JAMES J. SIPPEL
Defense Mapping Agency Aerospace Center
St. Louis, MO 63118

Automated Editing of Digital Graphic Data

Editing techniques for digital data files employed at the Defense Mapping Agency Aerospace Center.

INTRODUCTION

This paper describes the editing techniques for digital data files employed at the Defense Mapping Agency Aerospace Center (DMAAC), Cartography Department, Automated Cartography Division. A brief description of the hardware and its configuration follows:

CALMAGRAPHIC III SYSTEM
Model No: CG4
Manufacturer: CALMA Co./Systems, Science Software (S^3)

FEATURES

- Table Accuracy: ±0.003″ with compensating program.
- Resolution (recording accuracy): ±0.001″
- Repeatability: ±0.001″
- Special environment: Maximum temp. 78°F
- Programs supported: Digital Radar Landmass Simulation (DRLMS)
  Digital Terrain Data (Tercom Projects)
  Special digital data projects
  Data bases
  Automated cartography

ABSTRACT: *Different methods used to edit digital data files collected on the Lineal Input System and Calmagraphic III System together with different techniques of editing specific features and specified areas are discussed. Several practical examples of updating through interactive editing and batch programs are included. The methods of editing manifest the use of a cathode ray tube (CRT) display, Interactive Edit Station, and high-speed proofing plotter.*

COMPONENTS

- Two digitizing stations consisting of 4 components each: Digitizing table with a 46″ × 52″ working area, Alphanumeric keyboard, X,Y and Z coordinate display, Teletypewriter RO-33 (Table controller)
- NOVA 1200 mini-computer (16K)
- Teletypewriter ASR-33 (System controller)
- Magnetic tape transport
- Two Caelus disks (data storage)
- Calma Systems Software
- MASK Edit System
  4″ x 4″ message CRT
  6″ x 8″ image CRT
  Magnetic tape input/output
  Diablo disk (data storage)
  Alphanumeric keyboard, joystick
  Systems software

The Calmagraphic III is a digital collection and processing system which utilizes the NOVA 1220 programmable high-speed control computer. Included with the Calmagraphic III is the S^3 MASK System which is an edit device for Calmagraphic formatted data (Figure 1).

The system collects lineal information contained on graphic source in digital form. The system capabilities include an interactive editing function which provides for stored feature data to be corrected while in digital form.

The Calmagraphic III also is an expandable system. The hardware and software options expand horizontally to multi-input station systems and vertically to additional disks, CRT display and plotter systems.

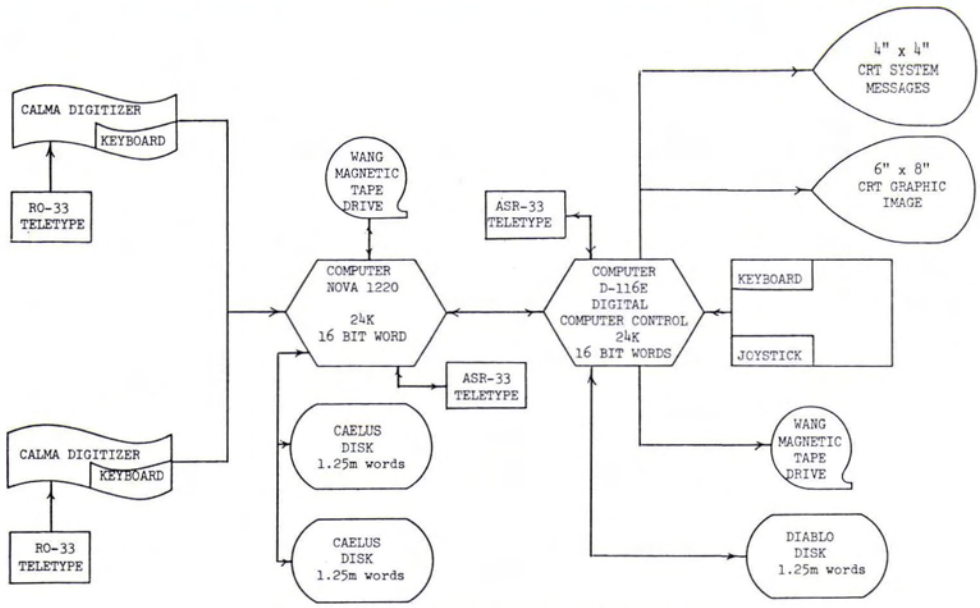

FIG. 1. Calma digitizing and editing system.

CALMAGRAPHIC III EDITING

The Calmagraphic System is equipped with several basic functions for locating specific data within a storage disk. Editing can be performed on each of the three levels of the Calmagraphic formatting hierarchy (in descending order: file, record, point). The term "pointer" will be used to describe the location on disk of the read/write head.

To initially identify features that need editing, the data is plotted off-line via UNIVAC 1108 processing and then overlayed on the source. Features to be edited, because of header or location error, are marked and indicated by the unique feature number. The source is put back on the digitizing table in the same table coordinate system if features are to be added or modified. If only deletions, elevation errors, and text changes are needed, it is not necessary to locate the source on the table. Any data files on tape may be dumped to disk for editing.

