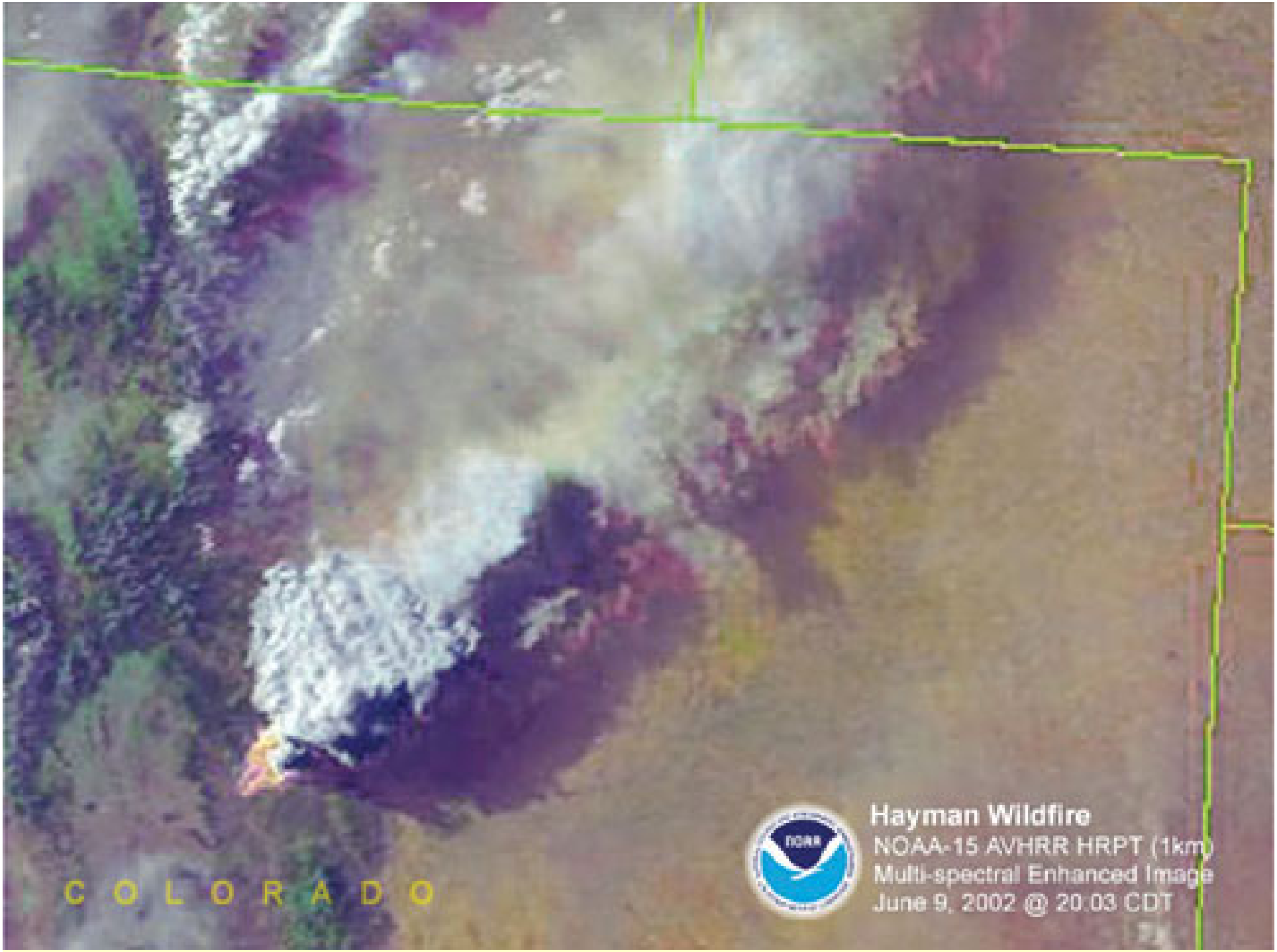
Bureau of Land Management
2004 National Petroleum Forum

Remote Sensing

More to Choose From

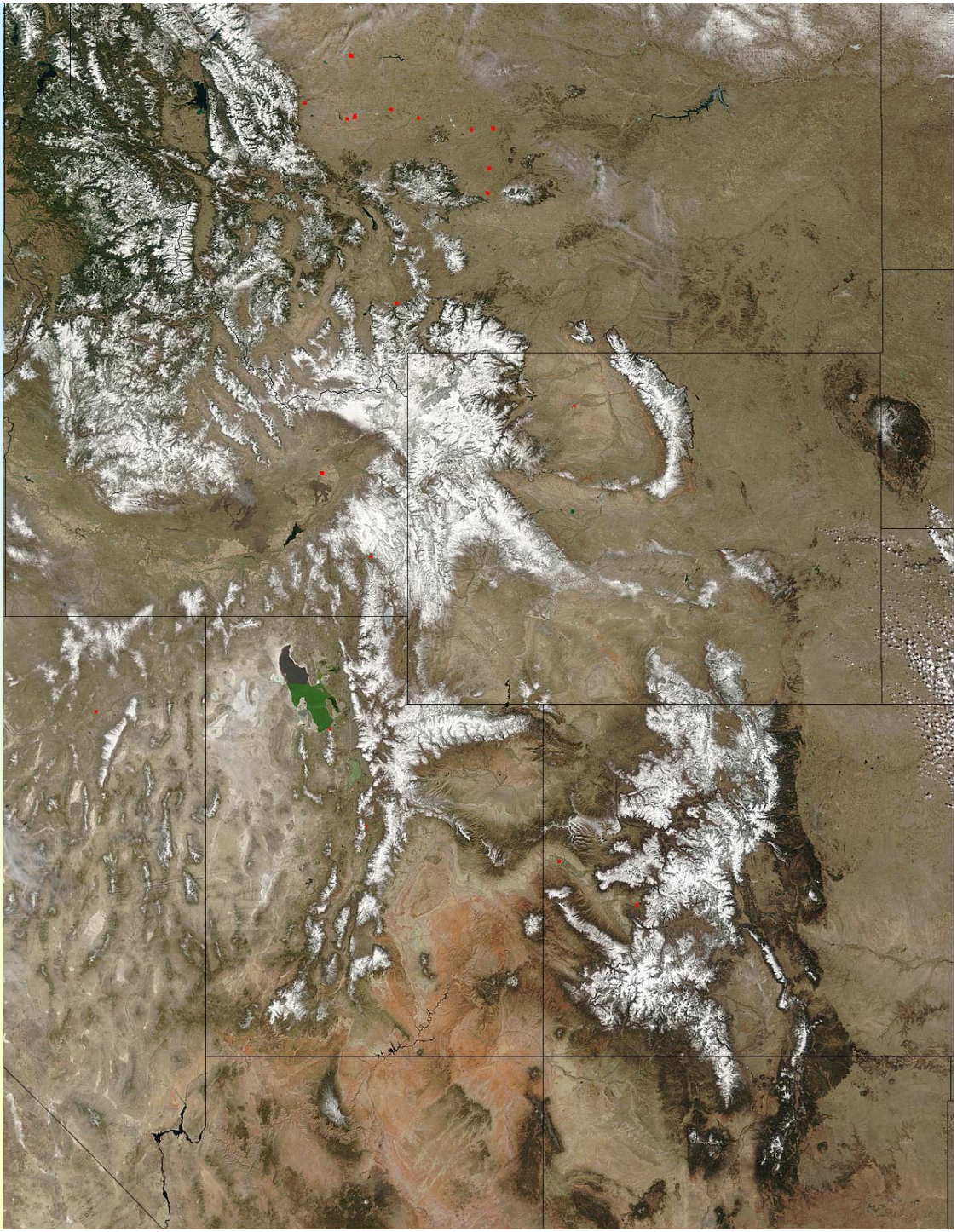
Ed Harne
Geographic Sciences Coordinator
Bureau of Land Management

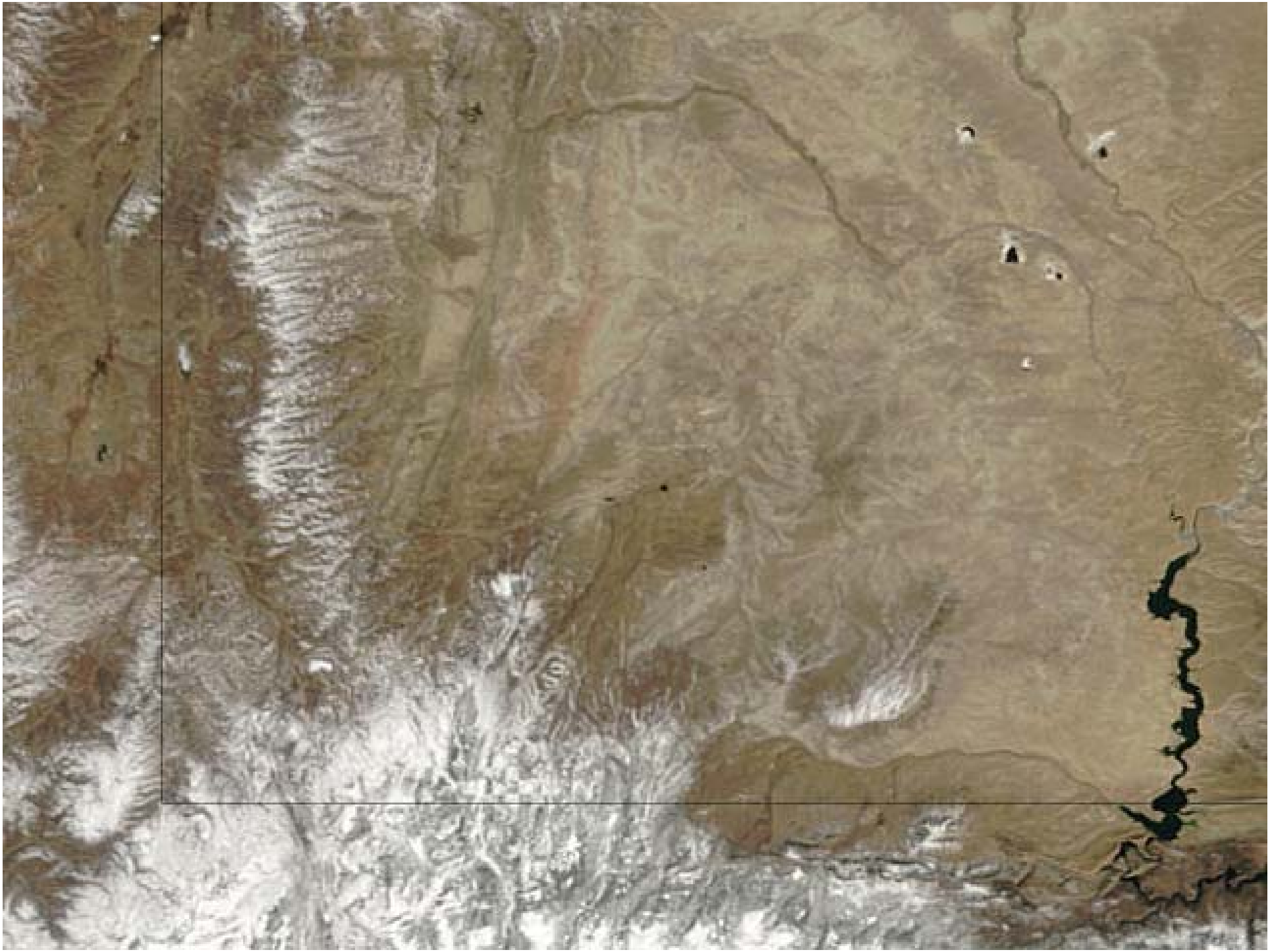

COLORADO
Hayman Wildfire
NOAA-15 AVHRR HRPT (1km)
Multi-spectral Enhanced Image
June 9, 2002 @ 20:03 CDT

