# *An Operational Report on Stereo-Templets**†

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ABSTRACT: *Stereo-templets are a new development in photogrammetry. While they resemble radial-templets they are basically more accurate since they are prepared from the stereoscopic model obtained from a precise plotting instrument rather than from a single photograph. The use of stereo-templets in production mapping as well as in a small research project indicates that the best accuracy, with a minimum of horizontal control, may be expected when the control is located on the perimeter of the project. For the materials and equipment now in use the most satisfactory scale for the stereo-templets is approximately that of the aerial negative. Additional tests are under way which will probably result in the development of materials, equipment and techniques to utilize more fully the inherent accuracy of stereo-templets.*

TEMPLET aerotriangulation is a system for making a horizontal-scale solution or determining map positions for individual or blocks of aerial photographs. The basic radial-line principles are well established both in theory and practice. The slotted-templet system was originated by C. W. Collier of the Soil Conservation Service in 1936 and the metal-arm system by S. P. Floore of the U. S. Geological Survey in 1938. Both systems had wide application in small-scale or reconnaissance-class mapping.

The stereo-templet system was suggested by Marvin B. Scher of the U. S. Geological Survey in 1949.[1] Superficially, the Scher system of templets is very similar to the Collier and Floore systems. The principal difference between it and the conventional systems is that the stereoscopic model from a plotting instrument, rather than a single aerial photograph, is the basis for preparation of the stereo-templets. A stereo-templet is a composite slotted-templet composed of two templets for the model, using opposite corner points as centers of radiation.

[1] Scher, M. B., "Stereotemplet Triangulation," PHOTOGRAMMETRIC ENGINEERING, Vol. XXI, no. 5, December 1955.

The theoretical advantages of stereo-templets may be listed as follows:

1. Stereo-templets may have the inherent accuracy of a horizontalized stereoscopic model rather than of a single aerial photograph. The projection of pass-point data is orthographic rather than perspective so that detrimental effects of tilt and terrain relief are eliminated.
2. Single models, pairs of models, whole strips, or even several strips may be used as the basis for a pair of stereo-templets.
3. With the pantograph attached to any of the direct-projection-type instruments, or by the use of a universal plotter, a wide scale-range of stereo-templets can be produced. This will usually allow aerotriangulation to be performed at the scale specified for map compilation.
4. Vertical, or any of the several kinds of oblique aerial photography, in almost any variety of flight heights, can be used in combination for the aerotriangulation of a project.

## INTRODUCTION OF STEREO-TEMPLETS INTO MAP PRODUCTION

From 1949 to 1954 stereo-templets were used in the Atlantic Region office of the Geological Survey for the aerotriangulation of several small specialized projects.

* Presented at the 23rd Annual Meeting of the American Society of Photogrammetry, Washington, D. C., March 4–6, 1957.
† Publication approved by the Director, U. S. Geological Survey.

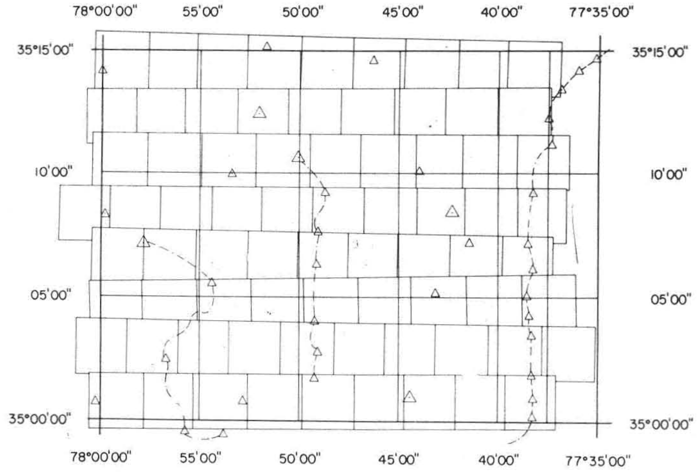



FIG. 1. Index of horizontal control and aerial photography—Part Goldsboro, N. C. Project.

