality control, quality assurance, delivery, review, and independent cross-verification of orthophoto projects. Whether for large-scale, small-area projects; large scale, multiple production contractor projects; or statewide and national mapping programs, *Accuracy Analyst* supports shared analytics and delivers consistency, standardization, coordination, and efficiency benefits to managed workflow solutions.

Novel Uses

Of interest to the imaging and mapping community are the new applications of the software that users are discovering that include the following:

- Rapid verification that camera systems, data acquisition, and production processing deliver data products that meet requirements and specifications.
- Testing the results of image compression on the ability to effectively photo-identify checkpoint locations for accuracy verification.
- Testing data from new camera and acquisition systems; using the tool in unanticipated ways to conduct in situ calibration.
- Integration of survey field notes in *PhotoBook* by scanning and saving survey sketches and including images in checkpoint libraries.
- Image chip (iChip) generation for enhanced quality control, comparing accuracy and quality of images collected over time, or testing the impacts of compression or other manipulation on geolocation accuracy of orthophotos.

Conclusions

With the growth of digital camera use for large scale mapping projects (whether for local, statewide, or national programs), verifying data platforms and processing methods as well as resultant products has become a necessity, delivering products that have been tested and verified to meet accuracy specifications in accordance with FGDC and NSSDA requirements. Project requirements for verification of high resolution, highly accurate mapping products are becoming mainstream, while methods to conduct and document accuracy verification and quality control have failed to keep up with changes in acquisition and production technologies.

Accuracy Analyst addresses this problem by providing standard and consistent approaches that are readily understood by all participants and may be adopted in a cost effective and efficient manner. The shared analytics capabilities and interoperability characteristics of the technology are continuing to evolve and the user community is actively participating to direct the enhancement of this new software in ways that will deliver further benefits to the mapping community.

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