

The Golden Age of Remote Sensing

Michael E. Hutt
mehutt@usgs.gov

Wealth of Information

- National Land Imaging Program (NLIP)- Landsat
- National Agricultural Imagery Program (NAIP)
- Civil Applications Committee (CAC)
- International Charter-‘Space and Major Disasters’
- Unmanned Aircraft Systems (UAS)
- Commercial Data
 - SPOT,
 - GeoEye,
 - Digital Globe,
 - Radar



Landsat Continuity:

Optical Observatories of the Earth

Landsat 1 - 3

Multi-Spectral Scanner (MSS) 79 meter
Return Beam Vidicon (RBV) 80/40 meter

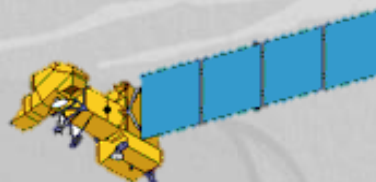


Landsat 4 - 5

Multi-Spectral Scanner (MSS) 79 meter
Thematic Mapper (TM) 30 meter

Landsat 7

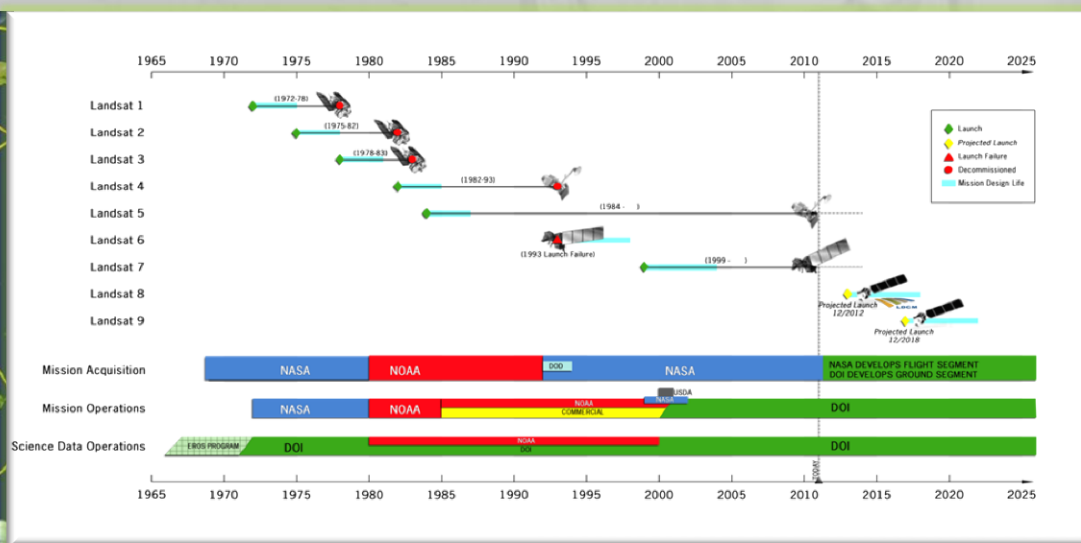
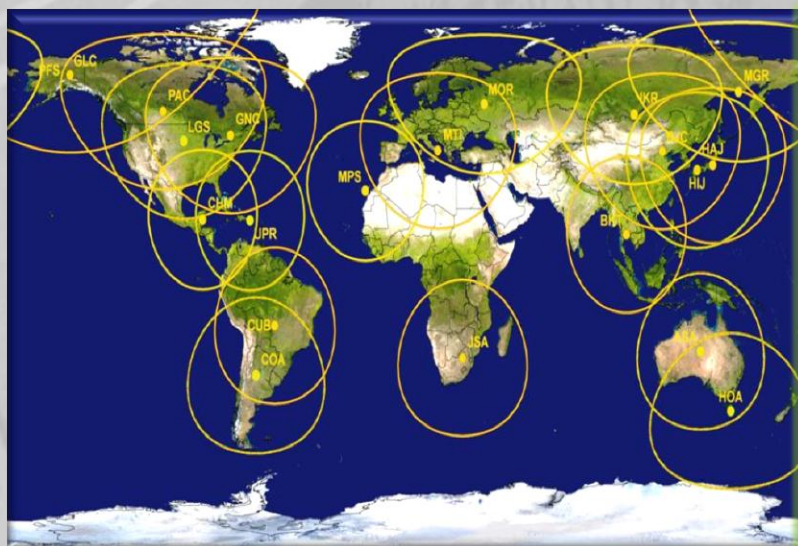
Enhanced Thematic Mapper
Plus (ETM+) 30/15 meter



