Operational Use of Remote Sensing within USDA

March 11, 2006

Glenn R. Bethel
USDA Remote Sensing Advisor
(202) 720-1280
USDA Imagery

- Multi-Platforms

- Acquisitions 2005
  - Satellite
  - Aerial

- Plans for 2006
High Altitude Airborne

Low Altitude Airborne

Boots on the Ground
32,000 employees
380,000 miles of roads
23,000 recreation sites
7,700 miles of scenic byways
860 million recreation days/yr
3.4 billion board feet timber sales
4,400 miles of wild and scenic rivers
$21 billion worth of hunting & fishing to U.S. economy
USDA Employees Create Information: Empowered With Imagery, GIS, GPS, and Digital Cameras
USDA Applications

- Agricultural Competitiveness
- Agro-Terrorism
- Base Maps
- Carbon Syntheses
- Compliance
- Crop Area Monitoring
- Crop Condition Assessment
- Cropland Data Layer

- Disaster Monitoring
- Drought Monitoring
- Early Warning
- Environmental Monitoring
- Fire Suppression
- Homeland Security
- Inventory
- Invasive Species
- Land Use Conversion
- Yield Monitoring
Remote Sensing Sources

Aerial photography
- Natural color, color infrared, B&W
- Scales from 1:2,000 to 1:60,000

Airborne digital
- Thermal infrared scanner
- Multispectral scanner
- Digital frame cameras
- Airborne video

Satellite
- IRS, AWIFS, LIS
- Landsat
- SPOT, SPOT Veg
- AVHRR, SeaWiFS
- MODIS
- IKONOS, QuickBird
Primary Imagery Users

- Foreign Agricultural Service (FAS)
- Farm Service Agency (FSA)
- Forest Service (FS)
- Natural Resources Conservation Service (NRCS)
- National Agricultural Statistics Service (NASS)
- Risk Management Agency (RMA)
- Agricultural Research Service (ARS)
- Animal and Plant Health Inspection Service (APHIS)

Acquires global imagery
Acquires US imagery (2 meters and less)
USDA Global Requirement
Satellites used by Foreign Agricultural Service

- **Geo-stationary satellites** monitor weather (rainfall & temperature) which is collected/processed by US Air Force Weather Agency (AFWA)
  - **GOES** (North & South America)
  - **METEOSAT** (Europe & Africa)
  - **GMS** (Asia and Australia)

- **Polar-orbiting satellites** monitor *NDVI* & generate *false-color composites* for year-to-year comparisons
  - *Daily repeat cycle*
    - **NOAA-AVHRR** (1-km and 8-km resolution)
    - **SPOT-VEG** (1-km resolution)
    - **Terra/Aqua** Satellites (MODIS sensor with 250 meter resolution)
    - **SSM/I** (Special Sensor Microwave Imager (SSM/I, 25-km) to monitor soil moisture)
  - *16-day and 5-24-day repeat cycle*
    - **Landsat** (30-m)
    - **AWiFS** (70-m) on IRS

- **Radar altimeter satellites** monitor lake water-level variations (10-day overpass)
Updated every 10 days, Crop Explorer provides Time Series Maps, Graphs and Charts:

Weather, Soil Moisture, and Vegetation Condition over Major Crop Regions

Maps and time-series charts for:

- **Weather Data**
  - Dekadal (10-day) precipitation & temperatures compared to climate normals

- **Soil Moisture & Crop Models**
  - Two-layer soil moisture
  - *Behind firewall:* Crop calendars & alarm models for wheat, corn, & sorghum

- **Vegetation Indices**
  - GAC (8-km) (behind firewall)
  - SPOT-VEG (1-km)
  - MODIS (250-m) for many regions.

http://www.pecad.fas.usda.gov/cropexplorer
Daily MODIS images (250-m) are loaded as twice per day.

All images available in JPG 2000 and GeoTIFF format for easy import into GIS.

