

Handling Of High Resolution Space Images In ImageStation

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Presentation Outline



Introduction

- Rigorous / Approximate Sensor Models
 - Rational Functions (RFs)
 - Advantages / Disadvantages of RFs
- Multi-sensor Triangulation Workflow
- Numerical Results
- Summary



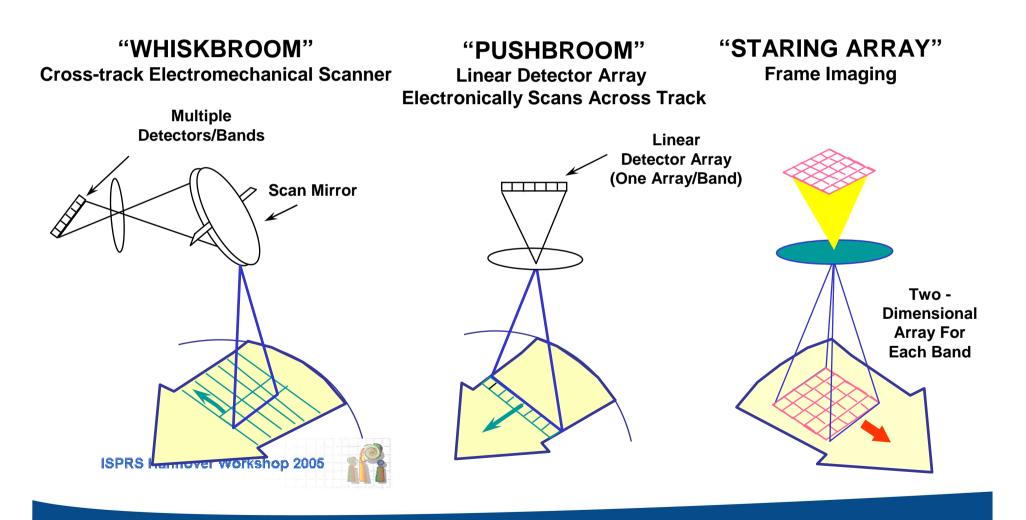
Satellite Orbital Characteristics



- Circular earth orbit
 - Sun-Synchronous
 - Asynchronous
- Altitudes of 200-680 km
- Average orbit revolution time ~ 90 minutes
- Revolutions are numbered with an average of 16 passes per day



Satellite Image Acquisition Principles



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Satellite Imagery - Advantages/Limitations

INTERGRAPH

Advantages:

- Global Access
- Wide area
- Frequent access
- Non-intrusive
- Digital downlink
- Worldwide archive (back to 1973)

Limitations:

- Atmospheric Conditions (clouds, haze, etc.)
- **Distribution networks**
- **Timeliness and Price**
- Data/Image Quality and Standards
- Education and Training
- **Government Regulations**
- International Copy Right Security and Criminal Use

Satellite Sensor Models



- Interpolative Models Collinearity Equations
- Projective Models Polynomials (1st, 2nd, 3rd order)
 - Depending upon the values of *i*, *j*, *k*, p_2 , and p_4)

$$x = \frac{p_1(X, Y, Z)}{p_2(X, Y, Z)} = \frac{\sum_{i=0}^m \sum_{j=0}^m \sum_{k=0}^m a_{ijk} X^i Y^j Z^k}{\sum_{i=0}^n \sum_{j=0}^n \sum_{k=0}^n \sum_{k=0}^n b_{ijk} X^i Y^j Z^k}$$
$$y = \frac{p_3(X, Y, Z)}{p_4(X, Y, Z)} = \frac{\sum_{i=0}^m \sum_{j=0}^m \sum_{k=0}^m c_{ijk} X^i Y^j Z^k}{\sum_{i=0}^n \sum_{j=0}^n \sum_{k=0}^n d_{ijk} X^i Y^j Z^k}$$

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Rigorous Sensor Models



Advantages:

- Time-dependant collinearity equations
- Rigorous orbital constraints (ephemeris data)
- "Exterior Orientation" on an orbital basis
- Platform and sensor distortion
- Earth, datum/map projection distortion

Disadvantages:

- Sensor physical parameters not often known
- Vendors may not publish sensor model
- Sensor model is complex requiring specialized software
- Real-time loop math must be changed for each sensor
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RFs – Advantages / Disadvantages



Advantages:

- Sensor independent
- Sufficient speed for real-time loop
- Support any map projection system
- Easy inclusion of external sensors

