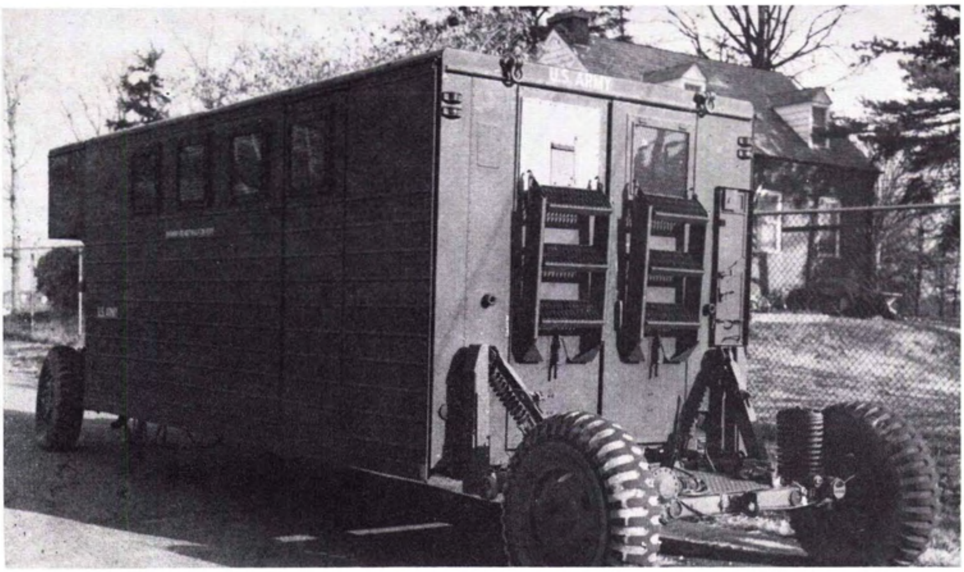

FIG. 1. The M-4 Expansible Van.

ANTHONY W. STOLL*
U. S. Dept. of the Army ETL
Fort Belvoir, Va. 22060

The Automatic Photomapper

An accurate system which may serve for rapid combat mapping.

INTRODUCTION

THE AUTOMATIC PHOTOMAPPER equipment, developed by the U. S. Army Engineer Topographic Laboratories as part of the Rapid Combat Mapping System (RACOMS), is a ruggedized van-mounted, highly mobile, mapping system capable of producing high-quality orthophotos and altitude line-drop charts. The equipment was designed for rugged military use and can be transported by ground or air to a theater of operation where it can be used to produce military maps for use by ground forces in the field. The equipment is capable of producing all the orthophoto and altitude line-drop charts required for mapping a four-15-minute quad area in 48 hours provided the scale of the photography is approximately 1:50,000 and the camera position and attitude data are accurately recorded along with each photograph.

The equipment operates on a digital computer-controlled closed-loop principle, utilizing electronic scanning and correlation techniques for information, detection, and data feedback. Under control of a digital computer and appropriate computer programs, the system scans similar object points on each photograph. The scanned information is analyzed by the electronic correlation circuitry to determine the height error. This information is then sent to the computer where it is analyzed and used to control the

* Presented at the Annual Convention of the American Society of Photogrammetry, Washington, D. C., March 1967. The Author's agency has recently been renamed U. S. Army Engineer Topographic Laboratories.

altitude printout while the video signal obtained from one of the photographs is used to produce a new orthographically correct photograph with all distortions removed.

The equipment will operate with vertical, convergent, or panoramic stereo photographs covering a wide range of focal lengths and flying heights.

ABSTRACT: *Concepts of modern warfare demand a capability for rapid preparation of up-to-date topographic and geodetic data of areas deep within unfriendly territories. Equipment presently used by Army Topographic Units are slow and time-consuming. The state of the art in automatic mapping has advanced to the point where an extremely sophisticated, highly accurate, transportable system has been developed for mapping in the field. The major component of such a system is the Van-Mounted Automatic Photomapper. A discussion of the operation of the system, along with test results obtained during preliminary and final acceptance testing, includes some aspects of maintenance and trouble shooting.*

SYSTEMS DESCRIPTION

Figure 1 shows an external view of the automatic photomapper with attached mobilizers. Each of the mobilizers has a hydraulic jack for raising or lowering the van. The sides of the van are expanded during operation of the equipment. The entire van with mobilizers attached can be transported by air.

