Oregon's 2005 Orthoimagery Efforts: Raising the Standard.

R. Sounhein - State of Oregon
C. Plank - U.S. Bureau of Land Management (Oregon/Washington)

May 16, 2006

Abstract

Contemporary Orthoimagery datasets are proving to be valuable assets to government and industry groups utilizing GISes to evaluate, analyze, or update ground condition data. The State of Oregon's Orthoimagery Framework Implementation Team (OFIT) created an imagery consortium to help facilitate the acquisition and sharing of 2005 USDA National Agriculture Imagery Program (NAIP) multi-resolution orthoimagery datasets. Cooperation and coordination amongst Federal, State, and Local agencies allowed for the efficient acquisition of datasets, which would have been unobtainable otherwise.

Introduction

Digital Orthoimagery datasets generated from aerial imagery are currently being used in multiple projects ranging from emergency response operations to environmental planning services. More importantly, these datasets are serving as the base layers or foundation datasets for many GIS systems throughout the world.

Over the last several years, many states have worked with the U.S. Department of Agriculture (USDA) to acquire both two-meter and one-meter natural color or infrared aerial imagery through the Farm Service Agency's (FSA) National Agriculture Imagery Program (NAIP). Though the impetus for the creation of NAIP was to provide imagery supporting administration of the Farm Compliance programs, other levels of government have partnered with the FSA to extend the coverage of NAIP and/or increase the resolution of the imagery products. The Farm Compliance effort typically requires two-meter resolution imagery, whereas one-meter and higher resolution imagery datasets are gaining in support though out the GIS community. Most recently, the National States Geographic Information Council (NSGIC) proposed a national vision in which federal funding would support nationwide production of standardized mutli-resolution products every three years, at least partially in concert with the NAIP.

Over the last few years the State of Oregon has been utilizing both first (1994-96) and second (2000-01) generation orthoimagery datasets, created from airborne acquisition utilizing black and white film. Typically these datasets were being renewed by agencies on a five-year cycle in somewhat of an opportunistic manner, but what was really needed was a more efficient method of acquiring these coveted datasets. In early 2005 while planning to acquire the next statewide orthoimagery datasets, the State of Oregon's OFIT decided that it would be more cost effective to acquire imagery through FSA's existing NAIP program.

Methods

In order to guarantee that complete statewide one-meter imagery datasets could be delivered via FSA's NAIP program, OFIT established a consortium of Federal, State, and Local agencies to ensure that there was enough support and funding for the project. OFIT then created a non-binding, non-fiduciary memorandum of understating (MOU) between all interested parties. The MOU was supported by the Oregon Geographic Information Council (OGIC) which help to increase awareness of the effort eventually resulted in the following agencies to commit up front funding: USDA's Farm Service Agency, Natural Resources Conservation Service, and US Forest Service, the Department of the Interior's Bureau of Land Management (BLM) and the US Geological Survey, several State of Oregon agencies, numerous counties, an irrigation districts, and some Tribes.

Once enough funds were in place, FSA's Aerial Photography Field Office (APFO) in Salt Lake City was then contacted to ensure a place on the list of states that FSA would capture at one-meter in 2005. FSA plans to acquire (five year cycle) one-meter imagery for all agricultural lands in each state throughout the nation. APFO uses several vendors under a single indefinite-delivery-indefinite-quantity (IDIQ) contract to acquire either one- or two-meter data for each state.

In addition to acquiring the one-meter datasets, OFIT desired to acquire statewide, half-meter imagery datasets from infrared film. The logic was that by acquiring the datasets from infrared film we could then also derive a false natural color - infrared dataset via a colorization process. This false natural color dataset would prove useful for those agencies needing to delineate vegetation and hydrographic features. Unfortunately, because timing precluded requesting both the color and infrared datasets, and do to the fact that the entire colorization process was untested and did not meet the original contract specification, only a natural color film would be used. This state of Oregon could still acquire a half-meter dataset (non infrared), but the creation/acquisition would become their sole responsibility, requiring a separate add-on contract. The BLM took the lead on creating the specifications for this additional contract and the Surdex Corporation was awarded both the NAIP one-meter contract, and additional half-meter add-on contract.