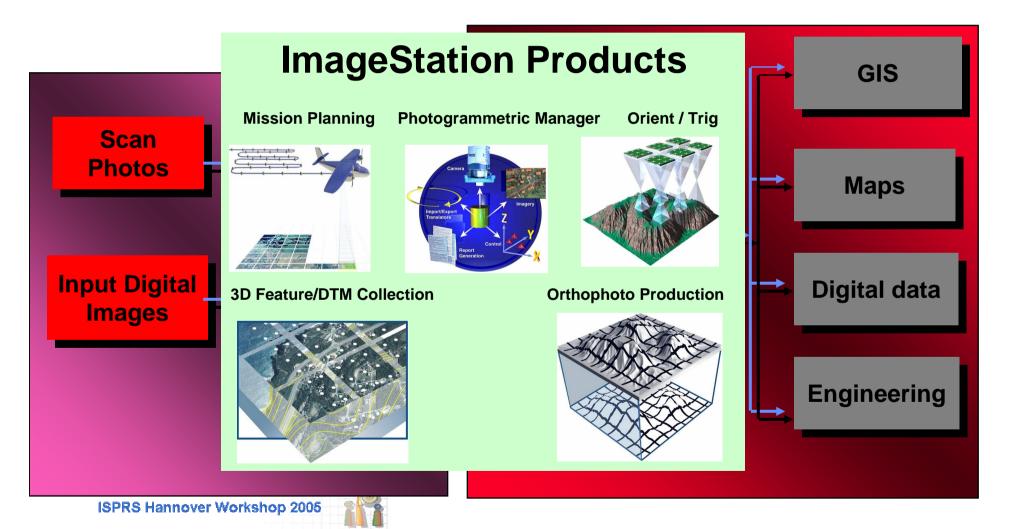
Disadvantages:

- Cannot model local distortions
- Coefficients do not have physical meaning
- Accuracy decreases when image gets larger
- Over parameterization

ISP Zero crossing

Digital Photogrammetry Workflow



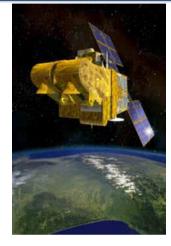


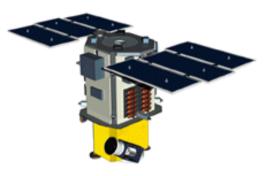
Implemented Satellite Sensors





IKONOS





QuickBird

SPOT







Landsat

Image Type and Format



Sensor	Image Support Data	Processing Level	Image Type
Landsat	FAST, FASTL7a, HDF	1G - Space Oblique Mercator	4 and 5 TM (30 m) 7 ETM (15 & 30m)
IRS	SuperStructure (LGSOWG)	1A	Pan sub-scene 1-9 Pan strip L, M, R
SPOT	CAP, DIMAP	1A	SPOT 1-3 (10-20 m) SPOT 4 (10-20 m) SPOT 5 (10, 5, 2.5 m)
QuickBird	ISD	1B (30m DTM)	Pan (0.61 m) Multi (2.44 m)



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Satellite Triangulation Workflow

- Create Satellite Project
- Import or Key in Control Point (WGS84)
- Read Ephemeris Data for Each Imagery
- Define Rational Function Bitmaps
- Measure Control/Check/Pass Points
- Perform Satellite Triangulation
- Generate Image/Object Grids
- Fit RFs to These Grids
- Use RFs for 3D Collection and Orthophoto Generation

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Coordinate System & Map Registration INTERGRAPH

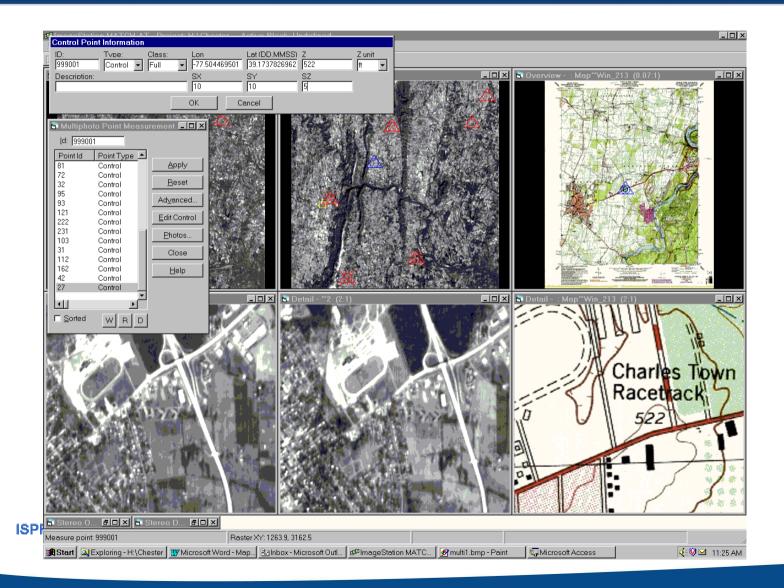
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Map Registration

