Know the Earth…Show the Way

Geopositional Accuracy Evaluations of QuickBird and OrbView-3

Civil and Commercial Applications Project (CCAP)

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High Spatial Resolution Commercial Imagery Workshop
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Outline

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- General Approach
- Accuracy Statistics
- Methodology
- Geopositional Test Sites
- Products Tested
- Results
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  - ORBIMAGE OrbView-3
- Summary

Objective

For each product type…

To determine whether a sample of panchromatic commercial imagery products met the vendor-stated absolute geopositional accuracy specifications

General Approach

- Evaluate absolute geopositional accuracy by comparing test imagery-derived ground coordinates to Ground Control Points

- SOCET Set photogrammetric software used to…
  - Measure photo-identifiable check points
  - Compute ground coordinates from test imagery support data
  - Difference computed and truth coordinates

- Evaluation in partnership with NGA's…
  - Precision Engagement Staff (PRT)
  - Front-end Processing Environment (FPE)

Accuracy Statistics

- Statistics
  - Circular Error 90% (CE90)
    - In horizontal plane
    - Radial error distance within which 90% of data points fall
  - Linear Error 90% (LE90)
    - In vertical dimension
    - Absolute value error distance within which 90% of data points fall
- Computations based upon whitepaper…
  - "An Analysis of Metric Accuracy: Definitions and Methods of Computation", 29 March 2004, by Thomas P. Ager, NGA/IXS
  - CE90 and LE90 computed by sorting deltas between measured and truth coordinates and cutting off at 90%

Methodology

1) National Imagery Transmission Format (NITF) 2.0 images imported into SOCET Set
   - Rational Polynomial Coefficient (RPC) / Rational Function Coefficient (RFC) support data automatically extracted by SOCET Set
2) Images minified to support zooming
3) Test imagery-derived ground coordinates photogrammetrically computed using pixel measurements and image support data
4) Check point deltas computed by subtracting truth ground coordinates from test imagery-derived ground coordinates
5) Deltas sorted in ascending order and cutoff at 90% to compute CE90 / LE90 statistics
6) Additional statistics computed:
   - Number of checkpoints
   - Min/max deltas
   - Mean
   - Standard deviation
   - Percentage of check points within specification

Methodology
Stereo Pair Testing

For both vendors, stereo pair products are not processed to be relatively-oriented