The first function performed is that which identifies in which of the ten files in the system the data to be edited is located. This is accomplished by entering the command Current File, followed by the file number (1 through 10). Instead of typing the entire command, the cartographer has the option of typing in the first letter of each word, e.g., CF for Current File. Commands for forward and backward movement are used until the desired location is reached. To position the pointer at the beginning of the file, Begin File is entered. A Read All is executed to double-check the header records, making sure the proper file has been entered for editing. (At this point the cartographer is ready to commence editing.) Several methods can be used to locate a specific point, header, or feature. When a specific feature is needed for editing, Scan Forward or Scan Backward is entered, followed by the unique header assignment number of the feature in question (Figure 2). The software responds by repeating the unique header assignment number when the feature is located.

When digitizing, Text Mode is used to indicate a header. A Line Mode or Point Mode indicates digital data. All data points under Point Mode are printed out (Figure 3), but under Line Mode only the start and stop points are printed; therefore, several records of data can be located under one Line Mode feature, depending on the length of the feature. Each data record holds 76 X's, Y's, or 38 points.

If the edit candidate feature has a small number of records, it is practical to print out the entire feature with a Read Record or Read All. After printing out the data the cartographer can visualize the entire feature to be edited. Realizing that the pointer is at the end of the last record read, a back space and a forward space of the pointer is used until the desired location is reached. The Previous and Next commands can be employed to move the pointer back and forth point-by-point, or the Scan Forward and Scan Backward may be used to find specific points.

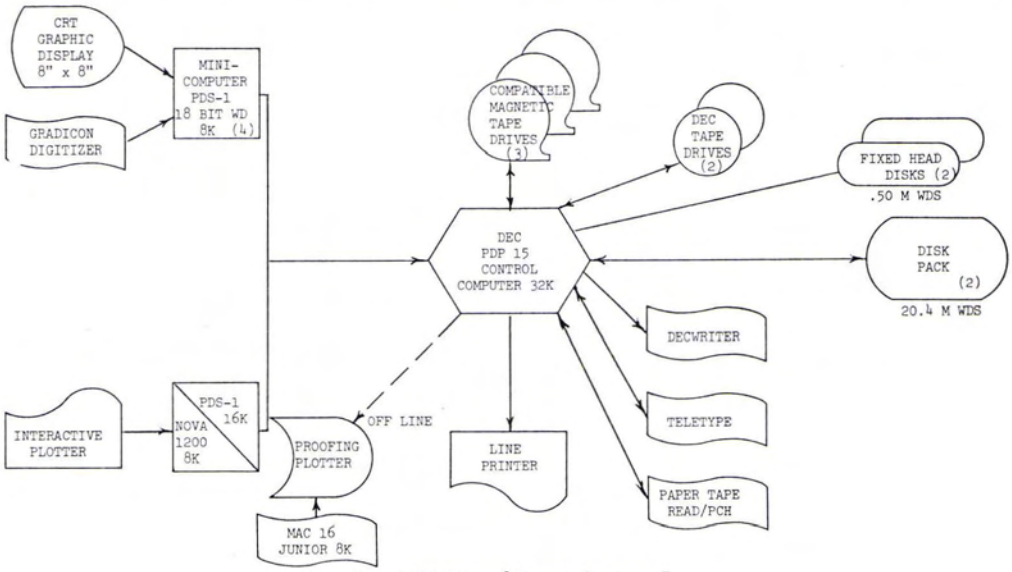

FIG. 4. ACS Lineal Input System I.

At this time the three major edit functions can be used: Edit, Coordinate, Edit Z (Elevation), and Edit Text. After entering the command for the proper edit function, the correction is made. Point and line data are edited in the same manner. To delete data, a Scan Forward is initiated to the first good point, the end data saved, a Scan Back to the last good point, and the end data is added; therefore, the data in between is covered up. In the same manner, data may be added to any record by saving the end data at the location of data insertion. The new data is digitized, followed by the old data that was saved. If bad data exists at the end of a file, the file is scanned to the last good point and Kill End is entered, deleting all the following data. An end-of-file is located after the last data record, and is automatically moved during editing and digitizing to insure that it remains there.

Two other types of pointer movement which can be helpful in editing are the Forward/Backward Z and the Forward/Backward Text. Each of these functions scan header-by-header or elevation-by-elevation for editing or verifying the quality of data. Upon completion of editing, the data file is plotted off-line in order to verify the edit modifications. The data is dumped to tape for further processing and use or data base storage.

MASK SYSTEM

The Systems, Science and Software Corporation's Mask System is an edit station adapted by DMAAC and S^3 to edit Calmagraphic data. It can be used off-line or on-line

```
%
*TM
.90000/2/@0,162          ▷ Header
.
*LM
%2920@5.425,3.224        ▷ Line Feature Data
5.425,3.222
%
*TM                  Unique Header Assignment Number
.90000/2/@0,163
.
*LM
%2880@5.543,3.64
5.542,3.644
%
*TM
.90000/2/@0,164
.
*LM
%2920@5.474,3.747
5.475,3.745
%                        } Records
*TM
.90000/2/@0,165
.
*LM
%2920@5.41,4.333
5.41,4.338
%
*TM
.90000/2/@0,166
.
*LM
%2920@5.349,6.119         ▷ Start Point
5.347,6.116
%
*TM
.90000/2/@0,167
.
*LM
%2920@5,6.473
5.825,6.473               ▷ Stop Point
%
*TM
.90000/2/@0,168
.
*LM
%1
%2960@5.998,5.919
5.997,5.919
%
*TM
.90000/2/@0,169
.
*LM
```

FIG. 2. Portion of a Calma data file — line features.

to access data from the collection disk or to input from a data save tape. This edit station increases the ability of the Calmagraphic editing capabilities via CRT display. This editing can be performed on-line and provides the capability to display and edit multiple features concurrently. The Mask System consists of a graphic console which includes an 11-inch CRT to display data, a 6-inch CRT message display, a joystick for cursor control, and a program function keyboard (PFK) for function control and message inspection. (Figure 1).

