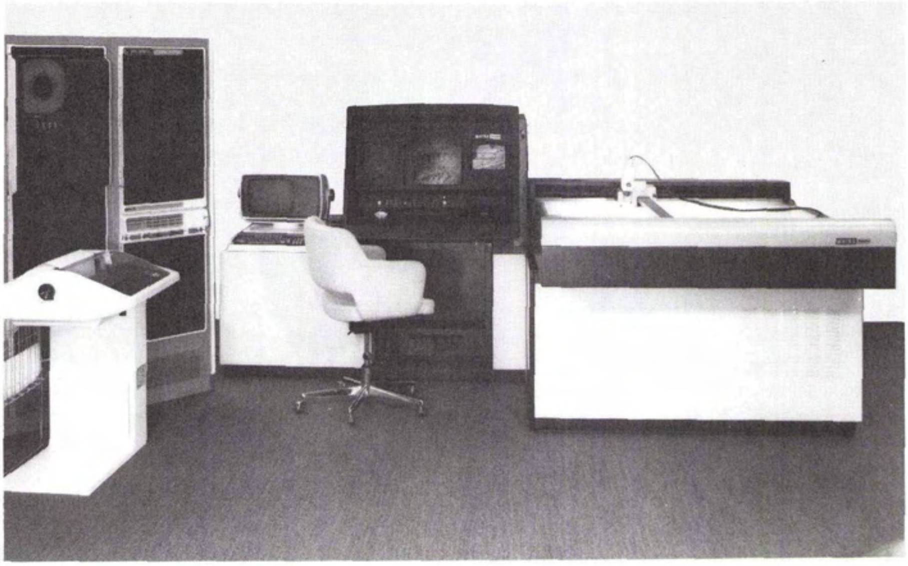

FRONTISPIECE. Complete TRASTER system.

MIKE HIGGINS
*Michael Higgins & Associates, Inc.*
*Napa, CA 94558*

# TRASTER SST Analytical Stereoplotter

Multiple TRASTER SST units can be installed on a single host processor, and the TRASTER SST can be operated remotely from the host.

*(Abstract on next page)*

## INTRODUCTION

THE TRASTER SST is an analytical stereoplotter manufactured and marketed by Matra Technology, Inc. (MTI). MTI developed the SST (Stereo Satellite Terminal) version of the TRASTER to provide an easy and economical way to incorporate the unique benefits of the TRASTER into virtually any computer-based mapping system.

The TRASTER SST is controlled by a powerful Intel microprocessor which allows the TRASTER to be interfaced as a *standard peripheral* to a host computer through a standard RS-232 interface. All real-time tasks are handled by the microprocessor while the host computer processes data collected by the TRASTER. This dramatically reduces the workload on the host computer, freeing it for other useful work. TRASTER data are available immediately for use in host resident graphics packages. As far as the host computer is concerned, the analytical plotter looks like an on-line stereo terminal.

Because each TRASTER SST has its own microprocessor, multiple TRASTER units can be installed on a single host computer without overloading it. The TRASTER SST can be linked to a remote computer using a modem, giving the user the freedom to place his photogrammetric workstation wherever it is most convenient for him. The host computer can even be a commercial timesharing system, relieving the user of software maintenance problems and their attendant costs. Software updates and problem diagnosis can be accomplished quickly and efficiently simply by dialing into the MTI service facility. The SST is ideal for remote maintenance of hardware and software.

PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING,
Vol. 49, No. 6, June 1983, pp. 771-776.

0099-1112/83/4906-0771$02.25/0

ABSTRACT: *The TRASTER SST, manufactured and marketed by Matra Technology, Inc. (MTI), is an analytical stereoplotter designed to be interfaced as a* standard peripheral *to a host computer. A built-in microprocessor-based controller performs all real-time calculations, leaving the host computer free for applications processing and other user operations.*

*The TRASTER stereoplotter differs from all other stereoplotters on the market in that the stereoscopic model is displayed on a direct viewing screen. The operator is not handicapped by the need to use binoculars in order to view the stereo image.*

*The stereo image is formed by projecting the two images of a stero pair through polarizing filters onto a screen, and viewing the screen through glasses equipped with polarized filters.*

*The TRASTER software provides a step-by-step interactive dialog which guides the operator through the process of setting up a stereo model and exploiting it. The operator explores the model by using a trackball for* X *and* Y *motion, and a rotating drum for* Z *motion. For digital terrain modeling, the TRASTER will automatically follow a grid pattern within a given area, freeing the operator to concentrate solely on tracking elevations. Contours and profiles can also be generated automatically.*

The TRASTER stereoplotter differs from all other stereoplotters on the market in that the stereoscopic model is displayed on a direct viewing screen. The operator is not handicapped by the need to use binoculars to view the stereo image. This gives the operator complete freedom of head movement, and enables the stero image to be viewed by several people simultaneously.

