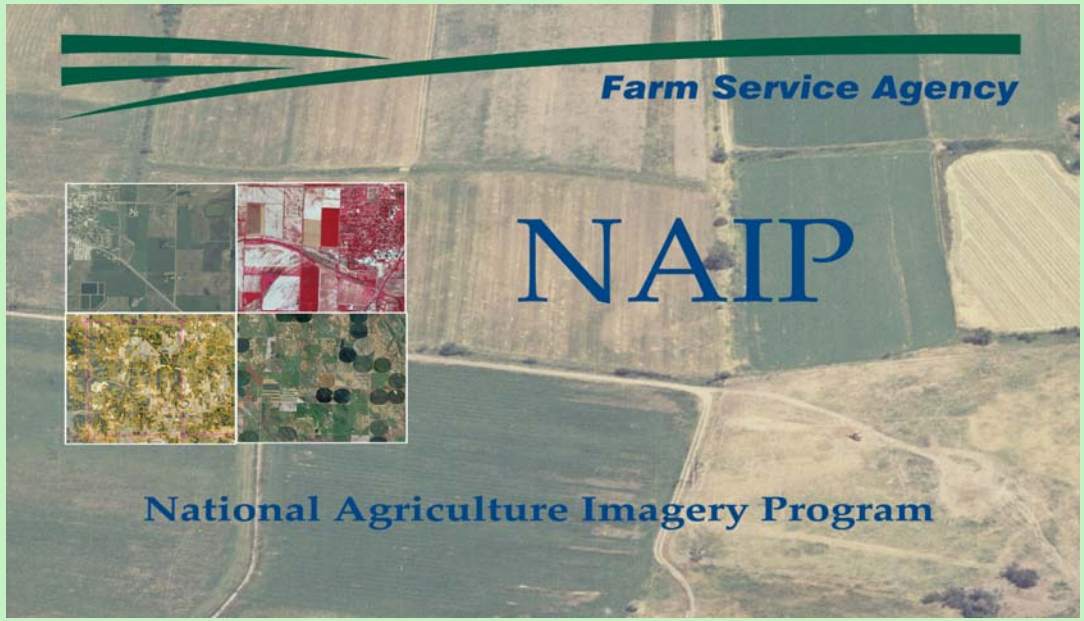


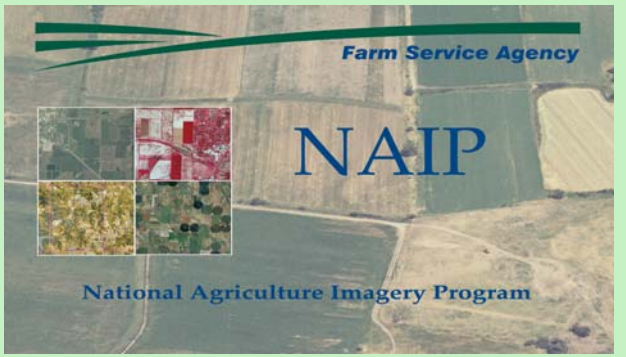
NAIP: Options and Challenges

Louise Mathews
David Davis
USDA Farm Service Agency
Aerial Photography Field Office

What is NAIP?

- National Agriculture Imagery Program
- Flown with leaf-on, during growing season
- 1m resolution for GIS base layer
- 2m resolution for program compliance checks and other uses
- Delivered as Digital Ortho Quarter Quads (DOQQs) or compressed County Mosaics (CCMs)
- Funded by FSA and Partner organizations
- Planned to be the 1-meter portion of the *Imagery for the Nation* program

Rio, Washington Parish, LA
2005 2-meter imagery



APFO

History of Aerial Imagery in USDA Farm Programs

- 1933: Agricultural Adjustment Act to aid farmers, in response to Depression and Dust Bowl
- 1940s: USDA established two aerial photography labs, in Asheville NC and Salt Lake City UT;
- 1976: consolidated labs in Salt Lake City
- 24” x 24” enlargements were sent to county offices. Acreages were calculated using a planimeter, and notations were made on the photography.

Tractored Out” Dorothea Lange, 1938
Website of USDA Wind Erosion Research Unit
With Kansas State University

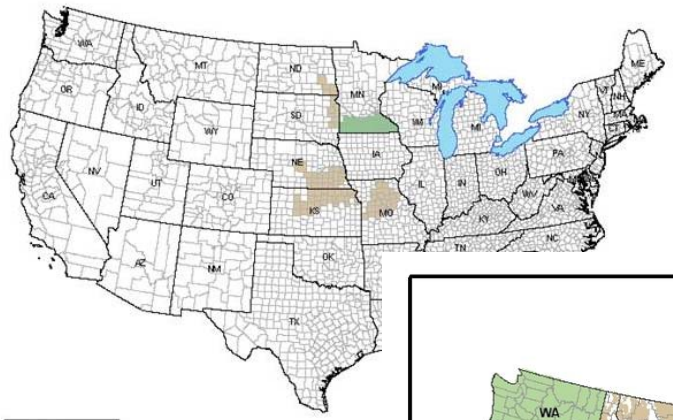
APFO

The Farm Service Agency Moves to GIS

- In the mid 1990s, the Farm Service Agency began exploring the possible use of GIS.
- APFO began making seamless, tonally balanced MDOQs (Mosaicked Digital Ortho Quads) from USGS DOQQs. These were used for Compressed County Mosaics (CCMs).
- Field and tract boundaries (Common Land Units, or CLUs) were digitized from the MDOQs.
- USDA made an enterprise purchase of GIS products from ESRI. The agency remains one of ESRI's biggest customers.
- The National Agriculture Imagery program began in 2002 with a pilot program, and has expanded.