The Mask System has been designed to maximize the amount of information which can be delineated on the CRT display and still perform useful work. All data is divided into cells. Cell placement can be accomplished with a cell outline which can contain text as a designator. Cells may be exploded (divided) so that modifications may be made cell-by-cell and level-by-level with both ease and speed. A cell may be displayed by specified levels. Editing may occur on any level on any cell. All cells designated by the same name will carry any modification made to any one cell with that name. Cells have a hierarchical structure which makes it possible to make cells from cells. A cell may be defined by selection of all features in a source file or by specifying the diagonal points of the desired area. The recalling of cell information is secured through parameter verification. Data displayed may include coordinate levels and names of cell members. Edit Functions of the Mask System include: stretchable components, grouping, duplication, merge, measure-and-move, scaling, blanking-and-deletion, zoom-and-window, grid, and ruler.

When using the stretchable components, any rectangle string or interconnect may be stretched or modified to allow rapid editing and ease of modification. Grouping provides the ability to gather all of the components of a feature file into a logical unit to be treated as an entity. The duplicate function allows the mass reproduction of geometry, individual features, cells or a group of features. The merge operation joins cells containing rectangular or string data. Any number of entities can be merged deleting common lines. The measure-and-move function measures distances from any feature and will move a feature in any direction for any distance indicated. Automatic scaling assures that a selected portion of data completely fills the screen in its longest direction. A controllable variable line width is available which is useful when trying to decipher dense data. As with system editing, lines, strings, closed, and open features may be created at any level. Of course the reverse is also true; any feature may be deleted for a file at any level. Blanking aids in the reduction of clutter and allows the operator to work with as few features as are needed in order to complete the edit.

For editing the Mask System allows 32 different levels of data division. Four additional functions which aid the operator with editing are the zoom, window, grid, and ruler, each of which can be used individually, or all may be used together. The zoom allows the operator to blowup any data to a larger scale for editing and then return it to its original scale. Window allows the user to choose a portion of the data file to be displayed at whatever scale fits on the screen. The grid and ruler can be projected on the screen to aid the operator in edit alignment and in the measurement of proper edit changes.

Upon completion of editing, the file can be dumped back to tape and stored in cells which constitute a data base. Cell descriptors list the geographic areas covered and type of data included.

Lineal Input System

Model No: Included after each item
System Design: RADC and PRC

COMPONENTS

- Four Gradicon digitizing stations consisting of six components each:
  Digitizing table with a 35″ x 48″ working area.
  Alphanumeric keyboard
  Special Function keyboard
  PDS-1 Computer, 8K core
  Interface (Table/CRT Display)
  CRT display (Refresh, 40/sec)
- PDP-15 Master Processor, 32K core
- Teletypewriter KSR-35 (system controller)
- Teletypewriter (DEC), (system monitor)
- Optical paper tape reader/punch
- DEC tape (program input/output)
- Three magnetic tape input/output units
- High speed on-line printer
- Two floating head disk pack drives (data storage)
- Interactive edit station
  Inverse plotter
  CRT image display
  Alphanumeric keyboard
  NOVA 1200 (8K)/PDS-1D (16K)
- Systems Software: PRC and Ph.D. Corp.
- Off-Line Xynetics Plotter

FEATURES

- Table Accuracy: +0.002″
- Resolution (recording accuracy): +0.001″

- Special Environment: Air Conditioned 68°-72°F Humidity controlled
- Programs Supported: Digital terrain data
  Special digital data projects
  Digital culture data
  Automated cartography

The Lineal Input System (LIS) is a digital collection and processing system (Figure 4) developed by Planning Research Corporation under contract with the Rome Air Development Center. The system will convert graphical information contained on source maps to digital data in table-coordinate form. The master processer (PDP-15) also contains batch programs for the transformation of the data to geographics, clip/join, section, panel and plot data. The system capability also includes on-line editing via CRT display. Once data is digitized and converted to geographic form, it can be changed to any scale, projection, or spheroid desired without regard for the source used. The Xynetics plotter is used for a "quick look" verification plot.

