Military Use of Satellite Systems

EV478

Resolution

- Spatial
  - pixel size (sometimes called ground sampled distance)
  - all detail within one pixel is averaged as a single digital number…you can't identify 1 pixel objects

- Spectral
  - number and width of bands of the spectrum imaged
  - multispectral < 10 bands, hyperspectral >> 10 bands

- Temporal
  - revisit cycle (time between successive imaging of same area)

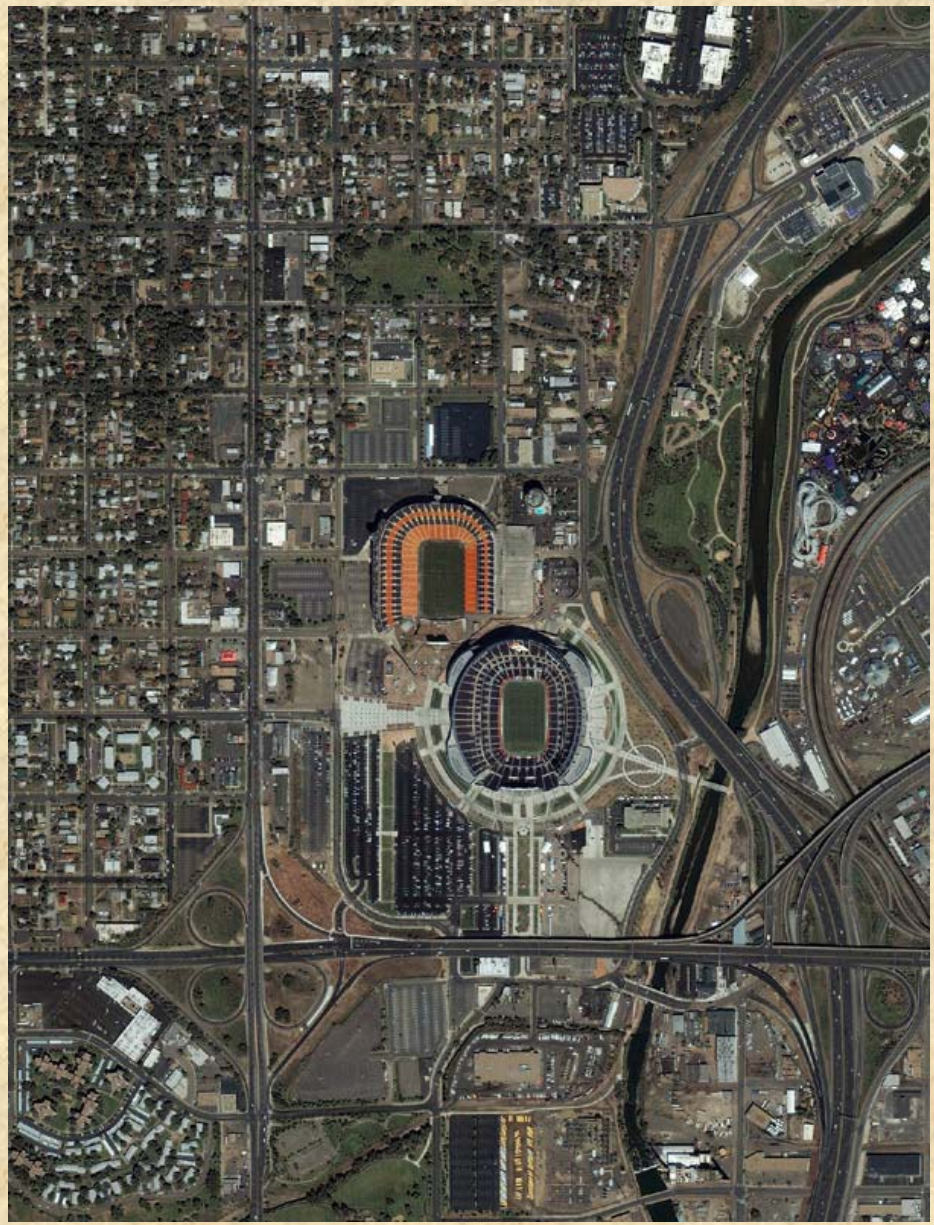
- Radiometric
  - number of data bits (∴ data range or number of gray levels) recorded for each pixel
  - 6 bits: 0-63, 8 bits: 0-255, 11 bits: 0-2047

