



Access and Availability of Resourcesat-1 AWiFS Data for Agriculture

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USDA Satellite Imagery Archive

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Topics

- **Why is USDA using AWiFS data?**
 - USDA use of medium resolution data
 - Landsat status
 - Land imaging alternatives
- **Questions to be resolved for new datasets**
 - What is the quality of the imagery?
 - Is the imagery suitable for USDA applications?
 - Do we have access to the imagery?



USDA Uses Medium Resolution Satellite Imagery

USDA has been using medium resolution satellite imagery since the early 1980's and is an outgrowth of two large USDA NASA cooperative programs

LACIE -- Large Area Crop Inventory Experiment

AgRISTARS – Agriculture and Resources Inventory Surveys through Aerospace Remote Sensing

Current applications include:

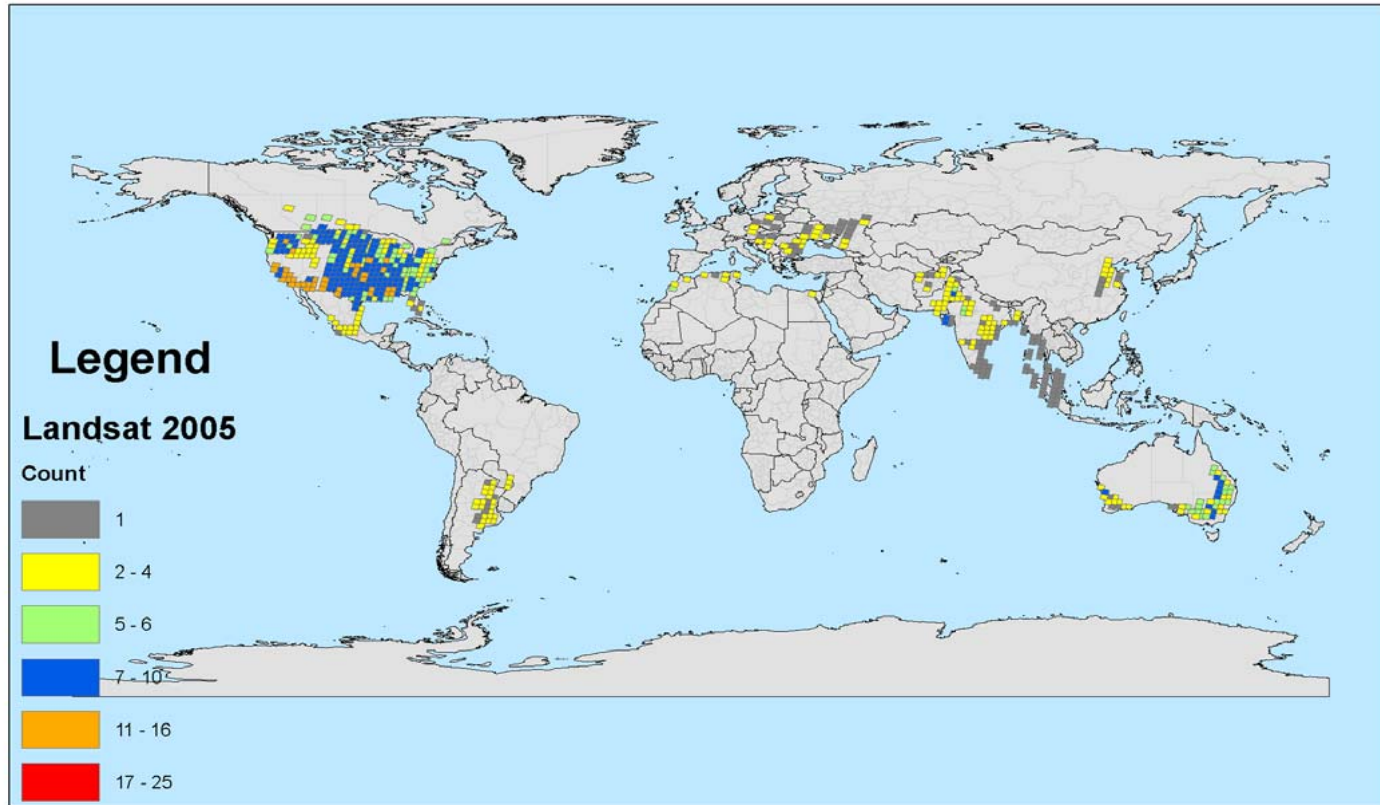
- Foreign crop condition monitoring (FAS)
- Area sampling frame construction (NASS)
- Cropland Data Layer (NASS)
- Input into crop acreage estimates for select States (NASS)
- Burned Area Estimates Report (Forest Service)
- Forest Inventory (Forest Service)
- Crop tillage (NRCS)
- Natural Resources Inventory (NRCS)
- Agricultural Research (ARS)
- Crop insurance compliance (RMA)
- Farm program compliance (FSA)
- Invasive species management (APHIS)

http://www.usda.gov/oce/remote_sensing/activities.htm



Landsat Satellite Data in the USDA-SIA

2005 Landsat in the USDA-SIA



USDA Satellite Imagery Archive (USDA-SIA)
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<http://www.pecad.fas.usda.gov/remote.cfm>

USDA-SIA
Collection includes Landsat 5
and Landsat 7
2005 Calendar year



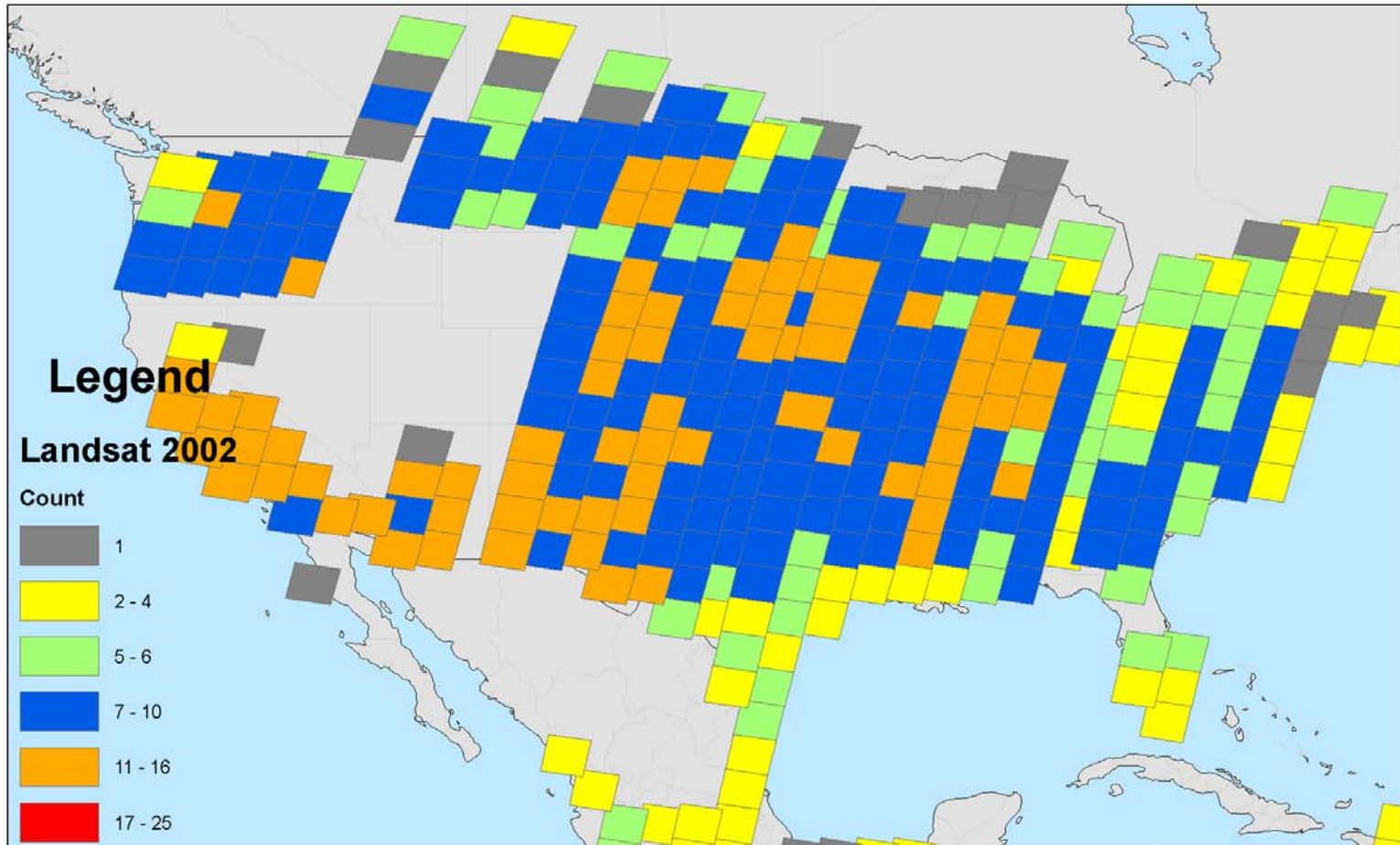
USDA-SIA

Sept. 12, 2006

USDA FAS Agricultural Applications Seminar 2006

Landsat Satellite Data in the USDA-SIA

2002 Landsat in the USDA-SIA



USDA Satellite Imagery Archive (USDA-SIA)
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<http://www.pecad.fas.usda.gov/remote.cfm>

