

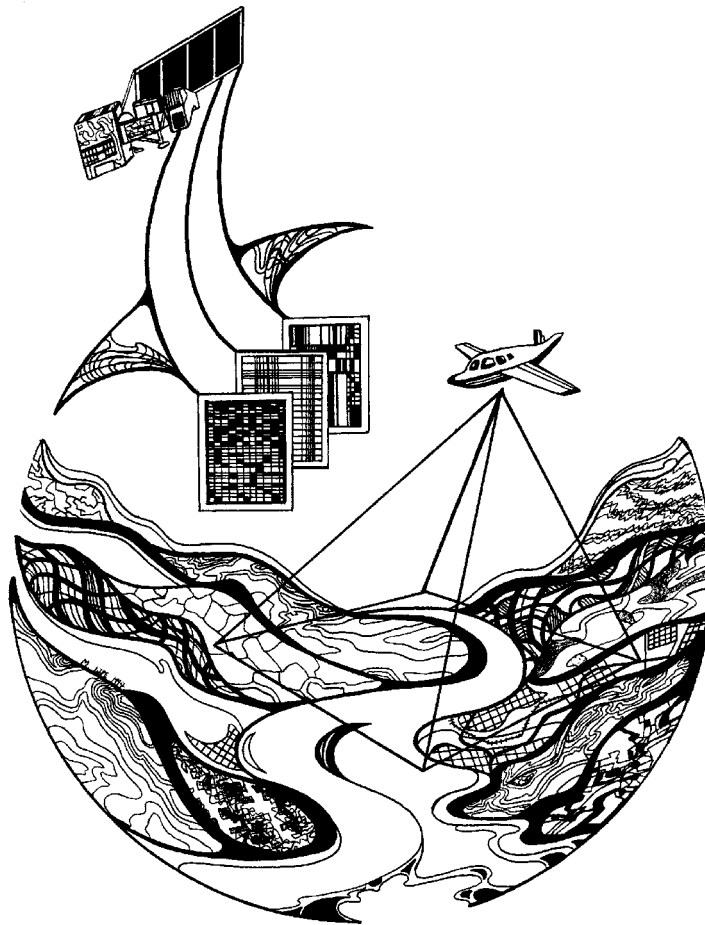
Long Term Resource Monitoring Program

Program Report

95-P008-4

Long Term Resource Monitoring Program
Standard Operating Procedures:

Automated Stereo Zoom Transfer Scope



November 1995

**Long Term Resource Monitoring Program
Standard Operating Procedures:
Automated Stereo Zoom Transfer Scope**

by

Larry Robinson
National Biological Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, an office of the National Biological Service, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, with guidance and Program responsibility provided by the U.S. Army Corps of Engineers. The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers.

The mission of the LTRMP is to provide decision makers with information to maintain the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products.

This report supports Strategy 4.1.1, *Develop and Update Information Management Guidance Documents* under Objective 4.1, *Provide Direction for Automation Activities* in the Operating Plan for the LTRMP. This report was developed with funding provided by the Long Term Resource Monitoring Program.

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Introduction

Under the Long Term Resource Monitoring Program, the Environmental Management Technical Center (EMTC) is using color-infrared aerial photography to develop spatial databases of land cover/use in a geographic information system (GIS). The photographs are interpreted and automated using traditional methods of transferring line work from photos to a base map, using a zoom transfer scope, and manually digitizing the base maps. The annual photography collection has revealed that some areas are undergoing rapid change in terms of species composition, density, and percent cover. These changes are associated with submersed, floating-leaved, and emergent life forms. In an effort to improve our ability to measure and quantify relatively small changes (2-5 m) with increased resolution, a Stereo Zoom Transfer Scope (ZTS) was acquired. The Stereo ZTS has the ability to automatically transfer line work to a GIS database after the photos are registered, using ground control points collected with differentially processed Global Positioning System (GPS) receivers. The following procedures provide the user with specific instructions in the use of the EMTC Stereo ZTS.

