*Map Accuracy Evaluation Procedures at Army Map Service**

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ABSTRACT: *The need for reliable map accuracy evaluations of existing maps of foreign areas is discussed. Procedures to provide a preliminary accuracy evaluation and to select the areas for further investigation are outlined. A summary of the stereo-photogrammetric procedures currently in use at AMS is given. Statistical methods used in the reduction of the test data to specific map accuracy classifications and the application of these results to future map planning are discussed.*

THE processes of determining the accuracy of maps and charts are probably as old as the art of cartography itself. Early mariners who were fortunate enough to obtain charts were constantly comparing their observations of land and sea with those features portrayed on their charts. Genoese, Venetians, and other western chart makers highly prized the more accurate work of the cartographers of the eastern world with which to compare their own charts.

In a military mapping organization, such as the Army Map Service, it is necessary to exploit foreign map sources in many ways. The urgency of military requirements may necessitate the reproduction of foreign maps with only minor changes in format. With adequate mapping materials available, photo revision and redrafting of existing maps may be the most economical and expeditious method of producing new map coverage. Even in the production of entirely new topographic maps by stereo photogrammetric methods, existing maps are valuable as guides in photo interpretation and in photo identification of control. A reliable evaluation of the horizontal and vertical accuracy of the source used in an emergency reproduction is essential to the map user. Also such an evaluation is necessary in planning the most economical and expeditious methods of new map compilation.

In the preparation of a map accuracy evaluation, a preliminary investigation is made of the map coverage. All available intelligence information on mapping methods and mapping standards of accuracy of the originating agency is evaluated. Routine checks of alignment and completeness of the planimetric features and general shape of the topographic features are made from aerial photography. A cartometric evaluation of the horizontal control is made to determine if the map position of the horizontal control is in agreement with all available geodetic information. The preliminary investigation may provide sufficient information to estimate the accuracy of the maps to be evaluated. If, however, during the preliminary investigation, inaccuracies are observed, or if discrepancies exist in available intelligence data which would tend to make the validity of the accuracy estimate doubtful, a stereo photogrammetric map accuracy test is warranted.

A representative number of quadrangles are selected within the questioned area for which control and aerial photography are available, and stereo-photogrammetric map accuracy tests of these quadrangles are made.

The general procedure followed in the performance of a stereo-photogrammetric map accuracy evaluation is to prepare a stereo-compilation of a portion of the map source. Information obtained during the preparation of this test compilation, and

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from the comparison of the test compilation with the map source is used as a basis for the classification of the map source.

A study of the project is made to determine the scale and the quality of the photography available, the amount and quality of the basic control within the area, and the photogrammetric instrument most suitable for the job. The selection of the photogrammetric instrument is based upon the scale of photography, the scale of contour interval of the map source, and to some extent, upon the type of terrain and the compilation methods used in the preparation of the original quadrangles. After determining the most economical method of compilation, compatible with the required accuracies, a specific area is selected for the test compilation. The choice of compilation area is determined, for the most part, by the relationship of the aerial photography to the quadrangles to be tested and the location and amount of control within the area.

Vertical and horizontal control data for the test area are obtained. Such control usually consists of Control Listings; these contain a sketch and description of the location of each station, and its grid coordinates. The control sketch, in most instances, consists of a small portion of a topographic map locating the general position of the station. The description of the control point is also usually quite vague. Distances expressed in terms of one hours walk from a village or twenty minutes by mule from a farm, are not uncommon. Fortunately, most control of this nature is located on hilltops and can be identified on aerial photography with some precision.

With horizontal and vertical control of this type, it is unusual to find in one stereo model sufficient control to permit an acceptable horizontal and vertical solution. To provide a strong solution for the compilation models, it is generally necessary to bridge several models. Model bridges may be accomplished by first-order instruments with graphical or mathematical adjustments as necessary. However, when accuracy requirements permit, triangulation is done on a Multiplex instrument, as this method provides a visual over-all horizontal and vertical adjustment on the short bridges.

After the best horizontal and vertical position of the selected compilation models have been established, measurement and recordings are made of any differences between the plotted positions and the stereo positions of the horizontal control, and also any differences in the vertical elevations. A compilation of the model or models is then made. Major planometric features—those which are readily identifiable on the stereoscopic model—are plotted for the entire compilation area. For economic reasons, only a portion of the model is selected for a complete planimetric compilation. The entire model is contoured, with a contour interval equal to that of the source map. Auxiliary contours if shown on the source map, are also shown.

