UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Digital Shoreline Mapping System (DSMS) User's Guide
Version 1.0

by

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and

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CONTENTS

(p. 3 follows)

INTRODUCTION

As development in coastal areas has increased, accurate measurements of historical shoreline changes have become a prerequisite for coastal management. Historical erosion rates, for example, are presently used in several U.S. states to locate oceanfront construction setback lines.

There is a need for a standardized method for obtaining historical shoreline position data from maps and aerial photographs. Such a method should comply with U.S. National Map Accuracy Standards, deal with various sources of error, and be compatible with a variety of Geographic Information System (GIS) software. The Digital Shoreline Mapping System (DSMS) meets these requirements and has several advantages over other shoreline mapping systems (Leatherman, 1983):

1) DSMS supports a wide variety of map projections and reference spheroids (see Evenden, 1990) for both map and photograph data.

2) DSMS offers distortion correction and user control of various parameters that affect the space resection solution for aerial photographs including:
   a) correction for atmospheric refraction;
   b) weighting of ground control and camera parameters to reflect *a priori* knowledge of their precision;
   c) providing an initial estimate of camera position, attitude and residual errors early in the mapping process to allow the user to check for bad data, and either redigitize or discard a given photograph;
   d) simultaneous triangulation of large groups of photographs, including photos of differing years, camera focal lengths, etc. using the same set of ground control points;
   e) adjustment to reflect the accuracy of the digitizing table and the digitizer operator; and to reflect the elevation of the feature being mapped.

3) DSMS contains extensive facilities for examining error propagation and assessing the accuracy of photographic transformations.

4) DSMS is flexible in that standard ASCII files are used throughout the system, and output can be easily modified to conform to common GIS input file formats (e.g. Arc/Info, Atlas GIS, AutoCAD, Intergraph WMS, etc.).

5) DSMS can also be used for mapping any feature that has a known, uniform elevation, such as wetland boundaries or lake/reservoir shorelines.

This paper summarizes the capabilities of the DSMS and explains the procedures for generating accurate digital shoreline position data from historical maps and aerial photographs.

DESCRIPTION

Most GIS computer software in use today supports the digitization of maps and charts, and analyses of errors resulting from the transformation of digitizer coordinates to geographic coordinates. The transformation (scaling and rotation) of two-dimensional data required for maps is fairly straightforward (Evenden, 1991). In the case of aerial photographs, however, a more complex three-dimensional transformation is required to to correct distortions within a photograph that are caused by scale changes, relief and tilt displacement. Other sources of error inherent in aerial photography, such as atmospheric refraction, lens distortion and media distortion, must also be removed. DSMS provides support for digitizing and transforming maps, but its primary emphasis is on the processing of digitized aerial photographs to remove most of these errors.

At the core of DSMS is the General Integrated Analytical Triangulation (*GIANT*) program (Elassal and Malhotra, 1987). This program provides the block adjustment, control weighting, error propagation, and atmospheric refraction correction features of DSMS. The initial routines in the DSMS series prepare data for *GIANT*. Output data from *GIANT* provides measures of the accuracy of the triangulation, and contains the necessary camera position and attitude information to solve for shoreline planimetry.

To determine the correct planimetric position of the shoreline in an aerial photograph, a technique called space resection determines the camera's position (latitude, longitude, elevation) and attitude (roll, pitch, yaw) at the instant of exposure. For a discussion of space resection, see Slama (1980). The following discussion addresses those aspects of photogrammetry that are germane to the requirements of DSMS program execution.

To perform a space resection for one aerial photograph, the following information must be known:

1) focal length of the aerial camera (usually printed on the photo or available from agency that holds the photography);

2) approximate location of the principal point of the photograph (can be calculated by using the fiducial marks around the photo border); and

3) Geographic coordinates and elevation of at least three (preferably 6-9) identifiable, stable ground control points (GCPs) in the photograph.

A ground control network must be constructed for each photograph, and the fiducial marks, GCPs and shoreline digitized. Typically, the wet/dry line on the beach (see Dolan and others, 1980; and Crowell and others, 1991), which approximates the Mean High Water Line shown on National Ocean Service and U.S. Geological Survey maps, is used to delineate the shoreline.

Once the necessary photographs and reference maps have been digitized, the initial DSMS programs are used to set up the ground control files and construct photo image space coordinates, based on digitizer values, used by the space resection and triangulation programs.

An initial estimate of the six camera parameters, as well as residual errors for the ground control, are provided by the DSMS space resection program. If any of the parameters are deemed suspicious (e.g. pitch of 20°), or the GCP residuals are too large (indicating a possible misidentification of the point or sloppy digitizing), the photograph can be redigitized and the space resection program can be run again.

