

INTERACTIVE GRAPHICS EDITING FOR IPIN

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INTRODUCTION

The digital terrain matrix will be the final product resulting from a number of collection, processing, and editing steps. The approach within IPIN will be to reduce the amount of required editing of the digital terrain matrix by editing the raw collected data before it contributes to the interpolation process. This implies it will be edited as close to its collection source as possible, such as the geomorphic and epipolar edit. The edit procedure will be a compromise between completely off-line editing and completely on-line editing. Each new data set will be plotted at a common scale and compared to existing maps, photo source, and other plots to determine which areas of data must require additional analysis. These areas will be marked on the initial plot and eventually windowed at the Interactive Graphics terminal of the Edit Station. The plot will be aligned with the data base through the data tablet associated with each terminal to assist the operators in windowing portions of the data base. All routines of the Edit Station operate on an area basis instead of a single point. This reduces the number of commands and the time required to complete the overall editing process.

Editing will be divided into five major modules corresponding to the steps in the production cycle that generates new data files. These modules will include Geomorphic Edit, Epipolar Edit, Matrix Edit, Fill-in Edit, and Edit of Model Joins. The following sections describe the basic operations that will occur within each module and a general description of the hardware components.

EDIT SYSTEM HARDWARE

The IPIN Edit System is composed of a central processor called the Edit Processor and several intelligent satellite terminals. It is designed to handle all the editing and plotting functions required for IPIN. A diagram of the hardware is shown in Figure 1.

Edit Processor

This processor is a ModComp II/45 mini-computer which acts as host processor to the Edit Stations and XY plotter. Its primary task is communications processing, but it is also available for background processing such as plot generation and some computations associated with terrain editing. It contains large scale disk storage for active edit files and high-speed communications link to the file manager.

XY Plotter

This is a high-speed flatbed plotter and controller and will function on-line to the Edit Processor. Plot files will be generated by the edit processor and plotted on a real-time basis or be spooled on a disk file for later retrieval by the plotter controller.

Edit Station

This is a collection of hardware and software to perform the actual editing. It contains a general purpose mini-computer, graphics controller, two data tablets, and two CRT display terminals. Each CRT display terminal and data tablet is considered as one edit terminal. Therefore, each edit station is composed of two independent edit terminals.

The general purpose mini-computer is a 16 bit system that will be time shared by two CRT display terminals through a graphics controller. It will have a minimum of 64K core and 10 million words of disk storage. It will be used for program development and in supporting the edit terminals.

The graphics controller will have computer graphics hardware/firmware designed to perform windowing, clipping, zooming, transformations, and vector/character generation. It will contain a 32K refresh buffer memory to be shared by the two CRT display terminals.

The edit terminal will be a high performance display CRT interfaced to the graphics controller. There will be two display CRT's per controller and the operation of each will be independent. The display CRT will have a minimum diagonal of 53 centimeters and a maximum spot size of .25 millimeters. The operator's interface to the terminal will be through a joystick, function switches, control dials, or keyboard.