Ikonos (Greek for Image) - GeoEye

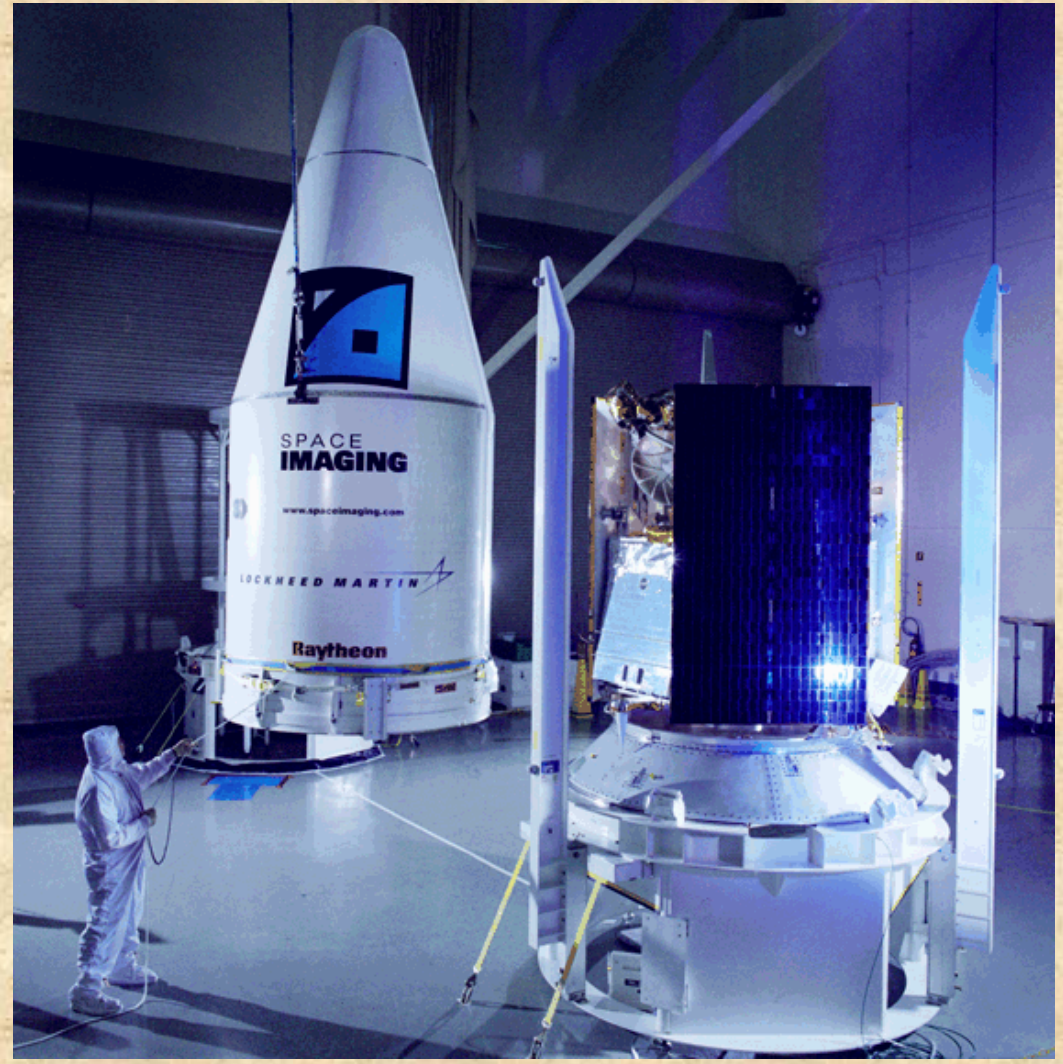
Ikonos 2 image courtesy of Space Imaging

Ikonos Program History (GeoEye)

