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Large Scale Photography: An Initial Look at the Application and Results of Large Scale Photography in the New Millennium

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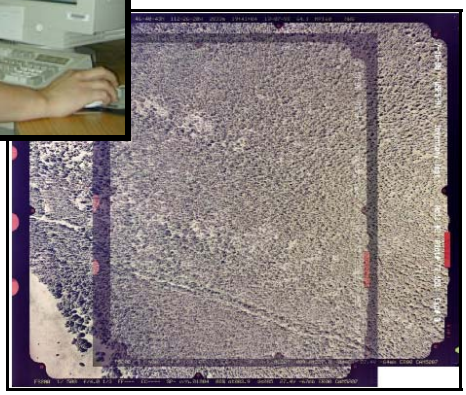

Report Prepared for
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Foreword

This report was initiated and funded by the Inventory and Monitoring Technology Development (IMTD) Steering Committee. This committee was chartered to identify emerging issues and provide oversight to the USDA Forest Service, Technology and Development (T&D) Program. The Remote Sensing Applications Center wishes to acknowledge the committee and the San Dimas Technology and Development Center for guidance, direction, and oversight on the project reported in this document.

Abstract

Historically, aerial photography has been an important source of remote sensing imagery. This is especially true when high-resolution imagery is required. Today, many resource specialists regularly use digital aerial photographs in the form of orthophotos. One of the unique characteristics of aerial photographs is to provide a stereoscopic, view of the ground. Stereoscopic analysis can now be performed inside a computer using digital stereo pairs.

With the advent of precise Global Positioning Systems (GPS), pre-specified locations on the ground can be captured with aerial photographs. When the aerial photos are combined with software and hardware capable of creating, and managing, large image files, traditional measurements made from stereo pairs are possible in softcopy.

This report assesses the state of softcopy photogrammetric technology and its application to forestry. Specifically, this report studies the ability of photo interpreters to capture detailed information from Forest Inventory and Analysis (FIA) forest plots. Digital scans of aerial photos were processed to view stereoscopically. Measurements were collected from the softcopy stereoscopic view and contrasted with the ground crew measurements.

The investigation found that measurements captured by photo interpreters (PI) using digital photographs provide accurate estimates of individual tree and forest stand variables. All of these measurements are within FIA tolerances. The measurements made include, tree height, species and condition class.

In some cases, plots were not discernable on the imagery because of; differences in GPS locations (contrasting the digital representation plot center to the field crew data), closed canopies, or large shadows. There was no method of overcoming these problems once the photos are acquired. Therefore, care must be taken to ensure correct GPS locations and timing of photo acquisition to ensure an unobstructed line of site.

The work presented in this report shows promise for future use of stereo-viewed digital aerial photos applied towards the measurement of forest plots. A second study is in progress, which is focused on statistical techniques required for large area application of the softcopy techniques.

Overview

Aerial photography continues to be an important source of information for natural resource managers. The beginnings of aerial photography date back to the times when people first developed the ability to capture photographs. Recently, aerial photography may seem to have taken a back seat to some of the more "glamorous" remote sensing systems and techniques, including earth orbiting and other aerial derived platforms. Higher performance computing and recent technological developments are creating new ways of using aerial photography, creating what may be a renaissance for the oldest of remote sensing data sources.

Aerial photography has always held an important role when very high resolution imagery is required. Spatial attributes from a known photo scale can be very valuable, allowing very precise measurements to be captured. The future of aerial photography will take advantage of these properties and new technologies that make high-precision measurements from digital aerial photography possible. The continued improvement of software and hardware make the application of aerial photographs a more viable option for ease of use with GPS (applying real pictures with a reference system) and GIS (through photo interpretation), both of which will rely on the ability of aerial photographs to be quickly and effectively orthorectified.

Technological advances, including GPS plot targeting, allow aerial photographs to be precisely captured on known FIA plot locations. Scanning the negatives at very high resolutions and creating stereo pairs in a soft copy, allow for digital stereo models to be developed, and photo interpreters are given the tools to capture data at many different scales from a single source.

Introduction

Forest inventories, including those conducted by the Forest Inventory and Analysis (FIA) program, are expensive endeavors. The large amounts of data collected, excessive travel time and increasing frequency with which data must be collected, contribute to the increasing expense. With many forest inventories under increased pressure to produce better and more information at reduced costs, alternative data collection methods are needed which make the inventories more economical.

Decades prior to the 1950's, aerial photos had been used in forest operations including the direct measurement of individual trees for the estimation of volume and growth (Spurr, 1954). Since the 1950's, the improvement of computing power led to advances in statistical utilization and software concerning the use of aerial photos for forest applications (Pope, 1962; Paine, 1965; Aldred and Kippen, 1967; Aldred and Hall, 1975; Spencer and Hall, 1988; and Patton et. al., 1998). These applications focus on the use of broadcast photo coverage and hard copy interpretation, where the flight path including overlap (both forward and sidelap) captures a relatively large area. A combination of recent technological advances allow for many improvements in the application of aerial photography. Both software and hardware advances allow for aerial photographs to be captured at known specific points on the ground, easily scanned at very high resolutions, and digital stereo pairs to be produced.

Statistical designs are known to help the cost effectiveness of gathering data. A “phase”, or “double” sample design allows for the information obtained at a first phase to provide more accurate estimates of the means, totals etc., of variables obtained in the second phase. Therefore, an improved estimate at a lesser cost is possible if the first phase is less expensive to acquire than the second.

This study focuses on the methods used and ability of interpreters to capture individual tree measurements from FIA plots using large scale, real time differential GPS, forward motion compensated, aerial photography, while also giving a conceptual overview concerning the use of a phase design with a finer sample.

History

While aerial photography has a long history dating to the time of developing photography, the advent of pinpointing the coordinates of a location and capturing this area with a stereo triplet is relatively new. The positional accuracy of aerial systems allow for data to be captured to within a few meters, an amazing feat considering the flying height of 1000 meters. This study uses a series of photographs that were captured using airborne inertial and GPS data. A two-part study followed the photo acquisition. Part one demonstrated that large-scale photos can accurately target known GPS ground points, accomplished by Reutebuch and others (2000). Part two, the current project, tests whether the large-scale aerial photographs can serve as a sufficient sampling and measurement to provide accurate estimates of selected individual tree and forest stand variables which are essential to resource managers.

Methods

Study Area and Forest Inventory Data

The study was conducted on the Helena and Beaverhead-Deerlodge National Forests located in Montana. Steep, rugged terrain and remote access areas, including wilderness areas characterize these forests. A total of 28 plots were used, 8 in the Helena National Forest and 20 in the Beaverhead-Deerlodge National Forest. All FIA plots consisted of a 5-subplot bowtie design based on a point sample (figure 1); where the probability of tallying a tree depends on a tree’s diameter at breast height (dbh), its distance from the sample point, and a predetermined basal area factor.

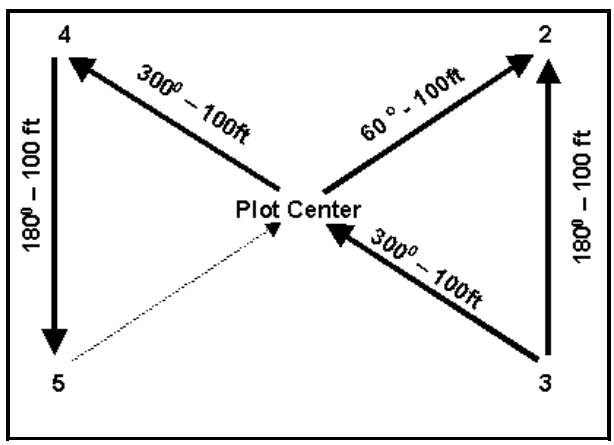

Figure 1—The bowtie design showing the location of the five subplots, with subplot 1 being the plot center.