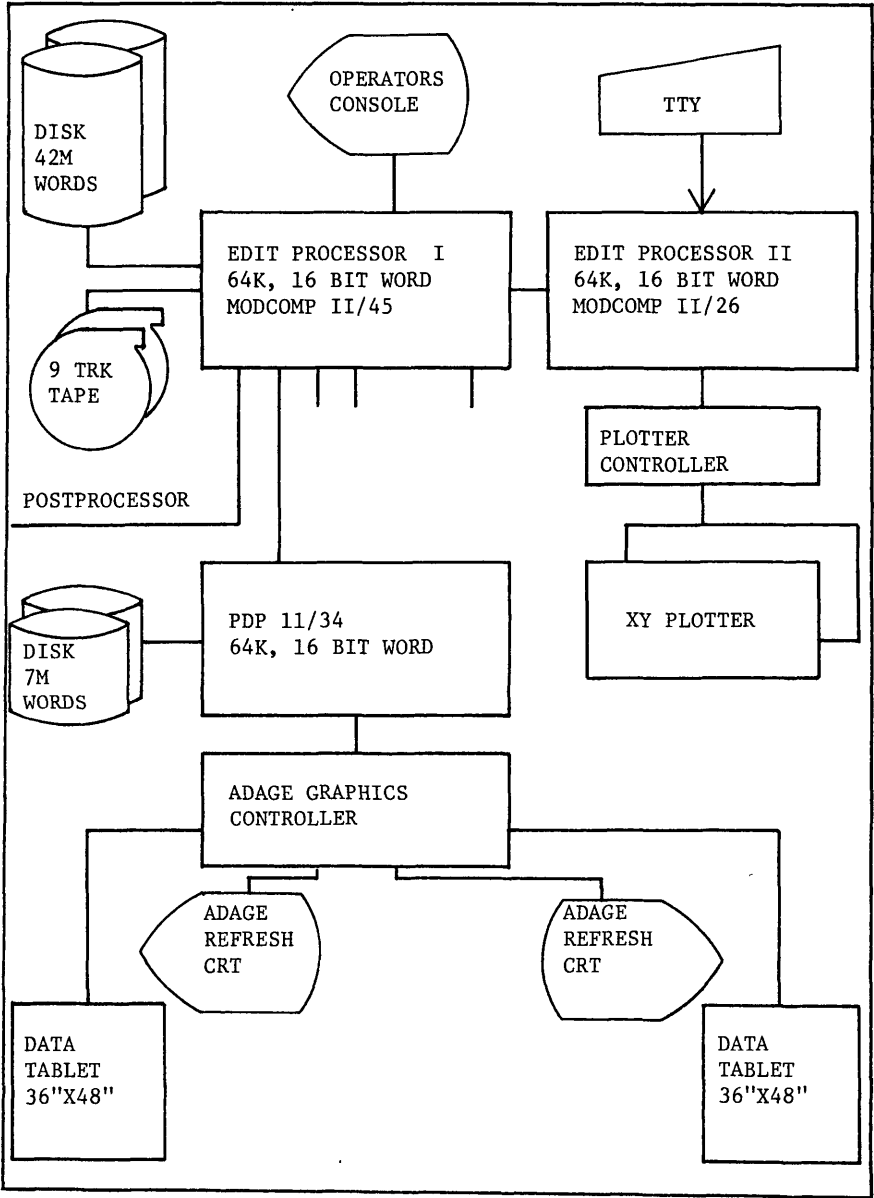


FIGURE 1. EDIT SYSTEM HARDWARE

Each edit terminal will also contain at least a 76 by 100 cm data tablet. Each data tablet will be interfaced to an edit terminal for operator interaction. A plot of the complete model data base and the operator's menu will be located on the data tablet.

EDIT PROCEDURES

The basic steps have been defined by the experience of DMAAC personnel in generating digital terrain data for the last three to five years. These anticipated edit steps, along with the volume of data and expected throughput helped to define the requirements for the Edit System hardware presented in the previous section. The software to execute each edit step is being designed and coded by DMAAC and the initial system is expected to be operational by July of 1980.

Edit of Geomorphic Data

Geomorphic data consists of natural features such as drainage patterns, lakes, ridges, cliffs, etc., and may contain some manmade features such as roads, railroads, canals, dams, etc. These features are compiled from aerial photography using X, Y and Z motions of an AS-11 Analytical Stereoplotter. The X and Y motions are controlled by handwheels to guide the floating mark and the Z motion is controlled by a footwheel to keep the floating mark on the ground. The primary source of errors that can be detected for the X and Y motions are procedural blunders, such as overshooting an intersection, placing incorrect labels on features, recording information while searching for features, etc. The primary editing of the X, Y elements of the lineal strings will be the deletion of the blunders without any attempt at smoothing features or performing any cartographic type corrections to lineal features, such as separating contours from lineal features or clipping intersections.

The footwheel controlling the Z motion of the stereoplotter is used to keep the floating mark on the model surface while following some feature. The footwheel requires a touch that is difficult to maintain. Hence, instead of a continuous decline or increase in the motion of the floating mark it is incremented in small steps. This vertical stepping is the primary source of error in the geomorphic data. The operator attempts to keep the floating mark on the surface but he continually overcorrects and undercorrects as he digitizes. The AS-11 stereoplotter records X, Y and Z coordinates of all collected data using an equal distance algorithm. Hence, if a drain or ridge line is considered as a straight line and each point were plotted on that line as a function of distance, then the plot would consist of a profile of the drain with equally spaced points. This information is used in the numerical smoothing algorithms to remove blunders and incremental steps of the X coordinate.

The numerical smoothing or editing of the data will occur at the collection devices before the photographs are removed.

