

Review

Photogrammetry Software Review

Purchasing Photogrammetry Software: Wading Through a Sea of Choices

By Kyle Bohnenstiehl

In this article I will give GIS practitioners who are considering purchasing photogrammetry software a sense of the types of questions they will want to ask software vendors about their products and a list of vendors to contact. Given the complexity of this type of software, and a price tag that runs between \$5,000 and \$70,000, prospective users of photogrammetry software are advised to research all of the options out there. The advantages to owning photogrammetry software are that users can take stereo satellite or aerial imagery and create accurate DEM's, orthophotos, and 3-D GIS data sets with full control over the entire process. For a review and primer on the discipline of photogrammetry, first read the *GISVision Magazine* April 2001 article "[Create Accurate Orthophotos with Softcopy Photogrammetry](#)".

For the purposes of this review, I will define photogrammetry software as a modular software program that allows for aerial photography (metric or non-metric potentially) or suitable satellite imagery (SPOT, Ikonos, Quickbird, ASTER) to be

- calibrated using a physical camera model and interior orientations or possibly a rational function model,
- georeferenced using ground control points or predetermined exterior orientations,
- block adjusted using aerial triangulation including the use of tie or pass points,
- used as input data to create DEM/DTM products using stereo overlap areas and autocorrelation algorithms,
- orthorectified using a DEM/DTM and the calculated exterior orientations, and
- processed sufficiently to be used directly for 3-D feature collection in a stereo editor.

This rather lengthy list of requirements excludes many traditional remote sensing and GIS software packages from the review. However, photogrammetric processing is a complex and specialized task. The advantages of using photogrammetric processing are well worth the effort for users that require a high degree of accuracy in both the horizontal and vertical dimensions. Most of the software packages have a linear, project-based workflow that is intuitive and can be mastered through vendor provided training, although it takes years of practice to become a fully competent photogrammetrist.

Digital Aerial and Satellite Data Sources

In the past, photogrammetry software was designed exclusively for the processing of standard aerial metric photography. This is in part due to the origins of the software that have a heritage in analog and analytical stereoplotters where human operators did much of the work that is done today by computer processing. With the advent of digital cameras and stereo satellite sensors, some photogrammetry software has been designed to exploit these data sources too. In the case of non-metric digital cameras, unknown variables such as the focal length and geometric stability of the detector array are modeled mathematically in the software by using well distributed ground control points across the image. Some software also supports videography data as an input source, which would be useful to orthorectify and create GIS data from, particularly in corridor mapping applications like rivers and pipelines.

Stereo satellite sensors like SPOT, Ikonos, Quickbird, and ASTER collect imagery with stereo overlap by using either in-track or cross-track stereo imaging. Satellite imagery offers numerous advantages including the fact that one image can cover a large area, thus reducing the amount of photogrammetric processing required. The reduced resolution (0.61m to 30+m) of satellite imagery may be a limiting factor for applications requiring engineering grade contours and very high resolution imagery.

I would strongly advise that GIS shops consider purchasing a package that will work with stereo satellite data and non-traditional digital camera data, in addition to supporting standard metric aerial photography.

Modular Approach to Software Components

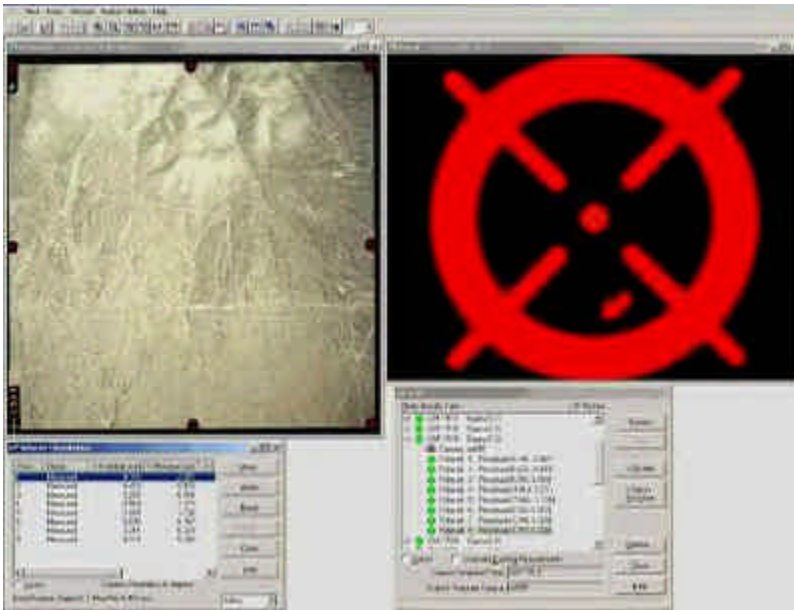
Photogrammetry software is generally marketed in modules that allow the user to purchase only the functionality they need to perform their work, with the option to add additional capability in the future. The downside to this approach is that prospective customers need to research the capabilities of each vendor's modules to come up with the best match. Modules are divided into roughly the following categories:



The Autometric SoftPlotter system illustrates the modular nature of photogrammetry software. Source: www.autometric.com

Image/Frame Manager Module: This module is typically the first step in the workflow. Here users add the raw data into the photogrammetric block either in the form of scanned aerial photography or digital satellite imagery. Scanned aerial images are often in either TIFF format or a photogrammetric scanner file format. Verify the image format required by the software package you select with a format you or your scanning vendor can supply. Under no circumstances should you work with compressed imagery because the lower quality of the imagery may impact your accuracy and most programs do not allow it. At this stage of the workflow, you will assign a camera/satellite model to each image. This consists of the focal length, radial distortion of the lens, and the location of the fiducial marks on the camera. For satellite imagery, the sensor model is usually contained in a header file associated with each image. Ask vendors about the capability to work with non-traditional camera models and support for new satellite sensors as they become available.

Interior orientation of the images is performed in this module. With aerial photography, users manually add this information by associating the fiducial marks on aerial photography with the coordinates of the camera model provided in the camera calibration report. A good interface is important here, with the ability to automatically drive to the next fiducial, zoom in very close on the center point of the fiducial, and adjust brightness/contrast. Some of the more advanced packages allow users to identify the fiducials in one image and then have the software automatically identify the fiducials in the remaining photos. This is a nice feature if you have more than 20 photos per project.



Intergraph ImageStation Interior Orientation Module

At this point in the workflow you should have the option to assign the exterior orientations to each frame. Exterior orientations consist of six parameters that are unique to each image. They describe the roll, pitch and yaw of the camera or sensor around an axis that is perpendicular to the ground surface, and the X, Y, and Z real world coordinates of the principal point of the focal plane of the camera or sensor where this axis terminates. In most cases, we do not know these orientation parameters and our goal is to determine them by the use of ground control points, tie points, and aerial triangulation. However, direct georeferencing by airborne GPS and inertial measurement units is becoming more common and software support for these techniques is a nice feature to have. Aerial triangulation of direct georeferencing data (by using tie points) and the ability to specify the errors associated with direct georeferencing data are critical components to have. Verify that the software is capable of reading ASCII files containing exterior orientation data provided by the aerial photography company.

Ground Control/Tie Point Measurement Module: This is the single most important module in terms of ease of use and features. Here, users will add in ground control points collected using GPS, conventional survey techniques, points taken from USGS topographic maps, or existing orthophotography/imagery and DEM's. Ideally, all control points will have an X, Y, and Z location, however horizontal or vertical only points may be used in conjunction with full control points. The ability to assign errors to each control point is very important so that you can mix high accuracy GPS points with less accurate USGS topographic map derived control points.

Tie points are added to tie adjacent frames and images together. A feature (several pixels that can be clearly identified) in one image that is identified in another image may be joined by using a tie point. Imagine pushing a map pin through an aerial photograph to tie them together at the same spot on the ground. By using control points in a well distributed manner, the coordinates of the tie points can be mathematically triangulated in the X, Y, and Z. This strengthens the overall geometric robustness of the image block and may reduce the amount of control actually necessary to get an accurate solution of the six exterior orientations. When reviewing software to purchase, you should definitely buy one that has an automatic tie point generation capability. This feature uses a few seed tie points that are manually placed to create several hundred automatically placed tie points.