They were first used for a large production-type project in 1954. At that time ten quadrangles of the thirty-five making up the Wright-Patterson, Ohio project were aerotriangulated by stereo-templets. The remainder of the project was triangulated using conventional instrument methods. Upon completion, both the accuracy and cost of the two methods were compared and the stereo-templet work found to be about equal to the conventional method on both scores.

Shortly after this date, the delivery of universal pantographs for use with the direct-projection instruments stimulated added interest and impetus in adopting stereo-templets as standard procedure for aerotriangulation. These pantographs were designed and purchased with the objective of performing map compilations at or near the map-publication scales. The stereo-templet procedure was found most attractive as aerotriangulation could be carried out directly at the map compilation-scale rather than at instrument model-scale as had been previously required when using direct-projection instruments. This is entirely desirable as it eliminates several steps in base-sheet preparation and in the reduction and transfer of horizontal pass-point data, and results in economy of both material and time.

## GOLDSBORO, N. C., STEREO-TEMPLET PERFORMANCE TEST

With emphasis on the desirability for using the stereo-templet system there was a consequent need for more information on the applicability, basic control requirements, and accuracy which might be expected of the system. In examining projects in the Atlantic Region scheduled for stereomapping, it was noted that the Goldsboro, N. C., project contained a wealth of existing basic horizontal-control which made it suitable as a test project without the necessity for additional and expensive ground-control. It was therefore selected and the aerotriangulation phases set up as a joint research project between the Photogrammetry Sections of the Topographic Division Staff and the Atlantic Region. Planning on the project was started early in 1955 and the work and final reports completed about one year later.[2] Pertinent data and highlights of the project are as follows.

The test area (see Figure 1) consisted of the Seven Springs and west-half of the Deep Run 15-minute North Carolina quadrangles. As mentioned above, there was a wealth of second- and third-order basic horizontal-control including transit traverse by the Corps of Engineers, the North Carolina Geodetic Survey, and the U. S. Geological Survey, and triangulation by the U. S. Coast and Geodetic Survey. The project was covered by convergent low-oblique aerial photography GS-CAB, 6-inch focal-length and 10,600-foot flight-altitude with an east-west flight direction, flown in 1954. Field identifications for all horizontal-control to be used in the tests

[2] Trone, E. K., and Thompson, M. M., "Stereotemplet Performance Tests," report in files of U. S. Geological Survey.

as well as the usual amounts of basic vertical and supplemental vertical-control were available. Base sheets were made on 0.005-inch Mylar at 1:10,000, 1:20,000, and 1:40,000 scales. Diapositive plates were prepared for the ER-55 projectors and the stereoscopic models were oriented at approximately 1:7,200 scale. Aerotriangulation data were recorded on the 0.005-inch Mylar. From this recording, sets of stereo-templets were prepared at approximately 1:10,000, 1:20,000, and 1:40,000 on 0.03-inch-thick pattern board. A precise pantograph was used to effect the necessary reductions and the stock was slotted with a Geological Survey slot-cutter designed and constructed several years ago for use with radial-templets.

Eleven control distribution patterns were selected for the tests. Two control points on the diagonal corners of the project afforded the minimum control, while a pattern of 12 points, more or less uniformly spaced at 7½-minute intervals, was the maximum. Tests were made for each of the eleven patterns at 1:20,000 scale, while only six patterns were used for the 1:10,000- and 1:40,000-scale laydowns. Thus a total of 23 laydowns were required for the project. After each templet laydown, the closures on the existing horizontal-control points which had not been used to control the laydown were recorded in terms of azimuth and distance. The azimuths were measured to the nearest degree with a protractor, and the distances were read with a Bausch & Lomb shop microscope capable of measurements to 0.001 inch. These distances were then converted to feet in nature.

It might be mentioned that a row or collar of uncontrolled templets was added to the west and north edges of each area of interest in some of the tests, to determine the effectiveness of such a procedure in improving perimeter accuracy.