Acquiring Aerial Photos into a Digital Format

Aerial photos were acquired during fly dates of July 9th 1999 and July 19th 1999, from early to late afternoon. Camera and film information includes: a 305 mm nominal focal length, natural color film, at a photo scale of approximately 1:3000. The negatives were scanned with a high-end photogrammetric scanner at a 12.5µ scanned resolution, which created images that had two-inch pixels (ground resolution).

Orthorectification and Stereo Pair Creation

Entering the camera information and orienting the photos by control points, with reference to the digital orthoimages and digital elevation models, effectively orthorectified the aerial photos (see Appendix 3). Selecting similar points on each photo, and allowing automatic tie points to be generated created a stereo alignment. For this project, a total MSE of less than 7 was acceptable for control and tie points.

Locating Field Plots and Tree Measurements

Locating the plot centers involved using all available information provided by the FIA location file. The FIA field crews use a 1: 20,000 scale photo with a pinprick locating the plot center. Diagrams were developed for each subplot; including field location (distance and azimuth to plot center), species and tree size for all tallied trees. In some cases, the field crew had taken 35mm pictures in the cardinal directions from plot center. All of these 'hints' were used to some degree in helping find the plot centers.

When plot centers were identified, the UTM coordinates were tallied from the stereo pair. It was imperative to visually identify all trees on a plot to confirm location. All trees were measured for species, height, condition (living / dead) and visible crown diameter. When possible, surrounding subplots were identified and individual trees were measured accordingly.

Two separate interpreters were involved with the individual tree measurements including tree height, visible crown diameter and condition, while an expert was used to determine tree species. The purpose of using two interpreters for tree measurements was to study differences between interpreters as they apply the latest technology. Each interpreter measured tree height five times. A single interpreter was used for determining tree species to eliminate bias, because the photo interpreters, at times, became very familiar with the plots and species located on them.

Paired-t and Student-Newman-Keuls (SNK) tests were used to determine significant differences between field crew data and aerial photo interpreted data for tree height. Differences in plot coordinates, species and condition were summarized and visible crown diameter was summarized.

Results

GPS Plot Coordinates

Of the twenty-eight plots available, eleven were successfully found on the aerial photos. Fourteen of the plots were not discernable for many reasons, including shadow cast by large trees onto the plot, closed canopy, and sample technique (basal / point sampling) not capturing all the trees visible from the aerial photos. Three plots had large differences in the location of the GPS coordinates and the pinpricked aerial photo provided by FIA field notes; these plots were similarly eliminated from the study. Within the eleven plots whose centers were located, a total of fourteen subplots were captured (including the plot center subplot).

Differences between the GPS recorded plot centers and the UTM coordinates from the LSP orthorectified stereo pair images were recorded. The absolute average of these differences was 23.5-meters for the X-coordinate and 6.7-meters for the Y-coordinate.

Tree Height

Tree height measurements were initially tested using a paired t-test ($\alpha = 0.05$) to contrast between the average of an individual interpreter, and the average of both interpreters with the field crew. There are no significant differences between the field values and the aerial photo measured values. It was thought the variation was too high for this test to be accurate as it included all trees with heights from under 10-meters to over 20-meters (figure 2).

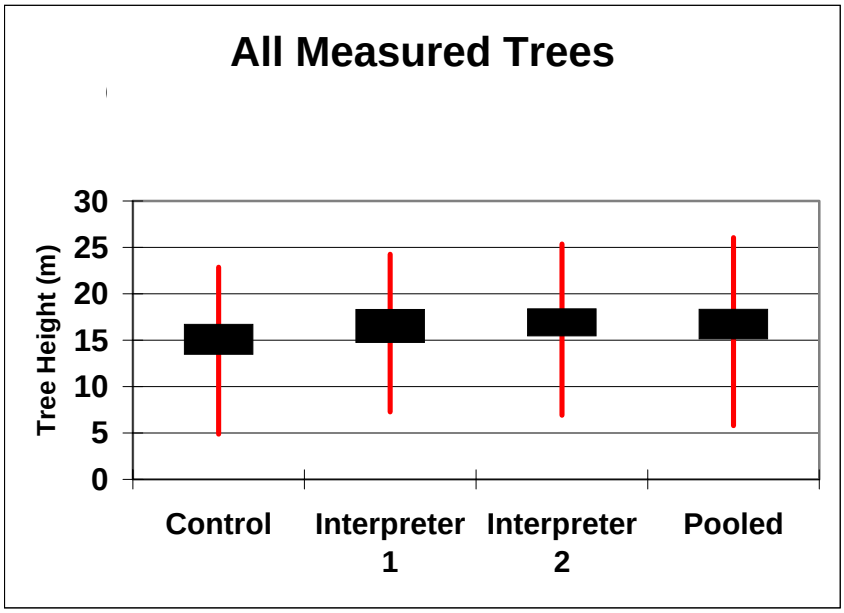

Figure 2—This figure includes a 95% confidence interval about the mean with max and min values (seen as box and whisker plots). There are no significant differences between the means as they are individually contrasted with the control for a paired t-test. A SNK test showed no significant differences between all means.

The sampled trees were divided into two groups, trees smaller than fifteen meters and larger than fifteen meters. Figure 3 shows significant differences of a Student-Neuman-Kuels (SNK) test (a paired test showed similar results for differences between the individual means contrasted with the field measurements and photo measurement averages). Figure 4 shows significant differences of a SNK test (a paired test showed similar results for differences between the individual means contrasted with the field measurements and photo measurement averages).

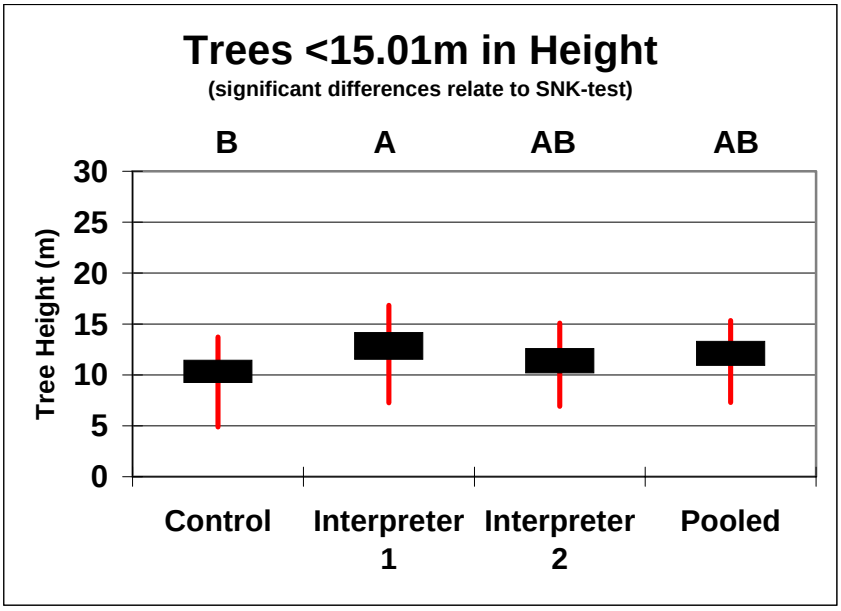

Figure 3—Includes a 95% confidence interval about the mean with max and min values. A SNK test shows the same significant differences as a paired t-test for individually contrasting the interpreter's work to the ground crew for trees shorter than 15.01 millimeters (control).