Figure 2 shows a scale model of the Automatic Photomapper. The equipment consists of a precision compilation table, a control console, a computer with associated controller and typewriter, the I/O pedestal, and a $3\frac{1}{2}$-bay electronics rack. The control console contains a stereoviewer and reference viewer used for setting up models and for monitoring system operation. Figure 3 shows a photograph taken inside the van. Prior to moving the van, the scanning table X and Y carriages are raised up off the ways and locked in a caged position; the control console, mounted on slides, is pushed toward the center of the van and picked up by a set of shock pins; the oscilloscope goes in the storage cabinet; the chair is clamped down; and the sides of the van are folded in.

SYSTEM OPERATION

The equipment was designed mainly for the compilation mode of operation. In addition, the equipment can be used as a precision comparator, and the computer can be utilized to generate the camera station and orientation data necessary for the compilation operation from the comparator measurements, known camera characteristics, and known geodetic control. The equipment can also use aircraft-position data in lieu of normal ground control for compiling outputs.

Figure 4 shows the required inputs and outputs for the compilation mode of operation. In this mode, the equipment operates using a mathematical model entered into the computer. The inputs to the scanning table are stereo glass plate diapositives of vertical, convergent, or panoramic photography. The inputs to the computer are the camera X, Y, Z-positions, the camera (ϕ, κ, ω) orientation data, the camera focal length, the camera lens characteristics, the contour interval desired, the area to be compiled, the location and symbols to be printed, and the center of the earth's curvature correction. The outputs are the orthophoto and altitude line-drop chart. During the set-up of the model, the operator may also enter information into the computer from the control console to take advantage of the adverse area routine and to

ANTHONY W. STOLL

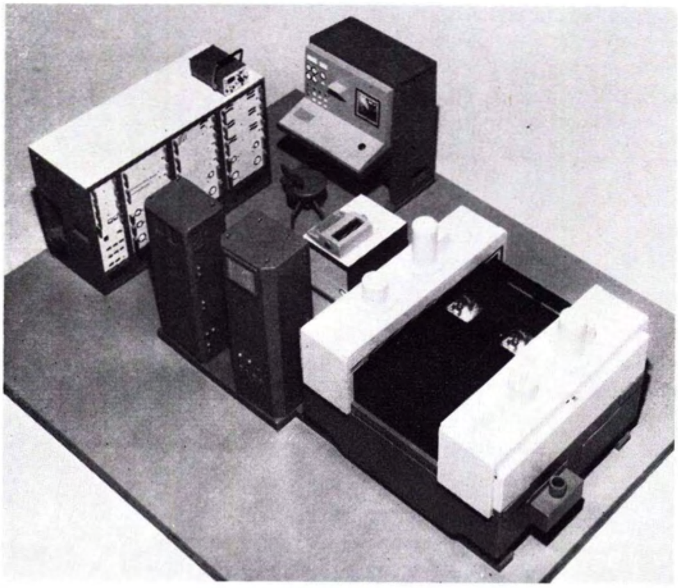

FIG. 2. Scale model of Automatic Mapper.

assist the equipment through difficult areas. Using the position control on the control console, the operator moves the light on the reference viewer (which holds a photograph of one of the diapositives) around any difficult areas and, with the keyboard, tells the computer when it gets to these areas either to hold altitude, to profile at slow speed, or to profile at medium speed.

TEST RESULTS

Preliminary and final acceptance testing of the equipment has been completed. The tests were conducted in accordance with an approved test plan. A brief description of the main tests conducted and the results obtained follow.

Instrument accuracy. A 9-by-9-inch precision grid was placed in the scanning table over lens Position No. 1. The grid intersections of 81 points were measured while moving the table over a 9-by-9-inch area. The table was then centered and 49 points were measured while moving the lens positioner over a 3-by-3-inch area. The procedure was repeated with the grid placed over lens posi-

FIG. 3. Automatic Photomapper equipment.