Once an acceptable space resection solution has been achieved for each photo, the photo data are formatted for batch processing in *GIANT*. After successive *GIANT* runs have produced satisfactory results, the output camera parameters are used to calculate the corrected shoreline position for each digitized photo. The output shoreline data are then formatted for export. Presently, DSMS shoreline data files are formatted for import into MapGrafix™, an Apple Macintosh®-based GIS. These ASCII files, however, can be modified to conform to most common GIS input file formats (e.g. GRASS, Arc/Info, Atlas GIS, AutoCAD, Intergraph WMS, etc.).

PROCEDURE FOR PRODUCTION OF DIGITAL SHORELINE DATA

The procedures for producing digital shoreline data involve three basic steps: 1) creating a suitable directory structure to manage data and assist in program execution; 2) executing the various programs; and 3) exporting the files to the desired GIS package.

Directory Structure

The first step in using the DSMS is making sure an appropriate directory structure is set up on the UNIX computer where map production is to be conducted. This structure permits the numerous files generated by DSMS to be kept in a logical order. Regardless of the ultimate disk space requirements for a given project, a large number of files are generated in the processing of even one basemap and one photograph (Table 1). DSMS requires the following user directory structure, where each directory within the top level mapping directory represents a **basemap** (Figure 1). Camera system information should be kept in a directory called **camera-files** (Figure 1).

```
% ls
aguadilla/      centralaguirre/ manati/         ptaverraco/     terms/
arecibo/        dorado/         mayaguez/       puertoreal/     tp-sheets/
barceloneta/    fajardo/        naguabo/        quebradillas/   troy/
bayamon/        galena/         oneonta/        rincon/         vegaalta/
bin/            guayama/        pldeponce/      riogrande/      vieques/
caborojo/       humacao/        ponce/          salinas/
camera-files/   isabela/        ptaguayanes/    sanjuan/
camuy/          jackson/        ptapuerca/      santaisabel/
carolina/       kinston/        ptatuna/        t-sheets/
```

Figure 1. Example directory structure for DSMS. Each directory represents a particular basemap, in this case standard USGS quadrangle maps.

Basemaps are arranged such that each basemap has its own directory. Files common to the procedures carried out at the "basemap level" (in this example, the *.ref*, *.gcp*, *.latlon*, *.proj* and *.utm* files -- See Table 1 for descriptions) should be placed in each basemap directory, such as the basemap directory **riogrande** (Figure 2). Each digitized

Table 1. Extension names and contents of files used in the DSMS.

File extension	Created by Program	File Contents	Directory
.cam	*camera*	Camera system ID and focal length. Corresponds to *GIANT* CAMERAS file.	user/camera-files
.dat	*digin*	Digitized fiducial marks, ground control points and shoreline for aerial photographs; digitized calibration points and GCPs for maps.	user/basemap/photo
.gcp	*digin*	Digitized basemap calibration and ground control points.	user/basemap
.gfrm	*frames*	Camera parameters (UTM) determined by *k371* for use in *GIANT* (geographic coordinate option). Corresponds to *GIANT* FRAMES file.	user/basemap/photo
.gimg	*images*	Camera system ID, camera focal length, digitizer standard deviation tolerance parameters, control point ID and control point coordinates used by *GIANT*. Corresponds to *GIANT* IMAGES file.	user/basemap/photo
.kfrm	*frames*	Camera parameters (UTM) determined by *k371* for use in *GIANT* (space-rectangular coordinate option). Corresponds to *GIANT* FRAMES file.	user/basemap/photo
.latlon	*ground*	Geographic (lat-lon) coordinates and elevations of ground control points. Corresponds to *GIANT* GROUND file.	user/basemap
.kgcp	*get.ground.points*	UTM coordinates and elevations of ground control points.	user/basemap/photo
.kimg	*images*	Camera system ID, camera focal length, digitizer standard deviation tolerance parameters, control point ID and control point coordinates used by *k371*.	user/basemap/photo
.proj	(text editor)	Geographic coordinates of basemap calibration points.	user/basemap
.log	*frames*	Report of space resection results determined by *k371* (camera position and attitude; image residuals).	user/basemap/photo
.map	*shoreline*	UTM coordinates of shoreline determined by *final.shore*. File formatted for output to MapGrafix™.	user/basemap/photo
.red	*shoreline*	UTM coordinates of shoreline determined by *final.shore* with a point reduction algorithm applied to remove excess data points. File formatted for output to MapGrafix™.	user/basemap/photo
.ref	(text editor)	Central longitude (in decimal degrees) of reference basemap.	user/basemap
.shr	*images*	Camera system ID, camera focal length, digitizer standard deviation tolerance parameters, shoreline point ID and shoreline point coordinates used by *final.shore*.	user/basemap/photo
.utm	*ground*	UTM coordinates and elevations of ground control points.	user/basemap

aerial photograph that corresponds to the area covered by the basemap should have its own sub-directory within each basemap directory to hold the various files that are unique to each photo (Figure 3). Directories are added within each basemap directory as needed to accommodate new digitized photographs. Naming conventions for each photograph directory is taken from the photo itself, such as **l4-262** (Figure 2).

```
% ls
clon.ref            14-263/             riogrande.gcp
k12-1300/           15-367/             riogrande.latlon
k14-1364/           15-368/             riogrande.proj
k15-1425/           lr12-80/            riogrande.utm
14-258/             lr12-81/
14-260/             lr12-82/
14-262/             lr12-83/
```

Figure 2. Basemap directory and aerial photo sub-directory structure for DSMS. See Table 1 for a description of the contents of each file.

```
% ls
14-262.dat     14-262.gimg    14-262.kimg    14-262.log    14-262.red
14-262.gfrm    14-262.kgcp    14-262.kfrm    14-262.map    14-262.shr
```

Figure 3. The directory **l4-262** contains the files that are unique to this aerial photograph. See Table 1 for a description of the contents of each file.

