Geometric Accuracy Assessment of IKONOS Data Sets

By

EROS Data Center and

South Dakota State University

U.S. Department of the Interior
U.S. Geological Survey
E.R.O.S Data Center

Data Dates and Sites

- May 1, 2000 Brookings, SD
- June 30, 2000 Brookings, SD
- June 30, 2000 EROS Data Center, SD
- July 30, 2000 EROS Data Center, SD

Process Used

Federal Geographic Data Committee
STD-007.3-1998

Appendix 3-C Testing Guidelines

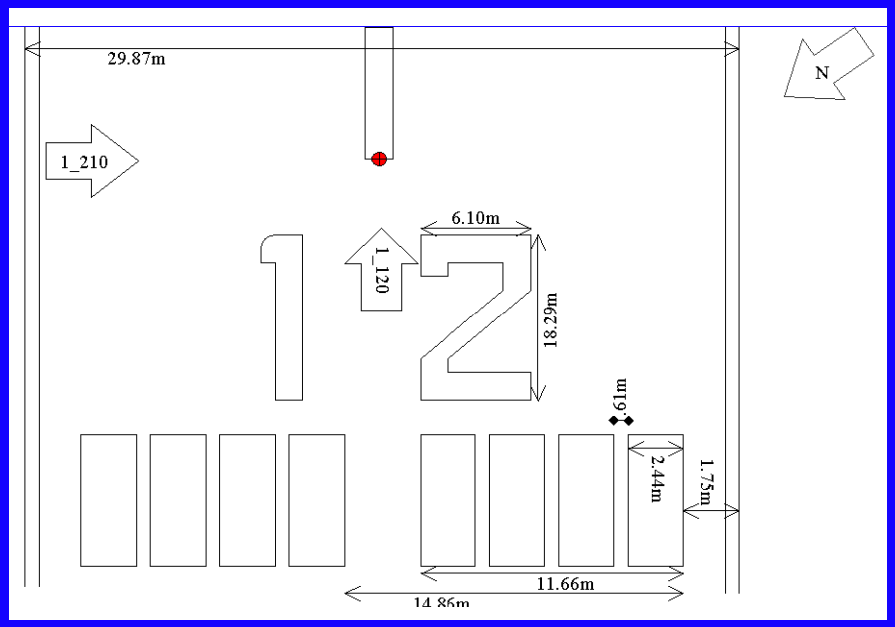
- Well Defined Points
- Data Acquisition for the independent source of higher accuracy
- Check point location

Data Specifications

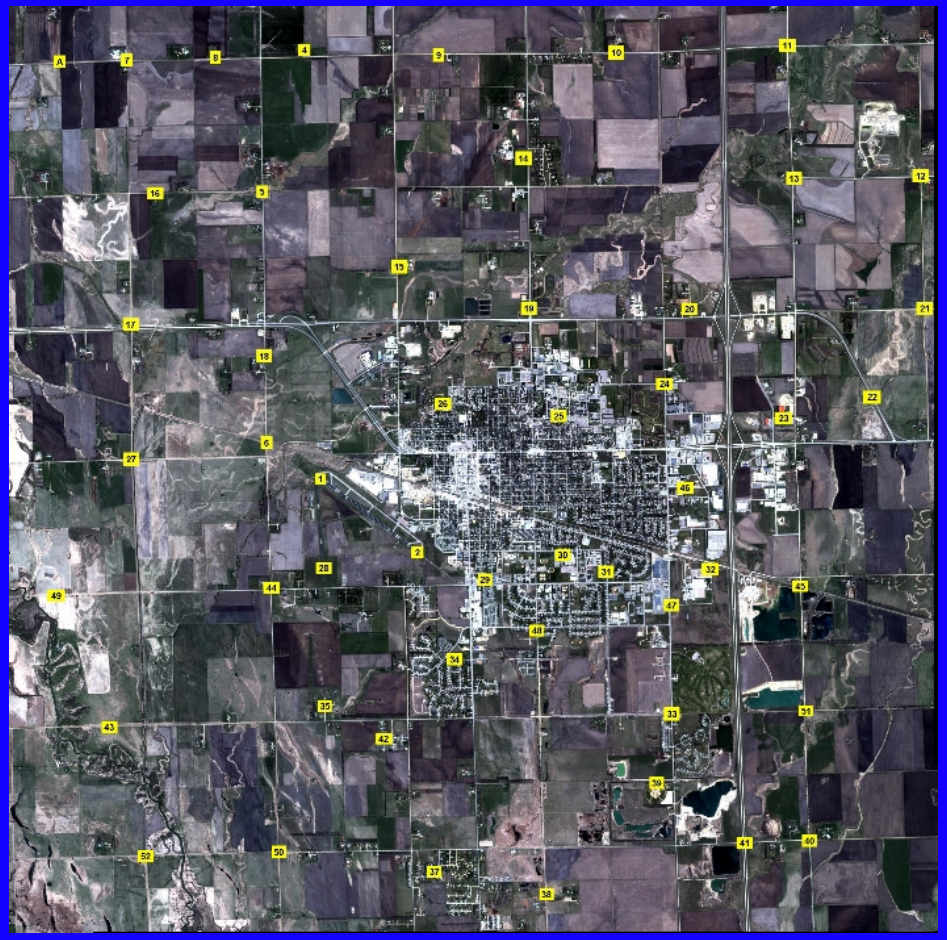
Specifications	NASA Original Panchormatic	NASA Original Multispectral
Absolute Horizontal Geometric Correction Accuracy (CE90)	Std 250 meters Precision 3 meters 90% circular error (Exclusive of terrain uncertainty. Mono images within 10 degrees off Nadir)	Std 250 meters Precision 5 meters 90% circular error (Exclusive of terrain uncertainty. Mono images within 10 degrees off Nadir)

Well-Defined Points– Brookings

Defining the Points



Brookings' Point Distribution



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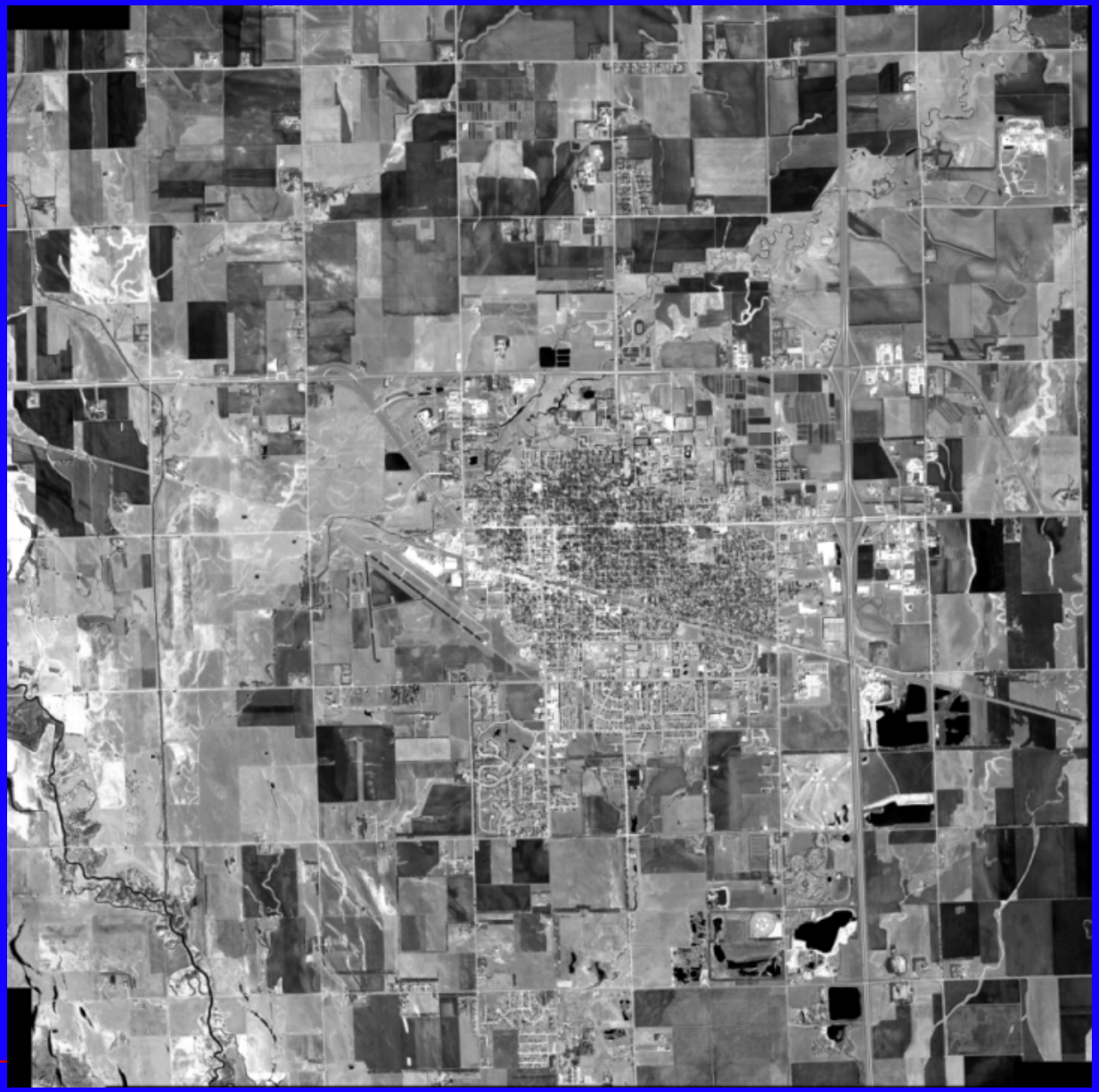
IKONOS 5/1 Brookings Pan