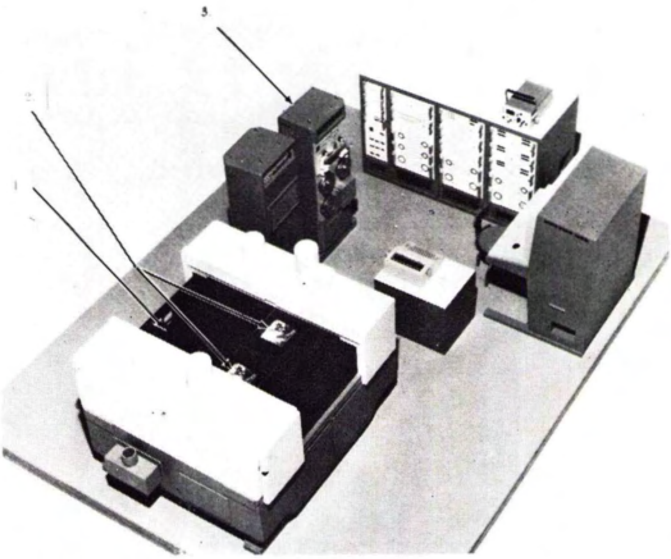

FIG. 4. Compilation mode of operation. (1) Outputs: orthophoto, altitude line-drop chart. (2) Material inputs: film positives or glass plates. (3) Data input: camera—XYZ-locations, ϕ,κ,ω-orientations, lens characteristics, focal lengths; operational data—scale of output, contour interval, area to be compiled, center of earth-curvature correction, location and symbols to be recorded.

tion No. 2. The RMSE varied from a low of 3 microns to a high 6 microns. All axes were within the 7 microns RMSE requirement.

Dynamic accuracy. A precision grid plate was scanned at maximum compilation speed and a negative copy of the grid was printed. The grid intersections of the printed grid were measured and compared to the original grid. The RMSE for the Y-axis was 14 microns, for the X-axis 19 microns. Both axes were within the 30-micron requirement.

REFERENCE VIEWER

A 9-by-9-inch precision grid was placed in the scanning table and a piece of vellum paper was placed over the reference viewer. As the table was moved to each intersection of the grid, the center of the spot of light on the reference viewer was marked on the vellum paper. The marked paper was then placed over the grid, and the maximum error was less than the required $\pm$.01 inches.

STEREOVIEWER

The unit provided the operator with satisfactory stereo images for monitoring system operation and for removing parallax by placing the electronic floating mark on the ground. The area viewed in the stereoviewer corresponds to one of two diapositive scan sizes available to the operator. Maximum scan corresponds to a raster size at the diapositive of 4 mm. by 5 mm., and normal scan corresponds to a raster size at the diapositive

FIG. 5. Orthophoto: camera altitude, 25,000 feet; focal length, 6 inches; scale of output, 1:50,000.

FIG. 6. Altitude line-drop chart: contour interval 40 feet; camera altitude, 25,000 feet; focal length, 6 inches; scale of output, 1:50,000.

of 1 mm. by 1.25 mm. During the set-up of a model, the imagery in the stereoviewer can be magnified by 2, 4, or 5 times by pressing the appropriate magnification switch.

Output Resolution

A standard USAF resolution test target was scanned at maximum compilation speed and printed at the output. The resolution of the printed output target was 35 lines/mm.

Equipment Speed and Accuracy

The time required for compiling a model depends on the accuracy required and the amount of adverse area in the model. The average time to compile a 4-by-8-inch model using a raster width (DX) of 0.5 mm. is 50 minutes. The C-factor of the instrument when using a DX of 0.5 mm. is approximately 1360. The average time to compile a 4-by-8-inch model using a raster width (DX) of 1.0 mm. is 26 minutes. The C-factor of the instrument when using a DX of 1.0 mm. is approximately 800.

Rectification

For rectification purposes a raster width (DX) of 4 mm. can be used. The time required to rectify a 9-by-9-inch photograph is 12 minutes.

Output Products

Successful compilations were made from vertical and 25-degree convergent photography. Figure 5 shows an orthophoto made from vertical photography. The scale of the orthophoto is 1:50,000. A raster width of 0.5 mm. was used to compile the model. Figure 6 shows the altitude line-drop chart for the same model. The contour interval is 40 feet. The altitude chart is made up of grey, white, and black shadings. The sequence of the shadings indicates up-hill or down-hill progression. The symbols around the upper right portion of the model outlines the adverse area selected by the operator. When the scanning table came to this area, the computer slowed the profiling date down to medium speed.

Maintenance

The equipment was designed for easy access to all the electronic components. To assist in trouble shooting the equipment, over 5,000 testpoints and 500 neon lights are wired into the system. In many instances, especially in the computer, malfunctions can be analyzed with only the aid of the neon lights.

The interface drawer in the electronics rack has a test panel for simulating the computer outputs, and is used to help calibrate and trouble shoot the equipment. Diagnostic tapes are also available for checking the computer, controller, and remaining logic.

Conclusions

An evaluation of the tests performed indicates that the automatic photomapper is an accurate mapping system that can be utilized as the heart of the RAPID COMBAT Mapping System (RACOMS) for effective mapping in the field.

See announcement of 1968 Congress in Switzerland on page 104.