Program Execution

The production of digital shoreline data involves running the programs and scripts of DSMS. A step-by-step summary of the processes involved in a theoretical shoreline mapping exercise is shown in Figure 4. It assumes that the necessary directories and structure set out in the section on **Directory Structure** will be established, and that the user is familiar with basic UNIX commands. For more complete descriptions of each program, see Appendix B (Program Documentation). Refer to Table 1 for descriptions of filename contents. The next section describes the process shown in Figure 4 in detail.

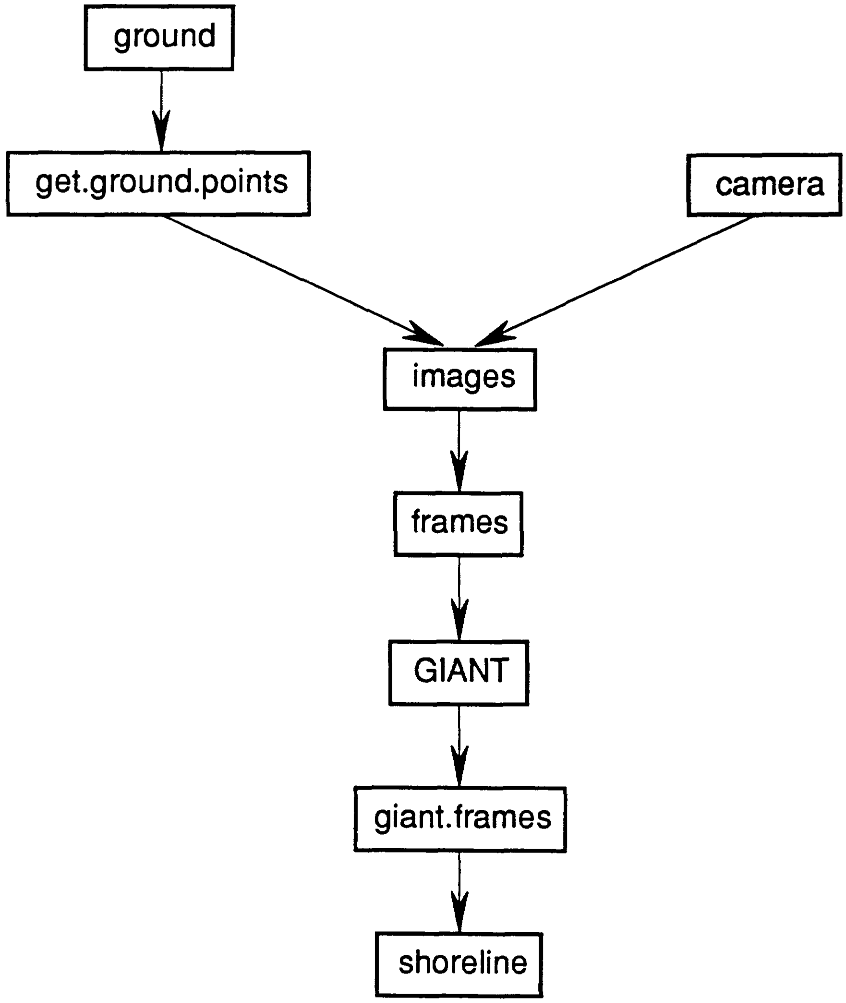

Figure 4. Flow diagram showing the order of DSMS program execution.

Using the Scripts and Programs of the DSMS

1) Run the *camera* script for each camera system used in the project to create the *.cam* files used by the later programs. This is accomplished by running *camera* in the **camera-files** directory.

2) Determine the central longitude of each reference basemap used to establish the ground control network for the aerial photographs. Use a text editor (such as *vi*) to create a file in each basemap directory called *clon.ref*. This file contains the central longitude of the reference basemap. An example is shown in Figure 5. Note that the central longitude of

the basemap must be expressed in decimal degrees, and specify degrees east or west of Greenwich (in this case, dw stands for "degrees west") (Evenden, 1990).

```
% more clon.ref
65.8125dw
```

Figure 5. The central longitude of the basemap in this directory is 65.8125 degrees west of Greenwich.

