GIS Research – Image Acquisition and Processing

Contract Number: BC352 RPWO 18

May 2005

Final Report

DISCLAIMER

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
in^2	squareinches	645.2	square millimeters	mm^2
ft^2	squarefeet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	^oC

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				

fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL

TEMPERATURE (exact degrees)				
^oC	Celsius	1.8C+32	Fahrenheit	^oF

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

Technical Report Documentation Page

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16. Abstract

The GIS basemap is an Arc/INFO coverage comprised of arcs, nodes, and a route system that geographically represents the roadways maintained in the Roadway Characteristics Inventory (RCI). Because of Florida's continued rapid growth, up-to-date imagery is constantly needed to help maintain the road system and plan for the future. The purpose of this project is to research the existence, acquisition and processing of imagery that is more recent than the 1999 DOQQs.

As a result of this project the Department has been able to acquire high resolution imagery for over 40 Florida counties. An inventory of the more up-to-date imagery was created, the imagery acquired and finally reformatted for use in the Department's Transportation Statistics Office and throughout other offices as well.

The Department can now more effectively manage the basemap, which is used for several purposes, including:

- Providing a QA tool for RCI feature lengths.
- Dynamic segmentation - the creation of GIS data layers from RCI features.
- Map production.
- Creation of the State's city-to-city mileage matrix.
- Modeling.

17. Key Word	18. Distribution Statement
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19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
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Executive Summary

"Today, where the orange groves once stood, houses now stand within a few feet of one another. The wide open roads…are bumper to bumper with exhaust-spewing autos. Leisurely Sunday drives are still available, if your idea of attractive scenery is boom cranes, buildings under construction, and dirt mounds on the horizon in all directions.—Jill Krueger, writing in the Orlando Business Journal on a changing Florida[1]

Florida continues to be a high growth state with no slow down in site. The current growth rate will have Florida surpassing New York as the third most populous state within twenty five (25) years.[2] Some estimates have the state's population more than doubling the 2000 count of just under sixteen (16) million to over 32 million by the 2050. These increases in population put a tremendous strain on Florida's transportation infrastructure and increase the need to effectively plan for future needs.

Florida has [approximately] 5.5 percent of the nation's population but just 2.8 percent of the road mileage. Plans to widen roads and add lanes can't keep up with the state's population growth.[3] Florida's sensitive ecosystems and every increasingly crowed coastlines makes planning future road projects a complex and challenging task.

In planning for future road improvements and development the Department often uses aerial photography. In the past one of the main sources of that photography was from the United States Geological Survey (USGS). In 1994, 1999 and for a final time in 2004 USGS produced a set of imagery known as the Digital Ortho(-photography) Quarter-Quads or DOQQs. The coverage was complete for the state but was color infrared (not true color or black and white) and at a one (1) meter resolution. In many parts of the state the images were quickly out of date and resolution not high enough for effective planning.

The Florida Department of Revenue (DOR) has as one of its mandates the requirement to supply aerial photography to each of Florida's counties every three (3) years. In the past this imagery was not ortho-rectified (ortho-rectified: having image distortion removed through a mathematical process using the terrain of the ground). This imagery was not useful in geographic information systems (GIS). In the last two (2) years DOR has been able to improve the products delivered to the counties and now does most of its image acquisition using ortho-rectified processes and has a resolution of one (1) foot or better in most cases.

This project addresses the process of finding the more accurate and up-to-date imagery in Florida and supplying it to the Department for use in assessing Florida's road systems and planning for the future. An inventory of imagery was produced and used to track the process of modifying the imagery to meet the GIS needs of the Department. Over forty (40) counties of imagery were made available as result of this project. A naming convention was established and technical issues resolved in manipulating the imagery into products that could be integrated directly into the Department's mapping and GIS efforts.

1 Jill Krueger, "Florida Living is Wonderful—I Sure Do Miss It," *Orlando Business Journal*, January 22, 1999.
2 News-press.com, "Let Voters have a say on growth", http://www.news-press.com/apps/pbcs.dll/article?AID=/20050503/OPINION/505030328/1015 May 3, 2005
3 Rachel Webb, "Growth Means More Traffic and, Sometimes, More Problems," *Bonita Banner*, February 24, 2001.

