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Issues and Solutions Involving the Resolution Merger of Panchromatic and Multi-Spectral Imagery from Digital Globe's QuickBird-2 2A Data

Gregory J Grohman, MS
Precision Engagement Division
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Background

An analyst presented the Front-end Processing Environment in St Louis with Quickbird2 data.

He wanted to have the highest accuracy we could acquire with his data.

Armed with BAE's Socet Set and ERDAS Imagine, we set out to see what we could do with the data...

Generating a Spatially Accurate Product from Quickbird data

Quickbird is ordered in 2 types, “Basic 1B” and “Standard 2A”.

Basic 1B has had no further rectification done to the image. It is ready to be geo-corrected and orthorectified.

Standard 2A has been projected and orthorectified to a “Course DEM”, which is DTED0 (1,000 meter posts). Standard 2A data can not be orthorectifed again; it can only have its x and y bias removed (gross horizontal error).

Unfortunately...

The analyst has acquired a set of Standard 2A data.

FPE quickly informs the customer that there are limitations to what we can do for him, but we can-and-will maximize the utility of the data that he has.

Complicating factor: the data comes to us with the pan in 2 pieces that cover the MSI data, so there will be 3 files to work with until the pan is merged together.

Overview

The issues encountered while performing this task included multi-spectral image preparation, image geopositioning, image mosaic, quantification levels, format and data merger.

So, why is 2A data problematic?
Aren’t orthophotos good?

Orthorectification

Orthophotos are “Photomaps” that do not contain scale, tilt or relief distortions- even in varying terrain- that characterize unprocessed remotely sensed imagery.

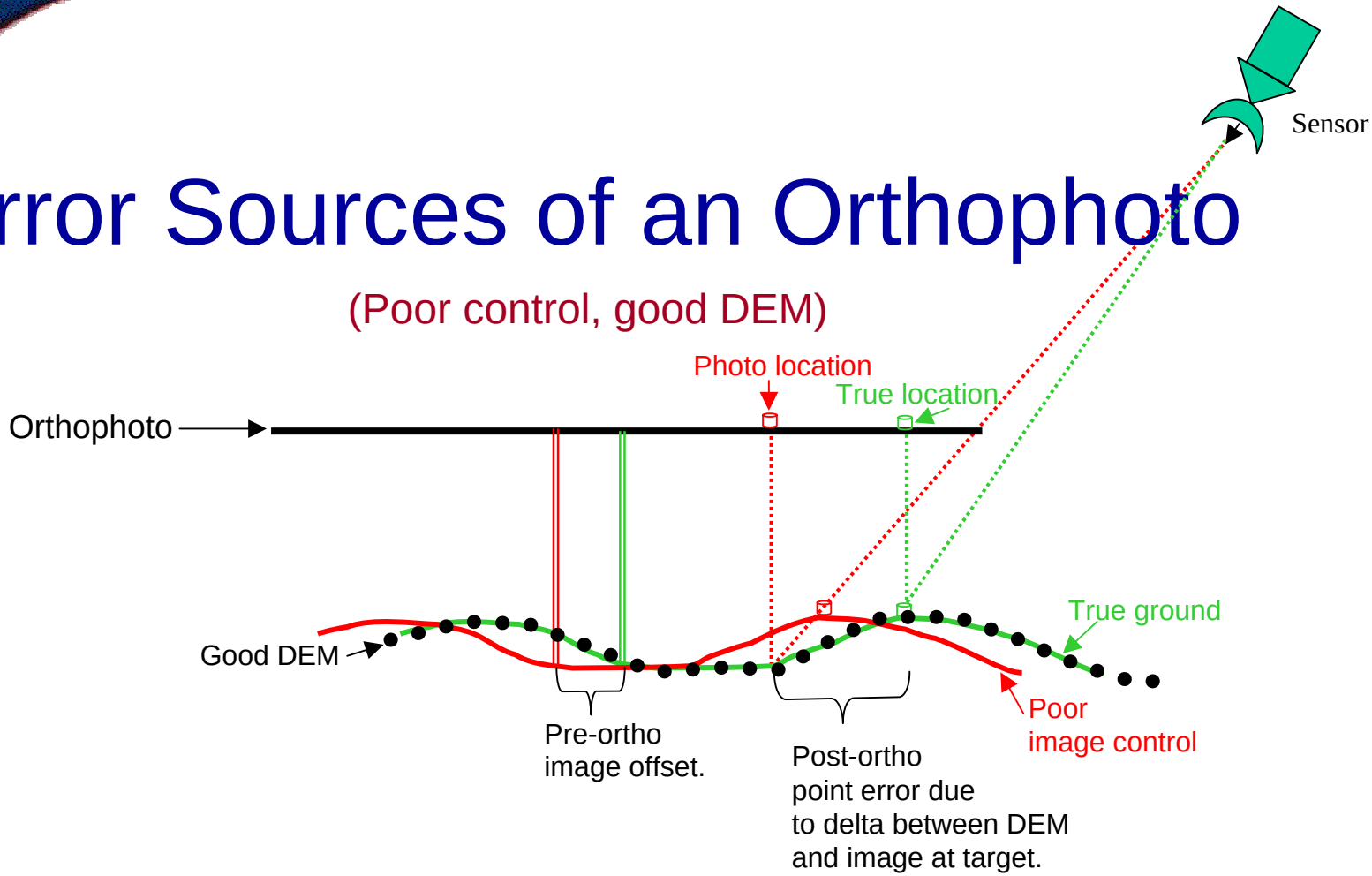
They offer analysts a product that can be be readily interpreted like any air photo, but its distances, angles and areas can be measured directly without further processing.

Because of these characteristics, orthophotos are the “Holy Grail” of the monoscopic image exploitation arena.

After Lillesand and Kiefer 1994

Error Sources of an Orthophoto

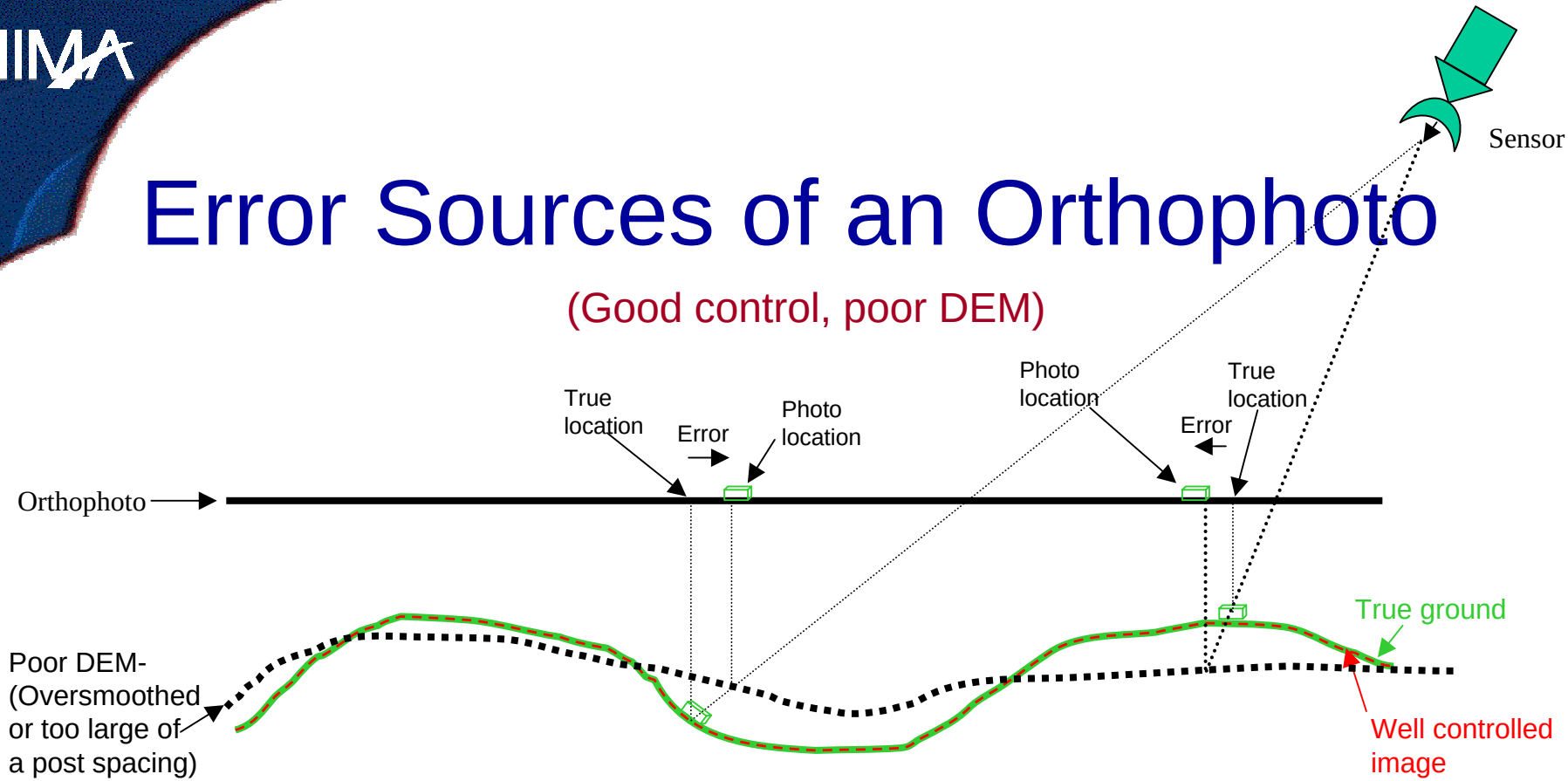
(Poor control, good DEM)