The stereo display is achieved through the use of an optical projection in polarized light of the two images forming the stereo pair. The stereoscopic effect is obtained by viewing the projected images on the screen through glasses equipped with polarized filters.

The TRASTER's high accuracy is due to a combination of the system's calculation techniques and a precise measuring system based on Abbé's principle for mechanical positioning without errors caused by backlash.

The TRASTER is a very fast system to use, usually requiring less than 10 minutes to set up a new model, and less than 5 minutes to regenerate a previously used model. Productivity has been measured at 35 to 65 percent better than mechanical projection stereoplotters.*

## HARDWARE

The TRASTER stereoplotter consists of several major subassemblies which have been combined into a compact system fully enclosed by a sturdy sheetmetal housing. The film carriages, optical system, control electronics, power supply, and console are all contained within a single unit. Special care has been given to design and integration of these subassemblies in order to assure an optical working position for the operator. Figure 1 shows an exploded view of the complete TRASTER SST system and Figure 2, is a block diagram of the microprocessor and host computer control system.

The operator has ready access to all TRASTER functions through the keyboard which is located directly below the display screen on the console. The organization of the console provides all controls at hand level when the operator is seated, and the display screen is directly in front of the operator at eye level. To the left of the display screen is a CRT screen used for communicating with the microprocessor and the host computer, in conjunction with the console keyboard. Figure 3 shows the TRASTER console from the operator's viewpoint. A complete TRASTER system is shown in the Frontispiece.

The TRASTER SST includes, in addition to the basic instrument, a computer-driven, backlighted drawing table with large working area for producing full-size drawings. The table can accomodate standard tracing materials or engraving coatings. A large portion of the drawing table's total area is directly accessible from the operator's control area, enabling the operator to monitor drawing operations without moving from his position at the console. This reduces eye fatigue and allows direct monitoring of plotting operations without significant effort on the part of the operator.

* Voss, A. W., 1981. *One Year's Experience with the TRASTER Analytical Stereoplotter.*

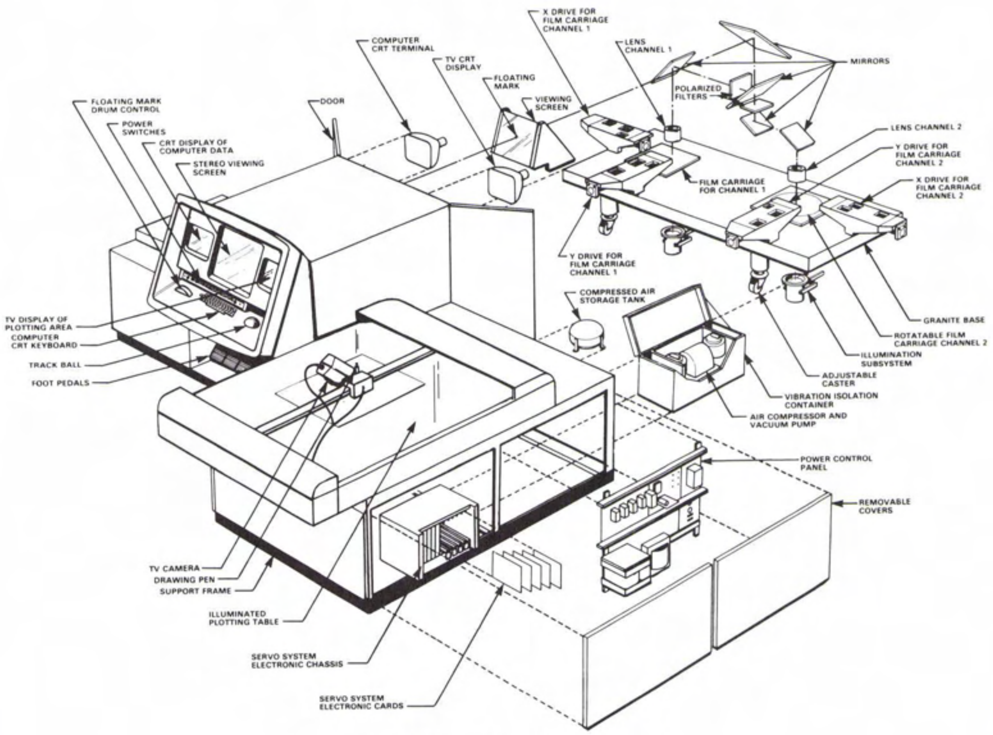


FIG. 1. TRASTER exploded view.