Introduction

The Transportation Statistics Office GIS Support Section at the Florida Department of Transportation is responsible for maintaining the Florida official highway basemap. The basemap is an ArcInfo (ESRI) route coverage of the State Highway System, and is a geographic representation of the roads maintained in the Office's Roadway Characteristics Inventory (RCI). The basemap is modified daily by the Transportation Statistics Office GIS Support Section utilizing the United States Geological Survey's (USGS) digital orthophoto quarter-quads (DOQQs) as the source for editing tasks. However, the DOQQs being used were originally created in 1999 and are currently updated on a five year cycle. With Florida continuing to lead the nation in many growth areas there is often a need for more up-to-date imagery in order to keep up with the dynamic nature of Florida's roads.

More accurate and up-to-date imagery is needed to better understand what the true situation is on the ground. The DOQQs are one (1) meter in resolution and do a good job of depicting what is on the ground but break down when more accuracy is needed. Road edges blur in close up viewing of the imagery making it impossible to obtain some of the information needed for effective planning. The DOQQs use the infrared spectrum of light waves. The reasoning behind this choice over visible light (RGB) is because the infrared portions allow users of the imagery to gain more knowledge concerning vegetation (type, health) than does the visible portion. This however makes it a bit harder to interpret in many cases and can lead to confusion for those using the imagery for purposes other than vegetation analysis.

At the beginning of this project two sets of DOQQs were available for Florida: 1994 and 1999. The plans from USGS were to acquire imagery every 5 years with USGS picking up approximately half of the bill each time. After September 11, 2001 the mission and focus of USGS has been changing. Florida did manage to obtain a 2004 set of DOQQs but had to pay the entire bill with USGS acting only as the contract manager. All current indications are that USGS will not be in the business of aiding the states in the future with DOQQ acquisition. Florida is aware of this situation and is taking steps to address the high resolution image acquisition needs of the future. Without a source for current imagery, the planning and maintenance of the state's road system will be seriously hindered.

Inventory

The first step was to create an inventory of available imagery. This started with the Department of Revenue (DOR). Detailed lists were obtained that indicated the schedules for image acquisition planned for the next three (3) years. The list included who was in charge of the acquisition, the resolution it would be collected at and whether or not it would be black and white or color.

None of the imagery would be the infrared spectrum of light. This was because the DOR supplies the imagery specifically to the county Property Appraisers and, in general, they are not interested in classifying vegetation, but rather depicting where on the ground land ownership occurs. Because color photography has traditionally been more expensive to acquire, the imagery is mostly black and white. Although color imagery will tell a more complete story, black and white imagery is almost as good for planning and road design issues.

Other state departments were contacted concerning the availability of imagery. Many of them had image data sets, but because this project is specifically looking for ortho-rectified imagery, no other state agency contacted was able to provide additional data sets.

The USGS was also contract and were able to supply data for four additional counties. They are aiding the Department of Homeland Security with air photography for certain urban centers in Florida and provided data for the Tampa Bay region.

Finally each county was contacted individually and asked about the availability of more current and higher resolution imagery. Many were able to provide the data sets for this project. Several counties had agreements with the photography vendors that prohibited us from acquiring and passing along to the Department.

Documentation - Metadata Collector and Data Retrieval

The importance of metadata (data/information about data) is becoming more and more important as there is an ever increasing number of image data sets available in Florida. Descriptions of the imagery are necessary not only to keep up with what data is available, but also knowledge of details about that imagery is essential for understanding exactly what the data represents.

The concept of metadata has been around for a long time but is something that is often ignored by many data managers. The Federal Geographic Data Committee (FGDC) has developed standards for vector data but has yet to come to a consensus for raster (image) data. This project developed what we think represents a good first cut at what that standard should look like. It is comprehensive in order to capture a complete set of details about an image data set and also allows the user to enter a minimum set of information for a thumbnail style sketch of the data.

The program uses Microsoft Access and takes advantage of its forms and reports. The database is uploaded to a server at FREAC where it is then accessible to the Internet. The Internet application then allows users to search the data in a number of different ways (Figure 1). More detailed records can be displayed after a user has found an image data set of interest (Figure 2). At this time no ability has been developed to allow for users downloading the data. Because these data sets often involve multiple gigabytes of data, it is delivered only via hard media at this time.