Procedures at the edit stations will involve correcting the remaining anticipated geomorphic errors such as, assigning the correct elevation to lakes and shoreline points, correcting double line drains so that opposite shorelines are at the same elevation and the drain flows in the correct direction with the appropriate slope, and finally that the intersections of all drains are approximately at the same elevation.

A sample plot of geomorphic data is shown in Figure 2. This plot contains several lakes and the drainage patterns of the area. The grid network represents the basic definition of the data storage cells within IPIN. Each square represents the ground area covered by sixty intervals of matrix data.

Edit of Epipolar Data

Epipolar data is collected by the Advanced Compilation Equipment (ACE) Epipolar Plotter and is output in X, Y and Z model coordinates. The postprocessing component of IPIN converts this data to geographics and separates it into two files dependent upon each collected points figure of merit. The figure of merit is provided by the ACE and represents some degree of confidence in the correlated data. All points below an acceptable level are separated and plotted on the XY plotter and are used to show the areas of the model where the ACE has trouble correlating. A sample of this type of plot is shown in Figure 3. When two or more points are deleted in sequence, they are represented by a straight line. The actual flagging of the data has been accomplished at its source hence, the edit station is used to define the model areas that must be recollected. The edited geomorphic plot and unacceptable epipolar plot are superimposed and then a boundary file is generated to designate the fill-in areas. A sample plot of these fill-in areas is shown in Figure 4. The large void area in the lower right hand corner of the plot is not designed as a fill-in area since it falls within the large lake shown in Figure 2.

The operators will have the capability to review all or part of the acceptable epipolar data at the edit station, but this is not recommended due to the large volume of data.

Edit of Matrix Data

The matrix data is interpolated from edited geomorphic and epipolar data, hence, it is assumed that this data will be very close to being a final product. The first step after the matrix interpolation is the generation of a contour plot of the complete model referenced to the data base coordinates of latitude and longitude. A sample plot of this data is shown