The drawing table can be driven under direct TRASTER control, or under host computer control. To the right of the display screen is a video monitor which provides a video display of the drawing operation in progress. The video image shows the drawing pen and an area surrounding the pen, large enough for the operator to be able to correlate the stereo image on the display screen with the video image from the drawing table. This is particularly useful in helping to identify ground control points.

The film carriages are mounted on a granite base, and are supported by air bearings. Film motion is provided by servomotors controlled by linear optical encoders with a resolution of 0.5 micrometres. The linear encoders eliminate any inaccuracies due to mechanical wear. The images of the two films are projected through polarizing filters onto the display screen. By using three sets of interchangeable projection lenses, magnifications of 25×, 17×, and 10× can be selected.

Movement of the film carriages is controlled by a trackball for $X$ and $Y$ directions, and a rotating drum for the Z direction. The trackball and drum are mounted on air bearings for extremely precise control.

All real-time processing is performed by the microprocessor, leaving the host computer free

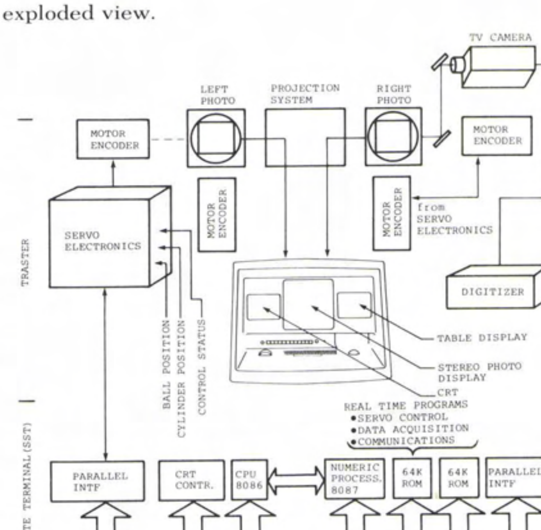


FIG. 2. Computer control block diagram.

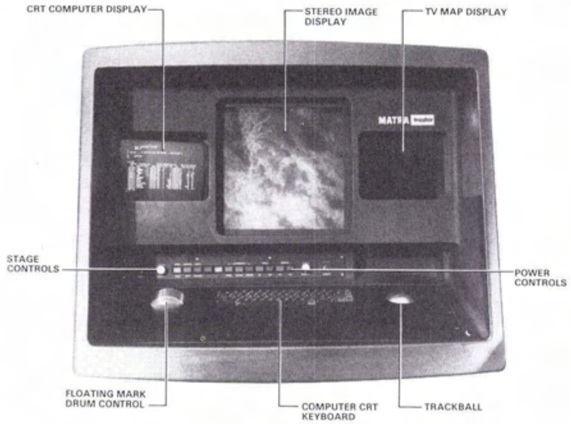


FIG. 3. TRASTER display console.

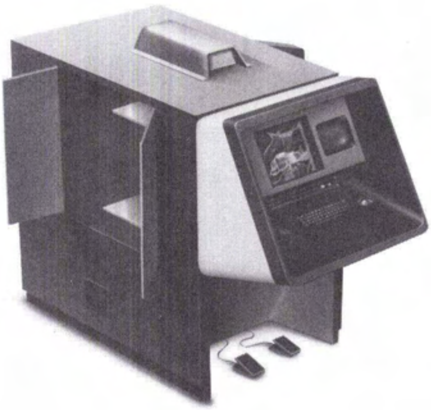

FIG. 5. TRASTER T2-SST.

for applications processing and other user operations. The microprocessor performs all calculations in double precision (60 bits) at 10 millisecond updates (100 cps). Isolation of the model maintenance functions in the microprocessor is so complete that the host computer can be disconnected after the model is set up, and the model can still be explored in stereo. Of course, the host computer must be connected in order to record points in the data base, although MTI is currently working on an off-line system that would record data on a disk for later transmission to the host computer. MTI has also developed a stand-alone microprocessor version of the TRASTER SST which utilizes the Intel SBC-330. A photograph of this complete system is shown in Figure 4, including a CRT terminal, microprocessor, 35MB solid disk, 1MB floppy disk, and line printer. The TRASTER SST is now compatible with DEC PDP 11/XX, DEC VAX 11/XX, and Data General S/XX and MVS/XX CPU's. Multiple analytical plotters can now be supported on a single host (for example, the VAX 11/750 will support up to six units simultaneously).