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Brookings 5/1 Pointing Angles

Nominal Collection Azimuth: 276.6060 °

Nominal Collection Elevation: 62.15969 °

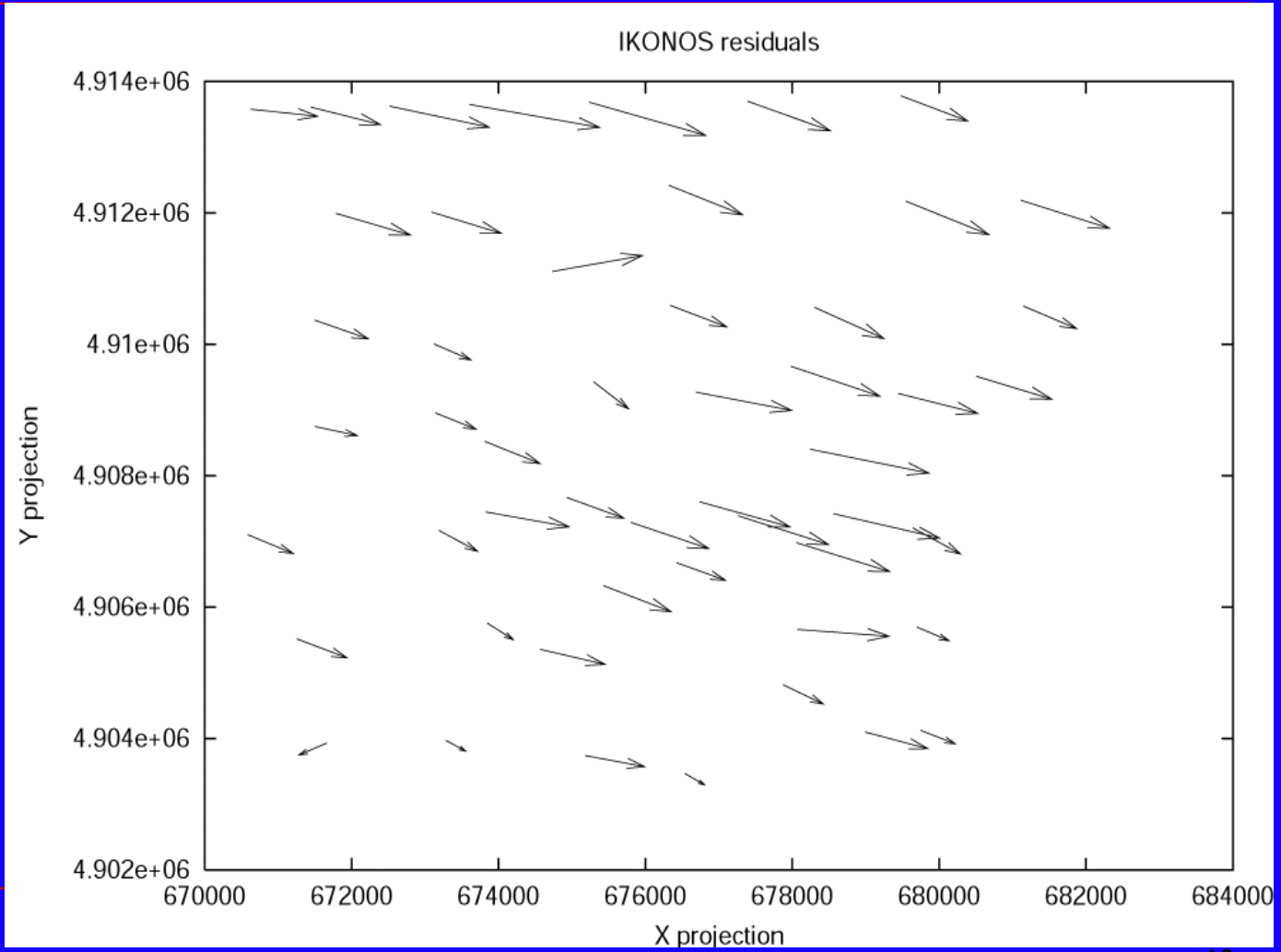
Sun Angle Azimuth: 151.2508 °

Sun Angle Elevation: 58.47338 °

Brookings 5/1 Deltas

Ref. Pt. #	DN	DE		Ref. Pt. #	DN	DE
A	-1.088	9.105		27	-1.383	5.745
1	-3.35	7.513		28	-2.264	11.366
2	-3.137	7.766		29	-3.965	10.571
4	-3.474	17.7		30	-3.807	12.29
5	-3.254	9.496		31	-4.385	12.294
6	-2.492	5.562		32	-3.697	14.486
7	-2.649	9.452		33	-1.033	12.474
8	-3.213	13.574		34	-3.941	9.179
9	-5.032	15.852		35	-2.503	3.52
10	-4.466	11.236		37	-1.663	8.072
11	-3.82	9.063		38	-1.717	2.658
12	-4.29	12.109		39	-2.92	5.459
13	-5.075	11.296		40	-2.038	4.678
14	-4.456	9.988		41	-2.527	8.493
15	2.429	12.281		42	-2.276	8.81
16	-3.314	10.159		43	-2.887	6.819
17	-2.842	7.262		44	-3.149	5.204
18	-2.422	5.005		45	-3.957	6.481
19	-3.277	7.696		46	-3.604	16.145
20	-4.753	9.442		47	-4.387	12.706
21	-3.441	7.263		48	-2.703	6.668
22	-3.476	10.276		49	-2.849	6.188
23	-3.032	10.807		50	-1.63	2.652
24	-4.546	12.11		51	-2.092	4.397
25	-2.76	13.017		52	-1.844	-3.82
26	-4.085	4.732				