Landsat 8



L A N D S A T
LDCM
Data Continuity Mission



NATIONAL AGRICULTURE IMAGERY PROGRAM

2003-2011 Imagery Available

1-2 Meter Resolution Imagery

Spectral Bands-

- natural color (Red, Green and Blue)
- RGB and Near Infrared

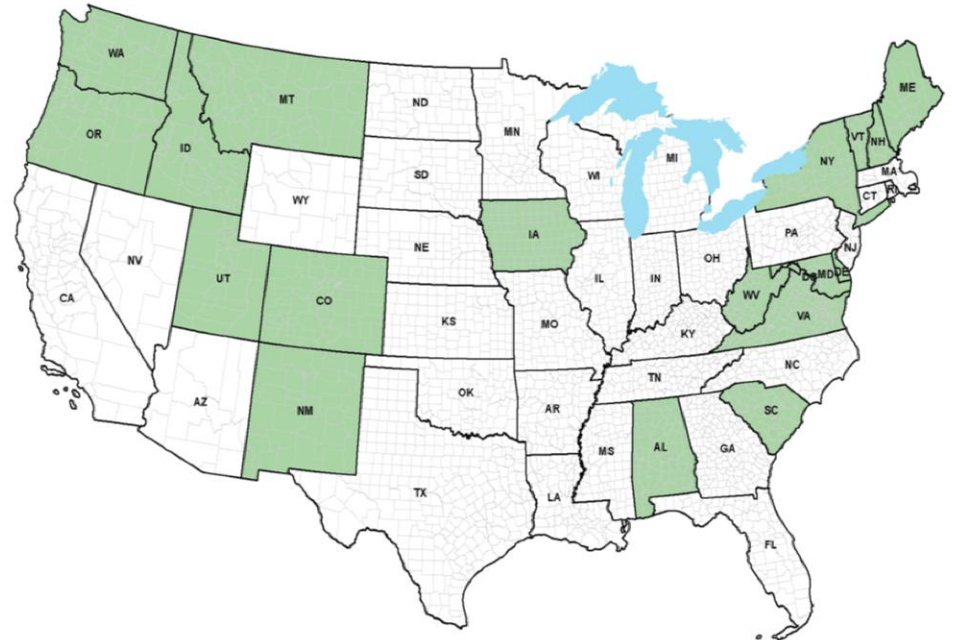
Formats-

- digital ortho quarter quad tiles or
- compressed county mosaics

Acquisition target- growing seasons
across the continental U.S.

Goal is to make imagery available to
governmental agencies and the public
within a year of acquisition.

2011 NAIP COVERAGE



<http://www.apfo.usda.gov>

Rapid Data Distribution System

<http://firedata.cr.usgs.gov>

or

<http://rmgsc.cr.usgs.gov/rdds>

Access and download of seamless raster data

Access restricted to emergency response community

Displays both vector and raster datasets

Dynamic layers representing current hazards events (wildfires, earthquakes, etc.)

Redirected to the authoritative sources

Viewable Incident Layers

[Earthquakes \(> 4 magnitude\)](#)

[Active Volcanoes](#)

[Active Fires](#)

[Active Fire Perimeters](#)

[Hurricanes](#)

[Stream Floods](#)

[Thermal MODIS](#)

[Remote Automated Weather Stations](#)

Downloadable Raster

Ortho Imagery- NAIP

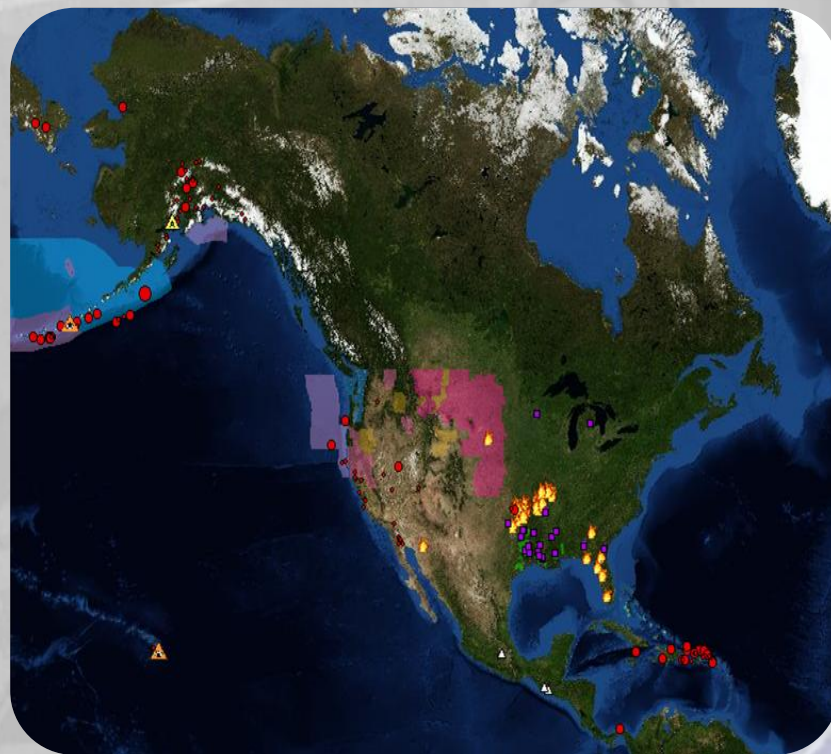
Digital Raster Graphics
(24K topos)

BLM Land Status 100K

Shaded Relief

Digital Elevation Models

Terrestrial Ecosystems



Viewable Base Map

[ESRI World Imagery](#)

[ESRI World Street Map](#)

U.S. Federal Lands

24K Index Grid

100K Index Grid





Civil Applications Committee (CAC)

- 1966** Study Conducted by President's Special Assistant for Science and Technology
- 1967** Steering Committee Formed by NASA, USDA, USGS, DOC
- 1973** Steering Committee Dissolved
- 1975** Rockefeller Commission Report Released
Presidential Order Issued Directing Implementation of Rockefeller Commission Recommendations
White House Memorandum Orders Secretary of the Interior to Form CAC – CAC Chartered by DCI, OMB, NSC
- 1976** First CAC Meeting Held
- 2000** Revised Charter Signed by DCI, OMB, NSC, DOI
- 2005** CAC Blue Ribbon Study
- 2010** Congressional line item funding for CAC

The CAC has Served the Civil Community for More than 35 Years

The International Charter 'Space and Major Disasters'

An International agreement among Space Agencies to support with space-based data and information relief efforts in the event of emergencies caused by major disasters.

