The Role of Testing and Evaluation in the Development of Photogrammetric Equipment

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ABSTRACT: *A successful test and evaluation program of photogrammetric equipment entails considerably more than strict testing and objective evaluation. Such a program must of a necessity embrace a certain amount of research, design, redesign and electronic support to ensure continuity of effort and optimum results. An extremely high degree of professional competence is required of personnel engaged in this work. This paper covers the rudiments of a test and evaluation program conducted by the Test and Evaluation Branch of the Photogrammetry Division, U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency (GIMRADA), Fort Belvoir, Virginia. Specific examples are cited to indicate problems and how they were solved.*

TREMENDOUS strides have been made in the field of military and civilian mapping in the past three decades. This progress has, if anything, been considerably accelerated by the environment of the Cold War for the obvious reason that the requirements made for adequate topographic coverage are potentially much more encompassing than even in a shooting war. As a consequence, the major effort in the field of military topographic research has been geared towards acceleration of the means of producing maps or map substitutes.

To achieve this purpose, it was found that an intensive testing and evaluation effort was required, as well as an all out research and development program. Such an effort has been carried out by the Corps of Engineers at Fort Belvoir, Virginia, for a good number of years and has resulted in a steady stream of official reports containing the results of this testing and evaluation work. In April of 1942, a report was published on Wide-Angle Mapping Equipment. In 1943, a report was published covering oblique multiplex equipment. In the next five years, a number of reports were published covering equipment such as the Iconoscope, the perspective sketchers, multiplex reduction printers, stereotopograph, KEK Plotter, stereoplanigraph and Klein Autograph.

It is apparent that in general the testing and evaluation program of the Corps of Engineers was initially limited to conventional equipment already in existence or to equipment that had been modified to some extent by the Corps of Engineers. As progress was made in the field of research and development, a gradual evolution occurred in the field of testing and evaluation and the major effort then became directed toward testing and evaluation of equipment developed by the Corps of Engineers and was designed to meet specific needs. At the same time, a door was left open for a continuation of the program of testing equipment developed by private industry. This is borne out by the development and testing of equipment such as the portable autofocus reflecting projector which took place principally in 1948 and was first reported in USAERDL Report No. 1125, "Interim Report—Development of Portable Autofocus Reflecting Projector," dated 13 May 1949, and other equipment such as the height finder reported in USAERDL Report No. 1158, "Development of Height Finder Oblique," dated 28 February 1950, "Printer, Photographic, Horizontal Projection, Rectifying, Tilts Under 70° for 9½ Inch Aerial Roll Film," dated 13 March 1950.

A steady stream of other reports followed in the next decade covering tests of equipment developed at USAERDL as well as commercial items as is indicated by such representative reports as USAERDL Report

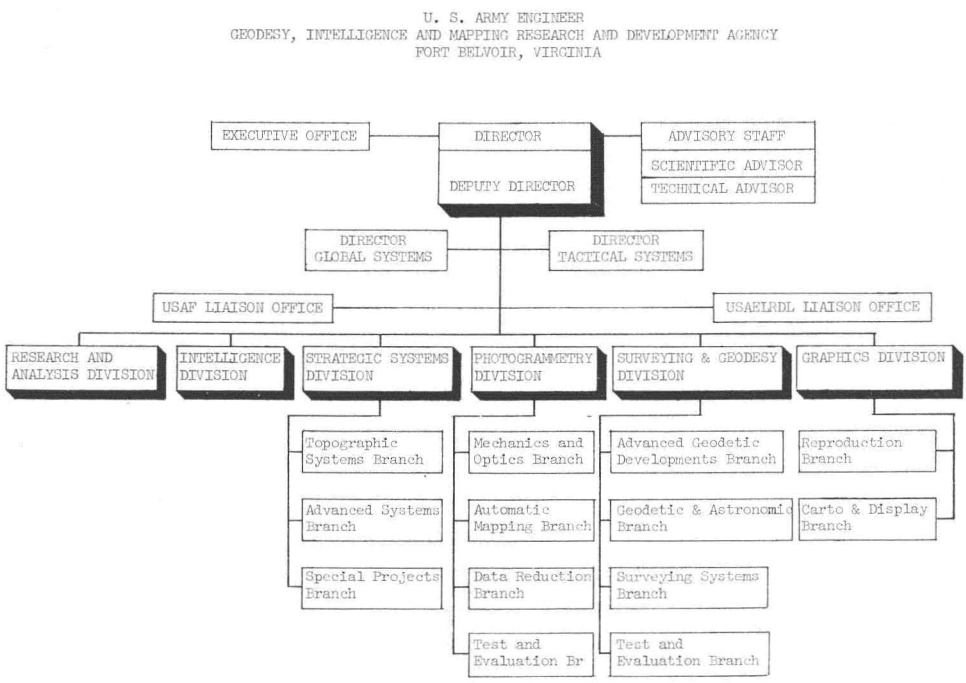

CHART I. Organization of GIMRADA.