These operating procedures are meant to be used in conjunction with the Stereo Zoom Transfer Scope Vertical Measurement System Instruction Manual (Image Interpretation Systems, Inc. 1992). While the manual is a good reference and contains more detailed explanations, the procedures presented here were written specifically for the type of work performed at the EMTC.

Background

The Stereo ZTS, through the use of parallax removal and spatial registration, is designed to create raw but extremely accurate digital files by digitizing directly from a stereo pair of interpreted aerial photographs into a computer. Parallax error is introduced as a result of flying conditions; wind and air turbulence create small horizontal and vertical offsets between photos, which require correction before digitizing can begin. Spatial registration is accomplished by acquiring ground control point coordinates. Differentially corrected GPS coordinates have an accuracy of 2-5 m and are the control points of preference, but coordinates may also be derived from any georeferenced map (lat/long, Universal Transverse Mercator [UTM], State Plane). The accuracy of the digital data file will be only as good as the accuracy of the map used.

Setup Procedures

1. Automated ZTS work must be done with high magnification lenses (2.3-16.1X) in place.
2. Set the py (y parallax) stage to "nominal zero" by using the py control on the back of the joystick housing to align the two arrows at the bottom and in the middle of the glass photo stage (→ ←).
3. Check that the reticle holders are mounted in the inside position (outside for low magnification).
4. Place the Alignment Bar black lines down against the front of the reticle holder. Adjust the Interpupillary Distance using the brown eyepiece housing, not the eyepieces themselves, and note the distance for future reference. Release X and Y locks and move the stage until the Alignment Bar is in the field of view. Check for proper image movement (forward = up) and adjust the image rotation control if necessary.

5. The black lines of the Alignment Bar should be horizontal and parallel to each other. Rotate the white dot on the left eyepiece to position the single black line within the double black line.

An alternate method for adjusting Y-phoria is to shut off the photo illumination and superimpose the two white dots in the field of view by rotating the left eyepiece.

6. Place each of two adjacent interpreted photos inside a photo carrier, adjust them so that both photo fiducials and carrier fiducials are aligned, and then tape the photos to the carrier. Notice that in the center of each photo carrier are small crosshairs indicating the photo's exact center (or principal point). Alignment notches on the carriers and shadows on the photos should point toward the operator.
7. Determine the right and left work photos and clamp each to its stage by aligning the photo carrier notch under the thumbscrew and tightening down. It will be necessary to either move the reticles to the rear of the photo stage and/or to carefully slide the photos under the reticles. Be sure that the photo carrier is fully seated and square with the stage mount.
8. Determine the percentage of overlap and set both right and left manipulator scales (by loosening thumbscrews and sliding the scale left or right) to approximately the same value. The overlap will usually be around 60%-65%. It is helpful to pick out a feature on both photos and make adjustments until they are superimposed or vertically aligned. Two sets of overlap numbers per mount should be on the photo stage. The inside numbers are for high magnification lenses and the outside are for low magnification.
9. Photos must also be squared to the stage by loosening the rotation thumbscrews and aligning the photos with a slight rotation.

Entering ZTS Constants

1. When digitizing a new photo, the ZTS memory must be cleared. To do this, press **RCALL UNITS 5 1 CLR**. **Note:** CLR must be held down momentarily or the keyboard will run through about a minute-long display diagnostic. Value/Memory display will read "DIA??" Press **.9**.
2. Determine if digitizing is to be done in metric or in English units and set the switch on the back of the Keyboard/Display Unit. Press UNITS to select the appropriate dimensional unit (millimeters, meters, or kilometers; inches, feet, or miles). Most work is performed in meters.
3. Set **Relative Orientation** grid distance between standard points by pressing **RCALL d**. Unless a previous value has been set, the default value will be displayed (90 mm). If this value is acceptable, proceed. If not, enter the desired value and press **SET**.