- Ikonos 1
  - launched April 1999 but failed to achieve orbit
- Ikonos 2
  - launched September 1999
  - On-orbit calibration and acceptance completed December 1999
  - in commercial service January 2000



Ikonos (GeoEye)

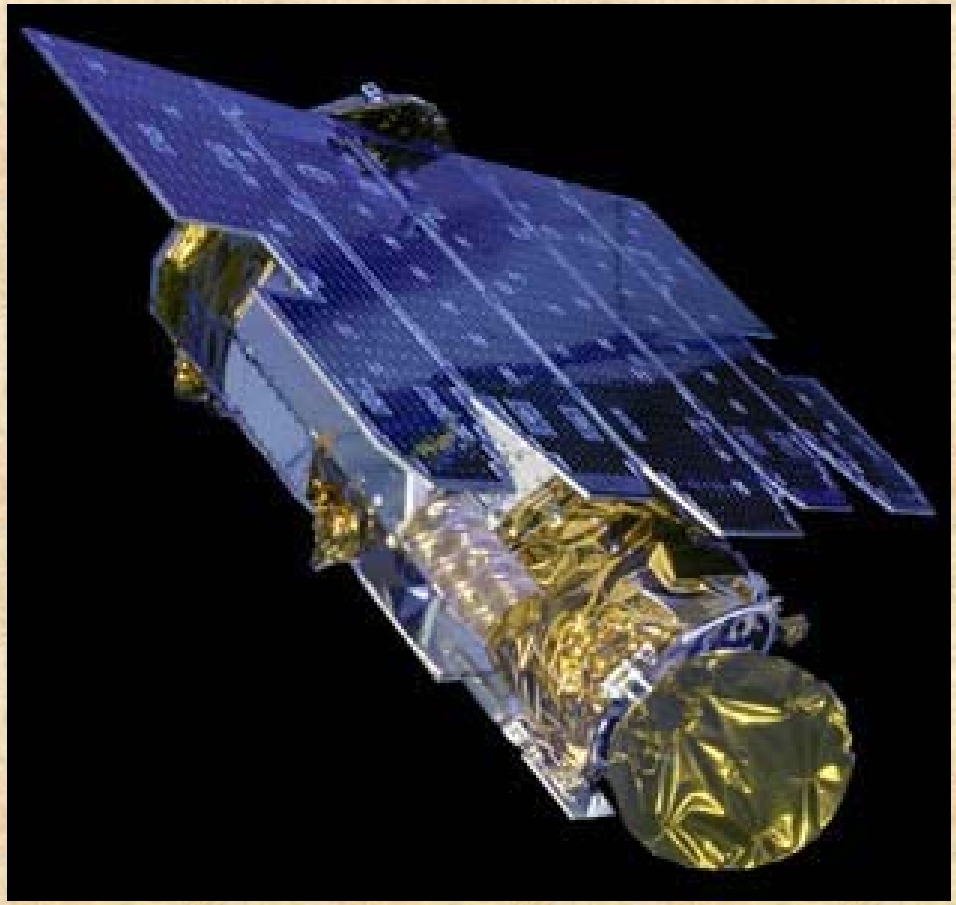


- First successful 1-meter (panchromatic) commercial imaging satellite
- 4 band multispectral system (4 meter) mimics Landsat bands
- Agile satellite can shoot up to 60 degrees off-nadir (daily revisit at GSD of 2.5 meters or less)

Ikonos 2 photo credit: Russ Underwood/Lockheed Martin, courtesy of Space Imaging.

Orbview Program History (GeoEye)

OrbView 3 (launched October 18, 2001; fueled for 5 years, deactivate April 23, 2007)



- One of the first successful high resolution commercial imaging satellite systems.
- 4 band multispectral system (4 meter) mimics Landsat bands.
- Agile spacecraft - in-track and cross-track pointing can shoot up to 45 degrees off-nadir.
- Nominal swath width 8.0 kilometers at nadir.

GeoEye 1 Program History (GeoEye)

GeoEye-1 (launched September 6, 2008).