USDA-SIA
Collection includes Landsat 5
and Landsat 7
2002 Calendar year

Landsat-7 Status

- **Landsat 7 and its Enhanced Thematic Mapper-Plus (ETM+) sensor reached the end of its five-year design life on April 15, 2004**
 - **ETM+ scan line corrector (SLC) anomaly occurred on May 31, 2003**
 - Only center third of each ETM+ scene unimpaired by gaps (see next slide)
 - **One of three attitude control gyros was shut down in May 2004 with no adverse impacts on image acquisition or data quality**
 - Probabilistic risk assessment conducted for failure of a second gyro
 - The probability of continuing the mission beyond 2007 is less than 10%
 - **Fuel depleted in 2011**
 - **ETM+ data quality remains high**
 - Radiometric and geolocation accuracies have not been affected by the SLC anomaly and gyro failure
 - **The USGS EROS Data Center is offering “gap-filled” composite products.**



Impact of the Landsat-7 ETM+ SLC Anomaly

PRE-SLC FAILURE



3 MARCH 2000

POST-SLC FAILURE



20 SEPTEMBER 2003

Note that the images show partial scenes

Sept. 12, 2006

USDA FAS Agricultural Applications Seminar 2006

Landsat-5 Status

- **Landsat 5 and its Thematic Mapper (TM) sensor are 20 YEARS OLD, 17 years past 3-year design life**
 - Satellite is only capable of the direct transmission of data in real time
 - TDRSS antenna transmitter failed in 1992; no onboard data recorder
 - EROS Data Center directly receives data only for CONUS
 - TM data are directly transmitted to a growing number of International Ground Stations (IGS's) since the Landsat 7 SLC anomaly
 - Only the Australian IGS sends tapes to the EROS Data Center
 - No redundancy remains: TM scan mirror operates in back-up “bumper mode”; battery performance at margin; down to last X-band transmitter, reaction wheel, thruster
 - Fuel depleted in Fall, 2008



Landsat-5 Status (continued)

- **Solar-array drive malfunction: November 30, 2005 through January 26, 2006**
 - Restored to operational status for acquiring both US and foreign coverage.
- **Power outage: March 16, 2006**
 - Traveling Wave Tube Amplifier (TWTA) tripped an Over Current Protection circuit.
 - Missed imaging Texas wildfires; however, operational status restored.
- **Solar-array drive malfunction: August 11, 2006**
 - Solar-array in fixed position at spacecraft “noon.”
 - Only US coverage, no foreign acquisition until power budget is restored.



Landsat Data Gap

- The extent of the Landsat Data Gap based on numerous assumptions:
 - Complete Gap: **2008 to 2011**
 - 2008: fuel depleted for Landsat-5; 10% probability for Landsat-7 gyro failure.
 - Landsat-5 solar array drive malfunction may increase gap.
 - 2011: launch of the Landsat Data Continuity Mission (LDCM)
 - Assumes one satellite, similar to Landsat-7.
 - Partial Gap: **2003 to Indefinite**
 - 2003: Landsat-7 SLC anomaly; Landsat-5 operational but only 16-day revisit.
 - Indefinite: No US government plans to provide better than 16-day revisit.
 - Does not meet requirements for operational agricultural applications.



Land Imaging Alternatives

Landsat Data Continuity Working Group

- **IRS-ResourceSat-1**

- Launched October 2003
- Status: Operational
- Revisit Rate: 24 days
 - *wide swath width for AWiFS allows 5-day revisit.*
- Data Product Characterization: Reviewed by JACIE
- Follow-on mission (ResourceSat-2) scheduled for mid 2008

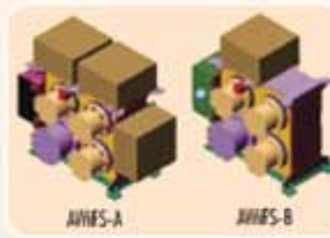
Better than 16-day revisit requirement met by AWiFS

- **CBERS-2**

- Launched October 2003
- Status: failed IR-MSS sensor and CCD sensor
- Revisit Rate: 26 days
- Data Product Characterization: Reviewed by JACIE
- Follow-on mission (CBERS-2B) scheduled for Oct. 20, 2006



Resourcesat-1 AWiFS Characteristics



PAYLOADS

	LISS-4	LISS-3	AWiFS
Spatial Resolution (m)	5.8	23.5	56
Swath (km)	23.9 (MX mode) 70.3 (PAN mode)	141	740
Spectral Bands (micron)	0.52-0.59 0.62-0.68 0.77-0.86	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70
Quantisation (bits)	7	7	10
Square Wave Response (at Nyquist)	>0.20	B2 > 0.40 B3 > 0.40 B4 > 0.35 B5 > 0.20	B2 > 0.40 B3 > 0.40 B4 > 0.35 B5 > 0.20
Power (W)	216	70	114
Weight (kg)	169.5	106.1	103.6
Data Rate (MBPS)	105	52.5	52.5

- Broad swath : AWiFS-A, AWiFS-B, each with a swath width of 350 km
- Four Bands: including SWIR
- High revisit rate: 5 to 24 days, depending on scene selection.

USDA Can No Longer Rely on Landsat to Meet Operational Needs

- USDA is no longer using Landsat imagery for operational applications because of the data gap.
 - No global coverage
 - No adequate revisit cycle
 - Not the best value for USDA
- Data gap is likely to persist indefinitely.



Unknowns

Will the USG acquire (through purchase or other means) medium resolution data for the US global archive in the absence of Landsat data? Will that help USDA mitigate the impact of the Landsat Data Gap?

- Will the USG have funds? How much? When?
- What will the Licensing Policy be? Would it exclude the use of imagery for operational USDA applications?
 - Prior data buys have excluded USDA from using imagery for operational use as the data was restricted to Science/Research.
- Will there be a government (US) to government (India) arrangement for a data buy or data transfer?
 - Will the data be scientific-level only? (level-0 , level-0R) Or higher level or value-added products?
 - How does the US Commercial Remote Sensing Policy apply to a government to government arrangement? Does it?



Topics

- Questions to be resolved for new datasets:

- What is the quality of the imagery?

- Joint Agency Commercial Imagery Evaluation (JACIE)
- NASA, USGS, and NGA

JACIE continues to examine and characterize

- Is the imagery suitable for USDA applications?

