The GeoEye Satellite Constellation

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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
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

<table>
<thead>
<tr>
<th>Product</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geo</td>
<td>15m CE90(^{(1)})</td>
</tr>
<tr>
<td>Geo Ortho-Kit(^{(3)})</td>
<td>15m CE90(^{(1)})</td>
</tr>
<tr>
<td>Standard Ortho</td>
<td>50 m CE90</td>
</tr>
<tr>
<td>Reference Orthomosaic</td>
<td>25m CE90</td>
</tr>
<tr>
<td>Pro Orthomosaic</td>
<td>10m CE90</td>
</tr>
<tr>
<td>Precision Orthomosaic</td>
<td>4m CE90(^{(2)})</td>
</tr>
<tr>
<td>Reference Stereo(^{(3)})</td>
<td>25m CE90</td>
</tr>
<tr>
<td></td>
<td>22m LE90</td>
</tr>
<tr>
<td>Precision Stereo(^{(3)})</td>
<td>4m CE90(^{(2)})</td>
</tr>
<tr>
<td></td>
<td>6m LE90(^{(2)})</td>
</tr>
<tr>
<td>Terrain Model</td>
<td>12m LE90</td>
</tr>
</tbody>
</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-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
AWiFS Sensor on RESOURCESAT-1

- 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**

- Equation: $y = 541.78x - 35.254$
- $R^2 = 0.9992$
- Response Linearity = 0.56% F.S.E.

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

- Equation: $y = 579.32x - 23.891$
- $R^2 = 0.9997$
- Response Linearity = 0.39% F.S.E.

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

- Equation: $y = 700.23x - 30.64$
- $R^2 = 0.9994$
- Response Linearity = 0.35% F.S.E.

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

- Equation: $y = 588.71x - 26.985$
- $R^2 = 0.998$
- 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
Dark Response Calibration
(Images Taken with Door Closed)

Pan Dark Response Stability (2005 vs 2001)

MS Dark Response Stability (2005 vs 2001)
Geometric Accuracy
OrbView-3 Absolute Accuracy

Mono

- 76 Images
- 698 Mono-drop Points
- 12.9 m CE90 Horizontal

Stereo

- 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

-10 -5 0 5
East (meters)

-10 -5 0 5
North (meters)

7.3 m
CE90

△ GCP 19  ■ CE90  □ GCP 21  □ GCP18
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.
Collection Capacity

OrbView-3 and IKONOS Combined Archive
253 million sq km of imagery
• **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
IKONOS Image Collections 2005.09.02
16:50:20.5 Z
40.1° Elevation Angle

IKONOS Image Collections 2005.09.02

GeoEye
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
16:52:10.8 Z
76° Elevation Angle
13,000 km² Total Image Collection on One Pass

IKONOS Image Collections 2005.09.02

GeoEye™
## IKONOS Deliveries on 2005.09.03

**Delivery Contents**

<table>
<thead>
<tr>
<th>Overview Images &amp; Shapes</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1m IKONOS Ortho Pan+MSI in GeoTIFF</td>
<td>30 GB</td>
</tr>
<tr>
<td>1m IKONOS Geo Pan+MSI in NITF</td>
<td>30 GB</td>
</tr>
<tr>
<td>1m RGB pre-Katrina Orthomosaic of New Orleans</td>
<td>12 GB</td>
</tr>
<tr>
<td>Public Relations Imagery</td>
<td>1 GB</td>
</tr>
<tr>
<td>5m pre-Katrina color orthomosaic of entire region</td>
<td>2 GB</td>
</tr>
<tr>
<td>NED DEM in DTED format of entire region</td>
<td>0.2 GB</td>
</tr>
</tbody>
</table>

**Total each delivery** 75 GB

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

- Total
  - 1 Terabyte

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**Color Balanced Orthomosaic 2005.09.07**

[Image of satellite view of New Orleans area]
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

• Operations
Thank You!

Questions?

• Customer Service
  800.232.9037
  703.480.7537

  customer.service
  @geoeye.com

• Online
  www.GeoEye.com

Shuttle Discovery, 2005.04.08