Note: The grid distance will normally be around 90 mm, which is the approximate distance between the two principal points on the stereo pair. Occasionally, it will be necessary to set **d** to a smaller or larger distance (50 mm, 100 mm) because 90 mm would place one or more standard points in open water.

To ensure proper orientation, the points must fall on or near an identifiable feature. Smaller values, however, are to be avoided if possible, since "d" values define the effective, or most accurate, work area. See Figure 1.

4. If the value is different than the default (152.4 mm), set the focal length by pressing **RCALL f**, enter length, and **SET**. Focal length is established by the aerial photographer and printed on the edge of the photograph with other flight information.
5. Clear X and Y parallax.
 - a. Position reticles over the *right* principal point and remove the X parallax by rotating the joystick knob, and the Y parallax by rotating the left photo. The parallax is removed when the floating dots in the center of the reticles appear to be "on the ground" or flush with whatever surface they are on, such as a building or the crown of a tree. The act of tightening the spring-loaded rotation thumbscrew causes a small additional amount of rotation and must be compensated for.

Note: When the X parallax is removed by aligning the floating dots using the joystick knob, height displacement is actually being removed. When the dots are superimposed, the Stereo ZTS assigns a height value to that particular point. For example, if the dots are flush with a river and are then moved to the top of a bluff, the dots will separate along the X axis, or horizontally. By rotating the joystick knob in the "up" direction, the dots can be realigned and a new elevation will be established. When "fusing" the dots, take care that they occupy the exact same point on each photo. The eyes naturally want to fuse the dots as they become closer together; thus, whenever possible, it is helpful to align on features such as roads or small, flush types of vegetation like grass or *Sagittaria*. Fine-tune the alignment by viewing each dot separately and making small adjustments until each dot has the exact same position on each photo.

- b. Fine-tune the overlap settings, if necessary, and remove any X and Y parallax after repositioning on the right principal point.
- c. Once parallax at the right principal point is cleared, press **CLR x/y**.
- d. Move reticles to the *left* principal point (keyboard display for Y should remain at 0.0). Align the left dot first, if necessary, by raising or lowering the dot using the PY control on the back of the joystick assembly until it is positioned within the crosshair. Once centered, rotate the right photo to clear the Y parallax and the joystick knob to remove the X parallax.

Return to the *right* principal point (again keeping the Y value on the keyboard display equal to 0.0) and check the positioning of the dot. The right and left photos will likely require finer and finer adjustments until all parallax is removed. This is accomplished when both dots traverse from principal point to principal point while the Y value remains at 0.0.

- e. After all parallax is cleared, press **RCALL b SET**. The display now shows the exact photo distance between the right and left principal points.

Relative Orientation

Note: The next three sections, Relative Orientation, Scaling, and Leveling, are used to construct a three-dimensional "grid" or matrix so that the floating dots occupy a unique location in space at all times. This is accomplished with control points where the values are known and entered for east/west (X) and north/south (Y) locations and elevation (Z), usually derived from topographic maps. As each control point is entered, the grid is fine-tuned so that the Stereo ZTS will be able to instantaneously calculate its X/Y/Z position within the grid.

Enter the calibration mode by pressing **CAL**. To begin *Relative Orientation* of standard points that are used to fine-tune the parallax correction and to construct a work area, or neat model, as shown in Figure 1, select **RCALL px/py**. The display will read "py1" since the reticle should still be at the left principal point.

With the parallax removed previously, press **SET** to establish standard point #1. Proceed up the Y axis to point #3. The distance to this point was set earlier (see "Entering ZTS Constants," #3) when the constants were entered. The numbers 1 through 6 will appear in the editor display as each point is established. The order in which the points are established does not matter, but moving clockwise from py1 (to py3, py4, py2, py6, and py5) is convenient and easy to remember.

Each point is surrounded by a "window," which is defined by an entrance beep and a higher-pitched exit beep. The point may be established anywhere inside this window as long as the dots are precisely superimposed via the PX and PY controls. Establishment of all six points completes Relative Orientation.