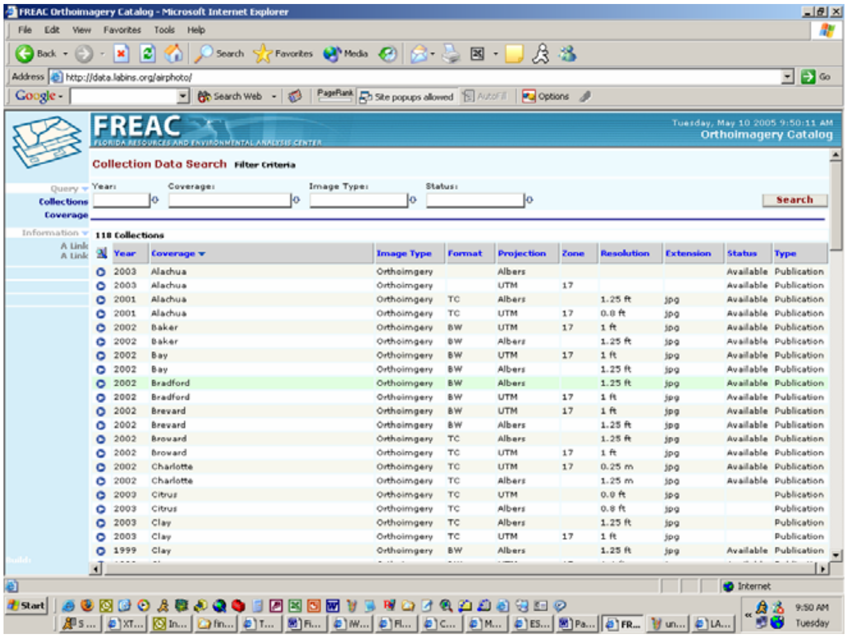

Figure 1

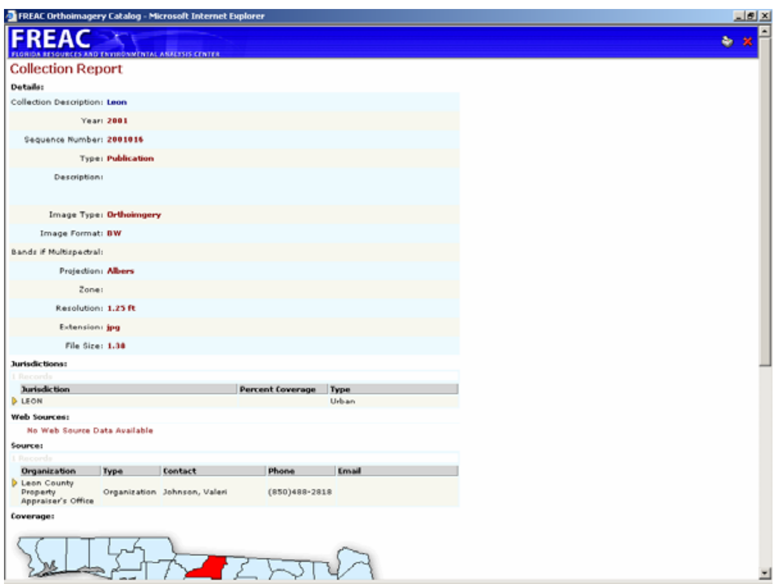

Figure 2

A web based interactive map was also developed as part of this project. It can be found at http://gsdb.freac.fsu.edu:8080/imf/DOT/imfStyle2e.jsp? (Figure 3) It allows users to use a map to locate an area of interest and then query the map to see what kind of imagery is available in that area. The tools are fairly simple and self-explanatory allowing a first time user to find information rapidly and without much effort.