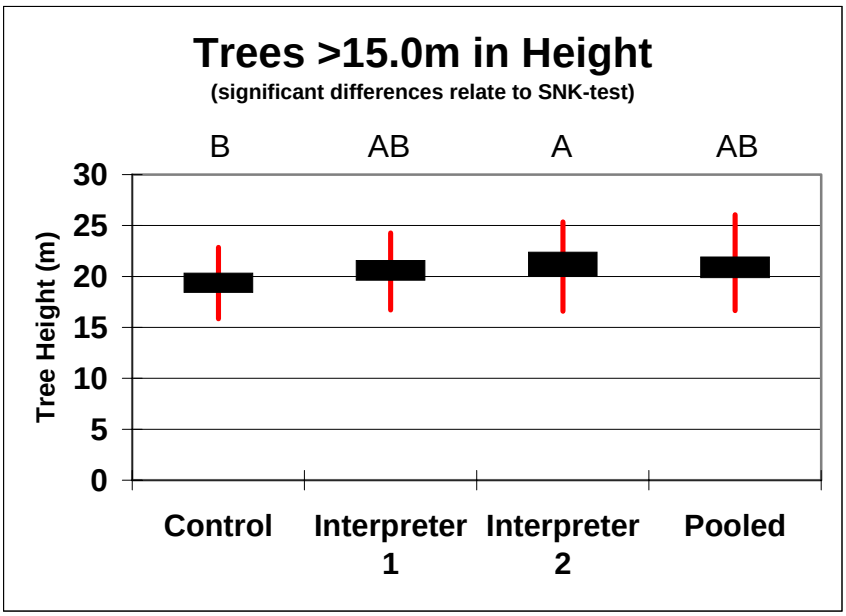

Figure 4—Includes a 95% confidence interval about the mean with max and min values. A SNK test shows the same significant differences as a pared t-test for individually contrasting the interpreter's work to the ground crew for trees taller than 15 millimeters (control).

Species and Condition
Species found on all the plots include: Douglas fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), ponderosa pine (*Pinus ponderosa*) subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), and whitebark pine (*Pinus albicaulis*). Of the 40 trees found, three were incorrectly identified. The three were: living, less than 15-meters in height, to some degree hidden by shade from taller trees, and are species known to be difficult to determine as younger trees.

All trees were identified correctly as dead or alive. Of the seven dead trees in our sample, all species were identified correctly (figure 5).

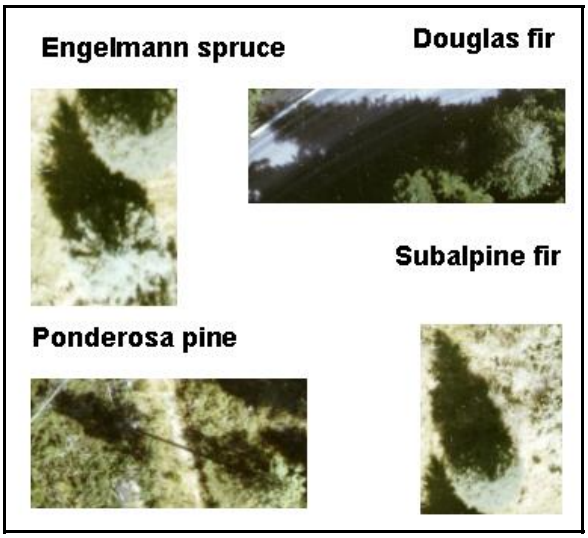

Figure 5—In these four examples we see four different species that may be difficult to discern.

Visible Crown Diameter
Visible crown diameter was measured for each tree tallied (descriptively summarized for 37 trees in Appendix 3).

Summary
The ability of an interpreter to measure forest variables from scanned aerial photography is determined by the photo quality, the scale of the photo, and scanning resolution. Unlike historical photo interpretation, today's interpreter can "zoom" into the stereo photos and capture very good detail at scales of 1:50. The maximum scale of the "zoom" is directly related to the scanned pixel size. A scanned photo from an original scale of 1:4000 can be viewed in stereo, with little distortion at 1:100 with a scanned pixel size of 10µ. This photo scale and scan resolution produces 0.128-foot resolution (1.5-inch) pixels, allowing individual leaves on a tree to be seen. The downside to this high resolution is the file size. A typical 9x9 aerial photo scanned at 10µ, will have up to a 1.5 gigabyte file size.

The ability of an interpreter to locate plot centers was confounded by a number of factors. Plots with closed canopies were nearly impossible to locate as it was difficult to specifically locate all the trees as determined by the ground crew. In some plots, most of the individual trees were visible, but the plot center was not discernable because more trees were visible in the photo than were measured by the field crew using a basal plot. Shadows cast by large trees over plot centers are problematic because smaller trees are not visible. In a few cases, tree tops of the smaller trees could be seen and some measurements were made. Some of the GPS coordinates given were not near the referenced aerial photo coordinates. These plots were not used.

Locating subplots on photos was confounded by field crews inconsistency in correcting for declination. The crews were not supposed to correct for declination, although some did note a correction, most noted no correction and some did not note anything. While this inherently should not be a problem the use of a reference tree as noted by the field crew was rendered useless in our system. The rectification of the aerial photos created a stereo pair visible 'towards' true north. Most field plot alignments were towards magnetic north. Hence our ability to locate most subplots was impaired.

The photo quality, scanning capability and software and hardware utilized in this study allowed us to measure tree height and determine tree condition within tolerable errors. FIA standards are ±10% of tree height is acceptable for a tree height measurement and no error in condition is acceptable. Species determination was successful due to the use of an expert interpreter and the ability to "zoom". Tree height measurements could have been more precise if the dates of photo acquisition and field measurements were closer. A difference of 4 years was most common, although a few of the field measurement dates were 9 years prior to aerial photo acquisition. This may account for the general increase in height when contrasting the ground crew data with the aerial photo interpreter's data.

A quick look at the two different interpreters ability to measure tree height indicate that there are different bias's associated with each individual. Interpreter 1 captures the taller trees better, while interpreter 2 captures shorter trees better. It is not uncommon for interpreters to have a bias, while it is also not uncommon for different photo interpreters to have different bias (Bonner 1968; Paine 1981). Methods of reducing bias are common, while not employed here, it is imperative a comprehension of an interpreters bias's be adjusted for during production.

