“AND THE VERDICT IS?”:
A MAP ACCURACY ASSESSMENT OF FILM VERSUS DIGITAL IMAGERY IN
SUPPORT OF LARGE SCALE PHOTOGRAMMETRY FOR THE PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

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ABSTRACT

The commercial deployment of advanced airborne digital sensor technology has revolutionized the
photogrammetric workflow process and supports new data products and services for end user applications. The
integration of airborne digital cameras in support of large scale photogrammetry for transportation design shows
great promise in reducing overall project cost and production delivery schedules but must be carefully assessed in
terms of its ability to meet required accuracies and standards without fundamentally changing current softcopy
workflow processes.

To test the feasibility of integrating digital imagery into its workflow process, the Pennsylvania Department of
Transportation’s Photogrammetry and Survey Section in conjunction with Photo Science Inc. are working (at the
time of abstract submission) to investigate map accuracies using NSSDA testing standards by comparing
photogrammetric data compiled from both scanned aerial photography and frame based DMC digital imagery for a
predefined study area along State Route 924 near Frackville, Pennsylvania. Film based imagery has been acquired
at 1,200’ AMT and 2,000’ AMT while digital imagery has been acquired at 2,000’ AMT. The project size is typical
of a large scale PENNDOT topographic mapping project. The accuracy assessment process will include both “in-
office” and “field-based” higher order control surveys with a minimum of 20 horizontal and 50 vertical test points
in support of map testing. Additionally, the clarity, dynamic range, and resolution of each imagery format will be
evaluated as it relates to both data accuracy and feature capture rates.

INTRODUCTION

PENNDOT’s Photogrammetry and Surveys Section provides photogrammetric aerial survey services to the eleven
engineering districts of PENNDOT. This data is used primarily as a base map for preliminary design and final design
for roadway improvements and new roadway construction. Photogrammetric data used to support final design
activities are required to meet the accuracy standards as outlined in Table 1. The accuracy needs of PENNDOT’s
design community are the main driving force in determining our section’s photogrammetric workflow. Project costs
are usually secondary to the accuracy requirements.
As digital airborne sensors become the industry standard, the impact to PENNDOT’s photogrammetric workflow becomes an issue. Frame based digital sensors appear to be the only choice available to reach accuracy requirements for large scale mapping. However, the format of these digital frame sensors is much smaller than traditional film cameras. Without deployment of flaps and landing gear, the speed of some aircraft including PENNDOT’s Piper Navajo along with the cycle time of digital cameras will necessitate higher flying heights.

PENNDOT’s standard for design scale mapping (1”=50’) is to fly at 1,500’ AMT. However, on some projects with increased accuracy demands, flying heights of 1,200’ or 1,000’ AMT are not uncommon.

Flying height is just one of many factors that contribute to the final accuracy of photogrammetric mapping data. Field control accuracy, aero-triangulation procedures, camera lens quality, film processing and scanning and many other factors must be considered. The purpose of this paper is to determine if the elimination of film processing and scanning in combination with increased resolution of pure digital imagery will offset inaccuracies introduced by higher flying heights.

**APPROACH**

In order to accomplish this purpose, The Photogrammetry and Surveys Section, Bureau of Design, PENNDOT teamed with Photo Science Inc. to acquire and test both film imagery from PENNDOT’s Leica RC30 and digital imagery from a Z/I DMC owned and operated by Photo Science. A PENNDOT photogrammetry project in Frackville, PA was chosen as the test site.
- April 9, 2005 - Flown with Leica RC30 film camera at 1,200’ AMT to satisfy accuracy requirements of the original PENNDOT project. (shown left)
- April 21, 2005 - Flown with Photo Science owned Intergraph DMC digital camera at 2,000’ AMT as part of this study (shown right)
- November 18, 2005 – reflown with RC30 film camera at 2,000’ AMT for
The photo missions consisted of two flight lines and various numbers of photos based on the scale and frame size of the cameras. The original 1,200’ AMT film mission flown for the PENNDOT project is shown in Figure 2. All subsequent missions were planned to coincide with these two flight line orientations.