Brookings 5/1 Distribution Plot



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Brookings 5/1 Findings

NSSDA:RMSEx = 9.525

NSSDA:RMSEy = 3.220

NSSDA:RMSEmin/RMSEmax = 0.338

NSSDA:RMSE Vector = 10.055

NSSDA:Accuracy (95 pct confidence) = 15.598

NMAS:Circular Standard Error(39 pct)= 6.373

NMAS:Circular Error Probable(50 pct)= 7.502

NMAS:Circular Map Accuracy Std(90 pct)= 15.258

Brookings 6/30 Pointing Angles

Nominal Collection Azimuth: 0.4540°

Nominal Collection Elevation: 73.11800°

Sun Angle Azimuth: 136.1032°

Sun Angle Elevation: 63.53359°

Brookings
6/30 Deltas

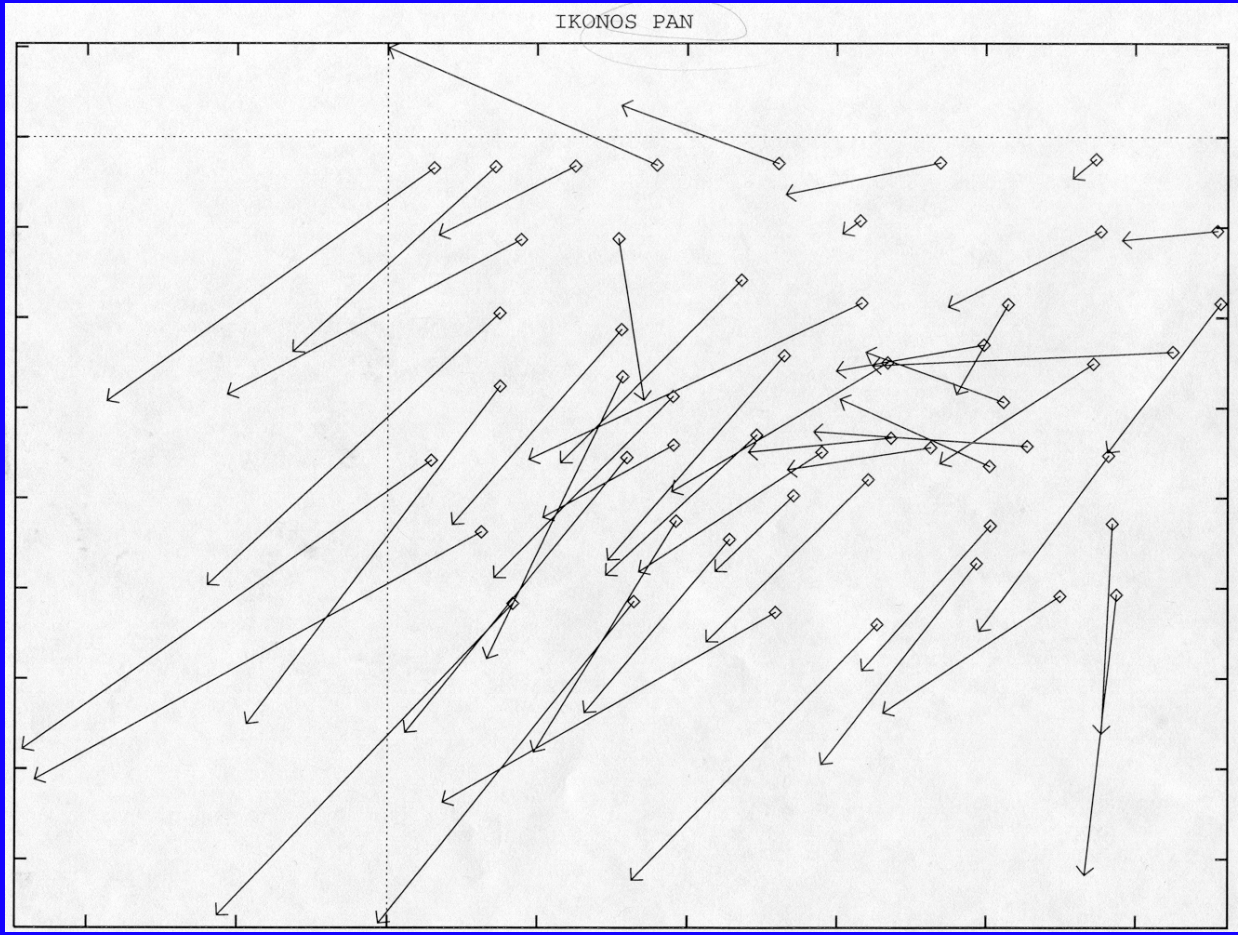
Point Ref. #	Delta X	Delta Y		Point Ref. #	Delta X	Delta Y
1	-2.39	4.02		27	-2.45	2.66
2	-2.02	3.11		28	-1.91	0.31
3	-2.1	-1.29		29	-1.92	0.48
4	-1.72	3.21		30	-2.86	-0.33
5	-3.89	6.03		31	-1.05	1.68
6	0.34	3.57		32	-1.89	5.12
7	-0.31	0.42		33	-4.44	4.21
8	-0.43	6.21		34	-3.28	5.65
9	-3.4	7.12		35	-2.08	4.45
10	-2.07	0.7		36	-3.57	-2.6
11	-1.27	0.21		37	-2.37	2.59
12	-2.04	1.67		38	-1.93	3.84
13	-0.24	0.29		39	-5.94	5.48
14	-2.41	4.05		40	-2.95	6.1
15	-3.91	3.43		41	-1.73	3.89
16	-2.25	4.32		42	-1.84	-1.11
17	-4.45	3.47		43	-2.01	-1.49
18	-0.69	1.99		44	-2.17	3.59
19	-1.51	3.3		45	-5.44	6.4
20	-4.03	0.31		46	-0.15	4.65
21	-2.06	2.21		47	-3.93	6.9
22	-1.98	0.57		48	-1.81	6.25
23	-2.89	2.86		49	-2.7	4.1
24	-2.36	4.53		50	-1.82	1.53
25	-3.37	7.49		51	-4.35	5.16
26	-1.74	1.61				

Brooking 6/30 Distribution Plot

Original

Standard

Data Set



Brookings 6/30 Findings

NSSDA:RMSEx = 2.715

NSSDA:RMSEy = 3.896

NSSDA:RMSEmin/RMSEmax = 0.6969

NSSDA:RMSE Vector = 4.749

NSSDA:Accuracy (95 pct confidence) = 8.219

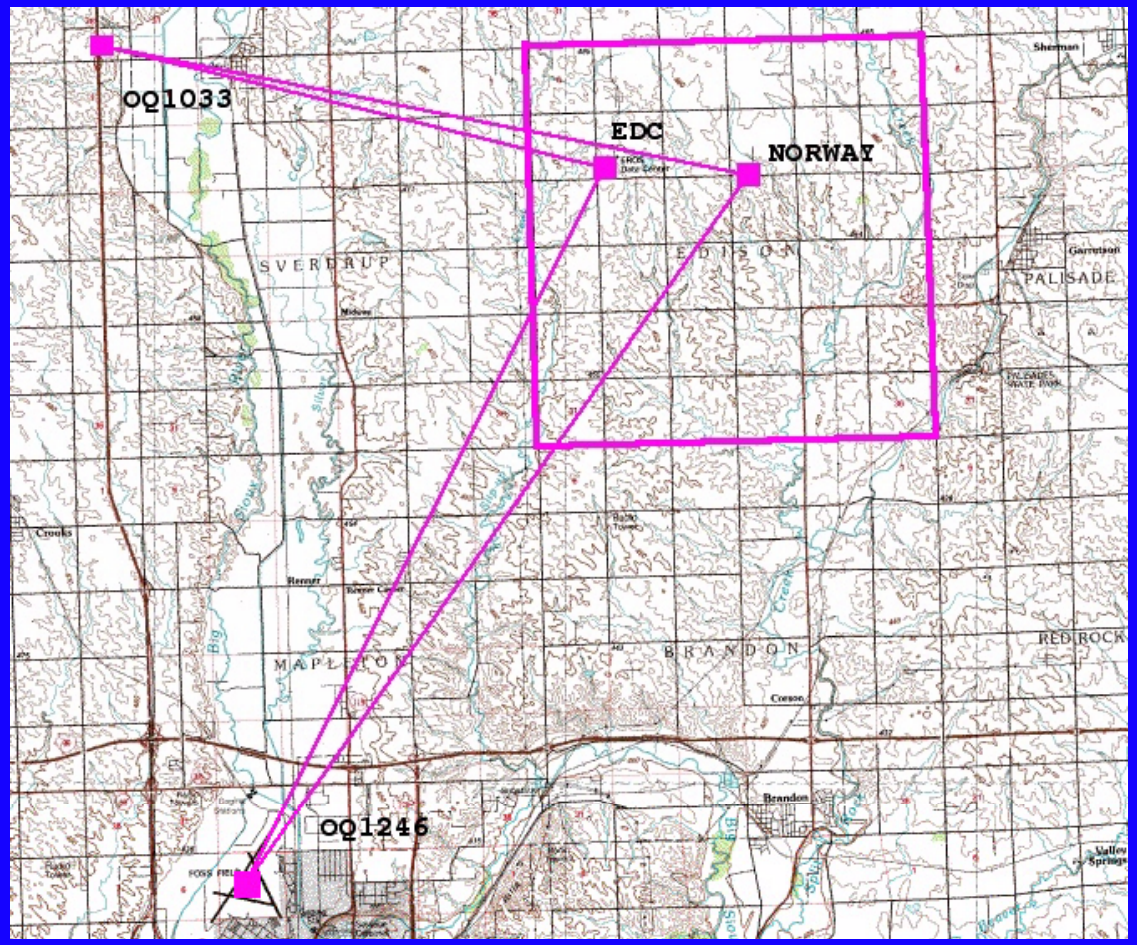
NMAS:Circular Standard Error(39 pct)= 3.358

NMAS:Circular Error Probable(50 pct)= 3.953

NMAS:Circular Map Accuracy Std(90 pct)= 7.368

Well-Defined Points– EDC Scene

Independent Source of Higher Accuracy



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EDC Control Point Set

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Stennis Crew, Norway Cemetery