Idaho, Montana, Utah, Wyoming Colorado

MODIS Image

250 Meter

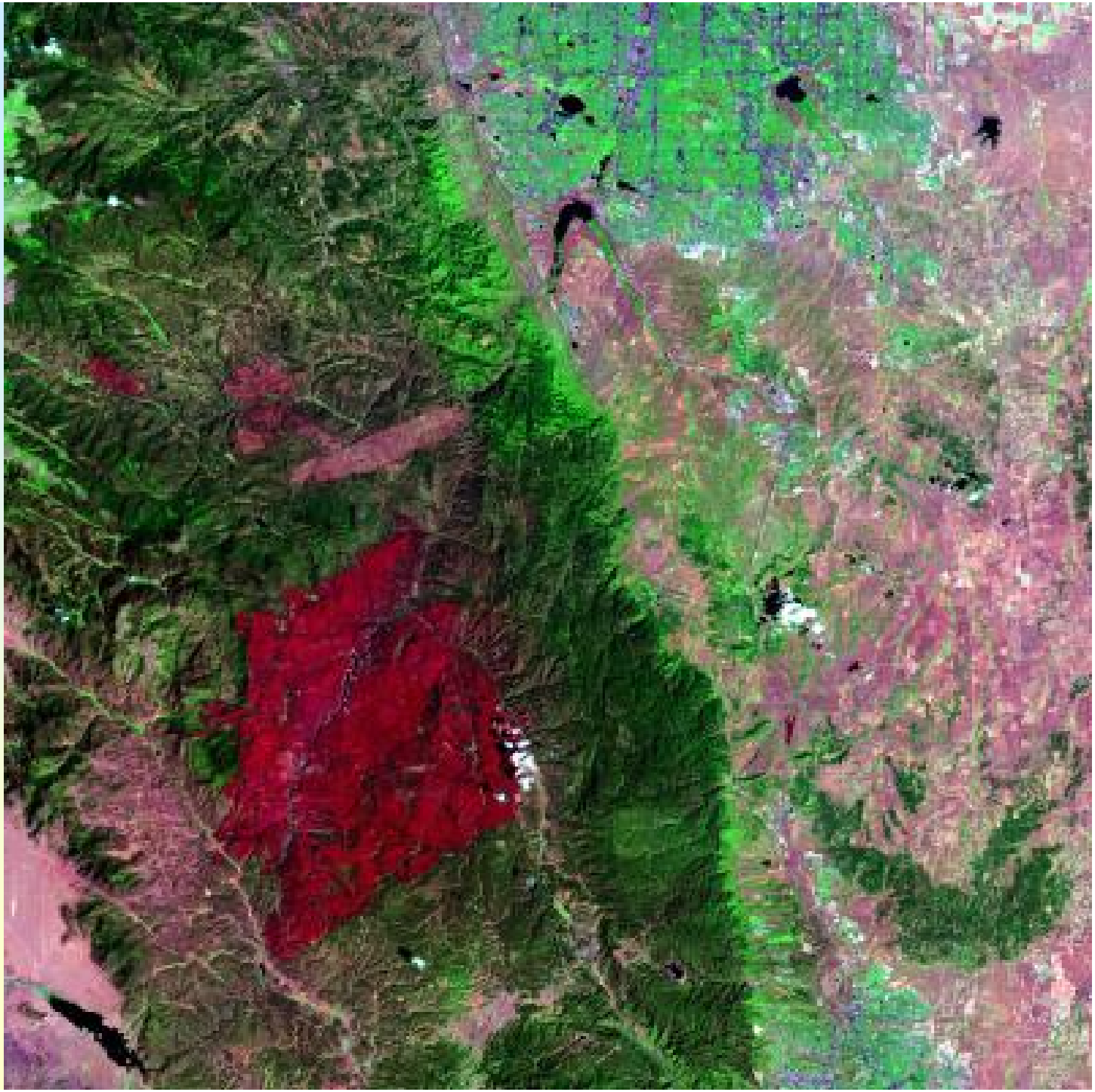




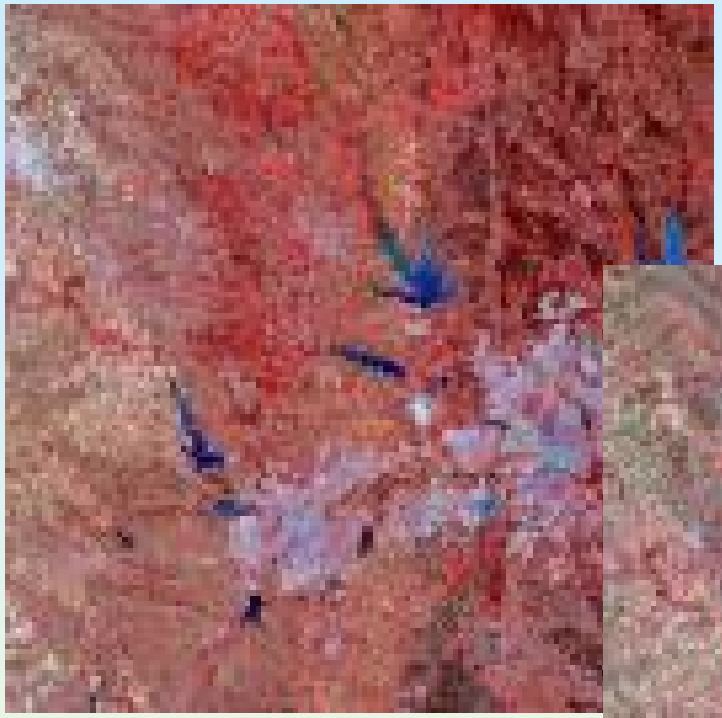
Hayman Springs Fire Colorado

Landsat 5 TM Image

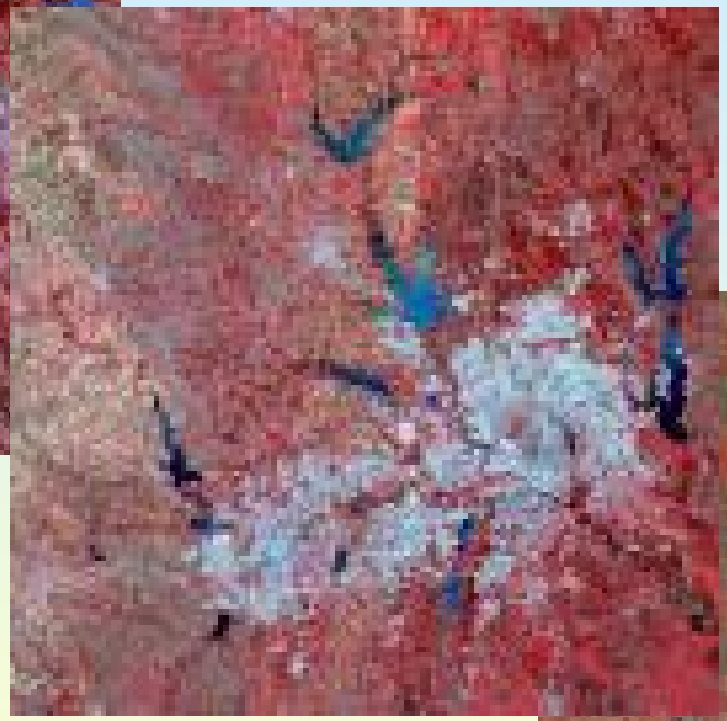
July 18, 2002



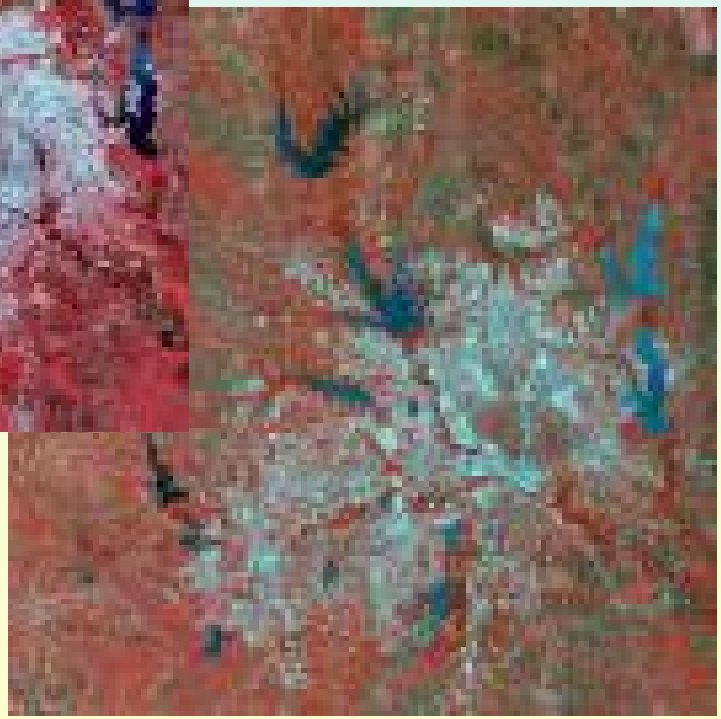
Dallas/Fort Worth



1974



1981

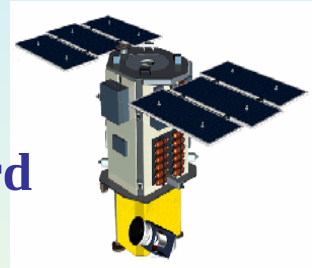


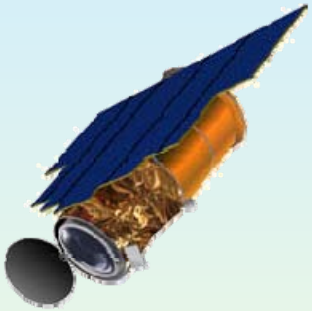
2003

Commercial Earth Observing Systems

IKONOS

QuickBird



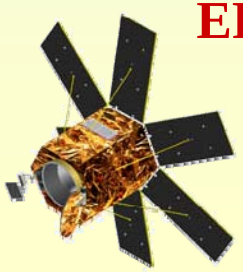


OrbView 2

SPOT 4

Spin 2

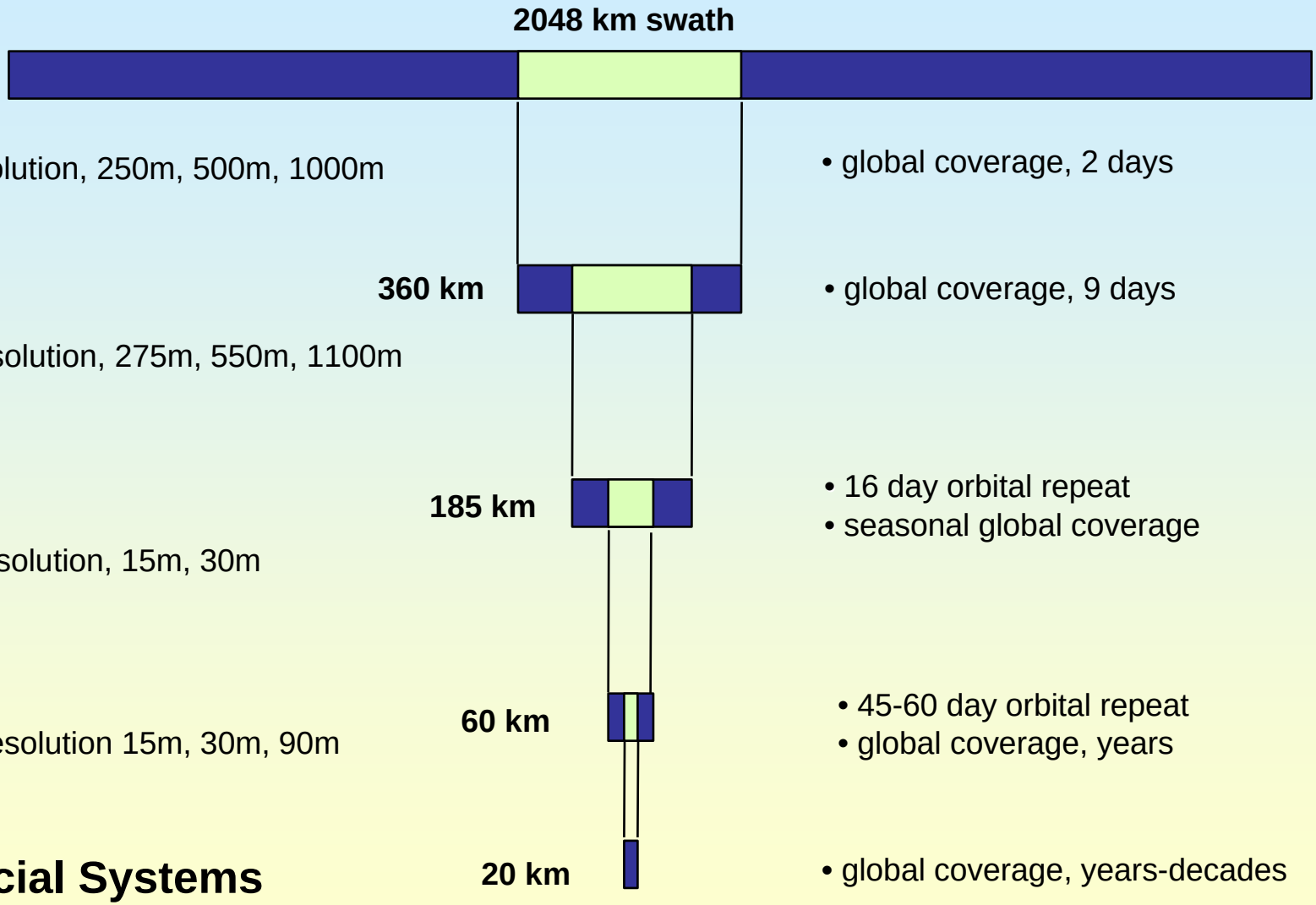
EROS 1A



Commercial Satellites

- SPOT: 5 Meter B&W/Color
- EROS-1A: 1.8 Meter B&W
- Ikonos 1.0 Meter B&W
  4.0 Meter Color & CIR
- Quick Bird .6 Meter B&W
  2.4 Meter Color & CIR

ESE Observations vs. Commercial Systems



AVHRR/ MODIS

- spatial resolution, 250m, 500m, 1000m
- global coverage, 2 days

MISR

- spatial resolution, 275m, 550m, 1100m
- global coverage, 9 days

Landsat

- spatial resolution, 15m, 30m
- 16 day orbital repeat
- seasonal global coverage

ASTER

- spatial resolution 15m, 30m, 90m
- 45-60 day orbital repeat
- global coverage, years

Commercial Systems

- spatial resolution 1m, 5m
- global coverage, years-decades

ImageSat International

EROS-1A

1.8 m

Digital Globe

Quick Bird

2 Meter

Space Imaging

IKONOS

2 meter

Coal Seam Fire Glenwood Springs, CO

IKONOS False Color NIR

4 meter

Image courtesy of Space Imaging, Inc.

