SoftPlotter® Functional Specification

Restricted Rights Notice

Acknowledgements

ERDAS™ and ERDAS IMAGINE™ are registered trademarks of ERDAS, Inc.

TERRAMODEL™ is a trademark of Spectra Precision Software, Inc.

IDELIX™ and PDT™ are trademarks of IDELIX Software Inc.

Stealth 3D Mouse™ is a trademark of GCS, Inc., Geometric Computer Services

SoftPlotter sales and product information inquiries should be directed to:

Boeing S&IS Mission Systems
80 Exchange Street
Suite 400
Bangor, Maine 04401
Tel: 207-945-6353
Fax: 207-942-9815
softwaresolutions@boeing.com

Customers in need of technical support should contact Technical Support at:

1-800-220-6081
ts@boeing.com

International customers should use the following numbers to contact our support services:

207-990-0017
207-945-6353

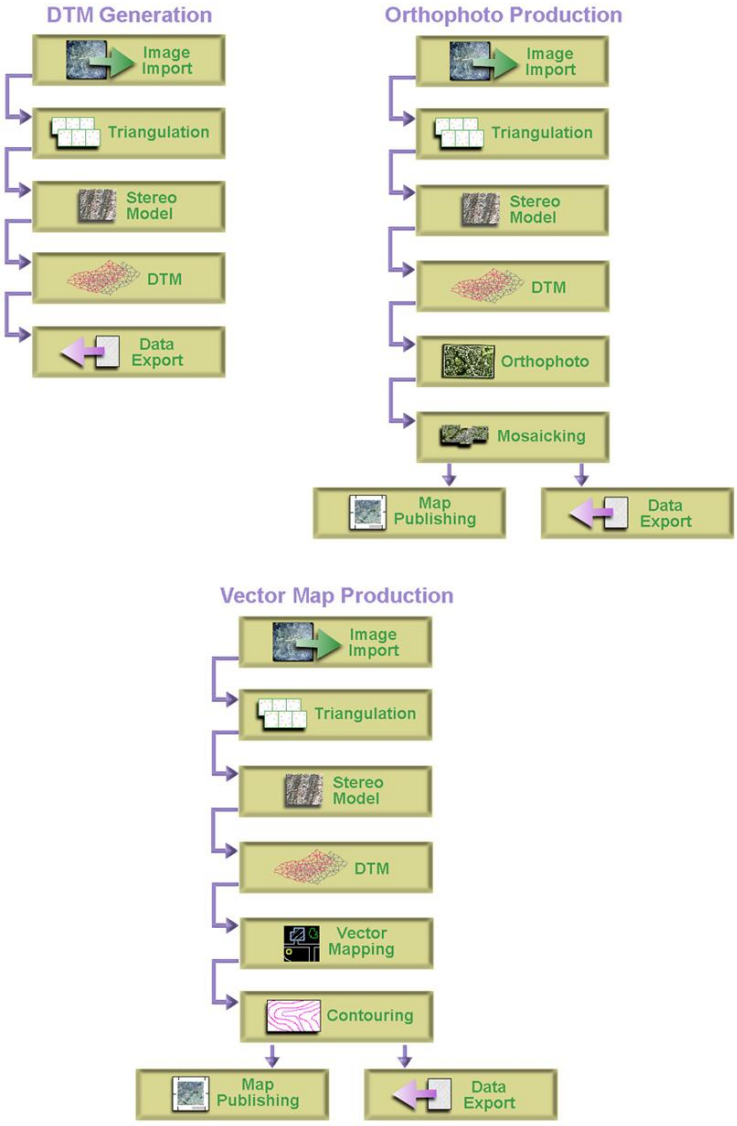
Table of Contents

INTRODUCTION

SoftPlotter® provides accurate and efficient extraction of terrain and feature data from digital imagery (scanned film aerial photography, digital aerial photography, and satellite imagery). It offers data preparation support for applications such as mapping, GIS, simulator and mission-planning database generation, and site and facility modeling.

SoftPlotter is an end-to-end softcopy photogrammetry system, supporting all aspects of digital map production, from importing raw images to producing finished mapsheets. SoftPlotter's modular design allows you to customize many aspects of the workflow to meet the needs of your production environment. Interfaces to external data sources and data formats ensure that SoftPlotter can be integrated into existing operations without requiring conversion to a completely digital operation.

The following illustration shows some typical workflows for performing various map production tasks.

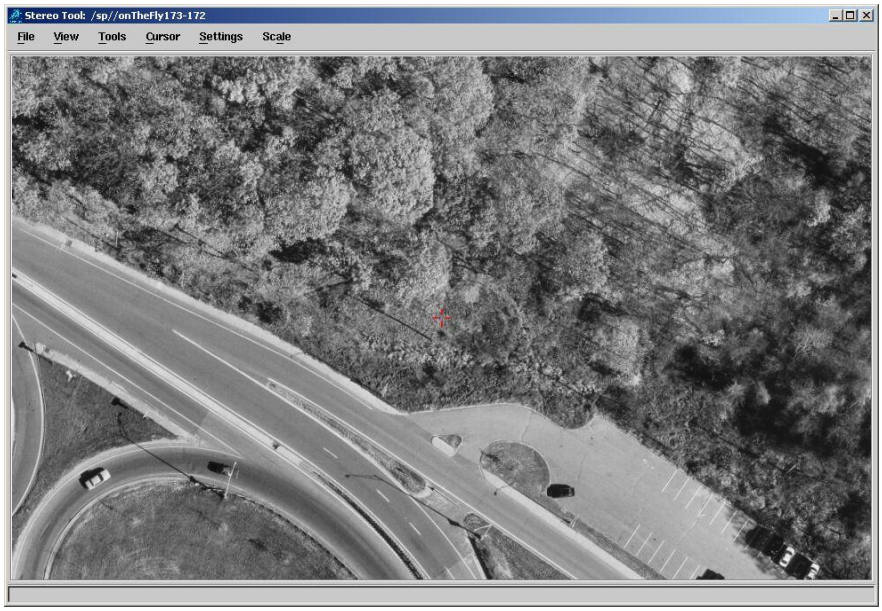


THE SOFTPLOTTER VIEWING WINDOW

A number of SoftPlotter tools invoke the SoftPlotter viewing window. The default SoftPlotter viewing window consists of controls and an image overview on the left side of the window, and an enlarged view of the image on the right side of the window.

The image on the right side of the window can be zoomed in and out using the user-defined Roam and Close-up settings in the viewing window. Some SoftPlotter tools, such as the Surface Tool, the KDMS Tool, and the DGN Tool, allow you to display information superimposed over the image on the right side of the window.