- Disaster response
- Multi-satellite data acquisition planning
 - Fast data turn-around – priority acquisition
- Archive retrievals and spacecraft tasking
- Data processing at pre-determined level
- Space Agency contribution in image/data
- Space Agency initiative for value-added-data fusion



Charter Member Agencies

CSA
Canada



NOAA
USGS
USA



CONAE
Argentina



CNES
France



ESA
DMC
Europe



CNSA
China



JAXA
Japan



ISRO
India



Hazards Data Distribution System (HDDS)

<http://hdds.usgs.gov/hdds/>

Radar	ERS-2, RADARSAT-1, RADARSAT-2, ENVISAT, ALOS PALSAR
Optical Moderate-to High-Resolution	SPOT-4, SPOT-5, IRS-1C, IRS-P6, IRS-P5, CHRIS/PROBA, LANDSAT 5, LANDSAT 7 ALOS AVNIR/PRISM, BILSAT, ALSAT, NigeriaSat, UKDMC, Beijing-1, CBERS-2, Kompsat Ikonos, QuickBird, WorldView, GeoEye, Formosat, Topsat
Optical	MERIS, POES, GOES, SAC-C



Brenda K. Jones
Phone 605.594.6503
bkjones@usgs.gov

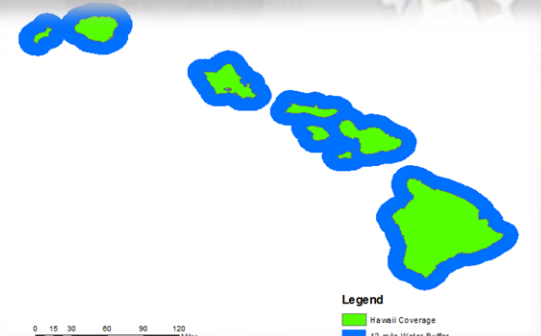
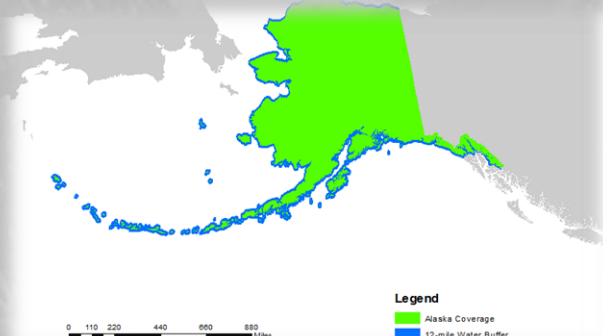
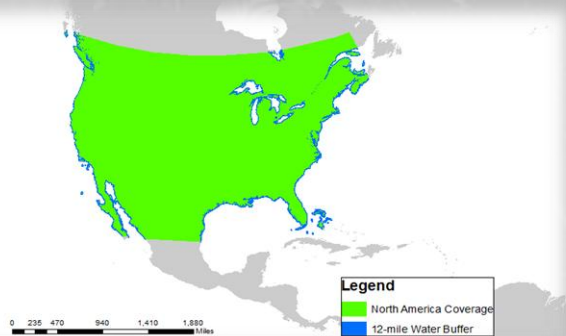
USGS SPOT Contract

- The USGS has contracted with SPOT Image Corporation, to receive moderate-resolution optical SPOT imagery through June 2012
- USGS EROS directly receives SPOT scenes and posts them for access over the Internet for U.S. Federal civil, state, local and tribal government users, per the licensing arrangements of the Data Buy contract.
- Scenes from the previous year's data buy are also available but are not licensed for tribal government use.
- Access to dataset- <http://earthexplorer.usgs.gov>
- Requests for new collects are made through the CIDR tool <http://cidr.cr.usgs.gov>.
- Contact Tom Cecere- tcecere@usgs.gov



North American Data Buy CY3 – Coverage

- Added Alaska and Hawaii
- Areas offshore within 12 miles are available upon request
- New clarification to licensing agreement will:
 - grant those working on behalf of the government access to the data
 - allow partners of the government to have access to the data for the purpose of working on Federal/Civil, State, Local and Tribal government projects