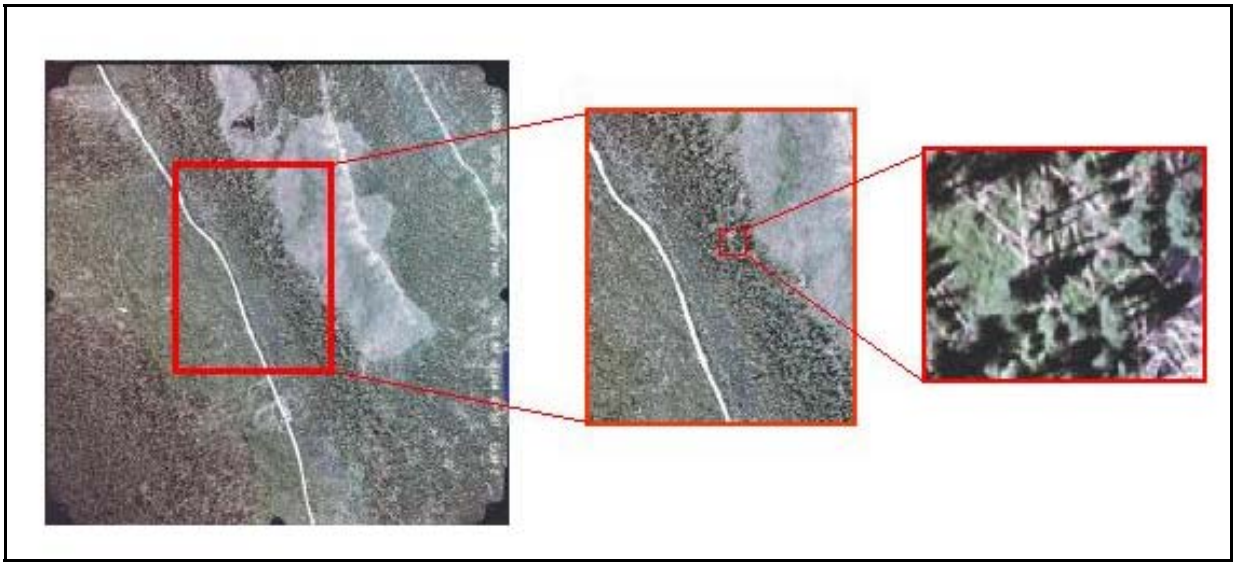

Figure 6—Zooming into the Photo. Our ability to "zoom" into a photo pair allows data to be captured at different scales. In the example, we see a single photo at a scale of 1:3000; the second picture shows a scale at approximately 1:1000 and the third picture represents a scale of approximately 1:80.

Conclusion

Technology allowed specific GPS ground coordinate locations to be captured by aerial photography, and individual tree measurements taken from a digital stereo pair. Future work is needed in the location of field plots on stereo aligned large-scale photos. Quality assessment of aerial photo interpreters, statistical design implications for application of measurements from aerial photography (development of inferred and modeled variables), and acceptance of aerial photography to provide value, is important for the interpretation of digital, large-scale photography to become operational.

The suggestion of replacing ground crews is not the intent of this work, rather, it is to raise awareness of the opportunity to optimizing data collection strategies by incorporating low altitude photography into the sample design.

This current study focused on photo interpreter' ability to capture individual tree data, and determine the effectiveness of the methods; both of which are a success. It is thought that the ability to capture data from a scanned digital method coupled with other remote sensing capabilities and some ground crew assessments can further add value to a more spatial comprehension of forest resources at many scales in a phase sampling design.

Future

Initial work shows promise towards acceptable measurements being captured from digital aerial photographs. It is envisioned that aerial photography can be used to augment ground data collection to make a cost effective product for FIA plots. A proposal for the year 2002 has been accepted to look into the application of aerial photo data in a phase sample with ground data on a single forest type (APPENDIX 1: Remote Sensing / Geospatial Technologies: Proposal). This work will focus on the use of phase sampling in a "quasi-production" mode to determine the value of the end product and study the cost effectiveness.

Other future considerations include:

- Cost benefit analysis
- Spatial measurement analysis
- Developing photo interpretation software tools (and other streamlining tools)
- Technology transfer

Production

It is thought that upon proof of concept, the daily operation of using aerial photographs in the current format will be passed on to the users, into a production mode. To this end, a proper conceptual and organized training will be necessary. Initial work in this area includes instructions on creating block files (APPENDIX 2 Creating Block Files in ERDAS Orthobase for use in ERDAS Stereo Analyst; an ordered flow.) and continued contact with interested parties towards developing operational concepts.

Current technology transfer is limited to individual training, although as interest increases a full scale training program is envisioned.

Reports

Reports and technology transfer materials that were a direct result of this project include:

- Presentation at 9th Biennial Forest Service Remote Sensing Applications Conference, San Diego, April 8-12th 2002
- Presentation at FIA Joint Band Meeting January 8-11, 2002; Tucson AZ.
- Report for 9th Biennial Forest Service Remote Sensing Applications Conference, San Diego, April 2002
- Remote Tip Report: Entitled "Application of High Resolution Scanned, GPS Controlled Large Scale Aerial Photography in a Forest Inventory"
- Poster (available at the RSAC website: http://fsweb.rsac.fs.fed.us/)

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Appendix 1—Visible Crown Diameter Statistics.

	Mean (m)	St. Error	Median	Kurtosis	Skewness	Range	Min	Max	Height (m)	DBH (in)	Species Code
Avg.	8.32	0.252	8.33	0.7647	0.0980	1.4	7.6	9.0	14.8	10.7	-
1	5.32	0.201	5.41	1.6480	-0.9856	1.2	4.6	5.8	12.19	20.6	93
2	5.81	0.264	5.87	2.7329	-1.4605	1.6	4.8	6.4	16.46	13.2	93
3	4.67	0.138	4.55	-2.6632	0.2786	0.7	4.3	5.0	20.73	10.0	93
4	6.02	0.209	5.90	3.3936	1.7831	1.2	5.7	6.8	10.06	9.0	108
5	5.23	0.119	5.20	-1.1820	0.0846	0.7	4.9	5.6	1.67	10.7	108
6	5.18	0.163	5.14	2.7464	1.3494	1.0	4.8	5.8	9.75	8.9	202
7	2.06	0.041	2.05	1.1232	-0.1081	0.3	1.9	2.2	10.97	13.8	108
8	1.88	0.065	1.87	1.0205	-0.663	0.4	1.7	2.1	9.45	7.2	108
9	5.76	0.189	5.69	-1.3886	0.5692	1.0	5.4	6.3	10.67	8.1	108
10	12.40	0.681	12.54	-1.9191	-0.3142	3.6	10.4	14.0	9.14	5.8	108
11	6.46	0.326	6.42	0.4429	-0.3495	2.0	5.4	7.4	13.72	12.7	108
12	7.97	0.235	7.76	4.0967	1.9888	1.3	7.6	8.9	6.71	5.1	108
13	8.06	0.253	8.09	0.5626	0.9204	1.4	7.5	8.9	10.97	7.1	108
14	15.83	0.474	15.39	2.1943	1.5135	2.7	14.9	17.6	12.19	7.1	108
15	16.46	0.835	17.16	-1.3834	-0.1678	4.7	14.1	18.8	10.06	5.7	108
16	10.22	0.218	10.11	-1.8347	-0.1039	1.1	9.6	10.7	21.03	8.6	108
17	3.93	0.175	3.86	-2.2090	0.1452	0.9	3.5	4.4	20.42	7.4	108
18	2.41	0.054	2.43	2.7114	-1.1814	0.3	2.2	2.5	19.51	7.9	108
19	6.78	0.161	6.77	1.2292	1.0124	0.9	6.4	7.3	17.68	7.8	108
20	3.10	0.096	3.11	-0.6513	0.5221	0.5	2.9	3.4	21.03	7.8	108
21	3.37	0.057	3.39	2.9028	-1.3647	0.3	3.2	3.5	20.42	9.3	108
22	4.77	0.197	4.88	-1.8477	-0.5258	1.0	4.2	5.2	21.64	10.4	108
23	2.97	0.125	2.95	1.2984	1.0720	0.7	2.7	3.4	17.68	11.0	108
24	22.01	0.209	21.87	1.3906	1.3209	1.1	21.6	22.8	16.76	12.3	202
25	16.82	0.240	16.99	4.4146	-2.0721	1.3	15.9	17.2	16.76	10.7	202
26	10.03	0.440	10.28	-0.4095	-0.2839	2.6	8.7	11.3	91.20	11.7	108
27	16.67	0.648	15.81	-2.3762	0.6470	3.3	15.3	18.6	19.81	13.5	108
28	12.43	0.576	13.20	-0.1380	-1.1629	2.9	10.5	13.4	17.07	10.7	108
29	13.44	0.171	13.36	2.7728	1.6045	1..0	13.1	14.1	10.97	15.4	108
30	7.84	0.166	7.66	-2.2789	0.6901	0.8	7.5	8.3	6.71	4.1	93
31	12.90	0.342	12.94	0.8751	0.4810	2.1	11.9	14.0	4.88	1.2	108
32	6.55	0.072	6.52	-0.0097	0.5311	0.4	6.4	6.8	11.58	7.4	108
33	4.69	0.159	4.62	3.3195	1.6091	0.9	4.32	5.3	13.72	8.9	101
34	5.20	0.146	5.18	1.5246	0.0028	0.9	4.7	5.7	22.86	24.5	101
35	12.07	0.577	12.31	1.0584	-1.1682	3.2	10.0	13.2	20.42	211.6	101
36	10.93	0.254	11.15	1.8752	-1.4031	1.4	10.0	11.4	12.19	19.6	101
37	9.71	0.054	9.75	3.2524	-1.7816	0.3	9.5	9.8	21.64	19.5	101