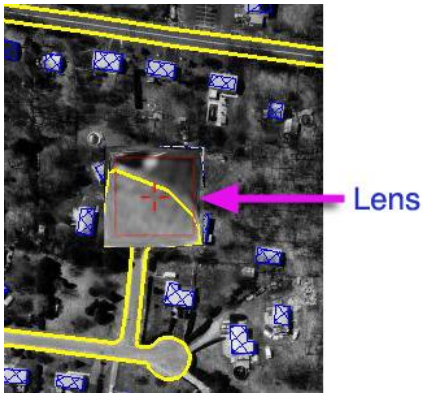
You can change the viewing window to display only the menu bar and image, without the controls and image overview. This is useful for maximizing the area in which an image is displayed after you have navigated to an area of interest in your image.



Viewing Window Features
Stereo and monoscopic viewing
Panning and drive controls
Idelix PDT lensing capability
XYZ cursor position display
Z cursor control
User-selectable cursor colors, shape, and pointing device selection
Reference frame and display units selection
Versatile zooming capabilities, including user-definable roaming and close-up settings to instantly toggle between overviews and close-ups of imagery
Brightness and contrast controls

IDELIX PDT LENSING CAPABILITY

SoftPlotter incorporates the Idelix™ Pliable Display Technology (PDT™) lensing capability. The Idelix PDT lens magnifies the portion of the imagery under the lens in real time. This allows the close-up view of imagery beneath the lens while maintaining an overview of imagery surrounding the lens, thereby facilitating navigation within the imagery without the need for zooming in and out.



Lens size, lens zoom level, and lens shoulder size are all user-configurable.

SOFTPLOTTER SOFTWARE

SoftPlotter is organized into "tools" which represent significant steps in the production process. All tools employ a common graphical user interface and are implemented as separate executables. The Toolbar serves as the launcher for the SoftPlotter software and other tools. It is structured to facilitate an orderly process flow, from left to right – although individual projects may not involve all SoftPlotter tools.

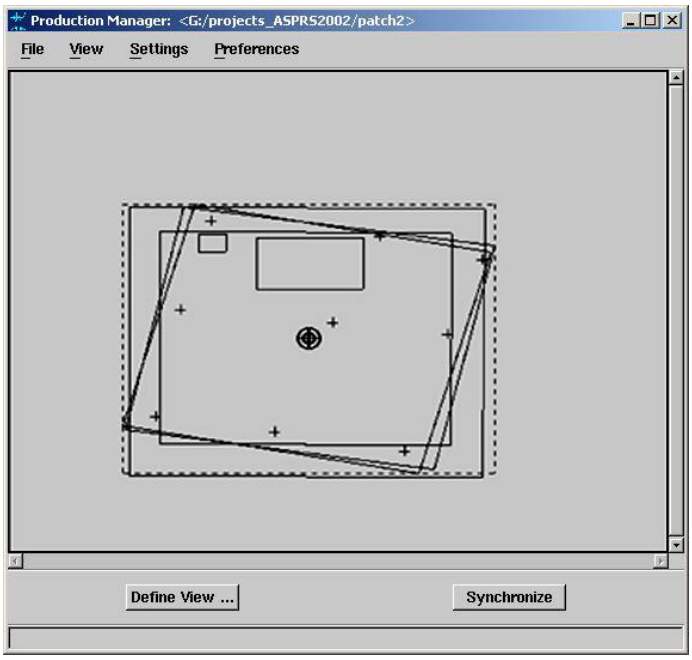
THE SOFTPLOTTER PROJECT

SoftPlotter is built around a project concept. A project contains the source data, interim products, and final products needed to satisfy a production effort. The Production Manager (PM) tool provides for project visualization and data management that further emphasizes the project approach.

Although a project could contain several block bundle adjustments — and the software supports this — it generally contains just one. The software supports the capability to split large blocks of imagery down into smaller blocks, process them, and then merge them back together for simultaneous block adjustment.

PRODUCTION MANAGER TOOL

The Production Manager (PM) Tool provides a graphical depiction of the status of activities in all other SoftPlotter Tools. The PM Tool displays information such as the location of control points and the outlines of the footprints of source imagery, collected DEMs, and defined orthos. The "Display Definition" control panel allows you to select what is displayed and assign the color of each element.



MODEL SETUP AND TRIANGULATION

Block Tool is used for the import of imagery, interior orientation of photographic imagery (registration of the pixel coordinates to the calibrated fiducials), the triangulation process, and creation of support data for all frames in the triangulation.

Block Tool Features
• Handles all aspects of block adjustment (triangulation) for standard frame (aerial camera), SPOT and other satellite, and panoramic imagery
• Support for full control (XYZ), horizontal control (XY), and vertical control (Z)
• Block split/merge: merging of subblocks into a single block to support simultaneous operations by multiple operators on the same block or to support temporarily breaking down larger blocks into more manageable pieces
• Storage of quality control points (tie points and ground control points) for visual

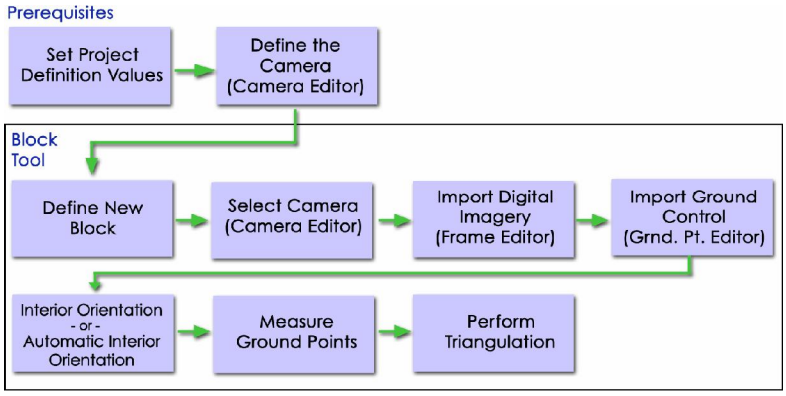
accuracy checks in subsequent data production processes
• Fully automatic tie and pass point selection and measurement (BTIE); this function automatically selects and measures tie and pass points for blocks of images based on overlap percentages and user-defined numbers and patterns of points per frame
• Liberal data import and export capabilities (see the section “Data Import/Export” on page 19 for information).
• Batch processing available for many Block Tool tasks (see the section “Batch Processing” on page 17 for information).