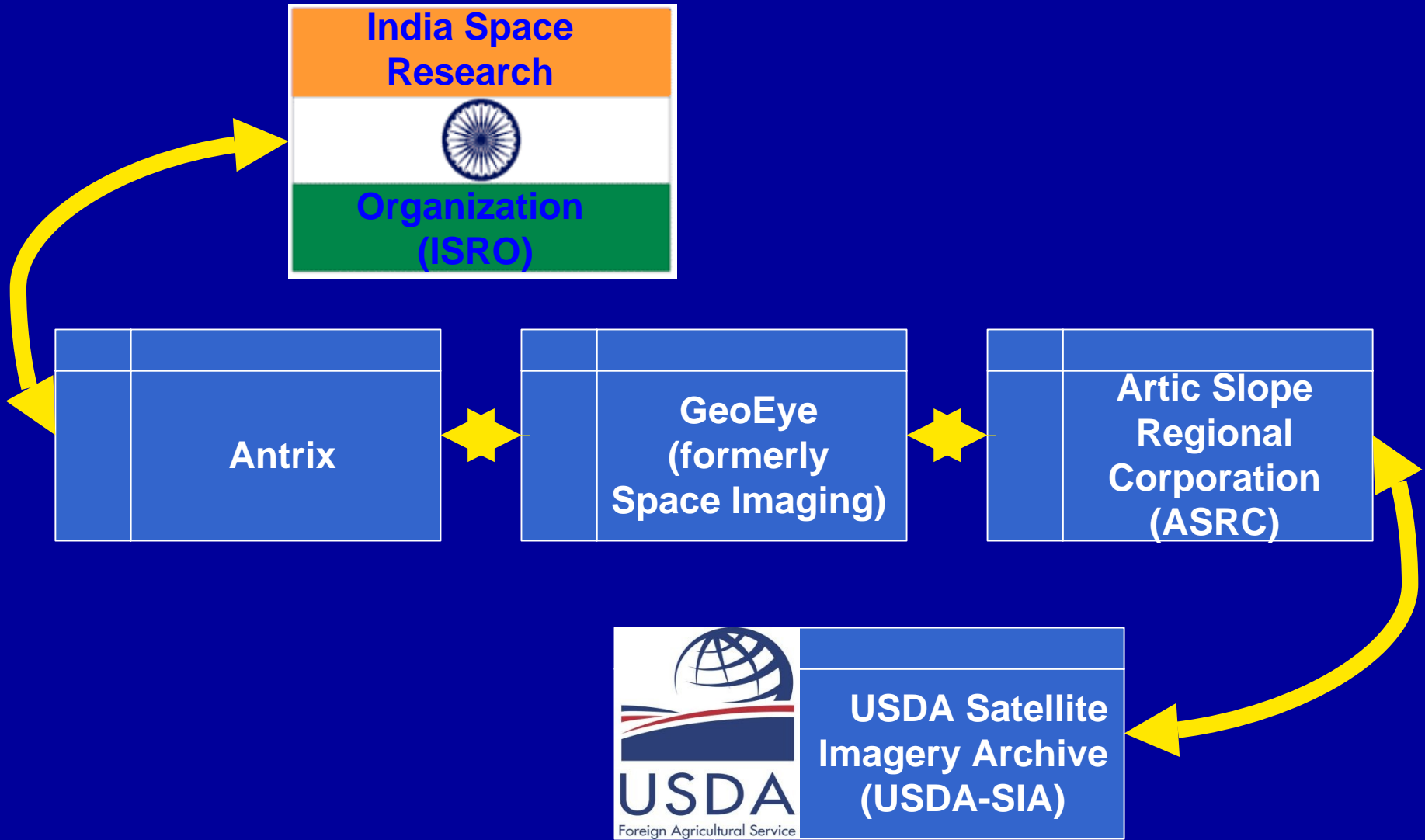
- National Agricultural Statistics Service

USDA NASS continues to examine data for its Cropland Data Layer

- Do we have **access** to the imagery?



Commercial Channel Facilitates Cooperation Between Governments



Background for USDA-SIA

- **USDA's Satellite Imagery Archive (USDA-SIA)**
 - Established in 2000
 - Must spend funds in private sector
 - Affiliated with USGS/EROS
 - Broad MOU for cooperative efforts.
 - Participating agencies: NASS, FAS, FSA, NRCS, RMA, Forest Service, ARS, APHIS
 - Based on subscription fees paid annually
- **Prior to FY2006, used to negotiate directly with prime satellite imagery vendors.**
- **FY2006 established contract with ASRC**
 - Government to commercial (FAR clauses)
- **ASRC (prime contractor) established contracts with 7 prime satellite imagery vendors**
 - Commercial to commercial (Commercial clauses)



Satellite Imagery Vendors under contract with ASRC MS

1. MDA Geospatial Services-Radarsat International

2. Earthsat (MDA Federal)

3. Eurimage

4. Space Imaging (GeoEye)

5. OrbImage (GeoEye)

6. Digital Globe

7. SPOT

750 products and services

- Multipsectral imagery (2.8 to 60 meters)
- Pan imagery (0.6 to 10 meters)
- Radar
- Services



Background for ASRC

- **Arctic Slope Regional Corporation (ASRC) is one of the original Alaska Native Corporations (ANC) formed in 1971.**
 - The Inupiat Inuit (ASRC) were required to give up rights to all but 5 million of the 56 million acres of the North Slope. Oil was discovered in 1968 in Prudhoe Bay.
- **In return for the land and mineral rights, ANCs are entitled to unique privileges under applicable federal regulations.**
 - ANCs are entitled to receive sole source contracts of any value. They are not subject to the \$3 million limitation applied to other 8(a) entities. 13 C.F.R. 124, 123, 311(b).
 - ANC's may operate multiple 8(a) companies providing that each company operates under a different primary SIC Code or NAICS Code. 108(c) and 112(c)(3).
 - SBA considers only the size of the particular tribal/ANC subsidiary at issue when determining the size of a firm owned by a tribe or ANC. 112(c)(2)(iii).

Background for ASRC

- **Arctic Slope Regional Corporation (ASRC) has been the largest Alaskan-owned company for 10 years in a row.**
 - \$3.25 billion in assets
 - \$1.3 billion dollars in annual revenue
 - Over 6,500 employees
- **ASRC manages over 5 million acres (remaining from ANCSA)**
 - ASRC has over 9,500 Inupiat shareholders
- **ASRC Management Services is the USDA-FAS prime contractor.**
 - Provides products such as Crop Explorer for Global Crop Production analysis.
 - Procures satellite imagery for USDA agencies and other agencies on an “as-needed” basis.

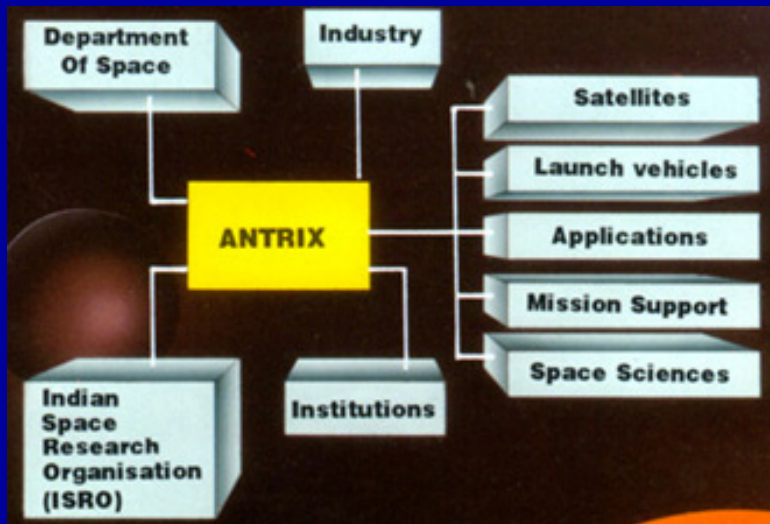


Background for GeoEye

- GeoEye was formed in Jan. 2006 when Orb Image acquired Space Imaging forming one company.
 - Headquarters: Dulles, Virginia
- GeoEye is the distributor of ResourceSat-1, IKONOS, and Orb View data.
 - GeoEye has contractual relationship with Antrix for marketing and distribution of IRS data.
 - GeoEye has contractual relationship with ASRC.