- Highest spatial resolution commercial imaging satellite system.
- Four band multispectral system (1.65 meter) mimics Landsat bands; 0.41 meter panchromatic.
- Nominal swath width 15.2 kilometers at nadir.

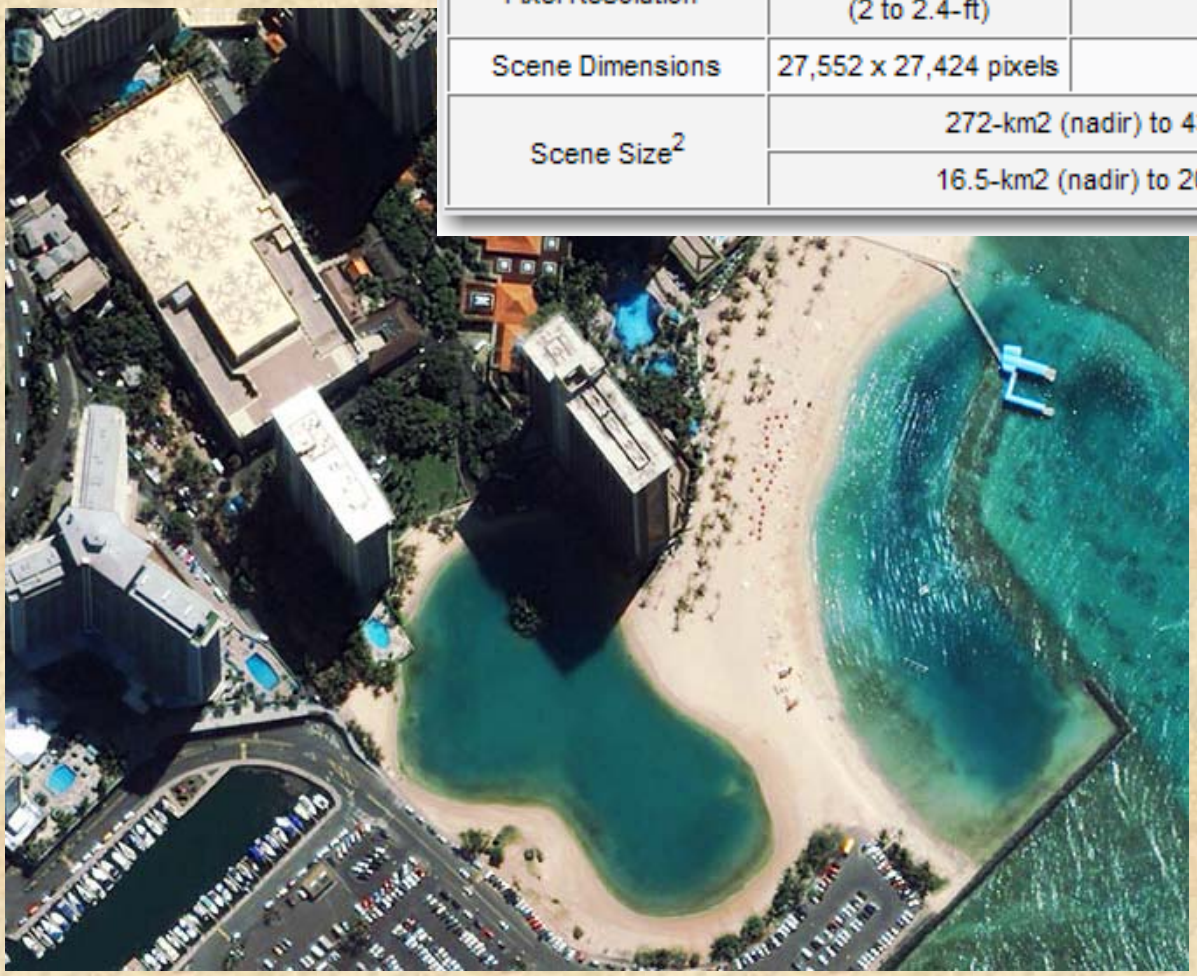
Quickbird & WorldView 1, 2 (DG)

Quickbird Program History (DG)

- Quickbird - Launched October 18, 2001, fueled for 7 years

Quickbird (DG)