The use of the Block Tool typically involves:

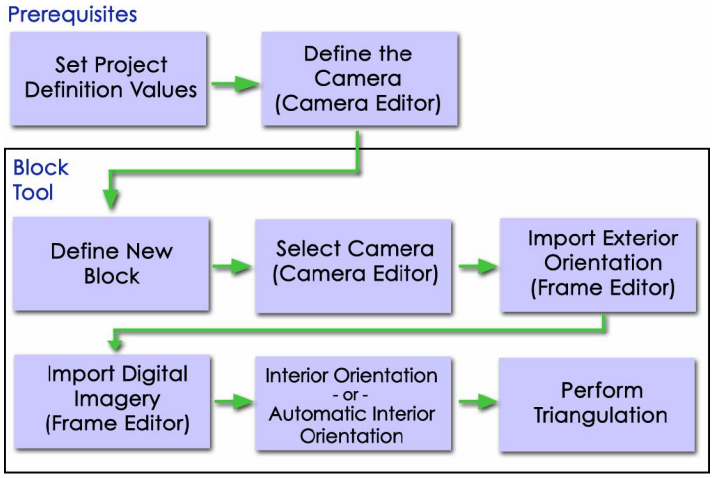
- preparatory steps to define the data to be used, including setting global project parameters, specifying the camera, importing imagery, and importing ground control data
- performing interior orientation (either manually or automatically)
- measuring ground points interactively
- performing triangulation

As with most tools in SoftPlotter, the Block Tool is designed to allow flexibility in the way information is brought into the tool, enabling you to tailor the tool to your particular workflow requirements. For example, for projects using digital cameras, interior orientation is not performed since digital cameras do not have fiducials. The following diagrams illustrate some commonly used Block Tool workflows.

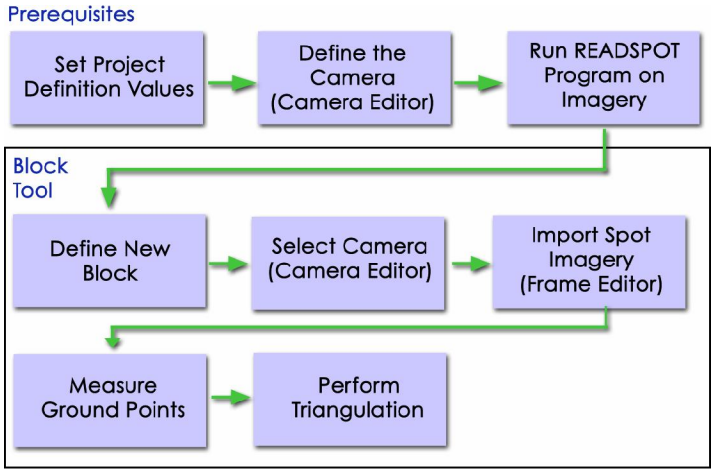
BLOCK TOOL – BASIC WORKFLOW



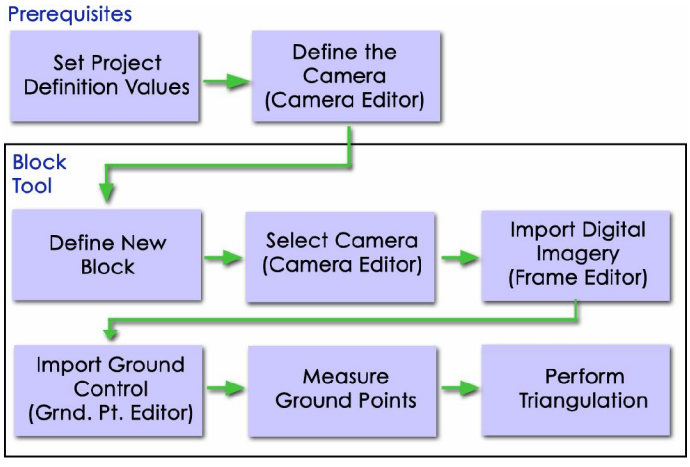
Block Tool – Workflow When Using Exterior Orientation Data



Block Tool – Workflow for SPOT Satellite Imagery



Block Tool – Workflow for Digital Cameras



Preparatory Steps

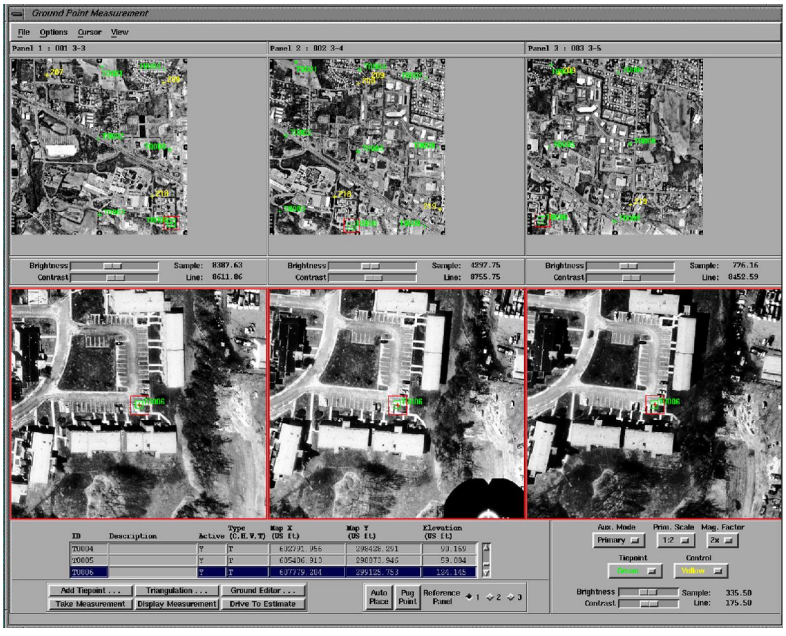
- The *Camera Editor* is used for entering/editing camera information including camera calibration data and exposure station data. Frame camera photography, as well as digital camera photography, is supported.
- The *Frame Editor* handles the importing of digital imagery into the current block. Standard frame photography does not always come with its exterior orientation data. The *Standard Frame Editor* provides for the input of these elements, as well as definition of frame status, the applicable camera, and pixel measurement precision of the digitized imagery. Imagery can be imported all at once, or as individual frames.
- Support for the import of imagery in a wide number of formats, including: binary, ERDAS IMAGINE, TIFF, VEXCEL, Wehrili, and Helava.
- Optional import of external triangulation results or airborne GPS exposure station coordinates.

Interior Orientation

- Fully automatic interior orientation (AIO) for most common cameras using a least squares, subpixel template correlation technique
- Manual interior orientation for cameras without built-in fiducial templates, with automatic measurement after the first two readings

Ground Point Measurement

- Ground point measurement and editing is accomplished using the *Ground Point Editor.*
- Measurement of ground control and tie point image coordinates on up to 3 or 6 images simultaneously, with semi-automatic digital image matching by least squares matching techniques



- Optional automatic generation of tie point IDs during ground point measurement
- Import of ground control from an ASCII file, including the saving of templates to describe common ground point file formats