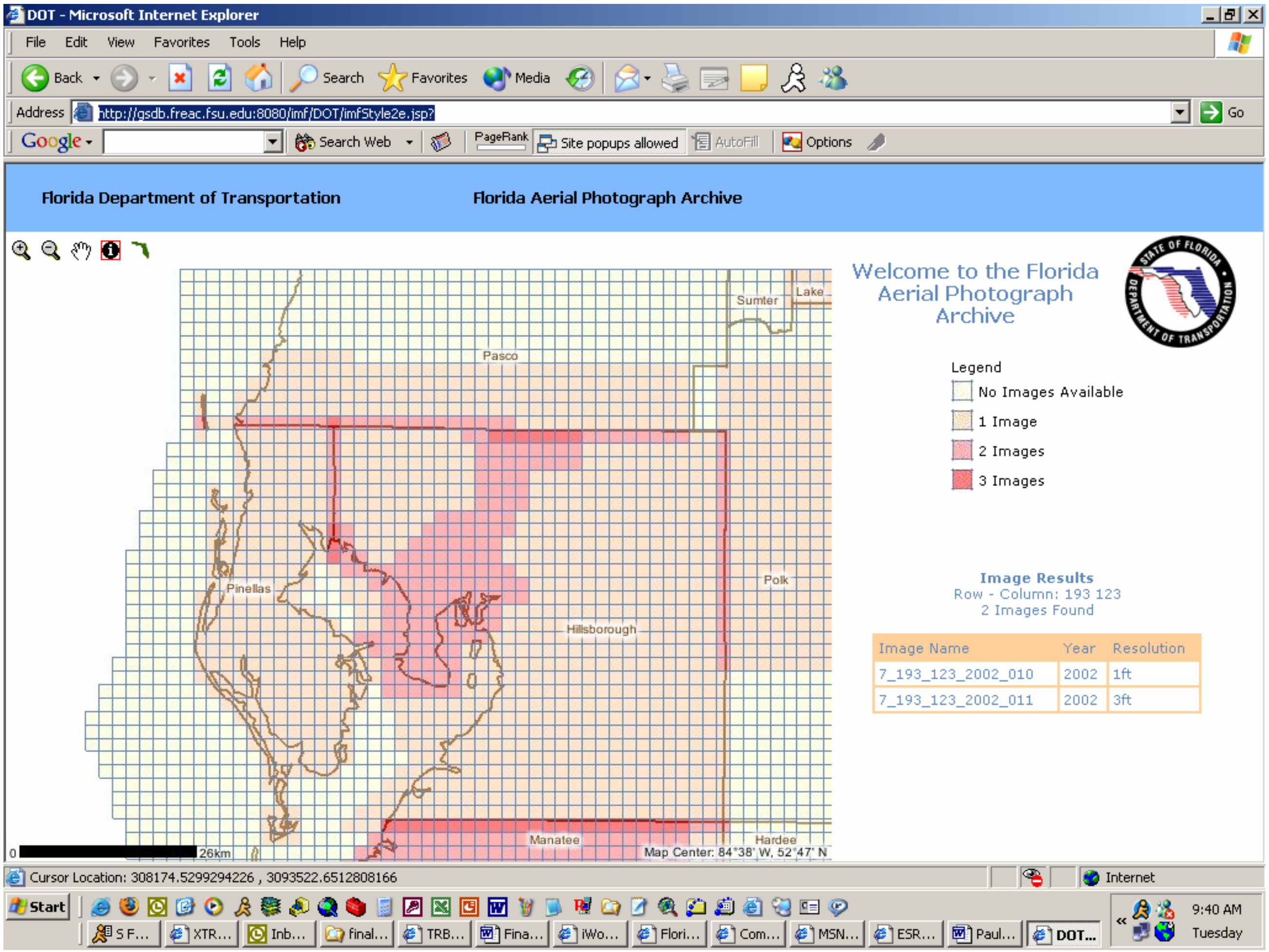

Figure 3

Data Management

One of the more interesting challenges of this project was how to deliver the images to DOT. It involved two aspects: a grid and a naming convention.

The Grid

When this project first began there was no standard way for vendors to deliver images. Some attempted to follow the Section/Township/Range grid, but many simply allow the vendor to deliver the image in what ever size chunks it wanted. The original images that we obtained were in many different sizes and projections.

The goal that we decided upon for a standard grid for this project was one that would produce image that, when compressed to a JPG format, would be a "reasonable" size to work with. Very large compressed image would take too long to display as they were being uncompressed during the draw phase and images that were fairly small would produce too many images creating somewhat of a management challenge for the Department. Care was taken when evaluating grid size to allow for variations in original image pixel size and whether or not the image was color or black and white. In general, color images will be about three (3) times the size of a black and white image.