Appendix 2—Remote Sensing/Geospatial Technologies—Proposal

Project Title: Improving cost effectiveness of forest inventories through large scale GPS controlled aerial photos

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Problem Statement

Forest inventories, like those conducted by the Forest Inventory and Analysis Program (FIA), are under increased pressure to produce better information at reduced costs and increased frequency. The objective of FIA is to estimate broad-scale forest population totals, and track how they are changing. In the past, inventories were conducted and estimates produced on a periodic basis (every 5 – 20 years). However, the 1998 Farm Bill requires that *each* year on *all* lands in the US, a proportion of all field plots must be measured (1/10 in the western US, 1/5 in the east), and forest population estimates must be updated. Funds are currently not available for such an expensive endeavor. The advances in large-scale real time GPS controlled, aerial photography (LSP) may present the opportunity to meet or exceed information requirements of this new legislation while reducing inventory costs in the following ways:

- *Information on nonsampled field locations.* Many areas are inaccessible to field crews for a variety of reasons like remoteness or hazardous conditions. Large numbers of nonsampled locations in any inventory reduces the quality of the information. Large numbers of difficult access plots greatly increases data collection costs. Measuring plots inaccessible to field crews, whether remote or hazardous, is possible using aerial photographs. Aerial photographs may also provide valuable information for reconnaissance and change detection.

- *Consistent and repeatable information.* There are variables collected on forest inventory plots that are often unrepeatable, or better collected at a scale different than that of the field ground plot. Improved data for certain scale dependent variables can easily be collected from aerial photographs.

- *Increased precision.* While satellite-based data greatly contributes to the precision of forest inventory estimates, National precision standards are seldom met. Merging information from satellite-based data and aerial photographs in appropriate estimation procedures may substantially improve precision of estimates.

- *Reduced cost.* Collecting more field data is seldom the most cost effective way to improve quality and timeliness of information. Analyses in the proposed study will focus on the economic trade-off between field data collection costs, and the costs of incorporating aerial photographs, including photo acquisition difficulties in different parts of the country.

Objectives

1. Determine the type and quality of information that can be collected on nonsampled field locations.

2. Explore LSP as an alternative to field sampling for forest metrics that are typically difficult or unrepeatable on the ground.

3. Quantify gains in precision to forest inventory estimates when LSP is coupled with satellite-based information in a multi-phase estimation process.

4. Understand the opportunity cost of using aerial photographs in parallel with field data and ancillary satellite-based information.

Proposed Development and/or Technology Transfer

Three phases are proposed, including small pilot tests in woodland and diverse forested areas like West Texas and the Fishlake National Forest, respectively. Exact areas to be flown will be decided in Phase 1 following sample design and cost analyses. Coordination and technology transfer between partners have been included.

Phase 1 – Project Planning (~1 month)

- Determine information needs and expectations from all partners.
- Technology transfer from Idaho National Forest and RSAC LSP experiences.
- Develop sample design and estimation protocol for Phase 2.

Phase 2 – Woodland / Diverse Forest Test Pilot (~5 months)

- Acquire aerial photos
- Collect field data for interpretation training
- Interpret photos
- Integrate with FIA and satellite-based information

Phase 3 – Analysis, reporting and recommendations (~1 month).

- Conduct analyses
- Report results
- Make recommendations for production-level inventories
- Technology transfer for application on existing photography on the Idaho Panhandle National Forest

Potential Benefits

The potential of this technique to play a part in data collection will be determined by the cost effectiveness of sample schematics and the use of the data collected. If these both prove to be within acceptable ranges, the use of aerial photographs and ground crews together will help managers meet their currently unattainable goals.

Data to be Acquired

- LSP in West Texas and/or on the Fishlake NF
- Training data in West Texas, Fishlake NF, and Idaho Panhandle NF for calibration of photo interpretation efforts

Cost Estimate

Photography ~ $15,000
RSAC time ~ 7 man-months
RSAC travel ~$3,000

In-kind Contributions from Partners

FIA
- Inventory data
  - Data collection
  - Data processing
  - Data delivery in a form suitable for project analysis
- Training data
  - Data collection
  - Data processing
  - Data delivery in a form suitable for project analysis
- Participation in planning and analyses

Region 1
- Participation in planning and analyses
- Feedback on project results and implications for National Forest activities
- Possible application of methodology to existing photography on Idaho Panhandle NF

Fishlake National Forest
- Participation in selection of study areas
- Feedback on project results and implications for National Forest activities

Appendix 3—Creating Block Files in ERDAS Orthobase for use in ERDAS StereoAnalyst: An Ordered Flow

Requirements

1.1 Hardware

- High end computer
- Stereo vision
- High end graphics card
- Plenty of space

1.2 Software

- ERDAS
    - Orthobase
    - StereoAnalyst

1.3 Other

- Forward motion GPS controlled aerial photos
- High resolution scanned images (Mr.Sid files will work)
- DOQ
- DEM
- Camera information / report
    - Photo orientation
    - Focal length
    - Fiducial marks
    - Radial distortion
    - Exterior orientation for each photo
    - Units of photo center point
    - Rotation measurements
    - Average fly height
    - Field angle units

2 Check

2.1 Projection

2.2 Spheroid

2.3 Datum

3 Tips

3.1 To change / convert GPS coordinates

3.1.1 From Main ERDAS

3.1.1.1 Tools

3.1.1.2 Coordinate Calculator

3.2 To reproject image

3.2.1 From Main ERDAS

3.2.1.1 Data Prep Icon

3.2.1.2 Reproject Images
3.3 To mosaic images
3.3.1 From Main ERDAS
3.3.1.1 Data prep icon
3.3.1.2 Mosaic images
4 Begin Orthobase
4.1 Name of new block file
4.2 Select model
4.3 Select reference system

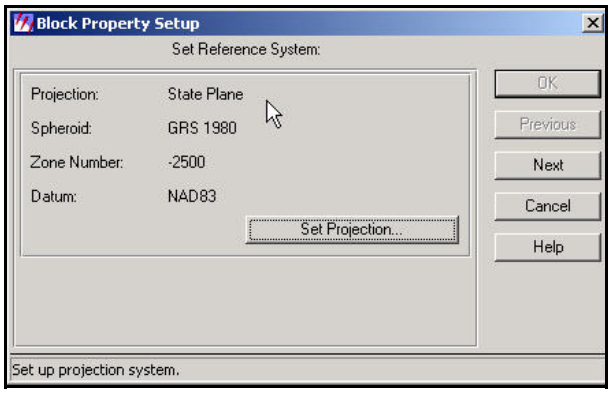
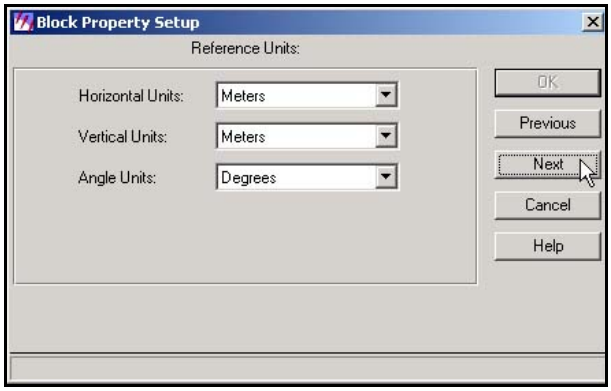


Figure A1—Block property setup, set reference system.