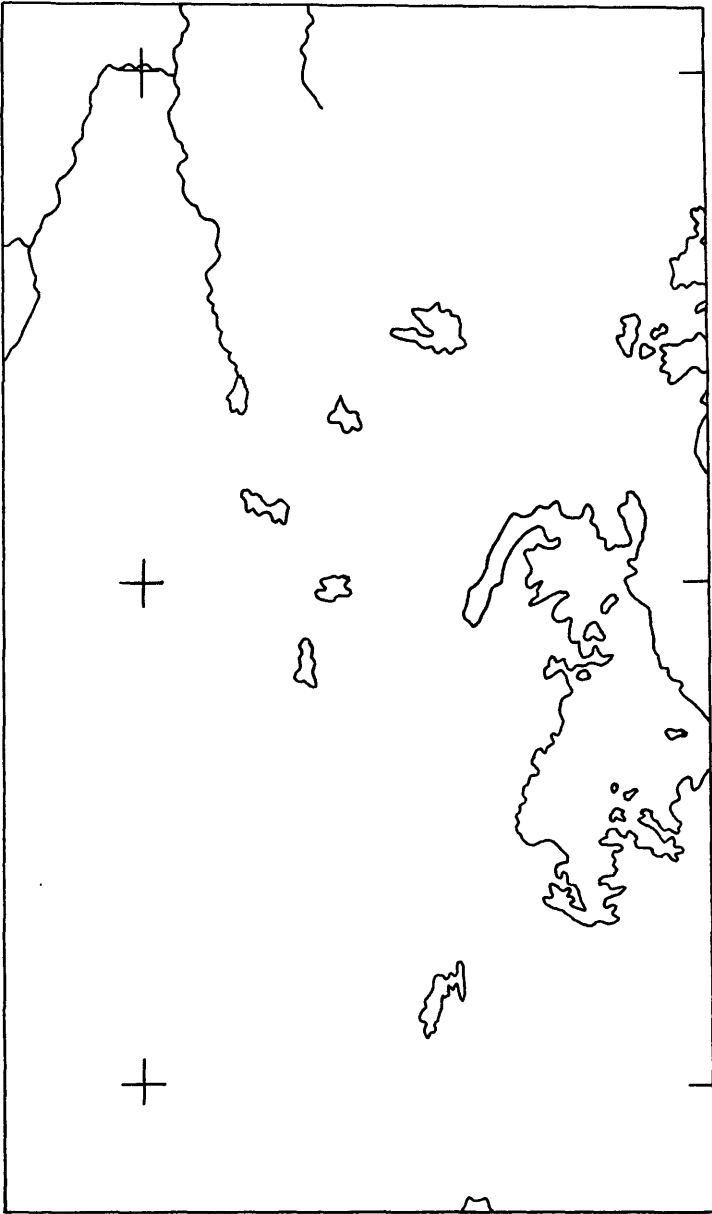


FIGURE 2. PLOT OF GEOMORPHIC DATA

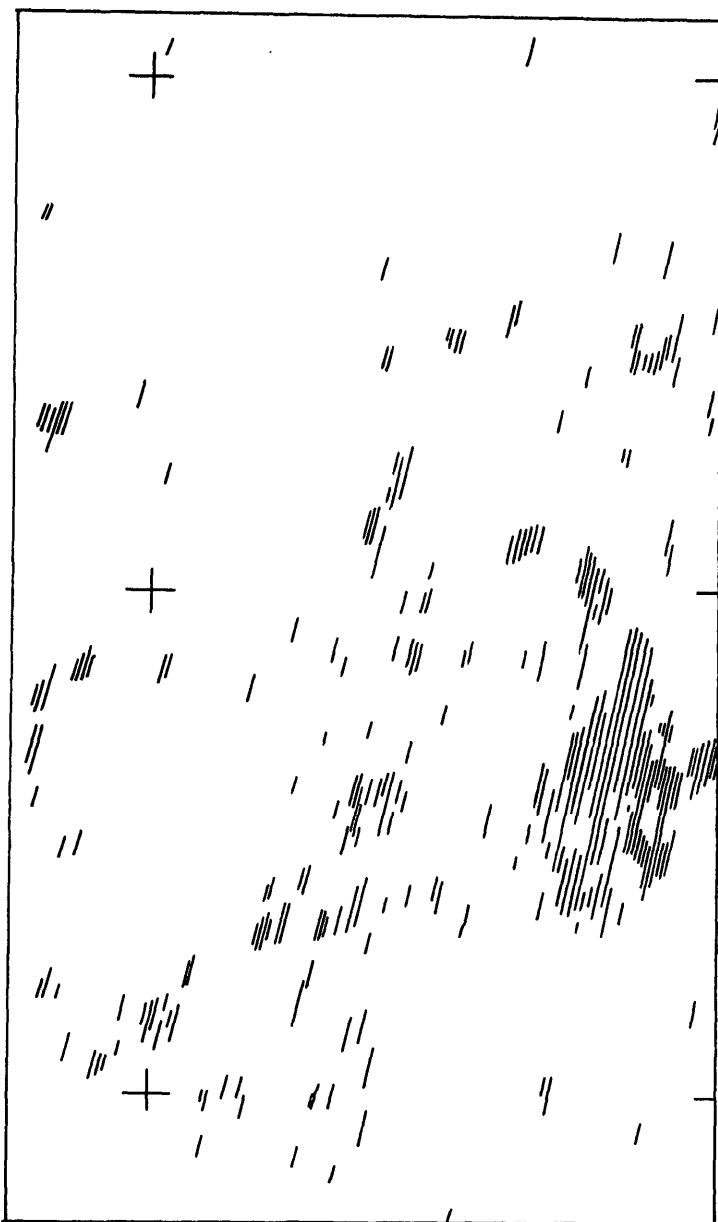


FIGURE 3. PLOT OF UNACCEPTABLE EPIPOLAR POINTS

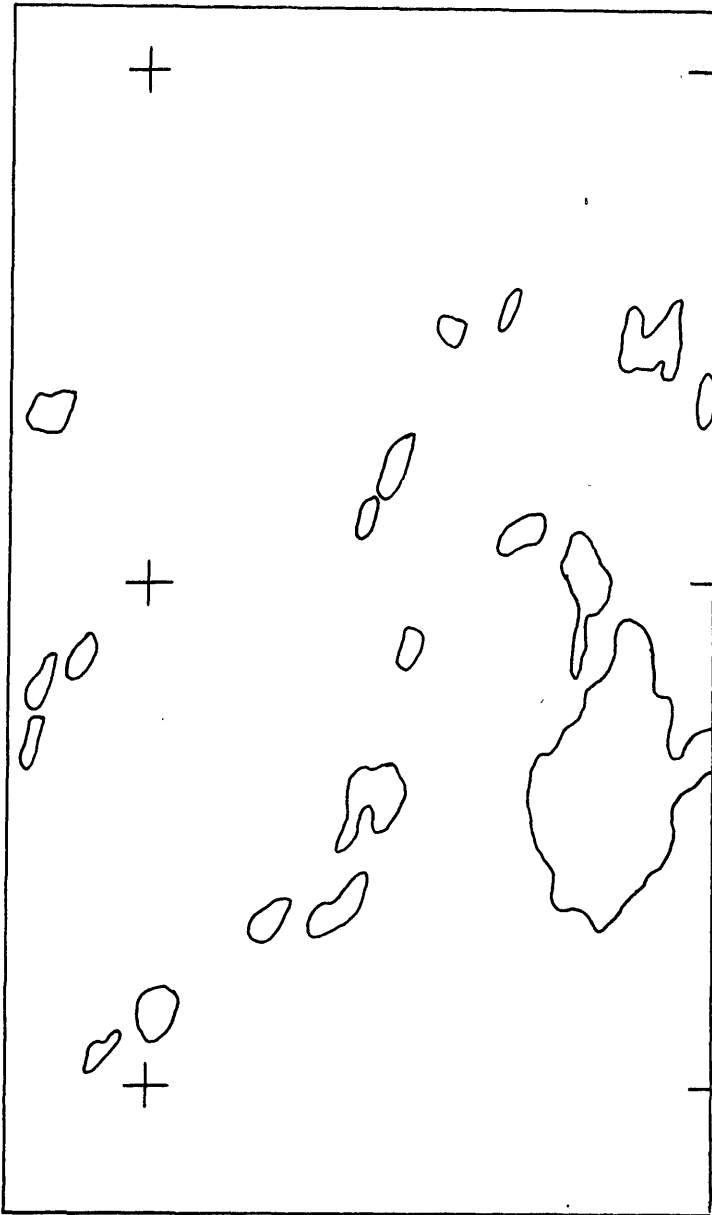


FIGURE 4. SELECTED EPIPOLAR FILL-IN AREAS

in Figure 5. The interpolation routine does not attempt to fill-in void areas. This is the reason the areas marked by the fill-in boundaries contain contours that are left hanging. The contour algorithm used for this plot is a simple linear routine to avoid misrepresenting the actual matrix.

The operator at the edit station will use the plot and all previous plots to locate areas outside the fill-in areas already defined that require his attention. He will have available most of the matrix edit routines that are currently being used to improve the aesthetic quality of the data or to designate additional fill-in areas. These routines include profile plots; polynomial smoothing by row and column or by area; deletion of data; interpolation routines; spike detection; etc. All of the routines are based on an area edit instead of single points.

Edit of Fill-in Data

Fill-in data is collected on the AS-11 Analytical Stereoplotter using the epipolar and matrix fill-in boundary files. These files are expanded by five rows and five columns to provide an overlap with the interpolated matrix data. The data is collected using a precise point matrix collection technique. The operator is directed to profile by the AS-11 Stereoplotter along meridians within the fill-in boundaries and the system records a point at every matrix interval. This matrix data is smoothed in the direction of collection on the AS-11 Stereoplotter and perpendicular to that direction at the edit station. The first step of the fill-in edit is the generation of a contour plot and then the comparison of this plot with all the previously generated plots. Next, each fill-in area is numerically compared to the interpolated matrix and is transformed using two rotations and a Z translation for each area to fit the interpolated matrix data. The operator at the edit station can use the derived statistics and elevation difference plots to determine if additional smoothing is required. He will be able to choose the common boundary of the two files, the method of data integration, (overlay, underlay, average of feather), and the acceptability of the completed matrix files. He also has all of the matrix edit functions available to correct any problems with the merged data sets. An example of the contour plots of the fill-in areas is shown in Figure 6.