Map/Image Registration





Generate Image/Object Grids & RFs

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After a Successful Bundle Adjustment:

- Create Image Grid for Each Imagery
- Project Image Coords. onto Several Elevation Planes
- Fit RFs to These Grids by Least Squares
- Analyze Results/Coefficients

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Use RF Coeffs. as Real-Time Math Model

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Data and Numeric Results



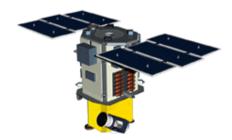
IKONOS (San Diego, US)

- Two Stereo Pair (Geo Product)
- 6 Control points
- SPOT5 (Avignon, France)
 - 4 Level 1A Images (5m, 2.5m)
 - 22 Control Points
- QuickBird (Denver, US)
 - 11 Basic Images
 - 70 Control points
 - USGS 10m DEM



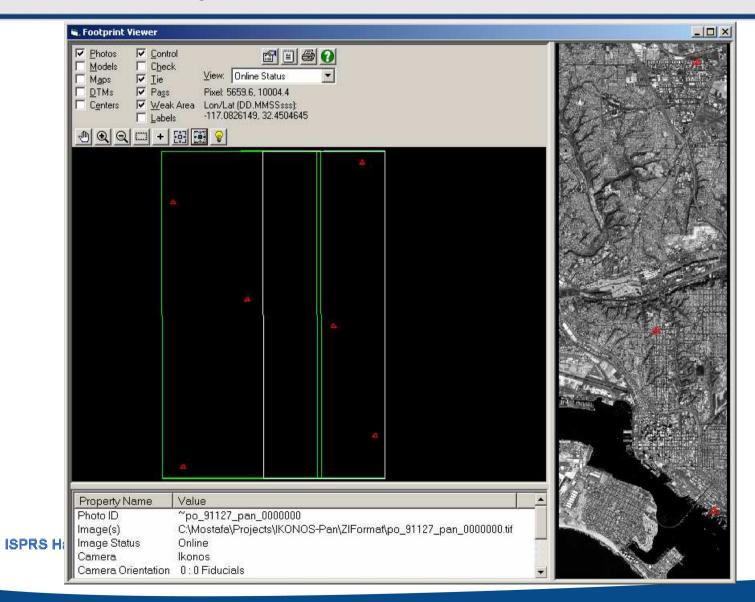






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IKONOS Adjustment





IKONOS – RFC Adjustment

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IKONOS Triangulation



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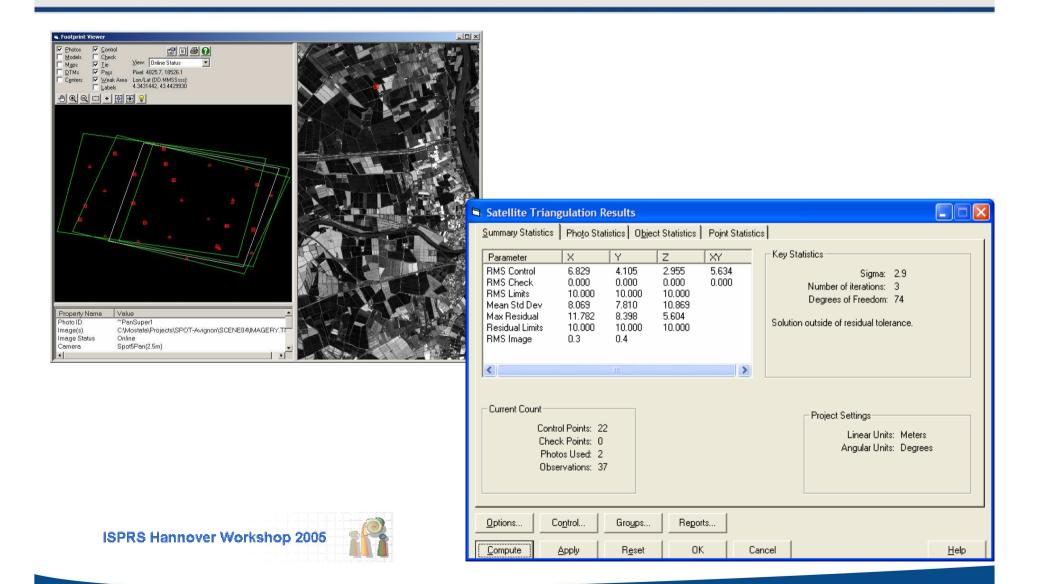
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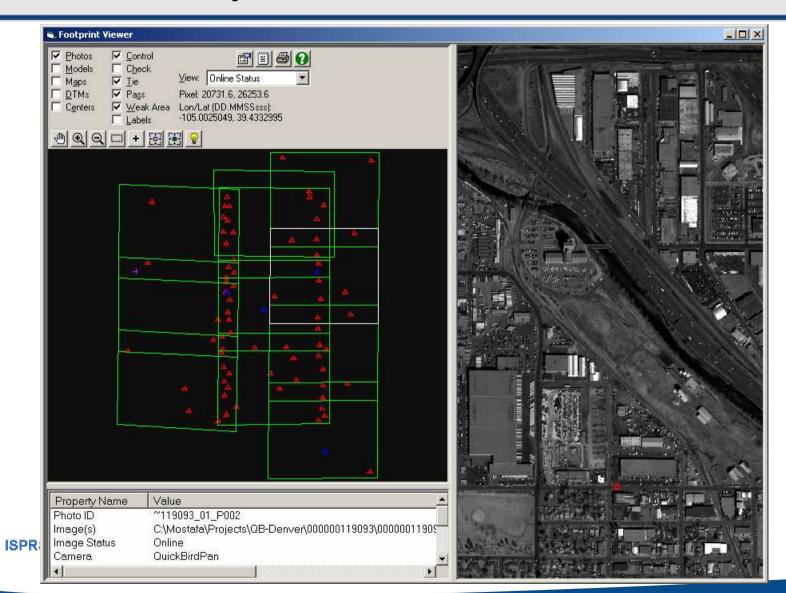
SPOT Triangulation





