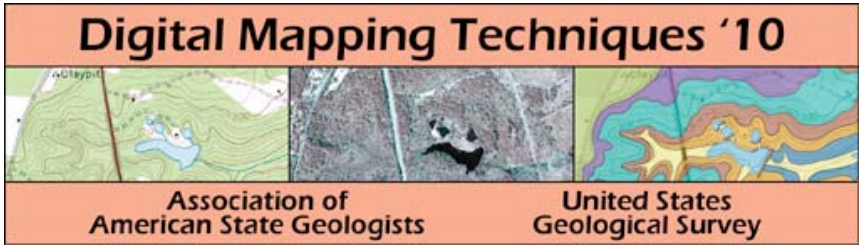


The following was presented at DMT'10
(May 16-19, 2010).

The contents are provisional and will be
superseded by a paper in the
DMT'10 Proceedings.

See also earlier Proceedings (1997-2009)
http://ngmdb.usgs.gov/info/dmt/

# GIS-BASED DIGITAL PHOTOGRAMMETRY FOR GEOLOGIC AND HAZARD MAPPING


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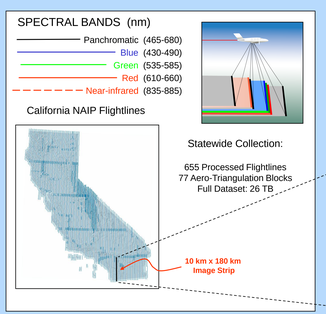
## ABSTRACT

The California Geological Survey (CGS) in 2008 completed the purchase of statewide digital stereo aerial photography, an ancillary product of the USDA National Agricultural Imagery Program (NAIP). This purchase was contingent on development of specialized commercial photogrammetric and GIS software applications, and development of massive data storage and large image transfer capabilities at CGS. The digital imagery resolution is comparable to moderate altitude film-based air photos (~1:30,000 to 1:40,000-scale; ~ 0.5 to 0.8m pixel dimension) and measured horizontal accuracies suggest that maps generated using this imagery could be published at 1:12,000-scale or better. Vertical accuracies are on the order of 2 meters. CGS is actively incorporating the use of this imagery in routine landslide, active fault and geologic mapping activities within several programs. In addition to improved accuracy and reduced map preparation time, the digital stereo imagery is anticipated to improve map peer review and geomorphic interpretation training at CGS. CGS recently has begun working with the San Diego Supercomputer Center to develop better ways to pre-process and distribute the NAIP stereo imagery.

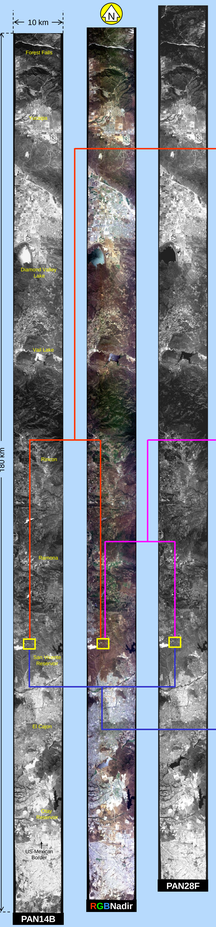

## STATEWIDE STEREO IMAGERY

The NAIP stereo imagery was collected in California using Leica Geosystems' ADS40 Airborne Digital Sensor, a "push-broom" type imaging system that simultaneously records five bands in the visible light spectrum through sensors arrayed at six different "look angles" or orientations (as shown below). The ADS40 sensor continuously records a long strip of imagery, and uses the different sensor look angles to create the parallax required for stereo viewing. A "color" stereo view is obtained by including an RGB color image for either the left or right eye. For the California NAIP project, the ADS40 sensor was flown at ~30,000 feet resulting in a 40 to 80cm pixel size, depending on ground elevation. The sample of imagery shown to the right extends from Forest Falls in San Bernardino County to Tijuana, Mexico. The three image strips shown are the 14° backward panchromatic, the nadir RGB, and the 28° forward panchromatic.