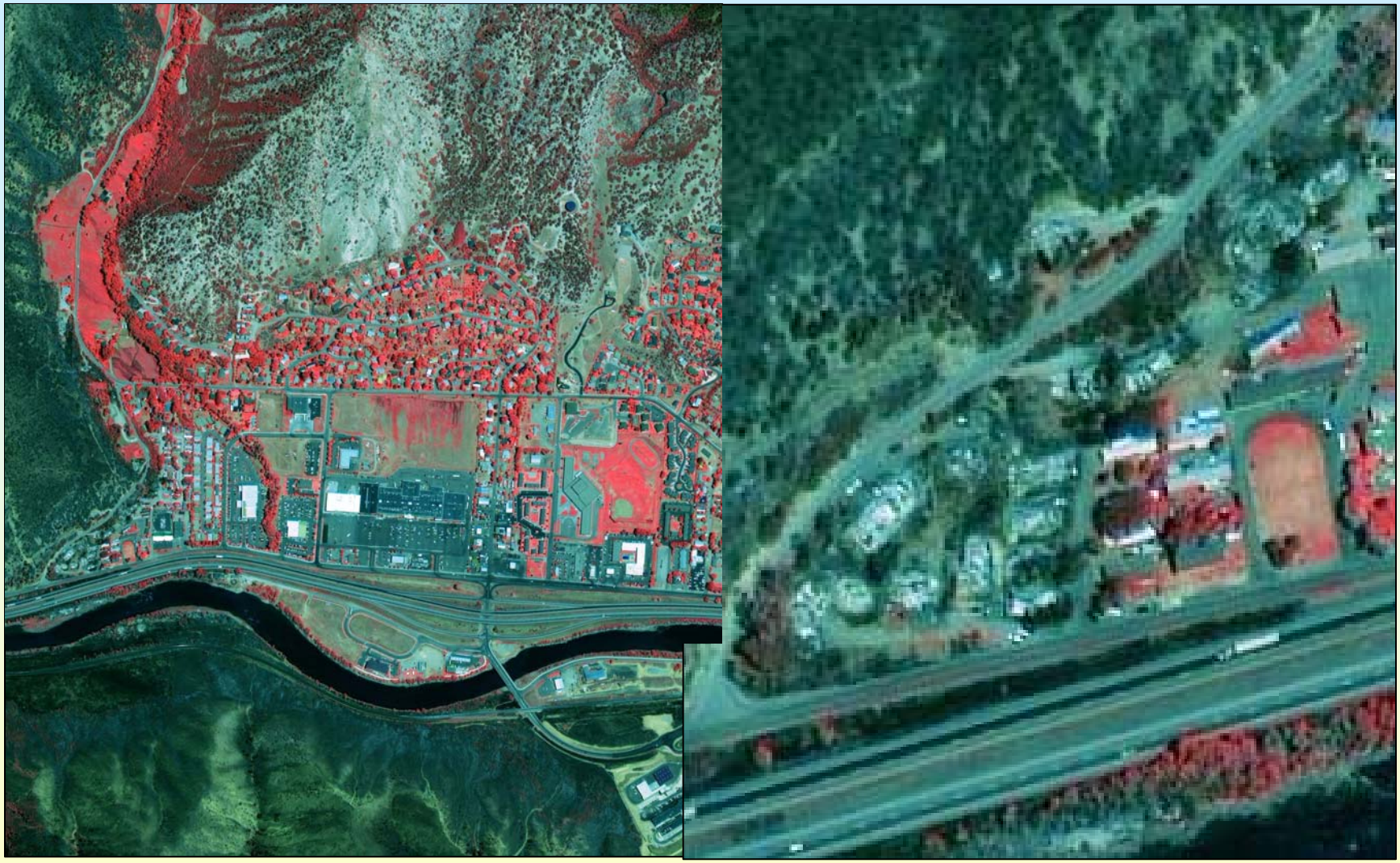
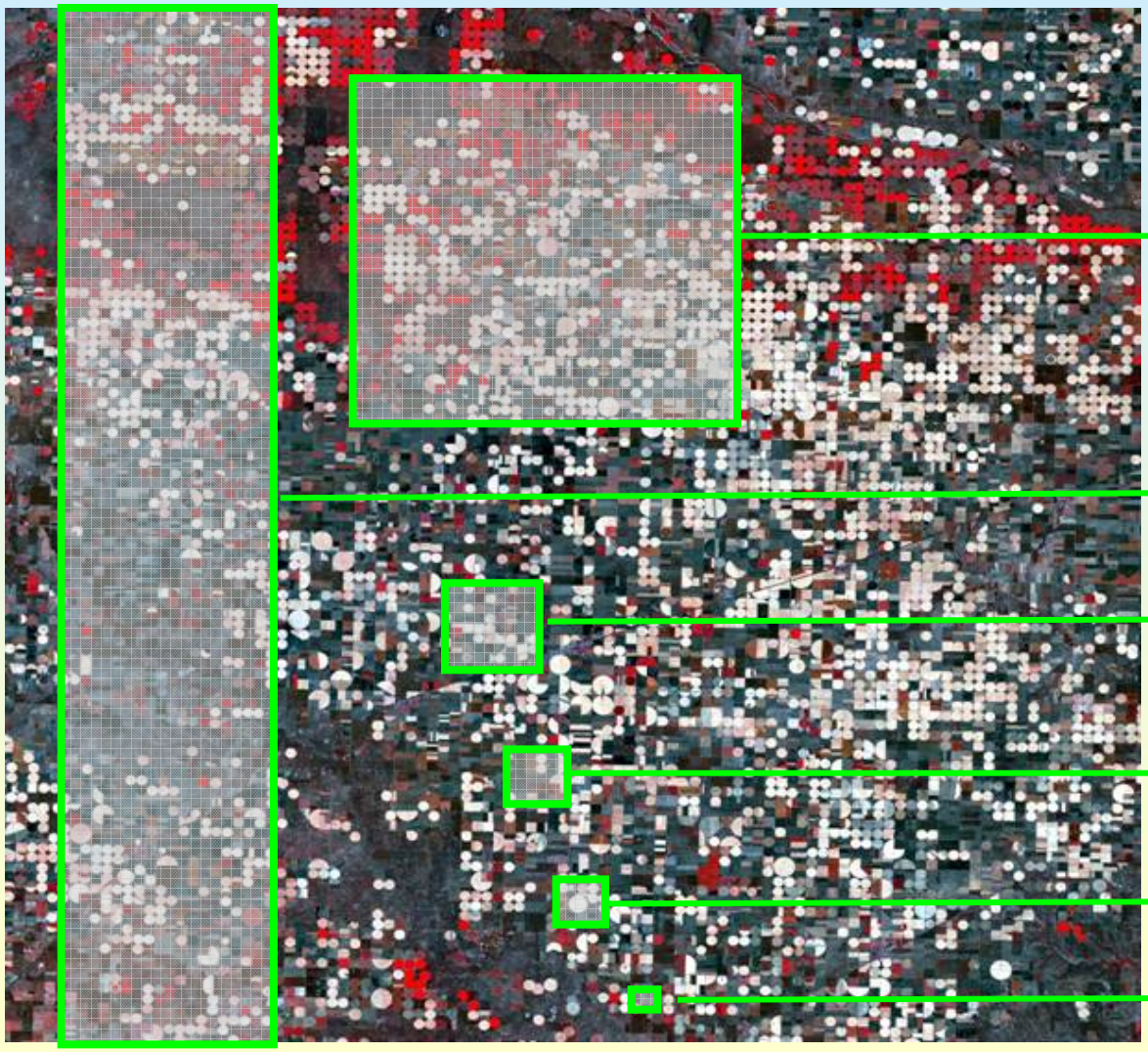


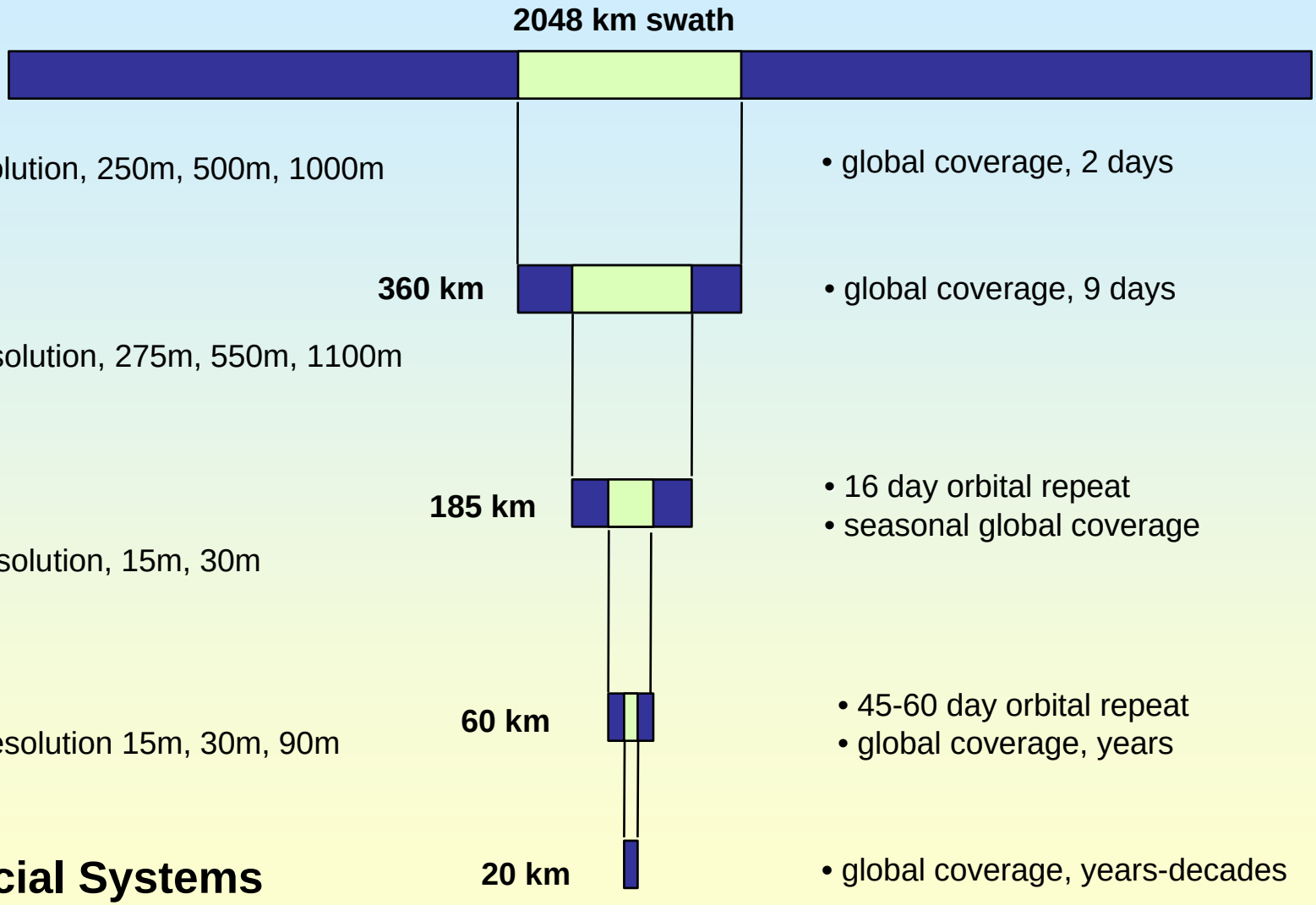
Image courtesy of Space Imaging, Inc.

Boulder, CO
Image courtesy of Space Imaging, Inc.

Imagery Comparisons



ESE Observations vs. Commercial Systems



AVHRR/ MODIS

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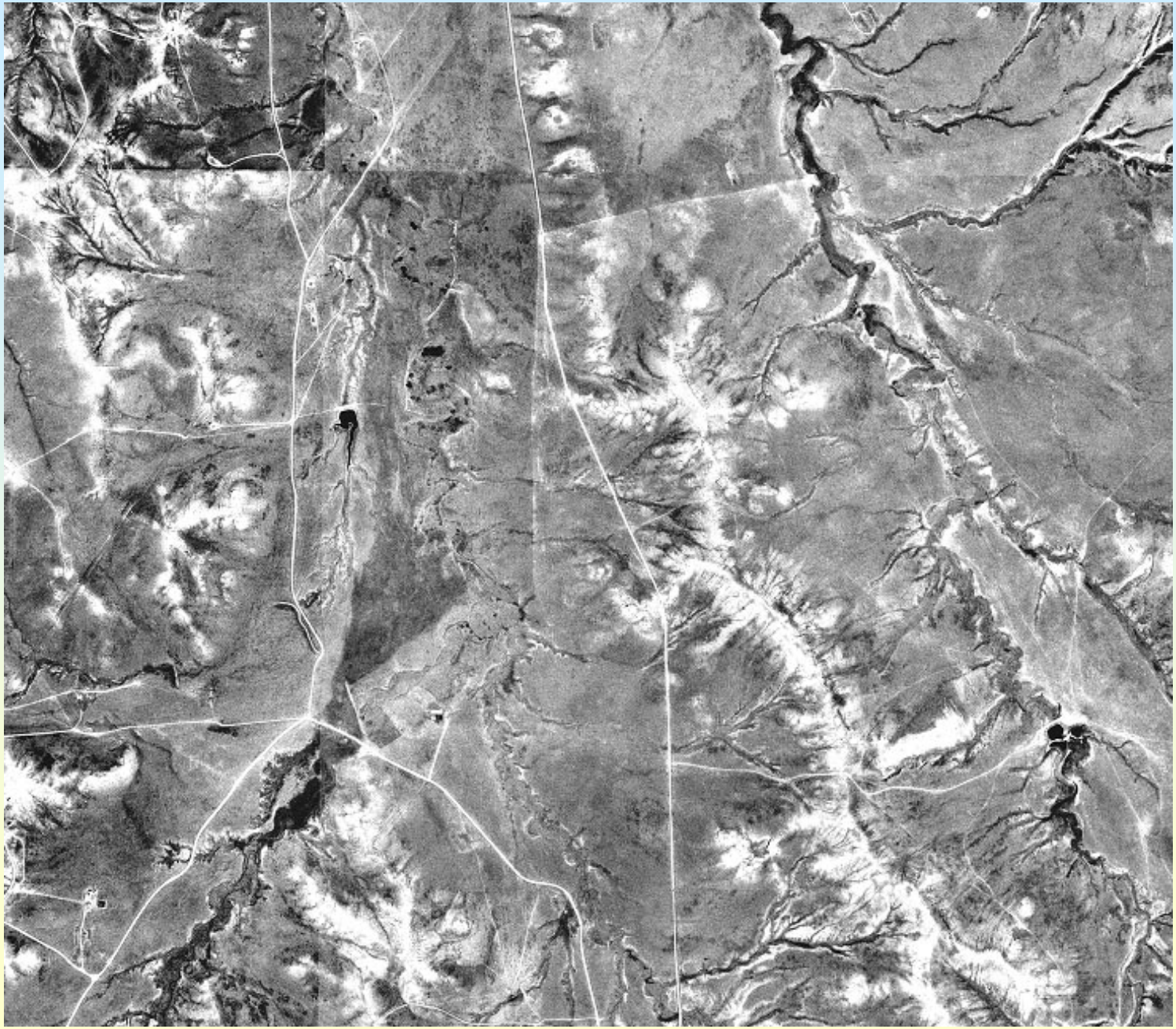
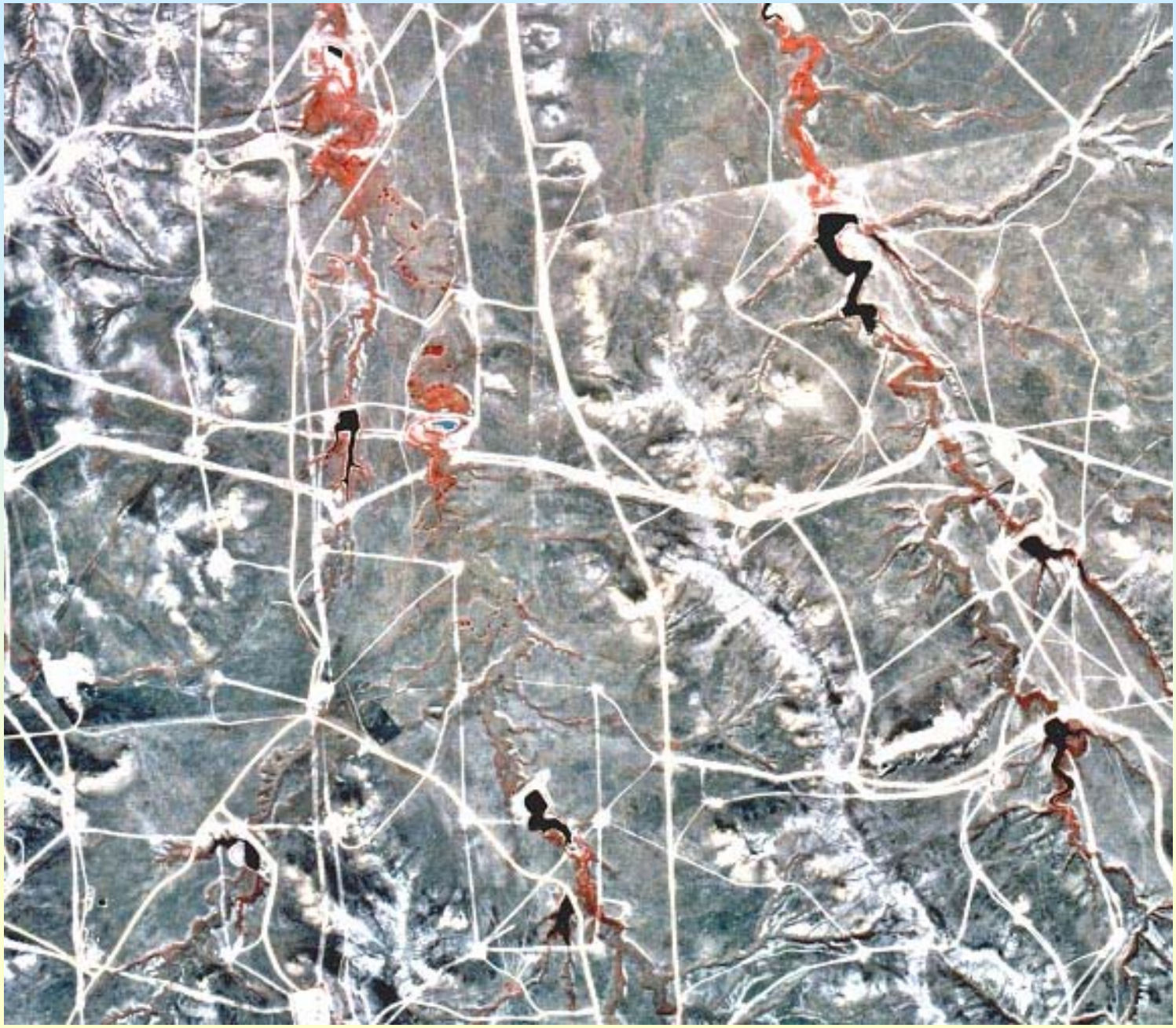
- global coverage, years