Osage County, KS
2006 1-meter imagery

2002 NAIP COVERAGE

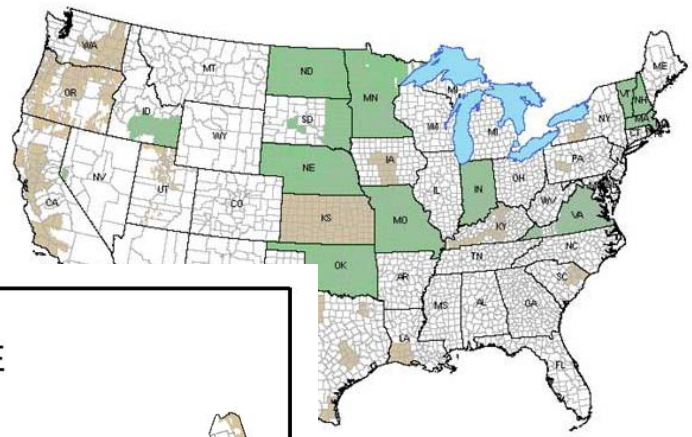


Farm Service Agency

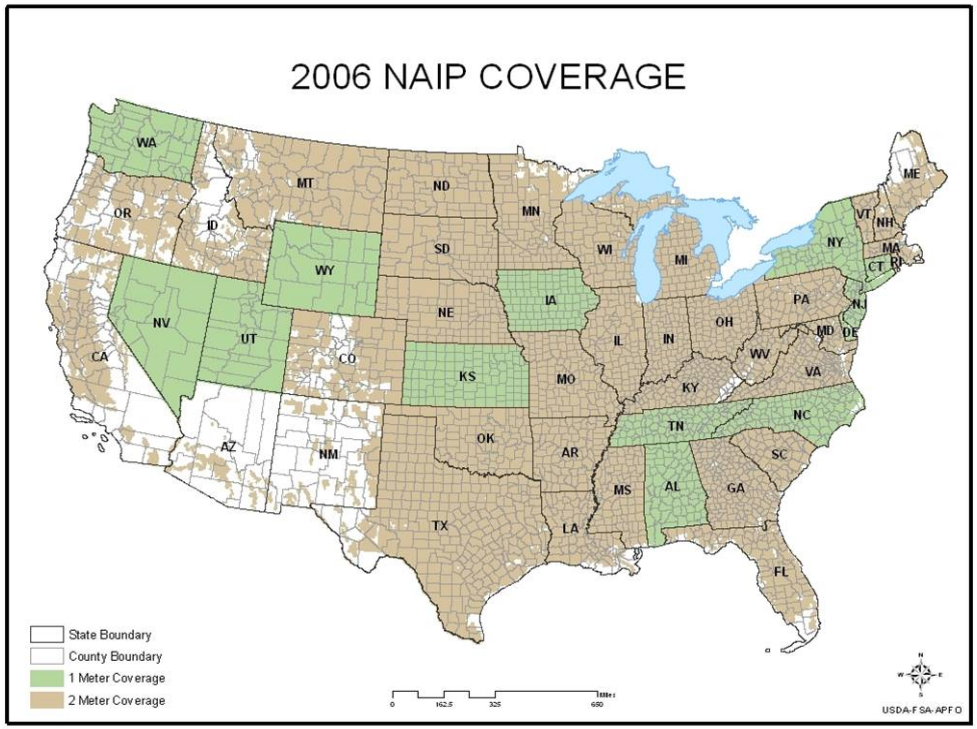
NAIP

National Agriculture Imagery Program

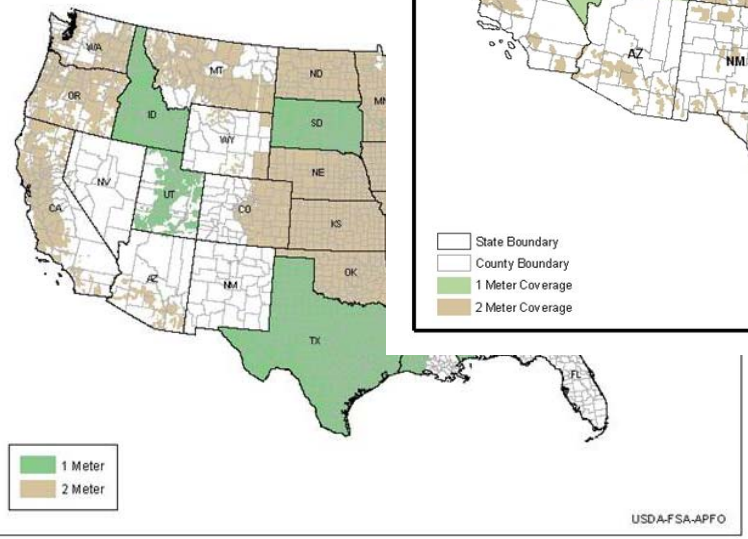
2003 NAIP COVERAGE



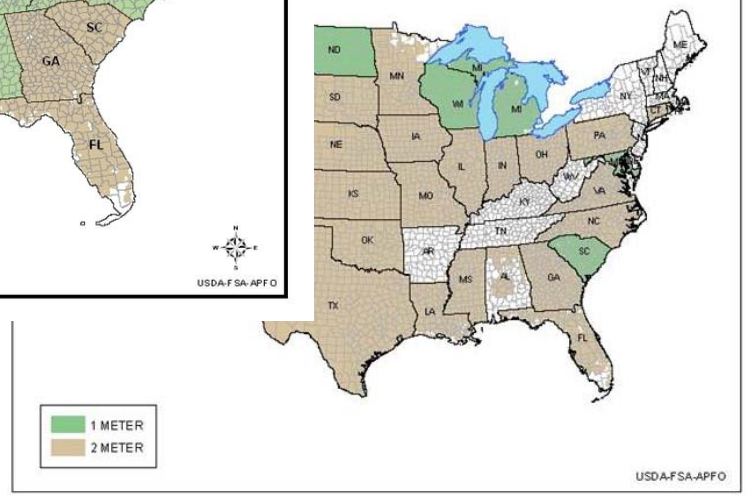
2006 NAIP COVERAGE



2004 NAIP CO



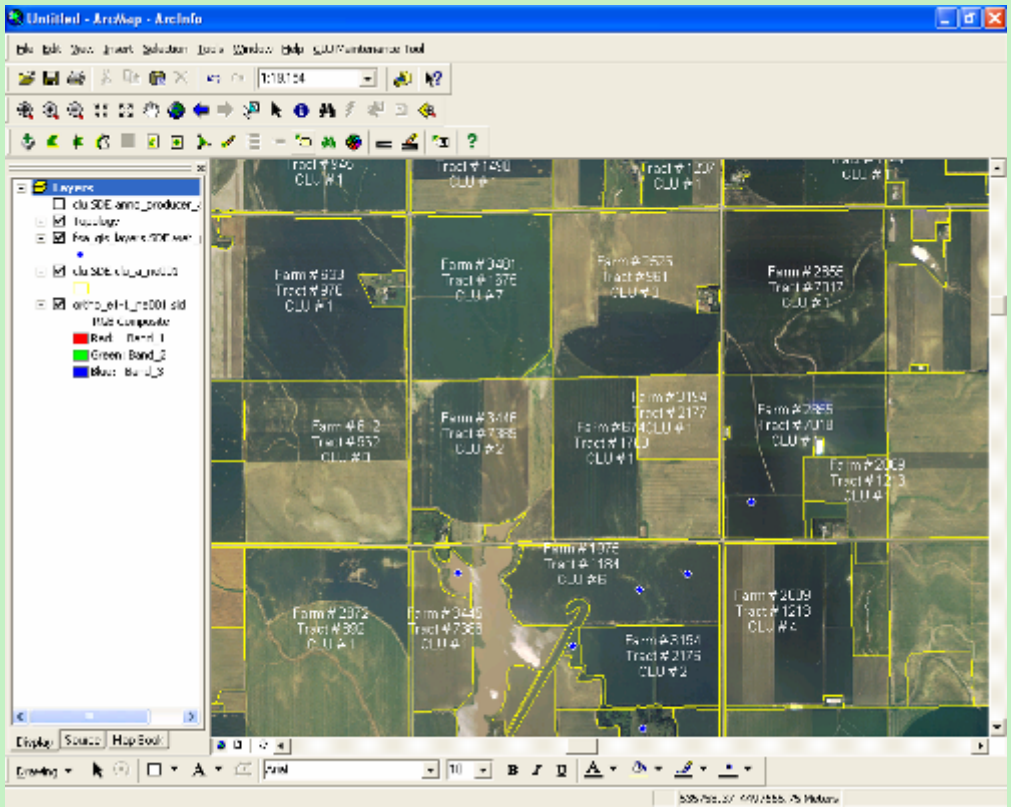
IAIP COVERAGE



APFO

What is NAIP imagery used for?