No. 1274, "Oblique Sketchmaster," dated 24 December 1952; USAERDL Report No. 1348, "Test and Evaluation of the 720 Plotter," manufactured by Bausch and Lomb Optical Company, dated 23 April 1954; USAERDL Report No. 1460-TR, "Test and Evaluation of 9×18 Rectifier for 12×24 Inch Focal-Length Photography," dated 7 September 1956; and USAERDL Report No. 1567-TR, "Test and Evaluation of the Zeiss Stereotope Stereoplotting Instrument," dated 11 February 1959.

The testing and evaluation of the equipment covered in all of these reports were carried out generally by the same organizational segment and personnel who were responsible for its development, or by personnel who were essentially charged with a primary development responsibility. This policy was followed with minor variations until 1960, when a major reorganization took place and the Topographic Engineering Department of the U. S. Army Engineer Research and Development Laboratories (USAERDL) was reconstituted as the U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency (GIMRADA), a Class II agency under the direct operational control of the Chief of Engineers, in August of 1960. The present organization of GIMRADA is shown in Chart I and is a product of natural evolutionary growth and change since its inception.

The largest organizational segment of GIMRADA, namely, the Photogrammetry Division, still retains its basic original organizational structure even though it has been charged with more responsibilities and has, consequently, been increased considerably in strength.

The most significant changes that have taken place in the Division have occurred in the Test and Evaluation Branch. Initially, this Branch was charged principally with responsibility for procurement of service test models, monitoring and evaluation of service tests, and special functions such as human factors, value and reliability engineering. The original strength of the Branch consisted of only four engineers. It was soon found that an effective photogrammetric test and evaluation program for the entire Division could not be carried out under such limiting conditions, particularly since a major portion of this endeavor fell into the field of automatic mapping. This field is an unusually complex one since the problem presented can be solved only by the employment of highly sophisticated electronic components, logic circuitry and extremely precise optical and mechanical subsystems. Since work in this field is still relatively speaking in a pioneering stage,

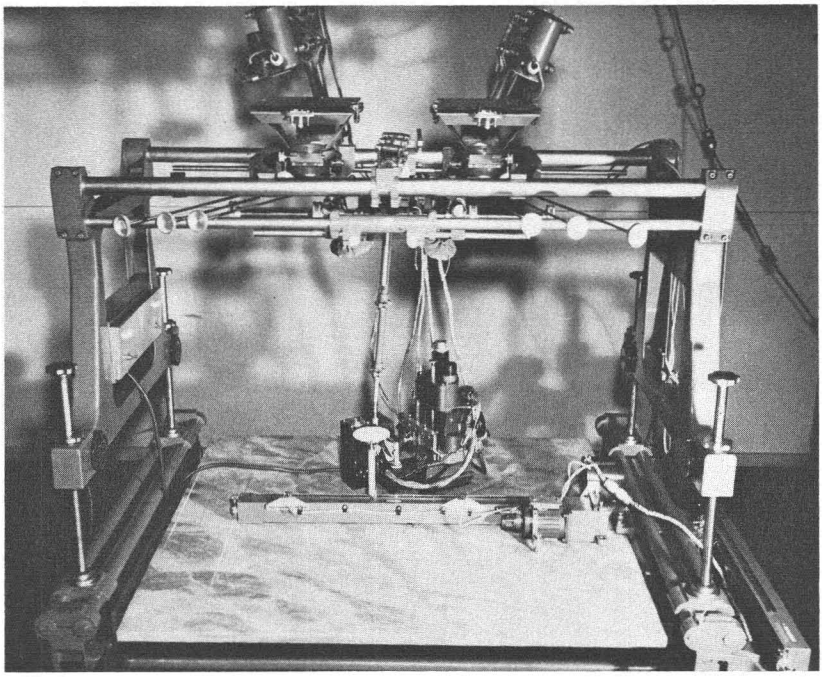

FIG. 1. Integrated mapping system.

inordinately difficult problems must be constantly solved to overcome malfunctions and inaccuracies which tend to impede testing and evaluation. Personnel engaged in the work of photogrammetric test and evaluation, in addition to a primary knowledge of photogrammetry and optics, must also have a thorough familiarity with electrical and mechanical engineering principles as well as the field of applied electronics.