Scaling

Begin the *Scaling* procedure by pressing **RCALL x/y**. Display will read "pxC." At this point, identify the two control points on the ground that are farthest apart and designate one "C" and the other "D."

Determine the ground coordinates and elevations using a maximum of six digits for each. It may be necessary to truncate coordinates and then shift X/Y at a later time; i.e., a UTM coordinate of 4,859,212.873 m would become 59,212.9 m and would later be shifted 4,800,000 m.

Position the reticle dots over point C and press **SET**. Display now reads "XC"; enter X coordinate and press **SET**. Display changes to "YC."

Enter Y coordinate and press **SET**. Display changes to "hC."

Enter the elevation in meters for point C and press **SET**. Display now reads "pxD?" Repeat the above procedure for point D. After setting the elevation for D, the display will read "x/y OK," and Scaling is complete.

Note: Digitizing may be accomplished using only three control points: C, D, and E. However, the most accurate means of digitizing uses a minimum of five: C, D, E, F, and G. By using at least five

points, Standard Deviation residuals can be calculated via the "least squares error fitting" of the conversion model. Residuals that are too high (>5.0 m) indicate the possibility of a bad point, and the conversion process allows the program to bypass or reenter the coordinates of that particular point to achieve a better model. The best model is constructed when point E forms an equilateral triangle (or as close as possible) with points C and D and points F and G. This process is explained in the section below and is illustrated in Figure 2.

Leveling

1. While still in **CAL** (calibration mode), begin *Leveling* by pressing **RCALL hc**. Display will read "pxE." Move reticle to point E, and press **SET**. Display asks "hE?" Enter elevation of E and press **SET**. Display reads "hE OK." Press **CYCLE** once and display will read "pxF." Move reticle to point F and repeat the procedure.

Repeat the above step for point G. After the elevation is entered for point G and the display reads "hG OK," Leveling is complete. Exit **CAL** by pressing **CAL**. The red light above **CAL** button indicates if **CAL** mode is on or off.

2. Coordinates are now entered for points E, F, and G. Press **RCALL hc**, then press **CYCLE** (five times) until "XE" is displayed. Enter the X coordinate for point E and press **SET**. **CYCLE** once to "YE" and enter Y coordinate and press **SET**. **CYCLE** through to "XF" and repeat procedure. Do the same for point G. After the Y coordinate is entered for G, the display will read "hc" to indicate that all photo calibration parameters are set and the residuals for Standard Deviation can now be obtained.

Note: If any coordinates are entered incorrectly, they may be reentered by pressing **CLR** and then the appropriate coordinate. If the mistake is discovered later, it will be necessary to return to the **CAL** mode and recall (**RCALL**) the Scaling (**x/y**) or Leveling (**hc**) parameters, cycle to the incorrect value, and reenter and set the correct information.

Determination of Standard Deviation

1. To load calibration parameters into the computer, enter the VMC software program by typing "vmc" at the C drive prompt (C:\VMC>), then "vmc" once more to access the Main Menu.

The Main Menu will be displayed with various program options. Select "1) Establish Control Point Calibration." Select <M> for meters. Select "C" to <C>hange calfile parameters. Enter the name of the new calfile; for example, the calfile might be named "ph175" for stereo pair #176 and #175. Up to eight letters or numbers may be used in naming files.

2. The program then asks to transfer calibration parameters by pressing **RCALL MODE 6 SET XFER**. The computer screen will then display the photo and UTM coordinates and ask if any more control points are to be edited or added. If yes, enter control point number (6, 7, etc.) and establish location using the **XFER** button on the joystick. Values for X, Y, and Z are entered on the computer keyboard. Entering additional control points can often result in lower residual error, and thus a more precise model. However, care must be taken to maintain an even control point distribution. If no

further editing is desired, enter "return." The option is then given to continue editing or to end by entering "return" once again.