- 1,200’ AMT film mission – 2 lines and 14 photos
- 2,000’ AMT film mission – 2 lines and 12 photos
- 2,000’ AMT digital mission – 2 lines and 24 photos

![Figure 2. Original photo mission layout.](image)

**Photogrammetric Orientation of Imagery**

Approximately 140 acres in the town of Frackville, PA and North along SR 924 were included in the test where sufficient ground control could be found.

All three sets of imagery were oriented for stereo compilation according to specifications found in PENNDOT Publication 122M. Film Imagery was scanned using an Intergraph Photoscan scanning system. Ground control from the original PENNDOT project was supplemented with three new map control points named ASPRS01 through ASPRS03. All control was visible on all three sets of imagery with the exception of H05-03-005. This point was destroyed before the 2,000’ AMT film imagery could be obtained. In order to maintain consistency between data sets, H05-03-005 was eliminated from all adjustments. The point was then observed as a vertical only control point using a horizontal location derived from the remaining adjustment. Control layout and map collection areas are detailed on Figure 3.
Ground Test Points

Forty five (45) map test points were surveyed for the purpose of testing the three sets of vector mapping data produced from the three sets of imagery. Twenty (20) points have both horizontal and vertical coordinates while the remaining twenty five points have vertical data only.

Differential leveling was used to determine vertical data on all map test points. Fast Static GPS surveying methods were used to derive horizontal data on the twenty horizontal points. Every attempt was made to ensure that the map test points were distributed over as large an area as possible. However, to simplify the ground survey tasks, test points were restricted to the town and rural roads outside of Frackville.

Accuracy Testing

We used 2 different methods to test the accuracy of the photography against ground test points.

Vector Map Data Testing. In an attempt to include factors like image quality in our accuracy test, compiled vector data was tested first. The test survey focused on photo identifiable features such as manhole centers and ends of curbs. If one imagery set has significantly better image quality, then one should expect that a technician would be able to record features more accurately on that set. DTM data might also be more accurately recorded on imagery of higher quality. For the purposes of this test, technicians were not aware of which points would be tested. They were given collection boundaries that encompassed the test points.

After successfully orienting all three sets of imagery, vector line work was collected in a CADD environment from the resulting stereo imagery. The main comparison would be between the film and digital 2,000’ AMT imagery. The 1,200’ AMT film was added to the test as a control data set which reflects a common PENNDOT photogrammetry
project. The 2,000' AMT digital and film stereo data was collected using Boeing’s Soft-plotter DGN tool software at Photo Science Inc. The 1,200' AMT film stereo data was collected using Intergraph’s Imagestation software. Detailed planimetric features were collected for horizontal testing and a detailed DTM surface was collected for vertical testing.

All technicians had a minimum of 10 years experience in photogrammetric stereo data compilation. One technician collected all data on the 1,200' AMT film imagery. This is being used as a control set. The remaining two technicians collected data on the 2,000' AMT film and digital imagery. The technicians broke the collection areas down into several sets and shared responsibility so that each technician compiled data in various random areas on both film and digital imagery.

Vector data collected as outlined above was compared against the survey data by comparing the measured coordinates from the map to the surveyed coordinates. Points V1 through V20, V32, V38 and MT05-03-93 through MT05-03-99 are identifiable ground features. Points V21 through V31 and V33 through V37 are random vertical only points.

All identifiable ground features were collected as part of the vectors and their coordinates were compared to the higher accuracy ground survey. Horizontal data was recorded from the planimetric feature collection and the vertical data was recorded from the DTM.

All random vertical only points were occupied as part of the fast static GPS ground survey for 1 minute sessions. These shorter sessions provided a horizontal accuracy of +/- 5.0 centimeters. The elevations were recorded from the compiled DTM at the coordinates obtained during this GPS session. This methodology was necessary due to the lack of quality identifiable points and snow cover at the time of our survey.

**Direct Stereo Model Testing.** In an attempt to eliminate factors such as technician experience and habits, the forty five (45) test points were then directly measured from the stereo imagery. After vector collection was complete, photo identifiable features were revealed to a technician. This technician was then asked to find these photo identifiable points in the stereo imagery and measure the coordinates directly.

**RESULTS**

At the time of submission deadline, results were not yet available. Results will be presented at the conference.

**CONCLUSION**

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