Currently, the Test and Evaluation Branch performs a unique function in the Photogrammetry Division in that it has the responsibility of not only performing testing and evaluation, but also is charged with the mission of applied photogrammetric research, original design in the case of special projects, as well as redesign subsequent to testing and evaluation of equipment or systems. Another major function is furnishing electronic support to the entire Division.

An example of new design which was recently performed is the preparation of technical requirements and criteria for an instrument of extremely high precision. This is an Enlarging Printer designed for preparation of glass or film diapositives from 70 mm. aerial photography. The diapositives will be used in extremely sensitive equipment; consequently, the resolution and distortion requirements are very critical. In effect some special procedures will have to be devised to check the distortion requirement of 3 microns, since this will necessitate employment of a grid reading to 0.75 micron, a measurement now beyond the state-of-the-art. A contract for development of this instrument has recently been awarded to Watson Electronics and Engineering Company, Inc., of Arlington, Virginia.

Examples of redesign which were recently accomplished or are in progress in this Branch are as follows:

A. THE INTEGRATED MAPPING SYSTEM (Figure 1).—When the Test and Evaluation Branch took over this project, development of Integrated Mapping System had not been completed. After considerable study and analysis of the problems entailed, competitive bids were solicited from several firms. Subsequent to a thorough evaluation of these bids, a contract was awarded to Atlantic Research Corporation to perform the necessary work, beyond the scope of this organization, to put the equipment in operational order. The task was performed as a cooperative project with the Project Engineer and the Chief of the Branch working very closely with the contractor's engineer in order to help solve the intricate problems that arose. Following are some of the problems that were solved:

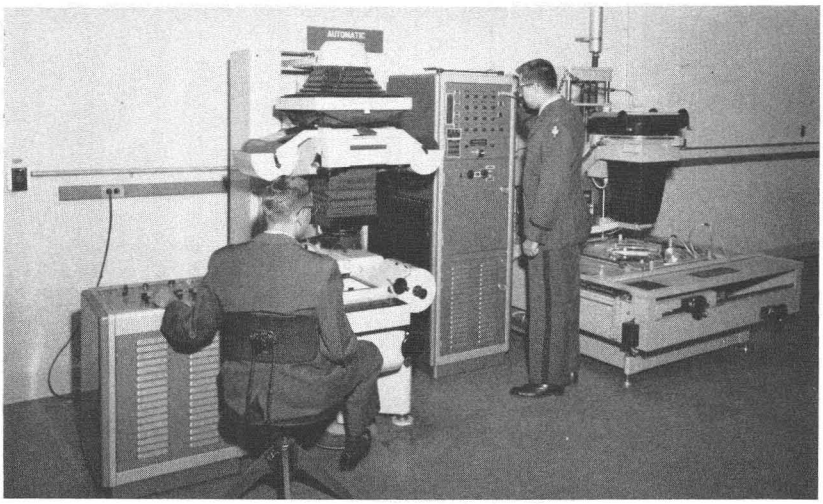

FIG. 2. Automatic mosaicking system.

(1) Difficulty was encountered in energizing selected outputs on the control console. This was solved by installation of cable shielding to eliminate cross interference between adjacent lines.
(2) Difficulty was encountered in getting data through the character unfolder. It was found that only a one-micro second pulse was given the first gate, through which data are fed into the bank of flip flops (electronic control switches). An additional amplifier card was designed and incorporated in the circuitry to remedy this situation.
(3) The Z-axis lead screw and gear train became locked. A gear train redesigned by the Project Engineer and manufactured at the U. S. Army Engineer Research and Development Laboratories remedied this situation.
(4) The convertor was found to be incapable of sending sufficiently accurate voltages to the *Z*-servo mechanisms. Precision resistors were installed in the system to overcome this difficulty.
(5) Interference was discovered when both tape handlers were operated simultaneously. Filtering elements were installed on each tape handler thereby eliminating the interference.

Numerous other difficulties were overcome by contractor personnel and Test and Evaluation Branch Personnel working as a team. As a result, the Government was saved a considerable amount of money since a large amount of the work was performed "in-house."

B. THE AUTOMATIC MOSAICKING SYSTEM[1] (Figure 2).—Responsibility for this project was taken over by the Test and Evaluation Branch in the early stages of its development. The Project Engineer worked very closely with the contractor (Union Instrument Corporation) in solving what appeared to be insurmountable problems, because an entirely new concept had to be pioneered and problems that had never arisen before had to be tackled. For instance, in order to correctly position each frame, the nadir-point location had to be imposed on each rectified photograph. An extremely ingenious mathematical solution was devised based on a unique displacement property of an automated rectifier.