## Analysis of Goldsboro, N. C., Results

Data for the tests described above was delivered to the Topographic Division Staff, Photogrammetry Section for analysis. The standard error for closures on the test positions, the number of models per control point, and number of control points per 100 square miles were computed and tabulated for each of the 23 templet laydowns. These data were then plotted on a graph, Accuracy of Horizontal Aerotriangulation with Stereo-Templets for Various Control Patterns. (See Figure 2.)

While the tests are not extensive enough to permit sweeping conclusions, certain indications are quite clear:

1. The stereo-templet system has no magic which produces accurate map-positions for an entire project from a few control points. Wishful thinking of this nature should not be permitted to influence operational practice as it will lead to unsatisfactory results and delay the development of a very useful and valuable photogrammetric technique.
2. The small-scale (1:40,000) templets are less accurate than print-scale (1:20,000) or large-scale (1:10,000) templets. However, the 1:10,000 templets are only slightly more accurate than the 1:20,000 templets. Since the 1:10,000 templets are more expensive to prepare and unwieldy to handle, there is a clear indication, in this case, that 1:20,000-scale templets are most efficient, and that the preferable scale for templet assembly is approximately the scale of the original aerial photography.
3. Both the pattern and the density of the basic control affect the accuracy of stereo-templets. In general the best accuracy with the least control was achieved when the control was spaced around the perimeter of the project. Additional control spaced through the interior of the project improved the accuracy to some extent but not in a direct ratio to the additional number of points.
4. The effect of triangulation overhang of templets beyond control was examined. (See patterns 4 and 6.) This situation is of interest as it bears directly on production mapping problems. While the results were not conclusive, it appeared that overhang or cantilever areas should be used with extreme caution as they are less accurate than areas within the control pattern.
5. The effect of perimeter or collar templets beyond the area of interest was examined. The results were inconclusive. This procedure appears to have merit and warrants further investigation.

## Present Use of Stereo-Templets in Map Production

The Topographic Division has an announced policy for adopting the "Integrated Photogrammetric System."[3] This