The TRASTER is still available in a non-SST version, with a Data General Eclipse S/XXX instead of a microprocessor. This is for users who wish to run the system with a dedicated minicomputer. MTI is also currently producing two new versions of the TRASTER SST, called the TRASTER T2-SST and the TRASTER CAPI SST.

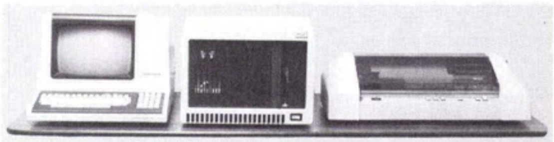

FIG. 4. Intel microprocessor system.

The TRASTER T2-SST is a less expensive, lower resolution model with an overall accuracy of 5 micrometres (compared to the standard SST's accuracy of 2 micrometres, edge-to-edge). To keep the cost down, the T2-SST has fixed magnification ($10\times$) between the film plane and the display screen. The film holder configuration is slightly different, minimizing the system footprint and making film loading easier. The drawing table is an option with the T2-SST. A photograph of the TRASTER T2-SST is shown in Figure 5.

The TRASTER CAPI SST is a *High Resolution* enhanced version of the SST, incorporating a zoom feature, with magnification range of $7.5\times$ to $30\times$, optical rotation of the image, and projected floating marks. A photograph of the TRASTER CAPI SST is shown in Figure 6. Table 1 summarizes the significant features of the TRASTER models.

## SOFTWARE

The TRASTER software provides a step-by-step interactive dialog which guides the operator

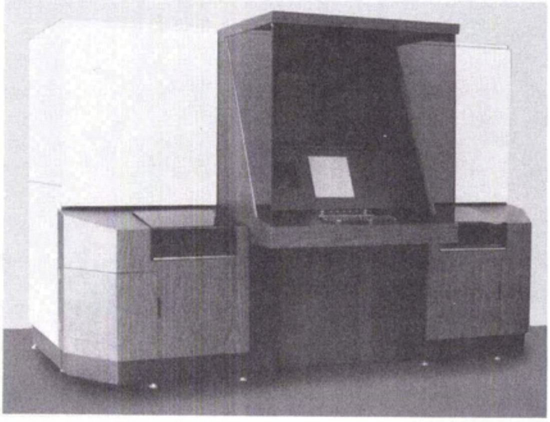

FIG. 6. TRASTER CAPI SST.

TABLE 1. COMPARISON TABLE OF TRASTER SYSTEM CHARACTERISTICS

| Characteristic or Feature | TRASTER SST | TRASTER T2-SST | CAPI TRASTER SST |
|---|---|---|---|
| COMPILER HARDWARE | | | |
| Input Film Carriages | | | |
| Size | 254 by 254 mm | 240 by 240 mm | 240 by 240 mm |
| Method of Support | Air bearings | Air bearings | Air bearings |
| Method of Holddown | Vacuum | Glass platen | Vacuum |
| Rotational capability | ±15° mechanical | None | ±360° optical |
| Optics Train | | | |
| Magnification | 10×, 17×, 27× by lens change | 10× fixed | 7.5× to 30× |
| Resolution | 60 line-pair per mm @10× | 80 line-pair per mm @10× | 220 line-pair per mm @30× |
| Field of View | 42 mm @10× | 40 mm @10× | 36 mm @7.5× |
| Optical Rotation | None | None | ±360° using dove prisms |
| Stage Positioning | | | |
| Accuracies—x & y | 1 micrometre | 2 micrometres | 0.5 micrometres |
| Viewing System | | | |
| Screen size | Rear surface projection screen—42 × 42 cm | Rear surface projection screen—40 × 40 cm | Rear surface projection screen—23.5 × 23.5 cm |
| Method of viewing stereo | Images projected in polarized light and viewed with polarized glasses. | Images projected in polarized light and viewed with polarized glasses. | Images projected in polarized light and viewed with polarized glasses. |
| Floating Mark | Fixed to rear surface of viewing screen. | Fixed to rear surface of viewing screen. | Projected floating marks in optical train. |
| Operator Controls | | | |
| X-Y Control | Air bearing trackball | Air bearing trackball | Air bearing trackball |
| Floating Mark Height Control | Rotating drum | Rotating drum | Rotating drum |
| Keyboard Controls | ASCII keyboard and alphanumeric CRT for computer dialog. | ASCII keyboard and alphanumeric CRT for computer dialog. | Additional function switches available for assigning trackball and drum to zoom & rotation. |
| Foot Pedals | 2 each | 2 each | 2 each |
| Servo Controls | Digital/analog | All digital microprocessor controlled. | All digital microprocessor controlled. |

through the process of setting up the stereo model and exploiting it.