Error size will vary with DEM separation <u>at each pixel</u>, i.e. horizontal error gets worse as delta increases

Error Sources of an Orthophoto

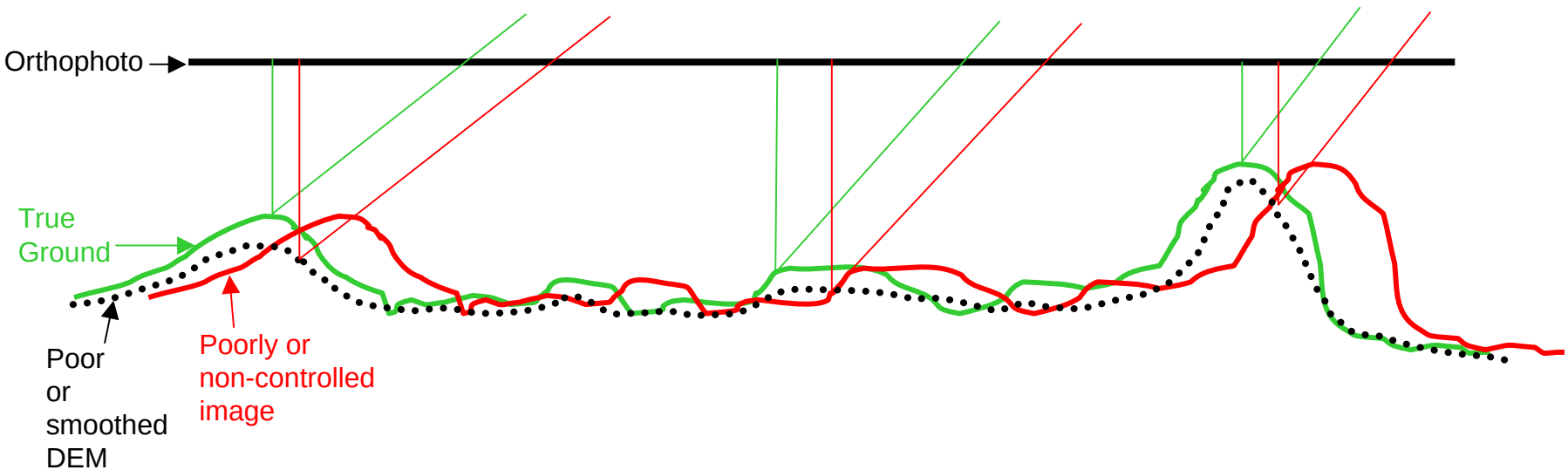
(Good control, poor DEM)



Error will vary in <u>magnitude</u> with surface/DEM separation, and in <u>direction</u> with whether DEM is above or below true ground at each pixel.

Error Sources of an Orthophoto

(Poor control and poor DEM-
it's too hard to draw!)



These errors become very important and noticeable as the image's <u>resolution gets smaller</u>.

Variables in Orthophoto Error

Variables that directly affect orthophoto accuracy are:
1) DEM accuracy
2) Image horizontal (X-Y) accuracy (control)
3) Sensor “look angle”, or obliquity

… And these assume that a proper image sensor model (rigorous or “3-D RPC”) is appropriately employed.

! Once you orthorectify an image, you permanently burn into the image these random, variable horizontal errors.

! You cannot “ortho” an image that has already been “ortho’d”.

! The horizontal errors are neither modelable nor removable.

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Initial imagery placement with the outline of final position.

Mean horizontal error was 646 meters in latitude and 10 meters in longitude.

This fact further compromised the horizontal accuracy, in which only DTED0 was used to orthorectify.

Poor initial accuracy combined with poor elevation data equals highly variable horizontal accuracy.

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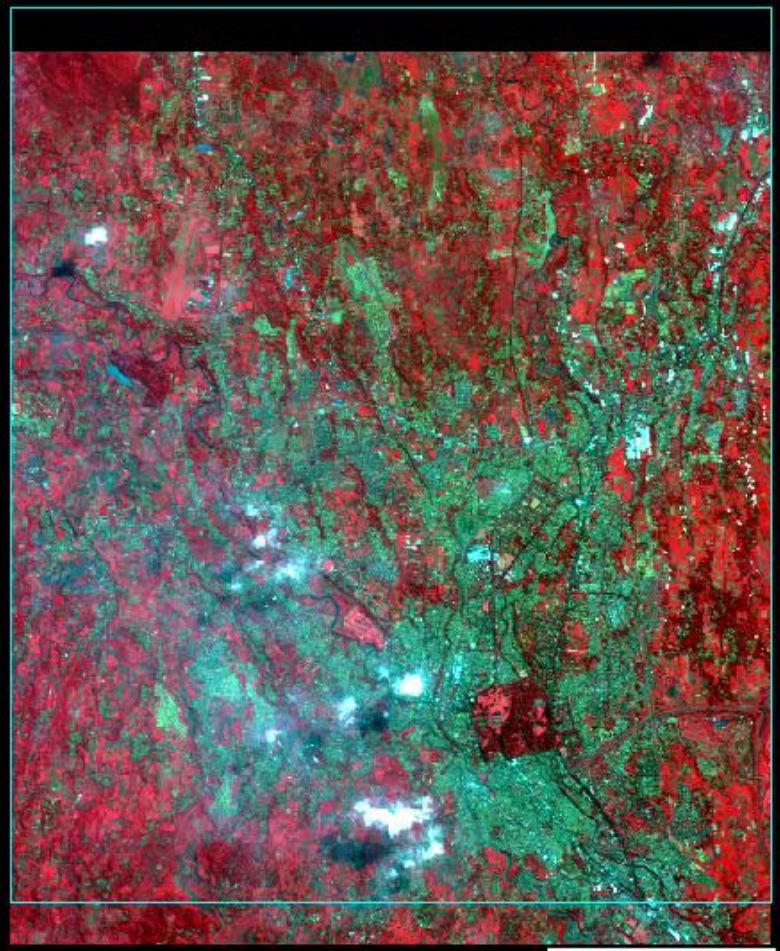
View1 : new_msi1 / new_msi1

A glance at the 4-3-2 false color composite in its initial position.



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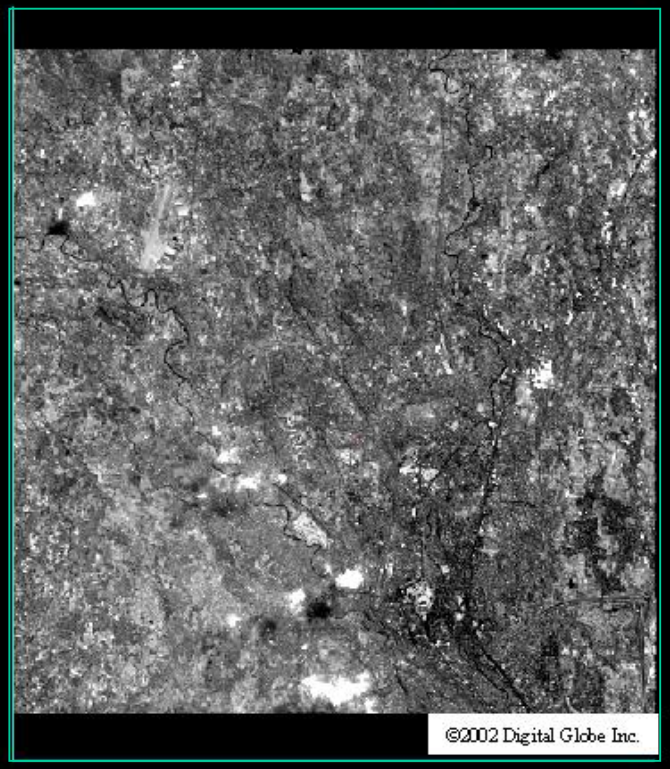
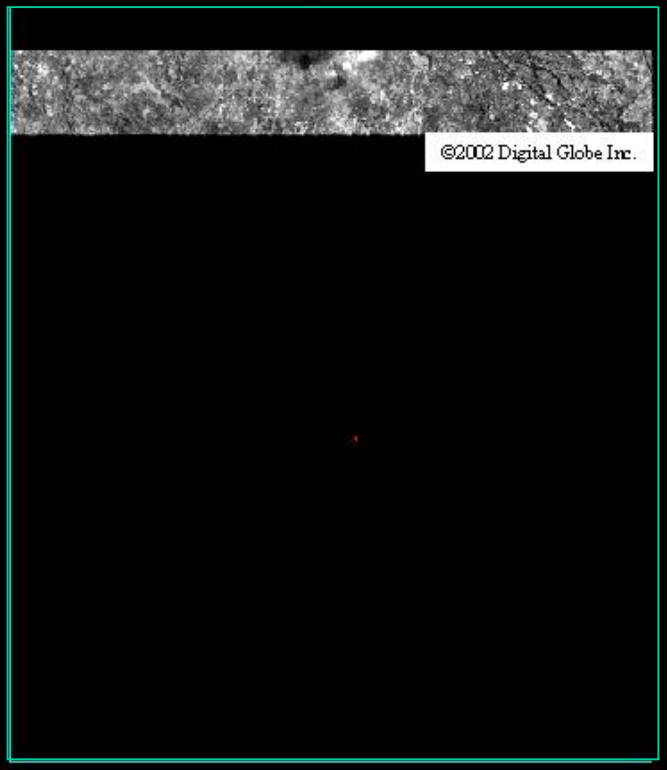
View1 : new_pan1 / new_pan2

Initial position of the 2 pan pieces. It's important to note how the small piece came in. It is actually several thousand meters off because the offset information in the header was unable to be correctly utilized by any of our software packages.