The LIS is an expandable system capable of handling eight digitizing stations and two edit devices. The Interactive Edit Station is equipped with an inverse plotter.

```
%@5.697,3.07
%
*TM
.80055/1/@0,005  ⊳ Header
.
*PM
%@.838,3.834
%@1.071,4.027
%@1.109,4.081
%@1.193,4.081
%@1.198,4.219
%@1.124,4.221
%@1.111,4.235
%@1.07,4.234      } Feature Vertex Points
%@1.06,4.222
%@.836,4.222
%@.836,4.058
%@.941,4.055
%@.837,3.966
%
*TM          Unique Feature Number
.80068/1/@0,006
*PM
%@1.125,4.219
%@1.126,4.258
%@1.06,4.257
%@1.059,4.223
.
*TM
.80078/1/@0,007
.
*PM
%@1.777,4.073
%@1.78,4.157
%@1.728,4.156
%@1.727,4.107
%@1.691,4.105
%@1.691,4.072
%
*TM
.80088/1/@0,008
.
*PM
%@1.732,4.231
%@1.805,4.262
%@1.755,4.31
%@1.791,4.345
%@1.794,4.402
%@1.732,4.403
%@1.68,4.383
%@1.582,4.382
%@1.584,4.23
%@1.614,4.236
```

FIG. 3. Portion of a Calma data file — point

XYNETICS PLOTTING SYSTEM 1200
Model No: 1200
Manufacturer: Xynetics

COMPONENTS

- Xynetics plotting table with a working area of 89" x 57"
- Lockheed Mac Jr. mini-computer controller (8K core)
- 9 Track tape drive input
- Teletypewriter ASR-33 controller

FEATURES

- Plotting Accuracy: ±0.005
- Repeatability: ±0.001
- Plot speed to 40 IPS (Skew rate)
- Programs Supported:
  LIS Output and general/miscellaneous data plotting

The Xynetics is a high-speed proof plotter with four-color pen/ink capability. Other options include scribing and multi-file plotting. The Mac Jr. Controller mini-computer has 8K core and programming capabilities. The plotting system was designed for specific use with the LIS.

LINEAL INPUT SYSTEM EDITING

DIGITIZING/EDIT WORK STATION

The value of editing digital data is supported and strengthened by the ease with which it can be accessed and modified. The Lineal Input System provides a fully interactive editing capability that includes modification and deletion of features within a file. Editing is done during data collection and/or after the completed file has been plotted and reviewed.

Features to be edited are selected directly from the source graphic which is registered to the digitizing table. The cursor is placed over the feature to be edited and a button is depressed to indicate a search for the feature. Initial verification is via display of the feature header. The feature retrieved from the LIS data base is portrayed on the CRT display. The cartographer may examine the feature visually through a 4½-inch "window" that under user control, may be walked along the entire feature. In this manner the user can review the data file, thus verifying the existence and form of any single feature. After the feature is verified, editing may begin.

The LIS utilizes two methods of editing: Type I and Type II. Type I is concerned only with the feature being digitized. The digitization process includes the capability of ceasing digitization at any time in order to correct operator error in cursor movement within approximately the last 3 inches of data (Figure 5). Any errors which occur beyond this eligible distance must be corrected later by means of Type II editing. To correct an error, as in Figure 5, the cartographer depresses a button in order to stop recording data points and projects the feature on the CRT display. He positions the cursor at a point before the error and "gangs"* the cursor. At this point all the data before the cursor position is left untouched and all the data after the cursor position is deleted. The cartographer will continue digitizing from this cursor position. A smoothing routine is incorporated into the edit change so that an acceptable join is obtained between the old data at the point where the cursor was ganged.

* Gang: join to the feature at the point over which the cursor is located.

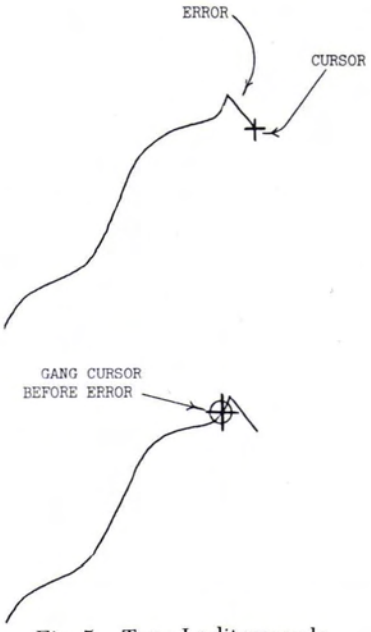

Fig. 5. Type I edit example.

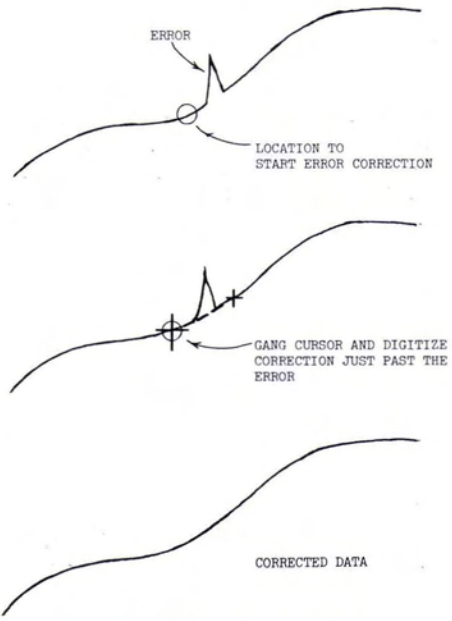

Fig. 6. Mid-segment modify.

