

# DIGITAL MAPPING TECHNIQUES 2013

The following was presented at DMT'13  
(June 2-5, 2013 - Colorado Geological Survey and Colorado School of Mines  
Golden, CO)

The contents of this document are provisional

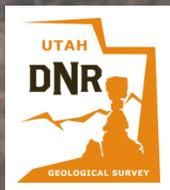
See Presentations and Proceedings  
from the DMT Meetings (1997-2013)

<http://ngmdb.usgs.gov/info/dmt/>

# State-Wide Stereo Model Coverage for Utah

Kent D. Brown  
Utah Geological Survey

June 2-5, 2013  
Golden, Colorado



## *State-Wide Stereo Model Coverage*

In 1990, the Utah Geological Survey began using photogrammetry technology to map the geology of Utah.



## *State-Wide Stereo Model Coverage*

### What is photogrammetry?

The science of making reliable and precise 3-D measurements by the use of stereo aerial photographs.

# *Analytical Photogrammetry*

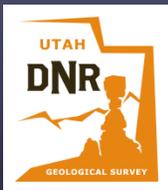
## Our First Phase

Analytical Photogrammetry:  
Stereoplotter and VrOne Software

# *Analytical Photogrammetry*



With a special legislative appropriation, the UGS purchased an analytical stereoplotter, the Alpha 2000.



# Analytical Photogrammetry

**Stereo Pair Used For Reference**

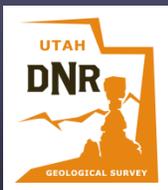
**Control Points Placed Using Digital Ortho**

**Digital Ortho And Control Points Draped Over DEM**

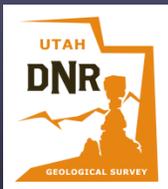
EXT	X	Y	Z_METERS	Z_FEET	TYPE
	426335.017	4483105.518	1402.166	4600.282	xyz
	426542.373	4480764.364	1736.328	5696.614	xyz
	426297.012	4481626.298	1556.78	5107.546	xyz
	427729.635	4482240.778	1567.549	5142.877	xyz
	427785.807	4480517.576	1882.849	6177.326	xyz

**3D Points Exported To Text File**

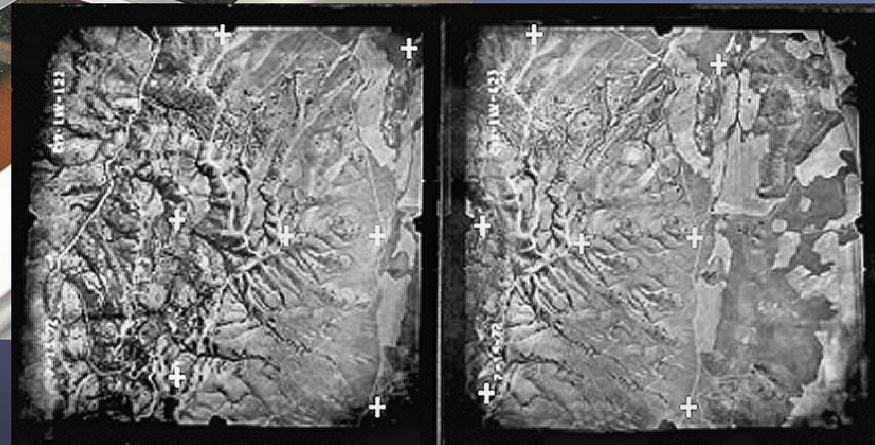
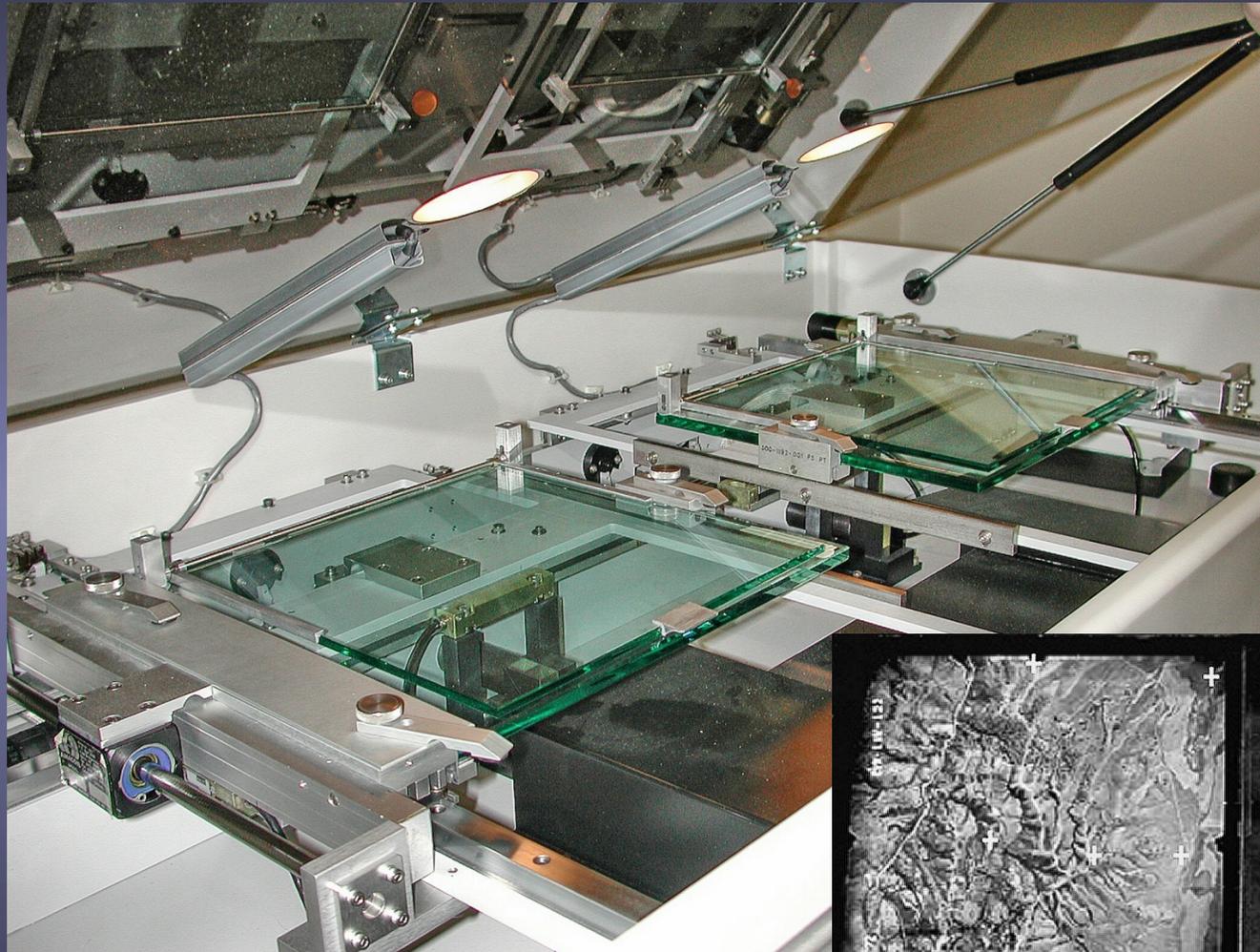
Establish hundreds of ground control points.