One –meter dataset:

The first phase of NAIP deliverables, was that of the Compressed County Mosaics (CCMs), would be due approximately 30 days after the aerial photography was acquired. These CCM's are mosaic's consisting of Digital Orthophoto Quarter-Quadrangles (DOQQs) and Oregon is covered by more than 7,5 00 DOQQs, (1,875 DOQ's). This photography was flown at altitudes ranging from 20,000-28,000 (1:40,000 scale) in a north/south pattern based on the National Aerial Photography Program (NAPP) line and stationing system. The film was then scanned at 20 microns using Leica Geosystems DSW 700 scanners. Flights were initiated on June 29, 2005 and continued through August 15, 2005.

All photography was acquired using metric mapping cameras and accompanied by the collection of airborne Global Positioning System (ABGPS) data. After scanning, the imagery was aerotriangulated in blocks of 200-1,000 photographs using the Z/I Imaging ImageStation Automatic Triangulation (ISAT) software package. Orthorectification was performed with Surdex-developed software using the USGS National Elevation Dataset for the elevation model. The digital orthophotos were radiometrically balanced in groups of 100-500 images using the Inpho OrthoVista product. Custom software automatically generated the MrSID project parameter file to control the insertion of the digital orthophotos in the final mosaic. Compressed County Mosaics were generated using MrSID Generation Three (MG3) format utilizing the maximum N-level setting with a target compression ratio of 15:1. Most CCMs for the State of Oregon fit on single DVDs, with the exception of a few large counties that required several files.

Figure 1. Example of the CCM datasets (15:1) viewed at 1:13,500scale. The photo is of the Bridge over The Yaquina River in Newport, Oregon. In the bottom right corner is the Oregon Aquarium, once home of Keiko the Killer Whale who starred in the movie "Free Willy."

Half-meter dataset:

After the NAIP deliverables were completed, the film was then rescanned at 10 microns to support the half-meter imagery products. These products included the creation of mosaics in thirty-minute blocks at 50:1 compression, full DOQs in several projections, and the raw scanned imagery for the creation of stereo prints. The creation and delivery of all half-meter data was accomplished for about 25% additional cost.

Quality Assurance/Quality Control (QA/QC):

Because the half-meter imagery was acquired via an add-on contract to the original 2005 FSA NAIP contract, all QA/QC processing had to be facilitated via some of the OFIT consortium members instead of FSA's APFO office in Salt Lake. With BLM providing the lead role on QA/QC processing, each of the scanned files (a total of 15,014) were opened and checked for general location and appearance. Compressed mosaics were then checked for color balance, shifting at cut lines, spatial accuracy, areas of smearing, and for artifacts.

The standards of spatial accuracy for the half-meter products were identical to those of the one-meter NAIP contract. First generation DOQQ's, produced by USGS between 1992 and 1996 were used to check the spatial accuracy of 5 meters at a 95% confidence level. Artifacts appearing in the images came from three sources: Debris captured during the film scans, compression artifacts at the interface between image and non-image, and mosaic artifacts that appeared in images. Smearing of small areas was found in areas of high relief. Camera position for the scale often left hillsides facing away from the camera. The software would stretch the photo to fit the elevation model, resulting in smearing. Adjacent imagery was used to fill in the missing data after ray-tracing software identified the locations. The compression artifacts appeared when the background pixels were turned transparent. They were removed through reprocessing the MrSID Generation 3 files using lossless compression first, followed by an optimizing compression to reach the target level. Mosaic artifacts were also caused by the mosaic software and were eventually removed.

Results/findings:

In November 2005 the CCM were delivered to the state with the initial response being positive. In portions of the imagery there were instances of smearing or occluding present in and around slopes and rugged terrain. Surdex was apprised of this situation and promptly corrected the problems by splicing adjacent imagery into the base DOQQs. The file size for a typical USGS one-meter black and white DOQ is roughly 190MB, whereas the file size for a half-meter color DOQ is approximately 2250MB. File sizes for one-meter full county CCM products ranged from approximately one to eight gigabytes in size; counties with large spatial extents and files sizes were broken into multiple files.

After distributing the imagery to OFIT, some agencies noted problems with trying to efficiently render some of the larger imagery files via PC computers. While all the CCMs were initially compressed at 15:1 ratios, some of the files were simply too large (2-3 gigabytes) to efficiently handle. A work-around solution was to further compress those larger CCMs to either 40:1 or 50:1 compression ratios using Lizard Tech's MrSID's GEOEXPRESS application, which created image files of approximately one gigabyte in size. This resolved the problem without degrading imagery quality.