Farm Service Agency Business

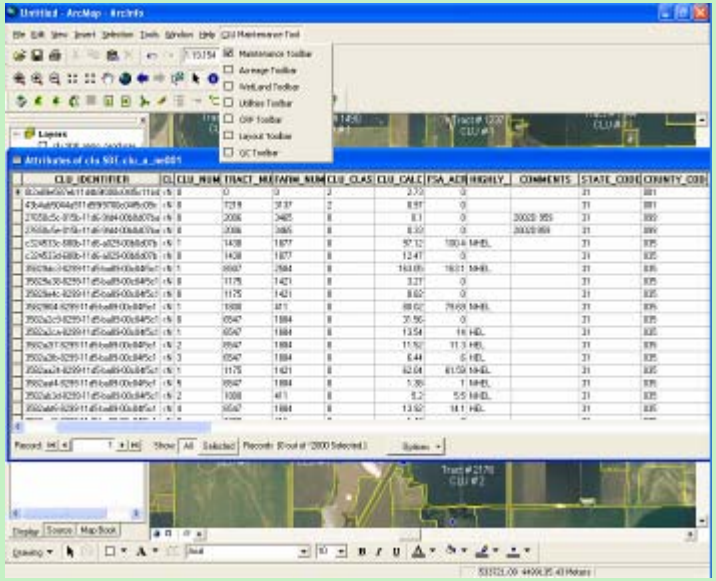


NAIP is the base layer for the County Service Center GIS records

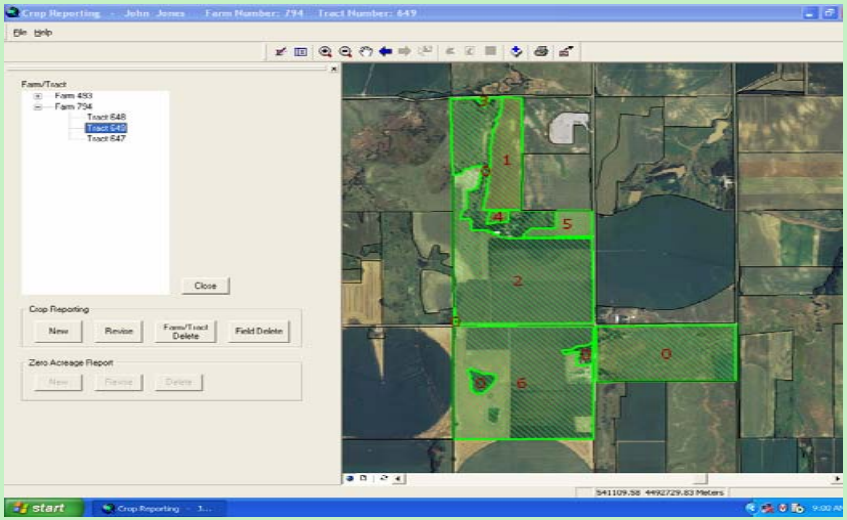
APFO

Service Center Activities

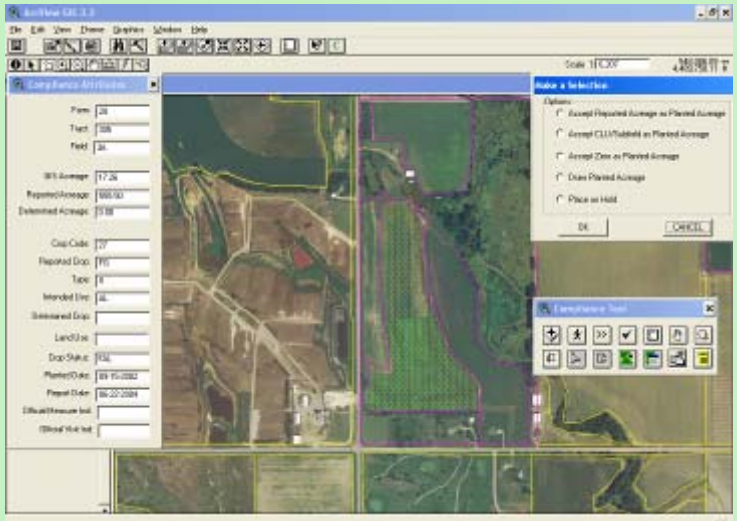
CLU/Farm Records Maintenance



Crop Reporting

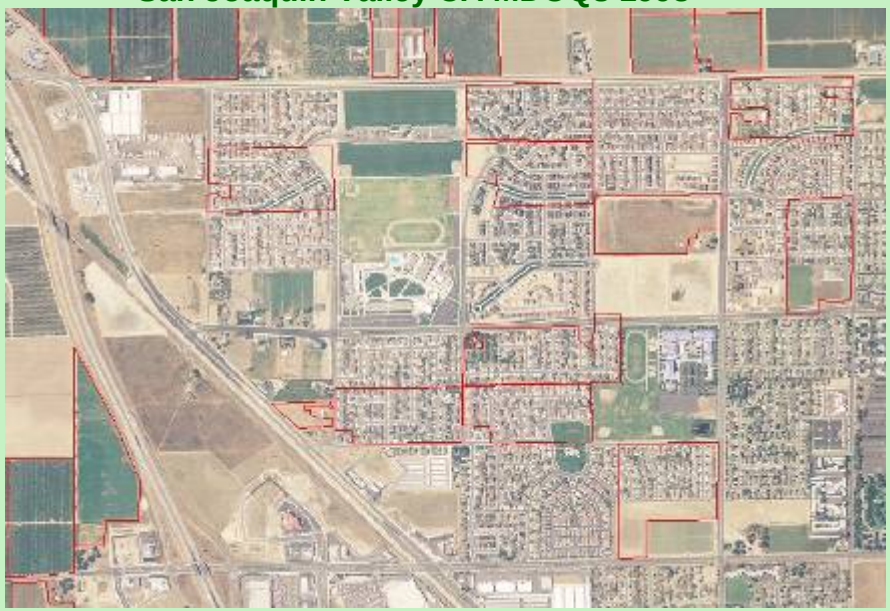


Compliance Activities



Tracking Land Use Change

San Joaquin Valley CA MDOQs 1998

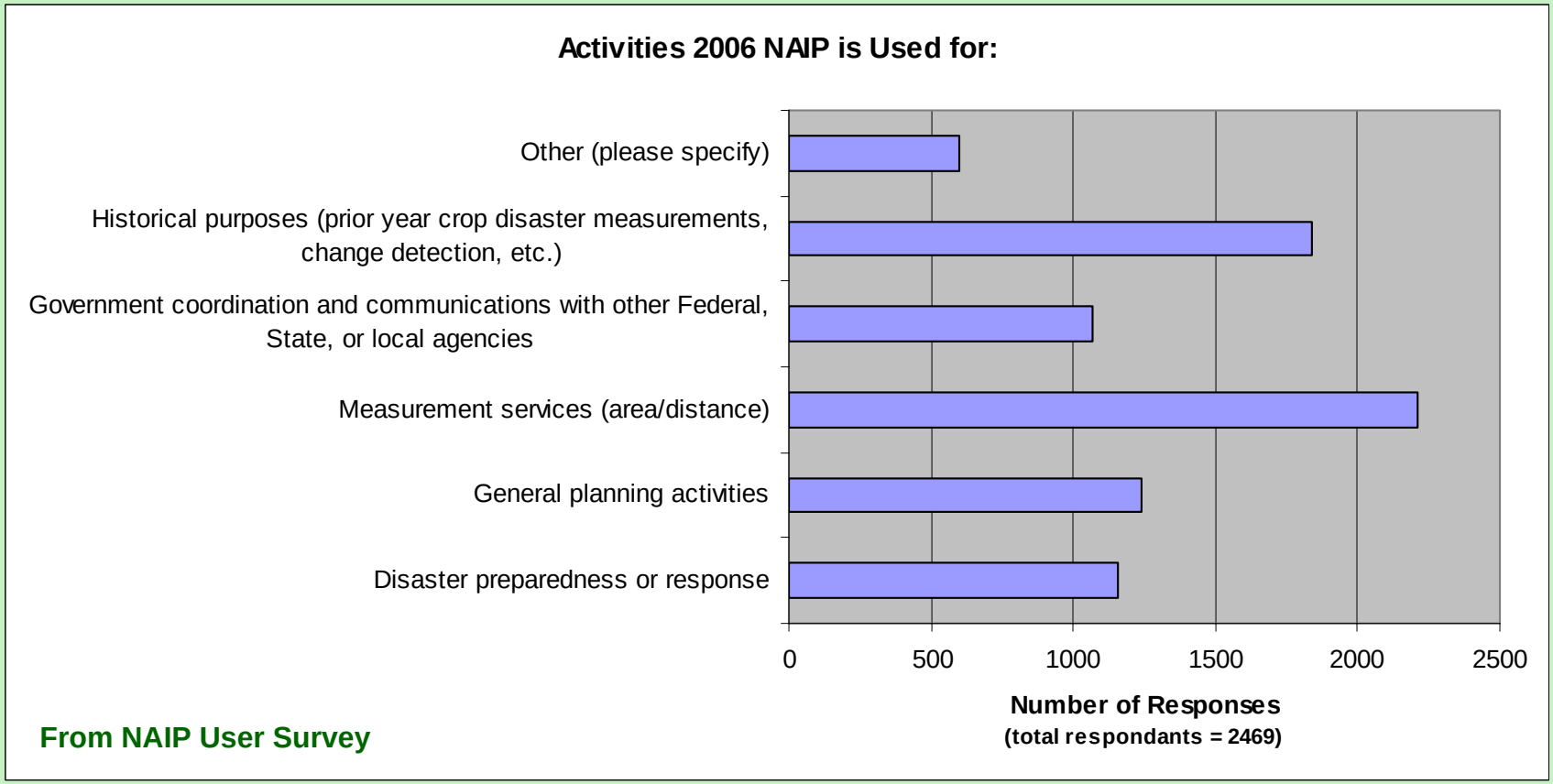


San Joaquin Valley CA, NAIP 2004

Disaster Response

Gulfport MS NAIP 2004

Gulfport MS NAIP 2005



From NAIP User Survey

- Range condition assessment
- Organic Certification
- Changes in pivot and wheel irrigation
- Construction and development
- Pond and fence removal
- Grass seed certification
- Clear readable mapping
- Revising acres for eminent domain
- Oilfield pipeline, gas wells
- Land owners wanting imagery
- New boundary delineation
- Grain bin locations
- Land classifications
- Real estate
- Drought determinations
- Water rights
- Forestry practices
- Environmental surveys
- Swamp violations
- Producer communications

APFO

NRCS Employees Create Information:
Empowered With
Imagery, GIS, GPS, and Digital Cameras

Other Agencies Use NAIP

BLM uses NAIP for Monitoring because:

- **It is a consistent source**
- **It is standardized**
- **It is a reasonable cost per square mile.**
- **It may be the only imagery source available for a local area**

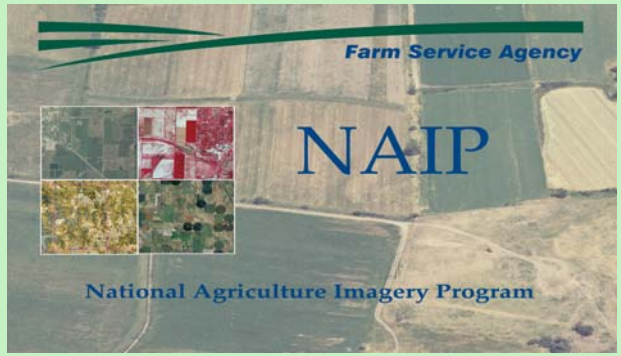
U.S. Forest Service Uses NAIP:

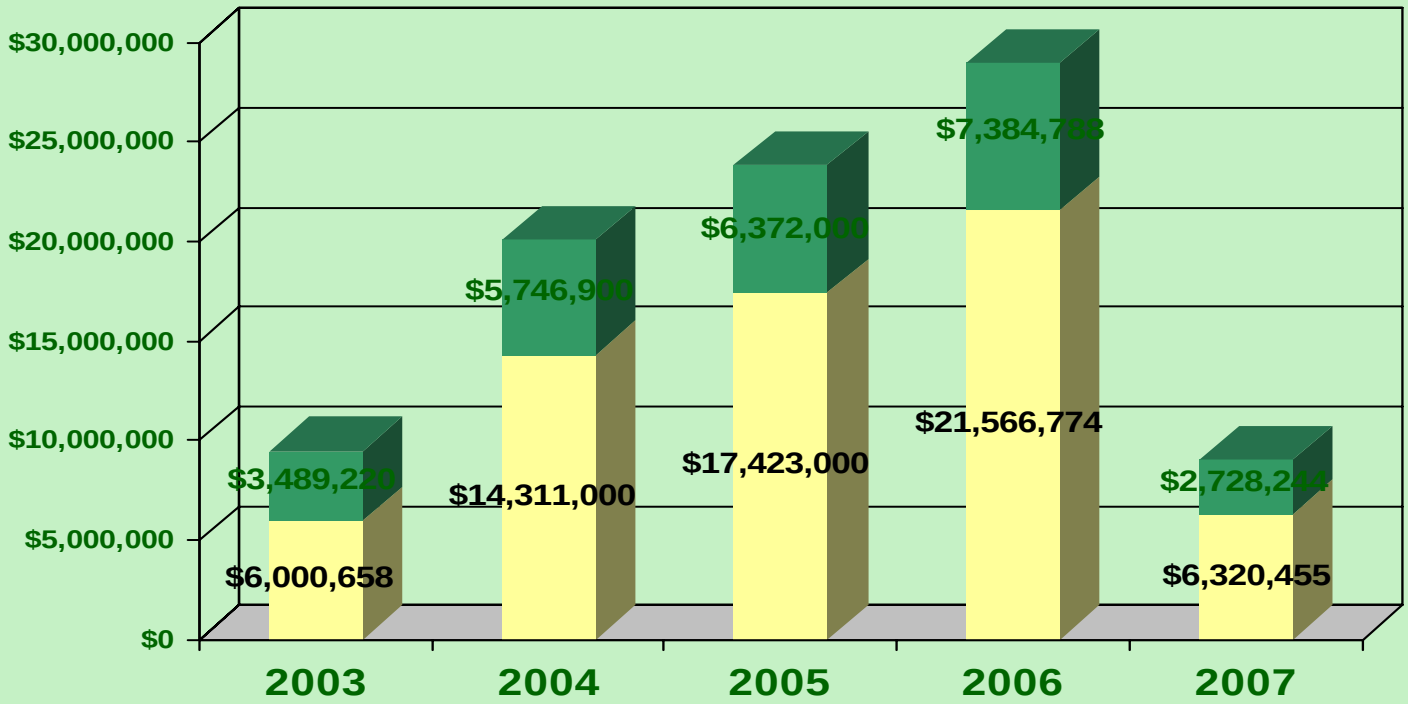
- **Forest planning**
- **Forest heath protection**
- **Watershed restoration**
- **Fire**
- **Disturbance processes**
- **Habitat**
- **Recreation**
- **Transportation**
- **Research**

APFO

Partnerships

- Natural Resource Conservation Service
- U.S. Forest Service
- U.S. Geological Survey
- Bureau of Land Management
- U.S. Air Force Space Command
- State Agencies

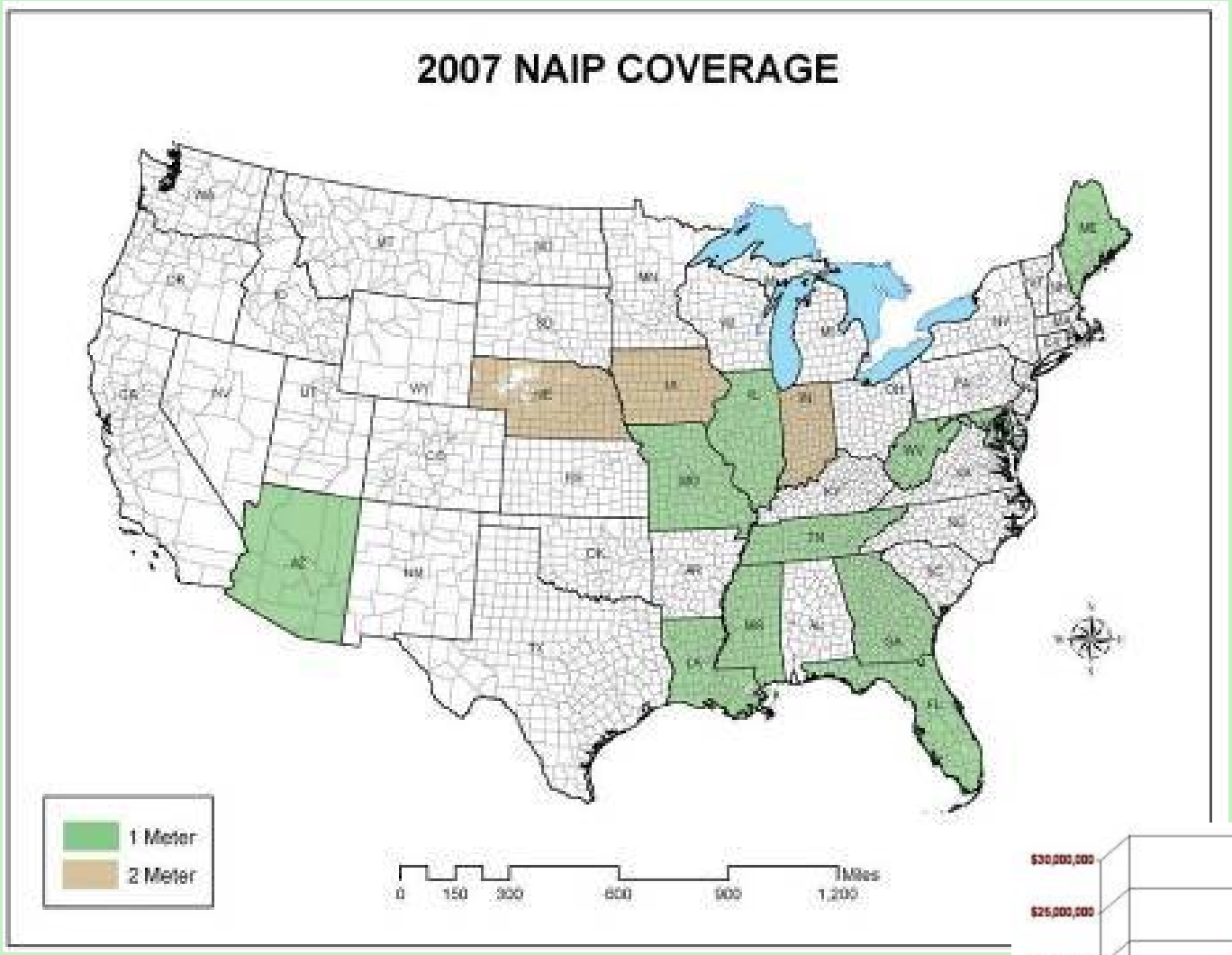




Why Partner?