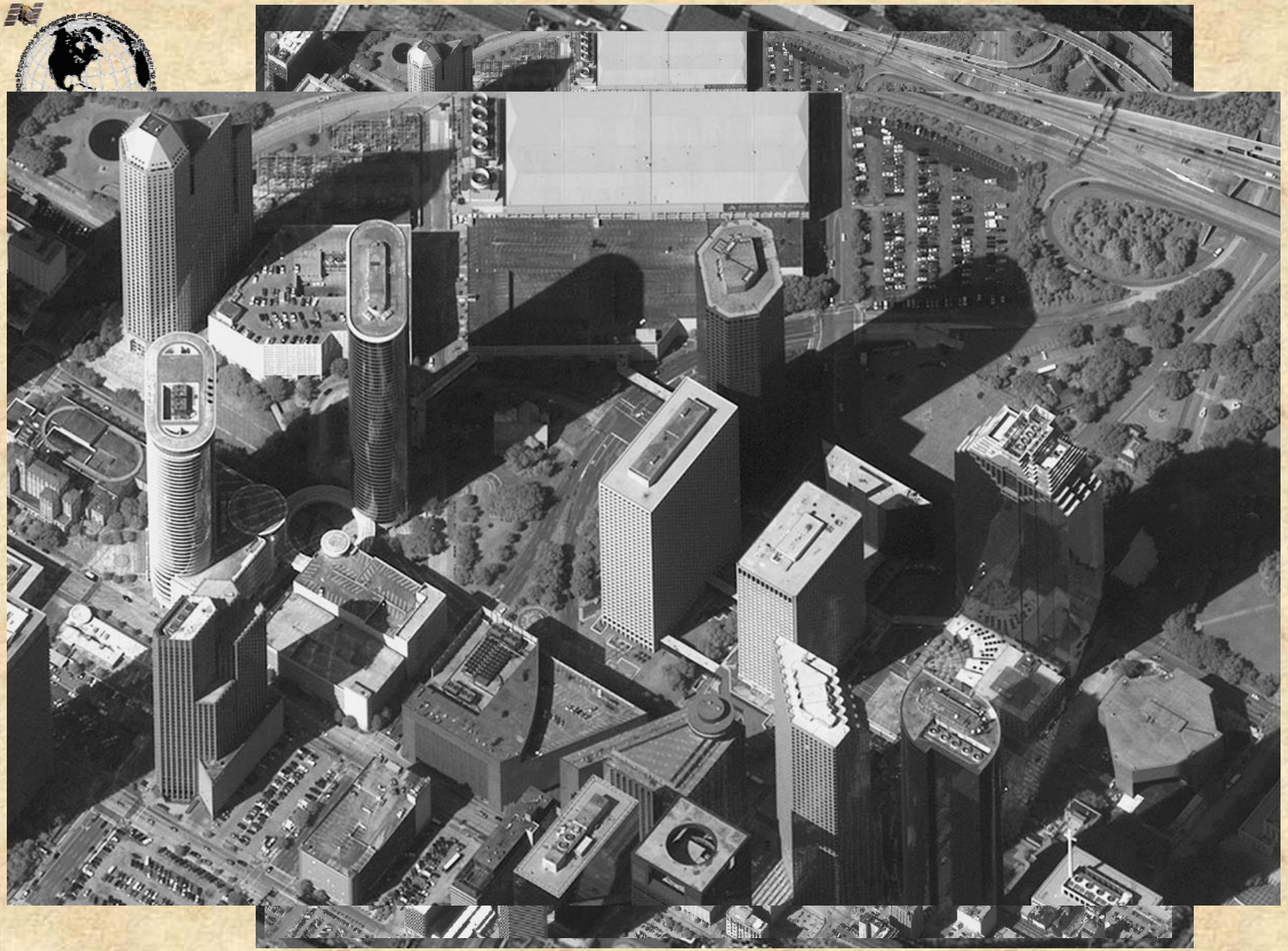
Spatial and Spectral Resolution					
	Panchromatic	Multispectral			
Spectral Characteristics	Black & White	Blue	Green	Red	Near IR
	450 to 900-nm	450 to 520-nm	520 to 600-nm	630 to 690-nm	760 to 900-nm
Pixel Resolution[1]	61-cm to 72-cm (2 to 2.4-ft)	2.44 to 2.88-m (8 to 9.4-ft)			
Scene Dimensions	27,552 x 27,424 pixels	6,888 x 6,856 pixels			
Scene Size[2]	272-km2 (nadir) to 435-km2 (25° off-nadir) (105 to 168-mi2)				
	16.5-km2 (nadir) to 20.8-km2 (25° off-nadir) 10.3 to 12.9-mi2)				