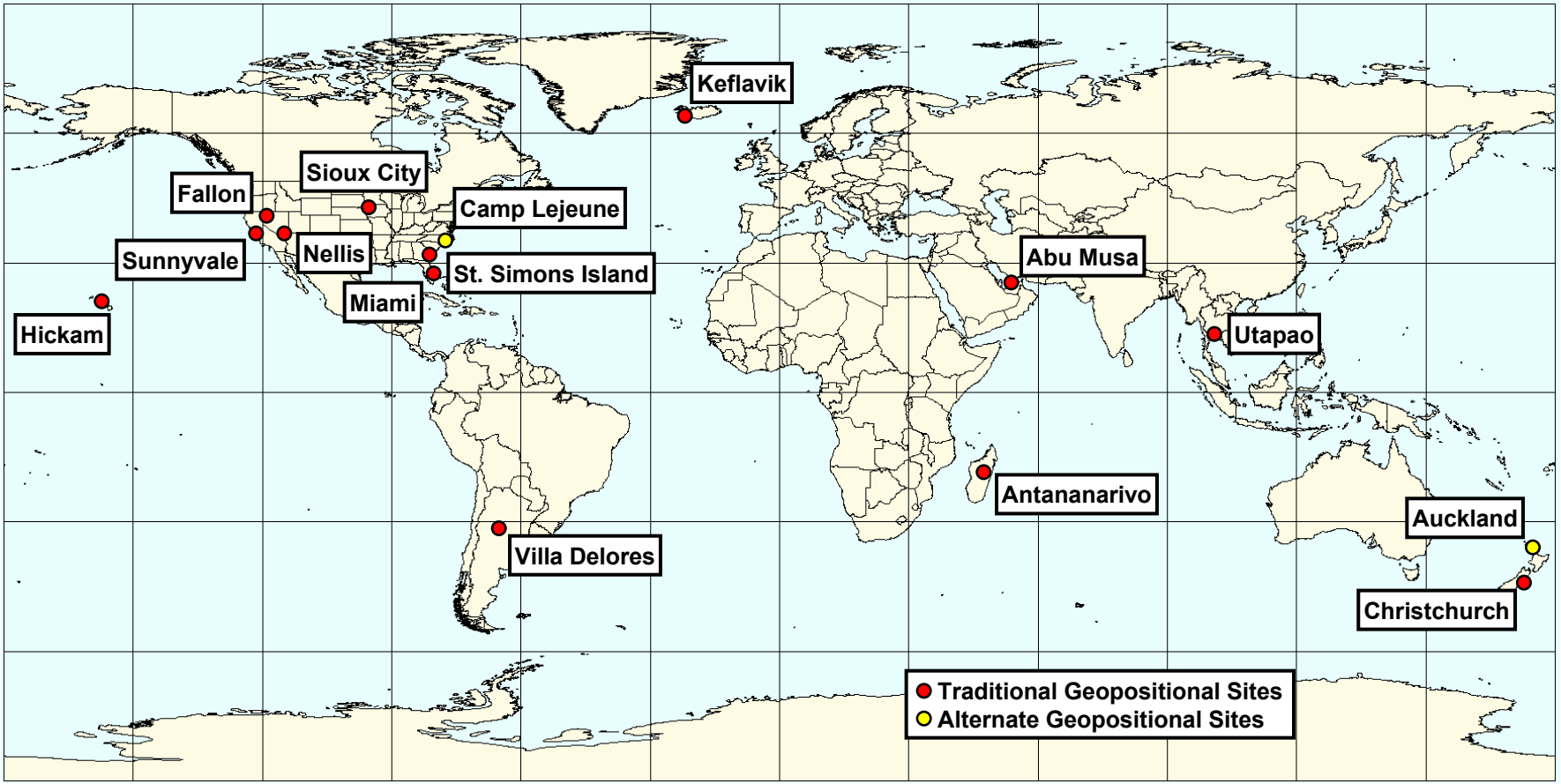
QuickBird

- Considerations
  - CCAP felt that users would not use product “as is”
  - Rigorous sensor model was available
  - No LE90 specification
- Testing Objective
  - To demonstrate that stereo pairs could be triangulated
    - Relative orientation
    - Triangulation with GCPs
  - Rigorous sensor model used

OrbView-3

- After discussion between CCAP and ORBIMAGE, agreement to test product “as is”
- Testing Objective
  - To test the product “as is” against stated CE90 / LE90 specification

Geopositional Test Sites



Products Tested

- DigitalGlobe QuickBird
  - Ortho Ready Standard 2A
  - 1:25,000 Orthorectified
  - 1:10,000 Orthorectified
  - Basic Stereo Pair

- ORBIMAGE OrbView-3
  - BASIC Enhanced Mono
  - BASIC Enhanced Stereo Pair
  - BASIC 1:50k Mono

DigitalGlobe QuickBird Results

DigitalGlobe QuickBird Test Matrix

Test Site	Basic 1B	Ortho-Ready Standard 2A	Orthorectified Products			Basic Stereo Pair
			1:25k	1:10k	Custom	
	23 m CE90*	23 m CE90*	12.7 m CE90	8.5 m CE90	Variable**	23 m CE90*
Abu Musa TC	•	•			•	
Antananarivo MA	•	•			•	•
Camp Lejeune NC	•					
Christchurch NZ	•	•			•	•
Fallon NV	•	•	•	•		•
Hickam HI	•					•
Keflavik IC		•				•
Miami FL	•	•	•	•		
Nellis NV	•	•	•	•		•
Sioux City IA	•	•	•	•		•
St. Simons Island GA	•	•				•
Sunnyvale CA	•	•		•		•
Utapao TH	•	•				
Villa Delores AR	•				•	•

* At nadir using truth elevation data
** Affected by the accuracy and quality of customer supplied ground control points and elevation matrix data

DigitalGlobe QuickBird Basic 1B Product
Results Reported at JACIE 2003

	Average Error (m)					Standard Deviation (m)		
	Latitude	Longitude	Horizontal	CE90	N	Latitude	Longitude	Horizontal
Abu Musa	1.97	8.39	8.63	9	25	0.41	0.69	0.65
Antananarivo	1.50	0.32	1.83	3	25	0.97	0.96	0.90
Camp Lejeune	2.81	-13.72	14.08	17	25	1.18	2.95	2.81
Christchurch	7.70	0.83	9.06	10	25	1.10	4.77	0.96
Fallon	0.37	11.82	11.83	13	25	0.53	1.03	1.03
Hickam	-2.76	-2.51	3.79	5	25	0.65	1.09	1.06
Miami	-4.09	-22.93	23.31	25	25	0.65	2.23	2.13
Nellis	-6.00	-3.74	7.10	9	25	1.27	1.24	1.63
Sioux City	-5.85	10.12	11.80	15	25	0.60	2.76	2.30
St. Simons	0.42	-13.30	13.34	17	25	0.92	4.10	4.11
Sunnyvale	9.26	-1.03	9.40	10	25	0.47	1.30	0.47
Utapao	4.53	-4.85	6.73	8	25	1.15	1.66	1.68
Villa Dolore	6.83	1.59	7.10	9	25	2.28	1.13	2.28
Average	**1.28**	**-2.23**	**9.85**	**11.54**		**0.94**	**1.99**	**1.69**

- 12 of 13 image products (92.3%) had CE90 values less than specification
- 311 of 325 check point horizontal deltas (95.7%) less than 23 meters
- Taking all check points together, overall CE90 assessed to be 17.4 meters

- QuickBird met its guaranteed accuracy using Attitude Determination Processor (ADP 2.1) processed data