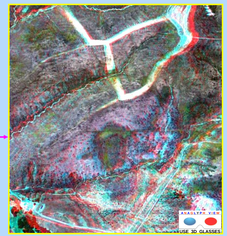

## STEREO IMAGE PROCESSING

In order to use the ADS40 imagery in Stereo Analyst for ArcGIS, the long image strips need to be "sliced" into manageable tiles. This is done using Leica Geosystems' GPro photogrammetric software. We have found that tiles that are 12,000 lines wide with a 30 percent overlap work very well for the software and hardware currently being used at CGS. CGS recently has started working with the San Diego Supercomputer Center at UC San Diego to develop methods to pre-process and distribute this stereo dataset, and thus avoid project-specific sliicing.

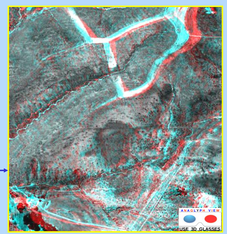



## VARIABLE VERTICAL EXAGGERATION COLOR IMAGE FUSION

PAN14B/RGBNadir (14° look angle difference)



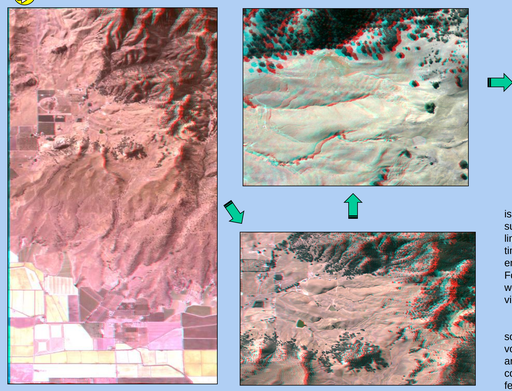
PAN28F/RGBNadir (28° look angle difference)



PAN14B/PAN28F (42° look angle difference)

Vertical exaggeration and color can be enhanced or reduced depending on the image pair combination used. The larger the "look angle" difference between image pairs, the larger the vertical exaggeration. The strength of the color perception is dependant on whether the color image is viewed by the user's dominant eye.

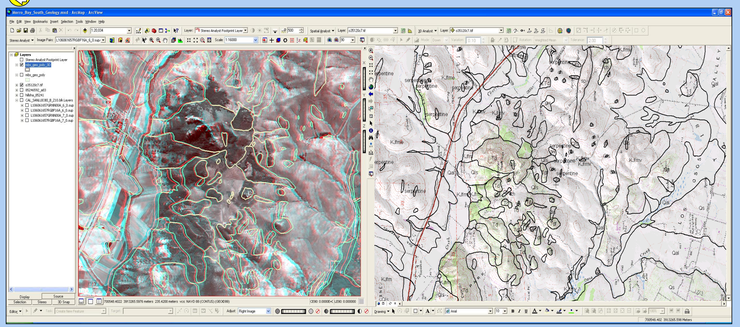
## DIGITAL STEREO VIEWING
## EASY ZOOM IN AND OUT; BRIGHTNESS AND CONTRAST ADJUSTMENT



Digital mapping of geomorphic features of varying sizes is facilitated by easy zoom control. With an optical system such as a mirrored stereoscope, image enlargement is limited by the power of the optical lenses available, and the time involved in changing them. In the digital stereo environment, image zoom is a simple click of the mouse. For each image presented here, brightness and contrast were adjusted to enhance the ground surface in the field of view.

Image to the far left is a full stereo scene covering the southeastern portion of the Sutter Buttes, a small extinct volcanic center north of Sacramento. Subsequent images are enlarged subsets showing portions of a large landslide complex. The last image has some interpreted landslide features digitized in 3D.

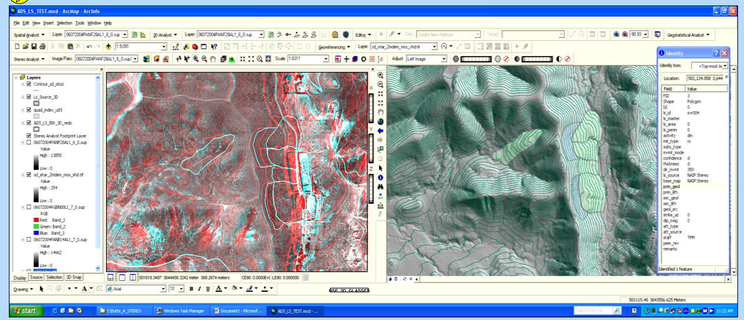
## 2D TO 3D CONVERSION – STEREO VIEW ANY VECTOR DATA



A typical setup for stereo viewing in Stereo Analyst for ArcGIS on a dual screen workstation. The stereo window, on the left, can be displayed on the left monitor, while the 2D map window, here showing the digital geologic map, can be displayed on the right monitor.