Background for Antrix and ISRO

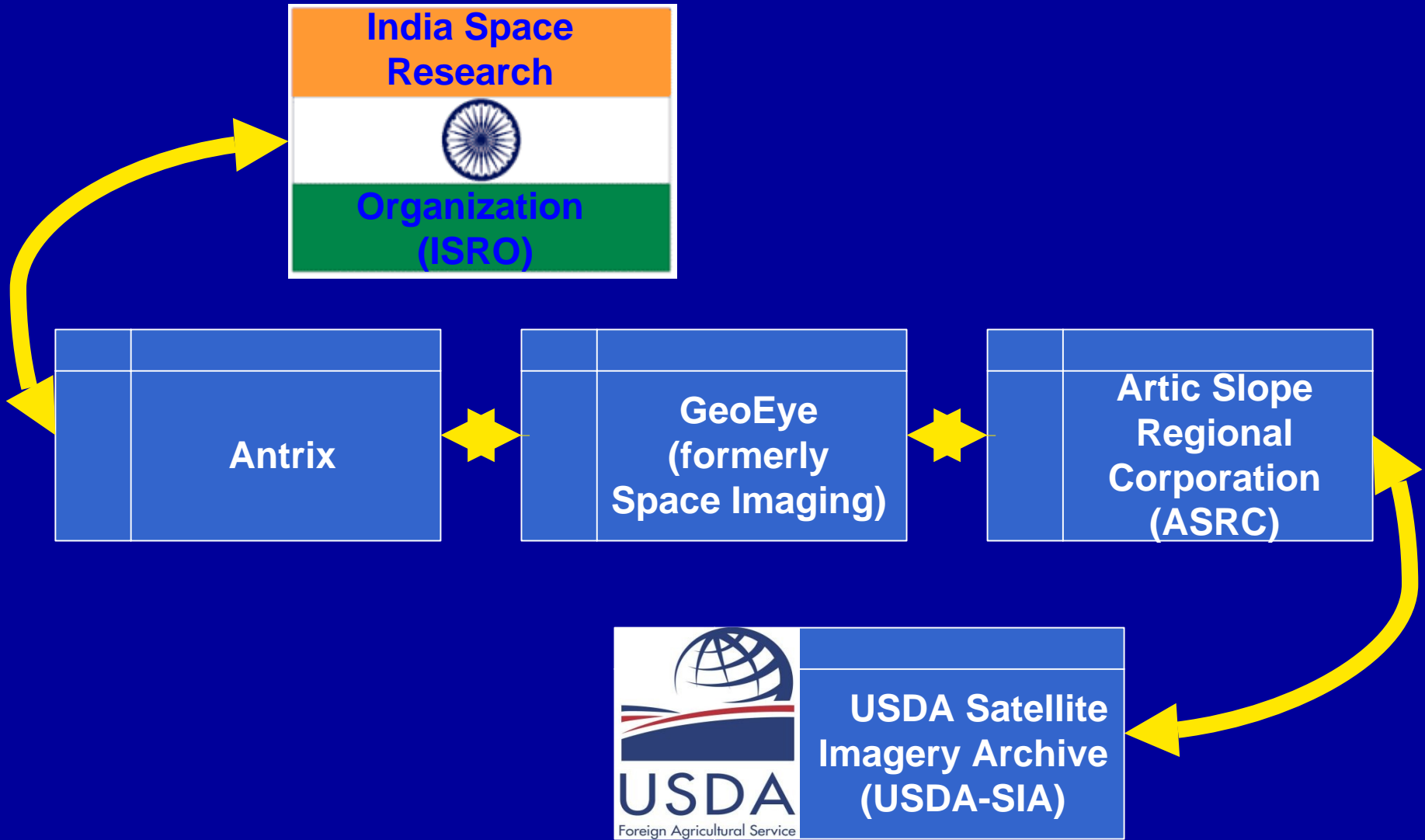


- **Antrix Corporation Limited**, the commercial arm of Department of Space (DOS) was incorporated in September 1992 for the promotion and commercial exploration of products and services from the Indian Space Program.

- **Indian Space Research Organization (ISRO)**

- *To develop space technology and its application to various national tasks.*
- *ISRO has established two major space systems,*
 - *INSAT for communication, television broadcasting and meteorological services, and*
 - *Indian Remote Sensing Satellites (IRS) system for resources monitoring and management.*
- *ISRO has developed two satellite launch vehicles, PSLV and GSLV, to place INSAT and IRS satellites in the required orbits.*

Commercial Channel Facilitates Cooperation Between Governments



Access and Availability

- **Contract**
 - Prices on a per scene basis or per AOI.
 - Delivery dates and formats
 - Enforceable terms
 - Availability of products and services
- **Coverage**
- **Acquisition Planning**
- **Distribution/Re-distribution**



Contract for ResourceSat-1 AWiFS Data

- **Contract Highlights**

- Price

- AWiFS orthorectified Quad
- Scene identification are Path: Row: Quad: Acquisition Date

- Format

- Orthorectified LCC, WGS-84, 8-bit, 4-band, Geo-TIFF, cubic convoluted

- Delivery terms

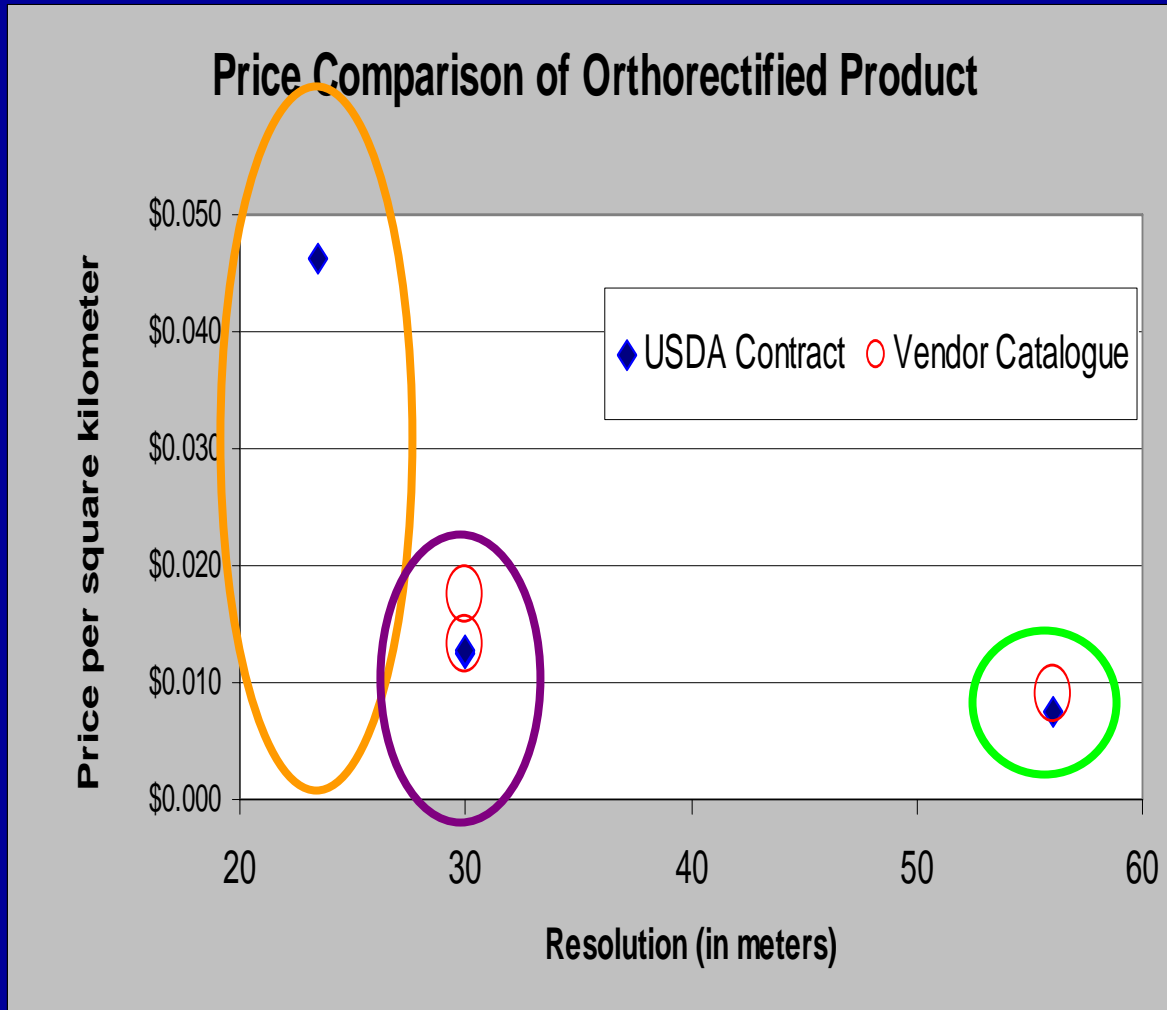
- Less than 10 calendar days after acquisition date (non-North America)
- Less than 5 days for North America