Worldview-1 (DG)

Launch on 18 September 2007

- Low Earth orbit of 496 km, sun synchronous
- Off nadir viewing up to 20 degrees
- Spatial resolution: 0.46 metre panchromatic sensor
- Temporal resolution: 1.7 day revist time at 1.0 m, 5.4 days at 0.5 m
- Radiometric resolution: 11-bits



IKONOS, Quickbird & Worlview-1 Pan Imagery

IKONOS

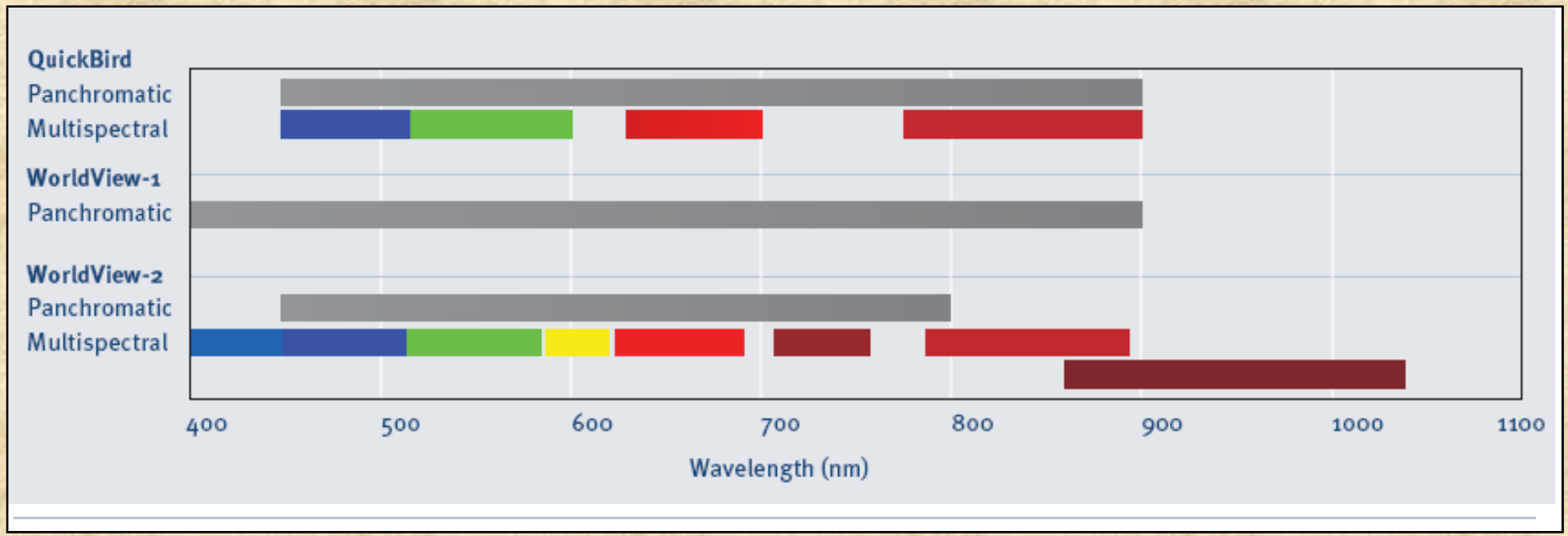
Quickbird

Worldview - 1

Worldview-2 (DG)