High Resolution Commercial Imagery

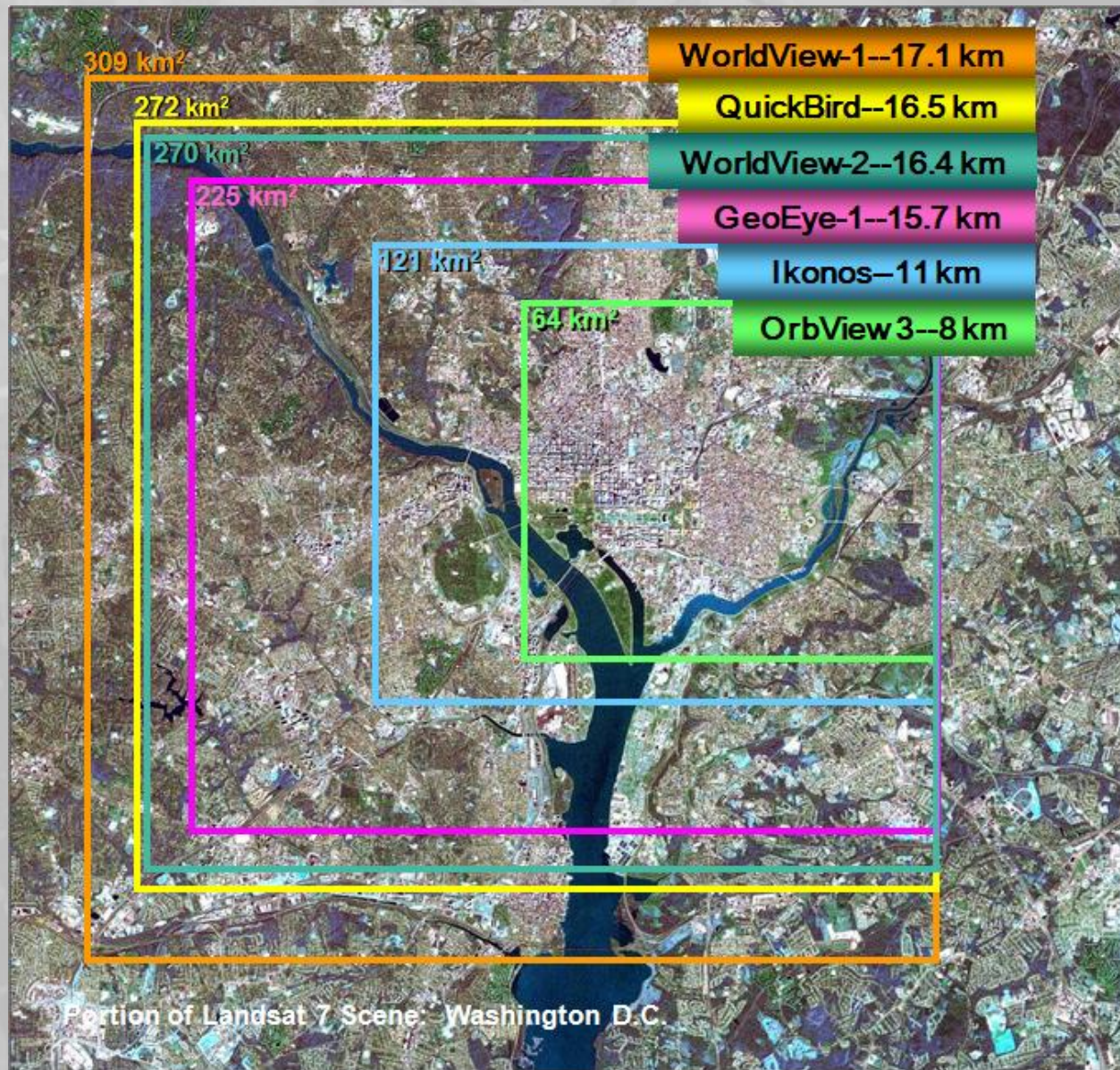
U.S. Commercial Satellites



- IKONOS (GeoEye)
- Quickbird (Digital Globe)
- OrbView 3 (archive only) (GeoEye)
- WorldView – 1 (Digital Globe)
- GeoEye -1 (Geo Eye)
- WorldView – 2 (Digital Globe)

NGA EnhancedView and family of contract vehicles

High Resolution Commercial Imagery Footprints



GEOEYE Spectral Bands

GEOEYE -1

GEOEYE-1 SPECIFICATIONS	
Spatial Resolution	
Panchromatic Sensor	0.41 meters x 0.41 meters
Multispectral Sensor	1.65 meters x 1.65 meters
Spectral Range	450–800 nm 450–510 nm (blue) 510–580 nm (green) 655–690 nm (red) 780–920 nm (near IR)

Ikonos

Spatial resolution

- 0.8 m panchromatic (1-m PAN)
- 4-meter multispectral (4-m MS)
- 1-meter pan-sharpened (1-m PS)

Spectral Resolution

Band	1-m PAN	4-m MS & 1-m PS
1 (Blue)	0.45-0.90 μm	0.445-0.516 μm
2 (Green)	*	0.506-0.595 μm
3 (Red)	*	0.632-0.698 μm
4 (Near IR)	*	0.757-0.853 μm

OrbView 3 (Archive Only)

OrbView-3 Specifications

Imaging Mode	Panchromatic	Multispectral
Spatial Resolution	1 meter	4 meter
Imaging Channels	1 channel	4 channels
Spectral Range	450-900 nm	450-520 nm (blue) 520-600 nm (green) 625-695 nm (red) 760-900 nm (near IR)

GEOEYE-1

View of Old and New Yankee Stadiums

February 21, 2009

Pixel Resolution

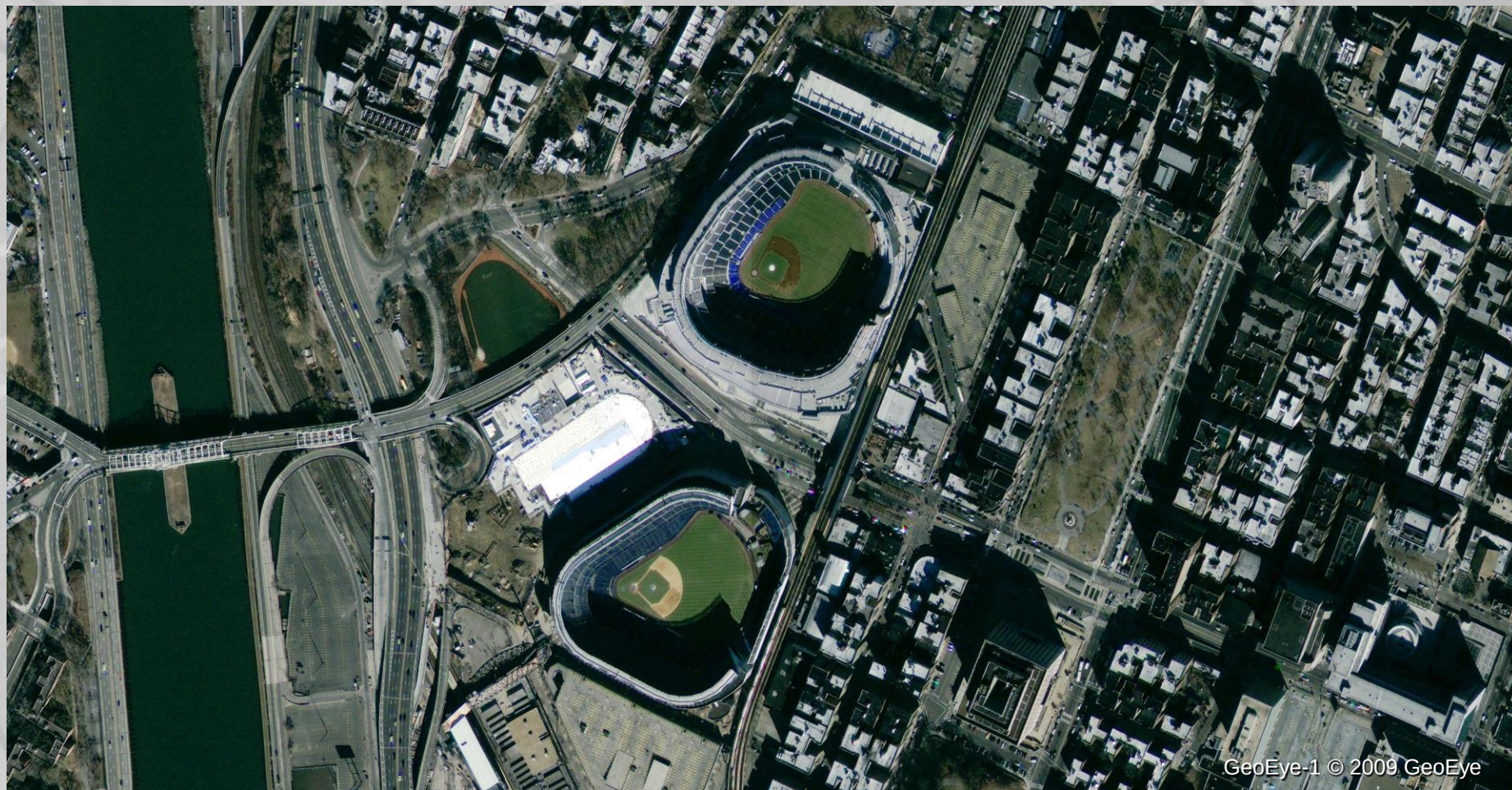
(at nadir)