3) Establish a ground control network for each photograph, and mark ground control points (GCPs) on the reference basemap. Use *digin* to digitize the basemap (see Appendix A for an explanation of the digitizing procedure). Save the file created by *digin* in the appropriate basemap directory as *file.gcp*, where *file* is the name of the basemap (Figure 2).

4) Use a text editor (such as *vi*) to create a file in each basemap directory called *file.proj*, where file is the name of the basemap. This file contains the geographic coordinates (longitude and latitude) of the calibration points created by the digitizing procedure. Appendix A has an example of the format for this file.

5) Run the *ground* script to create the *.utm* and *.latlon* files in each basemap directory. *Ground* automatically appends the necessary file extensions (*.gcp*, *.latlon*, *.proj*, *.utm*) when reading and writing files. Thus, it is necessary to enter only the filename, not the extension, of desired input and output files. The script must be run from the basemap-level directory. (i.e., the files needed, and those that will be written by the script, should reside in the same directory.)

6) Create a directory (within the basemap directory) for each photograph that uses the ground control from that basemap. Directory names can be any alphanumeric string up to eight (8) characters. We have found it useful to name the directories using the same photo identification as used for the photo files (see Figures 2 and 3).

7) Use *digin* to digitize the aerial photographs following the procedures outlined in Appendix A (Digitizing Maps and Aerial Photographs).

8) Run the *get.ground.points* script to create ground control files for each photograph. The frame names of the photos MUST BE THE SAME as the name of the directory in which they reside. The *.kgcp* file for each photo will be written to the directory for that photo and must conform to this convention. Frame names can be any alphanumeric string up to eight (8) characters. The ground point ID's for each photo MUST BE ENTERED IN THE SAME ORDER AS THE CONTROL POINTS ARE DIGITIZED ON THE PHOTO. Note that point ID's 1-9 must have a leading zero. See Appendix A for a complete description on digitizing the aerial photograph. This script must be run in the basemap-level directory.

9) Run the *images* script to reconstruct the camera image space coordinates used by *k371*, *GIANT* and *final.shore*. This script must be run in the basemap-level directory.

10) Run the *frames* script to calculate an initial estimate of camera position, residual errors and create the FRAMES files used by *GIANT*. It is important to note that *GIANT* need not be run if the camera parameters and residual errors produced by *k371* are acceptable. In that case, the *shoreline* script can be run immediately following *frames* to generate the UTM shoreline files. For most applications, however, it is desirable to take advantage of the features of *GIANT*. The *frames* script must be run in the basemap-level directory.

11) At the basemap level, organize the files needed by *GIANT*. Using a UNIX utility such as *cat*, concatenate the necessary IMAGES- and FRAMES-compatible files (files with *.gfrm* and *.gimg* extensions -- See Table 1) from EACH PHOTOGRAPH DIRECTORY and write them to the appropriate files. Copy the ground control file to the appropriate file name (Table 2).

Table 2. File equivalents for DSMS and *GIANT*.

DSMS files	*GIANT* filename	Created by Program
.cam	*for001.dat*	(*cat*)
.gimg	*for002.dat*	(*cat*)
.gfrm	*for003.dat*	(*cat*)
.latlon	*for004.dat*	*ground*
for007.dat	*for007.dat*	*common*
for008.dat	*for008.dat*	*GIANT*

12) Run the *common* script to create the job definition file for *GIANT*. This script should be run in the basemap-level directory. All of the *for00X.dat* files needed by GIANT should reside in the basemap directory (Figure 6).

```
% ls
clon.ref          14-258/          lr12-88/
for001.dat        14-260/          lr12-90/
for002.dat        14-262/          lr12-92/
for003.dat        14-263/          riogrande.gcp
for004.dat        15-367/          riogrande.latlon
for007.dat        15-368/          riogrande.proj
k14-1364/         lr12-80/         riogrande.utm
k15-1425/         lr12-86/
```

Figure 6. Files contained in the **riogrande** basemap directory. The *for00X.dat* files are ready for processing in *GIANT*.

13) Transfer the *for00X.dat* files to the VAX on which *GIANT* is available.

14) Run *GIANT*. After successive *GIANT* runs (see Elassal and Malhotra, 1987 for run strategies and data editing techniques) have produced satisfactory results, transfer the *for008.dat* file back to the basemap directory.

15) Run the *giant.frames* script to place the camera parameter information in the *for008.dat* file into the respective photo directories. This script must be run in the basemap directory level.

16) Run the *shoreline* script to calculate the planimetric shoreline coordinates for each photo in the basemap directory. This script is run in each photo directory within a basemap.

After the *shoreline* script is completed for a particular photo, the output will be ready for import into MapGrafix™, an Apple Macintosh®-based GIS software package. The administrator of the DSMS or any UNIX user familiar with shell script programming can easily modify *shoreline* to produce output compatible with other GIS software input formats.