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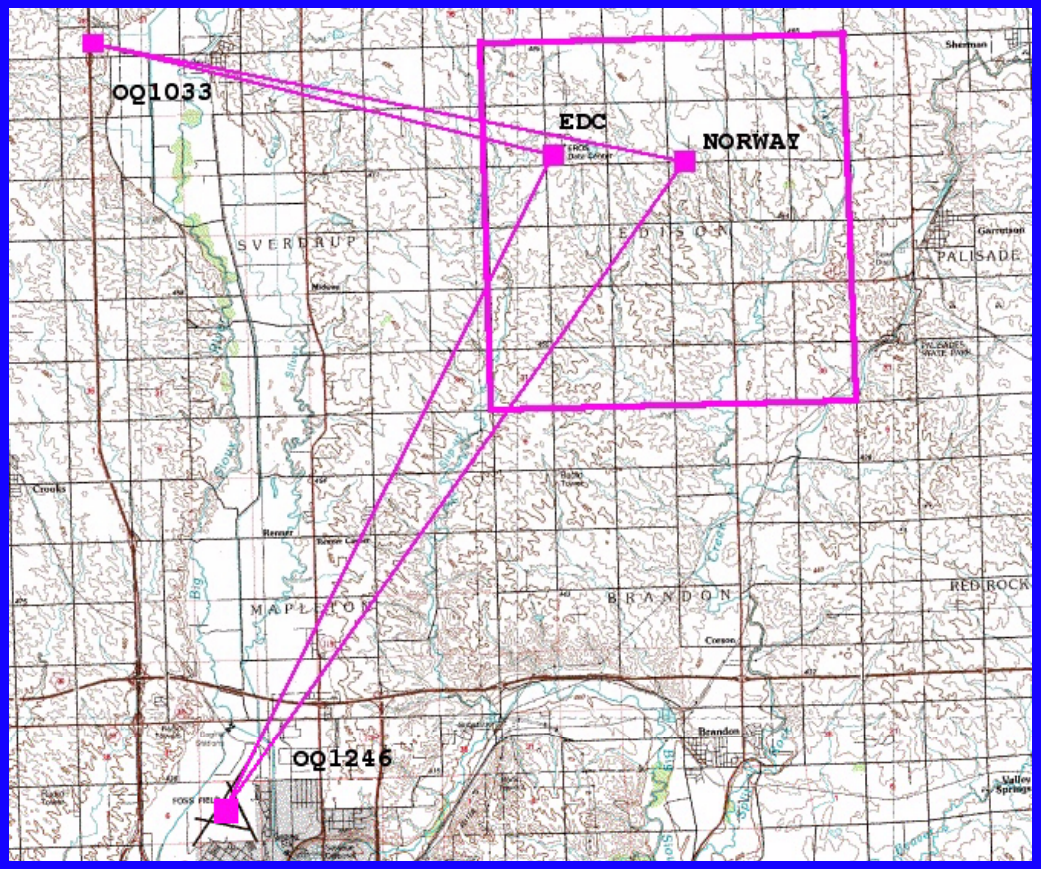
Well-Defined Points– EDC Scene

Independent Source of Higher Accuracy



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Well-Defined Points– EDC Scene

Target Preparation

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Well-Defined Points– EDC Scene

Panel Markers

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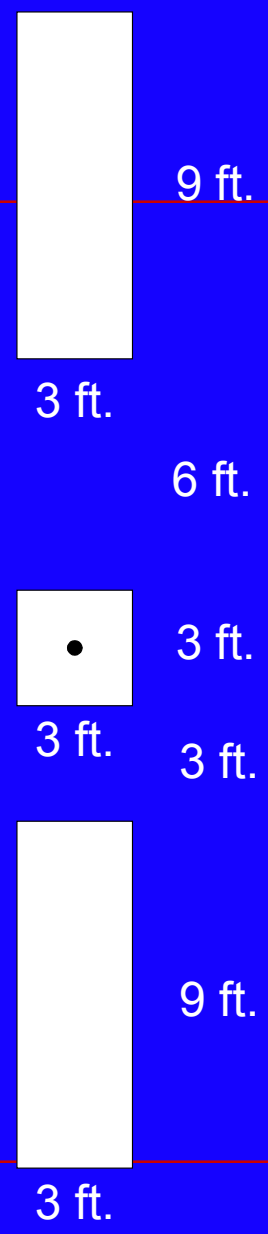
Panel Marker's Geometry



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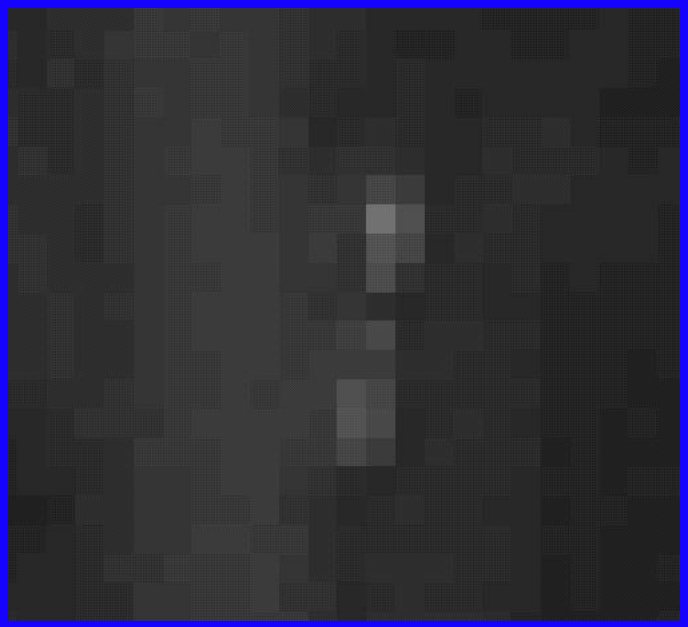
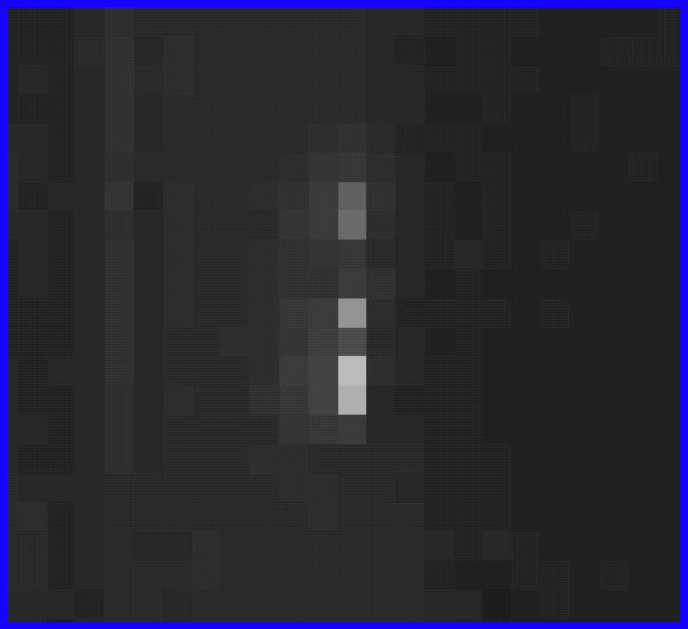
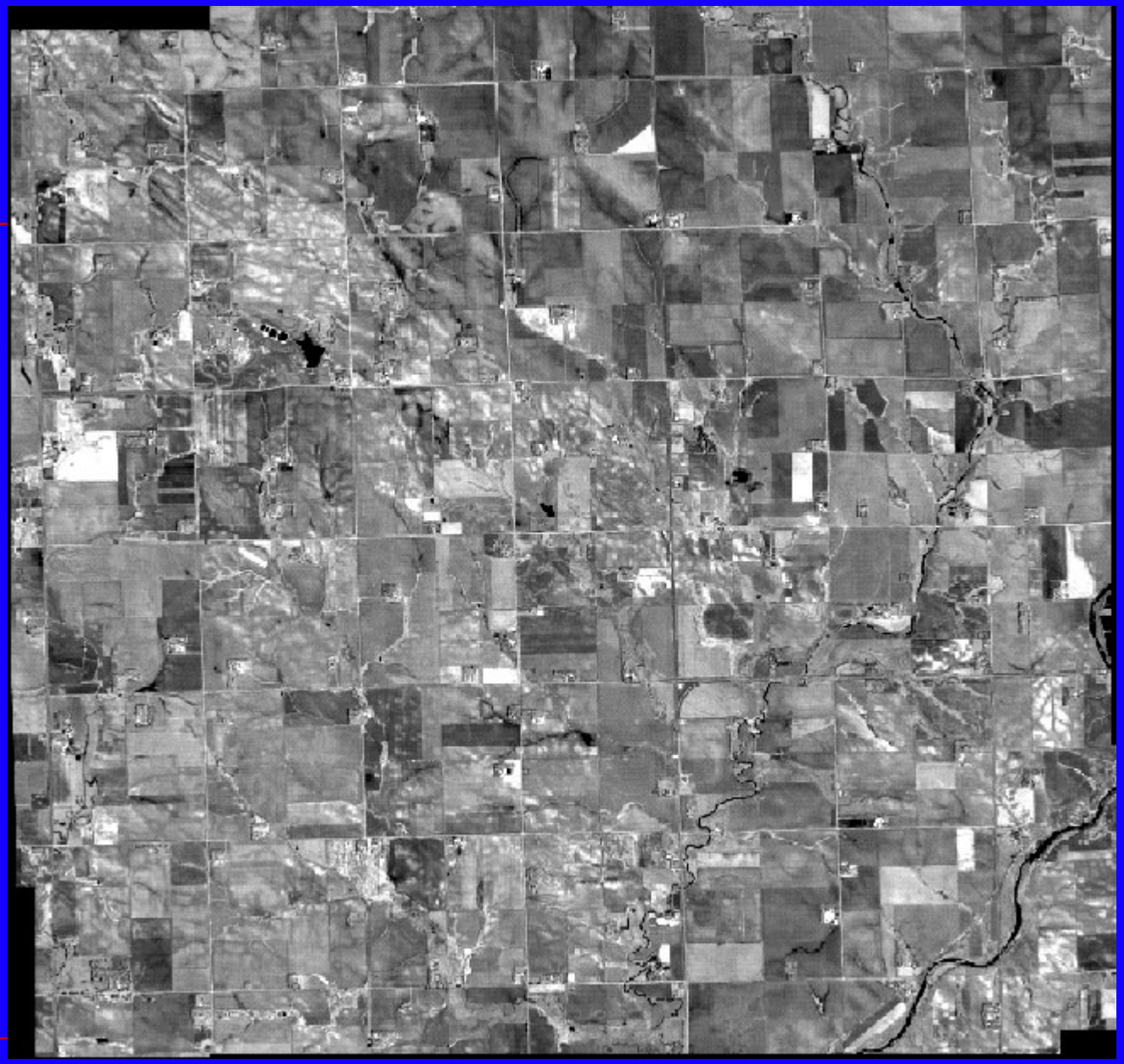
Panel Imagery