*.41 m – Pan**

1.65 m - MS

Swath Width

15.2km at nadir



GeoEye-1 © 2009 GeoEye

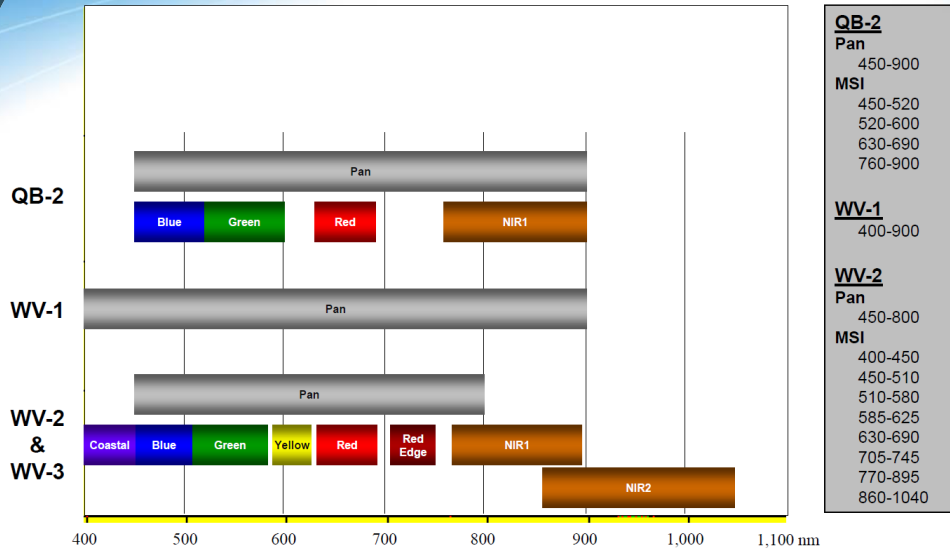
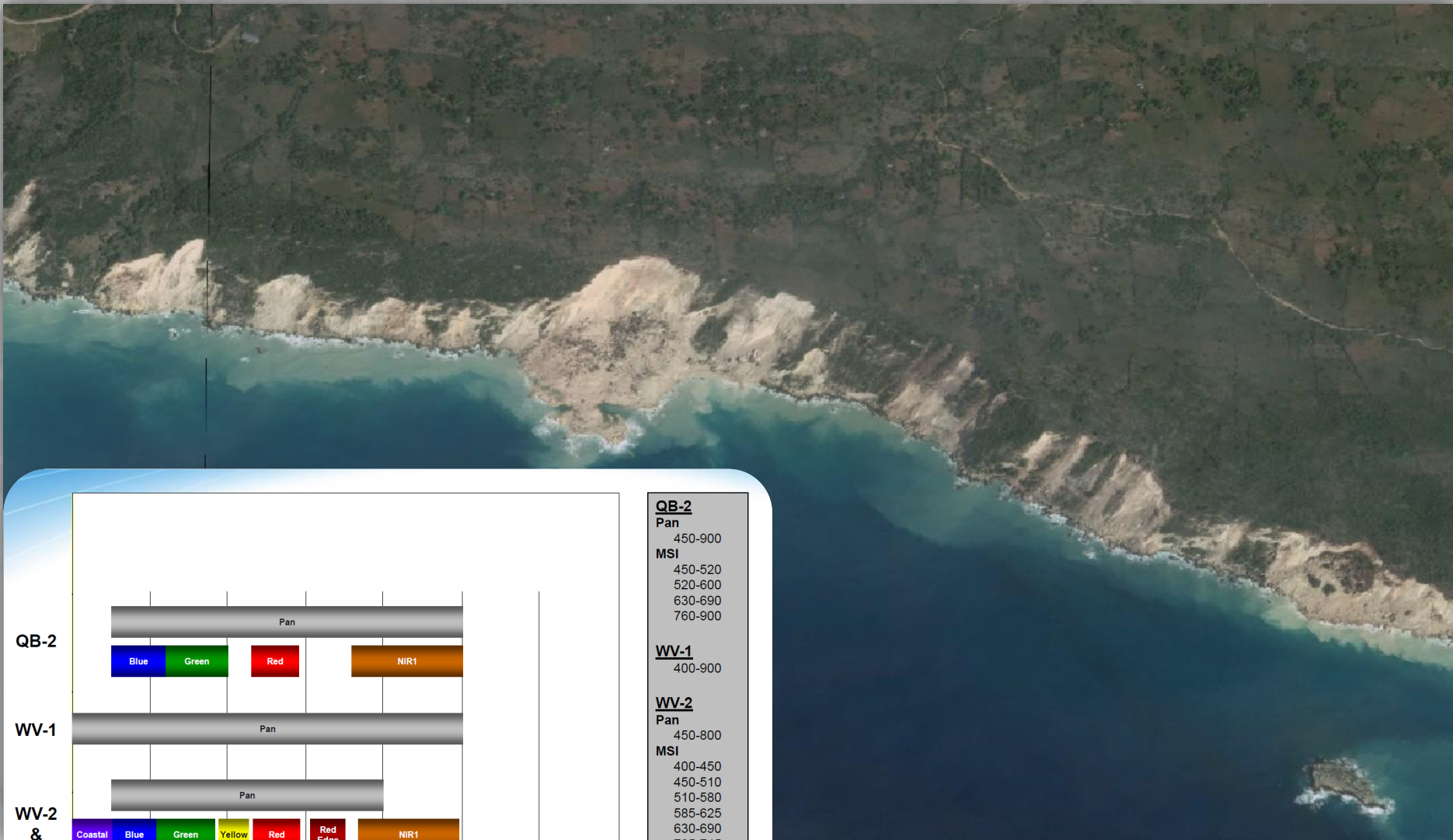
Digital Globe Suite:

DigitalGlobe Satellites	QuickBird	WorldView - 1	WorldView-2 (Q3-09)
Resolution	60 cm	50 cm	50 cm
Swath Width	16.5 km	17.6 km	16.4 km
Avg. Revisit	2.4 days	1.7 days	1.1 days
Slew Time	62 seconds	9 seconds	9 seconds
Spectral Bands	Pan + 4 MS	Pan	Pan + 8 MS
*Accuracy Spec.	24M CE90	6.5M CE90	6.5M CE90
Collection	210,000 km ² per day	750,000 km ² per day	975,000 km ² per day

*At nadir on flat terrain



WorldView 2: Haiti- landslides

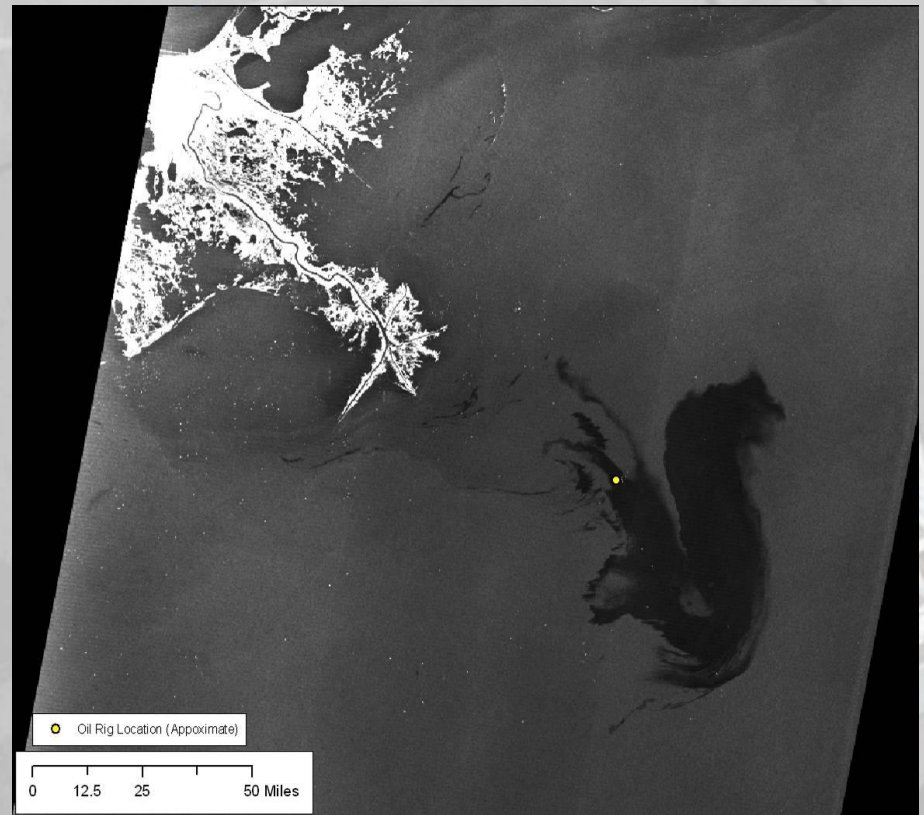


Commercial RADAR Imagery

NextView, Clearview, EnhanceView Contracts

Commercial RADAR
satellite imagery
vendors:

- Cosmo SkyMed
- ENVISAT
- TerraSAR
- RadarSat 1 & 2



USGS – Land Remote Sensing Program Unmanned Aircraft Systems Project Office

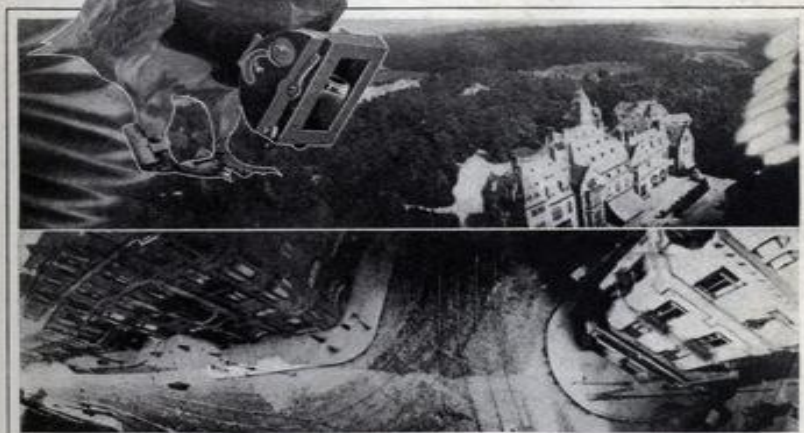
Carrier Pigeons Take Aerial Photos With New Camera



IT IS no longer necessary to send planes over enemy lines to get photos of troop operations—carrier pigeons have now been pressed into service for this hazardous task.

This unusual feat is made possible by the development in Germany of a new diminutive aerial camera which is strapped to the pigeon's breast, as illustrated in the accompanying photo. Two hundred views may be taken while in flight, the shots being made possible only after the bird has left the ground. Each bird also carries a message tube strapped to its leg.