Commercial Systems

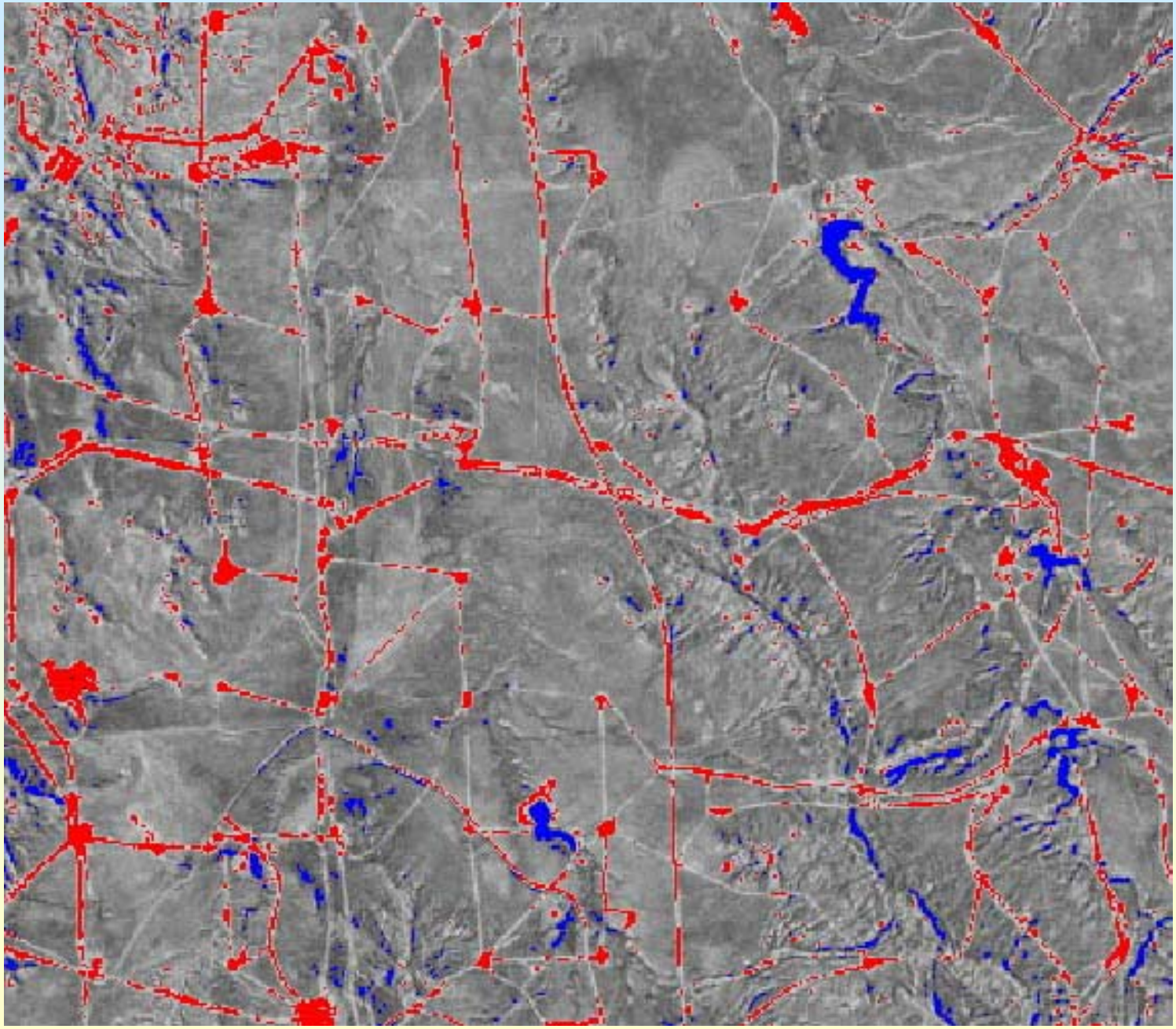
- spatial resolution 1m, 5m
- global coverage, years-decades



1994 B&W DOQQ



2001 NAPP CIR Photo – Scanned and registered to DOQQ

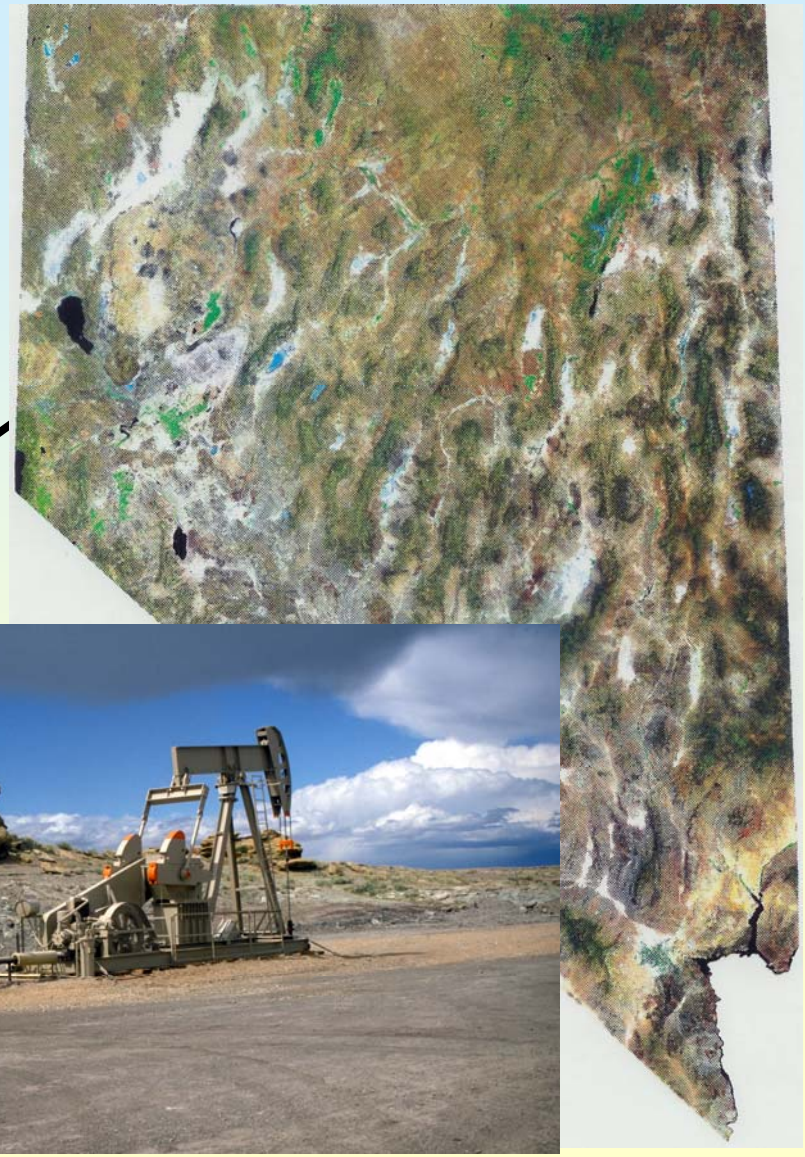


Example of 1994-2001 Automated Change Extraction

(Red= Dark to Light, Blue= Bright to Dark)

Regional Coverage vs High Resolution

How do I get both?



Aerial and Orthophotography

- USGS Digital Orthophotoquads (DOQs)
- USDA National Agricultural Imagery Program (NAIP)

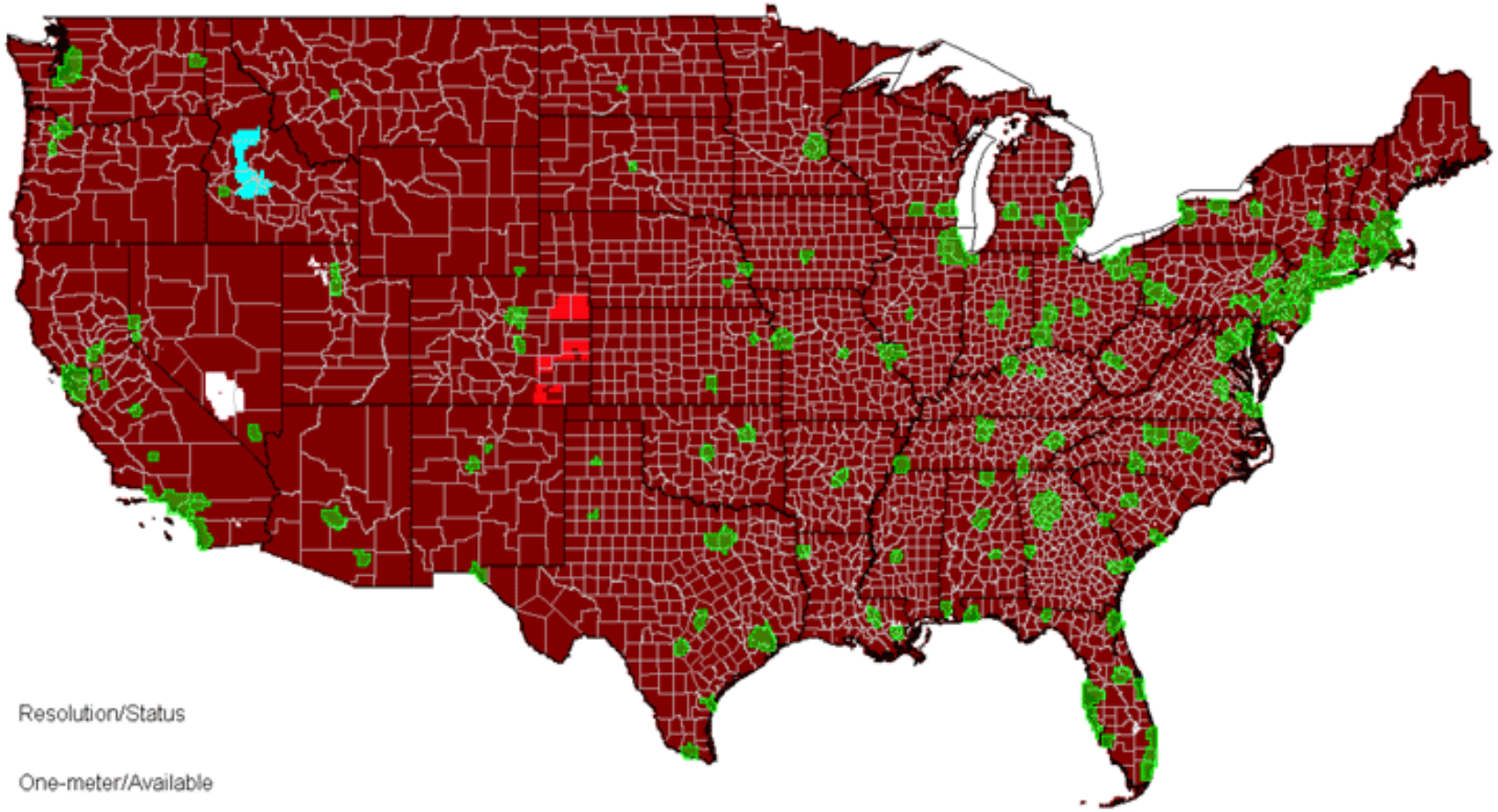
USGS 1m DOQ Production

– 1993	2,804 DOQs	$ 2.1 million (est.)
– 1994	5,738 DOQs	$ 3.7 million
– 1995	8,281 DOQs	$ 4.8 million
– 1996	18,941 DOQs	$14.9 million
– 1997	34,130 DOQs	$21.8 million
– 1998	36,779 DOQs	$22.8 million
– 1999	29,703 DOQs	$17.4 million
– 2000	24,000 DOQs	$15.0 million
– 2001	20,000 DOQs	$12.2 million
– 2002	5,453 DOQs	$ 3.3 million
– 2003	1,692 DOQs	$ 1.1 million
– 2004	548 DOQs	$ .4 million

NATIONAL DIGITAL ORTHOPHOTO PROGRAM

Status of Digital Orthophotoquad Production

First Generation Coverage



Resolution/Status

- One-meter/Available
- One-meter/In-work
- Two-meter/Available
- Holiday Area
- Urban Area Footprints (HSIP)