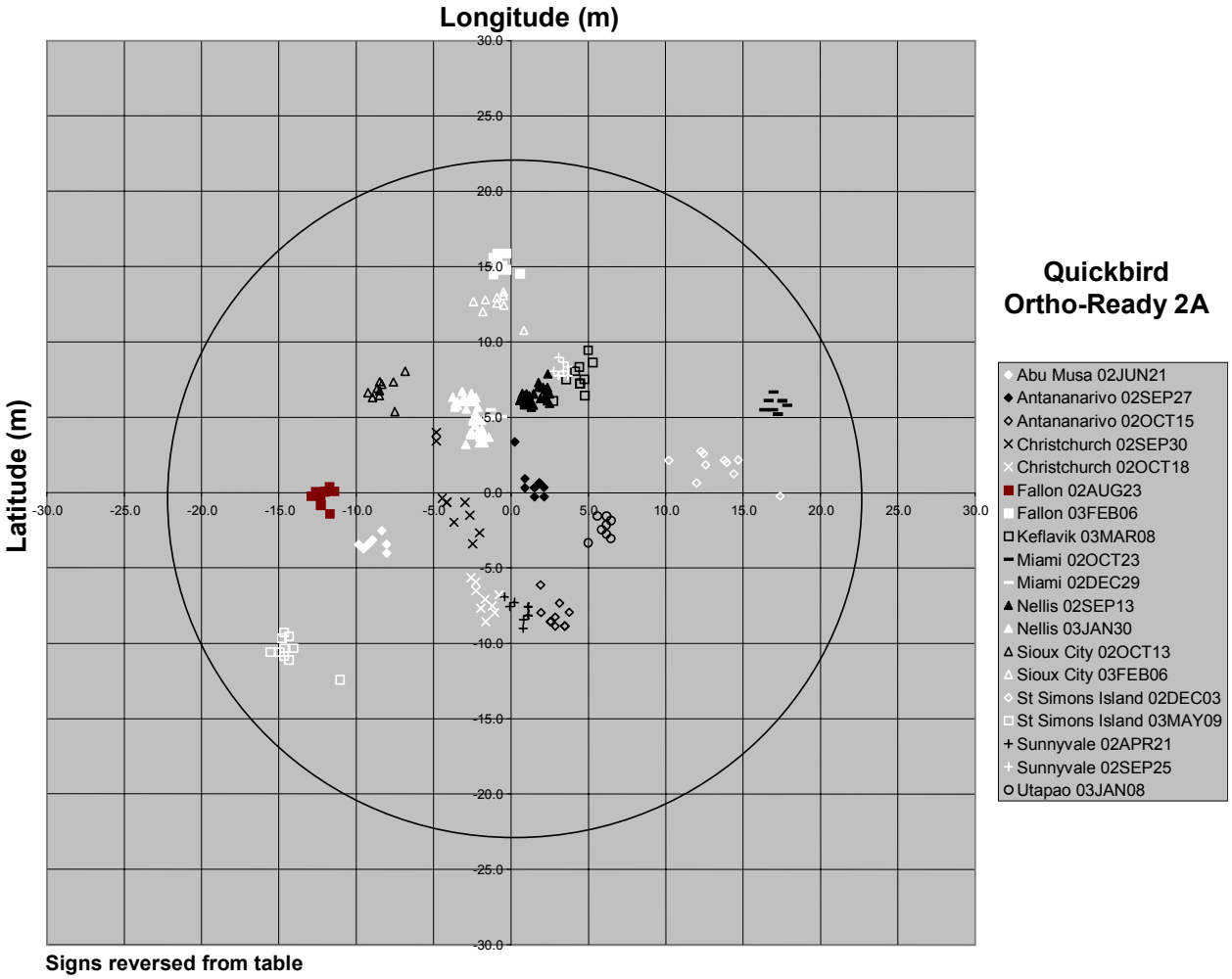
DigitalGlobe QuickBird

Ortho Ready Standard 2A Product Results

Test Site	Product Order Item Number	Collection Date	Processing Date	DPs	Absolute CE90 (m) 90% Cutoff	Mean Δ Long. (X) (m)	Mean Δ Lat. (Y) (m)	% Within 23 m (Hor.)
Abu Musa	52723	21-Jun-2002	28-May-2003	9	10.26	8.90	3.37	100
Antananarivo	52972	27-Sep-2002	28-May-2003	10	2.17	-1.46	-0.63	100
	52726	15-Oct-2002	28-May-2003	10	9.53	-2.86	8.14	100
Christchurch	52959	30-Sep-2002	28-May-2003	10	5.90	3.61	0.44	100
	52974	18-Oct-2002	28-May-2003	9	8.10	1.71	7.08	100
Fallon	52850	23-Aug-2002	28-May-2003	9	12.63	12.11	0.22	100
	52975	06-Feb-2003	28-May-2003	10	15.88	0.63	-15.16	100
Keflavik	52738	08-Mar-2003	28-May-2003	10	10.13	-4.36	-7.66	100
Miami	52981	23-Oct-2002	28-May-2003	9	18.59	-17.15	-5.81	100
	52852	29-Dec-2002	28-May-2003	10	5.40	1.67	-4.93	100
Nellis	52984	13-Sep-2002	28-May-2003	41	7.22	-1.36	-6.33	100
	52851	30-Jan-2003	28-May-2003	36	6.97	2.63	-5.15	100
Sioux City	52986	13-Oct-2002	28-May-2003	10	11.22	8.26	-6.84	100
	52853	06-Feb-2003	28-May-2003	9	13.11	0.91	-12.51	100
St. Simons Island	52990	03-Dec-2002	28-May-2003	10	14.86	-13.38	-1.73	100
	52854	09-May-2003	28-May-2003	10	18.32	14.31	10.46	100
Sunnyvale	52993	21-Apr-2002	28-May-2003	9	8.53	-0.65	7.85	100
	52855	25-Sep-2002	28-May-2003	9	9.32	-3.31	-8.13	100
Utapao	52997	08-Jan-2003	28-May-2003	8	6.81	-5.96	2.33	100
ALL Points				**238**	**15.35**	**0.33**	**-2.84**	**100**

- All 19 image products had CE90 values less than specification
- 100% of check point horizontal deltas less than 23 meters
- Taking all check points together, overall CE90 assessed to be 15.4 meters