The German government has opened a school to train carrier pigeons for service in aerial photography.



Above are two remarkable panoramic views taken by pigeon carrying aerial camera. Insert shows how camera is carried.



- Emerging Technology Investigation.....2005-2008
- UAS National Project Office Created.....May 2008
- First Systems Acquired.....November 2009
- Operational Procedures Memorandum.....March 2009
- Operator Training/ Demonstrations/ Introduction to COA.....2009 -2010
- Roadmap Released.....July 2011
- Operations.....Spring 2011
- Formal Concept of Operations..... Spring 2012
- DOI Systems.....Denver, Boise, Bozeman, Anchorage, Flagstaff

Where we are today

Raven UAS provides USGS and our partners with an enterprise level, low cost, low risk UAS capability to “cut our teeth”- Systems provided by DoD-Army to DOI-USGS

- Operator training and certification
- Develop user applications and standard operation procedures
- Establish air worthiness inspection criteria
- GAP Analysis- sensors, platforms



Aircraft (3 Each)



Day Payload
(3 Each)



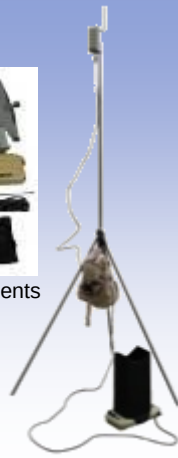
IR Payload
(2 Each)



GCS Components



Field
Repair Kit



Description

Wing Span	4.5 ft
Air Vehicle Weight	4 lbs
Range	10+ km (LOS)
Airspeed	27-60 mph
Altitude	>300 AGL
Endurance	90 min Lithium
Payload	EO/IR Full Motion Video
	GPS- Radio uplink & down link
GCS/RVT	- Combined Weight – 14 lbs

Characteristics

- Rapidly deployed
- Decentralized planning and execution
- Cost effective
- Easily transportable

Raven Operational Mission Sets

- Remote reconnaissance and surveillance
- Damage assessment
- Resource inventory Support

Benefits/Capabilities

- Provides enhanced situational awareness by providing expanded reconnaissance and surveillance coverage.
- Hand-launched
- GPS
- Manual or fully autonomous operations with in-flight retasking
- Commanded auto-loiter at sensor point of interest
- Executes lost link recovery procedures

Gasoline Micro Air Vehicle (gMAV)

Provides DOI-USGS with a UAS designed to meet the needs for a Reconnaissance and Surveillance (R&S) System with hover, persistent stare, and vertical launch/land capabilities. Systems Transferred from DoD- Army to DOI-USGS

Capabilities:

- Field level asset
- Single person portable
- Operates in complex terrain
- Manual or automated flight



Characteristics

AV Weight	18 lbs
System Weight	51 lbs
Range	10 km
Endurance	47 minutes
Payload	EO/IR/LD/LRF Sensor
Max Speed	45 mph
Flight Characteristics	Hover and Stare Capable

Potential Applications:

- Observing wildfire behavior
- Verification- Validation of test sites
- Archeological Site (cliff art) Mapping
- Small area photogrammetric projects
- Damage assessments
- Dam Inspections
- Monitoring Volcanic Activity

DOI UAS Project Descriptions:

- Training- Maintain Operator Currency (Idaho)
- Wildfire Support - Prescribed Burns (Florida)
- Sandhill Crane Population Inventory (Colorado)
- Rangeland Health Survey - Pygmy Rabbit Habitats (Idaho)
- Thermal Surveys of Lakes and Streams (Montana)
- Monitor Impacts of Missouri River Flooding (S. Dakota)
- Coal Seam Fires and Mine Monitoring – (W. Virginia)
- Monitoring Impacts of Elwha Dam Removal – (Washington)
- EPA Superfund Site - (Delaware)
- Haleakala National Park – (Hawaii)
- Mohave Desert – (California)
- Sage Grouse Habitat (Colorado)
- Moose, Wild Horses & Burro Population Inventory (CO & WY)
- Forest Health Inventory- Pine Beetle Infestation (Colorado)
- Mapping Dinosaur Tracks (Colorado)
- Glacier Temperature Study (Washington, Montana)
- Geologic Hazards – Landslides
- Badlands National Park Monitoring (S. Dakota)
- Carlsbad Caverns National Park (New Mexico)
- Wildfire (U.S.)
- Dam Inspections

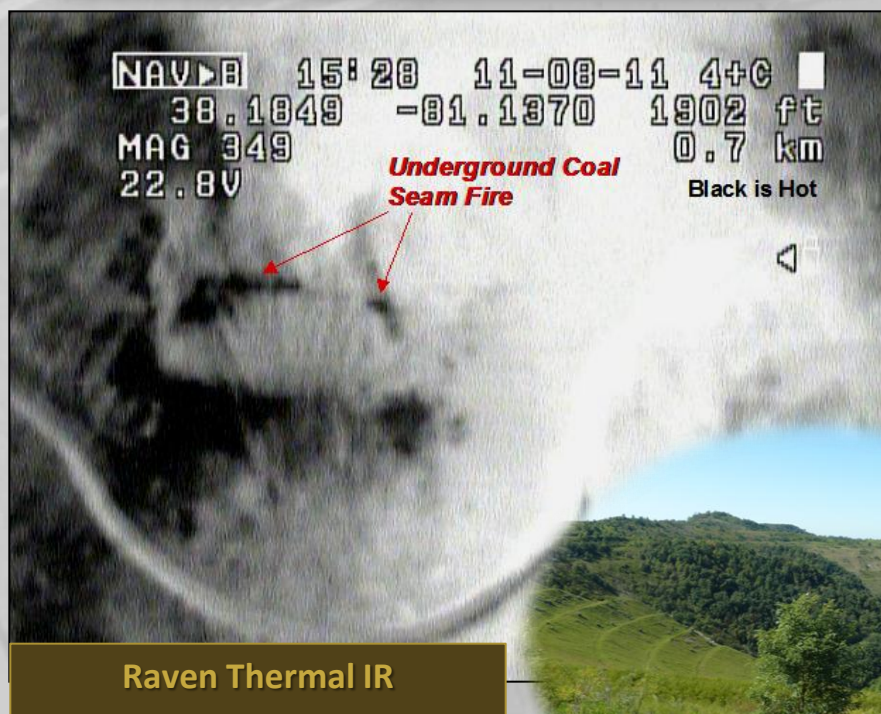


Fire Demonstrations— Utah/ Florida/ Colorado/ California

Electro-Optical Video of Prescribed Burn



UAS – OSM Mine Surveys – West Virginia



Raven Thermal IR



Raven video natural color

USGS and DOI Aviation Management Directorate Partnership



- Aviation Safety Programs
- Aircraft Management Services
- Procurement of Aircraft
- Service Contracts
- Coordination of Assets
- CONOPS