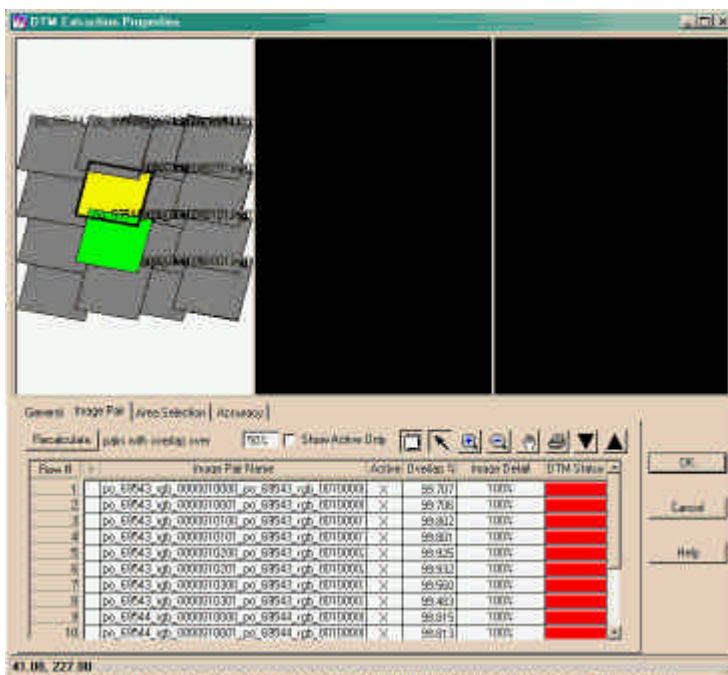
Nice features to have in this module include the ability to display up to six images at a time. This greatly eases the placement of control and tie points in stereo triplicates of images and in an adjacent flight line. It is also useful to be able to link with a viewer window that has an existing orthophoto or USGS topographic map, so that coordinates can be transferred directly into control point file list. The ability to transfer elevation data into this list from contour or DEM files is also a time saver. Almost all of the packages will allow you to import ASCII point data into the control point list rather than you having to key in the coordinates manually. Some programs will allow you to reproject on the fly so that ground control data in Lat/Long/WGS84 can be triangulated and then output the

exterior orientations in another coordinate system like UTM/NAD27. A full set of zoom, pan and brightness/contrast tools will allow you to navigate around images more easily.

Aerial Triangulation Module: This module takes the control and tie point information and triangulates it to get a best fit of the data within all images in the block. It relies on the accuracy of the input points, both in how well they were initially surveyed (ground coordinates) and in how well they were placed in the image (file pixel coordinates). The use of large aerial control panels (white crosses with a well defined center point) on the ground greatly increases the accuracy of how well they are placed in the image by the operator. Ideally, you should be able to specify an estimate of this accuracy in the software. The resulting output is a numerical estimate of how well the tie and control points fit within each other. Typically, an RMS error in meters or feet is reported, which can be used to fulfill your metadata requirement for the spatial accuracy of each photo and the resulting GIS data you create from it. The more advanced programs allow users the capability to assign part of the error budget to the camera model and to other distortion parameters caused by the atmosphere and scanning of the film. Overall, this is a blackbox type module with little user intervention allowed in many packages. Once again, the goal is to solve for the six unknowns for each frame so that you can move onto the next module.

DEM/DTM Generation Module: Perhaps the greatest innovation that softcopy photogrammetry software has realized is the automatic generation of DEM's from stereo imagery. What used to take hundreds of hours by manual contour tracing, has been replaced by sophisticated image matching and autocorrelation algorithms that take only minutes. In many packages, this capability is an expensive add-on module, but without it you can only orthorectify your data using an existing DEM of potentially low quality. It is probably worth the investment if your GIS shop works extensively with terrain data for mapping and if you want accurate orthophotos.

Once again, this is a blackbox part of the software, but some user intervention is desirable. The ability to specify which stereo pairs are to be used is important and allows flexibility in determining the areas for DEM collection.



Selecting stereo pairs for DEM creation in ERDAS Orthobase from the graphical chooser window

An even better feature to have is the ability to specify within a pair of photos the areas that you want to collect a DEM. For example, if we are only generating DEM's of land 0 to 100 feet from the water edge, the ability to digitize a polygon that encompasses this region would greatly speed up the DEM generation procedure.

Other user input in this module is the selection of the DEM posting interval and the parameters that affect

autocorrelation. The posting interval depends on the resolution of the imagery such that if you have 1-foot pixel aerial photography, you would probably specify a posting interval of every 5 feet for generating detailed contours. The ability to define the autocorrelation parameters is the most important tool. You need to be able to define the correlation threshold at which an elevation value that is extracted is considered valid. Some software will create a point status image that gives you a numeric value for the correlation quality of the collected point. Low quality points could be masked out later keeping only the best correlated elevation values. You will want to be able to change the moving search window sizes, the DEM filtering values, and the image band that is used for correlation with color imagery.