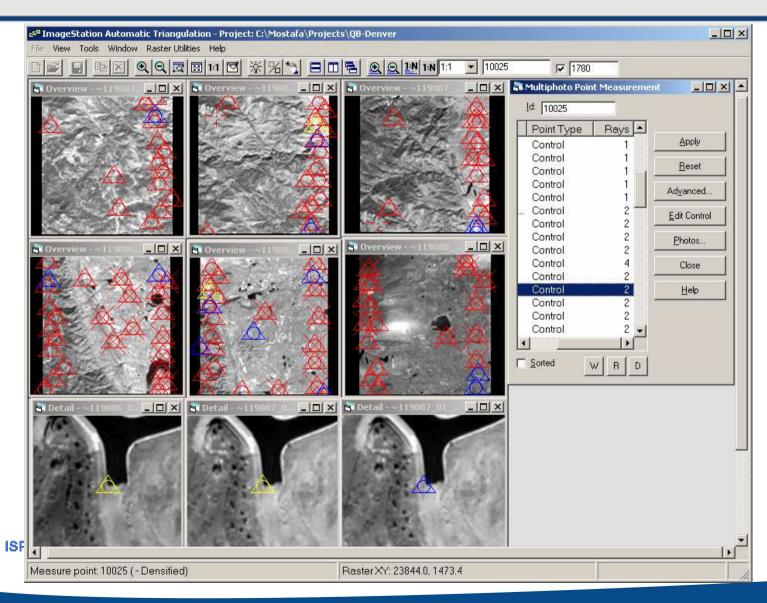
QuickBird Project





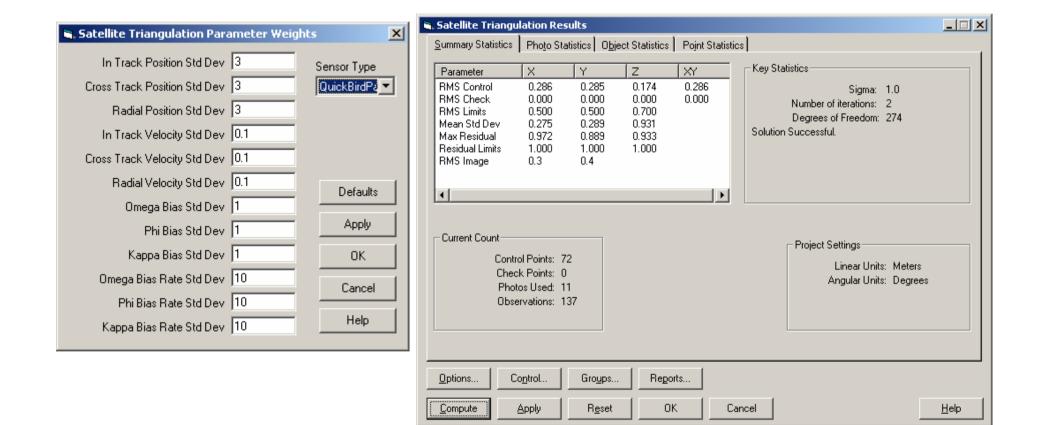
QuickBird - Measurements







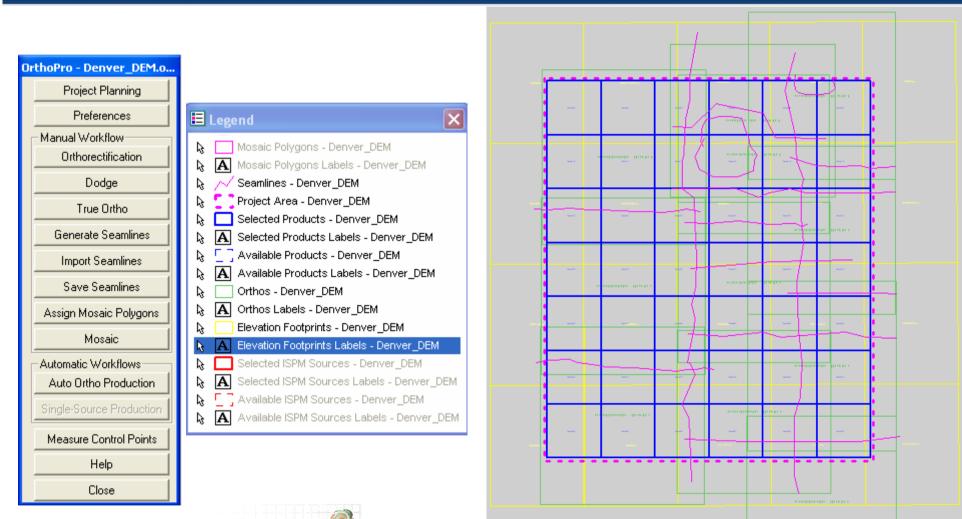
QuickBird Triangulation





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QuickBird Project Footprint



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QuickBird – Source Data



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QuickBird Orthos

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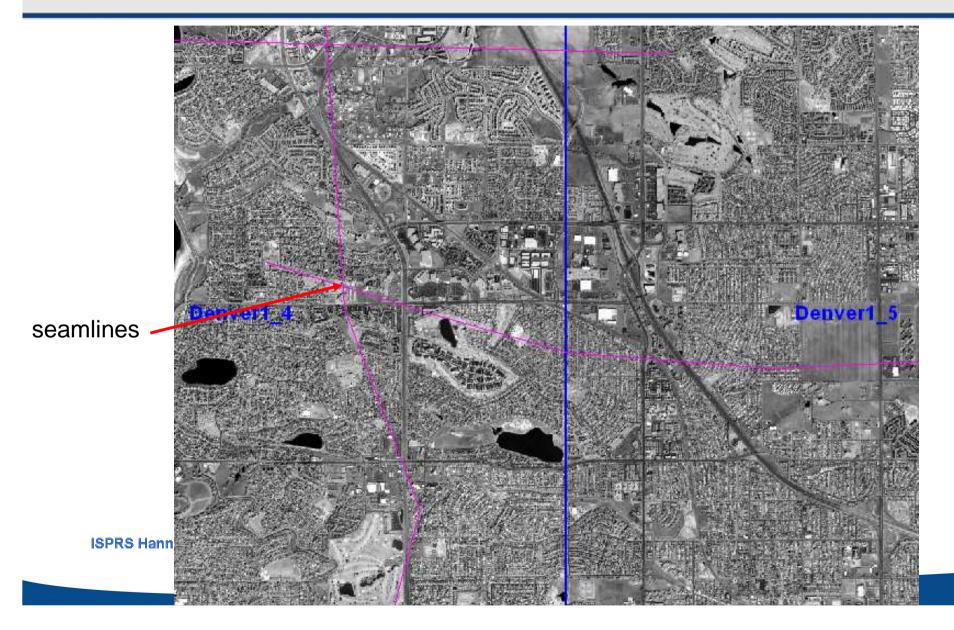


Click to zoom or press and drag.

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QuickBird Mosaic (1)





QuickBird Mosaic (2)



Summary



- ImageStation Satellite Triangulation is very flexible
 - Math model is implemented in a Microsoft Common Object Model (COM)-based code module
 - Allows support for new satellite remote sensor with relative ease
 - Accommodates variations in the number and scope of adjustable parameters
 - Unified, weighted, simultaneous least squares adjustment
 - IKONOS math model is based on rational polynomial functions modified by an affine transformation
- Mapping with high resolution space images is becoming a reality
- For several applications there is a direct competition between aerial and space images, and the choice of which product to use is purely economical

Thank you for your attention.