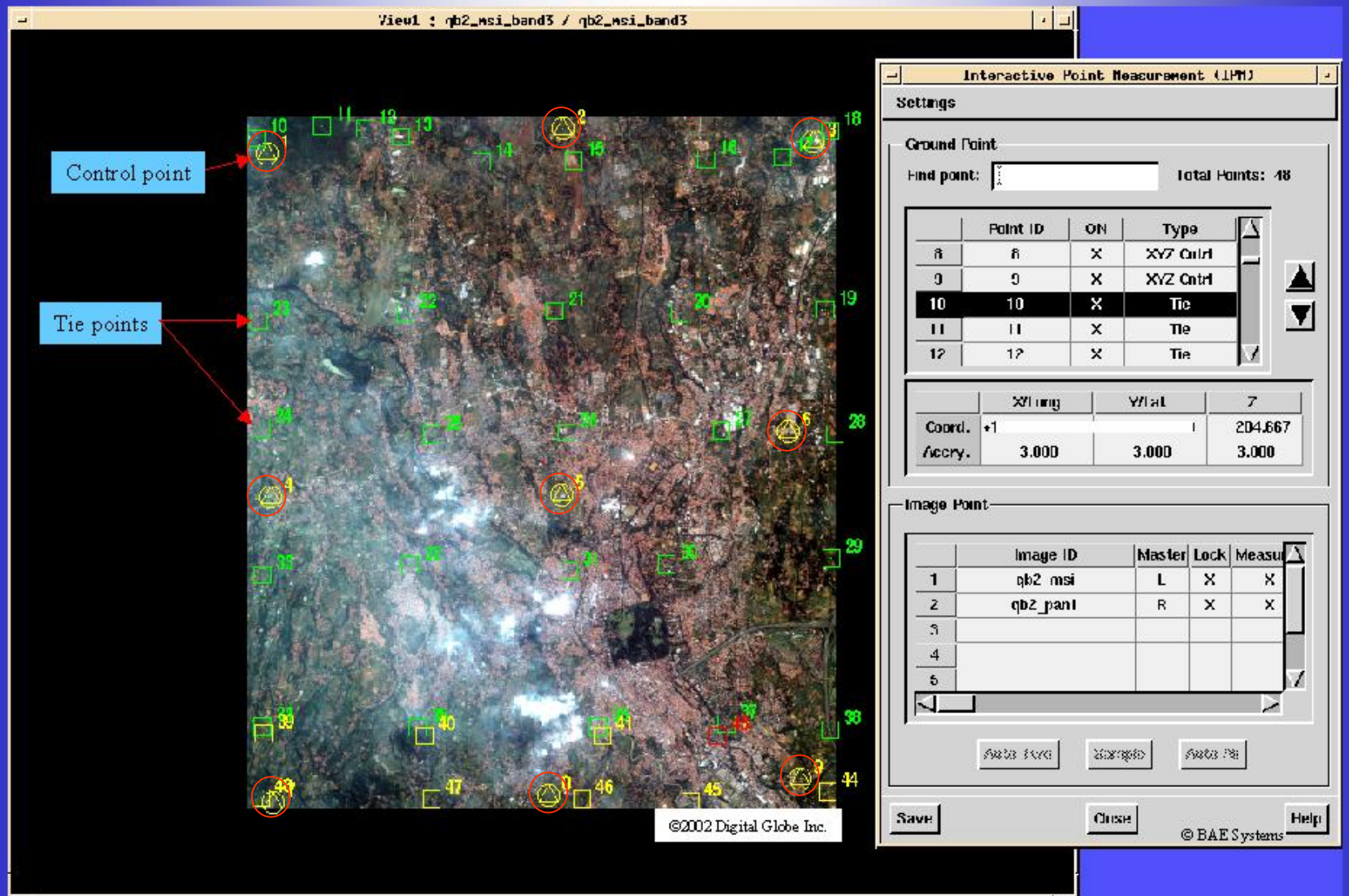


Control Plan

We will control the MSI image, since it is a whole image, using a photogrammetrically derived control base. We will then control the 2 pan images to their newly controlled MSI mate.
Then we will mosaic the pan images together.
Repositionings will be limited to X-Y shifting.

Issue: The pan data, unfortunately, butt-joins. A visible seam will be almost inevitable in this situation.

