The GeoEye Satellite Constellation

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March 14, 2006

JACIE 2006

IKONOS, 2004.09.18
(40.30 N, 104.76 W)
The GeoEye Constellation

- GeoEye Constellation
  - OrbView-2
  - OrbView-3
  - IKONOS™
  - IRS RESOURCESAT-1
- Calibration/Validation
  - Image Quality
  - Radiometry
  - Geometric Accuracy
  - Satellite Lifetime
  - Collection Capacity

OrbView-2
August 1997

IKONOS
September 1999

OrbView-3
June 2003

RESOURCESAT-1
October 2003

GeoEye-1
Spring 2007
IKONOS

- Launch
  - September 24, 1999
- Orbit
  - 681 km, Sun-synchronous
  - 10:20 equatorial crossing
- Imaging Sensors
  - 82 cm Pan, 3.2 m MS
    - Blue, Green, Red, NIR
  - 11 km swath
  - 11-bit radiometry
- Collection
  - Agile pointing & scanning
  - Bidirectional scanning
  - Mono or Stereo
- Revisit
  - 3 day at 60° elevation
  - 1 day at 45° elevation
IKONOS – 1-meter Color

Kuwait City, Kuwait
# IKONOS Image Products

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<th>Product</th>
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<td>6m LE90(2)</td>
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<tr>
<td>Terrain Model</td>
<td>12m LE90</td>
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</table>

### Formats:
- CIB
- NITF(3)
- J2000
- GeoTIFF
- 8/11 bits

### Band Combinations:
- 1m Pan
- 4m MSI(*)
- 1m Color(*)
- 1m Pan + 4m MSI(*)
- (*)RGB, CIR, or BGRN

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(1) Geo accuracy is exclusive of terrain.
(2) Ground Control Points required for precision.
(3) Includes RPC Camera Model
OrbView-3

- **Launch**
  - June 26, 2003
- **Orbit**
  - 470 km, Sun-synchronous
  - 10:30 equatorial crossing
- **Imaging Sensors**
  - 1 m Pan or 4 m MS imagery
    - Blue, Green, Red, NIR
  - 11-bit radiometry
  - 8 km swath at nadir
- **Collection**
  - NS or EW scanning
  - Mono or Stereo
- **Revisit**
  - 3 day at 35° elevation
OrbView-3 1 m Pan & 4 m MS Images

Great Pyramids of Giza, Egypt
Sand Island, near Midway
OrbView-3 Products

• Imagery Products
  – Basic Data Sets
    • Basic Express
    • Basic Enhanced
    • Basic 1:50k
    • Basic 1:24k
    • Basic 1:12k (Future)
  – Geo Data Sets
    • GEO Express
    • GEO 1:50k
    • GEO 1:24k
    • GEO 1:12k (Future)
  – Ortho Data Sets
    • Ortho 1:50k
    • Ortho 1:24k
    • Ortho 1:12k (Future)

• Derived Products
  – Digital Elevation Products
    • DSM
    • DEM
  – Thematic Map Products
    • Vegetation Index Maps
    • Land Cover Maps
  – Feature Maps
    • Topo 1:50k
    • Topo 1:24k
    • Topo 1:12k
OrbView-2

• Capabilities
  – Multispectral Imaging
  – Color Bands - 8
  – Spatial Resolution - 1 km
  – Swath Width - 2,800 km
  – Revisit Time - 1 day
  – Orbital Altitude - 705 km
  – Expected Life - 10 years

• Operations
  – Approaching 7 years in orbit
  – In-service availability >99%

• Applications
  – Fishing, Agriculture, Research
  – Environmental Monitoring & Naval Operations

GeoEye
GeoEye-1

• Launch
  – March 2007
• Orbit
  – 660 km, Sun Synchronous
  – 10:30 am equatorial crossing
• Imaging Sensors
  – Pan 41 cm at nadir
  – MSI 1.64 m, Blue, Green, Red, & NIR
  – 15.2 km swath at nadir
  – 11 Bit dynamic range
• Collection
  – >700,000 km2 per day
  – Mono or Stereo
  – < 3 day revisit
• Mission Life:
  – 7 years
  – Fuel >10 Years
Indian Remote Sensing RESOURCESAT-1

- Orbit
  - 817 km, Sun-synchronous
  - 10:30 equatorial crossing

- LISS-III Sensor
  - Bands: Green, Red, NIR, SWIR
  - 23.5 m GSD, 7-bit
  - 141 km swath

- LISS-IV Sensor
  - Bands: Green, Red, NIR
  - 5.8 m GSD, 7-bit
  - Swath: 3-band, 23 km swath or 1-band 70 km, Steerable ±26°

- AWiFS
  - Bands: Green, Red, NIR, SWIR
  - 56 m to 70 m GSD, 10-bit
  - 740 km swath
• Dual AWiFS Cameras
• 370 km x 370 km scene each (Compare to South Carolina)
• 60 meter GSD (1.1 pixel per acre)
• Green, Red, NIR, SWIR
• 10 Bit Radiometry
Calibration / Validation Status

IKONOS & OrbView-3
Image Quality
Quarterly Through-Focus Test

- Technique: Step through 32 steps of secondary mirror to determine ideal location
- Most recent adjustment: 8 steps (200 um = 2/3 depth of field) on 2005.02.09.
Radiometry

Good – Meets Spec, <5%

Better – Perceptible, <1%

Best – Imperceptible, <0.5%
IKONOS Linearity better than 1%

**MS-1 (BLU) Linearity - 2006**

\[ y = 541.78x - 35.254 \quad R^2 = 0.9992 \]

Response Linearity = 0.56% F.S.E.