- License for Distribution/Redistribution

- Tier 2 (Federal/Civilian agencies)

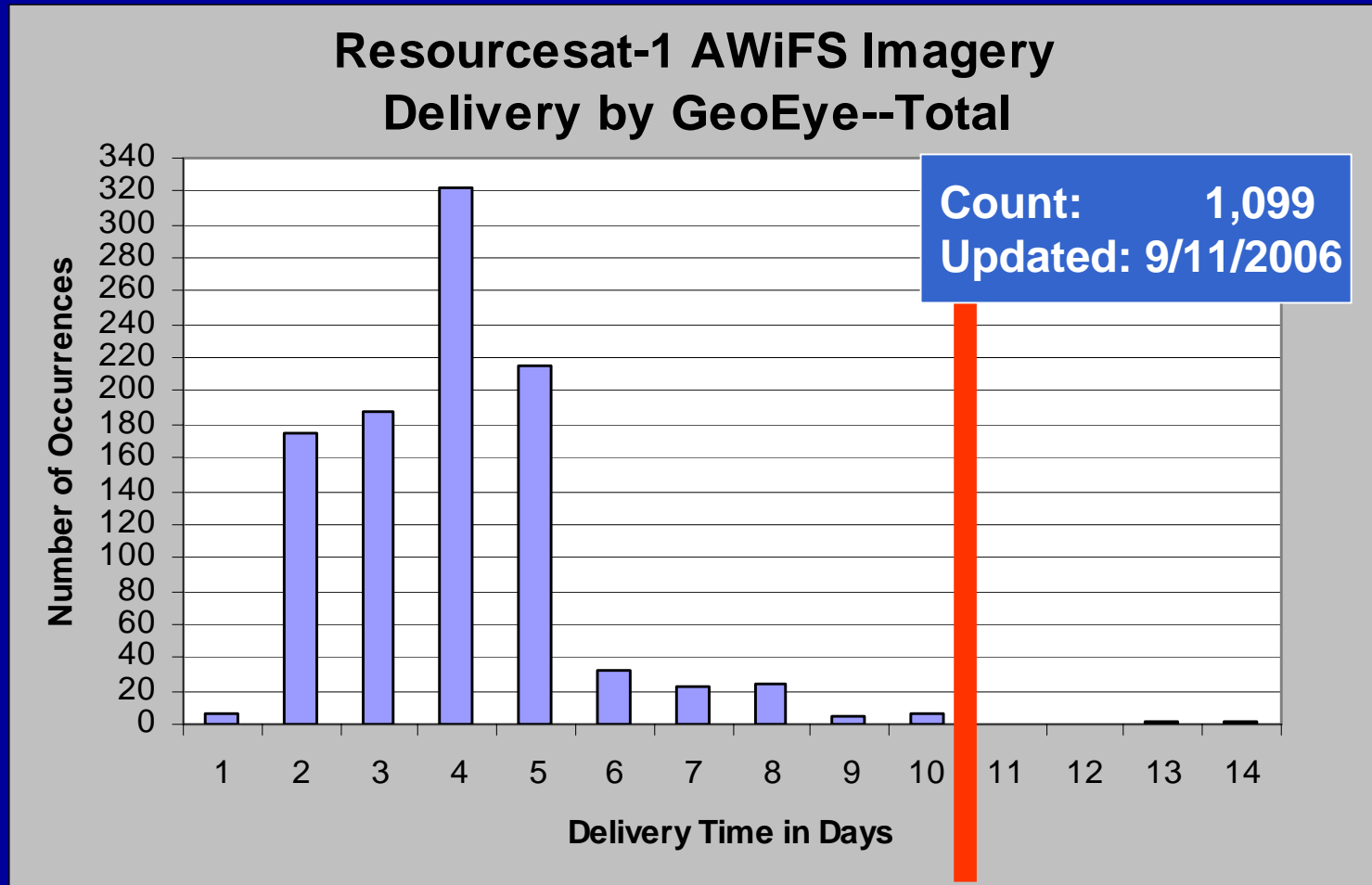


Access to Resourcesat-1 AWiFS Data: *Price*



- USDA is a price-sensitive purchaser of satellite imagery.
- Contract prices are lower than vendor's catalogue prices.
- Prices for **LISS3** are higher than **Landsat** and **AWiFS** prices are lower than **Landsat**.

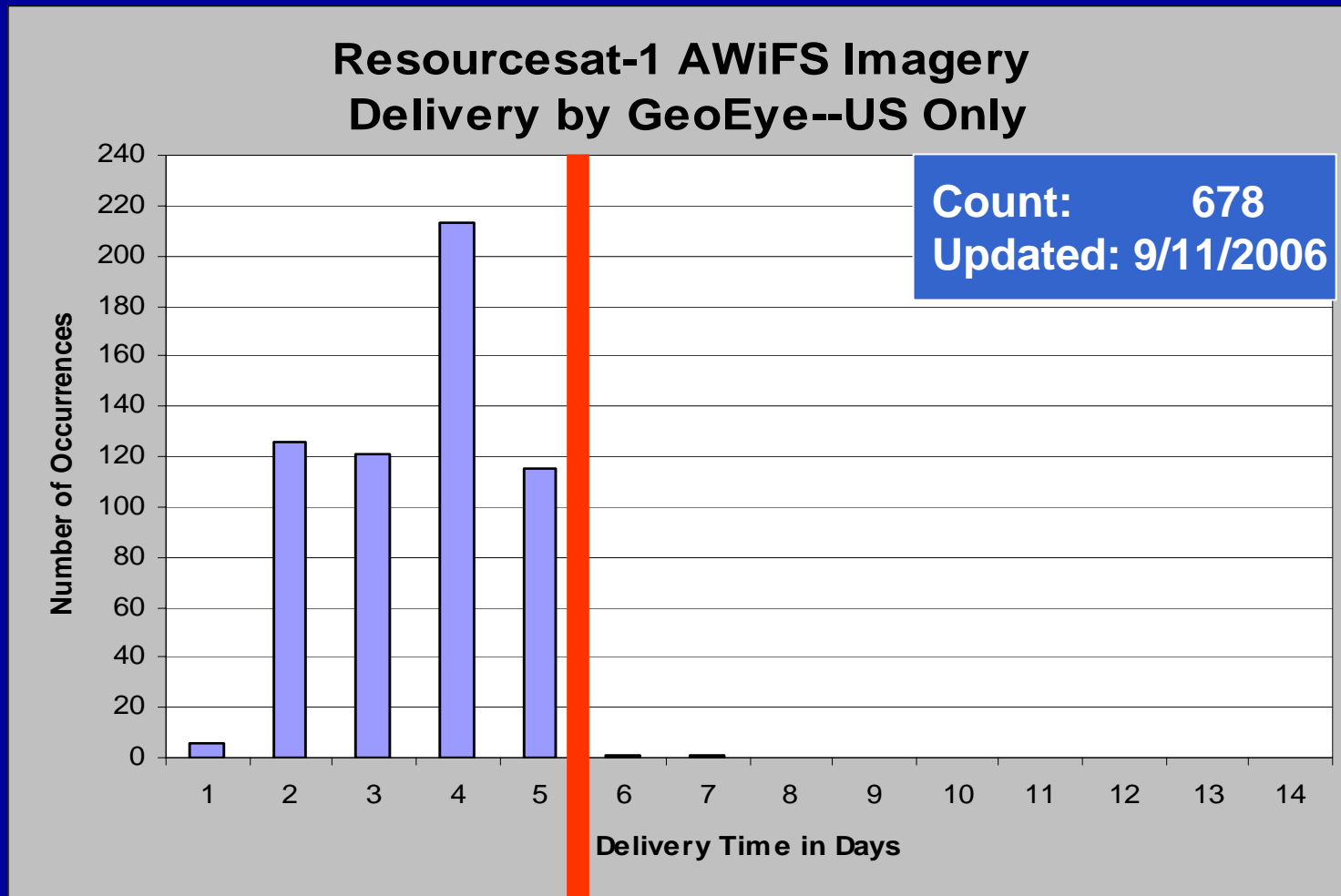
Access to Resourcesat-1 AWiFS Data: *Delivery*



AWiFS Delivery by GeoEye has met and *exceeded* contract specifications



Access to Resourcesat-1 AWiFS Data: *US Delivery*



AWiFS Delivery for US imagery has met and *exceeded* contract specifications



Access to Resourcesat-1 AWiFS Data: **Coverage**

a means of approaching, communicating with, or making use of

- **World-wide Coverage**

- International Ground Stations
- Standing Orders take ~ 15 days to implement. They consist of:
 - Start date
 - End Date
 - Path/Row/Quad
- Shutter control for coverage of India.