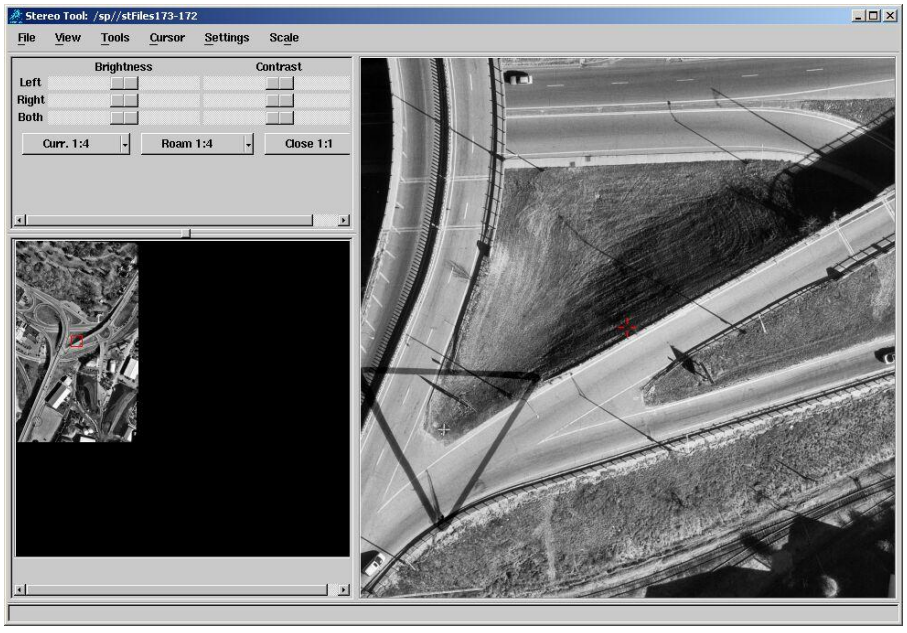
- Once ground control points and tie points have been established, they can be used as “quality control” points in any subsequent operations. For example, the tie and ground control points can be displayed superimposed on a stereo model so that the operator can determine if the elevation of the points is valid.

TRIANGULATION

- SoftPlotter triangulation employs a least squares block bundle adjustment approach. This approach is a fully weight-constrained solution with complete accommodation for precision of all measurements and parameter values. A rigorous error propagation is performed for use in troubleshooting and assessing the overall geometric health of the block.
- Triangulation pre-processing to weed out invalid data and estimation of unknown parameters
- Precision can be assigned to image measurements, exterior orientation parameters, ground control points, and any parameters involved in the solution. Individual image measurements, ground points, and images may be turned off and on, or deleted.
- Triangulation computation by the method of least squares using fully weight-constrained parameters and rigorous estimation for unknown parameters

STEREO MODEL GENERATION AND VIEWING

Stereo models are formed by epipolar resampling of the imagery to create a set of images that are free of Y parallax. Stereo models can be created for any type of imagery supported by the triangulation process. The stereo models and their support data files are sensor-independent for all subsequent operations.



STEREO TOOL

The Stereo Tool is used to generate and view stereo models of overlapping images in a SoftPlotter block. These stereo images are used by a number of SoftPlotter Tools for 3D collection and editing of DTM and planimetric data: DEM Tool, Surface Tool, KDMS Tool, and DGN Tool.

A stereopair is created by resampling and rectifying the triangulated block images into an "epipolar" orientation such that parallax in the y (line) direction (y-parallax) is removed and parallax in the x (sample) direction (x-parallax) is interpreted as differences in elevation.

Stereo Viewing

SoftPlotter provides *Quad Buffered Stereo* (QBS)**,** also known as OpenGL Stereo. QBS offers high stereo resolution, excellent panning performance (real-time, full-screen pan), and stereo display in a resizable window.

Viewing of "on-the-fly" epipolar resampled imagery is available. When this feature is enabled, SoftPlotter uses real-time stereopair generation whenever displaying the specified stereopair. This feature saves both processing time and disk space since you do not have to wait for epipolar resampled stereo pairs to be generated or stored as files on disk before viewing the images in stereo

Digital Terrain Model (DTM) Generation

A digital terrain model (DTM) refers generically to terrain data, which may be a digital elevation matrix/model (DEM), or triangulated irregular network (TIN). SoftPlotter supports both methods for definition of terrain data:

- A DEM consists of a gridded elevation data set that is oriented grid "North-up." This form of data storage is commonly encountered with government agency data and with smaller scales of map information (generally less than 1:25,000).
- A triangulated irregular network (TIN) is a form of ungridded elevation data storage in which "mass points" and "breaklines" are used to describe the terrain surface in a generally more accurate manner than DEMs. This is the most common form utilized by mapping firms working with larger map scales.

SoftPlotter includes modules which automatically extract DTM data from overlapping images. Surface Tool and DEM Tool can extract DTM information from stereo models or directly from the overlapping triangulated images. These two tools can be used separately or in conjunction with one another based on input or output DTM requirements.

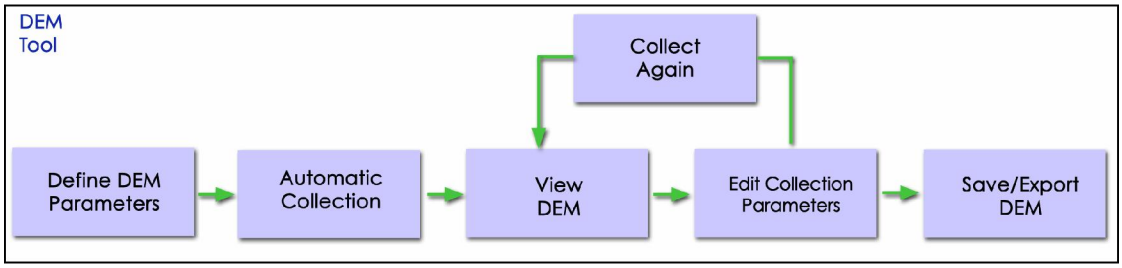
SoftPlotter DTM Generation Features
• Automatic collection of gridded or ungridded terrain data at high speed (50 to 1000+ points per second from stereo models, depending on hardware configuration)
• Proprietary digital correlation approaches using either block images or epipolar resampled (stereo model) imagery
• Selection of reference frame and linear units for viewing
• Retention of status and correlation quality on a point-by-point basis
• Assignment or reassignment of stereo models used for editing
• User definition of correlation strategy templates which tailor the automatic collection algorithms for specific imagery and terrain conditions
• Visualization of DEM data in either raster form (elevations assigned gray shades), relief-shaded view (sun angle and azimuth user-definable), or log file form (tabular results of correlation process)
• The DEM or TIN data can be displayed in stereo superimposed over a stereo image model for editing and accuracy verification. TIN editing allows the user to add breaklines, points, and defined surfaces to more accurately and efficiently represent the terrain. DEM and TIN data can also be imported from other sources such as USGS DEM and DTED.
• Liberal data import and export capabilities (see the section "Data Import/Export" on page 19 for information).

- Batch processing available for many DTM tasks and DEM and TIN file conversions (see the section "Batch Processing" on page 17 for information).

DEM Tool

The DEM Tool is used to automatically collect (autocorrelate) a ground space matrix of elevations from triangulated block image pairs or stereopairs generated by the Stereo Tool. In addition to autocorrelating DEMs, the DEM Tool can import existing DEMs. Several point and polygon editing features are available for DEM editing.