Recoverable / Repeatable Position Markers

IKONOS 6/30/00 EDC PAN



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EDC 6/30/2000 Pointing Angles

Nominal Collection Azimuth: 257.9207°

Nominal Collection Elevation: 81.85294°

Sun Angle Azimuth: 135.9381°

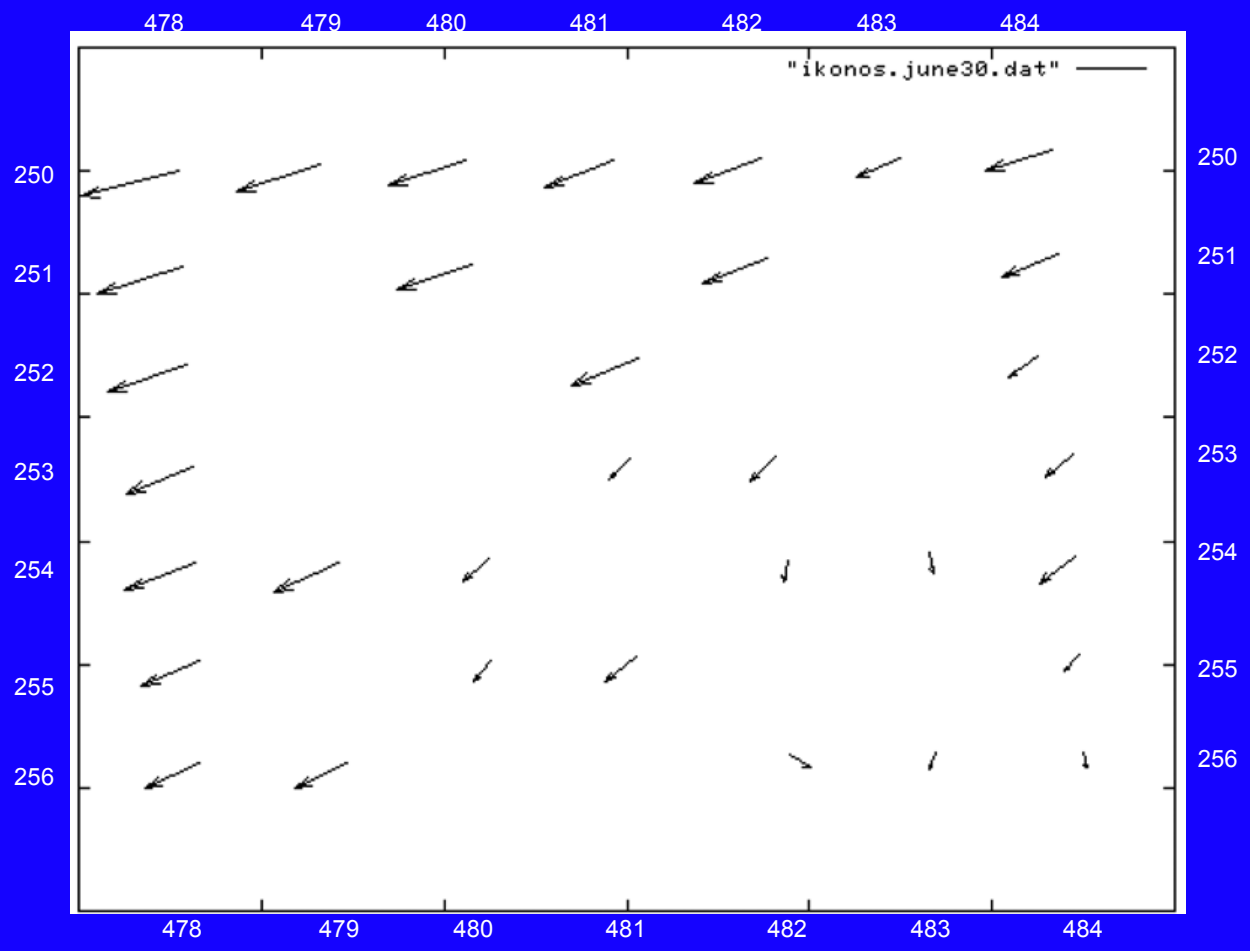
Sun Angle Elevation: 64.15141°

EDC 6/30/2000

Deltas

Point Ref. #	Delta X	Delta Y
250478	-10.62	-4.237
250479	-9.103	-4.328
250480	-8.41	-3.804
250481	-7.544	-4.218
250482	-7.093	-4.08
250483	-4.739	-3.148
250484	-7.266	-3.659
251478	-9.365	-4.341
251480	-8.191	-4.189
251482	-7.073	-4.064
251484	-6.281	-3.775
252478	-8.807	-4.541
252481	-7.372	-4.275
252484	-3.073	-3.595
253478	-7.836	-4.252
253481	-2.271	-3.629
253482	-2.709	-3.759
253484	-3.041	-3.78
254478	-7.608	-4.196
254479	-7.166	-4.826
254480	-2.67	-3.549
254482	-0.632	-3.362
254483	0.58	-3.416
254484	-3.881	-4.406
255478	-6.267	-3.825
255480	-1.925	-3.68
255481	-3.517	-3.998
255482	0.927	-2.665
255484	-1.491	-2.961
256478	-5.969	-4.095
256479	-5.815	-4.22
256482	2.476	-2.012
256483	-0.77	-2.876
256484	0.528	-2.338

EDC 6/30/2000 Distribution Plot



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EDC 6/30/2000 Findings

NSSDA:RMSEx = 5.885

NSSDA:RMSEy = 3.819

NSSDA:RMSEmin/RMSEmax = 0.649

NSSDA:RMSE Vector = 7.015

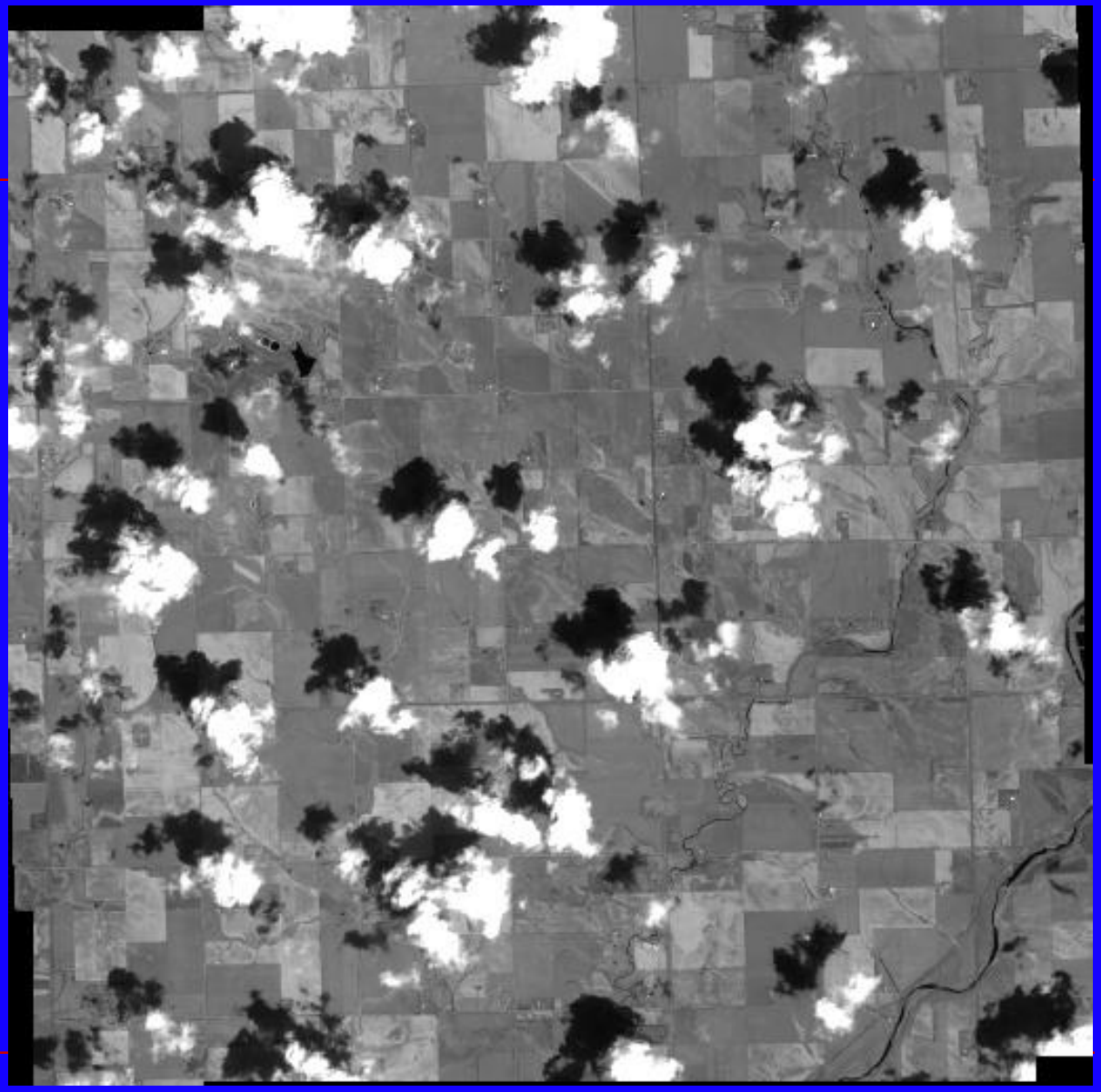
NSSDA:Accuracy (95 pct confidence) = 11.876