- Compressed County Mosaics (CCM) on delivery from vendors (30 days from flight)
- Quarter Quad Delivery (full resolution imagery) after inspection
- FGDC compliant metadata
- Ensure coverage for state - states with cost sharing not dropped
- Cost effective acquisition of imagery
- Ensure program continuity
- Add DOQQ coverage in addition to FSA requirements (agricultural lands - areas must be contiguous and/or substantial size)
- Upgrade imagery resolution from 2m to 1m (resolution of all imagery within a project area must be consistent)
- Change band (CP or CIR) with FSA approval
- Derivative contract opportunities
- Technical support services
- Contracting and quality assurance services with no administrative costs.

APFO

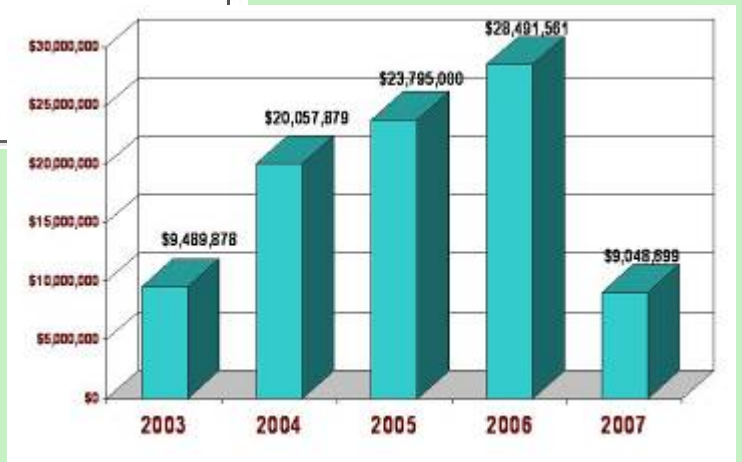


2007:

NAIP funding was cut back

Most imagery acquisitions will be 1-meter base replacements.

Partnerships in Arizona, Georgia, Maryland, and Tennessee



2007 Challenge:

Make the best use of funding for 2007, restore funding in 2008

APFO

New for NAIP 2007

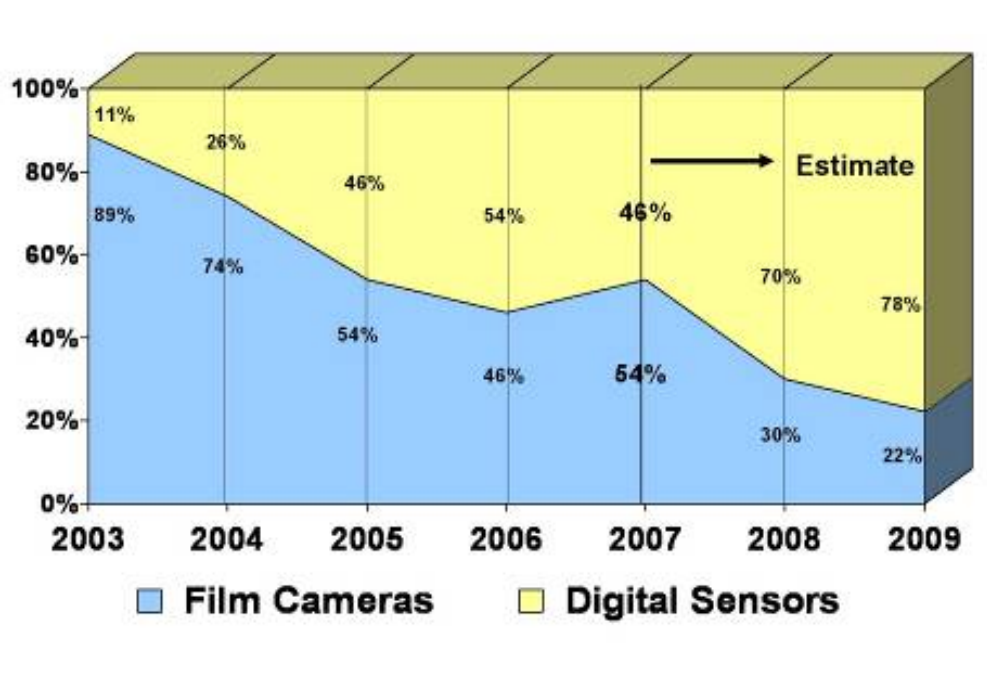
- Arizona will be flown in four bands (Red, Green, Blue, and Near Infrared).
- Arizona imagery will be terrain corrected with control points tied to true ground coordinates rather than to older imagery.
- Vendors will be required to use the most current Digital Elevation Model (DEM) from the National Elevation Dataset.
- Vendors will be required to match specific metrics for image quality.
- A seamline shapefile will be created for Arizona, showing the footprint of each exposure used in creating a CCM.
- Nine states will be flown using digital cameras; five will be flown with film.

Copiah County MS
2004 1-meter imagery

In addition, Yazoo County MS will be flown in a pilot study using IFSAR.

APFO

2007 Changes in Imagery Acquisition: Film to Digital Cameras



As NAIP became established, the ratio of film to digital acquisitions changed dramatically.

APFO

2007 Changes in Imagery Acquisition: Four Band Imagery

- In a pilot project, Arizona will be flown in four bands by Northwest Geomatics: Red, Green, Blue, and Near Infrared.
- DOQQs will be delivered as four band geotiffs; CCMs will be three band Natural Color.
- User can select Natural Color or Color Infrared by changing band assignments.
- Four band imagery will be more attractive to potential partners.

Maricopa County, AZ: 2006 2-meter imagery

APFO

2007 Changes in Imagery Acquisition: IFSAR in Mississippi

- This pilot is an earmarked project, and NOT a part of the NAIP contract. It may help in making future decisions about NAIP. Lessons learned from the pilot will help work with different options in the future
- Yazoo County will be flown with GeoSAR, by EarthData. This is dual-sided, dual frequency Interferometric Synthetic Aperture Radar (IFSAR).
- Data from this pilot will be used to develop and test the Automated Crop Cultivation and Assessment Tool.
- IFSAR could be useful in providing more accurate DEMs than currently available.
- IFSAR could aid in aerial acquisition problems common in the southeast: high humidity and cloud cover make flying difficult; tree canopies or shadows make defining field boundaries difficult.

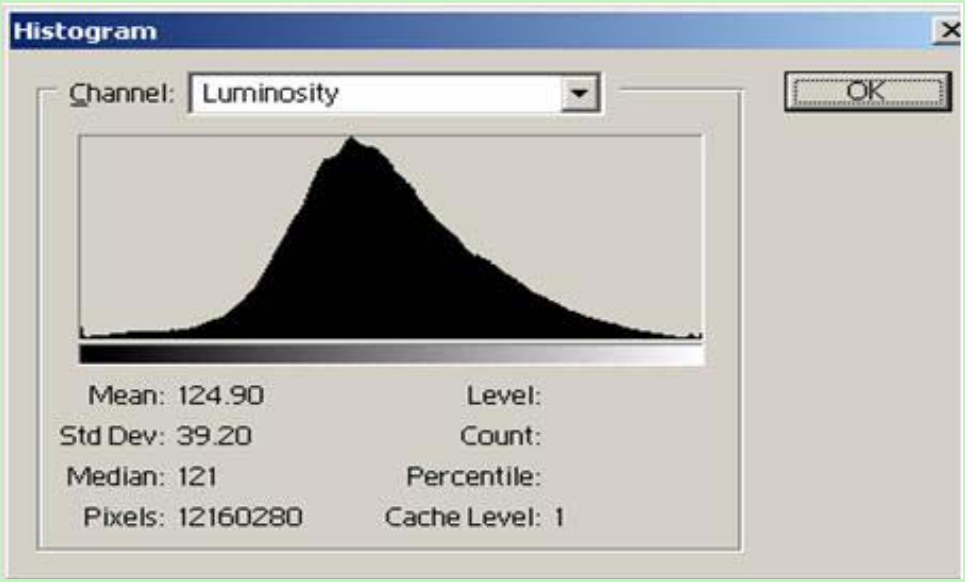
APFO

2007 Changes in Imagery Processing: Radiometric Quality

- After the 2006 flying season, FSA contracted with ITT Systems of Rochester NY, to determine parameters for image quality.
- The FSA user Sensitivity Study documented preferences of end users to image quality. Sufficient contrast and color saturation were especially important.
- In 2007, vendors will be required to meet ideal quantitative measurements for Overall Clipping, Contrast, Histogram Peak, and Color Balance

Rochester, Monroe County, NY
2006 1 meter imagery

Radiometric Quality Challenge: How to Quantify Image Tonal Values



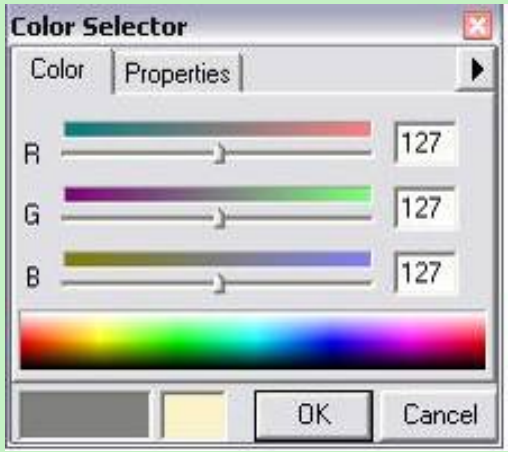
- NAIP is 8 bit imagery, so there are 256 possible tonal values for each pixel.
- The Luminosity Histogram is a composite for all three bands (RGB)
- The recommended Histogram Peak is ± 15% of the center value (256/2 = 127.5) or between 108 and 148

- Contrast refers to the difference between maximum and minimum values in an ideal color range. FSA users prefer at least 120, with a target of 150. Contrast is necessary for crop identification.
- Overall clipping refers to the number of pixels with values applied to the outer bins of the histogram. There should be no more than 2% of pixels in the outer bins, with a target of no more than 1%.

Radiometric Quality Challenge: How to Quantify Inspection

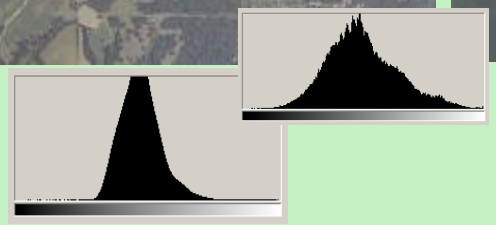
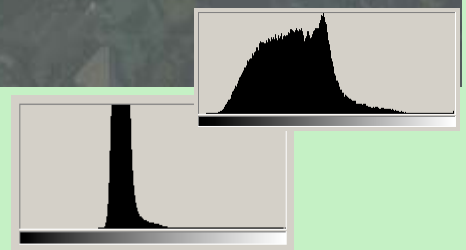
- Color Balancing refers to the pixel values of each (of three) bands when a given pixel displays a neutral gray tone. There should be no more than ±10 values between each band, with a target of no more than ± 5 values.

- ITT created some samples of corrected imagery from the same area in Mississippi. They were flown in 2004, 2005, and 2006, and are very different.