There are many pieces of input that will influence the projection used. The GPS locations used for photo acquisition, the UTM coordinates of the photos as they relate to the data captured during acquisition in the plane, the current projections of images acquired (including DOQ and DEM), and the projection of the final product.

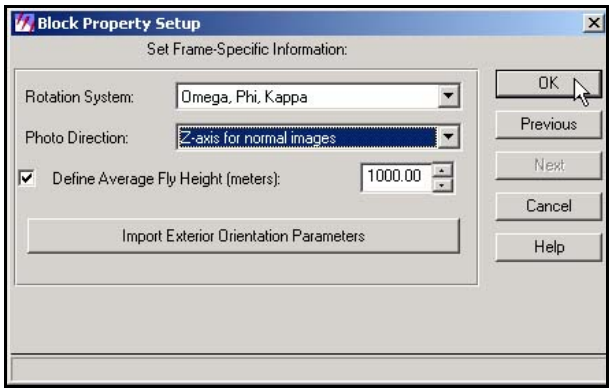
4.3.1 Projection
4.3.2 Spheroid
4.3.3 Zone
4.3.4 Datum
4.4 Reference units



Selecting units of the images as you measure items should be determined by the inputs required for 'exterior' information during the photo acquisition.

Figure A2—Block property setup, reference units

4.4.1 Horizontal Units
4.4.2 Vertical Units
4.4.3 Angle Units
4.5 Set frame specific information



Selecting frame information is determined by the inputs required for 'exterior' information during the photo acquisition.

Figure A3—Block property setup, set frame specific information

4.5.1 Rotation System
4.5.2 Photo Direction
4.5.3 Define average fly height (m)
4.6 Add frames
4.7 Compute pyramid layers (will take some time)
5 Press ‘i’

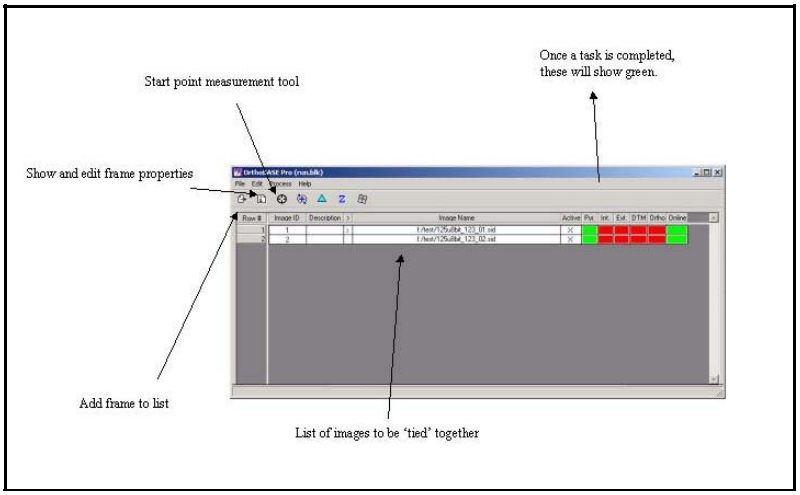


Figure A4—Orthobase main window

The main window for Orthobase includes information concerning the files included in the block file and progress.

5.1 Sensor
5.1.1 For every new sensor
5.1.1.1 Click ‘New’ button
5.1.1.1.1 General

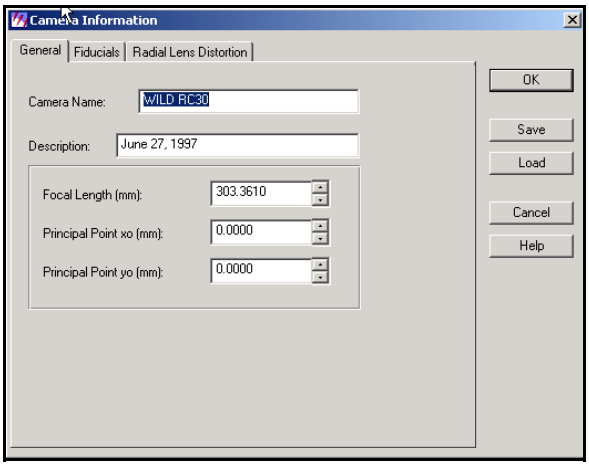


Figure A5—General camera information.

General information concerning the camera includes focal length and name of file name. Information should be referenced from the camera report.

5.1.1.1.1.1 Camera name
5.1.1.1.1.2 Description
5.1.1.1.1.3 Focal length
5.1.1.1.1.4 Principal point xo (mm)
5.1.1.1.1.5 Principal point yo (mm)
5.1.1.1.2 Fiducials

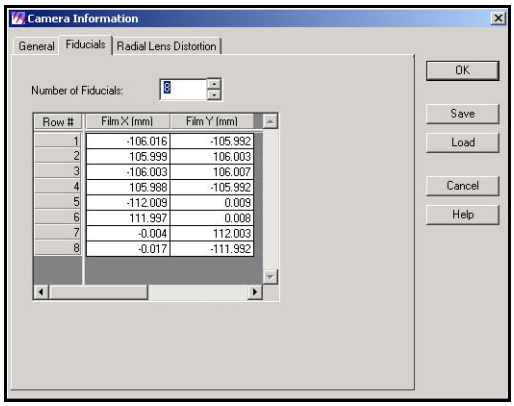


Figure A6—Camera information, fiducials.

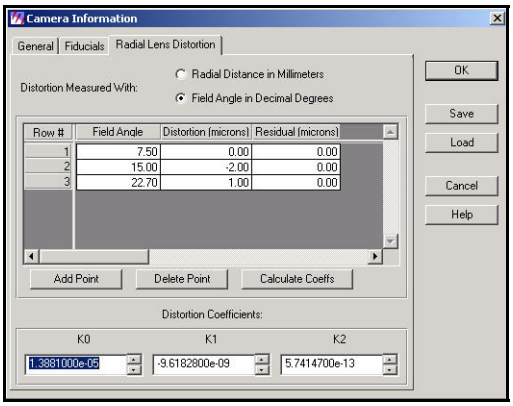


Figure A7—Camera information, radial lens distortion

All fiducial information should be located in a camera report.