In the end, a 2,000 meter grid was decided upon. A point in the Gulf of Mexico was strategically chosen so to ensure the that the lower left coordinates of each grid or cell would always be whole numbers and ending with the last three (3) digits of “000”. This would be critical to the naming convention explained in the next section.

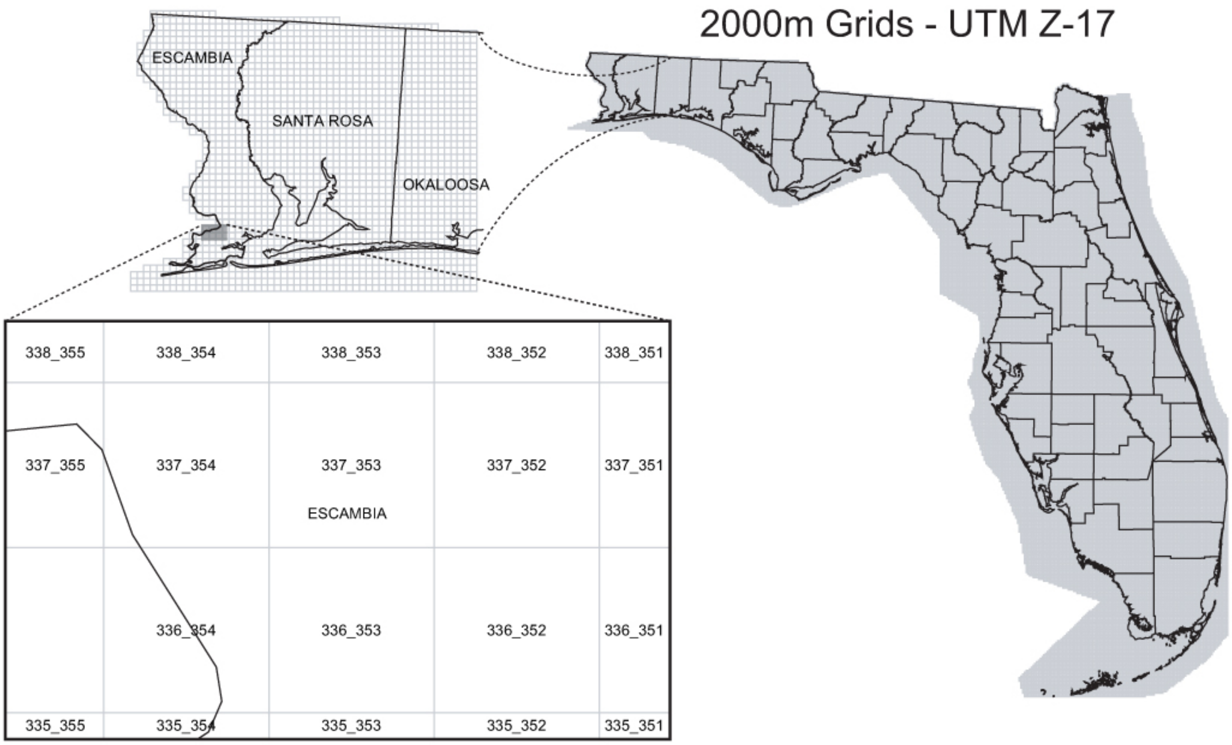

Figure 4

The Image Name

In January 2003 work began to develop a strategic approach for a statewide large-scale aerial photography program. Representatives from the Department of Transportation, the Department of Revenue, the Water Management Districts, and the Department of Environmental Protection considered options for developing a program. One of the topics discussed was the development of a naming convention for individual images. A smaller workgroup was established to consider different approaches. Because of FREAC’s work to develop an imagery inventory as part of this project, we were tasked with the responsibility of developing a naming convention. Other members on the naming convention workgroup consisted of representatives from DOT, DOR, and the WMDs. The first draft developed was a meaningful convention consisting of year, format, resolution, coordinate system, county, and state. The committee rejected this proposal recommending that a minimal level of meaningful data be kept in the name and that all metadata should be kept in an associated file. The final version of the name consisted of one (1) digit defining the projection of the image, a three (3) digit row followed by a three (3) digit column number, a four (4) digit year and a three (3) digit sequential number that could be used to tie back to the more detailed metadata. The row and column numbers were extracted from the coordinates by stripping off the final three (3) digits (“000”).