The DEM Tool stores the collected elevation data in a raster file format that requires even spacing between the points and cannot accommodate mass points or breaklines that are not at this even spacing. The DEM format is generally appropriate for small scale mapping (less than 1:20,000), but is not appropriate for larger scales due to the interference of man-made objects.



- DEM editing using "stereo edit" featuring stereoscopic display of DEM posts, represented by cross symbols, over stereo imagery. The collection of DEM edit controls include:

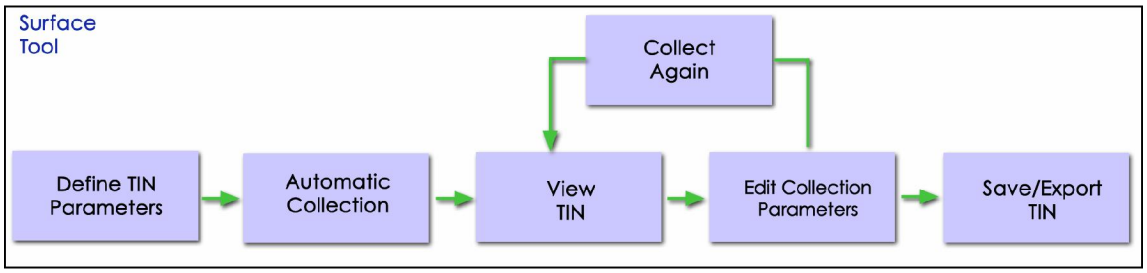
Point Inspect Mode	Displays coordinate information for the selected DEM post.
Point Edit	Changes the elevation for a single DEM post.
Polygon Equal	Applies a single elevation to multiple DEM posts, as indicated by a selection polygon.
Polygon Shift	Increases or decreases the elevations of selected points by a set amount
Polygon Face	Modifies the elevations of selected points such that they fall on a specified plane
Polygon Surface	Defines a surface within a specified region by allowing the influence of interpolated point elevations within a region
Polygon Interpolate	Allows for the updating of selected interpolated points
Cross Section Editing	Allows one to alter the elevations of DEM posts within a prescribed distance from a digitized line

- Display of DEM posts with variable cross size, color by status, density
- User-specified DEM post density control
- Statistical comparison of DEMs with histogram difference tables
- Capability to create custom terrain profiles for use with cross-section editing

SURFACE TOOL

The Surface Tool is used to create a Triangulated Irregular Network (TIN). TINs can be created by automated correlation techniques, by manual stereo collection, or by import of existing ASCII, DEM, DGN, or TIN format data. All TIN files are stored in Spectra Precision TERRAMODEL ".pro" format. Most professional mapping and engineering firms deal primarily with large scale (<1:20,000) imagery, and prefer the TIN format because of its superior surface representation and more efficient use of available storage.

Surface Tool provides stereoscopic viewing, verification, and interactive editing of TINs superimposed over a stereopair.



- TIN editing using "stereo edit" featuring stereoscopic display of TIN elevation postings, represented by crosses, over stereo imagery. TIN edit controls include:

Point Edit	Changes the height of a single point. Elevation may be derived manually with the digitizing device, or via the terrain following cursor.
Point Add	Adds a point or points to the TIN. Elevation may be derived manually with the digitizing device, or via the terrain following cursor.
Point Delete	Deletes a TIN point or points.
Breakline Add	Adds a breakline.
Breakline Delete	Deletes a breakline.
Breakline Split	Deletes a portion of an existing breakline, breaking it into two breaklines.
Breakline Join	Joins two existing breaklines together.
Breakline Append	Appends a breakline to an existing breakline.
Breakline Replace	Interactively edit an existing breakline.
Breakline Parallel	Adds a set of parallel breaklines.
Polygon Delete	Delete multiple TIN points, as defined by a selection polygon.
Polygon Equal	Applies a single elevation to multiple TIN points, as indicated by a selection polygon.
Polygon Cookie	Deletes a group of TIN points and creates a breakline.
Polygon Shift	Increases or decreases the elevations of selected points by a set amount.
Polygon Trim	Deletes all TIN points outside of a specified polygon.

- Near real-time contour generation with variable interval and color coding
- Control of TIN layer display allowing for both generation of new layers and editing of layers

- Access to the “KDMS Edit” option which embodies KDMS integrated with the TERRAMODEL surface and contour tools. This offers more professional contouring presentation and the use of common KDMS macro functions.

Digital Orthophoto Generation and Mosaicking

The Ortho Tool is used to create an orthophoto. The tool uses a triangulated image and a DTM as input to the orthorectification process. The resulting accuracy of the orthoimage is based on the accuracy of the triangulation, the resolution of the source image, and the accuracy of the DTM.

The Mosaic Tool is an interactive editor for producing digital orthophoto mosaics. The tool employs sophisticated histogram matching and feathering techniques to produce seamless mosaics with uniform radiometric and geometric characteristics. The Mosaic Tool may be used to produce mosaics consisting of both orthoimages and other mosaics.

The Mosaic Tool also supports the creation of simple “collages.” Collages are created by the simple insertion of source images into the mosaic in an order defined by the definition process and supported by interactive ranking. A collage is often useful by itself for smaller scale imagery and/or satellite imagery.

Ortho Tool

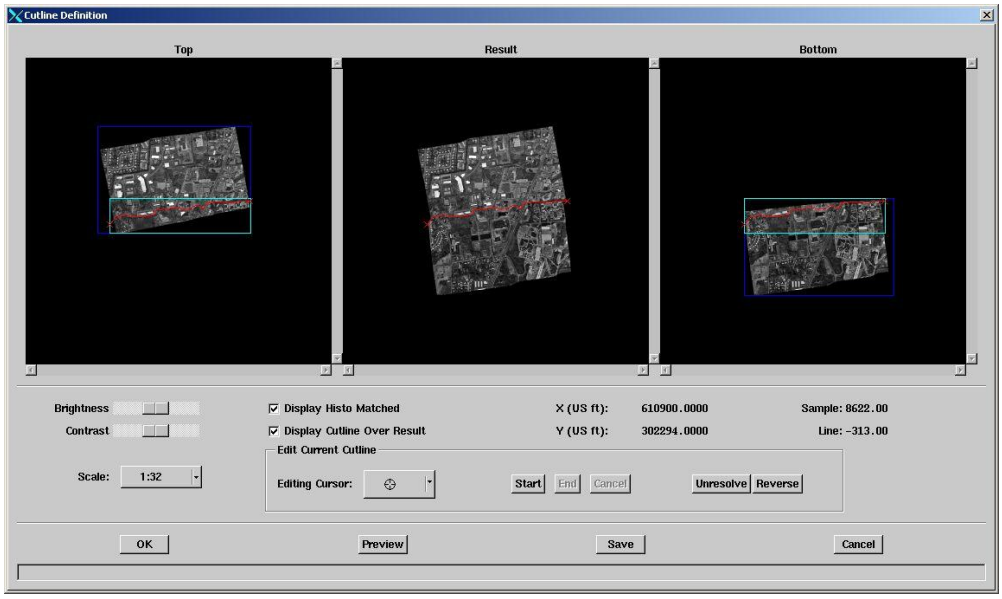
The Ortho Tool handles the orthorectification of images using triangulation results, and DEM, TIN, or planar terrain information. It is used to generate digital ortho images for mosaicking.