DigitalGlobe QuickBird
Ortho Ready Standard 2A Product Scatter Plot



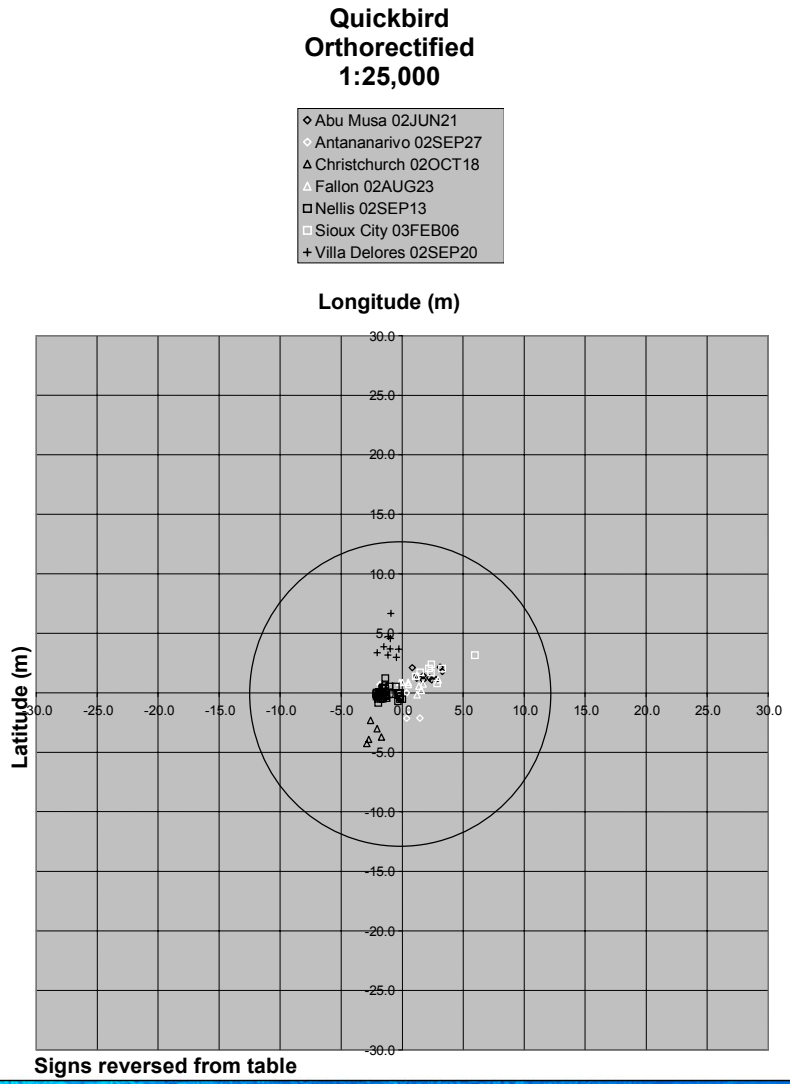
Signs reversed from table

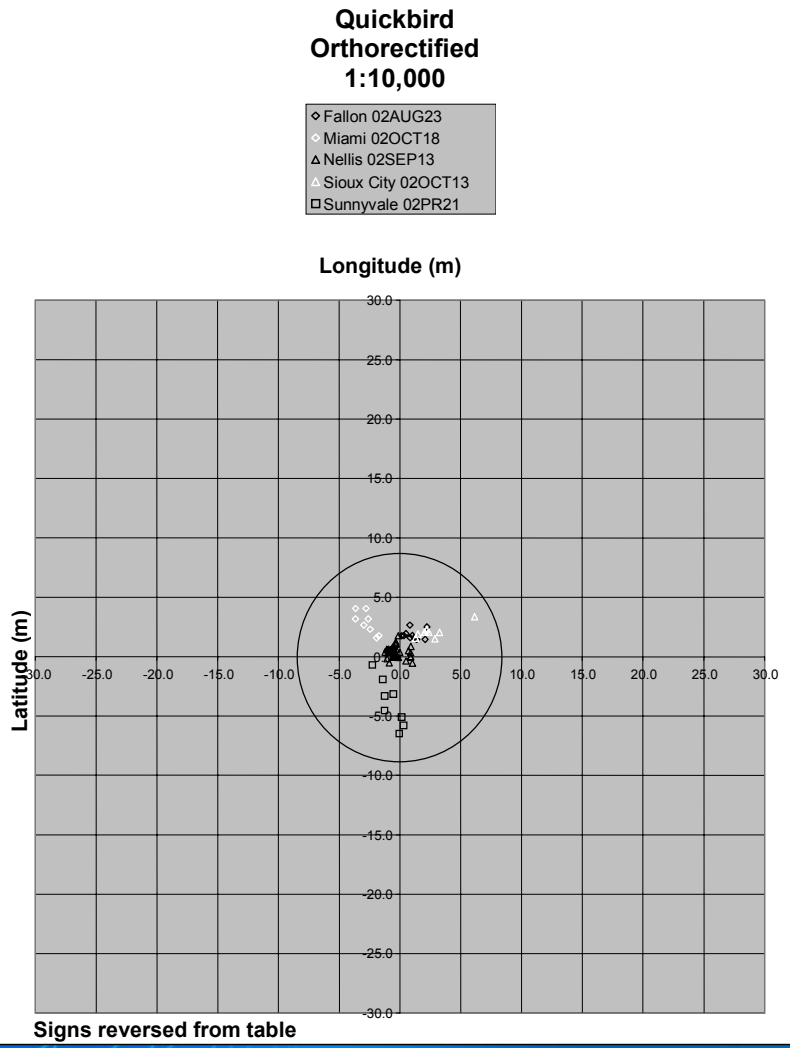
DigitalGlobe QuickBird
Orthorectified Product Results