**MS-2 (GRN) Linearity - 2006**

\[ y = 579.32x - 23.891 \quad R^2 = 0.9997 \]

Response Linearity = 0.39% F.S.E.

**MS-3 (RED) Linearity - 2006**

\[ y = 700.23x - 30.64 \quad R^2 = 0.9994 \]

Response Linearity = 0.35% F.S.E.

**MS-4 (NIR) Linearity - 2006**

\[ y = 588.71x - 26.985 \quad R^2 = 0.998 \]

Response Linearity = 0.57% F.S.E.
IKONOS Stability better than 1% per Year

MS Detector Stability Normalized to 2001 Data

- BLU: <1% Change per Year in each detector
- GRN: 0.0% per Year
- RED: -0.4% per Year
- NIR: -0.4% per Year

Year

2001 2002 2003 2004 2005 2006 2007
Dark Response Calibration
(Images Taken with Door Closed)
Geometric Accuracy
OrbView-3 Absolute Accuracy

**Mono**
- 12.9 m CE90

**Stereo**
- 11.2 m CE90

- 76 Images
- 698 Mono-drop Points
- 12.9 m CE90 Horizontal
- 36 Stereo Pairs
- 11.2 m CE90 Horiz.
- 7.8 m LE90 Vertical
IKONOS Accuracy & Stability

Absolute Accuracy
• How close the points are to zero error.

Relative Accuracy
• How close the points on a given day are to each other.

Stability
• Consistency from year to year.
IKONOS Accuracy Since Initialization

Calibration History by Production Date

2001.11.19 - Interior Orientation
   ~ 150 ppm scale

2002.01.31 - Exterior Orientation
   ~ 5 m offset

2005.01.17 – IO & XO
   ~ 1 pix between arrays

Pointing Error, 5/2000 to Present

7.3 m CE90
Lifetime
IKONOS Lifetime

- Reliability evaluation after 6 years on orbit
  - 73% to 1/1/2008
- Updated estimate to today (3/15/2006)
  - 80% to 1/1/2008
  - More than 20 years fuel
  - Solar Cells, Batteries & Sensors performing within specifications.

IKONOS Reliability Predictions

- At Launch
- After 6 Years

Years from launch
Reliability

3/15/06 1/1/08
Collection Capacity

OrbView-3 and IKONOS
Combined Archive
253 million sq km of imagery

GeoEye
Stereo Collection

- IKONOS Stereo Collection
  - Same Pass Stereo
- Strip Lengths
  - 280 km Maximum or
  - 2-strips, 112 km (1 deg) ea.
- Applications
  - Terrain & Site Models
  - Geolocation
  - Airfield Feature Extraction
Weather permitting, a one-degree Cell of monoscopic imagery with Sensor Elevation > 60 degrees can be collected in 8 days.
Collection Example - Katrina

IKONOS Image Collections 2005.09.02

GeoEye
16:49:39.3 Z
33.1° Elevation Angle

IKONOS Image Collections 2005.09.02
16:50:20.5 Z
40.1° Elevation Angle

IKONOS Image Collections 2005.09.02
16:50:48.4 Z
48.8° Elevation Angle

IKONOS Image Collections 2005.09.02
16:51:13.1 Z
64.9° Elevation Angle

IKONOS Image Collections 2005.09.02
16:51:37.9 Z
80.8° Elevation Angle

IKONOS Image Collections 2005.09.02
16:52:10.8 Z
76° Elevation Angle
13,000 km² Total Image Collection on One Pass
IKONOS Deliveries on 2005.09.03

Delivery Contents | Size
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Overview Images & Shapes | 0.02 GB
1m IKONOS Ortho Pan+MSI in GeoTIFF | 30 GB
1m IKONOS Geo Pan+MSI in NITF | 30 GB
1m RGB pre-Katrina Orthomosaic of New Orleans | 12 GB
Public Relations Imagery | 1 GB
5m pre-Katrina color orthomosaic of entire region | 2 GB
NED DEM in DTED format of entire region | 0.2 GB

Total each delivery | 75 GB

- Deliveries
  - 2x FTP
  - 9x counter-to-counter air freight
  - 2x will call
  - 1x internal

- Total
  - 1 Terabyte
OrbView-3 Katrina Collection

Coordination of OrbView-3 & IKONOS collection will improve emergency response in the future.
Conclusion

- GeoEye Constellation
  - IKONOS & OrbView-3 for high resolution
  - GeoEye with higher resolution 1Q2007
  - RESOURCESAT-1 for global crop assessment
  - OrbView-2 for ocean research & fish.

- IKONOS Performance in 2005
  - Stable Image Quality
  - Stable Radiometry
  - Stable Geometric Accuracy
  - Reliability: 80% to 2008.

- Operations
  - Demonstrated capacity for high-volume, quick-response collection & production.
Thank You!

Questions?

• Customer Service
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  703.480.7537

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  @geoeye.com

• Online
  www.GeoEye.com

Shuttle Discovery, 2005.04.08