Example:

7_262_067_2001_002.jpg

7 –	Projection is UTM
262 –	Row number
067 –	Column number
2001 –	Year the images was captured
002 –	Image collection number

The Process

The objective of this project is to re-project high resolution aerial photos of Florida counties to a Universal Transverse Mercator (UTM) Zone 17 projection using the North American Datum (NAD) for 1983 (GRS80) and clip them to a 2000 meter grid. The final product is a JPG image with 25% compression and 2nd order standard deviation stretch.

Since the resolution of the photos ranged from 0.25 feet to 2 feet, to keep a realistic file size for the output image, a new grid of 2000 meter quadrates for entire state was created (Figure 4.) The re-projected aerial photos were then clipped to this new grid. The output files are named using the naming convention established in the earlier phase of the project.

Processing was done using ERDAS Imagine 8.6, ArcGIS 8.3, ArcInfo 8.3 and Microsoft Access 2000 software packages. Perhaps the most challenging issue encountered during processing was the removal of the black edges created during the re-projection phase (Figure 5).

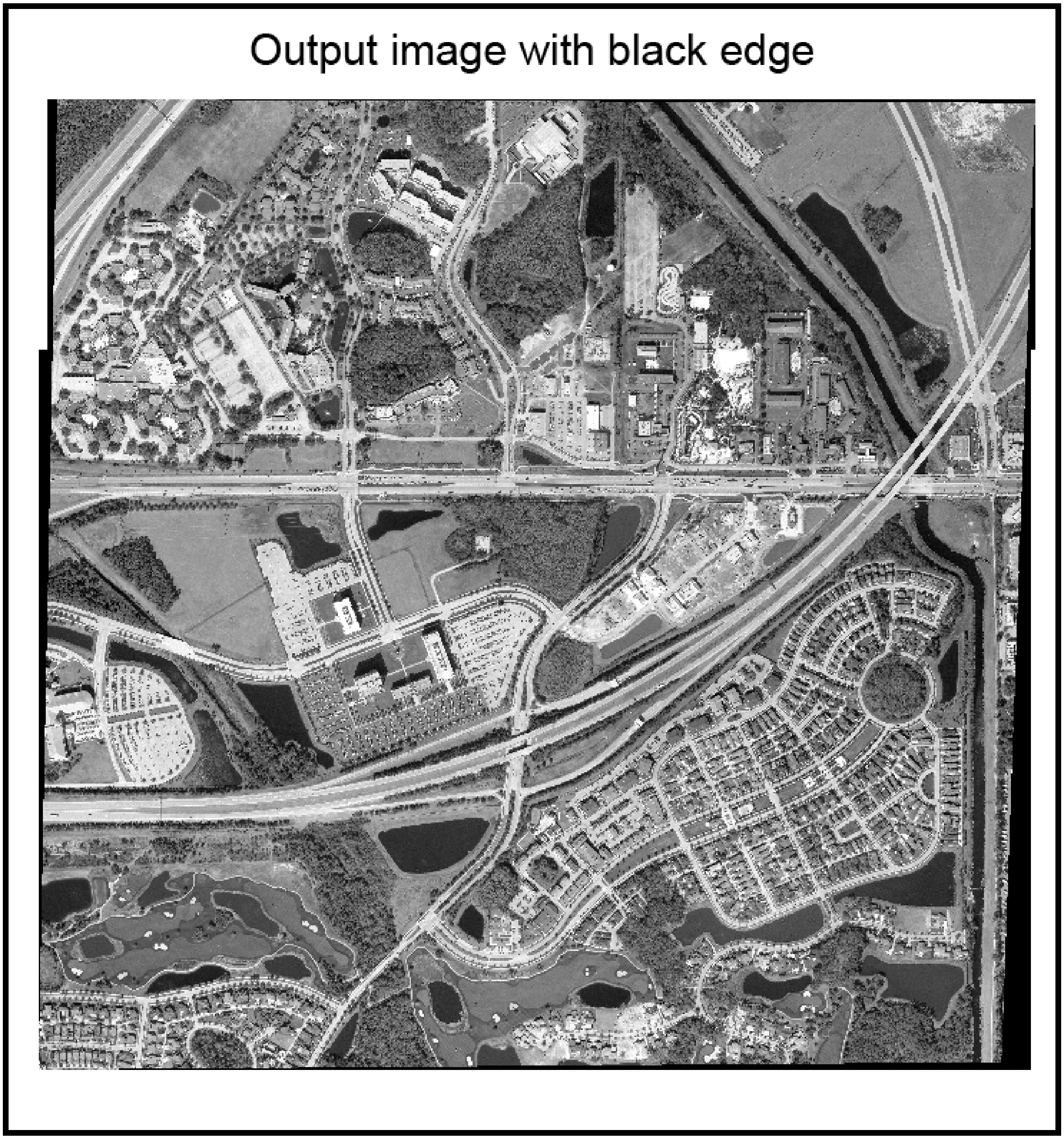

Figure 5

Because the aerial photos in their original format were in State Plane (feet) and were then re-projected to UTM Zone 17, datum NAD83 (meters), the final images were slightly rotated from their original orientation. Also, the output pixel size had to be expressed in terms of meters thus creating a dimension that had to be expressed in terms of a decimal number with many places of precision rather than two (2), or less, decimal places used in the original images. Decisions had to be made on the number of decimal places of resolution in the output pixel to carry so that there would not be any part of a pixel falling outside the "area of interest (AOI)" (each 2000 meter grid cell), thus adding an extra black pixel of NODATA.