Figure 2. Same aerial view as that of figure 1, except here the image is half-meter resolution. Notice how in this higher resolution image that the arches of the bridge are now in view.

Prior to distributing the half-meter mosaic, realizing that some of the one -meter imagery mosaic (CCM) file sizes were difficult to handle, some other

Figure3. Example of a one-meter (15:1) image of the Trojan Plant along the Columbia River. Notice how the image is a bit more grainy then that of the half-meter imagery as seen in figure 4.

mosaic format other then that of the CCM would need to be utilized. It was eventually determined that rectangular thirty-minute mosaic blocks compressed to MrSID MG3 file format at 50:1 ratios, could create mosaic files sizes of approximately one-half gigabyte.

When comparing the one-meter 15:1 compressed files to that of the half-meter 50:1 compressed files, one might assume that those files with a lower compression rate would actually display a more pleasing image depiction on a computer screen. However, as it turned out, the 50:1 half-meter imagery (figures 2 and 4) displays a better resolution than that of the 15:1 one-meter imagery (figures 1 and 3). The one-meter CCMs are very useful for those agencies needing to view an entire county backdrop on a computer screen.

Quality Assurance/Quality Control (QA/QC):

Because the half-meter imagery was acquired via an add-on contract to the original 2005 FSA NAIP contract, all QA/QC processing had to be facilitated via some of the OFIT consortium members instead of FSA's APFO office in Salt Lake. With BLM providing the lead role on QA/QC processing, each of the scanned files (a total of 15,014) were opened and checked for general location and appearance. Compressed mosaics were then checked for color balance, shifting at cut lines, spatial accuracy, areas of smearing, and for artifacts.

Spatial accuracy standards for the half-meter products were identical to those standards utilized in the one-meter NAIP contract. First generation DOQQ's, produced by USGS between 1992 and 1996 were used to check the spatial accuracy of 5 meters at a 95% confidence level. Artifacts appearing in the images came from three sources. Debris captured during the film scans, compression artifacts at the interface between image and non-image, and mosaic artifacts appeared in images. Smearing of small areas was found in areas of high relief. Camera position for the scale often left hillsides facing away from the camera. The software would stretch the photo to fit the elevation model, resulting in smearing. Adjacent imagery was used to fill in the missing data after ray-tracing software identified the locations. The compression artifacts appeared when the background pixels were turned transparent. They were removed through reprocessing the MrSID Generation 3 files using lossless compression first, followed by an optimizing compression to reach the target level. Mosaic artifacts were also caused by the mosaic software and were eventually removed.

Conclusions:

FSA's APFO standardized the NAIP program datasets to one- and two-meter products to support the Farm Compliance program's administration. The Oregon experience has essentially raising the bar to a half-meter and one-meter statewide Orthoimagery standard. While the problem of efficiently acquiring statewide imagery has now been solved, the issue of making the datasets publicly available is the next major challenge to overcome. Currently the State of Oregon, OFIT, and Oregon State University (OSU) are

in the RPF planning phase of implementing a web-based imagery portal that would be hosted inside of the Oregon Explorer Web Portal housed at the Institute for Natural Resources at OSU. http://ir.library.oregonstate.edu/dspace/handle/1957/29).

Figure 4: Example of half-meter imagery of the Trojan Nuclear Power Plant with the now imploded cooling tower in the bottom right. Notice the power lines visible to the left. Image file is MrSID file (50:1 compression) at 1: 6000 scale.

This portal would then provide users with access to statewide public domain. The idea is to host imagery as public domain datasets that could be easily accessed via a COTS imagery provisioning application. OFIT believes that ultimately this approach would prove more cost effective rather than building an entirely new application.

Overall, the project has been a success for the agencies involved in the consortium; no one agency could have acquired statewide imagery without the help of others. Currently, other states (State of Washington) are now following Oregon's consortium model by creating their own consortium of agencies to acquire NAIP one-meter and half-meter photography for 2006. With the advent of web-based applications such as Google Earth and Microsoft's Teraserver, aerial imagery and Orthoimagery datasets are becoming more readily available to the public. Both Google and Microsoft Corporations have requested the 2005 NAIP imagery from the State of Oregon, further increasing the access to half-meter and one-meter statewide Orthoimagery datasets.

State of Oregon (OFIT) 2005 NAIP Imagery Procurement Process