3. Residuals can now be calculated by selecting which control points (numbered 1 through 5, unless others have been added) are to be used. Initially, type "1(space)2(space)3(space)4(space)5," "enter," then "A" to <A>cept those control points.

Residuals are displayed for X, Y, Z, and an average for all three. If the average is less than 5.0 m, digitizing can begin. If not, select "R" to <R>epeat calibration and then examine coordinates for incorrect values. If a value has been entered incorrectly, refer to the "note" at the end of this section to reenter correctly.

If all coordinates are correct and the residual error remains greater than 5.0 m, then it is possible that one of the point locations is inaccurate. This can be determined by editing out point #5 (entering only points "1 2 3 4") and seeing if residuals are raised or lowered. Repeat this process of elimination by editing out individual control points and viewing the residual error. When the lowest residual error has been determined, reenter that series of points and select "C" to <C>ontinue.

Note: Occasionally, residual error below 5.0 m cannot be achieved and it will be necessary to repeat the Scaling and Leveling procedures by using either different control points or by rearranging the order of the current control points (E for C, C for D, etc.) to get a better model. This is done by pressing **CAL**, **RCALL x/y**, **CLR x/y** (this clears previously established Scaling parameters), **RCALL hc**, and **CLR hc** (clears Leveling parameters). New coordinates are established by repeating steps f through h in "Entering ZTS Constants." Next determine new residual error. Repeat this process as necessary and when the results are acceptable, digitizing can begin. On rare occasions, several standard points may fall within large bodies of water. When this occurs, residual error will be higher, perhaps 10 m or more, since there are no features to ensure proper alignment. In this instance, try several alignments and use the one with the lowest error.

Digitizing

1. After entering "C" to Continue, the Main Menu will be displayed. To digitize, select "2) Transfer and Convert VM Coordinates." A submenu of currently selected ".cal" and ".gnd" files is displayed with the options to "<V>erify or alter <C>alfile or <D>atafile or go to <M>ain Menu." Select "D" to create a new datafile. Enter the name of the new datafile; for example, "ph175." It is helpful to give the datafile the same name as the calfile to avoid confusion with other cal/datafiles. The two "ph175" files are distinguished by the suffixes ".cal" for calibration and ".gnd" for digitizing. After a new file is established, select "V" to display all or part of that file.
2. Program asks to "display features?" Select "enter" to display the datafile, which, since it is a new file, should be empty. If these photos are to be added to an existing datafile composed of adjacent photos, the screen will display previously digitized information.

3. "Selection OK?" is displayed. If yes, select "enter" (default is <Y>). If not, select <N> and reenter the correct datafile. Select line color (default is yellow) and "enter."
4. Select digitizing mode: 1) point, 2) line, or 3) polygon. "Line" is the default and the mode most frequently used for digitizing. Select the line number, which can be in sequence from 1 to 9999, with the default being "9999," and "enter."
5. Digitizing options are then displayed which can be <A>ccepted or <C>hanged. The default is "accept." If accepted, begin digitizing using **XFER** on the joystick assembly to trace interpreted polygons. Digitizing is accomplished by moving the dot along the segment and incrementally pressing **XFER**, the first button on the joystick. Curved lines require smaller increments; straight lines, fewer.

Note: The ZTS provides two options on the joystick assembly for ending an arc. The first is **SKIP**, which allows for a broken segment, or multiple arcs that the software treats as one segment. Thus, several polygons can be traced in the same area more quickly than if each arc were traced as a completed segment using the **END** button. The drawback is that if an arc needs to be deleted because of a mistake, then the whole segment has to be deleted as well. For this reason, it is not wise to digitize too many arcs (perhaps only one if the arc is particularly long and intricate), before saving the segment to the datafile. Otherwise, four or five smaller arcs could be digitized before ending and saving the segment. Also, it is helpful when digitizing to slightly "overshoot" or extend the arc where it intersects with another arc (Fig. 2). This makes editing much easier since these mini-arcs can be selected and deleted at a later time.