NMAS:Circular Standard Error(39 pct)= 4.852

NMAS:Circular Error Probable(50 pct)= 5.712

NMAS:Circular Map Accuracy Std(90 pct)= 10.646

IKONOS 7/30/00 PAN



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EDC 7/30/ 2000 Pointing Angles

Nominal Collection Azimuth: 122.2318°

Nominal Collection Elevation: 84.26382°

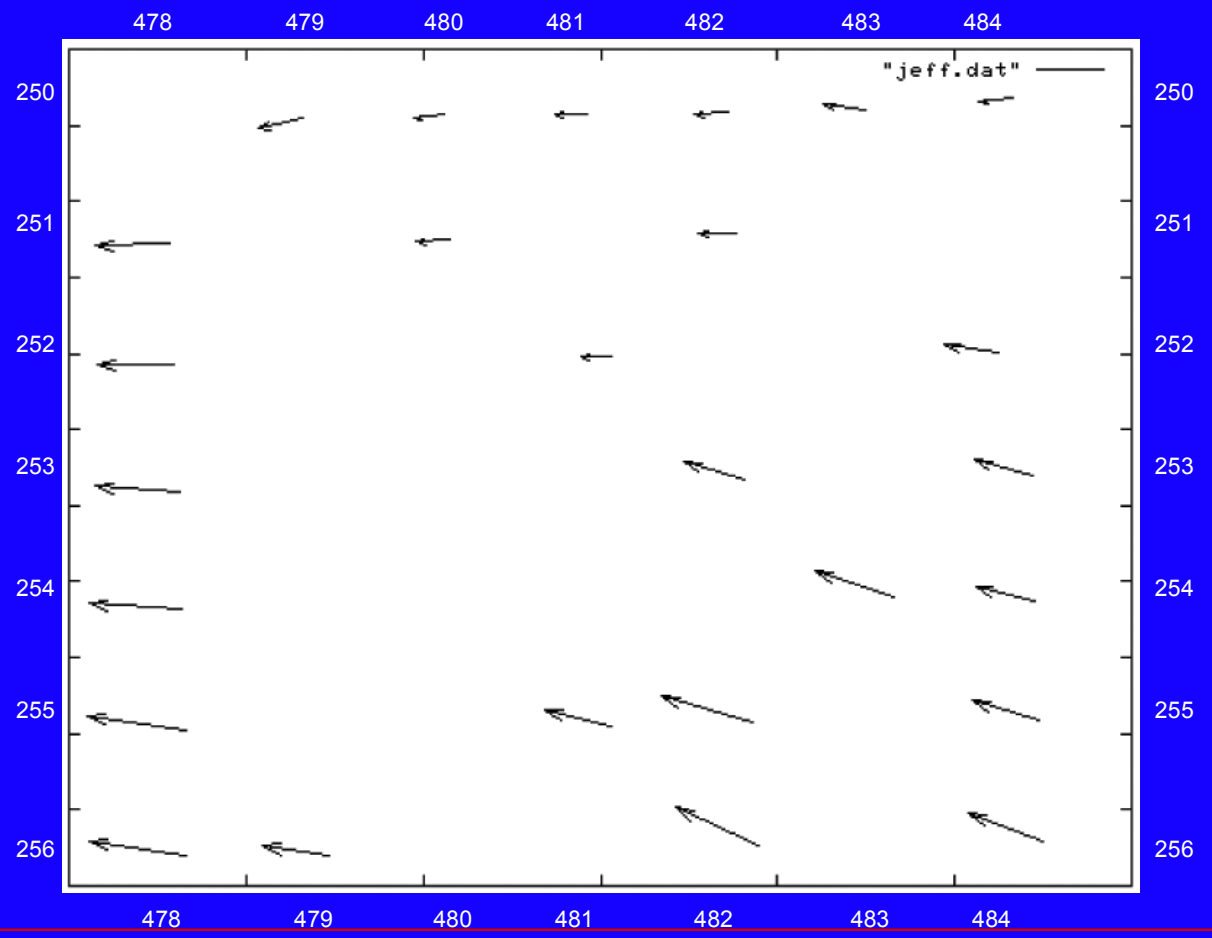
Sun Angle Azimuth: 137.9281°

Sun Angle Elevation: 59.07204°

EDC 7/30/2000 Deltas

Point Ref. #	Delta X	Delta Y
250479	4.919	1.442
250480	3.425	0.773
250481	3.565	0.211
250482	4.081	0.138
250483	4.77	0.845
250484	3.79	0.476
251478	8.359	0.249
251480	3.966	0.206
251482	4.172	0.135
252478	8.788	0.107
NORWAY	3.392	0.086
252484	6.182	1.245
253478	9.706	0.765
253482	6.935	2.245
253484	6.521	2.019
254478	10.477	0.926
254483	9.01	3.408
254484	6.596	1.684
255478	11.054	1.85
255481	7.457	2.058
255482	10.052	3.554
255484	7.528	2.785
256478	10.971	1.921
256479	7.574	1.225
256482	9.437	5.12
256484	8.444	3.714