Before measurements can be made from a stereo pair, a stereo model must be generated and the corresponding elements stored in the microprocessor. The model is established in the normal three step process: interior orientation, relative orientation, and absolute orientation.

During interior orientation, corrections are calculated for the distortions present on each half of the stereo pair. Corrections are included for orthogonality defects, film deformation, lens distortion, Earth curvature, and atmospheric refraction.

Relative orientation software calculates the rotations of the two halves of the stereo image in order to form the "best" model. The "best" model is produced by running a least-squares analysis of the two sets of coordinates and finding the best fit.

Absolute orientation software accomplishes the linking of the internal coordinate system of the model to the terrain coordinates. This is done by recording three or more known ground control points. The system will check for self-consistency, and will automatically reject as erroneous any point that is not in agreement with the others.

This entire process takes less than 10 minutes for a trained operator. Regeneration of a previously stored model takes less than 5 minutes, and requires only the internal orientation for set up.

Once the model has been set up, the operator can explore the model in three dimensions. The standard means of traveling around the model is to use the trackball for $X$ and $Y$ motion, and the rotating drum for $Z$ motion. The sensitivity of the trackball and drum can be changed by a simple keyboard command. The $X$, $Y$, or $Z$ directions can be individually locked, so that the trackball and drum will have no effect on the locked direction. As the location of the floating mark changes, the Cartesian coordinates of its position are displayed continuously at the top of the console CRT. The operator can also automatically move to a particular point by typing "GO" and the points's coordinates or prestored identification.

For digital terrain modeling, an automatic scan mode will move the floating mark along a regular grid pattern within an operator-defined window. The system will pause for a specified length of time, long enough for the operator to adjust the elevation of the floating mark, then automatically record the point's coordinates and move on to the next point. The system will automatically add an identifying tag to the coordinates, if desired.

This feature greatly increases productivity while reducing operator fatigue, because the operator is no longer burdened with the tedious task of moving the floating mark to each successive point to be digitized. All he has to do is track elevation while the system automatically traverses the desired area.

TRASTER plotting software includes capabilities for both on-line and off-line plotting, model setup from the drawing table, digitization of table coordinates, grid generation, and lettering.

To draw contours, the trackball is used to keep the floating mark on the ground. The drawing table automatically plots the contour as the operator follows ground elevation.

To draw profiles, the trackball is used to follow a stream bed or road, while the drawing table plots height against $X$ or $Y$.

In the near future, the software for utilizing imagery from the SPOT satellite will be available on all TRASTER products.

## SUMMARY

The TRASTER SST is designed to provide high accuracy combined with maximum operator comfort and convenience.

The TRASTER's unique direct-view display offers several advantages over conventional, binocular systems. The operator can shift his attention from the three-dimensional display to the console CRT, to the drawing table, all without leaving his seat or refocusing his eyes. Several people can view the stereo image simultaneously, a feature especially useful when training new operators.

The trackball and drum are easy to use and conveniently placed, to increase operator comfort and reduce fatigue. Both are mounted on air bearings for precise control with a minimum of effort. The sensitivity of the trackball and drum can be adjusted by the operator for further ease of use.

The film carriages are moved and measured using the Abbé principle for consistent high accuracy. The microprocessor relieves the host computer of all real-time calculations, freeing it for applications processing and servicing of other users.

The TRASTER SST can be operated remotely from the host computer any distance desired via telephone line if desired. Multiple TRASTER SST units can be installed on a single host processor.

(Received and accepted 5 October 1982)

# ANNOUNCEMENT AND CALL FOR PAPERS

## The Fourth Asian Conference on Remote Sensing

### Pegasus Reef Hotel, Colombo, Sri Lanka
### 10-15 November 1983

The Conference—organized in cooperation with the Centre for Remote Sensing, Survey Department, Sri Lanka—will include sessions on agriculture/forestry, land use, overall resources study, water resources, geology/geomorphology, and data processing/system design.

Those wishing to attend the Conference should submit a registration card and the registration fee of $20 U.S. by *10 August 1983*. Any person who would like to present a paper should submit an abstract together with the registration card not later than *10 August 1983* and should submit the final typed paper not later than 25 *September* 1983, to

Dr. Shunji Murai, General Secretary
Asian Association on Remote Sensing
Institute of Industrial Science
University of Tokyo
7-22, Roppongi, Minatoku, Tokyo, Japan