The instrument elevation of all identifiable spot elevations of the source map are determined and any differences noted. All hydrographic features are compiled but no vegetation is shown on the test compilation unless specifically requested.

The accuracy of the test compilation is evaluated by taking into consideration all the factors affecting the accuracy of the model, such as the amount and quality of basic control, quality of the photography, accuracy of orientation, and compilation methods. Proper planning and adequate materials should give compilation accuracies equal to or better than National Standards of Map Accuracy.

A film positive of the test compilation is obtained at the scale of the map source. The source map is checked against the film positive for alignment, position, and completeness of planimetric and hydrographic features. Hypsographic features are examined for shape and detail. Contour accuracy is determined by selecting arbitrary profile routes, usually grid lines, and comparing the contour elevations of the map with those of the test compilation. Where a contour crosses a profile route, the ground elevation of the point is interpolated from the contours of the test compilation and differences are recorded. A statistical analysis of these differences is made, and the results used in the final evaluation of the vertical accuracy of the map. Horizontal accuracies are determined by measuring displacements in the major planimetric features.

Based on the statistical results obtained from the test and the visual comparison of the film positive and the source map, the map is placed in one of the following classifications:

Class A—90 per cent of the well-defined planimetric features located within 0.02 inch of their true geographical position at reproduction scale, and 90 per cent of the contours accurate to within one-half contour interval. This is the equivalent of the National Standards of Map Accuracy.

Class B—90 per cent of the well-defined planimetric features are located within 0.04 inch of their true geographic position, and 90 per cent of all contours accurate to within one contour interval.

Class C—Horizontal and vertical accuracy less than that required for Class B. These maps are not suitable for use in military, or for military use.

The outlined methods are those usually employed in a photogrammetric map accuracy check. Test procedures often have to be modified to accommodate less than ideal conditions. The lack of adequate control is a factor that is encountered many times. One approach to a map accuracy test under these conditions is to photographically enlarge the source maps to Multiplex plotting-scale and to set the Multiplex models over these sheets. The bridged strip is adjusted to the best over-all fit of the more prominent planimetric features. Vertical position of the individual models in the strip is established through the use of spot elevations and contours. In this situation, all readily identifiable planimetric and hydrographic features are plotted for the entire strip. Topography is compiled for those models having the more reliable vertical control. On one occasion the only materials made available for a relative accuracy check were the original large-scale maps and contact prints of the aerial coverage. A reliable vertical check was not possible with the materials available, but a relative horizontal check was performed, using slotted templet methods. Maps so checked cannot be placed in any definite category. However, the relative horizontal and vertical accuracies obtained give an indication of the general reliability of the maps tested.

A report is prepared upon the completion of the test and a film-positive of the test compilation is included in the report to provide a graphic indication of the evaluation.

The information made available from a photogrammetric map test provides a reliable evaluation of the accuracy of the tested maps, and the reliability and adequacy of the basic control, as well as information on the adequacy of the photo coverage of the area. Such data are invaluable in establishing mapping priorities and the planning of mapping projects.

MEASUREMENTS WITH TELLUROMETER

Thirty-two engineers recently saw a highly exact mapping instrument measure distances of 27,414 feet within four inches at tests near Doylestown, Pa. The instrument is the Tellurometer, an electronic tool developed in South Africa which operates on radar principles. It is expected to cut basic ground mapping costs and time by 75 per cent or more.

These tests—first to be made for representatives of utilities, mining companies, and highway departments—were performed by field survey personnel of Aero Service Corp., Philadelphia. The world-wide mapping company has purchased several Tellurometers for use in its extensive survey operations. They will provide the necessary ground measurements for air surveys for highways, railroads, pipe lines, transmission lines, and other large scale developments. The new instrument measures distance by phase comparison. A 10 megacycle crystal oscillator in the "master" instrument transmits a pulse, which is compared with a pulse from a similar oscillator in the "remote" station. The remote station transmits 1,000 cycles above or below the 10 megacycle wave length. Rain or fog, daylight or dark do not affect the operation of the Tellurometer.

Aero will use the instrument for measurements ranging from one-half mile to 30 miles or more. On one recent test, over a 42,327 ft. distance, the Tellurometer proved to be accurate up to 1 part in 300,000.