Point Pattern



XY Control Residuals

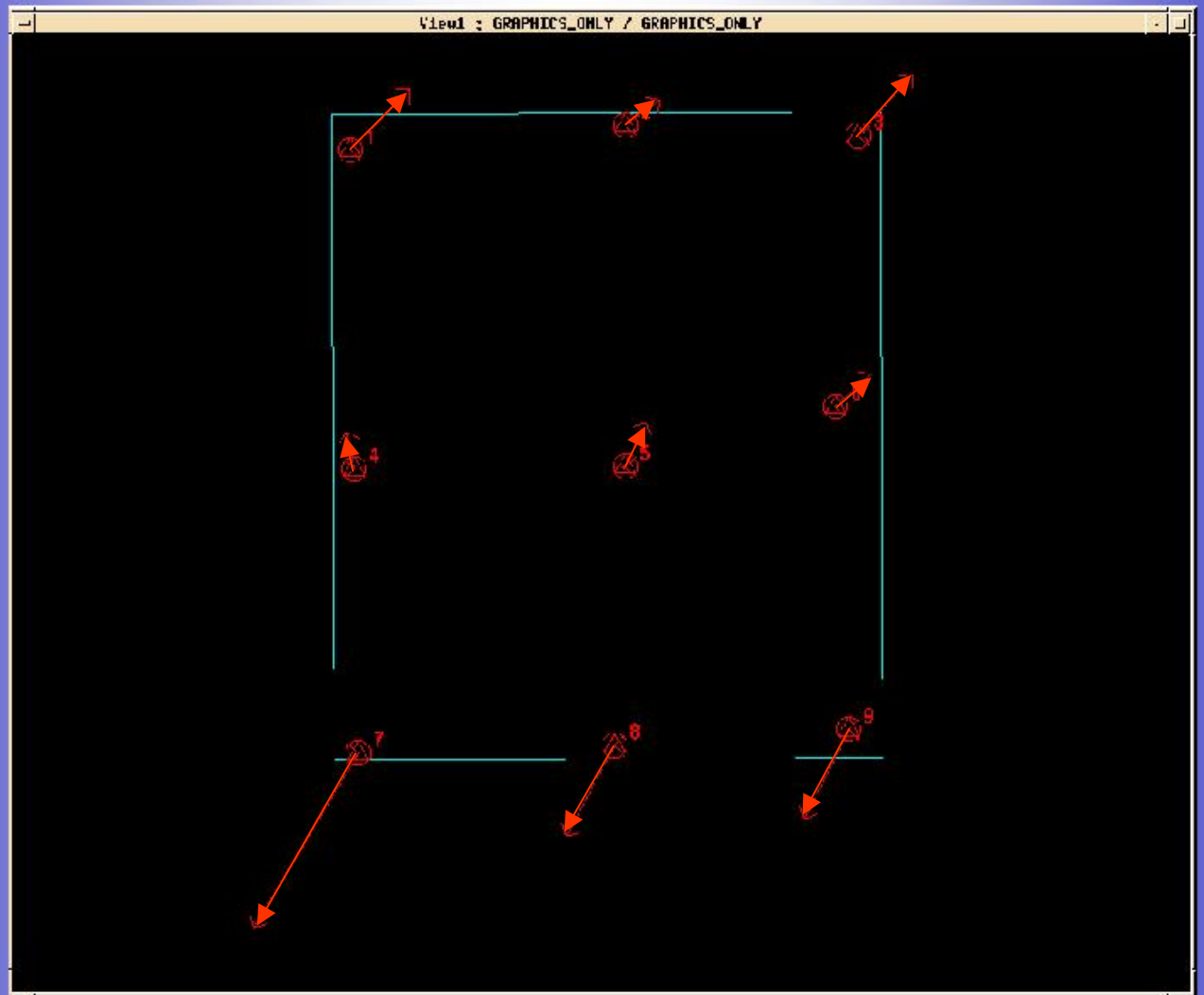
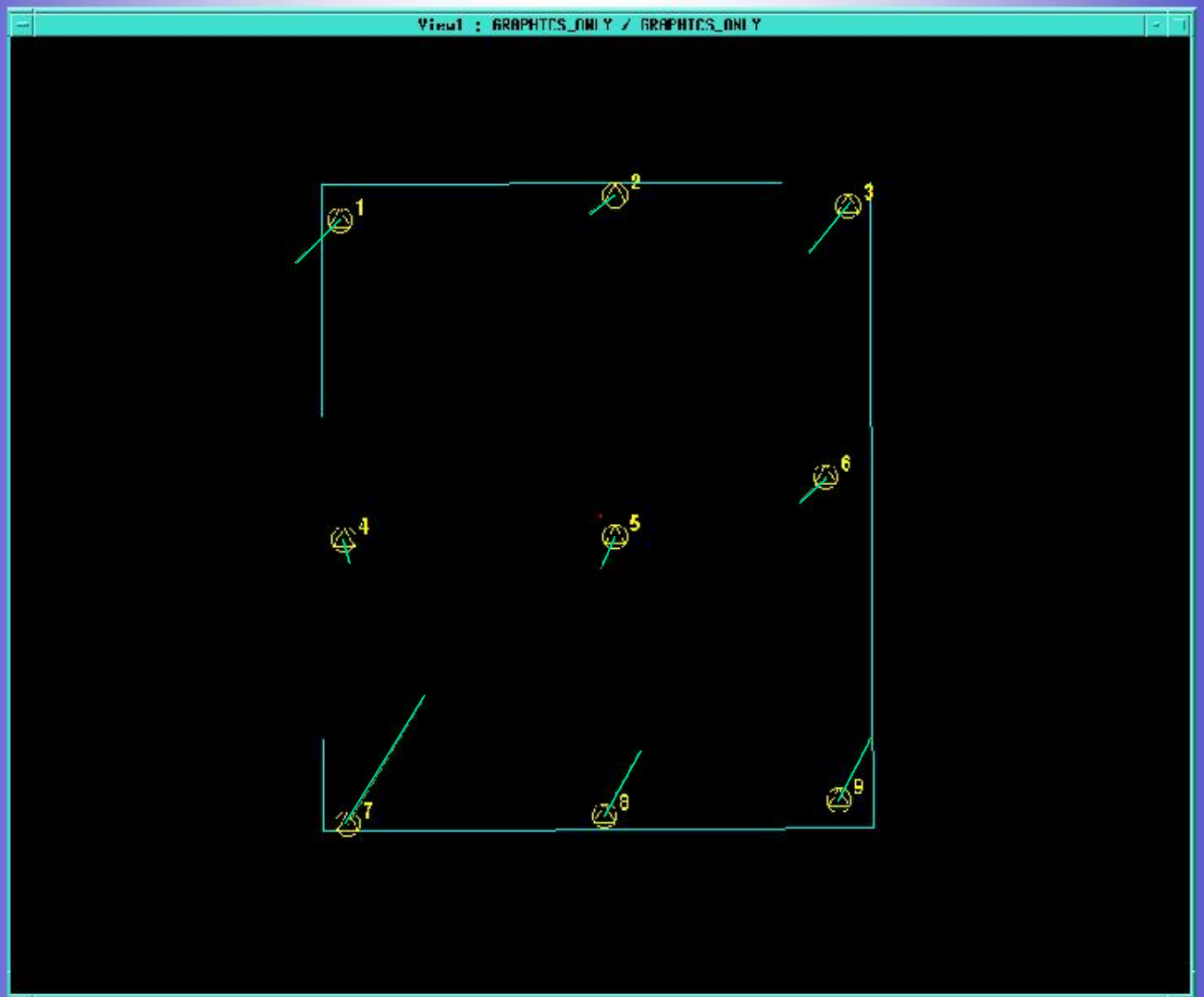


Image Residuals



From the MSI-Control Triangulation Results

GROUND POINT PARAMETERS -GROUND SPACE IN METERS

Image ID, Ground Pt	Number Images	Parameter Name	Original Value	Original Sigma	Residual Value	Adjusted Value	Adjusted Sigma
1	1	x (XYZ Cntrl)	:44:10.544	3.000	4.774	:44:10.700	no sigma
		y	:30:59.769	3.000	4.723	:30:59.615	no sigma
		z	187.583	3.000	-0.000	187.583	no sigma
2	1	x (XYZ Cntrl)	:47:11.841	3.000	2.728	:47:11.930	no sigma
		y	:30:43.342	3.000	1.936	:30:43.279	no sigma
		z	161.114	3.000	-0.000	161.114	no sigma
3	1	x (XYZ Cntrl)	:49:44.706	3.000	4.213	:49:44.843	no sigma
		y	:30:50.764	3.000	4.852	:30:50.606	no sigma
		z	177.099	3.000	-0.000	177.099	no sigma
4	1	x (XYZ Cntrl)	:44:13.604	3.000	-0.630	:44:13.583	no sigma
		y	:34:29.349	3.000	2.936	:34:29.253	no sigma
		z	204.283	3.000	0.000	204.283	no sigma
5	1	x (XYZ Cntrl)	:47:11.864	3.000	1.601	:47:11.917	no sigma
		y	:34:27.497	3.000	3.492	:34:27.383	no sigma
		z	245.274	3.000	-0.000	245.274	no sigma
6	1	x (XYZ Cntrl)	:49:29.710	3.000	2.799	:49:29.801	no sigma
		y	:33:48.209	3.000	2.611	:33:48.124	no sigma
		z	204.560	3.000	-0.000	204.560	no sigma
7	1	x (XYZ Cntrl)	:44:15.668	3.000	8.209	:44:15.400	no sigma
		y	:37:35.888	3.000	3.798	:37:36.337	no sigma
		z	395.946	3.000	0.000	395.946	no sigma
8	1	x (XYZ Cntrl)	:47:04.257	3.000	-3.851	:47:04.132	no sigma
		y	:37:31.115	3.000	-7.124	:37:31.347	no sigma
		z	323.963	3.000	-0.000	323.963	no sigma
9	1	x (XYZ Cntrl)	:49:38.225	3.000	-3.512	:49:38.111	no sigma
		y	:37:20.474	3.000	-7.044	:37:20.703	no sigma
		z	353.323	3.000	-0.000	353.323	no sigma

Straight line: 3.0m

Straight line: 16.0m

RMS x	==>	4.227
RMS y	==>	5.394
RMS z	==>	0.000
Total RMS	==>	7.611

Important reminder: These results are for a single example of Standard 2A data. They should not be considered a representative result.

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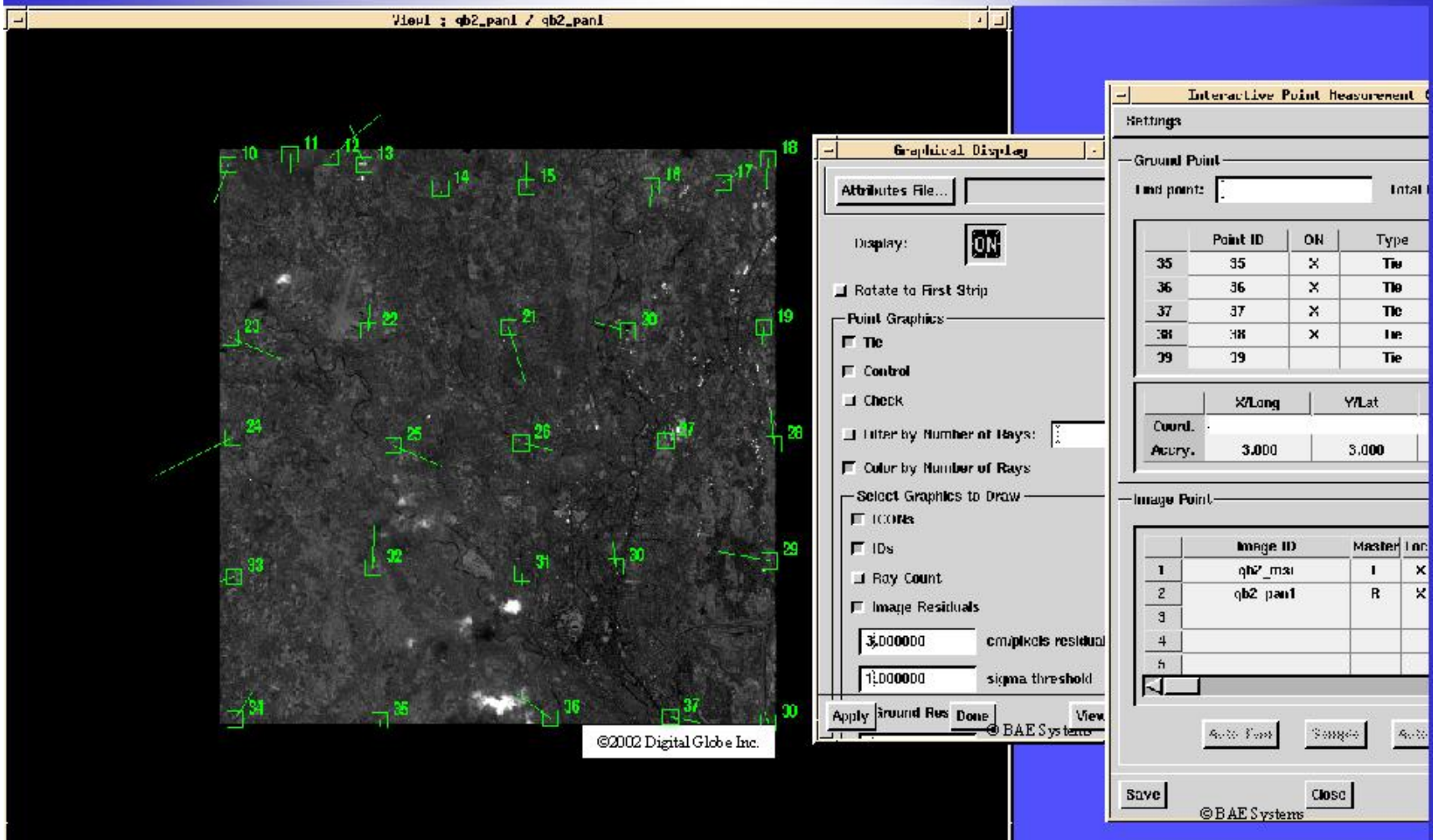
Point pattern on the top image of the pan pair