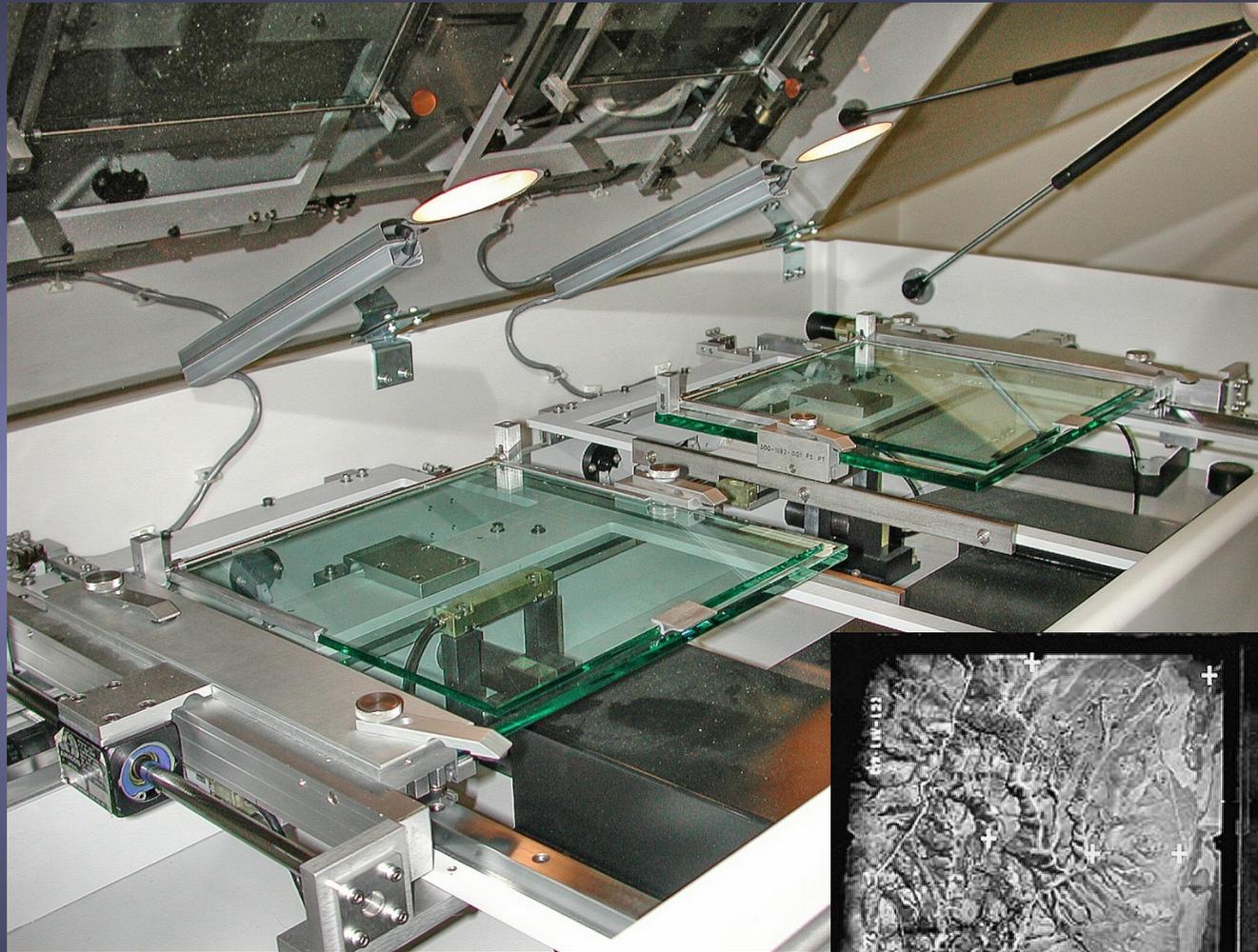
# *Analytical Photogrammetry*



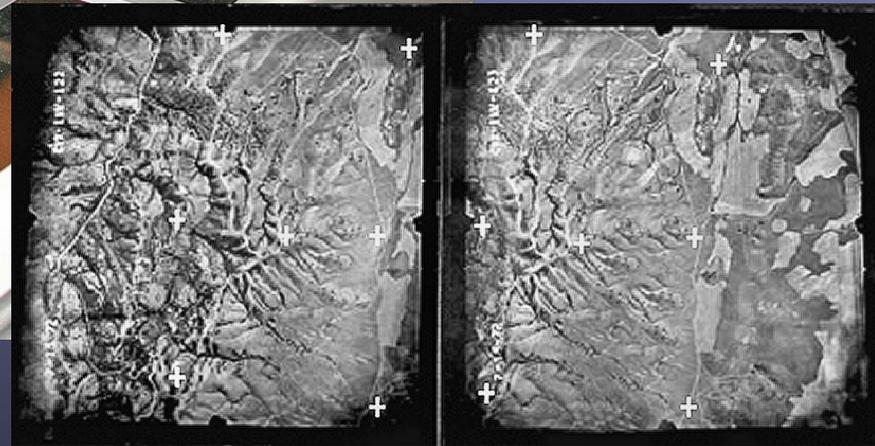
# *Analytical Photogrammetry*



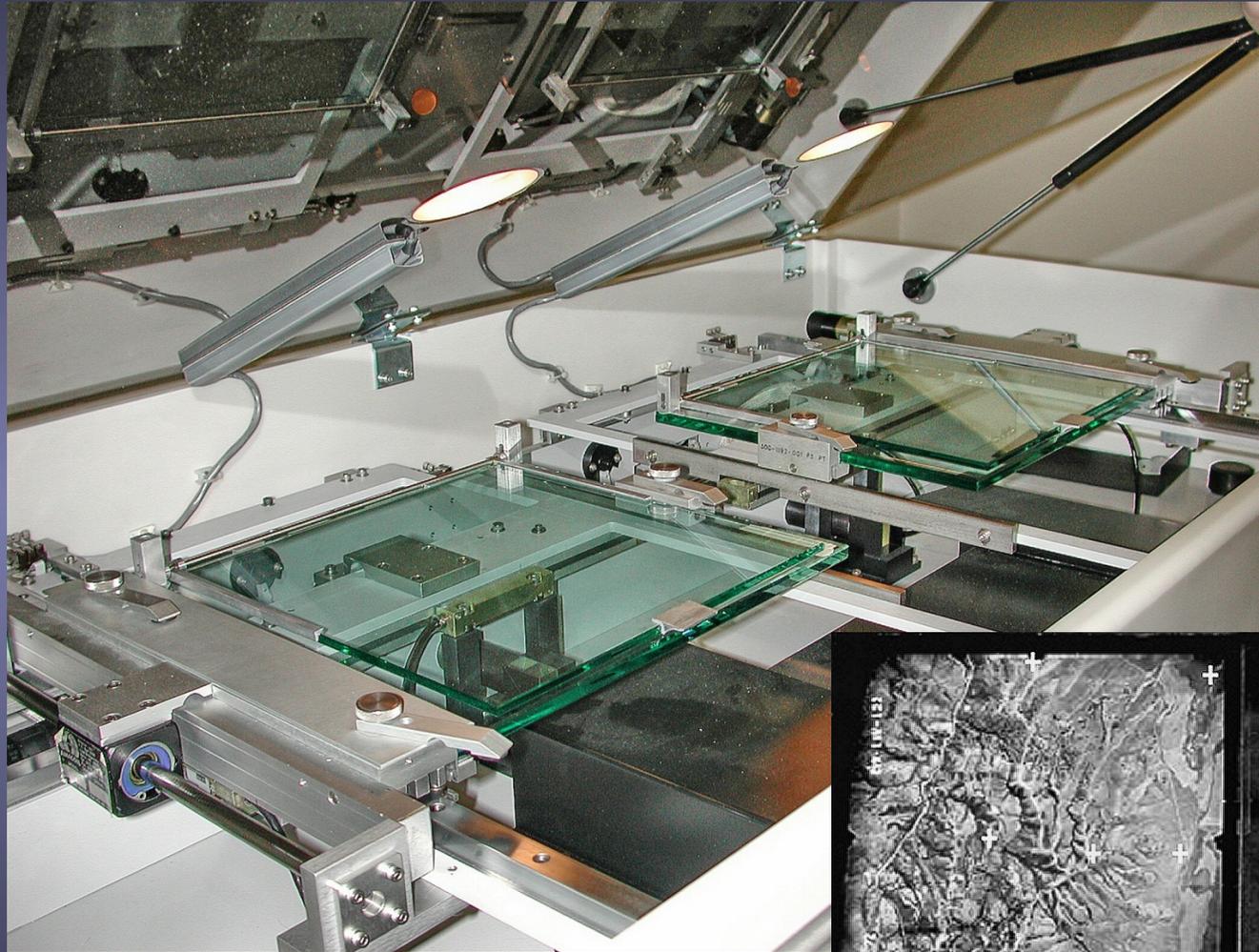
# *Analytical Photogrammetry*



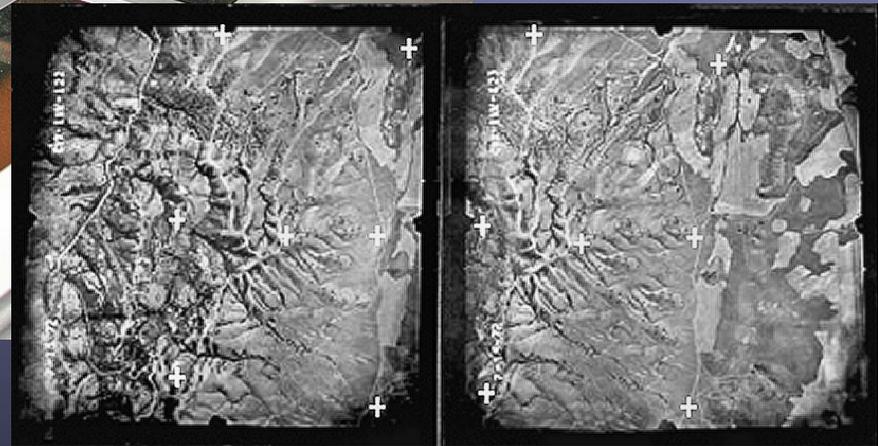
Three orientations:



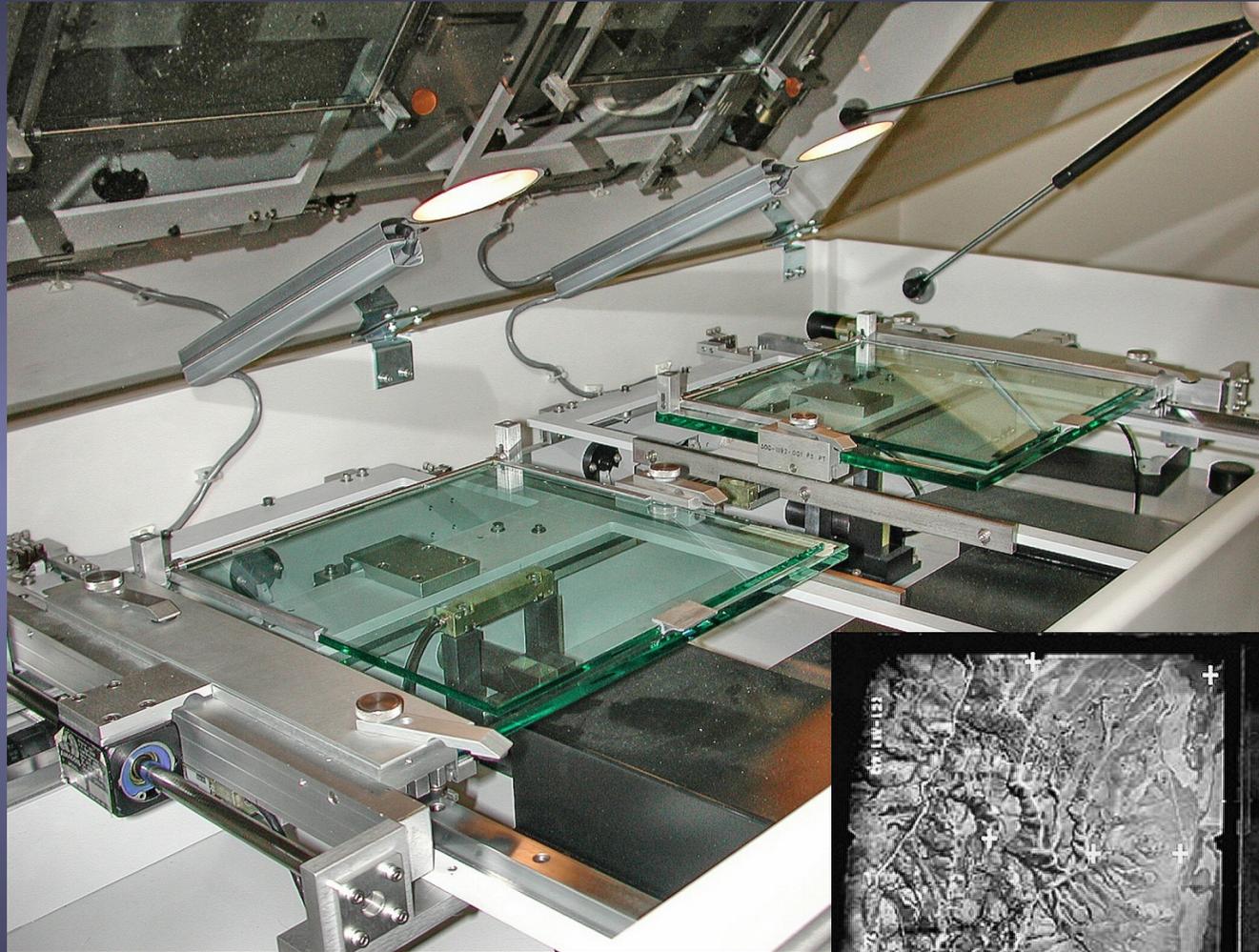
# Analytical Photogrammetry



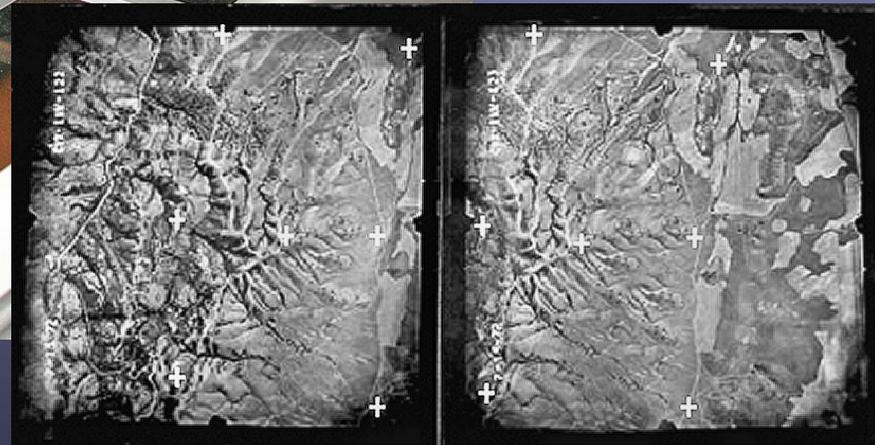
Three orientations:  
Inner Orientation



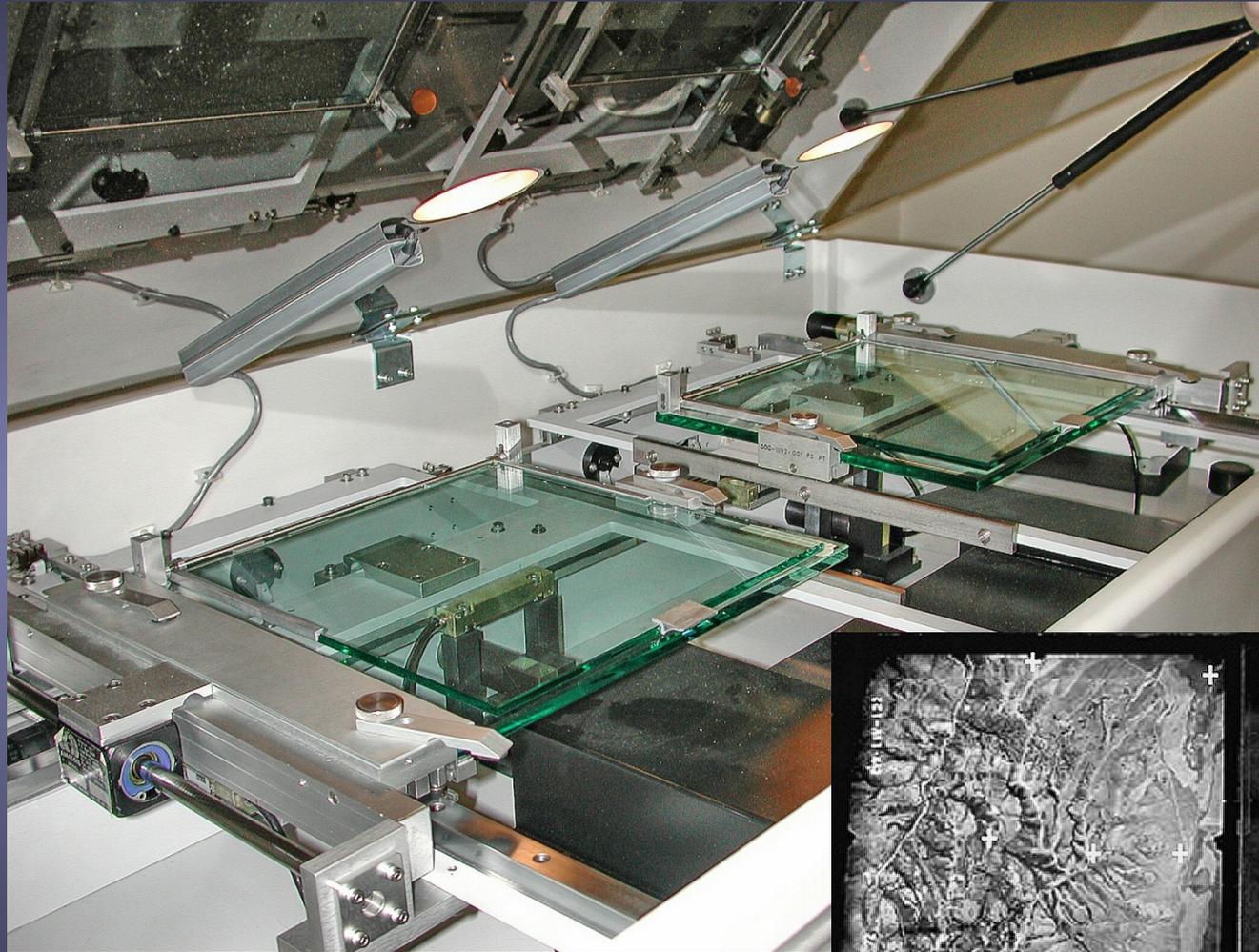
# Analytical Photogrammetry



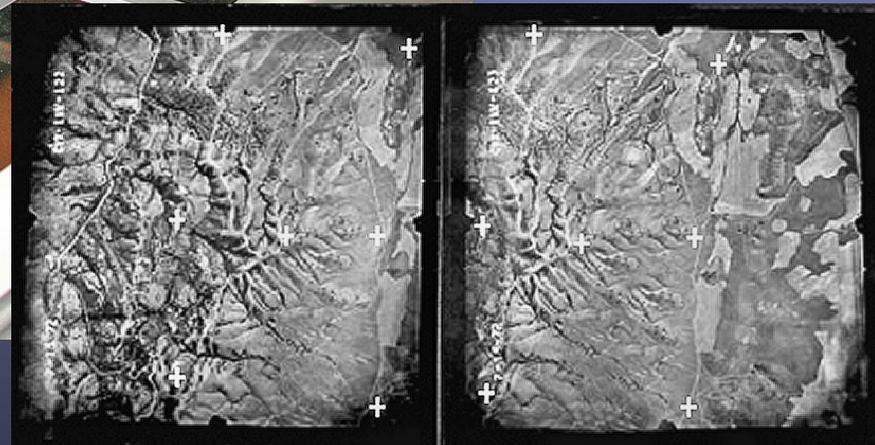
Three orientations:  
Inner Orientation  
Relative Orientation



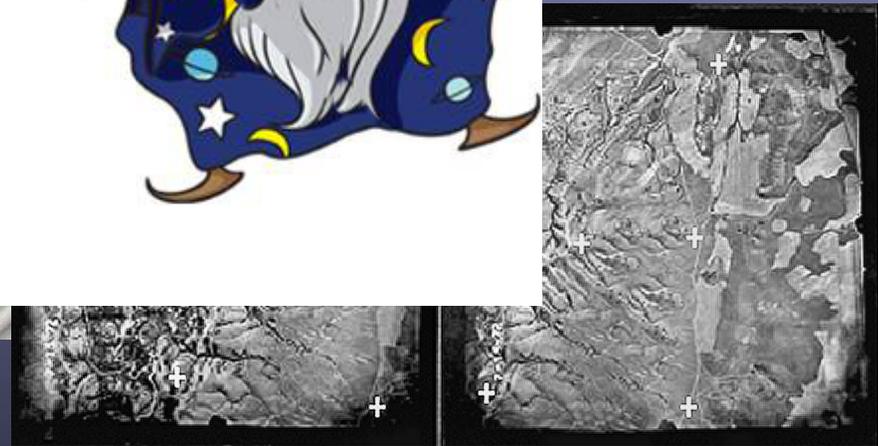
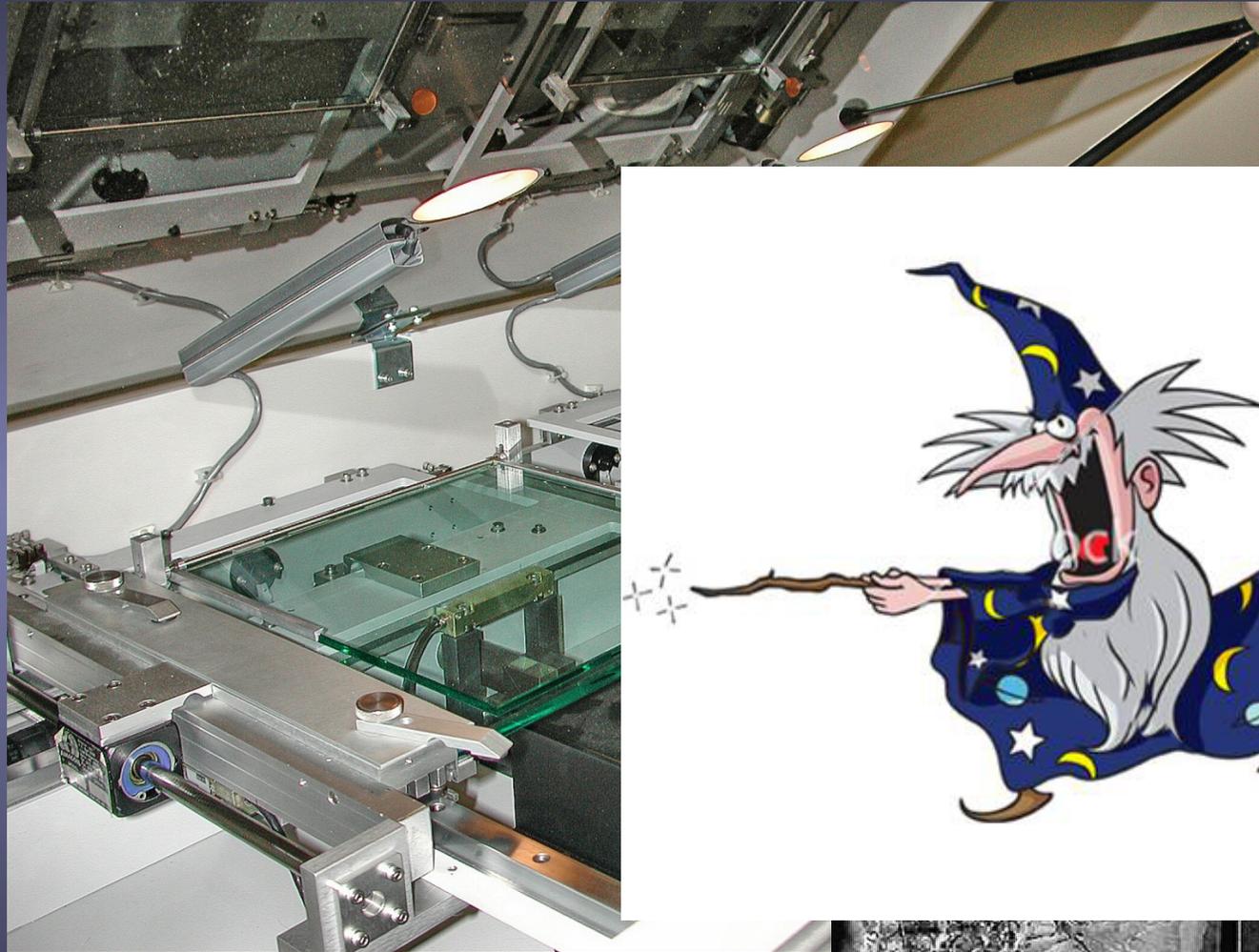
# Analytical Photogrammetry



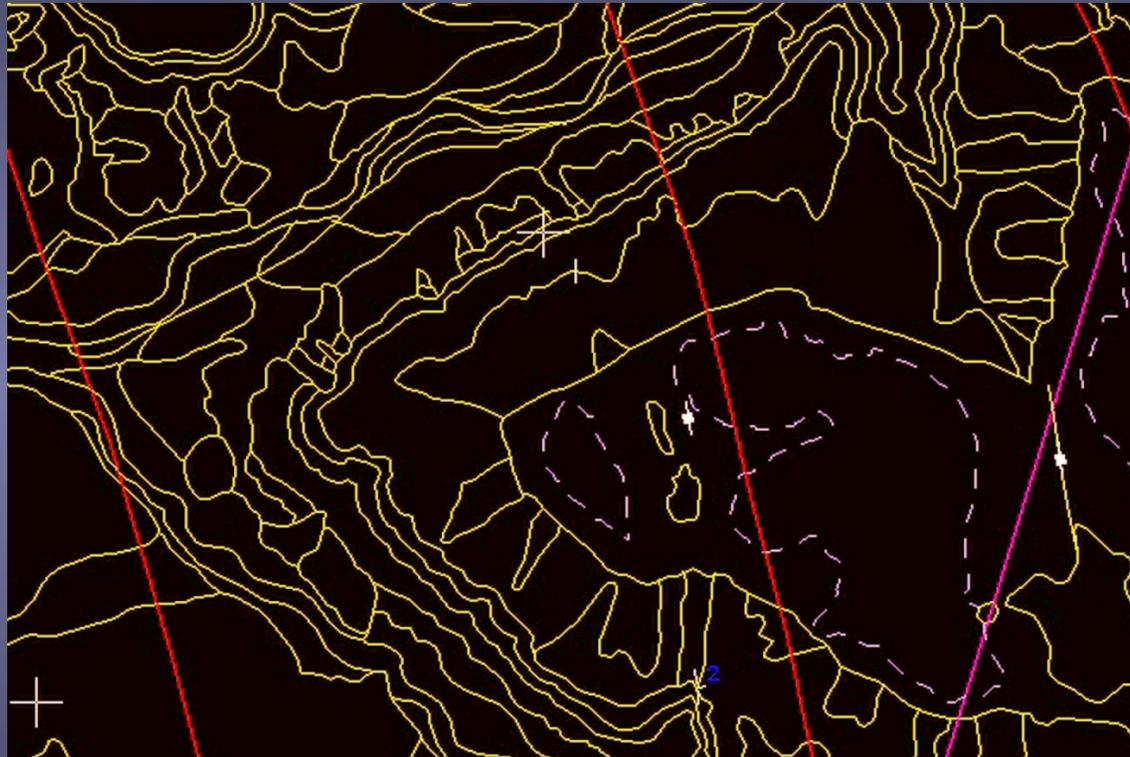
Three orientations:  
Inner Orientation  
Relative Orientation  
Absolute Orientation



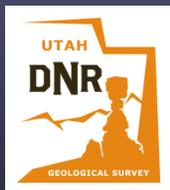
# *Analytical Photogrammetry*



# *Analytical Photogrammetry*



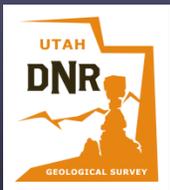
This is what you see on the applications computer screen.