The Project Engineer made a singular contribution to this system by devising a means for orienting the rectified film positives in the second stage of the Automatic Mosaicking System. This solution was of sufficient orginality to merit application for a patent. The Automatic Mosaicking System was tested extensively in the Test and Evaluation Branch, and a full report which will soon be published was prepared. An intensive effort is being made to devise means for further improvement of the system. The contemplated redesign will involve full automation of the data input system, a new method for prevention of double exposures and reduction in size and weight of the system.

C. THE AUTOMATIC STEREOMAPPING SYS-

[1] "An Automatic Mosaicking System," by Abraham Anson, PHOTOGRAMMETRIC ENGINEERING, Vol. XXVIII, No. 3, p. 512, July 1962.

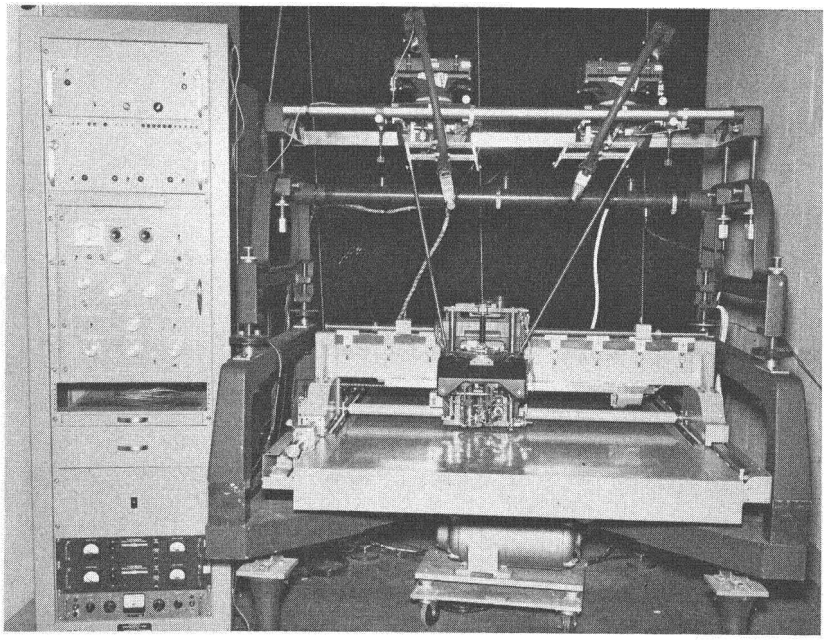

FIG. 3. Automatic stereomapping system.

TEM[2] (Figure 3).—Testing and evaluation of this system is nearing completion. To achieve a successful product, numerous design modifications have been made to the system. Some examples of these modifications are:

(1) Upon initiation of testing, it was discovered that sections of the space rods were bent. The rods were redesigned.
(2) The line drop system was found to be inadequate. A new line drop system was designed, fabricated at USAERDL and installed.
(3) The *X*-servo on the printing unit was found to be malfunctioning. Corrective action was taken.
(4) Contour interval selector was not functioning properly. Several modifications and adjustments were made to improve the operation.
(5) The quality of the line drop output was found to be erratic. The correlation circuitry was modified to permit switching of the contour interval only during periods of good correlation.
(6) The mechanical tilting capability was found to be deficient. Electronic circuitry was designed to accomplish this automatically by electronic control.

[2] "Automatic Map Compilation," by Dr. Sidney Bertram, PHOTOGRAMMETRIC ENGINEERING, Vol. XXIX, No. 1, p. 184, January 1963.

Several challenging research tasks were carried out recently by the Test and Evaluation Branch.

An investigation was conducted to determine the threshold in terms of vibration criteria, which can be tolerated by equipment designed to obtain measurements within a fraction of a micron. As a result of the study, guidelines were established which take into consideration vibration frequencies as well as displacement caused by frequencies.

Utilization of high mach aerial photography for map compilation was investigated. A preliminary conclusion was reached that distortions caused by shock waves would not preclude use of such photography for map compilation.

The experience of the Photogrammetry Division in conducting development and testing of photogrammetric equipment lends strong support to the theory that a separate organization staffed with highly qualified professional people can make a marked contribution towards development of equipment once initial design has been accomplished. This method of operation has the advantage of assuring a greater degree of specialization in the segments concerned with primary development, and at the same time develops a strong design supporting capability which may also be used to accomplish new design whenever required.