5.1.1.1.2.1 # fiducials
5.1.1.1.2.2 fiducial marks (values from camera report)
5.1.1.1.3 Radial lens distortion

Radial lens distortion information should be located in camera report.
5.1.1.1.3.1 Enter as needed from camera report
5.1.1.1.3.2 Distortion Measured with (units)
5.1.2 Press ‘save’
5.1.3 For previously saved camera information / reports
5.1.3.1 Click ‘New’ button
5.1.4 Click ‘load’ button (find in folder)
5.2 Interior information
5.2.1 Click viewer fiducial locator
5.2.2 Add fiducial references Make sure orientation is known)
5.2.3 Make sure the RMSE is at acceptable level
5.3 Exterior information

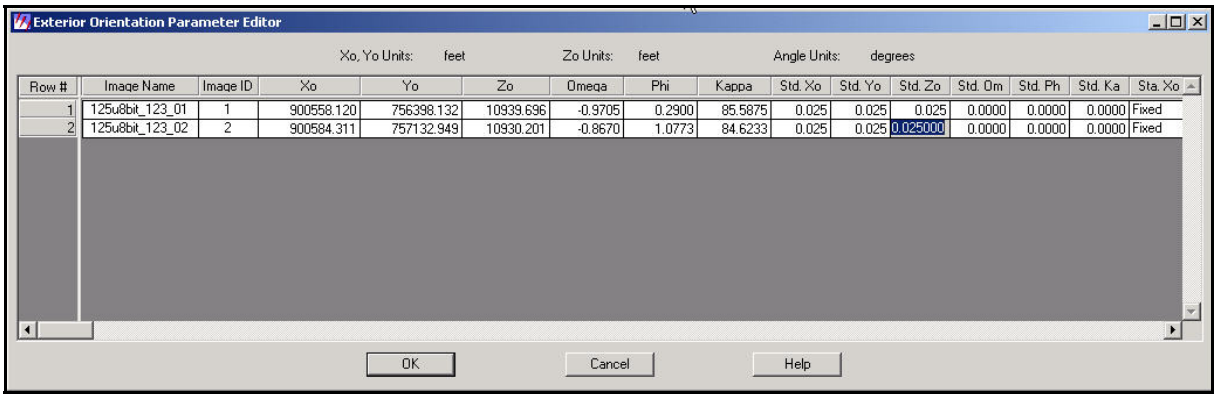


Figure A8—Exterior orientation parameter editor.

Exterior information unique to each photo and should be located in the camera report. Note the units and reference to frame information has been previously defined.

5.3.1 Enter values (Perspective center, Xo, Yo and Zo & Rotation Angle from camera report)
5.3.2 Press the check to change status to 'fixed' and check the set status
5.3.3 Press OK (the first image should have a green under the 'Int' column)
6 Press 'i' again
6.1 Click 'next' button (the title on top should change to the next photo)
6.2 The camera information should automatically be updated
6.3 Click the interior orientation (5.2) (do for as many images)
6.4 Click the exterior orientation (5.3) (do for as many images)
7 Press 'start measurement tool'

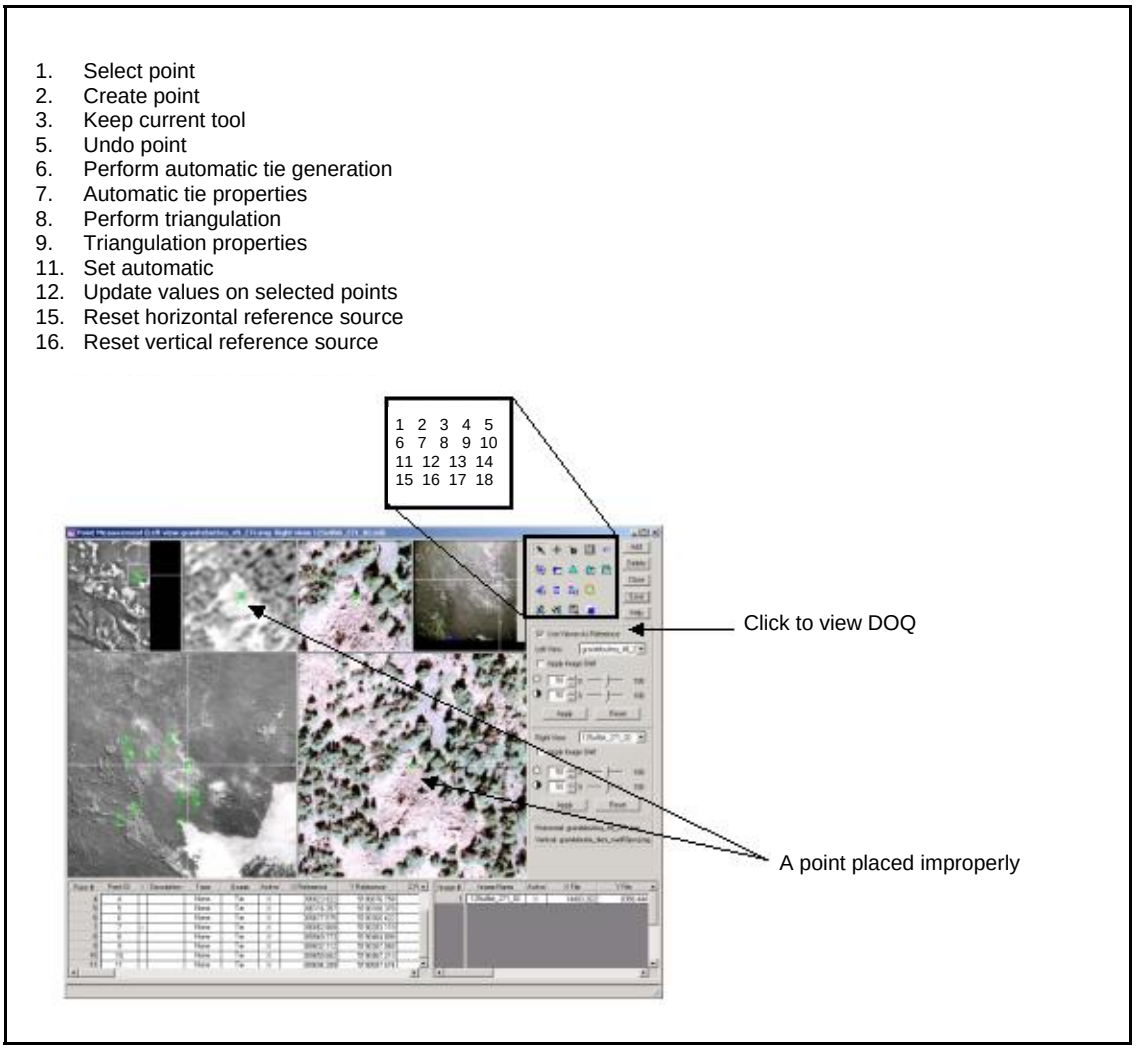


Figure A9—Point measurement tool.

7.1 Add vertical reference (DEM)
7.2 Add horizontal reference (DOQ)
7.3 Click on ‘use viewers as reference’
7.3.1 Locate exact point on DOQ and a photo
7.3.2 Click ‘add’ button
7.3.3 Click create point
7.3.3.1 Place point target on desired location of DOQ
7.3.4 Click create point
7.3.4.1 Place point target on desired location of image (should be the same place as the DOQ from 7.3.3.1)
7.4 Repeat steps 7.3.1 to 7.3.4.1 until at least 5 target points are referenced to the DOQ per image
7.5 Place all overlap points on all images (be very precise)
7.6 Highlight all manually entered points in rows
7.6.1 Change “type” to ‘full’
7.6.2 Change “usage” to ‘control’
7.6.3 Click update Z values on selected points (check to make sure the Z column has values entered)

8 Press ‘triangulation properties’
8.1 General

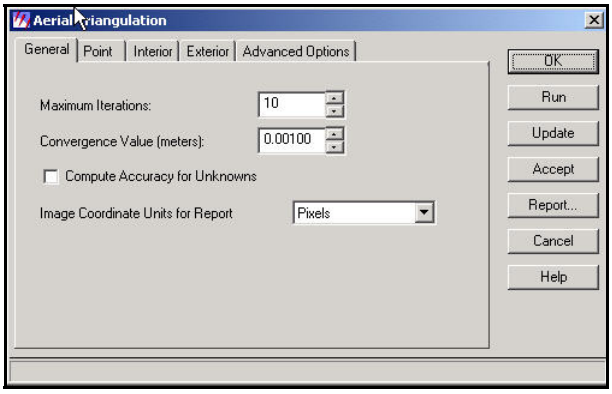


Figure A10—Aerial triangulation: general.