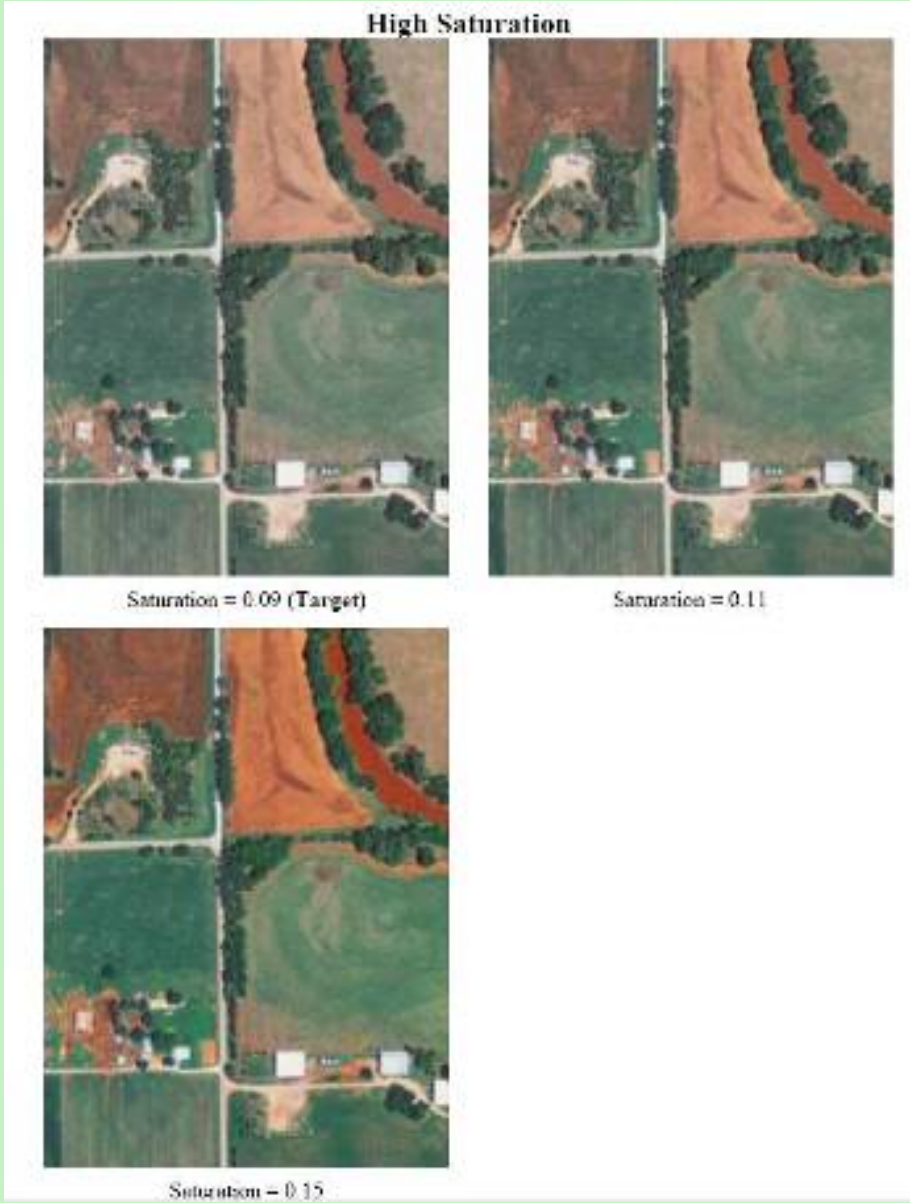


For example,

127 + 127 + 127 = gray

2004	2005	2006
		
		
Contrast 95	47	178
Color Balance [145,135,125]	[113, 121, 117]	[191, 175, 158]
Peak 118	96	133
Contrast 174	160	188
Color Balance [137,133,131]	[189,194,195]	[188, 189, 181]
Clipping 0.10%	0.0% clip	0.10% clip
Peak 118	124	115

Metric Specifications Not Implemented this Season



Metric Specifications Not Implemented this Season

Noise

σ for [R,G,B]=[2.57,2.97,2.38] **(Target)**

σ for [R,G,B]=[6.41,6.67,6.46]

σ for [R,G,B]=[12.12,12.15,11.90]

σ for [R,G,B]=[18.41,18.58,18.63]

Sharpness

RER = 0.910 **(Target)**

RER = 0.518

RER = 0.343

RER = 0.251

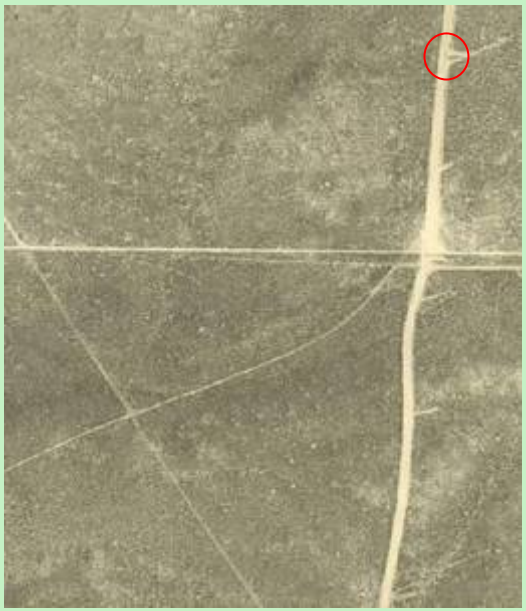
2007 Changes in Imagery Processing: Geometric Quality

- Vendors are required to use the "most current Digital Elevation Model from the USGS National Elevation Dataset when terrain correcting the imagery."
- Arizona will be a pilot for 2007, in the second year of rectifying ortho imagery with "Absolute Control".
  - Until 2005, NAIP used horizontal accuracy specifications relative to other imagery rather than to true ground control
  - Utah 2006 1-meter acquisition was a pilot project for absolute control.
  - Using absolute control will require changes at APFO in program preparation, partnerships, and inspection

APFO

Why Change to Absolute Control?

- Errors in original imagery would be replicated in NAIP.
- NAIP Accuracy Requirements:
  - 90% of inspected points on 1m imagery must fall within 5 meters of base image
  - 90% of inspected points on 2m imagery must fall within 10 meters of base image
- Example: If base is 5 meters off from true ground, NAIP could potentially be 10 meters off.



Why Change to Absolute Control?

- NAIP Absolute Accuracy
  - Pros:
    - Imagery represents more exact coordinates, not former imagery
    - Won't use errors and offset from former imagery
    - Imagery would match most other (vector) data sets
    - Potentially more NAIP partners
    - Less "maintenance" to CLU datasets after an initial shift
  - Cons:
    - Additional cost and time to acquire control
    - Additional time *may* be needed to produce imagery
    - No nationwide, standardized, photo-identifiable control point database for use in production & inspection
    - Changes to inspection, database, & contracting processes

- NAIP Relative Accuracy
  - New imagery tied to old imagery
  - Pro
    - CLU and other SCA data *should* match new imagery since both are tied to the old imagery
  - Con
    - Other data sets *may* not match because they are not tied to the old imagery

APFO

Challenge: Collecting Absolute Control Points

- **Research previously existing control points from other sources (USGS, USFS, NGS)**
- **2006: Partnership with Utah State government; Utah State Automated Geographic Reference Center (AGRC)**
- **Usability study of collected points: accuracy and documentation**
- **Development of inspection and archiving systems**

Accuracy Requirements

2006 NAIP UT 1m GSD Requirement

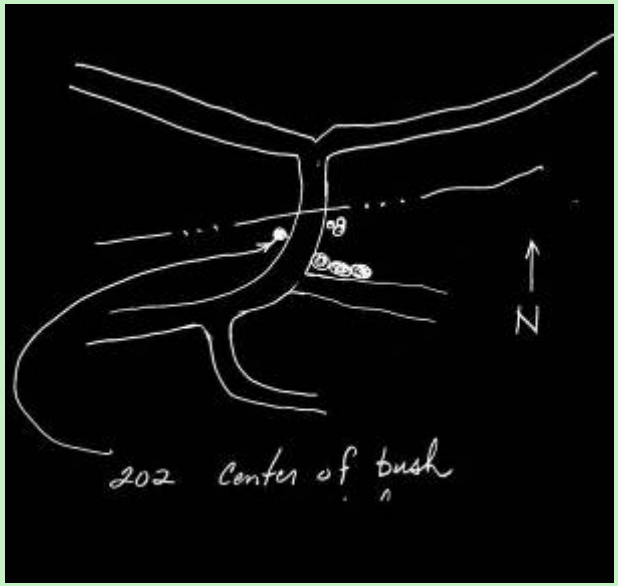
"95% of points tested must fall within six (6) meters of pre-determined quality assurance ground control points"

2007 NAIP 1m GSD Requirement

"95% of well-defined points tested shall fall within 6 meters of true ground"

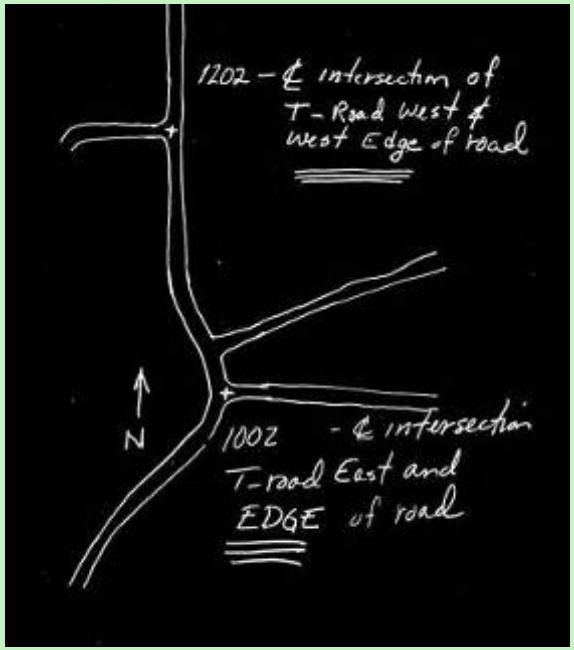
Meets or exceeds NMAS for 1:12000, ASPRS class 2, and Imagery for the Nation (last iteration)

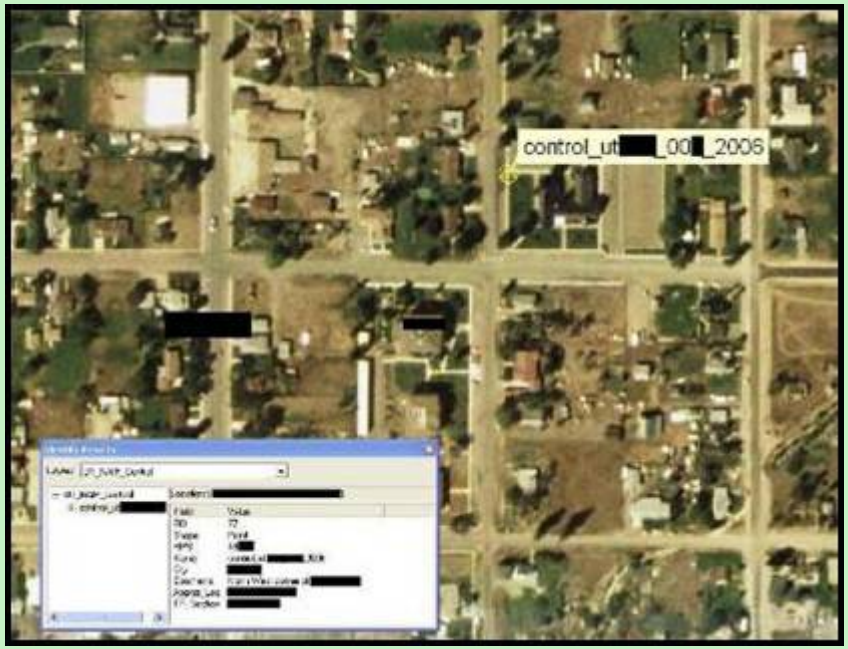
Challenge: Collecting Absolute Control Points



