BACKGROUND

Fugro EarthData (Fugro) was tasked as the Quality Control (QC) manager for the North Carolina statewide orthophotography project under AECOM's North Carolina contract. The main responsibilities covering this task were to ensure all orthophotography tiles were standardized in their delivery, had a percent of the tiles checked for errors, and generate MrSID tiles and mosaics for all accepted data.

To achieve the objectives Fugro designed the following process that was implemented during the orthophotography QC execution.

Macro Checks

When a processed delivery block was received the first step was to download all the data from the external hard drive. Next, a series of macro level checks were run against the imagery to ensure that the appropriate standardization criterion was followed. The macro checks performed were as follows:

- Completeness of coverage against expected
- Image size check against expected
- Ensure tfw files were provided
- Geotiff header check
    - Check for 'untiled' versus 'tiled' Geotiff
    - Check that correct datum and projection information were defined correctly
    - Check accuracy of Geotiff coordinates
- Ensure tiles were in Geotiff format and not just Tiff files
- Check to ensure tfw was provided as pixel center file
- Void check to ensure completeness of dataset
- Data completeness check against boundary files

All the macro checks were run as a batched process against the deliverable dataset. The results of the checks were reviewed by a technician to verify the errors reported. Datasets that failed a macro check were rejected, the issue/s identified, and a new dataset with corrections applied was shipped to Fugro EarthData.

Micro Checks

Once a delivery block passed the macro level checks it was ready to begin the micro level checks. Prior to receiving any delivery blocks Fugro pre-selected the tiles that would have a 100% QC performed.

The contractual obligation was for every delivery block to have 25% of their delivery tiles undergo a 100% review. To select the 25% from each delivery block Fugro utilized existing statewide shapefiles that identified features such as bridges, points of interest, urban areas, major highways, rail lines, and universities. These shapefiles represented areas that are most commonly impacted by the orthophotography production process and therefore needed to be included in the QC process. If 25% of the block tiles were not selected after applying the shapefiles then a technician randomly selected tiles until the required percent was achieved.

Fugro utilized ArcMap to do the micro checks. A technician would check out a block of images in ArcMap and do a 100% visual QC of the data. The scanning scale was 1:1000, meaning no issues were flagged if they were not clearly visible at that scale. There were several other criteria that were applied to the review as follows:

- Forest areas were of lesser concern
- Waterbodies were of lesser concern
- Artifacts created by solar reflectance in rural areas were of a lesser concern
- Snow was noted but only for metadata
- Flooding was noted but only for metadata
- Roads should not have separation

As a technician reviewed the imagery any potential issues were flagged and noted using a standardized list of common orthophotography errors. That list of flags was as follows:

- Artifact
- Turbulence
- Smear
- Blurry
- Wavy Feature
- Corrupt Data
- Missing Data
- Trans Obstruction
- Cloud
- Shadow
- Smoke
- Haze
- Snow
- Flooding
- Tile Boundary/Edge Issue
- Seamline
- Sensor Line
- Excessive Tilt
- Radiometry
- Band Registration

A comments field was additionally utilized should the technician require further detail on the flagged call.

After a block completed a full review of the selected QC tiles the flagged calls were reviewed by a senior technician. This review was done to ensure that all flagged calls were valid and within the scope of the QC work.

Once the senior review was completed a QC calls file geodatabase was output that contained all the flagged calls noted during the review. A summary report of the QC calls was prepared and the uploaded along with the geodatabase to the project SharePt site. The appropriate vendor, project PM, and state POC were notified that the blocks QC calls had been posted.

Vendors had two options based on the QC calls, correct the calls and return an updated tile or dispute the call can make a comment as to why the call was being disputed. Corrected tiles once returned were reviewed to ensure the flagged items were corrected and no new calls were introduced. When additional flags were found a second round of QC calls was sent out similar to the first round process.

The QC process continued until all the selected tiles (25% of the delivery block) passed the micro review process. Once a block was accepted the project PM and state POC were notified.

MrSID

As blocks were accepted they entered the MrSID generation phase. For all delivery blocks individual MrSID files were created using a 20:1 compression ratio. All final MrSID tiles were segregated by county. Ultimately there was a folder prepared for every county in the state containing the individual MrSID tiles.

Once a full county was accepted all the tiles were run through a MrSID mosaic process which output a MrSID mosaic with a compression of 50:1.

Final Drives

One final drive was prepared for each county in the state. The drives contained the counties individual Geotiff imagery, individual MrSID imagery, a MrSID county mosaic, metadata, flight lines, and tile index.

ISSUE/S

During the course of the quality control process there were several issues encountered in all phases described above. Below lists some of the more common issues observed.

Macro Check Issues

- The Geotiff header requirements were often wrong with key elements missing in all or a portion of the submitted tiles
- Boundary edge tiles that were partial tiles were often not cut to a smooth boundary but jagged
- There were often void areas in the data, sometimes quite large areas
- Black pixels instead of white pixels as void beyond boundary
- Void white pixels were not all 255
- Geotiffs were tiled instead of untiled
- A few areas of the coverage did not go completely to the boundary
- Extra tiles received in a delivery or tiles missing that were expected
- Incorrect tile extents and file sizes

Micro Check Issues

- There was an abundance of tiles with bad road separation
- Radiometry between blocks was quite noticeable
- Some deliveries had very sharp contrast and others were more blurry
- Harsh seam lines were visible between blocks
- Bridges, railway lines, roads and buildings were at times wavy
- Corrections often returned with the QC call not fixed and more errors introduced
- Incorrect tiles
- Artifacts – green, blue, pink lines
- Smearing
- Harsh lines along tile boundary/edge within blocks and between blocks
- Harsh lines within tiles (not edge or seamlines)
- Bright/blown out glare on roof tops
- Seamlines through buildings
- Seamlines not matching imagery
- Duplication, doubling of features

MrSID Issues

- Larger counties required systems with more memory
- Waiting for blocks to finish before counties can be generated
- Void pixel not always 255 due to compression issue
- Customer changed mosaic compression ratio after mosaics were started

Final Drive Issues

- Initial delivery by block and final delivery by county and dependent on surrounding counties created a bottleneck.
- Potentially using the incorrect county boundary file to define the county tiles.
- Additional rework occurring after some counties sent
- Recycler folder on drive, need to use system's recycle bin to clear out

RECOMMENDATION

The following are some general recommendations taking into account issues encountered and how to reduce the risk of repeating them should another similar project be undertaken.

One recommendation to resolve some of the issues encounter in the QC phase would be to provide a QC expectations document, critical files, and accompanying templates during the project kickoff. The expectations document would clearly list all macro and micro checks that would be performed and the expectation of each delivery. The document could also include screenshots from this year's project of issues that would not be acceptable in a delivery. The critical files should include a geotiff template, the final tile layout, the buffered boundary, and a metadata template.

A pilot submittal of all final deliverables is also recommended as it would serve to indentify issues with the execution of the scope of work early in the project. The pilot would also serve to show the vendors understanding of the project expectations and their ability to the templates.

There were many radiometric differences observed between vendors that could have been resolved by the use of a global histogram. Multiple radiometric pilots over different regions meant that even under the best conditions there would be distinct radiometric transition areas were one histogram segued into another. By defining a single histogram to be applied to all imagery each vendor's data would become unified in its radiometric balancing.

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