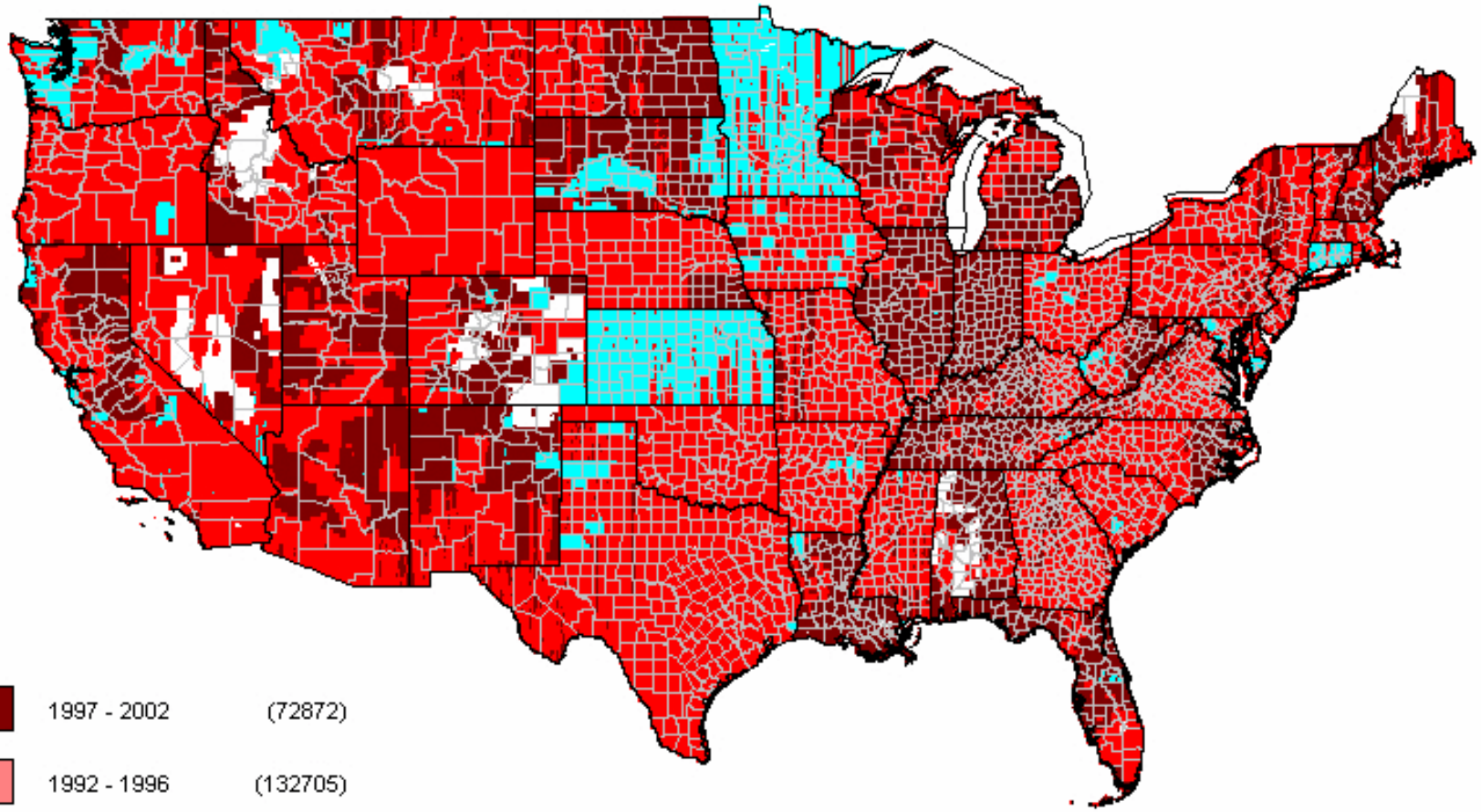
Prepared by: U.S. Geological Survey
National Mapping Discipline
Cooperative Topographic Mapping
02-June-2003

Ageing of 1m Orthophotoquads

AGE BRACKET	FY02	FY03	FY04	FY05
5 years or less	32%	25%	12%	9%
5-10 years	59%	62%	54%	45%
more than 10 years	9%	13%	34%	46%
total	100%	100%	100%	100%

NATIONAL DIGITAL ORTHOPHOTO PROGRAM

Source Year for Available Digital Orthophotoquads



1997 - 2002	(72872)
1992 - 1996	(132705)
1991 and earlier	(20085)

Source: Geospatial Data Architecture

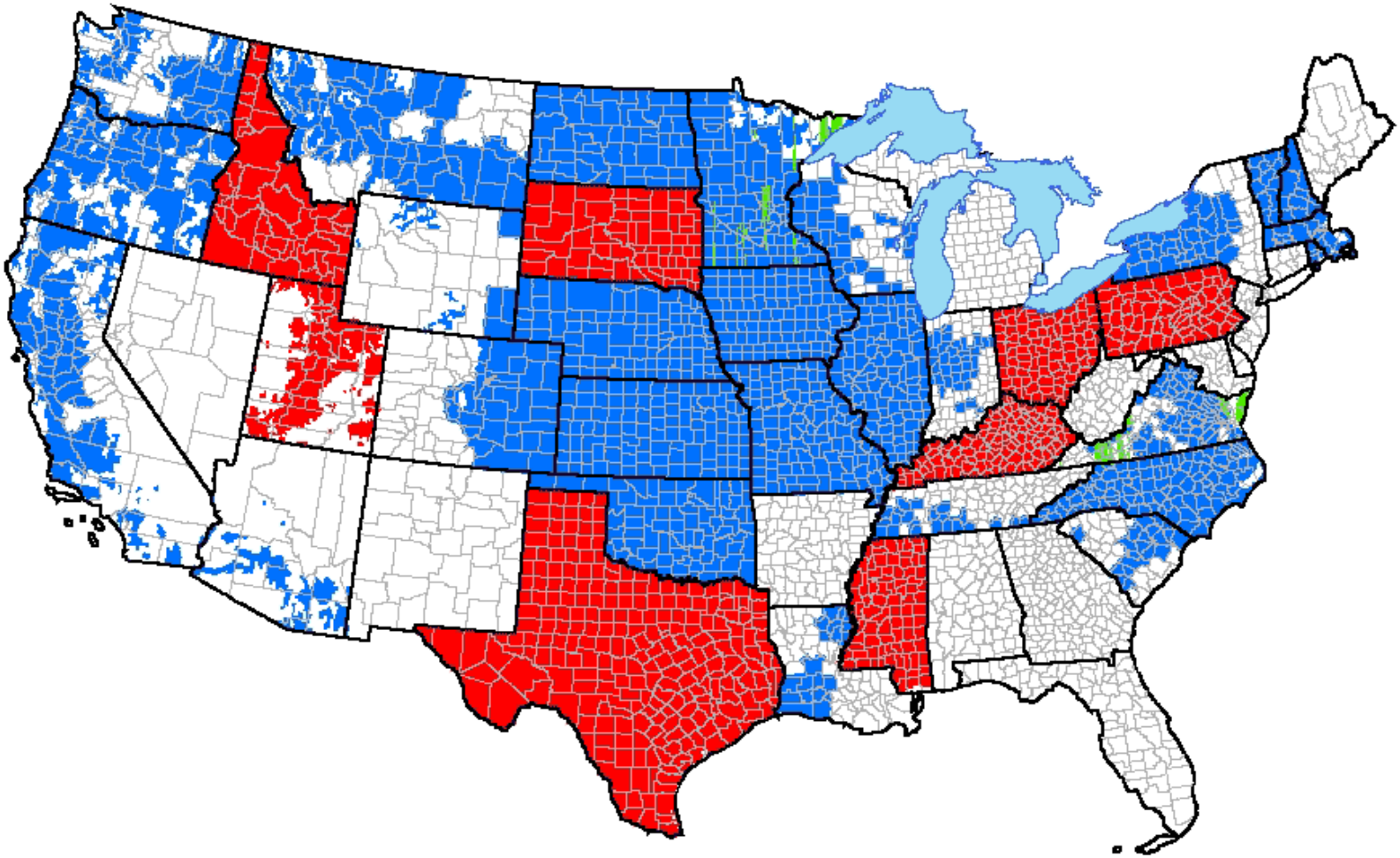
Prepared by: U.S. Geological Survey
National Mapping Discipline
Cooperative Topographic Mapping
03-September-2002

Orthophotography

- USGS Digital Orthophotoquads (DOQs)
- USDA National Agricultural Imagery Program (NAIP)

May 27, 2004

NAIP04 COVERAGE



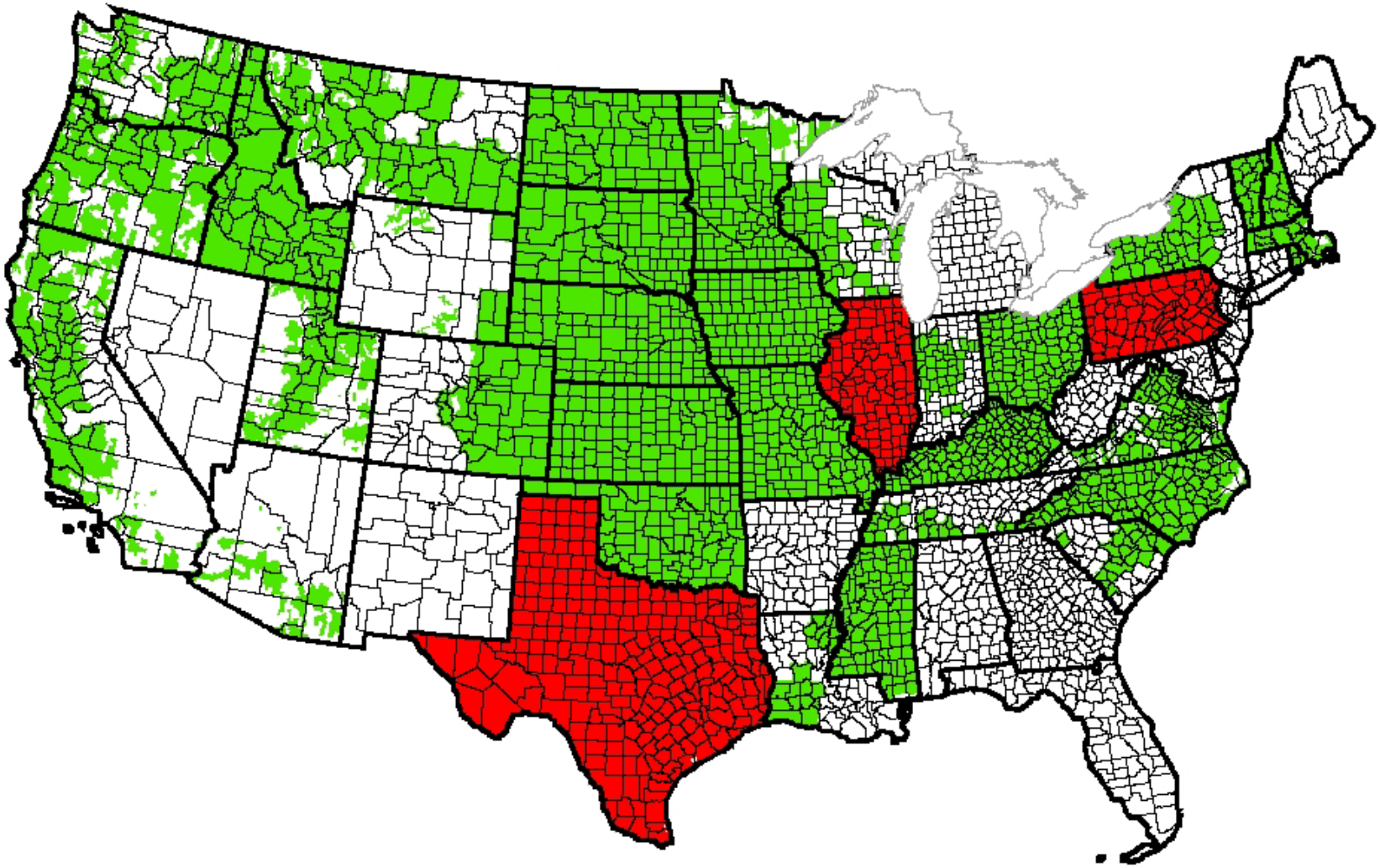
1 METER STATES
2 METER STATES
1 METER REPLACEMENT IMAGERY

USDA-FSA-APFO-Salt Lake City, Utah

U.S. Department of Agriculture
NATIONAL AGRICULTURE IMAGERY PROGRAM
SOLICITATION NO: USDA-NAIP-3-04
NATIONAL COVERAGE MAP