ENVIRONMENT AND AVAILABILITY

The Digital Shoreline Mapping System (DSMS) was developed on a Digital Equipment Corporation DECStation 5000 running version 4.1 of the Ultrix operating system. A Summagraphics Microgrid (48" × 60") backlit digitizing table with a resolution of 1000 lpi was used in the development of this software. Source code for the programs is available (as a UNIX *tar* file) from the authors. The authors will also provide periodic upgrades as new features become available.

The digitizing program *digin* was written in C for use with the Summagraphics digitizing table mentioned above. The source code can be modified for use with other digitizers by the administrator of the DSMS or any UNIX user familiar with C programming.

The General Integrated Analytical Triangulation (*GIANT*) program (v 1.1) was developed for the VAX computer. It was slightly modified (the default print output was changed from the system line printer to a print file) for use in DSMS and was successfully compiled and run on a Digital Equipment Corporation VAX 8250 using version 5.4 of the VMS operating system. The *GIANT* program and documentation is available from:

National Geodetic Information Branch (N/CG174)
Office of Charting and Geodetic Services
National Ocean Service, NOAA
Rockville, MD 20852
Telephone: (301) 443-8631

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Evenden, G. I., 1991, Notes on a Method to Transform Digitized Coordinates to Geographic Coordinates: Woods Hole, Massachusetts, U.S. Geological Survey Open-File Report 91-17, 5 p.

Leatherman, S. P., 1983, Shoreline mapping: A comparison of techniques: Shore and Beach, v. 51, p. 28-33.

Slama, C. C., ed., 1980, Manual of Photogrammetry: Falls Church, Virginia, American Society of Photogrammetry, 4th ed., 1056 p.

APPENDIX A

Digitizing Maps and Aerial Photographs

The production of digital shoreline maps requires digitization of maps used for ground control points as well as the aerial photographs themselves. Filename suffixes, such as *.proj*, are explained in Table 1 within the text.

Maps

DSMS provides utilities for transforming both digitized ground control and shoreline data from maps to UTM and lat-lon data files. Steps 1-4 are generalized digitizing procedures (see also Evenden, 1991), step 5a applies to ground control data, and Step 5b applies to shoreline data.

1) Tape the map down, making sure it is oriented so that North is toward the top of the digitizing table. Minimize any bends, etc. in the map.
2) Choose calibration points. These should be points of known latitude and longitude that form a polygon completely encircling the area to be digitized. As many calibration points as desired can be chosen, and they require no special placement; they do not have to be on the same parallels or meridians, top to bottom, side to side, etc. The only requirement is that they have a 1:1 correspondence with the order of calibration point entry in the *.proj* file (Table 1). In other words, note on the map the order in which you digitize the calibration points, and make sure you enter the latitude and longitude values of the calibration points in the *.proj* file in the same order. This file contains the geographic coordinates (longitude and latitude) of the calibration points. An example is shown in Figure A-1.

```
% more riogrande.proj
65d52'30"w      18d30'00"n
65d52'30"w      18d27'30"n
65d52'30"w      18d25'00"n
65d52'30"w      18d22'30"n
65d50'00"w      18d22'30"n
65d47'30"w      18d22'30"n
65d45'00"w      18d22'30"n
65d45'00"w      18d25'00"n
65d45'00"w      18d27'30"n
65d45'00"w      18d30'00"n
65d47'00"w      18d30'00"n
65d50'00"w      18d30'00"n
```

Figure A-1. The geographic coordinates of the calibration points for the digitized basemap *riogrande.gcp.*

3) Start the *digin* program.

4) Digitize the calibration points. Save the final output from *digin* in the appropriate basemap directory as *file.gcp*, where *file* is the name of the basemap.

5a) To produce a file used to determine the location of ground control points, terminate the calibration phase, and enter point mode. Digitize the points that will be used as GCPs for correcting the aerial photographs. Again, it is necessary to note on the map the order in which these points are digitized. Use the DSMS script *ground* to convert digitizer coordinates to ground control data. For a digitized map (ground control data), the file produced by *digin* should have the following format:

```
# -c                         indicates beginning of calibration
+21549  +12974  1            calibration point
+21667  +04339  1            calibration point
+17282  +08601  1            calibration point
+25935  +08716  1            calibration point
+22492  +13102  1            calibration point
+22327  +11809  1            calibration point
+25319  +11544  1            calibration point
+18196  +09535  1            calibration point
+20257  +09062  1            calibration point
+20821  +06671  1            calibration point
+20437  +05147  1            calibration point
+22445  +05180  1            calibration point
# -e                         indicates end of calibration
+18496  +12960  C            ground control point
+23494  +08962  C            ground control point
   .
```

```
          .
          .
+25898  +12330  C        ground control point
# -b                     indicates end of ground control point data
```

5b) To produce a UTM shoreline file from a digitized map, follow Steps 1-4 above. Then terminate the calibration phase, and enter stream mode (a setting of 5-10pts/sec is usually adequate) to digitize the shoreline. Turn off and restart stream mode when you encounter a break in the shoreline, such as a river mouth or inlet. This will ensure that the shoreline data is broken into separate strings. (The conversion to MapGrafix format will place the proper break in the shoreline data.) Use the DSMS script *mapshore* to convert the digitizer coordinates to map coordinates.