Test Site	Scale	Product Order Item Number	Collection Date	Processing Date	DPs	Absolute CE90 (m) 90% Cutoff	Mean Δ Long. (X) (m)	Mean Δ Lat. (Y) (m)	% Within Hor. Spec. (m)
Abu Musa	1:25k Custom	70041	21-Jun-2002	30-Jul-2003	10	3.76	-2.06	-1.47	100
Antananarivo	1:25k Custom	69764	27-Sep-2002	28-Jul-2003	7	2.31	0.09	0.67	100
Christchurch	1:25k Custom	69766	18-Oct-2002	30-Jul-2003	5	4.96	2.39	3.44	100
Fallon	1:25k	30270	23-Aug-2002	31-Oct-2002	10	1.87	-1.09	-0.72	100
	1:10k	25334	23-Aug-2002	22-Oct-2002	10	2.77	-1.05	-1.84	100
Miami	1:25k	30604	23-Oct-2002	20-Nov-2002	7	6.70	-5.66	-0.64	100
	1:10k	32677	18-Oct-2002	27-Nov-2002	8	5.01	2.72	-2.84	100
Nellis	1:25k	27815	13-Sep-2002	25-Oct-2002	37	2.04	1.39	0.07	100
	1:10k	27818	13-Sep-2002	24-Oct-2002	37	1.24	0.33	-0.40	100
Sioux City	1:25k	29658	13-Oct-2002	15-Nov-2002	8	4.42	-2.70	-1.91	100
	1:10k	29663	13-Oct-2002	15-Nov-2002	8	4.47	-2.71	-2.09	100
Sunnyvale	1:10k	25333	21-Apr-2002	26-Sep-2002	8	5.92	0.81	3.86	100
Villa Delores	1:25k Custom	69981	20-Sep-2002	30-Jul-2003	9	5.07	1.05	-4.08	100
ALL Points	**1:25k**				**93**	**4.85**	**-0.46**	**-0.76**	**100**
	1:10k				**71**	**4.65**	**0.12**	**-0.59**	**100**

- All 13 ortho products had CE90 values less than respective specifications
- 100% of check point horizontal deltas less than respective specifications
- Taking all check points together, overall CE90 assessed to be…
  - 4.9 meters for 1:25,000 orthos
  - 4.7 meters for 1:10,000 orthos

DigitalGlobe QuickBird
Orthorectified Product Scatter Plots





DigitalGlobe QuickBird
Basic Stereo Pair Product Results

Test Site	Product Order Item Number	Collection Date	Processing Date	Elevation Angles (°)	TPs	GCPs	ICPs	Absolute CE90 (m) 90% Cutoff	Absolute LE90 (m) 90% Cutoff	% Within 23 m (Hor.)
Fallon	30693	06-Feb-2003	08-Feb-2003	60.67 / 57.27	211	RO	25	19.85	32.01	100.00
						1	24	18.42	24.03	100.00
						3	22	3.11	2.51	100.00
						10	15	2.28	1.57	100.00
Keflavik	30697	08-Mar-2003	09-Mar-2003	58.73 / 61.89	174	RO	25	38.87	5.18	60.00
						1	24	31.74	2.75	79.17
						3	22	4.19	1.17	100.00
						10	15	1.61	1.09	100.00
Nellis	30701	30-Jan-2003	01-Feb-2003	58.90 / 59.75	255	RO	30	13.99	14.91	100.00
						1	29	10.90	12.25	100.00
						3	27	2.03	1.02	100.00
						10	20	1.74	1.57	100.00
Sioux City	30702	06-Feb-2003	08-Feb-2003	61.95 / 57.39	220	RO	22	7.52	19.79	100.00
						1	21	7.65	18.55	100.00
						3	19	2.48	1.69	100.00
						10	12	1.31	1.03	100.00
ALL Points						**RO**	**102**	**22.80**	**20.47**	**90.20**
						1	**98**	**20.55**	**21.15**	**94.90**
						3	**90**	**3.53**	**1.68**	**100.00**
						10	**62**	**1.75**	**1.42**	**100.00**

- Basic Stereo Pairs can be adequately triangulated when using sufficient number of tie points and GCPs
- Relative orientation cases have high errors
  - Basic Stereo Pairs should be triangulated with sufficient number of GCPs

ORBIMAGE OrbView-3 Results

ORBIMAGE OrbView-3 Test Matrix

Test Site	BASIC Enhanced		BASIC 1:50k	ORTHO 1:50k	ORTHO 1:24k
	Mono	Stereo Pair	Mono	Mono	Mono
	25 m CE90*	25 m CE90 / 44 m LE90	25 m CE90*	25 m CE90	12 m CE90
Abu Musa TC	•	•	•	Future	
Antananarivo MA	•	•	•	Future	
Christchurch NZ	•	•	•	Future	
Fallon NV	•	•	•		Future
Hickam HI	•	•	•	Future	
Keflavik IC	•	•	•	Future	
Miami FL	•	•	•		Future
Nellis NV	•	•	•		Future
Sioux City IA	•	•	•		Future
St. Simons Island GA	•	•	•		Future
Sunnyvale CA	•	•	•		Future
Utapao TH	•	•	•	Future	
Villa Delores AR	•	•	•	Future	