Image residual vectors are displayed



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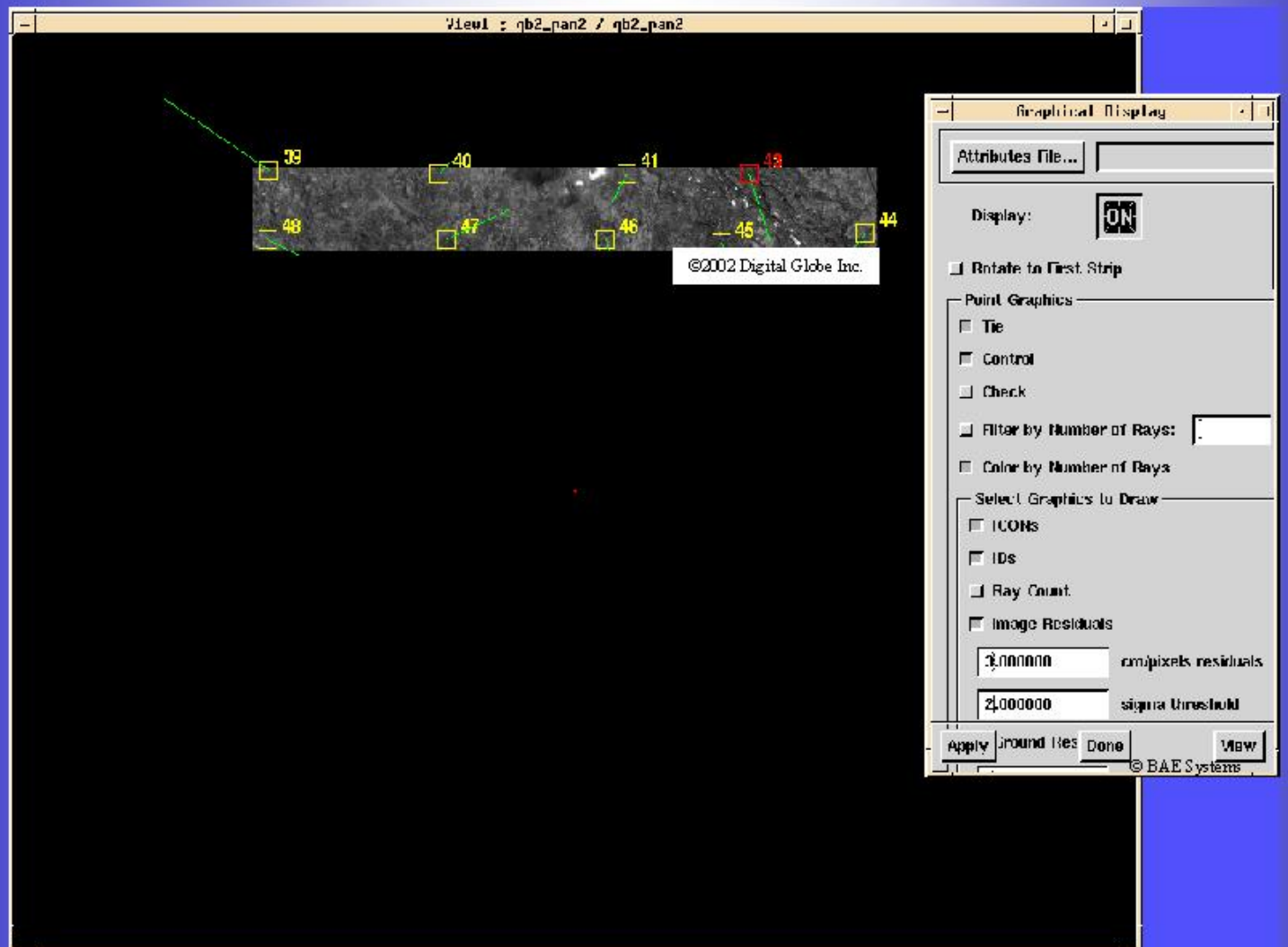
Point pattern on the bottom image of the pan pair

Image residual vectors are displayed



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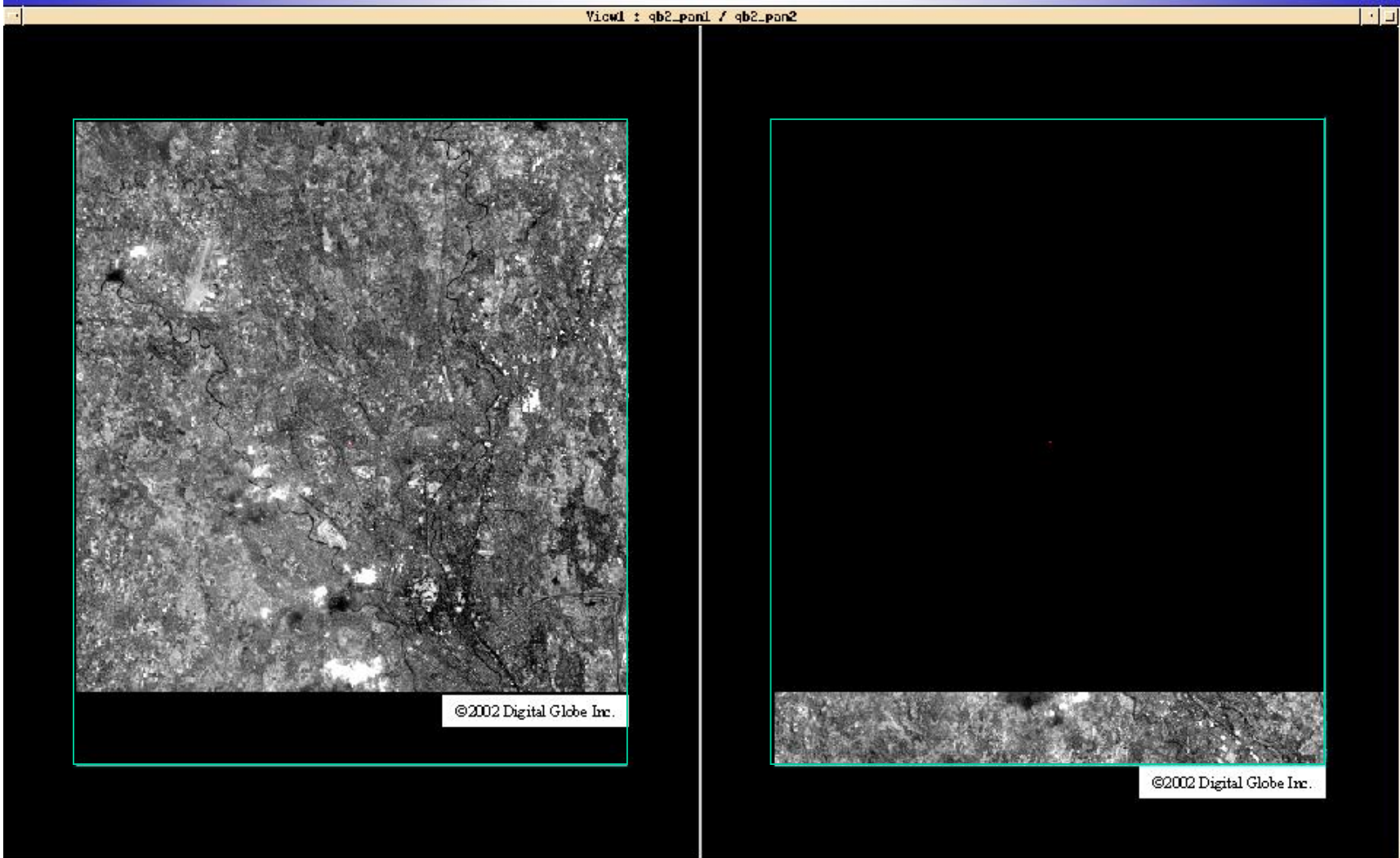
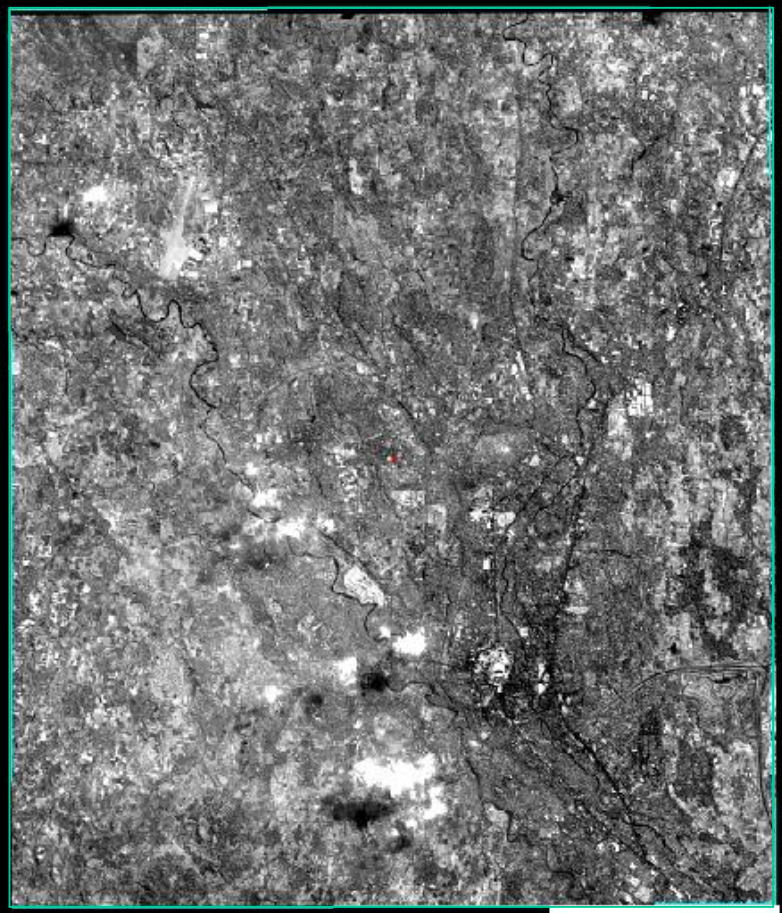
Both pan images after being controlled to their MSI mate