Autocorrelation coefficients are very important parameters for achieving good DEM generation results, ERDAS Orthobase has the important ones available

Also, does the software have preset values for forest, urban areas, mountainous, and other common land cover types? Does the vendor provide documentation with some good values to start experimenting with? All of this is a trial and error process but the more built in functionality, the better.

Another nice feature is the ability to save the autocorrelated elevation values out in a variety of formats. A raw gridded elevation file is useful, but the capability to export ASCII points, USGS DEM format, TIN formats, and other software specific formats (AutoCAD, TerraModel, ESRI) can save you from having to create these files in a convoluted manner later.

Orthophoto Generation Module: Now that you have generated a DEM and possibly done some editing to it with a stereo or raster editor, it is time to create a planimetrically correct image map. The software uses the DEM file to correct for terrain displacement, and the exterior orientations for georeferencing to create a very accurate orthophoto. It is suitable for use as a backdrop to vector GIS data and to create accurate GIS data. The user input in this module should allow you to specify the area of each frame to use, the output pixel size, maybe the capability to contrast match and mosaic, and maybe the ability to compress the file into a Mr.SID, JPEG or ECW format. The output format of the orthophoto can be in GeoTiff, TIFF with a world file, or a proprietary image format. It depends on the package so check this feature before buying. This part of the software is probably the simplest to use. Some packages allow the use of a DEM obtained from another source or the use of a flat surface at a constant elevation where no DEM exists.

The most basic photogrammetry packages all have this module and it is frequently provided as a standard tool in some GIS and remote sensing software. However, without aerial triangulation of an entire block of photos and the creation of a new DEM, the final accuracy of this single frame orthorectification process may not be sufficient to support GIS mapping at a large scale.

Stereo Editing Module: This module allows users to view the imagery in stereo and edit contours, DEM points, and TIN's interactively to create a Digital Terrain Model(DTM). Autocorrelation is not perfect and users that need engineering grade contours will have to perform manual contour editing. Adding in topographic breaklines, curb and gutter features, stream channels and other topographic features not collected during autocorrelation is time consuming, but creates very accurate DTM's. Also, erroneous contours can be moved in 3-D space so that they accurately represent the true terrain. For users trying to create 1:24,000 orthophotos to map vegetation, this step may not be necessary as the raw DEM can be filtered to remove some of the artifacts of autocorrelation and generate sufficiently accurate orthophotos.

Many photogrammetry packages support the creation of 3-D GIS data directly from the stereo pairs. The advantages to this include proper positioning of the features in 3-D space, the creation of Z values at each vertex, and the ability to digitize buildings as cubes rather than as rectangles for use in virtual reality modeling and CAD applications. Some can run as stand-alone applications, like [ERDAS Stereo Analyst](#) and the VR Mapping Software by [Cardinal Systems](#).

Minimum hardware specifications: Often when purchasing photogrammetry software, vendors will recommend the bundling of software with a hardware solution. The reason for this is that most GIS workstations are not up to the task of photogrammetric processing. Special graphics cards are essential for stereo viewing and require the purchase of LCD shuttered viewing goggles or screens. It is critical to verify stereo graphics hardware configurations to ensure software and CPU compatibility. Some cards will work with the Pentium 4 systems and others will not, so do your homework. To do stereo editing of contours and 3-D GIS digitizing, special mouse-like contraptions are sometimes included with the system to allow for faster, more comfortable editing, including the use of foot pedals.

Disk access is probably the limiting factor in the speed of DEM generation and orthorectification. High bandwidth SCSI drives are the norm although IEEE1394 "Firewire" drives show some promise. Until recently, UNIX operating systems were the choice for software developers, however Windows NT and 2000 are now commonplace platforms for photogrammetric software. In the future, I hope developers will look to LINUX as a platform given the ease with which large super-computing clusters can be created. Physical RAM is also important and 512 MB or more is optimum running on 1+Ghz CPU's.

Software Review

The final section of this article is a brief description of some of the more common photogrammetry software packages and the URL to the vendor's website. In almost all cases, vendors do not provide pricing information outside of quotation format, but I have tried to give a relative idea of what the software costs.