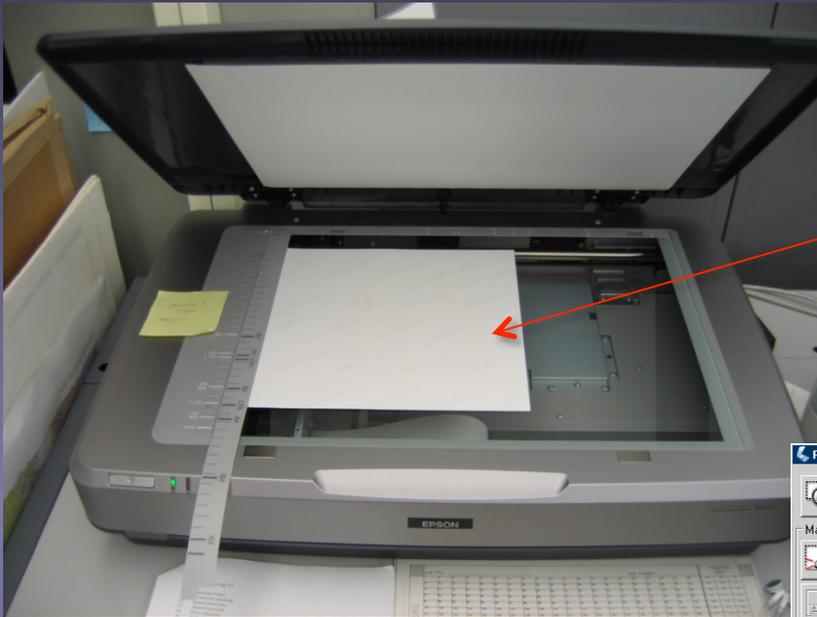
# *Digital Photogrammetry*

## Next Phase

Digital Photogrammetry:  
VrTwo

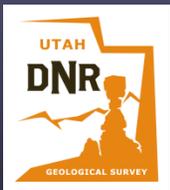
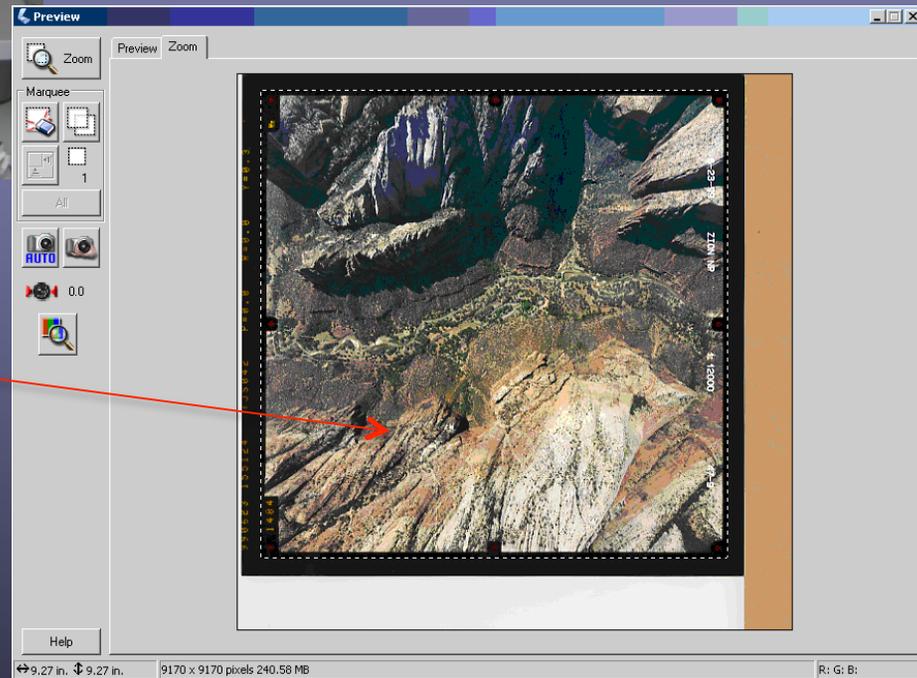


# Digital Photogrammetry



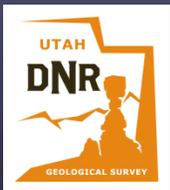
Scan aerial photos at high-resolution (>1000ppi)

Save images as TIF files



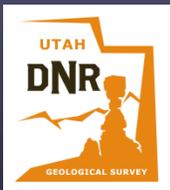
# *Digital Photogrammetry*

- Same ground control as with analytical



# *Digital Photogrammetry*

- Same ground control as with analytical
- Use TIF image files instead of paper prints



# *Digital Photogrammetry*

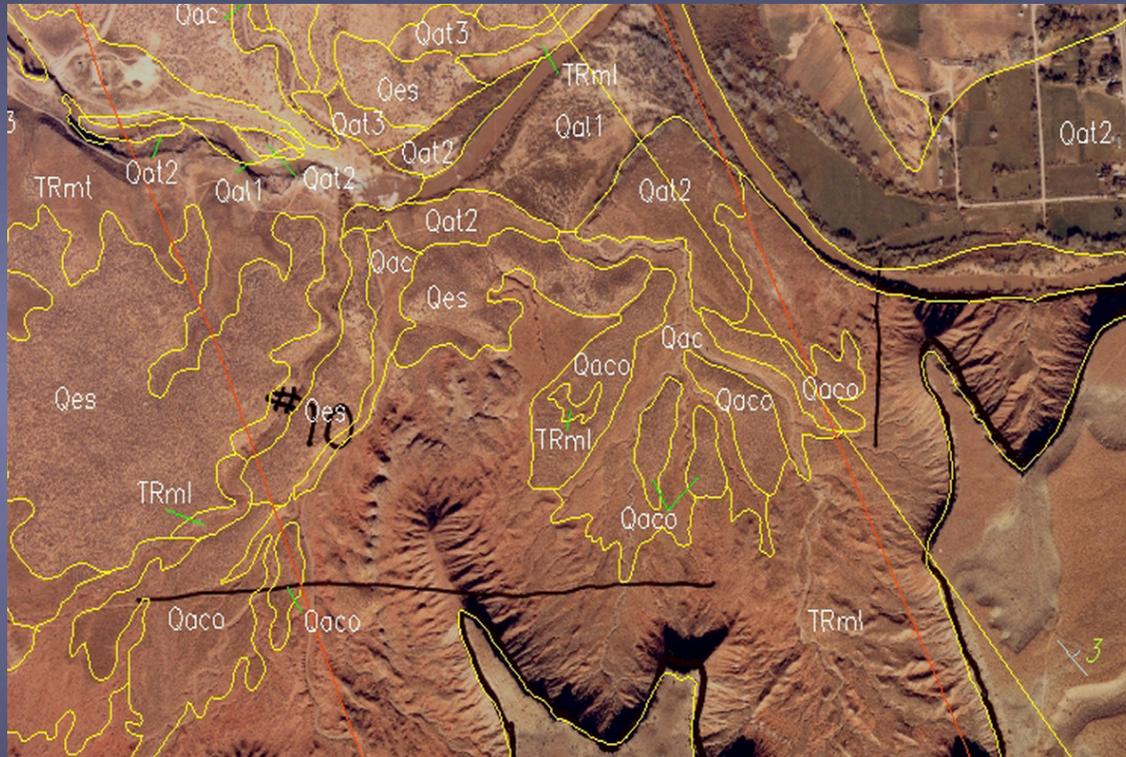
- Same ground control as with analytical
- Use TIF image files instead of paper prints
- Same as before!



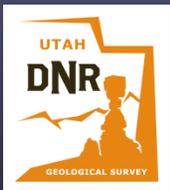
# *Digital Photogrammetry*



# *Digital Photogrammetry*



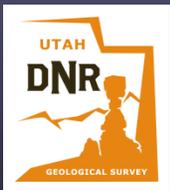
This is what you see on the CRT monitor.



# *Digital Photogrammetry*

## Great Technology but...

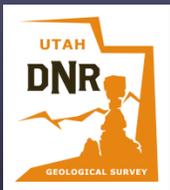
- Still need to locate and purchase suitable aerial photos



# *Digital Photogrammetry*

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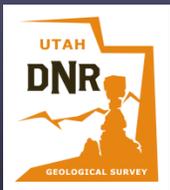
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- Still need to establish ground control for each project



# *Digital Photogrammetry*

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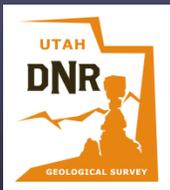
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- Still need to establish ground control for each project
- Scanning and image processing is time-consuming



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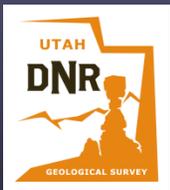
- Still need to locate and purchase suitable aerial photos
- Still need to establish ground control for each project
- Scanning and image processing is time-consuming
- Full process is still labor intensive, but is a great benefit for geologic mapping



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## Great Technology but...

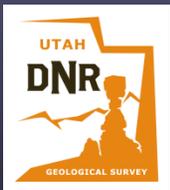
- Still need to locate and purchase suitable aerial photos
- Still need to establish ground control for each project
- Scanning and image processing is time-consuming
- Full process is still labor intensive, but is a great benefit for geologic mapping
- *Any way to streamline the process?*



# *Digital Photogrammetry*

## Fortunately...yes!

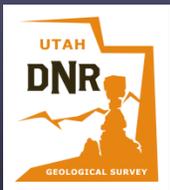
Let's look at the origin of the nation-wide digital orthophotos



## *Digital Photogrammetry*

# National Aerial Imagery Program (NAIP)

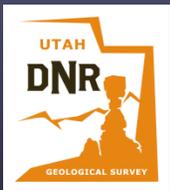
- A federal government contract program where every year approx. 1/3 of the nation is covered with new stereo aerial photography; so every state is covered on a 3-year cycle.



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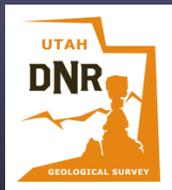
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- Utah was covered in 2006, 2009, and again in 2011.



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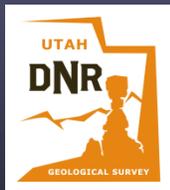
- A federal government contract program where every year approx. 1/3 of the nation is covered with new digital stereo aerial photos; so every state is covered on a 3-year cycle.
- Utah was covered in 2006, 2009, and again in 2011.
- This digital stereo aerial imagery is used to produce the 1-meter digital orthos for each state; a separate product.



# *NAIP Imagery Program*

## 2009 Utah NAIP Imagery

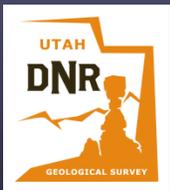
- Contracted to Surdex Corp., Chesterfield, MO



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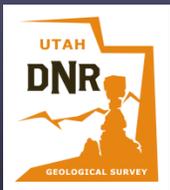
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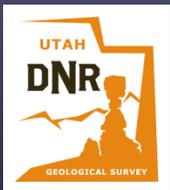
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- Imagery acquired with the Z/I DMC II digital frame aerial camera from Z/I Imaging Corp. Flown June through August, 2009.
- Image resolution is 12-microns or 2117 ppi.