View1 : pan_merge_on / pan_merge_on

The new mosaicked pan image



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…but what about the seam…

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Bilinear Interpolation Resampling

(Note stripe is continuous)

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Nearest Neighbor Resample

(Note stripe now broken up)

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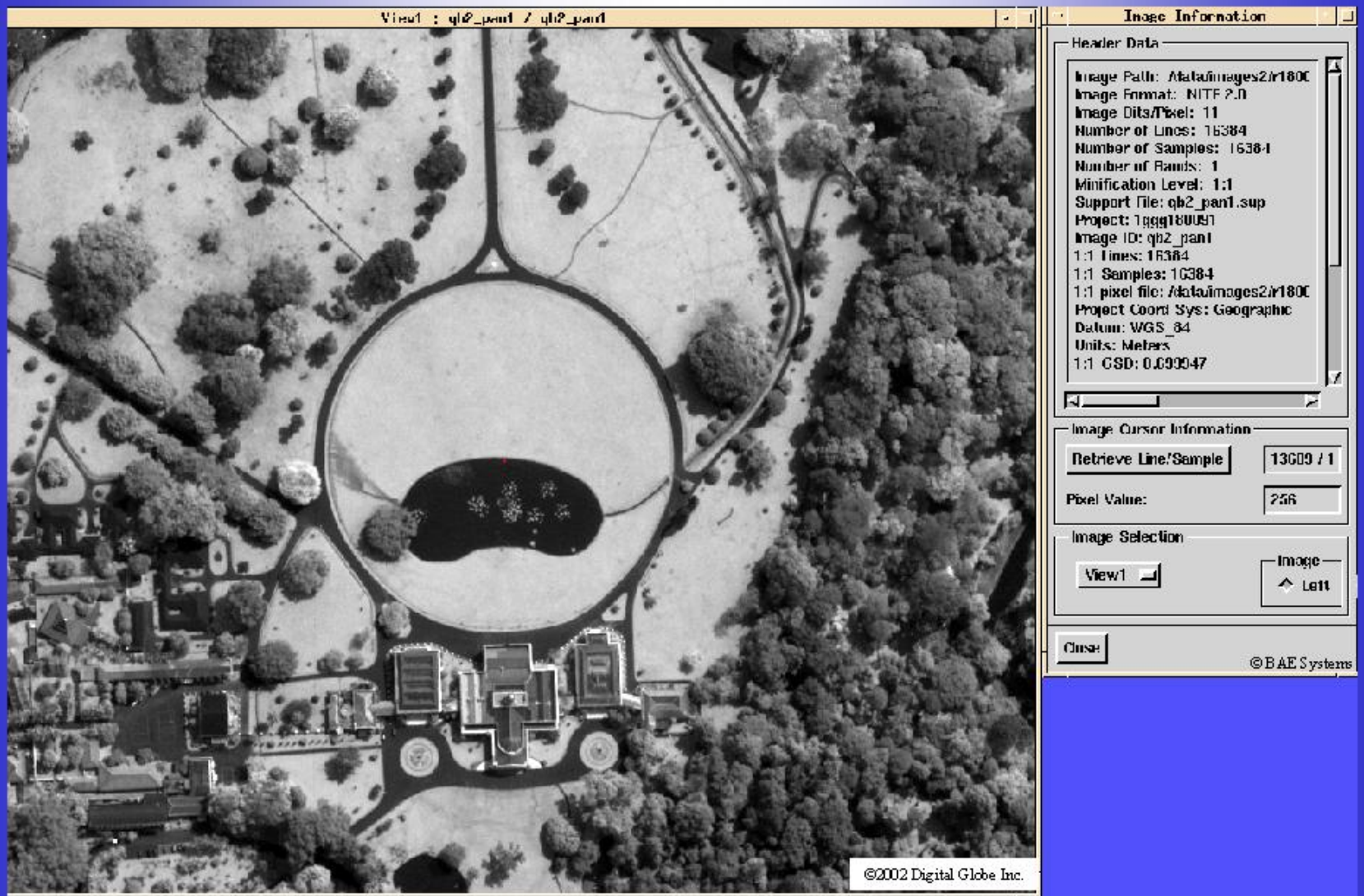
Quantization levels- the original 11-bit image



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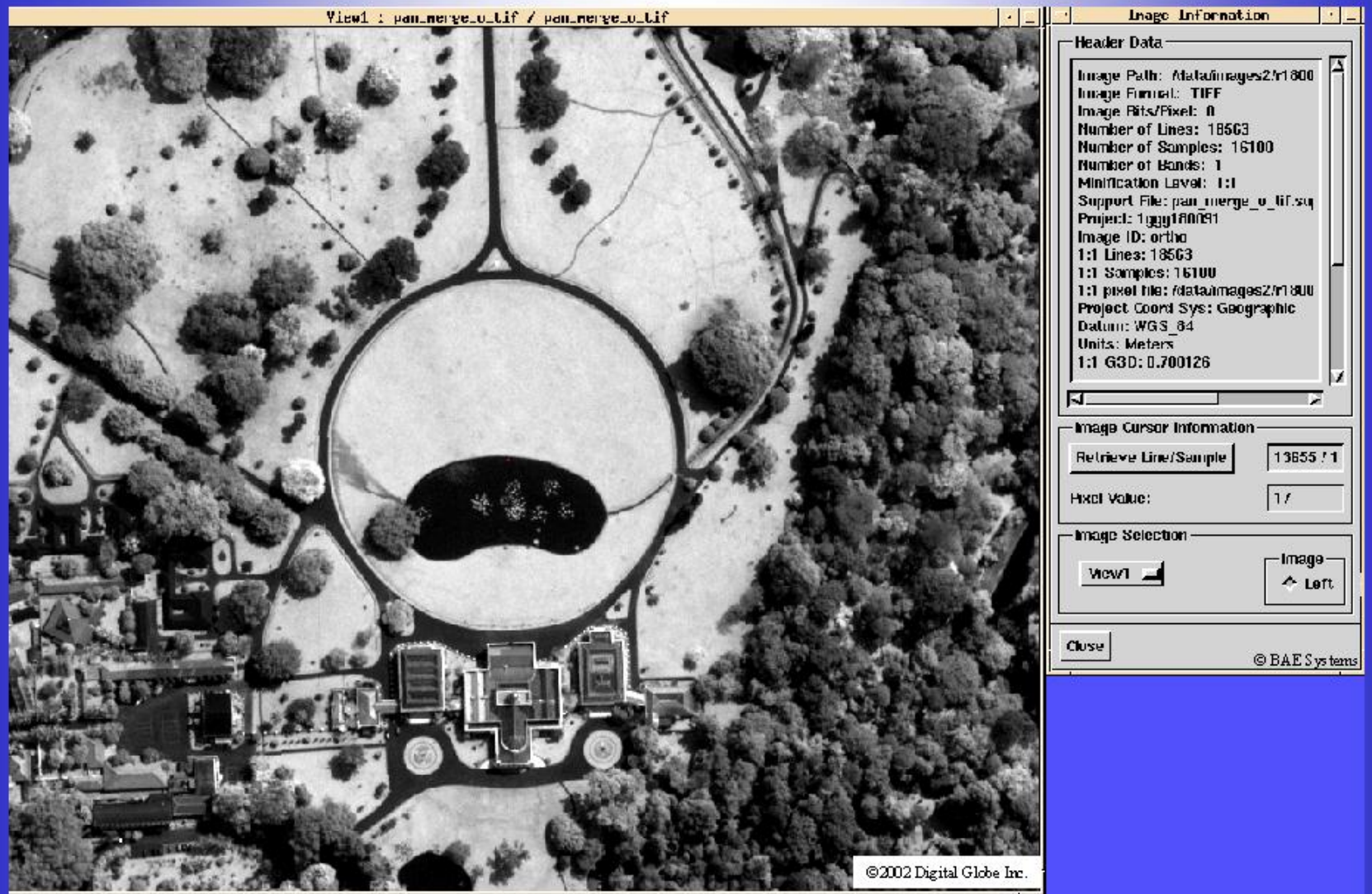
11 to 8 bit conversion using Socet Set