For a digitized map (shoreline data), the file produced by *digin* should have the following format:

```
# -c                     indicates beginning of calibration
+21667  +04339  1        calibration point
+17282  +08601  1        calibration point
+25935  +08716  1        calibration point
+22492  +13102  1        calibration point
+22327  +11809  1        calibration point
+25319  +11544  1        calibration point
+18196  +09535  1        calibration point
+20257  +09062  1        calibration point
+20821  +06671  1        calibration point
+20437  +05147  1        calibration point
+22445  +05180  1        calibration point
+25154  +06186  1        calibration point
# -e                     indicates end of calibration
+18496  +12960  C        shoreline coordinate
+18494  +12962  C        shoreline coordinate
          .
          .
          .
+25898  +12330  C        shoreline coordinate
# -b                     indicates end of shoreline data
```

Once the map digitization phase is complete for a particular basemap, the next step involves digitizing the aerial photographs.

Aerial Photographs

1) Tape the photo down, making sure it is oriented so that North is toward the top of the digitizing table. Minimize any bends, etc. in the photo.

2) Start the *digin* program.

3) The first four "calibration points" (see *digin* documentation) are the fiducial marks. Depending on the camera system that was used, the location of these points will vary. See Figure A-2 for the proper order for digitizing fiducial marks.

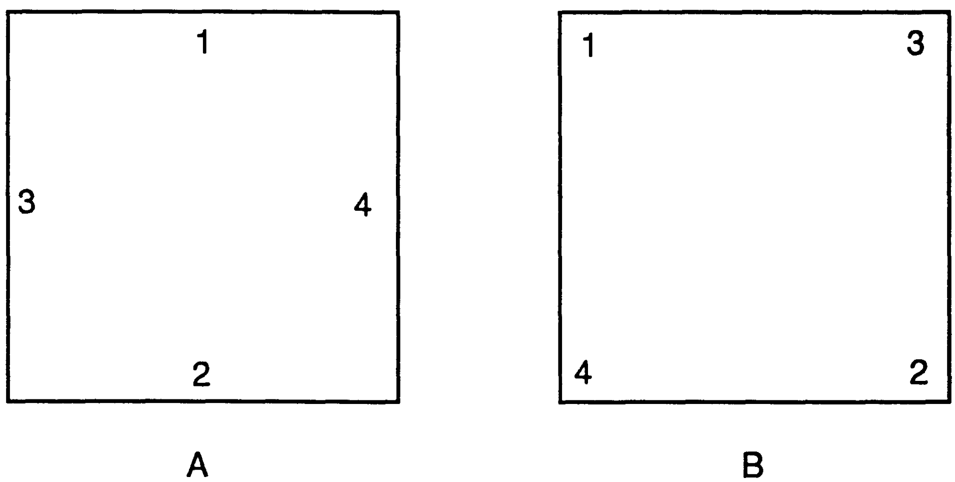

Figure A-2. Sequence in which to digitize fiducial marks for two different types of fiducial mark systems. A: marks in center of each side. B: marks in each corner.

4) The next series of points digitized are the ground control points (GCPs). These points are also digitized as "calibration points" (i.e., do not terminate the calibration phase until AFTER the ground control points are digitized). Make sure the GCPs have a 1:1 correspondence with the *.gr* file produced by *get.ground.points*. In other words, the ground points for each photo MUST BE DIGITIZED ON THE PHOTO IN THE SAME ORDER AS THEY ARE ENTERED IN *get.ground.points*.

5) Terminate the calibration phase, and enter stream mode (a setting of 5-10pts/sec is usually adequate) to digitize the shoreline. Turn off and restart stream mode when you encounter a break in the shoreline, such as a river mouth or inlet. This will ensure that

the shoreline data is broken into separate strings. (The conversion to MapGrafix format will place the proper break in the shoreline data.)

For a digitized aerial photograph, the file produced by *digin* should have the following format:

```
# -c                       indicates beginning of calibration
+21549  +12974  1          fiducial mark #1
+21667  +04339  1          fiducial mark #2
+17282  +08601  1          fiducial mark #3
+25935  +08716  1          fiducial mark #4
+22492  +13102  1          control point
+22327  +11809  1          control point
+25319  +11544  1          control point
+18196  +09535  1          control point
+20257  +09062  1          control point
+20821  +06671  1          control point
+20437  +05147  1          control point
+22445  +05180  1          control point
+25154  +06186  1          control point
# -e                       indicates end of calibration
+18496  +12960  C          shoreline coordinate
+18494  +12962  C          shoreline coordinate
       .
       .
       .
+25898  +12330  C          shoreline coordinate
# -b                       indicates end of shoreline data
```

APPENDIX B

UNIX Man Pages

NAME

camera - create camera system information files

SYNTAX

camera

DESCRIPTION

Camera is a csh script in the DSMS series that writes the camera system parameters (camera identification and principal distance) to a file used by *images* for formatting image datafiles. This file is in *GIANT* CAMERAS-compatible format, and can be passed to *GIANT* as a CAMERAS file.