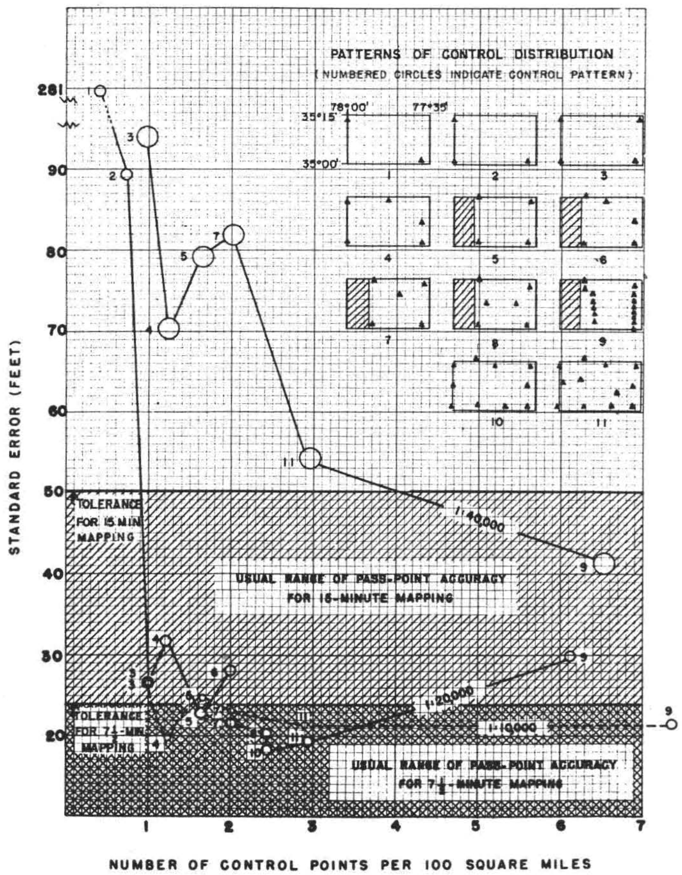


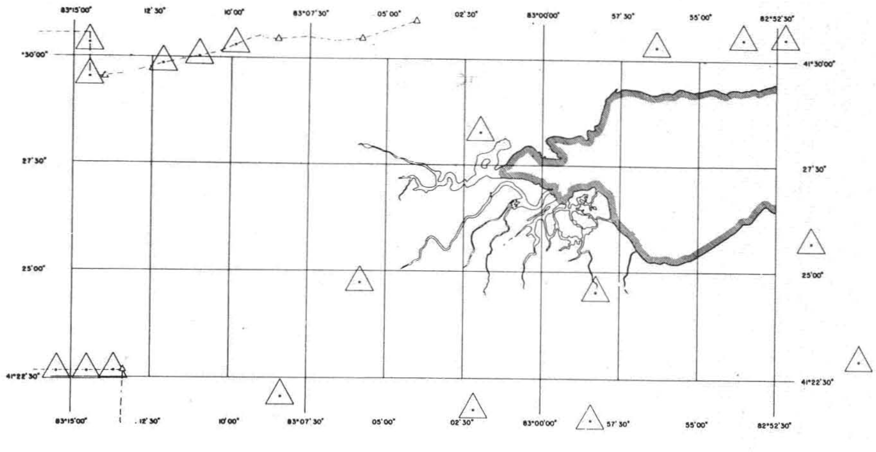

FIG. 2. Accuracy of horizontal aerotriangulation with stereo-templets, for various control patterns.

awesome title covers a collection of logical, simple, and entirely desirable objectives. In brief, the policy is to use the best obtainable (either existent, or through design development and manufacture) aerial cameras, diapositive printers, stereo-plotting instruments, map materials, and compilation techniques. The stereo-templet system is mentioned as one of the techniques. The Atlantic Region has made much progress into the actual use of the integrated system including the use of stereo-templets. At present the stereo-templet system is standard practice for nearly all aerotriangulation for the extension of horizontal-control for the orientation of stereo-models to be compiled by the photogrammetric instruments. The procedure used is very similar to that described in the Goldsboro test project.

Figure 3 illustrates the Bellevue, Ohio special project. The area covered is three 7½-minute quadrangles. Horizontal-control is indicated by the large triangles. It will be noted that the control pattern follows the findings of the Goldsboro tests. The major amount of control is spaced around the perimeter of the project with only a few points within the area.

Figure 4 shows the stereo-templet laydown for the Bellevue project. The existing horizontal control is marked as in the previous illustration. Individual templets, control and passpoint studs may be identified in this illustration. Some of the virtues

[3] Whitmore, G. D., "Economic Factors in the Integrated Photogrammetric System of the U. S. Geological Survey"; Bean, R. K., "Instrumentation for the Integrated Photogrammetric System," PHOTOGRAMMETRIC ENGINEERING, Vol. XXII, No. 2, April 1956.



BELLEVUE SPECIAL PROJECT
SCALE 1=24,000
F.H. 5,500 FT.
F.L. 6 IN. C.I. 5 FT.

FIG. 3.