6. After ending a segment with the **END** button, there is an option to <D>elete (if a mistake was made) or to <S>ave the segment. The next options are to <C>ontinue digitizing, Change <S>elections, or go to the <M>ain Menu. Selecting "C" allows the user to continue digitizing with the parameters set previously. If a different line color is desired, selecting "S" will allow for parameter changes.

Note: Due to a software quirk, the first arc digitized in any new session must be viewed immediately upon saving to ensure that the arc was generated. This is accomplished by selecting <S> and verifying the contents, the line number, and the number of coordinates in the current datafile. If the line number is "0," the arc was not saved and must be digitized again. Once this arc is saved and displayed, future arcs can then be saved or deleted without verification. If this initial verification is not done, the digitized coordinates will not be accepted even though the segment can be seen on the monitor.

Editing

The VMC software allows for minor editing during digitizing of the first twenty segments. If an errant segment is digitized and needs to be deleted, this can be accomplished in #2 of the Main Menu. Enter <V>erify to view a list of digitized segments. The program asks "Display Features: #s (1,2,..n) or all <enter>?"

Select all the segments to be retained, separated by a space or comma, and omit any unneeded segment(s). The program repeats selected #s and asks to either <A>cept or <C>hange.

If accepted, the program provides an opportunity to rename the data file and asks "Selection O.K. (<Y> <N>)?" If yes, proceed to digitizing; if no, repeat the editing process until the data file is acceptable. Any editing necessary after 20 segments are digitized must be performed in Production ARCEDIT (see below).

The PC currently being used for digitizing (a Dell Dimension XPS P90) has an internal tape drive, allowing for convenient backup of all files created with the VMC software. The Colorado Backup system is Windows-based and instructions in its use are given in the on-line documentation. All Stereo ZTS work is contained in the "VMC" directory and should be backed up on a weekly basis.

Converting to ARC/INFO

When all digitizing in a datafile is completed, that datafile can be converted into a GIS format from the Main Menu. Select "4) Convert To GIS Formats" and type in the name of the datafile to be converted (the default is the last datafile accessed and can be converted by entering "return"). A new file is created with the suffix ".arc" (e.g., ph175.arc) containing a line file which can be generated into a coverage, cleaned, built, and edited in ARC/INFO. For details on these procedures, see the Standard Operating Procedures for Production ARCEDIT Digitizing (Arndt and Olsen 1995), Appendix D.

Viewing/Deleting and Backing Up Files

A less frequently used option from the Main Menu is "6) Show Directory of Files." This allows the user to view and/or delete calfiles and datafiles. This is useful when saving arcs from a file that is partially corrupted into a new file. The corrupt file can then be deleted. Care must be taken when exercising this option, and it is recommended that all files be backed up before they are deleted.

Final Comments

The Stereo ZTS is capable of producing highly accurate coverages, provided it is used within its limitations and photos are properly set up. The Stereo ZTS has consistently digitized permanent features to within 5 m of their surveyed locations. However, inattention to detail and careless photo set up may result in errors and care must be taken to follow procedures explicitly.