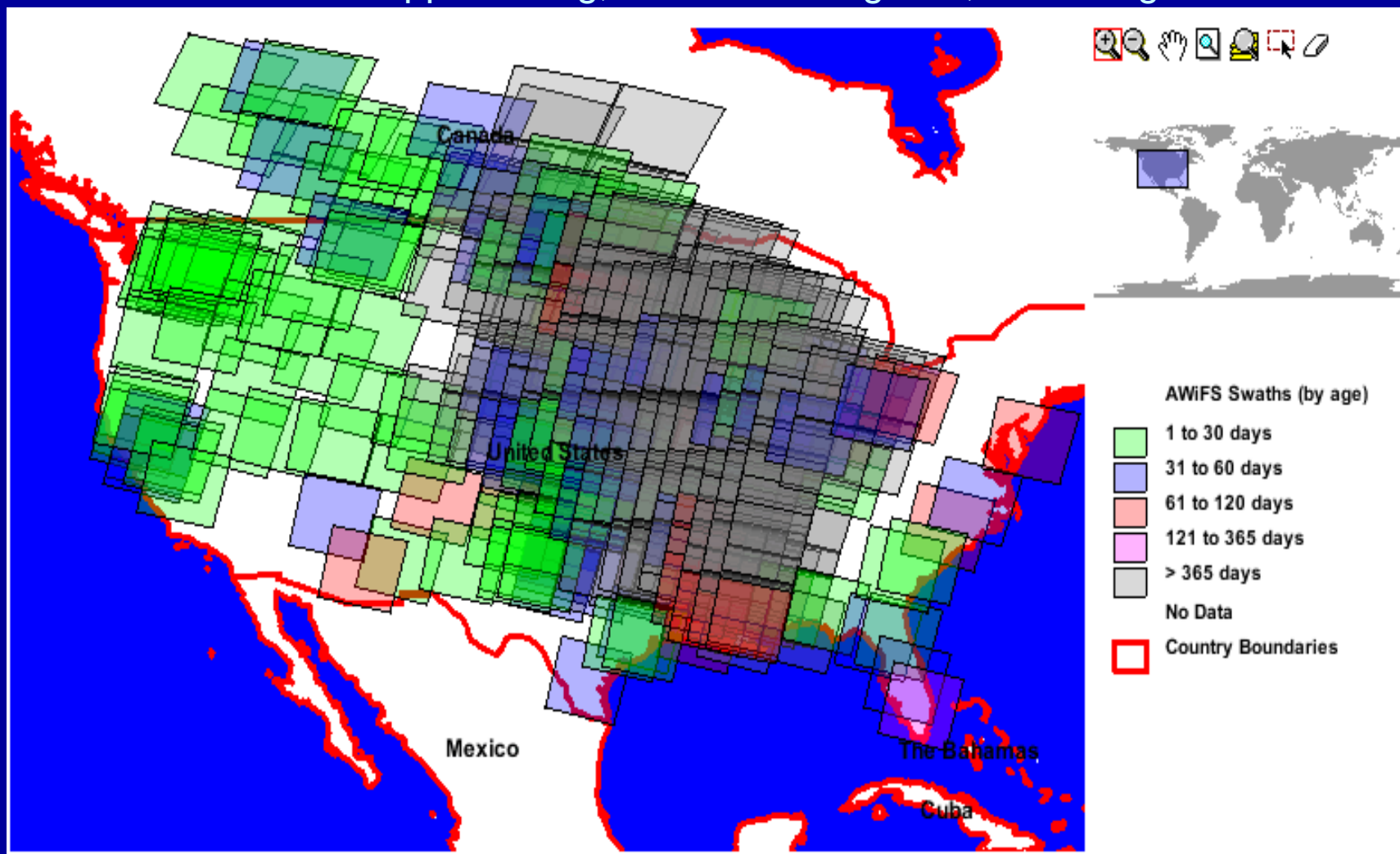
- **USDA-FAS Standing Orders in Process**

- Russia and Ukraine
- Siberia and Kazakhstan
- Europe
- China
- US
- Canada
- Pakistan
- Bangladesh
- Sri Lanka
- South Africa
- Argentina



Access to Resourcesat-1 AWiFS Data: *Coverage*

a means of approaching, communicating with, or making use of



USDA-SIA has 1,334 AWiFS scenes as of September 11, 2006



Availability of Resourcesat-1 AWiFS Data: *Planning*

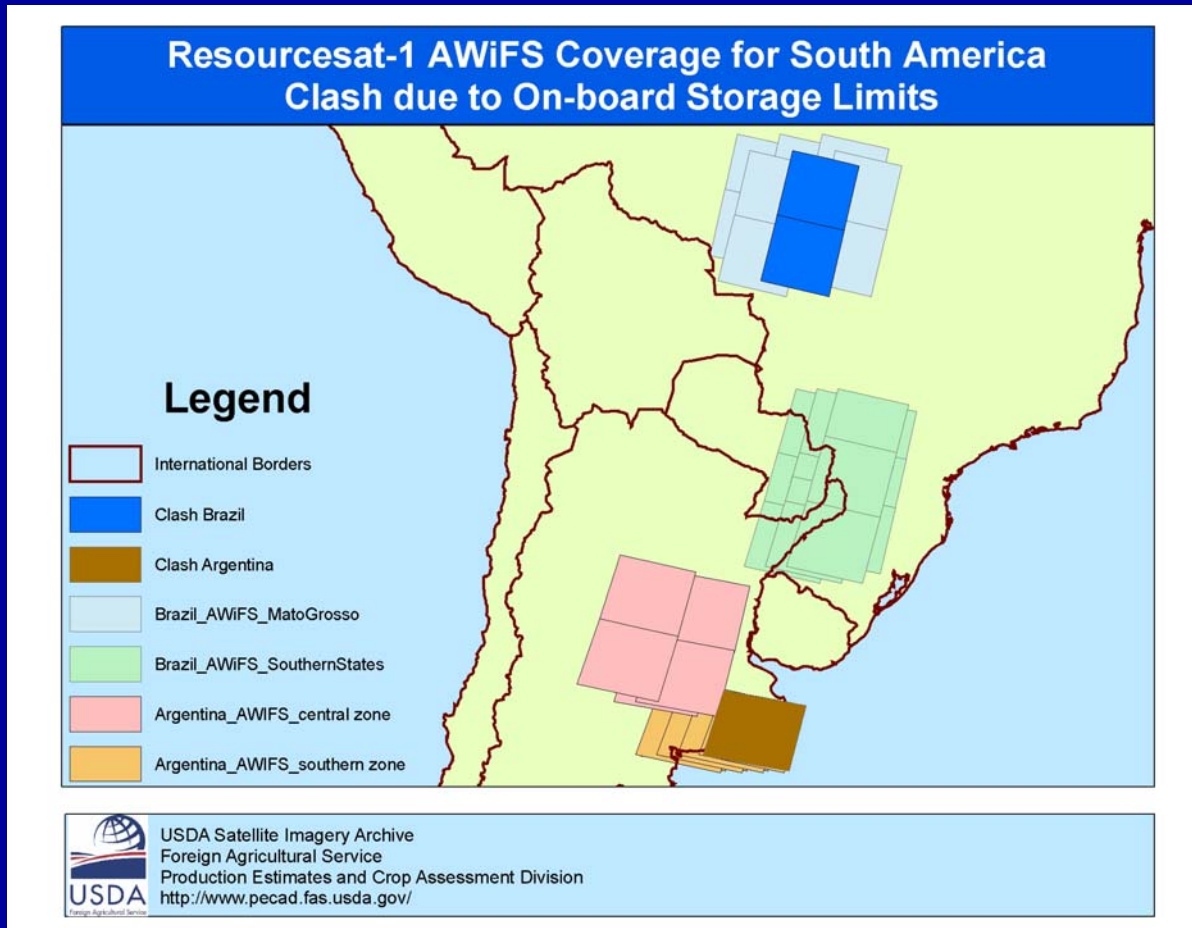
present and ready for use; at hand; accessible

- **On-board storage**
 - Clashes in South America
 - Norway ground station will alleviate many clashes.
 - Clashes are relieved by better planning.
- **Real-time collection mode (collect and downlink simultaneously) alleviates the problem with on-board storage**
 - US acquisitions have been OK.