Camera system identifications can be any alphanumeric string up to eight (8) characters. The principal distance (focal length) of the camera system is entered as a negative number if the digitized photo is a positive (the most common situation), a positive number if the digitized photo is a negative.

SEE ALSO

images, *k371*

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

NAME

common - create *GIANT* job definition file

SYNTAX

common

DESCRIPTION

Common is a csh script in the DSMS series that writes the job definition parameters to a file named *for007.dat*. This file is in *GIANT* COMMON-compatible format, and can be passed to *GIANT* as a COMMON file.

The *common* script prompts for each of the options listed in the *GIANT* User's Guide (Elassal and Malhotra, 1987). The default response is given in brackets at each prompt. Typing a <CR> invokes the default *GIANT* setting.

SEE ALSO

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

NAME

final.shore - compute geographic coordinates of shoreline data digitized from an aerial photo based on adjusted camera parameters.

SYNTAX

final.shore [file]

DESCRIPTION

Final.shore is a C program in the DSMS series that computes the geographic (lat-lon) coordinates of shoreline based on a vector intersection with a given spheroid elevation. The vector origin is based on input camera parameters previously determined by *GIANT* (the FRAMES file, *for008.dat*). The elevation above the reference spheroid (the default is Clarke, 1866) used to compute the geographic coordinates is 0.050 meters.

The program is called by the csh script *shoreline*, which passes the necessary file information and performs additional data formatting. If no file is passed to the program, one will be prompted for.

Portions of the source code were adapted from Lucas (1989).

FILES

Output *GIANT* camera parameters (*file.gfrm*).
Digitzed shoreline coordinates (*file.shr*).

SEE ALSO

shoreline

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

Lucas, J. R., 1989, GPS-assisted Phototriangulation Package (GAPP) User's Guide, Version 1.02: Rockville, Maryland, NOAA Technical Memorandum NOS CGS 2, 25 p.

NAME

frames - calculate initial estimate of camera parameters

SYNTAX

frames

DESCRIPTION

Frames is a csh script in the DSMS series that invokes *k371* to perform the initial space resection for an aerial photograph. Output data is in three files: *file.kfrm*, *file.gfrm* and *file.klog*. The *.kfrm* and *.gfrm* files are in *GIANT* FRAMES-compatible format. The *.klog* file is a summary of the resection performed by *k371*. Specifically, the camera parameters for each iteration of *k371* and the image residuals (in meters) are listed.

The script calls one *awk* program: *frames.awk.*

FILES

Ground control (*file.kgcp*).
Camera system information and image coordinates (*file.kimg*).

SEE ALSO

get.ground.points, *k371*

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

NAME

get.ground.points - create ground control files (*file.gr*) used by *k371*

SYNTAX

get.ground.points

DESCRIPTION

Get.ground.points is a csh script in the DSMS series that writes the control point file used by *k371* to perform the initial triangulation for a given photo.

The frame names of the photos must be the same as the name of the directory in which they reside. The *.kgcp* file for each photo will be written to the directory for that photo and must conform to this convention. Frame names can be any alphanumeric string up to eight (8) characters.

The ground point ID's for each photo MUST BE ENTERED IN THE SAME ORDER AS THE CONTROL POINTS ARE DIGITIZED ON THE PHOTO.

Note that point ID's 1-9 must have a leading zero.

The script calls two *awk* programs: *ground.latlon.awk* and *ground.utm.awk.*

FILES

UTM and elevation values for ground control points (*file.utm*).

SEE ALSO

k371, *ground*

NAME

giant.frames - sort *GIANT* for008.dat file

SYNTAX

giant.frames

DESCRIPTION

Giant.frames is a csh script in the DSMS series that separates the camera parameter data produced by *GIANT* (FRAMES file *for008.dat*) and writes the appropriate data to the file used by *final.shore* to determine planimetric shoreline position.

The script utilizes the UNIX utility *grep*.

FILES

Output FRAMES file produced by GIANT (*for008.dat*).

SEE ALSO

final.shore

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

NAME

ground - convert digitized basemap control points to UTM and lat-lon files

SYNTAX

ground

DESCRIPTION

Ground is a data conversion/formatting csh script in the DSMS series that creates UTM and lat-lon ground control data files for use in *k371* and *GIANT* from digitized control point data files created by *digin.*

Ground expects data to be of the form produced by the *digin* digitizing program, and must be in table units. The routine is interactive and prompts for the necessary input data.

Ground automatically appends the extensions required for input and output files (i.e., *.gcp* , *.proj*, *.utm* and *.latlon*).

The projection specified must be supported by *proj.* See Evenden (1990) for supported projections and proper syntax.