Ortho Tool Features
• High-speed orthorectification
• Optional generation of companion DEM file
• Selection of one or all bands of a multi-band image
• Specification of trim amount in pixels or percentage of frame size
• Support for multiple output file types (see the section “Data Import/Export” on page 19 for information)
• Selection of ortho boundary type; either to the centers of the boundary pixels, or to the outer edges of the pixels
• Batch processing available for ortho production tasks (see the section “Batch Processing” on page 17 for information)

Mosaic Tool

The Mosaic Tool handles the mosaicking of ortho imagery into a single image file. The tool employs sophisticated histogram matching and feathering techniques to produce seamless mosaics with uniform radiometric and geometric characteristics.

The tool includes the ability to “collage” an area (no cut line or feathering) or the use of interactive cut lines with or without feathering for seamless image generation. Imagery inputs include the ortho images from the project, IMAGINE ortho images, other mosaics, and an optional reference image or sigma stretch parameter.

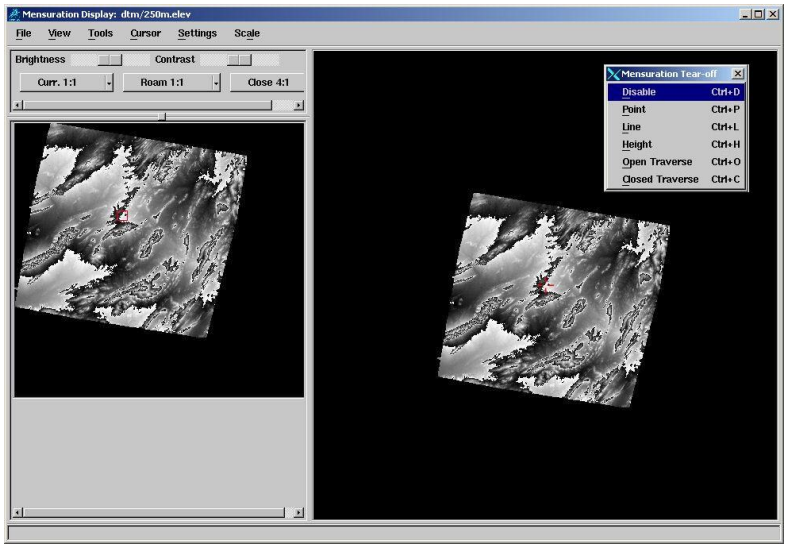


Until a mosaic is specifically saved, all operations are maintained as a "virtual mosaic," so there is no need for the generation of a large, interim image file. Sheets for an entire project area can be cut from the virtual mosaic.

Mosaic Tool Features
• Handles ortho images and mosaics of the same scale, orientation, and reference frame
• Automatic ortho image list generation based on mosaic bounds by sorting against the individual ortho bounds
• Automatic collection of overlap histograms
• Histogram matching optionally based on reference image
• Collage processing by rank order with or without histogram matching
• V Interactive cutline delineation of all images in overlap zone for precise location and avoidance of relief displacement problems
• Extensive cutline editing capabilities and exporting of cutlines
• Automatic identification of overlap area outlines
• Capability to manually edit, import, and export tile names and tile corner coordinates
• Preview of results of cut line processing
• Radiometric feathering within a feather zone in overlap area, user-specified feather widths
• Option to display vector data over the main collage view
• Support for multiple output file types (see the section "Data Import/Export" on page 19 for information)

MENSURATION

The Mensuration Tool provides the capability to perform general mensuration upon monoscopic imagery. This includes geopositioning, distance, slope, azimuth, area, and height measurements.



Mensuration Tool Features
• Can be used with raw imagery, triangulated imagery, ortho imagery, and stereopairs in a SoftPlotter program.
• Supports the use of a DTM for performing interactive 3D coordinate derivation
• Coordinate readout in 3D (user specified elevation for monoscopic images if a DTM is not present)
• Creation of ASCII report file of measurements (suitable for import to CAD or GIS)
• Display of point coordinates (X,Y,Z)
• Vertical object heights (triangulated imagery only — not orthophotos)
• User-modifiable linear units and reference frame settings
• Line azimuth, slope, change in elevation, endpoint coordinates
• Open or closed traverse legs (each expressed as a line), with area computation for closed traverses

VECTOR MAPPING/DATA CAPTURE

SoftPlotter is tightly integrated with KDMS vector mapping software for map compilation. KDMS is a production-oriented vector mapping package specifically designed for photogrammetry.

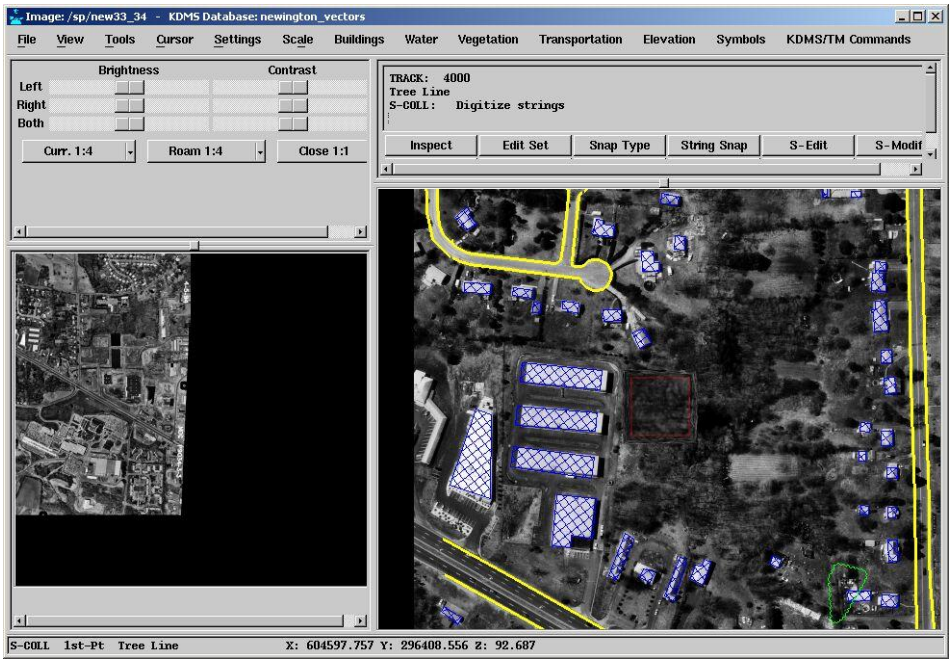
Boeing also offers the DGN Tool, which is based on Bentley Systems MicroStation software. This map compilation software is interoperable with the DGN (MicroStation Design) files. The DGN Tool features the capability to display multiple SoftPlotter viewing windows, each with a different image.