Availability of Resourcesat-1 AWiFS Data: *Planning*

present and ready for use; at hand; accessible



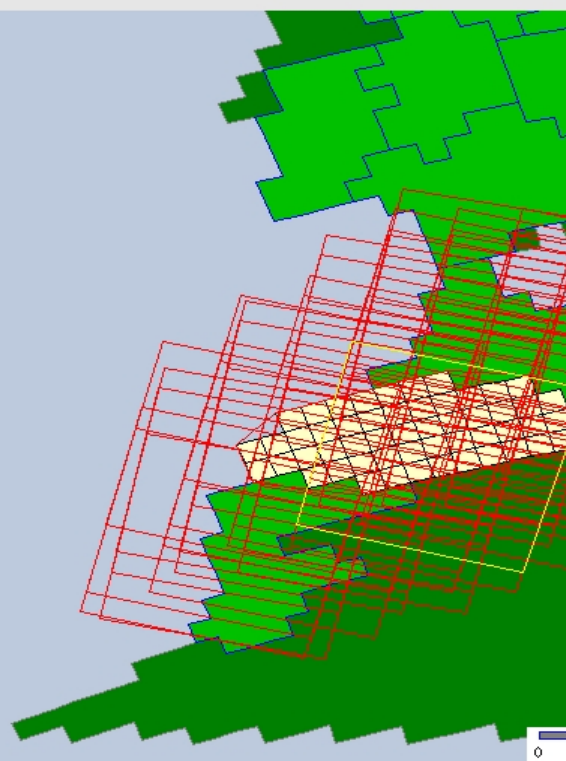
- On-board storage has a capacity of 120GB, which is ~ 9 minutes.
- Same-day / same-path clashes occur for first and last scenes in path.
- Either take Brazil or Argentina

USDA United States Department of Agriculture
Foreign Agricultural Service

Create Task Order

Review Task Order

Submit Task Order



Path	167	172	177	182	187	168	173	178	183	188	169	174	179	184	189	170	175	180	185	190	171	176	181	186	
	143	148	153	158	163	144	149	154	159	164	145	150	155	160	165	146	151	156	161	166	147	152	157	162	
	119	124	129	134	139	120	125	130	135	140	121	126	131	136	141	122	127	132	137	142	123	128	133	138	
	95	100	105	110	115	96	101	106	111	116	97	102	107	112	117	98	103	108	113	118	99	104	109	114	
	71	76	81	86	91	72	77	82	87	92	73	78	83	88	93	74	79	84	89	94	75	80	85	90	
	47	52	57	62	67	48	53	58	63	68	49	54	59	64	69	50	55	60	65	70	51	56	61	66	
	23	28	33	38	43	24	29	34	39	44	25	30	35	40	45	26	31	36	41	46	27	32	37	42	
	340	4	9	14	19	341	5	10	15	20	1	6	11	16	21	2	7	12	17	22	3	8	13	18	
	316	321	326	331	336	317	322	327	332	337	318	323	328	333	338	319	324	329	334	339	320	325	330	335	
	282	297	302	307	312	293	298	303	308	313	294	299	304	309	314	295	300	305	310	315	296	301	306	311	
	268	273	278	283	288	269	274	279	284	289	270	275	280	285	290	271	276	281	286	291	272	277	282	287	
	244	249	254	259	264	245	250	255	260	265	246	251	256	261	266	247	252	257	262	267	248	253	258	263	
	220	225	230	235	240	221	226	231	236	241	222	227	232	237	242	223	228	233	238	243	224	229	234	239	
	196	201	206	211	216	197	202	207	212	217	198	203	208	213	218	199	204	209	214	219	200	205	210	215	
					192					190					194					195				191	
Jan	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
	25	26	27	28	29	30	31																		
Feb								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
	18	19	20	21	22	23	24	25	26	27	28	29													
Mar	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31						
Apr	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
	30																								
May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
	24	25	26	27	28	29	30	31																	
Jun								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
	17	18	19	20	21	22	23	24	25	26	27	28	29	30											
Jul																1	2	3	4	5	6	7	8	9	10
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31				
Aug																							1	2	3
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	28	29	30	31																					
Sep					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	21	22	23	24	25	26	27	28	29	30															
Oct											1	2	3	4	5	6	7	8	9	10	11	12	13	14	
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31								
Nov																		1	2	3	4	5	6	7	
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
Dec																								1	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
	26	27	28	29	30	31																			

Table 4.2.1 Typical Orbital Calendar of IRS-P6



Availability of Resourcesat-1 AWiFS Data: *Distribution*

present and ready for use; at hand; accessible

- **Distribution/Redistribution**

- USDA-SIA determines which Resourcesat-1 scenes will be bought

- Input from participating agencies.
- Mixture of AWiFS and LISS3
- Limited budget

- Resourcesat-1 scenes bought through USDA's contract have Fed/Civil license.

- Redistribution

- Archive Explorer (web-based application)
 - Restricted use to participating agencies

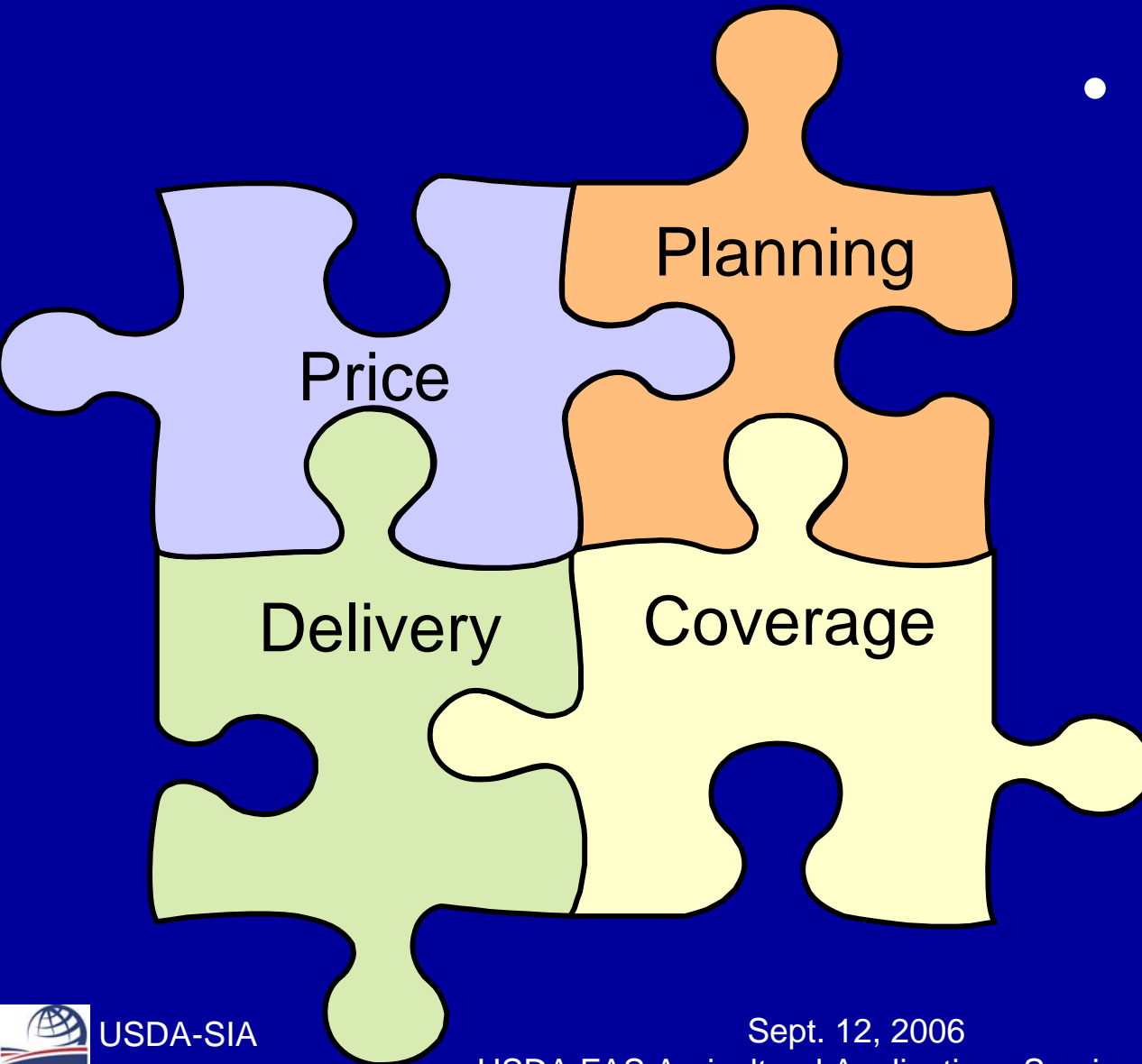
- Data swapping with USGS/EROS
- Access to Indian Archive