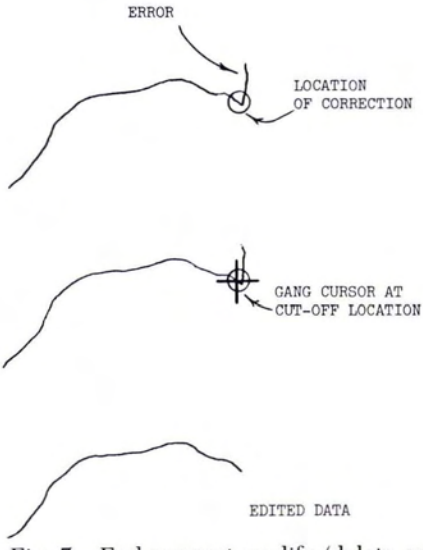

Fig. 7. End-segment modify (delete end segment).

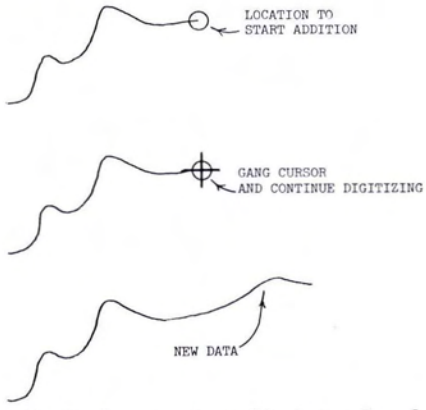

Fig. 8. End-segment modify (extend end segment).

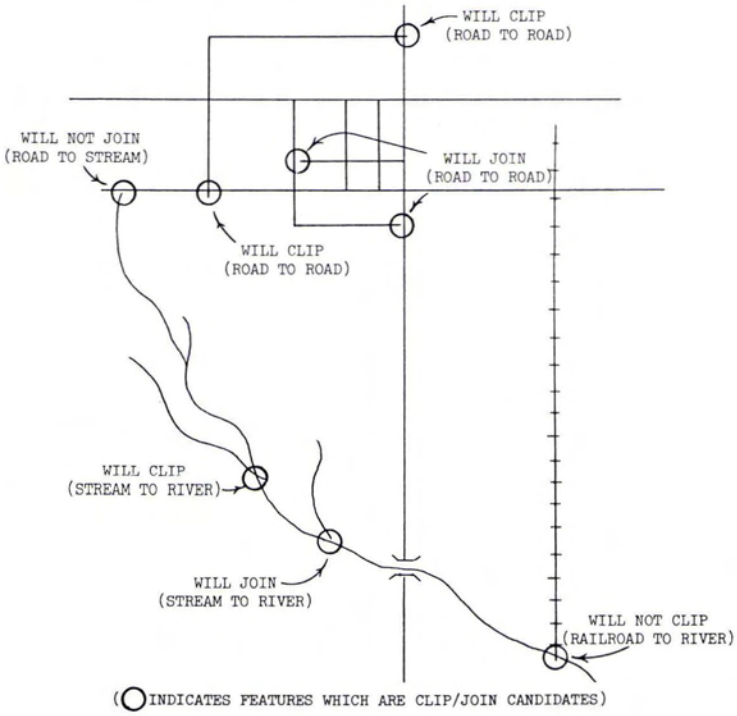

FIG. 9. Clip/join program.

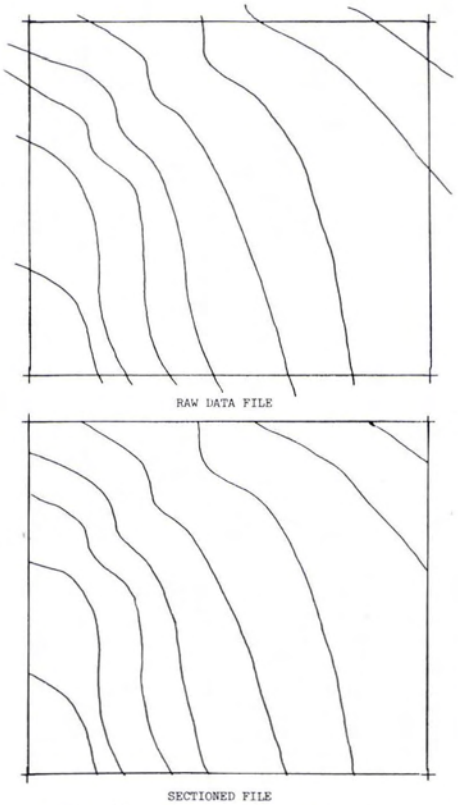

FIG. 10. Geographic sectioning.

Type II editing incorporates the ability to modify end-segments, modify mid-segments, join features, modify descriptor and delete a feature. Once the cartographer has plotted the desired data on the high-speed proofing plotter, he will indicate on the plot those features requiring modification. After the data file has been registered to the table, editing may commence. An existing feature may be modified to replace an internal segment with a new segment which can be longer, shorter, or the same size as the one being replaced. The cartographer indicates which feature is to be edited by locating the cursor over the feature and depressing a button to find the feature. After displaying the area to be modified (Figure 6), a mid-segment modify is indicated as the edit function to be used. The cartographer gangs the cursor before the error and digitizes the correction just past the error. The operator may accept or reject the change. A "reject" would display the old feature thus permitting the cartographer to correct the error again. An "accept" would initiate a change in the data base to the new feature. A smoothing routine again adjusts the corrected portions of the feature data that was not changed.