Both tools allow for vector collection and editing by vector superimposition over imagery in stereo or monoscopic mode. SoftPlotter operators may import existing 2D vector files and view the files with stereo superimposition by passing the horizontal coordinates through the DTM surface to determine elevations for all points. This is common when dealing with vector formats such as ESRI ARC/INFO (which is not completely “3D”) and when performing update mapping with older vector data.

Both the KDMS Tool and the DGN Tool include stereoscopic, monoscopic, or orthoscopic feature extraction capabilities.

KDMS Tool

KDMS automates the production of digital base maps and map files, through the photogrammetric compilation of topographic and planimetric data. KDMS facilitates both 2-D or 3-D geographic data collection.



The KDMS Tool offers both automatic and interactive editing capabilities. Automatic editing involves the use of support files that define the editing processes, so no special operator intervention is required. Interactive editing allows the operator to perform editing operations at any time during compilation or digitizing. The interactive editing operations are similar to the digitizing process itself.

KDMS Tool Features
• Liberal data import and export capabilities (see the section “Data Import/Export” on page 19 for information).
• Batch processing available for many KDMS tasks (see the section “Batch Processing” on page 17 for information).
• Select from a terrain following cursor (real-time correlation), DTM (surface) following cursor (follows attached DTM), or an epipolar cursor (operator control)
• Set rules to square features, define parallel lines, specify closure and fill, and automatically insert precise nodes at feature crossovers (e.g. at driveway intersections)
• Definable 3D snapping functions
• Automatically place spot elevations, as text, at a selected rotation

Automatic Editing

- Comprehensive batch editing capabilities reduce the need for operator interaction and allow for computationally intensive tasks to be run off-line during non-peak times.
- Smooth contours and other linear features.
- Delete selected line work within closed features (i.e., contours within buildings).

- Trim line work beneath annotation.
- Delete large portions of data for update mapping.
- Edge match and intersect nearly adjacent linear features from different stereomodels.
- Globally or selectively change feature attributes including elevation, feature code, character height, and character width.
- Subdivide selected line work at all intersection points.
- Snap and cut line ends to other lines within tolerances specified by feature.
- Filter excess data points.
- Concatenate multiple lines into a single feature.

Interactive Editing

- Delete lines, symbols, and annotations.
- Restore previously deleted features retained in the database.
- Snap and cut line ends to other lines.
- Change the shape of portions of lines.
- Spline, filter, or square existing lines.
- Generate parallels from existing lines.
- Modify elevation values.
- Move symbols and annotation.
- Cut line segments at intersections with other lines.

Macros

- Extensive capabilities for defining macros that combine the functionality of several commands and/or other macros. Macros can be used to automate nearly every aspect of KDMS, thereby simplifying production tasks.
- Advanced macro capabilities include “completion macros” which are run automatically when a specific task is completed, and expression evaluation, which allows macro functionality to be influenced by real-time input.
- Macros can be used to access and alter most of the information associated with a feature. “Feature Process Objects” can be chained together such that the output of one task is used as input for the next task. This powerful feature object manipulation capability allows for sophisticated production automation.

Symbology

- Extensive symbology specification and editing capabilities for customizing: color, size, point patterns, area fill patterns, line patterns, text, and text content analysis.
- Default symbology files provided with SoftPlotter can be used as is, or can be customized to fit production needs.

- Separate symbology sets can be defined for different devices, allowing, for example, to use one set of symbols on screen, and use a different set of symbols when plotting, without having to maintain separate vector files.

DGN Tool

The DGN Tool integrates the SoftPlotter viewing window with the Bentley Systems MicroStation mapping application. Through the use of the DGN Tool, you can superimpose MicroStation vectors on a SoftPlotter stereo image or mono image and digitize or edit vectors using the appropriate MicroStation tools. All edits are reflected in real-time on both the SoftPlotter viewing window(s) and the MicroStation window. The MicroStation vector window automatically pans in conjunction with panning of the image in the SoftPlotter viewing window.

DGN Tool Features
• Option to import existing DGN files and vector data in KDMS format.
• Supports the use of adjustable template cursors, which can help in determining if a feature meets the minimum requirements for collection.

Batch Processing

SoftPlotter features a batch scripting process to allow many of the computationally intensive tasks to be run off-line. Stereo model generation, digital terrain model collection, digital terrain model import, orthophoto rectification, frame import and automatic interior orientation, and automatic tie point and pass point selection (BTIE) may be set up to run when the computer is not being used for interactive processing. For many batch commands, the results of one operation may be "chained" together as the input for a subsequent operation, thereby allowing you to build sophisticated batch processing workflows.

The following table lists the batch processing commands available in SoftPlotter:

Block Tool	
interior	Automatic interior orientation
newupblock	Reference frame generation
acceptBlock	Block file updating
btie	Blockwise automatic tie point selection

readSpot	Read SPOT 9-track tapes, CD-ROMs, and any SPOT scenes stored on disk
DTM (DEM Tool and Surface Tool)	
dtmDefine	DTM definition
dtmepi	DTM epipolar collection
dtmortho	DTM collection
demMerge	Merging DEMs
compareDEM	DEM comparison
erdcolor	DEM IMAGINE color definition
usgsImport	USGS import
DEM File Conversions (Translators)	
demConvert	DEM conversion
img2dig	DEM binary conversion
img2dem	DEM IMAGINE conversion
dem2tin	DEM IMAGINE import
dem2dted	DEM to DTED conversion
dted2dem	DTED to DEM conversion
TIN File Conversions (Translators)	
aptpro	ASCII to TIN (.pro) file
pro2tin	GEO file creation
apt2tin	ASCII to TIN (.pro and .geo file) conversion
dgn2tin	DGN to TIN conversion
tin2dgn	TIN to DGN conversion
tin2img	TIN to IMAGINE DEM conversion
Stereo Tool	
stereoWarp	Stereopair warping
sfmwarp	Stereopair warping
sptwarp	Stereopair warping
OrthoTool	
orthoDefine	Image processing, single image
orthoDefine2	Batch image processing
geocode	Orthorectification
Ortho File Conversions (Translators)	
ortho2adri	Ortho to ADRI conversion
Mosaic Tool	
mosaicWrite	Mosaic image output
Image Tiling	
tileit	Non-tiled to tiled image conversion
untileit	Tiled to non-tiled image conversion
untiletiff	Tiled TIFF to non-tiled TIFF conversion
Miscellaneous	
allrrds	RRDS definition
autododge	Automatic dodging of scanned imagery
buildUTM	UTM definition
dumpgps	GPS text file creation

fileConvert	File conversion
geotiff_cp	Adding GeoTIFF data to a TIFF file
geotiff_list	Extracting GeoTIFF header information
imgRotate	Image rotation
spversions	Version information display

DATA IMPORT/EXPORT

SoftPlotter, through its component programs, can import and export data in a wide variety of formats. The import capabilities enable the use of legacy data and help maximize current technology investments. The export capabilities help ensure data delivery in the format required by clients or for post-processing procedures.