Project Information:

Satellite Information for Agricultural Monitoring - A Joint NASA/USDA Project
NASA Satellites Improve Response To Global Agricultural Change

http://www.pecad.fas.usda.gov/cropexplorer/modis_summary/
Pick A Region, Browse and Download

Eastern China - MODIS Image Gallery
Click on a region to see MODIS images
2003 Landsat Acquisitions
2006 Acquisitions will include Commercial Satellite Imagery for Pacific Basin and Alaska

Maug

Medinilla

Pajaros
Satellite Acquisitions

Foreign Agricultural Service (FAS) Provides Contract Support Global Satellite Imagery and Services Image Library

- Digital Globe
- Earthsat
- Eurimage
- MDA Geospatial Services-Radarsat International
- OrbImage
- Space Imaging
- SPOT
- USGS
Aerial Acquisitions:

Farm Service Agency Provides Contract Support

- USDA Aerial Photography Field Office
  - Contracting of major USDA aerial needs
  - Centralized Photography/Image Library
  - Over 10 million exposures
USDA Aerial Contract Awards

10 Year History

Total Contract Awards


- 1996: $1,809,503
- 1997: $1,650,326
- 1998: $1,663,754
- 1999: $1,824,335
- 2000: $4,212,343
- 2001: $8,435,737
- 2002: $7,382,612
- 2003: $27,949,208
- 2004: $37,664,569
- 2005: $33,455,497
FY 2005 CONTRACT AWARDS: $33,455,497

- Small Area Contract (NRI): $635,222 (2%)
- USFS & Other Resource: $623,997 (19%)
- NRCS Soil Survey: $1,678,554 (5%)
- USDA NAIP IMAGERY: $24,013,952 (71%)
- Non-Imagery Purchases: $619,881 (2%)
- NRCS NRI ALASKA: $274,890 (1%)

USDA Contract Awards
PROPOSED 2006 RESOURCE AERIAL PHOTOGRAPHY PROJECTS

USDA-FSA-APFO Salt Lake City, Utah

Western States Area  February 9, 2006
FY 2005 NRI Locations

70,406 Locations Contacted
Base Photo Periods

St_nsew.shp

<table>
<thead>
<tr>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 15 - May 31</td>
</tr>
<tr>
<td>Apr 15 - Jun 15</td>
</tr>
<tr>
<td>May 1 - Jul 31</td>
</tr>
<tr>
<td>May 15 - Jul 15</td>
</tr>
<tr>
<td>May 15 - Jul 31</td>
</tr>
<tr>
<td>May 15 - Aug 15</td>
</tr>
<tr>
<td>May 15 - Sep 30</td>
</tr>
<tr>
<td>Jun 1 - Jun 30</td>
</tr>
<tr>
<td>Jun 1 - Jul 15</td>
</tr>
<tr>
<td>Jun 1 - Jul 31</td>
</tr>
<tr>
<td>Jun 1 - Aug 15</td>
</tr>
<tr>
<td>Jun 1 - Sep 30</td>
</tr>
<tr>
<td>Jun 15 - Jul 15</td>
</tr>
<tr>
<td>Jun 15 - Jul 31</td>
</tr>
<tr>
<td>Jun 15 - Aug 15</td>
</tr>
<tr>
<td>Jun 15 - Sep 30</td>
</tr>
<tr>
<td>Jul 1 - Jul 31</td>
</tr>
<tr>
<td>Jul 1 - Aug 15</td>
</tr>
<tr>
<td>Jul 1 - Aug 31</td>
</tr>
<tr>
<td>Jul 1 - Sep 30</td>
</tr>
<tr>
<td>Jul 15 - Aug 15</td>
</tr>
<tr>
<td>Jul 15 - Sep 15</td>
</tr>
<tr>
<td>Aug 1 - Aug 31</td>
</tr>
<tr>
<td>Aug 1 - Sep 30</td>
</tr>
<tr>
<td>Aug 15 - Sep 15</td>
</tr>
</tbody>
</table>
FILM

7,920 / (125 lp/mm x 1000 mm/m) = GRD
0.063 m or 0.206 ft or 2.5 in = GRD

SCAN

7,920 / (600 dpi / 12”) = GSD
1.1 ft = GSD
Note: In New Mexico, USDA Agencies cost-shared with State run Acquisition for NAIP-like products.
2005 NAIP Funding Sources

- Natural Resources Conservation Service  $2,800,000
- U.S. Forest Service  $840,738
- U.S. Geological Survey  $666,000
- U.S. Air Force Space Command  $202,400
- U.S. Department of Interior Agencies  $160,600
- State/County Government Agencies  $1,702,268

