TESTING PROCEDURES FOR ANALYTICAL STEREOPLOTTERS

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INTRODUCTION

Many procedures for testing analytical stereoplotters (A/P) have been previously defined in many areas throughout the international photogrammetric community. The target of this document, by direction of Working Group (WG) II/1, is the collection of these testing procedures developed over the years by the instrument manufacturers along with various users in the military, civil government, and the academic community. These procedures have dealt primarily with the hardware components of the stereoviewer and plotting table. On the other hand, workings of an A/P are created by the invisible actions within the soft environment of the electronic controller. A multitude of decisions and computations are made in this environment during the solution of various photogrammetric problems. Therefore, a complete test of an A/P will include the interaction of the operator with this environment. Given the variety of viewer hardware, controller hardware with the operating system, and the philosophy of implementing photogrammetric algorithms, the overall solutions are as numerous as the number of A/P models. Testing procedures to handle all A/P's would require numerous unique tests for all the combinations. The members of the WG II/1 Subworking Group for Analytical Plotter Testing Procedures were solicited for information on the current status of testing procedures for A/P's. A total of nine responses were received: two A/P procurement specifications, one manufacturer's testing procedure document, one government agency's test and development document, one paper on dynamic testing procedures, and four 1-page correspondences with general comments on testing procedures. The response breakdown was: six from instrument manufacturers, one from government, and two from the academic community. This breakdown correlates with the makeup of the working group which is well represented by instrument manufacturers and the academic community. In addition, there exists material from previous Commission II activities along with symposia material generated from the current WG II/1.

This document is designed to provide some direction for those parties seeking information on testing A/P's for acceptance and evaluation. A collection of the various hardware testing procedures are presented. In those areas where support material was lacking, some comments on the experience at the National Ocean Service (NOS) are given. In addition, comments on software testing procedures (through the experience gained in modifying software and in developing new software on the NOS Analytical Stereoplotter (NOSAP)) are presented. The results from many of the testings can provide quantitative information that can be used as input to the comprehensive evaluation form in the "Analytical Stereoplotter Evaluation Guide."

VIEWER SERVO POSITIONING SYSTEM

The servo positioning system is a sophisticated electronics package which receives digital input from a control computer and converts this information into proportional stage movements. Tests for the servo positioning system have been discussed in previous documents: the viewer structure and stage dynamic characteristics (Jaksic 1980), stage calibration (Fritz 1980, 1973), and dynamic performance (Makarovic 1982, 1965). In addition, some instrument manufacturers include specialized software that provides stage calibration tests, the output from which is usually automatically introduced into the operational modes of the A/P.

In addition to the above servo positioning tests, a "smooth movement" was of interest (from NOS experience). This test, although subjective, provided confidence on the overall function of the servo system. This test was performed with good photographic imagery on the stages so that the movement of the stage and each input device connected to the viewer (handwheels, footwheels, tackballs, etc.) were tested independently. The process included a "general movement" and a "pointing" test. The general movement test was accomplished by moving the measuring mark over the imagery using an input device at "slow" speeds with a random motion. A slow speed is understood to be one that is used for stereocompilation. This type of motion generated sufficient acceleration changes to fully exercise the servo system. The operator could verify that the measuring mark movements were directly proportional to the input without any perceptible jitter. Also, the entire length of travel for each axis was exercised to insure that there were no anomalies in the stage transport system. All of the input devices were tested on one stage and thereafter the primary input device only was used to test the other stage or stages.

As before, the pointing test was performed using all input devices on one of the stages. The full test included all stages. This test was done by selecting a well-defined object (e.g., a fiducial mark) and making several pointings using each input device. Again, the movement of the stages was observed not only for being smooth and proportional to the input but also such that the operator had confidence in the pointings.

PLOTTING TABLE AND SERVO POSITIONING SYSTEM

The information available to this subworking group on testing procedures for plotting tables has been limited. One instrument manufacturer's response included the table calibration with their stage calibration software. An additional software package submitted tests which provide for the tracing of various geometric figures. The dynamic performance test (Makarovic 1982, 1965) utilizes the plotting table and, as such, includes the dynamic performance testing of the table.

The use of a laser interferometric measuring system for table calibration has been discussed (Perry 1982). The system eliminates manual pointing normally associated with table calibration. This, along with a 1-micron accuracy and the capability to measure a long axis, makes it an attractive tool for table calibration.