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- Nominal photo scale is 1:40,000



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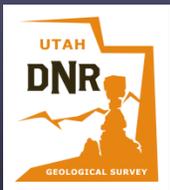
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- Nominal photo scale is 1:40,000
- Over 13,000 photos to cover the state of Utah



# *NAIP Imagery Program*

## 2009 Utah NAIP Imagery

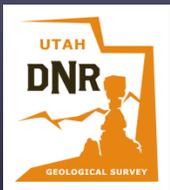
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- Imagery acquired with the Z/I DMC II digital frame aerial camera from Z/I Imaging Corp. Flown June through August, 2009.
- Image resolution is 12-microns or 2117 ppi.
- Nominal photo scale is 1:40,000
- Over 13,000 photos to cover the state of Utah
- UGS purchased full state-wide stereo coverage for \$14,000



# *Digital Orthophoto*

Digital ortho  
quad from 2009  
NAIP imagery

Santa Clara, UT  
quadrangle



# *Digital Orthophoto*

Digital ortho  
quad from 2009  
NAIP imagery

Santa Clara, UT  
quadrangle



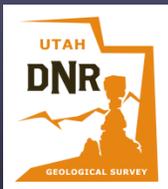
Region of  
interest



# *Digital Orthophoto*



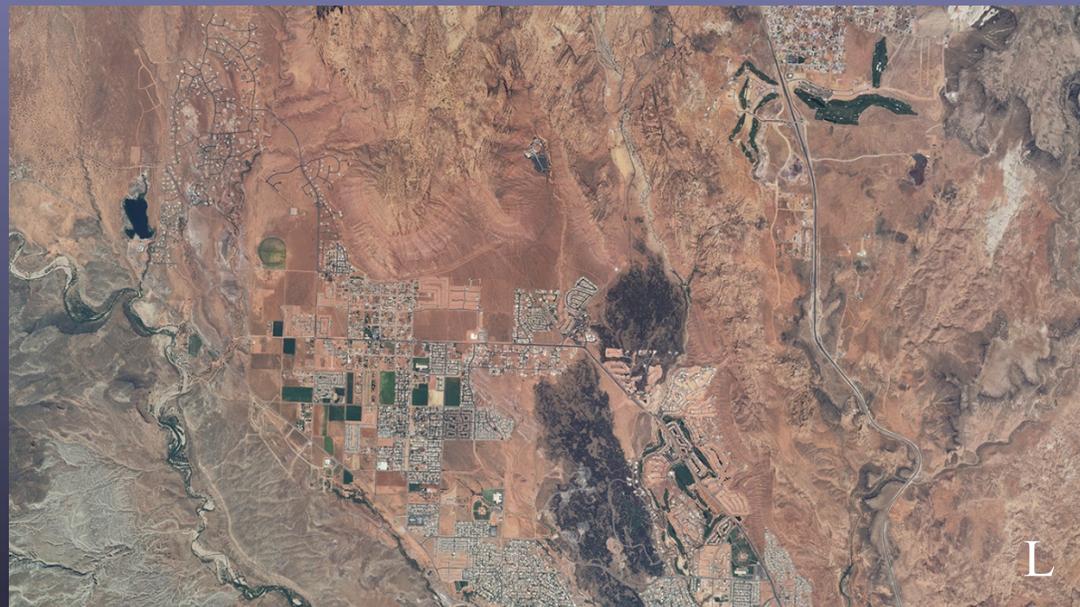
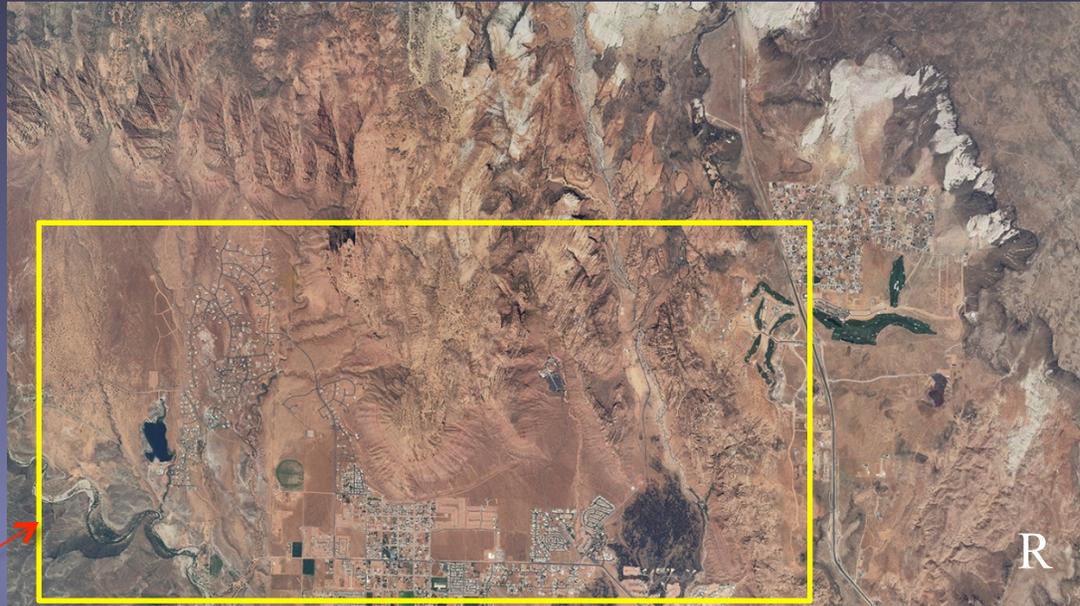
Enlarged region of interest from 2009 digital ortho  
Santa Clara, UT quadrangle



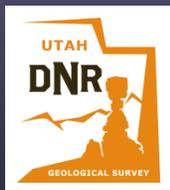
# Digital Stereo Pair

Stereo pair  
from digital  
aerial camera,  
Surdex Corp.,  
2009 NAIP  
imagery.

Same area as  
digital ortho  
region of  
interest



Direction of flight

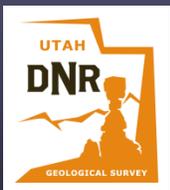
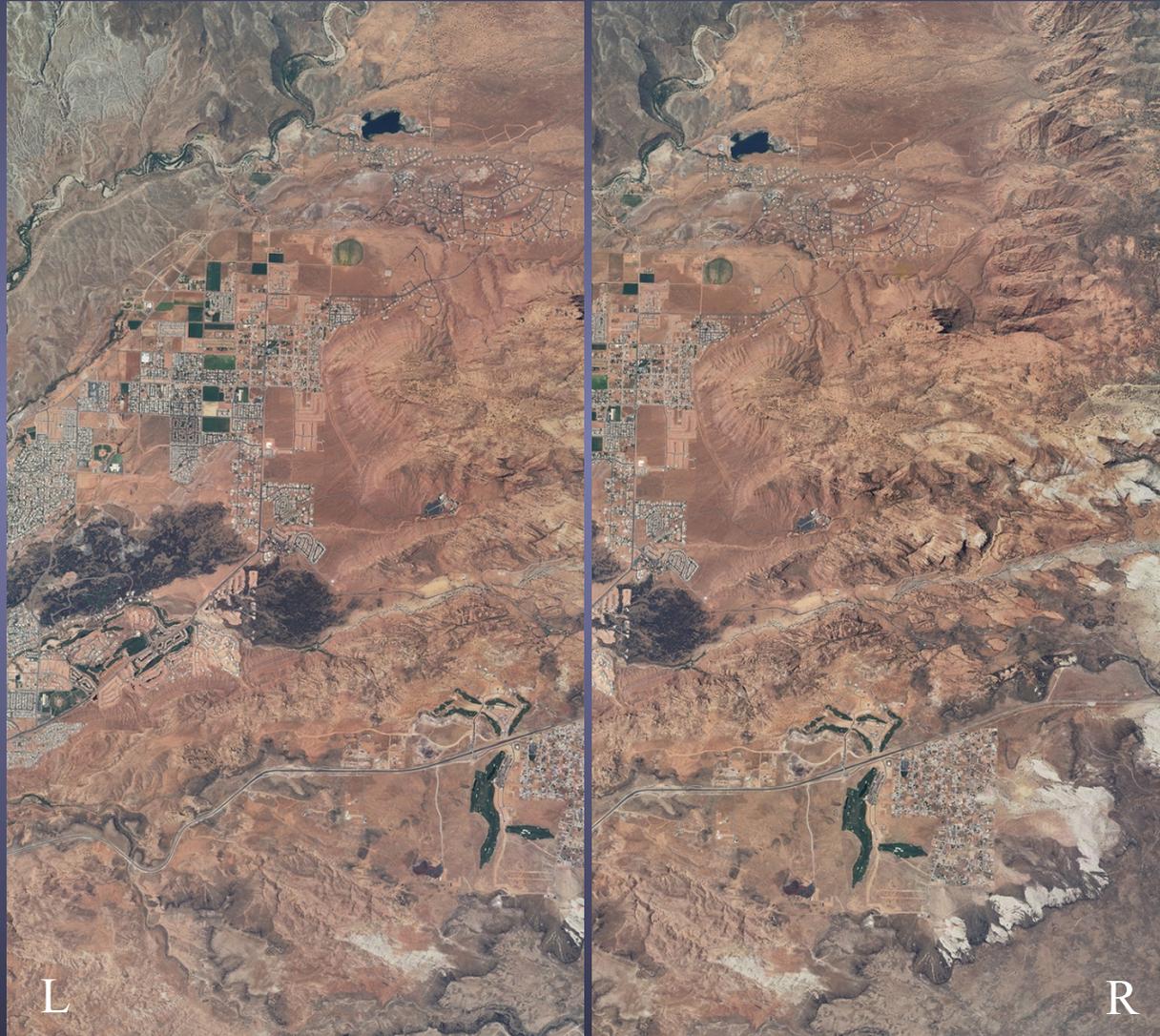


# *Digital Stereo Pair*

To see in stereo, the images must be viewed from left-to-right, with overlap in the center, so they have been rotated 90°.



Direction of flight

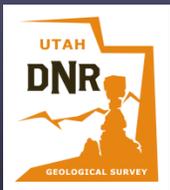
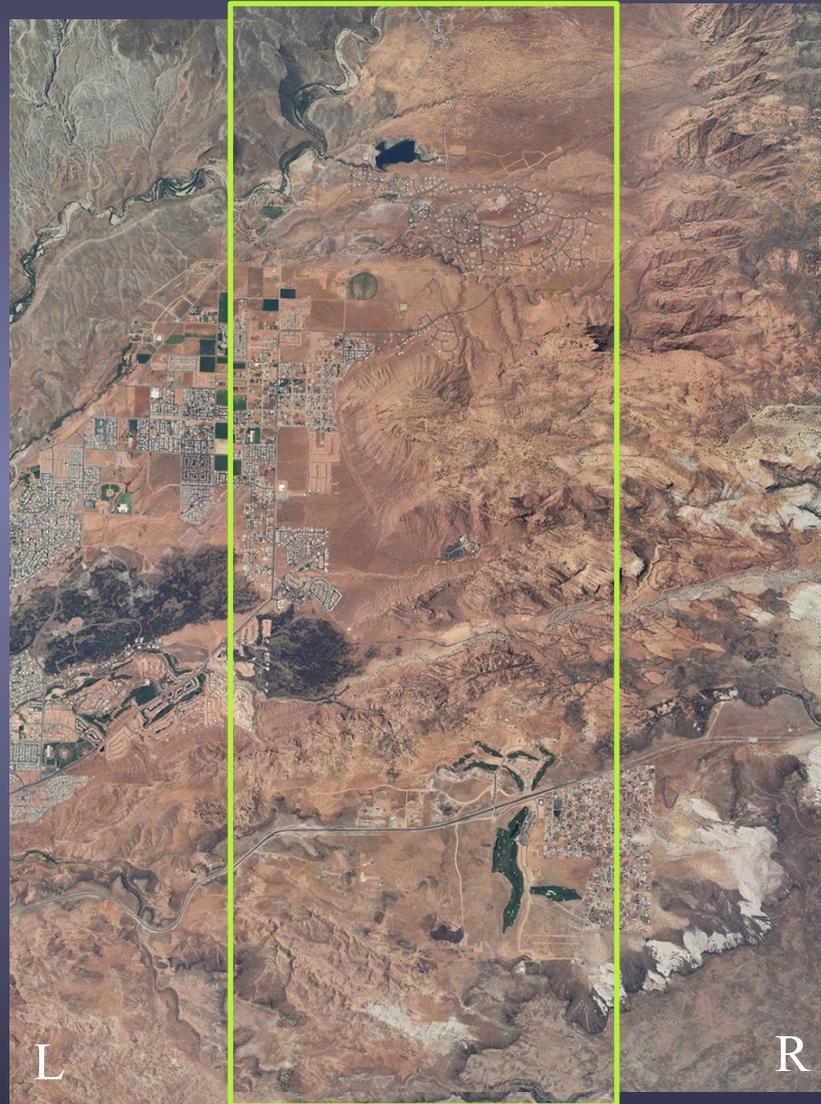


# *Digital Stereo Pair*

Standard overlap for stereo pairs is between 50-60%.