Launch on 8 October 2009

- Low Earth orbit of 770 km, sun synchronous
- Off nadir viewing up to 20 degrees
- Spatial resolution: 0.46 metre panchromatic sensor
- Temporal resolution: 1.1 day revist time at 1.0 m, 3.7 days at 0.5 m
- Radiometric resolution: 11-bits



Worlview-2 Imagery (DG)

U.S. Commercial Systems Comparison

System	Landsat 7	Quickbird	IKONOS	Orbview 3	GeoEye 1	WorldView1	WorldView 2
Altitude	705 km	715 km	682 km	470 km	684 km	496 km	770 km
Equatorial Crossing	0945	1030	1030	1030	1030	1030	1030
Image Area	185 km x 185 km	16.5 km x 16.5 km	11 km x 11 km	8 km x 8 km	15.2 km x 15.2 km		16.4 km x 16.4 km
Temporal Resolution	16 days	3 Days	2-3 days off nadir	2-3 days off nadir	2-3 days off nadir	1.7 days off nadir	1.1 days off nadir
Spatial Resolution	Pan: 15 m TM: 30 m	Pan: .61 m MSS: 2.4 m	Pan: 0.82 m MSS: 3.2 m	Pan: 1m MSS: 4 m	Pan: .41 m MSS 1.64m	Pan: .46 m	Pan: .46 m MSS: 1.84 m
Spectral Resolution	3 Visible	3 Visible	3 Visible	3 Visible	3 Visible		5 Visible
	1 NIR	1 NIR	1 NIR	1 NIR	1 NIR		3 NIR
	2 SWIR						
	1 Thermal						
	1 Pan	1 Pan	1 Pan	1 Pan	1 Pan	1 Pan	1 Pan
Off Nadir Viewing Angle	Nadir Only	25 degrees	60 degrees	50 degrees	60 degrees	20 degrees	20 degrees
Radiometric Resolution	8 bit	11 bit	11 bit	11 bit	11 bit	11 bit	11 bit

NRO Spy Satellites

U.S. National Reconnaissance Office (NRO)operates satellites for the U.S. intelligence community. American reconnaissance spacecraft, including the NRO's major equipment, are launched to Earth orbit by the U.S. Air Force and are known by a variety of code names. They are spysats and they include these general types: optical satellites that use a large mirror to gather visible light for photography -- like a Hubble Space Telescope pointing down at Earth rather than looking out into deep space.

- infrared and ultraviolet satellites that record invisible infrared and ultraviolet light from below.

- radar imaging satellites that uses microwave signals to peer through cloud cover and scan Earth's surface.

- combo radar, optical, infrared and ultraviolet satellites that see wide areas of Earth's surface with more detail than the separate types.

- signals intercept and detection satellites that tune in on radio, telephone and data transmissions.

- ocean observation satellites used to locate and determine the intent of ships at sea.

Example Spy Satellite

Lacrosse

The NRO operates a clutch of radar-imaging spysats known as Lacrosse. They also have been referred to as Onyx, Vega, Indigo and other code names. Each of these huge sky-high night watchers weighs 15 tons and is as big as a school bus. They orbit 400 miles above Earth's surface.

Lacrosse is built around a synthetic aperture radar (SAR), which can see through clouds and send down photographic-quality images. Each satellite has a huge wire-mesh radar antenna and 150-ft. solar panels to generate the kilowatts of electricity required by its powerful radar transmitter.

Each Lacrosse passes over its assigned observation target on the ground twice a day, peering down through bad weather to show military commanders elsewhere on the ground where to strike and what damage was caused by strikes. Lacrosse satellites can show objects as small as a foot across at night and in bad weather. Big objects on the ground, like tanks or surface-to-air (SAM) missiles, can be seen even if hidden in a woods.

Keyhole

NRO also has digital-imaging satellites known as Keyhole. For example, a KH-11 is a school bus-sized satellite in a polar orbit from where it can deliver very high resolution pictures in visible light and infrared. It can see at night in good weather.

Military Use of Satellite Systems

Other Satellites ?

What are these things?

- DSP
- SBIRS
- SDS
- Milstar
- Wideband Gapfiller Satellites
- **Other Mil Comm Sats**
- DMSP
- Navstar GPS
- XSS-11