Operational Procedures Memorandum 11-11:

- Operator Certification
- Operator Currency Requirements
- Aircraft Safety Inspection Criteria
- Certificate of Authorization Process



Way Forward – Collaboration is the Key

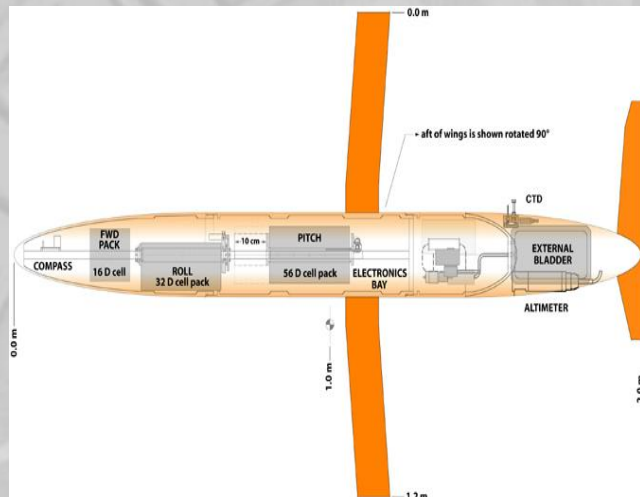
- Improve awareness of potential applications- projects
- Pool assets and leverage resources
- Develop Standard Tasking, Processing, Exploitation & Dissemination (TPED) Procedures
- Develop Data Sharing Agreements across military, civil, private industry & academia
- Assist the FAA in collecting the data necessary to develop UAS operating plans and procedures



CBP Support to Fire Community-



Possibilities – Where we can go...



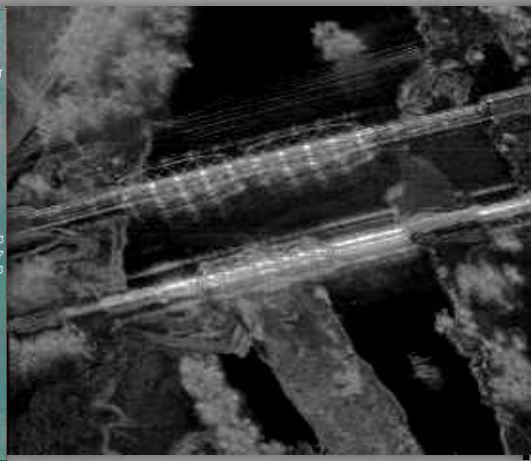
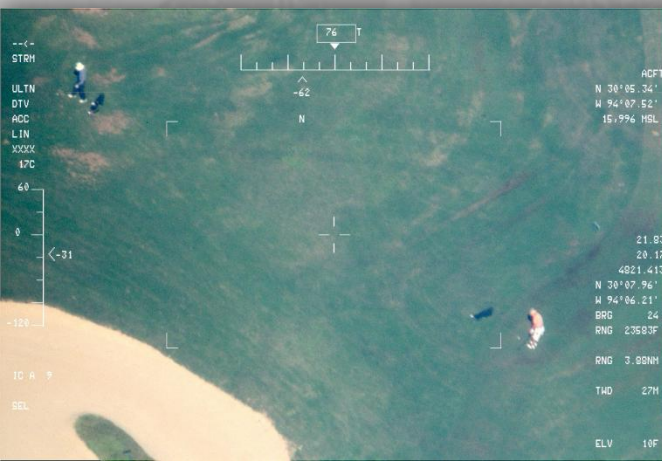
Solutions – Sensor Flexibility

Small UAS < 20 pounds:

- Full Motion Video
- Small Format Frame Camera
- Thermal- Infrared
- Chemical- Gas Plume Detection
- Meteorological- temperature
- Radio Telemetry
- Electromagnetic
- Laser Range Finder

Larger UAS Platforms:

- LiDAR
- Hyperspectral
- Radars (SAR)
- Traditional Mapping Camera
- True Multispectral



Initial Camera Testing and Integration

Photoscan- Photogrammetric Image “Point Cloud”



FAA Modernization and Reform Act of 2012:

Expedited access for UAS public aircraft

- Setting a 30 Sept., 2015 deadline for full integration of UAS into the NAS
- Requiring a comprehensive integration plan within nine months
- Requiring the FAA to create a annual UAS roadmap
- Requiring sUAS (under 55 pounds) to be allowed to fly within 27 months
- Requiring six UAS test sites to be established within six months
- sUAS (under 55 pounds) be allowed to fly in the U.S. Arctic, 24 hours a day, beyond line-of-sight, at an altitude of at least 2,000 feet, within one year
- Requiring expedited access for public users, (government) such as law enforcement, firefighters, emergency responders,
- Allowing public users to fly very small UAS (4.4 pounds or less) within 90 days- LOS, below 400 ft., daylight, outside 5 miles from airport or other aviation activities
- Requiring the FAA to study UAS human Factors and causes of accidents



Questions?

Mike Hutt (303)-202-4296

mehutt@usgs.gov

Jeff Sloan (303)-236-2897

jlsloan@usgs.gov

<http://uas.usgs.gov/>