VIEWING SYSTEM

The task of the viewing system is to transfer pictorial images and the measuring mark to the viewing station. Several means and options have been demonstrated by A/P manufacturers in performing this task. The information available to this subworking group on testing procedures of the viewing system has been minimal. However, many of the government specifications documents for the procurement of A/P's define some test procedures on the viewing systems. Most of these tests are directed to the resolution and magnification characteristics of the viewing system. Testing procedures on many of the other characteristics, previously defined (Jaksic 1978), appear to have been addressed from verbal communications but not fully documented.

NOS has performed several tests on the viewing system of NOSAP. These tests have evolved from in-house experience and communications with the A/P community. As in the case of others, they have not been fully documented. The heart of the sophisticated viewing system of NOSAP are variable measuring marks (10 to 160 microns) coupled to independent, computer-controlled zooms (from 5x to 45x), so that the apparent mark size for each photo remains constant during magnification changes. The optical path is further complicated by the capability of binocular viewing of either stage.

Some of the tests performed included measuring resolution, measuring magnification, determining the measuring mark size, and observing the optical alignment. In addition, the analog indicators (for mark size and magnification) associated with each stage were adjusted from the results of the magnification and the mark size tests. The resolution observations (of U.S. Air Force resolution targets) were recorded at four positions on each stage with three observers. Four magnification settings that covered the range of the zooms were used during these observations at each position.

The magnification test was performed by introducing an identical grid pattern (sized photographically) at the stage and in front of the eyepiece. One grid pattern was positioned on the stage plate. Positioning the other required removing the eyepiece, placing the grid pattern in front of the exposed optics, and replacing the eyepiece. The latter grid pattern was cut in half such that the observer's field of view consisted of a lower semicircle containing the eyepiece grid and the upper semicircle containing the stage view. The stage in question could then be positioned such that both grids were viewed simultaneously and magnification observations recorded by comparing the two grids.

The diameter of the mark size was observed by positioning a glass scale (10 um graduations) on the stage in question and positioning the stage such that the dot and scale were in the proper relation for observing the diameter of the measuring mark. This test was used to observe the range of variable measuring mark diameter, the indicator readings, and the proper effect on measuring mark size with respect to magnification changes.

Optical alignment was observed by inserting a 150-micron circle behind the eyepiece and observing that the center of the measuring mark remained within the confines of the circle.

SOFTWARE TESTING

In response to the solicitation, very little reference was made to the area of "software evaluation." Where mentioned, the suggested tests of software concentrated on specific A/P application and, in most cases, were not universal with regard to instrumentation. That is the tests would apply to only one specific instrument. From past experience at NOS in the procurement and evaluation of an A/P (Fritz 1980) along with recent developments of a systems approach to the applications of A/P (Perry 1982, Slama 1982), the following is a brief discussion on the subject of software evaluation.

An A/P is a mechanical device under complete control of one or more computers that react to input from a human operator. The computers (when digital) contain a series of programs (software) that evaluate mathematical expressions (algorithms) which "model" specific physical properties of nature. For instance, the main algorithm is designed to simulate the geometry of the exposure of a precision aerial frame camera where the instrument is used for topographic applications. The most popular approach is to use a central perspective transformation with modifications for assumed models of atmospheric refraction of light, geometric lens distortions, Earth's figure, film stability, and equipment irregularities (both camera and instrument). In most cases, the designer of the software selects those mathematical expressions which (in their opinion) best "fit" the physical phenomena and satisfy the restriction of the digital computer being used. To support this routine a series of application programs are developed which derive specific constants needed for central perspective transformation along with controls for data extractions. Finally, the entire process is brought into the real world through the introduction of a series of servomechanisms. From this description it becomes fairly obvious that one cannot design a single set of test procedures that would serve to evaluate all combinations of software that have evolved through the development of various A/P's. On the other hand, it is equally obvious that a standardization of input and output parameter definitions in an A/P system will alleviate a certain amount of diversity in this and could lead to universal test procedures. In other words, if the description of the orientation of a photograph in space is restricted to six parameters, the internal geometry of a camera is standardized and a universal output is adopted for the coordinate definition of spatial features, test procedures could be designed which would be capable of evaluating the algorithms and software of any A/P for topographic applications. These tests would be independent of the type of camera systems that are employed (i.e., nonframe type) since these definitions are internal to the transformation algorithms. Similarly, standardization in close range applications could lead to the same benefits as those in topographic applications. Until the standardizations are adopted, any test procedures used will be incapable of separating the effects of human observation, software, algorithm definition, and mechanical deficiencies from the results of the test. Conversely, with standardization the evaluation of software can be designed to be a "stand alone" type test that is independent of the other facets of the A/P.

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