EDC 7/30/2000 Distribution Plot



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EDC 7/30/2000 Findings

NSSDA:RMSEx = 7.404

NSSDA:RMSEy = 1.996

NSSDA:RMSEmin/RMSEmax = 0.270

NSSDA:RMSE Vector = 7.668

NSSDA:Accuracy (95 pct confidence) = 11.505

NMAS:Circular Standard Error(39 pct)= 4.700

NMAS:Circular Error Probable(50 pct)= 5.534

NMAS:Circular Map Accuracy Std(90 pct)= 11.637

Brookings 6/30 Precision Data Pointing Angles

Nominal Collection Azimuth: 302.1298°

Nominal Collection Elevation: 85.58673°

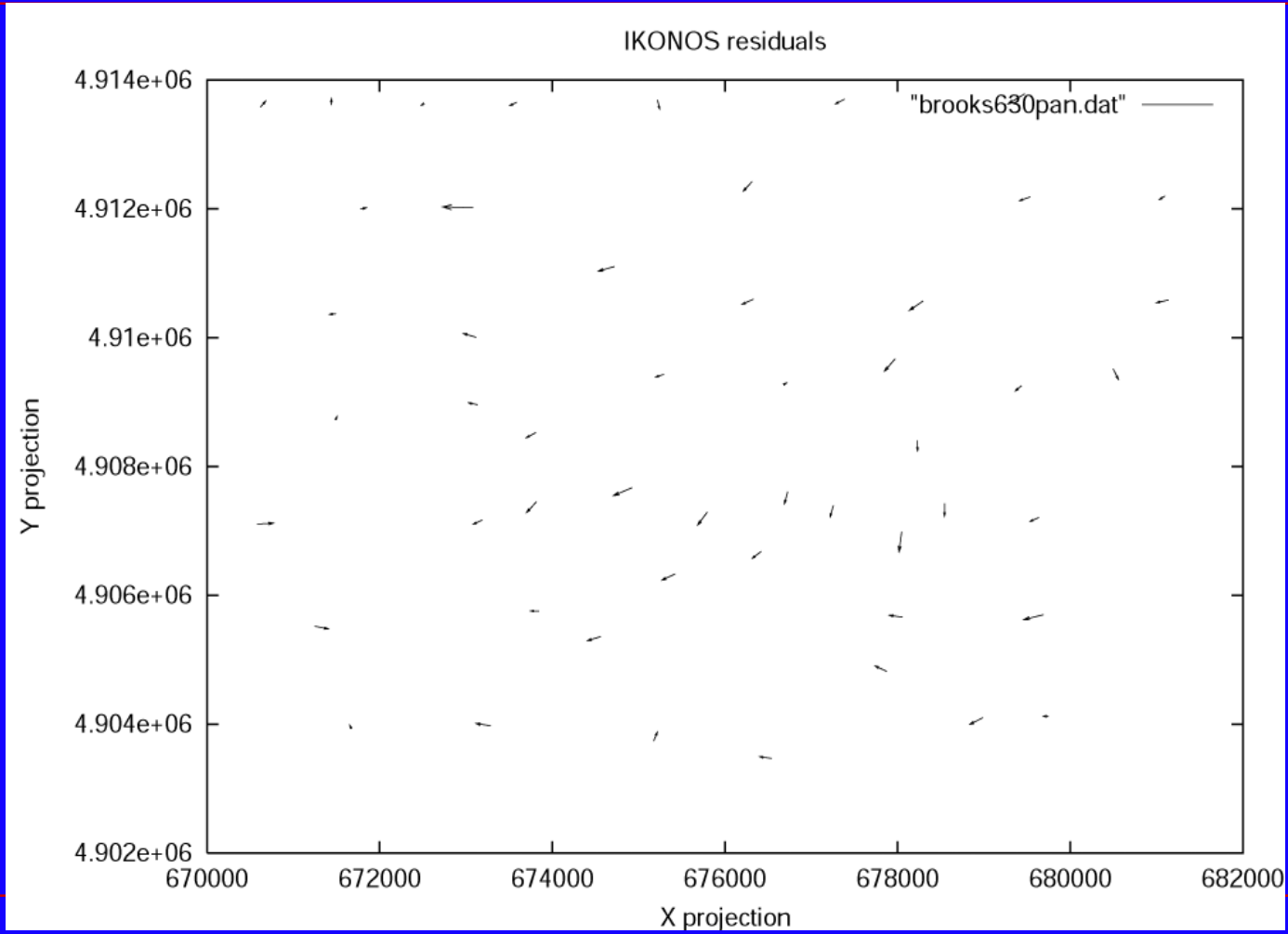
Sun Angle Azimuth: 136.2818°

Sun Angle Elevation: 63.58415°

Brookings 6/30 Precision Deltas

Ref. Pt #	DN (m)	DE (m)		Ref. Pt #	DN (m)	DE (m)
A	0.912	0.605		27	0.277	0.075
1	-0.77	-1.067		28	-1.644	-1.134
2	-1.227	-2.154		29	-1.965	-1.099
4	-0.474	-0.8		30	-1.807	-0.38
5	0.146	-3.504		31	-1.725	-0.376
6	0.308	-1.038		32	-1.947	-0.014
7	0.951	0.052		33	0.297	-1.526
8	-0.213	-0.226		34	-0.941	-1.491
9	-1.432	0.252		35	-0.003	-0.98
10	-0.716	-1.014		37	1.337	0.402
11	-1.57	-1.937		38	0.283	-1.342
12	-0.54	-0.641		39	0.83	-1.291
13	-0.575	-1.204		40	-0.038	-0.572
14	-1.456	-1.012		41	-1.027	-1.507
15	-0.691	-1.839		42	-0.616	-1.52
16	0.186	0.659		43	-0.387	1.569
17	-0.092	-0.738		44	-0.649	-1.046
18	0.578	-1.495		45	-0.607	-1.019
19	-0.777	-1.304		46	-1.604	0.015
20	-1.423	-1.558		47	-3.057	-0.294
21	-0.441	-1.407		48	-1.043	-1.002
22	-1.606	0.606		49	0.151	1.858
23	-0.782	-0.693		50	0.37	-1.678
24	-1.886	-1.22		51	-0.762	-2.273
25	0.24	0.347		52	0.486	-0.15
26	-0.425	-0.938				

Brookings 6/30 Precision Distribution Plot



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Brookings 6/30 Precision Data Findings

NSSDA: RMSEx = 1.213

NSSDA: RMSEy = 1.057

NSSDA: RMSEmin/RMSEmax = 0.872

NSSDA: RMSE Vector = 1.609

NSSDA: Accuracy (95 pct confidence) = 2.778

NMAS: Circular Standard Error (39 pct) = 1.135

NMAS: Circular Error Probable (50 pct) = 1.336

NMAS: Circular Map Accuracy Std (90 pct) = 2.441

EDC Pan Precision Original—
Data Evaluation

- One Person Initial Evaluation
- Two Additional People Evaluate Image
- Second Independent Calculation
- Cross Comparison of Results

Deltas

Deltas in the X and Y of the there data interpolators

Point Ref. #	MC Delta X	JW Delta X	KP Delta X		MC Delta Y	JW Delta Y	KP Delta Y
250478	-5.347	-5.355	-4.863		-0.711	-0.712	-0.633
250479	-3.891	-3.916	-3.503		-0.629	-0.687	-0.566
250480	-3.412	-3.474	-3.054		-0.02	-0.058	-0.757
250481	-2.02	-2.047	-1.759		-0.176	-0.265	-0.244
250482	-2.092	-2.058	-2.16		-0.183	-0.132	-0.172
250483	0.259	0.319	0.266		0.584	0.613	0
250484	-2.376	-2.234	-2.001		0.349	0.378	0.322
251478	-3.536	-3.628	-3.499		-0.534	-0.425	-0.147
251480	-3.164	-3.08	-2.882		-0.468	-0.336	-0.239
251482	-2.017	-2.014	-1.845		-0.456	-0.813	-0.218
251484	-1.391	-1.468	-1.018		0.083	-0.036	0.22
252478	-3.532	-3.541	-3.369		-1.083	-1.313	-1.256
252481	-2.234	-2.169	-2.218		-0.349	-0.405	-0.48
252484	1.924	1.844	1.781		0.41	0.387	0.356
253478	-2.295	-2.429	-2.462		-0.722	-1.04	-0.888
253481	2.743	2.686	2.7		0.67	0.423	0.355
253482	2.552	2.498	2.554		0.354	0.244	0.216
253484	1.687	1.778	1.941		0.254	0.258	0.408
254478	-2.113	-2.317	-2.176		-0.419	-1.174	-0.433
254479	-2.031	-2.162	-2.025		-1.126	-1.147	-0.9
254480	2.125	2.251	2.281		0.164	0.263	0.418
254482	4.385	4.384	4.349		0.577	0.272	0.349
254483	5.249	5.472	5.463		0.576	0.597	0.46
254484	1.207	1.005	0.88		-0.177	-0.237	-0.053
255478	-1.046	-1.188	-1.111		0.046	0.258	0.681
255480	3.069	3.046	3.167		0.352	0.337	0.217
255481	1.624	1.624	1.651		0.014	0.005	-0.036
255482	5.899	5.909	6.014		1.347	1.345	1.514
255484	3.391	3.228	3.394		0.984	0.706	1.191
256478	-0.954	-0.978	-0.888		-0.092	-0.125	0.6
256479	-0.842	-0.804	-0.584		-0.306	-0.227	-0.186
256482	7.483	7.61	7.55		1.997	1.738	2.065
256483	4.27	4.042	4.162		1.143	1.149	1.497
256484	5.432	5.302	5.473		1.679	1.732	2.016

Sigma's

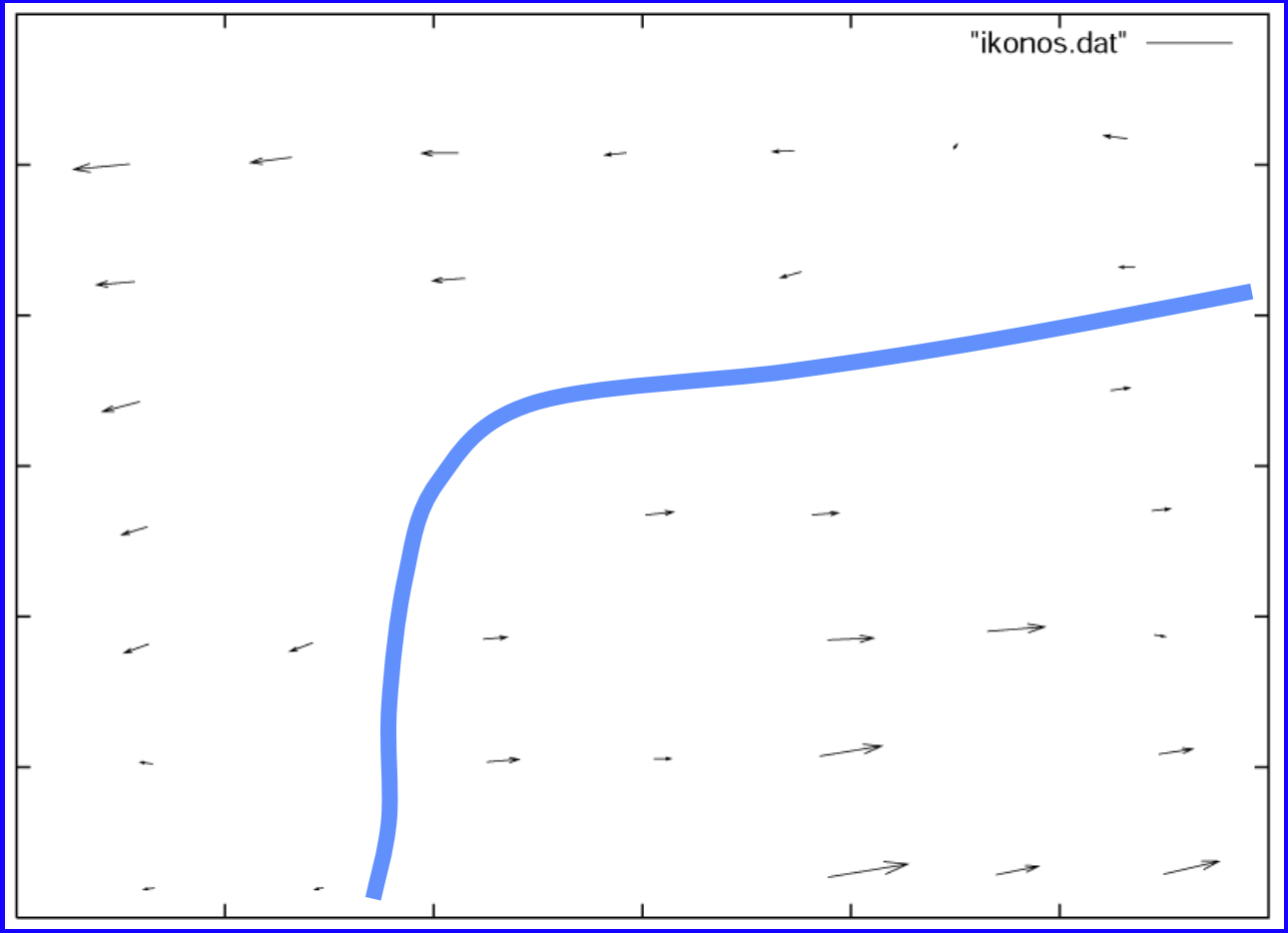
Standard Deviations of each point in X, Y, and R.