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Example of light area washout using Socet Set to convert from 11 to 8 bit

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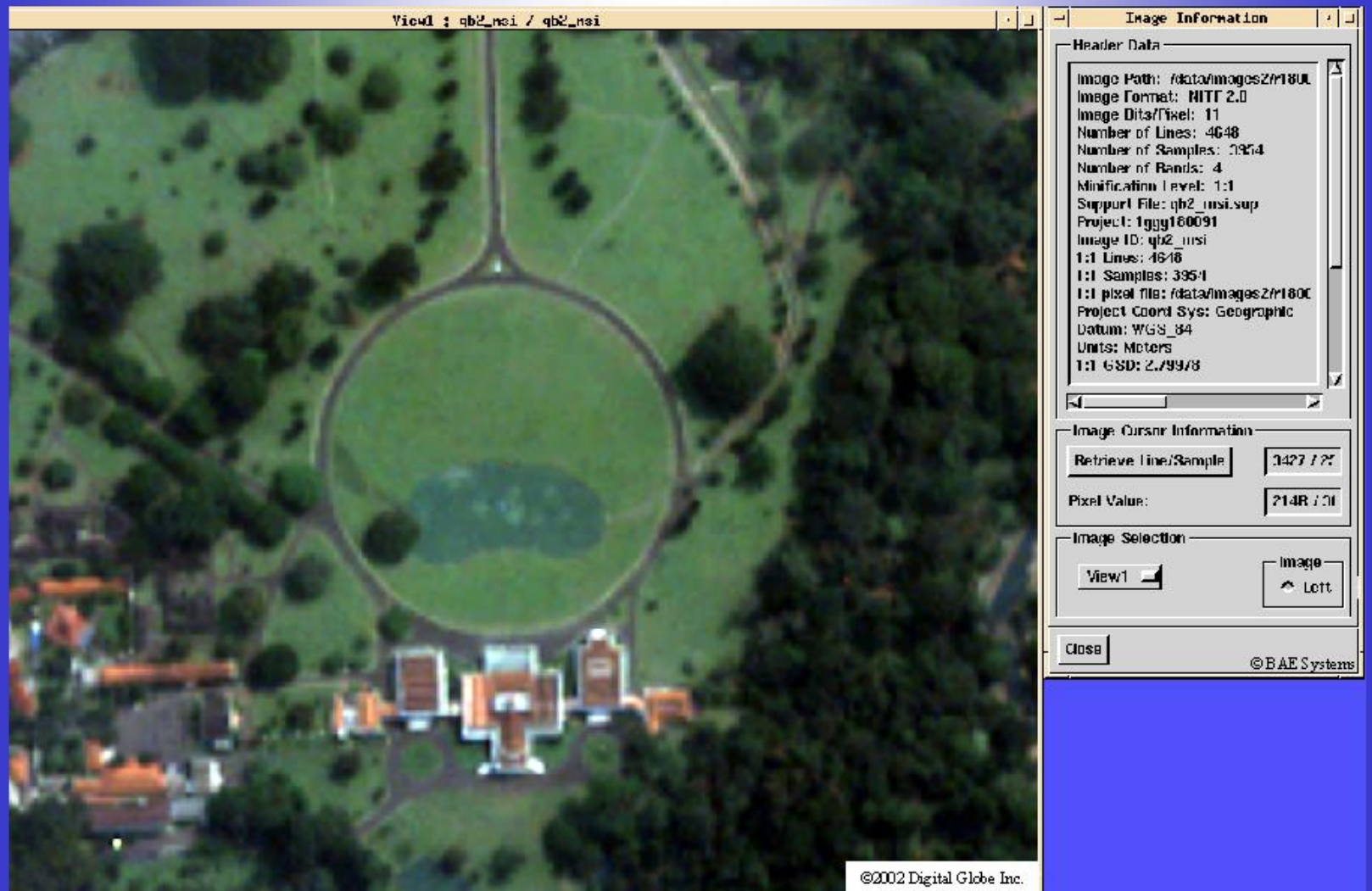
Problem of converting 11 bit multispectral to 8 bit using Socet Set



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The resulting image cannot be recovered via any image enhancement techniques

View1 : qb2_msi_band3n / qb2_msi_band3n

Image Information

Header Data

Image Path: /data/images2/r10009
Image Format: NITF 2.0
Image Bits/Pixel: 8
Number of Lines: 4648
Number of Samples: 3954
Number of Bands: 3
Minification Level: 1:1
Support File: qb2_msi_band3n.sup
Project: 1ggg160001
Image ID: qb2_msi
1:1 Lines: 4648
1:1 Samples: 3954
1:1 pixel file: /data/images2/r10009/qb2_msi
Project Coord Sys: Geographic
Datum: WGS 84
Units: Meters
1:1 GSD: 2.79976

Image Cursor Information

Retrieve Line/Sample | 3133 / 2530

Pixel Value: | 54R / 255G / 156B

Image Selection

View1

Image: Left Right

Close

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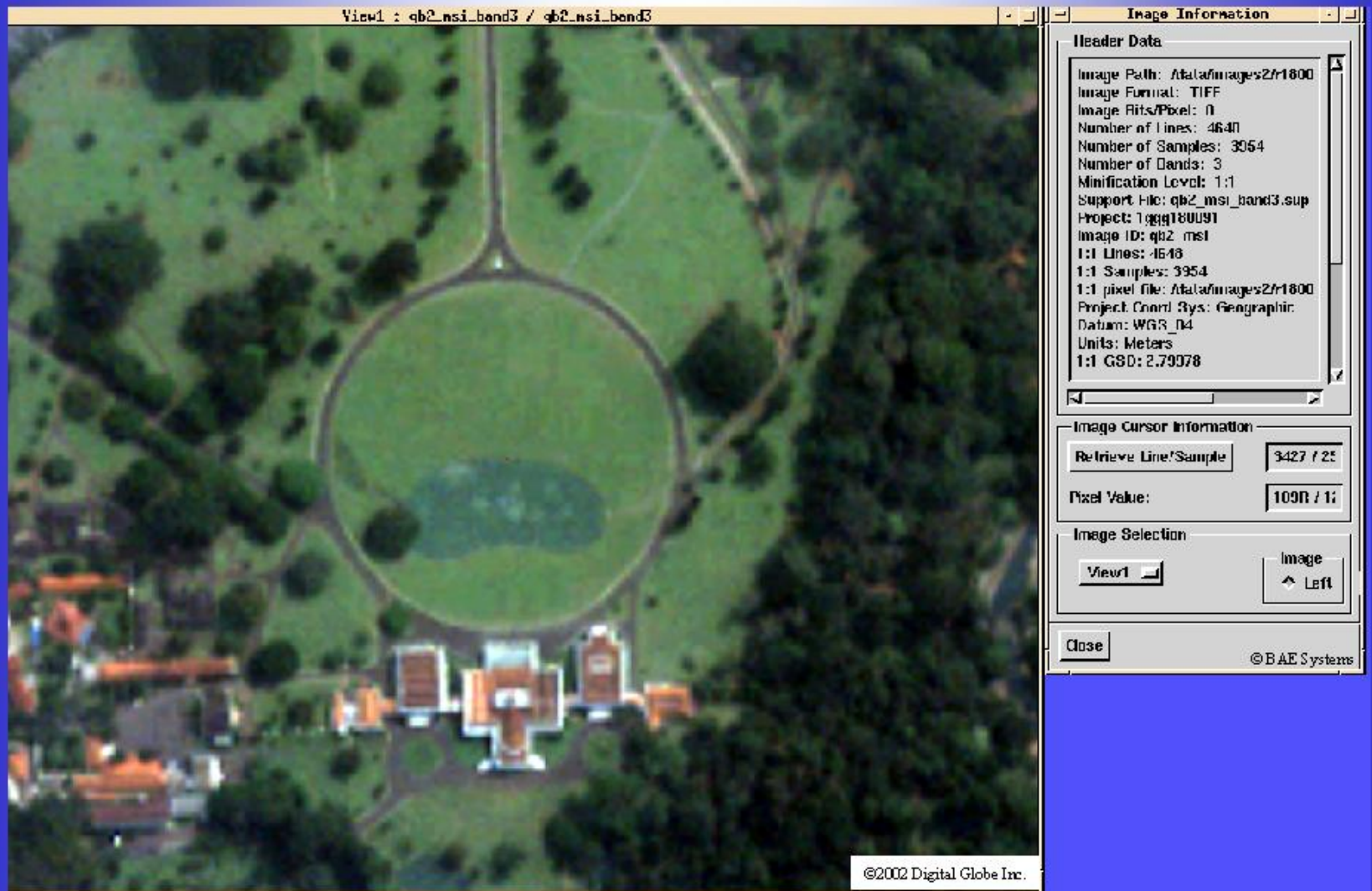
Using ERDAS Image's Lookup Table Stretch to output an 8-bit 3 band TIFF image