An end-segment modification is very similar to mid-segment in that an existing feature may be shortened or lengthened from the

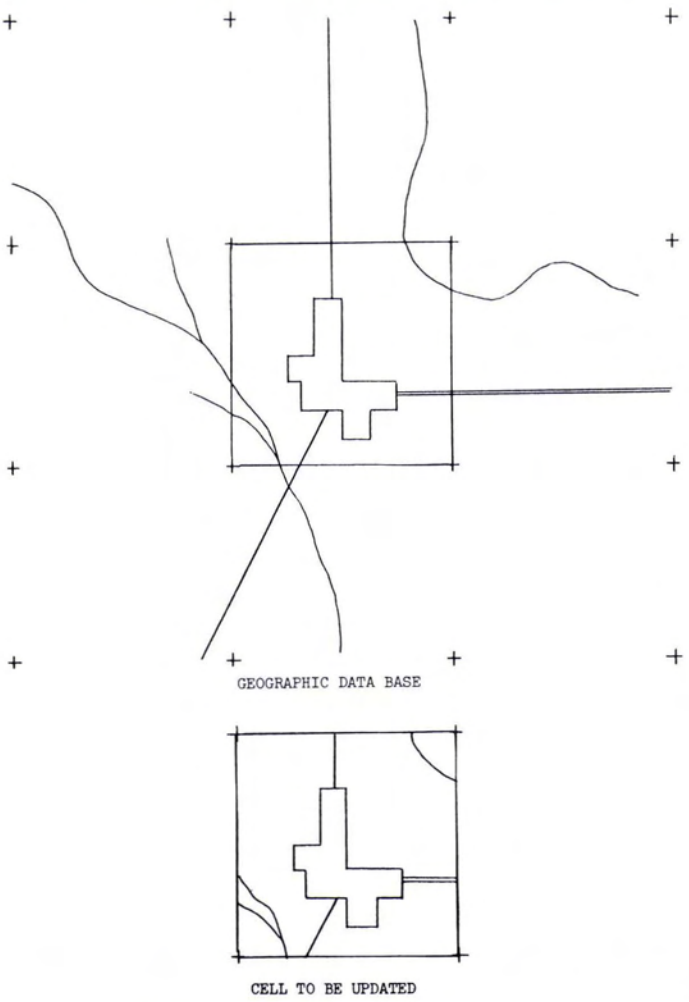

FIG. 11. Data base update, geographically defined — cell extraction.

existing terminal or starting point. Obviously, this does not include a closed feature. After the feature has been located, the cartographer indicates which end of the feature is to be modified. After this has been done, he will proceed either to shorten or to lengthen the feature. To shorten a feature, the cursor is located over the end of the feature to be truncated (Figure 7). The cursor is ganged at the point to be truncated and an end of feature is indicated with the proper button. The edited feature is displayed for rejection or acceptance. To extend a line segment, again the cursor is located over the end of the feature to be extended (Figure 8). The cursor is ganged near to or at the end of the feature and the desired extension of the line segment is digitized (Figure 8). When finished, the feature will be displayed for acceptance or rejection. A smoothing adjustment is incorporated in order to force the new extension to fit the previously digitized data.

The join-feature function is used to join two individual features to form one cartographic feature with one unique header describing that feature. This function only deals with joining end-points, and is easily done by indicating the two features to be joined.

Descriptor modification deals with the textual information of a feature being changed because of error in description or the reflection of a new update from current information, e.g., changing the name of a culture feature. The final function that can be performed on an individual feature is the deletion of that feature from a file or data base without the altering of any existing data. The cartographer simply locates the cursor over the fea-