Edit of Model Merge

The most time consuming operation at an edit station is the merging of geographic matrix data derived from two photogrammetric models. A major assumption of this process is that the control for each model is derived from the same photogrammetric block adjustment and that orientation and Z adjustment of each model is based solely on that control. This implies that any problems with model joins must be



FIGURE 5. CONTOUR PLOT OF INTERPOLATED CONTOUR DATA

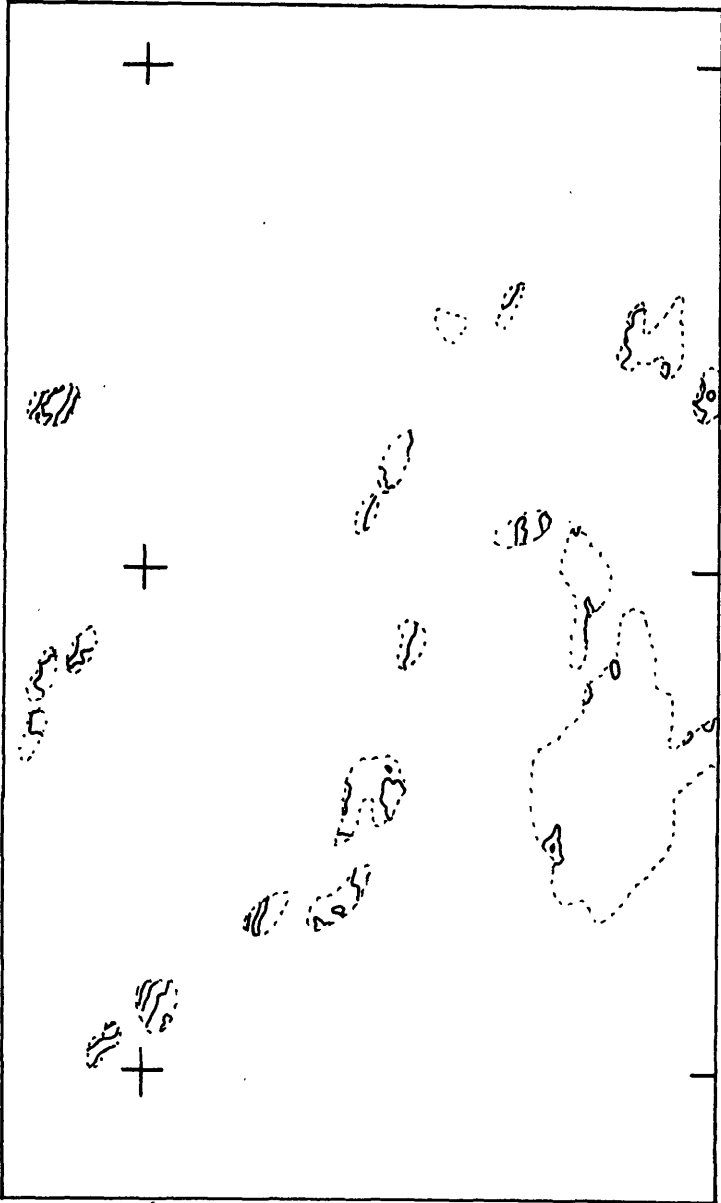


FIGURE 6. CONTOUR PLOT OF MATRIX FILL-IN AREAS

absorbed in the merger if the differences are within the predicted error of triangulation. The only type of merging that is allowed is for the common data sets to be averaged or feathered across the model join lines.

The procedure at the edit station is for the operator to load the matrix data in the overlap areas of both models and to compare common storage cells on each end and middle of the overlap region. These three areas are used to determine what technique and how many points should be used for this merger. The edit station will provide statistics, difference plots, and profile plots to assist the operator. Once the merge parameters are determined, then the complete overlap area is merged numerically and the statistics of each storage cell are computed. The operator has the same edit routines to correct or plot the merged matrix data as the matrix edit module.

All the models from a common photogrammetric strip are merged first. The matrix data for one model is then unique along that strip. Next, the overlap between adjoining strips are merged and this then generates a unique matrix file for each model. The last step of the process is the generation of a composite one degree square of information or submatrix that is not based upon model definitions, but data base areas. The basic area is a one degree square, which can vary according to matrix interval. Therefore, the basic matrix output file contains matrix data with a maximum of 1200 columns of elevations data and 1201 elements per column. The southwest corner of each submatrix is always a multiple of 1200 intervals times the matrix interval.

SUMMARY AND CONCLUSIONS

The Edit System has been defined for IPIN and its software development is well underway. It was designed to handle large volumes of data and to meet a stringent production schedule. There are several cartographic edit systems available, but this is the first system that attempts to operate in the realm of digital terrain matrices and pushes the state-of-the-art in interactive graphics.