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PHOTO #175

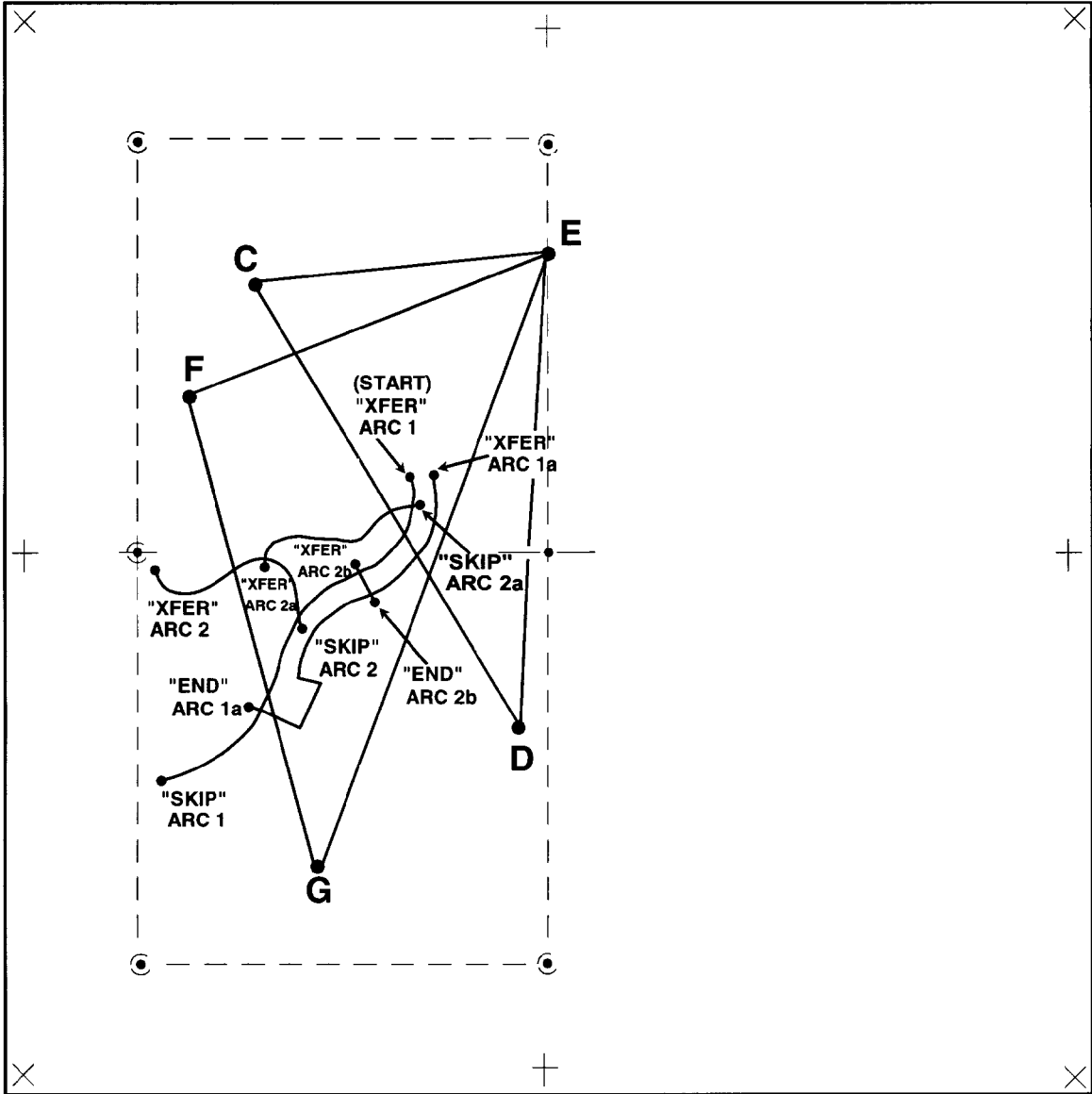


Figure 2. Example of control point identification and distribution, and digitizing using the "XFER," "SKIP," and "END" joystick commands. **Note:** The arcs are deliberately overshoot for easier editing.

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13. ABSTRACT (Maximum 200 words) The Stereo Zoom Transfer Scope is used to create ASCII file "coverages" by digitizing directly from stereo pairs of interpreted aerial photos. This is accomplished by removing all parallax error along the flight line and referencing the photos to the Earth's surface with control points acquired using differentially corrected Global Positioning System data. The ASCII files are then converted to an ARC/INFO format, where they can be generated into a digital coverage, edited, labeled, and archived.			
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The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information to maintain the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the National Biological Service, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.