Tool	Import	Export	Comments
Block Tool	PAT-B, JFK, ISBBA, Albany, Z/I DMC, ASCII triangulation data ASCII ground point coordinates ASCII external orientation data (such as GPS) Satellite ephemeral data Imagery: binary, IMAGINE, TIFF, VEXCEL, Wehrli, Helava	ASCII triangulation report files ASCII "block dump" file ASCII ground point file ASCII tie and pass point file ISBBA	
Stereo Tool	DPPDB		
DEM Tool	IMAGINE DEM file DTED USGS DEM	IMAGINE DEM file Binary DEM file ASCII report file DTED	The DTED export is an optional module
Surface Tool	TERRAMODEL TIN file IMAGINE DEM file Binary DEM file ASCII mass point file DGN	TERRAMODEL TIN file ASCII points file IMAGINE DEM file DGN	
Ortho Tool	IMAGINE IMG files	Binary, IMAGINE, TIFF, GeoTIFF, Intergraph COT image files ASCII report file	
Mosaic Tool	IMAGINE IMG files (through Ortho Tool) Binary TIFF	Binary, IMAGINE IMG files, TIFF, GeoTIFF, COT image files ASCII report file	
KDMS Tool	KDMS file SoftPlotter DEMs DXF ARC/Info TERRAMODEL TIN file	KDMS file TERRAMODEL TIN file DXF ARC/Info	Korktran translators can be used to convert to and from other formats

Tool	Import	Export	Comments
Korktran	DXF EXP DGN ARC/INFO ArcView KDMS	DXF DGN ARC/INFO ArcView KDMS	Optional for each format except KDMS to KDMS
DGN Tool	DGN KDMS	DGN KDMS	
Mensuration Tool		ASCII report file	

SYSTEM COMPONENTS

SoftPlotter is designed to provide flexible growth in both hardware and software. It is based on open systems concepts and complies with commercial and industry standards.

Compliance with commercial standards allows SoftPlotter to quickly take advantage of commercial-off-the-shelf hardware and software advances as they come to market. This means SoftPlotter will be able to take advantage of new hardware and software technology in support of advanced stereo displays, enhanced rectification, DTM and vector data collection, and orthophoto creation with little or no impact to the existing baseline software.

The SoftPlotter hardware configuration is composed entirely of commercial-off-the-shelf components. No unique hardware boards or components are required, though certain criteria must be met for SoftPlotter to perform at a production level. SoftPlotter can function as a standalone unit or be integrated into a networked environment.

SoftPlotter uses the fastest, most powerful workstations on the market. Boeing is continuously working to support state-of-the-art high performance workstations as they are released (and sometimes prior to general release) by the manufacturers.

STEREO VIEWING SYSTEMS

Stereo viewing is provided through either the StereoGraphics stereo viewing systems (http://www.stereographics.com/products/body_products.html) or the NuVision stereo viewing systems (http://www.nuvision3d.com/products.html). Available systems are:

- Stereoscopic wireless glasses that work in conjunction with an infrared emitter to provide stereo viewing. StereoGraphics offers the CrystalEyes wireless eyewear system. The emitters plug directly into the workstation.

Stereoscopic viewing panels that fit over a computer screen and are used in conjunction with lightweight polarized glasses to deliver stereo viewing capability. StereoGraphics offers the Monitor ZScreen 2000 viewing panel. NuVision offers the 21SX viewing panel.

3D POINTING DEVICES

The SoftPlotter interface can be manipulated using a traditional mouse pointing device, or by using the Stealth 3D Mouse™ pointing device or the SoftPlotter SoftMouse pointing device.

The Stealth E-mouse (http://www.stealth3dmouse.com/) was designed by ABC Software Developers, and resembles pointing devices used with analytical stereoplotters. The Stealth E-mouse features two data buttons on the back, six programmable buttons on the front for control of software functions, two data buttons on the top, and a centrally located Z thumb wheel.

Stealth E-Mouse

The SoftMouse (http://www.immersion.com/industrial/3Dmouse/) was designed by Boeing, and is also similar to the pointing device used in several common analytical stereoplotters. There are two data buttons on the back, six programmable buttons on top for control of software functions, two data buttons in front, and a centrally located Z thumb wheel. A handwheel/footdisk assembly can also be used as a pointing device but needs to be operated through the Immersion Softmouse interface.

The workstation mouse can be used in lieu of the SoftMouse or Stealth E-mouse, with somewhat less operator efficiency.

ACCURACY

Accuracy is achieved through the rigorous modeling of the imaging sensor, platform, and all data processing in the production chain. Photogrammetric image space-to-object space projective relationships are derived based on the characteristics of the sensor system and its platform. In this manner, the imaging event can be reconstructed using only physically significant parameters. There is no need to employ the use of polynomial approximations in defining rigorous photogrammetric transformations when developing camera system projective geometry models. This is significant in that it eliminates the potential geometric errors encountered using such modeling approaches and reduces the amount of control and tie points required for an adequate solution since the number of unknown parameters is less than the rubber sheet (Nth order polynomial) approach.

Rigorous sensor geometric models are required for single photo resection, triangulation, rational polynomial development, data collection and product compilation. Currently incorporated into SoftPlotter are rigorous sensor/platform models for SPOT, panoramic, and frame camera systems. Implicit within each sensor geometric model are corrections that are applied for known systematic errors based on calibration reports, acquisition conditions, and physical system characteristics, i.e. lens distortion, principal point, earth curvature, CCD array characteristics. Boeing has implemented the SPOT mathematical model as specified in the SPOT user's handbook and makes full use of all image support data.

In general, with adequate ground control and normal operating procedures a “1.5 pixel” rule can be used to describe the output accuracy of the entire process. This includes interior orientation, triangulation, DTM collection and edit, orthorectification, mosaicking, and all computational error budgets. Thus, the complete orthophoto or mosaic should be within 1.5 pixels at digitization scale of the original imagery. For example, 1:40,000 imagery scanned at 25 microns/pixel (roughly 1 meter GSD) should produce an orthophoto at an accuracy of ±1.5 pixel and therefore ±1.5 meter. Our experience has shown that the largest error source in the process is generally the DTM collection and edit step. Improper selection of DTM spacing, poor editing (failure to edit bad points), and lack of adequate *ad hoc* points or breaklines are the usual culprits.