2D vector data from any source can be draped over an existing DEM (10 m USGS DEM is sufficient) and converted to a 3D vector file. The 3D vector data is then viewable and editable in the stereo window. However, the higher spatial accuracy of the stereo imagery (~6 m horizontal) may result in discrepancies with vector lines compiled on other base maps, such as 7.5-minute topographic sheets. The geology shown on this figure is from the Geologic Map of the Morro Bay South 7.5' Quadrangle, San Luis Obispo County, California: a Digital Database, Version 1.0 by Mark O. Wiegers; Digital Database by Mark O. Wiegers and Carlos I. Gutierrez, 2009.

## DIGITAL LANDSLIDE MAPPING



An example of a convenient landslide mapping setup for Stereo Analyst for ArcGIS on a dual screen workstation. The stereo view on the left includes the stereo image (panchromatic as left image and color as right image). The right side shows a 2D view of the polygons digitized in 3D on a shaded relief base map and contours derived from a 2m DEM. An example attribute table is shown to the right.

Geomorphic interpretation of past landsliding is greatly facilitated by working in the digital stereo environment. While traditional workflows require a time-consuming process of interpretation, digitization and attribution, often requiring repeated setups of the same imagery, landslide inventory mapping in the digital stereo environment is a "one-stop" process. Interpretation and digitizing can occur nearly simultaneously and attribution occurs as soon as digitizing is completed. Any data layers pertinent to the interpretation/attribution - terrain, geology, soils, vegetation, etc. - can be displayed in the 2D map window. The capability of multiple viewers allows for improved peer review and enhanced training opportunities. By digitizing directly onto the stereo imagery, the loss of positional accuracy associated with visually transferring interpreted landslides to a topographic base, which can be significant for small landslide features, is greatly reduced.

## MAPPING WITH DIGITAL STEREO IMAGERY

ADVANTAGES:

1. Easy Zoom In / Out – No need to change stereoscope optics
2. Paired Color and Panchromatic Images - Fused color view
3. Variable Vertical Exaggeration – Vary according to terrain
4. Adjustable Brightness / Contrast – Can work in bright and dark areas
5. Good Spatial Accuracy – Comparable to hand-held GPS
6. GIS Platform – Collect attributes while viewing in stereo
7. 3D Display Any Vector Data – Peer review, validate, modify
8. Multiple Viewers – Training capabilities
9. Paper Prints – Relatively easily prepared; field copies

REMAINING ISSUES:

Hardware:
Large Datasets - Data Storage, Data Delivery
Goal is to Pre-Process Entire Dataset
Software:
Memory Allocation Issues With ArcGIS
Stereo Analyst Bugs – Responsive Software Developers
Usage:
Workflow Development – In Progress
District Office Setups – Specialized Hardware
Training – Takes Time
Paper Print Stereo Imagery:
Effectively Capturing Data from Existing Libraries of Vintage Photography

## CONCLUSIONS

The California Geological Survey has been working to incorporate the 2005 NAIP/ADS40 stereo imagery into various geologic mapping workflows. The digital imagery resolution is comparable to 1:40,000-scale film-based imagery and measured horizontal accuracies suggest that maps generated using this imagery could be published at better than 1:12,000-scale. Vertical accuracies are on the order of 2 meters. While lacking the clarity of low-altitude (~1:10,000) film based air photos, the added benefits of either panchromatic or color imagery, nearly unlimited enlargement, adjustable vertical exaggeration, and direct application within GIS, make the NAIP/ADS40 imagery a useful, low cost source of digital stereo imagery for regional mapping applications. The result of this effort is a totally digital work environment that we anticipate will decrease map production time, increase map accuracy by a factor of 2 to 3, and provide improved training and peer review opportunities for CGS geologists.