For illustration purposes, the images are overlapped to show that extent.

This area is will be used to create the stereo model.

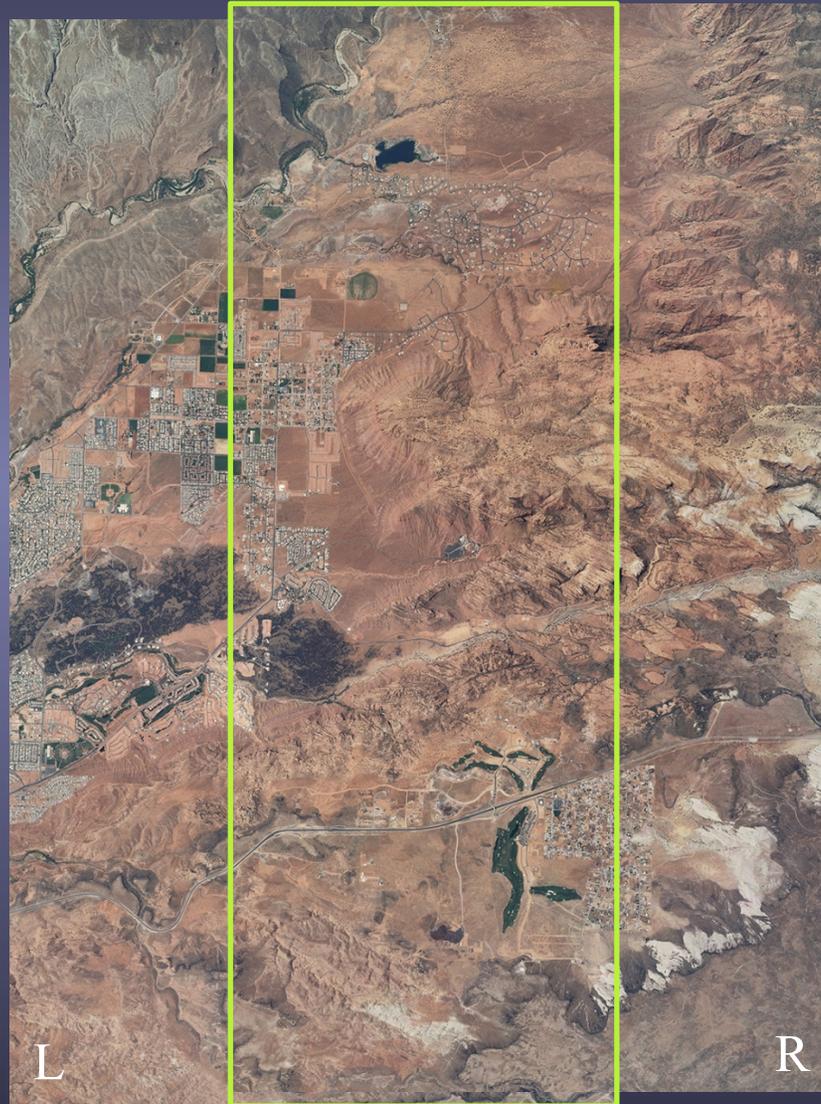


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At this point the stereo pairs are raw, uncontrolled images.

Three orientations are needed to create the controlled stereo models.

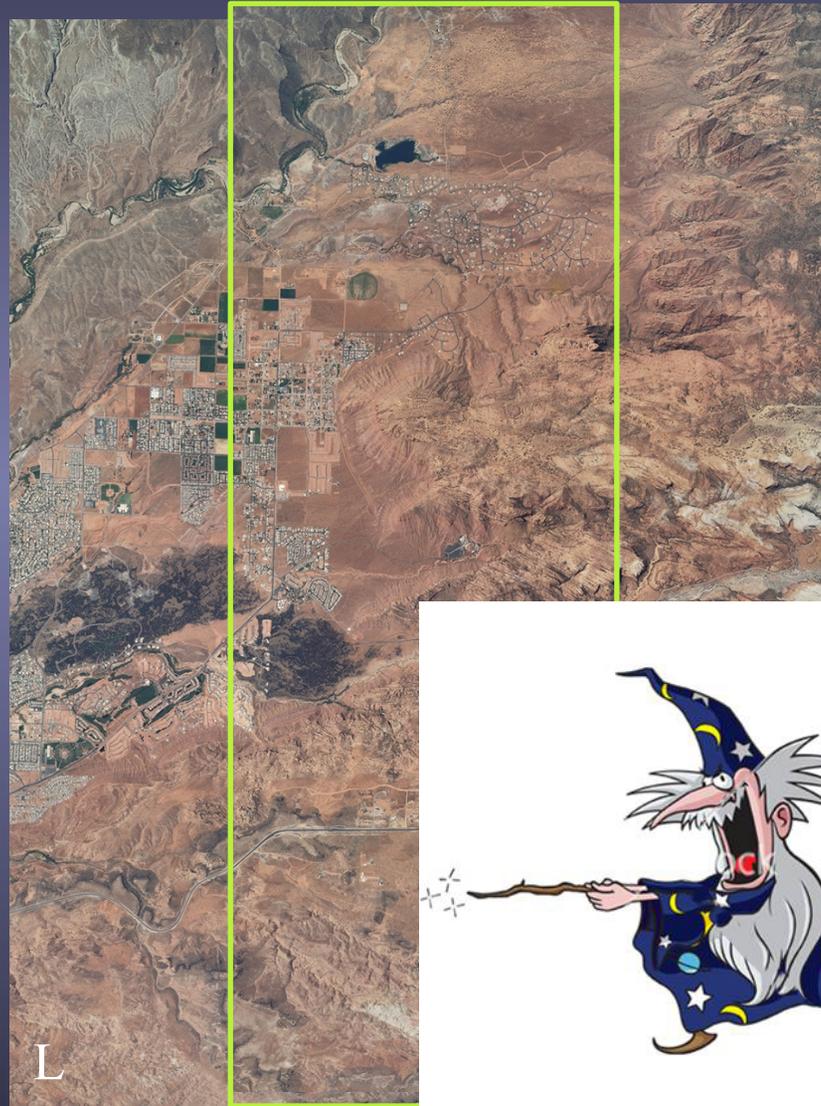


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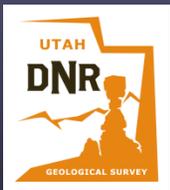
# *Digital Stereo Model*

After the  
photogrammetric  
orientations are done, a  
new controlled stereo  
pair is created.



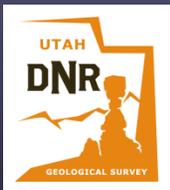
# *Digital Stereo Model*

It doesn't look like much from this screen capture, but this is what it looks like when viewed in stereo using VrTwo, the photogrammetry software we use at UGS.