The height of each ground control point is requested until the end of the file is reached.

The script calls two awk programs: *ground.utm.awk* and *utm2latlon.awk.*

EXAMPLE

The following is an example of I/O for *ground*:

```
Filename of digitized basemap ? riogrande <CR>
Projection of basemap ? poly <CR>
File containing the basemap calibration points) ? riogrande <CR>
Filenames for output UTM and lat-lon datafiles ? riogrande <CR>
Converting digitizer coordinates to UTM values ... Done.

**** Ground point elevation entry ****

Height (in meters) of ground point 1 ? 3.24 <CR>
Height (in meters) of ground point 2 ? 1.709 <CR>
           .
           .
           .
Height (in meters) of ground point 44 ? 1.00 <CR>
Converting UTM coordinates in riogrande.utm to lat-lon pairs ... Done.
```

FILES

Central longitude of reference basemap (*clon.ref*).
Digitized basemap data (*file.gcp*).
Calibration points for the basemap (*file.proj*).

SEE ALSO

digin, proj, k371

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

Evenden, G. I., 1990, Cartographic Projection Procedures for the UNIX Environment - A User's Manual: Woods Hole, Massachusetts, U.S. Geological Survey Open-File Report 90-284, 63 p.

NAME

images - reconstruct camera image space for *k371*, *GIANT* and *final.shore*.

SYNTAX

images

DESCRIPTION

Images is a csh script in the DSMS series that reformats raw digitized aerial photo data files to the input data formats required by *k371*, *GIANT*, and *final.shore* (*file.kimg*, *file.gimg*, and *file.shr*, respectively).

File.kimg and *File.gimg* are the input camera parameters, measurement standard deviations and ground control points associated with each aerial photograph. These files are in *GIANT* IMAGES-compatible format.

The script calls three *awk* programs: *images.k371.awk*, *images.giant.awk*, and *images.awk*.

FILES

Digitized aerial photograph (*file.dat*).
Camera system information (*file.cam*).

SEE ALSO

k371

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

NAME

k371 - perform space resection for an aerial photograph

SYNTAX

k371

DESCRIPTION

K371 is a FORTRAN IV program in the DSMS series that performs the inital estimates of camera position and attitude based on input ground control, image coordinate, camera system and digitizing table data.

The program performs a three-dimensional projective transformation using a least-squares space resection solution. Photo coordinates are fitted to corresponding ground positions, providing camera position and attitude and adjustment residuals. Output is formatted as a *GIANT* FRAMES-compatible file. Camera orientation angles are "ground-to-photo."

Format variables ICONT (control data format), IMEAS (measured data format) and IOUT (output data format) are set for *GIANT*-compatible I/O. SCP (scale factor) is set for a digitizing table with a resolution of 1000 lpi. Uncomment the appropriate lines in the source code if input prompts are desired.

SEE ALSO

get.ground.points, *images*

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

NAME

mapshore - create UTM shoreline file from digitized map shoreline

SYNTAX

mapshore

DESCRIPTION

Mapshore is a csh script in the DSMS series that creates a UTM shoreline file from a digitized map and reduces the number of points defining the shoreline using the iterative point reduction algorithm, *redl*;

Mapshore expects data to be of the form produced by the *digin* digitizing program, and must be in table units. The routine is interactive and prompts for the necessary input data.

Mapshore automatically appends the extensions required for input and output files (i.e., *.dat* , *.proj*, *.smap* and *.rmap*).

The projection specified must be supported by *proj*. See Evenden (1990) for supported projections and proper syntax.

FILES

Digitized map calibration and shoreline data (*file.dat*).
Calibration points for the map (*file.proj*).

SEE ALSO

digin, *redl*

Evenden, G. I., 1990, Cartographic Projection Procedures for the UNIX Environment - A User's Manual: Woods Hole, Massachusetts, U.S. Geological Survey Open-File Report 90-284, 63 p.

NAME

shoreline - determine planimetric shoreline position and reduce number of points defining shoreline

SYNTAX

shoreline

DESCRIPTION

Shoreline is a csh script in the DSMS series that 1) converts the lat-lon data produced by *final.shore* to UTM values; 2) reduces the number of points defining the shoreline using the iterative point reduction algorithm, *redl*; and 3) places the output data into an ASCII file that is ready to be imported into MapGrafix™, an Apple Macintosh®-based Geographic Information System (GIS).

The script calls one *awk* program: *shoreline.awk.*

FILES

Central longitude of reference basemap (*clon.ref*).

SEE ALSO

final.shore, *redl*

Elassal, A. A., and Malhotra, R. C., 1987, General Integrated Analytical Triangulation Program (GIANT) User's Guide: Rockville, Maryland, NOAA Technical Report NOS 126 CGS 11, 66 p.

Lucas, J. R., 1989, GPS-assisted Phototriangulation Package (GAPP) User's Guide, Version 1.02: Rockville, Maryland, NOAA Technical Memorandum NOS CGS 2, 25 p.