IKONOS Applications

Gene Dial
Jacek Grodecki
IKONOS Overview

Space Segment
- Image Sensor
- GPS, ST’s, & Gyros

Ground Segment
- Satellite Control
- Communications
- Archive
- Order Entry
- Image Processing

Imagery for Applications
IKONOS Satellite

Image Collection

- Simultaneous Pan and Multispectral images
- 1m panchromatic pixels
- 4m multispectral pixels (Blue, Green, Red, NIR)
- Linear detector arrays scan in any direction
- Swath width >11 km, length to 1000 km

Photogrammetry

- 680-km near-polar, sun-synchronous orbit.
- GPS receivers determine Ephemeris
- Gyros & Star Trackers determine Attitude.
- Solid state focal plane with calibrated interior orientation.
- Same pass stereo imaging.
IKONOS Pixel Characteristics

82-centimeter GSD at nadir

- 4 meter multi-spectral pixels
  (Blue, Green, Red, NIR)
  ~ Landsat Bands 1 - 4
- 1 meter panchromatic pixels
  - High resolution texture
  - Simultaneously collected
  - Solid state image detectors
  - Digital recording & transmission
- 11-bit grayscale resolution
- Swath width
  - 13816 pan pixels
  - 3454 MSI pixels
• Color enhances interpretation for
  • Material Identification,
  • Camouflage vs. Vegetation, and
  • Human visual understanding.
# Ground Station Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Accuracy</th>
<th>Formats:</th>
<th>Band Combinations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geo</td>
<td>N/A</td>
<td>GeoTIFF</td>
<td>1m Pan</td>
</tr>
<tr>
<td>Geo Ortho-Kit</td>
<td>15m CE90&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>CIB</td>
<td>4m MSI (*)</td>
</tr>
<tr>
<td>Reference Ortho</td>
<td>25m CE90</td>
<td>NITF</td>
<td>1m Color (*)</td>
</tr>
<tr>
<td>Pro Ortho</td>
<td>10m CE90</td>
<td>TIFF</td>
<td>1m Pan + 4m MSI(*)</td>
</tr>
<tr>
<td>Precision Ortho</td>
<td>4m CE90&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>MrSID</td>
<td>(*) RGB, CIR, or 4-band.</td>
</tr>
<tr>
<td>Reference Stereo</td>
<td>25m CE90 22m LE90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision Stereo</td>
<td>4m CE90&lt;sup&gt;(2)&lt;/sup&gt; 6m LE90&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrain Model</td>
<td>12m LE90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Georectified image accuracy is exclusive of terrain displacement.
2. Ground Control Points required for precision products.

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

**Formats:** GeoTIFF, CIB, NITF, TIFF, MrSID

**CD, DVD, Disk, Electronic**

**NITF format not suitable for orthorectified imagery! Please use GeoTIFF!**
### NASA SDP Products

#### All products in same format
- Pan + MSI (B, G, R, N)
- DRA Off, MTFC On
- GeoTIFF, CD-ROM
- WGS84, UTM
- License permits sharing data between scientists.

#### NASA Model (Stereo + DEM)
- Stereo Images w/ RPC
- Epi-polar Projection
- TIFF format
- 25m CE90 / 22m LE90
- DEM in USGS DEM format
- 7m RMSE Accuracy

#### Standard Original
- Georectified w/o GCP

#### Precision Original
- Georectified w/ GCP
- Leaving hundreds of meters of terrain displacement error

#### Standard Master
- Orthorectified w/o GCP
- 10m CE90 Accuracy

#### Precision Master
- Orthorectified w/ GCP
- 2m CE90 Accuracy
Georectified or Orthorectified?

**Georectified**
- “Original”
- Terrain displacement errors
- Quick, Low cost

**Orthorectified**
- “Master”
- DEM corrects for terrain displacement
- Accuracy for mapping
IKONOS Applications

Image Analysis
- Georectified Images

Cartography
- Orthorectified Images

Photogrammetry
- RPC Camera Model
- Mono or Stereo Images
Image Analysis Applications

Global Image Availability
Current Events
Intelligence, Surveillance
Disaster Response
Environmental Monitoring
Geological Studies
Rapid Image Collection
Extracting Detail in Shadows

11-bit radiometry facilitates information extraction
**Rapid Image Collection Rate**