* At truth elevation

ORBIMAGE OrbView-3

BASIC Enhanced Mono and 1:50k Results

BASIC Enhanced

Test Site	Sub-Image Identifier	Collection Date	Geometric Calibration Date	DPs	Absolute CE90 (m) 90% Cutoff	Mean Δ Long. (X) (m)	Mean Δ Lat. (Y) (m)	% Within 25 m (Hor.)
Abu Musa	131500	25-Mar-2004	8-Sep-2003	32	5.9	2.17	4.45	100
Antananarivo	187460	18-Jul-2004	8-Sep-2003	29	11.8	-7.37	-7.66	100
Christchurch	131580	16-Dec-2003	8-Sep-2003	36	9.6	4.75	6.17	100
Fallon	131620	19-Jan-2004	8-Sep-2003	29	9.5	-1.20	8.05	100
Hickam	131600	15-Dec-2003	8-Sep-2003	50	14.4	-10.54	3.54	100
Keflavik	132780	28-Apr-2004	8-Sep-2003	33	8.4	6.34	2.19	100
Miami	131640	24-Jan-2004	8-Sep-2003	41	3.9	-0.28	2.35	100
Nellis	131680	17-Dec-2003	8-Sep-2003	49	8.2	-3.20	6.68	100
Sioux City	131720	12-Mar-2004	8-Sep-2003	48	9.2	-1.39	6.33	100
St. Simons Island	131700	29-May-2004	8-Sep-2003	35	11.7	3.34	9.99	100
Sunnyvale	131760	16-Dec-2003	8-Sep-2003	30	11.7	-10.84	0.65	100
Utapao	131540	21-Dec-2003	8-Sep-2003	31	13.8	-0.90	12.43	100
Villa Delores	131520	19-Jan-2004	8-Sep-2003	30	18.9	-2.43	16.82	100
All Points				**473**	**13.5**	**-1.84**	**5.52**	**100**
Site Means				**13**	**12.1**	**-1.66**	**5.54**	**100**

BASIC 1:50k

Test Site	Sub-Image Identifier	Collection Date	Geometric Calibration Date	DPs	Absolute CE90 (m) 90% Cutoff	Mean Δ Long. (X) (m)	Mean Δ Lat. (Y) (m)	% Within 25 m (Hor.)
Abu Musa	189090	25-Mar-2004	8-Sep-2003	32	5.8	1.72	4.27	100
Antananarivo	190270	18-Jul-2004	8-Sep-2003	29	11.0	-8.28	5.75	100
Christchurch	190070	16-Dec-2003	8-Sep-2003	36	9.3	-5.67	3.53	100
Fallon	190250	19-Jan-2004	8-Sep-2003	29	9.2	0.17	7.92	100
Hickam	190090	15-Dec-2003	8-Sep-2003	53	12.9	-7.56	5.08	100
Keflavik	190230	28-Apr-2004	8-Sep-2003	33	4.5	2.56	0.45	100
Miami	190110	24-Jan-2004	8-Sep-2003	41	3.3	-1.16	0.64	100
Nellis	190210	17-Dec-2003	8-Sep-2003	49	7.1	-0.54	5.97	100
Sioux City	190130	12-Mar-2004	8-Sep-2003	48	9.0	-3.09	5.80	100
St. Simons Island	190190	29-May-2004	8-Sep-2003	38	9.7	-2.71	8.35	100
Sunnyvale	190150	16-Dec-2003	8-Sep-2003	30	8.1	-7.09	0.11	100
Utapao	190170	21-Dec-2003	8-Sep-2003	31	8.8	-0.12	7.35	100
Villa Delores	190050	19-Jan-2004	8-Sep-2003	30	17.6	-5.49	14.85	100
All Points				**479**	**11.9**	**-2.94**	**5.29**	**100**
Site Means				**13**	**9.8**	**-2.87**	**5.39**	**100**

BASIC Enhanced Mono

- All 13 image products had CE90 values less than specification
- 100% of check point horizontal deltas less than 25 meters
- Taking all test site means together, overall CE90 assessed to be 12.1 meters

BASIC 1:50k Mono

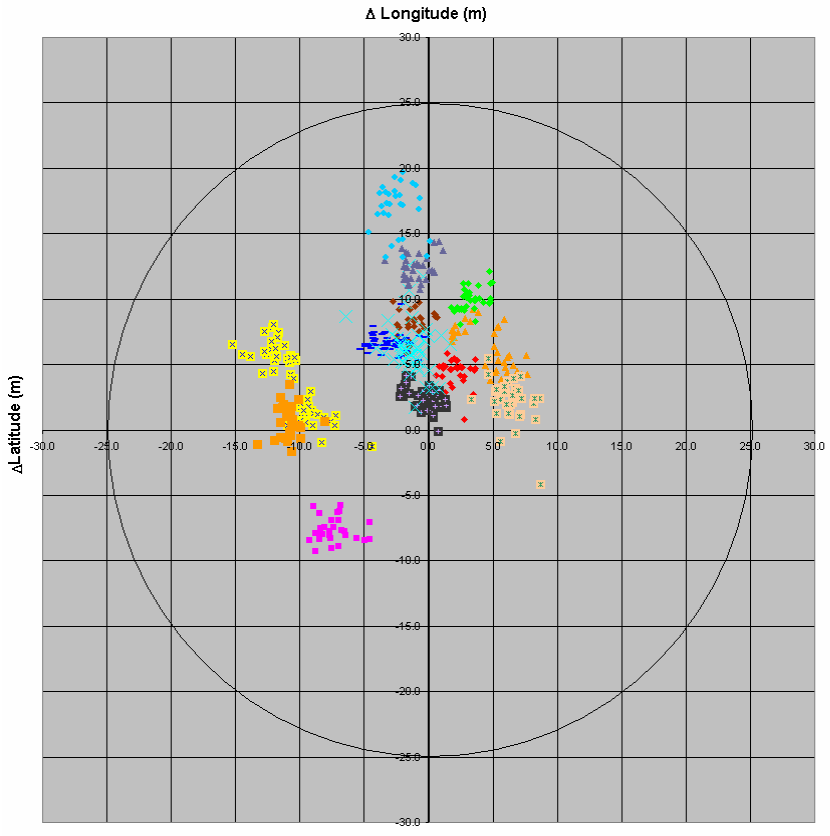
- All 13 image products had CE90 values less than specification
- 100% of check point horizontal deltas less than 25 meters
- Taking all test site means together, overall CE90 assessed to be 9.8 meters

Because of differing number of check points per site, “site means” used instead of “all points” for overall CE90