Point Ref. #	std deve of X	std deve of Y	std deve of R			
250478	0.281775	0.0453	0.2374			
250479	0.23157	0.0605	0.1758			
250480	0.22672	0.415	0.157			
250481	0.15906	0.0465	0.053			
250482	0.05194	0.0268	0.2379			
250483	0.03281	0.3458	0.2379			
250484	0.18933	0.028	0.1897			
251478	0.0664	0.1996	0.0755			
251480	0.1448	0.1149	0.1563			
251482	0.0985	0.2995	0.16507			
251484	0.2407	0.1281	0.2281	Average Sigma X =		0.1042
252478	0.0968	0.1198	0.0907	Average Sigma Y =		0.1536
252481	0.0337	0.0657	0.0341			
252484	0.0717	0.0271	0.0756	Average Sigma R =		0.126
253478	0.0884	0.159	0.1299			
253481	0.0297	0.1658	0.0593			
253482	0.0318	0.0729	0.0352			
253484	0.1287	0.0878	0.1415			
254478	0.1045	0.4319	0.2408			
254479	0.0774	0.1369	0.1159			
254480	0.0828	0.128	0.0968			
254482	0.0205	0.1586	0.03			
254483	0.1262	0.0737	0.1234			
254484	0.165	0.0938	0.1695			
255478	0.0711	0.3233	0.1341			
255480	0.0642	0.0739	0.0577			
255481	0.0156	0.0267	0.0158			
255482	0.0637	0.097	0.0845			
255484	0.095	0.2433	0.15436			
256478	0.0466	0.4094	0.0912			
256479	0.1393	0.061	0.149			
256482	0.0635	0.1725	0.0428			
256483	0.1141	0.2027	0.1268			
256484	0.0893	0.1812	0.1279			

The Three Results

People	RMSEx	RMSEy	RMSEr	Min/Max	Accuracy R
MC	3.2878	0.7289	3.368	0.2217	4.9157
JW	3.2967	0.6728	3.3647	0.2041	4.8581
KP	3.235	0.6617	3.3019	0.2045	4.7689
All units are in meters.					

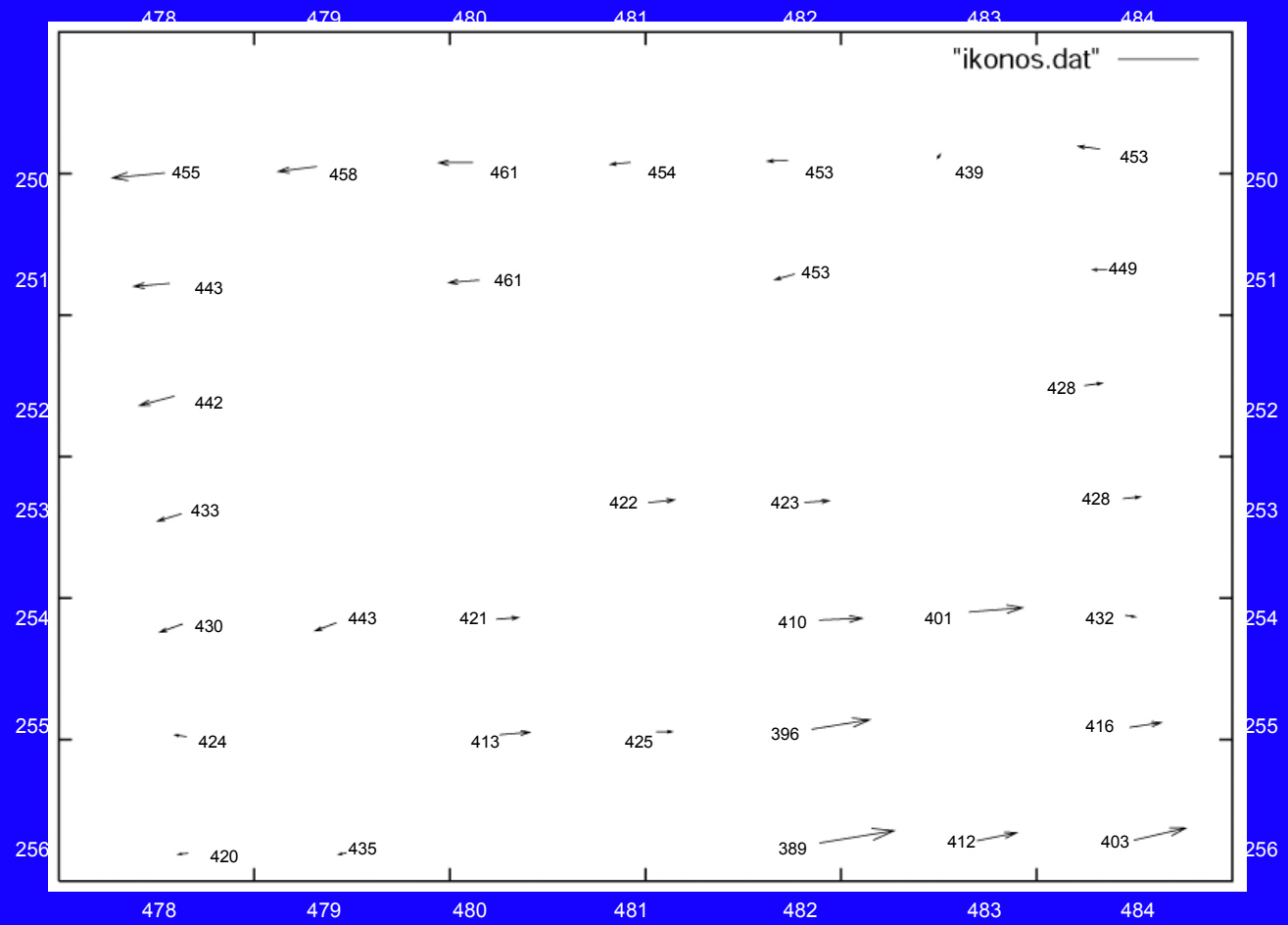
Shifts Across the Scene



Concerns

- Shift in X ordinate
  - Non-symmetric shift
    - - 5.1 to + 5.4 (NW to SE)
- FDGC std-007.3 Case 2, does not apply
    - RMSE min / RMSE max < 0.6

Elevation Correlation



USGS
E.R.O.S. Data Center

6/30 Precision Data Set Findings

NSSDA: RMSEx = 3.292

NSSDA: RMSEy = 0.722

NSSDA: RMSEmin/RMSEmax = 0.219

NSSDA: RMSE Vector = 3.371

NSSDA: Accuracy (95 pct confidence) = 4.914

NMAS: Circular Standard Error (39 pct) = 2.007

NMAS: Circular Error Probable (50 pct) = 2.364

NMAS: Circular Map Accuracy Std (90 pct) = 5.115

Color Co-Registry

Color and Pan points exhibited similar shifts

Summary Table

	5-1 Std	6-30 Std	7-30 Std	6-30 Pre
Brookings	15.258	7.368		2.441
EROS		10.646	11.637	5.115

	Standard	Precision
Pan Spec	250	3
Multi Spec	250	5