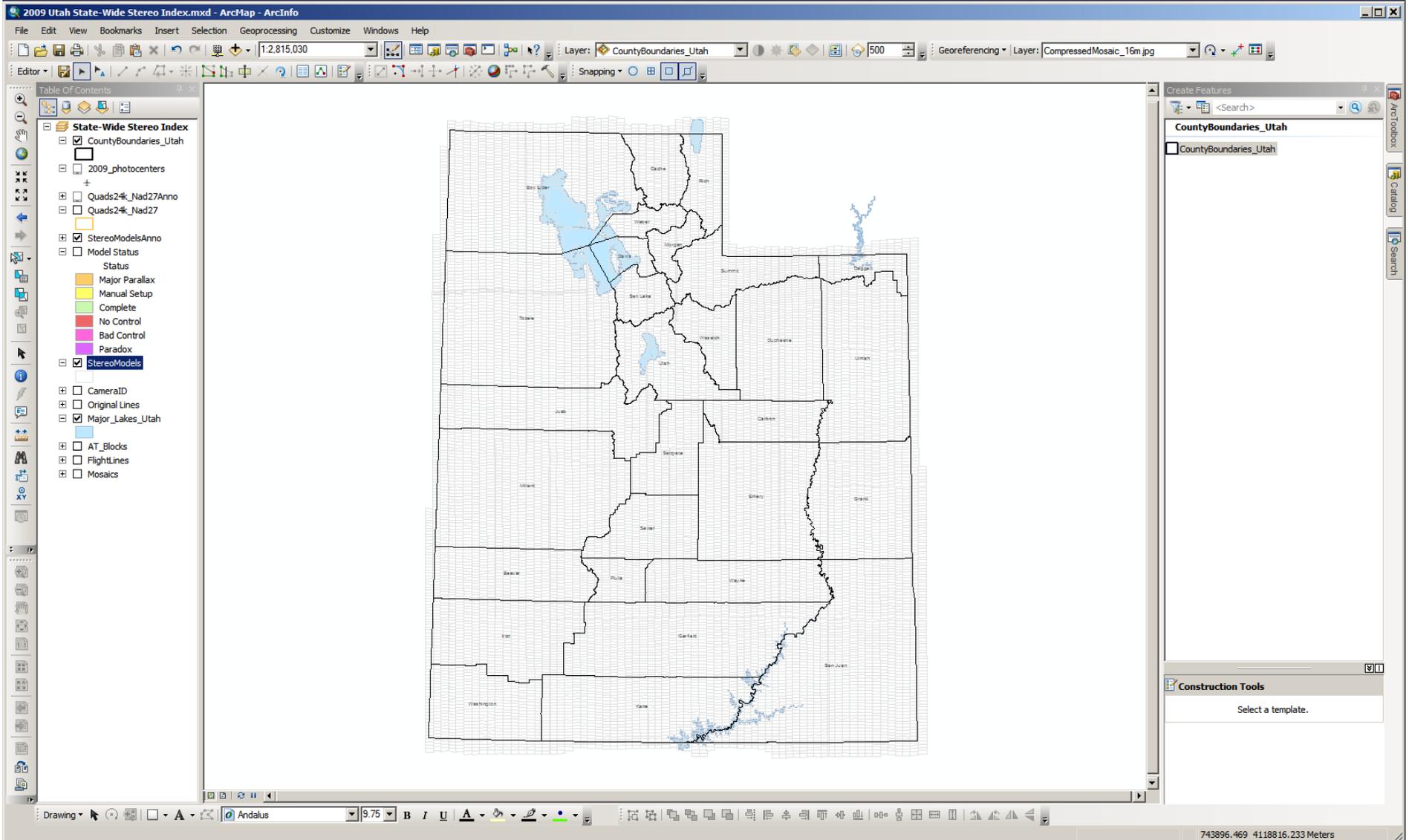


## *State-Wide Stereo Model Index*

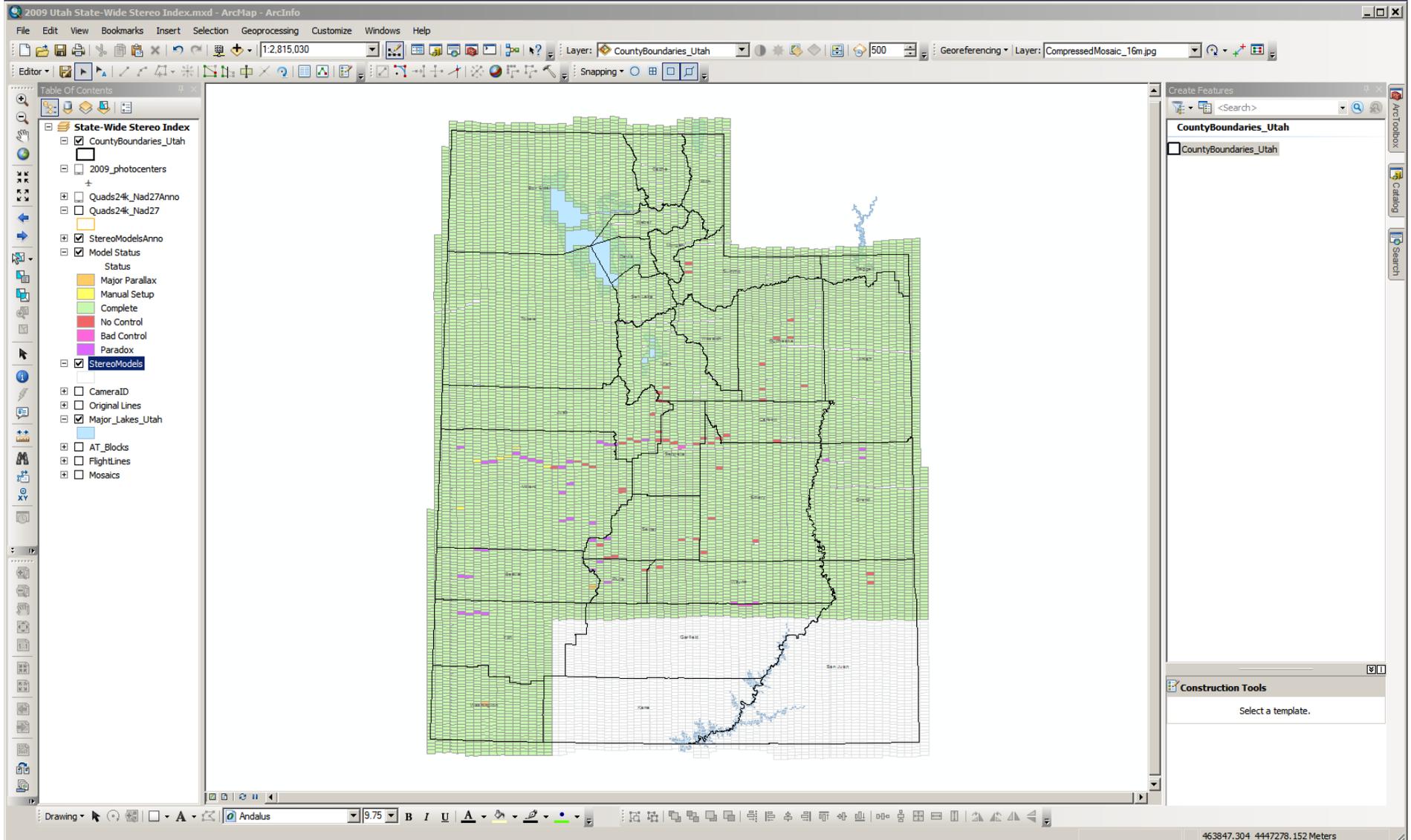
With 13,000 stereo models, we need an index!



# State-Wide Stereo Model Index



# State-Wide Stereo Model Index



# State-Wide Stereo Model Index

The screenshot displays the ArcMap interface for a project titled "2009 Utah State-Wide Stereo Index.mxd". The main map area shows a satellite-style mosaic of Utah with black lines representing county boundaries. The Table of Contents on the left lists several layers, including "State-Wide Stereo Index", "CountyBoundaries\_Utah", "2009\_photocenters", "Quads24k\_Nad27Anno", "Quads24k\_Nad27", "StereoModelsAnno", "Model Status", "StereoModels", "CameraID", "Original Lines", "Major\_Lakes\_Utah", "AT\_Blocks", "FlightLines", and "Mosaics". The "Model Status" layer is expanded to show a legend with categories: Major Parallax (orange), Manual Setup (yellow), Complete (green), No Control (red), Bad Control (purple), and Paradox (pink). The "CountyBoundaries\_Utah" layer is also checked. The bottom status bar shows the current location as "Andalus" with a scale of 9.75 and coordinates 326057.157, 4634225.866 Meters.

# State-Wide Stereo Model Index

The screenshot displays the ArcMap interface for a project titled "2009 Utah State-Wide Stereo Index.mxd". The main map area shows a grayscale terrain model of Utah with a yellow grid overlay representing the stereo model index. County boundaries are shown as black lines. The Table of Contents on the left lists several layers, including "State-Wide Stereo Index", "CountyBoundaries\_Utah", "2009\_photocenters", "Quads24k\_Nad27Anno", "Quads24k\_Nad27", "StereoModelsAnno", "Model Status", "StereoModels", "CameraID", "Original Lines", "Major\_Lakes\_Utah", "AT\_Blocks", "FlightLines", and "Mosaics". The "Create Features" panel on the right shows a search for "CountyBoundaries\_Utah" and "Quads24k\_Nad27". The "Construction Tools" panel at the bottom right prompts the user to "Select a template." The status bar at the bottom indicates the current location as "Andalus" with a scale of 9.75 and coordinates 358828.868 4589537.17 Meters.

# State-Wide Stereo Model Index

2009 Utah State-Wide Stereo Index.mxd - ArcMap - ArcInfo

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:289,974 Layer: CountyBoundaries\_Utah 500 Georeferencing Layer: CompressedMosaic\_16m.jpg

Table Of Contents

- State-Wide Stereo Index
  - CountyBoundaries\_Utah
  - 2009\_photocenters
  - Quads24k\_Nad27Anno
    - Default
    - Quads24k\_Nad27
  - StereoModelsAnno
  - Model Status
    - Major Parallax
    - Manual Setup
    - Complete
    - No Control
    - Bad Control
    - Paradox
  - StereoModels
    - CameraID
    - Original Lines
    - Major\_Lakes\_Utah
    - AT\_Blocks
    - FlightLines
    - Mosaics

Create Features

- CountyBoundaries\_Utah
- Quads24k\_Nad27
- Quads24k\_Nad27Anno
  - Default

Construction Tools

Select a template.

Andalus 9.75 B I U 348643.741 4369999.638 Meters

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2009 Utah State-Wide Stereo Index.mxd - ArcMap - ArcInfo

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

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14-107-108 15-107-107 15-110-109 17-109-110 18-109-110 19-108-107 20-107-108 21-109-108 22-109-110 23-112-111 24-112-113 25-112-112 26-111-112

14-106-107 16-109-108 17-108-109 18-108-109 19-107-106 20-106-107 21-108-107 22-108-109 23-111-110 24-111-112 25-111-111 26-110-111

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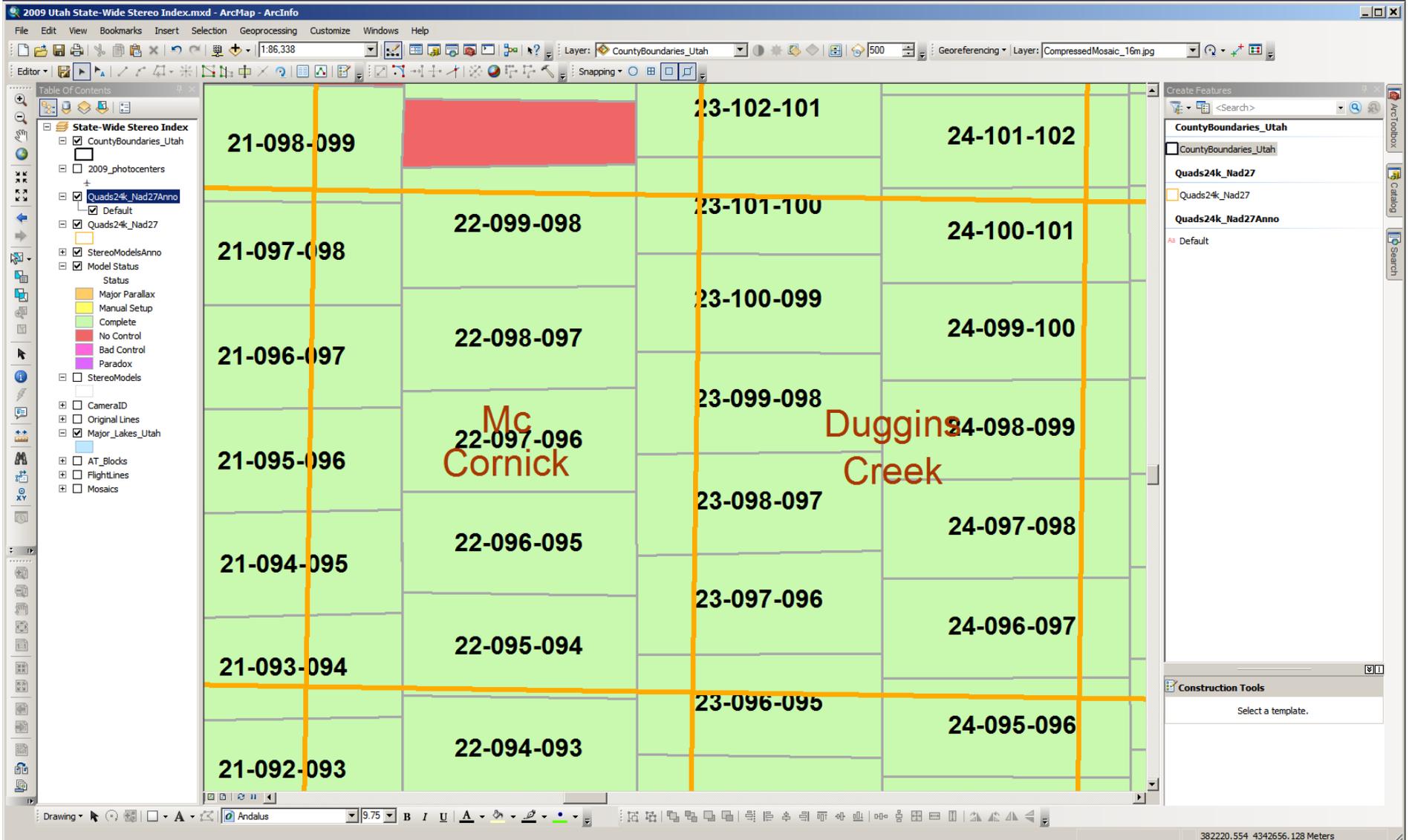
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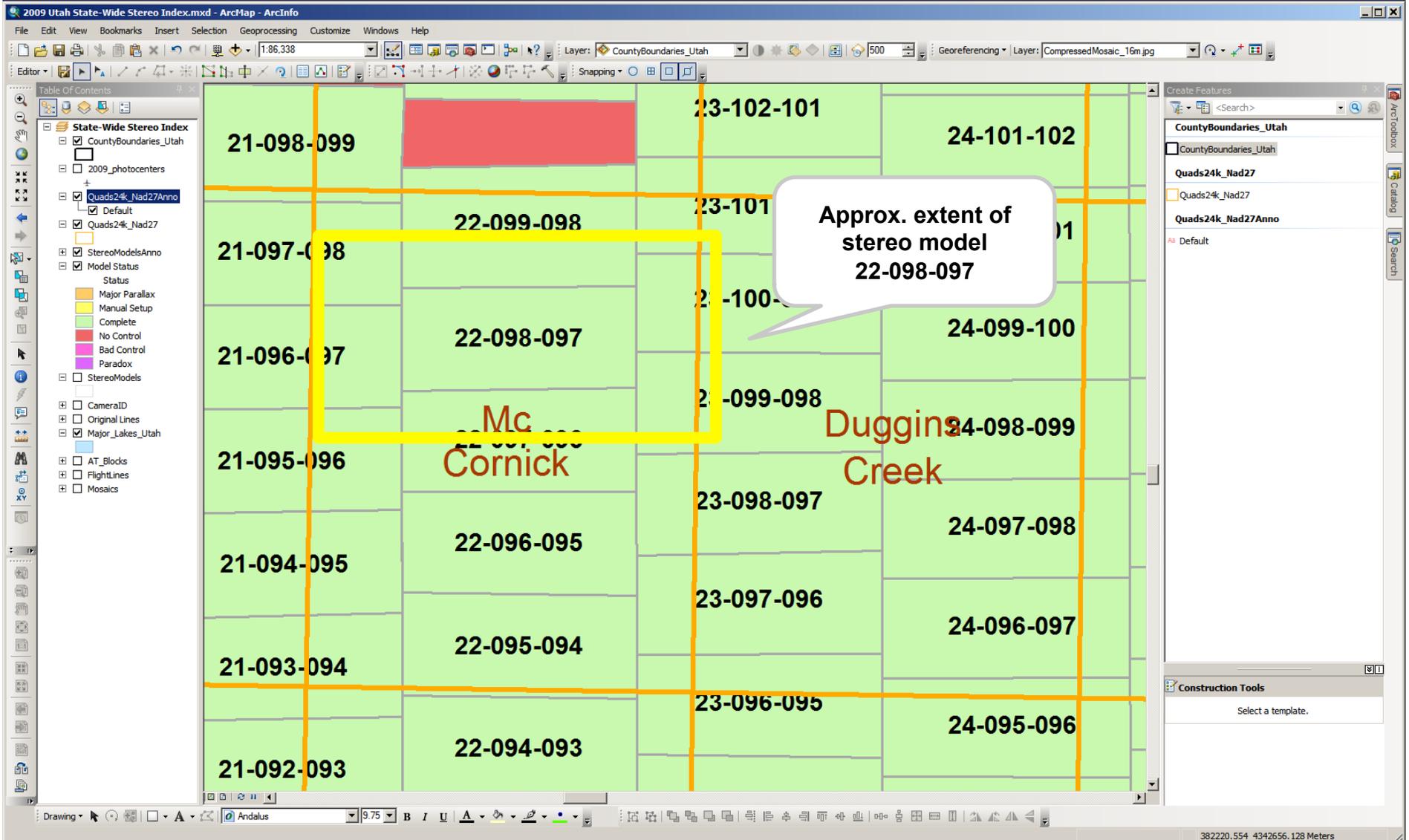
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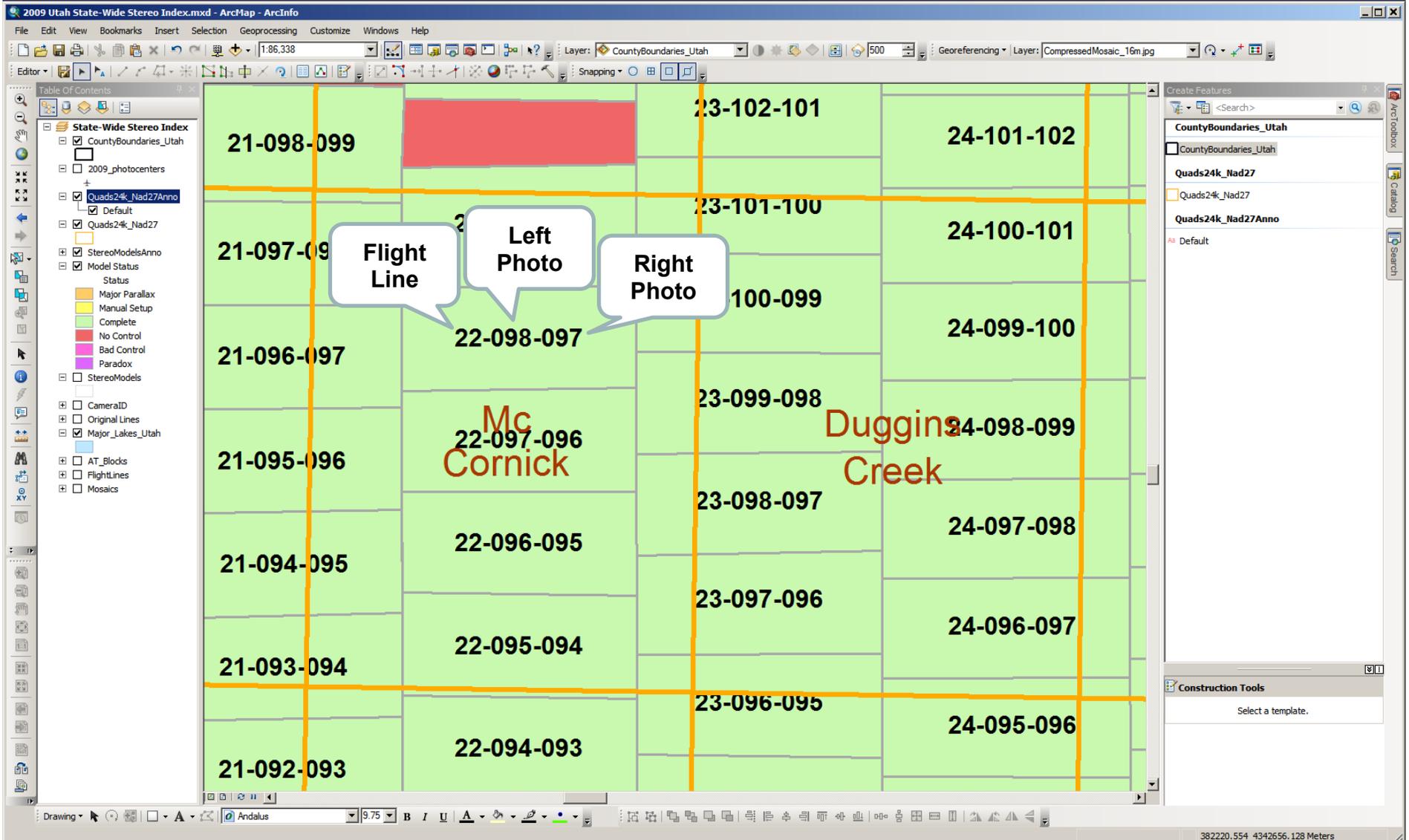
# State-Wide Stereo Model Index