Total 2005 Cost Shares:  $6,372,006

- Farm Service Agency  $17,423,348

2005 NAIP Funding Total:  $23,795,354
State/County Government Partnerships for 2005 NAIP

11 Wisconsin Counties
**Average Costs 2004 and 2005**

**1m Ortho Rectified**
- Digital Image
- ABGPS & IMU
- Control DOQ
- Elevation Model

'05 Actual Avg. Price Awarded
$171.85 per DOQQ

'04 Actual Avg. Price Awarded
$12.58 per Sq. Mi.
$177.17 per DOQQ

**2m Ortho Rectified**
- Digital Image
- ABGPS & IMU
- Elevation Model

'05 Actual Avg. Price Awarded
$158.02 per DOQQ

'04 Actual Avg. Price Awarded
$10.09 per Sq. Mi.
$137.19 per DOQQ
NAIP DOQQ Pricing History
2002 - 2005 USDA NAIP Contracts

<table>
<thead>
<tr>
<th>Year</th>
<th>Two Meter</th>
<th>One Meter</th>
<th>Marginal Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>$160.00</td>
<td>$148.31</td>
<td>$137.19</td>
</tr>
<tr>
<td>2003</td>
<td>$157.27</td>
<td>$171.85</td>
<td>$244.68</td>
</tr>
<tr>
<td>2004</td>
<td>$148.31</td>
<td>$137.19</td>
<td>$200.00</td>
</tr>
<tr>
<td>2005</td>
<td>$160.00</td>
<td>$177.17</td>
<td>$200.00</td>
</tr>
<tr>
<td>2006</td>
<td>$155.22</td>
<td>$157.27</td>
<td>$244.68</td>
</tr>
</tbody>
</table>
**Prime Contractors**
- Aerial Services, Inc
- Aero-Metric, Inc
- Horizons, Inc
- LandAir Mapping
- NW Geomatics Ltd
- Photo Science Inc
- Sanborn Mapping Co
- Surdex Corporation
- Triathlon Ltd now MDA
- Vargis L.L.C.

**Subcontractors**
- Airborne Sensing Corp
- Delorme
- EarthData
- Great Lakes Aerial Surveys
- Groupe Alta
- James W. Sewell
- Keystone Aerial Surveys
- MD-Atlantic Technologies
- Pixxures
- Richard Crouse & Associates
- Tim Tyler Surveying and Mapping
- Tuck Mapping Solutions
- Woolpert, Inc

**Prime Contractors were also Subcontractors**
2005 NAIP DIGITAL OR FILM ACQUISITION AREAS

Note: New Mexico, Digital Acquisition

Digital Acquisition
Film Acquisition
Digital Sensors

- NAIP 2003 – 2004
  - Leica ADS40 Airborne Digital Sensor
- NAIP 2005
  - Vexcel UltraCam™ Digital Aerial Camera
  - Intergraph's Z/I Imaging Digital Mapping Camera (DMC)
  - Leica ADS40 Airborne Digital Sensor
NAIP Trends
Digital vs. Film Cameras

Projected >


Percentage: 0%, 20%, 40%, 60%, 80%, 100%

Legend:
- Digital Cameras
- Film Cameras
What Does NAIP Provide?

- **Yearly Coverage of CONUS Ag Areas (Goal)**
  - Two Meter, Natural Color or CIR

- **Base Map Updates Every 5 Years (Goal)**
  - One Meter, Natural Color or CIR

**Deliverable Products:**

- Digital Orthorectified Imagery
  - Compressed County Mosaics (CCM)
    - Fielded 30 days after acquisition (Goal)
  - MrSID MG3 format → JPEG2000 (Future)
  - Compression Ratios: 50:1 2004 → 15:1 2005
  - 1 or 2 meter Quarter Quads GEOTIFFS

- Film
2002 NAIP
121 Counties

2004 NAIP
2,089 Counties

2003 NAIP
1,038 Counties

2005 NAIP
2,445 Counties
NAIP Compressed County Mosaic (CCM)
Example NAIP Mosaics for Lafayette Parish, LA

2004

2005

Much better than using 10-10,000 quarter quads
2-meter imagery still provides great information!
Specification Changes

- **2004 season:**
  - Radiometric correction required (CCM)
  - Satellite vendors allowed (subcontracts)
  - One year product warranty added
  - Vendors allowed to resell “derived” material

- **2005 season:**
  - Pan-sharpen sensors allowed on 1m products
  - Changed compression ratio from 50:1 to 15:1
  - 1m accuracy changed from ±3m to ±5m

- **2006 season:**
  - Require CCM samples for color balance
  - Divide several states in multiple project areas
Contractor Resale of NAIP Derivative Products

Contractor may Sell “after contract” products:

- **Image Type:**
  - Color Infrared vs. Natural Color
- **Projection System:**
  - State Plane vs. UTM
- **Higher Resolution:**
  - Sub-meter vs. 1 meter
USDA Contract Awards

FY 2006 FUNDING ESTIMATES: $39,000,000

- $30,000,000 (77%)
- $6,500,000 (17%)
- $2,000,000 (5%)
- $500,000 (1%)

Categories:
- Small Area Contract (NRI)
- USFS & Other Resource
- USDA NAIP Imagery
- Other Purchases

USDA Contract Awards

FY 2006 FUNDING ESTIMATES: $39,000,000

- $30,000,000 (77%)
- $6,500,000 (17%)
- $2,000,000 (5%)
- $500,000 (1%)

Categories:
- Small Area Contract (NRI)
- USFS & Other Resource
- USDA NAIP Imagery
- Other Purchases
Estimated 2006 Funding Sources

USDA Agencies: $4,400,000
Other Federal Agencies: $2,250,000
State/County Gov’t Agencies: $700,000

Estimated 2006 Cost Shares: $7,350,000

Estimated FSA Funding: $22,200,000

2006 NAIP Funding Total: $29,550,000
Wisconsin Only
CIR State

48 States
3,015 Counties
181,957 DOQQs
2,601,081 Square Miles
8,084 Photo Stations, 3,846 DOQQs, 4 Photo Seasons

2006 State Project Map
CALIFORNIA

Number of Counties - 47
Number of Lines - 439
Number of Photo Stations - 8,084
Number of DOQQs - 3,846
Square Miles - 56,242
Linear Miles - 17,443

2006 State Acquisition Periods
CALIFORNIA

- Apr 15 - May 31 (Season 1)
- Jun 1 - Jun 30 (Season 2)
- Jun 21 - Jul 31 (Season 3)
- Jul 7 - Aug 7 (Season 4)

MOA Areas
Restricted Areas
2006 Louisiana

Areas not funded
Search for Best Available Pre-Hurricane Imagery

- 1 meter or better
  - LA: NDOP/NAPP 2004
  - MS: NAIP 2004
  - TX: NAIP 2004
  - FL: NDOP and State Agencies

Obtain and package imagery not in-house

Inform response community of imagery availability. Package and deliver imagery.
Issues/More Analysis Required

Future Deliverables
- When to take delivery on original digital collections?
- Rectification Solution / enhancement as a deliverable?
- Additional bits. (8 bit → 11 bit → 16 bits)

Frame based vs. Line Scanner Cameras
- GPS/IMU vs. GPS/IMU and AT solutions.
- 4-band image creation.
- During technical evaluation, an we rate the value of one camera vs. another?

What are the Maximum Pan Sharpening ratios that should be allowed?
- 1 meter true color image
  - all three bands be acquired at 1 meter or less
Issues/More Analysis Required

- Standards that can be quality controlled:
  - Tone balancing mosaics
  - Consistent Color (image to image, year to year)
  - Post Processing Haze Reduction
  - 16 bit or 11-bit to 8 conversion
  - Detail loss at one or both ends of the histogram
  - Automation of Quality Control to the Maximum Practical Extent

- During technical evaluation of a contract proposal, can we rate one camera vs. another?
  - Framing vs. push-broom.
Mosaic Issues: Washed out, Haze …
Mosaic Issues: Washed out, Haze ...
Mosaic Issues: Washed out, Haze …
Mosaic Non-Issue:
Mosaic Non-Issue:
Mosaic Non-Issue:
Links for Future Information and Data

- **USDA Aerial Photography Field Office**
  - NAIP and USDA Aerial
    - [http://apfo.usda.gov](http://apfo.usda.gov)
  - Web Mapping Services
    - [http://gdw.apfo.usda.gov/naip/viewer](http://gdw.apfo.usda.gov/naip/viewer)
    - [http://gdw.apfo.usda.gov/mdoq/viewer](http://gdw.apfo.usda.gov/mdoq/viewer)

- **USDA Data Gateway**
  - Data products packaged by county

- **Forest Service geospatial data clearinghouse**
  - Data for National Forests

- **Forest Service's Remote Sensing Applications Center (RSAC)**
  - Fire Mapping, Resource Information
    - [http://www.fs.fed.us/eng/rsa](http://www.fs.fed.us/eng/rsa/)

- **Foreign Agricultural Service Crop Explorer (Global imagery, weather)**
Questions?