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Both images are prepared for resolution merge in Socet Set- both are 8 bit and are in NITF* format

View1 : pan_msi_resmerge_o / pan_msi_resmerge_o
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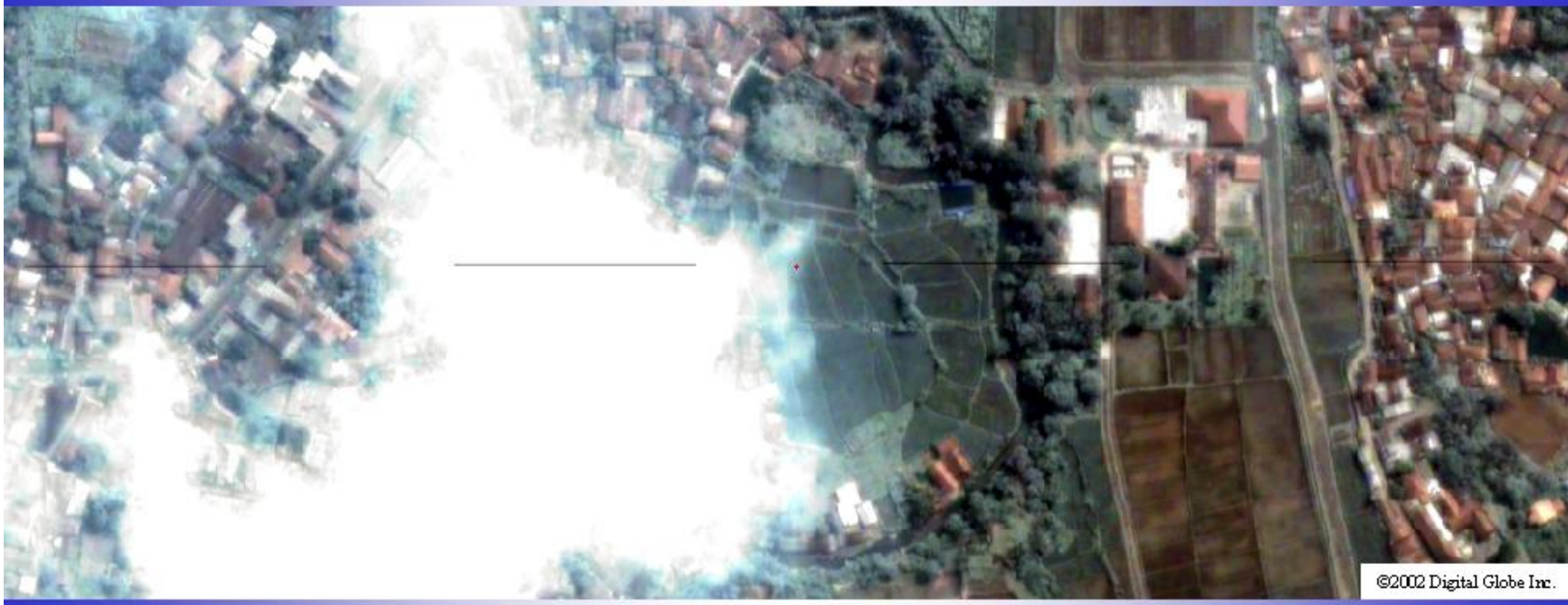
How the seam looks in the resolution merged image



Issues and Solutions

Socet Set will not control a 4-band image. -We made a 3 band image in Socet Set via a command-line instruction.

Socet Set will not resolution merge 11 bit data. -We made 8 bit data using ERDAS Imagine instead.

Quickbird 2A is ortho'd to a course DEM and can come in pieces. -We removed as much mean (x-y) error as possible from the largest image and tied the smaller pan image mates to it.

NOTE: The newer Attitude Determination Processes (ADP's) from Digital Globe will correct the very large (646 meter) initial image offset we found. With ADP 2.1 this kind of error should not happen.

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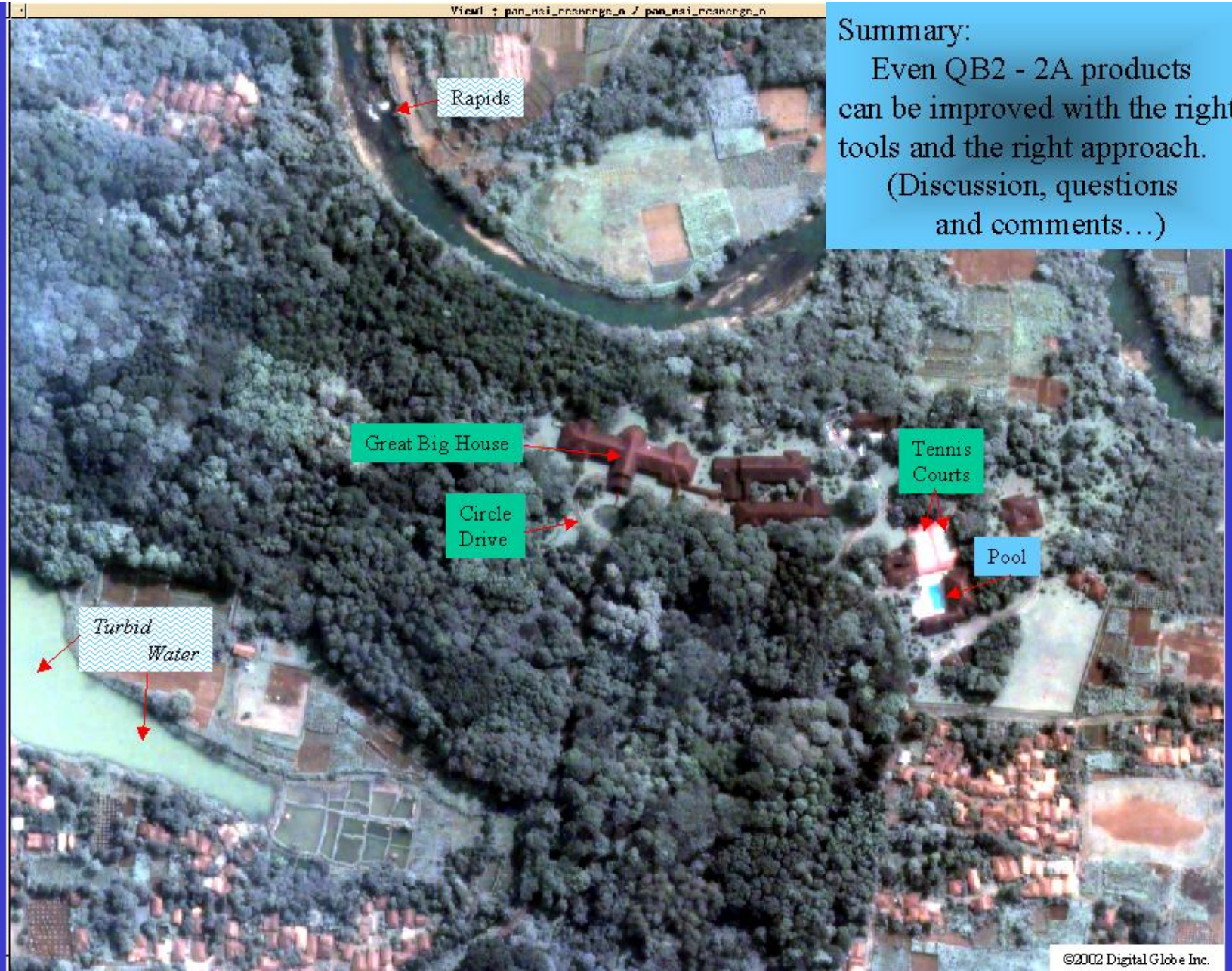

Summary:

Even QB2 - 2A products can be improved with the right tools and the right approach.

(Discussion, questions and comments…)

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