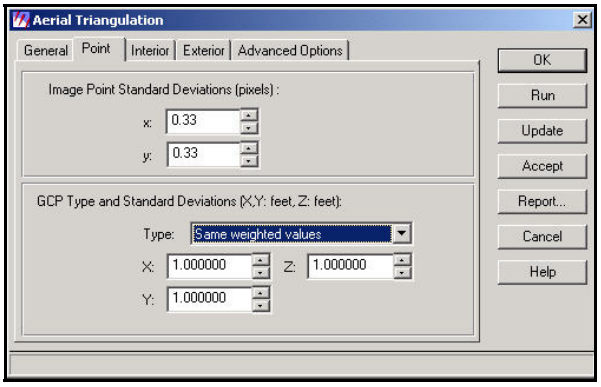


Figure A11—Aerial triangulation: point

See Orthobase manual for decision tips.

8.1.1 Max
8.1.2 Convergence
8.1.3 Image Units
8.2 Point

See Orthobase manual for decision tips.

8.2.1 Image Point Standard Deviation
8.2.2 GCP Type
8.3 Interior

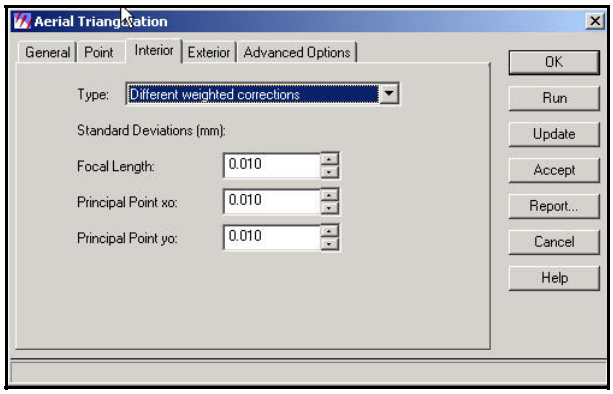


Figure A12—Aerial Triangulation: Interior.

See Orthobase manual for decision tips.

8.3.1 Type
8.3.2 Focal Length
8.3.3 Principle Point Xo
8.3.4 Principle Point Yo
8.4 Exterior
See Orthobase manual for decision tips.

8.4.1 Type
8.4.2 Standard Deviations
8.5 Advanced Options
See Orthobase manual for decision tips.
8.5.1 Model
8.5.2 Check
8.5.3 Blunder checking
8.5.4 Check
8.6 Click 'run', make sure the RMSE is acceptable (can use residuals to locate problems).

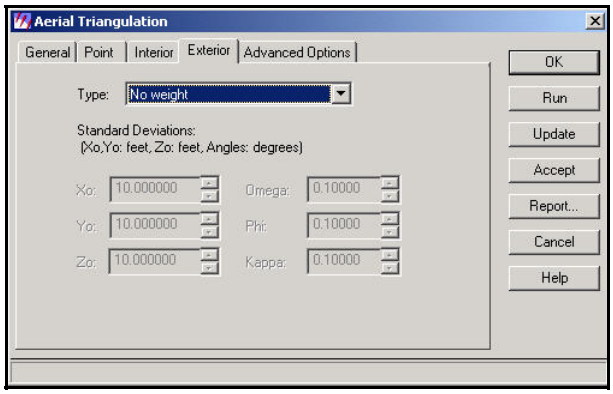


Figure A13—Aerial triangulation: Exterior.

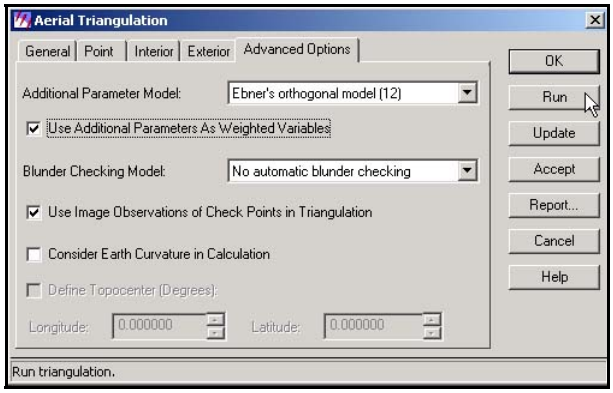


Figure A14—Automatic tic point generation properties.

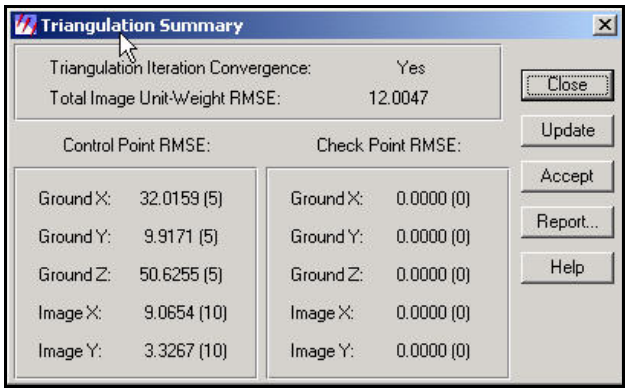


Figure A15—Triangulation Summary.

The total and directional MNSE is located in this window and allows one to decide how accurate the points are referenced. This will influence the accuracy of the measurements captured from the block file. A low value is better.

8.7 Press accept and update then ok
9 Press 'automatic tie properties

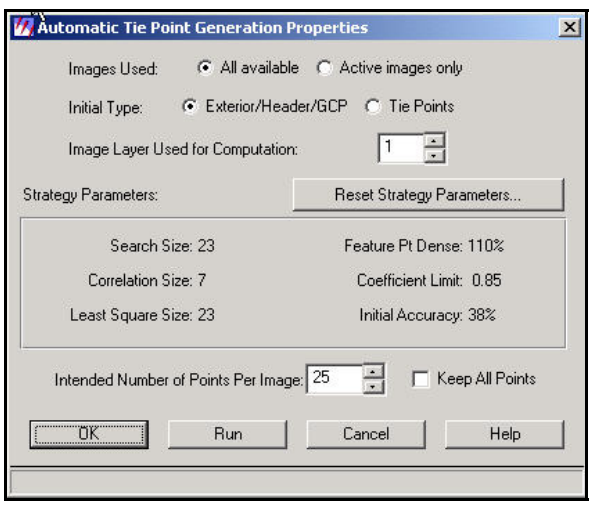


Figure A16—Automatic tic point generation properties.

See Orthobase manual for decision tips.
9.1 Images used
9.2 Initial type
9.3 Image layer used for computation
9.4 Intended number of points per image
9.5 Click 'reset strategy parameters' (change as needed)
9.5.1 Search Size
9.5.2 Correlation Size

9.5.3 Least Square Size
9.5.4 Feature Point Density
9.5.5 Coefficient Limit
9.5.6 Initial Accuracy
9.6 Click run
9.7 wait
10 Press ‘triangulation properties’
10.1 Click run
10.2 Check to make sure the RMSE is satisfactory
10.2.1 If no, check to see if the tie points are good: if good go to 10.2.3 else 10.2.2
10.2.2 Check the residuals of the model and make changes (need to delete old tie points and rerun from 8), and double check all points on DOQ and images.
10.2.3 There may be problems with the reference of points, entered camera info, or the GCP points are just not good, recheck and redo as needed.
11 View in StereoAnalyst to make sure the alignment is acceptable!

If there are reference measurements, check these to make sure the correct values are attributed to the location.