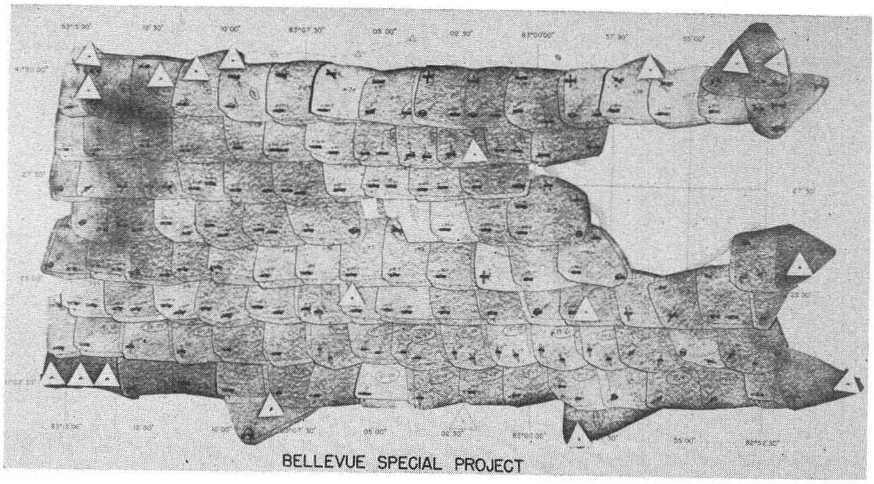



FIG. 4.
Scale 1=24,000
F.H. 5,500 ft.
F.L. 6 in. C.I. 5 ft.

of the stereo-templet technique are clearly demonstrated, as follows:

1. An area solution and adjusted pass-point data are derived in a single process.

2. The bridging is across as well as along the lines of flight. This furnishes a simple means for completing aerotriangulation in irregular land areas such as that at the east end of this project, without additional horizontal control.

3. Several flight heights of aerial photography are readily combined into a single templet-laydown. This project is covered by convergent low-oblique photography at a flight height of 5,500 feet. The "ear" templets on the NE corner and on the south edge were prepared from vertical photography at a height of 14,800 feet.

## FUTURE DEVELOPMENT OF STEREO-TEMPLETS

Stereo-templets have proven entirely practical and desirable in production use. At the same time experience in their use as well as the Goldsboro test has fully demonstrated that major improvements are desirable and possibly attainable. As a result, in April 1956 a second stereo-templet research project was undertaken as a joint responsibility of the Staff Photogrammetry and Instrument Design Sections, and the Atlantic Region Photogrammetry Section. Phase I of the project is to cover the evaluation of available stereo-templet materials and templet-slotting machines in order that the most suitable items in each category may be determined and adopted on a divisionwide basis. Phase II is to determine the accuracy characteristics of stereo-templet assemblies for various combinations of scales, control density and pattern, and sequences of templet assembly. This project while incomplete is mentioned to indicate a continued interest in developing and perfecting the stereo-templet system further.

The use of templet materials and the design and manufacture of studs and cutters particularly suitable for stereo-templets, rather than the continued use of materials designed for use with radial templets, is to be expected. Research tests and production experience will be needed to determine the best use of these improved photogrammetric tools.

# *A Do-It-Yourself Terrain Model**

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ABSTRACT: *There are many ways to construct a relief model. Degrees of refinement run from sand-table efforts to precise plastic reproductions. The method presented here lies somewhere between these extremes. Its simplicity permits rapid construction by someone having only a basic knowledge of map reading and little material; yet the same procedure can produce a more complete product depending on the time, skill and material available. The method can be taught "by the numbers" in a basic map-reading course. Even "do-it-yourself" kits could be made—produced complete with instructions.*

TERRAIN models have always appealed to both map makers and map users. During World War II, many models were made by the Navy and reproduced in rubber. These models were beautifully painted to achieve the maximum in realism. Following the war, the Army Map Service began an extensive model program which has resulted in the production of great numbers of excellent plastic relief maps. These maps, made by vacuum forming, from an original carved model, carry all the information shown on the flat map but presented in a three-dimensional manner. Many recent developments have reduced the man-hours required to make these models and subsequent relief maps. However, a need still exists for a simple method that can be used by field units to make models rapidly without special materials, equipment or technical training. Such models, of course, need not equal the accuracy of those now being made by the Army Map Service and the Navy Photographic Interpretation Center, but they would serve many useful purposes.

The method of constructing such a simplified model should be one that can be taught in basic map-reading courses with the materials available at that level.

* This paper was delivered at the Society's 23rd Annual Meeting, Hotel Shoreham, Washington, D. C., March 6, 1957.

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