For example, when processing 1.5 ft original resolution image, the resolution of the output would be 0.4572009608 meters. Through trial and error it was discovered that a 0.4575 meters pixel was necessary to ensure that no part of a pixel was extended outside the AOI. Each original image pixel size had to be experimented with in order to find the number of decimals needed for the exact fit needed. Simply using four (4) decimals each time did not work. See figure 6 for how the final image is clipped to the exact boundary of the grid.

Figure 6

Other issues dealt with while processing were the input image formats and file sizes. While some counties had the images in the MrSid format others were in TIF, JPG or ECW (ER Mapper) formats. If the file format is JPG and the resolution was very high (say 0.25 ft), it was necessary to convert the original JPG files to IMG (ERDAS) format in order to speed up processing times. Due to a bug in the ERDAS software we also had to import some of the TIF files to an IMG format for purposes of assigning the original projection information to them.

Table 1 shows the counties that were processed for this project. The Year_Sq column is what is used to link back to the metadata.

Counties Processed

County	Year_Sq		County	Year_Sq
Alachua	2001_001		Lake	1998_001
Alachua	2003_021		Lake	2003_011
Baker	2002_001		Lee	2002_023
Bay	2002_002		Leon	1996_001
Bradford	2002_014		Leon	2001_008
Brevard	2002_003		Levy	2002_021
Broward	2002_005		Liberty	2003_019
Charlotte	2002_006		Madison	2002_009
Citrus	2003_005		Manatee	2002_016
Citrus	2003_013		Manatee	2002_019
Clay	1999_001		Martin	2000_006
Clay	1999_002		Miami-Dade	2003_003
Clay	2003_009		Miami-Dade	2003_004
Collier	2000_002		Monroe	2003_001
Collier	2000_003		Osceola	2001_004
De Soto	2004_001		Palm Beach	2002_024
Escambia	1999_003		Palm Beach	2002_025
Escambia	1999_004		Palm Beach	2002_026
Flagler	2001_002		Pasco	2002_018
Gilchrist	2003_017		Pinellas	2002_017
Gulf	2002_015		Polk	2001_007
Hamilton	2001_003		Sarasota	2002_027
Hardee	2004_003		Seminole	2001_005
Hendry	2002_007		St. Lucie	2000_004
Highlands	2002_008		St. Lucie	2000_005
Hillsborough	2002_010		St.Johns	2002_012
Hillsborough	2002_011		St.Johns	2002_013
Hillsborough	2002_020		Volusia	2002_022
Indian River	2001_006		Wakulla	2000_001
Indian River	2003_002		Washington	2003_015
Jefferson	2002_004			

Table 1