<table>
<thead>
<tr>
<th>Collection</th>
<th>Days</th>
<th>Optimum Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td>60° Mono</td>
<td>13</td>
<td>700 km</td>
</tr>
<tr>
<td>60° Stereo</td>
<td>37</td>
<td>700 km IT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>560 km XT</td>
</tr>
<tr>
<td>60°/72° Stereo</td>
<td>61</td>
<td>400 km IT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>320 km XT</td>
</tr>
</tbody>
</table>

40° latitude, no weather or competition

**Optimum collection rate**
- Long strips, e.g., 112 km for 1° or 224 km for 2° of latitude
- Lowest elevation angle meeting accuracy & image quality requirements.
Iraq Archive (<20% Clouds)
IKONOS Multispectral Calibration

Band | DN/ (mW/cm²-ster)
--- | ---
Blue | 728
Green | 727
Red | 949
NIR | 843


Question: What are the optimum multispectral bandpass values for our next generation satellite?
Multispectral Classification & Automated Extraction

Multispectral Classification

- Radiometric resolution & stability
- High (4-meter) resolution.
- MSI bands approximately match Landsat bands 1-4

Automated Extraction

- High resolution texture
- Combined with MSI, improves reliability.
Cartographic Extraction

Choose ortho accuracy to meet your project requirements.

Extract features on simple monoscopic workstations.
# NIMA Applications

## Space Imaging production of NIMA products

<table>
<thead>
<tr>
<th>Product</th>
<th>IKONOS Source</th>
<th>SI Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topographic Line Maps</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Image Maps</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Controlled Image Base</td>
<td>Yes</td>
<td><em>Coming Soon</em></td>
</tr>
<tr>
<td>Feature Foundation Data</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Image City Map</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>City Graphics</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Digital Point Position Database</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Digital Terrain Elevation Data (I-II)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

![1:50,000 Topographic Line Map](image)
Photogrammetric Applications

Applications

- Multi-image or multi-source block adjust to improve accuracy.
- Triangulation with GCP to improve accuracy.
- Orthorectification with DEM
- 3-D Stereo Feature extraction

Data

- Mono or Stereo Imagery
- RPC Camera Model
# Software Certified for IKONOS Photogrammetry

<table>
<thead>
<tr>
<th>Company</th>
<th>Software</th>
<th>Block Adjust</th>
<th>Extract DEM</th>
<th>Ortho-rectify</th>
<th>Extract 3-D Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAE SYSTEMS</td>
<td>SO CET SET®</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Leica Geosystems</td>
<td>ERDAS IM AGINE®</td>
<td>(2)</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stereo Analyst ®</td>
<td></td>
<td></td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>OrthoBASE PRO®</td>
<td>(2)</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>PCI</td>
<td>OrthoEngine®</td>
<td>(2, 3)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Z/I Imaging</td>
<td>ImageStation®</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Block adjust improves accuracy with multiple images and/or GCP.
- DEM extraction creates surface topography models.
- Ortho-rectification uses a DEM to correct imagery for terrain distortion.
- 3-D feature extraction creates vector data for maps and analysis.

**Caveats:**
1. Epi-polar stereo only; not map-projected.
2. GCP with single image only; not multi-image block adjust.
3. IKONOS RPC model only; “Rigorous Camera Model” is not recommended.
Geo Ortho Kit

Monoscopic Image
- Elevation Angle > 60°
- Option for angle > 72°

RPC Camera Model
- Describes image orientation.

Software Applications
- Improve accuracy w/ GCP
- Orthorectify with DEM
Stereo Imagery

RPC Model for each Image

Applications

- 3D Feature Extraction
- DEM Extraction
- Orthorectification
Same Pass Stereo Image Collection

Stereo image pair collected on the same orbital pass.
Identical content & lighting in both images facilitates terrain extraction.

Asymmetric stereo collection angles
- One image > 72° elevation for orthorectification.
- 2nd image > 60° elevation with 0.5 < B/H < 0.8 for DEM.
RPC Camera Model

- Simple equations with coefficients fit to physical camera model to 0.05 pixels.
- Can improve accuracy by multi-image block adjust or with GCP.
- Can be used to orthorectify imagery.

Accuracy without GCP: 15m CE90 (Absolute Accuracy)

Accuracy with GCP: 2m CE90 (Relative Accuracy)
IKONOS Applications

Image Interpretation
- High Resolution Panchromatic (Black & White) Images
- Multispectral Radiometry or Pan-Sharpened Color
- Rapid collection & processing of large areas

Cartographic Extraction
- 2D Vectors from ortho images
- 3D Vectors from stereo images
- Different accuracy grades to suit application requirements

Photogrammetry
- RPC Camera Model implemented in COTS software packages
- Monoscopic and Stereoscopic Images available.