Previously collected control had a wide variety of documentation styles

APFO selected sites for control which AGRC collected





Clear documentation assists with inspection

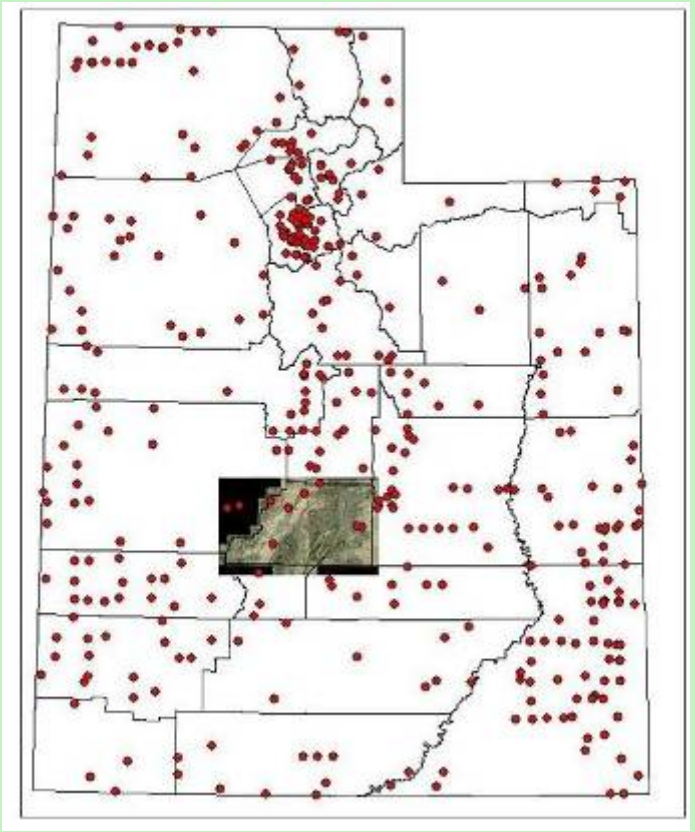
NAIP 2006 GPS Observation Sheet

Control Station		
Station Name	State Utah	County
Contact: Name	Contact: Phone	
Source Agency AGRC	Date 01	

Rover Receiver		
Type Trimble	Model 5800	
Serial Number	Antenna Type 5800	Antenna Height 3.19 ft

Monument Description and Comments

North west corner of church lawn



Challenge: Creating a Control Point Database

- Control Point Database: database of all photo-identifiable ground control points used for NAIP inspection
  - Start with UT pilot
  - Design geared towards National coverage (long term)
  - Flexibility
    - Can “handle” most data delivery formats
      - Numerous data sources (USGS, USFS, States, NGS, Private, etc.)
      - Accommodating field types and lengths
- Maintained as .dbf this year
  - Future Oracle table
- Capable of adding x,y (lat,lon) “events” into ArcMap
- Not for public disbursement

Challenge: Expanding the Control Point Database

- Continued in-house research on existing control data
- Partnership opportunities
- Commercial datasets (last resort)

2007 Changes in Imagery Acquisition: The Seamline Shapefile

Butt-matched DOQQs can make a checkerboard effect in a CCM.

DOQQs may contain parts of more than one exposure.

A seamline shapefile will identify each exposure used in the CCM.

Northwest Geomatics will deliver this file as a pilot study in Arizona.

Darlington County, SC: 2006 1-meter imagery

APFO

2007 Changes in Imagery Acquisition: Compression Formats: Options Explored, No Change this Year

- MrSID from LizardTech used initially because other agencies used it. It could compress images into a seamless mosaic.
- A change from MrSID Generation 2 (MG2) to Generation 3 (MG3) was considered in 2004, implemented in 2005.
- MG3 version currently in use offers flexibility in reprojecting imagery, updating,dealing with differents GSDs, color balance.
- A change to JPEG2000 is being considered. The primary concern is that JPEG2000 outputs from different sources may have tonal variations.
- The 2007 NAIP contract does not specify a compression format; this will be in individual task orders. The option is open for a later change.
- A future change will probably be to a non-proprietary format, such as JPEG 2000.

2007 Data Distribution Options

- Geospatial Data Gateway: download CCMs (ftp) or order (CD or DVD)
- Geospatial Data Warehouse (GDW): add DOQQs into an ArcGIS document for viewing only
- NAIP Viewer: View data from GDW without GIS software
- Order any digital data from APFO's Customer Service Section for cost of reproduction. Older CCMs, DOQQs, and MDOQs ordered through APFO.
- Bulk orders of NAIP on hard disk drives
- APFO Online ordering system in development
- NAIP incorporated into Google Earth, ArcGIS Online
- 1 meter, leaf-on contribution to *Imagery for the Nation*

Minnehaha County, SD
2006 2-meter imagery

APFO

Annual NAIP Timeline

May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mar | April | May

Image Acquisition (Flying season may vary for different states)

30 Days

45 Days

Up to 1 year

-Inspection
-Final vendor payment

-Compressed County Mosaic
to APFO & Cost Share Partners
-Phase I inspection of CCMs
-CCMs available on Gateway
-Vendor payment 60%

-DOQQs, Reports, Film,Shapefiles
-Phase II & III inspection begins
-Imagery available through ArcIMS
-Vendor payment 30%

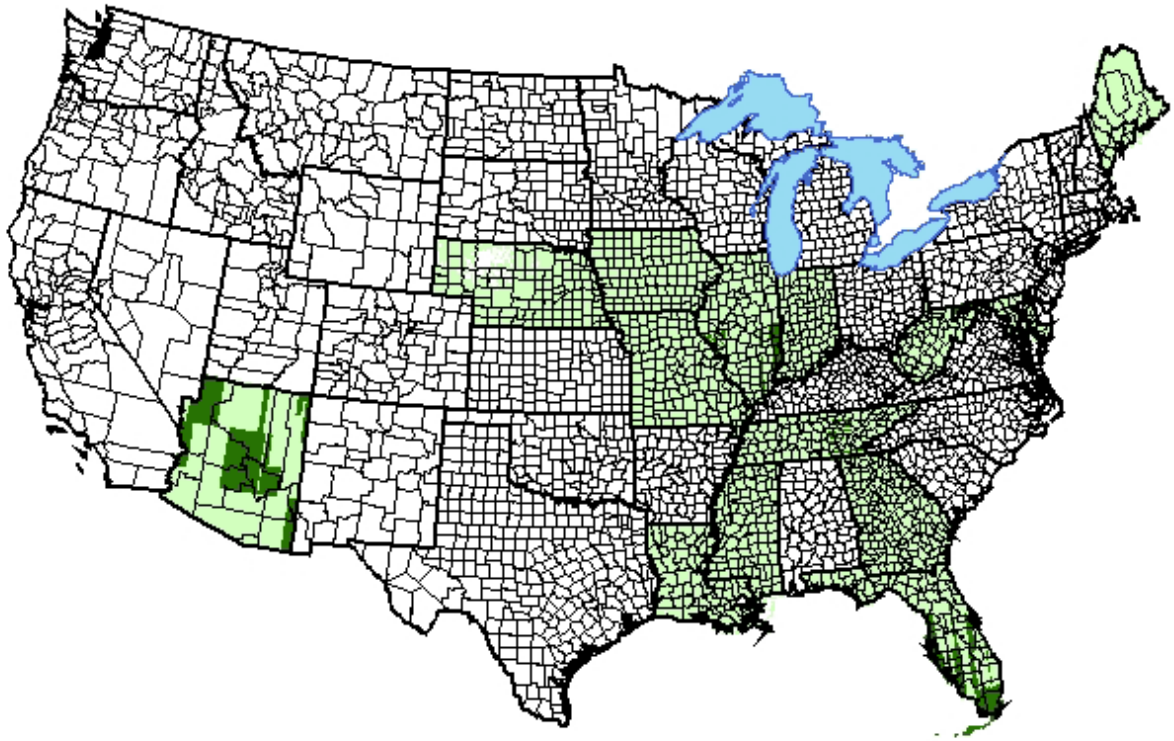
Quality Assurance (Up to 1 year)