NAIP04 CIRP AND NATURAL COLOR COVERAGE

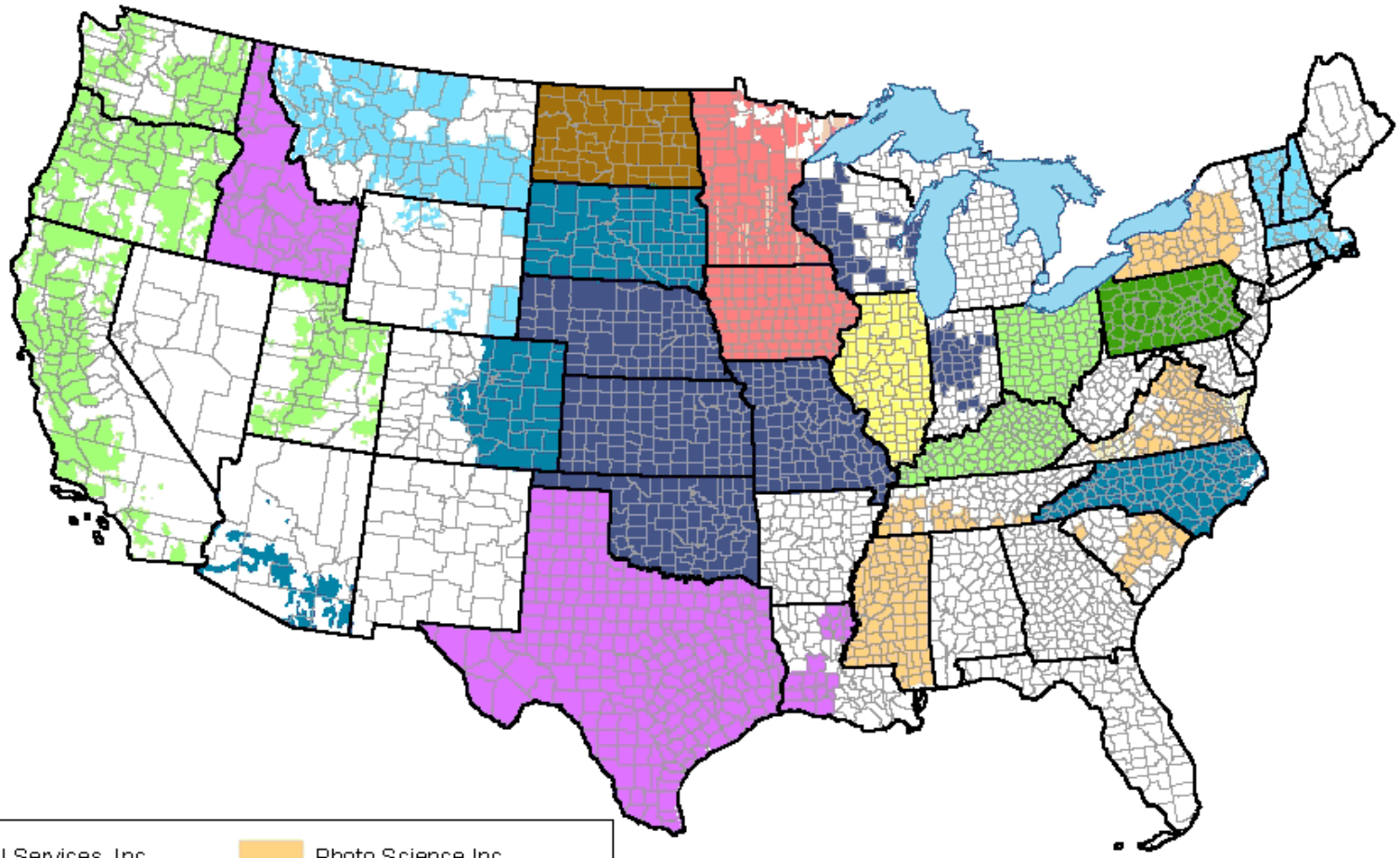
JUNE 4, 2004



USDA-FSA-APFO-Salt Lake City, UT

June 8, 2004

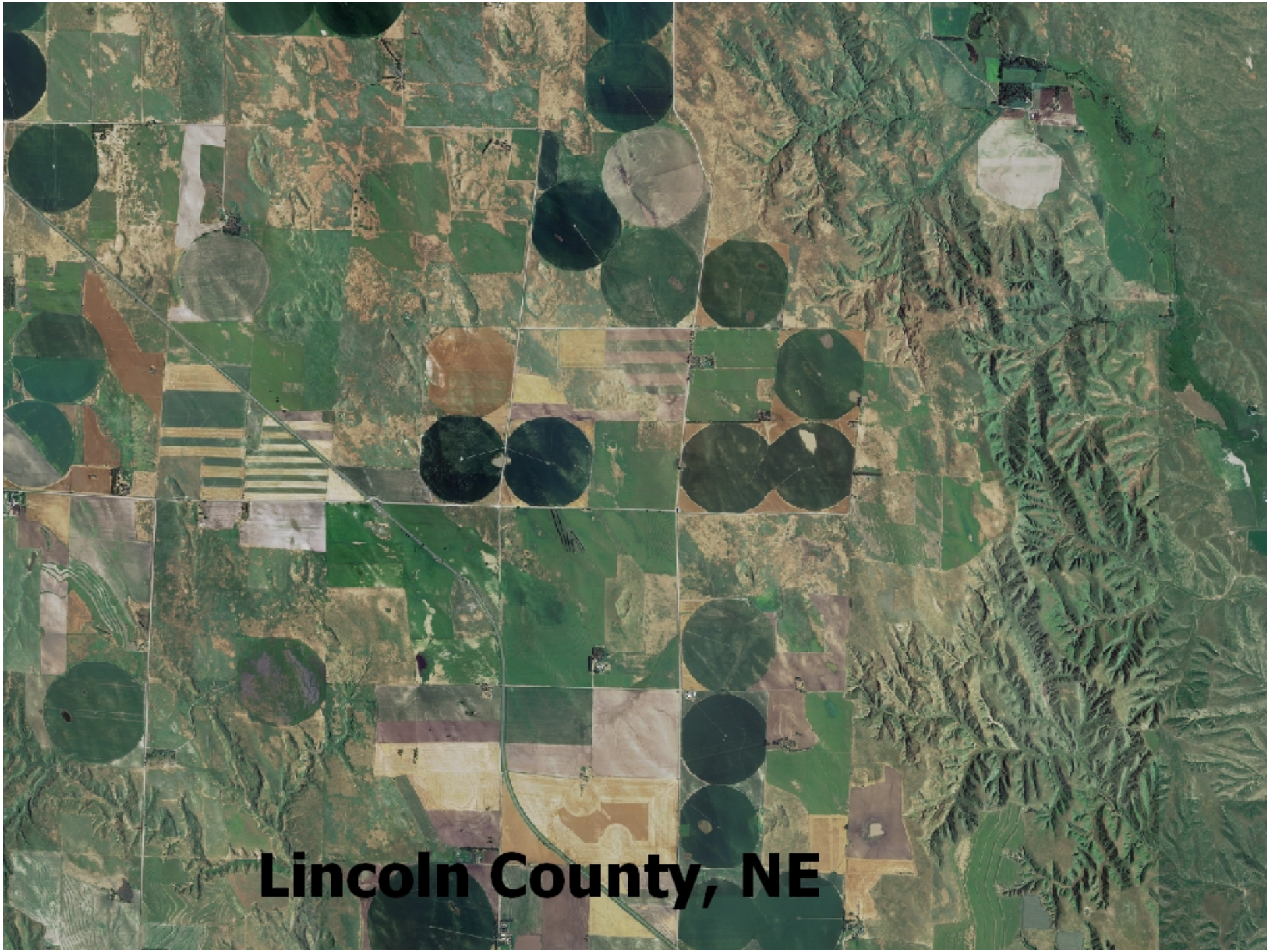
2004 NAIP CONTRACTORS



- Aerial Services, Inc.
- Aero-Metric, Inc.
- Horizons Inc.
- LandAir Mapping,Inc.
- North West Geomatics, Ltd
- Photo Science Inc.
- The Sanborn Map Co. Inc.
- Surdex Corporation
- Triathlon, Ltd
- Vargis, LLC

USDA-FSA-APFO Salt Lake City, Utah

Lincoln County, NE


Lincoln County, NE

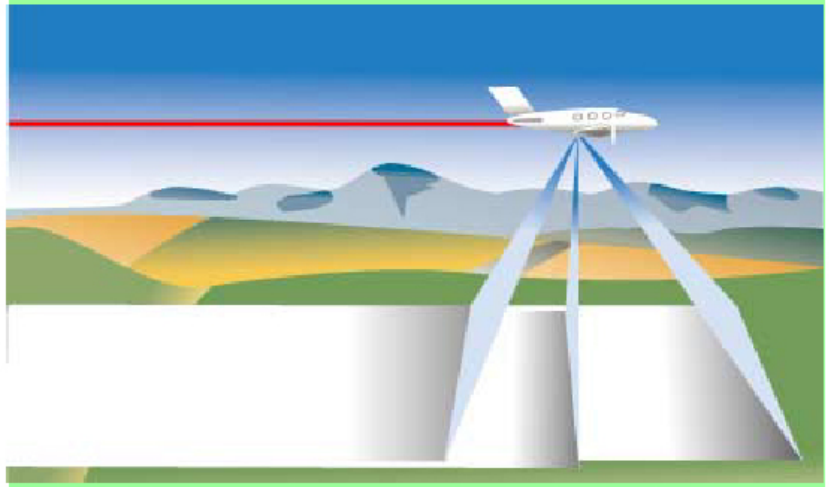
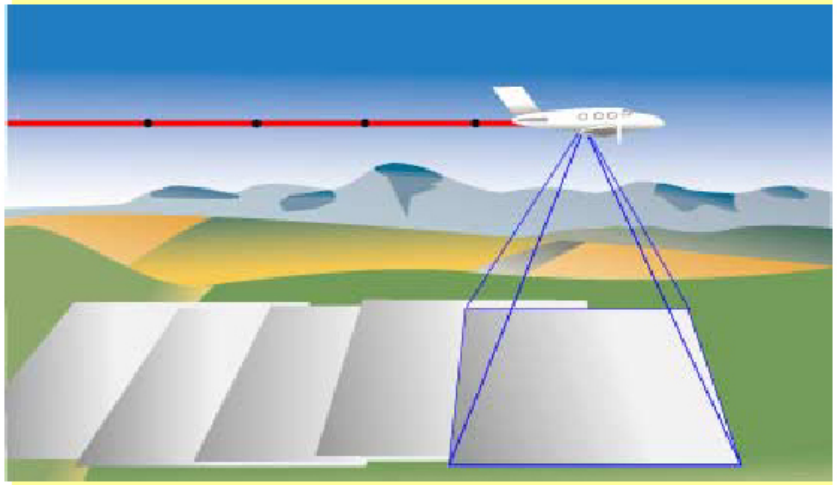
Digital Aerial Cameras

- Leica ADS-40
- Z/I DMC
- Vexcel UltraCam

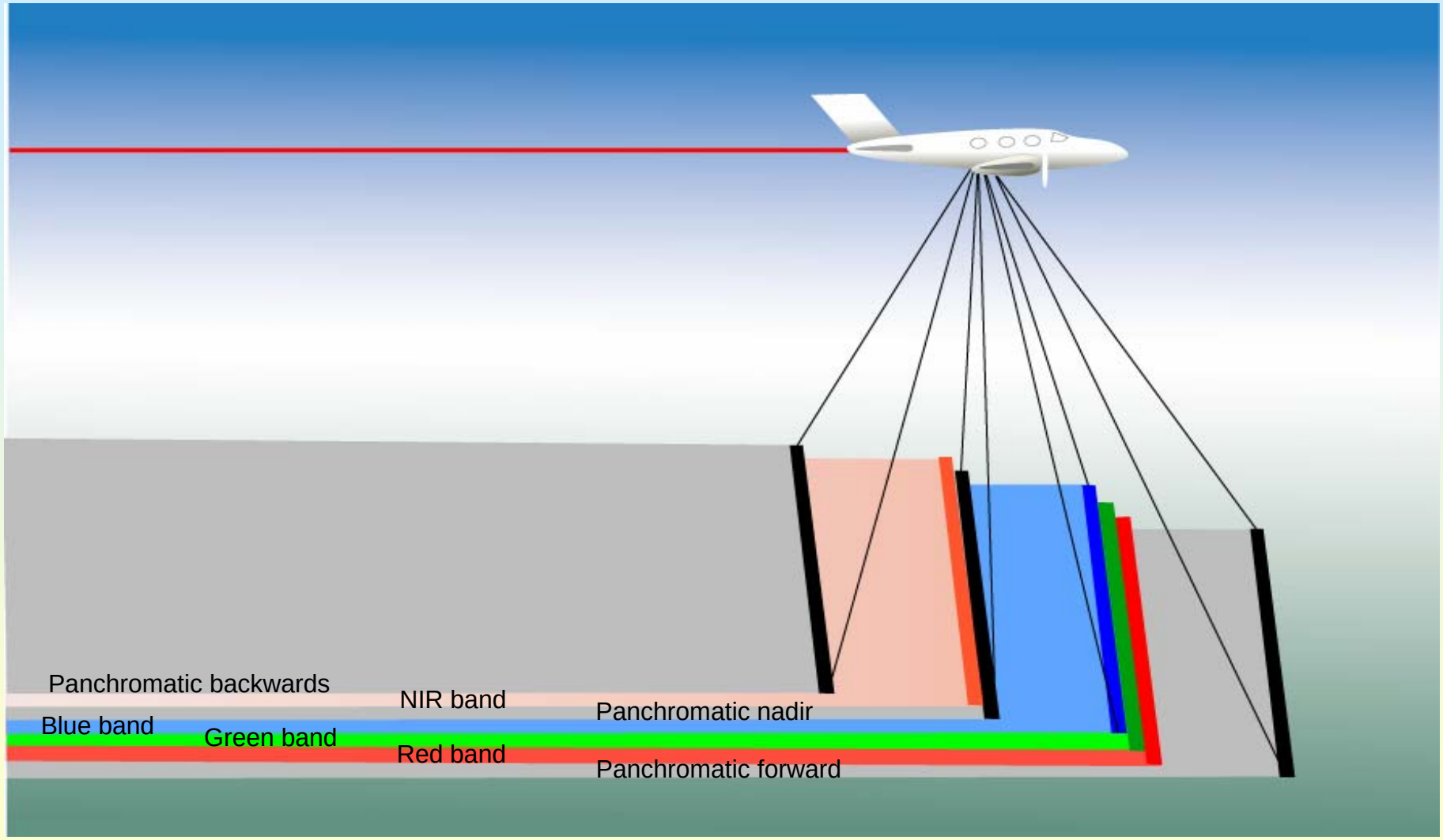
Airborne Digital Camera

- 3 panchromatic CCD lines each 2 x 12,000 pixels, staggered by 3.25 μm
- 4 multispectral CCD lines, each 12,000 pixels
- Pixel size: 6.5 μm x 6.5 μm
- Field of view (FoV) or swath angle: 64°
- Focal length: 62.77 mm
- Stereo angles: 14°, 28°, 42°