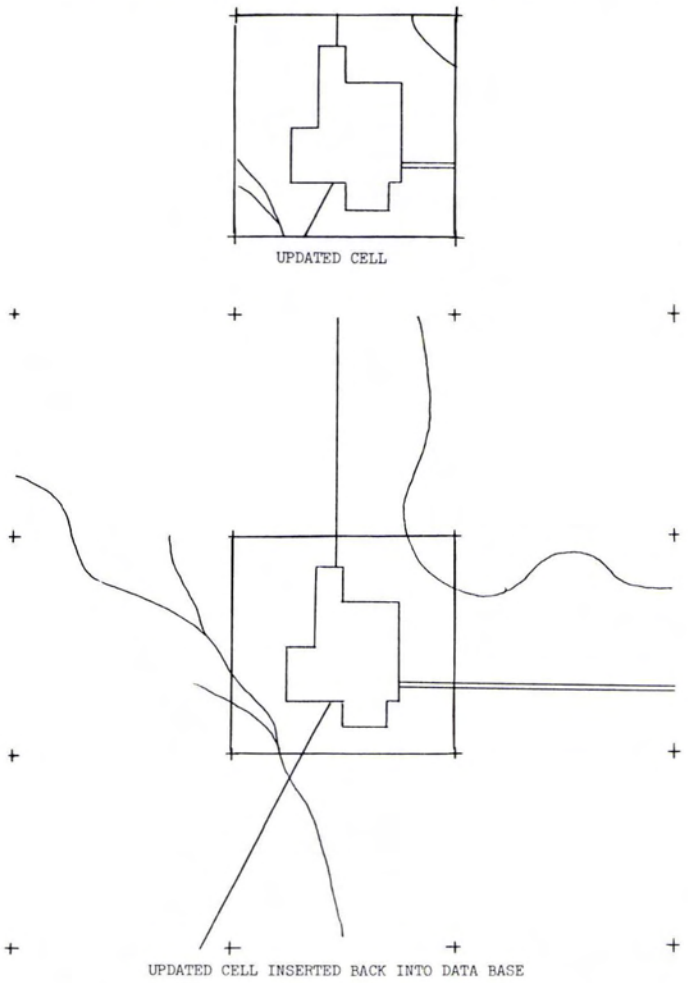

FIG. 12. Data base update, geographically defined — cell insertion.

ture to be deleted, finds the feature in the file, and indicates with the delete feature function the purging of that feature from the data base.

Once data has been digitized, edited, and stored in a data base, it may be recalled at any time for updating or corrections and returned to the data base for storage and further use. All points in the data base are in geographic form. When calling up a specific area of data it may be transformed to any scale, projection, or spheroid the user wishes.

BATCH SOFTWARE EDITING

The first "batch" routine is designed for culture features in a data base. Clip/Join is an automated editing routine in which the entire data base is searched for inadvertent overruns or underruns at the junction of features. An important input option is the override to the clip/join threshold. The operator, after producing a proofing plot, can decide how large to set the threshold for clip/join candidates. When clipping or joining, a software check is made of headers to assure that it is working with the same class of features. (Figure 9 displays a sample file before the clip/join program has been induced and the possible clip/join candidates of that file.)

A second "batch" routine which can be used in several beneficial ways is sectioning. When sectioning, the output data is assumed to have well-defined straight-line borders. The sectioning program works with geographic or machine-coordinate files. One example of application is its use along sheet edges. After a file of data is digitized and edited, features obviously need clipping along the sheet edge (Figure 10). The cartog-

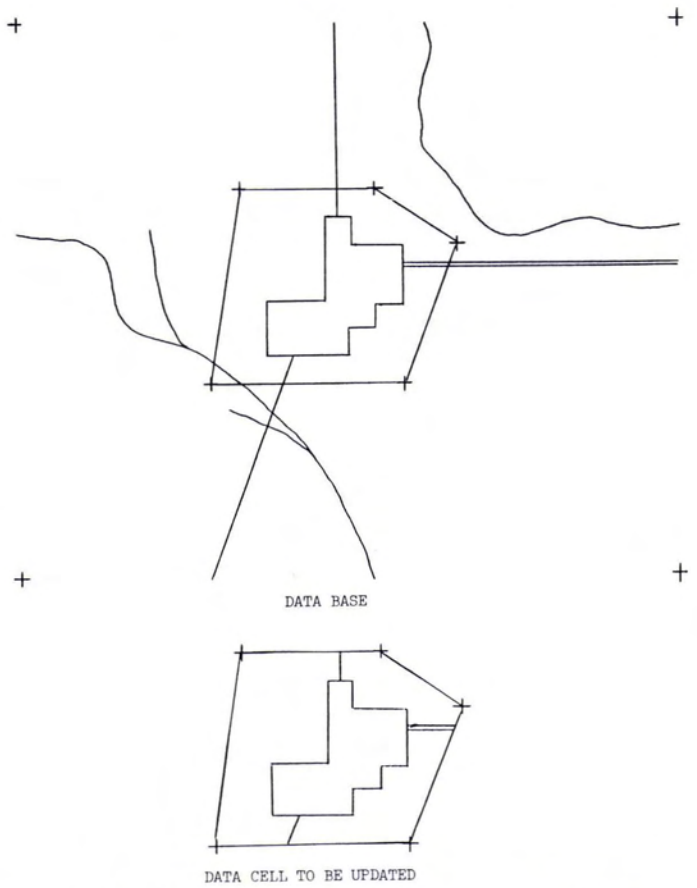

FIG. 13. Data base update, location defined — cell extraction.

rapher inputs the minimum and maximum longitude and latitude parameters of the sheet as the data limits. Figure 10 also shows the results of a geographically sectioned file.

A second application of sectioning can be performed in two ways: geographically defined and location defined. A geographical section for a data base update is done in the same manner as the section along sheet edges, but with different results. First, the area to be updated must be defined by selecting the closest known geographic values for the minimum and maximum latitude and longitude (Figure 11). Once the parameters are chosen, the data base can be processed by the section program which would extract the area defined for updating (Figure 11). After extraction, all the previously discussed edit functions may be used to update the data. Features can either be modified to the new specifications or deleted and re-digitized. At the completion of editing, the updated file (Figure 12) can be inserted (paneled) into the original data base. The panel program performs several tasks in addition to inserting the edited file. The first task is to check headers of features close enough to panel together, making sure they match. Features with the same header within a specified tolerance will be paneled together making one unique feature with one header. An override option is also built into this program which will smooth joins between two features and at the same time re-sort the data into one continuous string. After completion of one feature it will search through the data file looking for other panel candidates until it has checked every situation. Upon completion of the panel, a report is given stating the discrepancies in panel candidates, such as features close enough to panel, but with unlike headers. After the insertion is performed, a plot of the corrected data base is executed on the proofing plotter in order to verify the update and insertion to the data base (Figure 12).