Contract Payment schedule

60% Acquisition, 30% Delivery,10% QA complete

June 12, 2007

2007 NAIP IMAGERY STATUS



AREAS FLOWN

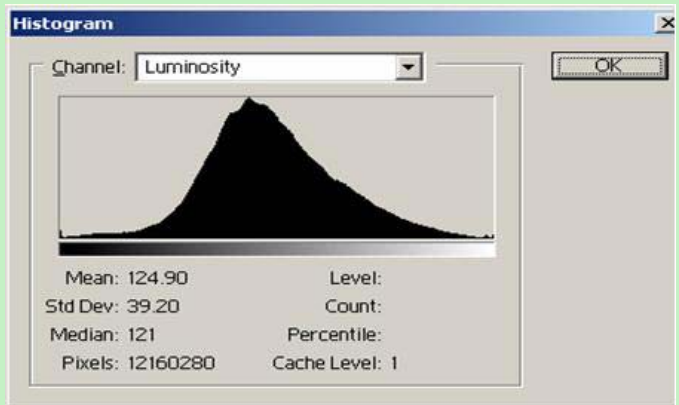
AREAS CONTRACTED

APFO

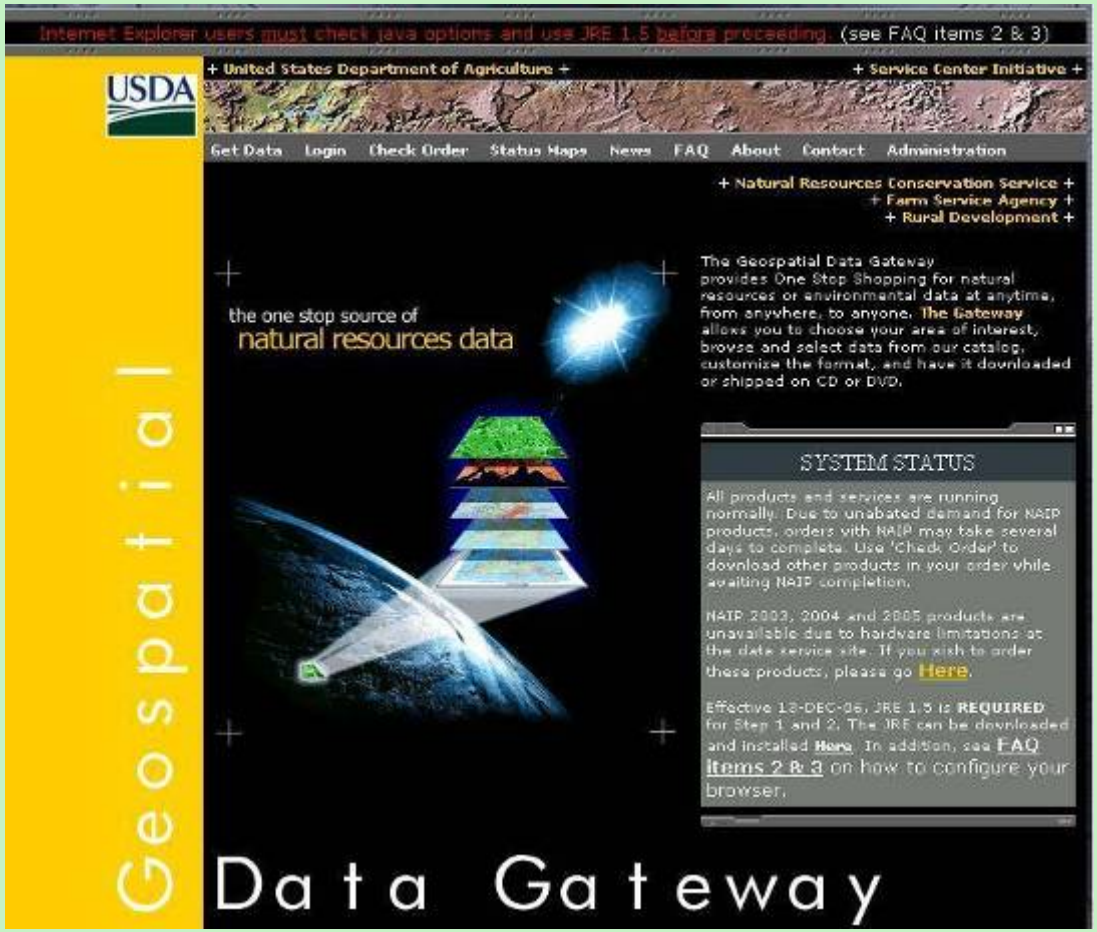
APFO sends an interim version of the CCM to state offices as soon as it is received. It is put on their server for county personnel to use in working with the farmers. A final version is sent after inspection.

APFO Inspection Process

- Initial python script checks basics such as GSD, UTM zone, file format
- In-house custom interactive inspection program; inspectors check for geometric accuracy, cloud cover, image quality
- New in 2007 – histogram metrics checked in PhotoShop
  - Clipping
  - Histogram Peak
  - Contrast
  - Color Balance



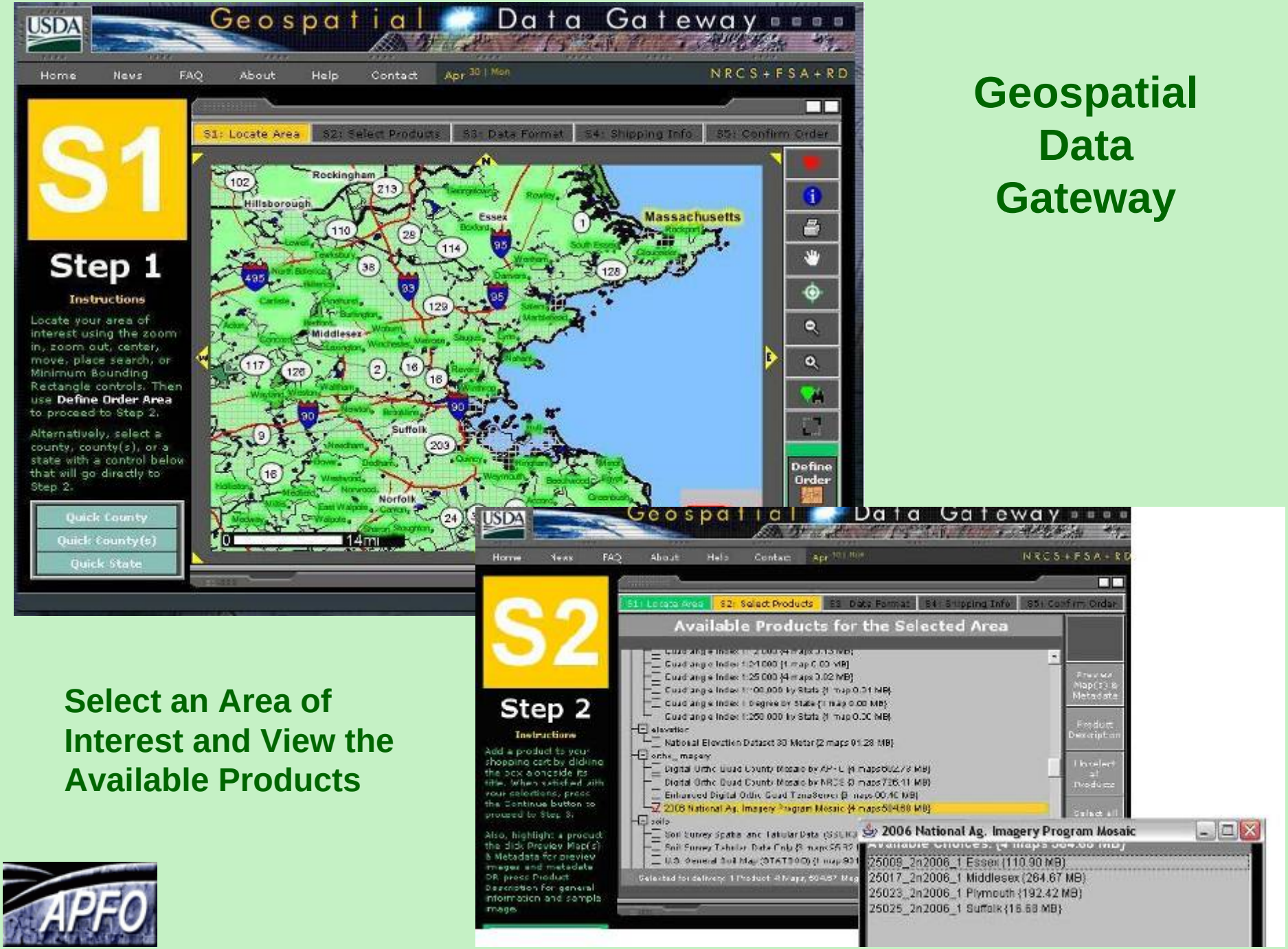
Geospatial Data Gateway



- Hosted with NRCS in Fort Collins
- Free downloads of recent CCMs only
- High volume of downloads has led to problems
- www.datagateway.nrcs.usda.gov

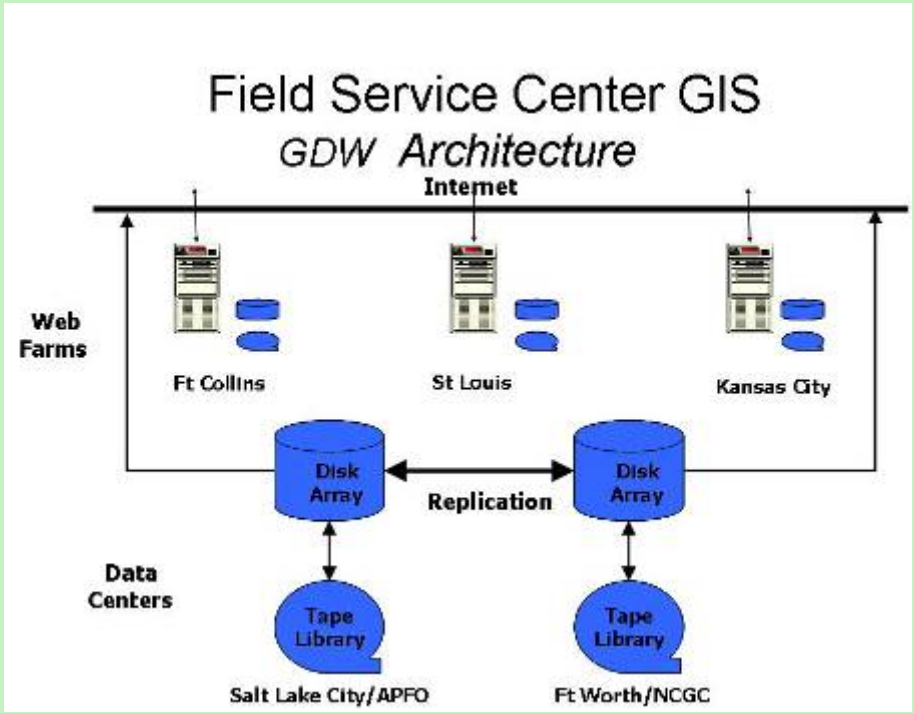
APFO

Geospatial Data Gateway



Select an Area of Interest and View the Available Products

APFO

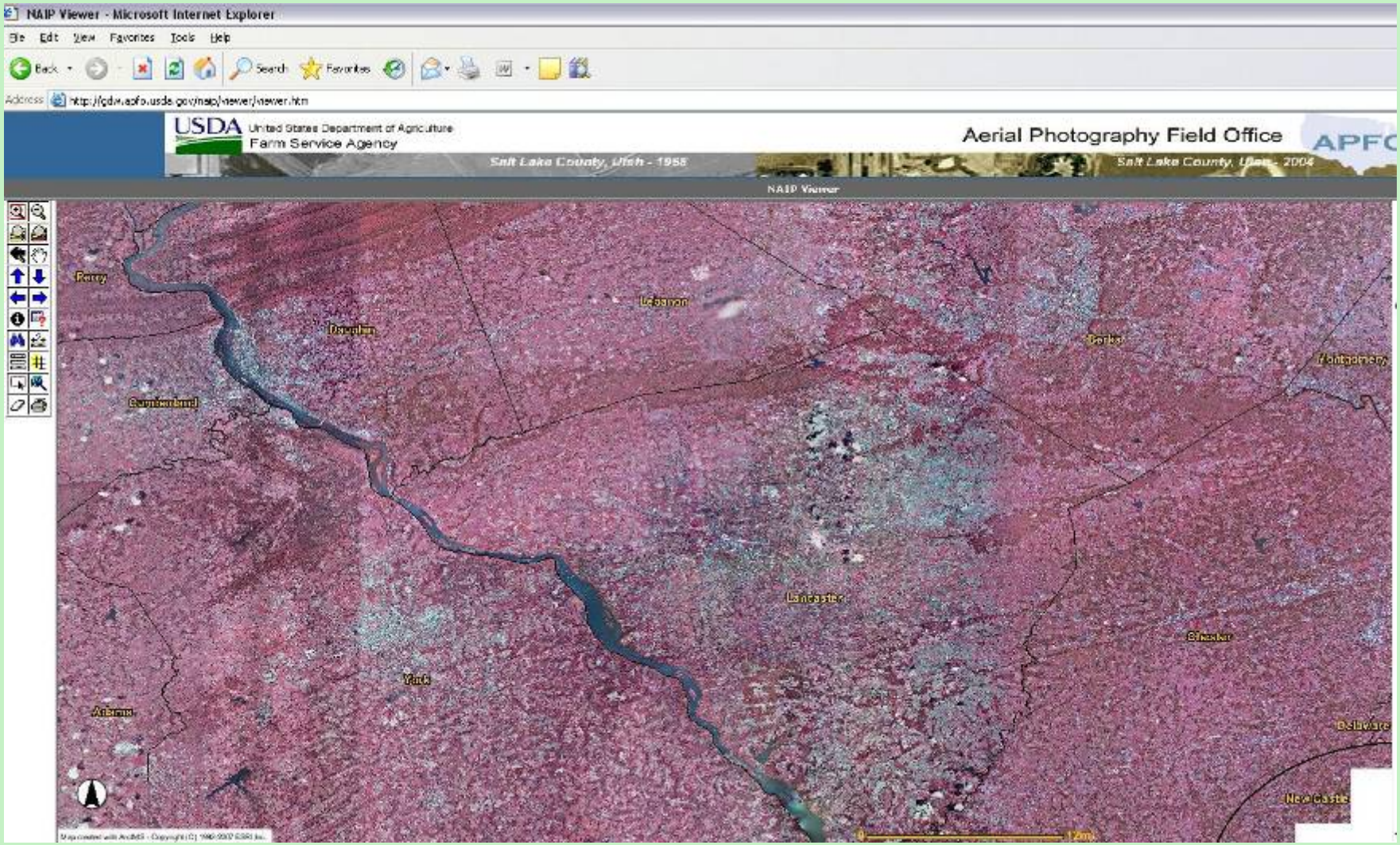


Geospatial Data Warehouse

- Warehouse for storing raster, vector and tabular data
- Two main warehouses in Salt Lake City (APFO) and Fort Worth (NCGC)
- Data accessed through ArcIMS server: http://gdw.apfo.usda.gov