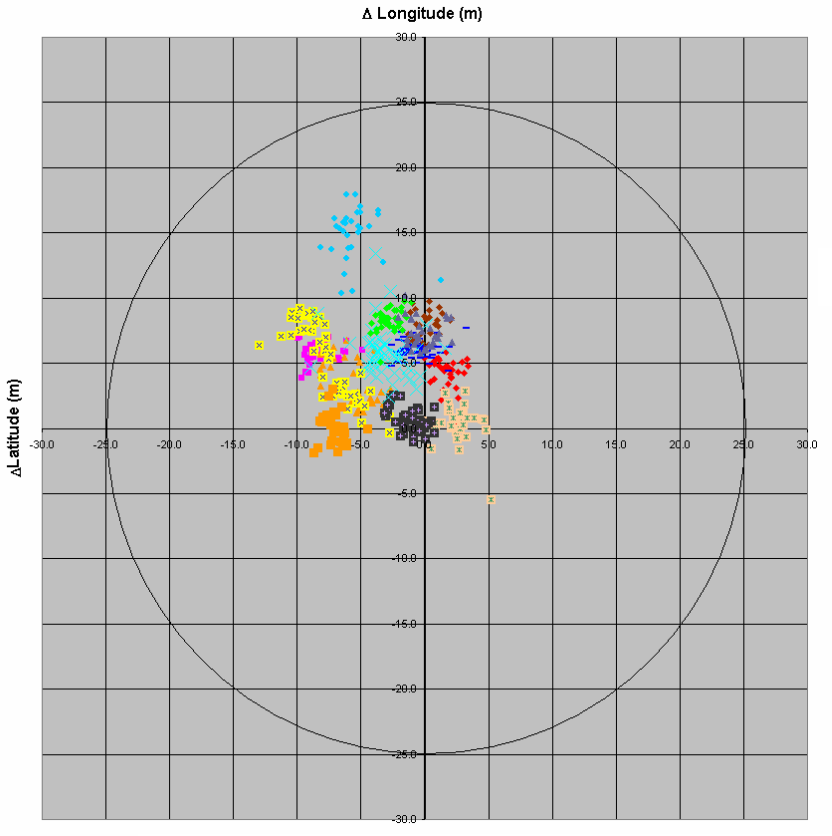
ORBIMAGE OrbView-3

BASIC Enhanced Mono and 1:50k Scatter Plots

BASIC Enhanced Mono



BASIC 1:50k Mono



OrbView-3

- Abu Musa
- Antananarivo
- Christchurch
- Fallon
- Hickam
- Keflavik
- Miami
- Nellis
- Sioux_City
- St_Simons_Island
- Sunnyvale
- Utapao
- Villa_Delores

ORBIMAGE OrbView-3

BASIC Enhanced Stereo Pair Results

Test Site	Collection Date	Sub-Image Identifiers		Elevation Angles (°)		DPs	Absolute CE90 (m)	Mean Δ Long. (X) (m)	Mean Δ Lat. (Y) (m)	% Within 25 m (Hor.)	Absolute LE90 (m)	Mean Δ Elev. (Z) (m)	% Within 44 m (Vert.)
		1st	2nd	1st	2nd		90% Cutoff				90% Cutoff		
Abu Musa	9-Feb-2004	132500	132520	71.06	74.23	33	3.3	2.37	1.49	100	7.0	-4.80	100
Antananarivo	22-Apr-2004	131330	131350	75.46	69.89	36	15.9	-6.74	12.67	100	2.3	0.59	100
Christchurch	19-Dec-2003	132740	132760	71.31	70.42	44	15.3	-13.04	0.17	100	12.5	-9.74	100
Fallon	18-Mar-2004	131290	131310	69.61	62.82	29	8.8	2.05	7.55	100	6.9	-5.41	100
Hickam	23-May-2004	131810	132210	70.89	67.32	70	7.6	-4.38	4.77	100	2.3	1.00	100
Keflavik	19-Apr-2004	131370	131390	69.42	65.72	33	6.9	-4.11	-1.45	100	9.7	6.93	100
Miami	30-Dec-2003	131970	131990	75.59	69.64	34	2.0	-0.20	-1.20	100	12.7	-11.60	100
Nellis	27-Mar-2004	132230	132250	73.96	69.05	49	5.9	1.85	4.46	100	3.8	-1.58	100
Sioux City	27-May-2004	132440	131950	70.12	67.97	48	11.4	-6.75	5.39	100	20.7	-12.73	100
St. Simons Island	12-Jun-2004	132540	132560	74.69	70.70	44	8.5	-5.15	5.55	100	7.9	-5.82	100
Sunnyvale	5-Jan-2004	131850	131870	67.90	69.03	28	3.3	-1.24	-2.08	100	8.0	-6.30	100
Utapao	17-Mar-2004	131890	131910	74.07	70.30	31	5.3	0.91	3.31	100	7.3	-3.49	100
Villa Delores	26-Mar-2004	132460	132480	66.75	64.18	30	16.5	-12.30	9.47	100	4.0	-1.42	100
All Points						**509**	**14.8**	**-3.86**	**3.98**	**100**	**11.3**	**-4.11**	**100**
Site Means						**13**	**14.0**	**-3.59**	**3.85**	**100**	**11.0**	**-4.18**	**100**