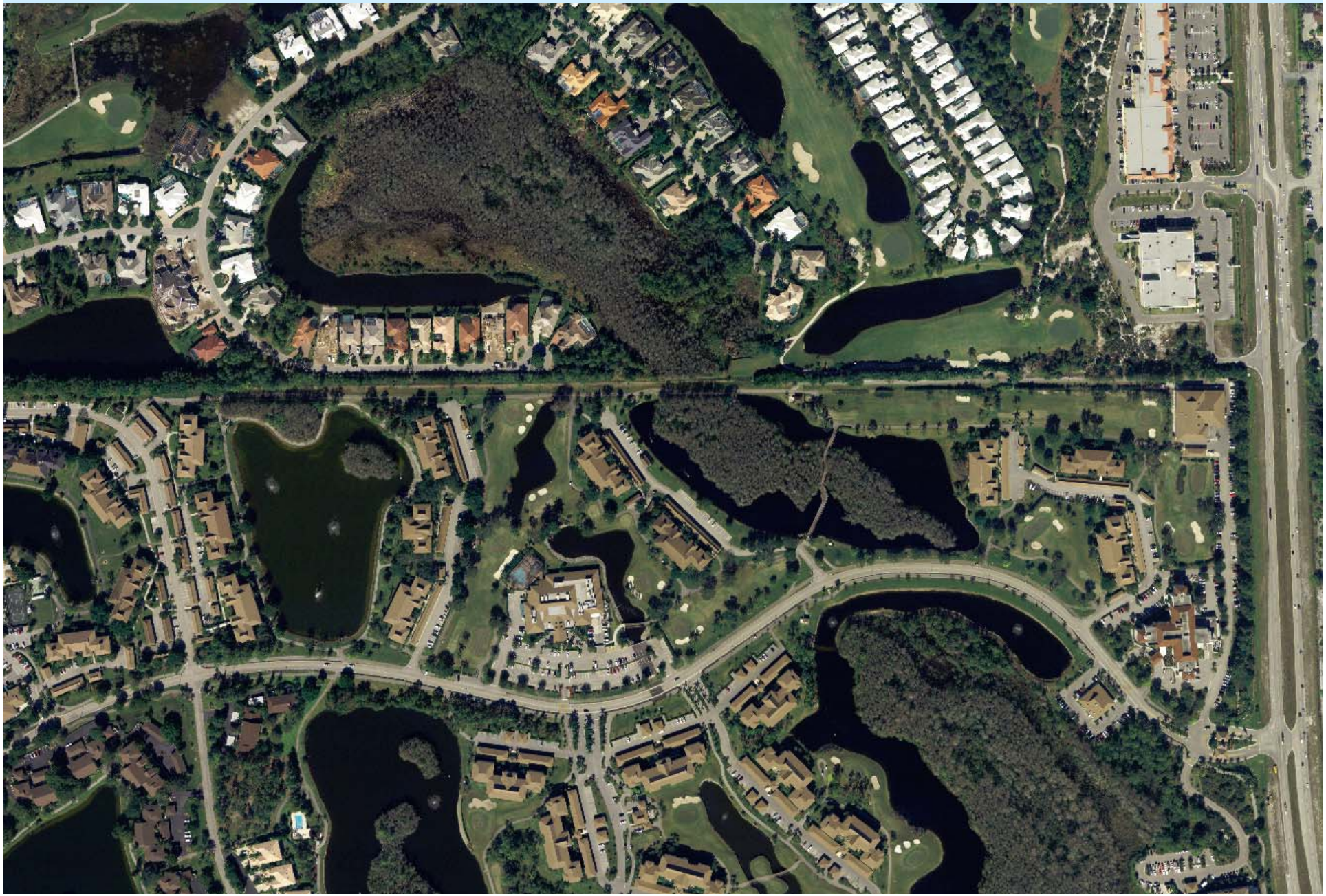
ADS-40 Operation

Airborne digital sensor ADS40	Analog aerial camera RC30
continuous pushbroom scanning	discrete perspective images
	
forward view nadir view backward view	overlapping aerial photographs

Panchromatic and spectral band filters



ADS-40 Sample Imagery (6” Pixel)



ADS-40 Sample Imagery (6” Pixel)

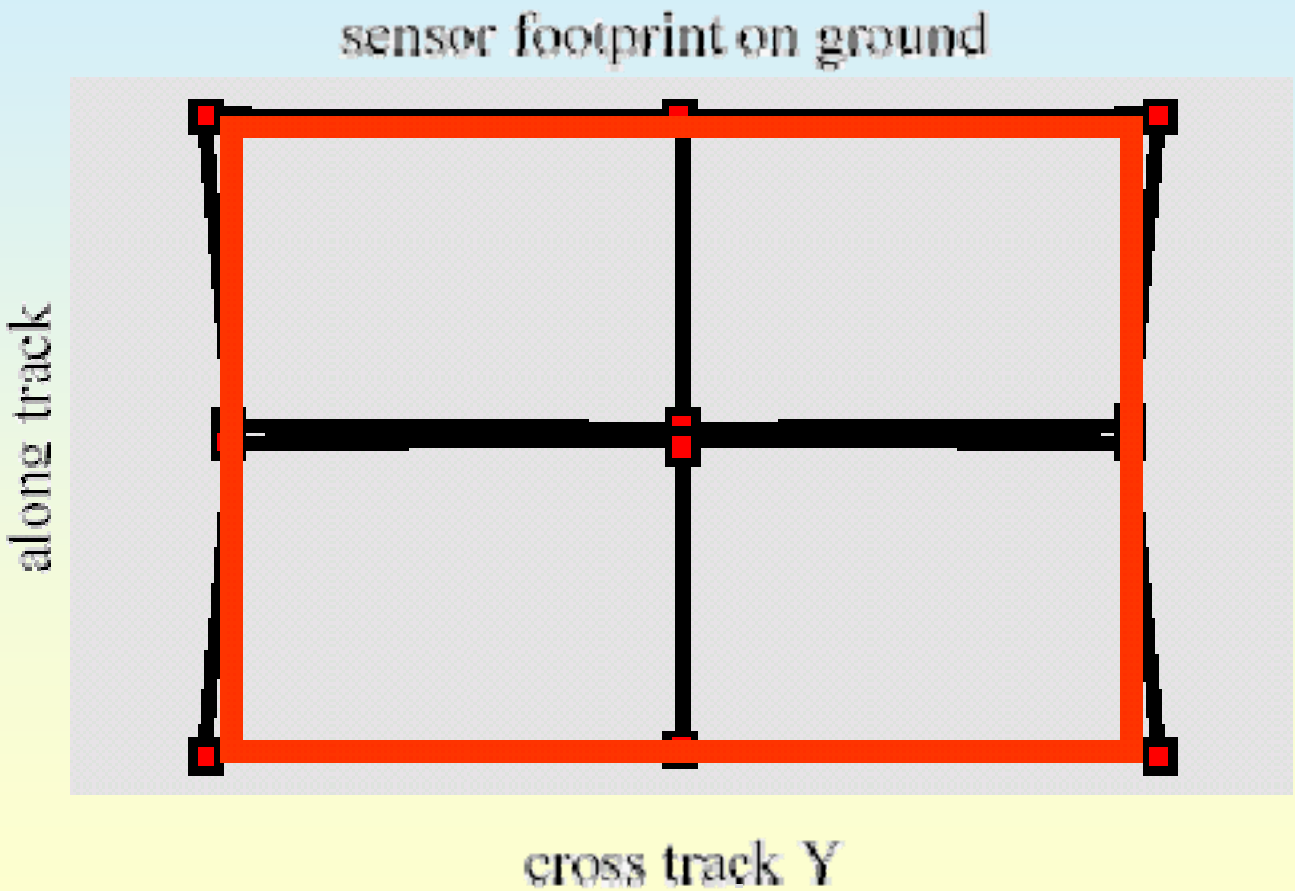
Digital Aerial Cameras

- Leica ADS-40
- Z/I DMC
- Vexcel UltraCam-D

Z/I DMC CCD Array

- Charge Coupled Devices (CCD) captures light intensity, not color
- Filters are used to allow breakout spectral bands (R,G,B, Near IR)
- Results in a vivid and sharp image
- Pan is captured at native resolution
  - R,G,B and CIR are captured at 1/4 Resolution (i.e. 6-inch Pixel Pan = 2-foot R,G,B and CIR)
  - R,G,B and CIR are then Pan Sharpened
- All of the data is “In the Can”, as opposed to film

Z/I DMC Quad Head Ground Coverage



DMC Sample Imagery (3” Pixel)

Z/I DMC || Nashville, TN

usbank
usbank
usbank
usbank

DMC Imagery 1.5 inch Pixel

Pan Sharpened Color

QuickBird Panchromatic

+

QuickBird Multispectral

=

QuickBird Pan Sharpened

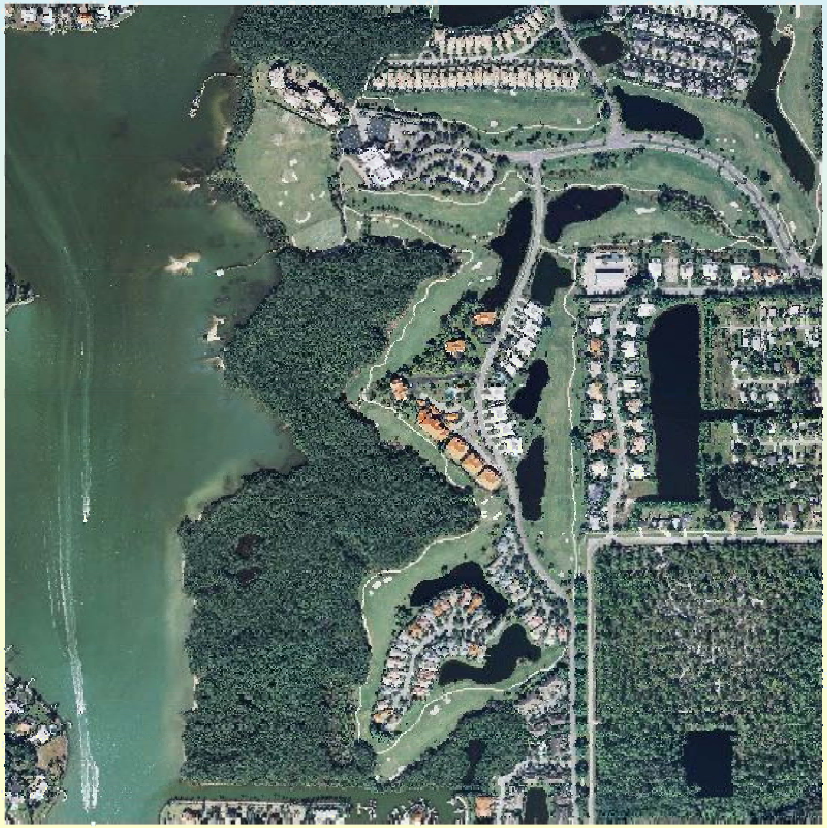
Examples of Panchromatic, CIR, and Color Data Capture from a Single Flight Using the Z/I DMC. Imagery is from a Project Completed in San Juan, New Mexico.

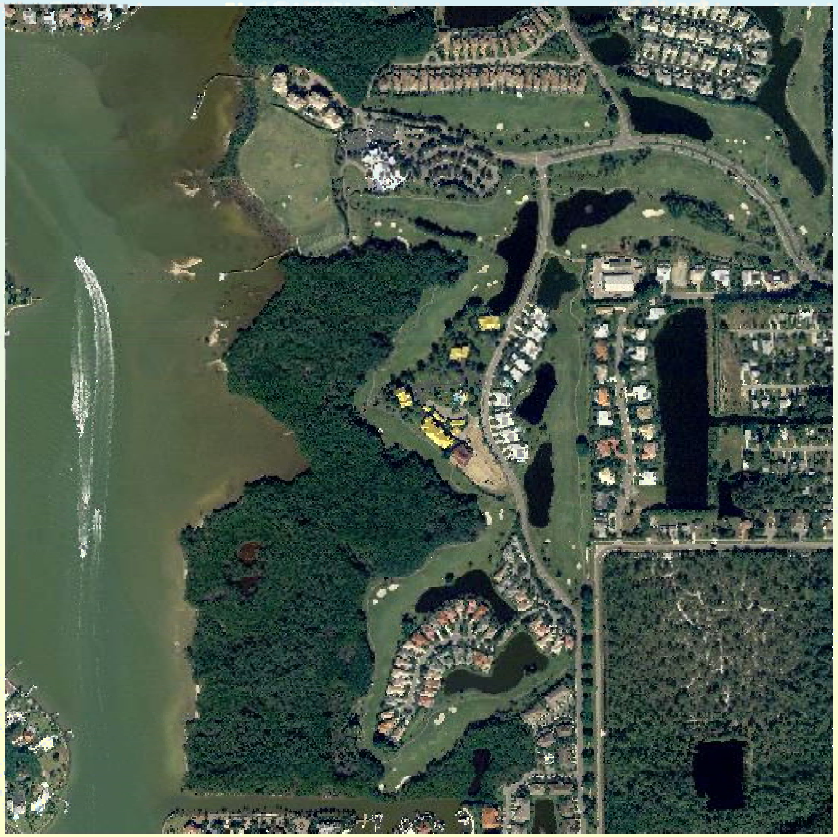
12-Bit Data Adjustment to Reduce Shadows During Mapping

Comparison of Systems

System	Advantage	Disadvantage
ADS-40	**Seamless Image Strip (Less Control and Building Lean)**	**Depends on GPS and IMU**
	6-Inch Pixel and Larger	**No Engineering Application**
	True Multi-spectral Capture	**No Stereo Color Imagery (Pan Only)**
Z/I DMC	**Direct Replacement for Film in Existing workflows (AT)**	**Still Manual Approach to AT and Ortho Processing**
	2-Inch Pixel and Larger (1.25-Inch in Testing)	**Cost of Engineering Application Still High**
	Multi-Spectral Capture (All in Stereo)	**Remote Sensing Limited – Color is ¼ resolution (colorized B/W)**