Add data to ArcGIS for viewing only

NAIP Viewer

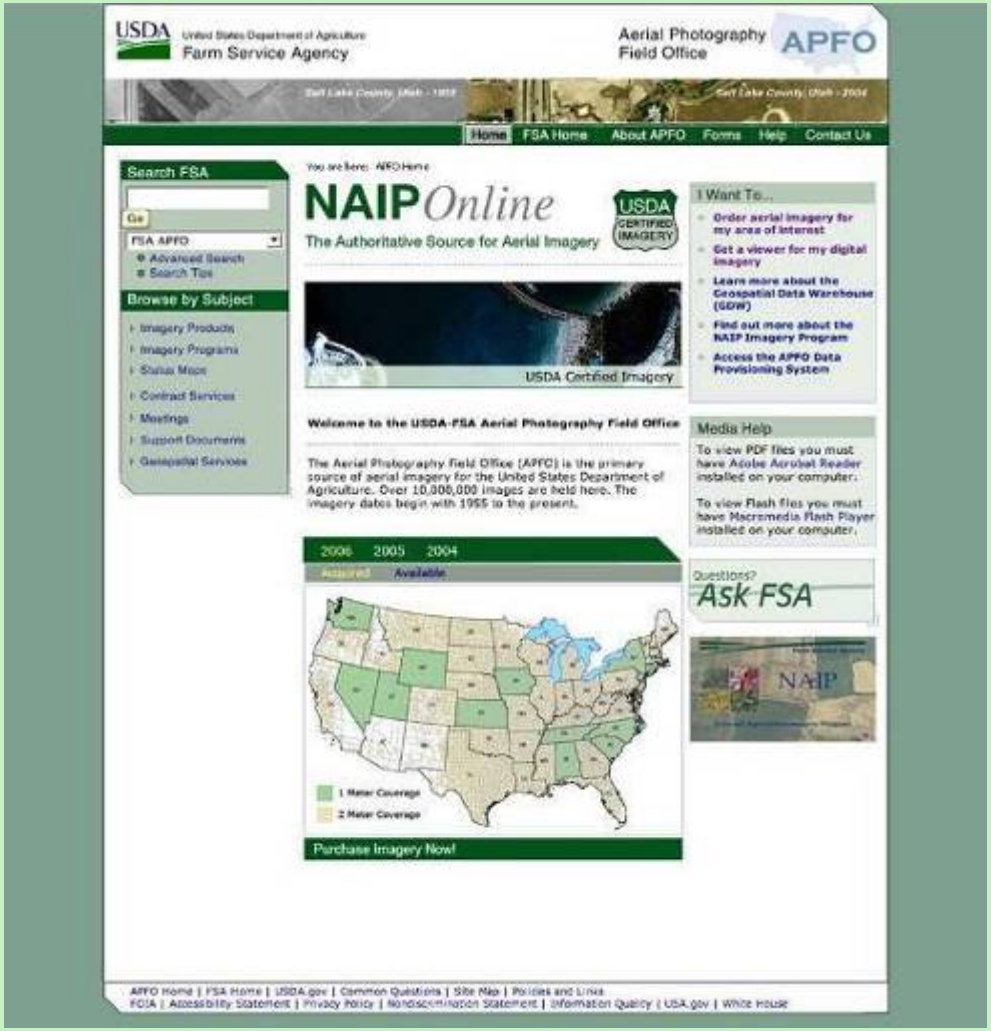


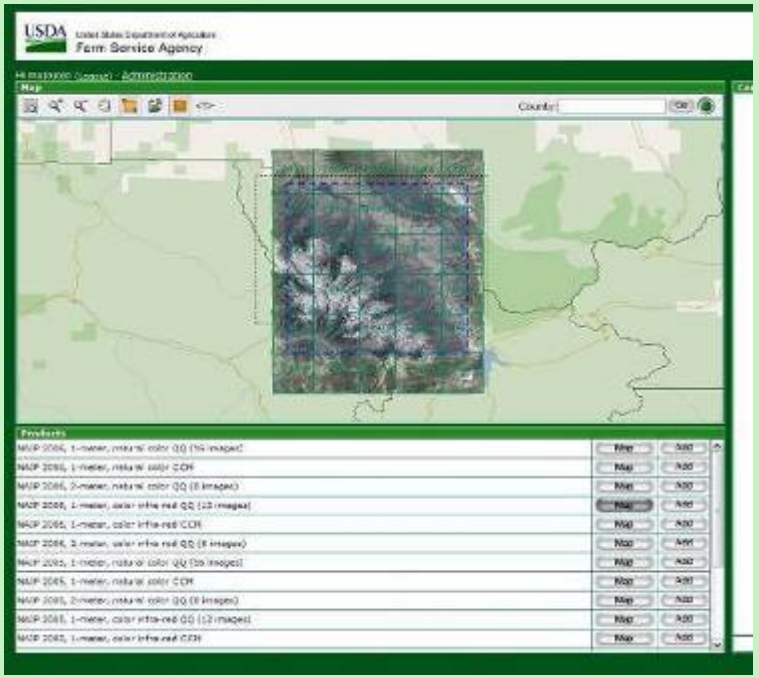
- http://gdw.apfo.usda.gov/naip/viewer or
- http://gdw.apfo.usda.gov/mdoq/viewer
- No GIS software required

APFO Customer Service Section

- Call, write, or email with a map or shapefile of area of interest
- OR visit our office in Salt Lake City
- Order CCMs or DOQQs from NAIP or earlier MDOQ products.
- Bulk orders on hard disk drives; data available “as is:” no QC or versioning – newer imagery will need to be downloaded
- APFO has one of the largest collections of historical aerial photography in the country. Custom scans are available
- apfo.sales@slc.usda.gov
- phone: 801-975-3503
- fax: 801-975-3532
- NAIP Contact information sheet available afterwards or at our booth
- Pricing and order information sheet for hard OR softcopy products available afterwards or at our booth

APFO Customer Service Section: Online Ordering System in Development

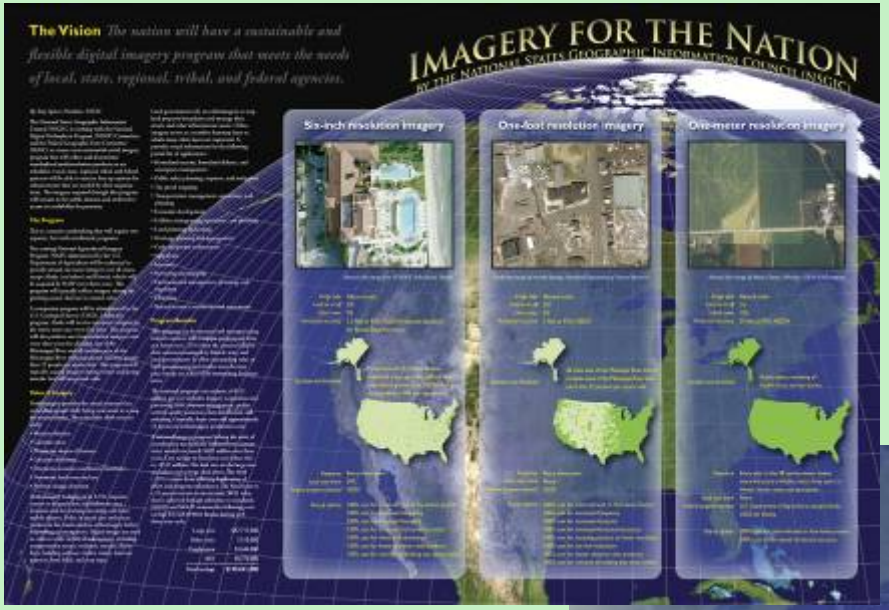




- ***EarthWhere,* by SANZ, *now used internally at APFO.***
- ***Should be online this fall for basic ordering.***
- ***Eventually will include data provisioning, allowing the user to merge, mosaic, reproject, color correct, before purchase.***

APFO

Imagery for the Nation



Federal Program Steward:
U.S. Department of Agriculture
Farm Service Agency
Except USGS for Alaska

Location and threshold

Entire nation, including all insular areas and territories

Frequency: **Every year in the 48 conterminous states, Every five years in Alaska, Every three years in Hawaii, insular areas & territories.**

Buy-up Options: **100% cost for CIR or 4 band products, 100% cost for increased horizontal accuracy.**

- **One meter resolution**
- **Natural color**
- **Leaf-on**
- **10% cloud cover**
- **25 feet at 95%, NSSDA**

www.nsgic.org

APFO

NAIP Satisfaction Survey 2006

- Required of all county offices receiving 2006 imagery
- Second year of survey
- To be done annually to track improvement
- Online with Survey Monkey
- Final report will be posted on APFO website
- Most users are satisfied with NAIP, but there is room for improvement

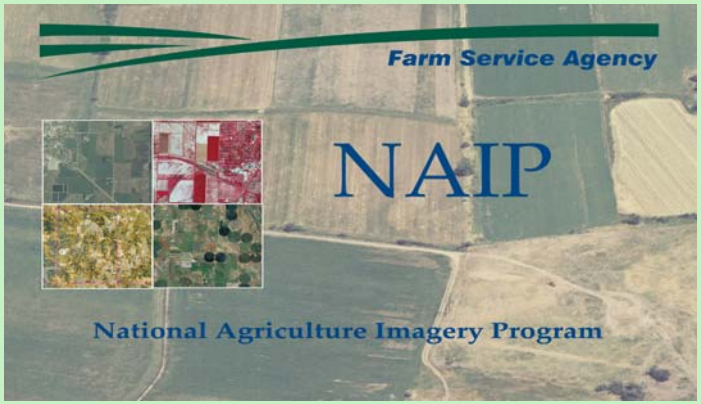
NAIP Vision for the 2007 and Beyond

We can't foresee the future

BUT

APFO is committed to the goal of providing a quality service for FSA, for other Federal and State agencies, and for the general public

We'll continue to make NAIP a "super deal"



Thank you for attending!

APFO

Aerial Photography Field Office
2222 W 2300 S
Salt Lake City, UT 84119
www.apfo.usda.gov
801-975-3500

APFO

USDA