} *Pending*



Access and Availability of Resourcesat-1 AWiFS Data:

Summary



- **AWiFS data has elements for successful applications in agriculture.**
 - Reasonable Prices
 - Timely Delivery
 - Acquisition Planning
 - Global Coverage

Backup slides



USDA-SIA

Sept. 12, 2006

USDA FAS Agricultural Applications Seminar 2006

Next Steps

Input into Requirements for Resourcesat-2

- **USDA Foreign Agricultural Service will be organizing a workshop on applications of Resourcesat-1 data for agriculture.**
 - Participants include
 - ISRO (Indian Space Research Organization)
 - ANTRIX (Marketing and commercial arm of ISRO)
 - GeoEye (worldwide distributor of Resourcesat-1 data)
 - USDA agencies
 - Others?
- If interested, please contact Bob Tetrault at
 - 202 690-0130
 - Robert.tetrault@usda.gov



Availability of Resourcesat-1 AWiFS Data: *Purchase*

present and ready for use; at hand; accessible

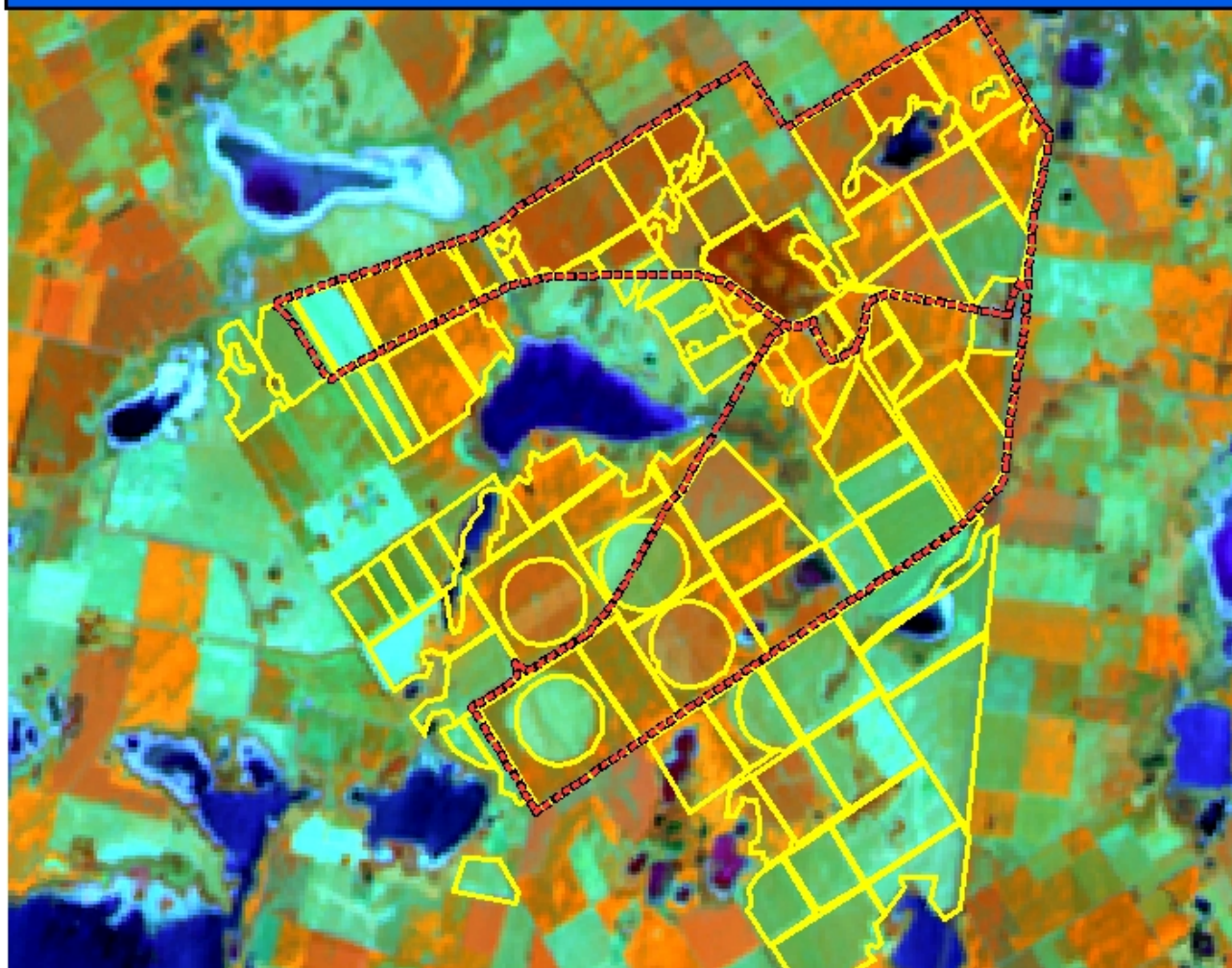
Ordering data through USDA-SIA :

1. Contact Bob Tetrault (COTR) to place an order
 - robert.tetrault@usda.gov
 - Call Bob Tetrault at 202-690-0130
2. Send detailed requirements (Agency to USDA-SIA)
3. Review bids (Agency and USDA-SIA)
4. Transfer funds via AD-672 (Agency to USDA-SIA)
5. Receive imagery



El Carmen: January 19, 2006

Venado Tuerto Delegation, Santa Fe Province, Argentina



El Carmen Field Map
Courtesy of ADECO



4,300 2,150 0 4,300 8,600 Meters



Fieldwork 2005

- GPS tracks
- Fields_0405



U.S. Department of Agriculture
Foreign Agricultural Service
Production Estimates and Crop Assessment Division
<http://www.pecad.fas.usda.gov/>

Field Data: USDA/FAS/PECAD
Image Data: IRS-AWIFS (IR, SWIR, R)
Projection: Lambert Conformal Conic, WGS 84
Contact: Nicole.C.Wagner@usda.gov

USDA Uses Resourcesat-1 Satellite Data

- Resourcesat-1 launched October 17, 2003
- Sample data to USDA/NASS August, 2004
- Sample data to USDA/FAS December, 2004

Space Imaging receives FCC license to download data at Norman, OK January, 2005

- Purchases by USDA/NASS August, 2004
- Purchases by USDA/FAS November, 2005
- First standing order December, 2005: Southern Hemisphere

Space Imaging and Orb Image merge into GeoEye, January, 2006

- Current USDA Inventory: 242 scenes



Access and Availability

- **Delay in use results from:**

- Concerns about data quality

- Geometric and radiometric

- Applications for 56 meter resolution data.

- Poor initial delivery terms

JACIE continues to examine and characterize

USDA NASS continues to examine data for its Crop Land Data Layer

USDA SIA Contract emphasizes access and availability



Access to Resourcesat-1 Data: *Coverage*



Source: http://www.spaceimaging.com/whitepapers_pdfs/IRSwhitepaper_LoRes.pdf

- **Coverage for areas outside of communication cones achieved through new Svalbard, Norway ground station.**