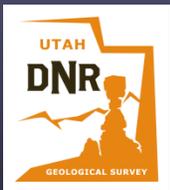
# State-Wide Stereo Model Index



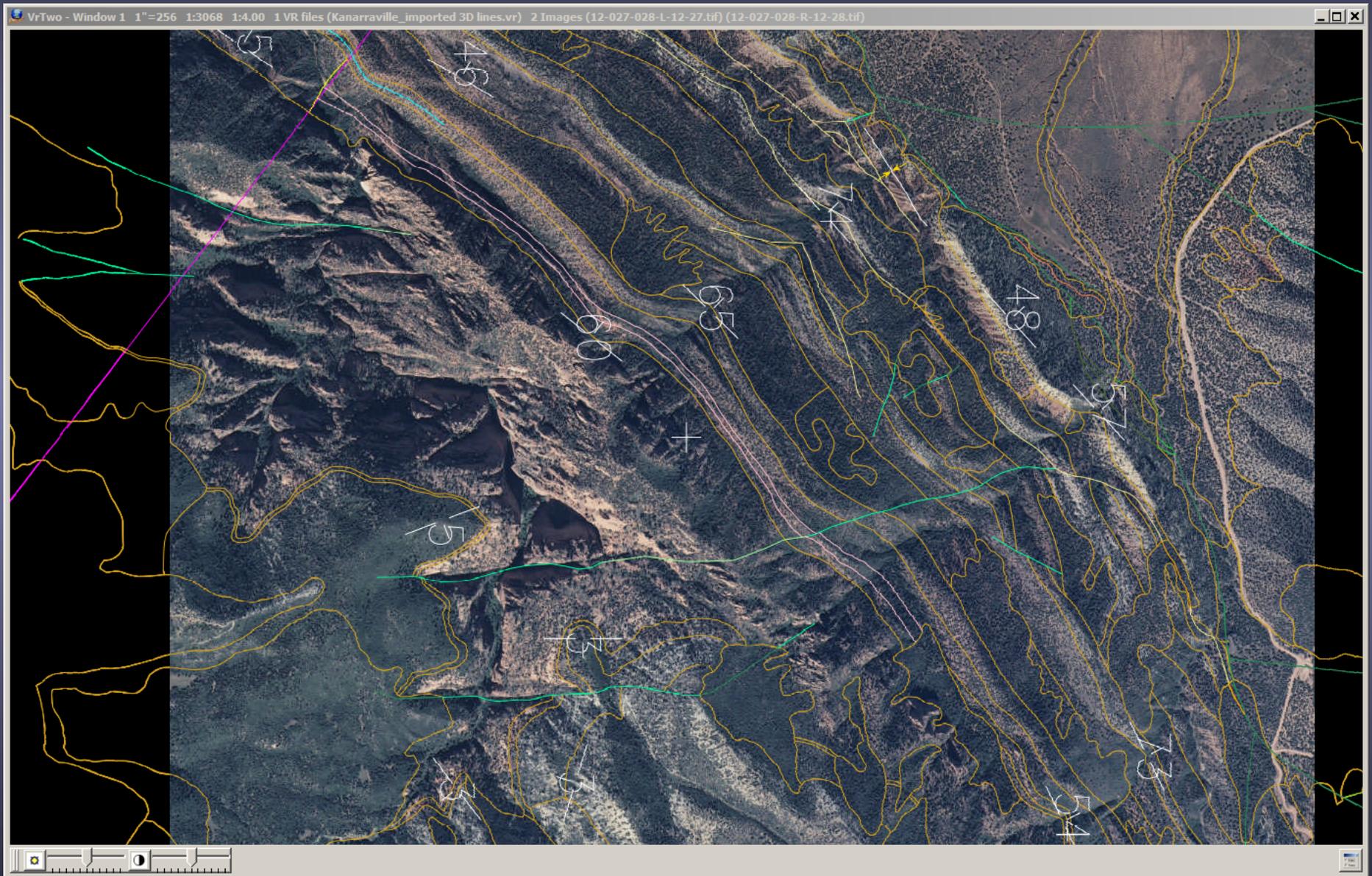
# State-Wide Stereo Model Index



# *State-Wide Stereo Model Coverage*



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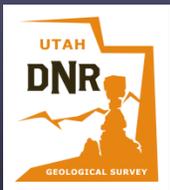
# *State-Wide Stereo Model Coverage*



## *State-Wide Stereo Models*

What's the benefit of all this?

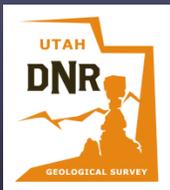
- You can view stereo models from any area of Utah.



## *State-Wide Stereo Models*

### What's the benefit of all this?

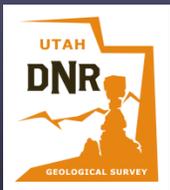
- You can view stereo models from any area of Utah.
- Tremendous cost savings by not purchasing expensive photo coverage at the Air Photo Field Office.



## *State-Wide Stereo Models*

### What's the benefit of all this?

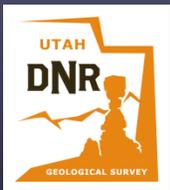
- You can view stereo models from any area of Utah.
- Tremendous cost savings by not purchasing expensive photo coverage at the Air Photo Field Office.
- No more laborious job of establishing ground control.



## *State-Wide Stereo Models*

### What's the benefit of all this?

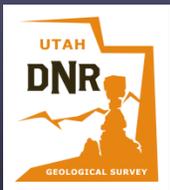
- You can view stereo models from any area of Utah.
- Tremendous cost savings by not purchasing expensive photo coverage at the Air Photo Field Office.
- No more laborious job of establishing ground control.
- The system can benefit anyone who has a need to map on a 3-D surface, in stereo.



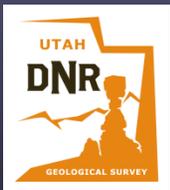
## *State-Wide Stereo Models*

### What's the benefit of all this?

- You can view stereo models from any area of Utah.
- Tremendous cost savings by not purchasing expensive photo coverage at the Air Photo Field Office.
- No more laborious job of establishing ground control.
- The system can benefit anyone who has a need to map on a 3-D surface, in stereo.
- Approx. 500 custom geologic mapping functions in VrTwo.



## *State-Wide Stereo Models*



You too can be stylin'

# Questions?

**Kent Brown**

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<http://geology.utah.gov>