The second method of performing a data file update is location-defined. If the cartog-

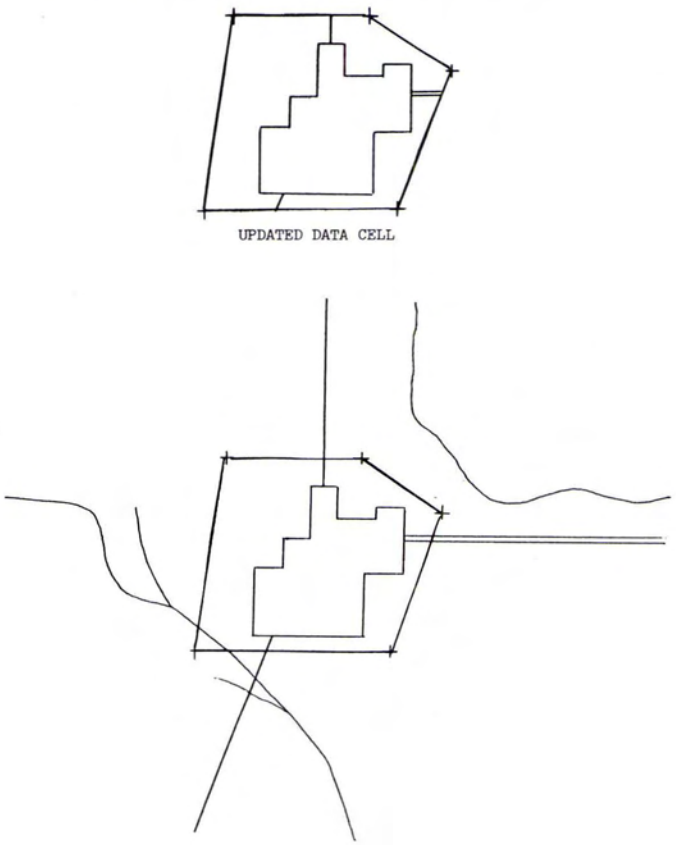

FIG. 14. Data base update, location defined — cell insertion.

rapher cannot geographically define the area to be updated, he can physically locate the cursor on the source documented and indicate the vertex points surrounding the area to be updated (Figure 13). The parameters of this method restrict the user to defining a polygon with three to eight vertices. Again, the area to be edited is sectioned from the data base (Figure 13) and updated (Figure 14). After the changes have been made, it is paneled to the data base (Figure 14).

If the graphic data file is small enough,* the edit functions may be performed directly to the LIS data base instead of to an extracted portion.

INTERACTIVE EDIT STATION

The LIS also is equipped with an interactive edit station, developed by Concord Control Incorporated, which utilizes an inverse plotter and CRT display. All of the previously mentioned edit functions also can be performed at this device. In addition to those functions, the cartographer has a number of additional tasks which will aid him in the correction of digital data.

While the user is editing data on the CRT display, he can plot the results as they occur. The option for changing plotting scale also is offered. If the cartographer wishes, he can choose a specific feature or features to be plotted. For addition to the area of the plotter designated for data, a small "scratch" area can be used to plot any feature at any scale desired. This option is especially useful for plotting features being currently edited. The four color plotting capability allows the cartographer to choose any color pen to plot any feature or features desired. The edit device is used for the editing of completed files, although digitation also may be performed.

CONCLUSION

The procedures and techniques described provide a capability for editing, modifying,

* The size of the data file is dependent on the density of data and the scale with which the cartographer wishes to work.

and updating both graphic features that have been digitized and individual data files. Both the Mask System and Interactive Edit Station are now being fully explored in a test and evaluation environment. A refinement of techniques in conjunction with innovative ideas surely will fully develop their editing capabilities.

References

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Planning Research Corporation, Information Sciences Company. *Lineal Input System Users Manual*, Volume I, II, III, September 1973.

Systems, Science, Software. *Mask System Description and Users Manual*, January 1974.

Notice to Contributors

1. Manuscripts should be typed, double-spaced on $8\frac{1}{2} \times 11$ or $8 \times 10\frac{1}{2}$ white bond, on *one* side only. References, footnotes, captions—everything should be double-spaced. Margins should be $1\frac{1}{2}$ inches.
2. Ordinarily *two* copies of the manuscript and two sets of illustrations should be submitted where the second set of illustrations need not be prime quality; EXCEPT that *five* copies of papers on Remote Sensing and Photointerpretation are needed, all with prime quality illustrations to facilitate the review process.
3. Each article should include an abstract, which is a *digest* of the article. An abstract should be 100 to 150 words in length.
4. Tables should be designed to fit into a width no more than five inches.
5. Illustrations should not be more than twice the final print size: *glossy* prints of photos should be submitted. Lettering should be neat, and designed for the reduction anticipated. Please include a separate list of captions.
6. Formulas should be expressed as simply as possible, keeping in mind the difficulties and limitations encountered in setting type.