Zeiss-Intergraph ImageStation www.ziimaging.com

Zeiss-Intergraph of Huntsville, AL offers a module to do about everything that you can do with photogrammetry. Running exclusively on Windows NT, ImageStation is usually marketed as a hardware/software bundle for high-end photogrammetric processing of satellite and aerial photo data. This is a fairly expensive solution but delivers high-end capability to users that need it.

Imagine 8.5 Photogrammetry Suite www.erdas.com

ERDAS Imagine 8.5 is a full-featured remote sensing program that has a photogrammetry add-on bundle called Orthobase. This suite has all of the basic photogrammetry tools like block adjustment, orthophoto creation, metric and non-metric camera support, and satellite image support for SPOT, Ikonos, and others, with planned support for Quickbird. The upgrade to Orthobase PRO allows users to create DEM's from stereo data and Stereo Analyst 1.2 is a stereo viewer and GIS data editor that can be bundled. Overall, this easy to use, robust package has many advanced tools built in, at a reasonable price.

DAT/EM International Summit Evolution www.datem.com

The Summit Evolution package by DAT/EM of Anchorage, AK allows for 3-D data capture within AutoCad and Microstation from oriented stereo pairs of aerial imagery. The interface is easy to understand and offers good tools to setup the stereoscopic model. There is no support for satellite imagery or automatic DEM generation. The software is sold as a hardware/software bundle and requires AutoCad release 14 or higher, or MicroStation SE or J.

OrthoMapper www.orthomapper.com

This might be the best package for the GIS professional who needs to create orthophotos occasionally. With full block adjustment capability and favorable pricing, this simple to use package can mosaic orthophotos too. The vendor, Image Processing Software, Inc. also expects to have a DEM extraction module available soon. No support for satellite imagery but will support non-metric cameras.

ISM DiAP www.askISM.com

This very informative website has loads of useful information about softcopy photogrammetry. Their flagship product, DiAP, runs within Bentley MicroStation Cad software and is a full-featured photogrammetry system. Their new release will allow for custom sensor modeling so that stereo satellite imagery can be incorporated.

ALBANY www.eriotech.com

Erio Technologies in Roseville, CA produces the ALBANY software which stands for Adjustment of Large Block of Anything. This program is only designed for the aerial triangulation phase of softcopy photogrammetry, but does support large blocks (up to 4,000 photos) and is marketed as the most accurate method of block adjustment. Prices for the ALBANY module alone are upwards of \$8,000.

ATLAS Photogrammetric Software www.kltassoc.com

KLT Associates out of Peabody, MA has been in business for 16 years and is an industry leader in photogrammetry software. ATLAS/DSP is their flagship product but is geared more towards large orthophoto production shops rather than GIS users who need to make orthophotos occasionally. No satellite imagery support.

LH Systems www.lh-systems.com

Leica Geosystems Systems acquired ERDAS, Inc. and LH Systems on April 25, 2001. It is still unclear how the ERDAS and LH Systems products lines will merge or compete with one another. Their flagship product SOCET-SET has been the standard by which all other photogrammetry packages are measured against. There are a myriad of modules that offer any conceivable capability users may need. There is full support for Ikonos and other satellite sensors. Pricing is on the expensive side for this feature rich software.

Boeing-Autometric Softplotter www.autometric.com

A subsidiary of Boeing, Inc. since August 3, 2000, Autometric was one of the early pioneers of softcopy photogrammetry software. Their Softplotter software is easy to use and has a nice linear workflow with enough bells and whistles to do the job without overwhelming new users. ERDAS remarkets Softplotter as Orthomax on the UNIX platform. Overall, this software is a good value given its price and functionality.

DVP www.dvp.ca

DVP-GS, Inc. of Levis, Canada introduced one of the first softcopy photogrammetry packages in 1990. They offer a full set of configurations with a variety of modules focused on stereo data collection, orthorectification, and aerial triangulation. Their software is fully compatible with MicroStation and AutoCad to allow for powerful digitizing functions.

PCI Geomatica www.pcigeomatica.com

PCI Geomatics of Richmond Hill, Ontario produces the OrthoEngine suite of software. This full featured, easy to use program runs on all Windows platforms, LINUX and UNIX systems. Besides DEM extraction, aerial triangulation, and stereo data capture, OrthoEngine supports the widest range of camera and satellite sensor

models of any system on the market including the ASTER satellite. If you had to choose between ERDAS Orthobase Pro and PCI OrthoEngine, it would be a toss up. All of the key features are here for GIS users, along with good pricing.

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