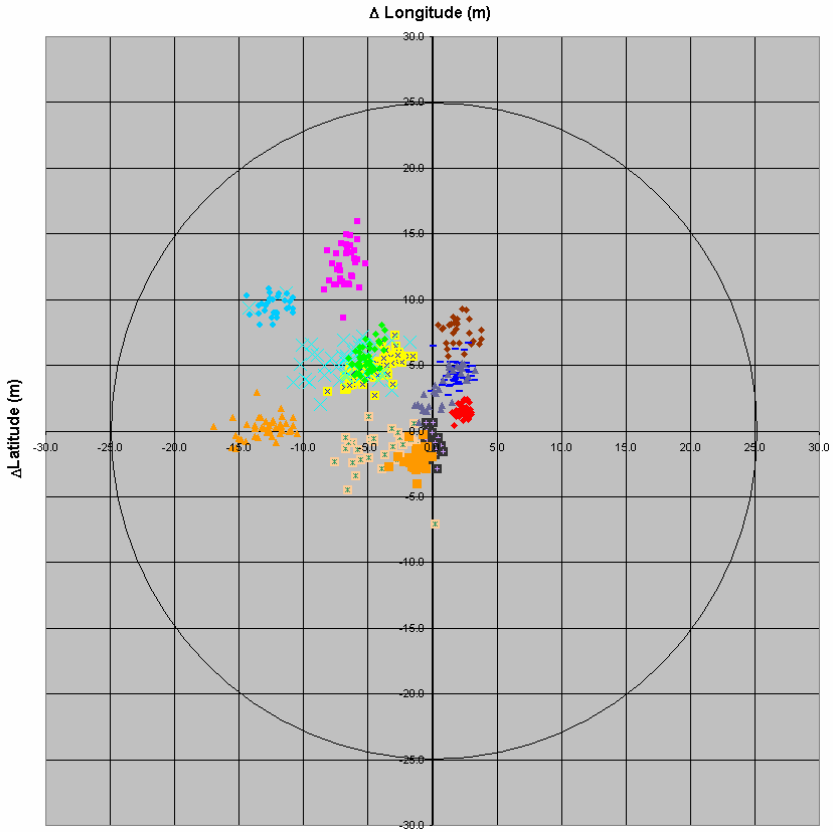
- All 13 image products had CE90 / LE90 values less than specification
- 100% of check point deltas less than 25 m horizontally and 44 m vertically
- Taking all test site means together, overall CE90 assessed to be 14.0 meters and overall LE90 assessed to be 11.0 meters

Because of differing number of check points per site, “test site means” were used instead of “all points” for overall CE90 / LE90

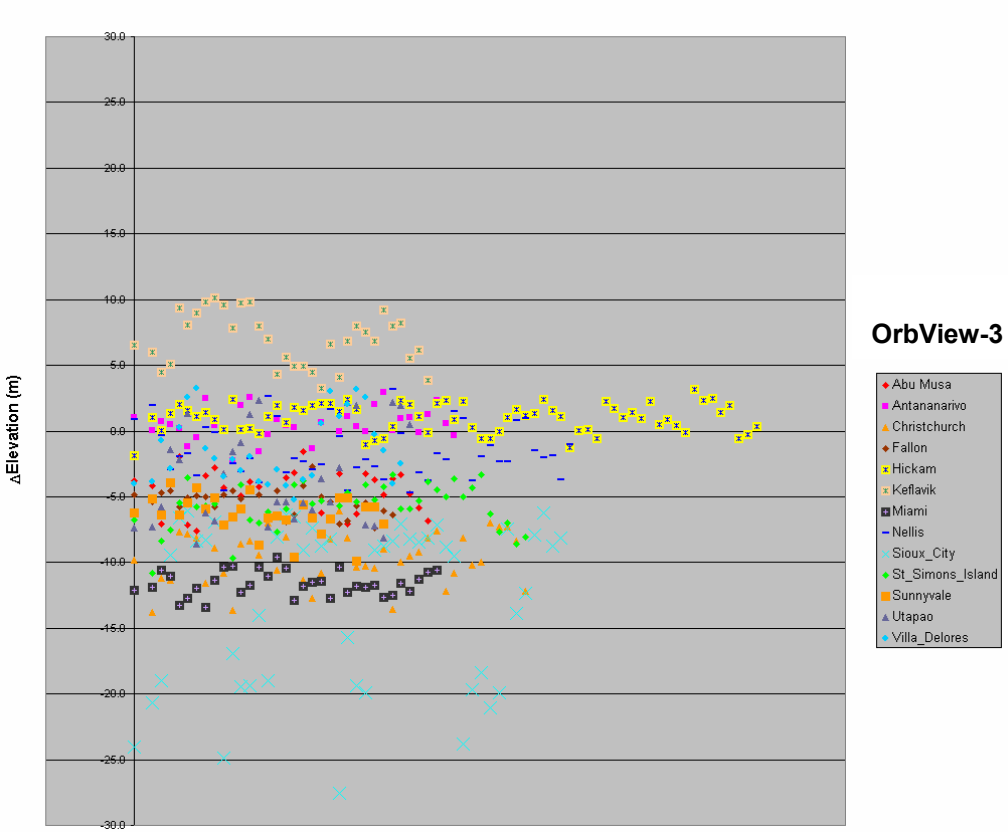
ORBIMAGE OrbView-3

BASIC Enhanced Stereo Pair Scatter Plots

Horizontal



Vertical



x-axis is check point number

Summary

- DigitalGlobe QuickBird
  - Ortho Ready Standard 2A, 1:25k Orthorectified, and 1:10k Orthorectified panchromatic products met vendor-stated absolute accuracy specifications
  - Basic Stereo Pair product can be adequately triangulated, but some GCPs should be used instead of relative orientation only
- ORBIMAGE OrbView-3
  - BASIC Enhanced mono, BASIC Enhanced stereo pair, and BASIC 1:50k mono panchromatic products met vendor-stated absolute accuracy specifications
  - ORTHO 1:50k and ORTHO 1:24k products will be evaluated soon

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