ZI/DMC vs ADS-40



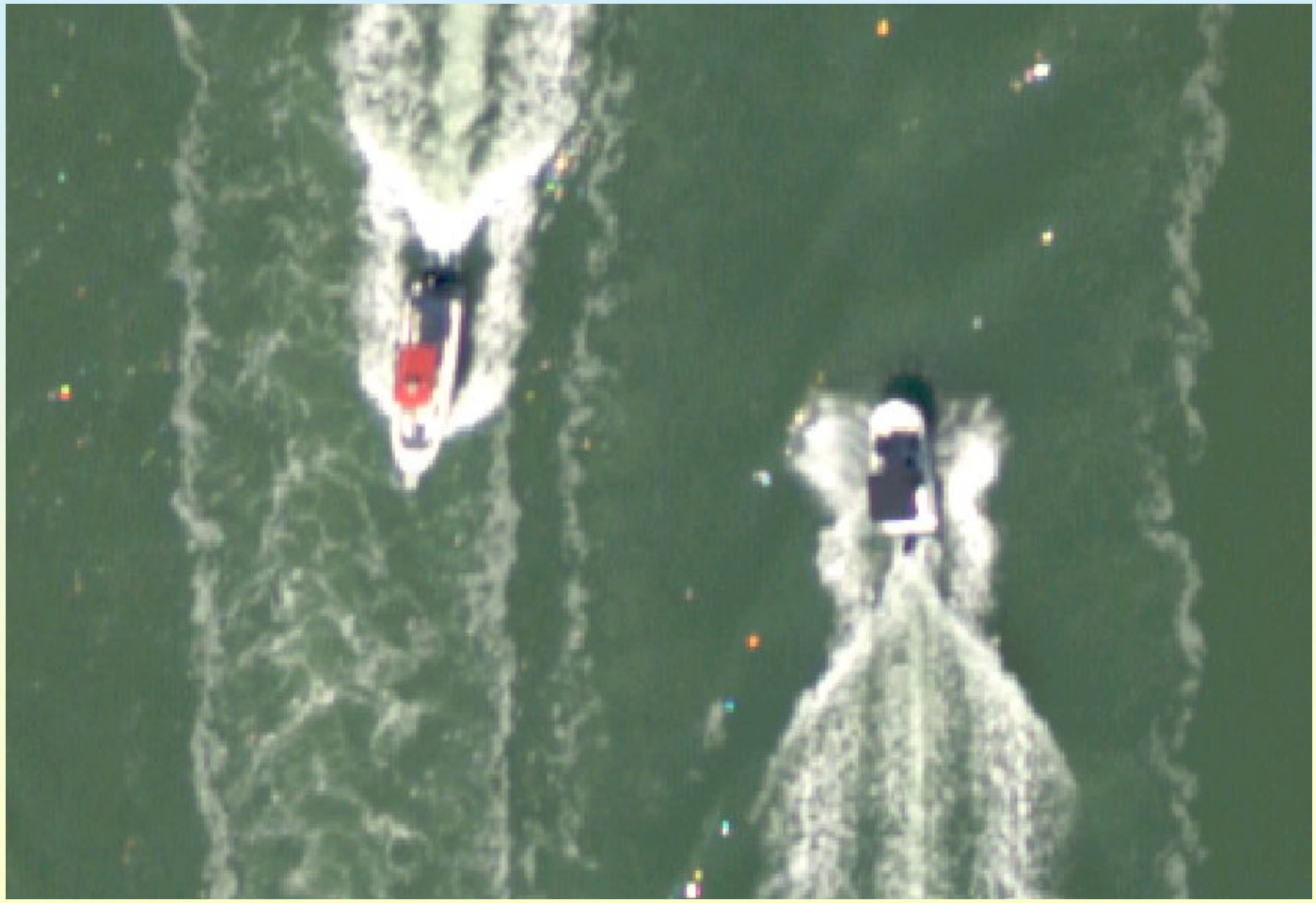


ZI/DMC vs ADS-40

ZI/DMC vs ADS-40

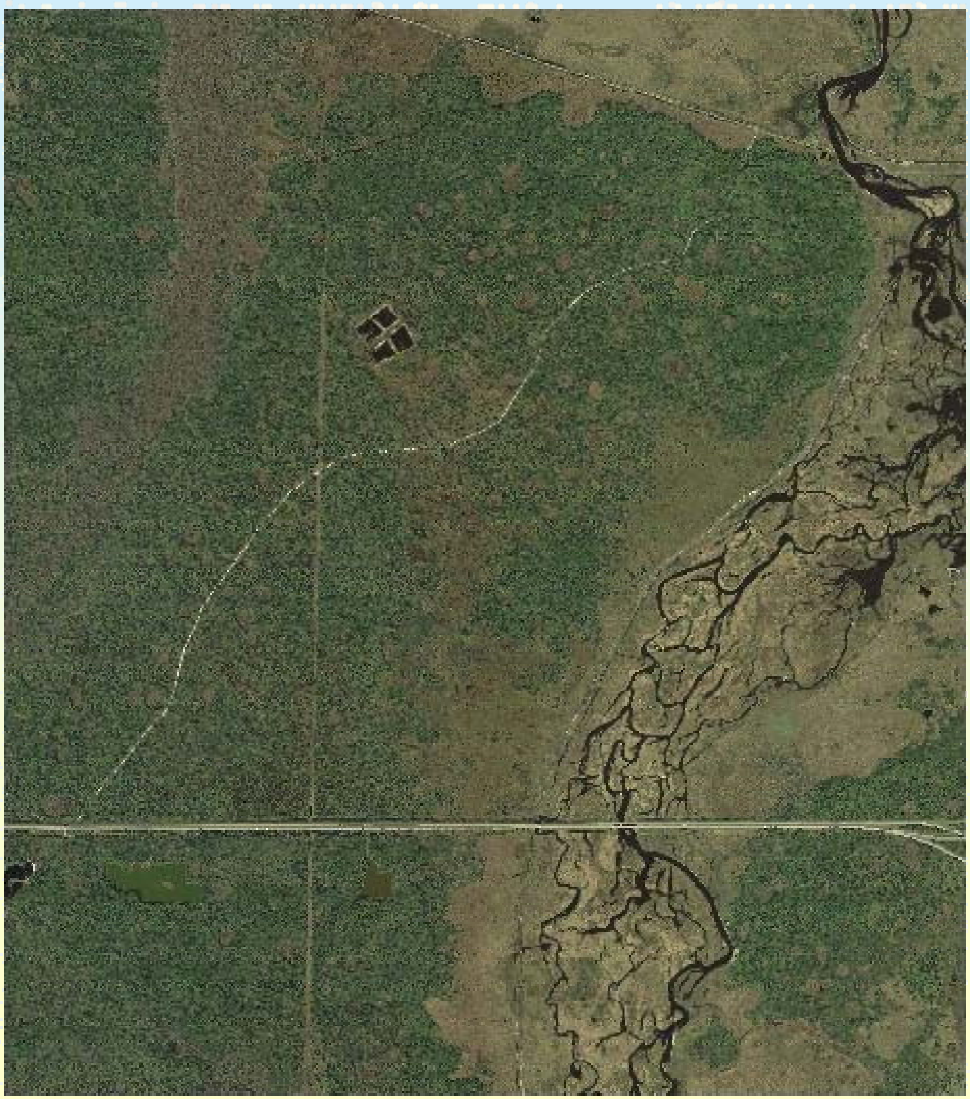
ZI/DMC vs ADS-40

ADS-40 Motion Effect



ADS-40 Motion Effect

ADS-40 1 Meter Imagery



ADS-40 1 Meter Imagery

ADS-40 1 Meter Imagery

ADS-40 1 Meter Imagery

ADS-40 1 Meter Imagery

ADS-40 1 Meter Imagery

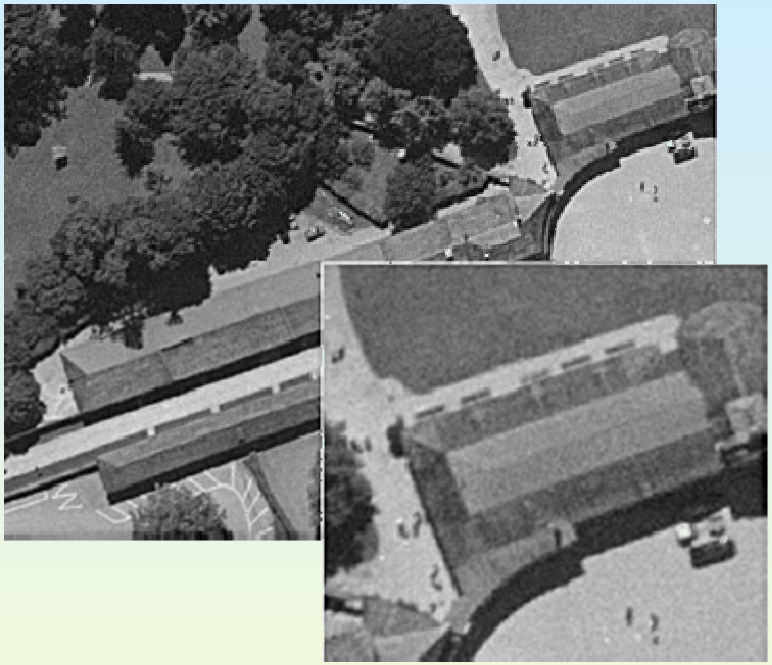
Digital Aerial Cameras

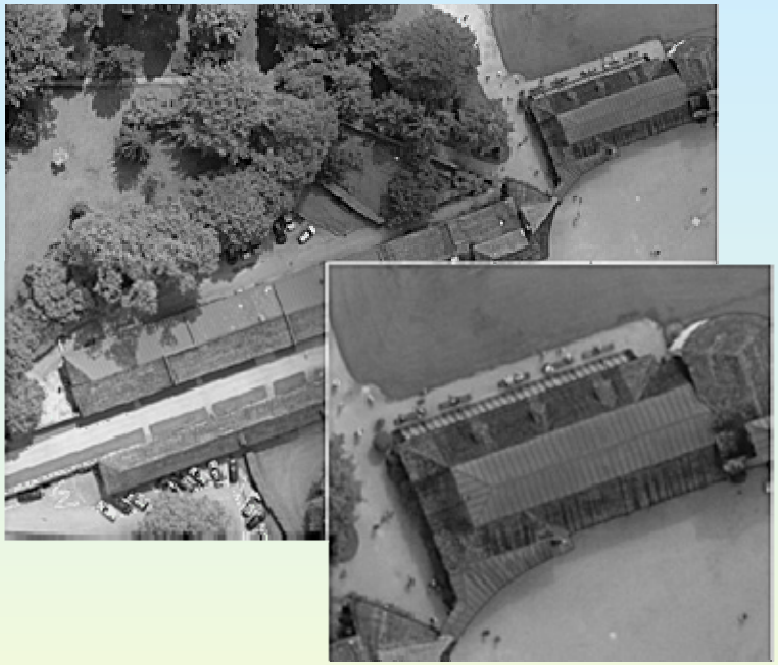
- Leica ADS-40
- Z/I DMC
- Vexcel UltraCam

Vexcel UltraCam D

- 11,500 x 7500 pan resolution
- Four color channels (red, green, blue, near ir)
- 12-bit per channel

Vexcel UltraCam-D





Segment of a scanned film image (left) and a digital image captured with the UltraCam-D (right). Ground sampling distance is 17cm on the digital image and 16cm on the film image. Fillm was scanned at 12.5 microns.

Vexcel UltraCam-D

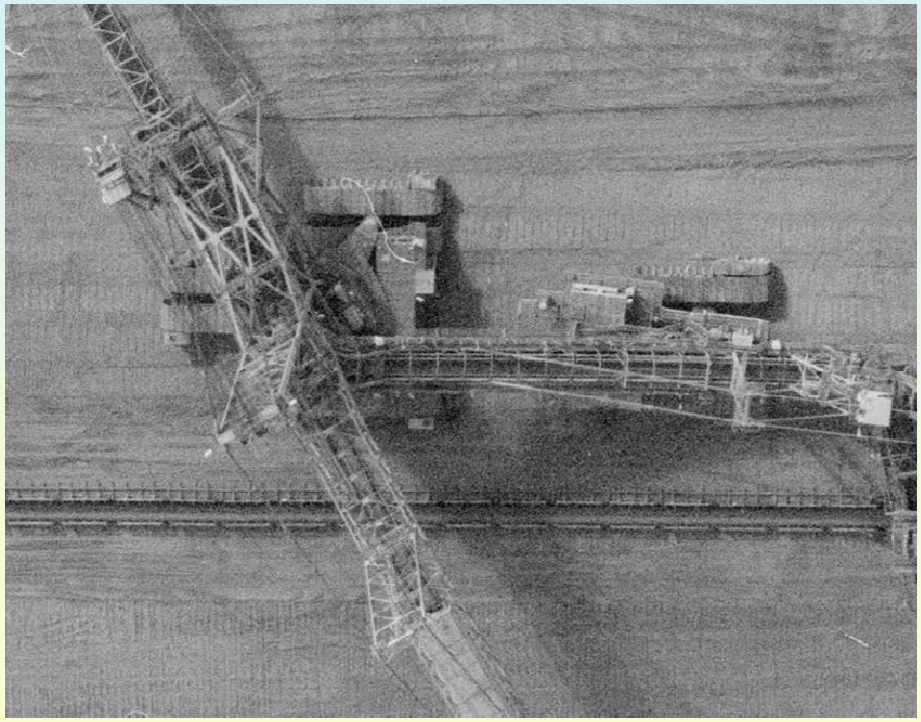
Features:

•Much lower cost that other digital cameras
•12 bit dynamic range and no grain-noise
•Imagery is compatible with existing photogrammetric procedures
•Superior work flow in-flight and on the ground
•High repeat rate images increase redundancy at no added cost
•Geometric accuracy equals scanned aerial film
•Camera is capable of 6 hours of uninterrupted data collection
•Noise-free, high radiometry image pairs for superior stereoscopy
•Clarity and matching accuracy 2.5 times better than scanned film

Aerial Film

UltraCam-D

Film vs UltraCam-D



Film Image GSD = 11 cm

UltraCam GSD = 11 cm

FILM

UltraCam-D

Data Volume (MB) per Sq Km
1 Meter Imagery

Products	Leica ADS-40	Z/I DMC	Vexcel UltraCam-D
Pan Forward	2	NA	NA
Pan Nadir	2	3.2	3.2
Pan Back	2	NA	NA
Full Res. Blue	2	2	2
Full Res. Green	2	2	2
Full Res. Red	2	2	2
Full Res. IR	2	2	2
Nat Color Orthophoto	6	6	6
Color IR Orthophoto	6	6	6
Nat. Color MrSid Mosaic	.3	.3	.3
CIR MrSid Mosaic	.3	.3	.3
Total MB per 1 Sq Km	26.6 MB	23.8 MB	23.8 MB

Data Volume (MB) per Sq Km
1 Meter Imagery

Products	Leica ADS-40	Z/I DMC	Vexcel UltraCam-D
Pan Forward	2	NA	NA
Pan Nadir	2	3.2	3.2
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Full Res. Blue	2	2	2
Full Res. Green	2	2	2
Full Res. Red	2	2	2
Full Res. IR	2	2	2
Nat Color Orthophoto	6	6	6
Color IR Orthophoto	6	6	6
Nat. Color MrSid Mosaic	.3	.3	.3
CIR MrSid Mosaic	.3	.3	.3
Total MB per 1 Sq Km	26.6 MB	23.8 MB	23.8 MB
Total MB per 1 Sq Mile	68.9 MB	61.6 MB	61.6 MB

Estimated Data Volumes

	Leica ADS-40	Z/I DMC	Vexcel UltraCam-D
Quarter Quad	861 MB	770 MB	770 MB
Full Quad	3.5 GB	3.0 GB	3.0 GB
Typical FO	875 GB	750 GB	750 GB
Typical SO	3.6 TB	3.1 TB	3.1 TB
All BLM Land	30 TB	26 TB	26 TB

Estimated Data Volumes

	Leica ADS-40	Z/I DMC	Vexcel UltraCam-D
Quarter Quad	861 MB	770 MB	770 MB
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All BLM Land	**30 TB**	26 TB	26 TB

Summary

- Imagery and remote sensing are important tools for our land management mission
- High resolution remote sensing data that covers all BLM interest areas could meet many enterprise land management information needs.
- New technologies promise to improve geospatial data quality and enhance our ability to acquire and use data
- BLM should strive to improve its access to high resolution remote sensing data through the use on new technologies and partnership with other agencies

Questions ?

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